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Late Valanginian ammonoids: Mediterranean and Boreal elements – Implications on sea-level controlled migration (Ebenforst Syncline; Northern Calcareous Alps; Upper Austria)

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Abstract

Ammonoids of Early Cretaceous age were collected at the Northern Calcareous Alps in the southernmost part of the Reichraming Nappe (Ebenforst Syncline). The cephalopods, which derive from the Rossfeld Formation indicate an earliest Late Valanginian age (Saynoceras verrucosum Zone; Karakaschiceras pronecostatum Subzone).

The deposition of the marly limestones and marls in this interval occurred during unstable environmental conditions which led to a mixed autochthonous/allochthonous ammonoid fauna. The ammonoid fauna comprises 10 different genera, each apparently represented by 1-2 species. Ammonitina are the most frequent components (89%, represented by Haploceras, Neocomites, Oosterella, Eleniceras, Olcostephanus, Prodichotomites), followed by the lytoceratids (5%, Lytoceras, Leptotetragonites), the phylloceratids (5%, Ptychophylloceras) and the ancyloceratids (1%, Bochianites). The cephalopod fauna consists of numerous Mediterranean elements (dominated by Olcostephanus) and scarce Boreal ammonoids (the latter represented by Prodichotomites). The described Prodichotomites provides the first evidence of Boreal ammonoids within the Northern Calcareous Alps during the Valanginian and moreover the southernmost occurrence of this genus so far.

1. Introduction

Lower Cretaceous pelagic sediments are known to form a major element of the northernmost tectonic units of the Northern Calcareous Alps (e.g. Ternberg-, Reichraming-, Frankenfels-, and Lunz Nappes). In the Reichraming Nappe, Valanginian cephalopod-bearing deposits are recorded in two different facies, the Schrambach and the Rossfeld formations. Upper Valanginian sediments of the Schrambach Formation are composed of limestones with turbiditic sandstone intercalations, whereas the Rossfeld Formation comprises turbiditic marls and sandstones (Vašíček and Faupl 1996, 1998, Lukeneder 2003). The stratigraphy of the Lower Cretaceous sediments in the investigated area is based on ammonoids. During the 1990s, a rich fauna of cephalopods was collected from the surrounding area (Vašíček and Faupl 1996, Vašíček and Faupl 1998, Vašíček et al. 1994; see also Faupl et al. 2003). The presented cephalopod fauna was collected in marly sediments of the Rossfeld Formation.

Several seaways (the Danish-Polish seaway; the East European seaways - Russian and Mid-Uralian; the North American seaways - North Canadian and Alaskan; the Chukotka seaway in Asia) existed between the Boreal and Tethyan Realms in the earliest Cretaceous (Rawson 1973, 1993, 1994, 1995, 1999, Kakabadze 1996, Marcinowski and Gasinski 2002, Vašíček and Michalik 2002, Baraboshkin 2002). These connections provided routes to floral and faunal migration during the early Late Valanginian transgression phase. A dominance of marine European faunas of Tethyan affinity throughout the latest Berriasian - latest Hauterivian is punctuated by three intervals of Boreal influxes: 1. in the earliest Late Valanginian, 2. in the latest Valanginian to earliest Hauterivian and 3. in the Late Hauterivian (Mutterlose and Borneman 2002). During the latter intervals the Danish-Polish furrow provided the main migration route for Boreal ammonoids into the Tethyan Realm. This furrow persisted almost through the whole Early Cretaceous (Marek and Raczyńska 1973) and therefore allowed the genus Prodichotomites to expand into southern regions of Europe (Thiéuloy 1977, Kemper 1987), Rawson (1993, 1994, 1995) and Hoedemaeker (2002) tried to correlate the Early Cretaceous standard Mediterranean ammonoid Zones with the Boreal ammonoid zones using horizons where both faunas, Boreal and Mediterranean, occur together.

Mediterranean ammonoid descendants clearly dominate the Austrian Early Cretaceous cephalopod fauna. The Boreal elements are very rare in the Berriasian to Barremian ages in the Tethyan Realm and seem to occur only at specific levels, as noted for the Mediterranean area by Rawson (1999). Due to the rarerness the documented specimen of Prodichotomites is one of the most important findings in Lower Cretaceous ammonoids from the Northern Calcareous Alps.

2. Geographical setting

Outcrop. The outcrop is situated in the Reichraming Nappe in Upper Austria, about 5 km south of Brunnbach (652 m, ÖK 1:50 000, sheet 69 Großraming; Fig. 1a, b). The stream outcrop is located near the middle of the Eibeckgraben in the south-easternmost part of the east-west striking Ebenforst Syncline, running between the Sulzkoogel (840 m) to the west and the vicinity of the Eibeck (916 m) to the east.

The succession, comprising the ammonoid-bearing beds, is located on the southern side of the Hochkogel (1157 m). The occurrence is badly exposed on the left side of the stream. The exact position of the ammonoid-occurrence was determined by GPS (global positioning system); N 47°47′14″ and E 14°31′31″ (Fig. 2). Steep terrain and the ‘soft nature’ of the marly rocks made sampling very difficult.

3. Geological setting and dating

Setting. The Upper Valanginian succession of southeast Upper...
Austria was deposited in an unstable shelf setting characterized by thick limestone units that reflect transgressive histories punctuated by tectonic events, as shown by the deposition of conglomerates and sandstones (see Faupl 1979). The terrigenous, proximal, deep-water turbiditic Rossfeld Formation of the Reichraming Nappe represents a synorogenic development (Vašíček and Faupl 1998).

The Ebenforst Syncline is situated in the southernmost part of the Reichraming Nappe. Three more synclines are present to the north: the Anzenbach Syncline, the Schneeberg Syncline of the Reichraming Nappe, and the Losenstein Syncline of the Ternberg Nappe, all of which consist of Lower Cretaceous sediments in their cores. Lower Cretaceous sediments are represented at the Eibeck section by two formations, the Schrambach Formation (approx. 50 m, Berriasian) and the overlying Rossfeld Formation (approx. 150 m, Upper Valanginian) (Fig. 2).

**Lithology.** The Eibeck section consists of essentially ochreous calcareous marls and grey, silty marlstones accompanied by conglomerates and sandstones of the Rossfeld Formation. The CaCO₃ (calcium carbonate content, equivalents calculated from total inorganic carbon) display values of about 31 %. The weight % TOC values (total organic carbon) are about 2.9 % within the marls of the outcrop. The total sulphur content is positively correlated to the TOC values. The maximum amount of 1.76 mg/g sulphur stems from a marl bed in the middle of the section.

**Fauna.** The invertebrate fauna consists of ammonoids, coleoids, aplachi, serpulids, echinoderms (Phyllocrinus), bivalves (Inoceramus), brachiopods, ophiuroids, benthic and planktonic foraminifera and radiolarians. The only benthic macrofossils observed in the ammonoid beds are bivalves. The abundant and generally well-preserved cephalopods (except for fragmentation) are dominated by olocostephanids. The fairly fossiliferous part of the section shows remarkably abundant olocostephanids (Fig. 3).

The mixing of allochthonous and autochthonous elements in the Eibeck section is based on specimens derived from the local community and preserved in 'life-position' (or as an 'in place assemblage') as well as fossils that were transported from other habitats.

Vašíček and Faupl (1998) assumed that the most apparent difference between localities of the investigated area (Reichraming Nappe) and localities in the Vocontian basin, is seen in the abundance of olocostephanids within sediments of the Vocontian basin and adjacent shelf, whereas they occur only sporadically in the Reichraming Nappe. As shown in the presented paper, their described olocostephanids from the R1 locality display more the rule than the exception for this region. In contrast to the opinion stressed in Vašíček and Faupl (1998), the present contribution shows that olocostephanids form a major and important group (46 %) in the investigated area and assumes that this is true for the whole Ebenforst Syncline. Accordingly, the Austrian site and its ammonoid assemblages are absolutely comparable with the equivalent French deposits of the same ammonoid Zone (Sayneceras verrucosum
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Figure 3: Ammonoid assemblage from the Eibeck locality. Note the dominance of the Ammonitina and its abundant genus Olcostephanus.

Zone), which were for example described by Bulot (1993) (see Lukeneder, 2004). Due to its faunal assemblage and the abundance of Olcostephanus guebhardi, the Eibeck section is definitively comparable with the Olcostephanus Level from the more northerly KB1-A section of the Ternberg Nappe, described by Lukeneder, 2004. The latter level is also of Late Valanginian age (verrucosum Zone; Karakaschiceras pronecostatum Subzone and/or the Neocomites peregrinus Subzone).

Biostratigraphy. The association indicates that the cephalopod-bearing beds of the Rossfeld Formation belong to the Saynoceras verrucosum ammonoid Zone (Karakaschiceras pronecostatum Subzone) of the early 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: Ptychophylloceras semisulcatum, Lytoceras subfimbriatum, Leptotetragonites cf. honnoratianus, Haploceras graminum, Olcostephanus guebhardi, Neocomites neocomiensis, Neocomites teschenensis, Eleniceras sp., Dichtotomites sp., Bochianites neocomiensis.

Although S. verrucosum (for the zone) and K. pronecostatum (for the subzone) are missing, the typical ammonoid association hints towards the verrucosum Zone, and especially to the pronecostatum Subzone.

4. Material, preservation and methods

During the course of this study, 129 ammonoids and 4 lamellaptychi were examined. A single belemnite specimen Conobelus sp. and additional ammonoids were collected by Heinz Kollmann (Natural History Museum, Vienna) in the early 1970s and have been prepared by the author.

In general the material is moderately well preserved. Some of the ammonoids show remnants of altered shell. The phragmocones are mostly flattened, whereas the body chambers are better preserved because of early sediment infilling. Due to the high number of specimens, however, even extraordinarily well-preserved individuals (e.g. lappets of microconchs) were collected. The fragmentation is due to preburial transport, sediment compaction and considerable tectonic deformation, which hampers the precise determination of most cephalopods with chambered hard-parts (e.g. ammonoids and belemnoids).

Calcium carbonate contents (CaCO3) were determined using the carbonate bomb technique. Total carbon content was determined using a LECO WR-12 analyser. Total organic carbon (TOC) contents were calculated as the difference between total carbon and carbonate carbon, assuming that all carbonate is pure calcite. All the chemical analyses were carried out in the laboratories of the Department of Geology and the Department of Forest Ecology at the University of Vienna.

5. Palaeontology

Conventions. The material examined is deposited in the palaeontological collection of the Natural History Museum, Vienna, Austria (NHMW). All specimens in Plate 1 and 2 were coated with ammonium chloride before photographing. The systematic descriptions are intentionally short and the synonymy lists are tightened (at most 3 references) with the reference to other authors (cum syn.). The paragraphs Remarks refer to others who have presented more detailed comparisons and conclusions. Numbers
given in brackets are only for figured specimens. The author follows the classification of Cretaceous Ammonoidea by Wright et al. (1996) and the systematics adopted by the following authors: Joly (1976), Kemper (1978), Immel (1987), Rebourlet (1995), Vašíček and Faupl (1999) and Wippich (2001).

Phyllium Mollusca Cuvier, 1795
Class Cephalopoda Cuvier, 1795
Order Ammonoidea Zittel, 1884
Suborder Phylloceratina Arkell, 1950
Superfamily Phyllocerataceae Zittel, 1884
Family Phylloceratidae Zittel, 1884
Subfamily Ptychophylloceratinae Collignon, 1956

Genus Ptychophylloceras Spath, 1927
Type species. Ptychophylloceras feddeni/Waagen 1875. Barremian, France. Ptychophylloceras ptychoicum (Quenstedt 1845)

(pl. 1, fig. 5)

1845 Ammonites ptychoicum Quenstedt. p. 683.
1996 Ptychophylloceras cf. ptychoicum (Quenstedt) Vašíček and Faupl, p. 105, pl. 1, figs. 3-4
2000 Ptychophylloceras (Semisculcoceras) ptychoicum (Quenstedt) Holy, p. 126, pl. 31, figs. 1-3 (cum. syn.)

Material: 7 specimens from the ‘Olcostephanus Level’ from the Eibeck section (NHMWzoo80/0022).

Locality: Stream outcrop of the Eibeck section at 735 m (Fig. 2).

Description: Rather involute, high whorl height and a relatively broad umbilicus, venter rounded, smooth shell, 5-7 narrow constrictions pass from the umbilical wall to the venter on the last whorl, accompanied by external short ribs or elevated ridges.


Distribution: Lower Tithonian to Valanginian sediments of Austria, Czech Republic, France, Hungary, Italy, Madagascar.

Suborder Lytoceratina Hyatt, 1889
Superfamily Lytocerataceae Neumayr, 1875
Family Lytoceratidae Neumayr 1875
Genus Lytoceras Suess, 1865
Type species. Ammonites limbiatus Sowerby, 1817. Lower Jurassic, England.

Lytoceras subfimbriatum (d’Orbigny)

(pl. 1, fig. 1-2)

1841 Ammonites subfimbriatus d’Orbigny – p. 121, pl. 35, figs. 1-4.
1994 Lytoceras subfimbriatum (d’Orbigny) - Rebourlet; p. 193, pl. 37, 6-7; pl. 38, figs. 5-7.
2001b Lytoceras subfimbriatum (d’Orbigny) - Lukeneder, p. 130, pl. 2, fig. 1. (cum. syn.)

Material: 2 specimens from the ‘Olcostephanus Level’ from the Eibeck section (NHMWzoo80/0001, NHMWzoo80/0021).

Locality: Stream outcrop of the Eibeck section at 735 m (Fig. 2).

Description: Rather evolute, low whorl height and broad umbilicus, whorl section round, venter rounded, shell with dense fine ribs, ribs passing over venter, stronger ribs are periodically intercalated on the last whorl.


Distribution: Hauterivian to Barremian sediments of Austria, Czech Republic, France, Hungary, Bulgaria, Romania, Italy, Switzerland, Spain.

Genus Leptotetragonites Spath, 1972
Type species. Ammonites honnoratianus d’Orbigny 1841. Valanginian, France.

Leptotetragonites cf. honnoratianus (d’Orbigny)

1841 Leptotetragonites honnoratianus d’Orbigny, p. 124, pl. 37.
1987 Leptotetragonites honnoratianus (d’Orbigny) - Immel, p. 63, pl. 2, fig. 7.
2001b Leptotetragonites honnoratianus (d’Orbigny) - Lukeneder, p. 130, pl. 2, fig. 1 (cum. syn.).

Material: 5 specimens from the ‘Olcostephanus Level’ from the Eibeck section (NHMWzoo80/0019-20).

Locality: Stream outcrop of the Eibeck section at 735 m (Fig. 2).

Description: Rather evolute, sculpture on the internal mould is formed by thin, relatively sharp, widely spaced (ca. 1.5 to 2 cm) simple ribs, they start at the umbilicus and form a prorsiradiately rounded bow at the flanks and pass the ventral side of the shell, the uniform ribs occur in numbers of 6 to 8 on the last half whorl.


Occurrence: Berriasian to ?Barremian sediments of Austria, SE-France, Hungary, Italy, Czech Republic and Bulgaria.

Suborder Haploceratina Hyatt, 1889
Superfamily Haplocerataceae Zittel, 1884
Family Haploceratidae Zittel, 1884
Genus Haploceras Spath, 1870
Type species. Ammonites Grasianus d’Orbigny, 1841. Valanginian, France.

Haploceras grasianum (d’Orbigny)

(pl. 1, fig. 6)

1841 Ammonites Grasianus d’Orbigny – p. 141, pl. 44, figs. 1-2
1987 Haploceras (Neolissoceras) grasianum (d’Orbigny) – Company, p. 97, pl. 2, figs. 1-9
1996 Haploceras (Neolissoceras) grasianum (d’Orbigny) – Wippich, p. 64, pl. 43, fig. 1 (cum. syn.).

Material: 17 specimens from the ‘Olcostephanus Level’ from the Eibeck section (NHMWzoo80/0023).

Locality: Stream outcrop of the Eibeck section at 735 m (Fig. 2).

Description: Semi-evolute, smooth shells with narrow whorls, whorl section high-ovate, flanks are smooth and parallel directed, funnel-shape of the umbilicus, venter rounded.
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Remarks: The relatively large whorl height distinguishes the species from the related Haploceras (Neolissoceras) desmoceratoides, which also has a larger umbilicus.


Occurrence: Upper Valanginian sediments of the Eibeck section. S. verrucosum Zone (K. proncecostatum Subzone).

Distribution: Berriasian to Hauterivian sediments of Austria, Spain, Italy, the Czech Republic, Bulgaria, Spain, the Crimea, North Africa, the Mid-Orient (Israel), Mexico, Cuba, India and Madagascar.

Superfamily Perisphinctacea Steinmann, 1890
Family Oosterellidae Breistroffer, 1940
Genus Oosterella Killian, 1911
Lectotype. Oosterella gaudryi Nickles, 1892. Upper Valanginian, Spain.
Oosterella gaudryi (Nickles)
(pl. 1; fig. 7)

1892 Mortoniceras gaudryi Nickles – p. 188-191, pl. 7, figs. 1-3; pl. 8, fig. 1.
1996 Oosterella gaudryi(Nickles) – Reboulet, p. 139, pl. 28, figs. 9-22 (cum syn.).
1999 Oosterella gaudryi(Nickles) – Vašíček; p. 596, pl. 1, figs. 10-12.

Material: 1 specimen from the ‘Olcostephanus Level’ from the Eibeck section (NHMWzoo80/0024).

Locality: Stream outcrop of the Eibeck section at 735 m (Fig. 2).

Description: Evolute small shell, umbilicus rather broad, relatively rounded whorl section, on the inner whorl parts prorsiradiately arcuate thick main ribs which do not cross the venter; ribs start at small umbilical bends, thickening of the ventral part of the ribs, furrows on external side.


Occurrence: Upper Valanginian sediments of the Eibeck section. S. verrucosum Zone (K. proncecostatum Subzone).

Distribution: Lower Valanginian to Upper Hauterivian sediments of Austria, Czech Republic, Hungary, Bulgaria, Romania, France, Spain.

Family Olcostephanidae Haug, 1910
Subfamily Olcostephaninae Haug, 1910
Genus Olcostephanus Neumayr, 1875
Type species. Ammonites astierianus d’Orbigny 1840. Upper Valanginian, France
Olcostephanus guebhardi Killian, 1902
morph. type querolensis Bulot, 1992
(pl. 1, figs.- 8-13)

1860 Ammonites astierianus d’Orbigny – Pictet and Campiche: p. 289, pl. 43, figs. 1-2.
1987 Olcostephanus densicostatus Wegner – Company, p. 169-170, pl. 15, figs. 1-8, pl. 19, figs. 16-17.
1992 Olcostephanus (Olcostephanus) guebhardi Killian – Bulot, p. 151-152, pl. 1, figs. 2a-2b (cum syn.).

Material: 62 specimens from the ‘Olcostephanus Level’ from the Eibeck section (NHMWzoo80/0002-7).

Locality: Stream outcrop of the Eibeck section at 735 m (Fig. 2).

Description: Discoccone to sphaerococone (involute with ovate whorls) shape, shell is meso- to longidome (body chamber is 60 to 100 per cent of the last whorl), secondary ribbing is fairly dense, short bullate primary ribs are slightly rursiradiate to rectiradiate, primaries (from beginning) start at the umbilical seam and cross the umbilical shoulder, from which they begin to form thick bullae, at least 20 (M) and 16 bullae (m) occur, each giving rise to 4-6 secondary ribs, which are slightly prorsiradial and show no bifurcations at all, secondaries diverge in fasciculate bundles to pass uninterrupted across the venter, microconchs (up to 42 mm in diameter) show spatulate lateral lappets at the apertures, whereas the macroconchs (up to 102 mm in diameter) show simple collared apertures (peristomes) (Fig. 5).


Occurrence: Upper Valanginian sediments of the Eibeck section. S. verrucosum Zone (K. proncecostatum Subzone).

Distribution: Upper Valanginian sediments of SE-France, Germany, Austria, Morocco. Within the Arc de Castellane, the acme of O. (O.) guebhardi is situated in the upper part of the Busnardolites campylo-totrous Zone along with Karakaschiceras (Bulot 1992). Bulot has restricted the querolensis morphotype to the verrucosum Zone.

Family Neoconomites Uhlig, 1905
Type species. Hoplitites teschenensis Uhlig, 1902. Valanginian, Czech Republic.
Neoconomites teschenensis (Uhlig 1905)
(pl. 2, figs. 3-7)

1902 Hoplitites teschenensis n. sp. Uhlig – p. 56, pl.3, fig. 4.
1995 Neoconomites teschenensis (Uhlig) – Reboulet, p. 91., pl. 6., fig. 3 (cum syn.).
2001 Neoconomites (Neoconomites) aff. teschenensis (Uhlig, 1902) – Wippich; p. 107, pl. 40, figs. 4-5.

Material: 17 specimens from the ‘Olcostephanus Level’ from the Eibeck section (NHMWzoo80/0008-11).

Locality: Stream outcrop of the Eibeck section at 735 m (Fig. 2).

Description: Rather involute with relatively flat flanks, steep umbilical wall, whorl section is very high with smooth, straight ventral side, ribs flexuous-prorsiradiate bifurcate in small sheaves from slight umbilical tubercles, ribs end in small, slightly oblique bullae, up to spatulate-ventrolateral clavi, ribbing is sharp and straight on inner whorls, microconchs with long lappets.


Occurrence: Upper Valanginian sediments of the Eibeck section. S. verrucosum Zone (K. proncecostatum Subzone).

Distribution: Upper Valanginian sediments of Austria, Czech Republic, Romania, Bulgaria, SE-France, Spain, Italy and Morocco. Its characteristic occurrence culminates in the verrucosum Zone (Vašíček et al. 1994).
Type species. *Ammonites neocomiensis* d’Orbigny, 1841.

Neocomian, SE-France.

*Neocomites neocomiensis* (d’Orbigny) (pl. 2, figs. 8-11)

1841 *Ammonites neocomiensis* d’Orbigny – p. 202, pl. 59, figs. 8-10.

1995 *Neocomites neocomiensis* (d’orbigny) – Reboulet, p. 86., pl. 4., figs. 1-12; pl. 5, figs. 4-12; pl. 6, figs. 7-8; pl. 7., figs. 7-8.

2001 *Neocomites* (*Neocomites*) *neocomiensis* (d’Orbigny, 1841) – Wippich; p. 106, pl. 36., figs. 1, 3-6; pl. 37, figs. 1-2 (cum syn.).

**Material.** 20 specimens from the ‘*Olcostephanus Level*’ from the Eibeck section (NHMWzoo80/0012-15).

**Locality:** Stream outcrop of the Eibeck section at 735 m (Fig. 2).

**Description:** Rather involute, with flat sides, ribs flexuous and sharp, ribbing prorsiradiate, branching in small sheaves from slight umbilical tubercles and generally branching irregularly higher up the side or intercalated, all ribs ending at the ventral shoulder, venter is smooth and flat, ribbing on body chamber unchanged; venter becoming only slightly rounded.


**Occurrence:** Upper Valanginian sediments of the Eibeck section. *S. verrucosum* Zone (*K. pronoecostatum* Subzone).

**Distribution:** Lower Valanginian-Lower Hauterivian sediments of Austria, Argentina, Bulgaria, Czech Republic, France, Hungary, Italy, Madagascar, Morocco, Poland, Spain and Tunisia.

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**Genus Eleniceras Breskovski, 1967**

**Type species.** *Eleniceras stevrecense* Breskovski, 1976.

Hauterivian, Bulgaria.

*Eleniceras* sp. (pl. 2, fig. 12)

**Material.** 1 specimen from the ‘*Olcostephanus Level*’ from the Eibeck section (NHMWzoo80/0025).

**Locality:** Stream outcrop of the Eibeck section at 735 m (Fig. 2).

**Description:** Rather evolute, with flat sides, ribs flexuous and sharp, ribbing prorsiradiate, branching in small sheaves from slight umbilical tubercles and generally branching irregularly higher up the side or intercalated, all ribs ending at the ventral shoulder, venter is smooth and flat, ribbing on body chamber unchanged; venter becoming only slightly rounded.

**Occurrence:** Upper Valanginian sediments of the Eibeck section. *S. verrucosum* Zone (*K. pronoecostatum* Subzone).

**Distribution:** Lower Valanginian-Lower Hauterivian sediments of Austria, Czech Republic, Slovakia, Bulgaria, Romania, Poland and France.

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**Family Polyptychitidae Wedekind, 1918**

**Subfamily Polyptychinae Wedekind, 1918**

**Genus Prodichotomites Kemper, 1971**

**Type species.** *Polyptychites polytomus* Koenen, 1902. Upper Valanginian, Germany.

*Prodichotomites* sp. (pl. 2, figs. 1-3)

**Material.** 3 specimens from the ‘*Olcostephanus Level*’ from the Eibeck section (NHMWzoo80/0016-18). Due to their bad preservation the determination of 2 specimens on figures 2-3 are doubtful.

**Locality:** Stream outcrop of the Eibeck section at 735 m (Fig. 2).

**Description:** Rather involute, steep umbilical walls, round-roughed, primary ribs accentuated on umbilical wall, primaries are strong, short, tubercle like, irregularly umbilical bullae are strongly elevated and thickened, secondaries straight, strong and sharp, they seem to cross venter, ribbing is bidichotomous (pl. 2, figs. 2-3), becoming irregularly polyschizotomous on body chamber (pl. 2, fig. 1), intercalated single ribs, with occasionally collateral narrow constrictions.

**Remarks on genus:** *Prodichotomites* can be distinguished from resembling body chambers of Karakashiceras (e.g. *K. quadri- strangulatum* Sayn) (see Reboulet 1995, p. 1, fig. 10) by its straighter secondaries, the most likely continuous crossing over the venter (calculated from length and bending of the secondaries), and the irregularity and different thickness of the umbilical bullae. For detailed remarks on the genera *Prodichotomites* and *Dichotomites* see Jeletzky and Kemper (1988).

**Occurrence:** Upper Valanginian sediments of the Eibeck section. *S. verrucosum* Zone (*K. pronoecostatum* Subzone).

**Distribution:** Upper Valanginian sediments of Austria, Bulgaria, France, Poland, Germany, England, Georgia, Russia, Canada, California.
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6. Discussion

6.1. Mediterranean versus Boreal elements

Boreal ammonoids spread to the northern shelf areas of the Tethys when sea level rise reached a peak at the beginning of the Late Valanginian (verrucosum Zone) and basin margin transgression was widespread (Rawson 1993, Kakabadze 1996).

In NW Germany ammonoid faunas are dominated by Boreal taxa (Prodichotomites, Dichotomites), which are common throughout the Late Valanginian (Mutterlose and Borneman 2002). The genus Dichotomites developed from polyptychid ancestors possibly in the lower part of the Late Valanginian of Northern Siberia and appear considerably later in the 'lower Dichotomites Beds' of Northwest Germany (Jeletzky and Kemper 1988, Kemper 1978). The time of its first occurrence can approximately be used to determine the base of the Prodichotomites hollwedensis Zone, which is regarded as forming the highest part of the Early Valanginian (the Early/Late Valanginian boundary is drawn in the middle of the hollwedensis Zone). According to Jeletzky and Kemper (1988) Prodichotomites is treated herein as independent genus. Prodichotomites hollwedensis is ancestral to late dichotomids and displays therefore the ancestor of the genus Prodichotomites (Jeletzky and Kemper 1988). During the latest Early to earliest Late Valanginian times, the Boreal taxon Prodichotomites evolved into a complex group of forms in the West European Province before giving way to Dichotomites (Jeletzky and Kemper 1988, Rawson 1993). The taxonomic difficulties within the genera Dichotomites and Prodichotomites were reviewed and discussed by Kemper (1978) and Jeletzky and Kemper (1988).

At the beginning of the earliest Late Valanginian time, the relative size of the genus Prodichotomites migrated to the high boreal Realm and the Arctic area, whereas 'Dichotomites' (in most cases now designated as Prodichotomites) mainly dispersed through the Polish furrow into the Tethyan Realm (Mediterranean Province) (see Uhlig 1902, Kemper 1978, Thieuloy 1977, Reboulet 1995, Vašiček and Michalík 2002, Vašiček et al. 1994a) (Fig. 6) and to the north (see Jeletzky and Kemper 1988, González et al. 1994). Several ammonoid species ('Dichotomites' has not been detected) of subboreal origin migrated through the Danish-Polish Furrow into both the Siberian and the Pieniny Klippen Zone (Vašiček and Michalík 2002). Baraboshkin (2002) appointed that phase with the term 'sixth boreal expansion event' (the mid-Valanginian event of Rawson (1994)).

As stated by various authors (e.g. Wippich 2003 - Morocco; Company 1987 and pers. comm. - Spain; Cecca 1998 and pers. comm. - Italy; Fözy pers. comm. - Hungary; Avram and Gradinaru 1993, Baraboshkin 2002 and Melinte 2002 - Romania; Dimitrova 1976, Mandov 1976, Mandov and Nikolov 1992 - Bulgaria) no dichotomids have been detected in sediments of these countries so far. A single doubtful specimen of 'Polyptychites bidichotomus Leymerie' was documented (not figured) by Somogyi (1914) from Hungary. Only two Boreal genera (Polyptychites, Jeanthieuolites) were identified in the early Late Valanginian (verrucosum Zone) from the Romanian Carpathians (Avram and Gradinaru 1993, Baraboshkin 2002). The occurrences of 'Dichotomites' in SE France (Thieuloy 1977, Reboulet 1995) represents the southernmost occurrence on the European continent and therefore within the Tethyan Realm so far. Thieuloy (1977) described and figured Boreal ammonoids from southeast France. He accentuated the importance of the boreal dichotomids for the correlation between the Boreal and the Tethyan provinces. According to Kemper (1978) and Jeletzky and Kemper (1988) all the identifications on species-level made by Thieuloy (1977) were incorrect, except the new described species ('Dichotomites' are mostly Prodichotomites). The paper of Kemper (1978), based on the material from northwest Germany includes the descriptions of many species of Dichotomites (e.g. D. cf. bidichotomus, D. cf. ramulosus, D. aff. 'biscissoides, D. bidichotomus, D. vergunnorum'). The earliest 'Dichotomites' in France was reported from the Karakščieras pronecostatum Zone, which correlates with the Dichotomites crassus Zone in Germany. The latest 'Dichotomites' was reported from the Criospharinella furcillata Zone in France, which correlates with the Dicostella tuberculata Zone in Germany. This means that the ranges of the genus 'Dichotomites' in France and Germany are exactly the same. Dichotomites bidichotomus was reported by Reboulet (1995; see p. 271, fig. 42 and pl. 31. figs. 4-6) from SE France (Angles - Alpes de Haute-Provence; La Charce - Drome; Chateauvieux - Hautes Alpes) in beds of the trimodosum and verrucosum ammonoid zones. For the facies distribution of Prodichotomites (deep-water; Voconian basin) and Dichotomites (shelf area in SE-France, see Bulot (1993).

New findings of Prodichotomites from the Austrian locality of Eibeck indicate a more southern migration than previously reported. The Northern Calcareous Alps were situated in the Valanginian at the eastern border of the Alpine-Carpathian Block, which was located at the western margin of the Tethys (for example Cecca 1997, 1998; Vašiček and Michalík 1999, Stampfl and Mosar 1999, Lukeneder 2003).

As noted by Vašiček et al. (1994b) and Vašiček and Faupl (1998,
6.2. Taphonomic implications

The taphonomic investigations among cephalopod-assemblages provide insight not only into the autecology of these organisms, but also into their palaeoenvironment and palaeocommunity structure (Bottjer et al. 1995, Brett and Baird 1986). 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. Based on its abundance, the genus Olcostephanus is the most valuable constituent of the described fauna for palaeogeographic and taphonomic interpretation. As noted by Lukeneder and Harzhauser (2003) in their paper on Olcostephanus guebhardi as a cryptic habitat, macroconchs and microconchs could have lived in different habitats, evidenced by their different mode of fragmentation and different extent of encrustation. Assuming an analogous situation for the Eibeck section would explain the fragmented macroconchs accompanied by intact microconchs (with lappets) at that locality too. Macroconch transport apparently yields mixed faunal elements from different places. The interpretation of the faunal origin is strengthened by the suggested palaeogeographic position of the studied section (Lukeneder and Harzhauser 2003).

Therefore, the author assumes that the Eibeck cephalopods constitute a mixed autochthonous/allochthonous fauna.

Inoceramid fragments are found compounded to other shell fragments of the same shell, which hints at fragmentation through sediment pressure. The fragmented ammonoid specimens lack any encrustation, indicating rapid sinking of the animal without any transport on the seafloor or lying for quite a long time on the sea-floor. The shell transport took place after the embedding in the sediment as ‘mudflows’, as is reflected in the different alignments of the ammonoid shells and fragments within the sediment. This fact was also noted by Vašíček and Faupl (1996). The interpretation of a mixed origin of the fauna is strongly supported by the preservational history of additional belemnoid findings with intact phragmocone and proostracum (Lukeneder in prep.) Note that caution should be exercised when applying the terms autochthonous and allochthonous in cephalopods.

7. Conclusions

The macrofauna of the Eibeck section is represented especially by ammonoids, belemnoids, aptychi and bivalves. The whole section has yielded 129 ammonoids. The bad preservation (mostly internal moulds, limonitic steinkerns) of the ammonoids and the lithologic character of the Rossfeld Formation makes the sampling difficult.

The fauna can be assigned to the Saynoceras verrucosum Zone (Karaskachiceras pronecostatum Subzone) sensu Hoedemaeker et al. (2003). It contains descendants of the Mediterranean Province and a single Boreal genus. According to the stratigraphic investigations the boreal ammonoid corresponds to the genus Prodichotomites. The described Boreal descendant Prodichotomites provides the first evidence of Boreal ammonoids within the Alpine region (Northern Calcareous Alps) during the Valanginian, and marks the southernmost limit of migration of the genus.
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The deposition of the marls took place during conditions of relatively stable water masses and high sedimentation rates but under unstable sedimentological (e.g. turbidites, bottom morphology) conditions. The shells were transported within ‘mudflows’ following embedment in the sediment.

The abundant olostephanid specimens seem to have been redeposited from shallower shelf regions into a deeper shelf environment. The fauna of the Eibeck section is therefore interpreted as a mixed assemblage, comprising transported elements from the shallower shelf and autochthonous benthic and paraautochthonous pelagic elements from the open sea. Different life habitats are assumed for males (microconchs) and females (macroconchs) of the genus Olostephanus. Microconchs probably lived in the open sea, whereas the macroconchs dwelt in the shallower water of the lower shelf.

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**Plate 2:**

**Figure 1:** Prodichotomites sp., adult specimen, Eibeck section – x 1, NHMWzoo80/0016.

**Figure 2:** Prodichotomites sp., juvenile specimen, Eibeck section – x 1, NHMWzoo80/0017.

**Figure 3:** Neocomites teschenensis (Uhlig), Eibeck section – x 1, NHMWzoo80/0018.

**Figure 4:** Neocomites teschenensis (Uhlig), Eibeck section – x 1, NHMWzoo80/0009.

**Figure 5:** Neocomites teschenensis (Uhlig), Eibeck section – x 1, NHMWzoo80/0009.

**Figure 6:** Neocomites teschenensis (Uhlig), Eibeck section – x 1, NHMWzoo80/0010.

**Figure 7:** Neocomites teschenensis (Uhlig), Eibeck section – x 1, NHMWzoo80/0011.

**Figure 8:** Neocomites neocomiensis (d’Orbigny), Eibeck section – x 1, NHMWzoo80/0012.

**Figure 9:** Neocomites neocomiensis (d’Orbigny), Eibeck section – x 1, NHMWzoo80/0013.

**Figure 10:** Neocomites neocomiensis (d’Orbigny), Eibeck section – x 1, NHMWzoo80/0014.

**Figure 11:** Neocomites neocomiensis (d’Orbigny), Eibeck section – x 1, NHMWzoo80/0015.

**Figure 12:** Eleniceras sp., Eibeck section – x 1, NHMWzoo80/0025.

**Figure 13:** Indet body chamber of ? neocomitid ammonoid, Eibeck section – x 1, NHMWzoo80/0027.

**Figure 14:** Indet body chamber of ? neocomitid ammonoid, Eibeck section – x 1, NHMWzoo80/0028.

**Figure 15:** Bochianites neocomiensis (d’Orbigny), Eibeck section – x 1, NHMWzoo80/0026.