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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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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 lycoceratids (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 Michalík 2002, Baraboshkin 2002). These connections provided routes to floral and faunal migration during the early Late Valangian transgression phase. A dominance of marine European faunas of Tethyal affinities throughout the latest Berriasian - latest Hauterivian is punctuated by three intervals of Boreal influxes: 1. in the earliest Late Valangian, 2. in the latest Valangian 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 Raczynska

1973) and therefore allowed the genus *Prodichotomites* to expand into southern regions of Europe (Thieuloy 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 rareness 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 Sulzkogel (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°31'00" (Fig. 2). Steep terrain and the 'soft nature' of the marly rocks made sampling very difficult.

3. GEOLOGICAL SETTING AND DATING

Setting. The Upper Valangian succession of southeast Upper

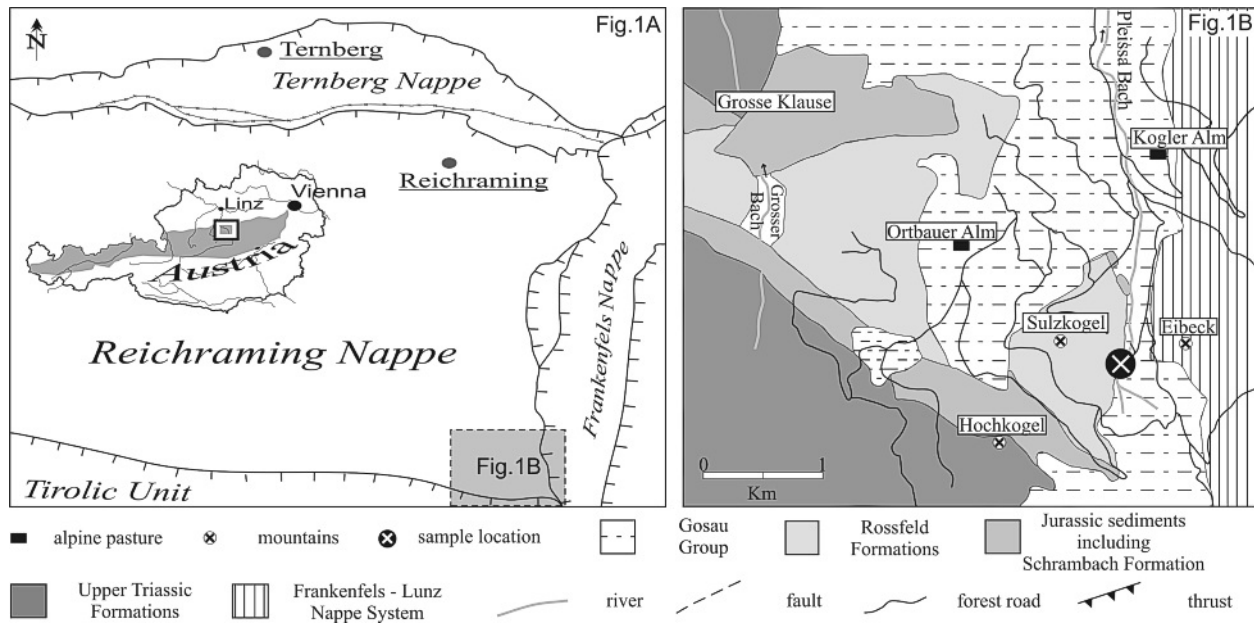


FIGURE 1 A: Locality map of Upper Austria showing the outcrop of Lower Cretaceous sediments (black) around the section investigated within the Northern Calcareous Alps. **FIGURE 1 B:** Position and lithological formations of the Ebenforst Syncline.

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 (Vašiček 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 contents, 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, aptychi, serpulids, echinoderms (*Phyllocrinus*), bivalves (*Inoceramus*), brachiopods, ophiurids, 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 olcostephanids. The fairly fossiliferous part of the section shows remarkably abundant olcostephanids (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 of fossils that were transported from other habitats.

Vašiček 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 olcostephanids 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 olcostephanids from the R1 locality display more the rule than the exception for this region. In contrast to the opinion stressed in Vašiček and Faupl (1998), the present contribution shows that olcostephanids 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 (*Saynoceras verrucosum*



FIGURE 2: Exposure of the investigated detailed log and position of the outcrop at the Eibeck section, which is situated in the Rossfeld Formation.

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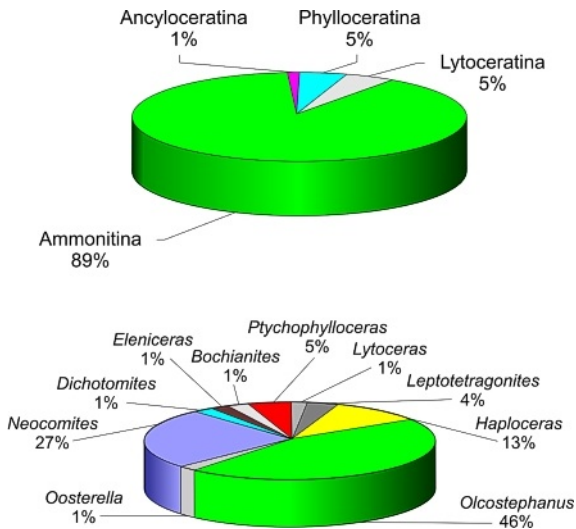


FIGURE 3: Ammonoid assemblage from the Eibeck locality. Note the dominance of the Ammonitina and its abundant genus *Olcostephanus*.

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 grasianum*, *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 phrag-mocones 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. PALAEOLOGY

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

		Stages	Zones	Subzones
HAUTERIVIAN	Upper		<i>P. ohmi</i>	<i>P. picteti</i>
				<i>P. catulloi</i>
				<i>P. ohmi</i>
	Lower		<i>L. nodosoplicatum</i>	<i>O. (J.) jeannoti</i>
				<i>C. loryi</i>
				<i>C. loryi</i>
VALANGINIAN	Upper		<i>C. furcillata</i>	<i>T. callidiscus</i>
				<i>C. furcillata</i>
				<i>O. (O.) nicklesi</i>
	Lower		<i>S. verrucosum</i>	<i>N. peregrinus</i>
				<i>K. pronecostatum</i>
				<i>S. verrucosum</i>
Upper		<i>B. campylotoxus</i>	<i>K. biassalense</i>	
			<i>B. campylotoxus</i>	
			<i>T. pertransiens</i>	
BERRIASIAN	Upper		<i>S. boissieri</i>	<i>T. otopeta</i>
				<i>T. alpillensis</i>
				<i>B. picteti</i>
	Middle		<i>S. occitanica</i>	<i>M. paramimounum</i>
				<i>D. dalmasi</i>
				<i>B. privasensis</i>
Lower			<i>T. subalpina</i>	
			<i>B. jacobi</i>	

FIGURE 4: The stratigraphic position within the Upper Valanginian (*S. verrucosum* Zone, *K. pronecostatum* Subzone) of the Eibeck fauna (in grey) in the Ebenforst Syncline. Table after Hoedemaeker *et al.* (2003, with modifications).

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), Reboulet (1995), Vašíček and Faupl (1999) and Wippich (2001).

Phylum 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. *Phylloceras 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 (Semiscalcatoceras) ptychoicum* (Quenstedt) Joly, 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.

Remarks: See Vašíček and Faupl (1996), and Joly (1976, 2000).

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

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 fimbriatus* 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) - Reboulet; p. 193, pl. 37, 6-7; pl. 38, figs. 5-7.

2001b *Lytoceras subfimbriatum* (d'Orbigny) - Lukeneder, p. 130, pl. 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.

Remarks: See Immel (1987), Reboulet (1995), Wippich (2001) and Lukeneder (2001b).

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

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. 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.

Remarks: See Immel (1987), Vašíček and Faupl (1996) and Lukeneder (2001b).

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

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

Suborder Ammonitina Hyatt, 1889
Superfamily Haplocerataceae Zittel, 1884
Family Haploceratidae Zittel, 1884

Genus *Haploceras* Zittel, 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.

Remarks: See Company (1987), Reboulet (1995), Vašíček and Faupl (1996) and Wippich (2001).

Occurrence: Upper Valanginian sediments of the Eibeck section. *S. verrucosum* Zone (*K. pronecostatum* 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 Perisphinctaceae Steinmann, 1890

Family Oosterellidae Breistroffer, 1940

Genus *Oosterella* Kilian, 1911

Lectotype. *Oosterella gaudryi* Nickles, 1892. Upper Valanginian, Spain.

Oosterella gaudryi (Nickles)

(pl. 1 ; fig. 7)

1892 *Mortonicerias 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.

Remarks: For more details see Company (1987), Reboulet (1995), Vašíček and Faupl (1996) and Wippich (2001).

Occurrence: Upper Valanginian sediments of the Eibeck section. *S. verrucosum* Zone (*K. pronecostatum* 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 Kilian, 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* Kilian – 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: Discocone to sphaerocone (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 (strong 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 prorsiradiate 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).

Remarks: See Company (1987), Bulot (1990, 1992), Wippich (2001), Lukeneder and Harzhauser (2003), and Lukeneder, 2004.

Occurrence: Upper Valanginian sediments of the Eibeck section. *S. verrucosum* Zone (*K. pronecostatum* 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 *Busnardoites campylotoxus* Zone along with *Karakaschicerias* (Bulot 1992). Bulot has restricted the *querolensis* morphotype to the *verrucosum* Zone.

Family Neocomitidae Salfeld, 1921

Subfamily Neocomitinae Salfeld, 1921

Genus *Neocomites* Uhlig, 1905

Type species. *Hoplites teschenensis* Uhlig, 1902. Valanginian, Czech Republic.

Neocomites teschenensis (Uhlig 1905)

(pl. 2, figs. 4-7)

1902 *Hoplites teschenensis* n. sp. Uhlig – p. 56, pl. 3, fig. 4.

1995 *Neocomites teschenensis* (Uhlig) – Reboulet, p. 91., pl. 6., fig. 3 (cum syn.).

2001 *Neocomites* (*Neocomites*) 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.

Remarks: See Company (1987), Reboulet (1995), Vašíček and Faupl (1999) and Wippich (2001).

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

Remarks: See Company (1987), Reboulet (1995), Vašíček and Faupl (1999), and Wippich (2001).

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

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

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, whorl section moderately compressed, venter gently rounded, ribs dense and relatively broad, ribs slightly falcooid, trituberculate stronger ribs are intercalated by 2-4 weaker single ribs, main ribs stronger on body chamber, ribs ending on venter in small tubercles.

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

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

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-whorled, 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 *Karakaschicerias* (e.g. *K. quadristrangulatum* Sayn) (see Reboulet 1995, pl. 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. pronecostatum* Subzone).

Distribution: Upper Valanginian sediments of Austria, ?Mexico, France, Poland, Germany, England, Georgia, Russia, Canada, California.

Suborder Ancyloceratina Wiedmann, 1966

Superfamily Ancylocerataceae Gill, 1871

Family Bochianitidae Spath, 1922

Subfamily Bochianitinae Spath, 1922

Genus *Bochianites* Lory, 1898

Type species. *Baculites neocomiensis* d'Orbigny, 1842,

Valanginian, France

Bochianites neocomiensis d'Orbigny 1842

(pl. 2, fig. 15)

1842 *Baculites neocomiensis* d'Orbigny – p. 560.

1995 *Bochianites neocomiensis* (d'Orbigny) – Reboulet, p. 179, pl. 26, figs. 1-19 (cum syn.).

2001 *Bochianites neocomiensis* (d'Orbigny) – Wippich, p. 115, pl. 43, figs. 4-6.

Material: 2 specimens from the 'Olcostephanus Level' from the Eibeck section (NHMWzoo80/0026).

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

Description: Straight shaft, whorl section highly ovate, strong-prorsiradiate ribs, no tubercles or other additional sculpture elements are observed.

Remarks: See Company (1987), Reboulet (1995), Vašíček and Faupl (1999), and Wippich (2001).

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

Distribution: Valanginian to Hauterivian sediments of Austria, SE-France, Czech Republic, Romania, Bulgaria, Spain, Italy, Mexico, and NW-Germany. It is most abundant in the Upper Valanginian.

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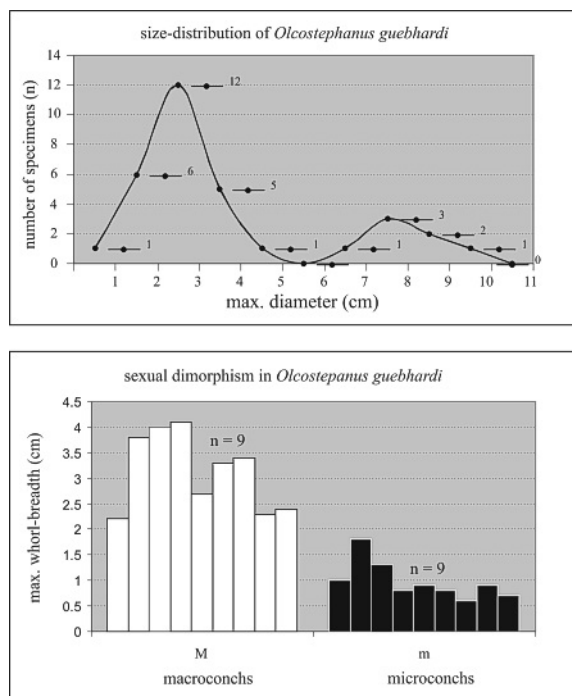


FIGURE 5: Bimodal distribution curves showing two peaks of adult maximum size in *Olcostephanus guebhardi* (max. diameter against number of specimens). In general the macroconchs (M) are larger than microconchs (m), but the size ranges of the two antidimorphs overlap. Detected M (final constriction) and m (lappets) were compared at their maximum whorl breadth.

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 emergence 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 relatives

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, Vašíček and Michalík 2002, Vašíček *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 Silesian and the Pieniny Klippen Zone (Vašíček 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*, *Jeanthieuloyites*) 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. vergunorum*). The earliest '*Dichotomites*' in France was reported from the *Karakschiceras pronecostatum* Zone, which correlates with the *Dichotomites crassus* Zone in Germany. The latest '*Dichotomites*' was reported from the *Criosarasinella 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 *trinodosum* and *verrucosum* ammonoid zones. For the facies distribution of *Prodichotomites* (deep-water; Vocontian 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; Vašíček and Michalík 1999, Stampfli and Mosar 1999, Lukeneder 2003).

As noted by Vašíček *et al.* (1994b) and Vašíček and Faupl (1998,

1999), so far no Boreal ammonoids have been detected from the Lower Cretaceous of the Northern Calcareous Alps. Moreover, no Boreal ammonoids were reported by Immel (1987) in his extensive paper on the Cretaceous ammonoids from the Northern Calcareous Alps. The same holds true for the many papers of Lukeneder, 1997, 1998, 2001a and b, 2003, 2004. The presented specimens provide the first evidence for Boreal migrants (ammonoids) into the Alpine region during the Valanginian.

It is worthwhile to note that during the earliest Late Valanginian, Mediterranean ammonoids, also present in the herein described cephalopod assemblage, migrated from the Tethyan Realm into the Boreal Realm (Kemper 1976, Bulot 1990, Rawson 1973, 1993, 1992, Melinte 2002, Marcinowski and Gasinski 2002, Mutterlose and Bornemann 2002, Vašiček and Michalík 2002). The following ammonoids are common to the Boreal Realm and the Eibeck locality (Mediterranean Province): *Olcostephanus guebhardi*, *Neocomites* sp., *Eleniceras* sp. and *Bochianites neocomiensis*.

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 sea-surface 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 Vašiček 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 (*Karakaschiceras 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.



FIGURE 6: Valanginian palaeogeography combined from Kiessling (2003), Scotese (2001), Kotetichvili (1988) and Wiedmann (1988). Indicated are localities of *Dichotomites* and assumed migration routes. Sea = blue, assumed land = yellow.

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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 *olcostephanid* 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 parautochthonous pelagic elements from the open sea. Different life habitats are assumed for males (microconchs) and females (macroconchs) of the genus *Olcostephanus*. Microconchs probably lived in the open sea, whereas the macroconchs dwelt in the shallower water of the lower shelf.

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PLATE 1:

FIGURE 1: *Lytoceras subfimbriatum* (d'Orbigny), Eibeck section – x 1, NHMWzoo80/0001.

FIGURE 2: *Lytoceras subfimbriatum* (d'Orbigny), Eibeck section – x 1, NHMWzoo80/0021.

FIGURE 3: *Leptotetragonites cf. honnoratianus* (d'Orbigny), Eibeck section – x 1, NHMWzoo80/0019.

FIGURE 4: *Leptotetragonites cf. honnoratianus* (d'Orbigny), Eibeck section – x 1, NHMWzoo80/0020.

FIGURE 5: *Ptychophylloceras ptychoicum* (Quenstedt), Eibeck section – x 1, NHMWzoo80/0022.

FIGURE 6: *Haploceras grasianum* (d'Orbigny), Eibeck section – x 1, NHMWzoo80/0023.

FIGURE 7: *Oosterella gaudryi* (Nickles), Eibeck section – x 1, NHMWzoo80/0024.

FIGURE 8: *Olcostephanus guebhardi* (Kilian), Eibeck section – x 1, NHMWzoo80/0002.

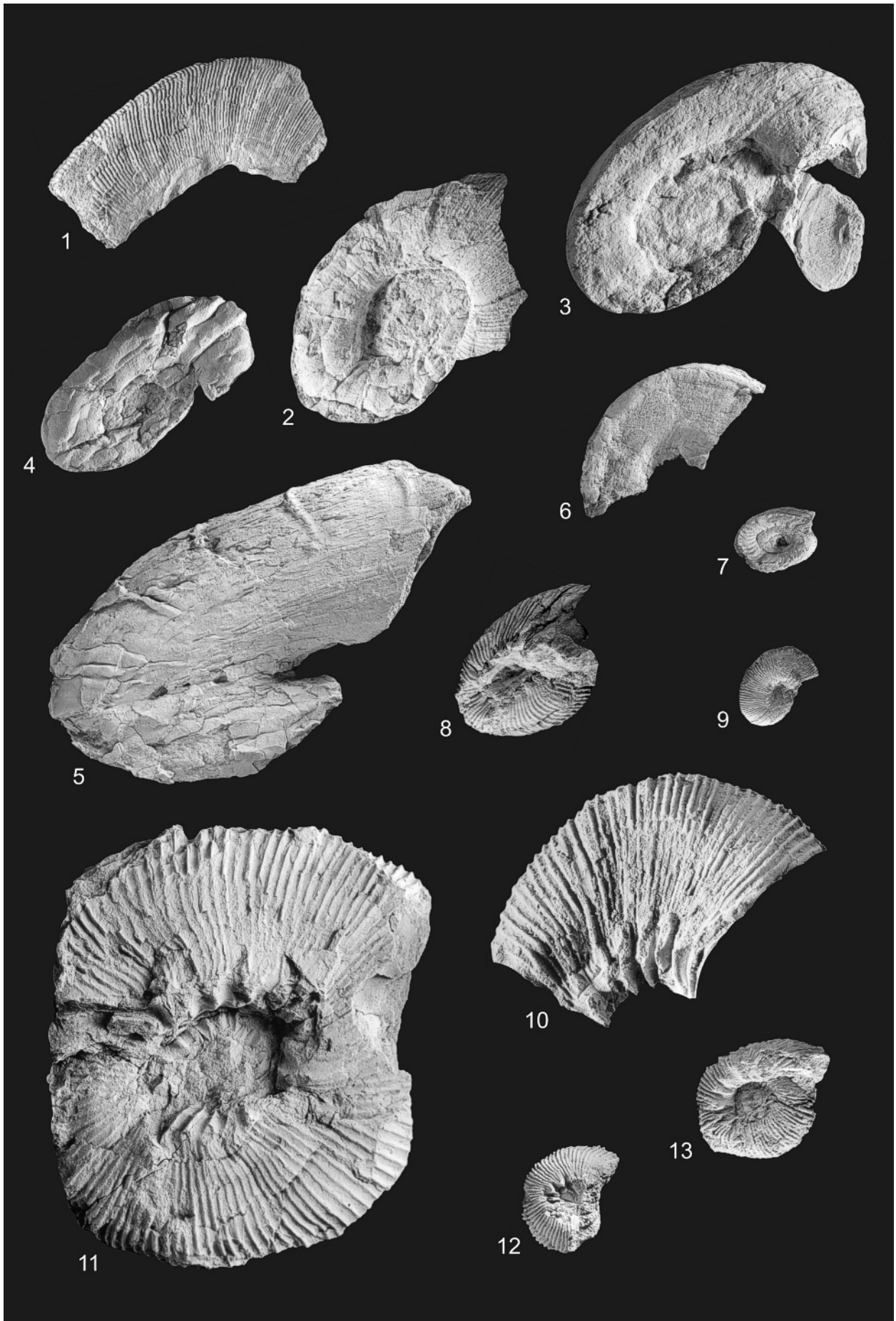
FIGURE 9: *Olcostephanus guebhardi* (Kilian), Eibeck section – x 1, NHMWzoo80/0003.

FIGURE 10: *Olcostephanus guebhardi* (Kilian), Eibeck section – x 1, NHMWzoo80/0004.

FIGURE 11: *Olcostephanus guebhardi* (Kilian), Eibeck section – x 1, NHMWzoo80/0005.

FIGURE 12: *Olcostephanus guebhardi* (Kilian), Eibeck section – x 1, NHMWzoo80/0006.

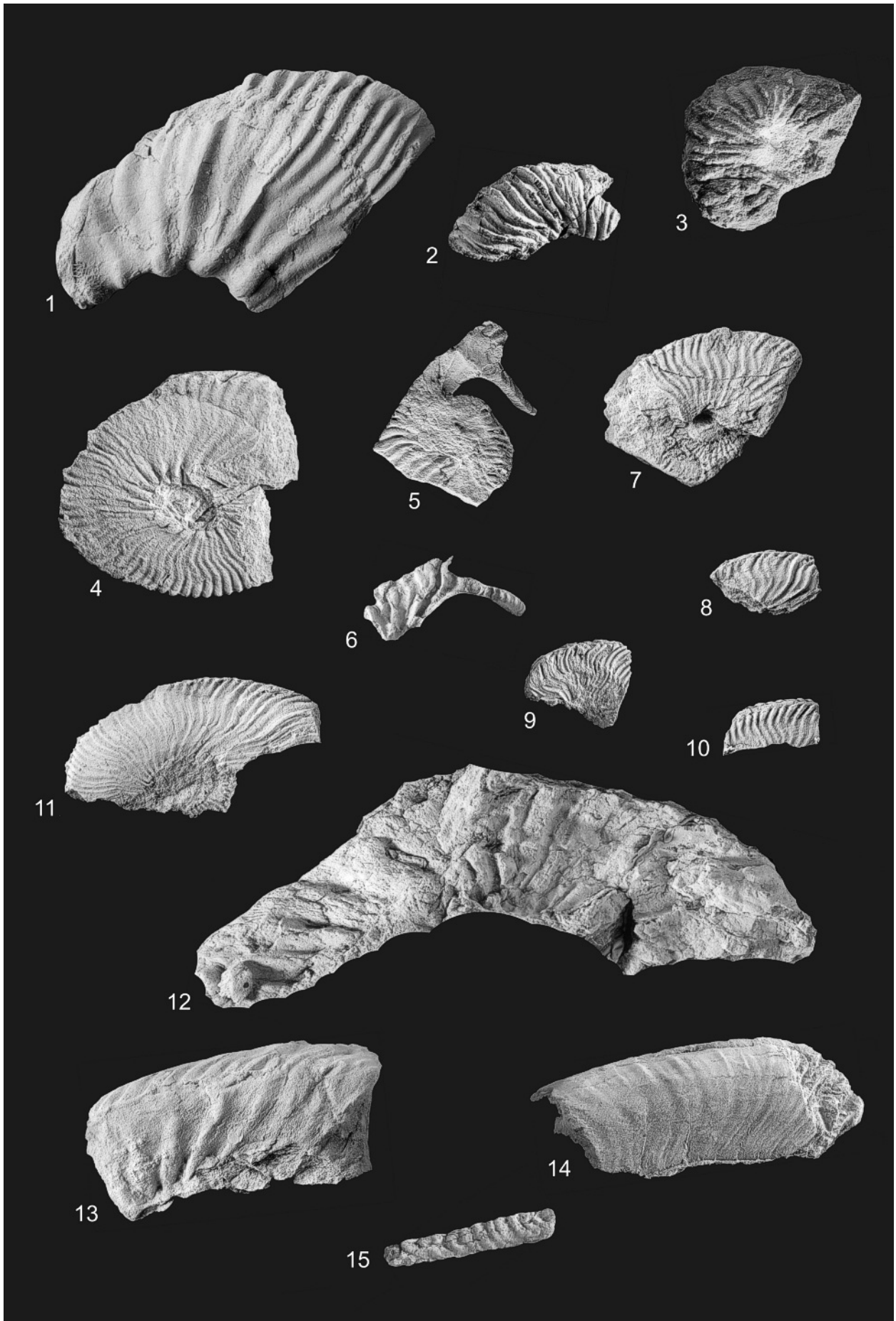
FIGURE 13: *Olcostephanus guebhardi* (Kilian), Eibeck section – x 1, NHMWzoo80/0007.



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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: ?*Prodichotomites* sp., juvenile specimen, Eibeck section – x 1, NHMWzoo80/0018.
FIGURE 4: *Neocomites teschenensis* (Uhlig), Eibeck section – x 1, NHMWzoo80/0008.
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.



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