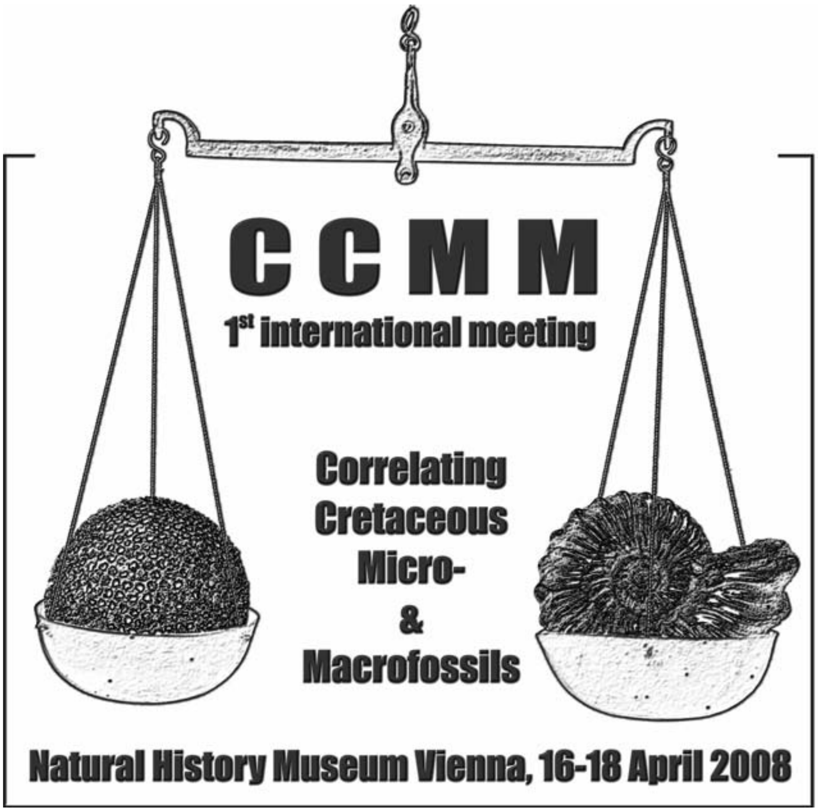


1st International Meeting
on
CORRELATION
of
CRETACEOUS MICRO- and MACROFOSSILS
16-18 April 2008
Vienna

1st International Meeting on Correlation of Cretaceous Micro- and Macrofossils

16-18 April 2008, Vienna

Natural History Museum Vienna

Scientific Program, Abstracts, Excursion Guide

Convener: ***Alexander LUKENEDER***

Co-convener: ***Hans EGGER and Michael WAGREICH***

Edited by Alexander LUKENEDER

Geologische Bundesanstalt

Berichte der Geologischen Bundesanstalt, Band 74

ISSN 1017- 8880

Wien 2008

1st CCMM

1st International Meeting
on
CORRELATION
of
CRETACEOUS MICRO- and MACROFOSSILS
16-18 April 2008

Convener: ***Alexander LUKENEDER***

Co-convener: ***Hans EGGER and MICHAEL WAGREICH***

Scientific Program, Abstracts, Excursion Guide

Edited by Alexander LUKENEDER

Natural History Museum Vienna

Preface

A cordial welcome to the **1st International Meeting on Correlation of Cretaceous Micro- and Macrofossils, 2008,** and to Vienna – a famous and charming city in the mid of new Europe, situated between the easternmost branches of the Northern Calcareous Alps and the Vienna Basin to the east.

The intention and main goal of the convener was to bring different scientists together, for an opportunity to discuss recent investigations. For the younger colleagues this meeting gives a grea topportunity to meet and get to known to more established scientist. Working groups can be established and possibilities of new methods can be discussed,

We are proud to announce the registration of 35 scientists from 15 different countries, which enabled us to compile a highly diverse program on Cretaceous topics. The different fields of investigations will be presented as oral presentations, posters and field trips. Experts will talk on isotopes, climates, microfossils, microvertebrates, facies changes, environments, correlation and many other topics of the Cretaceous period. Results on most recent investigations from all over the world will be presented, in some cases for the first time to a broader scientific community.

I would like to bring in a, my main, request: work together and correlate as much as you can. Correlation is everything to be sure that we speak about the same facts.

Much fortune and fun for you in your scientific and Cretaceous future.

Yours sincerely

Alexander **LUKENEDER**

Natural History Museum Vienna

Organisation of the 1st international meeting on CORRELATION OF CRETACEOUS MICRO- AND MACROFOSSILS, 2008, VIENNA

Venue

Natural History Museum Vienna, Burgring 7, A-1010 Vienna, Austria

Convener

Dr. Alexander LUKENEDER, Natural History Museum Vienna

Scientific Committee

Dr. Hans EGGER, Geological Survey of Austria

Dr. Michael WAGREICH, Department for Geological Sciences, University Vienna

Responsible for the oral and poster sessions

Dr. Alexander LUKENEDER

Fieldtrip guide

Dr. Alexander LUKENEDER, Dr. Oleg MANDIC, both Natural History Museum Vienna

Meeting logo

Dr. Mathias HARZHAUSER, Natural History Museum Vienna

Editors of the abstract volume

Dr. Alexander LUKENEDER, Natural History Museum Vienna

Editor of the proceeding issue

Dr. Andreas KROH, Natural History Museum Vienna

Dedication

Dedication

to

ALEXANDER TOLLMANN

1928-2007

The present meeting „Correlating Cretaceous Micro- and Macrofossils“ is dedicated to Prof. Dr. Alexander TOLLMANN (1928 – 2007), one of Austria's most prominent earth scientists of the last century. At a first view it seems astonishing to devote a meeting treating correlation-problems of the Cretaceous time period to a person whose major scientific work focused on tectonic problems of the Eastern Alps. And indeed, among the impressive total scope of TOLLMANN´s publications, we find only a minor amount articles dealing directly with stratigraphic problems of the Cretaceous time period. However, they are important enough to deserve discussion. TOLLMANN´s contributions to this subject concern the following thematic fields:

- Revision of the Lithostratigraphic Nomenclature of the Northalpine units
- Mesozoic
- Exact timing of Cretaceous orogenetic events
- Contributions to Cretaceous micropaleontology

Biographic remarks

Born in Vienna (27.6.1928) during hard times, TOLLMANN started his studies at the University of Vienna immediately after World War II. In 1953 he finished his studies with a PhD in geology *sub auspiciis praesidentis.* He continued his professional career at the Institute of Geology (Vienna University), where he became a recognized academic lecturer in 1962. Ten years later he obtained the very prestigious chair for geology at the same university which he held until 1996, when he became emeritus.

As well trained young man TOLLMANN mapped enormous areas in high mountainous regions of the Central Alps and the Northern Calcareous Alps. The insights gained from this demanding field work enabled him to write the pioneering book “Ostalpensynthese” (= Synthesis of the Eastern Alps) in 1963. The new ideas he introduced in this landmark paper caused numerous long lasting vigorous discussions. Between 1973 – 1986, TOLLMANN wrote six thick monographic books with reference to the geology of the Northern Calcareous Alps and the geology of Austria, all together more than 4000 pages! A detailed summary of TOLLMANN´s further scientific publications, more than 200 single papers – some of them book-size – are listed in the recently published memorial address (LEIN 2007).

TOLLMANN´s contributions to Cretaceous stratigraphy

1. Revision of the Lithostratigraphic Nomenclature

In the sixties and seventies of the last century a lot of non-Austrian earth scientists worked in the Alps. Many of them were unfamiliar with the well established regional lithostratigraphic nomenclature. By using pure descriptive lithologic terms instead, they introduced considerable academic confusion. TOLLMANN was one of the first who opposed this detrimental practice and the incorrect use of stratigraphic terms. In many controversial discussions concerning lithostratigraphic nomenclature TOLLMANN often disarmed his opponents at least by asking “How can you say this? Have you ever been at the type locality (of the discussed formation)?” Most of them had not.

The result of years of careful studies was a monographic analysis of the Mesozoic sedimentary sequences of the Northern Calcareous Alps. Regarding this topic, this book was and still is unique. 62 out of the 580 pages of this seminal work are about the description of Cretaceous lithostratigraphic units. Beside this compilation TOLLMANN also made some original contributions to Cretaceous micropaleontology and sedimentology (e.g. TOLLMANN, 1960; FAUPL & TOLLMANN 1978).

2. Timing of Cretaceous orogenetic events

Soon after the introduction of the concept of nappe tectonics, the idea of world wide simultaneous orogenetic events originated. STILLE (1924) was the first who worked out this idea systematically. This concept, first widely accepted, was brought into discredit later on when in some cases the proposed synchronism of certain tectonic events turned out to be wrong.

The revision of the stepwise tectonic evolution of the Alps with its culmination in Cretaceous times motivated TOLLMANN to investigate the timing of Alpine mountain building processes again in-depth. The results of this research, earned from the field evidences in the Eastern Alps and Western Carpathians, was a reanimation of the old STILLE-concept (TOLLMANN 1966). TOLLMANN also coined two new terms: the **Austroalpine phase** (TOLLMANN 1963:193, 1966:18) denoting the first signs of orogenetic disturbances in the sedimentary record in the middle part of the Early Cretaceous; the **Mediterranean phase** (1964:86, 1966:69), marking the short stratigraphic gap caused by the “pregosauic” nappe tectonics.

3. TOLLMANN´s contributions to Cretaceous micropaleontology

TOLLMANN´s later fame as renowned expert at regional tectonics almost make us forget his early work when he had a strong paleontological lop-side. For his PhD field-work in Neogene soft sediments of the Vienna Basin it was necessary for him to obtain practical experience in micropaleontology. Therefore his first publications were micropaleontological studies treating the stratigraphic evolution of Miocene foraminifers.

Later on, already fully involved in emotionally and academically trying struggles concerning his new concept of the tectonic evolution of the

Eastern Alps, TOLLMANN tried to obtain the award of a recognized academic lecturer of paleontology besides his university lectureship for geology. For this purpose he wrote a monographic description (TOLLMANN 1960) of a very rich Upper Coniacian microfauna from the Gosau-Group of the Aussee-Weissenbach valley, which he had detected when mapping this region. In this paper TOLLMANN described two foraminifer's species as new. The holotype of one of them, of ***Neoflabellina laterecompressa*** (Fig.1) is deposited in the micropaleontological collection of the National Museum of Natural History in Vienna.

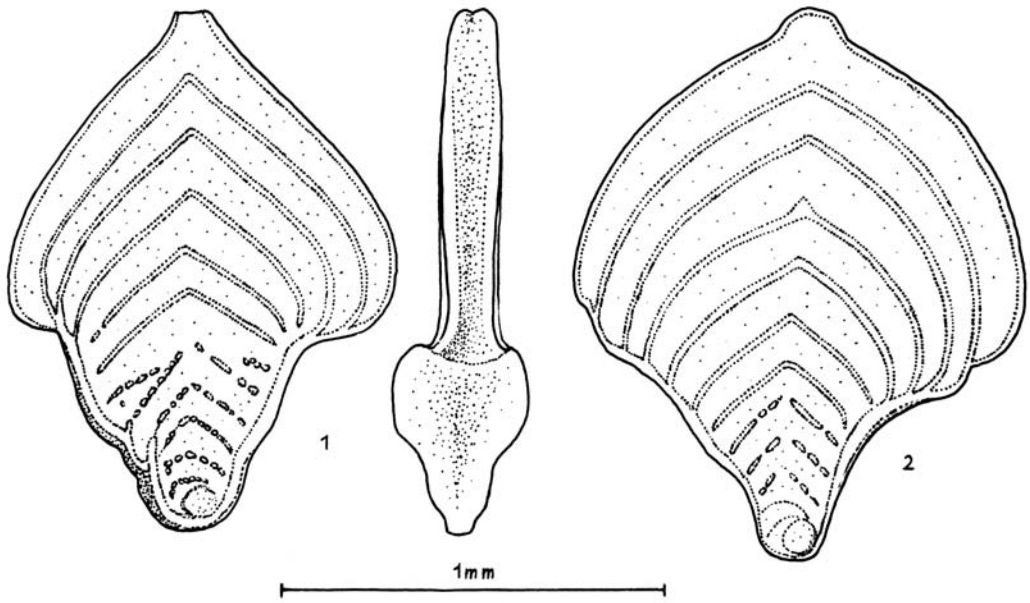


Fig. 1. *Neoflabellina laterecompressa* TOLLMANN

Years later TOLLMANN was again occupied with the genus *Neoflabellina.* Together with his wife Edith KRISTAN-TOLLMANN (1934-1995), a well known micropaleontologist, he described some additional new species (*N.hanzlikovae, N.extensa* and *N.ramosa*) from the Gosau-basin of Gams (KRISTAN-TOLLMANN & TOLLMANN 1976).

The most exciting discovery both made while comparing Upper Cretaceous foraminifera from Europe and North-America faunas (KRISTAN-TOLLMANN & TOLLMANN 1990). Their finding of the benthic foraminifer *Neoflabellina laterecompressa*, first described in Europe and formerly considered as an "endemic" taxon, in Cretaceous sediments of Texas revealed a transatlantic spreading of rare benthonic Cretaceous foraminifers. Many of them had been described under different names on both sides of the Atlantic Ocean before. A nomenclatural revision as proposed by TOLLMANN and his wife therefore is an urgent demand for the future.

Richard **LEIN**

References

FAUPL, P. & TOLLMANN, A. 1978: Die Roßfeldschichten: Ein Beispiel für Sedimentation im Bereich einer tektonisch aktiven Tiefseenrinne aus der kalkalpinen Unterkreide.- Geol. Rundschau, **68**, 93-112, Stuttgart.

KRISTAN- TOLLMANN, E.& TOLLMANN, A. 1976: Neue Neuflabellinen (Foraminifera) aus dem Senon der Gamser Gosau, Österreich.- Sitz.-Ber. Öster. Akad. Wiss., math.-naturwiss.Kl., Abt.I, **185**, 307-321, Wien.

KRISTAN- TOLLMANN, E. & TOLLMANN, A. 1990: Neoflabellinen aus der Oberkreide beiderseits des Atlantiks.- Mitt. österr. geol. Ges., **82**, 135-171, Wien.

LEIN,R. 2007: Alexander Tollmann (27.3.1928 – 8.8.2007).- Int. J. Earth. Sci., **100**, 238-250, Wien.

STILLE, H. 1924: Grundfragen der vergleichenden Tektonik.- 433 S., Berlin (Borntraeger).

STILLE, H. 1950: Nochmals die Frage der Episodizität und Gleichzeitigkeit der orogenetischen Vorgänge.- Geol. Rundschau, **38**, 108-111, Stuttgart.

TOLLMANN, A. 1960: Die Foraminiferenfauna des Oberconiac aus der Gosau des Ausseer Weißenbachtales in Steiermark.- Jb. Geol.-B.-A., **103**, 133-203, Wien.

TOLLMANN, A. 1963: Ostalpensynthese.- 256 S., Wien (Deuticke).

TOLLMANN, A. 1964: Übersicht über die alpidischen Gebirgs-bildungsphasen in den Ostalpen und Westkarpaten.- Mitt.Ges.Geol.Berg-baustud.Wien, **14** (1963), 81-88, Wien.

TOLLMANN, A. 1966: Die alpidischen Gebirgsbildungsphasen in den Ostalpen und Westkarpaten.- Geotekt.Forsch., **21**, 156 S., Stuttgart.

TOLLMANN, A. 1976: Analyse des klassischen nordalpinen Mesozoikums.- 560 S., Wien (Deuticke).

Cretaceous History of Austria

Michael **WAGREICH**, Alexander **LUKENEDER**, Hans **EGGER**

Cretaceous of the Eastern Alps

Within the Eastern Alps, a segment of the Alpine fold-and-thrust belt, Cretaceous rocks were identified for the first time in the late 18th century. In the early 19th century detailed investigations and correlations of Cretaceous strata by Sedgewick & Murchison (1832) and Lill von Lilienbach (1830) were undertaken, followed by monographs on various aspects of the Cretaceous from ca. 1850 onwards, e.g., Reuss (1854), Zittel (1866) and Redtenbacher (1873).

The Eastern Alps originated within the northwestern Tethys palaeogeographic belt due to repeated convergence between the European and the African plate and intervening microplates. A Jurassic-Cretaceous, "Eoalpine" orogeny was followed by Meso- and Neoalpine deformational events (e.g. Faupl & Wagreich 2000). The evolution of the orogen, especially Cretaceous geodynamics in the Eastern Alps and the Western Carpathians, are strongly discussed because of polyphase young deformations overprinting Mesozoic structures, the incompleteness of the sedimentary record and the weakly constrained palaeogeographic and palaeotectonic positions of some units. Proposed paleogeographic models differ in the inferred positions and timing of subduction zones and collisions (e.g. Faupl & Wagreich 2000; Von Eynatten & Gaupp 1999; Wortmann *et al.* 2001; Stampfli & Borel 2002).

Three major tectonic units with different types of sedimentary basins and basement units can be distinguished within the Cretaceous Alps (Fig. 1, 2): (1) the Helvetic s.l. European shelf units, platforms and basins on continental crust; today, these units form the northernmost thrust complexes of the orogen and are partly continuous into autochthonous successions of the North Alpine foreland, (2) the Penninic units, partly overthrust onto Helvetic units s.l. and exposed as large tectonic windows below overthrusting units of more internal derivation(3) the Austro-Alpine and the Southern Alpine units which originated from the northern margin of the Adriatic plate (Haubold *et al.* 1999). The Northern Calcareous Alps (NCA) represent a complicated pile of cover nappes including significant Cretaceous to Paleogene strata.

In the segments of the Eastern Alps and the Western Carpathians, Alpine orogeny commenced with the closure of a Triassic Tethys Gulf (Hallstatt-Meliata Ocean, e.g. Channel & Kozur 1997) within the Austro-Alpine domain during the Jurassic to Early Cretaceous. Contemporaneously, the Penninic Ocean (Part of the Liguria-Piemont Oceanic domain; Alpine Tethys of Stampfli et al., 2002) opened by oblique rifting and spreading between the European shelf and the Austroalpine microplate, connected to the opening of the Atlantic Ocean (Frisch 1979;

Stampfli *et al.* 2002). The Penninic-Austroalpine plate boundary changed from transtension to transpression during the mid-Cretaceous (Wagreich 2003). From Early Cretaceous times onwards, the sedimentary cover of the NCA was sheared off from its basement and stacked into a complex nappe pile. Deposition of synorogenic to postorogenic strata followed until renewed orogenesis during the Eocene to Oligocene. A complex history of synorogenic basins with strongly varying geometries and short-lived subsidence and uplift events characterizes the Austro-Alpine unit, especially during mid- and Late Cretaceous (Figs. 2, 3).

Facies overview

Helvetic/Ultrahelvetic Units

The Helvetic paleogeographic realm represents the depositional area on the southern border of the European continent during Mesozoic-Paleogene times. The Helvetic nappes extend from the western part of the Eastern Alps (Austria and Germany), where they disappear below the Austro-Alpine nappe system to Switzerland. These Helvetic units comprise sedimentary strata deposited on the shelf and upper continental slope of the European continent in a passive margin setting during the Cretaceous. The Early Cretaceous is characterized by a southward-prograding carbonate platform. Following the Cenomanian transgression, basinal hemipelagic to pelagic sediments dominate until Maastrichtian times. Towards the south, hemipelagic to pelagic deeper-water sediments of the Ultrahelvetic Zone, e.g., the Gresten Klippen Zone in eastern Austria, mark the transition into the Rhenodanubian Flysch Basin. The Upper Cretaceous-Paleogene Bunmergelserie, a variegitated successions of pelagic and hemipelagic marls and shales, is present in the Ultrahelvetic Gresten Klippen Zone of the Eastern Alps. Dark grey and black shales and limestone prevail from Aptian to Cenomanian up to a distinct black shale interval at the Cenomanian-Turonian boundary. The following Turonian to Upper Campanian is characterized by red marls and light grey to white limestones (Wagreich & Neuhuber, 2007; Neuhuber et al., 2007). Campanian to Maastrichtian marls again display medium to dark grey colours and increasing input of clay and silt. Upper Campanian ammonites are reported from this interval in Upper Austria (Kennedy & Summesberger 1984, 1999).

Penninic Units

The Penninic units comprise different parts of the Ligurian-Piemontais-Penninic-Valais oceanic systems, and include remnants of marginal continental fragments. The opening of these partly oceanic basins was linked to the Jurassic opening of the North Atlantic (Frisch 1979; Stampfli & Borel 2002). Mesozoic to Paleogene parts of the Penninic units are preserved as non-metamorphic cover nappes, comprising mainly turbidite successions in Switzerland and Austria, while other parts occur in various stages of metamorphism within tectonic windows below the overriding Austro-Alpine units.

The Rhenodanubian Flyschzone

The Rhenodanubian Flyschzone, which constitutes a 500-km-long imbricated thrust pile, trending ENE-WSW parallel to the northern margin of the Eastern Alps. To the south of Lake Chiemsee (Bavaria) it is interrupted for a short distance and so it has been subdivided into an eastern and western part.

The sedimentary succession of the Rhenodanubian Flyschzone consists of deep-water deposits, which have been considered a lithostratigraphic group (Egger & Schwerd, 2007). This Rhenodanubian Group (RG) consists primarily of siliciclastic and calcareous turbidites of Lower Barremian to Ypresian age. Thin, hemipelagic claystone layers occur in all formations of the RG and indicate a deposition below the local calcite compensation depth, probably at palaeodepths >3000 m (Butt, 1981; Hesse, 1975). Palaeocurrents and the pattern of sedimentation suggest that the deposition occurred on a flat, elongate, weakly inclined abyssal basin plain and was not disturbed by syndepositional tectonic deformation (Hesse, 1982, 1995).

Postdepositional thrusting and wrenching have destroyed the original basin configuration and the relationship to source areas. The RG has been deposited in the Penninic basin to the south of the European Plate, however, the exact palaeogeographic position of its sedimentation area is still a matter of discussion (Butt, 1981; Hesse, 1982; Oberhauser, 1995; Wortmann, 1996; Mattern, 1999; Trautwein, 2000; Egger et al., 2002).

The Cretaceous part of the RG attains a maximum thickness of about 1500m. Lower Cretaceous deposits of the RG recently have been studied biostratigrapically using dinoflagellates (Kirsch 2003): the 11 dinoflagellate zones found indicate the Upper Barremian to Upper Albian. During the major part of this episode, stratigraphically important calcareous nannoplankton species are exceedingly rare, as most of the encountered assemblages consist exclusively of monospecific nannofloras of *Watznaueria barnesiae*, which do not provide significant stratigraphic solution. Species richness is increasing in Upper Albian to lower Cenomanian (calcareous nannoplankton zone CC9) varicoloured marlstone (Untere Bunte Mergel; Egger, 1992; Wagreich et al., 2006).

This varicoloured marlstone is overlain by grey turbiditic marlstone (Ofterschwang Formation) or by the thick-bedded siliciclastic turbidites of the Reiselsberg Formation. Another dearth of turbidite sedimentation is indicated by varicoloured hemipelagic claystone with intercalated thin turbidite beds (Seisenburg Formation) of middle Coniacian to lower Campanian age (Zones CC14-CC18). The formation of these red beds seems to have been an effect of the high sea-level during this period. Another result of this highstand was the formation of the calcareous Röthenbach Subgroup, which is interfingering with the Seisenburg Formation. The calcareous turbidites prograded from the west and form a thickening and coarsening up-ward succession, which is often overlain by the thin-bedded turbidites and red claystone of the Perneck Formation of Late Campanian age (Zones CC21-CC22). The youngest Cretaceous lithostratigraphic unit is the primarily siliciclastic Altlengbach Formation, which comprises the Upper Campanian to Paleocene.

Austro-Alpine and Southern Alpine basins

The Austro-Alpine units are a characteristic unit of the Eastern Alps. Based on palaeomagnetic data the Austro-Alpine domain is considered to be a partly independent microplate situated along the northern margin of the Adriatic (Apulian) plate, and represents the northern tip of continental fragments of African affinity during the Cretaceous (e.g. Haubold et al. 1999; see also Stampfli & Borel 2002). Eoalpine deformation strongly influenced Cretaceous sedimentation and the formation of sedimentary basins within of the Austro-Alpine domain. Thus, a complex history of synorogenic basins with strongly varying geometries and short-lived subsidence and uplift events characterizes the Austro-Alpine realm, especially during mid- and Late Cretaceous times.

The best documented Cretaceous successions of the Austro-Alpine domain are preserved within the Northern Calcareous Alps (NCA, Fig. 3). Cretaceous deformation resulted in thrusting and faulting within the NCA. Based upon a restoration of younger faulting (Frisch et al. 1998), the Eastern Alps had about half the length of the present day mountain chain during the Late Cretaceous.

The Northern Calcareous Alps

Pelagic and synorogenic sedimentation in the Early Cretaceous

Within the Northern Calcareous Alps deep-water carbonate and marls predominate in the Lower Cretaceous. Synorogenic clastic successions and marl facies of the Lower Cretaceous comprises Maiolica-type limestones at their base grading into a shale-limestone cyclic facies. Resedimented clasts of shallow-water Urgonian-type carbonates (e.g. Schlagintweit 1991) give evidence that small carbonate platforms were present in northern parts of the NCA during the Early Cretaceous, but were later completely eroded. The deposits are interpreted as pelagic sedimts of the deep-water shelf to slope of the passive margin of the Austroalpine microplate. The onset of silicilcastic synorogenic strata marked the change to a tectonically active margin due to compression at the Austroalpine-Penninic margin (e.g. von Eynatten & Gaupp 1999; Wagreich 2003).

The Kimmeridgian - Early Berrasian Oberalm Formation represents a pelagic deep-water limestone with grey, cherty, bedded micrites including carbonate turbidites of varying thicknesses. The microfauna is dominated by radiolarians, calpionellids and foraminifera (e.g., Weidich 1990; Reháková *et al.* 1996; Boorová *et al*. 1999). Turbiditic Barmstein Limestone beds within the Oberalm Formation contain a diverse fauna of calcareous algae and foraminifera indicating an Early Berriasian age. The Upper Jurassic to Berriasian carbonate platforms of the Plassen Formation (Schlagintweit & Ebli 1999; Gawlick et al. 2006) can be regarded as the source for the resedimented shallow-water material.

The Oberalm Formation grades into grey micritic limestones and limestones-marl rhytmites of the Schrambach Formation (e.g. Vašíček & Faupl 1999; Rasser *et al.* 2003; Lukeneder, 2003, 2004, 2005; *Aptychus* limestone and Ammergau Formation p.p. of some authors) during the Berriasian. Sandy turbidites are largely absent in the Schrambach Formation, and the amount of marl intercalations increases upwards. Considering different tectonic units of the NCA both the base and especially the top of the Schrambach Formation are diachronous.

In more internal nappe complexes of the NCA (Tirolic units west and south of Salzburg; Reichraming and Lunz nappes further to the east), deep-water limestones graded into synorogenic terrigenous facies of the Rossfeld Formation during Valanginian to Aptian time (Decker *et al*. 1987; Vašíček & Faupl 1998). The Rossfeld basin is interpreted as a deep-water foreland to piggyback trough in front of overthrusting higher NCA-nappes (Decker *et al*. 1987). The Rossfeld Formation comprises a coarsening upward succession of marls and sandstones, grading into deep-water conglomerates/breccias as well as slump deposits sedimented on an active north-facing slope. The sandstones contain considerable amounts of siliciclastic and ophiolitic detritus from southern source terrains, including chrome spinels from ophiolites of the Tethys-Vardar-Hallstatt suture (Pober & Faupl 1988; von Eynatten & Gaupp 1999).

Lower Cretaceous Formations of the eastern part of the Northern Calcareous Alps

During the Lower Cretaceous the Mediterranean palaeogeographic domain was characterized by the presence of microplates located in the middle of the Tethyan oceanic corridor between the African and European landmasses. As noted by many authors (for example Cecca, 1997, 1998; Stampfli & Mosar, 1999), the region (Northern Calcareous Alps) on which the investigated areas were situated during the Lower Cretaceous was formed at the eastern border of the Alpine-Carpathian Block, which was located at the western margin of the Tethys.

Lower Cretaceous pelagic sediments are well known to form a major element of the northernmost tectonic units of the Northern Calcareous Alps (e.g., Ternberg-, Reichraming-, Frankenfels-, and Lunz Nappes) (see Lukeneder, 1998, 1999, 2001, 2003, 2003a, 2004; Lukeneder & Harzhauser, 2003). They cover wide areas both within the latter (e.g., Rossfeld, Losenstein, Schneeberg, Anzenbach, Ebenforst, and Flössel Synclines) and in various other European areas (e.g., Vocontian basin, Dolomites, Umbria, Western Carpathians, Gerecse and Mecsek Mountains and others) (Lukeneder & Aspmair 2006).

The Steinmühl Formation (approx. 15 m) is of Early Berriasian to late Early Valanginian age. Its lower part consisting of red (‘Ammonitico rosso’ type) and its upper part of grey (‘Maiolica’ type) condensed pelagic limestones with a few ammonoids, but abundant calpionellids and calcareous dinoflagellates enabling precise biostratigraphic correlations. The brachiopod *Pygope cattuloi* is abundant in the topmost bed (Lukeneder, 2002).

Schrambach Formation (approx. 150 m): Late Valanginian to late Barremian in age, consisting of pale grey, even bedded limestones intercalated with grey to black calcareous marlstones (laminated ‘black shales’), and marls. The beds are intensively bioturbated, and the trace fossils *Zoophycos*, *Chondrites* and *Planolites* occur throughout (Lukeneder, 2001).

The wavy boundary between the Steinmühl and the Schrambach Formation is marked by a primary hardground characterized by fragmented, encrusted, and partly eroded ammonoids and several bored cephalopods (e.g. belemnites; Lukeneder, 1998).

The evolution of marine biota on the southern European shelf was influenced by continuing disintegration of carbonate platforms during the Lower Cretaceous. Their pelagic influence also became more pronounced in former reef and shallow areas. The morphological highs (elevations or swells) in the pelagic environments were characterized by condensed sedimentation of the 'Ammonitico rosso' facies (Cecca et al., 1993, 1994).

Only elevated, firmer parts of the bottom were typically inhabited by benthic micro-organisms at that time. Nannoconid biomicrites prevailed both in the hemipelagic and pelagic environments over the extensive sea floor, formerly (during the Late Jurassic) characterized by diversified sedimentation. Pelagic marine environments were characterized by a uniformly soft unconsolidated muddy bottom. Nannoconids persisted in dominance during the Valanginian and Hauterivian, while the calpionellid share in the microplankton association decreased. Reorganization of the Mediterranean Tethys palaeogeography correlated with a change in current patterns resulted in a new Berriasian - Valanginian 'bloom' in plankton development.

The biostratigraphic data on the transition between the Schrambach and the Tannheim Formation of the northeastern Northern Calcareous Alps (Upper Austroalpine) are remarkable scarce (Weidich, 1990; Wagreich 2003). This fact reflects the absence of identifiable ammonoid macrofossil fauna as well as the absence or bad preservation of relevant microfossils. The corresponding boundary however has an extraordinary importance for the reconstruction of Austroalpine geodynamics as marking the initial siliciclastic input into the basin reflecting the starting point of the Penninic Ocean subduction beneath the Upper Austroalpine (Wagreich, 2003). Newly discovered outcrops in the Wienerwald (Vienna Woods), should now fill that gap. In these sections the critical interval has been found for the first time in an environment comprising extraordinarily rich accumulations of planktonic foraminifera.

Synorogenic mid-Cretaceous of the Northern Calcareous Alps

With the termination of the Rossfeld sedimentary cycle in the Barremian-Early Aptian, synorogenic basin subsidence shifted to tectonically lower (northern) zones of the NCA, the Frankenfels-Ternberg-Allgäu nappe system. Piggyback basins evolved in front of north to northwestward propagating thrusts, such as the Tannheim-Losenstein basin (Late Aptian to Early Cenomanian; Wagreich 2003). Deposits of the Tannheim-Losenstein basin (Fig. 2) form the core of faulted and partly overturned, narrow synclines. Within these units the Schrambach Formation is overlain by a few metres of marlstones and calcareous shales of the Tannheim Formation followed by a 100 - 350 m thick coarsening-upward clastic cycle of the Losenstein Formation.

The Tannheim Formation comprises grey and minor red and black shales and marlstones of Late Aptian to Middle/Late Albian age (Weidich, 1990). The marlstones and calcareous shales of the Tannheim Formation can be classified as hemipelagites, being a mixture of an autochthonous biogenic carbonate fraction, mainly planktonic foraminifera and calcareous nannoplankton, a terrigenous siliciclastic fine silt and clay fraction, and organic carbon. Bathyal depositional depth of at least a few hundred meters have been estimated based on the high content of planktonic foraminifera and the lack of shallow water foraminifera (Weidich 1990). Black shales with organic carbon up to 2% (Wagreich & Sachsenhofer 1999) are present in the Lower Albian, inlcuding OAE 1b with ammonites such as *Leymeriella tardefurcata* (Kennedy & Kollmann 1979; Kennedy *et al.* 2000).

The Tannheim Formation is overlain by the up to 350 m thick coarsening-upward cycle of the Losenstein Formation (Middle Albian - lowermost Cenomanian; Kollmann 1968; Weidich 1990), comprising turbidites, deep-water conglomerates and slump horizons. In the lower part of the Losenstein Formation, thin sandy turbidites and laminated siltstone-shale intervals prevail. Sandstone beds are up to 30 cm thick and show grading and both complete and partly incomplete Bouma-cycles. The amount of conglomeratic layers increases upsection. Both normal and inversly graded clast-supported conglomerates and matrix-supported pebbly mudstones and pebbly sandstone are found. Overall, the thickness of pebbly mudstones and slump intervals increases in the upper part of the Losenstein Formation. Slump intervals comprise folded beds of laminated siltstone-shale intervals with only minor sandstone intercalations. The uppermost preserved facies type includes thick slump intervals and olistostromes. The facies association was interpreted as a coarse-grained deep-water slope apron along the active northern margin of the Austroalpine microplate (Wagreich 2001, 2003).

The synorogenic Branderfleck Formation (Cenomanian-Turonian; up to Early Campanian in the western NCA) unconfomably overlies faulted and folded older NCA strata. (Gaupp 1982). Basal breccias and shallow-water sandstones containing orbitolinids pass into tens of metres of deep-water hemipelagic and turbiditic deposits, including olistoliths of Triassic to Jurassic carbonates (Schlagintweit & Wagreich, 2006).

Upper Cretaceous Gosau Group

In the Turonian, as a consequence of the Eoalpine orogeny, most of the deformed Austroalpine domain was elevated above sea level. In front of the Austroalpine microplate, an accretionary wedge existed as a result of subduction of the Penninic Ocean under a dextral transpressional regime (comp. Fig. 2). This wedge comprised tectonic slices of Austroalpine units and obducted ophiolite remnants. The NCA, which had probably already been sheared off from their metamorphic basement, were situated during this time at this tectonically active continental margin.

In Late Turonian time, a new sedimentary cycle started with the deposition of the Gosau Group, which rests unconfomably upon the Eoalpine deformed pre-Gosau strata and also on metamorphic Austroalpine basement south of the NCA. As unconformable Upper Cretaceous strata are widespread in the Alpine-Carpathian mountain chain, the term Gosau has been used from the NCA to Slovakia, Hungary and Romania for such deposits (e.g. Willingshofer *et al.* 1999). Basin formation is still discussed as a result of a complex interplay of sedimentation and tectonism during the Late Cretaceous history of the whole Austroalpine block, and several basin types were recently interpreted for these basins, e.g. compressional piggy back and synthrust basin models (e.g. Ortner 2001) or extensional and pull-apart basin models (e.g. Willingshofer *et al.* 1999; Wagreich & Decker 2001).

Recent data on the biostratigraphy, lithostratigraphy and isotope stratigraphy of the Gosau Group can be found, among others, in Summesberger (1985), Wagreich (1992), Tröger & Summesberger, Summesberger & Kennedy (1996), Summesberger *et al.* (1999), Steuber (2001), Wagreich et al. (2003), Hradecka et al. (2005).

The Gosau Group of the NCA can be divided into two subgroups as a consequence of different basin geometries and subsidence histories (Wagreich 1993, 1995; Wagreich & Faupl 1994). The lower Gosau Subgroup (Upper Turonian - Campanian; Maastrichtian-Paleogene only in the southeastern NCA) consists of diachronous terrestrial deposits at the base and passes gradationally into shallow-marine successions (Fig. 3). At the base, karst bauxites of probably Turonian age are present (Mindszenty & D'Argenio 1987), giving evidence for pronounced subaerial exposure of at least parts of the NCA during this time. Sandstones and sandy limestones together with rudist-bearing limestones, storm-influenced inner and outer shelf facies and shelf/slope transitional facies are the main facies of the lower Gosau Subgroup (Wagreich & Faupl 1994, Sanders *et al*. 1997; Sanders & Pons 1999). Locally, high contents of ophiolitic detritus are a conspicous feature of sandstones of this subgroup. The lower Gosau Subgroup was deposited mainly in small strike-slip basins (Wagreich & Decker 2001) which originated due to extension or transtension after mid-Cretaceous thrusting and transpression along the Penninic-Austroalpine boundary (Wagreich & Faupl 1994).

The upper Gosau Subgroup comprises deep-water deposits (Fig. 7), such as hemipealgic and pelagic slope marls (Nierental Formation; Butt 1981; Wagreich & Krenmayr 1993; Krenmayr, 1996) and a broad variety of deep-water clastics, deposited above and below the calcite compensation level (Fig.3). Facies distribution and palaeocurrent data indicate a pronounced fault-controlled relief of a generally north-facing palaeoslope (Faupl & Wagreich 1994). A conspicuous unconformity separates the lower from the upper subgroup, and parts of the lower Gosau Subgroup have been eroded at this unconformity. In contrast to the lower Subgroup, the terrigenous material of the deep-water successions comprises predominantly metamorphic detritus. Shallow-water components, such as corallinacea, orbitoid foraminifera, bryozoa etc., point to the existenece of a coeval carbonate platform in the south of the NCA (Wagreich & Faupl 1994).

The subsidence event into bathyal depths shifted diachronously from the Santonian/Campanian from the northwest towards the southeast of the NCA. The easternmost parts of the NCA were involved as late as Maastrichtian to Paleocene times. This strong subsidence pulse has been explained by subcrustal tectonic erosion, eliminating parts of the accretionary wedge along the northern margin of the Austroalpine plate (Wagreich 1993, 1995).

Several sites with a fairly complete record of the Cretaceous/Paleogene boundary were found within the Gosau Group of the NCA at Gosau (Elendgraben section), at Gams (Knappengraben section) and near Berchtesgaden/Lattengebirge (Herm *et al.* 1981; Preisinger *et al*. 1986; Peryt *et al.* 1993). A detailed biostratigraphy and magnetostratigraphy was established for these sites and several impact-related features were reported from the deep-water boundary clays of the Gosau Group, e.g. iridium enrichment, shocked quartz crystals, etc. (Preisinger *et al.* 1986).

References

BOOROVÁ, D., LOBITZER, H., SKUPIEN, P. & VAŠIČEK, Z., 1999. Biostratigraphy and facies of Upper Jurassic-Lower Cretaceous pelagic carbonate sediments (Oberalm-, Schrambach- and Roßfeld-Formation) in the Northern Calcareous Alps, south of Salzburg. *Abhandlungen der Geologischen Bundesanstalt*, **56**, 273-318.

BUTT, A., 1981. Depositional environments of the Upper Cretaceous rocks in the northern part of the Eastern Alps. *Cushman Foundation for Foraminiferal Research Special Publication*, **20**, 1-81.

CECCA, F., 1997. Late Jurassic and Early Cretaceous uncoiled ammonites: trophism-related evolutionary processes. - C. R. Acad. Sci. Paris, sér. II **325**: 629-634, Paris.

CECCA, F., 1998. Early Cretaceous (pre-Aptian) ammonites of the Mediterranean Tethys: Palaeoecology and palaeobiography. – Palaeogeogr. Palaeoclimat., Palaeoecol. **138**: 305-323, Amsterdam.

DECKER K., FAUPL P. & MÜLLER A., 1987. Synorogenic sedimentation on the Northern Calcareous Alps during the Early Cretaceous. In: FLÜGEL, H.W. & FAUPL, P. (eds) *Geodynamics of the Eastern Alps*, 126-141, Vienna (Deuticke).

EGGER, H. 1992. Zur Geodynamik und Paläogeographie des Rhenodanubischen Flysches (Neokom - Eozän) der Ostalpen. Zeitschrift der deutschen geologischen Gesellschaft 143, 51-65.

EGGER, H., HOMAYOUN, M. & SCHNABEL, W., 2002. Tectonic and climatic control of Paleogene sedimentation in the Rhenodanubian Flysch Basin (Eastern Alps, Austria). *Sedimentary Geology*, **152**, 147-162.

EGGER, H., SCHWERD, K. 2007. Stratigraphy and sedimentation rates of Upper Cretaceous deep-water systems of the Rhenodanubian Group (Eastern Alps, Germany), Cretaceous Research, doi:10.1016/j.cretres.2007.03.002

FAUPL, P. & WAGREICH, M., 2000. Late Jurassic to Eocene palaeogeography and geodynamic evolution of the Eastern Alps. *Mitteilungen der Österreichischen. Geologischen Gesellschaft*, **92**, 79-94.

FRISCH, W., 1979. Tectonic progradation and plate tectonic evolution of the Alps. *Tectonophysics*, **60**, 121-139.

FRISCH; W., KUHLEMANN, J., DUNKL, I. & BRÜGEL, A., 1998. Palinspastic reconstruction and topographic evolution of the Eastern Alps during late Tertiary tectonic extrusion. *Tectonophysics*, **297**, 1-15.

GAWLICK, H.-J.; SCHLAGINTWEIT, F.; SUZUKI, H., 2006. Berriasian drowning of the Plassen carbonate platform at the type-locality and its bearing on the early Eoalpine orogenic dynamics in the Northern Calcareous Alps (Austria). - International Journal of Earth Sciences, 95, 451-462.

GAUPP, R., 1982. Sedimentationsgeschichte und Paläotektonik der kalkalpinen Mittelkreide (Allgäu, Tirol, Vorarlberg). *Zitteliana*, **8**, 33-72.

HAUBOLD, H., SCHOLGER, R., FRISCH, W., SUMMESBERGER, H & MAURITSCH, H.J., 1999. Reconstruction of the geodynamic evolution of the Northern Calcareous Alps by means of paleomagnetism. *Physical Chemical Earth* (A), **24**, 697-703.

HERM, D., VON HILLEBRANDT, A. & PERCH-NIELSEN, K., 1981. Die Kreide/Tertiärgrenze im Lattengebirge (Nördliche Kalkalpen) in mikropaläontologischer Sicht. *Geologica Bavarica*, **82**, 319-344.

HESSE, R., 1975. Turbiditic and non-turbiditic mudstone of Cretaceous flysch sections of the East Alps and other basins. Sedimentology 22, 387-416.

HESSE, R., 1982. Cretaceous-Paleogene Flysch Zone of the east Alps and Carpathians: identification and plate-tectonic significance of „dormant" and „active" deep-sea trenches in the Alpine-Carpathian Arc. In: Leggett, J.K. (Ed.). Trench-forearc geology. Geological Society of London Special Publication 10, 471-494.

HESSE, R., 1995. Bed-by-bed correlation of trench-plain turbidite sections, Campanian Zementmergel Formation, Rhenodanubian Flysch Zone of the Eastern Alps. In: Pickering, K.T., Hiscott, R.N., Kenyon, N.H., Ricci Lucchi, F., and Smith, R.D.A. (Eds.): Atlas of Deep Water Environments: Architectural style in turbidite systems, 307-309, London (Chapman & Hall).

HRADECKA, L., LOBITZER, H., OTTNER, F., SCHLAGINTWEIT, F., SVOBODOVA, M., SZENTE, I., SVABENICKA, L. & ZORN, I:, 2005. Biostratigraphy and palaeoenvironment of the Lower Gosau Subgroup of Eisenbach Brook in Salzkammergut (Upper Austria). Gmundner Geo-Studien, 3.

KENNEDY, W.J., GALE, A.S., BOWN, P.R., CARON, M., DAVEY, R.J., GRÖCKE, D. & WRAY, D.S., 2000. Integrated stratigraphy across the Aptian-Albian boundary in the Marnes Bleues, at the Col de Pré-Guittard, Arnayon (Drôme), and at Tartonne (Alpes-de-Haute-Provence), France: a candidate Global Boundary Stratotype Section and Boundary Point for the base of the Albian Stage. *Cretaceous Research*, **21**, 591-720.

KENNEDY, W. J. & KOLLMANN, H. A., 1979. Lower Albian ammonites from the Tannheim Formation near Losenstein, Upper Austria. *Beiträge zur Paläontologie Österreichs*, **6**, 1-25.

KIRSCH, K.-H., 2003, Dinoflagellatenzysten-Zonierung der höheren Unterkreide des Rhenodanubischen Flysches. Zitteliana A43, 143-158.

KOLLMANN, H. A., 1968. Zur Gliederung der Kreideablagerungen der Weyerer Bögen (O.-Ö.). *Verhandlungen der Geologischen Bundesanstalt*, **1968**, 126-137.

KOLLMANN, H.A. & SUMMESBERGER, H. 1982. Excursions to Coniacian – Maastrichtian in the Austrian Alps. *WGCM, 4th Meeting Gosau Basins in Austria*.

KRENMAYR, H.G., 1996. Hemipelagic and turbiditic mudstone facies associations in the Upper Cretaceous Gosau Group of the Northern Calcareous Alps (Austria). *Sedimentary Geology*, **101**, 149-172.

LILL VON LILIENBACH, 1830. Ein Durchschnitt aus den Alpen mit Hindeutungen auf die Karpathen. *Leonhard und Bronns Jb*., Heidelberg, 153-220.

LUKENEDER, A., 1998. Zur Biostratigraphie der Schrambach Formation in der Ternberger Decke (O.-Valanginium bis Aptium des Tiefbajuvarikums-Oberösterreich). *Geol. Paläont. Mitteil. Innsbruck* 23, 127-128.

LUKENEDER, A., 1999. Excursion-guide to the Lower Cretaceous sequence of the Flösselberg Syncline (Lower Austria). 5th International Symposium "Cephalopods - Present and Past", 17 p., Wien.

LUKENEDER, A., 2001. Palaeoecological and palaeooceanographical significance of two ammonite mass-occurrences in the Alpine Early Cretaceous. *PhD-Thesis*, Univ. Vienna, 1-316.

Lukeneder, A., 2003. The *Karsteniceras* Level: Dysoxic ammonoid beds within the Early Cretaceous (Barremian, Northern Calcareous Alps, Austria). *Facies*, 49, 87-100.

LUKENEDER, A. 2003a. Ammonoid stratigraphy of Lower Cretaceous successions within the Vienna Woods (Kaltenleutgeben section, Lunz Nappe, Northern Calcareous Alps, Lower Austria). In: Piller W.E. (Ed.): *Stratigraphia Austriaca. Austrian Acad. of Sci. Series*, *"Schriftenreihe der Erdwissenschaftlichen Kommissionen"* 16, Vienna, 165-191.

Lukeneder, A., 2004. The Olcostephanus Level: An Upper Valanginian ammonoid mass-occurrence (Lower Cretaceous, Northern Calcareous Alps, Austria). *Acta Geologica Polonica*, 54, 1, 23-33.

Lukeneder, A., 2005. Taphonomy and stratigraphy of Early Cretaceous ammonoid mass occurrences (Late Valanginian, Northern Calcareous Alps; Upper Austria). *Austrian Journal of Earth Sciences*, 98, 34-51.

Lukeneder, A. (2005): An equivalent of the Karsteniceras Level within the Vienna Woods (Sparbach section, Lunz Nappe, Northern Calcareous Alps, Lower Austria). - Geologica Carpathica, 56, 4, 307-315, Bratislava.

LUKENEDER, A. & ASPMAIR, C. 2006. Startigraphic implication of a new Lower Cretaceous ammonoid fauna from the Puez area (Valanginaian - Aptian, Dolomites, Southern Alps, Italy). *Geo.Alp*, **3**, 55-91.

LUKENEDER, A., HARZHAUSER, M. 2003. Olcostephanus guebhardi as cryptic habitat for an Early Cretaceous coelobite community (Valanginian, Northern Calcareous Alps, Austria). *Cretaceous Research*, **24**, 477-485.

MATTERN, F., 1999. Mid-Cretaceous basin development, paleogeography, and paleogeodynamics of the western Rhenodanubian Flysch (Alps). *Zeitschrift der Deutschen Geologischen Gesellschaft*, **150**, 89-132.

MINDSZENTY, A. & D'ARGENIO, B., 1987. Bauxites of the Northern Calcareous Alps and the Transdanubian Central Range: A comparative estimate. *Rend. Soc. Geol. It*., **9**, 269-276.

NEUHUBER, S., WAGREICH, M., WENDLER, I. & SPÖTL, C., 2007. Turonian Oceanic Red Beds in the Eastern Alps: Concepts for palaeoceanographic changes in the Mediterranean Tethys. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 251, 222–238.

OBERHAUSER, R., 1995. Zur Kenntnis der Tektonik und der Paläogeographie des Ostalpenraumes zur Kreide-, Paleozänund Eozänzeit. Jahrbuch der Geologischen Bundesanstalt 138, 369-432.

ORTNER, H., 2001. Growing folds and sedimentation of the Gosau group, Muttekopf, Northern Calcareous Alps, Austria. *International Journal of Earth Sciences*, **90**, 727-739.

PERYT, D., LAHODYNSKY, R., ROCCHIA, R. & BOCLET, D., 1993. The Cretaceous/Paleogene boundary and planktonic foraminifera in the Flyschgosau (Eastern Alps, Austria). *Palaeogeography, Palaeoclimatology, Palaeoecolology,* **104**, 239-252.

POBER, E.& FAUPL, P., 1988. The chemistry of detrital chromian spinels and its implications for the geodynamic evolution of the Eastern Alps. *Geologische Rundschau*, **77**, 641-670.

PREISINGER, A., ZOBETZ, E., GRATZ, A., LAHODYNSKY, R., BECKE, M., MAURITSCH, H.J., EDER, G., GRASS, F., RÖGL, F., STRADNER, H. & SURENIAN, R., 1986: The Cretaceous/Tertiary boundary in the Gosau Basin, Austria. *Nature,* **322,** 797-799.

RASSER, M.W., VAŠÍČEK, Z., SKUPIEN, P., LOBITZER, H. & BOOROVÁ, D., 2003. Die Schrambach-Formation an ihrer Typuslokalität (Unter-Kreide, Nördliche Kalkalpen, Salzburg): Lithostratigraphische Formalisierung und „historische“ Irrtümer. In: PILLER, W.E. (ed) *Stratigraphia Austriaca*. - Österreichische Akademie der Wissenschaften, Schriftenreihe der Erdwissenschaftlichen Kommissionen, **16**, 193-216.

REHÁKOVÁ, D., MICHALIK, J. & OŽVOLDOVÁ, L., 1996. New microbiostratigraphical data from several Lower Cretaceous pelagic sequences of the Northern Calcareous Alps, Austria (preliminary results). *Geologisch-Paläontologische Mitteilungen Innsbruck*, *Spec. Vol.,* **4**, 57-71.

REDTENBACHER, A., 1873. Die Cephalopodenfauna der Gosauschichten in den nordöstlichen Alpen. *Abhandlungen der Geologischen Reichsanstalt*, **5**, 91-140.

REUSS, A.E., 1854. Beiträge zur Charakterisitk der Kreideschichten der Ostalpen, besonders im Gosauthale und am Wolfgangsee. *Denkschriften der Österreichischen Akademie der Wissenschaften, mathematisch-naturwissenschfatliche Klasse*, **7**, 156 S.

SANDERS, D., KOLLMANN, H. & WAGREICH, M., 1997. Sequence development and biotic assemblages on an active continental margin: the Turonian-Campanian of the northern Calcareous Alps, Austria. *Bulletin Societe géologique de France*, **168**, 351-372.

SANDERS, D. & PONS, J.M., 1999. Rudist formations in mixed siliciclastic-carbonate depositional environments, Upper Cretaceous, Austria: stratigraphy, sedimentology, and models of development. *Paleogeography, Paleoclimatology, Paleoecology*, **148**, 249-284.

SCHLAGINTWEIT, F., 1991. Allochthone Urgonkalke in mittleren Abschnitt der Nördlichen Kalkalpen: Fazies, Paläontologie und Paläogeographie. *Münchner geowissenschaftliche Abhandlungen*, **A 20**, 119 pp.

SCHLAGINTWEIT, F. & EBLI, O., 1999. New Results on Microfacies, Biostratigraphy and Sedimentology of Late Jurassic – Early Cretaceous platform carbonates of the Northern Calcareous Alps. Part I: Tressenstein Limestone, Plassen Formation. *Abhandlungen der Geologischen Bundesanstalt*, **56/2**, 379-418.

SCHLAGINTWEIT, F. & WAGREICH, M., 2005. Micropaleontology of „Orbitolina Beds“ of Lower Austria (Branderfleck Formation, Lower Cenomanian). Jahrb. Geol. Bundesanst. 145, 115-125.

SEDGWICK, A. & MURCHISON, R., 1832. A sketch of the structure of the Eastern Alps. *Geological Society of London, Transactions, Series* **23/2**, 301-420.

STAMPFLI, G.M. & BOREL, G.D., 2002. A plate tectonic model for the Paleozoic and Mesozoic constrained by dynamic plate boundaries and restored synthetic oceanic isochrons*. Earth and Planetary Science Letters*, **196**, 17-33.

STAMPFLI, G.M., BOREL, G., MARCHANT, R. & MOSAR, J., 2002. Western Alps geological constraints on western Tethyan reconstructions. *Journal Virtual Explorer*, **8**, 77-106.

STAMPFLI, G., MOSAR, J., 1999. The making and becoming of Apulia. - Mem. Scié. Géol. (University of Padova). Special volume, 3rd Workshop on Alpine Geology **51**/1, Padova.

STEUBER, T., 2001. Strontium isotope stratigraphy of Turonian-Campanian Gosau-type rudist formations in the Northern Calcareous and Central Alps (Austria and Germany). *Cretaceous Research*, **22**, 429-441.

SUMMESBERGER, H., 1985. Ammonite zonation of the Gosau Group (Upper Cretaceous, Austria). *Annalen des Naturhistorischen Museums Wien*, **87**, 145-166.

SUMMESBERGER, H. & KENNEDY, W.J., 1996. Turonian Ammonites from the Gosau Group (Upper Cretaceous; Northern Calcareous Alps; Austria) with a revision of *Barroisiceras haberfellneri* (HAUER 1866). *Beiträge zur Paläontologie Österreichs*, **21**, 1-75.

SUMMESBERGER, H, WAGREICH, M, TRÖGER, K.-A. & JAGT, J.W.M., 1999. Integrated biostratigraphy of the Santonian/Campanian Gosau Group of the Gams Area (Late Cretaceous; Styria, Austria). *Beiträge zur Paläontologie Österreichs*, **24**, 155-205.

TRAUTWEIN, B., 2000. Detritus Provenance and Thermal History of the Rhenodanubian Flysch Zone: Mosaicstones for the Reconstruction of the Geodynamic Evolution of the Eastern Alpes. Tübinger Geowissenschaftliche Arbeiten A 59, 75 pp.

TRÖGER, K.-A. & SUMMESBERGER, H., 1994. Coniacian and Santonian inoceramid bivalves from the Gosau-Group (Cretaceous, Austria) and their biostratigraphic and paleobiogeographic significance. *Annalen des Naturhistorischen Museums Wien*, **96** A, 161-197.

VAŠÍČEK, Z. & FAUPL, P., 1998. Late Valanginian cephalopods in relation to the palaeogeographic position of the Rossfeld and Schrambach Formation of the Reichraming Nappe (Northern Calcareous Alps, Upper Austria). *Zentralblatt für Geologie und Paläontologie, Teil I*, **1996**, 1421-1432.

VAŠÍČEK, Z. & FAUPL, P., 1999. Zur Biostratigraphie der Schrambachschichten in der Reichraminger Decke (Unterkreide, oberösterreichische Kalkalpen). *Abhandlungen der Geologischen Bundesanstalt*, **56/2**, 593-624.

VON EYNATTEN, H. & GAUPP, R., 1999. Provenance of Cretaceous synorogenic sandstones in the Eastern Alps: constraints from framework petrography, heavy mineral analysis and mineral chemistry. *Sedimentary Geology*, **124**, 81-111.

WAGREICH, M., 1992. Correlation of Late Cretaceous calcareous nannofossil zones with ammonite zones and planktonic foraminifera: the Austrian Gosau sections. *Cretaceous Research*, **13**, 505-516.

WAGREICH, M., 1993. Subcrustal tectonic erosion in orogenic belts - A model for the Late Cretaceous subsidence of the Northern Calcareous Alps (Austria). *Geology*, **21**, 941-944.

WAGREICH, M., 1995. Subduction tectonic erosion and Late Cretaceous subsidence along the northern Austroalpine margin (Eastern Alps, Austria). *Tectonophysics*, **242**, 63-78.

WAGREICH, M., 2001. A 400-km-long piggyback basin (Upper Aptian-Lower Cenomanian) in the Eastern Alps. *Terra Nova*, 13, 401-406.

WAGREICH, M., 2003. A slope-apron succession filling a piggyback basin: the Tannheim and Losenstein Formations (Aptian – Cenomanian) of the eastern part of the Northern Calcareous Alps (Austria). *Mitt. Österr. Geol. Ges*. 93, 31-54.

WAGREICH, M. & DECKER, K., 2001. Sedimentary tectonics and subsidence modelling of the type Upper Cretaceous Gosau basin (Northern Calcareous Alps, Austria). *International Journal of Earth Sciences*, **90**, 714-726.

WAGREICH, M. & FAUPL, P., 1994. Palaeogeography and geodynamic evolution of the Gosau Group of the Northern Calcareous Alps (Late Cretaceous, Eastern Alps, Austria). *Paleogeography, Paleoclimatology, Paleoecology*, **110**, 235-254.

WAGREICH, M. & KRENMAYR, H.-G., 1993. Nannofossil biostratigraphy of the Late Cretaceous Nierental Formation, Northern Calcareous Alps (Bavaria, Austria). *Zitteliana*, **20**, 67-77.

WAGREICH, M., KÜCHLER, TH. & SUMMESBERGER, H., 2003. Correlation of calcareous nannofossil zones to the local first occurrence of *Pachydiscus neubergicus* (von Hauer, 1858) (Ammonoidea) in European Upper Cretaceous sections. *Netherlands Journal of Geosciences*, **82**, 283-288.

WAGREICH, M. & MARSCHALKO, R., 1995. Late Cretaceous to Early Tertiary palaeogeography of the Western Carpathians (Slovakia) and the Eastern Alps (Austria): implications from heavy mineral data. *Geologische Rundschau*, **84**, 187-199.

WAGREICH, M., NEUHUBER, S., 2007. Stratigraphie und Fazies von Helvetikum und Ultrahelvetikum in Oberösterreich. In: Egger, H., Rupp, Ch. (Ed.): *Beiträge zur Geologie Oberösterreichs*. Arbeitstagung '07. Geologische Bundesanstalt, 27-40.

WAGREICH, M., PAVLISHINA, P. & MALATA, E., 2006. Biostratigraphy of the lower red shale interval in the Rhenodanubian Flysch Zone of Austria. *Cretaceous Research*, 27, 743-753.

WAGREICH, M. & SACHSENHOFER, R. F., 1999. Organic carbon-rich calcareous shales in the Lower Albian of the Northern Calcareous Alps (Austria). *Zentralblatt für Geologie und Paläontologie, Teil I*, **1997**, 951-962.

WEIDICH, K. F., 1990. Die kalkalpine Unterkreide und ihre Foraminiferenfauna. *Zitteliana*, **17**, 1-187.

WILLINGSHOFER, E., NEUBAUER, F. & CLOETINGH, S., 1999. The significance of Gosau-type basins for the Late Cretaceous tectonic history of the Alpine-Carpathian belt. *Physical Chemical Earth (A)*, **24**, 687-695.

WORTMANN, U.G., 1996. Zur Ursache der hemipelagischen schwarz/grün Zyklen im Apt/Alb der bayerischen Flyschzone. 212 p. (Diss. TU München).

WORTMANN, U.G., WEISSERT, H., FUNK, H. & HAUCK, J., 2001. Alpine plate kinematics revisited: The Adria problem. *Tectonics*, **20**, 134-147.

ZITTEL, K.A., 1866. Die Bivalven der Gosaugebilde. *Denkschrift der Österreichischen Akademie der Wissenschaften*, **25**, 73-198.

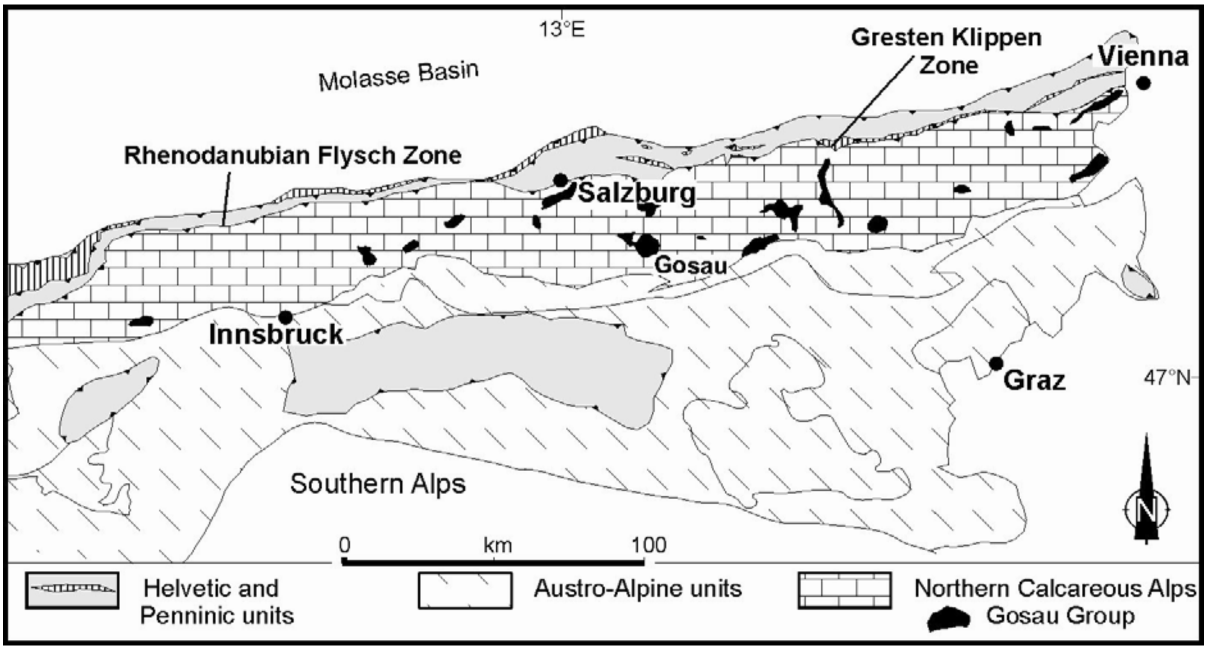


Fig. 1. Schematic geological map of the Eastern Alps including major tectonic zones and Gosau Group localities.

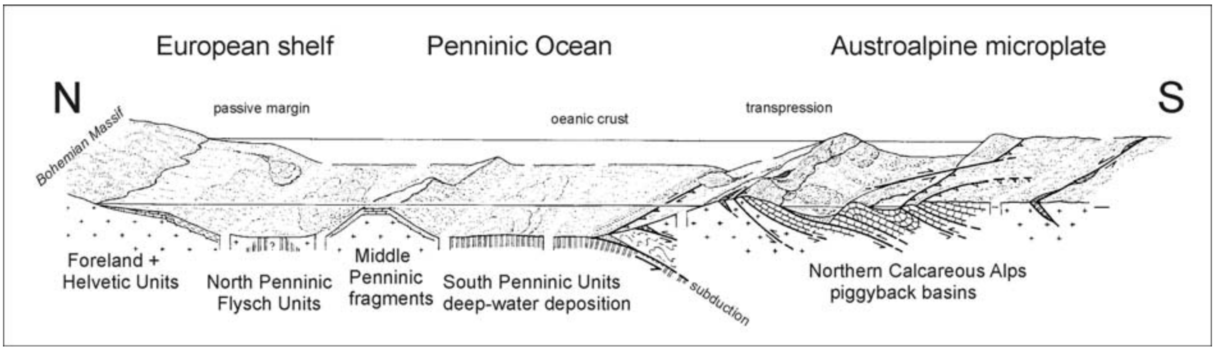


Fig. 2. Palaeogeographic sketch for the Cenomanian of the Eastern Alps

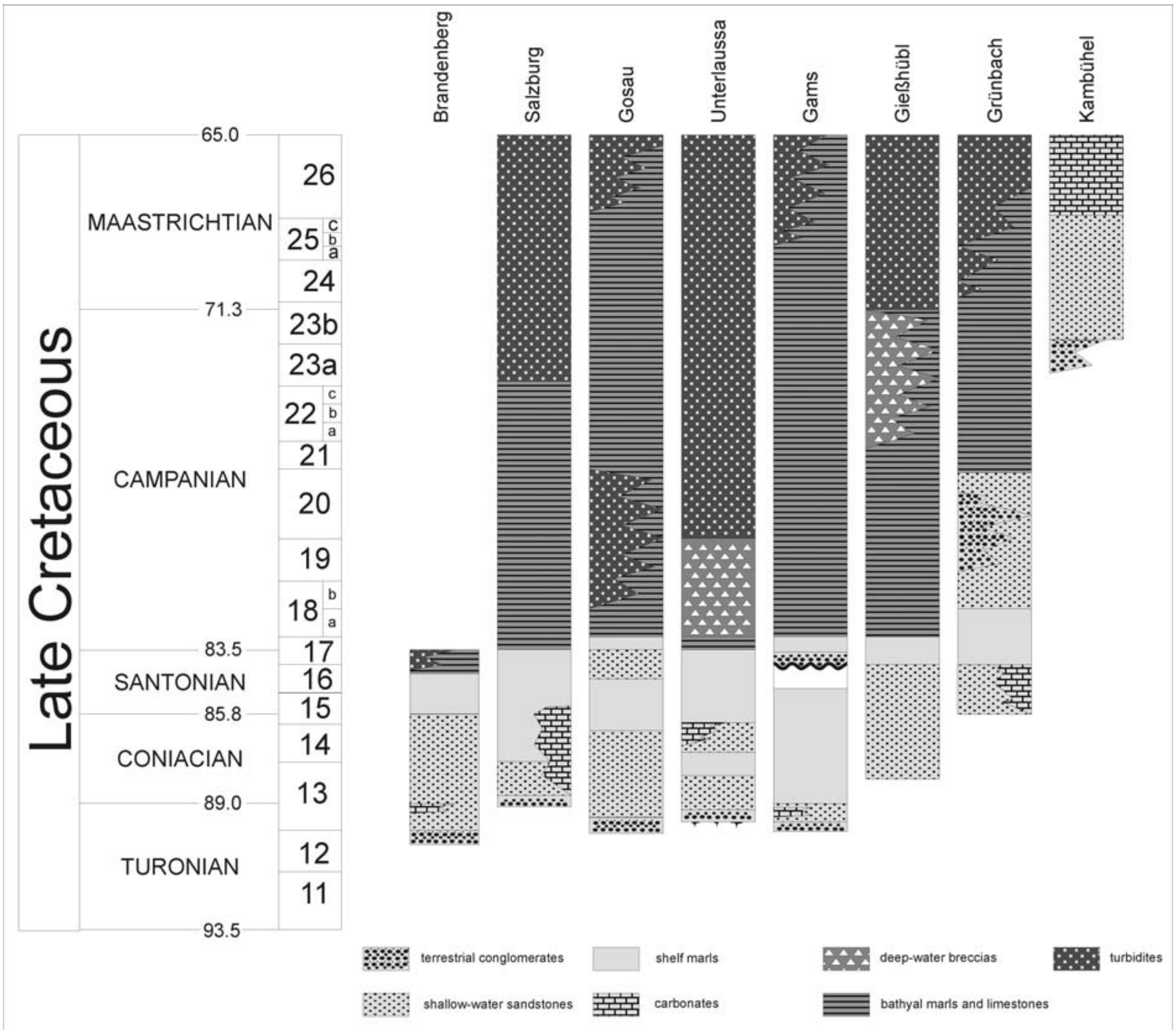


Fig. 3. Chronostratigraphy, nannoplankton zonation and facies of the Gosau Group of the Northern Calcareous Alps (Wagreich & Faupl 1994; Faupl & Wagreich 2000)

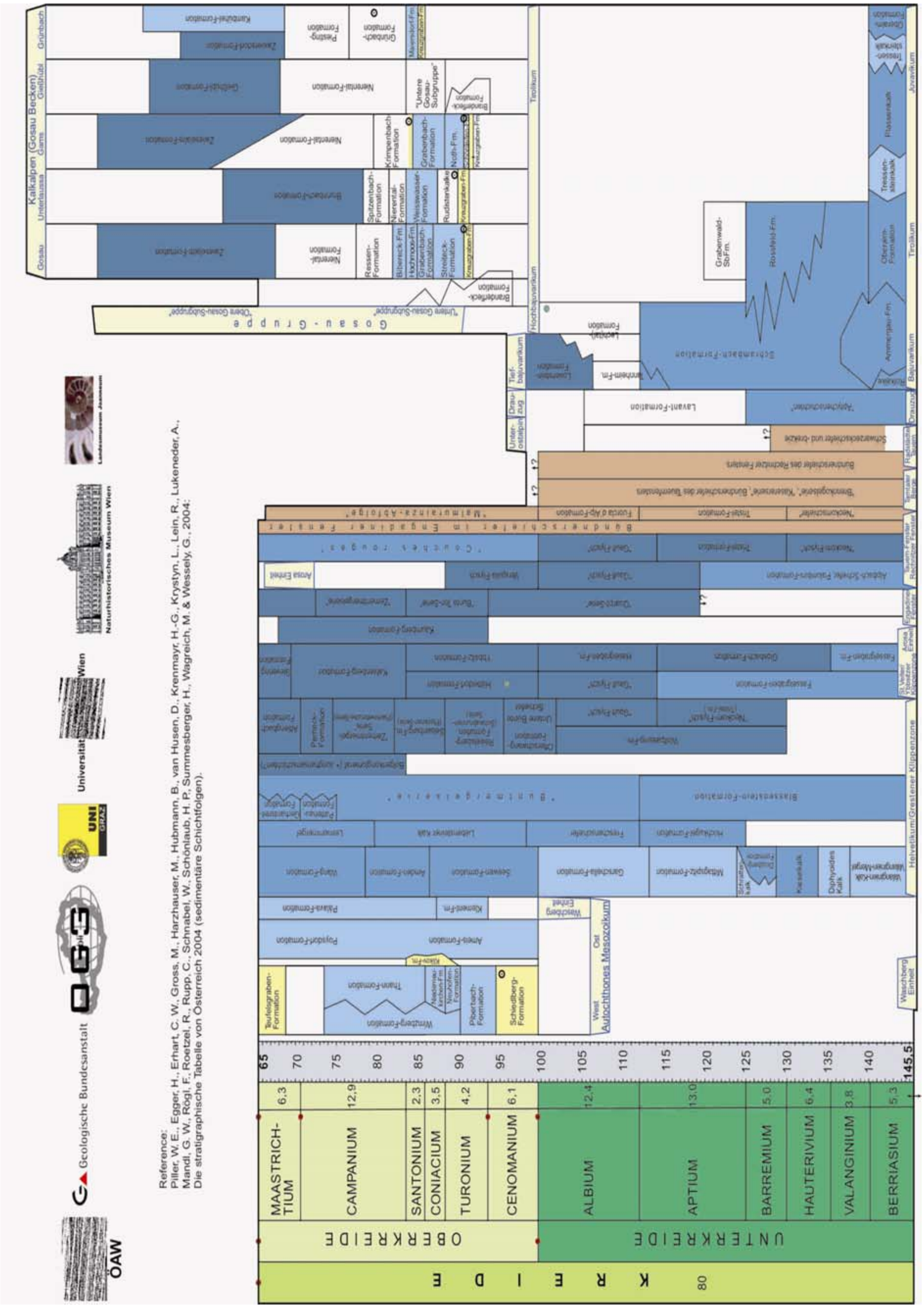
STAGES		ZONES	SUBZONES	HORIZONS
HAUTERIVIAN	Upper	*Pseudothurmannia ohmi*	*Pseudothurmannia picteti*	
			Pseudothurmannia catulloi	
			P. ohmi	
		Balearites balearis		
		Plesiospitidiscus ligatus		
		Subsaynella sayni		
				Cruasiceras cruasense
	Lower	*Lyticoceras nodosoplicatum*		
				Olcostephanus (O.) variegatus
		Crioceratites loryi	*Olcostephanus (Jeannoticeras) jeannoti*	
			C. loryi	
		Acanthodicus radiatus		*Breistrofferella castellanensis*
VALANGINIAN	Upper	*Criosarasinella furcillata*	*Teschenites callidiscus*	
			C. furcillata	
		Neocomites peregrinus	*Olcostephanus (O.) nicklesi*	
			N. peregrinus	
		Saynoceras verrucosum	*Karakaschiceras pronecostatum*	
			S. verrucosum	
	Lower	*Busnardoites campylotoxus*	*Karakaschiceras biassalense*	*Neocomites platycostatus*
				Saynoceras fuhri
			B. campylotoxus	
		Tirnovella pertransiens		
BERRIASIAN	Upper	*Subthurmannia boissieri*	*Thurmanniceras otopeta*	
			Tirnovella alpillensis	
			Berriasella picteti	
			Malbosiceras paramimounum	
	Middle	*Subthurmannia occitanica*	*Dalmasiceras dalmasi*	
			Berriasella privasensis	
			Subthurmannia subalpina	
	Lower	*Berriasella jacobi*		

Table 1. Ammonite zonation of the Berriasian-Hauterivian stages.

STAGES		ZONES	SUBZONES	HORIZONS
ALBIAN	Upper	*Stoliczkaia (S.) dispar*	*S. (S.) dispar*	
			Stoliczkaia (Faraudiella) blancheti	
		Mortoniceras inflatum		
			Diploceras cristatum	
	Middle	*Euhoplites lautus*		
		Euhoplites loricatus		
		Hoplites dentatus	*Hoplites spathi*	
			Lyelliceras lyelli	
	Lower	*Douvilleiceras mammillatum*		
		Leymeriella tardefurcata		
APTIAN	Upper	*Hypacanthoplites jacobi*		
		Acanthohoplites nolani		
			Diadochoceras nodosocostatum	
	Middle	*Parahoplites melchioris*		
		Epicheloniceras martini	*Epicheloniceras buxtorfi*	
			Epicheloniceras gracile	
			Epicheloniceras debile	
	Lower	*Dufrenoyia furcata*		
		Deshayesites deshayesi	*Deshayesites grandis*	
		Deshayesites weissi		
		Deshayesites oglanlensis		
BARREMIAN	Upper	*Martelites sarasini*	*Pseudocrioceras waagenoides*	
				Leptoceratoides puzosianum
		Imerites giraudi		
				Heteroceras emerici
				I. giraudi
		Hemihoplites feraudianus		
		Gerhardtia sartousiana	*Gerhardtia provincialis*	
			G. sartousiana	
		Toxancyloceras vandenheckii	*Barrancyloceras barremense*	
			Heinzia sayni	
		Holcodiscus uhligi		
	Lower	*Coronites darsi*		
		Kotetishvilia compressissima		
		Nicklesia pulchella		
		Kotetishvilia nicklesi		
		Taveraidiscus hugii auctorum		

Table 2. Ammonite zonation of the Barremian-Albian stages.

Tables from REBOULET, ST., HOEDEMAEKER, P.J., AGUIRRE-URRETA, M., ALSEN, P. & al. (20 other authors) 2006. Report on the 2nd meeting of the IUGS lower Cretaceous Ammonite Working Group, the 'Kilian Group' (Neuchatel, Switzerland, 8 September 2005). *Cretaceous Research*, **27**, 712-715.



Stratigraphic chart of the Cretaceous sediments of Austria

1st CCMM

1st international meeting on

CORRELATION OF CRETACEOUS MICRO- AND MACROFOSSILS

16-18 April 2008

Natural History Museum Vienna

Convener

Dr. Alexander LUKENEDER, Natural History Museum Vienna

Scientific Committee

Dr. Hans EGGER, Geological Survey of Austria

Dr. Michael WAGREICH, Department of Geodynamics and Sedimentology, Center of Earth Sciences, University Vienna

Responsible for the oral- and poster sessions: Alexander LUKENEDER

Fieldtrip guide: Alexander LUKENEDER, Oleg MANDIC

Editors of the abstract volume: Alexander LUKENEDER, Michael WAGREICH

TIME TABLE

Wednesday, 16. April

9.30 – 10.30

Registration

Chair person: Alexander LUKENEDER

10.45

Inauguration of the meeting: A. **Lukeneder**

MAIN GOALS OF THE 1ST CCMM, VIENNA 2007. INTRODUCTORY REMARKS.

Oral presentations

Room: cinema hall

11.00

Talk: O. **Szives**

ENVIRONMENTALLY CONTROLLED AMMONITE ASSEMBLAGES FROM THE LATE ALBIAN OF HUNGARY

11.30 – 13.00

Lunch Break

Chair person: Michael WAGREICH

13.15 – 13.45

Talk: G. **Price**

THE CORRELATION OF EARLY CRETACEOUS EVENTS USING STABLE ISOTOPE RECORDS

13.45 – 14.05

Talk: S. **Raisossadat**

THE EARLY APTIAN AMMONITE BIOZONATION IN MEDITERRANEAN PROVINCE

14.05 – 14.25

Talk: I. **Fözy**

EARLY CRETACEOUS CEPHALOPOD AND CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE BERSEK QUARRY (GERECSE MTS, TRANSDANUBIAN RANGE, HUNGARY)

14.25 – 14.45

Talk: O. **Mandic**

DATING THE PENNINIC OCEAN SUBDUCTION: NEW DATA FROM PLANKTONIC FORAMINIFERA
(SITTENEDOF, LOWER AUSTRIA)

14.45 – 15.00

Talk: M. **Wagreich**

ARE LOWER CRETACEOUS OCEANIC RED BEDS TRIGGERED BY COOL CLIMATE?

15.00

Poster session

R. Aguado, C. Gonzalez-Arreola, R. Barragan-Manzo, M. Company, R. Consuegra, M. Garza, A. Kroh, G. Lopez, A. Lukeneder, O. Mandic, M. Radl, St. Reboulet, J. Sandoval, P. Schnabl, A. Soliman, H. Summesberger, T. Suttner, J. Tavera etc.

18.00 – 21.00

Social Event

Ice Breaker Party; Dinosaur Hall 10 at the Museum

Thursday, 17. April

Oral presentations

Room: cinema hall

Chair person: Daniela REHAKOVA

9.40 – 10.00

Talk: A. **Kroh**

CRINOIDS FROM THE LATE JURASSIC – EARLY CRETACEOUS OF THE NUTZHOF SECTION (LOWER AUSTRIA, PIENINY KLIPPENBELT)

10.00 – 10.20

Talk: P. **Pruner**

PRELIMINARY RESULTS OF MAGNETOSTRATIGRAPHIC INVESTIGATIONS ACROSS THE JURASSIC/CRETACEOUS BOUNDARY STRATA IN THE NUTZHOF, AUSTRIA

10.20

Coffee break

11.00 – 11.20

Talk: D. **Rehakova**

CALCAREOUS MICROPLANKTON AND NANNOPLANKTON ASSEMBLAGES RECORDED IN THE WEST CARPATHIAN LATE JURASSIC/EARLY CRETACEOUS SEDIMENTARY SEQUENCES – TOOLS FOR BIOSTRATIGRAPHY AND PALEOENVIRONMENTAL RECONSTRUCTION

11.20 – 11.40

Talk: H. **Gebhardt**

INTEGRATED BIOSTRATIGRAPHY OF THE CENOMANIAN TO CONIACIAN NKALAGU FORMATION IN THE LOWER BENUE TROUGH, NIGERIA

11.40-13.00

Lunch Break

Chair person: Hans EGGER

13.15 – 13.35

Talk: J. **Pouech**

CORRELATION BETWEEN MICROVERTEBRATES BIODIVERSITY AND CONDITIONS OF DEPOSITION ALONG A SEDIMENTARY SERIES (BERRIASIAN, CHERVES-DE-COGNAC, FRANCE)

13.35 – 13.55

Talk: V. **Mitta**

THE BERRIASIAN (=RYAZANIAN) STAGE OF THE RUSSIAN PLATFORM: THE FIRST CRETACEOUS INVASION OF TETHYAN AMMONITES

13.55 – 14.15

Talk: T. **Suttner**

AMMONOIDS AND PLANKTONIC FORAMINIFERA OF THE CHIKKIM SYNCLINE (CRETACEOUS, SPITI VALLEY, INDIA)

14.15 – 14.35

Talk: I. **Lakova**

TRANSGRESSIVE-REGRESSIVE CYCLES IN THE TITHONIAN AND BERRIASIAN PELAGIC LIMESTONES OF THE WEST BALKAN UNIT, BULGARIA

14.35 – 14.55

Talk: H. **Egger**

CRETACEOUS DEEP-WATER SYSTEMS OF THE RHENODANUBIAN GROUP (EASTERN ALPS):
STRATIGRAPHY AND SEDIMENTATION RATES

14.55

Talk: M. B. **Hart**

FORAMINIFERA AND SEQUENCE STRATIGRAPHY OF THE SPEETON CLAY FORMATION
(LOWER CRETACEOUS) IN N. E. ENGLAND

15.00-17.00

Poster session

R. Aguado, C. Gonzalez-Arreola, R. Barragan-Manzo, M. Company, R. Consuegra, M. Garza, A. Kroh, G. Lopez, A. Lukeneder, O. Mandic, M. Radl, St. Reboulet, J. Sandoval, P. Schnabl, A. Soliman, H. Summesberger, T. Suttner, J. Tavera etc.

Award for the best poster.

Friday, 18. April

9.30 – 11.30

Guiding tour through the Natural History Museum (A. Lukeneder, M. Harzhauser; From the depot-collections on to the roof of the Natural History Museum).

11.30 – 12.15

Lunch break

12.30

Excursion Sittendorf (Aptian Schrambach- and Tannheim Formation; foraminifera limestone) and Sparbach (Valanginian-Barremian limestones in a wild-pig-park) in the Wienerwald (Vienna Woods).
Meeting point: side entrance of the Natural History Museum.
Return at approx. 17.00-18.00.

End of 1st CCMM meeting.

Abstract Volume

INTEGRATED STRATIGRAPHY OF THE UPPERMOST HAUTERIVIAN-LOWER BARREMIAN PELAGIC SEQUENCE OF ARROYO GILICO (BETIC CORDILLERA, SE SPAIN)

Roque **AGUADO**, Miguel **COMPANY**, Luis **O'DOGHERTY**, Inmaculada **PALOMA**, José **SANDOVAL**, José M. **TAVERA**

An integrated stratigraphic study has been carried out on the Arroyo Gilico section, located in the pelagic domain (Subbetic Zone) of the Betic Cordillera. Stratigraphic distribution of ammonites, calcareous nannofossils and planktonic foraminifera, as well as the evolution of the $\delta^{13}C$ and $\delta^{18}O$ records and clay mineralogy, have been analysed and correlated for the interval spanning from the uppermost Hauterivian up to the lowermost Upper Barremian.

Ammonites are abundant and well preserved, which has enabled the precise identification of all the Mediterranean standard zones (Reboulet et al., 2006) included in this interval; i.e., from bottom to top, the *Crioceratites balearis*, *Pseudothurmannia ohmi*, *Taveraidiscus hugii*, *Kotetishvilia nicklesi*, *Nicklesia pulchella*, *Kotetishvilia compressissima*, *Coronites darsi*, and *Toxancyloceras vandenheckii* Zones.
Calcareous nannofossil assemblages are, in general, highly diverse. They have a strong Tethyan character, being largely dominated by the genera *Watznaueria*, *Nannoconus*, *Micrantholithus*, *Lithraphidites*, *Diazomatolithus* and *Rhagodiscus*, although the genera *Biscutum*, *Zeugrhabdotus*, *Discorhabdus* and *Assipetra* are also common. The interval studied corresponds to the Subzones NC5B, NC5C and NC5D of Bralower et al. (1995). The boundary between the Subzones NC5B and NC5C, marked by the LO of *Lithraphidites bollii*, coincides with the boundary between the *P. ohmi* and *P. mortilleti* ammonite subzones and with the base of the Faraoni Level equivalent. Other significant events are the FO of *Nannoconus circularis*, recorded in the upper part of the *P. mortilleti* Subzone, and the LO of *Calcicalathina oblongata*, which marks the boundary between the Subzones NC5C and NC5D, within the *K. nicklesi* ammonite Zone.
Planktonic foraminifera are represented exclusively by praehedbergellids (mainly the genera *Praehedbergella* and *Gorbachikella*). Specimens with radially elongate chambers (belonging to the species *P. similis* and *P. eocretacea*) are especially abundant (up to 50% of the entire assemblage) between the upper part of the *K. compressissima* Zone and the lowermost part of the *T. vandenheckii* Zone. The FO of *Globigerinelloides blowi* has

been recorded in the lower part of the *T. vandenheckii* Zone.

The curve displays a gentle increase (from 1.1‰ to 1.6‰) throughout the uppermost Hauterivian, punctuated by a more accelerated shift corresponding to the Faraoni Level equivalent. The general trend becomes slightly negative in the lowermost Barremian, until reaching a minimum (0.5‰) in the middle part of the *K. compressissima* Zone. From this point, mean values of $\delta^{13}C$ rapidly increase up to reach a maximum (1.9‰) in the *T. vandenheckii* Zone.

Roque AGUADO
Universidad de Jaén
Departamento de Geología
Escuela Universitaria Politécnica de Linares
Alfonso X El Sabio 28, 23071 Linares
Spain
e-mail: raguado@ujaen.es

Miguel COMPANY
Universidad de Granada,
Departamento de Estratigrafía y Paleontología,
Facultad de Ciencias,
Campus de Fuentenueva s/n, 18002 Granada
Spain
e-mail: mcompany@ugr.es

Luis O'DOGHERTY
Universidad de Cádiz,
Departamento de Ciencias de la Tierra,
Facultad de Ciencias del Mar y Ambientales
Campus del Río San Pedro, 11510 Puerto Real
Spain
e-mail: luis.odogherty@uca.es

Inmaculada PALOMA
Universidad de Granada,
Departamento de Mineralogía y Petrología,
Facultad de Ciencias
Campus de Fuentenueva s/n, 18002 Granada
Spain
e-mail: ipalomo@ugr.es

José SANDOVAL
Universidad de Granada
Departamento de Estratigrafía y Paleontología
Facultad de Ciencias
Campus de Fuentenueva s/n,
18002 Granada
Spain
e-mail: sandoval@ugr.es

José M. TAVERA
Universidad de Granada,
Departamento de Estratigrafía y Paleontología,
Facultad de Ciencias
Campus de Fuentenueva s/n, 18002 Granada
Spain
e-mail: jtavera@ugr.es

FACIES CHANGES AND ITS FOSSIL RECORD THROUGH THE BARREMIAN – APTIAN TRANSITION ON A CARBONATE PLATFORM SETTUNG OF NORTEAST MEXICO: THEIR ENVIRONMENTAL AND BIOCHRONOSTRATIGRAPHIC SIGNIFICANCE

Ricardo **BARRAGÁN-MANZO**, Florentin J-M. R. **MAURRASSE**, Reinaldo **ROJAS-CONSUEGRA**

Northeast Mexico is characterized by a sedimentary cover mainly composed of Upper Jurassic-Lower Cretaceous marine facies. Excellent outcrops of stratigraphic sequences of Barremian-Aptian age are well-exposed in this area. The classical paleogeographic reconstructions of northeast Mexico stand out the development of extensive shallow carbonate platforms during the Barremian and early Aptian times. The drowning of those platforms at the end of the early Aptian is envisaged via an exaggerated deepening of the sedimentary conditions through a global transgressive event.

Current research deals with a sedimentary sequence that records the Barremian-Aptian transition within the Durango State in northeast Mexico. The sequence is composed of formal lithostratigraphic units described as the Cupido Formation of Barremian-early Aptian age, and the La Peña Formation, deposited from the late-early through the late Aptian.

Detailed analyses that included vertical variations of microfacies and their micropaleontological components, ammonite assemblages, and organic carbon contents throughout the studied section, set the basis for the characterization of the depositional environments and the prevailing paleoceanographic conditions through the Barremian-Aptian transition, as well as for the evolution of those conditions during the rest of the Aptian.

The Barremian-Aptian transition in the area of study is recognized through the stratigraphic ranges of index species of benthonic foraminifera in shallow carbonate platform facies that belong to the top of the Cupido Formation. Those sedimentary conditions prevailed through the remaining of the early Aptian. By the end of the early Aptian, the shift in the sedimentary regime from the Cupido carbonate platform into facies of the La Peña is coincident with increments on the Total Organic Carbon content from less than 1% to values that oscillate between 3 and 5%. The shift is also characterized by an increase on the terrigenous input and it is also coeval with the sudden appearance of planktonic fauna and ammonites, and with a marked impoverished benthonic production, suggesting a depletion of the dissolved oxygen on the basin in relation to a local sea level rise.

Biochronostratigraphically, these local changes in the sedimentary conditions can be correlated to the Tethyan standard ammonite zone *Dufrenoyia furcata* of the late-early Aptian. By middle Aptian, the recovery of the benthonic production and a drop on the total organic carbon values below 1%, suggest a reestablishment of the normal paleoceanographic conditions.

The dysoxic conditions recorded herein at the beginning of deposition of the La Peña Formation are coincident in time with other reports of global temperature increments of the oceans associated to high magnitude magmatic events. Those conditions may have expanded the Oxygen Minimum Zone over the Aptian platforms on a global scale. Thus, the sudden interruption of the benthonic production is herein interpreted as a direct effect of these changes on the bottom waters rather than an extreme deepening of the basin. In other words, it is assumed herein that the absence of benthonic elements in these facies exaggerates the deepening effect on the paleobathimetric interpretations of the Aptian basins of northeast Mexico.

Ricardo BARRAGÁN-MANZO
Departamento de Paleontología,
Instituto de Geología,
UNAM. Ciudad Universitaria,
Coyoacán, C. P. 04510, México, D. F.
MÉXICO
e-mail: rbarra01@hotmail.com

Florentin J-M. R. MAURRASSE
Department of Earth Sciences,
Florida International University,
University Park Campus, Miami,
Florida, 33199
U.S.A
e-mail: maurrass@fiu.edu

Reinaldo ROJAS-CONSUEGRA
Museo Nacional de Historia Natural
Obispo 61, Plaza de Armas
Habana Vieja, C. P. 10100, C. Habana
CUBA
e-mail: rojas@mnhnc.inf.cu

CRETACEOUS DEEP-WATER SYSTEMS OF THE RHENODANUBIAN GROUP (EASTERN ALPS): STRATIGRAPHY AND SEDIMENTATION RATES

Hans **EGGER,** Klaus **SCHWERD**

In the Bavarian Alps (Germany), west of the Isar River, the abyssal deposits of the Lower Barremian to Upper Campanian Rhenodanubian Group consist of siliciclastic and calcareous turbidites alternating with hemipelagic non-calcareous mudstones. The up to 1500-m-thick succession, deposited in the Penninic Basin to the south of the European Plate, is characterized by a low mean sedimentation rate (ca. 25 mm kyr^{-1}) over 60 million years. Palaeocurrents and turbidite facies distribution patterns suggest that sedimentation occurred on a weakly inclined abyssal plain. The highest sedimentation rates (up to 240 mm kyr^{-1}) were associated with the calcareous mudturbidites of the newly defined Röthenbach Subgroup, which includes the Piesenkopf, Kalkgraben and Hällritz Formations (Middle Coniacian to Middle Campanian). These calcareous turbidites prograded from the west and interfinger towards the east with red hemipelagic claystone. A high sea-level presumably favoured pelagic carbonate production and accumulation on the shelves and on internal platforms in the western part of the basin, whereas siliciclastic shelves with steep slope angles have bordered the eastern part of the basin, where a dearth of turbidite sedimentation and increased Cretaceous oceanic red beds (CORBs) deposition occurred. In contrast to the eustatically induced Middle Coniacian to Lower Campanian CORBs (calcareous nannoplankton Zones CC14 to CC18), red hemipelagites of Early Cenomanian age (upper part of calcareous nannoplankton Zone CC9) and early Late Campanian age (upper part of Zone CC21 and Zone CC22) can be interpreted as the result of regional tectonic activity.

Hans EGGER
Geological Survey of Austria
Neulinggasse 38
A-1030 Vienna)
Austria
e-mail: johann.egger@geologie.ac.at

Klaus SCHWERD
Bavarian Environment Agency
Geological Survey
Lazarettstraße 67
D-80636 Munich
Germany
e-mail: Klaus.Schwerd@lfu.bayern.de

EARLY CRETACEOUS CEPHALOPOD AND CALCAREOUS NANNOFOSSIL BIOSTRATIGRAPHY OF THE BERSEK QUARRY (GERECSE MTS, TRANSDANUBIAN RANGE, HUNGARY)

István **FŐZY**, Attila **FOGARASI**, Nico M.M. **JANSSEN**

An integrated biostratigraphic subdivision, on the basis of macrofossils (ammonites and belemnites) and microfossils (mainly calcareous nannofossils), is proposed for the Lower Cretaceous siliciclastic succession of the Bersek Quarry (Gerecse Mts, Hungary). A thick succession of Early Valanginian strata that crop out in the lower part of the quarry yielded no cephalopods, hampering detailed zonation. Above it, a rich ammonite fauna permit recognition of many of the recently established Mediterranean ammonite zones. The upper, fossiliferous part of the Bersek Marl Formation starts with the Upper Valanginian *Varlhedeites peregrinus* and *Criosarasinella furcillata* ammonite Zones. This is overlain by a moderately condensed Hauterivian succession, reduced in thickness especially in its upper part, in which the *Acanthodiscus radiatus*?, *Crioceratites loryi*, *Lyticoceras* n*odosoplicatum* ?, *Subsaynella sayni*, *Plesiospitidiscus ligatus*, *Crioceratites balearis* and *Pseudothurmannia ohmi* ammonite Zones are recognised. These Hauterivian are in turn overlain by the Lábatlan Sandstone Formation, the lower part of which is Lower Barremian. A complete succession of the *Taveraidiscus hugii, Nicklesia pulchella, Subpulchellia compressissima* and *Moutoniceras moutonianum* ammonite Zones are documented by rich fossil assemblages. Beds above yielded a diverse fauna characteristic for the *Toxancyloceras vandenheckii* ammonite Zone, indicating the base of the Upper Barremian. The topmost part of the sampled succession in the quarry yielded poorly preserved fossils only, hampering the recognition of any higher Upper Barremian zones. On the basis of the rich belemnite fauna an Upper Valanginian to lowermost Hauterivian, a Lower Hauterivian, an Upper Hauterivian to lowermost Barremian, and a "Mid" Barremian associations were distinguished. The biostratigraphic and paleobiogeographic interpretations of the belemnite assemblages agree well with those based on ammonite studies. The late Valanginian to early late Barremian cephalopod succession of the Bersek Quarry has a pronounced Mediterranean affinity, showing significant similarities with ammonite assemblages from the Subbetic Domain of south-east Spain. The detailed cephalopod stratigraphy was correlated with the calcareous nannofossil zonation and events. The Lower Cretaceous deposits of the Bersek Quarry serve as useful reference section in the Mediterranean Realm.

Istvan FÖZY
Hungarian Natural History Museum
Department of Palaeontology
1431 Budapest, Pf. 137
Budapest
Hungary
e-mail: fozy@nhmus.hu

Attila FOGARASI
MOL Rt.
Budapest, 1039
Batthyány u. 45
Hungary
e-mail: AFogarasi@mol.hu

Nico M.M. JANSSEN
Geertekerkhof 14bis
3511 XC Utrecht
The Netherlands
e-mail: hibolithes@hotmail.com

INTEGRATED BIOSTRATIGRAPHY OF THE CENOMANIAN TO CONIACIAN NKALAGU FORMATION IN THE LOWER BENUE TROUGH, NIGERIA

Holger **GEBHARDT**

Micro- and macrofossil assemblages of three sections of the Nkalagu Formation, including the type-section of this Formation, have been studied. Zonations for several fossil groups have been erected, integrated and were correlated with international standard zonations to allow for high resolution biostratigraphy.

Biozones were identified for planktic foraminifera (*Praeglobotruncana* cf. *stephani*-Zone (Middle Turonian), *Marginotruncana sigali*-Zone (Late Turonian), *Dicarinella primitiva*-Zone (latest Turonian), *Dicarinella concavata*-Zone (Coniacian)), benthic foraminifera (*Planulina beadnelli* (=*Gavelinella dakotaensis*)-*Ammoastuta nigeriana*-Zone (Cenomanian to Early Santonian)), calcareous nannofossils (*Eiffellithus eximius*-Zone (Middle Turonian to early Late Turonian), *Marthasterites furcatus*-Zone (late Turonian to Coniacian)), and ostracods (*Cytherella* spp.-Zone (latest Cenomanian), *Cythereis vitiliginosa reticulata*-Zone (Middle to Late Turonian), *Cythereis* sp. 2-Zone (latest Turonian to Coniacian)). Inoceramid and ammonite assemblages from several horizons complement the datasets and confirm the ages of the microfossil zones. Integration of fossil groups allows separation of 6 integrated zones with an average duration of about 0.4 Ma. IZ-A: latest Cenomanian (dominance of *Cytherella* spp.), IZ-B: Middle Turonian (until LA *P*. cf. *stephani*), IZ-C: (?basale) Late Turonian (LA *P*. cf. *stephani* to FA *M. furcatus*, with *Inoceramus*), IZ-D: middle Late Turonian (*M. furcatus* to LA *C. vitiliginosa reticulata*, with *Inoceramus* and *Mytiloides*), IZ-E: late Late Turonian (FA *D. primitiva*, *Cythereis* sp. 2, with *Prionocycloceras*), IZ-F: Coniacian (from FA *D. concavata*, with *Didymotis*-event).

Latest Cenomanian sediments were deposited in a dysoxic to maximally suboxic, normal marine environment of an inner shelf area close to the coastline. Middle Turonian to Coniacian sediments were deposited in the upper bathyal under normal marine salinity and low oxic conditions of the bottom-water.

Planktic foraminifera and calcareous nannofossils show distinctive Tethyan influences and indicate warm waters. Agglutinated foraminifera show endemic tendencies on species level (restriction to the Benue Trough). Calcareous smaller benthonic foraminifera are generally pandemic and are restricted in their distribution only by facies differences. Marine ostracods are generally endemic and belong to the West African Province.

The data and interpretations provide a base for basinwide correlation in the Lower Benue Trough and in parts also for its middle and upper regions. They allow a direct correlation with other West African basins and with worldwide biostratigraphic zonal schemes.

Holger GEBHARDT
Geologische Bundesanstalt
Neulinggasse 38
A-1030 Vienna
Austria
e-mail: gebhol@geologie.ac.at

FORAMINIFERA AND SEQUENCE STRATIGRAPHY OF THE SPEETON CLAY FORMATION (LOWER CRETACEOUS) IN N. E. ENGLAND

Malcolm B. **HART**, Gregory D. **PRICE**

The Speeton Clay Formation is exposed in the cliffs north of Flamborough Head in North East England. The formation ranges in age from the Ryazanian to the Albian but is often poorly exposed in the sea cliffs and on the foreshore. The foraminiferal assemblage is often dominated by long-ranging nodosariids, although, at some levels, the fauna is dominated by epistominids. Diversity of foraminifera varies throughout the succession, with the maximum diversity being recorded in the Late Hauterivian. Using information from the (i) diversity, (ii) distribution of epistominids, (iii) glauconite and (iv) pyrite it is possible to identify possible sequence boundaries in the Late Ryazanian (138 Ma), Early Valanginian (136 Ma), mid-Hauterivian (129 Ma) and Early Barremian. These four events are very close in age to the events (K20, K30, K40, K50) described by Sharland and co-workers in Arabia.

The distribution of the foraminifera will be discussed in the context of the sequence stratigraphy and the relationship between abundant epistominids and Maximum Flooding Surfaces, the stable isotope stratigraphy and changes in sea level. Other examples of similar distribution patterns from the Lower Cretaceous and mid-Upper Jurassic of Southern England will be discussed.

Malcolm B. HART
School of Earth, Ocean & Environmental Sciences
University of Plymouth
Drake Circus, Plymouth PL4 8AA
United Kingdom
e-mail: M.Hart@plymouth.ac.uk

Gregory D. PRICE
School of Earth, Ocean and Environmental Sciences
University of Plymouth
Drake Circus
Plymouth, Devon, PL4 8AA
United Kingdom
e-mail: G.Price@plymouth.ac.uk

CRINOIDS FROM THE LATE JURASSIC – EARLY CRETACEOUS OF THE NUTZHOF SECTION (LOWER AUSTRIA, PIENINY KLIPPENBELT)

Andreas **KROH**, Alexander **LUKENEDER**

The Nutzhof section, 5 km north of Hainfeld, comprises an 18 metre long succession of strongly tilted, inverse, well-bedded intercalation of marls and limestone. At the base marls and marly limestone bands dominate, being replaced by increasingly pure limestones towards the top. Based on preliminary data from the ammonite, nannofossil and calpionellid data (see Rehakova et al., this volume) the lower part could be assigned to the Early Tithonian and the upper part to the Middle Berriasian.

Microfacies analysis of the more strongly lithified parts of the section revealed high abundances of crinoidal remains, in particularin the lower part. Based on cross section shape these fragments could be tentatively assigned to saccocomid crinoids.

In order to obtain three-dimensional specimens of the crinoids, as well as other microfossils commonly observed in the thin sections (namely foraminifera, ostracods, rhyncholiths, small aptchi, ophiuroid remains, etc.) the marly parts of the succession (i.e. the lower 8 m) were sampled intensely. A first survey of the residues shows high abundances of the pelagic crinoid *Saccocoma tenella* (Goldfuss, 1831) in the lower 6 metres of the section. The crinoids are represented by isolated radial and brachial ossicles mainly. The former being characterized by their arrow-head like shape with serrated edges and coarse reticulate sculpture, the latter by its disc-like wings (in the proximal brachials). Above, calyxes of phyllocrinid microcrinoids and undetermined columnals appear, while saccocomid remains become rare and vanish. In the upper part of the section bulk sampling was unsuccessful due to low mud content and high lithification of the rocks. Thin sections, however, show that the saccocomid-rich microfacies is replaced by a calpionellid microfacies, that can be interpreted as, more distally situated pelagic limestone facies of deeper waters. It is likely that the observed changes in lithology and microfauna are related to changes of current patterns, possibly caused by geodynamically induced palaeogeographic changes and basinal deepening.

Andreas KROH
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: andreas.kroh@nhm-wien.ac.at

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

TRANSGRESSIVE-REGRESSIVE CYCLES IN THE TITHONIAN AND BERRIASIAN PELAGIC LIMESTONES OF THE WEST BALKAN UNIT, BULGARIA

Iskra **LAKOVA,** Elena-Koleva **REKALOVA,** Daria **IVANOVA,** Lyubomir **METODIEV,** Silviya **PETROVA**

Two Tithonian and Berriasian sections of pelagic limestone-marl alternations have been studied for determination of transgressive-regressive cycles based on the bedding pattern and abundance curves of microfossils. The biostratigraphy was provided by calpionellids, calcareous nannofossils and calcareous dinoflagellates (Lakova et al., 1999). The studied interval comprises the Upper Tithonian and Berriasian (p.p.) as documented on the continuous succession of the calpionellid zones *Crassicollaria, Calpionella* and *Calpionellopsis* and their subzones. The time interval spans 5.4 Ma between the Lower-Upper Tithonian boundary (147.2 Ma) and *Csis simplex* – *Csis oblonga* subzones boundary (141.8 Ma)

Relatively monotonous medium- to thin-bedded micritic and intraclastic limestones with thinner marly interlayers crop out. They belong to the slope and basinal environments of the Late Jurassic and Early Cretaceous basin in the West Balkan tectonic unit. The measuring is bed by bed and thin-section samples have been taken at each 1 m.

The Upper Tithonian and Lower Berriasian (Glozhene Formation) represent mainly limestones, the bed thickness ranging from 10 to 30 cm, exceptionally 5 cm or up to 70 cm. Very thin marly interbeds of 1-3 cm occur randomly separating the limestone beds. A total of 147 beds are counted, deposited within a time interval of 5.0 Ma. The Upper Tithonian is 10 m thick and consists of 42 beds (“elementary cycles” in the sence of Pasquier, Srtasser, 1997), each formed at average time of 40 Ka. The Lower Berriasian is 20 m thick and consists of 105 limestone beds or limestone-marl alternations, each “elementary cycle” of 32 Ka duration.

The overlaying part of Salash Formation (Upper Berriasian, p. p., *Csis oblonga* Subzone) is an irregular alternation of micritic limestones, clayey limestones and marls representing a fast shift onto hemipelagical depositional environment. The bed thickness is normally 5-10 cm, exceptionally 20-30 cm. The thickness is 10 m and the time interval of deposition is 0.4 Ma. The number of limestone-marl alternations is 42. Each “elementary cycle” deposited during average time 10 Ka, and the rate of sedimentation dramatically increased to 25 mm/Ka compared to 6-7 mm/Ka for the Glozhene Formation.

The limestones represent mudstones, rarely wackstones, built up of recrystalised carbonate of micritic size and planktonic microfossils – calpionellids, calcareous dinoglagellates, globochaetes, radiolarians, as well as ammonite aptichi. In addition, less common benthic foraminifers, ostracods, bivalves, and crinoids occur deriving from hemipelagic or platform areas.

The bedding pattern has been analysed in order to differentiate zones of maximum flooding, boundaries of T-R cycles and transgressive-regressive trends. These are directly correlated to the parallel abundance curves of calpionellids, calcareous dinoflagellates and nannofossils. The maxima of microfossil abundance approximately coincide with zones of thinner and more marly beds and are interpreted as maximal transgressions. The minima of the microfossils abundance correspond to thicker, pure limestone beds and are considered as regressive surfaces or sequence boundaries. The elementary cycles have been grouped into seven 3rd-order T-R cycles, covering a time interval of 5.4 Ma, and have been correlated to the sequences chart by Handerbol et al. (1998).

This study is a contribution to the Project NZ-1516 of the Bulgarian National Scientific Fund.

References

HANDERBOL, J., THIERRY, J., FARLEY, M.B., JACQUIN, T., DE GRACIANSKY, P.-C., VAIL, P.R. 1998. Cretaceous chronostratigraphy. In: *Mesozoic and Cenozoic Sequence Stratigraphy of European Basins* (De Graciansky, P.-C. Et al., eds). *Special Publication, Society of Sedimentary Geology*, 60.

LAKOVA, I., STOYKOVA, K., IVANOVA, D. 1999. Calpionellid, nannofossil and calcareous dinocyst bioevents and integrated biochronology of the Tithonian to Valanginian in the Western Balkanides, Bulgaria. *Geologica Carpathica*, 50, 2, 151-168.

PASQUIER, J.-B., STRASSER, A. 1997. Platform-to-basin correlation by high-resolution sequence stratigraphy and cyclostratigraphy (Berriasian, Switzerland and France). *Sedimentology*, 44, 1071-1092.

Iskra LAKOVA
Geological Institute
Bulgarian Academy of Sciences
1113 Sofia
Bulgaria
e-mail: lakova@geology.bas.bg

Elena-Koleva REKALOVA
Geological Institute
Bulgarian Academy of Sciences
Acad. G. Bonchev St., Bl. 24, 1113 Sofia
Bulgaria
e-mail: e_koleva@geology.bas.bg

Daria IVANOVA
Geological Institute
Bulgarian Academy of Sciences
Acad. G. Bonchev St., Bl. 24, 1113 Sofia
Bulgaria
e-mail: dariaiv@hotmail.com

Lyubomir METODIEV
Geological Institute
Bulgarian Academy of Sciences
Acad. G. Bonchev St., Bl. 24, 1113 Sofia
Bulgaria
e-mail: lubo@geology.bas.bg

Silviya PETROVA
Geological Institute
Bulgarian Academy of Sciences
1113 Sofia
Bulgaria
e-mail: silviya_p@geology.bas.bg

DISTRIBUTION OF ALBIAN INOCERAMIDS IN SOUTHERN EUROPE

Gregori **LÓPEZ**

Inoceramids are pterioid bivalves disappeared at the end of the Cretaceous period and have a reputed biostratigraphical value. They are of high importance to develop biostratigraphic Cretaceous frameworks, similar to that of a classical biostratigraphic tool, the ammonites. They are very abundant in basin and outer platform sequences and their record allow precise correlations, as in Western and Eastern European areas. Nevertheless, Albian inoceramids are not so diversified as those form Upper Cretaceous, and in many areas are restricted to the distribution of *Actinoceramus* genus.

Inoceramids are a very abundant bivalve group in the Spanish Upper Cretaceous sequences; but they are very scarce on Albian sequences. They are just represented by few species at the Internal Prebetic (Alicante province), Mallorca Island and the Navarro-Cantabrian Basin.

Heinz (1936) studied Albian inoceramids from Spain for first time, describing species collected in few localities at the Mallorca Island, and Wiedmann and Kauffman (1978) studied later some specimens from the same locality. Albian sequences at the Internal Prebetic show some beds with abundant inoceramids (Gallemí et al. 1997); but these inoceramids are just restricted to two species widely distributed in Europe: *Actinoceramus concentrica* (Parkinson) represented by abundant specimens and *Inoceramus anglicus* Woods represented by scarce specimens. *Inoceramus athabaskensis* McLearn is the only species recognised in the Albian sequences of the Navarro-Cantabrian Basin (Santamaría and López, 1996). This species of big size is abundant in North America but has not been yet described in other European areas.

Radial ribs species, as *Actinoceramus sulcatus* (Parkinson) and *Actinoceramus subsulcatus* (Wiltshire), are not present in Spain, at despite that they are abundant in France, especially at the Bouches du Rhône in Southern France and in the Paris Basin at Northern France. Rebutty, Vergons and other southern France localities show close similarities with Spanish faunas; main differences are the absence of radial ribs species in Spain and the absence of big size species as *I. athabaskensis* in France.

References

GALLEMÍ, J., LÓPEZ, G., MARTÍNEZ, R., MUÑOZ, J., PONS, J. M. 1997. Albian-Cenomanian and Campanian-Maastrichtian biostratigraphy of southeast Spain. *Cretaceous Research*, 18: 355-372.

HEINZ, H. 1936. Inocerámidos de Alicante, Valencia y Baleares. *Boletín de la Real Sociedad Española de Historia Natural*, 36, 91-99, 1 pl.

SANTAMARÍA, R., LÓPEZ, G. 1996. Aspectos bioestratigráficos de los ammonites e inocerámidos (Bivalvia) del Albiense superior al Maastrichtiense de la provincia de Alava. *Revista Española de Paleontología, (Núm. ext.)*, 148-159.

WIEDMANN, J., KAUFFMAN. E. G. 1978. Mid-Cretaceous biostratigraphy of northern Spain. *Annales du Museum d'Històire naturelle deNice.* IV Mid-Cretaceous events reports on the biostratigraphy of key areas, 4, III.1-III.34, 12 pls.

Gregori LÓPEZ
Department Geologia (Paleontologia)
Facultat de Ciencies
Universitat Autònoma de Barcelona
E-08193 Bellaterra
Spain
e-mail: gregori.lopez@uab.es

LOWER CRETACEOUS ALLODAPIC LIMESTONES (KALTENLEUTGEBEN SECTION, NORTHERN CALCAREOUS ALPS, LOWER AUSTRIA)

Alexander **LUKENEDER**

Allodapic limestone layers (thickness up to 10 cm) are described for the first time from the Lower Cretaceous Schrambach Formation of the Lunz Nappe (Kaltenleutgeben section, Northern Calcareous Alps). They are composed almost exclusively of bioclasts such as echinoids (about 50 %), bryozoa, coralline red algae, foraminifera and remains of stromatoporoids and belemnoids; calcareous green algae are missing. The stratigraphic age of these layers can be indicated as Upper Hauterivian based on the findings of the *Euptychoceras* abundance Zone. The occuring biota indicate a source area in an upper slope position indicating the transition to real shallow water areas. From the time-interval between the Plassen Formation (up to Lower/Middle Berriasian) and the allochthonous Urgonian limestones (from Upper-Barremian onwards) no records of a shallow water evolution in the Northern Calcareous Alps were known up to now. A relationship to equivalent biodetritus within the Rossfeld Formation, without biostratigraphic data so far, is possible. Last but not least, due to the occasional occurrence of chrome spinel and the nappe tectonic position of the locality, transportation from southern directions is assumed.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

CORALS AND AMMONOIDS – CONNECTING AN INCOMPATIBLE CONNECTION (CRETACEOUS, ITALY)

Alexander **LUKENEDER**

Early Cretaceous (Valanginian – Aptian) deposits of the Puez locality in N.-Italy (Dolomites, Southern Tyrol) yield remarkable amounts of specimens of different ammonoid taxa (28 genera, n = 424) showing unique epifaunal encrustations by the solitary coral *Cycloseris*. The pattern of infestation clearly documents a preference of the adherent taxa for the outer shell surface of the ammonoids, whereas the inner surface remains barren. Such a remarkable dwelling palaeocommunity is described for the first time. The ammonoid shell of the dead animal sank to the sea bottom and became encrusted by the coral larvae, which documented by the location of the epibionts only on one side of the deposited ammonoid shells. The relation between the latter fossil groups is reported for the first time from the Early Cretaceous.

The cephalopod fauna consists of numerous Mediterranean elements from the Tethyan Realm. The cephalopod fauna from the marly limestones to marls here indicates Early Valanginian to Early Aptian age.

Lower Cretaceous deposits form a major element of the Southern Alps and especially of the Dolomites (Hoernes, 1876; Haug, 1887, 1889; Uhlig, 1887; Rodighiero, 1919; Baccelle and Lucchi-Garavello 1967a, b; Stöhr, 1993, 1994; Costamoling and Costamoling 1994). The geology of the Dolomites and adjacent areas has been described and summarized in detail by Pozzi (1993), Geyer (1993), Heissel (1982), Bosellini (1998), and Bosellini *et al.* (2003). In the Dolomites, Lower Cretaceous cephalopod-bearing deposits are mainly recorded in two different facies, the Biancone Formation (calcareous limestones, Maiolica Formation) and the Puez Formation (marls-marly limestones). The investigated outcrop, comprising the Biancone- and the Puez Foramtion, is situated on the Puez-Odle-Gardenaccia Plateau in the Dolomites (Trentino – Alto Adige; South Tyrol). The exact position is about 30 km northeast of Bozen.

The extraordinarily rich invertebrate fauna consists of ammonoids, ammonoid jaws (aptychi), coleoids, bivalves, brachiopods, serpulids, sea urchins, ophiurids, corals, benthic/planktonic foraminifera and radiolarians. The benthic macrofossils observed in the ammonoid beds comprise bivalves, brachiopods and, surprisingly, corals. Huge numbers of encrusting species like serpulids and corals were examined.

The most exciting feature of the fauna is the fact that solitary corals of *Cycloseris* lived on ammonoid shells during the Early Cretaceous of the Dolomites. This is not known from other sediments and localities through time and space. The relation between the latter fossil groups is reported for the first time from the Mesozoic Era.

In most cases only the round basal plate of the corals is visible attached to the steinkerns of the ammonoids. Only rare specimens (2) show three-dimensional preservation of the coral body with its septa. All kinds of ammonoids are attached with relics of solitary corals: lytoceratids, phylloceratids, ammonitids and ancyloceratids, ribbed species as well as smooth species. Host "ammonoids" are: *Leptotetragonites honnoratianus* (d'Orbigny), *Phyllopachyceras infundibulum* (d'Orbigny), *Phyllopachyceras bontshevi* Manolov, *Phylloceras thetys* (d'Orbigny), *Lytoceras subfimbriatum* (d'Orbigny), var. A. in Lukeneder 2006, *Silesites vulpes* (Coquand), *Melchiorites cassioides* (Uhlig), *Barremites psilotatus* (Uhlig), *Crioceratites krenkeli* (Sarkar), *Ancyloceras matheronianum* (d'Orbigny).

Therefore a secondary hard ground is needed for settling. The hard substrate must have been available for the epibionts over a quite long time so they had enough time to settle and grow. The morphology is similar to that of Early Cretaceous *Cycloseris* from Spain and Late Cretaceous solitary corals like *Connolites* or *Micrabacia* from all over Europe. Basal plates are from 2 mm up to 4 cm in diameter. Internal structures, septa and composition, are comparable with the latter species. Despite these similar features it is not known from corals like *Connolites* or *Micrabacia* that they could have lived on ammonoid shells. Serial thin sections were made and show remarkable differences from other known solitary corals. The solitary coral *Cycloseris* needed some time to grow up to a maximal size of 4 cm in diameter. The number of about 20 corals attached on ammonoid shells shows that this is common at the Puez locality. A single ammonoid shell could be attached by up to 6 corals.

The main focus of future studies of the Puez area will be on the palaeoecology and synecology of the cephalopod fauna of the Puez section. Therefore the author will investigate the relation of the hosts (ammonoids) and their encrusting epibionts at the Puez locality. From great interest will be the evolution of the relationship between these normally unconnected fossil groups through time (e.g. Early Cretaceous).

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

UPPER VALANGINIAN CEPHALOPODS FROM THE HOCHKOGEL SECTION (*VERRUCOSUM* ZONE, NORTHERN CALCAREOUS ALPS, UPPER AUSTRIA)

Alexander **LUKENEDER**

Upper Valanginian deposits of Upper Austria yield large amounts of ammonoids. The new occurrence was detected during paleoecological and sedimentological studies at an outcrop in the Ternberg Nappe in (Upper Austria, Ebenforst Syncline). The associated cephalopod fauna indicates a Late Valanginian age (*Verrucosum* Zone sensu Hoedemaeker & Rawson, 2000; Reboulet et al. 2006).

The outcrop is situated in the Reichraming Nappe in Upper Austria. The exact position is about 5 km south of Brunnbach (652 m, ÖK 1:50000, sheet 69 Großraming). The outcrop is located in the southernmost part of the east-west striking Ebenforst Syncline along a forest road, running between the Sulzgogel (840 m) to the north and the Hochkogel (1157 m) to the south at the topmost part of the Reixengraben at 885 m.

The Upper Valanginian cephalopods described were fully collected from a little outcrop containing sandstones intercalated with 3 marly limestone beds, each of about 10-25 centimeter thickness, and is located at the southern margin of the Ebenforst Syncline. The exact position of the ammonoid-occurrence is fixed by GPS data (N 47°47'15'' and E 14°30'00''.

Over 300 hundred specimens have been collected in 2003. The ammonoid fauna comprises 14 different genera, each apparently represented by 1 or 2 species, and a single deepwater nautiloid. The cephalopod fauna is accompanied by lamellaptychi. *Haploceras* (Ammonitina) and *Bochianites* (Ancyloceratina) are the most frequent components (each about 40%). Lytoceratina, Phylloceratina together with *Neocomites* (Ammonitina) are roughly balanced (all about 5%). Olcostephanids (Ammonitina) are very rare (about 3%). Most specimens show fragmentation. Due to the high number of specimens, however, even extraordinarily well-preserved individuals (e.g. lappets of microconchs) can be observed. The well-preserved specimens show unusual (in Lower Cretaceous sediments of the Northern Calcareous Alps) shell preservation. The cephalopod fauna consists only of Mediterranean ammonoids.

The deposition of the limestones in this interval occurred in an unstable environment. The fragmentation of most ammonoids furnishes evidence for a post-mortem transport of the cephalopod shells. The shells were deposited in somewhat shallower habitats, where they were probably partly fragmented. Later, the shells were transported into the final depositional area on the deeper shelf or upper slope. This reconstruction allows a tentative interpretation of the habitat of the ammonoids investigated, which, accordingly, might have dwelled in more shallow waters instead of open marine offshore areas.

References

HOEDEMAEKER, P.J., RAWSON, P.F. 2000. Report on the 5th International Workshop of the Lower Cretaceous Cephalopod Team (Vienna, 5 September 2000; LUKENEDER, A. (org.). – *Cretaceous Research*, 21, 857-860.

REBOULET, ST., HOEDEMAEKER, P.J., AGUIRRE-URRETA, M., ALSEN, P. & al. (20 other authors) 2006. Report on the 2nd meeting of the IUGS lower Cretaceous Ammonite Working Group, the 'Kilian Group' (Neuchatel, Switzerland, 8 September 2005). *Cretaceous Research*, 27, 712-715.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

THE *KARSTENICERAS* LEVEL: DYSOXIC AMMONOID BEDS WITHIN THE EARLY CRETACEOUS (BARREMIAN, NORTHERN CALCAREOUS ALPS, AUSTRIA)

Alexander **LUKENEDER**

An Early Cretaceous mass-occurrence of ammonites in the Ternberg Nappe of the Northern Calcareous Alps (Upper Austria) is described for the first time. The mass-occurrence (section KB1-B = Klausrieglerbach 1, section B) dominated by *Karsteniceras ternbergense* Lukeneder is of Early Barremian age (*Moutoniceras moutonianum* Zone). The *Karsteniceras* mass-occurrence comprises eight different genera, each apparently represented by a single species, of which four are identified to species level. About 300 specimens of *K. ternbergense* between 5 and 37 mm in diameter were investigated. Two groups showing thick main ribs but different maximum size are distinguishable. The latter parameters are suggested to reflect sexual dimorphism within *K. ternbergense*, a condition that is most probably applicable to the whole leptoceratoid group. The geochemical results indicate that the *Karsteniceras* mass-occurrence within the described Lower Cretaceous succession was deposited under intermittent oxygen-depleted conditions associated with stable, salinity-stratified water masses. The rhythmicity of laminated black-marly limestone layers and light-grey bioturbated, organic-poor limestones suggests that the oxic and dysoxic conditions underwent highly dynamic changes. The deposition of the limestones in this interval occurred in an unstable environment and was controlled by short- and long-term fluctuations in oxygen levels. *Karsteniceras* inhabited areas of stagnant water with low dissolved oxygen; it showed peak abundance during times of oxygen depletion, which partially hindered other invertebrates from settling in such environments. The autochthonous *Karsteniceras* mass-occurrence can be assigned to the deposition-type of ‘Konservat Lagerstätte’, which is indicated by the preservation of phosphatic siphuncle structures and proved by the *in situ* preservation of aptychi within *Karsteniceras ternbergense*. Based on lithological and geochemical analysis combined with investigations of trace fossils, microfossils and macrofossils, an invasion of an opportunistic (r-strategist) *Karsteniceras* biocoenosis during unfavourable conditions over the sea bed during the Lower Barremian is proposed for the KB1-B section.

The proposed *Karsteniceras* Level currently has only local biostratigraphic value. Its potential status as a stratigraphic horizon or sub-zone depends on its potential for correlation and its extension toThe geochemical results indicate that the assemblage was deposited under conditions of intermittent oxygen-depletion associated with stable water masses. The rhythmicity of laminated black shale layers and light-grey bioturbated, organic-depleted limestones suggests that the oxic and dysoxic conditions episodically changed. A highly dynamic environment, controlled by short- and long-term fluctuations in oxygen levels, and poor circulation of bottom-water currents within an isolated, basin-like region led to the accumulation of the *Karsteniceras* Level. The lamination generally indicates a very quiet depositional environment, which was not disturbed by currents.

Within the Schrambach Formation, dysaerobic (not anaerobic) conditions prevailed, allowing endobenthic colonization of the incompletely bioturbated sediment by *Chondrites* (accompanied by *Planolites* in some beds). Increasing levels of dissolved oxygen in bottom waters over time are suggested by well bioturbated, pale grey limestone beds, whereas dysaerobic conditions are expressed through thin, black, laminated limestones ('black shales'). The *Karsteniceras* mass-occurrence is situated in the laminated horizons. The following features are observable: (1) high TOC, (2) high sulphur content, (3) concentrations of pyrite, (4) phosphatic siphuncle structures, (5) indistinct lamination, (6) almost monospecific trace fossil community (e.g. *Chondrites*), (7) fish remains, (8) extremely rare benthos (e.g. inoceramids, 'paper pectens'), (9) rare microfauna, (10) 'mass-mortality' of *Karsteniceras*, very abundant and small in size, (11) nearly 'monospecific' faunal spectrum and (12) *in situ* aptychi.

It is assumed that, based on the described features from KB1-B and literature data, *Karsteniceras* most probably had an opportunistic (r-strategist) mode of life and was adapted to dysaerobic sea-water. These ancyloceratids most likely inhabited regions reaching from the sea floor to at least a few tens of meters into the overlying water-column, based on the *in situ* aptychi and the nearly monospecific faunal assemblage of small heteromorphs. Most of the associated other ammonites (e.g. *Barremites* cf. *difficilis*) show different overgrowth stages (serpulids); these can be explained as a reflection of life in the upper, oxygenated water-column, with subsequent sinking to the sea floor or drifting after death. *Karsteniceras* probably inhabited areas of water stagnation with low dissolved oxygen, showing abundance peaks during times of oxygen depletion, which hindered other invertebrates from colonising such environments. The described autochthonous *Karsteniceras* mass-occurrence features fit well into the scheme of a 'Konservat Lagerstätte'.

The evidence for an oxygen-depleted formation of the *Karsteniceras* mass-occurrence needs to be supplemented by additional analysis of the micropalaeontological record (e.g. benthic foraminifera, nannofossils) and further investigations on the organic carbon material (e.g. type and producers). Further work has to be done on the influence of oxygen-depleted benthic environments on pelagic organisms, and to this end biomarker analyses are planned. Information on syngenetic or diagenetic formation of pyrite will be provided by TOS/S plots.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

LOWER CRETACEOUS MASS OCCURRENCES OF AMMONOIDS – IMPLICATIONS ON TAPHONOMY AND STRATIGRAPHY (UPPERMOST VALANGINIAN; NAPPE; NORTHERN CALCAREOUS ALPS; UPPER AUSTRIA)

Alexander **LUKENEDER**

Lower Cretaceous pelagic sediments are known to form a major element of the Staufen-Höllengebirgs Nappe. Valanginian to Hauterivian cephalopod-bearing deposits are recorded in two different facies, the Schrambach and the Rossfeld formations. Upper Valanginian sediments of the Rossfeld Formation are mainly composed of turbiditic sandstone intercalations, whereas the Rossfeld Formation comprises turbiditic marls and sandstones (Immel 1987).The stratigraphy of the Lower Cretaceous sediments in the investigated area is based on ammonoids.

The Upper Valanginian succession of southernmost part of Upper Austria was deposited in an unstable shelf setting characterized by thick sandstone units that reflect transgressive histories combined by tectonic events (see Faupl, 1979). The terrigenous, proximal, deep-water turbiditic Rossfeld Formation of the Staufen-Höllengebirgs Nappe represents a synorogenic development (see also Vašíček & Faupl 1998; Lukeneder 2004).

The locality is situated in the southernmost part of the Tirolic Unit which underlays and/or neighbours in this region a small 'Hallstädter Scholle'. The Tirolic Unit is a part the 'Traunalpen Scholle' which at this region displays the westernmost part of the Staufen-Höllengebirgs Nappe.

Lower Cretaceous sediments are represented at the area around the Kolowratshöhe section by two formations, the Rossfeld Formation (approx. 120 m, Upper Valanginian) and the Schrambach Formation (approx. 40 m, Hauterivian).

The macro-invertebrate fauna consists of ammonoids, aptychi, brachiopods (*Triangope*). The only benthic macrofossils observed in the ammonoid beds are brachiopods. Macro-vertebrates are only represented by shark-tooth (*Sphenodus*). Brachyphyllum is the only determinable remnant of plants. The abundant and generally well-preserved cephalopods are dominated by olcostephanids. The fairly fossiliferous part of the section shows remarkably abundant olcostephanids.

The association indicates that the cephalopod-bearing beds of the Rossfeld Formation belong to the *Criosarasinella furcillata* ammonoid Zone (*Criosarasinella furcillata* Subzone) of the latest Late Valanginian (according to the results of the Lyon meeting of the Lower Cretaceous Ammonite Working Group of the IUGS; 'Kilian Group'; HOEDEMAEKER *et al.* 2003).

The following ammonoids were observed:, *Phylloceras serum, Phyllopachyceras winkleri, Lytoceras subfimbriatum*, *Lytoceras sutile*, *Leptotetragonites* sp., *Protetragonites*, *Haploceras* (*Neolissoceras*) *grasianum*, *Haploceras* (*Neolissoceras*) *desmoceratoides*, *Olcostephanus densicostatus*, *Neocomites praediscus*, *Neocomites subpachydicranus*, *Rodighieroites* sp., *Jeanthieuolyites*, *Crioceratites* sp., *Criosarasinella furcillata*, *Bochianites oosteri*.

The typical ammonoid association and the appearance of *Criosarasinella furcillata* denote the *Criosarasinella furcillata* Zone, and especially the *C. furcillata* Subzone. *Neocomites praediscus* is in fact a species restricted to the *C. furcillata* Subzone.

The tectonically strongly deformed Lower Cretaceous sediments of the Ebenforst Syncline do not represent the best conditions for excellent preservation of entire ammonoids. The fragmentation of most ammonoids furnishes evidence for post-mortem transport, breakage on the sea floor through current effects, and/or consequences of predation of the cephalopod shells. The fragmentary preservation of such assemblages points to at least a minimal transportation. Most of the fractures in transported ammonoids do not appear to be of biogenic origin. In most cases they have resulted from the impact of shells with other bioclasts during episodes of current transport before interbedding.

The described specimens were deposited in sediments of the outer shelf. This reconstruction allows a tentative interpretation of the original habitat of the ammonoids investigated. They probably dwelled in more shallow waters than those in which they were ultimately deposited.

References

FAUPL, P. 1979. Turbidite series within the Cretaceous sequence of the Austroalpine unit and their paleogeographical significance. In: J. Wiedmann (Editor): Aspekte der Kreide Europas. IUGS Series, A 6, 403-411.

HOEDEMAEKER, P.J., REBOULET, ST., AGUIRRE-URRETA, M., ALSEN, P., AOUTEM, M. ATROPS, F., BARRANGUA R., COMPANY, M., GONZALES, C., KLEIN, J., LUKENEDER, A., PLOCH, I., RAISOSSADAT, N., RAWSON, P., ROPOLO, P., VAŠÍČEK, Z., VERMEULEN, J. AND WIPPICH, M., 2003. Report on the 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group, the 'Kilian Group' (Lyon, 11 September 2002). Cretaceous Research, 24, 89-94.

IMMEL, H. 1987. Die Kreideammoniten der Nördlichen Kalkalpen. Zitteliana, 15, 3-163.

VAŠÍČEK, Z. and FAUPL P. 1998. Late Valanginian cephalopods in relation to the palaeogeographic position of the Rossfeld and Schrambach Formation of the Reichraming Nappe (Northern Calcareous Alps, Upper Austria). - Zentralblatt für Geologie und Paläontologie, Teil 1 H 11/12, 1421-1432.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

EARLY CRETACEOUS BIOSTRATIGRAPHY AND AMMONOID FAUNA FROM THE DOLOMITES (SOUTHERN ALPS, ITALY)

Alexander **LUKENEDER**

Lower Cretaceous ammonoids (n = 424) were collected at the Puez locality in the Dolomites of Southern Tyrol. The cephalopod fauna from the marly limestones to marls here indicates Late Valanginian to Early Aptian age (Lukeneder & Aspmair, 2006). The underlying Biancone Formation (Maiolica Formation) is Early Valanginian, whereas the lowermost Rosso Ammonitico is of Jurassic to Berriasian age. The deposition of the marly limestones and marls in this interval occurred during unstable conditions.

The ammonoid fauna comprises 27 different genera, each apparently represented by 1-2 species. The complete occurrence at the Puez section is dominated by the Phylloceratina (30%) and the Ammonitina (34%). *Phyllopachyceras* (17%) and *Phylloceras* (13%) from the Phylloceratina are the most frequent components, followed by *Lytoceras* (12%) from the Lytoceratina, and *Barremites* (10%) and *Melchiorites* (8%) from the Ammonitina. Phylloceatidae and Desmoceratidae are dominating the cephalopod-fauna.

Some ammonoid zones defined by Hoedemaeker *et al.* (2003) can be recognized. The following index fossils were examined within the collections of the NHMW (Austria) and the NMB (Italy): for the uppermost Valanginan *Criosarasinella furcillata* (*C. furcillate* Zone and Subzone), for the middle Lower Hauterivian *Olcostephanus (Jeannoticeras) jeannoti* (*O.(J.) jeannoti* Subzone) and for the middle Lower Hauterivian *Olcostephanus (Jeannoticeras) jeannoti* (*O. (J.) jeannoti* Subzone) and *Heinzia sayni* for the lowermost Upper Barremian (*H. sayni* Subzone; Reboulet and Hoedemaeker (reporters) *et al.*, submitted).

The ammonoid fauna contains only descendants of the Mediterranean Province (Tethyan Realm). Most affinities of the cephalopod fauna are observed with faunas from the adjacent areas of Italy (Lessini Mountains, Belluno, southern Trento Plateau), the Northern Calcareous Alps and the Bakony, Geresce and Mecsek Mountains of Hungary. This is explained by the neighbouring position of the latter areas during the Early Cretaceous on the Apulian/Adria block and the Alpine-Carpathian microplate.

The frequency of the ammonoids and the richness of the fauna make this section especially suited to accurately study the vertical ammonite distribution. The main focus in the future will be to investigate in detail the stratigraphic framework of the Puez section. Bed-by-bed collecting is required to obtain crucial data on the ammonoid distribution and occurrence (range). A cooperative project with this aim is planned by the Natural History Museum in Vienna and the Southern Tyrol "Natur Museum" in Bozen.

A further study on the the palaeoecology and synecology of the cephalopod fauna of the

Puez section is currently under preparation by Alexander Lukeneder. It focuses on the autecological features exhibited by different fossil groups (annelids, bryozoans, foraminifera, corals) on ammonoid shells, which act as cryptic habitats for different encrusters in the Lower Cretaceous of the Puez locality.

References

LUKENEDER, A. & ASPMAIR, C. 2006. Startigraphic implication of a new Lower Cretaceous ammonoid fauna from the Puez area (Valanginaian - Aptian, Dolomites, Southern Alps, Italy). *Geo.Alp*, **3**, 55-91.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

THE PUEZ REGION (DOLOMITES, ITALY) AS A NEW KEY-SECTION OF THE TETHYS REALM: A NEW INTERGRATED FWF PROJECT

Alexander **LUKENEDER**

The Mediterranean palaeogeographic domain is characterized by microplates located in the middle of the Tethyan oceanic corridor between the African and European landmasses. The Southern Alps are a Northern Italian chain that emerged during the deformation of the passive continental margin of the Adriatic. Lower Cretaceous deposits form an important element of the Southern Alps and especially of the Dolomites. Surprisingly, one of the most complete, most fossiliferous and best outcropping Lower Cretaceous localities of Europe has not yet been studied sufficiently. We would like to take the opportunity to extract information from this exciting, unique section by using modern integrative methods. The main, starting locality within the herein proposed project is located in huge outcrops located at the southern margin of the Puez Plateau. It is located within the area of the Puez-Geisler Nature park in the northern part of the Dolomites (Trentino – Alto Adige; South Tyrol).

The main investigation topics of the submitted project within the above-described framework are the biostratigraphic, palaeoecological, palaeobiogeographic, lithostratigraphic, cyclostratigraphic and magnetostratigraphic development of the Early Cretaceous of the Puez area. This area is ment to have the potential to become a key section within the Dolomites and has a connecting and intermediate position on the Alpine-Carpathian microcontinent and furthermore an intercessional position in the European Tethyan Realm. Further topics of investigation are the original position and environmental conditions of the sedimentation area. This raises the question of whether the ammonite levels are autochthonous or allochthonous. The answers we expect are essential to reach geodynamic, palaeooceanographic and palaeobiological conclusions. This further leads to the question of the original water depths during the formation of the sediments. Finally, a new understanding about the habitat and the palaeobiology of Alpine Cretaceous ammonites is expected. As a multitasking project, one aim is to underline a crucial fact in working within Lower Cretaceous sediments worldwide: interdisciplinary collaboration with other scientists is essential. Producing major results with a broad impact requires using tools such as isotopes, magnetostratigraphy, cyclostratigraphy along with specific macrofossil groups like ammonites, belemnites, brachiopods, microfossil groups like radiolarians and foraminiferans, as well as nannofossils. This combination will provide a picture of the Lower Cretaceous sea level changes, allow conclusions to be drawn on palaeoclimate and yield results on the biostratigraphic age coupled with more stable, exact ages resulting from the well-established techniques of magnetostratigraphy. In line with the integrative starting point of the proposed project, the ultimate aim is to establish a new European key section for Cretaceous workers through the full range of interdisciplinary fields of palaeontology in the heart of Europe.

We will combine investigations on different fossil groups within fields of isotopic, magnetostratigraphic, cyclostratigraphic and geochemical analysis to extract the Early Cretaceous history of environmental changes as displayed by the sea level and climate; they combined this with calibrating ammonite biostratigraphy and magnetostratigraphy through isotopes.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

BARREMIAN AMMONOIDS FROM THE NORTHERN CALCAREOUS ALPS (SCHNEEBERG SYNCLINE, EARLY CRETACEOUS, UPPER AUSTRIA)

Alexander **LUKENEDER**

An Early Barremian ammonoid fauna from the Lower Cretaceous Schrambach Formation of the Schneeberg Syncline (Reichraming Nappe, Northern Calcareous Alps) yielded 8 genera, each represented by 1 or 2 species. The exclusively Mediterranean ammonoids are dominated by *Barremites* (54.2%) of the Ammonitina, followed by the Lytoceratina (22.9%), Phylloceratina (12.5%) and *Karsteniceras* (10.4%) from the Ancyloceratina.

The macrofauna is represented especially by ammonoids. The whole section yielded about 48 ammonoids. Due to the preservation (moulds) of the cephalopods and the lithologic character of the Schrambach Formation, collecting and preparing ammonoids is difficult. Probably one ammonoid zone defined by Reboulet et al. (2003) can be recognized.

The stratigraphic investigation of the ammonoid fauna revealed that the Hirner section comprises uppermost Lower Barremian sediments (probably *M. moutonianum* Zone or *C. darsi* Zone) and belongs exclusively to the Mediterranean Province.

Sorting and packing due to sedimentological or biological effects, and alignments or concentration due to transport or bottom currents, cannot be observed. The analysis of the macrofauna and the sedimentological data support the interpretation of a palaeoenvironment on the outer shelf to slope.

The presented paper is a further step toward correlating rare Barremian faunas (e.g. layers of ammonoid occurrences) in Lower Cretaceous sediments within the Northern Calcareous Alps. Most of the ammonoids found at the Hirner section were apparently abundant or accumulated in few beds over the whole section (e.g. *Barremites*-abundance zone). Such beds show extraordinary abundance of more or less one species (see Lukeneder, 2003). This was investigated on bedding planes from the Hirner section.

The main future investigation topics concerning these ammonoid abundance zones and biohorizons within the above-described framework will be the palaeoecological, palaeobiogeographic and biostratigraphic development of Lower Cretaceous ammonoid beds within the Northern Calcareous Alps.

References

LUKENEDER, A. 2003. Ammonoid stratigraphy of Lower Cretaceous successions within the Vienna Woods (Kaltenleutgeben section, Lunz Nappe, Northern Calcareous Alps, Lower Austria). In: Piller W.E. (Ed.): *Stratigraphia Austriaca. Austrian Acad. of Sci. Series*, *"Schriftenreihe der Erdwissenschaftlichen Kommissionen"* 16, Vienna, 165-191.

REBOULET, ST., HOEDEMAEKER, P.J., AGUIRRE-URRETA, M., ALSEN, P. & al. (20 other authors) 2006. Report on the 2nd meeting of the IUGS lower Cretaceous Ammonite Working Group, the 'Kilian Group' (Neuchatel, Switzerland, 8 September 2005). *Cretaceous Research*, 27, 712-715.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Ammonite stratigraphy of Lower Cretaceous successions within the Vienna Woods (Kaltenleutgeben section, Lunz Nappe, Northern Calcareous Alps, Lower Austria)

Alexander **Lukeneder**

Detailed palaeontological, lithological and sedimentological studies of the Lower Cretaceous of the Lunz Nappe (Kaltenleutgeben section, Northern Calcareous Alps, Lower Austria) uncovered spectra of Upper Valanginian to Barremian macrofaunal elements (e.g. ammonites, belemnites). Cephalopod-bearing strata of the *trinodosum* Zone (middle Late Valanginian) to *angulicostata* auctorum Zone (*angulicostata* auct. Subzone, latest Hauterivian) have been investigated. The Barremian ammonites could only be recognized in isolated blocks.

The outcrop is situated in an abandoned quarry within the Flössel Syncline (part of the Lunz Nappe), which is formed of Upper Triassic dolomite, followed by a reduced Jurassic sequence. The core of the Flössel Syncline consists of the Lower Cretaceous Schrambach Formation.

Several significant ammonite abundance zones are presented, and a few of them are suggested to be of major importance for stratigraphic correlation. The '*Bochianites*/*Phyllopachyceras*-abundance zone', the '*Bochianites*-abundance zone', the '*Olcostephanus (J.) jeannoti*-abundance zone', the '*Euptychoceras*-abundance zone', and the '*Crioceratites krenkeli*-abundance zone' can be recognized at the investigated outcrop.

The '*Pseudothurmannia*-beds' and the '*Olcostephanus (J.) jeannoti*-Subzone' are important abundance zones ('marker-beds') at the investigated section.

The cephalopod fauna at the investigated quarry belongs exclusively to the Mediterranean Province.

Alexander Lukeneder
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

MORPHOLOGY, FEEDING HABITS AND PHYLOGENETIC IMPLICATIONS OF THE CRETACEOUS COLEOID *DORATEUTHIS SYRIACA* WOODWARD.

Alexander **LUKENEDER**, Mathias **HARZHAUSER**

The main problem in interpreting fossil coleoids and their relation to extant taxa is the extremely rare preservation of soft tissues. With few exceptions, the dataset on soft part morphology – e.g. the digestive systems – of the manifold fossil coleoid groups is still too poor to integrate such information in a consistent phylogenetic tree. One of the most promising localities to solve questions concerning the soft tissue morphology of fossil coleoids is located in Lebanon. There, the Upper Cretaceous "fish-shale" ("Fischschiefer") yields a large number of coleoid cephalopods along with crustaceans and fishes, being known to science since the late 1870s (LARTRET 1877, LEWIS 1878, FRAAS 1878, WOODWARD 1883, 1896, ROGER 1946).

An exceptionally preserved coleoid from the Upper Cretaceous (Upper Santonian) of Lebanon is described. The specimen represents the rare species *Dorateuthis syriaca* WOODWARD 1883 of the family Plesioteuthididae and is characterized by indications of soft tissue such as the buccal mass, mandibles, oesophagus, arms and the gladius. These details allow a refined description of the species, which WOODWARD (1883) based on a poorly preserved holotype and presented as a strongly idealized drawing. Furthermore, the specimen displays the stomach content, comprising exclusively fish remnants. The amount of ingested food reveals *Dorateuthis syriaca* as a voracious feeder whose diet suggests similar predatory habits as documented from modern squids.

The specimen of the coleoid *Dorateuthis syriaca* WOODWARD 1883 is housed in the collection of the Natural History Museum Vienna (Inv. NHMW1998z0105/0000). It was bought by the Museum in 1998 and derives from the Sahil Alma section in Lebanon. Only one slab is available, containing the dorsal part of the squid in ventral view. The counterpart of the slab is missing. This individual is conspecific with other specimens of *Dorateuthis syriaca* WOODWARD 1883 collected at the same locality. A comparison with photographs of the holotype housed in the Natural History Museum London, kindly provided by Dirk Fuchs (Berlin), confirmed the identification but showed that the original definition by WOODWARD (1883) was highly idealized and lacked important information. The specimen is exceptionally preserved and includes soft tissue, which is indicated as a brownish cover on the pale calcareous marl slab. Although the specimen is slightly distorted and compressed, it is sufficiently complete to allow biometric measurements of shape and size.

The first dating of the Sahil Alma section as "Senonian" by FRAAS (1878) was refined by EJEL & DUBERTRET (1966) as Upper Santonian based on planktonic foraminifera.

Dorateuthis syriaca was an active predator feeding at least partly on fish. Remnants of its digestive system suggest the presence of a chyme-filled caecum or caecal sac next to stomach. Based on the mass and preservation of the ingested food, the specimen is interpreted to have preyed on fish only a few hours before its death. This species was an octobrachian, coleoid with 3 types of arms. Like several other Plesioteuthididae, it shows a tendency to a stalked preservation of the circumoral appendages. Both features could be argued to indicate a close relation with the Octobrachiomorpha. In contrast, the gladius of *Dorateuthis syriaca* is reminiscent of that of a decabrachian oegopsid. It cannot be excluded, however, that the similarities with oegopsids (overall body-outline and gladius-shape) represent analogous developments due to adaptation to similar habits. Information on whether the Plesioteuthididae had a crop could support a decision on a potential affiliation with the vampyromorphs. This calls for putting more emphasis on soft part morphologies of exceptionally preserved specimens in future studies. More detailed analysis of the so-called stomach contents might reveal differentiations of crop, stomach and caecum areas, which could then be applied to phylogenetic schemes if consistent patterns turn up. The octobrachian nature of the specimen supports the still controversial systematic position of the Plesioteuthididae within the Octobrachiomorpha. The oegopsid affinities of the gladius therefore point to parallel evolution.

References

EJEL, F., DUBERTRET, L. 1966. Sur l'age précis du gisement de poisons et de Crustacés crétacés de Sahel Alma (Liban). – Société géologique de France, Comptes Rendues somm. Séanc., 1966: 353-354.

FRAAS, O. 1878. Geologisches aus dem Libanon. – Jahrbuch des Vereins für Vaterländische Naturkunde in Württemberg, 34: 257-391.

LARTRET, L. 1877. Exploration géologique de la Mer Morte de la Palestine et de l'Idumée. – 320 p., Paris (Bertrand).

LEWIS, E.R. 1878. The fossil fish localities of the Lebanon. – Geological Magazine Decade 2, 5, 214-220.

ROGER, J. 1946. Les invertébrés des couches du Crétace Supérieur du Liban. – Mémoires Société Géologique France, N. S., 51: 1-92.

WOODWARD, H. 1883. On a New Genus of Fossil "Calamary" from the Cretaceous Formation of Sahel Alma, near Beirut, Lebanon, Syria. – Geological Magazine, N. S., 10: 1-5.

WOODWARD, H. 1896. On a Fossil *Octopus* (*Calais Newboldi*, J. De C. Sby. MS.) from the Cretaceous of the Lebanon. – Quaternary Journal of the Geological Society, 52: 229-234.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Mathias HARZHAUSER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: mathias.harzhauser@nhm-wien.ac.at

LOWER CRETACEOUS FACIES-CHANGES AND BIOSTRATIGRAPHY (TERNBERG NAPPE, NORTHERN CALCAREOUS ALPS, UPPER AUSTRIA)

Alexander **LUKENEDER**, Daniela **REHÁKOVÁ**

Lithological, sedimentological and palaeoecological studies of the Lower Cretaceous (KB1-A section, Ternberg Nappe, Northern Calcareous Alps, Upper Austria) uncovered rich spectra of Early Berriasian to Late Valanginian macro and microfaunal elements in addition with microfloral members.

The evaluation of the thin sections indicates a change from a calpionellid facies to a echinoid facies within the Steinmühl Formation whereas the Schrambach Formation consists of mudstones with rare microfossils.

Several compositional changes in calcareous dinoflagellate and calpionellid assemblages (bio-events) are detected at the Austrian KB1-A section. They correspond to eustatic sea-level fluctuations observed in the Early Cretaceous of the West-Carpathian and correlate with the Nozdrovice Breccia (Nozdrovice event) at the end of the Late Berriasian (Calpionellopsis Zone) and with the Oravice turbidite event at the Early Valanginian (Calpionellites Zone).

The surface of the topmost bed of the Steinmühl Formation (latest Early Valanginian) is characterized by an accumulation of pygopids, partly eroded ammonoids with crinoidal epifaunas, and belemnites with *Acrothoracica* burrows. Additionally a probably small biostratigraphic gap in the calpionellid subzonation between the Steinmühl- and the Schrambach Formations show a sedimentation stop (omission) during the pygopid accumulation.

Several compositional changes in dinoflagellate and calpionellid assemblages (bio-events), which are explained by eustatic sea-level fluctuations in the West-Carpathian (Early Cretaceous; Late Berriasian and Early Valanginian), can be observed in the Austrian KB1-A (Northern Calcareous Alps) section.

The two events, the Nozdrovice Event (Nozdrovice Breccia) at the end of the Late Berriasian Calpionellopsis Zone explained by a regressive phase and the Oravice Event (Early Valanginian), also explained by a rapid sea-level lowering. Both phases manifested in the Nozdrovice and Oravice events, at the approximate end of the Late Berriasian and the end of the Early Valanginian, are evident in the KB1 section. These severe sea-level falls mark the base and the top of the Maiolica-like, light grey biomicritic wackestones of the topmost Steinmühl Formation with abundant *Pygope catulloi*. This interval is not a transition but an independent step. The last sea-level fall was followed by a huge rise in sea level, manifested in the Late Valanginian (Verrucosum Zone) succession of the lowermost Schrambach Formation; it is formed by light grey spotted limestones with marly intercalations, which are very fossiliferous in micro- and macrofossils.

The evaluation of the thin section indicates a change from the calpionellid facies (lower part of the ‘Ammonitico rosso’ type limestone), to an echinoid facies (upper part of the Steinmühl Formation) up to nannoconic facies (the Schrambach Formation) with rare echinids and foraminifera.

Beds with the abundant brachiopod *Pygope catulloi* (*Pygope*-bed) reflect a phase of drastic sea-level fall. These layers are represented by the Maiolica-like light grey biomicritic wackestones of the topmost Steinmühl Formation, just below the Schrambach Formation. The *Pygope* accumulation, partly eroded ammonoids with crinoidal epifaunas, belemnites with *Acrothoracica* burrows, as well as the probably small biostratigraphic gap in the calpionellid subzonation between the Steinmühl- and the Schrambach Formations show a sedimentation stop (omission) during the pygopid accumulation. This favoured the building of a firm- to hardground, which allowed the pygopids and other epifaunal elements to settle on the sea-floor. The associated calpionellid fauna indicates an Early Valanginian (Calpionellites Zone; major Subzone) age of the *Pygope catulloi*-bearing bed. Thus, the occurrence of abundant pygopids and the additional analysis of the micro- and macrofauna support the interpretation of a hardground palaeoenvironment on a swell of the outer shelf.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Daniela REHÁKOVÁ
Faculty of Natural Sciences, Comenius University
Mlynská dolina G 1
842 12 Bratislava
Slovakia
e-mail: rehakova@nic.fns.uniba.sk

TRACE FOSSILS OF THE EARLY VALANGINIAN IN THE HOCHKOGEL SECTION (UPPER AUSTRIA, NORTHERN CALCAREOUS ALPS): THEIR IMPACT ON LOG ORIENTATION AND PALAEONVIRONMENTAL INTERPRETATIONS

Alexander **LUKENEDER**, Alfred **UCHMAN**

The Hochkogel section (Ebenforst Syncline, Northern Calcareous Alps) belongs to the the Rossfeld Formation. The stratigraphic investigation of the microfauna revealed that the Hochkogel section comprises Lower Valanginian sediments of the *Calpionellites* Zone (*Darderi* and *Major* Subzones), which corresponds to the *B. campylotoxus* and/or *T. pertransiens* ammonoid zones (Lukeneder, 2005).

The deposition of the sandstone-limestone beds in this area took place in an unstable environment disturbed by gravitational sediment flows, which transported different sedimentary components and accompanying fossils (mostly ammonites) from a source area situated to the south. The sandstone beds were deposited by turbidity currents. They display graded bedding and common concentration of plant debris at their top. The fossils were sorted, packed, aligned and concentrated by the bottom currents and occasionally influenced by bioturbation. The macrofauna and the sedimentological features support the interpretation of a highly dynamic palaeoenvironment on the basin slope, where turbiditic currents redeposited fragmented ammonite shells from shallower areas.

The Rossfeld Formation is mainly composed of grey silty marls accompanied by conglomerates and sandstones. The sandstones are fine-grained and some of their beds show convolute or slump structures. The intercalated marly bioturbated limestones are light-coloured and are associated with a relatively monotonous benthic macrofauna (brachiopods and bivalves). The fabric is mottled to completely homogenised due to bioturbation and indicates intensive benthic colonization.

The Rossfeld Formation at the Hochkogel section is represented by an approx. 30 m-thick succession of grey, fine-grained calcareous sandstone beds, which are 5-50 cm thick. Three intercalated sandstone-limestone beds are 10-40 cm thick. The beds no. 1-3 are rich in calpionellids and ammonoids. These sandstone-limestone beds contain thin, 2-3 cm thick sandstone layers in the lower part, which pass gradually in the marly limestones in the upper part. The sandstone layers show sharp, erosive bases and a general graded bedding towards the transition to the limestone layer. They display incomplete Bouma intervals, mostly the parallel lamination sandstones (Tb) followed by cross lamination (Tc) and, bioturbated marly limestones (Td-e). The limestones contain dispersed sand grains in the lower part. Some, thinner sandstone layers are bioturbated, and they do not display any primary lamination. In many cases, the beds are welded and only the sandstone layers mark lower parts of turbiditic flows.

The incidental sedimentation of several, sandstone-limestone layers correspond to the period of the so-called Oravice Event, which is widespread throughout the Carpathians. Microfossils and other evidences from sections point to a large siliciclastic input in the West Carpathians during the Oravice Event, which is correlated with a third-order sea-level fall (Reháková, 2000).

New data on the trace fossils and sedimentology detect that the bed succession in the Hochkogel section is inverse. This is shown by the sharp lower boundaries of the sandstone-limestone beds, their general graded bedding, the diffusive transition between sandstones and limestones in the beds and the superposition of Tc on Tb Bouma intervals. Moreover, the full-relief preservation of *Scolicia* on a bed sole, a typically wrapped up axial part of *Zoophycos* and branching down *Chondrites* prove way up orientation. The trace fossils are abundant and show dominance of *Chondrites*, *Zoophycos* and *Planolites*. *Thalassinoides*, *Palaeophycus*, *Trichichnus*, *Phycosiphon*, "*Scolicia* and an unnamed small spreiten form are less common. The trace fossil association is typical of the *Zoophycos* ichnofacies, which is placed on the basin slopes in the classical ichnofacies model. Noteworthy is the occurrence of *Scolicia* in the Lower Valanginian because this trace fossil is very rare in the Lower Cretaceous. *Scolicia* is produced by irregular echinoids, which colonized deep seas since the Tithonian (Tchoumatchenco & Uchman, 2001). It became more common since the Late Cretaceous.

References

LUKENEDER, A. 2005. An Early Cretaceous ammonoid association from Upper Austria (Late Valanginian, Northern Calcareous Alps. Beiträge zur Paläontologie von Österreich, 29, 1-13.

LUKENEDER, A., REHÁKOVÁ D. 2007. Chronostratigraphic significance of an early Valanginian (Cretaceous) calpionellid association (Hochkogel section, Upper Austria, Northern Calcareous Alps). Geological Quarterly, 51(1), 27-38.

REHÁKOVÁ D. 2000. Calcareous dinoflagellate and calpionellid bioevents versus sea-level fluctuations recorded in the West–Carpathian (Late Jurassic/Early Cretaceous) pelagic environments. Geolocica Carpathica, 51/4, 229 – 243.

TCHOUMATCHENCO, P., UCHMAN, A. 2001. The oldest deep-sea *Ophiomorpha* and *Scolicia* and associated trace fossils from the Upper Jurassic - Lower Cretaceous deep-water turbidite deposits of SW Bulgaria. Palaeogeography, Palaeoclimatology, Palaeoecology, 169(1-2): 85-99.

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Alfred UCHMAN
Institute of Geological Sciences
Jagiellonian University
Oleandry 2a
30-063 Kraków
Poland
e-mail: alfred.uchman@uj.edu.pl

DATING THE PENNINIC OCEAN SUBDUCTION: NEW DATA FROM PLANKTONIC FORAMINIFERA (SITTENEDOF, LOWER AUSTRIA)

Oleg **MANDIC**, Alexander **LUKENEDER**

The Penninic Ocean was a side tract of the Central Atlantic Oceanic System intercalated between the European and the Austroalpine plates. Its closure started during the Early Cretaceous, as subduction of the oceanic crust beyond the Austroalpine plate. The turnover of the deposition on the Austroalpine shelf from pelagic carbonates into the deep-water siliciclastics correlated with the denudation of the accretionary wedge resulting from that subduction. Within the Bajuvaric Unit of the Upper Austroalpine, this transition is reflected by the lithostratigraphic boundary between the Schrambach and the Tannheim Formation. This boundary is well outcropped in a newly discovered site at Sittendorf, SW of Vienna, bearing around the critical interval an extraordinarily rich planktonic foraminifera assemblage. Along with the biostratigraphic analysis, C_{org}, $CaCO_3$ and S content estimation and the gamma-log outcrop measurement were carried out proving still more accurate stratigraphic interpretation of the section intersecting a small-scale isoclinal fold.

The Schrambach Formation (10 m) comprises pelagic limestones - mudstones to wackestones with matrix dominated by large nannoconid phytoplankton. Radiolarians are partly very abundant, whereas planktonic foraminifera are scattered in most of the formation except for its topmost part. The assemblage is dominated by small, five-chambered *Praehedbergella*, particularly by *P. infracretacea*. *Blowiella blowi* and *Praehedbergella occulta* traced already in the lower part of the section, allow its correlation with the upper part of the *B. blowi* Interval Zone and dating to the uppermost Barremian and lowermost Aptian. The planktonic foraminifera assemblage of the topmost Schrambach Formation changes radically. From here upwards, zooplankton blooms characterize the succession up to its top. Common *Leupoldina* and large specimens of *Blowiella blowi* point to the *Leupoldina cabri* Acme Zone. The base of the latter Zone superimposes the Lower Aptian Oceanic Anoxic Event "Selli" and has an inferred age of about 124 Ma. Up to now, the presence of a planktonic foraminifera assemblage with *Leupoldina* was unknown from the investigated depositional cycle (Schrambach - Tannheim - Losenstein Formation).

The lower part of the Tannheim Formation is still characterized by the common occurrence of *Leupoldina*, whereby the occurrence of *Praehedbergella luterbacheri* and *Globigerinelloides ferreolensis* point therein to the upper part of the Acme Zone. Upwards the last occurrence of *Leupoldina* allowed the approximation of the Lower/Upper Aptian boundary correlating roughly with the base of the *Globigerinelloides ferreolensis* Interval Zone, whereas the subsequent introduction of

Globigerinelloides barri points to the upper part of that zone.

The data from the topmost part of the section demonstrated the position of the section within a slightly northwards overturned, isoclinal syncline fold. Not only the inverse succession of biostratigraphic units but also the inverse gamma log pattern, proved the block for a tectonically inverted structure. Hence above the first fault, the large, thick-walled, 8-chambered (the last whorl) *Hedbergella trocoide*a appear pointing to the Upper Aptian *H. trocoidea* Interval Zone. They are replaced upward by smaller more primitive 7-chambered representatives, accompanied by extremely large specimens of *G. algerianus* proving the stratigraphically older Upper Aptian *G. algerianus* Taxon Range Zone. Finally above the second fault the assemblage of the *Leupoldina cabri* Acme Zone reappears. The stratigraphic discontinuity must be a product of the lateral pressure and the block escape movements in that southern wing of the syncline.

In conclusion, the range of the section is estimated to be about 10 m.y. and to include 5 Aptian planktonic foraminifera zones. The terrigenous input bounded to initial subduction of the Penninic Ocean under the Austroalpine Microplate started at about 123 Ma (Early Aptian). This date corresponds with that determined for the lithostratigraphic boundary between the Schrambach Formation and the Tannheim Formation. Although the section is discontinuous in its upper part (Tannheim Formation), the studied lithostratigraphic boundary is positioned within the continuous part of the section. Finally, thin slice biostratigraphy of planktonic foraminifera proved, also in the Northern Calcareous Alpidic shelf, to be a powerful tool for stratigraphic dating of Aptian deep-water successions. This paper is a contribution to the Austrian Science Fund Project P-16100.

Oleg MANDIC
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: oleg.mandic@nhm-wien.ac.at

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

LOWER CRETACEOUS DEEP WATER CARBONATES OF KALTENLEUTGEBEN SW VIENNA (LUNZ NAPPE, NCA, AUSTRIA)

Oleg **MANDIC**, Alexander **LUKENEDER**

The limestone succession at abandoned quarry of Flößlberg S of Kaltenleutgeben in the Vienna Wood (E Austria) represents a deep water facies of the Schrambach Formation. It belongs to the Lunz Nappe of the Northern Calcareous Alps and ranges - based on ammonite stratigraphy - from Upper Valenginian to uppermost Hauterivian or lowermost Barremian. The measured section comprises a 300m thick succession dominated by monotonous gray to yellowish marly limestones and calcareous marls. The lower third of the section bear sandstone intercalations. They thin and disappear upward possibly due to gradual deepening of the depositionary environment. The upper third of the section comprises again distal debris flows. They are now represented by 2 to 10 cm thick echinoid dominated allodapic limestones. The intercalations comprise additionally brachiopod, bryozoan and mollusc remains originated from a shallow water carbonate platform coexisting during the Late Hauterivian. The microfacies development of the section has been documented by 88 thin slices from 44 samples. Generally, except for the sandstones and the bioclastic packstones of carbonate intercalations, the slices show throughout monotonous, radiolarian dominated micritic mudstones and wackestones. Nannoconid remains can be partly abundant in the matrix. Lamination is generally absent whereas intensive bioturbations can be present. The upper part of the succession bear scattered echinoid fragments, small sized planktonic foraminifera, benthic foraminifera and ammonite fragments.

Oleg MANDIC
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: oleg.mandic@nhm-wien.ac.at

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

THE BERRIASIAN (=RYAZANIAN) STAGE OF THE RUSSIAN PLATFORM: THE FIRST CRETACEOUS INVASION OF TETHYAN AMMONITES

Vasily **MITTA**

The first Cretaceous invasion of Tethyan ammonites on the Russian platform is usually explained by paleogeographic reorganizations which have opened seaways from the Northern Caucasus through Mangyshlak to Central Russia. The genus *Riasanites* Spath supposedly played an important role in this invasion as the majority of researchers regards the Central Russian *Riasanites* as migrants from the Northern Caucasus (Sazonova, 1971; Sey & Kalacheva, 1997; and others). However, the ancestors of *Riasanites* have not been found in the Northern Caucasus, and the North Caucasian origin of this genus cannot be supported. In contrast, Jeletzky (1984) suggested that the basin of the Oka River was the center of origin of *Riasanites* (from “*Pavlovia*-like Boreal perisphinctids”), where from they spread to the Northern Caucasus and the Crimea through the Peri-Caspian and Mangyshlak, and in a westward direction through the Polish strait to Poland. A weak point of this theory is the absence of ancestors of *Riasanites* among the Boreal ammonites.

The morphology of the shell and the sculpture of *Riasanites* show their undoubtedly “Tethyan” origin. Probably, they were direct descendant of Tithonian taxa. It is possible that the very close resemblance of *Riasanites* and *Corongoceras* Spath (Himalayitidae) resulted from closely related heterochronous homoeomorphy – similar morphological characters are observed in the same phylogenetic line through several generations of taxa. The first representatives of *Riasanites* (*R. swistowianus* (Nikitin)) appeared in Central Russia, and there are no positive records of this species in other regions. The specimens close to the *R. swistowianus* have been found, infrequently, only in Mangyshlak. The revision of *Riasanites* (Mitta, in press), has shown that the North Caucasian members of this genus belong to *R. maikopensis* (Grigorieva), and the Crimean ones – to *R. crassicostatus* (Kvantaliani et Lyssenko). However, the "early" *Riasanites* from the Northern Caucasus are closer not to the early *Riasanites* from Russian platform, but, on the contrary, to the late morphs of *R. rjasanensis* (Nikitin). Therefore it seem most likely that the ancestors of *Riasanites* migrated from the Western Tethys through the Polish (Brest) passage into the Central Russian sea, where the genus evolved. Later *Riasanites* spread up to the basin of the Vyatka River in the north, and through Mangyshlak to the Northern Caucasus to the Crimea, in the south.

Transcaspiites Luppov is another genus from the family Himalayitidae with a similar distribution – the Northern Caucasus, Mangyshlak and Central Russia. The genus also included *T. hundesianus* (Uhlig) from the Himalayas. *Transcaspiites* probably originated in the Central Tethys, and later migrated to the north – to the Caucasus and then through Mangyshlak to Central Russia. This genus has not been recorded from the Crimea or Western Europe.

Another genus of Tethyan origin is *Subalpinites* Mazenot (Neocomitidae). This genus has been described from the Berriasian of France and has been recorded from Mangyshlak. Some species of *Subalpinites*, (some as yet unpublished) are widespread in the Ryazanian Stage of the Russian platform. The genus *Subalpinites* is practically unknown in the Crimea and the Caucasus, except two small specimens from the basin of the Belaya River (Northern Caucasus), probably belonging to this genus. Thus the migration of sub-Mediterranean *Subalpinites* through the Polish passage into the Central Russian Sea and further on to the South-East – to Mangyshlak seems very probable.

The time of the opening of the Polish Strait is determined differently by different researchers, from the Tzikwinianus chron of the Ryazanian up to Early Valanginian. Our data allow earlier dating of this event – to the Rjasanensis chron.

The sea-regression maximum in Central Russia at the J/K boundary coincided with the first half of the Nodiger time (latest Volgian), and a new marine transgression had begun by its second half (the Milkovensis moment). The opening of the narrow Polish Strait in the West and a wide strait in the South-East, probably coincided with the maximum of this transgression at the beginning of the *Rjasanensis* time (earliest Ryazanian). These straits were short-lived, as in the second half of the *Rjasanensis* time the migration of ammonites from the Western Tethys stopped, and the same happened to the exchange of faunas with the Peri-Caspian Sea. The records of Marek (1967; and others) of ammonites similar to *Riasanites* in Poland (Kuyav), appear to be in agreement with the above theory.

This study is supported by the program of the Presidium of the Russian Academy of Sciences “The Origin and Evolution of the Biosphere” (project “Coevolution in the Marine Pelagic Biota and its Response to Abiotic Changes in the Critical Epochs of the Paleozoic and Mesozoic”).

Vasily MITTA
Paleontological Institute of Russian Academy of Sciences
Profsoyuznaya 123
Moscow 117997
Russia
e-mail: mitta@paleo.ru

LATE VALANGINIAN FORAMINIFERA AND AMMONITE FROM THE TARAISES FORMATION OF THE CUENCAMÉ REGION, DURANGO, NE MEXICO

Lourdes **OMAÑA**, Celestina **GONZÁLEZ ARREOLA,** Margarita **RAMÍREZ GARZA**

In the central-east part of the Durango State a section was measured 6.28 m thick from the base of the upper member of the Taraises Formation. This sequence consists of grey limestone, shale and white marl that provides a rich paleontological material which allow to study of the ammonite and the microfossils (foraminifera) associated to them.

The examined section contains several species of ammonite as *Oosterella begastrensis*, *O*. *gaudryi*, *O. cultrata*, *O. cultrataeformis*, *Ceratotuberculus linguituberculatus, Rodighieroites belimelensis*, *Olcostephanus* (*Olcostephanus*) *balestrai*, *O*. (*Jeannoticeras*) *colorinensis*, *Karakaschiceras* sp. and *Bochianites* spp. that are regarded as the Late Valanginian (*Peregrinus* Zone) of the standard biozonal scheme for the Mediterranean Faunal Province.

With respect of the planktic foraminifera, they display small size and low diversity. *Hedbergella sigali*, *Caucasella hoterivica*, *Globigerinelloides* sp and *Gorbachikella* sp. are identified.

On the basis of the planktic foraminiferal assemblage is defined the *Hedbergella sigali-Hedbergella intermedia* Zone of the Late Valanginian.

The occurrence of the hedbergellids suggested an epipelagic setting of an open-shelf water mass. Also the Olcostephanids and the Neocomitids could have lived in the upper part of the water column.

Lourdes OMAÑA
Departamento de Paleontología
Instituto de Geología
Universidad Nacional Autónoma de México
Ciudad Universitaria, 04510
Mexico, D.F.
Mexico.
e-mail: lomanya@geologia.unam.mx

Celestina GONZÁLEZ ARREOLA
Departamento de Paleontología
Instituto de Geología
Universidad Nacional Autónoma de México
Ciudad Universitaria, 04510, Mexico, D.F.
Mexico
e-mail: arreola@servidor.unam.mx

Margarita RAMÍREZ GARZA
Posgrado en Ciencias de la Tierra
Instituto de Geología
Universidad Nacional Autónoma de México
Mexico
e-mail: maggiergarza@gmail.com

THE CORRELATION OF EARLY CRETACEOUS EVENTS USING STABLE ISOTOPE RECORDS

Gregory D. **PRICE**

Carbon stable-isotope profiles through Cretaceous successions typically show consistent stratigraphic trends that provide a sound basis for high-resolution global correlation. In areas where the analysis of bulk pelagic sediments is not possible the analysis of macro fossils has provided the means to develop a carbon-isotope stratigraphy and correlate distal records (e.g. Boreal to Tethyan systems). The advantages of this approach, as demonstrated by Volgian-Valanginian belemnite isotope data derived from the Yatria River, Western Siberia, is that not only a carbon isotope stratigraphy can be developed, inferences regarding marine palaeotemperatures can be made via oxygen isotope analysis. In this example, a positive shift in carbon isotope values during the late Valanginian is correlatable with cooler temperatures, possibly exposing the effectiveness of carbon sinks and their ability to draw down atmospheric CO_2, the 'inverse greenhouse' effect. The development of detailed fossil-wood carbon-isotope stratigraphies has potentially provided a powerful method to correlate non marine or marginal marine successions with fully marine sections. Fossil-wood isotope data can also provide inferences regarding the carbon-cycle and changes in atmospheric CO_2 concentrations. Problems do exist, whereby sections containing both wood and marine carbonate are far and few between. Such approaches also rely upon detailed, robust and stratigraphically well constrained marine carbon isotope stratigraphies, which are not always available. A stratigraphic, biostratigraphic and isotopic investigation performed on early Cretaceous Crimean sections revealed a wood-based carbon isotope curve comparable to Tethyan stratigraphies. This clastic-dominated Crimean succession consisted of a series of bioturbated inter-bedded shallow-marine silty sands, claystones and some oolitic sands. A detailed study of the ammonite fauna has demonstrated that the succession can also be compared to standard Tethyan schemes. The wood carbon-isotope ratios range in the Early Valanginian from –24‰ to –22‰, and in the mid-*verrucosum* Zone values shift abruptly towards more positive values and peak at –18‰ in the lower *callidiscus* Zone. Wood carbon-isotope ratios decrease gradually through the remainder of the *callidiscus* Zone and return to pre-excursion values in the *tauricum* Zone. The structure, magnitude and timing of the terrestrial carbon-isotope curve is very similar to the marine carbonate curve for the Valanginian. A delta-delta relationship between organic matter and carbonate, indicates that there was a possibly drop in atmospheric CO_2 concentrations during the Valanginian. Nevertheless a full evaluation of such reasoning needs to be made using successions that actually contain both wood and marine carbonates. Further research has hence now focussed on the Early Cretaceous

(Valanginian–Hauterivian) interval from Khatanga River, Siberia. This section contains both belemnites and terrestrial wood fragments and therefore provides a section to determine whether the relationship for the Valanginian from Crimea is a global phenomenon. As demonstrated in other early Cretaceous sections (e.g. the Yatria River), the belemnite record from the Khatanga River, central Siberia reveals a positive carbon isotope excursion within the late Valanginian. A fossil-wood carbon-isotope stratigraphy also reveals a coeval positive carbon-isotope excursion (within the *bidichotomus* zone). The delta-delta relationship between organic matter and carbonate from the Khatanga River data is consistent with that observed in the Crimea. For this reason, the two records taken together demonstrate the dependable nature of carbon isotope stratigraphies in correlation as well as confirming inferences regarding carbon-cycling and changes in atmospheric CO_2 concentrations.

Gregory D. **PRICE**
School of Earth, Ocean and Environmental Sciences
University of Plymouth
Drake Circus
Plymouth, Devon, PL4 8AA
United Kingdom
e-mail: G.Price@plymouth.ac.uk

CORRELATION BETWEEN MICROVERTEBRATES BIODIVERSITY AND CONDITIONS OF DEPOSITION ALONG A SEDIMENTARY SERIES (BERRIASIAN, CHERVES-DE-COGNAC, FRANCE)

Joane **POUECH**, Jean-Michel **MAZIN**

At the end of the Jurassic, an important regression affect the west of Europe. On the Northern margin of the Aquitaine Basin (France), huge depressions of salted water are isolated, leading to gypsum deposits, known on at least 100 kilometers. In this context, the quarry of Cherves-de-Cognac (Berriasian, Early Cretaceous, France) yields a sedimentary series of 87 levels, registering the continental evolution of the basin. The exposed layers begin with intercalations of black marl and gypsum, then evolve in marly deposits, more carbonated at the top of the series. Sedimentological data give a general vision of the depositionnal model, a change from a salted lagoon to a fluviatile then lacustrine environment.

Micro-vertebrates bring another kind of informations to understand depositionnal modalities. In the series of Cherves-de-Cognac, 63 non-gypseous layers have been sampled and all of them yield vertebrates micro-remains. They are represented by an important taxonomic richness since 24 vertebrates families have been identified, from all the major clades (chondrichthyans, osteichthyans, amphibians, turtles, lepidosaurians, crocodilians, dinosaurs, birds and mammals). Moreover, important quantity of dental remains are found, until 37,000 teeth per metric ton of sediment in the richest layer. These three conditions: representativity along the sedimentary series, diversity and richness, allow to use micro-vertebrates to understand depositionnal modalities.

The present work is based on teeth remains, in order to use numerical data. Graphic representations are first used to reflect biodiversity distribution at the family level, then several statistics treatments and indices are applied, i.e. cluster analysis, evenness values, principal components analysis. These tools allow to propose a scenario for the depositionnal environment of Cherves-de-Cognac. On the bottom of the series, the hydrographic network become more and more important and bring increasingly quantities of biological remains in a basin under evaporitic conditions. Then, in the middle of the sedimentary series, these quantities strongly increase but the proportions between each family remain equivalent. This episode corresponds to a huge influx of sedimentary material in the basin. The paroxysm is recorded in a level yielding a terrestrial association, thought to be consequent to a flood event. Finally, we observe return to quieter conditions, and a progressive faunal replacement in main osteichthyans families. A lacustrine environment takes place at the top of the sedimentary series.

Joane POUECH
UMR CNRS 5125 PEPS
Université Claude Bernard Lyon 1 - Campus de la Doua
2 rue Dubois – Bâtiment Géode
69622 VILLEURBANNE Cedex
France
e-mail: joane.pouech@pepsmail.univ-lyon1.fr

Jean-Michel MAZIN
UMR CNRS 5125 PEPS
Université Claude Bernard Lyon 1 - Campus de la Doua
2 rue Dubois – Bâtiment Géode
69622 VILLEURBANNE Cedex
France
e-mail: jean-michel.mazin@univ-lyon1.fr

PRELIMINARY RESULTS OF MAGNETOSTRATIGRAPHIC INVESTIGATIONS ACROSS THE JURASSIC/CRETACEOUS BOUNDARY STRATA IN THE NUTZHOF, AUSTRIA

Petr **PRUNER,** Petr **SCHNABL**, Alexander **LUKENEDER**

A high resolution study focusing on the detailed biostratigraphy of the limestone-, marly limestone- and marl succession at Nutzhof has been carried out at a new outcrop in the Pieniny Klippenbelt of Lower Austria. The assembled outcrop is located about 20 km south of Böheimkirchen and 5 km north of Hainfeld. The surrounding area is called Kleindurlas and the locality itself Nutzhof. Lithological, sedimentological and palaeoecological studies of the succession uncovered rich spectra of Tithonian to Berriasian macro- and microfaunal elements. The evaluation of the thin sections and washed samples indicates a change from a saccocomid facies to a calpionellid facies within the succession.

The Pieniny Klippenbelt is in this area a small band of Upper Jurassic to Lower Cretaceous sediments from 200-500 m breadth. It is surrounded by mighty sediments of the Rhenodanubian Flysch Zone. Tectonically, the outcrop is situated only 5 km north of the main border of the Rhenodanubian Flysch Zone and the more southern Northern Calcareous Alps. The log at Nutzhof contains 18 m of inverse, cm to dm beds showing at meter 6 the Jurassic-Cretaceous boundary. The stratigraphic investigation of the micro- and nannofauna revealed that the Nutzhof section comprises sedimentary sequence of Early Tithonian to Middle Berriasian in age. The ammonites from the lower part strengthen these results. The upper part shows only aptychi but is barren of ammonites. The fact that the Jurassic-Cretaceous boundary is detected in this outcrop and the detailed biostratigraphy makes a magnetostratigraphic study reasonable.

The principal aim of a detailed magnetostratigraphic and micropalaeontological investigation of the Jurassic/Cretaceous (J/K) boundary limestones in the basal portion (18m) of the Nutzhof section is to determine precisely the boundaries of magnetozones and narrow reverse subzones, and to find a correlation between magnetostratigraphic data (reflecting global events).

A summary of results of magnetostratigraphic and micropalaeontological investigations of the Jurassic/Cretaceous (J/K) boundary strata in the Tethyan realm hitherto obtained at three localities yielding reliable interpretation results. The localities in the Tethyan realm include the J/K sections at Brodno near Žilina (Western Carpathians, W Slovakia), the Bosso Valley (Umbria, central Italy) and at Puerto Escaño (Province of Cordóba, S Spain). These localities provided very detailed to high-resolution magnetostratigraphic data across the J/K boundary.

The reverse subzones were precisely localized in all the sections in analogous relative positions in magnetozones M20n and M19n, respectively. The reverse subzones proposed to be named ”Kysuca Subzone” in M20n and ”Brodno Subzone” in M19n were precisely localized. All the magnetozones and subzones are well correlable with the M-sequence of marine magnetic anomalies. At the locality of Brodno, the transition from N (R) to R (N) polarity of the Earth´s palaeomagnetic field was inferred indicating the duration of transition within a time interval of ± 5ka.

Oriented hand samples (38) from the Nutzhof section were cuting to 86 laboratory specimens. Remanent magnetization (RM) was investigated to study the magnetic polarity for magnetostratigraphic purposes. Progressive stepwise alternating field (AF) demagnetization up to a maximum field of 150 mT was performed with a 2G Enterprises degausser system or thermal demagnetization employing the MAVACS demagnetizer in 12–13 thermal fields up to the unblocking temperatures of minerals – carriers of palaeomagnetization. After each demagnetization step, the remanent magnetization was measured on a 2G Enterprises cryogenic magnetometer or JR-6A spinner magnetometer in the Paleomagnetic laboratory, Praha (GACR 205-07-1365). The measured data were subjected to the multi-component analysis of remanence. The mean ChRM directions were analyzed using the statistics on sphere.

Low-field magnetic susceptibility (k) ranges from -5.9 to 94.9×10^{-6} SI and the intensity of the natural remanent magnetization (NRM) varies between 0.31 and 6.15×10^{-4} A/m. The samples display a two- to three-component remanence. Our study concentrated on the investigation of the basal 18-m thick portion of the section, on the limestone strata around the J/K boundary, to preliminary determine the boundaries of magnetozones M17R to M22R (six reverse and five normal zones). The average sampling density for the whole section was around two samples per 1 m of true thickness of limestone strata. Although both magnetic polarities are present, the directions are highly scattered. Consequently, the mean direction for samples with normal polarity is D=314.7°, I=32.0°, α_{95}=14.1° and reverse polarity, D=131.8°, I=-58.6°, α_{95} =21.9°. This normal polarity direction is in agreeement with the magnetic field for the J/K, but the reverse polarity presents high inclination. The next step of magnetostratigrafic investigation will be to determine the boundaries of submagnetozones M19 and M20 the average sampling density for the whole section must be around 5 to 8 samples per 1 m and 20 and more samples per 1 m in critical portions of the section.

Petr PRUNER
Paleomagnetic laboratory
Institute of Geology
ASCR vvi., Rozvojová 269
Praha 6
Czech Republic
e-mail: Pruner@gli.cas.cz

Petr SCHNABL
PhD student
Paleomagnetic laboratory
Institute of Geology
ASCR vvi., Rozvojová 269
Praha 6
Czech Republic
e-mail: schnabl@gli.cas.cz

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

CRETACEOUS FORAMINIFERA OF THE GOSAU GROUP (KRAPPFELD, CARINTHIA)

Michaela **RADL**

The sequence of the Gosau Group in the Krappfeld area (van Hinte, 1963) is divided into the Windisch Formation, Mannsberg Fm., Wendel Fm. and Pemberger Fm., and ranges from the Campanian to the Maastrichtian. The entire succession measures more than 2000m and consists of limestone, marly limestone, calcarenite, conglomerate and breccias. Eocene sediments form the sedimentary cover. One of the most continuous sections of the Upper Cretaceous measured belongs to the Pemberger Fm. located near Wietersdorf (Krappfeld, Carinthia) has recently been investigated.

The section consists of dark-grey marl, light-grey to pink limestone (wacke-, pack- and rudstone), grey marly limestone, light-grey calcarenite, light-grey, green and black conglomerate and light-grey, green and black breccias. A total thickness of about 118m was measured. The section shows well bedded deposits of flysch character, which were affected by a complex fault system that results in different dipping of the beds. 14 sedimentary cycles were recognized all starting with fine breccias except the last one. The base of cycle 14 is represented by a 12m thick mega-breccia which is due to a tectonic event during the Campanian-Maastrichtian. The mega-breccia is overlain by well bedded limestones, which are followed by marly limestone and marls to the top of the unit. Each cycle represents a fining upward sequence.

Throughout the section foraminifera, red algae, small phytoklasts and ostracods could be observed from thin sections as well as from sieved residues of some bulk samples. Rudist, bivalves and echinid fragments are obtained most of them are described by van Hinte (1963) and Schreiber (1979, 1980). The mega-breccia passes into rudstone facies (approx. 5m thickness). It yields bivalves (*Radiolites* sp., *Hippurites* sp., *Inoceramus* sp.) and also a huge number of foraminifera which are represented by planktic (*Globotruncana* sp. and ?*Globigerina* sp.) and benthic taxa (*Gyroidinoides* sp., *Gavelinella monterelensis*, *Gavelinella* sp., *Pseudotextularia* sp., *Heterohelix* cf. *globifera*, *Lagena* sp., *Nodosaria* sp. and ?*Cibicides* sp.) and ostracods (*Xestoleberis* sp. and ?*Cytheretta* sp.). Out of three sieved samples (basal, middle and upper part of the section) the P/B ration been concluded: lower part (sample 20R): nearly 100% planktic foraminifera; middle part (sample 81R): 70/30 P/B; upper part (sample 22L): 50/50 P/B.

The P/B ratio of the microfossil assemblage shows that the relative abundance of planktic foraminifera declines along the section. This indicates a shallowing of the depositional environment, which is also reflected by the occurrence of rudists within the mega breccia that derive from sublithoral settings.

References

HINTE, J.E. VAN 1963. Zur Stratigraphie und Mirkopaläontologie der Oberkreide und des Eozäns des Krappfeldes (Kärnten). – Jb. Geol. B.-A. Sonderband 8: 1-147.

SCHREIBER, O.S. 1979. Heterohelicidae (Foraminifera) aus der Pemberg-Folge (Oberkreide) von Klein-Stankt Paul am Krappfeld (Kärnten). - Beitr. Paläont. Österr. 6: 27-59 (Sonderdruck), Wien.

SCHREIBER, O.S. 1980. Benthonische Foraminiferen der Pemberger-Folge (Oberkreide) von Klein-Sankt-Paul am Krappfeld (Kärnten). – Beitr. Paläont. Österr. 7: 119-237, Wien.

Michaela RADL
University of Graz
Institute of Earth Sciences (Geology and Palaeontology)
Heinrichstrasse 26
A-8010 Graz
Austria
e-mail: 04radlmi@stud.uni-graz.at

The Early Aptian ammonite biozonation in Mediterranean Province

Seyed Naser **Raisossadat**, Hugh G. **Owen**, Joaquin **García-Mondéjar**, Peter F. **Rawson**

The Lower Cretaceous biozonation of the Tethys has been discussed during recent years. A biozonation has been introduced based on Deshayesitidae for the Upper Barremian-Lower Aptian (e.g. Bogdanova & Tovbina, 1994); a scheme accepted by the Lower Cretaceous Cephalopod Team as a standard for the Mediterranean area (Hoedemaeker *et al*., 1993). Genera of the family are recorded throughout the Tethyan Realm and extend into the Boreal Realm. Three genera of the family, *Turkmeniceras*, *Deshayesites* and *Dufrenoyia*, are well distributed in the Mediterranean region of Tethys and provide good indices for biozonation. *Turkmeniceras provides a good index of late Barremian age; Deshayesites* and *Dufrenoyia* are used for the Lower Aptian biozonation.

The ammonite faunas of the Early Aptian of Aralar Mountain in north Spain have been studied recently (publication submitted, García-Mondéjar et al., 2008). The reported genera and species permit a correlation of the successions in the Mediterranean Tethyan Belt. They demonstrate that the ammonite succession in the Kopet Dagh (Turkmenistan and north east Iran) at the opposite ends of the northern Mediterranean Tethyan belt (firmly established (Raisossadat, 2002), is uniform.

A Deshayesites tuarkyricus Zone had been proposed for the earliest Early Aptian. However, Raisossadat (2002) showed that *Deshayesites oglanlensis* was more characteristic of this time interval and this revision was accepted by 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group (Hoedemaker et al., 2003). This species could be traced throughout the Mediterranean basin. The assemblage of this Zone is closely comparable in the north Tethyan province successions in Spain, France and the Kopet Dagh (Turkmenistan and north east of Iran). The English *fissicostatus* Zone (Casey, 1961) can be correlated with the *Deshayesites oglanlensis* Zone.

The succeeding Early Aptian ammonite zone is the *Deshayesites weissi* Zone. The *weissi* Zone is established from the stratigraphical range of two species, *Deshayesites weissi* and *Deshayesites planus*. While *D. weissi* is known only from North Germany, Romania, the Greater Balkans, Taurkyr and Kubadag (Kopet Dagh), the latter species is more widespread. It is believed that the *weissi* Zone in Transcaspia can be correlated with the *forbesi* Zone (Casey, 1961) in England and the *weissi* Zone (Kemper, 1976) in Germany.

The *weissi* Zone is succeeded by that of *Deshayesites deshayesi,* a common species of *Deshayesites* distributed throughout most of the areas from which the genus is recorded. It is thus used widely as the index fossil of the penultimate Early Aptian zone. There is now general agreement that the *Deshayesites deshayesi* Zone of Casey (1961) corresponds to the *deshayesi* Zone of other European authors.

Dufrenoyia is a widely distributed genus and *D. furcata* is the index fossil for the latest Early Aptian in the Mediterranean region. Casey (1961) proposed for this interval an index fossil, *Tropaeum bowerbanki*, which is associated with species of *Dufrenoyia* in southern England. *Tropaeum* is a heteromorph ammonite and is facies restricted and thus unsuitable as a widely recognisable index fossil. The distribution of Deshayesitidae family genera and their species in Mediterranean regain will be discussed in this paper.

References

BOGDANOVA, T., TOVBINA, S. Z. 1994. On development of the Aptian ammonite zonal standard for the Mediterranean region. *Géologie Alpine* Mémoire H. S. no 20, 51-59.

CASEY, R. 1961. The stratigraphical palaeontology of the Lower Greensand. *Palaeontology* 3, 487-621.

GARCÍA-MONDÉJAR, J., OWEN, H.G., RAISOSSADAT, N., MILLÁN, M.I., FERNÁNDEZ-MENDIOLA, P.A. (submitted) The Early Aptian of Aralar (north Spain): stratigraphy, ammonite biozonation and OAE1a. *Cretaceous Research*

HOEDEMAEKER, PH. J., et al., 1993. Ammonite zonation for the Lower Cretaceous of the Mediterranean region; basis for stratigraphic correlations within IGCP-project 262. *Revista Española de Paleontologica* 8, 117-120.

HOEDEMAEKER, PH. J., et al. 2003. Report on the 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group, the 'Kilian Group' (Lyon, 11 July 2002), *Cretaceous Research* 24, 89-94.

RAISOSSADAT, S.N. 2002. Lower Cretaceous (Upper Barremian-Lower Albian) Ammonite faunas of the Kopet Dagh Basin, NE Iran. Unpublished PhD thesis, University College London, London, UK, 337 pp.

Seyed Naser RAISOSSADAT
Geology Department
Birjand Univerity, Faculty of Science
P.O.Box 97175/ 615, Birjand
Iran
e-mail: snaser_rais@yahoo.co.uk

J. GARCÍA-MONDÉJAR
Departamento de Estratigrafía y Paleontología
Facultad de Ciencia y Tecnología
Universidad del Pais Vasco, Apartado 644
48080 Bilbao
Spain
e-mail: joaquin.garciamondejar@ehu.es

Hugh G. OWEN
Department of Paleontology
The Natural History Museum
Cromwell Road
London, SW7 5BD
UK
e-mail: l.steel@nhm.ac.uk

Peter F. RAWSON
Department of Earth Sciences
University College London
Gower Street
London, WC1E 6BT
UK
e-mail: peter.rawson1@btinternet.com

ORIGINATION OF *HIMANTOCERAS* (HETEROMORPHIC AMMONOIDS) RELATED TO PALAEOCEANOGRAPHIC AND CLIMATIC CHANGES DURING THE VALANGINIAN

Stéphane **REBOULET**

The aim of this work is to investigate the possible connections between ammonoid evolution and palaeoenvironmental changes (modifications in carbon cycle, global cooling and glacio-eustatic events, changes in trophic resources) from the *Campylotoxus* to *Peregrinus* zones (REBOULET *et al*. 2006), stratigraphic interval for which recent data on palaeoceanographic and climatic conditions are available (Pucéat *et al*., 2003; McArthur *et al*., 2007).

In SE France basin, in the *Biassalense* and *Verrucosum* subzones, a large majority of the typically Lower Valanginian ammonoid genera and species disappears (*Busnardoites*, *Kilianella*, *Saynoceras*, *Valanginites*, etc. (Reboulet, 1996; Reboulet & Atrops, 1999). Even if some genera cross this extinction phase, they decline rapidely and are much less abundant in the Upper Valanginian. *Neocomites* appears at the top of *Biassalense* subzone; it will be at the origin of the Upper Valanginian neocomitids. This genus is also the ancestor of *Himantoceras,* heteromorphic ammonoids which appear at the base of the Nicklesi subzone, by way of *Neocomites beaumugnensis, Rodighieroites belimelensis* and *R. cardulus*; this phyletic trend takes place during the Pronecostatum subzone and Peregrinus zone (Reboulet, 1996).

Perturbations in the global carbon cycle are the final expression of large-scale and rapid environmental changes which could have affected the biota. The Biassalense-Verrucosum subzones are characterized by a positive $\delta^{13}C$ excursion, correlated with the Valanginian Weissert OAE (McArthur *et al*., 2007, and references therein). The major extinction event in the history of Valanginian ammonoids occurs simultaneously with a global perturbation of the carbon cycle which takes place across the Lower-Upper Valanginian boundary. The Verrucosum subzone is also characterized by the disappearance of several species and genera of belemnites (Janssen & Clément, 2002). The faunal caesura in the evolution of these cephalopods is followed by the origination of *Himantoceras* which takes place during the decrease of carbon isotope values. Similar observations have been made in the Bajocian of Betic Cordillera (Spain). The origination of uncoiled *Spiroceras* coincides with a shift to lighter values in $\delta^{13}C$ and it is associated with a major ammonoid extinction (O'Dogherty *et al.,* 2006).

An important decrease in sea-water temperature (around 7°C) is recorded in the Western Tethyan marine basins between the Lower and Upper Valanginian (Pucéat *et al*., 2003) and the maximum cooling probably takes place in the *Peregrinus* subzone (McArthur *et al*., 2007). A significant sea level drop, partly caused by the formation of polar ice during this cooling event, could explain the extinction of numerous ammonoid taxa due to the reduction of their habitat space in proximal palaeoenvironments (for example, exposure of Provence platform). The decrease in sea-water temperature is also an important stress factor for these Tethyan species. The evolutionary trend of *Neocomites* towards *Himantoceras* (during Pronecostatum-Peregrinus subzones) takes place just after the major extinction event. This probably results in decreased competition for habitats after the disappearance of numerous species. The change in geometry shell (from involute/evolute planispirals to uncoiled ammonoids) occurs during high environmental stress generated by a major sea-level lowstand and the maximum sea-water cooling which takes place during the Peregrinus zone.

Trophic resources in the water column was an important factor controlling the diversity and abundance of ammonoids with respect to their habitat and mode of life. Heteromorphs probably had different trophic behaviour than involute/evolute planispirals; the former probably could better occupy new ecological niches (Reboulet *et al*. 2005). A quantitative study made in the uppermost Albian of the SE France basin has shown that involute/evolute planispirals are abundant during intervals characterized by oligotrophic conditions and stable conditions. Albian heteromorphs, which are dominant during mesotrophic conditions, could have been more competitive than involute/evolute planispirals when palaeoenvironmental conditions become more unstable caused by periods of increased precipitation, fresh-water input and introduction of associated nutrients into marine realm (Reboulet *et al*. 2005). The disappearance of numerous planispiral ammonoid species across the Lower-Upper Valanginian boundary and the origination of heteromorphs in the Peregrinus zone could be due to variations in sea-water productivity and food availability during unstable conditions.

References

O'DOGHERTY, L., et al. 2006. Carbon-isotope stratigraphy and ammonite faunal turnover for the Middle Jurassic in the Southern Iberian paleomargin. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 239: 311-333.

JANSSEN, N.M.M., CLÉMENT, A. 2002. Extinction and renewal patterns among Tethyan belemnites in the Verrucosum Subzone (Valanginian) of southeast France. *Cretaceous Research*, 23: 509-522.

MCARTHUR, J.M. et al. 2007. Palaeotemperatures, polar ice-volume, and isotope stratigraphy (Mg/Ca, δ18 O, δ13 C, 87 Sr/86 Sr): The Early Cretaceous (Berriasian, Valanginian, Hauterivian). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 248: 391-430.

PUCÉAT, E. et al. 2003. Thermal evolution of Cretaceous Tethyan marine waters inferred from oxygen isotope composition of fish tooth enamels. *Paleoceanography*, 18, 1029, doi:10.1029/2002PA000823.

REBOULET, S. 1996. L'évolution des ammonites du Valanginien-Hauterivien inférieur du bassin vocontien et de la plate-forme provençale (Sud-Est de la France): relations avec la stratigraphie séquentielle et implications biostratigraphique. *Documents des Laboratoires de Géologie de Lyon*, 137: 371 p.

REBOULET S., Giraud F., Proux O., 2005. Ammonoid abundance variations related to changes in trophic conditions across the

Oceanic Anoxic Event 1d (Latest Albian, SE France). *Palaios*, 20: 121-141.

REBOULET, S., ATROPS, F. 1999. Comments and proposals about the Valanginian-Lower Hauterivian ammonite zonation of south-east France. *Eclogae geologicae Helvetiae*, 92: 183-197.

REBOULET, S., Hoedemaeker, P.J., reporters (19 other authors) 2006. Report on the 2^nd International Meeting of the IUGS Lower Cretaceous Ammonite Working Group, the "Kilian Group" (Neuchâtel, Switzerland, 8 September 2005). *Cretaceous Research*, 27: 712–715.

Stéphane REBOULET
UFR Géosciences, UMR 5125, PEPS – Bâtiment Géode,
Rue Raphaël Dubois, Université Lyon I
F-69622 Villeurbanne cedex
France
e-mail: Stephane.Reboulet@univ-lyon1.fr

CALCAREOUS MICROPLANKTON AND NANNOPLANKTON ASSEMBLAGES RECORDED IN THE WEST CARPATHIAN LATE JURASSIC/EARLY CRETACEOUS SEDIMENTARY SEQUENCES – TOOLS FOR BIOSTRATIGRAPHY AND PALEOENVIRONMENTAL RECONSTRUCTION

Daniela **REHÁKOVÁ,** Eva **HALÁSOVÁ**

This contribution discusses the results of an integrated study of three microplankton groups (calpionellids, calcareous dinoflagellates and calcareous nannofossils) and partialy with the stable isotope data ($\delta^{18}O$, $\delta^{13}C$) as well, in the Late Jurassic and Early Cretaceous pelagic sedimentary sequences. Generaly, in the Western Carpathians these sequences are lack of ammonite fauna. At that time, calpionellids, calcareous dinoflagellates and nannofossils were the most important constituents of tropical and subtropical calcareous microplankton and calcareous nannoplankton. Calpionellids rarely dominated over the phytoplankton associations and they were always eliminated in environments in which radiolarians prevailed in abundance. The bio-events investigated emphasises the potential of these planktonic groups as proxies in biostratigraphy, palaeoecology and palaeoceanography. The stable isotope data underline environmental changes. Correlation of the calcareous microplankton distribution and stable isotope analyses was used in the characterization of the J/K boundary interval and also the Aptian anoxy called there as Koňhora event (Michalík et al. in print).

The biostratigraphical study based on the distribution of calpionellids and nannofossils allowed us to distinguish nine calpionellid zones with their fifteen subzones and ten nannofossils zones with ten subzones (Reháková, Michalík 1997, Halásová 2004). A distribution patterns of the cysts studied permit a rough selection of diagnostic bioevents suitable for a definition of the cyst zones. Nine cyst zones and seven ecological event zones were distinguished (Reháková, 2000).

The high-resolution quantitative analysis of calpionellids, dinoflagellates and calcareous nannofossil assemblages indicates major variations in relative abundance of species, species variability and assemblage diversity and also in the structural composition of their tests. In the West Carpathian sequences studied, the mass abundance of these microfossils was closely connected predominantly with shallow intrashelf basins and its elevated ridges. These environments were characterized by the permanent current regime positively influencing the nutrient input. The high nutrient potential (in accordance to the composition) activated the explosion waves in evolution of specific planktonic association and also selected forms. Such relatively dense environment invoked the feedback pressure on the planktonic organisms. It seems that small usually less calcite calpionellid forms coincided with the environments rich in nutrients and they occured with higher fertility-related nannofossils. On the other hand, the big elongated calpionelid forms with composed collars (created usually diversified associations) were bind directly with the food specialization. Diversified calpionelid associations are linked with blooms of k-selected highly calcified coccoliths/nannoliths. It is worth of mentioned, that the abundance and size of calpionellid loricas decrease also towards to open marine environments.

During calpionellid evolution the lorica composition changed several times, probably in connection with changes in sea-water temperature and chemistry. Two distinct overturn events (change of microgranular lorica into the hyaline one) recorded in the Middle Tithonian and during the Middle Aptian were synchroneous with investigated peaks in nannoplankton abundance. Microgranular calpionellids were replaced by hyaline forms. The increase of water temperature (result of enhanced ? volcanic activity) and contemporaneous climate change could influence the depletion of micrograndullar forms or could lead to cessation of their loricas production. The rests of ? cysts/bags visible localy in microgranular loricas could be signalize the stress in environmental conditions. On the other hand, the increase of water temperature and high concentration of $CaCO_3$ influenced the flourishing of nannoplankton. Ciliate protozoans feeding on calcareous phytoplankton started to agglutinate their loricas with the rests of nannofossils. It seems that the nannoplankton diversity influenced strictly calpionellid diversification. The radiation and diversification of hyaline calpionellids coincided with diversification of calcareous nannoplankton. Intervals in which small hyaline calpionellid forms were dominated coincided with the abundance radiations of nannoconids. Salinity variations should have been also responsible for thinning of calpionellid loricas observed during the Late Tithonian, Latest Berriasian and Early Valanginian. Valanginian episode of greenhouse climate associated with increased evolutionary rates in competetive planktonic communities (foraminiferas, calcareous nannoplankton, radiolarians) could led to total calpionellid decimation.

The ecological calcdinocyst events caused by the blooming of one single species characterized by composed oblique wall structure combined with nannofossil indicators of warm water condition could be a proxy of increasing sea surface temperature. Cooling trends is correlable with onset of tabulated cyst species. If compare their distribution with eustatic pulses, calpionellid and dinoflagellate asoociations are dominated during transgressive and highstand interval, in the frame of which their acme accumulation, radiation and diversification events were identified.

References

HALASOVÁ E. 2004. Biostratigraphic zonation of the Upper Jurassic and Lower Cretaceous sequences of Western Carpathians on the base of calcareous nannoplankton. PhD Thesis, MS, Comenius University Bratislava, 127 p. (in Slovak).

MICHALÍK J., SOTÁK J., LINTNEROVÁ O., HALÁSOVÁ E., BAK M., SKUPIEN P., BOOROVÁ D. in print. The stratigraphic and palaeoenvironmental setting of Aptian OAE black shale deposits in the Pieniny

Klippen Belt, Slovak Western Carpathians. *Cretaceous Research.*

REHÁKOVÁ D. 2000. Evolution and distribution of the Late Jurassic and Early Cretaceous calcareous dinoflagellates recorded in the Western Carpathian pelagic carbonate facies. *Mineralia Slovaca* 32., 79 – 88.

REHÁKOVÁ D., MICHALÍK J. 1997. Evolution and distribution of calpionellids – the most characteristic constituents of Lower Cretaceous Tethyan microplankton. *Cretaceous Research* 18., 493 – 504.

Acknowledgment

The contribution was supported by Slovakian grant agency: APVV-0465-06, APVV 51-011305 and VEGA 1/4039/07.

Daniela REHÁKOVÁ
Department of Geology and Palaeontology
Faculty of Natural Sciences, Comenius University
Mlynská dolina G 1
842 12 Bratislava
Slovakia
e-mail: rehakova@nic.fns.uniba.sk

E. HALÁSOVÁ
Department of Geology and Palaeontology
Faculty of Natural Sciences, Comenius University
Mlynská dolina G-1
842 15 Bratislava,
Slovak Republic
e-mail: halasova@fns.uniba.sk

THE JURASSIC-CRETACEOUS BOUNDARY IN THE AUSTRIAN KLIPPEN BELT (NUTZHOF, LOWER AUSTRIA): IMPLICATIONS ON MICRO- AND NANNOFACIES ANALYSIS

Daniela **REHÁKOVÁ**, Eva **HALSOVA**, Alexander **LUKENEDER**

Limestones studied at the Nutzhof sectin in the Klippen belt of Lower Austria are wackestones, packstones or mudstones in their structures. Fine-grained micrite with pelagic microfossils (calpionellids, calcareous dinoflagellates, radiolarians and nannofossils) are common in open-marine environments. Rare skeletal debris derived from fragmented and disintegrated shells of invertebrates (benthic foraminifers, echinoderms, molluscs) comming from shallower environments. Microfacies are typical for basinal settings which could be situated also in tectonicaly influenced subsiding shelf areas. The stratigraphic investigation of the micro- and nannofauna revealed that the Nutzhof section comprises sedimentary sequence of Early Tithonian to Middle Berriasian in age. Following dinofalgellate and calpionellid associations and zones (Reháková 1995, 1998, 2000a, b, 2002) were recognized.

The following microfossil zones from Early Tithonian to Middle Berriasian could be detected from Nutzhof:

Tithonica Zone (the interval limited by samples 18,0 – 17,2). Early Tithonian
Malmica Zone (the interval limited by samples 17,0 – 14,8). Early Tithonian
Semiradiata Zone (samples 14,6 – 11,8). Early Tithonian
Chitinoidella Zone (samples11,6 – 11,0). Middle Tithonian
Praetintinnopsella Zone (samples 10,8 – 10,4). Earliest Late Tithonian
Crassicollaria Zone, Remanei Subzone (samples 10,2 – 10,1). Late Tithonian
Crassicollaria Zone (samples10,0 – 7,2). Late Tithonian
Calpionella Zone, Alpina Subzone (samples 7,0 – 5,6). Lower Berriasian – J/K boundary
Calpionella Zone, Ferasini Subzone (samples 5,4 – 4,4). Lower Berriasian
Calpionella Zone, Elliptica Subzone (samples 4,2 – 0,0). Middle Berriasian

The correlation of microfossils shows good results what concerning distribution, environmental conditions and stratigraphy of the Jurassic – Cretaceous boundary interval. Similar results were also documented by Michalik et al. (2007).

The following nannofossil zones from Early/Middle Tithonian to Middle Berriasian could be detected from Nutzhof:

No 18,0. Conusphaera mexicana mexicana Zone NJ-20
Range: Lower to Middle Tithonian
17,0. Conusphaera mexicana mexicana Zone NJ-20
Range: Lower to Middle Tithonian

16,0. Conusphaera mexicana mexicana Zone NJ-20

Range: Lower to Middle Tithonian

15,0. Conusphaera mexicana mexicana Zone NJ-20

Range: Lower to Middle Tithonian

14,0. Conusphaera mexicana mexicana Zone NJ-20

Range: Lower to Middle Tithonian

13,0

Conusphaera mexicana mexicana Zone NJ-20

Range: Lower to Middle Tithonian

12,0. Conusphaera mexicana mexicana Zone NJ-20

Range: Lower to Middle Tithonian

11,0. Conusphaera mexicana mexicana Zone NJ-20

Range: Lower to Middle Tithonian

9,0. ?Microstaurus chiastius Zone NJK, Bralower et al. 1989

Range: Upper Tithonian to lowermost Berriasian, Chron M 20 - M 17

8,0

Microstaurus chiastius Zone NJK, Bralower et al. 1989

Range: Upper Tithonian to lowermost Berriasian, Chron M 20 - M 17

7,0

Microstaurus chiastius Zone NJK, Bralower et al.

Range: Upper Tithonian to lowermost Berriasian, Chron M 20 - M 17

6,0

Microstaurus chiastius Zone NJK, Bralower et al.

Range: upper Tithonian to lowermost Berriasian, Chron M 20 - M 17.

5,0

Microstaurus chiastius Zone NJK, Bralower et al. 1989

Range: Upper Tithonian - lowermost Berriasian, Chron M 20 - M 17

4,0

Nannoconus steinmannii steinmannii Zone NK-1 Bralower et al., 1989

Range: Middle Berriasian, Chron M 17 to M 16.

3,0

Nannoconus steinmannii steinmannii Zone NK-1 Bralower et al., 1989

Range: Middle Berriasian, Chron M 17 to M 16.

2,0

Nannoconus steinmannii steinmannii Zone NK-1 Bralower et al., 1989

Range: Middle Berriasian, Chron M 17 to M 16.

References

REHÁKOVÁ D., 1995. New data on calpionellid distribution in the Upper Jurassic/Lower Cretaceous formations (Western Carpathians). Mineralia Slovaca 27, 308 - 318. (In Slovak).

REHÁKOVÁ D., 1998. Calpionellid genus *Remaniella* Catalano 1956 in Lower Cretaceous pelagic deposits of Western Carpathians. Mineralia Slovaca 30, 443 – 452.

REHÁKOVÁ D., 2000a. Evolution and distribution of the Late Jurassic and Early Cretaceous calcareous dinoflagellates recorded in the Western Carpathian pelagic carbonate facies. Mineralia Slovaca 32, 79 – 88.

REHÁKOVÁ D., 2000b. Calcareous dinoflagellate and calpinellid bioevents versus sea-level fluctuations recorded in the West-Carpathian (Late Jurassic/ Early Cretaceous) pelagic environments. Geologica Carpathica 51, 4, 229 – 243.

REHÁKOVÁ D., 2002. Chitinoidella Trejo, 1975 in Middle Tithonian carbonate pelagic sequences of the West Carpathian tethyan area. Geologica Carpathica 55, 6, 369 – 379.

MICHALÍK J., REHÁKOVÁ D., HALASOVÁ E., LINTNEROVÁ O., 2007. Integrated stratigraphy of the Jurassic/Cretaceous boundary at the Brodno section (the Kysuca Unit, Pieniny Klippen Belt, Western Carpathians). Abstract book, International geological correlation programe 506 – Jurassic marine: non-marine correlation, University of Bristol, p. 3.

Daniela REHÁKOVÁ
Faculty of Natural Sciences, Comenius University
Mlynská dolina G 1
842 12 Bratislava
Slovakia
e-mail: rehakova@nic.fns.uniba.sk

E. HALÁSOVÁ
Department of Geology and Palaeontology
Faculty of Natural Sciences, Comenius University
Mlynská dolina G-1
842 15 Bratislava,
Slovak Republic
e-mail: halasova@fns.uniba.sk

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

PRELIMINARY RESULTS OF MAGNETIC MINERALOGY INVESTIGATIONS OF UPPER JURASSIC AND LOWER CRETACEOUS SEDIMENTS FROM NUTZHOF, AUSTRIA

Petr **SCHNABL,** Alexander **LUKENEDER,** Petr **PRUNER**

The rockmagnetic studies help to distinguish magnetic minerals, therefore they support the high resolution magnetostratigraphic research of the J/K boundary at Nutzhof. This profile is compound of limestone-, marly limestone- and marl succession. The outcrop is part of the Pieniny Klippenbelt of Lower Austria, which is surrounded by the Rhenodanubian Flysch Zone. The sediments contain rich spectra of Tithonian to Berriasian macro- and microfaunal elements.

METHODS

Isothermal remanent magnetization (IRM) to saturation was measured to identify coercivity spectra. Every mineral and his magnetic granulometry have the coercivity spectra different. Magnetite has the IRM saturated between 100 and 200 mT, by contrast hematite saturates over 3000mT. The whale rock samples were magnetized on the Pulse Magnetizer MMPM 10, demagnetized on LDA-3 AF Demagnetizer and measured on JR6a magnetometer. The used field range was 10 to 2900 mT.

Determination of Curie point is another method used to distinguish the magnetic minerals. The Curie point of hematite is at 675°C and of pure Fe magnetite is at 580°C. The samples were demagnetized in MAVASC (Magnetic Vacuum Control System) and measured on 755R Superconducting Rock Magnetometer.

MAIN MAGNETIC MINERALS

Magnetite can be found in all limestone layers on the Nutzhof J/K boundary. Due to its extremely high magnetic susceptibility (MS) and natural remanent magnetisation (NRM) is the most important magnetic mineral on the profile. Its' Curie point is at 470°C, which means that there is high titanium content in the magnetite lattice. The most probable explanation is that the magnetite has detrital origin and it contain primary NRM component.

Hematite has smaller MS and NRM than magnetite. The high amount of hematite was proved in the samples N0170, N1310 and N1790. Between layers N1350 and N1630 was determined minor amount of hematite, that has no effect on magnetostratigraphic results.

MAGNETOSTRATIGRAPHIC APPLICATION

MS ranges from -5.9 to 94.9×10^{-6} SI and the intensity of NRM varies between 0.31 and 6.15×10^{-4} A/m. All samples with normal or reverse polarity contain primary NRM component. In conclusion, the Nutzhof profile is convenient for magnetostratigraphic investigation. The next step of magnetostratigrafic investigation will be determination of temperature dependent variations of MS that can also identify some paramagnetic minerals.

The rock magnetic measurements were supported by GACR agency (205-07-1365).

Petr SCHNABL
PhD student
Paleomagnetic laboratory
Institute of Geology, ASCR vvi.
Rozvojová 269
Praha 6
Czech Republic
e-mail: schnabl@gli.cas.cz

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Petr PRUNER
Paleomagnetic laboratory
Institute of Geology
ASCR vvi.
Rozvojová 269
Praha 6
Czech Republic
e-mail: Pruner@gli.cas.cz

DINOCYSTS AND AMMONOIDS OF UPPER CRETACEOUS SEDIMENTS OF THE PEMBERGER QUARRY (KRAPPFELD, CARINTHIA, AUSTRIA)

Ali **SOLIMAN**, Thomas J. **SUTTNER**, Alexander **LUKENEDER**; Herbert **SUMMESBERGER**

Upper Cretaceous sediments of the Krappfeld in Carinthia (Austria) yield numerous ammonoids and dinoflagellate cysts as well as benthic foraminifera (Schreiber, 1979, 1980). Earlier investigations on the macro- and microfauna were done by Thiedig and Wiemann in 1976.

In general, the investigated deposits belong to the Gosau Group and cover a surface of about 100 km² with a thickness up to 1500 m of flyschoid limestone and marl within the Krappfeld area (compare Tiedig & Wiemann 1976). According to the foraminifera Lower Maastrichtian was suggested for the investigated deposits belonging to the Krappfeld-Group by Schreiber (1980). This age can more or less be confirmed by the micro-, and macrofossils of recent investigations, as some of the fossil remnants hint to Late Campanian age.

Abundant and diverse dinoflagellate cyst assemblages from the sampled log of the Pemberger Quarry are reported, e.g. *Dinogymnium* spp., *Florentinia* spp., *Xiphoridinium* spp., *Fromea* spp., *Hystrichosphaeridium* spp., *Palaeoperidinium* spp., *Pervosphaeridium* spp., *Surculosphaeridium* spp. and *Kleithriasphaeridium* spp. Due to the presence of *Florentinia mayii* (79.01-71.86 Ma), *Cannosphaeropsis utinensis* and *Cerodinium diebelii* (Williams et al., 2004) Campanian age is suggested for the investigated sequence.

Ammoniods collected by Thiedig in 1976 are *Pseudokossmaticeras brandti*, *Pseudokossmaticeras tercense*, *Pseudokossmaticeras galicianum* and *Pachydiscus carinthiacus*. Additional specimens, which might belong to a new genus were found within the uppermost part of the Cretaceous sequence.

The fauna has been dated by ammonites as Early Maastrichtian by THIEDIG & WIEMANN (1976). This seems to be outdated through the wrong use of *P. brandti* for indicating Early Maastrichtian (Hancock & Kennedy, 1993).

Recent findings show that the ammonoid fauna (*Pseudokossmaticeras tercense* (Seunes, 1892) indicates a Late Campanian age of the upper part of the Cretaceous at the Krappfeld.

The ammonoid specimens are accompanied by lamellaptychi, belemnites, bivalves, serpulides, fish remains, trace fossils and plant debris.

References

SCHREIBER, O. S. 1979. Heterohelicidae (Foraminifera) aus der Pemberger-Folge (Oberkreide) von Klein-Sankt Paul am Krappfeld (Kärnten). – Beiträge zur Paläontologie von Österreich, 1979 (6), 27-59, Wien.

SCHREIBER, O. S. 1980. Benthonische Foraminiferen der Pemberger-Folge

(Oberkreide) von Klein- Sankt Paul am Krappfeld (Kärnten). – Beiträge zur Paläontologie von Österreich, 1980 (7), 1-206, 16 plates., Wien.

THIEDIG, F., WIEMANN, J. 1976. Ammoniten und Alter der höheren Kreide (Gosau) des Krappfeldes in Kärnten (Österreich). – Mitt. Geol.-Paläont. Inst. Univ. Hamburg, 45, 9-27, Hamburg.

WILLIAMS, G. L., BRINKHUIS, H., PEARCE, M. A., FENSOME, R. A., AND WEEGINK, J. W. 2004. Southern Ocean and global dinoflagellate cyst events compared: index events for the Late Cretaceous–Neogene. – *In* Exon, N.F., Kennett, J.P., and Malone, M.J. (Eds.), Proceedings of the Ocean Drilling Program, Scientific Results, 189: 1-98.

Ali SOLIMAN
Austrian Academy of Sciences
University of Graz, Institute of Earth Sciences (Geology and Palaeontology)
Heinrichstrasse 26
A-8010 Graz
Austria
e-mail: ali.soliman@uni-graz.at

Thomas J. SUTTNER
Austrian Academy of Sciences
University of Graz, Institute of Earth Sciences (Geology and Palaeontology)
Heinrichstrasse 26
A-8010 Graz
Austria
e-mail: thomas.suttner@uni-graz.at

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Herbert SUMMESBERGER
Natural History Museum Vienna,
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: herbert.summesberger@nhm-wien.ac.at

AMMONOIDS AND PLANKTONIC FORAMINIFERA OF THE CHIKKIM SYNCLINE (CRETACEOUS, SPITI VALLEY, INDIA)

Thomas J. **SUTTNER**, Alexander **LUKENEDER**, Rufus J. **BERTLE**

The Cretaceous sequence of the Chikkim Syncline (Tethys Himalaya, northern India) is represented by the Giumal and Chikkim formations. The age of the Giumal Formation in Spiti is expected to be Lower Cretaceous in age by a recently discovered ammonoid fauna (LUKENEDER *et al*., in prep.) and by planktonic foraminifera of the Chikkim Formation constraining the latter to range between Late Albian and Campanian (BERTLE & SUTTNER 2005).

The Giumal Formation measures about 350 m and consists of brown coloured sandstone and dark shale. Five cycles could be distinguished within the succession, of which each starts with a several metres thick interval of black shale intercalated by single beds of fine grained quartz arenites. Along the cycle, sandstone beds become more abundant and increased in thickness (decimetre-bedded), forming 10 to 40 metres thick intervals towards the top. Thickening upward of the beds as well as coarsening upward of its components is observed in each cycle. Usually the uppermost bed of the sandstone-interval is composed of coarse grained matrix with several layers of disarticulated bivalve shells intercalated. While fine grained sandstone beds have a dark, micritic matrix, topmost coarse grained arenites are mature. Sandstone beds content high amounts of quartz, yield glauconite grains and limonitic clasts. In the lower part of the sandstone-intervals of cycle 2 and 5, ammonoids occur, comprising well preserved planspiral and criocone shell-types.

Ammonoid taxa occurring are for the Berriasian *Subthurmannia*, *Blanfordiceras* and for the Aptian-Albian *Sinzovia, Cleoniceras* and *Australiceras*.

The Giumal Formation is overlain by the carbonatic sequence of the Chikkim Formation (minimum thickness: 65 m). The base of the Chikkim Formation starts with a relatively sharp contact of well bedded micritic carbonates to a strongly weathered interval of grey calcareous shale of the uppermost part of the Giumal Formation. Within the occurrence of the first limestone beds (representing the base of the Lower Chikkim Member) planktonic foraminifera occur (e.g., *Planomalina buxtorfi* and *Rotalipora appenninica*). Microfacies changes at the boundary of the Lower to the Upper Chikkim Member, where medium-bedded micritic limestone beds are replaced by thin-bedded carbonaceous marls. The lower part of the Upper Chikkim Member shows Campanian age, which could be determined by the occurrence of *Globotruncanita elevata* and *Gansserina gansseri*.

The observed cyclicity of the Giumal Formation most probably represents a siliciclastic slope facies with distal to proximal turbidite fans. Micritic limestones, rich in planktonic foraminifera, hint to pelagic settings, at least for the deposits of the Lower Chikkim Member.

References

BERTLE, R.J., SUTTNER, T.J. 2005. New biostratigraphic data for the Chikkim Formation (Cretaceous, Tethyan Himalaya, India). *Cretaceous Research*, 26 (6): 882-894.

Thomas J. SUTTNER
Austrian Academy of Sciences
University of Graz, Institute of Earth Sciences (Geology and Palaeontology)
Heinrichstrasse 26
A-8010 Graz
Austria
e-mail: thomas.suttner@uni-graz.at

Alexander LUKENEDER
Natural History Museum
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Rufus J. BERTLE
GEOGNOS Bertle ZT GmbH,
Kronengasse 6
A–6780 Schruns
Austria
e-mail: rufus.bertle@geologie-bertle.at

ENVIRONMENTALLY CONTROLLED AMMONITE ASSEMBLAGES FROM THE LATE ALBIAN OF HUNGARY

Ottilia **SZIVES**

The Late Albian ammonite record from Hungary is extremely rich and well documented (Scholz, 1979; Horváth, 1985, 1989; Szives (ed.) 2007). Ammonites are known from boreholes and surface outcrops as well, from two different paleotectonic units – the Bakony Mountain of the Alcapa Unit and the Villány Mountain of the Tisza Unit. The surface assemblages of the Bakony Mts. region – Jásd 1 Quarry, Bakonynána and Tiloserdő - contains *Ostlingoceras, Stoliczkaia, Salaziceras, Neophlycticeras, Anisoceras* and *Scaphites* in great abundance, and *Ficheuria, Turrilitoides, Zuluscaphites, Engonoceras,* members of Hamitidae and Hoplitidae as additional elements of the fauna. These faunistic composition suggest so-called „Tethyan" affinity from paleobiogeographical point of view. The sediment itself is a light, yellow marl. In contrast, the same aged borehole assemblages of the Bakony Mts – Jásd-36 and Jásd-42 boreholes -, which are geographically now very close to the surface outcrops, show absolutely differenf faunistic record with the high dominance of Hoplitidae – *Discohoplites*, *Hyphoplites* –, and the additional occurence of *Lechites*, *Paraturrilites*, *Mariella* and *Stoliczkaia*. Paleobiogeographically, the Hoplitid dominance was interpreted as a „Boreal" feature (Birkelund et al., 1984; Horváth, 1985, 1989). The sediment is a dark grey siltstone and light grey marl.

The present, very nearby geographic position of the boreholes and surface outcrops in the Bakony Mts. with the very differenf faunistic picture, and without any sign of great tectonic movements between them suggest, besides the paleogeographic significance there should be other controlling factor.

The ammonite assemblage of Bóly-1 borehole from the Villány Mts. is documented by Bujtor (1989) and Szives & Bujtor (2007), and also indicates Late Albian age. The dark grey siltstone consist *Desmoceras, Puzosia, Tetragonites, Lechites* and *Scaphites* in great abundance and with the additional appearence of Hamitidae, *Kossmatella* and *Worthoceras*. This ammonite record suggests „Boreal" paleobiogeographical affinity, besides the well-known and documented different tectonic position (Csontos & Vörös, 2004) of the Tisza Unit.

After the taxonomic interpretation of the Hungarian Late Albian ammonite assemblages, the same aged ammonite successions from Europe were analyzed. Considering the tectonical, biogeographical and paleoecological interpretations, it is likely that the ammonite record of the surface outcrops of the Bakony Mts. indicates shallower marine environment, the borehole assemblages indicate somehow deeper neritic environment while the Villány Mts. succession suggest pelagic - deep basin environment in the Late Albian.

A microfossil correlation and geochemical studies should be done in the further work.

References

BIRKELUND, T.; HANCOCK, J.; HART, M.; RAWSON, P.; REMANE, J.; ROBASZYNSKY, F.; SCHMIDT, F.; SURLYK, F. 1984. Cretaceous stage boundaries - proposals. *Bulletin of the Geological Society of Denmark*, 33: 3-20.

BUJTOR, L. 1989. *A Villányi-hegység albai és cenomán képződményei mollusca faunájának őslénytani vizsgálata*. Szakdolgozat. ELTE Őslénytani Tanszék. [The paleontologic interpretation and evaluation of the mollusc fauna of the Villány Mts., Hungary. Masters' Thesis, ELTE Department of Paleontology]. p. 1-191, pls. 1-11.

CSONTOS, L., A. VÖRÖS 2004. Mesozoic plate tectonic reconstruction of the Carpathian region. *Palaeogeography, Palaeoclimatology, Palaeoecology* 210: 1-56.

HORVÁTH, A. 1985. Ammoniten-Stratigraphie der Pénzeskut Mergel-Formation. *Österreichische Akademie der Wissenschaften Schriftenreiche der Erdwissenschaftlichen Kommissionen.* Band 7, p. 149-170.

HORVÁTH, A. 1989. Zur Lebensweise der Ammoniten der Pénzeskut-Formation (Alb-Cenoman), Ungarn. *In*: J. Wiedmann (ed.). 1989. Cretaceous of the Western Tethys. *Proceedings of the 3rd International Cretaceous Symposium Tübingen*, 1987. p. 469-482.

SCHOLZ, G. 1979. Die Ammoniten des Vracon (Oberalb, Dispar-Zone) des Bakony-Gebirges (Westungarn) und eine revision der Wichtigstein Vracon-arten der West-Mediterranen Faunenprovinz. *Palaeontographica* Abt. A, 165, 1-136. Stuttgart.

SZIVES, O. (ed.). 2007. Aptian-Campanian ammonites of Hungary. *Geologica Hungarica series Palaeontologica* fasciculus 57. p. 1-188, Pl. 1-41, Text-figs. 1-60, Tables 1-18.

SZIVES, O., L. BUJTOR 2007. Bóly-1 borehole. *In*: O. Szives (ed.). 2007. Aptian-Campanian ammonites of Hungary. *Geologica Hungarica series Palaeontologica* fasciculus 57. p. 86-89.

Ottilia SZIVES
Hungarian Natural History Museum
Department of Palaeontology
1088 Ludovika tér 2
H-1431 Budapest
Hungary
e-mail: sziveso@nhmus.hu

ARE LOWER CRETACEOUS OCEANIC RED BEDS TRIGGERED BY COOL CLIMATE?

Michael **WAGREICH**

Cretaceous oceanic red beds (CORBs, Hu et al., 2005) are typical deep-marine fine-grained deposits of the Late Cretaceous. Lower Cretaceous CORBs are comparable scarce, and only a few examples have been investigated so far (Hu et al., 2006). Lower Cretaceous red pelagic carbonates are present in the Northern Calcareous Alps (NCA) within a pelagic to hemipelagic succession and can be correlated to other CORBs, e.g., in Italy and Spain.

Red pelagic intervals of Early Cretaceous age are known from the Schrambach Formation and the Tannheim Formation. The Schrambach Formation comprises grey, sometimes spotty pelagic micritic limestones and marlstones. Red intervals of a few meters within the dominantly grey succession (Anzenbach Member) form a distinct stratigraphic level of red marls southeast of Salzburg, where a Late Berriasian to early Valanginian age has been proven.

Aptian/Albian *Hedbergella*-limestones mark the base of the Tannheim Formation at the boundary between pelagic micrites and overlying marls. These dark red limestones (foraminiferal packstones) constitute a condensed facies extremely rich in planktonic foraminifera of the genus *Hedbergella* and grade into red marlstones. A late Aptian to early Albian age can be confirmed by planktonic foraminifera and strontium isotope stratigraphy.

Remarkably, these two red intervals coincide with the times of cool climate and suspected icehouse conditions for the Early Cretaceous. Both the (late Berriasian to) Early Valanginian and the Late Aptian/Early Albian are times of maximum glendonite and dropstone occurrences and times of relatively low ocean temperatures. This indicates a possible causal link of cool climate interludes with more widespread oxic bottom conditions at least in the Tethys region. Brief cooling periods may have resulted in increased production of oxygen-rich bottom waters and led to oxidation of bottom sediments. Longer term sea-level lowstands as recognized in the Valanginian and Late Aptian may also support this hypothesis and indicate the presence of minor polar ice.

References

HU, X., JANSA, L., WANG, C., SARTI, M., BAK, K., WAGREICH, M., MICHALIK, J., SOTÁK, J. 2005. *Cretaceous Research*, v. 26, p. 3-20.

HU, X., JANSA, L., SARTI, M. 2006. *Palaeogeography, Palaeoclimatology, Palaeoecology*, v. 233, p. 163– 186.

Michael WAGREICH
Department for Geological Sciences
University Vienna
Althanstrasse 14
A-1090 Vienna
e-mail: michael.wagreich@univie.ac.at

EARLY CRETACEOUS CARBON ISOTOPE STRATIGRAPHY: PROBLEMS AND QUESTIONS

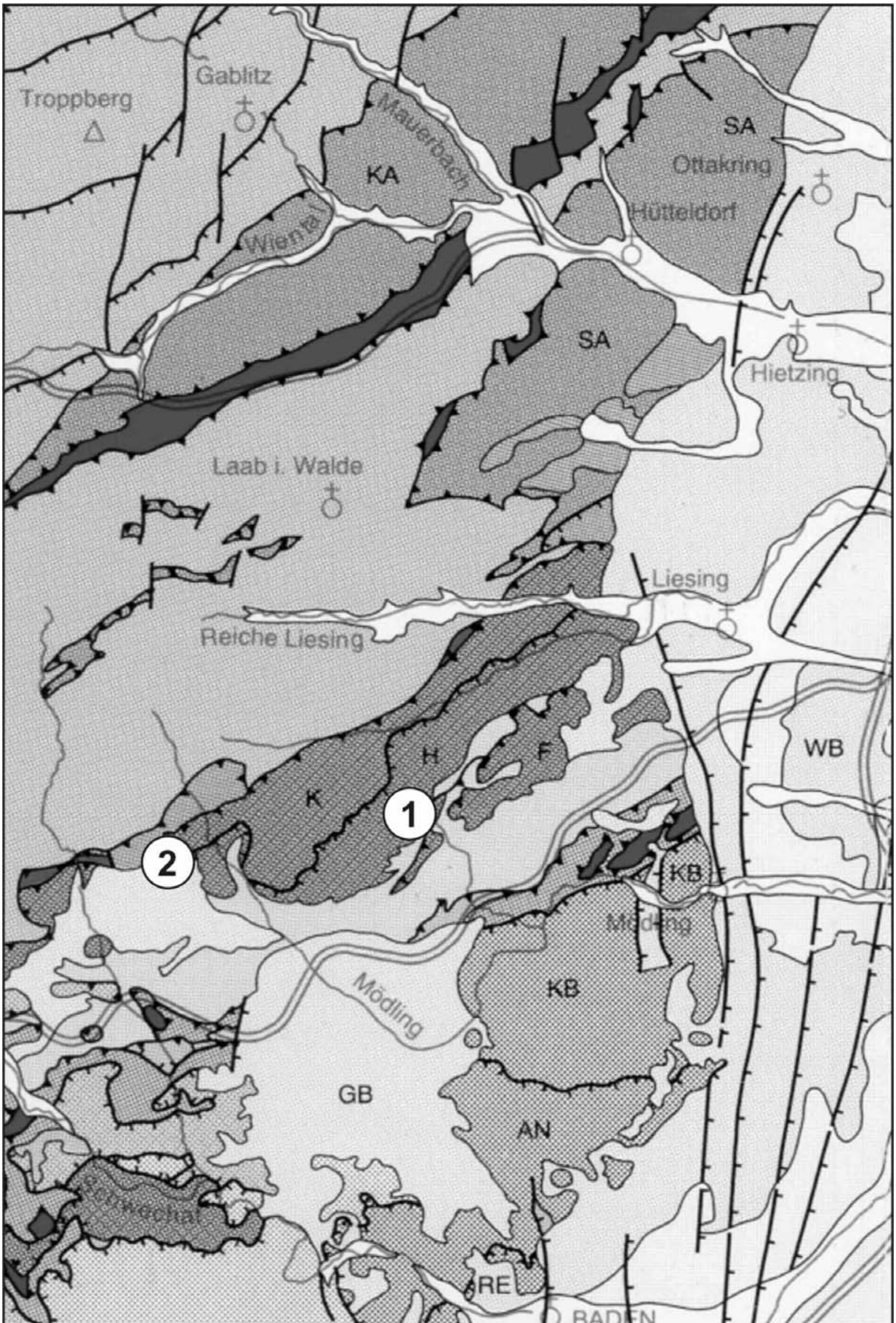
Helmut **WEISSERT**

Chemostratigraphy uses chemical fingerprints stored in sediments and sedimentary rocks for stratigraphic correlation. Stable isotope signatures fixed in sedimentary inorganic and organic matter are among the most powerful methods used in chemostratigraphy. Early Cretaceous carbon isotope stratigraphy established in pelagic limestone successions form the Southern Alps (N. Italy) is often used as an informal reference curve. With carbon isotope stratigraphy established in ammonite-dated hemipelagic sediments from the Vocontian Trough (S. France) a tool is available for correlation of ammonite biozones with magnetostratigraphy. The beginning of the Valanginian carbon isotope excursion starts in *campylotoxus* ammonite zone Ct4, and the boundary between *campylotoxus* and *verrucosum* zones falls into magnetozone CM11. This correlation differs by about one magnetozone form other published correlations. The Barremian-Aptian carbon-isotope stratigraphy from the Vocontian Trough differs in absolute values and in the excursion pattern from the carbon-isotope stratigraphy established at the locality Cismon (S. Alps, N. Italy). Differences can be explained with sedimentary gaps in studied sections and with differences in oceanography and depositional conditions.

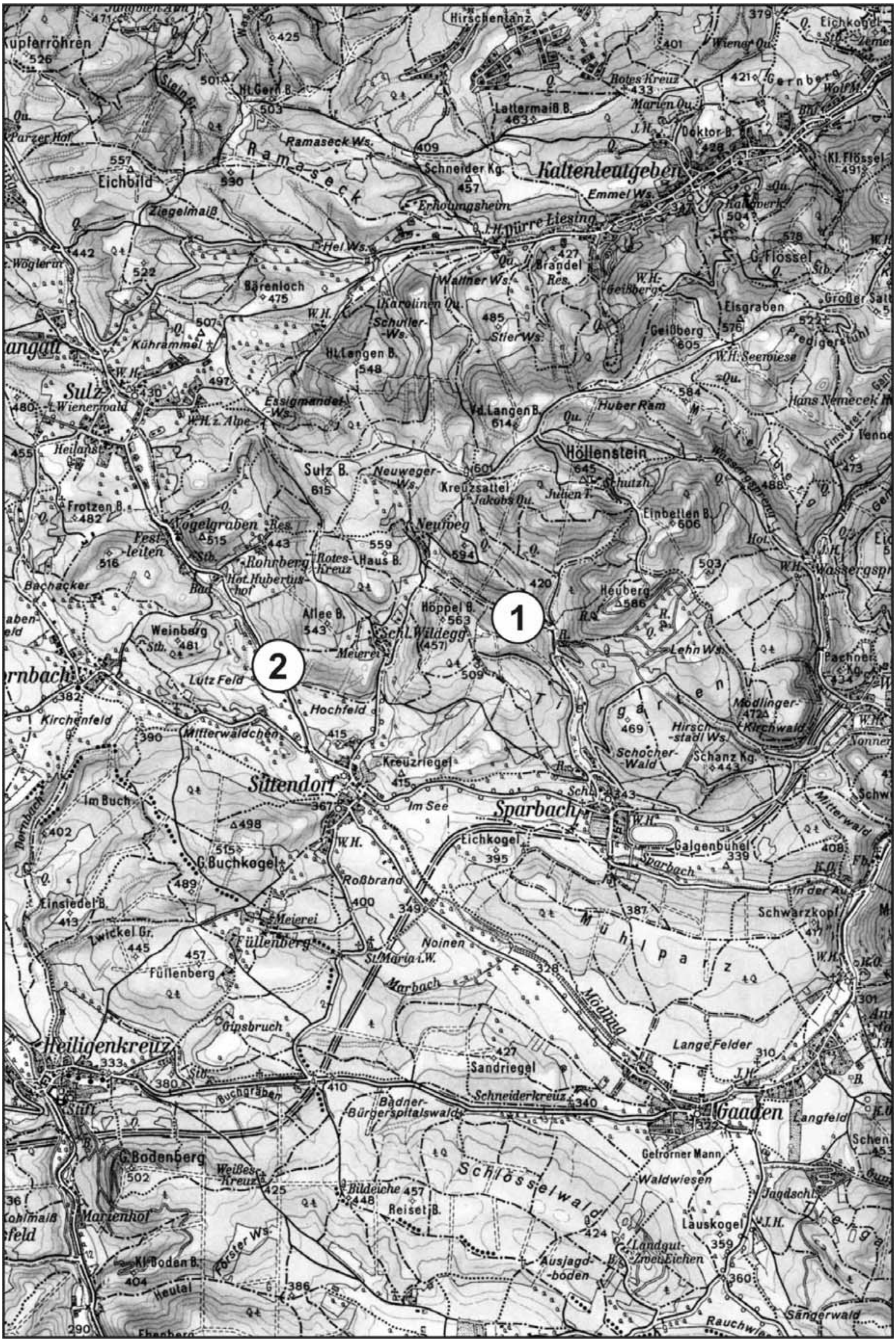
Helmut **WEISSERT**
D-ERDW, ETH-Zürich
CH-8092 Zürich
Switzerland
e-mail: helmut.weissert@erdw.ethz.ch

FIELD TRIP

Friday, 18. April, 2008



Texctonic map of field trip rout in the Vienna Woods



Topographic map of fiel trip route in the Vienna Woods

FIELD TRIP

Friday, 18. April, 2007

Excursion to Lower Cretaceous sites.

Stop 1. Hauterivian to Barremian limestones near Sparbach in the Vienna Woods (Valanginian-Barremian limestones in a wild-pig-park).

Stop 2. Aptian limestones and marls near Sittendorf in the Vienna Woods (Aptian Schrambach- and Thannheim Formation; foraminifera limestone).

STOP 1. SPARBACH (SCHRAMBACH FORMATION; VALANIGINIAN TO BARREMIAN)

An equivalent of the Early Cretaceous **Karsteniceras** *Level within the Vienna Woods (Sparbach section, Lunz Nappe, Northern Calcareous Alps, Lower Austria)*

Compendium from Alexander LUKENEDER (2005)

Abstract: Detailed palaeontological and lithological studies of Lower Cretaceous sediments from the Northern Calcareous Alps in Lower Austria uncovered spectra of Lower Barremian macrofaunal elements (e.g. ammonoids). Within the Sparbach section, these investigations also uncovered an equivalent of the *Karsteniceras* Level, which is characterized by the abundance of *Karsteniceras ternbergense* Lukeneder and was initially described 150 km away in the Ternberg Nappe. Striking similarities in faunal spectra, lithology and geochemistry between these two laterally correlated occurrences are reported.

The newly detected ammonoid mass-occurrence (Sparbach section) dominated by *Karsteniceras ternbergense* is of Early Barremian age (*Coronites darsi* Zone). About 250 specimens of *K. ternbergense* between 7 and 29 mm in diameter were investigated. The geochemical results indicate that the *Karsteniceras* mass-occurrence within this Lower Cretaceous succession was deposited under intermittent oxygen-depleted conditions. Due to the additional finding of the *Karsteniceras* Level at Sparbach, the formerly described *Karsteniceras* Level (KB1-B section, Upper Austria) takes on the status of a more widespread, laterally, biostratigraphically significant 'horizon', at least for the Northern Calcareous Alps. Its potential status as a stratigraphic horizon and its potential for correlation is underlines by its broad geographic range. The cephalopod fauna at the outcrop belongs exclusively to the Mediterranean Province.

Introduction

The discovery of a Lower Cretaceous cephalopod mass-occurrence in the Losenstein Syncline (KB1-B section, Ternberg Nappe, Northern Calcareous Alps, Upper Austria), of Early Barremian age, was recently published by Lukeneder (2003b). A *Karsteniceras* mass-occurrence in two beds only 150 mm thick was reported in the latter paper. An invasion of an opportunistic (r-strategist) *Karsteniceras* biocoenosis during unfavourable conditions over the sea-bed during the Early Barremian was proposed for the KB1-B section. As noted by Lukeneder (2003b), the deposition of the limestones in this interval occurred in an unstable environment and was controlled by short- and long-term fluctuations in oxygen levels. The author therefore assumed that *Karsteniceras* inhabited areas of stagnant water with low dissolved oxygen.

Such 'ammonoid beds' are the result of bio-events often manifested by an abundance or mass-occurrence of ammonoids. The *Karsteniceras* Level described herein is also observable some 150 km west in the Ternberg Nappe. This indicates that both mass-occurrences were formed by the same bio-event and that the former is therefore an equivalent of the Upper Austrian occurrence. The present paper argues for the lateral correlation of such ammonoid mass-occurrences and for the establishment of ammonoid abundance zones in stratigraphic correlations within the Northern Calcareous Alps.

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; Fig. 1). This outcrop is located in the south-easternmost part of the northeast-southwest striking Flössel Syncline, running between the Höppelberg (700 m) to the west and near the Heuberg (680 m) to the east. It lies at the southern side of the Sparbach stream, 300 m west of the Johannstein ruin within the nature park of Sparbach. The exact position of the ammonoid-occurrence was determined by GPS (global positioning system): N 48°05'15'' and E 16°11'00'' (Fig. 2).

The fossiliferous beds are part of the Schrambach Formation within the Flössel Syncline. The general tectonic style is that of steep synclines and anticlines (e.g., Höllenstein Anticline, Flössel Syncline) (see Toula 1886; Richarz 1905, 1908; Spitz 1910; Schwinghammer 1975). The Flössel Syncline is formed of Upper Triassic dolomite, followed by a reduced Jurassic sequence (see also Rosenberg 1965; Plöchinger & Prey 1993). The core of the Flössel Syncline consists of the Lower Cretaceous Schrambach Formation, which occurs throughout the Northern Calcareous Alps. Within the Lunz Nappe the Schrambach Formation comprises Upper Valanginian to Lower Barremian sediments.

Material and ammonoid fauna

Bed-by-bed collecting and a systematic-taxonomic study provide the basic data for statistical analysis of the investigated ammonite 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.

Carefully selected and washed samples of distinct laminated limestones contain primarily fine silt-sized, angular quartz grains, some pyrite and phosphatic material (fish scales, teeth and bones, ichthyoliths). The rare, generally poorly preserved micro-invertebrate fauna consists of a few arenaceous foraminifera (planktonic), radiolarians, ostracods, and sponge spicules (investigated in thin sections).

The macrofauna from bed K1 (beds 1-2; samples 1a-2c) and K2 (bed A; sample Aa) (Figs. 3 and 4) is predominated by sculpture-moulds of cephalopods. The poorly preserved limonitic ammonite moulds are accompanied by a single lamellaptychus-like ammonoid jaw.

Six genera of Ammonitina and Ancyloceratina (suborders), comprising 3 different species, are reported in this paper. The cephalopod fauna at the outcrop covers exclusively forms of the Mediterranean Province, which are typical for the Northern Calcareous Alps. The cephalopods can be found in the whole sequence but seem to be concentrated at a certain level.

About 250 specimens of *Karsteniceras ternbergense* between 7 and 29 mm in diameter were investigated (122 specimens were measured). Most of the specimens are observable on one side only; they are entire and show no fragmentation. Juvenile stages and the ventral area can be observed in just a few specimens. The very abundant small heteromorphs are generally poorly preserved. Their casts (sculpture moulds), with perfectly preserved sculpture, are usually pyritized. The current paper follows the classification of the Cretaceous Ammonoidea summarized by Wright et al. (1996).

The *Karsteniceras* Level at Sparbach yields important ammonoid taxa such as *Eulytoceras* sp., *Barremites (Barremites)* cf. *difficilis* (d'Orbigny 1841), *Pulchellia* sp., *Holcodiscus* sp., *Anahamulina* cf. *subcincta* (Uhlig 1883) and *Karsteniceras ternbergense* Lukeneder (in Lukeneder & Tanabe 2002). The cephalopod fauna is accompanied by aptychi (*Lamellaptychus*) and bivalves (*Propeamusium*) (Figs. 5 and 6).

The analysis of the fauna supports the interpretation of a soft to level bottom palaeoenvironment with a cephalopod-dominated community living near the epicontinental (epeiric) sea floor.

Lithology of the *Karsteniceras* Level

The Lower Cretaceous Schrambach Formation is a sequence of deep-water limestones and marls marked by rhythmically intercalated turbiditic sandstones, sedimented under relatively deep-water conditions. A short-term sedimentation is proposed for the sandstone layers, whereas the limestone- and marl-beds reflect 'normal' sedimentation rates.

Dark marls and grey, spotted limestones are highly bioturbated biogenic mudstones to wackestones. The occurrence of chrome spinel supports the correlation with the turbiditic intercalations in the Schrambach Formation of the Reichraming Nappe (Upper Austria), a western equivalent of the Lunz Nappe, and supports the interpretation that the sandstone intercalations are derived from a more southerly situated land-swell (Vašíček et al. 1994).

The calcium carbonate contents within the *Karsteniceras* Level (K1 and K2; Fig. 4) ($CaCO_3$ 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. 7).

The distinct-laminated appearance of the rock is a result of wispy, discontinuous, flaser-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 radiolaria now replaced by microcrystalline chalcedony.

Biostratigraphy: The *Karsteniceras* 'Abundance Zone'

An abundance zone is a stratum or rock-body in which the abundance of a particular taxon or specified group of taxa is significantly greater than is usual in the adjacent parts of the section (Salvador 1994). Its boundaries consist of biohorizons and the name is given by the abundant taxon or taxa. Biohorizons are for example characterized by a sharp and significant biostratigraphic change within the fossil assemblage and/or a change in the frequency of its members (see Salvador 1994; Steininger & Piller 1999). Such biohorizons are of great importance for lateral correlation (see Lukeneder 2003a).

The presence of abundance zones ('ammonoid-beds'; characterized by abundance or mass-occurrence of ammonoids) seems to be related with sea-level rises or falls (see also Hoedemaeker 1994; Aguirre-Urreta & Rawson 1998, 1999). Abundance of ammonoids generally occurs in condensed parts of sediment successions. Condensation occurs at the maximum flooding levels of depositional sequences (pers. comm. Hoedemaeker). These abundance zones are of exceptional value for the interregional correlation in the Early Cretaceous. For a review of such Lower Cretaceous 'uniformity-beds' formed by a monotonous ammonoid assemblage over at least a single bed up to a few metres thickness see Lukeneder (2003a).

At the Sparbach section, the following ammonoid abundance zone (characterized by abundance or mass-occurrence of ammonoids) was detected. The names of the separated beds reflect the dominating genus or species (Fig. 3).

Karsteniceras-abundance zone (Early Barremian), at metre 160, 0.3 m thickness, dark grey, distinctly laminated, marly limestones, dipping 320/40°, dominated by the occurrence of *Karsteniceras ternbergense* (Fig. 6).

The ammonoid association indicates that the cephalopod-bearing beds in the Schrambach Formation belong to the latest Early Barremian (e.g. *Moutoniceras moutonianum* ammonoid Zone; according to the results of the Vienna meeting of the Lower Cretaceous Ammonite Working Group of the IUGS; Hoedemaeker & Rawson 2000; see also Lukeneder 2001) (Fig. 8). The *M. moutonianum* Zone was recently replaced (according to the results of the Lyon meeting of the Lower Cretaceous Ammonite Working Group of the IUGS) by the *Coronites darsi* Zone (Hoedemaeker et al. 2003) (Fig. 8). Due of its noticeable similarities with the KB1-B occurrence (*Karsteniceras Level*; Lukeneder 2003b), although *Moutoniceras moutonianum* and *Coronites darsi* are missing, the typical association hints to the latest Early Barremian

Sparbach versus KB1-B: differences and affinities

Remarkable similarities between the Sparbach (Lower Austria) and the KB1-B setion (Upper Austria) are observable in age, fabric, lithology, thin sections and faunal spectra.

The number and thickness of abundance beds can be correlated precisely over a distance of more than 150 kilometers.

One of the few apparent differences lies in the geochemical results. The sulphur and TOC contents within beds of the *Karsteniceras* Level at Sparbach are considerably lower than in corresponding beds of the equivalent at the KB1-B section (see list below); this yields brighter colors of the sediments at the Sparbach locality.

<u>Sparbach</u>

Age: Early Barremian, *Coronites darsi* Zone
Thickness: 2 beds a 0.15 m
Colour: light grey
Fabric: indistinctly laminated
Lithology: marly limestones
Geochemistry:
CaCO$_3$ varies between 73 and 83%.
TOC varies between 0.03 and 0.52%.
Sulphur 0.27 to 0.57%
Environment: (less) dysoxic
Dipping: 320/40°
Cephalopod fauna: *Eulytoceas* sp., *Barremites (Barremites) difficilis*, *Pulchellia* sp., *Holcodiscus* sp., *Anahamulina* cf. *subcincta*, *Karsteniceras ternbergense*.
Specimens of Karsteniceras: n = 250

<u>KB1-B</u>

Age: Early Barremian, *Coronites darsi* Zone
Thickness: 2 beds a 0.15m
Colour: dark grey to black
Fabric: indistinctly laminated
Lithology: marly limestones
Geochemistry:
CaCO$_3$ varies between 66 and 80%
TOC varies between 1.6 and 4.6%.
Sulphur 0.33 to 1.4%
Environment: dysoxic
Dipping: 080/70°
Cephalopod fauna: *Phylloceras* sp., *Eulytoceras* cf. *phestum*, *Holcodiscus* sp., *Barremites* cf. *difficilis*, *Pseudohaploceras* sp., *Pulchellia* sp., *Moutoniceras moutonianum*, *Karsteniceras ternbergense*,
aptychi (*in situ* in *Karsteniceras*) and *Rhynchoteuthis* sp.
Specimens of Karsteniceras: n = 326

(7-29 mm)

Benthic forms: *Propeamusium*

Thin section: Laminated radiolarian wackestone calcified radiolarians, sponge spicules, aptychi, ostracods, crinoids, roveacrinids, rhyncholite fragments, *Colomisphaera heliosphaera* (Vogler), *Spirillina* sp.

(5-37 mm)

Benthic forms: *Inoceramus*

Thin section: Laminated radiolarian wackestone, calcified radiolarians, sponge spicules, aptychi, ostracods, crinoids

Results and conclusions

The macrofauna of the Lower Cretaceous beds in the Sparbach succession (Flössel Syncline), as already stated, is represented especially by ammonoids, aptychi and bivalves. The frequency of one ammonoid species (*Karsteniceras ternbergense*) and the typical composition of the cephalopod assemblage makes this section especially suited for an accurate study of the vertical ammonoid distribution. In the whole section, a total of 270 ammonoids were found. About 250 specimens of *Karsteniceras ternbergense* between 7 mm and 29 mm in diameter were investigated. Juveniles and adults could be separated. The limonitic ammonoid moulds are restricted to the distinctly laminated beds. Due to the bad preservation (limonitic steinkerns) of the ammonoids and the lithologic character of the Schrambach Formation, they are difficult to collect. Nevertheless, one ammonoid zone defined by Hoedemaeker et al. (2003) can be recognized. The stratigraphic investigation of the ammonoid fauna revealed that the Sparbach section comprises Lower Barremian sediments. Whether the Valanginian to Hauterivian are represented at the Sparbach section remains unclear due to the bad outcrop-situation along the rest of the sequence and are correlated moreover under the appliance of the characteristic sediments and their lithology. The Early Cretaceous of the Flössel Syncline is considered to range from the Late Valanginian to the Early Barremian. The stratigraphy within this paper follows the compiled reference stratigraphy papers by Hoedemaeker & Rawson (2000), but basically adheres to Hoedemaeker et al. (2003). Only ammonoid species of Mediterranean character were observed at the Sparbach section.

Due to the additional finding of the *Karsteniceras* Level at Sparbach, the *Karsteniceras* Level (KB1-B section, Upper Austria) proposed by Lukeneder (2003b) currently has the status of a more widespread, laterally, biostratigraphically significant 'horizon', at least for the Northern Calcareous Alps. Its potential status as a stratigraphic horizon and its potential for correlation is manifested due to its extension over a wide geographical area (approx. 180 km).

The geochemical results indicate that the assemblage was deposited under conditions of intermittent oxygen-depletion associated with stable water masses. The accumulation of the sediments of the *Karsteniceras* Level was promoted by a highly dynamic environment 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 assumed for the KB1-B sequence. No evidences for condensationan can be found.

Based on the described features from the Sparbach section, the KB1-A and literature data, *Karsteniceras* probably had an opportunistic (r-strategist) mode of life and was adapted to dysaerobic seawater (Lukeneder 2003b). *Karsteniceras* probably inhabited areas of water stagnation with low dissolved oxygen; it showing abundance peaks during times of oxygen depletion, which hindered other invertebrates from colonising such environments.

The evidence for an oxygen-depleted formation of this mass-occurrence needs to be supplemented by additional analysis of the micropalaeontological record (e.g. benthic foraminifera, nannofossils) and further investigations on the organic carbon material (e.g. type and producers).

The present paper is a further step in correlating abundance zones (layers of ammonoid mass-occurrences) in Lower Cretaceous sediments within the Northern Calcareous Alps. Most of the ammonoids found at the Sparbach section were apparently abundant or accumulated in the following bed over the whole eastern part of the Northern Calcareous Alps: *Karsteniceras* Level (*Karsteniceras*-abundance Zone).

Future work on these ammonoid abundance zones and biohorizons within the above-described framework will concentrate on the palaeoecological, palaeobiogeographical and biostratigraphic development of Lower Cretaceous ammonoid-beds within the Northern Calcareous Alps.

References

Aguirre-Urreta, M.B. & Rawson, P.F., 1998: The early Cretaceous (Valanginian) ammonite *Chacantuceras* gen. nov. - a link between the Neuquén and austral basins. *Rev. Asoc. Geol. Argentina* 53 (3), 354-364.

Aguirre-Urreta, M.B. & Rawson, P.F., 1999: Lower Cretaceous ammonites from the Neuquén Basin, Argentina: *Viluceras*, a new Valanginian subgenus of *Olcostephanus*. *Cretac. Research* 20, 343-357.

Faupl P., Vašíček Z., Michalik J. & Rehaková D. 1994: Stratigraphische Daten zur Unterkreide der Lunzer und Reichraminger Decke (Östliche Kalkalpen, Ober- und Niederösterreich). *Jb. Geol. B.-A.* **137**, 407-412.

Hoedemaeker, P.H. 1994: Ammonite distribution around the Hauterivian-Barremian boundary along the Río Argos (Caravaca, SE Spain). In: Bulot, L., Argot, M. & Arnaud, H. (Eds.): Lower Cretaceous Cephalopod Biostratigraphy of the Western Tethys: Recent Developments, Regional Synthesis and Outstanding Problems. *Géol. Alpine* 20, 219-277.

Hoedemaeker, P.J. & Rawson, P.F., 2000: Report on the 5th International Workshop of the Lower Cretaceous Cephalopod Team (Vienna, 5 September 2000; Lukeneder, A. (org.). *Cretac. Research* 21, 857-860, London.

Hoedemaeker, P.J., Reboulet, St., Aguirre-Urreta, M., Alsen, P., Aoutem, M., Atrops, F., Barrangua R., Company, M., Gonzales, C., Klein, J., Lukeneder, A., Ploch, I., Raisossadat, N., Rawson, P.F., Ropolo, P., Vašíček, Z., Vermeulen, J. and Wippich, M., 2003. Report on the 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group, the 'Kilian Group' (Lyon 2002). *Cretac. Research* 24, 89-94.

Immel, H., 1987: Die Kreideammoniten der Nördlichen Kalkalpen. *Zitteliana* 15, 3-163.

Lukeneder, A., 1998. Zur Biostratigraphie der Schrambach Formation in der Ternberger Decke (O.-Valanginium bis Aptium des Tiefbajuvarikums-Oberösterreich). *Geol. Paläont. Mitteil. Innsbruck* 23, 127-128.

Lukeneder, A., 1999: Excursion-guide to the Lower Cretaceous sequence of the Flösselberg Syncline (Lower Austria). 5th International Symposium "Cephalopods - Present and Past", 17 p., Wien.

Lukeneder, A., 2001: Palaeoecological and palaeooceanographical significance of two ammonite mass-occurrences in the Alpine Early Cretaceous. *PhD-Thesis*, Univ. Vienna, 1-316.

Lukeneder, A. 2003a. Ammonoid stratigraphy of Lower Cretaceous successions within the Vienna Woods (Kaltenleutgeben section, Lunz Nappe, Northern Calcareous Alps, Lower Austria). In: Piller W.E. (Ed.): *Stratigraphia Austriaca. Austrian Acad. of Sci. Series*, *"Schriftenreihe der Erdwissenschaftlichen Kommissionen"* 16, Vienna, 165-191.

Lukeneder, A. 2003b: The *Karsteniceras* Level: Dysoxic ammonoid beds within the Early Cretaceous (Barremian, Northern Calcareous Alps, Austria). *Facies* 49, 87-100.

Lukeneder, A. & Tanabe, K. 2002: In situ finds of aptychi in the Barremian of the Alpine Lower Cretaceous (Barremian, Northern Calcareous Alps, Upper Austria). *Cretac. Research* 23, 15-24.

Plöchinger, B. & Prey, S. 1993: Der Wienerwald. *Sammlung geol. Führer* 59, Berlin-Stuttgart, 1- 168.

Richarz, P.S. 1905: Die Neokombildungen bei Kaltenleutgeben. *Jb. Geol. R. -A.* 54, 343-358.

Richarz, P.S. 1908: Ein neuer Beitrag zu den Neokombildungen bei Kaltenleutgeben. *Verh. Geol. R. -A.* 1908, 312-320.

Rieber, H. 1977: Eine Ammonitenfauna aus der oberen Maiolica der Breggia-Schlucht (Tessin/Schweiz). *Ecl. geol. Helv.* 70/3, 777-787.

Rosenberg, G. 1965: Der kalkalpine Wienerwald von Kaltenleutgeben (NÖ und Wien). *Jb. Geol. B. -A.* 108: 115-153.

Salvador, A. 1994: International stratigraphic guide - A guide to stratigraphic classification, terminology and procedure. *Union Geol. Sci. and Geol. Soc. Amer. Inc.*, Boulder, Colorado, 1-214.

Schwinghammer, R. 1975: Stratigraphie und Fauna des Neokoms von Kaltenleutgeben, NÖ. - *Sitzber. Österr. Akad. Wiss., math.-naturw. Kl., Abt.* 1/183, 149-158.

Spitz, A. 1910: Der Höllensteinzug bei Wien. *Mitt. Geol. Ges. Wien* 3, 315-434.

Steininger, F.F. & Piller, W.E. 1999: Empfehlungen (Richtlinien) zur Handhabung der stratigraphischen Nomenklatur. *Cour. Forsch.-Inst. Senckenberg* 209, 1-19.

Toula, F., 1886: Mittelneokom am Nordabhange des Großen Flösselberges bei Kaltenleutgeben. *Verh. Geol. R. -A.* 1886, 189-190.

Vašíček, Z. & Faupl, P. 1998: Late Valanginian cephalopods in relation to the palaeogeographic position of the Rossfeld and Schrambach Formation of the Reichraming Nappe (Northern Calcareous Alps, Upper Austria). *Zbl. Geol. Paläont.* (Teil 1) 11/12, 1421-1432.

Vašíček, Z. & Klajmon, P. 1998: Contribution to the knowledge of some small Early Barremian ammonites from Silesian Unit (Outer Carpathians, Czech republic). Věst. Čes. Geol. Úst. 73, 331-342.

Vašíček, Z, Michalík, J., Reháková, D. & Faupl, P. 1994: Stratigraphische Daten zur Unterkreide der Lunzer und Reichraminger Decke (Östliche Kalkalpen, Ober- und Niederösterreich). *Jb. Geol. B.-A.* 137: 407-412.

Vašíček, Z. & Wiedmann, J. 1994: The Leptoceratoidinae: small heteromorph ammonites from the Barremian. *Palaeontology* 37, 203-239.

Wright, C.W., Calloman, J.H. & Howarth, M.K. 1996: Treatise on invertebrate paleontology, Part L, Mollusca 4 revised (Cretaceous Ammonoidea). *Geol. Soc. of Amer., Boulder and University of Kansas Press*, Lawrence, 1-362.

Captions

Fig. 1. Sketch map of the excavation site N of Sparbach. The Upper Austroalpine Northern Calcareous Alps extend from the Austrian western border to the city area of Vienna. The white square indicates the geological area of the sketch map below.
Sketch map of the NE spur of the Northern Calcareous Alps. WB – Vienna Basin, GB – Gaadener Basin; Flysch Zone: KA – Kahlenberg Ridge, SA – Satzberg Ridge; Frankenfels - Lunz Nappe System: K – Kalksburger Unit, H – Höllenstein Unit, F – Föhrenberg Wasserspreng Unit; Ötscher Nappe System: KB – Kalenderberg Scale, AN – Anninger Scale, RE – Rauheneck Scale
(scale 1:400 000). Map after ÖK 1:50 000, sheet 58 Baden, Geological Survey Vienna, 1997). White square indicates the area of sketch map Fig. 2.

Fig. 2. Geological situation and sediments of the Flössel Syncline with indicated position of the Sparbach locality.

Fig. 3. The locality with indicated position of the *Karsteniceras* Level (K 1 - K 2). On the right side, two longitudinal scans of the polished surface of the beds 0-2c from the abundance beds. Note the indistinct lamination of beds 1a-2a. Beds 2b and 2c are not laminated due to bioturbation. Black arrows indicate positions of limonitic specimens of *Karsteniceras*.

Fig. 4. Fauna and position of the *Karsteniceras* Level within the log (Schrambach Formation).

Fig. 5. Ammonoid spectrum from the Sparbach locality. Note the dominance of the genus *Karsteniceras* (Ancyloceratina). Size distribution (below) of the species *Karsteniceras ternbergense*. Conventions: max. D., shell diameter; max. B., maximum breadth; WH, maximum whorl height; NW, umbilicus width; WB, whorl breadth.

Fig. 6. Early Barremian Lytoceratina, Ancyloceratina, aptychi and bivalves from the Flössel Syncline (Schrambach Formaion). Typical representatives of the Sparbach assemblage.
1 – *Eulytoceras* sp.; 2004z00/0001, x1. 2 – *Barremites (Barremites)* cf. *difficilis* (d'Orbigny 1841), 2004z00/0002, x1. 3-4 – *Pulchellia* sp., 2004z00/0003-04, x1. 5 – *Hoclodiscus* sp., 2004z0045/0005, x1. 6-15 – *Karsteniceras ternbergense* Lukeneder 2002, 2004z0045/0006-15, x1. 16 – *Anahamulina* cf. *subcincta* (Uhlig 1883), 2004z00/0016, x1. 17 – *Lamellaptychus* sp., 2004z00/0017, x4. 18 – *Prepeamusium* sp. (bivalve), 2004z00/0018, x1.
All specimens were collected at the Sparbach section, coated with ammonium chloride before photographing and are stored at the Museum of Natural History Vienna (Burgring 7, A-1014, Vienna).

Fig. 7. Geochemical parameters from the Sparbach section within and around the *Karsteniceras* Level.

Fig. 8. Stratigraphic position within the Early Barremian (*C. darsi* Zone) of the Sparbach fauna (in grey). Table modified after Hoedemaeker et al. (2003).

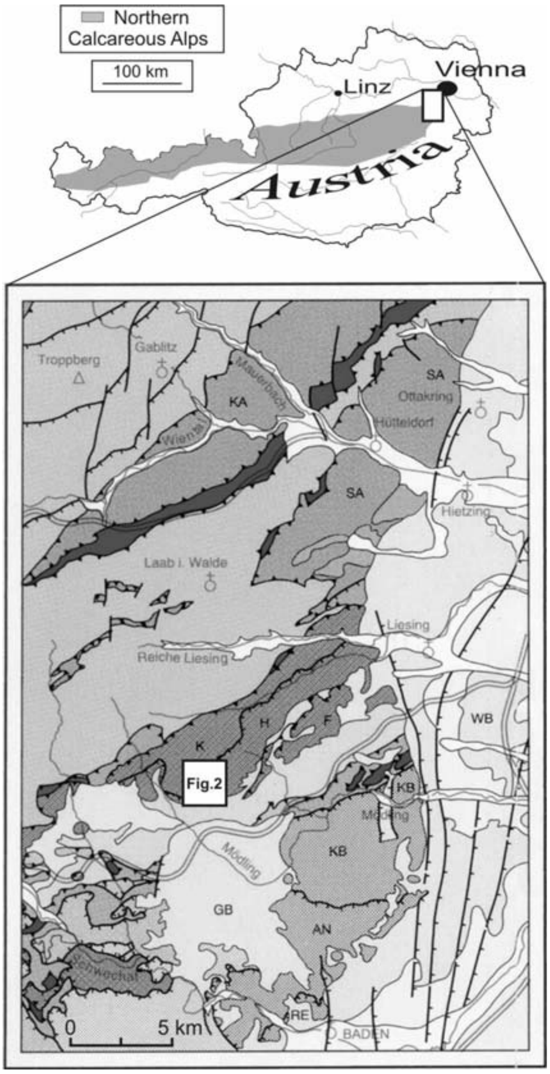


Fig. 1.

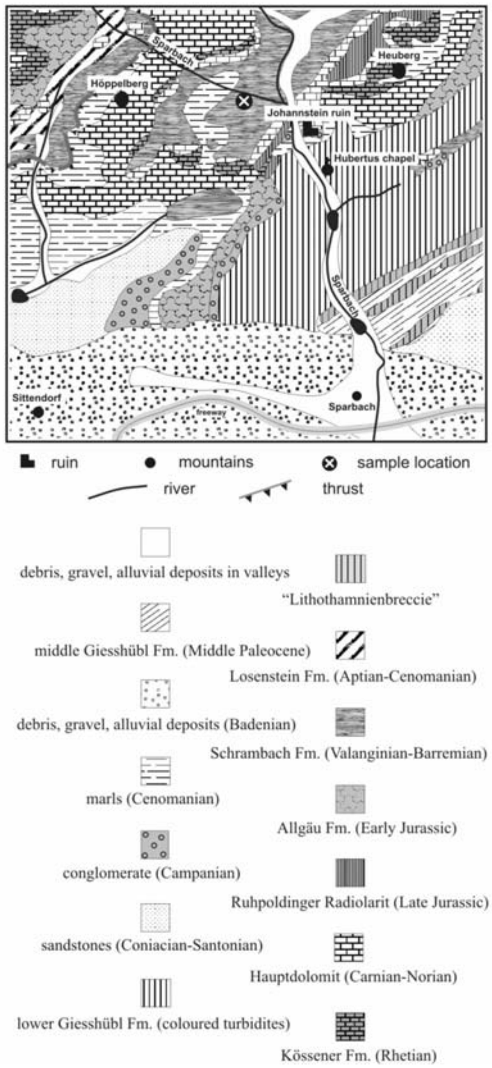


Fig. 2.

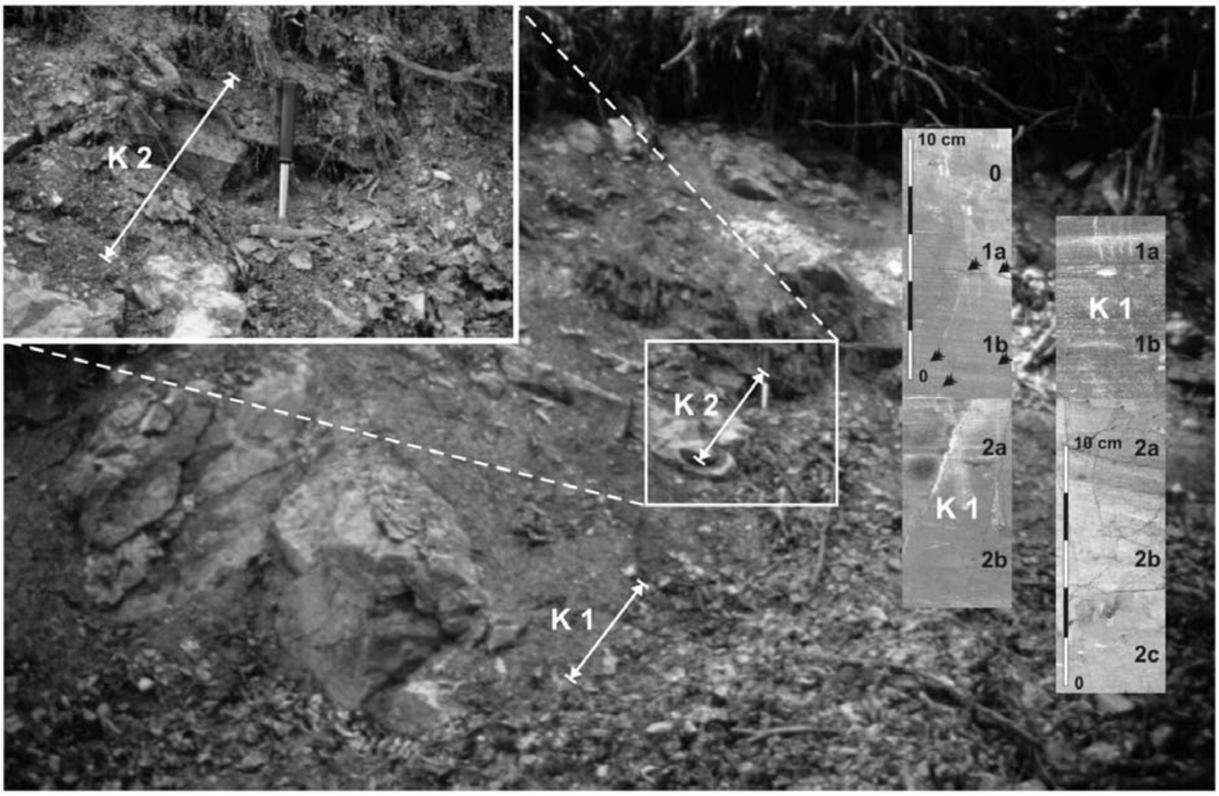

K 2
K 2
K 1
10 cm
0
1a
1b
0
K 1
2a
2b
1a
K 1
1b
10 cm
2a
2b
2c
0

Fig. 3.

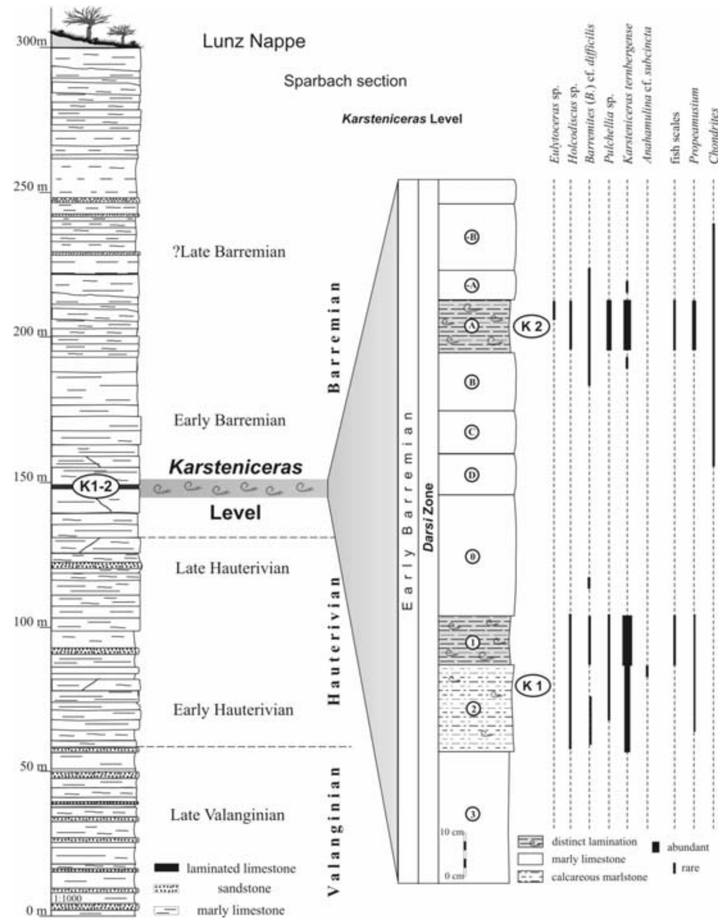

Lunz Nappe
Sparbach section
Karsteniceras Level
300m
250 m
200 m
150 m
100 m
50 m
0 m
?Late Barremian
Early Barremian
K1-2
Karsteniceras
Level
Late Hauterivian
Early Hauterivian
Late Valanginian
Barremian
Hauterivian
Valanginian
Early Barremian
Darsi Zone
Eulytoceras sp.
Holcodiscus sp.
Barremites (B.) cf. difficilis
Pulchellia sp.
Karsteniceras ternbergense
Anahamulina cf. subcincta
fish scales
Propeamusium
Chondrites
K 2
K 1
10 cm
0 cm
1:1000
laminated limestone
sandstone
marly limestone
distinct lamination
marly limestone
calcareous marlstone
abundant
rare

Fig. 4.

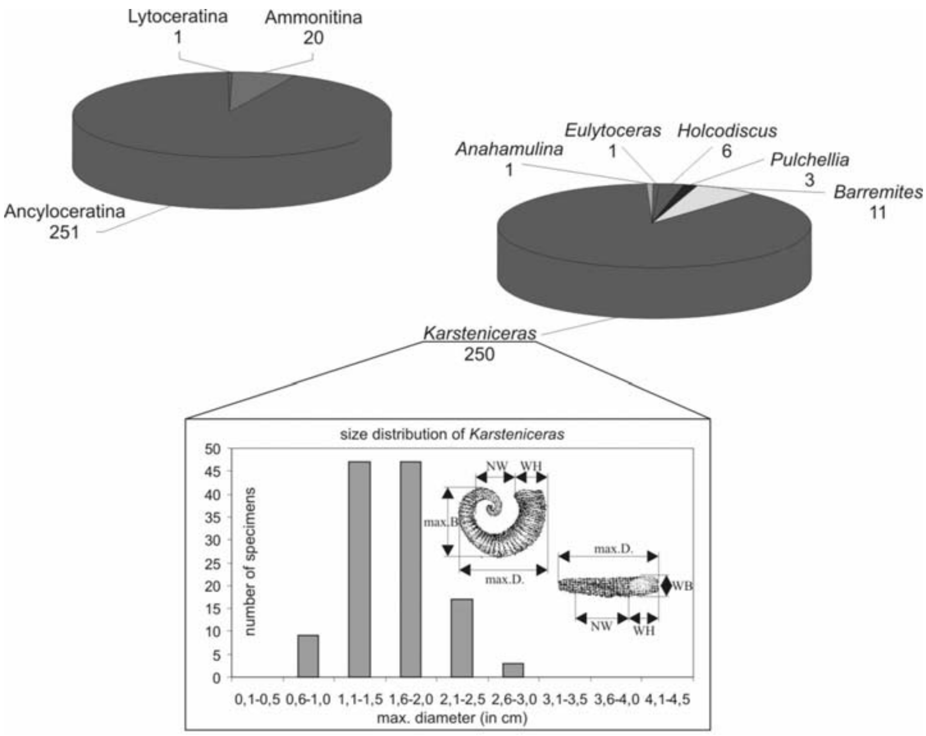

Lytoceratina
1
Ammonitina
20
Ancyloceratina
251
Anahamulina
1
Eulytoceras
1
Holcodiscus
6
Pulchellia
3
Barremites
11
Karsteniceras
250
size distribution of Karsteniceras
number of specimens
max. diameter (in cm)
0,1-0,5 0,6-1,0 1,1-1,5 1,6-2,0 2,1-2,5 2,6-3,0 3,1-3,5 3,6-4,0 4,1-4,5
NW WH
max.B
max.D.
WB

Fig. 5.

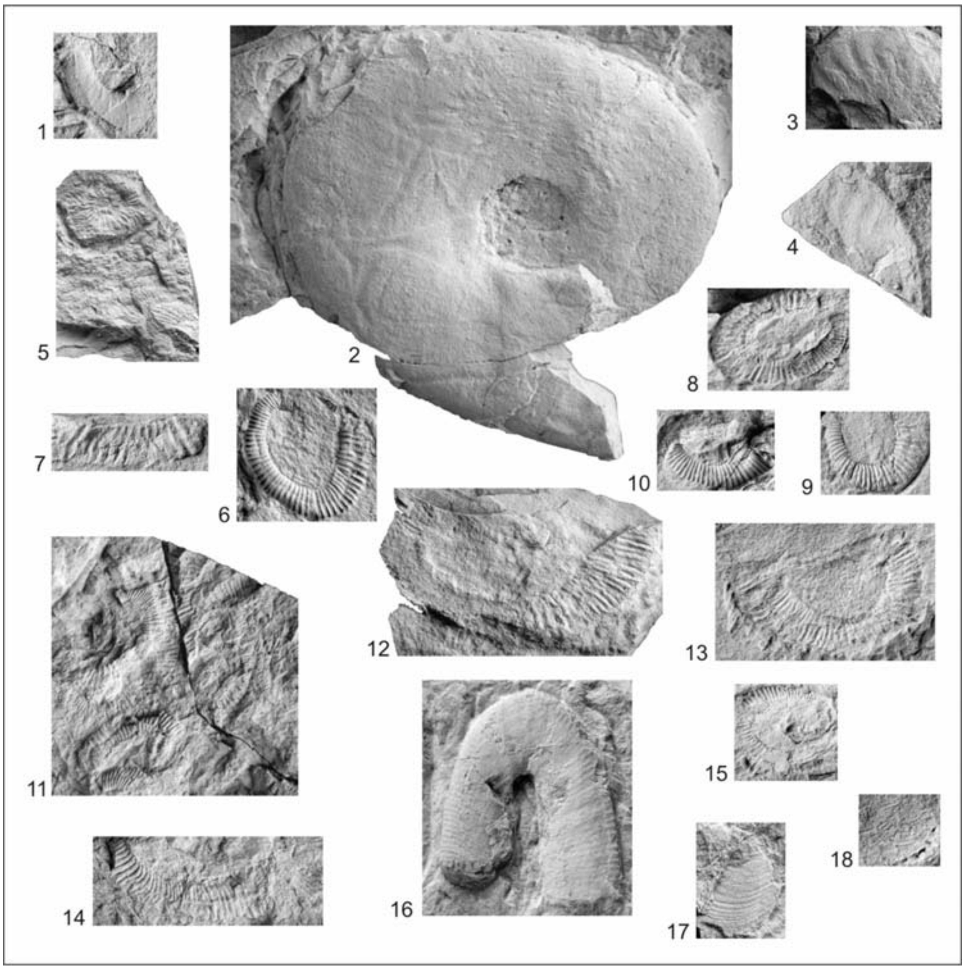

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18

Fig. 6.

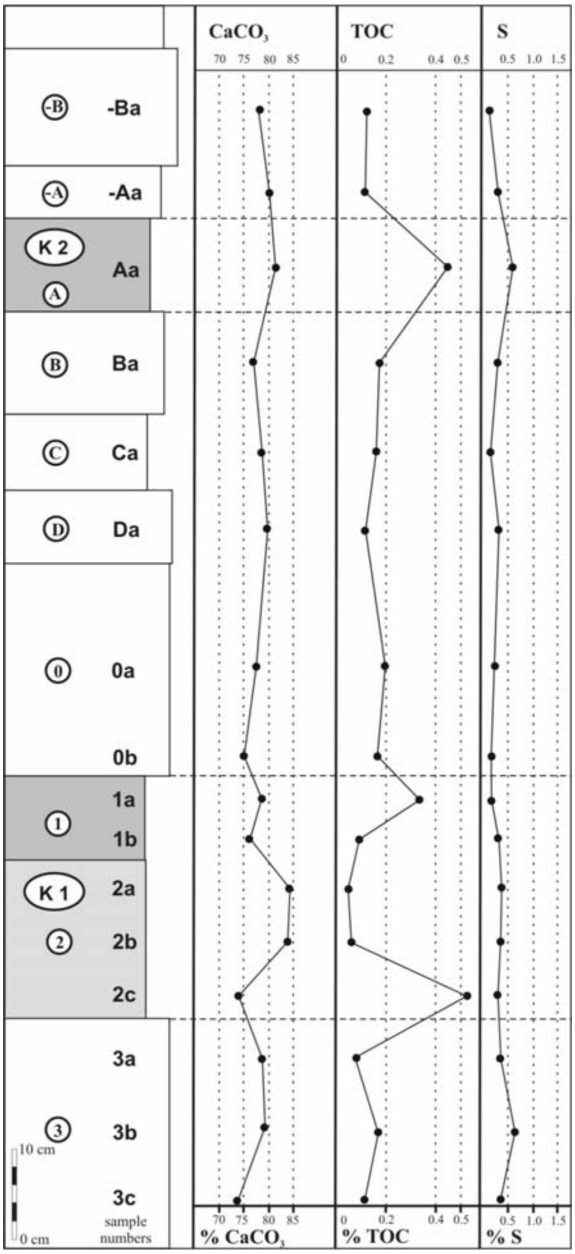


Fig. 7.

BARREMIAN	Upper	*P. waagenoides*	
		C. sarasini	
		I. giraudi	
		H. feraudianus	
		G. sartousiana	*G. provincialis*
			G. sartousiana
		A. vandenheckii	
	Lower	*C. darsi*	
		K. compressissima	
		N. pulchella	
		K. nicklesi	
		T. hugii auct.	

Fig. 8.

STOP 1. SPARBACH (SCHRAMBACH FORMATION; VALANIGINIAN TO BARREMIAN)

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

Compendium from Alexander LUKENEDER, Miroslava SMREČKOVA (2006)

Abstract: Detailed palaeontological and lithological studies of Lower Cretaceous sediments from Lower Austria uncovered spectra of Lower Barremian microfaunal elements (e.g. radiolarians). Lower Barremian radiolarians are figured for the first time from the Northern Calcareous Alps. The radiolarian assemblage from Sparbach was obtained out of marly limestone beds of the *Karsteniceras* Level. The Early Barremian level is dominated by the ammonoid *Karsteniceras ternbergense* (*Coronites darsi* Zone). The geochemical results (e.g. TOC, S, and $CaCO_3$) combined with preservational features (e.g. different pyrititization stages) of the radiolarian fauna indicate that the *Karsteniceras* Level was deposited under oxygen-depleted conditions, showing partly eutrophic peaks and producing mass occurrences of pyritized radiolarians in laminated, dark sediments.

Introduction

The Early Cretaceous of the Flössel Syncline is considered to range from the Late Valanginian to the Early Barremian (Lukeneder in press). 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 (in press). 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 section. As noted by Lukeneder (2003b), the deposition of the limestones in this interval occurred in an unstable environment and was controlled by short- and long-term fluctuations in oxygen levels.

The main focus of this paper is to give a detailed description and stratigraphy combined of the known ammonoid zonation (Lukeneder in press) correlated with new microfossil data. As preservation and radiolarian abundance reflects primary environmental conditions the described radiolarian fauna is also investigated on these patterns. It has to be noted that the radiolarian abundance and their preservation depends on many factors, e.g. fertility of sea-water surface and amount of dissolution by sinking on the sea floor and in sediment.

In systematics and stratigraphy of Lower Cretaceous radiolarian faunas (mostly Europe) we refer to the extensively and accurate papers of Bak (1999), Baumgartner (1984), Baumgartner et al. (1995), Jud (1994), O' Dogherty (1994), Schaaf (1984), Goričan (1994) and De Wever et al. (2000). Most of these papers also deal with topics of biology, ecology and taphonomy. The most detailed compendium of the Jurassic and Lower

Cretaceous radiolarian systematic framework was done by Baumgartner et al. (1995). This book is till present days state of the art.

Specific investigations on microfacies and changing environmental conditions during Upper Jurassic and Lower Cretaceous times within the Northern Calcareous Alps and adjacent areas in the Carpathians were undertaken by Boorová et al. (1999), Ondrejíčková et al. (1993), Ožvoldová (1990), Ožvoldová and Peterčáková (1992), Peterčáková (1990), Reháková (2000), Sýkora – Ožv. 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; Fig. 1; Schnabel 1997). This outcrop is located in the south-easternmost part of the northeast-southwest striking Flössel Syncline, running between the Höppelberg (700 m) to the west and near the Heuberg (680 m) to the east. It lies at the southern side of the Sparbach stream, 300 m west of the Johannstein ruin within the nature park of Sparbach. The exact position of the radiolarian-occurrence was determined by GPS (global positioning system): N 48°05'15'' and E 16°11'00'' (Fig. 1).

The fossiliferous beds (metre 160, 0.3 m thickness, dipping 320/40°) are part of the Schrambach Formation within the Flössel Syncline (see Toula 1886; Richarz 1905, 1908; Spitz 1910; Schwinghammer 1975). The Flössel Syncline is formed of Upper Triassic dolomite, followed by a reduced Jurassic sequence (see also Rosenberg 1965; Plöchinger & Prey 1993). The core of the Flössel Syncline consists of the Lower Cretaceous Schrambach Formation, which occurs throughout the Northern Calcareous Alps. Within the Lunz Nappe the Schrambach Formation comprises Upper Valanginian to Lower Barremian sediments.

Lithology

The Lower Cretaceous Schrambach Formation is a sequence of limestones and marls marked by rhythmically intercalated turbiditic sandstones, sedimented under relatively deep-water conditions (2003a). A short-term sedimentation is proposed for the sandstone layers, whereas the limestone- and marl-beds reflect 'normal' sedimentation rates. Dark marls and grey, spotted limestones are highly bioturbated biogenic mudstones to wackestones (Lukeneder in press).

The distinct-laminated appearance of the rock is a result of wispy, discontinuous, flaser-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 radiolaria 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, seldom roveacrinids, crinoid ossicles, fragments of fish fish-scales, -teeth and -bones, ichthyoliths, planktonic foraminifers (*Favusella* sp.), benthic foraminifers (*Patellina* sp.). There are also small disintegrated floral fragments distributed in matrix, framboidal pyrit, organic matter accumulated in the nests and very rare glauconite grains. Carefully selected and washed samples of distinct laminated limestones contain primarily fine silt-sized, angular quartz grains, some pyrite and phosphatic material.

The calcium carbonate contents within the radiolarian beds (K1 and K2) ($CaCO_3$ 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 study provide the basic data for statistical analysis of the investigated 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 assamblages were extracted from the marly limestone by means of dissolution in the 12% acetic acid (5 days). After sieving through 40μm screen and drying residue was prepared for picking up of specimens under the binocular microscope. Species determination was made by SEM.

The most abundant assemblage, obtained from sample 1a comprise 10 species of radiolarians, belonging to the order Nassellaria and 7 species to Spumellaria (Fig. 2). The assemblage analyzed is dominated by the species *Holocryptocanium barbui* DUMITRICA, representative of spherical cryptothoracic and cryptocephalic Nassellaria from the family *Williriedellidae*. The assemblage also includes nassellarians *Crolanium puga* (SCHAAF), *Cryptamphorella clivosa* (ALIEV), *Dibolachras tytthopora* FOREMAN, *Dictyomitra pseudoscalaris* (Tan), *Hiscocapsa asseni* (TAN), *Pseudodictyomitra lilyae* (TAN), *Sethocapsa dorysphaeroides* (NEVIANI), *Sethocapsa orca* FOREMAN, *Thanarla brouweri* (TAN) and *Xitus clava* (PARONA). Spumellarians, which are less common are represented by the species *Acaeniotyle diaphorogona* FOREMAN, *Acaeniotyle umbilicata* (RŰST), *Archaeospongoprunum patricki* JUD, *Pantanellium squinaboli* TAN, *Paronaella cf. trifoliacea* OŽVOLDOVÁ, *Suna hybum* (FOREMAN) and by the genus *Praeconosphaera* sp., which prevails among them. The radiolarians are pyritized, what is common in Lower Cretaceous literature (Ožvoldová 1990, Bak, 1995, 1996; Pessagno 1977; Thurow 1988) but not well understood till the recent paper of Bak and Sawlowicz (2000).

The macrofauna from bed K1 (beds 1-2; samples 1a-2c) and K2 (bed A; sample Aa) is predominated by sculpture-moulds of cephalopods which are described by Lukeneder (in press). The *Karsteniceras* Level at Sparbach yields important ammonoid taxa such as *Eulytoceras* sp., *Barremites (Barremites)* cf. *difficilis*, *Pulchellia* sp., *Holcodiscus* sp., *Anahamulina* cf. *subcincta* and *Karsteniceras ternbergense*. The cephalopod fauna is accompanied by aptychi (*Lamellaptychus*) and bivalves (*Propeamusium*).

The analysis of the fauna supports the interpretation of a soft to level bottom palaeoenvironment with a cephalopod-dominated community living near the epicontinental (epeiric) sea floor (Lukeneder, in press).

Biostratigraphy

The ammonoid association indicates that the cephalopod-bearing beds in the Schrambach Formation belong to the latest Early Barremian (probably to the *Moutoniceras moutonianum* 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. moutonianum* Zone was recently replaced (according to the results of 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 moutonianum* and *Coronites darsi* are missing, the typical association hints to the latest Early Barremian. The radiolarian fauna of the Schrambach Formation belong to the *Coronites darsi* Zone ammonite Zone of the latest Lower Barremian (Hoedemaeker et al. 2003; Lukeneder 2001). The biostratigraphical evaluation of radiolarian assemblages was based on the biozonation of Baumgartner et al. (1995). The composition of association represents the longer stratigraphical 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 radiolarians tests is restricted to the distinctly laminated beds. The radiolarian assemblage enfolds a stratigraphical range from Early Hauterivian - earliest Late Aptian. The stratigraphic investigation of the accompanying ammonoid fauna constricts the age data 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 as in comparable darker beds elsewhere in the Northern Calcareous Alps (e.g. KB1-B, Upper Austria). No evidences for condensationan can be found.

In the radiolarian assemblage nassellarians are dominant. Within the latter, 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 dominates above all other species.

Holocryptocanium barbui DUMITRICA is a cryptocephalic and cryptothoracic species of the family *Williriedellidae* and in addition with the thick-walled forms of the genus *Praeconosphaera* hint to a deep-water fauna. The latter forms predominate over the spumellarians showing spiny test (e.g. *Acaeniotyle umbilicata, Pantanellium squinaboli*) which indicate shallower levels in the water column.

Bartolini et al. (1999) showed that the reproduction-speed of deep-water populations is much higher, where mixed water layers prevail containing high nutrient supply. Such conditions are proposed for the investigated radiolarian mass occurrence at the Sparbach. We therefore assume that the radiolarian association at Sparbach indicates eutrophic conditions and high flux of organic matter towards the sea-bottom. This presumption is supported by the geochemical and faunal facts given by Lukeneder (in press) for the same beds.

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

From Heackel´s time (1873-1887) to up to date the opinion outlasts, that spumellarians are more abundant in shallow waters and nassellarians prefer deeper water and/or oceanic conditions. However, Bartolini et al. (1999) pointed out, that spumellarians/nassellarians ratio is a more complex problem, where important role play many factors such as quantity nutrient, temperature and salinity gradient.

Based on the described features from the Sparbach section radiolarians are showing abundance peaks during times of oxygen depletion at the sea floor. This leads to the conclusions that “plankton blooms” (e.g. radiolarian blooms) at the sea-water surface induced a reduction of oxygen content at lower water layers at the sea floor. The increasing content of biogene particles at the sea floor leds to an 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)

As dark laminated deposits are preferentially enriched in radiolarians, phases of high nutrient availability and primary productivity are suggested to be a motor of the formation of such radiolarian rich, dark, laminated sediments. A distal deeper environmental position of the place of accumulation is assumed and the facies hints to eutrophication of parts of the water mass above. Concerning the conclusions of Bak and Sawlowicz (2000) on the significance and the preservation of pyritized radiolarians, pyritization of radiolarians herein is to weak to presume a formation while floating within the anoxic water column. The pyritization of the radiolarian tests described took most probably place on the sea floor and /or in the sediment. This strengthens the results of Lukeneder (in press) who proposed in his recent investigations on these laminated sediments of the same locality a low oxygen environment combined with decreasing bottom-current activity.

References

Bak, M. (1995): Mid Cretaceous radiolarians from the Pieniny Klippen Belt, Carpathians. *Poland. Cretaceous Research*, **16**, 1-23.

Bak, M. (1996): Abdomen wall structure of *Holocryptocanium barbui* (Radiolaria). Journal of *Micropalaeontology*, **15**, 131-134.

Bak, M. and Sawlowicz, Z. (2000): Pyritized radiolarians from the Mid-Cretaceous deposits of the Pieniny Klippen Belt – a model of pyritization in an anoxic environment. *Geologica Carpathica*, **51**, 2, 91-99.

Bartolini, A., Baumgartner, P.O. & Guex, J. (1999): Middle and Late Jurassic radiolarian palaeoecology versus carbon-isotope stratigraphy. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **145**, 43-60,

Baumgartner, P.O. (1984): A Middle Jurassic-Early Cretaceous low latitude radiolarian zonation based on Unitary Associations and age of tethyan radiolarites*.* *Eclogae Geologicae Helvetiae*, **77**, 3, 729-837, Basel.

Baumgartner, P.O., O' Dogherty, L., Gorican, S., Urquhart, E., Pillevuit, A. and De Wever, P. (Eds.) (1995): Middle Jurassic to Lower Cretaceous Radiolaria of Tethys: Occurrences, Systematics, Biochronology. *Mémoires de Géologie* (Lausanne), **23**, 900 pp.

Boorová, D, Lobitzer, H., Skupien, P. and Vašíček, Z. (1999): Biostratigraphy and Facies of Upper Jurassic-Lower Cretaceous pelagic carbonate sediments (Oberalm-, Schrambach- and Rossfeld-Formation) in the Northern Calcareous Alps, South of Salzburg. *Abhandlungen der Geologischen Bundesanstalt*, **56**/2, 273-318, Wien.

De Wever, P. de, Dumitrica, P., Caulet, J.P., Nigrini, C., and Caridroit, M. (2002) : Radiolarians in the Sedimentary Record. Taylor & Francis, pp. 533, New York.

Faupl, P., Vašíček, Z., Michalik, J. & Reháková, D. 1994: Stratigraphische Daten zur Unterkreide der Lunzer und Reichraminger Decke (Östliche Kalkalpen, Ober- und Niederösterreich). *Jb. Geol. B.-A ,.* **137**, 407-412.

Gorican, S. (1994): Jurassic and Cretaceous radiolarian biostratigraphy and sedimentary evolution of the Budva Zone (Dinarides, Montenegro). *Mémoires de Géologie* (Lausanne), **18**, 120 pp.

Hoedemaeker, P.J. & Rawson, P.F., 2000: Report on the 5th International Workshop of the Lower Cretaceous Cephalopod Team (Vienna, 5 September 2000; Lukeneder, A. (org.). *Cretac. Research,* **21**, 857-860, London.

Hoedemaeker, P.J., Reboulet, St., Aguirre-Urreta, M., Alsen, P., Aoutem, M., Atrops, F., Barrangua R., Company, M., Gonzales, C., Klein, J., Lukeneder, A., Ploch, I., Raisossadat, N., Rawson, P.F., Ropolo, P., Vašíček, Z., Vermeulen, J. and Wippich, M., 2003. Report on the 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group, the 'Kilian Group' (Lyon 2002). *Cretac. Research,* **24**, 89-94.

Immel, H., 1987: Die Kreideammoniten der Nördlichen Kalkalpen. *Zitteliana,* **15**, 3-163.

Jud. R. (1994): Biochronology and Systematics of Early Cretaceous Radiolaria of the Western Tethys. *Mémoires de Geology* (Lausanne), **19**, 147 pp.

Lukeneder, A., 1998. Zur Biostratigraphie der Schrambach Formation in der Ternberger Decke (O.-Valanginium bis Aptium des Tiefbajuvarikums-Oberösterreich). *Geol. Paläont. Mitteil. Innsbruck,* **23**, 127-128.

Lukeneder, A., 1999: Excursion-guide to the Lower Cretaceous sequence of the Flösselberg Syncline (Lower Austria). 5th International Symposium "Cephalopods - Present and Past", 17 p., Wien.

Lukeneder, A., 2001: Palaeoecological and palaeooceanographical significance of two ammonite mass-occurrences in the Alpine Early Cretaceous. *PhD-Thesis*, Univ. Vienna, 1-316.

Lukeneder, A. 2003a. Ammonoid stratigraphy of Lower Cretaceous successions within the Vienna Woods (Kaltenleutgeben section, Lunz Nappe, Northern Calcareous Alps, Lower Austria). In: Piller W.E. (Ed.): *Stratigraphia Austriaca. Austrian Acad. of Sci. Series*, *"Schriftenreihe der Erdwissenschaftlichen Kommissionen"* 16, Vienna, 165-191.

Lukeneder, A. 2003b: The *Karsteniceras* Level: Dysoxic ammonoid beds within the Early Cretaceous (Barremian, Northern Calcareous Alps, Austria). *Facies,* 49, 87-100.

Lukeneder, A., 2004a. Late Valanginian ammonoids: Mediterranean and Boreal elements - implications on sea-level controlled migration (Ebenforst Syncline; Northern Calcareous Alps; Upper Austria). Austrian Journal of Earth Sciences, 95/96, 46-59.

Lukeneder, A., 2004b. The *Olcostephanus* Level: An Upper Valanginian ammonoid mass-occurrence (Lower Cretaceous, Northern Calcareous Alps, Austria). Acta Geologica Polonica, 54(1), 23-33.

Lukeneder, A., 2004c. Ein Ammoniten-Massenvorkommen aus der Unterkreide - Der *Olcostephanus* Leithorizont (Nördliche Kalkalpen, Oberösterreich). Oberösterreichische Geonachrichten, 19, 25-41.

Lukeneder, A., 2004d. A Barremian ammonoid association from the Schneeberg Syncline (Early Cretaceus, Northern Calcareous Alps, Upper Austria). Annalen des Naturhistorischen Museums Wien, 106A, 213-225, Wien.

Lukeneder, A. 2005. First nearly complete skeleton of the Cretaceous duvaliid belemnite *Conobelus*. Acta Geologica Polonica, 55 (2), 147-162.

Lukeneder, A. 2005, in press. The Early Cretaceous Karsteniceras Level in the Vienna Woods (Northern Calcareous Alps, Lower Austria). Geologica Carpathica, 56 (4).

Lukeneder, A. and Harzhauser, M., 2003. *Olcostephanus guebhardi* as cryptic habitat for an Early Cretaceous coelobite community (Valanginian, Northern Calcareous Alps, Austria). Cretaceous Research, 24, 477-485.

O' Dogherty, L. (1994): Biochronology and Paleontology of Mid-Cretaceous radiolarians from Northern Apennines (Italy) and Betic Cordillera (Spain). *Mémoires des Géologie* (Lausanne), **21**, 415 pp.

Ondrejíčková, A, Borza, V., Korábová, K. and Michalík, J. (1993): Calpionellid, radiolarian and calcareous nannoplankton association near the Jurassic – Cretaceous boundary (Hrušové section, Čachtické Karpaty Mts., Western Carparthians). *Geologica Carpathica*, **44**, 3, 177-188, Bratislava.

Ožvoldová, L. 1990: Occurrence of Albian radiolaria in the underlier of the Vienna Basin. *Geologický zborník - Geologica Carpathica,* **41,** 2, 137-154, Bratislava.

Ožvoldová, L. and Peterčáková , M. 1992:Hauterivian Radiolarian association from the Lúčkovská Formation, Manín Unit (MT: Butkov, Western Carpathians). *Geologica Carpathica*, **43**, 5, 313-324, Bratislava.

Pessagno, E.A. (1977): Lower Cretaceous radiolarian biostratigraphy of the Great Valley Sequence and Franciscan Complex, California Coast Ranges. Cushman Foundation for

Foraminiferal Research, Special Publication, **15**, 1-87, Washington.

Peterčáková , M. 1990: Radiolaria from cherts of the Kališčo limestone Formation of the Manín Unit (Butkov, West Carpathians). *Geologický zborník - Geologica Carpathica,* **41,** 2, 155-169, Bratislava.

Plöchinger, B. & Prey, S. 1993: Der Wienerwald. *Sammlung geol. Führer,* **59**, Berlin-Stuttgart, 1- 168.

Reháková, D. and Michalík, J. (1994): Abundance and distribution of Late Jurassic – Early Cretaceous microplankton in Western Carpathians. *Geobios*, **27**, 2, 135-156, Villeurbanne.

Reháková, D., Michalík, J. and Ožvoldová, L. (1996): New Microbiostratigraphical data from several Lower Cretaceous pelagic sequences of the Northern Calcareous Alps, Austria (preliminary results). – *Geologisch-Paläontologische Mitteilungen,* Innsbruck, Sonderband **4**, 57-81, Innsbruck.

Reháková, D. 2000: Calcareous dinoflagellate and calpionellid bioevents versus sea-level fluctuations recorded in the West Carpathian (Late-Jurassic/Early Cretaceous) pelagic environments. *Geologica Carpathica*, **51** (4), 229-243, Bratislava.

Richarz, P.S. 1905: Die Neokombildungen bei Kaltenleutgeben. *Jb. Geol. R. -A.* 54, 343-358.

Richarz, P.S. 1908: Ein neuer Beitrag zu den Neokombildungen bei Kaltenleutgeben. *Verh. Geol. R. -A.* 1908, 312-320.

Rosenberg, G. 1965: Der kalkalpine Wienerwald von Kaltenleutgeben (NÖ und Wien). *Jb. Geol. B. -A.,* **108,** 115-153.

Schwinghammer, R. 1975: Stratigraphie und Fauna des Neokoms von Kaltenleutgeben, NÖ. - *Sitzber. Österr. Akad. Wiss., math.-naturw. Kl., Abt.,* **1/183**, 149-158.

Schnabel, W. (1997): Geologische Karte des Republik Österreich 1: 50 000, **58** Baden. Geologische Bundesanstalt, Wien.

Spitz, A. 1910: Der Höllensteinzug bei Wien. *Mitt. Geol. Ges., Wien* 3, 315-434.

Thurow, J. (1988): Cretaceous radiolarians of the North Atlantic Ocean. ODP Leg. 103. Proceedings of the Ocean Drilling Program, Scientific Results, **103**, 379-416, College Staton.

Toula, F., 1886: Mittelneokom am Nordabhange des Großen Flösselberges bei Kaltenleutgeben. *Verh. Geol. R. -A.* 1886, 189-190.

Vašíček, Z. & Faupl, P. 1998: Late Valanginian cephalopods in relation to the palaeogeographic position of the Rossfeld and Schrambach Formation of the Reichraming Nappe (Northern Calcareous Alps, Upper Austria). *Zbl. Geol. Paläont.,* (Teil 1) **11/12**, 1421-1432.

Vašíček, Z, Michalík, J., Reháková, D. & Faupl, P. 1994: Stratigraphische Daten zur Unterkreide der Lunzer und Reichraminger Decke (Östliche Kalkalpen, Ober- und Niederösterreich). *Jb. Geol. B.-A.,* **137,** 407-412.

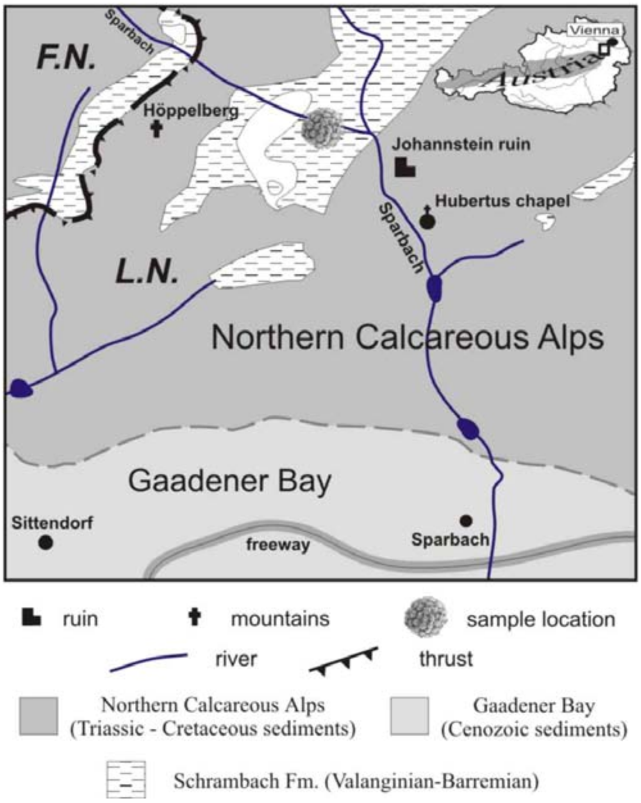


Fig. 1. Sketch map of the excavation site N of Sparbach and the geological situation and sediments of the Flössel Syncline. The Upper Austroalpine Northern Calcareous Alps extend from the Austrian western border to the city area of Vienna. Map after ÖK 1:50 000, sheet 58 Baden, Geological Survey Vienna, Schnabel 1997).

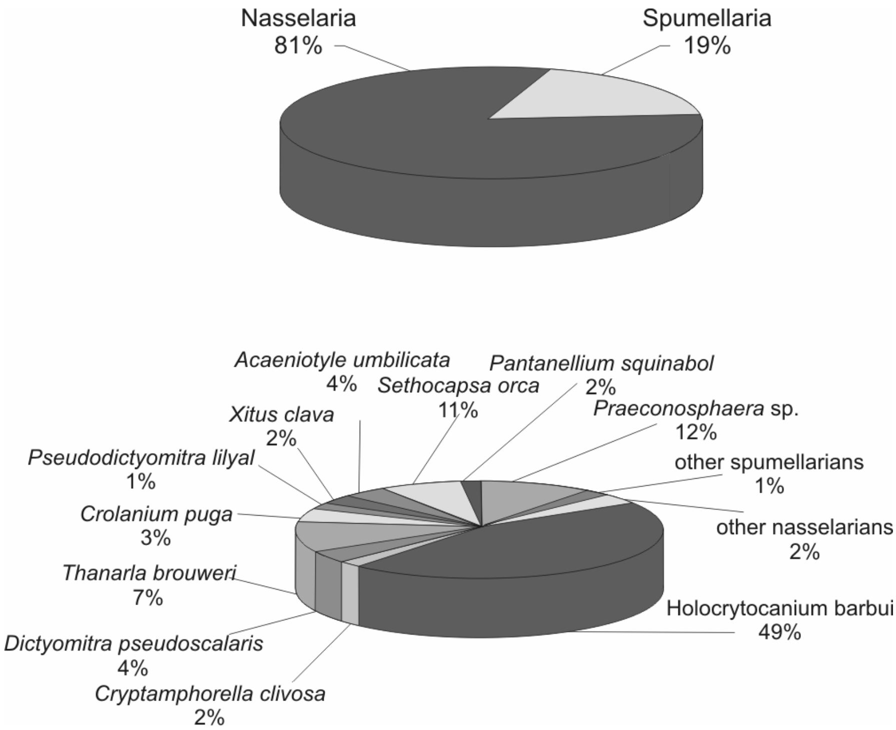


Fig. 2. Radiolarian spectrum from the Sparbach locality.
Note the dominance of the genus *Holocryptocanium* (Nassellaria).

BARREMIAN	Upper	*P. waagenoides*	
		C. sarasini	
		I. giraudi	
		H. feraudianus	
		G. sartousiana	*G. provincialis*
			G. sartousiana
		A. vandenheckii	
	Lower	*C. darsi*	
		K. compressissima	
		N. pulchella	
		K. nicklesi	
		T. hugii auct.	

Fig. 3. Stratigraphic position within the Early Barremian (*C. darsi* Zone) of the Sparbach fauna (in grey). Table modified after Hoedemaeker et al. (2003).

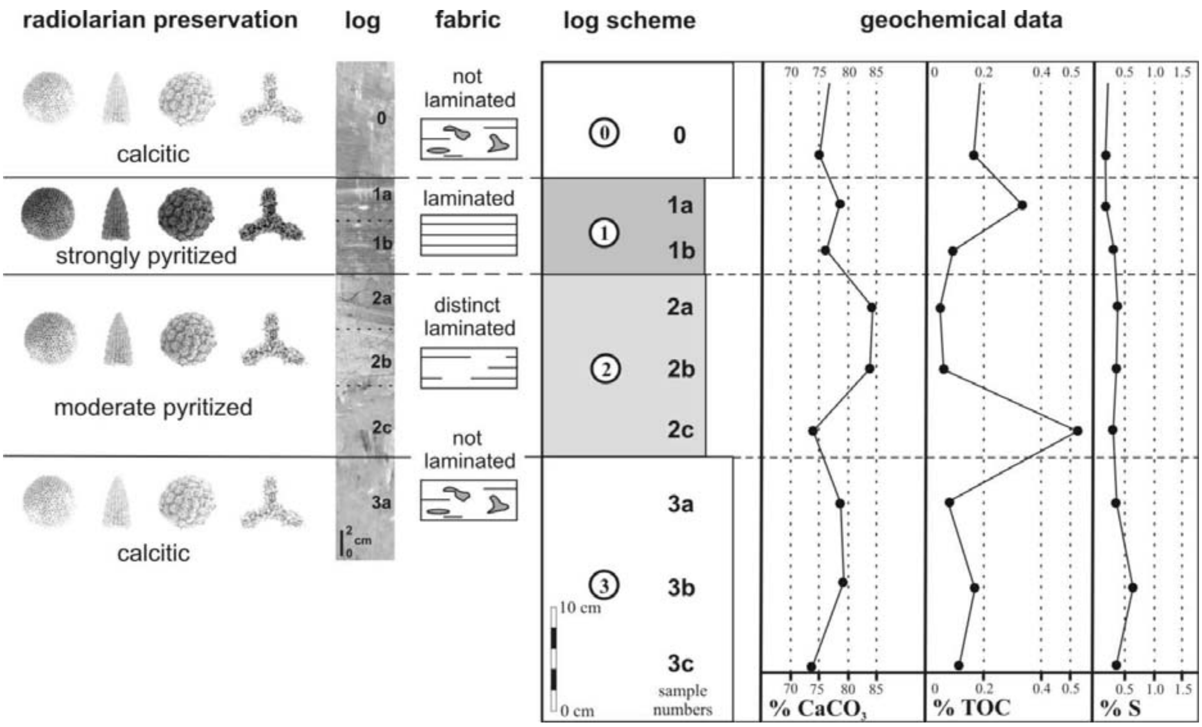


Fig. 4. The different preservational features of the radiolarian fauna. Correlated with the original log (longitudinal scan of the polished surface), the sediment fabric (laminated. distinct laminated and not laminated), and the geochemical parameters from the Sparbach section within and around the *Karsteniceras* Level.

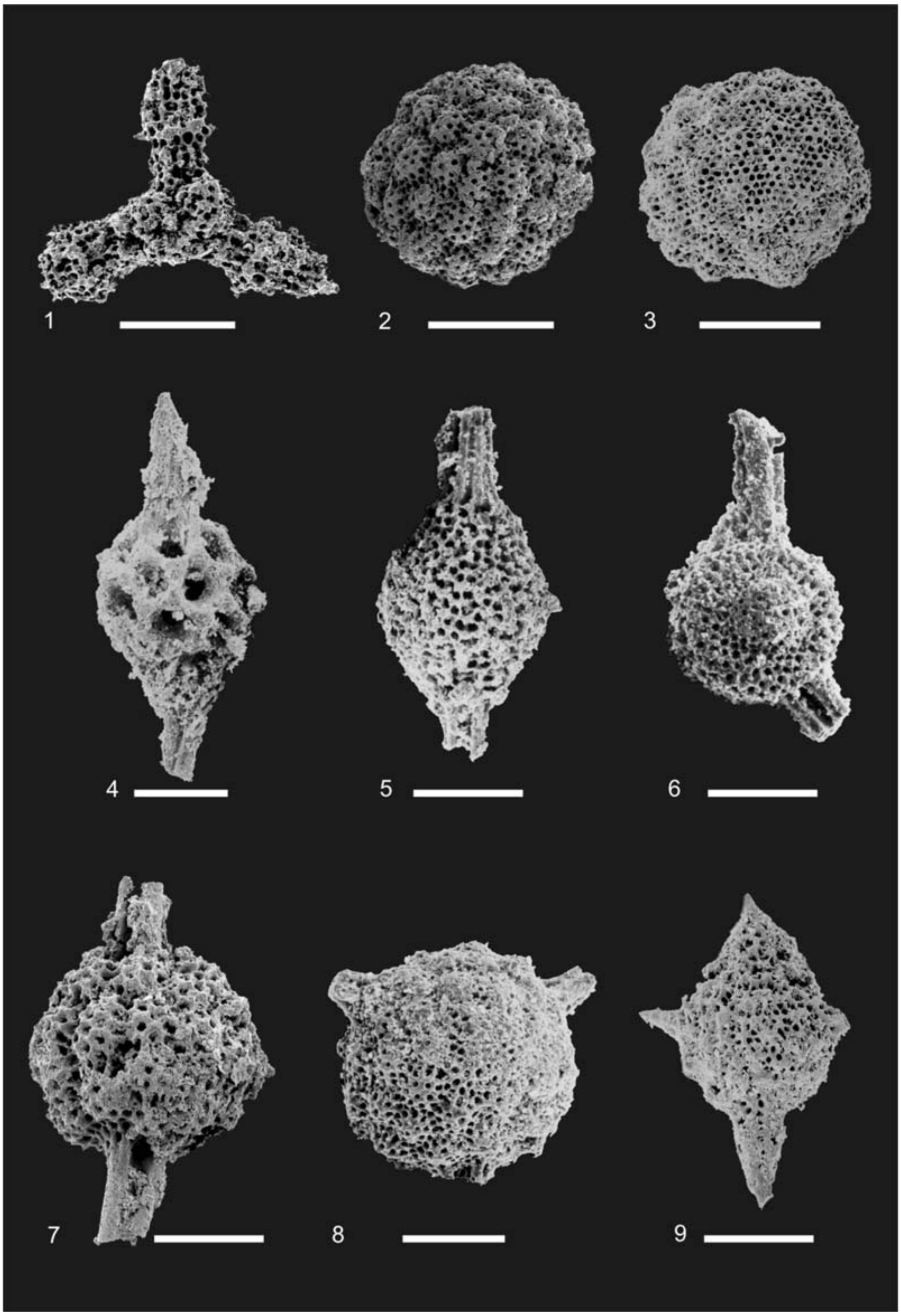


Plate 1.

All specimens figured on plate 1 are Spumellaria from bed 1a,

except Fig. 9 which belongs to Nasselaria.

Fig. 1. *Paronaella* cf. *trifoliacea* OŽVOLDOVÁ - x 120. Fig. 2-3. *Praeconosphaera* sp. - x 180. Fig. 4. *Pantanellium squinaboli* TAN - x 100. Fig. 5. *Archaeospongoprunum patricki* JUD - x 120. Fig. 6. *Suna hybum* (FOREMAN) - x 120. Fig. 7. *Acaeniotyle umbilicata* (RŰST) - x 125.Fig. 8. *Acaeniotyle diaphorogona* FOREMAN - x 130. Fig. 9. *Dibolachras tytthopora* FOREMAN - x 120.

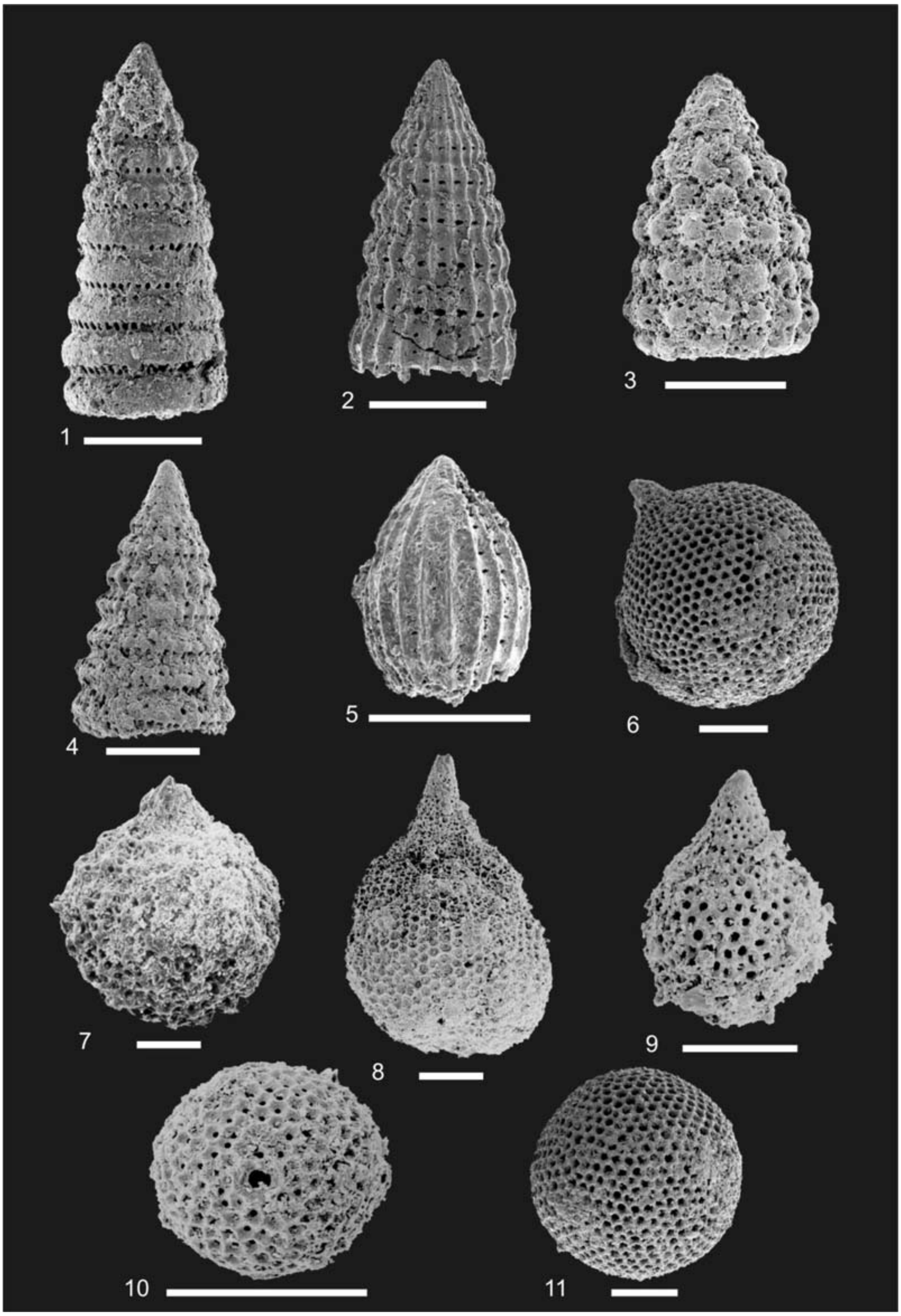


Plate 2.

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

Fig. 1. *Pseudodictyomitra lilyae* (TAN) - x 130. Fig. 2. *Dictyomitra pseudoscalaris* (Tan) - x 120. Fig. 3. *Xitus clava* (PARONA) - x 110. Fig. 4. *Crolanium puga* (SCHAAF) - x 110. Fig. 5. *Thanarla brouweri* (TAN) - x 130. Fig. 6. *Sethocapsa orca* FOREMAN - x 110. Fig. 7. *Cryptamphorella clivosa* (ALIEV) - x 125. Fig. 8. *Sethocapsa dorysphaeroides* (NEVIANI) - x 125. Fig. 9. *Hiscocapsa asseni* (TAN) - x 160. Fig. 10-11. *Holocryptocanium barbui* DUMITRICA - x 160.

STOP 2. Sittendorf (Schrambach and Tannheim Formations; Aptian)

THE PENNINIC OCEAN SUBDUCTION: NEW DATA FROM PLANKTONIC FORAMINIFERA

Compendium from Oleg Mandic and Alexander Lukeneder (2008)

Introduction

The biostratigraphic data on the transition between the Schrambach and the Tannheim Formation of the northeastern Northern Calcareous Alps (Upper Austroalpine) are remarkable scarce (Weidich 1990, Wagreich 2003). This fact reflects the absence of identifiable ammonoid macrofossil fauna as well as the absence or bad preservation of relevant microfossils. The corresponding boundary however has an extraordinary importance for the reconstruction of Austroalpine geodynamics as marking the initial siliciclastic input into the basin reflecting the starting point of the Penninic Ocean subduction beneath the Upper Austroalpine (Wagreich 2003). Therefore the newly discovered outcrop NW of Sittendorf in the southwestern Vienna Woods, should now fill that gap. In that section the critical interval has been found for the first time in an environment comprising extraordinarily rich accumulations of planktonic foraminifera.

Penninic Ocean and Austroalpine Shelf

The Penninic Ocean (Fig. 1) was initiated in the Late Triassic by rifting and disjunction of the Austroalpine microcontinent from the southern European Plate margin. It was the eastern prolongation of the North Atlantic Rift-System effecting the final disintegration of the Permotriassic Pangea Supercontinent (e.g. Faupl 2003). The formation of the oceanic crust and the sea floor spreading lasted from the Middle Jurassic to the Early Cretaceous, terminating with the introduction of its southward-directed subduction beneath the northern Austroalpine plate margin (Faupl and Wagreich 2000). The active plate margin including the transpressional accretionary wedge and the northern parts of the Austroalpine microplate thereby underwent accelerated uplift and erosion; this is reflected in the beginning siliciclastic input into the southern, adjoining marine environments (Wagreich 2003).

The Northern Calcareous Alps, originally encompassing the southern part of the Austroalpine microplate, are positioned today at the northern margin of the Austroalpine nappe complex (Faupl and Wagreich 2000). In the Early Cretaceous the complex started to drift northwards, overriding progressively the northern parts of the Austroalpine plate (Fig. 2). At the front of the overthrust a piggyback basin developed, supplied from the north by a marine slope apron deposition (Wagreich 2003). The pelagic carbonate sedimentation, which already started in the Late Jurassic, therefore changes within several meters of the section into a siliciclastic dominated sedimentation. The gradual convergence of the slope apron depositional front and filling of the piggyback basin is reflected by a coarsening upward sequence ending with coarse sand and conglomerate intercalations at the top of the succession.

Depositional and tectonic setting

The studied section at Sittendorf includes the slope-apron succession of the Frankenfels Nappe representing the NNE part of the Northern Calcareous Alps and the Bajuvaric Unit nappe-system. The Lower Cretaceous pelagic sediments of the Bajuvaric Unit represent its major sedimentation cycle. The significant depositional change from the carbonate to the siliciclastic depositional system is reflected in the boundary between the Schrambach and the Tannheim Formations. Accordingly, the Schrambach Formation represents the phase of autochthonous pelagic sedimentation with the light-colored, aptychi-bearing nannoconid limestones and marly limestones. The Tannheim Formation, on the other hand, features typically dark, laminated pelagic marls and marly limestones whose formation was triggered by erosion and intensive redeposition (Wagreich 2003). The macro-invertebrate fauna of the succession is very sparse, comprising ammonoids, aptychi, belemnites, brachiopods and rare bivalves. The micro-fauna is in contrast abundant, with dominating radiolarians in the Schrambach Formation and planktonic foraminifera blooms within the Tannheim Formation.

Planktonic foraminifera patterns

The Cretaceous record of planktonic foraminifera generally shows a threefold pattern with periods of rapid diversifications alternating with periods of stasis (Premoli Silva and Sliter 1999). The investigated section represents the first diversification phase defined by latter authors lasting from the Early Valanginian to the latest Aptian. The continuous diversification therein is briefly interrupted only during the "Selli" event, where a smaller-scale turnover event occurred. The diversification phase begins with the rise of the first hedbergellids in the Early Valanginian followed in the Early Hauterivian with the first occurrence of small planispiral *Blowiella*. Intensification of taxonomic diversification, abundance increase together with the increase of the overall test size started within the Barremian. Finally with the Aptian the planktonic foraminifera blooms became frequent (cf. Premoli Silva and Sliter 1999). The assemblage prior to the Selli Event is still dominated by relatively small-sized, thin-walled and simple morphotypes (e.g. Coccioni et al. 1992). Following the Selli Event, medium-sized, clavate *Leupoldina* become typical, followed by the first occurrence of the thick-walled *Globigerinelloides*. Whereas *Leupoldina* soon retreats, *Globigerinelloides* goes through a remarkable evolution characterized by size and chamber number increase (Moullade et al 2005). This culminated in the Late Aptian, with *G. algerianus* being the first large-sized planktonics in the evolutionary history of the genus, attaining maximum diameters of ~700µm (Leckie et al. 2002). Synchronously, the same evolutionary trend is followed by the hedbergellids, with the remarkably large and massive *Hedbergella trocoidea* arising from the more primitive *Praehedbergella* *praetrocoidea* (Moullade et al. 2002). The brief global cooling (Herrle and Mutterlose 2003; Skelton 2003) by the end of Aptian initialized enhanced ocean mixing and thermocline destruction, triggering extinctions and the final drop in plankton diversity.

Lithology and facies distribution

The N-S striking section was measured from 11 m below and 12 m above the lithostratigraphic boundary between the Schrambach and the Tannheim Formation (Fig. 6). The layers dip at a very high angle toward the north (2nd section's meter: 326/70, 340/60; 16th section's meter: 000/70, 353/90).

The base of the measured section overlies a smaller-scale fault within the Schrambach Formation. Upsection, up to the 9 m mark, the Schrambach Formation exposes a monotonous series of hard, finely (at 10 cm scale), wavy bedded, micritic limestones. These mudstones to wackestones are typically light gray and contrast with the more strongly weathered and more marly portions (from 2 to 4 m, and around the 8 m mark), which are dark gray to olive green. Small-scale bioturbations are common in places, forming cm-thick horizons. Typical features include about 1-mm-thick, small, dark-colored, tube-shaped burrows unevenly distributed in the sediment.

The 9 m to 13 m level marks the transitional interval between the Schrambach and the Tannheim Formation. The boundary is defined with the top of the uppermost light gray bed at 10.9 m. The interval is characterized by a gradual upsection increase of the siliciclastic, clayey component. Nine 20- to 40-cm-thick limestone interlayers are intercalated – their boundaries show occasional minor fault structures. The lower 4 intercalations are light gray mudstones to packstones. The intervening marly intervals are light gray in the first meter, thereafter becoming dark gray laminated marls to marly limestone up to the top of the transitional interval; an exception is one 5-cm-thick dark clay horizon at 12.4 m. The other 5 micritic limestone intercalations are dark gray, laminated (first two) or homogeneous, bioturbated wackestones to packstones.

From 13 m to the top of the section, dark gray to greenish gray marls and marly limestones are present. These mostly wackestones can be laminated or bioturbated. Between 16 m and 17 m, at 18 m and at 22 m, 40- to 100-cm-thick, more limy, less weathered intervals are intercalated. At about 14.5 m and 20 m, steep fault structures occur. Above the uppermost limestone bed the outcrop situation becomes unclear. Except for one small bivalve shell, no microfossils were found.

Biostratigraphy

For the 23-m-long section in Sittendorf, 5 planktonic foraminifera Zones were detected. The Zones span from the Late Barremian to the older part of the Late Aptian (Gargasian sub-age in Ogg at al. 2004). Moreover, the occurrence of *Praehedbergella occulta* already within the first meter of the section points to the Early Aptian (Bedoulian sub-age in Ogg et al. 2004) for the lowermost part of the section. The studied sequence therefore correlates largely with the Aptian.

Interpretation of the section

The biostratigraphic analysis proved that the lower part of the section, including the investigated lithostratigraphic boundary between the Schrambach and Tannheim Formations, is continuous. In contrast, the upper part the section shows two distinct stratigraphic discontinuities. Moreover the biostratigraphy clearly demonstrates that the package between the two faults is a tectonically inverted block with a stratigraphically older strata overlying the younger one.

The gamma-log curve supports the biostratigraphic data very well. The gamma response becomes gradually stronger in the lower, undisturbed part of the section. The inverted block from the upper part of the section shows the highest gamma responses, remaining vertically at about the same mean intensity level. The uppermost package of the section, however, shows an upsection decreasing gamma response. The curve pattern therefore shows a vertically inverted picture of the corresponding biostratigraphic interval of the lower part of the section. This strongly suggests that the package from the uppermost part of the section represents an inverted block as well.

These data allow a precise reconstruction of the tectonic setting of the studied section. Accordingly, the best fit tectonic interpretation for the section's stratigraphic pattern is a position in a laterally (N-S) compressed, isocline, slightly overturned, syncline fold as illustrated in Fig. 8. The interpolation of the successional biostratigraphic horizons beyond the large inverted package in the upper part of the section yields the most reasonable reconstruction. Therefore, the latter block must have been pushed out from the southern fold wing apex due to the pressure from progressing lateral compression. The reconstructed offset is about 5 to 6 m.

Conclusions

The Schrambach Formation comprises the lower 10.9 m of the section. Those pelagic limestones and marly limestones are mudstones to wackestones whose matrix is dominated by large nannoconid phytoplankton. Among the microplankton, radiolarians are often abundant, especially in the topmost portions. Planktonic foraminifera are, except for the topmost part, scattered; in the lower part they are still small sized, becoming distinctly larger upwards. The assemblage is dominated by small, five-chambered *Praehedbergella*, particularly by *P. infracretacea*. The presence of *Blowiella blowi* together with *Praehedbergella occulta* already in the lower part of the section allows the section to be placed into the upper part of the *B. blowi* Interval Zone and to be correlated with the uppermost Barremian and lowermost Aptian.

The uppermost part of the Schrambach Formation (10 m to 10.9 m) displays already marly intercalations, and therein also the C_{org} values suddenly drop from previously enhanced values (1-2%) to distinctly lower ones (<1%). Except for one sample close to the dark clay intercalation, the lowered C_{org} values persist upward throughout the Tannheim Formation. The planktonic foraminifera also undergo a radical change, not only in taxonomic composition, size and wall thickness, but particularly in abundance. From here upwards, zooplankton blooms characterize the succession up to its top. The planktonic foraminiferal assemblage is characterized by the common *Leupoldina* and large specimens of *Blowiella blowi*, defining its stratigraphic position within the *Leupoldina cabri* Acme Zone. The base of the latter Zone superimposes the Early Aptian Oceanic Anoxic Event "Selli" and has an inferred age of about 124 Ma. Up to now, the presence of a planktonic foraminiferal assemblage with *Leupoldina* was unknown from the investigated depositional cycle (Schrambach - Tannheim - Losenstein Formation).

The larger part of the succession within the lower portion of the Tannheim Formation (between 10.9 m and 14 m) is characterized by the common occurrence of *Leupoldina*. For the upper part of the Acme Zone, a characteristic feature is the occurrence of *Praehedbergella luterbacheri* and *Globigerinelloides ferreolensis*. The last occurrence of *Leupoldina* in the section approximates the base of the *Globigerinelloides ferreolensis* Interval Zone, correlating roughly with the Early/Late Aptian boundary. The presence of the upper part of the Interval Zone is indicated by the introduction of *Globigerinelloides barri*. This species with 9 chambers in the last whorl represents the limb in the gradual evolution from *G. ferreolensis* (7-8) to *G. algerianus* (10 to 12).

The uppermost part of the Sittendorf exposure (14 m to 23 m) follows a fault structure and comprises another fault at the 20 m of the section. Except for those two faults, the succession comprising the Tannheim Formation has been originally presumed for being principally continuous. Yet, the biostratigraphic analysis together with the analysis of the gamma-log curve trend proved clearly highly complicated tectonic setting.

Hence the samples above the fault showed distinctly younger planktonic foraminifera assemblage than the ones below the fault. The large, thick-walled *Hedbergella trocoide*a with 8 chambers in the last whorl, along with the absent *Globigerinelloides algerianus*, underpinned the Late Aptian *H. trocoidea* Interval Zone.

Further upsection, up to the next fault, the reverse succession has been detected. Then not only the extremely large specimens of *G. algerianus* in that samples proved the exact correlation with the Late Aptian *G. algerianus* Taxon Range Zone, but also the *Hedbergella trocoide*a has been found therein present exclusively by the distinctly smaller, primitive, 7-chambered morphotypes. Hence, this particular part of the section has been clearly proved for being a tectonically inverted block.

The latter block is delimited from the topmost part of the section by the second fault positioned at its 20 m. The reoccurrence of *Leupoldina cabri* Acme Zone in those topmost samples is highly significant. Hence it proves the stratigraphically reversed position of the uppermost section part. It proves, as well, the significant tectonic movement at the fault causing the stratigraphic gap of one planktonic foraminifera zone (i.e. *G. ferreolensis* IZ). The decreasing gamma log values together with the characteristic pattern, which is reversely symmetrical to the corresponding pattern in the lower, undisturbed part of the section, correspond well with the interpretation of that block as a tectonically inverted structure.

The presented data underpin well the rather complicated, structural geological interpretation of the section. Hence the studied exposure is apparently positioned within a slightly northwards overturned, isoclinal syncline fold. The discontinuity in the upper section is a product of the lateral pressure, block escape movements in the southern wing of the syncline.

In conclusion, the range of the section is estimated to be about 10 m.y. and to include five Aptian planktonic foraminifera zones. The terrigenous input bounded to initial subduction of the Penninic Ocean under the Austroalpine Microplate started at about 123 Ma (Early Aptian). This date corresponds with that determined for the lithostratigraphic boundary between the Schrambach Formation and the Tannheim Formation. Although the section is discontinuous in its upper part (Tannheim Formation), the studied lithostratigraphic boundary is positioned within the continuous part of the section, making it suitable for the present investigation. Finally, thin section biostratigraphy of planktonic foraminifera proved, also in the Northern Calcareous Alpidic shelf, to be a powerful tool for stratigraphic dating of Aptian deep-water successions.

References

Aguado, R., Company, M., O'Dogherty, L., Sandoval, J., Tavera, J.M., 1992. Biostratigraphic analysis of the pelagic Barremian/Aptian in the Betic Cordillera (southern Spain): preliminary data. Cretaceous Research 13, 445-452.

Aguado, R., Castro, J.M., Company, M., Gea, G.A. de, 1999. Aptian bio-events - an integrated biostratigraphic analysis of the Almadich Formation, Inner Prebetic Domain, SE Spain. Cretaceous Research 20, 663-683.

Altiner, D., 1991. Microfossil Biostratigraphy (mainly foraminifers) of the Jurassic-Lower Cretaceous Carbonate Successions in north-western Anatolia (Turkey). Geologica Romana 27, 167-213.

Bartenstein, H., Bolli, H.M., 1986. The Foraminifera in the Lower Cretaceous of Trinidad, W.I.Part 5: Maridale Formation, upper Part; Hedbergella rohri Zone. Eclogae geol. Helv. 79/3, 945-999.

Bodrogi, I., Fogarasi, A., 2002. New data on the stratigraphy of the Lower Cretaceous of the Gerecse Mts. (Hungary) and the Lackbach section (Austria). In: Wagreich, M. (Ed.). Aspects of Cretaceous Stratigraphy and Palaeobiogeography. Österr. Akad. Wiss., Schriftenr. Erdwiss. Komm. 15, 295-313.

Bolli, H.B., 1959. Planktonic foraminifera from the Cretaceous of Trinidad, B.W.I. Bulletins of American Paleontology 39, 257-277.

Boudagher-Fadel, M.K., Banner, F.T., Simmons, M.D., 1997. The Early Evolutionary History of Planktonic Foraminifera. British Micropalaeontological Society Publication Series, 269 pp.

Bralower, T.J., Leckie, R.M., Sliter, W.V., Thierstein, H.R., 1995. An integrated Cretaceous microfossil biostratigraphy. In: Geochronology Time Scales and Global Stratigraphic Correlation. SEPM Special Publication 54: 65-63.

Bralower, T.J., Fullagar, P.D., Paull, C.K., Dwyer, G.S., Leckie, R.M., 1997. Mid-Cretaceous strontium-isotope stratigraphy of deep-sea sections. GSA Bulletin 109/10, 1421-1442.

Bralower, T.J., CoBabe, E., Clement, B., Sliter, W.V., Osburn, C.L., Longoria, J., 1999. The record of global change in mid-Cretaceous (Barremian-Albian) sections from the Sierra Madre, northeastern Mexico. Journal of Foraminiferal Research, 29/4: 418-437.

Coccioni, R., Premoli Silva, I., 1994. Planktonic foraminifera from the Lower Cretaceous of Rio Argos sections (southern Spain) and biostratigraphic implications. Cretaceous Research 15, 645-687.

Coccioni, R., Erba, E., Premoli-Silva, I., 1992. Barremian-Aptian calcareous plankton biostratigraphy from the Gorgo Cerbara section (Marche, central Italy) and implications for plankton evolution. Cretaceous Research 13, 517-537.

Erba, E., Channell, J.E.T., Claps, M., Jones, C., Larson, R., Opdyke, B., Premoli Silva, A., Riva, A., Salvini, G., Torricelli, S., 1999. Integrated stratigraphy of the Cismon Apticore (Southern Alps, Italy): A "reference section" for the Barremian-Aptian Interval at low latitudes. Journal of Foraminiferal Research, 29/4: 371-391.

Faupl, P., Wagreich, M., 2000. Late Jurassic to Eocene Palaeogeography and Geodynamic Evolution of the Eastern Alps. Mitteilungen der Österreichischen Geologischen Gesellschaft 92, 79-94.

Faupl, P., 2003. Historische Geologie: eine Einführung. Facultas, Wien, 271 pp.

Gorbachik, T.N., 1986. Jurassic and Lower Cretaceous planktic foraminifera of the south USSR. Nauka, Moscow, 239 pp. (in Russian).

Herrle, J.O., Mutterlose, J., 2003. Calcareous nannofossils from the Aptian-Lower Albian of southeast France: palaeoecological and biostratigraphic implications. - Cretaceous Research, 24: 1-22.

Kretchmar, V., Gorbachik, T.N., 1971. In: Gorbachik, T.N. (Ed.). On Early Cretaceous Foraminifera from Krimea. - Vop. Mikropaleont. 14, 125–139 (In Russian, English abstract).

Leckie, R.M., Bralower, T.J., Cashman, R., 2002. Oceanic anoxic events and plankton evolution: biotic response to tectonic forcing during the mid-Cretaceous. Paleoceanography 17/3: 10.1029/2001PA000623.

Lipson-Benitah, Sh., Almogi-Labin, A., 2004. Aptian planktonic foraminifera from Israel. Israel Journal of Earth Sciences 53/1, 27 - 46.

Longoria, J.F., 1974. Stratigraphic, Morphologic and Taxonomic Studies of Aptian Planktonic Foraminifera. Revista Española de Micropaleontologia, Num. Extr., 107 pp., 27 pls.

Lukeneder, A., 2003. Ammonoid stratigraphy of Lower Cretaceous successions within the Vienna Woods (Kaltenleutgeben section, Lunz Nappe, Northern Calcareous Alps, Lower Austria). In: Piller W.E. (Ed.). Stratigraphia Austriaca. Austrian Acad. of Sci. Series, "Schriftenreihe der Erdwissenschaftlichen Kommissionen" 16, 165-191.

Lukeneder, A., 2004a. Late Valanginian ammonoids: Mediterranean and Boreal elements – implications on sea-level controlled migration (Ebenforst Syncline; Northern Calcareous Alps; Upper Austria). Austrian Journal of Earth Sciences 95/96, 46-59.

Lukeneder, A., 2004b. Stratigrafische Erkenntnisse aus einem neuen Vorkommmen von Unterkreide-Ammonoideen in der Losensteiner Mulde (Ternberger Decke, Nördliche Kalkalpen). Jahrbuch der Geologischen Bundesanstalt 144/2, 173-189.

Masse, J.P. et al. (12 co-authors), 2000. Early Aptian. In: Dercourt, J., Gaetani, M. et al. (Eds.). Atlas Peri-Tethys, Palaeogeographical Maps. Map 13, (CCGM/CGMW) Paris.

Moullade, M., Tronchetti, G., Kuhnt, W., Masse, J.-P., 1998. Les Foraminifères benthiques et planctoniques du stratotype historique de l'Aptien inférieur dans la région de Cassis - La Bédoule (SE France). Géologie Méditerranéenne 25/3-4, 187-225.

Moullade, M., 1966. Etude stratigraphique et micropaleontologique du Crétacé inférieur de la 'Fosse Vocontienne'. Documents du Laboratoire de Géologie, Faculté des Sciences, Lyon 15, 1-369.

Moullade, M., 1974. Zones de foraminiferes du cretace inferieur mesogeen. C.r. Acad. sci., D, 278, 1813-1816.

Moullade, M., Bellier, J.-P., Tronchetti, G., 2002. Hierarchy of criteria, evolutionary processes and taxonomic simplification in the classification of Lower Cretaceous planktonic foraminifera. Cretaceous Research 23: 111-148.

Moullade, M., Tronchetti, G., Bellier, J.-P., 2005. The Gargasian (Middle Aptian) strata from Cassis-La Bédoule (Lower Aptian historical stratotype, SE France): planktonic and benthonic foraminiferal assemblage and biostratigraphy. Carnets de Géologie /Notebooks on Geology, Brest, Article 2005/02 (CG2005_A02).

Ogg. J.G., Agterberg, F.P., Gradstein, F.M., 2004. The Cretaceous Period. In: Gradstein, F.M., Ogg. J.G. and Smith, A.G. (Eds.) A Geologic Time Scale 2004. - 334-383, Cambridge University Press.

Omana, L., González-Arreola, C., Ramírez-Garza, B.M., 2005. Barremian planktonic foraminiferal events correlated with the Ammonite zones from the San Lucas Formation, Michoacán (SW Mexico). Revista Mexicana de Ciencias Geológicas 22/1, 88-96.

Premoli Silva, I., Erba, E., Salvini, G., Locatelli, C., Verga, D., 1999. Biotic changes in Cretaceous oceanic anoxic events of the Tethys. Journal of Foraminiferal Research 29/4, 352-370.

Premoli Silva, I., Sliter, W.V., 1999. Cretaceous paleoceanography: Evidence from planktonic foraminiferal evolution. In: Barrera, E., and Johnson, C.C. (Eds.). Evolution of the Cretaceous Ocean-Clymate System. Geological Society of America Special Paper 332, 301-328.

Premoli Silva, I., Verga, D., 2004. Practical Manual of Cretaceous Planktonic Foraminifera. - International School on Planktonic Foraminifera, 3° Course: Cretaceous, Tipografia Pontefelcino, Perugia, 283 pp. + CD-ROM.

Rückheim, S., Mutterlose, J., 2002. The Early Aptian migration of planktonic foraminifera to NW Europe: the onset of the mid-Cretaceous plankton revolution in the Boreal Realm. Cretaceous Research 23, 49-63.

Skelton, P.W., 2003. 5 Changing climate and biota - the marine record. Skelton, P.W. (Ed.): The Cretaceous World. The Open University and Cambridge University Press, Cambridge, UK, pp.163-184.

Sliter, W.V., 1989. Biostratigraphic Zonation for Cretaceous Planktonic Foraminiferas Examined in Thin Sections. Journal of Foraminiferal Research 19/1, 1-19.

Sliter, W.V., 1992. Cretaceous planktonic foraminniferal biostratigraphy and paleoceanographic events in the pacific ocean with emphasis on indurated sediment. In: Ishizaki K., Saito, T. (Eds.). Centenary of Japanese Micropaleontology. Terra Scientific Publishing Company, Tokyo, pp. 281-299.

Sliter, W.V., 1999. Cretaceous Planktic Foraminiferal Biostratigraphy of the Calera Limestone, Northern California, USA. Journal of Foraminiferal Research 29/4, 318-339.

Strasser, A. Caron, M., Gjermeni, M., 2001. The Aptian, Albian and Cenomanian of Roter Sattel, Romandes Prealps, Switzerland: a high-resolution record of oceanographic changes. Cretaceous Research 22, 173-199.

Verga, D., Premoli Silva, I., 2002. Early Cretaceous planktonic foraminifera from the Tethys: the genus *Leupoldina*. Cretaceous Research 23, 189-212.

Verga, D., Premoli Silva, I., 2003a. Early Cretaceous planktonic foraminifera from the Tethys: the small, few-chambered represenatatives of the genus *Globigerinelloides*. - Cretaceous Research 24, 305-334.

Verga, D., Premoli Silva, I., 2003b. Early Cretaceous planktonic foraminifera from the Tethys: the large, many-chambered representatives of the genus *Globigerinelloides*. Cretaceous Research 24, 661-690.

Verga, D., Premoli Silva, I., 2005. Early Cretaceous planktonic foraminifera from the Tethys: the Upper Aptian, planispiral morphotypes with elongatae chambers. Cretaceous Research 26, 239-259.

Wagreich, M., 2003. A slope-apron succession filling a piggyback basin: the Tannheim and Losenstein Formations (Aptian - Cenomanian) of the eastern part of the Northern Calcareous Alps (Austria). Mitt. Österr. Geol. Ges. 93, 31-54.

Weidich, K.F., 1990. Die kalkalpine Unterkreide und ihre Foraminiferenfauna. Zitteliana 17, 1-312.

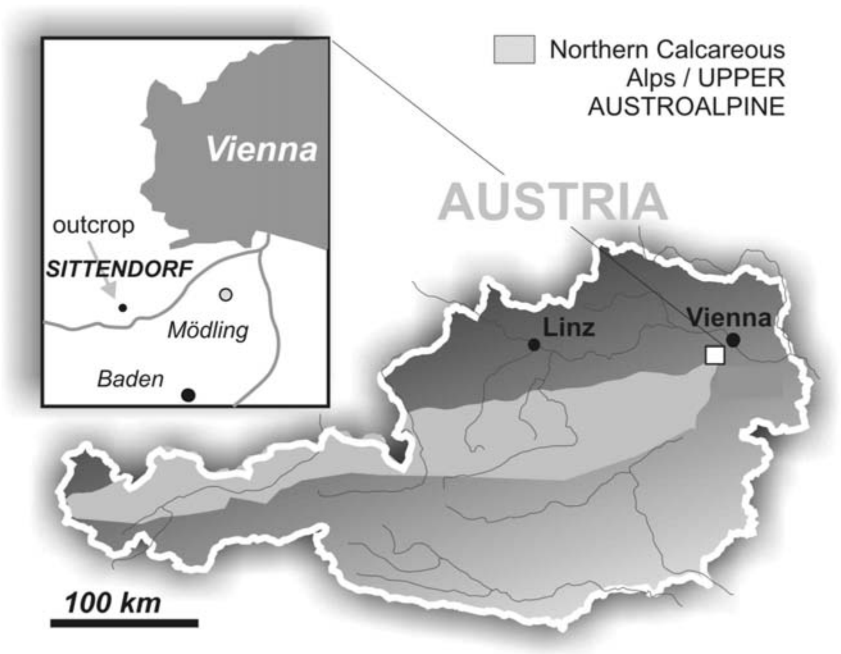


Fig. 1. Geographic position and regional geologic setting of the studied outcrop at Sittendorf.

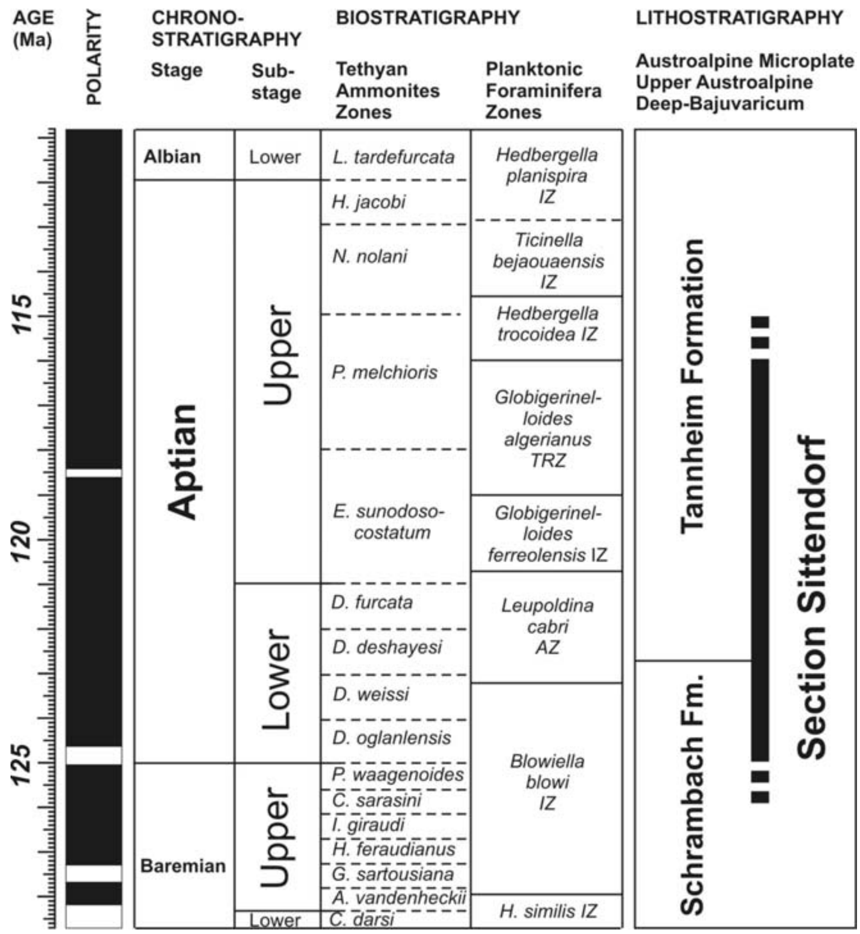


Fig. 2. Stratigraphic Correlation Table (modified after Ogg et al. 2004)

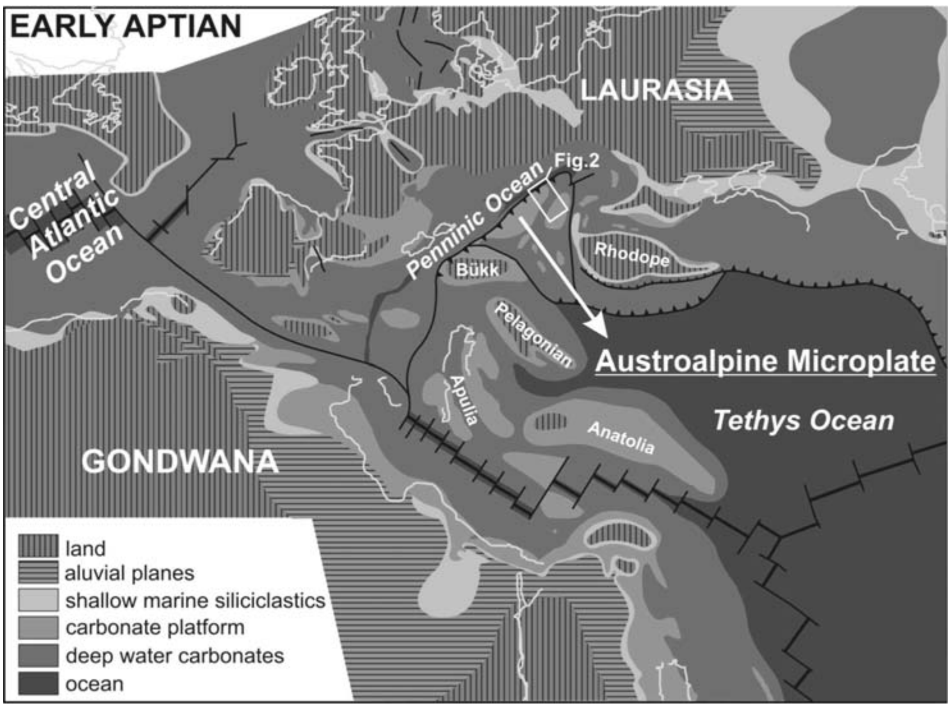


Fig. 3. Palinspastic setting and position of the Penninic Ocean subduction (modified after Masse et al. 2000)

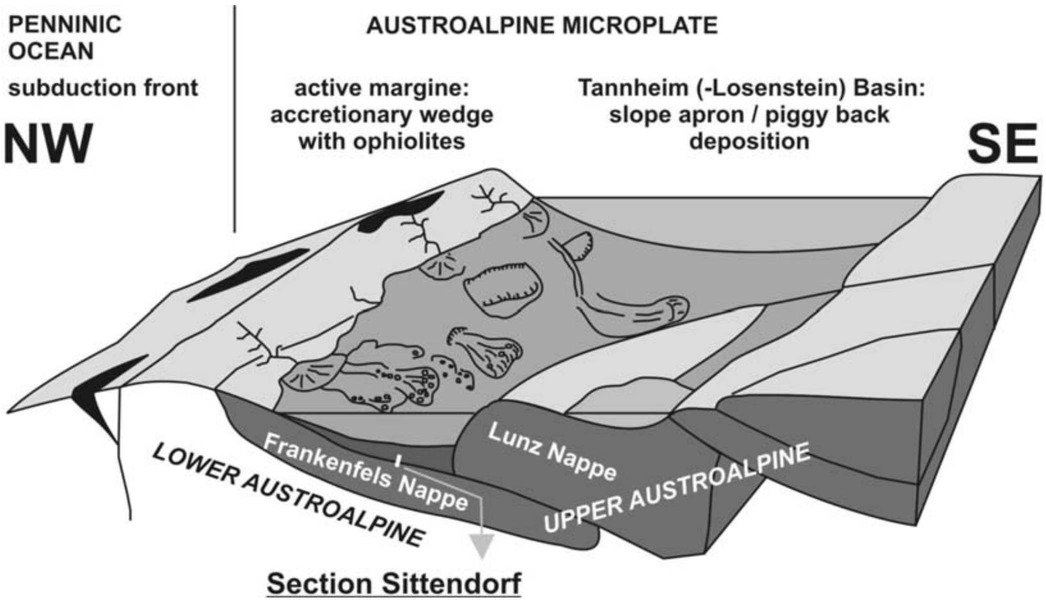


Fig. 4. Schematic paleogeographic reconstruction of the Tannheim Basin with indicated position of the Sittendorf Section (modified after Wagreich 2003)

Fig. 5. Outcrop Sittendorf with indicated sample positions, including lithostratigraphic and chronostratigraphic results of the present study.

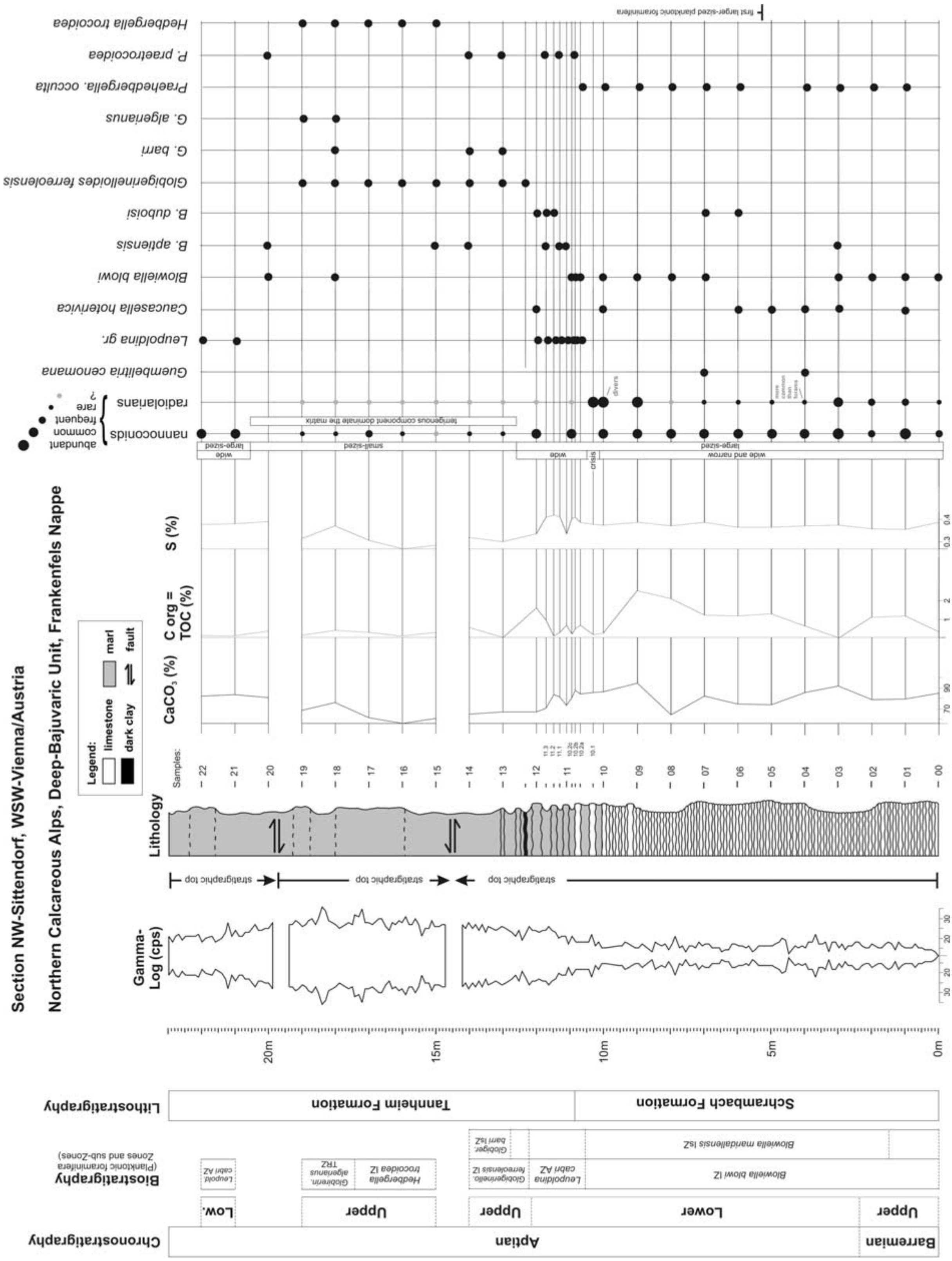


Fig. 6. Section Sittendorf showing the lithostratigraphic, biostratigraphic and chronostratigraphic interpretation. Indicated are lithologies, sampling positions, distribution of radiolarians, nannoconids and selected planktonic foraminifera as well as results of geochemical and geophysical investigations.

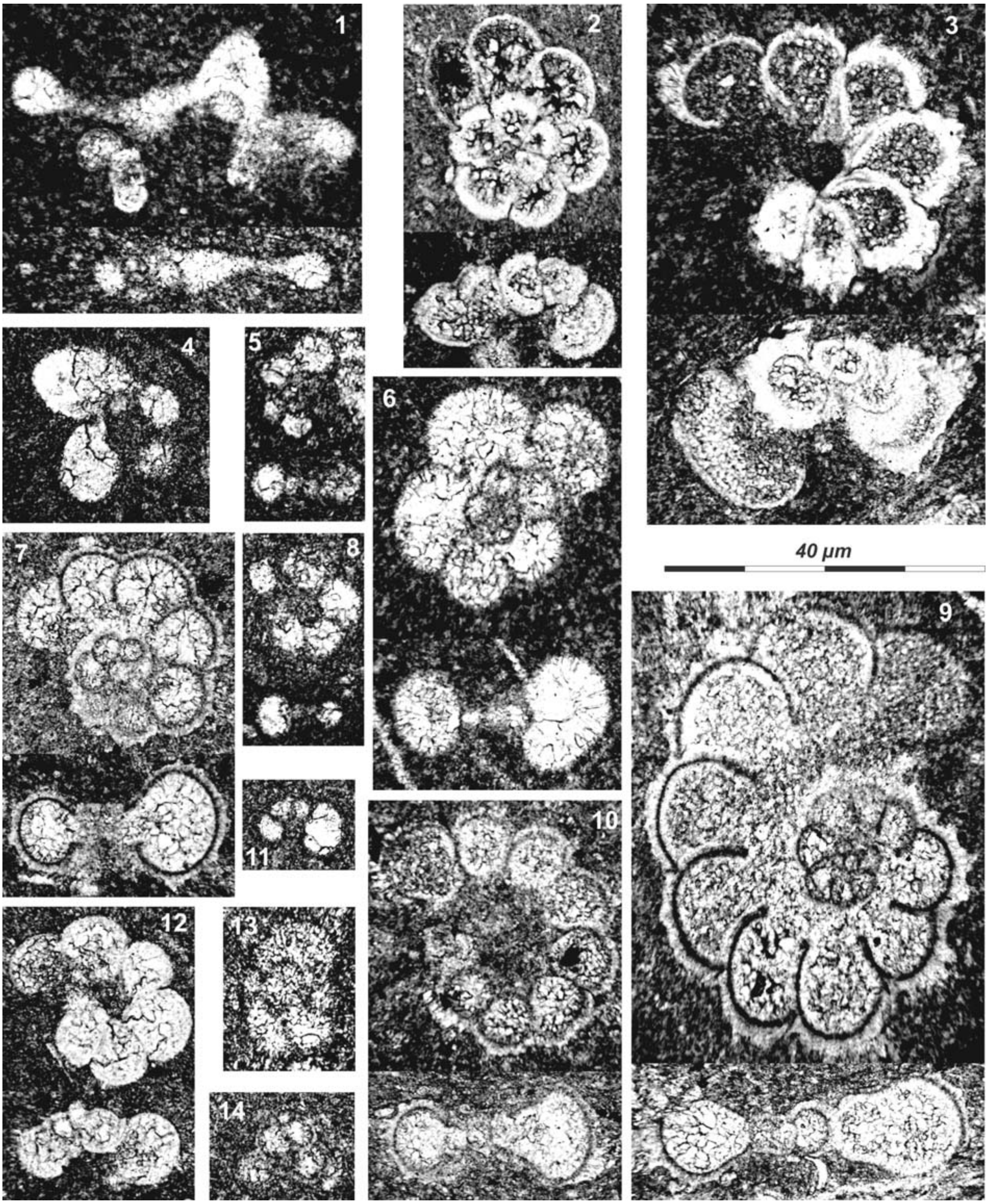


Fig. 7. 1, *Leupoldina cabri - pustulans* Group, Sittendorf (SI) 10.2b. 2-3, *Hedbergella trocoidea*. 2, SI 18. 3, SI 16. 4, *Blowiella duboisi*, SI 06. 5, *Blowiella aptiensis*, SI 03. 6, 8, *Blowiella blowi*, 6, SI 10.2b. 8, SI 01. 7, *Globigerinelloides ferreolensis*. 7, above, SI 13. 7, below, SI 14. 9, *Globigerinelloides algerianus*. 9, above, SI 18. 9, below, SI 19. 10, *Globigerinelloides barri*, SI 14. 11, *Praehedbergella occulta*, SI 04. 12, *Praehedbergella praetrocoidea*, SI 13. 13, *Caucasella hoterivica*, SI 13. 14, *Guembelitria cenomana*, SI 04.

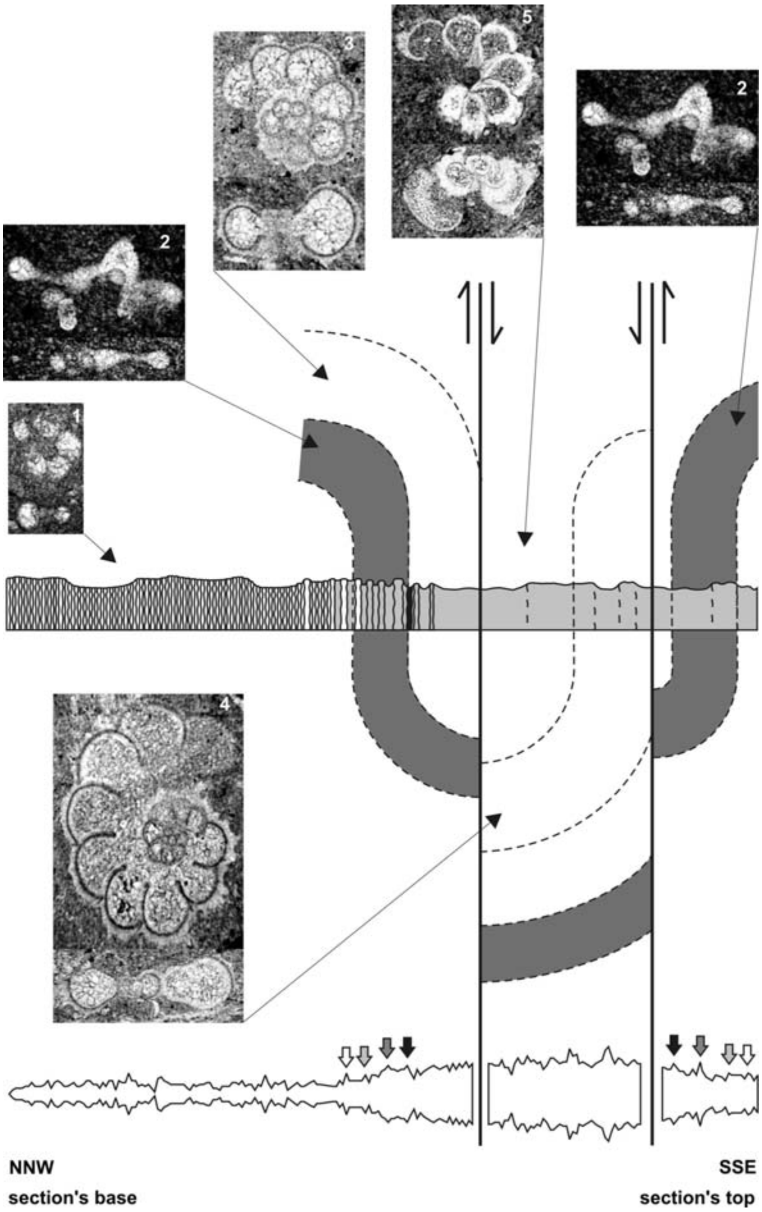


Fig. 8. Tectonic interpretation of the Section Sittendorf based on the evaluation of biostratigraphic and geophysical data. Each thin section photograph represents the name-giving taxon of the indicated biozone: 1: *B. blowi* Interval Zone (IZ), 2. *L. cabri* Acme Zone, 3. *G. ferreolensis* IZ, 4. *G. algerianus* Taxon Range Zone, 5. *H. trocoidea* IZ.

Adresses and Affiliations

Roque **AGUADO**
Universidad de Jaén, Departamento de Geología, Escuela Universitaria Politécnica de Linares, Alfonso X El Sabio 28, 23071 Linares
Spain
e-mail: raguado@ujaen.es

Ricardo **BARRAGÁN-MANZO**
Departamento de Paleontología, Instituto de Geología, UNAM. Ciudad Universitaria, Coyoacán, C. P. 04510, México, D. F.
MÉXICO
e-mail: rbarra01@hotmail.com

Rufus J. **BERTLE**
GEOGNOS Bertle ZT GmbH,
Kronengasse 6
A–6780 Schruns
Austria
e-mail: rufus.bertle@geologie-bertle.at

Miguel **COMPANY**
Universidad de Granada, Departamento de Estratigrafía y Paleontología, Facultad de Ciencias,
Campus de Fuentenueva s/n, 18002 Granada
Spain
e-mail: mcompany@ugr.es

Luis **O'DOGHERTY**-
Universidad de Cádiz, Departamento de Ciencias de la Tierra, Facultad de Ciencias del Mar y Ambientales
Campus del Río San Pedro, 11510 Puerto Real
Spain
e-mail: luis.odogherty@uca.es

Hans **EGGER**
Geological Survey of Austria
Neulinggasse 38
A-1030 Vienna
Austria
e-mail: johann.egger@geologie.ac.at

Attila **FOGARASI**
MOL Rt.
Budapest, 1039
Batthyány u. 45
e-mail: AFogarasi@mol.hu

Istvan **FÖZY**
Hungarian Natural History Museum
Department of Palaeontology
1431 Budapest, Pf. 137
Budapest
e-mail: fozy@nhmus.hu

Joaquin **GARCÍA-MONDÉJAR**
Departamento de Estratigrafía y Paleontología
Facultad de Ciencia y Tecnología
Universidad del Pais Vasco
Apartado 644
48080 Bilbao
Spain
e-mail: joaquin.garciamondejar@ehu.es

Holger **GEBHARDT**
Geologische Bundesanstalt
Neulinggasse 38
A-1030 Vienna
Austria
e-mail: gebhol@geologie.ac.at

Celestina **GONZÁLEZ ARREOLA**
Departamento de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510, Mexico, D.F.
Mexico
e-mail: arreola@servidor.unam.mx

Eva **HALÁSOVÁ**
Department of Geology and Palaeontology
Faculty of Natural Sciences, Comenius University
Mlynská dolina G-1
842 15 Bratislava,
Slovak Republic
e-mail: halasova@fns.uniba.sk

Malcolm B. **HART**
School of Earth, Ocean & Environmental Sciences,
University of Plymouth,
Drake Circus, Plymouth PL4 8AA,
United Kingdom
e-mail: M.Hart@plymouth.ac.uk

Nico M.M. **JANSSEN**
Geertekerkhof 14bis
3511 XC Utrecht
The Netherlands
e-mail: hibolithes@hotmail.com

Andreas **KROH**
Natural History Museum,
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: andreas.kroh@nhm-wien.ac.at

Iskra LAKOVA
Geological Institute
Bulgarian Academy of Sciences
1113 Sofia
Bulgaria
e-mail: lakova@geology.bas.bg

Michael **LEIN**
Department for Geological Sciences
University Vienna
Althanstrasse 14
A-1090 Vienna
e-mail: richard.lein@univie.ac.at

Gregori **LÓPEZ**
Dep. Geologia (Paleontologia),
Facultat de Ciencies
Universitat Autònoma de Barcelona
E-08193 Bellaterra
Spain
e-mail: gregori.lopez@uab.es

Alexander **LUKENEDER**
Natural History Museum,
Geological-Palaeontological Department
Burgring 7
A-1010 Vienna
Austria
e-mail: alexander.lukeneder@nhm-wien.ac.at

Oleg **MANDIC**
Natural History Museum
Department of Geology and Palaeontology
Burgring 7, A-1010, Vienna
Austria
e-mail: oleg.mandic@nhm-wien.ac.at

Florentin J-M. R. **MAURRASSE**
Department of Earth Sciences, Florida International University, University Park Campus, Miami, Florida, 33199
U.S.A
e-mail: maurrass@fiu.edu

Jean-Michel **MAZIN**
UMR CNRS 5125 PEPS
Université Claude Bernard Lyon 1 - Campus de la Doua
2 rue Dubois – Bâtiment Géode
69622 VILLEURBANNE Cedex
France
e-mail: jean-michel.mazin@univ-lyon1.fr

Vasili **MITTA**
Paleontological Institute, Russian Academy of Sciences
Profsoyuznaya 123, Moscow 117997
Russia
e-mail: mitta@paleo.ru

Lourdes **OMAÑA**
Departamento de Paleontología, Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510, Mexico, D.F.
Mexico.
e-mail: lomanya@geologia.unam.mx

Hugh G. **OWEN**
Department of Paleontology
The Natural History Museum
Cromwell Road
London SW7 5BD
e-mail: e-mail: l.steel@nhm.ac.uk

Inmaculada **PALOMA**
Universidad de Granada, Departamento de Mineralogía y Petrología, Facultad de Ciencias
Campus de Fuentenueva s/n, 18002 Granada
Spain
e-mail: ipalomo@ugr.es

Joane POUECH
UMR CNRS 5125 PEPS
Université Claude Bernard Lyon 1 - Campus de la Doua
2 rue Dubois – Bâtiment Géode
69622 VILLEURBANNE Cedex
France
e-mail: joane.pouech@pepsmail.univ-lyon1.fr

Gregory D. **PRICE**
School of Earth, Ocean and Environmental Sciences
University of Plymouth
Drake Circus
Plymouth, Devon, PL4 8AA
United Kingdom
e-mail: G.Price@plymouth.ac.uk

Petr **PRUNER**
Paleomagnetic laboratory
Institute of Geology
ASCR vvi.
Rozvojová 269
Praha 6
Czech Republic
e-mail: Pruner@gli.cas.cz

Michaela **RADL**
University of Graz, Institute of Earth Sciences (Geology and Palaeontology)
Heinrichstrasse 26
A-8010 Graz
Austria
e-mail: 04radlmi@stud.uni-graz.at

Seyed Naser **RAISOSSADAT**
Geology Department
Birjand Univerity, Faculty of Science
P.O.Box 97175/ 615, Birjand
Iran
e-mail. snaser_rais@yahoo.co.uk

Margarita **RAMÍREZ GARZA**
Posgrado en Ciencias de la Tierra
Instituto de Geología
Universidad Nacional Autónoma de México
Mexico
e-mail: maggiergarza@gmail.com

Peter F. **RAWSON**
Department of Earth Sciences
University College London
Gower Street
WC1E 6BT
London
UK
e-mail: peter.rawson1@btinternet.com

Stéphane **REBOULET**
UFR Géosciences, UMR 5125, PEPS – Bâtiment Géode,
Rue Raphaël Dubois, Université Lyon I
F-69622 Villeurbanne cedex
France
e-mail: Stephane.Reboulet@univ-lyon1.fr

Daniela **REHÁKOVÁ**
Geological Institute of Slovak Academy of Sciences
Dúbravská cesta 9, 842 26 Bratislava, Slovakia; Department of Geology and Palaeontology, Faculty of Natural Sciences, Comenius University,
Mlynská dolina G 1, 842 12 Bratislava
Slovakia
e-mail: rehakova@nic.fns.uniba.sk

Reinaldo **ROJAS-CONSUEGRA**
Museo Nacional de Historia Natural
Obispo 61, Plaza de Armas
Habana Vieja, C. P. 10100, C. Habana
CUBA
e-mail: rojas@mnhnc.inf.cu

José **SANDOVAL**
Universidad de Granada, Departamento de Estratigrafía y Paleontología, Facultad de Ciencias,
Campus de Fuentenueva s/n,
18002 Granada
Spain
e-mail: sandoval@ugr.es

Petr **SCHNABL**
PhD student
Paleomagnetic laboratory
Institute of Geology, ASCR vvi.
Rozvojová 269
Praha 6
Czech Republic
e-mail: schnabl@gli.cas.cz

Klaus **SCHWERD**
Bavarian Environment Agency
Geological Survey
Lazarettstraße 67
D-80636 Munich
Germany
e-mail: Klaus.Schwerd@lfu.bayern.de

Ali **SOLIMAN**
Austrian Academy of Sciences, Commission for the Palaeontological and Stratigraphical Research of Austria c/o University of Graz, Institute of Earth Sciences (Geology and Palaeontology)
Heinrichstrasse 26
A-8010 Graz
Austria
or
Geology Department / Faculty of Science
Tanta University
Tanta, 31527
Egypt
e-mail: ali.soliman@uni-graz.at

Herbert **SUMMESBERGER**
Natural History Museum Vienna, Department of Geology and Palaeontology
Burgring 7
A-1010 Vienna
Austria
e-mail:herbert.summesberger@nhm-wien.ac.at

Thomas J. **SUTTNER**
Austrian Academy of Sciences, Commission for the Palaeontological and Stratigraphical Research of Austria c/o University of Graz, Institute of Earth Sciences (Geology and Palaeontology), Heinrichstrasse 26
A-8010 Graz
Austria
e-mail: thomas.suttner@uni-graz.at

Ottilia **SZIVES**
Hungarian Natural History Museum,
Department of Palaeontology
1088 Ludovika tér 2
H-1431 Budapest
Hungary
e-mail: sziveso@nhmus.hu

José M. **TAVERA**
Universidad de Granada, Departamento de Estratigrafía y Paleontología
Facultad de Ciencias
Campus de Fuentenueva s/n, 18002 Granada
Spain
e-mail: jtavera@ugr.es

Alfred **UCHMAN**
Institute of Geological Sciences
Jagiellonian University
Oleandry 2a
30-063 Kraków
Poland
e-mail: alfred.uchman@uj.edu.pl

Michael **WAGREICH**
Department for Geological Sciences
University Vienna
Althanstrasse 14
A-1090 Vienna
e-mail: michael.wagreich@univie.ac.at

Helmut **WEISSERT**
D-ERDW, ETH-Zürich
CH-8092 Zürich
Switzerland
e-mail: helmut.weissert@erdw.ethz.ch