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The *Olcostephanus* Level: an Upper Valanginian ammonoid mass-occurrence (Lower Cretaceous, Northern Calcareous Alps, Austria)

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ABSTRACT:

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The Early Cretaceous mass-occurrence of *Olcostephanus (Olcostephanus) guebhardi* morph. *querolensis* BULOT from the Late Valanginian *Saynoceras verrucosum* Zone of the KB1-A section, Ternberg Nappe, the Northern Calcareous Alps (Upper Austria) is described. This horizon, spanning an interval of almost 3 metres, is interpreted as a long-term accumulation from the water column combined with temporary redeposition from local submarine highs. The fauna of the *Olcostephanus* horizon is composed of nine genera and ten species. The *Olcostephanus* mass-occurrence represents a widespread phenomenon. It appears most commonly at oceanographic elevations where olcostephanid shells accumulated on the sea-floor during sea-level highs.

Key words: Ammonoids, Lower Cretaceous, Northern Calcareous Alps, Mass-occurrence, *Olcostephanus* Level.

INTRODUCTION

The ammonite genus *Olcostephanus* originated apparently in the western Mediterranean during the Early Valanginian. By the Late Valanginian sea-level rise it was dispersed over many parts of the world, when the '*guebhardi* chronocline' extended to Mexico, Argentina, the Antarctic Peninsula, South Africa, Madagascar, and into the Boreal Realm (especially the West European Province) (BULOT 1990), although it never penetrated into truly boreal areas (RAWSON 1993). Two well recorded *Olcostephanus* mass-occurrences, one at the top of the Lower Valanginian and the other at the top of the Upper Valanginian (KEMPER & *al*. 1981) are well known from France and NW Europe. The most spectacular is undoubtedly the latest Valanginian event, with its record known as the 'Astierien Schichten' (*Astieria* = older synonym for *Olcostephanus*), well known for decades in the geological literature.

The aim of the present paper is to discuss the origin, environment and the palaeogeographical significance of the upper *Olcostephanus* mass-occurrence, based on its record from the KB1-A section in the Northern Calcareous Alps, Austria.

THE KB1-A SECTION

Location

The KB1-A section is situated in the Ternberg Nappe of the Northern Calcareous Alps in Upper Austria (Text-fig. 1). Its exact position is about 7 km west of Losenstein, 1 km south of Kienberg and 500 m southwest of the Klausriegler inn (652 m, ÖK 1:50000, sheet 69 Großraming, Text-fig. 1). The stream outcrop (N 47°54'32", E 14°21'10") crosses the western part of the east-west striking Losenstein Syncline at a line between the

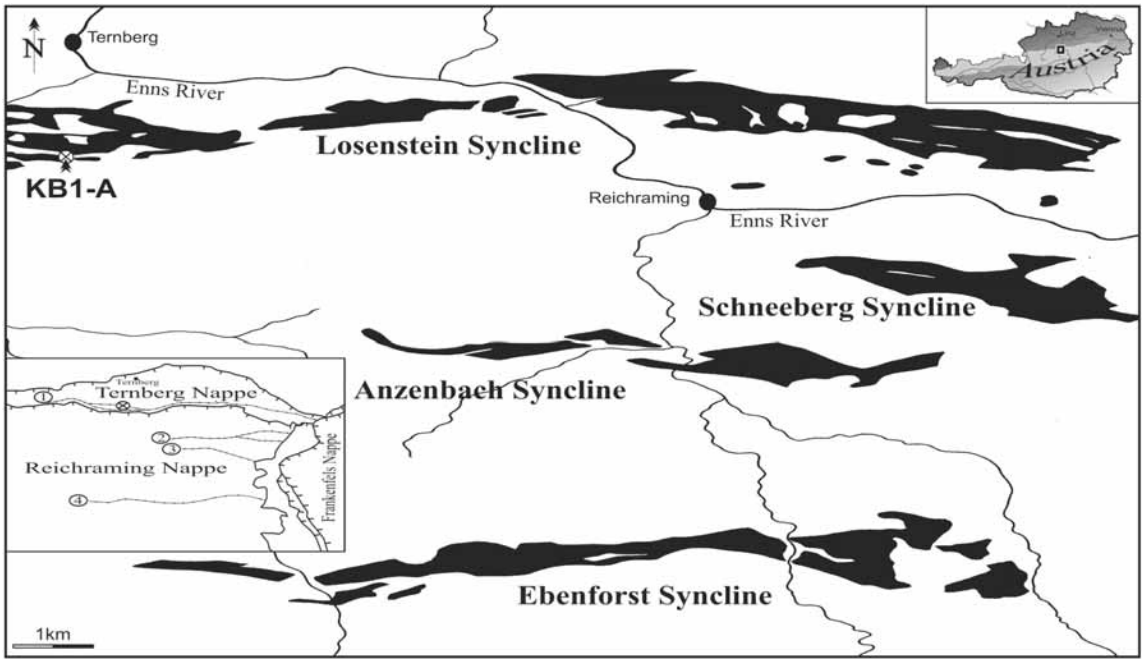

Fig. 1. Position of the section investigated, KB1 (KB1-A) along a stream outcrop. Inset map (left margin) shows the geological setting and the geographical position of the study area, indicating the synclines of the area: 1) Losenstein Syncline, 2) Schneeberg Syncline, 3) Anzenbach Syncline and 4) Ebenforst Syncline. Lower Cretaceous sediments indicated in black

Kreuzmauer (853 m) to the north and the Pfaffenmauer (1218 m) to the south. For detailed descriptions of the investigation area see LUKENEDER (1997, 1998, 1999). The *Olcostephanus* horizon is situated in the uppermost part of the KB1 ravine (800 m), located on the left wall of the gorge (dipping 080/70), forming an exposure 15 m long and 5 m high (Text-fig. 2). Rich vegetation, steep terrain and the soft marly rocks made the sampling very difficult.

Lithology and palaeontological content

The *Olcostephanus* horizon occurs at the base of the Schrambach Formation just above the Steinmühl Formation (Text-fig. 2). The upper part of the latter consists of dm-bedded, wavy grey (*Maiolica* type) limestones, rare in ammonites, but containing abundant pygopids and microfossils (e.g. foraminifera) and a highly diverse accompanying fauna consisting of echinoids, bivalves and very abundant juvenile shark teeth.

The Schrambach Formation (TOC between 0.2 and 7.3 %) consists of pale grey limestones intercalated with grey to black calcareous marls. Important macrofossils are ammonoids, belemnites, aptychi, pygopids, phyllocrinids, ophiuroids and and bivalves (inoceramids of the *Inoceramus neocomiensis* group). The beds are intensively bioturbated, and the trace fossils *Zoophycos*, *Chondrites* and *Planolites* occur throughout.

The calcium carbonate content ($CaCO_3$ equivalents calculated from total inorganic carbon) varies between 88 and 96% within the Steinmühl Formation, and between 54 and 88% within the Schrambach Formation. Sulphur contents range between 0.1 and 1.0 mg/g within the Steinmühl Formation and have their maximum value within the Schrambach Formation in bed 30 at 1.5 mg/g (LUKENEDER & REHÁKOVÁ submitted; text-fig. 3).

The *Olcostephanus* horizon is dominated by ammonites, which represent 98 % of the macrofauna. This abundant, but in general poorly preserved assemblage, consist of nine genera: *Phylloceras*, *Lytoceras, Leptotetragonites*, *Protetragonites*, *Olcostephanus*, *Neocomites*, *Neohoploceras*, *Rodighieroites*, and *Bochianites* (Text-fig. 5). About 200 specimens of *Olcostephanus guebhardi* were collected.

Stratigraphy

The *Olcostephanus* horizon belongs to the *verrucosum* Zone (LUKENEDER & HARZHAUSER 2002). The ammonite association indicates the *Karakaschiceras pronecostatum* Subzone and/or the *Neocomites peregrinus* Subzone (according to the results of the Vienna meeting of the Lower Cretaceous Ammonite Working Group of the IUGS).

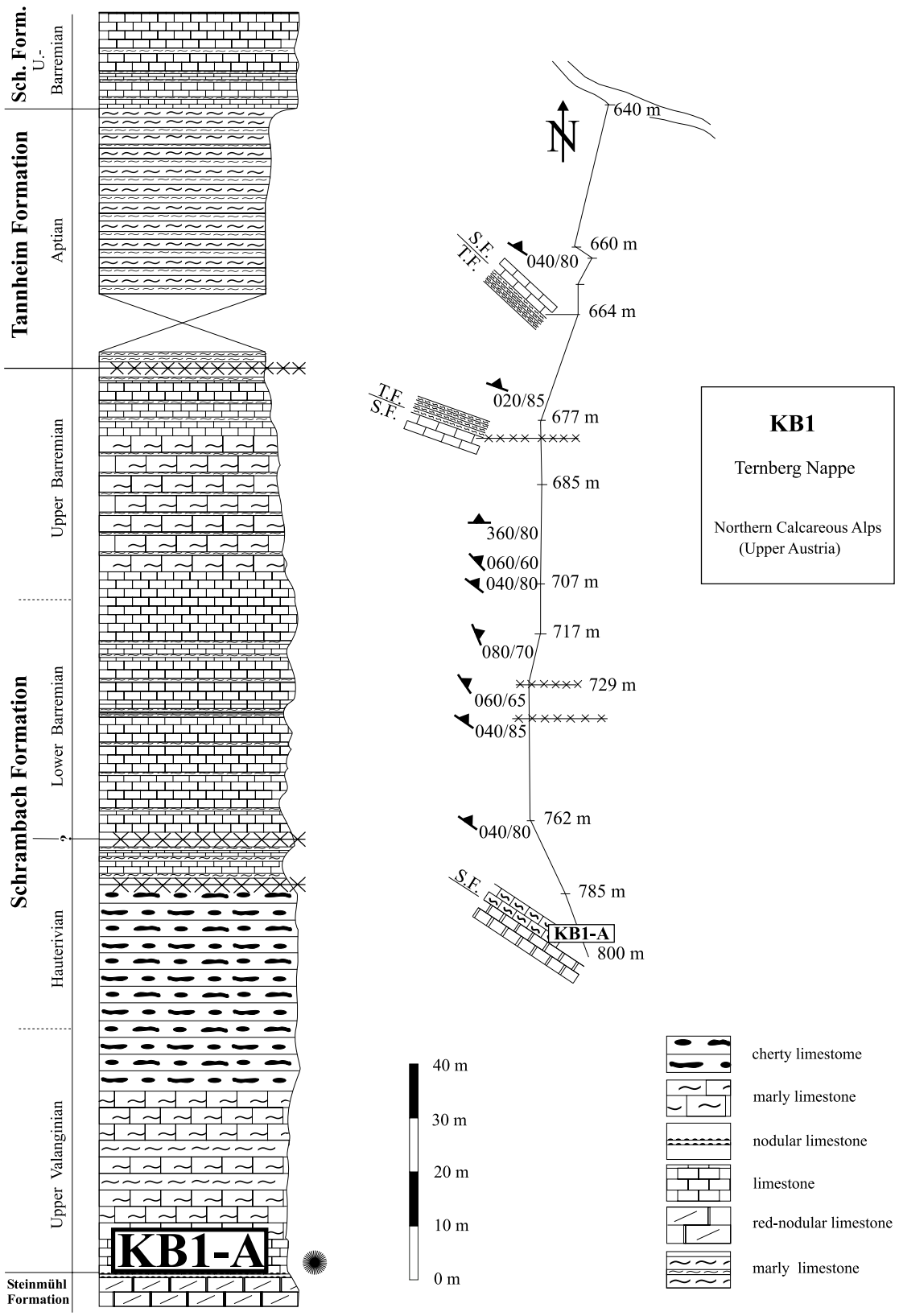

Fig. 2. Stratigraphical log of the section investigated, consisting of the Steinmühl, the Schrambach and the Tannheim Formations, indicating the position of the *Olcostephanus* Level (KB1-A)

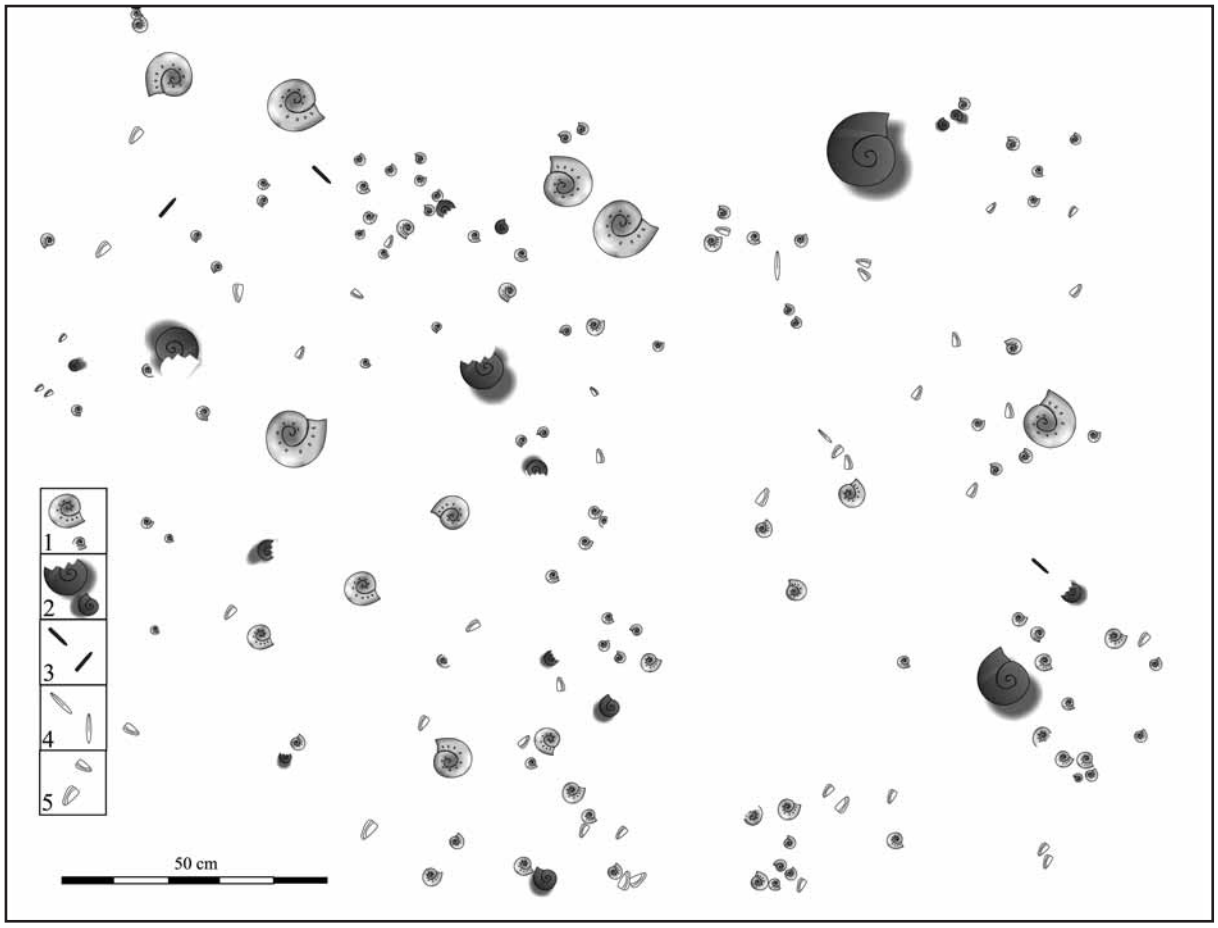

Fig. 3. Excavation area of 4.6 m^2 within the *Olostephanus* Level at section KB1-A (bed 4). The small square indicates the position of the rhynchoteuthid-sampling area (0.25 m^2). Drawings show size and position of complete and fragmented specimens of *Olcostephanus (O.) guebhardi* (1), *Leptotetragonites honnoratianus* (2), *Bochianites neocomiensis* (3), *Pseudobelus bipartitus* (4) and lamellaptychi (5). Among the cephalopod-dominated macrofauna, *Olcostephanus (Olcostephanus) guebhardi* is represented by 102 specimens (n) (modified after LUKENEDER & HARZHAUSER 2002)

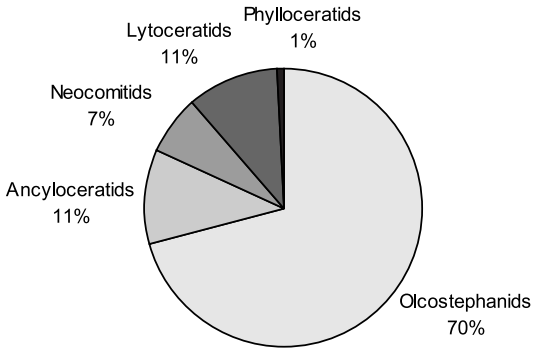

Fig. 4. Ammonite spectrum of the *Olcostephanus* Level

SYSTEMATIC PALAEONTOLOGY

Conventions

The standard dimensions for normally coiled ammonites are given in millimetres. The following abbreviations have been used: M = macroconch, m = microconch, D = shell diameter, W = whorl width; NHMW = Museum of Natural History Vienna. IPV = Institute of Palaeontology Vienna. The author follows the classification of the Cretaceous Ammonoidea by WRIGHT & *al.* (1996). Complete or well-preserved specimens have been measured and documented. Only specimens identified to species level are described in the following chapter.

Order Ammonoidea ZITTEL, 1884
Suborder Ammonitina HYATT, 1889

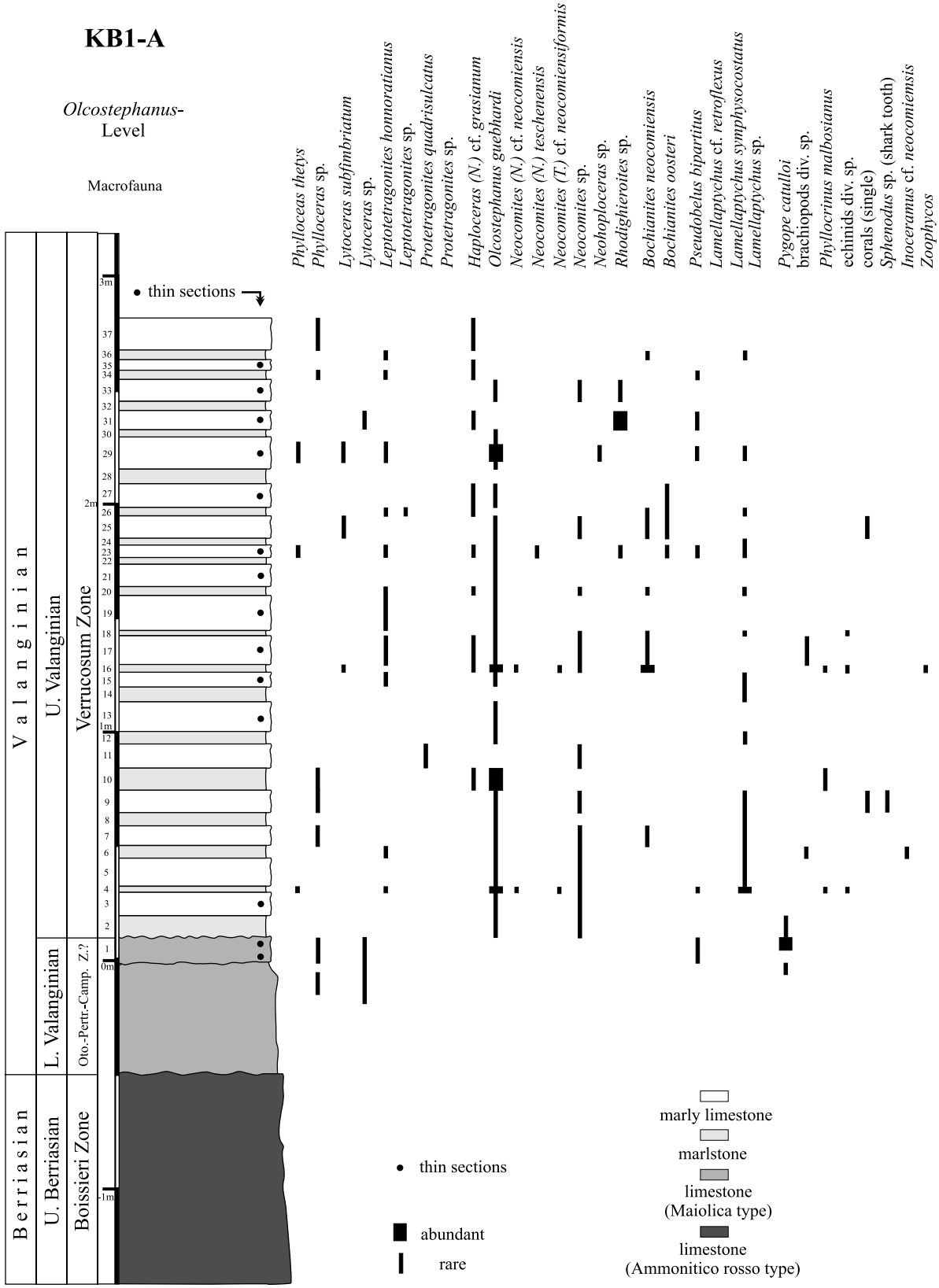

Fig. 5. Stratigraphical log showing the ammonite fauna and other macrofauna of the KB1-A sequence

Superfamily Perisphinctaceae STEINMANN, 1890
Family Olcostephanidae HAUG, 1910
Subfamily Olcostephaninae HAUG, 1910
Genus *Olcostephanus* NEUMAYR, 1875
Subgenus *Olcostephanus* NEUMAYR, 1875

TYPE SPECIES: *Ammonites astierianus* (d'ORBIGNY) 1840, Upper Valanginian, France

Olcostephanus (Olcostephanus) guebhardi KILIAN 1902
morph. type *querolensis* BULOT 1992
(Text-fig. 6, figs 1-6)

1860. *Ammonites astierianus* d'ORBIGNY; F.J. PICTET & G. CAMPICHE, p. 289, pl. 43 fig. 1-2.
1878. *Olcostephanus astierianus* d'ORBIGNY; E. BAYLE, pl. 55, fig. 1.
1902. *Olcostephanus (Astieria) guebhardi* KILIAN, p. 866, pl. 57, fig. 2.
1981. *Olcostephanus (Olcostephanus)* sp. ('*Proasteria*' STOLLEY); E. KEMPER & *al*., p. 268-269, pl. 35, fig. 2.
1987. *Olcostephanus densicostatus* WEGNER; M. COMPANY, p. 169-170, pl. 15, fig. 1-8, pl. 19, figs 16-17.
1992. *Olcostephanus (Olcostephanus) guebhardi* KILIAN; L. BULOT, p. 151-152, pl. 1, figs 2a-2b. (with synonymy)

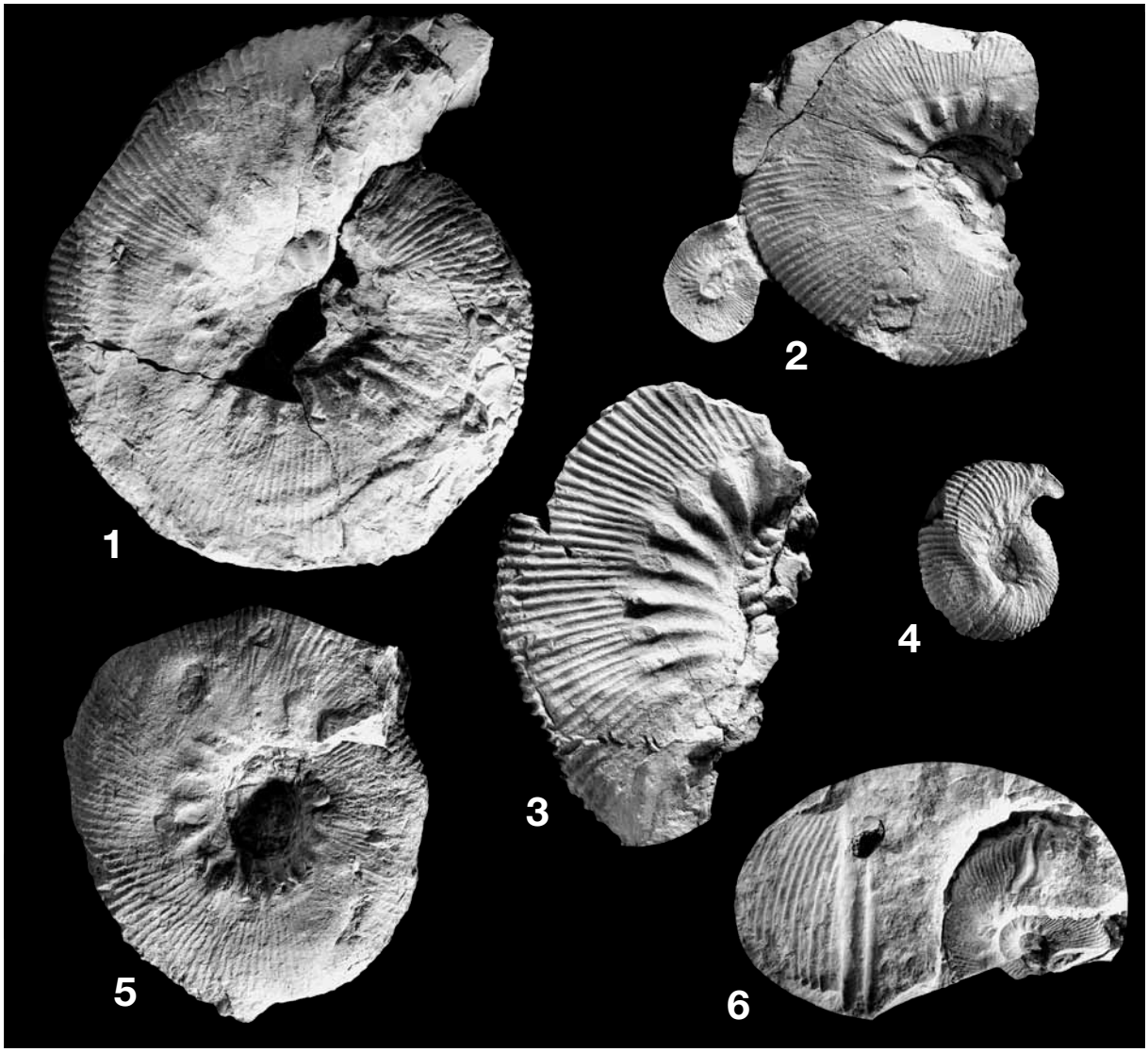

Fig. 6. *Olcostephanus (Olcostephanus) guebhardi* (KILIAN) morph. type *querolensis* BULOT. **1** – M, bed 10, 2002z0070/0001. **2** – M+m, bed 4, 2002z0070/0005. **3** – M, bed 4, 2002z0070/0004. **4** – m, bed 4, 2002z0070/0002. **5** – M, bed 10, 2002z0070/0006. **6** – M+m, m with lappet, bed 29, 2002z0070/0003. All specimens from Figure 1 to 6 are × 1. The specimens were coated with ammonium chloride before photographing. All material examined is deposited in the palaeontological collections of the Natural History Museum (Burgring 7, A-1014, Vienna) or is stored in the collection of the Dapartment of Palaeontology of Vienna (Althanstrasse 14, A-1090 Vienna)

MATERIAL: About 200 specimens, with very variable preservation; all from the *Olcostephanus* horizon of the KB1 section (IPV/2001/Olco0001-0200).

OCCURRENCE: From bed 2 up to bed 33; very abundant in beds 4, 10, 16, and 29 (Text-fig. 5).

DESCRIPTION: The shape is from discocone to sphaerocone (involute with ovate whorls), and is meso- to longidome (body chamber is 60 to 100 per cent of the last whorl). The secondary ribbing is fairly dense. The short bullate primary ribs are slightly rursiradiate to rectiradiate. The primaries (strong from the beginning) start at the umbilical seam and cross the umbilical shoulder, from where 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. The secondaries diverge in fasciculate bundles to pass uninterrupted across the venter. The 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). No suture lines are observable (Text-fig. 6).

SEXUAL DIMORPHISM: The sexual dimorphism in the genus *Olcostephanus* is discussed in detail by DAVIS & *al*. (1996) and COOPER (1981). As in other ammonoids, the ontogenetic development of the shell in this genus is similar in both antidimorphs (sensu DAVIS 1972) until the onset of maturity. Within the material studied the sexual dimorphism is clearly apparent due to the unusually large size attained by macroconchs (M; measured specimens = adult size), some of which exceed 102 mm in diameter. In contrast, the largest microconch (m) found measures slightly above 42 mm in diameter, with the average size for the material distinctly lower (Text-fig. 7). The macroconchs range in size from 82 to 100 mm and the microconchs from 20 to 42 mm, indicating size overlap between antidimorphs of approximately 20 % of their total combined size range (Text-fig. 7). At the aperture, the microconchs show the final constriction together with lateral lappets, whereas the macroconchs show only the final constriction.

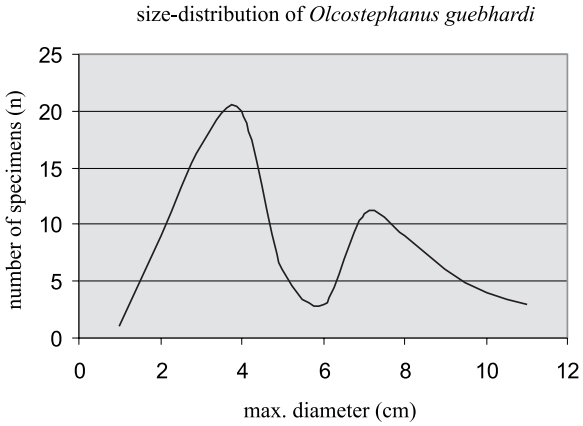

Fig. 7. Bimodal distribution curve showing two peaks of adult maximum size in *Olcostephanus guebhardi* (maximum size against number of specimens). In general the macroconchs (M) are larger than microconchs (m), but the size ranges of the two antidimorphs overlap

REMARKS: The specimens studied herein represent the morphotype *querolensis* described by BULOT (1992). They are very similar e.g. to COMPANY's (1987) specimens of *O. densicostatus* (COMPANY 1987, pl. 15, figs 1-8; pl. 19, figs. 16-17), from La Querola, Alicante Province, Spain, referred subsequently to the variety *querolensis* by BULOT (1992).

From *O.* (*O.*) *guebhardi sensu stricto* the morphotype *querolensis* differs in its larger size and denser ribbing. For detailed discussion on the genus *Olcostephanus* and its species-attributes see BULOT (1990).

OCCURRENCE: Within the Arc de Castellane, the acme of *O.* (*O.*) *guebhardi* is situated in the upper part of the *campylotoxus* Zone, where it co-occurs with *Karakaschiceras* (BULOT 1992). BULOT (1992) has restricted the *querolensis* morphotype to the *verrucosum* Zone. This is confirmed by the Austrian material.

INTERPRETATIONS

Facies relationship of *Olcostephanus*

The studies on the Early Cretaceous ammonites from SE France provided good evidence of depth control on ammonite distribution. Among the Ammonitina the best examples are from Olcostephaninae and Neocomitidae, the assemblages of which differ clearly between the basin and outer shelf (BULOT 1993, REBOULET 1996, REBOULET & ATROPS 1997). In the case of *Olcostephanus,* the splitting into two different 'lineages': the *Olcostephanus (Olcostephanus) guebhardi* (KILIAN) lineage, restricted to the outer shelf facies, and the *Olcostephanus (Olcostephanus) tenuituberculatus* (BULOT) lineage, restricted to the basin facies (BULOT 1993), is observed during most of the Valanginian (Text-fig. 8).

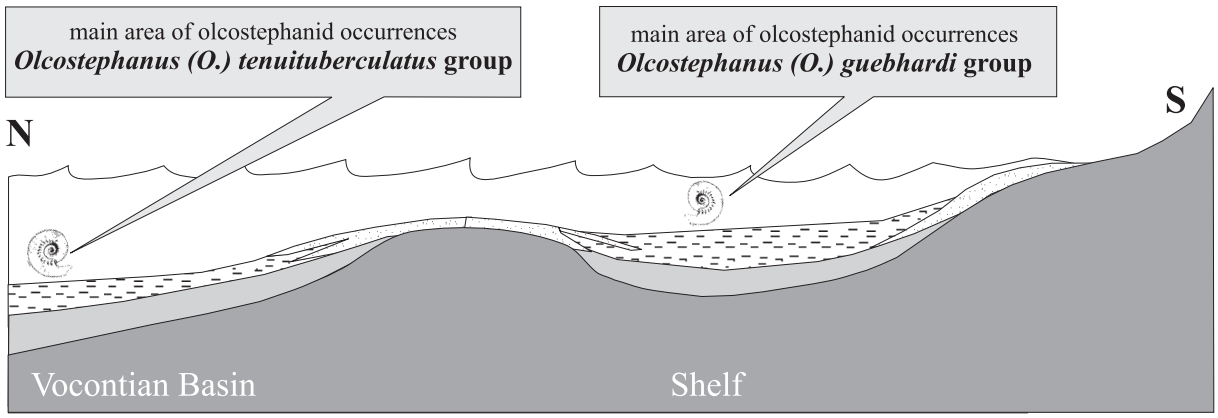

Fig. 8. Different habitat distribution of two species of the genus *Olcostephanus* within the Vocontian Basin (S France). The *Olcostephanus guebhardi* group had its preferred habitat on the shallower shelf, whereas the *Olcostephanus tenuituberculatus* group, for example, inhabited the deeper regions of the basin

This differentation is also suggested by data from other areas of the western Tethys, such as Northern Caucasus (KVANTALIANI & SAKHAROV 1986), Spain (COMPANY 1987), and Switzerland (BULOT 1989, 1992), suggesting a general pattern for the entire Tethys Realm (BULOT & COMPANY 1990).

Sea-level record

Lithological differences observed around the *Olcostephanus* horizon are consequences of changing palaeoceanography, related to sea-level fluctuations during the Berriasian and the Valanginian (LUKENEDER & REHÁKOVÁ submitted). The *Olcostephanus* horizon occurs within the transgressive facies of the basal Schrambach Formation, which may be interpreted as a response to a distinctive sea-level rise in the Late Valanginian *verrucosum* Zone as postulated by HOEDEMAKER (1990).

Palaeoenvironment

The macrofauna of the *Olcostephanus* horizon comprises predominantly moulds of cephalopods, rare belemnites and scattered echinoderms. The latter are represented by regular and irregular echinoids and by numerous calyxes of the crinoid *Phyllocrinus*. In general, however, the macrofauna shows a rather poor and low-diversity benthic assemblage. In contrast, the microfauna is very rich and diversified. A sample from bed 4 yielded an unexpectedly well-preserved and rich mesofossils consisting of numerous elements of ophiuroids. Olcostephanid specimens with encrusting foraminifera, bivalves and bryozoans on their inner shell surface indicate poor circulation of bottom-water, which allowed epifauna to settle on hard substrates (LUKENEDER & HARZHAUSER 2002). The fragmentation and encrustation of the body chambers point to transportation from shallower areas situated to the north.

Variations in the ratios between leiostracan and trachyostracan ammonites at the locality of KB1-A were investigated by LUKENEDER & REHÁKOVÁ (submitted). The *Olcostephanus* horizon shows a value from 5 to 10% of leiostracan ammonoids (e.g. lytoceratids and phylloceratids).

Lithofacies analysis of the KB1 section indicates a change from a calpionellid facies (lower part of the *Ammonitico rosso*-type limestone, samples 15m to 2H, calpionellid wackestones), to a more echinoid facies (upper part of the Steinmühl Formation, samples 1.5H to 3, bioclastic wackestones). The Schrambach Formation (samples 7 to 35) consists of mudstones with rare echinoids, and microfossils, such as ostracods, radiolarians and foraminifera (e.g. *Lenticulina, Planopsilina,* etc.).

Thus, the analysis of the fauna indicates a soft to level-bottom palaeoenvironment with an ophiuroid-dominated benthic fauna in the upper bathyal or deep sublittoral for the lowermost part of the Schrambach Formation at the *Olcostephanus* horizon. Based on the suggested palaeogeographic position of the studied section, an influence of turbiditic redeposition and allochthonous origin of some faunal elements (e.g. fragmented olcostephanids, phyllocrinids) is proposed for several beds (beds 4, 10 and 16). For a more detailed palaeoenvironmental discussion of the fragmentation, encrustation and transport of the olcostephanids from the bioclastic layers see LUKENEDER & HARZHAUSER (2003).

DISCUSSION AND CONCLUSIONS

No sorting or packing due to sedimentological or biological effects can be observed, whereas concentrations due to subsequent transport or bottom currents can be seen in several beds. An enrichment by redeposition, currents or turbidites is proposed for a few marly layers (e.g. 4, 10 and 16) with accumulated fragmented olcostephanids. The olcostephanids were deposited within a phyllocrinid-ophiuroid association. Irregular echinoids proved soft bottom conditions of the secondary allochthonous depositional environment.

The mass-occurrence of *Olcostephanus (Olcostephanus) guebhardi* morph. *querolensis* over an interval of almost 3 metres is interpreted to be the result of a combination of a long-term accumulation from the water column (autochthonous parts) during a favourable time interval and of redepositonal phases (allochthonous parts) of the Late Valanginian. The abundant olcostephanids reflect less offshore influences and the proximity of shallow environments. Parts of the *Olcostephanus* horizon show some similarities to a 'Kondensat-Lagerstätte'.

The *Olcostephanus* horizon in the KB1-A section occurs in the transgressive facies, marking a distinct Late Valanginian sea-level rise. This was probably within the Late Valanginian trangression, which also led to a world-wide (e.g. Argentina, Mexico, Colombia, Spain, France, Italy, Switzerland, N. Germany, Austria, Czech Republic, Romania, Bulgaria, Russia, Tunisia, Algeria, South Africa, Madagascar, Pakistan) spreading or even explosion and occupation of new regions (e.g. Boreal Realm) by the *Olcostephanus* group, mostly due to the creation or renewal of sea-ways. By comparing field evidence and published data from the Vocontian Trough (e.g. BULOT 1993), it seems valid to propose a facies dependence (e.g. depth, outer-inner shelf) of *Olcostephanus* (*Olcostephanus*) *guebhardi* morph. *querolensis* also for the Austrian KB1-A occurrence. The descendants are most probably inhabitants of the outer shelf and related areas. It is also suggested that *Olcostephanus* (*Olcostephanus*) *guebhardi* morph. *querolensis* has its acme within the *verrucosum* Zone, whereas the ancient *Olcostephanus* (*Olcostephanus*) *guebhardi sensu stricto* is most abundant in the uppermost Lower Valanginian (*inostranzewi* Zone) (BULOT 1992).

Comparable occurrences have been recognized by VAŠÍČEK & *al*. (1994), who reported (briefly) an Upper Valanginian 'lumachelle-like' occurrence of *Olcostephanus* NEUMAYER (pl. 1, fig. 2) and *Haploceras* sp. from the Rossfeld Formation in the Ebenforst Syncline (Upper Austria). The olcostephanid shown in their paper lacks bifurcation of the secondary ribbing and is therefore herein suggested to be an *Olcostephanus (Olcostephanus) guebhardi sensu stricto*. Thus, the association described by VAŠÍČEK & *al*. (1994) is probably older (e.g. latest Early Valanginian?) than the olcostaphanid accumulation of the KB1 section. The extraordinary KB1-A occurrence was most probably formed on an elevation near a sloping ramp that dipped to the south. The redeposited specimens were transported from a nearby deep-water swell.

Acknowledgements

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