GEOLOGICA CARPATHICA, DECEMBER 2005, 56, 6, 483–491

Hauterivian calciturbidites within the Schrambach Formation (Kaltenleutgeben section, Lunz Nappe, Northern Calcareous Alps, Lower Austria)

ALEXANDER LUKENEDER[1] and FELIX SCHLAGINTWEIT[2]

[1]Natural History Museum, Department of Geology and Paleontology, Burgasse 7, A-1010 Vienna, Austria;
alexander.lukeneder@nhm-wien.ac.at
[2]Lerchenauerstr. 167, D-80935 Munich, Germany; EF.Schlagintweit@t-online.de

(Manuscript received November 10, 2004; accepted in revised form June 16, 2005)

Abstract: A single turbiditic coarse limestone layer (thickness up to 10 cm), interpreted as distal calciturbidite, is described for the first time from the Lower Cretaceous Schrambach Formation of the Lunz Nappe (Kaltenleutgeben section, Northern Calcareous Alps). It is composed almost exclusively of bioclasts derived from echinoids (about 50 %), bryozoans, coralline red algae, foraminifers, and remains of stromatoporoids and belemnoids; calcareous green algae are missing. The stratigraphic age of this layer is Late Hauterivian based on the findings of the *Euptychoceras* Abundance Zone. The biota, indicate a source area in an upper slope position marking the transition to shallow-water areas. This is the first record of a shallow-water evolution in the Northern Calcareous Alps from the time-interval between the Barmstein limestones (Late Tithonian–Late Berriasian), the Plassen Formation (up to Early/Middle Berriasian) and the allochthonous Urgonian limestones (since Late Barremian onwards). A relationship to equivalent biodetritus within the Rossfeld Formation, which currently lacks biostratigraphic data, is possible. Finally, transportation from southern directions is assumed due to the occasional occurrence of chrome spinel and the nappe tectonic position of the locality.

Key words: Hauterivian, Austria, Northern Calcareous Alps, Schrambach Formation, ammonoids, microfacies, calciturbidites.

Introduction

The study area within the Northern Calcareous Alps was situated on the eastern border of the Alpine-Carpathian Block, along the western margin of the Tethys Sea, during the Early Cretaceous as noted by many authors (for example Cecca 1997, 1998; Vašíček & Michalík 1999; Stampfli & Mosar 1999).

Lower Cretaceous pelagic sediments (e.g. Schrambach, Rossfeld, Tannheim and Losenstein Formations) were deposited on major elements of the northern tectonic units of the Northern Calcareous Alps, such as the Ternberg, Reichraming, Frankenfels, and Lunz Nappes, where they cover wide areas within the Northern Calcareous Alps (e.g. Rossfeld, Losenstein, Schneeberg, Anzenbach, Ebenforst, and Flössel Synclines and in several other Alpine areas of Europe (e.g. Vocontian Basin, Dolomites, Umbria, Western Carpathians, Gerecse and Mecsek Mountains, among others).

The earliest publications dealing with the section at Kaltenleutgeben situated in the Flössel Syncline were by Richarz (1905, 1908). Schwinghammer (1975) reported a low-diversity fauna and described a section from the same locality. The most recent contribution on the ammonoid fauna and stratigraphy of this locality was by Lukeneder (2003). He proposed a system of several ammonoid 'abundance zones' for a detailed stratigraphy of the Lower Cretaceous sediments. The benthic foraminifers of the Kaltenleutgeben section were investigated by Weidich (1990: p. 62), who noted an impoverished microfauna consisting of some *Lenticulina* and *Spirillina* and scarce radiolarians, which did not allow precise dating. The outcrop and logs described in the present paper are visible in the quarry today and lie 100 meters above the location described by Schwinghammer (1975).

Geological setting

The investigated outcrop is an abandoned quarry at the Flösselberg near Kaltenleutgeben (Fig. 1). It is situated in the Lunz Nappe, one of the Bajuvaric tectonic units of the Northern Calcareous Alps (Lukeneder 1999, 2003) consisting of steep synclines and anticlines (e.g. Höllenstein Anticline, Flössel Syncline). The Flössel Syncline at the Flösselberg is formed of Upper Triassic dolomite and the Kössen Formation, followed by a reduced Jurassic succession consisting of the Ruhpoldinger Radiolarite and the Allgäu Formation (see also Toula 1886; Spitz 1910; 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 (Fig. 2). Within the Lunz Nappe the Schrambach Formation comprises Upper Valanginian to Lower Barremian sediments.

The Lower Cretaceous Schrambach Formation is a deep-water limestone/marl sequence marked by intercalated turbiditic sandstones. A short-term sedimentation is proposed for the turbidite sandstone layers, whereas the

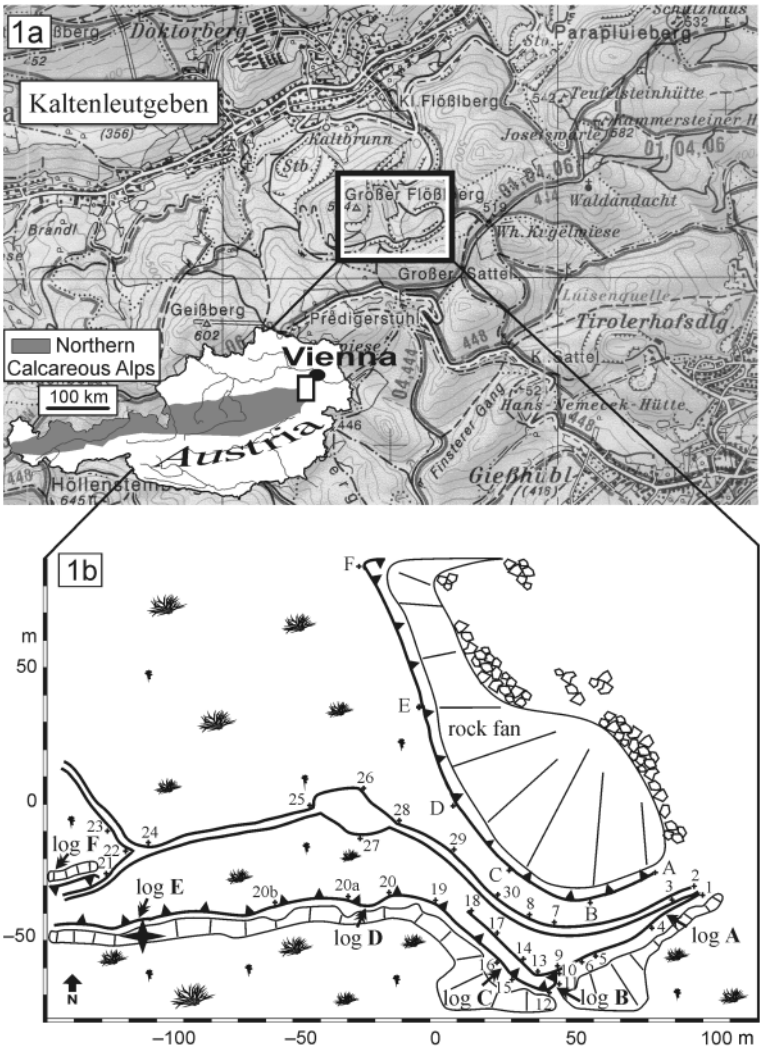

Fig. 1. The excavation site south of Kaltenleutgeben. **a** — The rectangle indicates the area of sketch map below. **b** — Horizontal projection of the outcrop area around Kaltenleutgeben with indicated position of the calciturbidite bed, black cross near log E (after Lukeneder 2003).

limestone/marl rhythmites reflect the 'normal' deep-water limestone sedimentation rates.

The dark marls and grey-spotted limestones are intensively bioturbated biogenic mudstones to wackestones. The occurrence of chrome spinel in the terrigenous sandstones supports the assumption that the turbiditic intercalations in the Schrambach Formation of the Reichraming Nappe (Upper Austria), are equivalent to the Lunz Nappe. It also supports the interpretation that the turbiditic sandstones were derived from a more southerly source area (Decker et al. 1987; Vašíček et al. 1994; Vašíček & Faupl 1998).

The paleogeographical reconstruction of the investigated area for the Early Cretaceous shows that the sedimentation of the turbiditic sandstones in the internal and eastern parts of the Northern Calcareous Alps (southernmost parts of the Bajuvaric Unit) may be related to an uplift of the most southern parts. This reflects either the beginning of the subduction of the Penninic Ocean in the north and/or the obduction of oceanic crust of the former Vardar Ocean at the boundary of the Austroalpine/Southern Alps (e.g. Schlagintweit 1991).

The basal part of the succession is characterized by its higher content of sandy intercalations (Fig. 2). Based on the occurrences in the western parts of the NCA, this development been unfortunately designated as Rossfeld Formation (Geol. Map 1:50,000, sheet 58 Baden; Schnabel 1997). According to our interpretation, however, the proximal Rossfeld Formation with a deep-water clast facies is situated more to the south (southern parts of the Reichraming Nappe, and not in the northernmost parts of the NCA). Our interpretation is in agreement with Vašíček et al. (1994), who included the limestones with turbiditic sandstone intercalations into the Schrambach Formation (located in the northern Reichraming Nappe), and not into the Rossfeld Formation (Schnabel 1997).

Lithology and microfacies of the calciturbidites

The Upper Hauterivian succession of the easternmost parts of the Northern Calcareous Alps was deposited on an unstable shelf setting characterized by thick limestone/marl units reflecting transgressive histories punctuated by tectonic events, as shown by the deposition of sandstones and calciturbidites.

At the Kaltenleutgeben section, the Lower Cretaceous is represented by a single formation: the Schrambach Formation (approx. 150 m), with a stratigraphic range of Late Valanginian–Early Barremian. The section consists of grey marly limestones, ocher calcareous marls and grey silty marlstones accompanied by sandstones and a single calciturbidite bed. The $CaCO_3$-content of the limestones and marly limestones varies between 56 and 89 %. TOC values range from 0.2 up to 7.3 % and the sulphur contents attain 0.1 to 1.5 mg/g. The highest TOC values of about 7.3 % occur in distinct single, black to dark-grey limestone beds which indicate dysoxic to anoxic deposits.

The intercalated calciturbidite bed occur in an irregular layer from 2–10 cm in thickness and shows wavy, irregular boundaries. Lower boundary is sharp, whereas the top of the layer passes more gradually into a 'normal micritic limestone bed'. This redeposited layer shows the typical brightness of echinoderm debris on their broken surfaces.

The following data concerning microfacies and micropaleontology refer to sample Ka 110, from which 20 thin-sections were prepared. The material examined is stored in the paleontological collection of the Natural History Museum, Vienna, Austria (NHMW).

The calciturbidite bed consists of bioclastic grainstones. Biogenic components (0.5 to 1.0 mm in diameter) are domi-

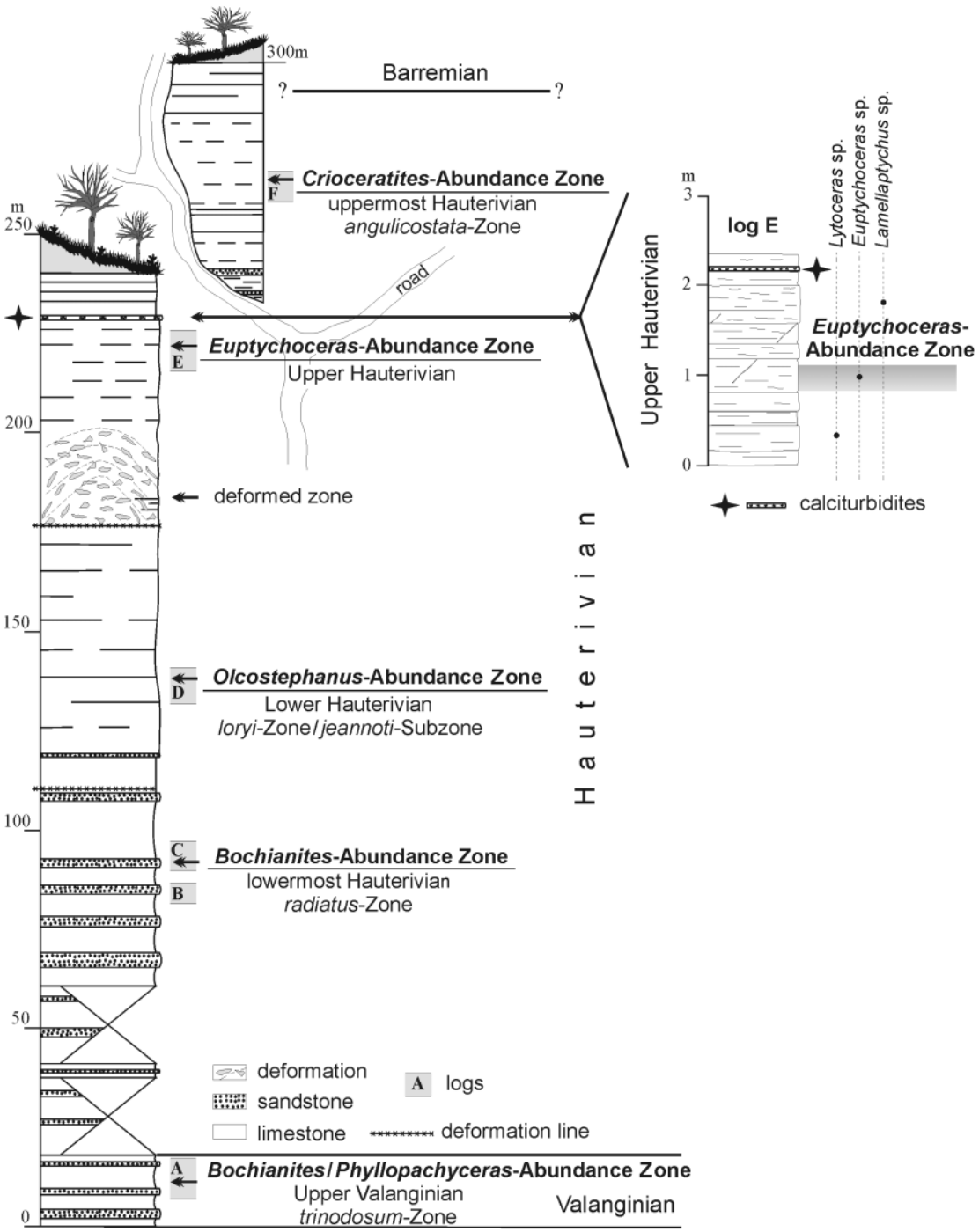

Fig. 2. Composite lithological log of the whole Schrambach Formation from the section Kaltenleutgeben with indicated stratigraphy and positions of the calciturbidite bed (black cross in log E).

nated by echinoid fragments (about 50 %), bryozoans, mollusc and brachiopod shells, benthic foraminifers, serpulid tubes, calcareous algae (e.g. Corallinaceae), and remains of pharetronid sponges and stromatoporoids (Figs. 3 and 4). Due to the typical orthogonal microstructure (with dark median line) the stromatoporoid fragments can probably be referred to *Actinostromaria*. Sections of belemnoids are also present. Cross-sections are comparably frequent of *Carpathiella triangulata* Mišík, Soták et Ziegler, interpreted as serpulid tubes (Mišík et al. 1999; Schlagintweit et al. 2003b).

The low-diversity microfauna includes textulariids, arenaceous encrusting foraminifers, *Charentia* sp. and calcareous foraminifers, most typically *Lenticulina* sp., *Spirillina* sp. and more rarely *Neotrocholina* sp. Amongst the calcareous algae, the absence of green algae such as dasycladales is striking. Instead, fragments of coralline red algae including *Parakymalithon phylloideum* (Bucur et Dra-

gastan) Moussavian, peyssonelliacean red algae with *Polystrata alba* (Pfender) Denizot and, scattered remains of *Marinella lugeoni* Pfender, which is interpreted as an ancestral Rhodophyceae by Leinfelder & Werner (1993) occur (Fig. 4). In addition scattered fragments of the colonial microorganism incertae sedis *Koskinobullina socialis* Cherchi et Schroeder were observed.

Some echinoid fragments and bryozoan skeletons show impregnation by glauconite, which can also occur as single grains. Occasionally, small grains of chrome spinel are visible. Due to the fine grain-size and the comparably good sorting, the layer of the Kaltenleutgeben section are recognized as a distal calciturbidite.

Stratigraphy

Twenty-three genera of Lytoceratina, Phylloceratina, Ammonitina and Ancyloceratina (suborders), comprising 25 different species, were reported from the whole Kaltenleutgeben section in a recent paper by Lukeneder (2003). The cephalopods are especially enriched in certain levels (ammonoid "abundance zones"; see Salvador 1994; Steininger & Piller 1999). The following important genera were determined: *Lytoceras*, *Leptotetragonites*, *Phylloceras*, *Phyllopachyceras*, *Oosterella*, *Olcostephanus*, *Haploceras*, *Kilianella*, *Thurmanniceras*, *Eleniceras*, *Spitidiscus*, *Acanthodiscus*, *Leopoldia*, *Neocomites*, *Barremites*, *Pulchellia*, *Himantoceras*, *Crioceratites*, *Bochianites*, *Karsteniceras*, *Euptychoceras*, *Hamulina* and *Anahamulina*. For a detailed list of the ammonoid species see Lukeneder (2003). Most ammonoid species are of poor biostratigraphic use.

According to Lukeneder (2003) the *Euptychoceras*-Abundance Zone hints at a Late Hauterivian age for the interval around the calciturbidte layers (see also Vašíček et al. 1994, '*Euptychoceras* beds'). Vašíček et al. (1994) reported abundant occurrences of *Euptychoceras* from the *Plesiospitidiscus ligatus* Zone from the central Western Carpathians. Similar occurrences of euptychoceratids were stated from the Reichraming Nappe (Upper Austria) by Vašíček & Faupl (1999). According to the latter authors the *Euptychoceras*-abundance in the Reichraming Nappe is located in the *Subsaynella sayni* Zone. At the investigated section the *Euptychoceras*-Abundance Zone is located between the *Olcostephanus (J.) jeannoti*-Abundance Zone and the *Crioceratites krenkeli*-Abundance Zone (Fig. 5). *Olcostephanus (J.) jeannoti* is the index fossil of the *jeannoti* Subzone within the *Crioceratites loryi* Zone (middle Early Hauterivian). *Crioceratites loryi* (Sarkar), the index ammonite for the *loryi* Zone and for the *loryi* Subzone, was also detected about 40 meters below the calciturbidites. The occurrence of *Crioceratites krenkeli* hints at the *Pseudothurmannia angulicostata* Zone (latest Hauterivian) (Hoedemaeker et al. 2003).

Based on the latter implementations and the intermediate position of the *Euptychoceras*-Abundance Zone, the intercalated calciturbidite bed is assumed to be of early Late Hauterivian age.

The microfossils resedimented in the calciturbidite do not allow a precise dating. Only the occurrence of the corallinaceans led to a minimum age of Early Hauterivian, which is the oldest indicator so far recorded in the literature (Arias et al. 1995; Aguirre et al. 2000). *Parakymalithon phylloideum* (Bucur et Dragastan) Moussavian was so far only known from Barremian to Aptian strata (Bucur & Dragastan 1986; Moussavian 1987). Recent findings presented in this paper make it necessary to enlarge its stratigraphic range up to the Late Hauterivian. The species has already been recorded by Moussavian (1987) from the upper portion of the Rossfeld Formation, assigned to the Late Barremian–Early Aptian.

Discussion and comparisons

As reported by Faupl (1979), three turbidite intervals occur within the Cretaceous sequence of the Austroalpine unit during three different time periods, representing characteristic phases in the Alpine Orogeny: **1** — in the lower part of the Lower Cretaceous, **2** — in the uppermost part of the Lower Cretaceous to mid-Cretaceous and **3** — within the Upper Cretaceous (Gosau) (see also Decker et al. 1987).

In the general paleogeographical and biostratigraphic framework, the calciturbidite layer of the Kaltenleutgeben section enables a comparison with the Barmstein limestones, the Rossfeld Formation (see also Vašíček & Faupl 1998), and allodapic Urgonian limestones. It is noteworthy that no records of a shallow-water facies have been reported in the Northern Calcareous Alps between the Barmstein Limestones (Late Tithonian–Early/Middle Berriasian according to Gawlick et al. in print; after Boorová et al. 1999 up to Late Berriasian; see also Lukeneder et al. 2003) and the oldest allodapic Urgonian limestones of Late Barremian age (Hagn 1982).

The Barmstein Limestones are mass-flow deposits that occur as intercalations in the basinal facies of the Oberalm Formation of the Tauglboden Basin (Steiger 1981; Gawlick et al. in print). It belongs tectonically to the Lower Tyrolic Unit sensu Gawlick & Frisch (2003). The redeposited carbonate material of the Barmstein Limestones has been derived from the Trattberg rise at the boundary of the Lower–Upper Tyrolic Nappe (for explanation see Gawlick & Frisch 2003). The Barmstein Limestones are characterized by densely packed grainstones (lithoclasts and bioclasts), predominantly of the Plassen Formation of different facies zones (slope, platform margin, back-reef, closed lagoon). At the type-locality, the Barmstein near Hallein (Salzburg), extraclasts of older strata of Jurassic and Late Triassic age also occur.

Remains of coralline red algae such as *Sporolithon rude* (Lemoine), bryozoans, and echinoids are known as bioclasts in sandstones of the Rossfeld Formation (Schlagintweit 1991: p. 54). It is worth mentioning that lenticulinids and neotrocholinids have already been recorded by Faupl & Tollmann (1979) from the marly lower parts of the Rossfeld Formation. The occurrence of calcareous algae in the Schrambach Formation could either be derived from a

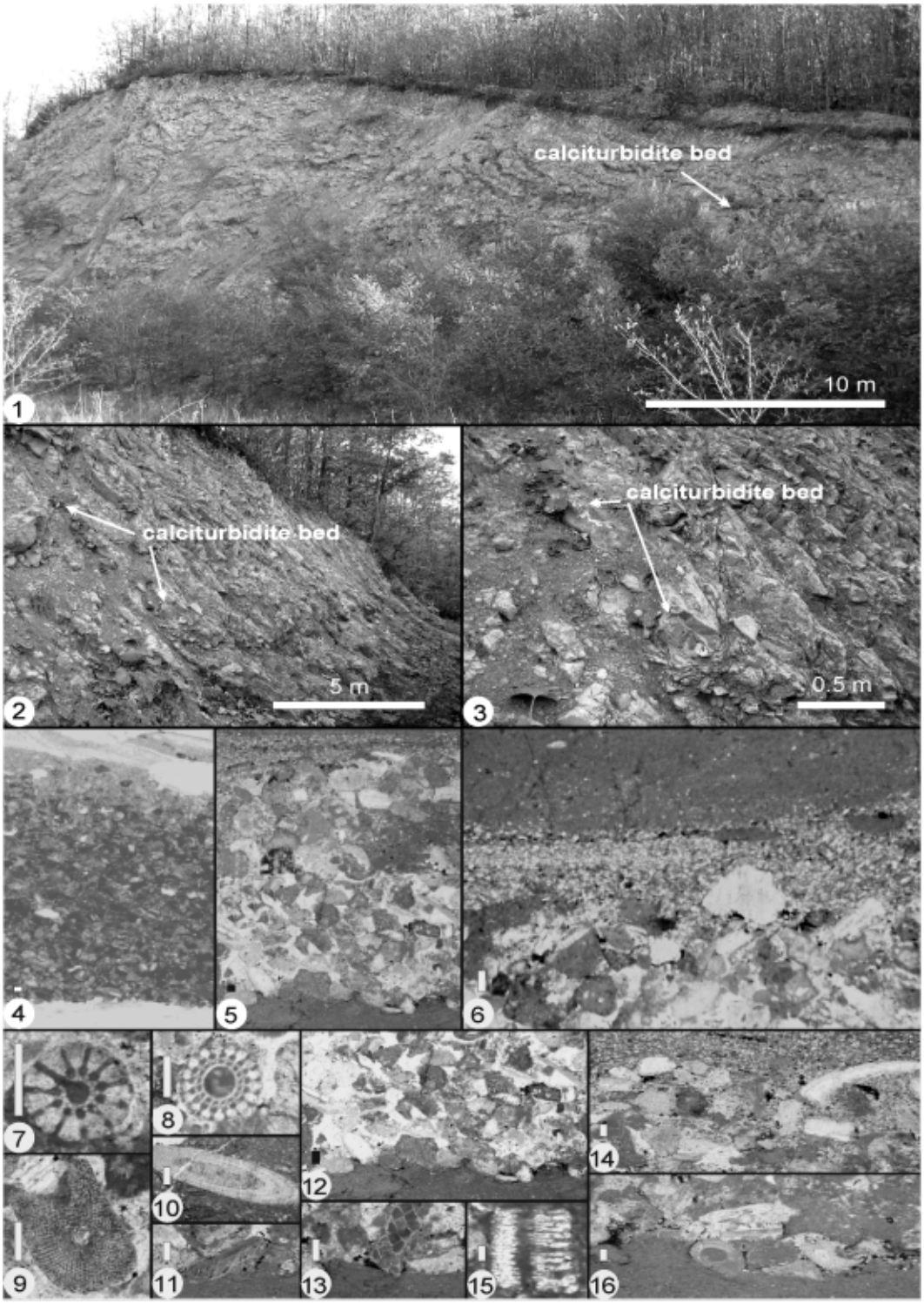

Fig. 3. Position and outcrop situation at the Kaltenleutgeben locality. Facies and abundant fossil groups of the calciturbidite (thin sections). **1** — Overview of the Hauterivian limestones of the Kaltenleutgeben outcrop. Calciturbidites are situated at the right margin of the photograph. **2** — Detailed position of the calciturbidite bed. **3** — Enlarged area of Fig. 2 with calciturbidite layer in the middle. **4** — Polished section of the calcitutbidite bed with transition in marly limestone to the top; 2004z0168/0001. **5** — Enlarged thin sections of the calcitutbidite bed with bottom and top; 2004z0155/0004. **6** — Top transitional section of the calcitutbidite bed. Normal grading; 2004z0164/0001. **7** — Echinoid spine; 2004z0157/0001. **8** — Echinoid spine; 2004z0156/0001. **9** — Crinoid brachial; 2004z0165/0001. **10** — Belemnite rostrum; 2004z0166/0001. **11** — *Lamellaptychus* sp.; 2004z0155/0002. **12** — Bottom of the calciturbidite bed in thin section. Note sharp boundary; 2004z0155/0004. **13** — Bryozoan colony at the bottom of the calciturbidite bed; 2004z0160/0001. **14** — Top transitional section of the calcitutbidite bed. Normal grading; 2004z0155/0003. **15** — Crinoid stem fragment; 2004z0157/0002. **16** — Bottom transitional section of calcitutbidite bed. Note sharp boundary; 2004z0159/0001. Scale bar: Figs. 4–16 = 0.2 mm.

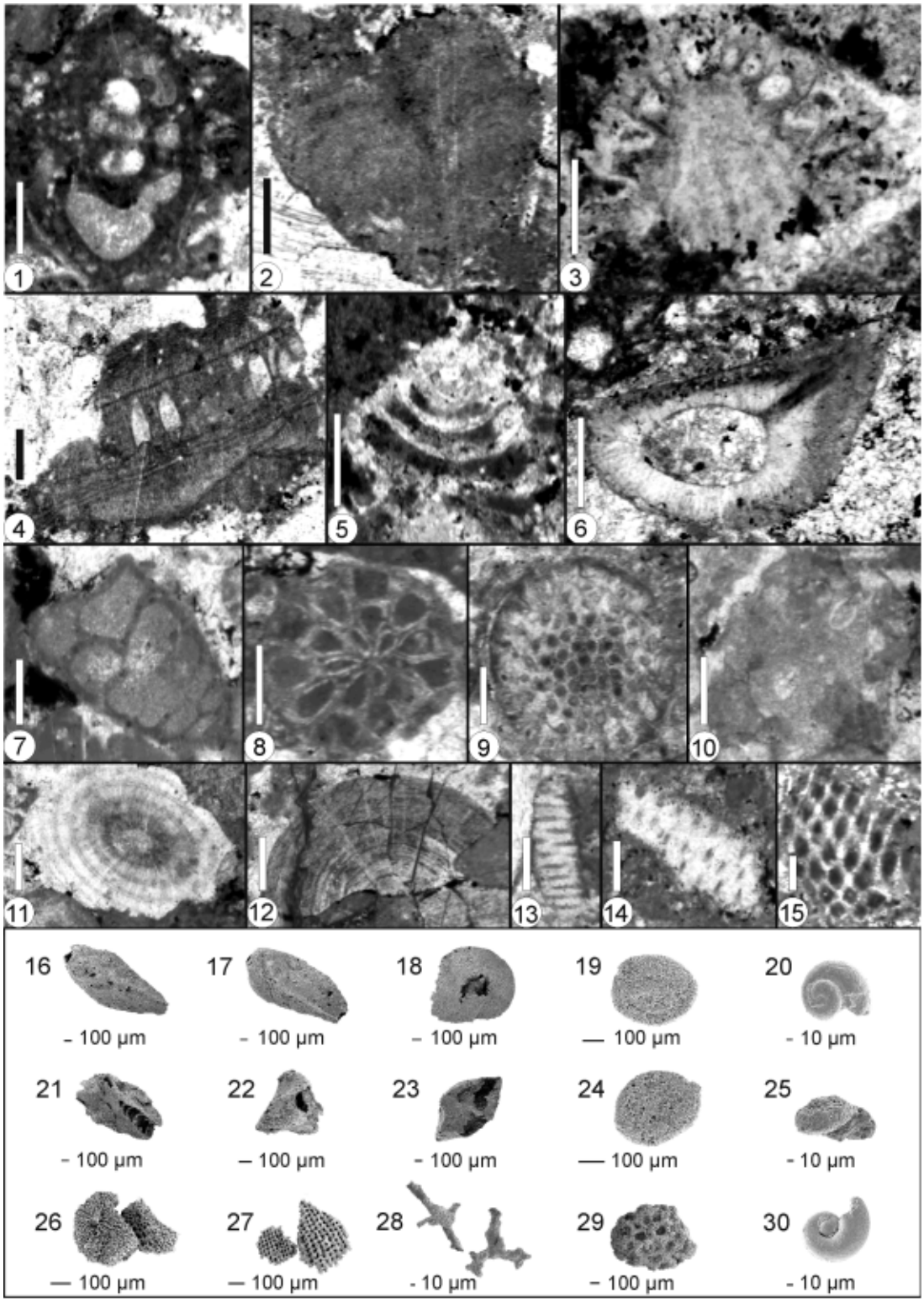

Fig. 4. Microfacies and micropaleontology of the Upper Hauterivian calcitutbidite of the Kaltenleutgeben section. **1** — Benthic foraminifer *Charentia* cf. *cuvillieri* Neumann; 2004z0160/0002. **2** — Ancestral Rhodophyceae *Marinella lugeoni* Pfender; 2004z0161/0001. **3** — Benthic foraminifer *Neotrocholina* sp.; 2004z0155/0001. **4** — Coralline red alga *Parakymalithon phylloideum* (Bucur et Dragastan) Moussavian; 2004z0167/0001. **5** — Benthic foraminifer *Neotrocholina* sp.; 2004z0161/0002. **6** — Problematic serpulid tube *Carpathiella triangulata* Mišík, Soták et Ziegler; 2004z0161/0003. **7** — Arenaceous foraminifer; 2004z0160/0003. **8** — Bryozoan colony; 2004z0164/0002. **9** — Bryozoan colony; 2004z0165/0002. **10** — Lithoclast containing calpionellid; 2004z0162/0001. **11** — Eroded belemnite rostrum; 2004z0163/0001. **12** — Fragmented belemnite rostrum; 2004z0160/0004. **13** — Brachiopod shell; 2004z0166/0002. ***Continued on next page.***

Stages		Zones	Subzones
HAUTERIVIAN	Upper	*P. angulicostata* auctorum	*P. catulloi*
			P. angulicostata auct.
		B. balearis	
		P. ligatus	
		S. sayni	
	Lower	*L. nodosoplicatum*	
		C. loryi	*O. (J.) jeannoti*
			C. loryi
		A. radiatus	

Fig. 5. The suggested stratigraphic range of the calciturbidites (in grey) in the Flössel Syncline. Table from Hoedemaeker et al. (2003, with modifications).

shallow-water facies situated towards the south of the depositional area of the Rossfeld Formation or can be interpreted as a lateral influx from the internal Late Barremian–Albian "Urgonian platform". The latter possibility was favoured by Schlagintweit (1991) because no stratigraphic data were available from these sandstones and a time-equivalent position to the allochthonous Urgonian limestones has been assumed. The calciturbidites of the Schrambach Formation from Kaltenleutgeben, however, are of Hauterivian age and, thus, older than the first records of the Urgonian platform known so far as Late Barremian (Hagn 1982). The Urgonian platform contains diverse benthic foraminifers (e.g. orbitolinids, lituolids, and miliolids), calcareous green algae (Dasycladales, Halimedaceae), and remains of corals, and, thus, differs from the calciturbidites of the Schrambach Formation from Kaltenleutgeben. Whereas the biogenic composition of the calciturbidite layer of the Kaltenleutgeben section reflects foramol type sediments, the allodapic Urgonian limestones belong to the chlorozoan type sediments according to the classification of Less & Buttler (1972) and Carannante & Simone (1987). These differences, however, should not be overestimated because they may merely reflect different water depths of the primary depositional area in connection with variable siliciclastic influx. Due to the total absence of dasycladalean green algae (approx. 20 m water depth), the dominance of echinoids and bryozoans, and the abundances of lenticulinid foraminifers, an upper circalittoral (e.g. Masse 1988) source area (= upper slope) is assumed. In contrast, the allodapic Urgonian limestones derived from outer platform or platform margin position (= external infralittoral) (Fig. 6).

This yields two possibilities for the origin of the calciturbidites of the Schrambach Formation from Kaltenleutgeben: a shallow-water facies south of the depositional realm

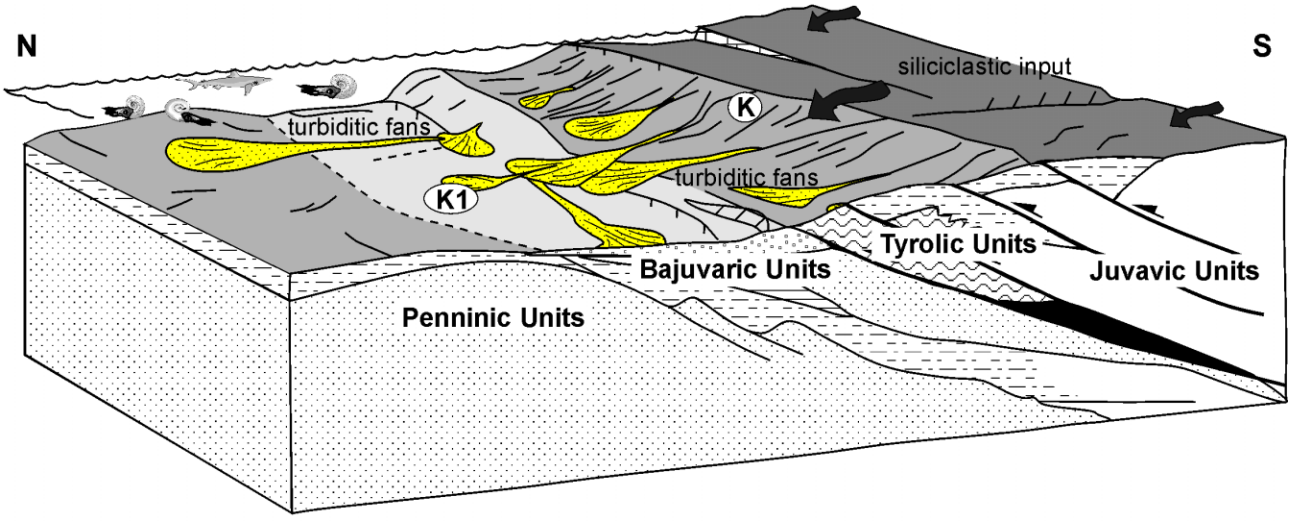

Fig. 6. Model for the paleogeographical transect and sedimentary origin of the calciturbidite layer of the Schrambah Formation at Kaltenleutgeben during the Hauterivian (model adapted from Faupl & Tollmann 1979). **K** — source area, **K1** — final deposition after transport.

Fig. 4. ***Continuation.*** **14** — Brachiopod shell; 2004z0158/0001. **15** — Bryozoan colony; 2004z0157/0003. **16** — Arenaceous foraminifer; 2004z0169/0001. **17** — Arenaceous foraminifer; 2004z0169/0002. **18** — *Lenticulina* sp.; 2004z0169/0003. **19** — *Ammodiscus* sp.; 2004z0169/0004. **20** — Gastropod; 2004z0169/0005. **21** — Arenaceous foraminifer, 2004z0169/0006. **22** — Arenaceous foraminifer; 2004z0169/0007. **23** — *Lenticulina* sp.; 2004z0169/0008. **24** — *Ammodicus* sp.; 2004z0169/0009. **25** — Gastropod, 2004z0169/0010. **26** — Sponge skeleton; 2004z0169/0011. **27** — Sponge skeleton; 2004z0169/0012. **28** — Sponge spiculae; 2004z0169/0013. **29** — Bryozoan colony; 2004z0169/0014. **30** — Gastropod; 2004z0169/0015. Scale bar: Figs. 1–15 = 0.2 mm. All specimens (exclusively thin sections) were coated with gold before photographing (REM). All specimens are stored at the Museum of Natural History (Burgring 7, A-1010, Vienna).

of the Rossfeld Formation; or an initial stage of the carbonatic Urgonian platform that was formed by shallowing similar to the Upper Jurassic Plassen Formation (Schlagintweit et al. 2003a). The latter drowned during the Berriasian, as evidenced by the Upper Berriasian calpionellid-rich limestones of the *oblonga* Subzone on top of the Plassen Formation (Schlagintweit et al. 2004).

Unfortunately, information about the clasts of the coarse-grained upper Rossfeld Formation are not available until now. Faupl & Tollmann (1979) mentioned only reworked sandstones from the lower Rossfeld Formation, and Schweigl & Neubauer (1997: p. 333) indicate Triassic and Jurassic clasts "of the Tyrolic- or Upper Juvavic units", and shale clasts of Permian Haselgebirge or Triassic Hallstatt limestones of the "Lower Juvavic unit".

Conclusions

In some cases, such calciturbidite material together with coarse clasts from conglomerates — can be the only relics of sedimentary successions that have totally eroded during orogenesis (e.g. Urgonian platform). The intercalations can also provide useful information on the platform basin transitions and stratigraphic correlations between both. Our results show that both, basin and shallow-water facies can be developed throughout the Cretaceous and especially in the Lower Cretaceous of the Northern Calcareous Alps. In siliciclastic-influenced successions, however, the stratigraphic identification will become problematic, whereas especially in carbonate resediments, stratigraphically significant shallow-water microfossils can be expected. Generally, in more coarse-grained proximal gravity flow deposits, the identification of microfossils and lithoclasts is much easier than in distal portions, which often contain little or no information on the biostratigraphy or lithological composition of the source areas. In this paper new aspects for the correlation between Lower Cretaceous ammonoids and microfossils are given and show the enhanced value of ammonoid marker-beds ('abundance zone') for the stratigraphy of geodynamic processes. The cephalopod fauna at the outcrop covers exclusively forms of the Mediterranean Province, which are typical for the Northern Calcareous Alps.

The Upper Hauterivian calciturbidites of Kaltenleutgeben are the first evidence for the existence of a shallow-water facies in the time interval between the "ending" of the Plassen Formation (Early/Middle Berriasian) and the "beginning" of Urgonian type facies, dated as Late Barremian.

With respect to formal lithostratigraphic definitions, calcareous turbiditic layers are not known from the Berriasian type-locality of the Schrambach Formation (Rasser et al. 2003). As a consequence of these observations, the formal lithostratigraphic definition of the Schrambach Formation has to be enlarged.

Acknowledgments: Thanks are due to the Austrian Science Fund (FWF) for financial support in project FWF P16100-N06. Our sincere thanks are extended to Herbert Summesberger (Vienna). The author is grateful to Peter Faupl (Vienna), Zdenek Vašíček (Ostrava) and Jozef Michalík (Bratislava) for their valuable comments which helped improving the quality of the paper. Thin-sections were done by Franz Mayer (Vienna).

References

Aguirre J., Riding R. & Braga J.C. 2000: Diversity of coralline red algae: origination and extinction patterns from the Early Cretaceous to the Pleistocene. *Paleobiol.* 26, 4, 651–667.

Arias C., Masse J.-P. & Vilas L. 1995: Hauterivian shallow marine calcareous biogenic mounds: S.E. Spain. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 119, 3–17.

Boorová D., Lobitzer H., Skupien P. & 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. *Abh. Geol. B.-A.* 56, 2, 273–318.

Bucur I.I. & Dragastan O. 1986: *Archaeolithothamnium phylloideum*, nouvelle espèce de Corallinacée du Crétacé inférieur de l'Ouest de la Roumania. *Rev. Micropaleont.* 28, 4, 227–232.

Carannante G. & Simone L. 1987: "Temperate" versus "tropical" Cretaceous carbonate platforms in Italy. *Rend. Soc. Geol. Ital.* 9, 1986, 153–156.

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

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

Decker K., Faupl P. & Müller A. 1987: Synorogenetic sedimentation on the Northern Calcareous Alps during the Early Cretaceous. In: Flügel H.W. & Faupl P. (Eds.): Geodynamics of the eastern Alps. Wien, 126–141.

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

Faupl P. & Tollmann A. 1979: Die Roßfeldschichten: Ein Beispiel für Sedimentation im Bereich einer tektonisch aktiven Tiefseerinne aus der kalkalpinen Unterkreide. *Geol. Rdsch.* 68, 1, 93–120.

Hagn H. 1982: Neue Beobachtungen in der Unterkreide der Nördlichen Kalkalpen (Thierseer Mulde SE Landl, Kalkalpine Randschuppe SW Bad Wiessee). *Mitt. Bayer. St.-Samml. Paläont. Hist. Geol.* 22, 117–135.

Gawlick H.-J. & Frisch W. 2003: The Middle to Late Jurassic carbonate clastic radiolaritic flysch sediments in the Northern Calcareous Alps: sedimentology, basin evolution, and tectonics — an overview. *Neu. Jb. Geol. Paläont. Abh.* 230, 163–213.

Gawlick H.-J., Schlagintweit F. & Missoni S. in print: Die Barmsteinkalke der Typlokalität nordwestlich Hallein (hohes Tithonium bis tieferes Berriasium; Salzburger Kalkalpen, Deutschland, Österreich) — Sedimentologie, Mikrofazies, Stratigraphie und Mikropaläontologie: neue Aspekte zur Entwicklungsgeschichte der Ober-Jura-Karbonatplattform und der tektonischen Interpretation der Hallstätter Zone von Hallein - Bad Dürrnberg. *Neu. Jb. Geol. Paläont. Mh.*

Hoedemaeker P.J., Reboulet St., Aguirre-Urreta M., Alsen P., Aoutem M., Atrops F., Barrangua R., Company M., Gonza-

les C., Klein J., Lukeneder A., Ploch I., Raisossadat N., Rawson P., Ropolo P., Vašíček Z., Vermeulen J. & Wippich M. 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.

Leinfelder R.R. & Werner W. 1993: Systematic position and palaeoecology of the Upper Jurassic to Tertiary alga *Marinella lugeoni* Pfender. *Zitteliana* 20, 105–122.

Less A. & Buttler A.T. 1972: Modern temperate-water and warm-water shelf carbonate sediments contrasted. *Marine Geol.* 13, 67–73.

Lukeneder A. 1999: Excursion-guide to the Lower Cretaceous sequence of the Flösselberg Syncline (Lower Austria). *5th International Symposium "Cephalopods — Present and Past", Wien,* 1–17.

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. *Österr. Akad. Wiss. Schriftenr. Erdwiss. Komm.* 16, Wien, 165–191.

Lukeneder A., Krystyn L., Rasser M.W. & Märzendorfer G. 2003: A unique ammonite fauna from the Upper Jurassic Loser section (Northern Calcareous Alps, Salzkammergut). In: Piller W.E. (Ed.): Stratigraphia Austriaca. *Österr. Akad. Wiss. Schriftenr. Erdwiss. Komm.* 16, Wien, 217–229.

Masse J.-P. 1988: L'étagement bionomique des milieux benthiques néritiques actuels: Signification bathymétrique et implications paléobathymétriques. *Géol. Méditerr.* 15, 1, 91–102.

Mišík M., Soták J. & Ziegler V. 1999: Serpulid worms *Mercierella* Fauvel, *Durandella* Dragastan and *Carpathiella* nov. gen. from the Jurassic, Cretaceous and Paleogene of the Western Carpathians. *Geol. Carpathica* 50, 4, 305–312.

Moussavian E. 1987: *Parakymalithon*, eine neue Gattung der Corallinaceen (Rhodophyceae) aus der Unterkreide. *Facies* 16, 187–194.

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

Rasser M.W., Vašíček Z., Skupien P., Lobitzer H. & Boorová D. 2003: Die Schrambach-Formation an ihrer Typlokalität (Unter-Kreide, Nördliche Kalkalpen, Salzburg): Lithostratigraphische Formalisierung und „historische" Irrtümer. In: Piller W.E. (Ed.): Stratigraphia Austriaca. *Österr. Akad. Wiss. Schriftenr. Erdwiss. Komm.* Wien, 16, 193–216.

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.

Salvador A. 1994: International Stratigraphic Guide (A Guide to Stratigraphic Classification, Terminology and Procedure). *2nd Ed., XIX + 214 Intern. Union Geol. Sci. Geol. Soc. Amer.*

Schlagintweit F. 1991: Allochthone Urgonkalke im Mittleren Abschnitt der Nördlichen Kalkalpen: Fazies, Paläontologie und Paläogeographie. *Münchner Geowiss. Abh.* A 20, 1–120.

Schlagintweit F., Gawlick H.-J. & Lein R. 2003a: Die Plassen-Formation der Typlokalität (Salzkammergut, Österreich) — neue daten zur fazies, sedimentologie und stratigraphie. *Mitt. Gesell. Geol. Bergbaustud. Österr.* 46, 1–34.

Schlagintweit F., Gawlick H.-J. & Sanders D. 2003b: Serpulid tubes of the genus *Carpathiella* Mišík, Soták & Ziegler, 1999 from the Upper Jurassic to Paleogene of the Northern Calcareous Alps (Austria, Germany). *Mitt. Gesell. Geol. Bergbaustud. Österr.* 46, 91–110.

Schlagintweit F., Gawlick H.-J. & Lein R. 2004: Die Bedeutung der pelagischen Ober-Berriasium Sedimente der Überlagerung der Plassen-Formation (Kimmeridgium bis Unter-Berriasium) der Typlokalität (Plassen bei Hallstatt, Österreich) für die Rekonstruktion der Entwicklungsgeschichte der Ober-Jura/Unter-Kreide Flachwasserkarbonatplattform in den Nördlichen Kalkalpen. *Ber. Inst. Erdwiss. Karl-Franzens-Univ. Graz* 9, 361–363.

Schnabel W. 1997: Geologische Karte der Republik Österreich 1:50,000, 58 Baden. *Geol. B. A.*, Wien.

Schweigl J. & Neubauer F. 1997: New structural, sedimentological and geochemical data on the Cretaceous geodynamics of the central Northern Calcareous Alps (Eastern Alps). *Zbl. Geol. Paläont. Teil I*, 1996, 329–343.

Schwinghammer R. 1975: Stratigraphie und Fauna des Neokoms von Kaltenleutgeben, NÖ. *Sitz.-Ber. Österr. Akad. Wiss., Math.-Naturw. Kl., Abt. 1*, 183, 149–158.

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

Stampfli G. & Mosar J. 1999: The making and becoming of Apulia. *Mem. Sci. Géol. Univ. Padova. Spec. Vol.* 51, 1, 141–154.

Steiger T. 1981: Kalkturbidite im Oberjura der Nördlichen Kalkalpen (Barmsteinkalke, Salzburg, Österreich). *Facies* 4, 215–348.

Steininger F.F. & Piller W.E. 1999: Empfehlungen (Richtlinien) zur Handhabung der stratigraphischen Nomenklatur. *Cour. Forschungsinst. 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 I, H.* 11, 12, 1421–1432.

Vašíček Z. & Michalík J. 1999: Early Cretaceous ammonoid paleobiogeography of the west Carpathian part of the Paleoeuropean shelf margin. *Neu. Jb. Geol. Paläont. Abh.* 212, 241–262.

Vašíček Z., Michalík J. & Reháková D. 1994: Early Cretaceous stratigraphy, palaeogeography and life in Western Carpathians. *Beringeria* 10, 3–169.

Weidich K.F. 1990: Die kalkalpine Unterkreide und ihre Foraminiferenfauna. *Zitteliana* 17, 1–312.