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The clasts of Cretaceous marls in the conglomerates of the Konradsheim Formation (Pöchlau quarry, Gresten Klippen Zone, Austria)

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Abstract: Investigations were carried out on foraminiferids and radiolaria from redeposited clasts within the conglomerates of the Konradsheim Formation (Gresten Klippen Zone) in the area of the Pöchlau hill, east of Maria Neustift. These shales and marls are of Middle to Late Jurassic and Early Cretaceous age. In the latter clasts, foraminiferal assemblages with *Tritaxia* ex gr. *gaultina* as well as radiolaria species *Angulobracchia portmanni* Baumgartner, *Dictyomitra communis* (Squinabol), *Hiscocapsa asseni* (Tan), *Pseudodictyomitra lodogaensis* Pessagno, *Pseudoeucyrtis hanni* (Tan), *Rhopalosyringium fossile* (Squinabol) were found. In one block from the uppermost part of the sequence there is an assemblage with *Caudammina* (*H*) *gigantea*, *Rotalipora appenninica* and *Globotruncana bulloides*. However, the brecciated character of this block and occurrence near a fault suggest that it was probably wedged into the conglomerates of the Konradsheim Formation during tectonic movements. In pelitic siliceous limestones below the Konradsheim Limestone radiolarian assemblages of Middle Callovian to Early Tithonian age were found. They enable correlation with the Scheibbsbach Formation. In a marly sequence, above the conglomeratic limestone, the foraminiferal assemblages contain taxa from mid-Cretaceous up to Paleocene. The present biostratigraphic investigation confirmed the previous stratigraphic assignments and imply clearly that the sedimentation of deposits similar to the Konradsheim Formation also occurred at the end of the Early Cretaceous and deposition of conglomeratic limestones within the Gresten Klippen Zone, and especially within the Konradsheim Formation, was repeated several times during the Late Jurassic and Early Cretaceous.

Key words: Cretaceous, Paleogene, Austria, Gresten Klippen Zone, Konradsheim Formation, biostratigraphy.

Introduction

The Gresten Klippen Zone is part of the Ultra-Helvetic realm ranging in Austria — apart from Vorarlberg — from Salzburg in the West to the Wienerwald (Vienna Forest, Lower Austria) in the East. The rocks are divided into "Cores" and "Envelopes". The former contain blocks of granites and sediments ranging from Lower Jurassic to Lower Cretaceous. They form the characteristic klippes. The envelope lithology is represented by the "Buntmergel" Formation ranging from Upper Cretaceous to Eocene. Despite long-lasting stratigraphic investigations (Aberer 1951; Schnabel 1970, 1992; Faupl 1975; Widder 1988; Ślączka & Höck 2000; Höck & Slaczka 2001; Höck et al. 2003, 2005; Ślączka et al. 2006) a lot of problems remain, including the age of the Konradsheim Formation and its accompanying rocks (see also Widder 1988). Many of the earlier findings, indicating only Jurassic ages, are not consistent with our data. Because of the stratigraphic importance of the Konradsheim Formation for the Ultra-Helvetic but also for the neighbouring Penninic realm we report new biostratigraphic results from two quarries at the Pöchlau hill in Lower Austria.

Geological setting

The Gresten Klippen Zone is situated at present in front of the Northern Calcareous Alps, generally to the South of the Rheno-Danubian Flysch Zone (Fig. 1). Further to the East it prolongs into the Hauptklippenzone between the Laab and Greifenstein Nappes (Schnabel 2002). Generally the older, Jurassic and Cretaceous part of lithostratigraphic succession of the Gresten Klippen Zone is represented by separate blocks (klippes) from tens to hundreds of meters in diameter which are covered by variegated marls and shales of Late Cretaceous

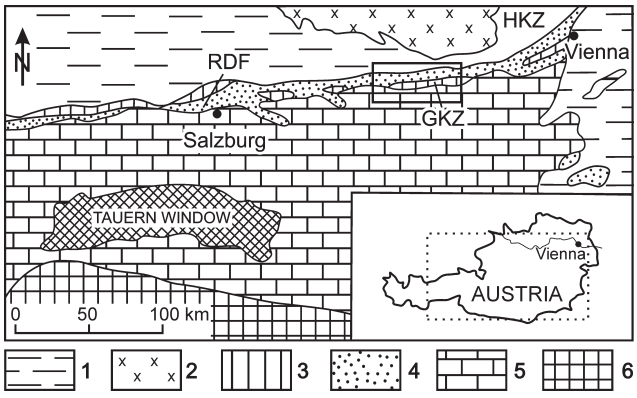

Fig. 1. Geological sketch map of the Eastern Alps with depicted area of study shown in detail in Fig. 2. **1** — Alpine Foredeep, **2** — Bohemian Massif, **3** — Helvetic zone including the Grestem Klippen Zone (GKZ) and the Hauptklippen Zone (HKZ), **4** — Rheno-Danubian Flysch (RDF), **5** — Austroalpine nappes, **6** — Southern Alps.

to Paleogene age which create the klippes mantle (Aberer 1951; Widder 1989). Usually only a part of the succession is visible in individual klippe.

The most characteristic lithofacies of the Gresten Klippen Zone is the Gresten Formation of Early Jurassic age with arkoses, sandstones and shales intercalated by coal in the lower part (Hettangian), and calcareous deposits in the upper part (Sinemurian–Toarcian). The Gresten Formation is followed by a succession beginning with spotted marls (Aalenian), which pass upwards into the Posidonia Marls (Bajocian–Callovian) and cherty limestones with radiolarites (Oxfordian, Lampelsberg Formation). The Malmian and Neocomian are represented mainly by turbiditic siliceous limestones (Scheibbsbach Formation), micritic Arthof Limestones, Aptychus limestones (Lower Blassenstein Formation) and spotted marls (Upper Blassenstein Formation) that are lasted till the Barremian–Aptian (Wessely 2006) similar to the deposits known in the Pieniny Klippen Belt (Pieniny Limestone Formation; Birkenmajer 1977) and in the Northern Calcareous Alps (Oberalm Formation, Aptychenkalk). The characteristic sediments in the higher part of this succession include the lenses of conglomerates named the Konradsheim Limestone (Konradsheim Beds according to Decker 1987, Ruttner & Schnabel 1988, lately Konradsheim Formation of Piller et al. 2004) that created several intercalations within the Scheibbsbach Formation, Arthof Limestones and probably Blassenstein Formation during a period from Late Oxfordian to earliest Cretaceous (Berriasian; Trauth 1950; Aberer 1951; Schnabel 1970; Oberhauser 1980; Decker 1987; Widder 1988; Höck et al. 2003; Wessely 2006). However, Schnabel (1970) mentioned the occurrence of the Cretaceous foraminifers *Hormosina ovulum* (Grzybowski) in marly intercalations within the conglomerates of the Konradsheim Limestones type near Konradsheim village. Recent investigations (Höck et al. 2003, 2005) carried out in the *locus typicus* of the conglomeratic part of the Konradsheim Formation near Konradsheim village and in the Pechgraben area south of Maria Neustift village suggest that sedimentation of the conglomerates of the Konradsheim Formation also took place during the higher part of the Early Cretaceous.

The original paleogeographic position of the Gresten succession is thought (Oberhauser 1980; Decker 1987; Schnabel 1992) to have been north of the Rheno-Danubian Flysch Basin on the southern margin of the Bohemian Massif, which is a part of the European plate. However the Jurassic and Cretaceous sediments, apart from the Gresten Formation, encountered above the Bohemian Massif in the boreholes, below the Molasse Zone, generally differ from the sediments of the Gresten Klippen Zone.

The Gresten Formation, which lay unconformably on the crystalline and Paleozoic rocks of the southern part of the Bohemian Massif consists of deltaic clastics with coal beds and of prodeltaic shales similar to those from the Gresten Klippen Zone. Their age, however, in the basement of the Molasse Zone is younger than in the Gresten Klippen Zone (Wessely 2006) and they represent the Middle Jurassic (?Aalenian–Bathonian). They are covered by dolomitic and quartzitic sandstones with cherts of Callovian age (Nikolčice-Höflein Formation). The Upper Jurassic is represented by dolomitic limestones, bioclastic limestones (Vranovice Formation; Oxfordian), platform carbonates including sponge and coral reefs (Altenmark Formation), dark grey marls (Mikulov Formation; Oxfordian–Tithonian), calcarenites (Kurdejov Formation; Tithonian) and limestones, dolomites and marly limestones with cherts at the base (Ernstbrunn Formation; Tithonian). A similar Upper Jurassic facies as described above is also known from the Waschberg Unit, which is overthrust from the South onto the Bohemian Massif. They are represented mainly by grey marly limestones with cherts and grey sandy clays with ammonites and belemnites (Klentnice Formation; Kimmeridgian–Tithonian; Hanzliková & Andrusov 1983), as in the more northern area by limestones of the Ernstbrunn Formation. Further to the West, the Jurassic deposits of the Bohemian Massif, which consist of the Doggerian sandstones and Malmian limestones (Wessely 1988), were found beneath the Molasse in the borehole Grünau 1, situated SW from Steyr. According to the mineralogical investigations of Faupl (1975), granitoids found within the Gresten Klippen Zone, mainly in the mantle envelope, show an affinity to the Bohemian Massif and the Brunovistulicum. Generally, the Upper Jurassic sediments known from the Bohemian Massif and Waschberg Zone represent shelf and slope facies of the southern slope of the European Platform, whereas neritic lithofacies known from the Gresten Klippen Zone strongly resemble the open sea Alpine facies. It should be noted that the Gresten Formation is known not only from the southern margin of the Bohemian Massif. Lower Jurassic coarse sandstones and conglomerates with intercalations of limestones regarded as similar to Gresten Formation, covered by limestones and Posidonia Formation, were described from the western part of the Pieniny Klippen Belt in Slovakia (Andrusov 1959). The higher, Upper Jurassic sediments with radiolarites and cherty limestones (Pieniny Limestone Formation) also show similarities to the deposits of the Gresten Klippen Zone of the same age. The Gresten Formation with coal deposits is also known from the Mecsek Mts in Hungary (Haas 2001). Gresten sandstones are developed in the Bihor Zone of the Northern Apuseni Mts (Ianovici et al. 1976) and in the Southern Carpathians (Burchfield 1976) of Romania, but the Upper Jurassic sediments are represented generally by shallow water limestones. The occurrence of the Gresten sandstones was recently mentioned from the Pieniny Klippen Belt (Józsa & Aubrecht 2008). These occurrences of the Gresten Formations in different areas of the Alpine-Carpathian range suggests that this litho-facies was widespread in that realm. Areas chracterized by sedimentation of the Gresten Formation probably represent fragments of the southern part of the European plate which separated from the main part of this plate during Jurassic rifting and record the development of a sedimentary basin of the Alpine realm.

Area of investigations and its geology

Our studies were carried out in quarries at the Pöchlau hill, which is situated between the villages Konradsheim and Maria Neustift (Figs. 2, 3). According to Aberer (1951) this hill was built up of the Malmkalk klippe enveloped by the Gresten Formation from the North and Upper Cretaceous marls from the South.

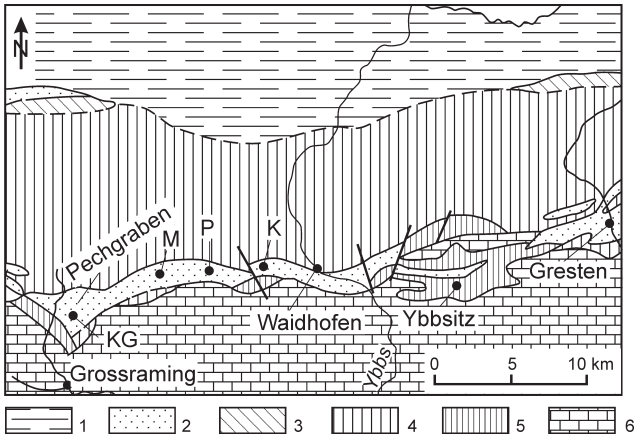

Fig. 2. Sketch map of the Klippen Zone and adjacent areas between Gresten and Pechgraben based on Schnabel (1992). **1** — Alpine Foreland, **2** — Gresten Klippen Zone, **3** — Helvetic Zone, **4** — Rheno-Danubian Flysch Zone, **5** — Ybbsitz Klippen Zone, **6** — Northern Calcareous Alps; **P** — Pöchlau Klippe; **K** — Konradsheim, **M** — Maria Neustift, **KG** — Kohlgraben.

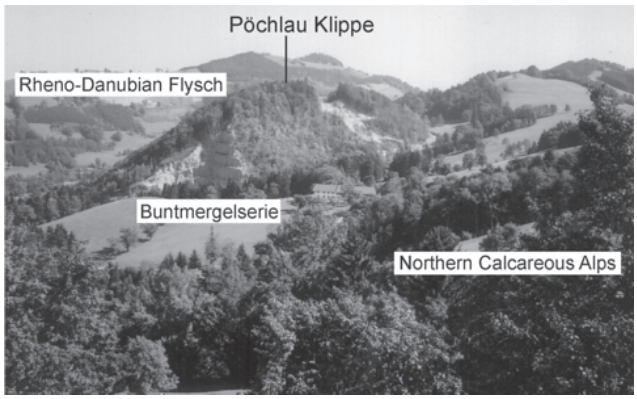

Fig. 3. General view of the Pöchlau Klippe. Two quarries are visible, lower on the left and higher on the right.

Recent research shows that this klippe (approximately 550 meters long and 250 meters wide, Fig. 4), includes a succession of dark, siliceous shales (Fig. 4) with radiolaria of not preciselly determined Jurassic age probably representing the transition between the Lampelsberg and Scheibbsbach Formations. They are covered by a complex 25 m thick, of thin- to medium-bedded, grey, pelitic and graded siliceous limestones, marls and sporadic cherts, which shows similarities to the Scheibbsbach Formation of Widder (1988). Locally, thin intercalations of red limestones and radiolarites occur. A few layers of micritic limestones appear at the top of this succession. Within the upper part of the succession there are a few intercalations of locally developed conglomeratic layers, that are lithologically similar to the conglomerates of the Konradsheim Formation (see also Widder 1988). They could represent primary intercalations and/or a tectonic repetition caused by local thrust faults or/and refolding. An example of refolding is visible in an exposure in the eastern part of the klippe (Fig. 5.1).

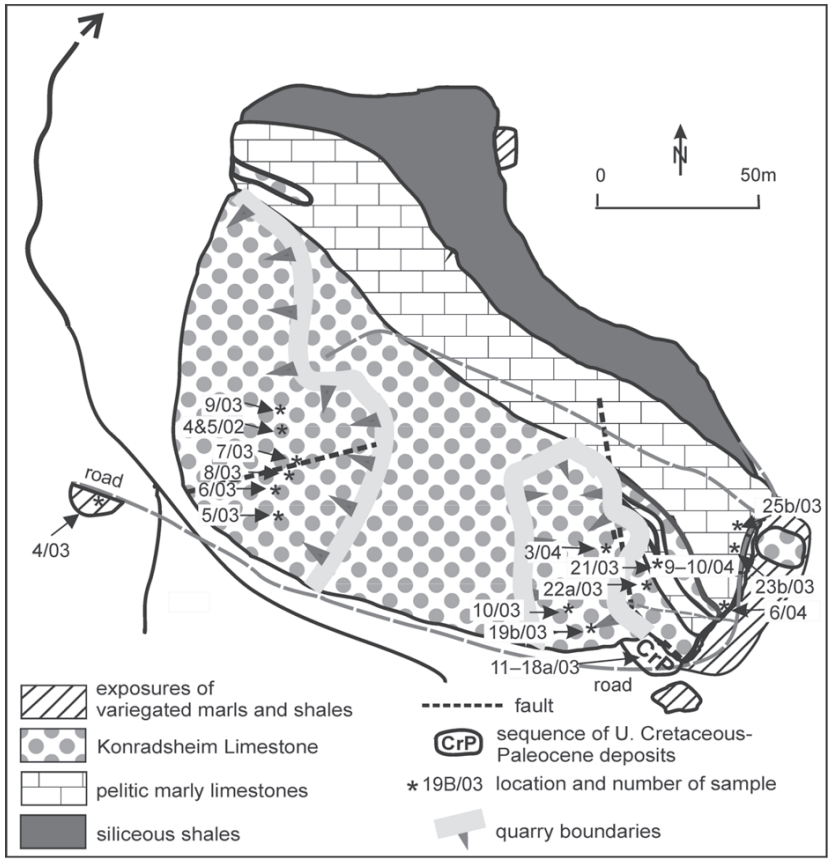

Fig. 4. Geological sketch-map of the Pöchlau hill, according to Wessely (state in 2005).

In the higher part of the succession, the klippe is built up of complex clast-supported conglomerates and sedimentary breccias, up to 80 meters thick. Small erosional channels mark the boundary to the underlying pelitic limestones (Fig. 5.2). The character of these deposits corresponds to the conglomerates of the Konradsheim Formation. They are developed as very thick, usually amalgamated, clast- and matrix-supported conglomerates and sedimentary breccias, often displaying gradation (comp. Faupl 1975; Decker 1987). Pelitic intercalations are very rare and thin. Characteristic is the occurrence of clasts of black, grey and greenish marls and shales. These clasts vary in diameter from a few centimeters to more than one meter (Fig. 5.2, 5.3). They are rounded and subrounded. One clast of black shale contains tiny shells of *Bositra*. The sedimentary structures indicate that these sediments represent deposits of debris flows. Generally, coarser sediments with blocks of conglomeratic limestones and exceptionally big marly clasts exist in the lower part of the sequence that is exposed in the

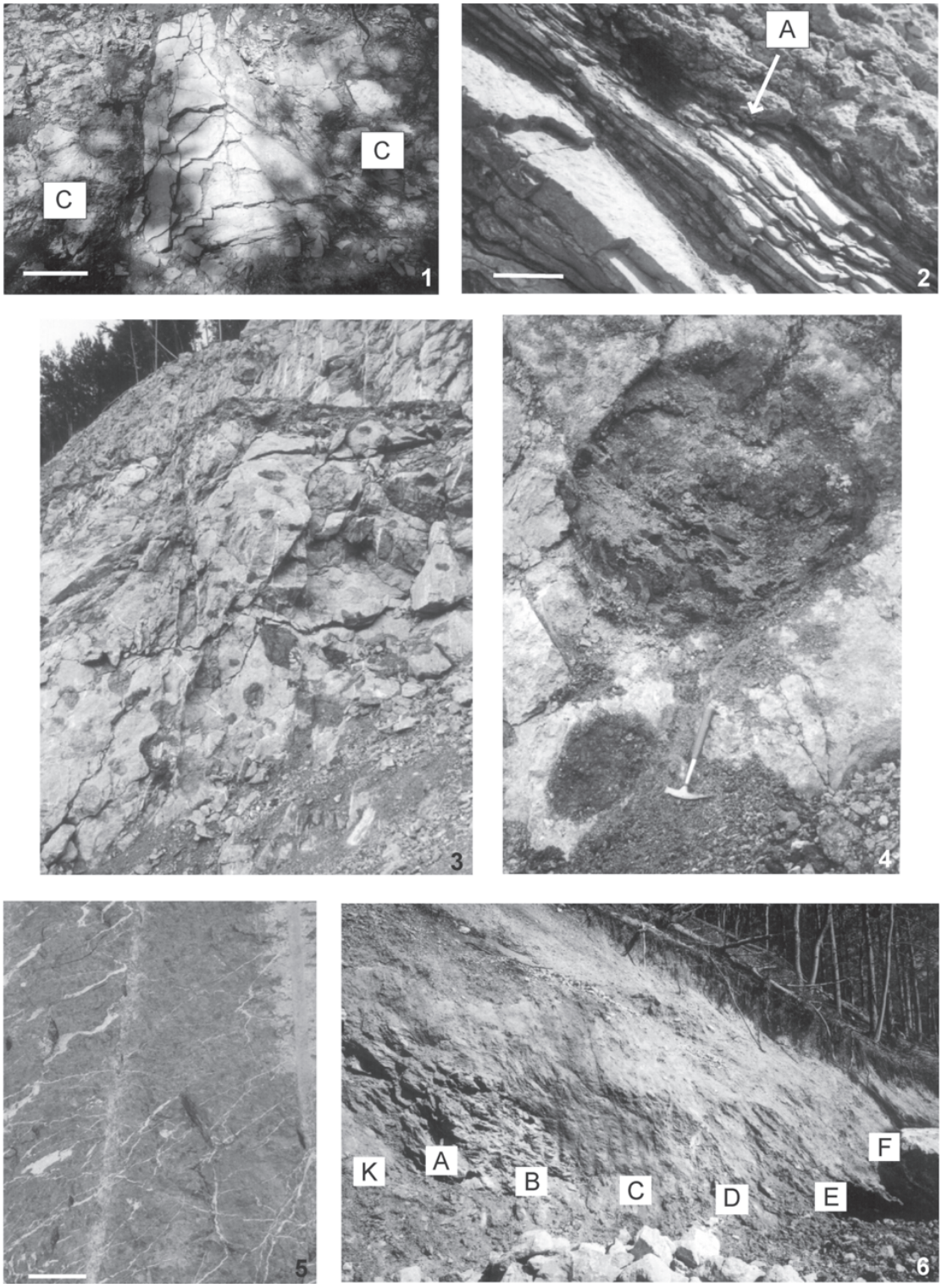

Fig. 5. Pictures of exposures: **1** — Local fold. Light grey pelitic and arenaceous limestones in crest of anticline and conglomerates (C) on the limbs. Length of bar 0.5 m. Road along eastern border of the klippe. **2** — Contact between light grey limestones and debris flow (Konradsheim Limestone). A small erosional channel is visible (A). Length of bar 0.5 m. Upper quarry. **3** — Lower part of the Konradsheim Limestone. Submarine slump, several meters thick, with pelitic clasts, up to 1.5 meters in diameter. Lower quarry. **4** — Detailed picture of the Konradsheim Limestone breccia with clasts. Lower quarry. Length of hammer is 45 cm. **5** — Upper part of the Konradsheim Limestone. Fine-grained conglomerate with clasts up to 20 cm in length. Length of bar 0.2 m. Length of hammer is 45 cm. **6** — Sequence of the Late Cretaceous-Paleocene marls and shales. **A** — dark grey and black shales (samples 11–13/03), **B** — green marls (sample 14/03), **C** — red marls (sample 15/03), **D** — grey-green marls (sample 16/03), **E** — sandy shales (sample 17/03), **F** — green-grey marls (sample 18/03). On the left a contact with the Konradsheim Limestones is visible (K). East wall of entrance to the higher quarry.

lower quarry (Fig. 5.3). In the upper part of the sequence small marly clasts prevail (Fig. 5.4). In the lower quarry the complex of conglomerates is cut by a fault dipping to the South.

The klippe is partly enveloped by variegated marls and shales of Late Cretaceous age. Only in one place, along the entrance to the higher quarry (Fig. 5.6) a different succession, several meters long, was found between the klippe and the envelope. The succession starts with black and green marls, partly tectonized. They are followed by red marls, green-grey marls, sandy shales with intercalations of medium-bedded conglomeratic sandstones and terminated by olive marly sandstones. This succession is lying directly on the conglomerates of the Konradsheim Formation with a sharp and tectonized boundary and probably represents the immediate cover of the Pöchlau klippe. The upper contact is also tectonic.

Methods and material

To establish the age of the conglomeratic limestones and their substratum, several samples were taken for micropaleontological investigations from the lower and upper quarry and from their vicinty (Fig. 4):

— 4 samples were taken from the grey, pelitic siliceous limestones (Scheibbsbach Formation) below the complex of conglomeratic limestones (samples: 19b/03, 21/03, 23/03, 25b/03);

— 14 samples were taken from the clasts within the conglomerates of the Konradsheim Formation (samples: 4/02 — dark grey marl, 5/02 — black marl, 6/03 — greenish-grey marl, 7/03 — brecciated greenish marl, 8/03 — dark grey marl, 9/03 — dark grey marl, 10/03 — black marls, 22/03 — brownish marl) and 3/04 — brown marl);

— 8 samples were taken from the succession along the entrance to the higher quarry (with samples: 12/03 — black marls, 14/03 — green marls, 15/03 — red marls, 16/03 — green-grey marls, 17/03 — sandy shales with intercalations of medium-bedded conglomeratic sandstones, 18/03 — olive marly sandstones);

— 1 sample was taken from the variegated marls and shales from the variegated marls (Buntmergelserie) envelope (4/03);

—1 sample was taken from green marls from a contact between the klippe and its envelope (6/04).

Unfortunately due to the progress of the exploitation of both quarries the sites of the samples from the quarries are not preserved any more.

The samples were analysed for foraminiferal (4/03, 6/03, 7/03, 8/03/, 9/03, 22/03, 10-18/03), radiolarian (4/02, 5/02, 19B/03, 21/03, 23/03, 25B/03) and nannoplankton (Kg. 1–8/04) content.

Standard processing methods (Glauber's salt, multiple heating and freezing) were applied for the analyses of the foraminiferal content. The dried residuum was sieved, with a final sieve size of 63 μm. Some samples, due to their hardness, have been analysed only in thin sections. The taxa were identified using both stereoscope microscope and SEM. In general, samples contain relatively numerous microfauna, however a part of them were almost barren without identifiable taxa.

Radiolarian samples were prepared by standard chemical cleaning procedures for marl and shale using hot Glauber's salt solution, and sieving with a 63 μm sieve. The nannoplankton samples were prepared as standard smear slides.

Micropaleontological analysis and results

Foraminiferida

The assemblages of microfauna represent the Late Jurassic, Late Cretaceous and Paleogene ages (see Figs. 6, 7. 8 and 9). Samples from Lampelsberg/Scheibbsbach Formations (below the Konradsheim Formation) contain only Middle Callovian-Early Tithonian radiolarians. The foraminiferal assemblages from the dark grey, brownish and black marly clasts from the Konradsheim Formation mainly contain calcareous benthic taxa such as *Paalzovella*, *Spirillina* and *Trocholina* of Late Jurassic–Early Cretacous age. Clasts of brecciated greenish marls of the Konradsheim Formation contain mainly Late Cretaceous agglutinated foraminiferids with admixture of calcareous benthic taxa. Samples collected from the variegated, green, red and grey olive marls of Buntmergelserie are mainly composed of Late Cretaceous–Paleogene index planktonic as well as of calcareous and agglutinated benthic foraminiferids (see Fig. 6).

Radiolaria

Six samples contained radiolarian assemblages with identifiable species suitable for biostratigraphic study. Radiolarians are common and abundant in all the samples but poorly preserved. Surface features of many of the tests are intensively recrystallized or further obscured by pyritization or calcitization. Only a small number of moderate to well-preserved specimens occur.

The radiolarian assemblages identified in samples 19b/03, 21/03, 23b/03, 25b/03 from the siliceous limestones below the Konradsheim Formation are dominated by spumellarians, many of which remain undifferentiated due to poor preservation. The recognizable species: *Gongylothorax favosus* Dumitrica, *Homoeoparonaella*(?) *gigantea* Baumgartner, *Mirifusus dianae minor* Baumgartner, *Obesacapsula bullata* Steiger, *Parahsuum stanleyense* (Pessagno), *Paronaella broennimanni* Pessagno, *Parvicingula altissima* (Rust), *Sethocapsa funatoensis* Aita, *Spongocapsula palmerae* Pessagno, *Spongocapsula perampla* (Rust), *Williriedellum carpathicum* Dumitrica, allow a correlation with the Middle Callovian through the Early Tithonian Unitary Associations (UA 8–12) of Baumgartner et al. (1995). For the list of identified taxa see Fig. 6. The particular species are presented on Figs. 10 and 11.

The majority of the species have been identified in the second radiolarian assemblage from clasts of the Konradsheim Formation (samples 4/02 and 5/02), which contains mostly nassellarians. Representatives of the families Archaeodictyomitridae, Pseudodictyomitridae and Dorypylidae (sensu O'Dogherty 1994) (Fig. 12) are dominant both in terms of abundance and diversity. The presence of species *Angulobracchia portmanni* Baumgartner, *Dictyomitra communis* (Squinabol), *Hiscocapsa asseni* (Tan), *Pseudodictyomitra lodogaensis* Pessagno, *Pseudoeucyrtis hanni* (Tan), *Rhopalo-*

Sample No.	Formations and samples lithology	Microfossils (selected)	Age (approx.)
19b/03	**Lampelsberg/Scheibbsbach Fms**, dark grey marls	**R:** *Homoeoparonaella* (?) *gigantea*, *Paronaella broennimanni*	Middle Callovian – Early Kimmeridgian
21/03	**Lampelsberg/Scheibbsbach Fms**, dark grey marls	**R:** *Parvicingula altissima*, *Homoeoparonaella* (?) *gigantea*, *Paronaella broennimanni*	Middle Callovian – Early Tithonian
23b/03	**Lampelsberg/Scheibbsbach Fms**, dark grey marls	**R:** *Spongocapsula perampla*, *Spongocapsula palmerae*, *Mirifusus dianae minor*, *Obesacapsula bullata*, *Sethocapsa* aff. *S. trachyostraca*, *Gongylothorax favosus*	Middle Callovian – Early Tithonian
25b/03	**Lampelsberg/Scheibbsbach Fms**, dark grey marls	**R:** *Parahsuum stanleyense*, *Stichocapsa robusta*, *Williriedellum carpathicum*, *Sethocapsa funatoensis*, *Paronaella broennimanni*, *Gongylothorax favosus*	Middle Callovian – Early Tithonian
4/02	**Konradsheim Formation** (clast) black, grey and greenish marl	**R:** *Dictyomitra communis*, *Pseudodictyomitra lodogaensis*, *Halesium biscutum*, *Angulobracchia portmanni*, *Rhopalosyringium fossile*, *Stichocapsa pulchella*	Early Aptian
5/02	**Konradsheim Formation** (clast) black, grey and greenish marl	**R:** *Dictyomitra communis*, *Halesium biscutum*, *Pseudodictyomitra lodogaensis*, *Obeliscoites* cf. *O. vinassai*, *Pseudoeucyrtis hanni*, *Hiscocapsa asseni*, *Rhopalosyringium fossile*, *Paronaella trifoliacea*, *Angulobracchia portmanni*, *Sethocapsa simplex*, *Thanarla pseudodecora*, *Paronaella tubulata*	Early Aptian
6/03	**Konradsheim Formation** (clast) greenish marl	unidentified	unknown
7/03	**Konradsheim Formation** (clast) brecciated greenish marl	**F:** *Haplophragmoides* sp., *Caudammina gigantea*, *Astacolus* sp., *Ramulina* sp., *Lenticulina* sp., ?*Contusotruncana* sp.	Late Cretaceous
8/03	**Konradsheim Formation** (clast) dark grey marl	**F:** *Heterohelix striata*, *Gansserina gansseri*, *Planoglobulina acervulinoides*, *Guembelitria* sp., *Bulimina* sp.	Campanian – Maastrichtian
9/03	**Konradsheim Formation** (clast) dark grey marl	**F:** *Paalzovella* sp., *Spirillina* sp., *Trocholina* sp.	Jurassic – E Cretaceous
10/03	**Konradsheim Formation** (clast) black marl	**F:** *Paalzovella* sp., *Spirillina* sp., *Trocholina* sp.	Jurassic – E Cretaceous
22a/03	**Konradsheim Formation** (clast) brownish marl	**F:** *Paalzovella* sp., *Spirillina* sp., *Trocholina* sp.	Jurassic – E Cretaceous
3/04	**Konradsheim Formation** (clast) brown shale	unidentified piritized Radiolaria moulds	unknown
4/03	**Buntmergelserie** variegated marl	**F:** mixed? microfauna: *Ammobaculites* sp., *Haplophragmoides* sp., *Trochammina* sp., *Trochamminoides* div. sp., *Tritaxia* ex gr. *gaultina*, *Gaudryina* sp., *Caudammina gigantea*, *Uvigerinammina* cf. *jankoi*, *Lenticulina* sp., *Subbotina triloculinoides*, *Globigerina* sp.	Cretaceous – Paleogene
11/03	**Buntmergelserie** dark grey marl	**F:** *Tritaxia* ex gr. *gaultina*, *Karrerulina* sp., *Gaudryina* sp.	mid-Late Cretaceous
12a/03	**Buntmergelserie** black marl	**F**: Piritized specimens: *Caudammina gigantea*, *Tritaxia* sp., *Trochammina* sp., *Gaudryina* sp., *Lenticulina* sp., *Dentalina* sp., *Globotruncana* sp.	Late Cretaceous
13/03	**Buntmergelserie** black shale	unidentified microfauna	unknown
14a/03	**Buntmergelserie** green marl	**F:** mixed microfauna: *Globotruncana* ex gr. *lapparenti*, *G.bulloides*, *Rotalipora appenninica*, *R.* cf. *cushmani*	Cretaceous (Albian – Maastrichtian)
15/03	**Buntmergelserie** red marl	**F:** *Tritaxia* ex gr. *gaultina*, *Textularia* sp., *Recurvoides* sp., ?*Karrerulina* sp., *Caudammina ovulum*, *Arenobulimina* sp., *Spiroplectammina* sp., *Globigerinelloides* sp.	Late Cretaceous
16/03	**Buntmergelserie** green-grey marl	**F:** *Ammobaculites* sp., *Tritaxia* ex gr. *gaultina*, *Gaudryina sp.*, *Caudammina gigantea*, *Dentalina* sp., *Pleurostomella* sp., *Lenticulina* sp., *Cibicides* sp., ?*Contusotruncana* sp.	Late Cretaceous
17a/03	**Buntmergelserie** olive marl	**F:** *Marssonela oxycona*, *Spiroplectammina* sp., *Triloculina* sp., *Morozovella aequa*, *Subbotina triloculinoides*, *Pullenia* sp., *Nummulites* sp.	Late Paleocene
18a/03	**Buntmergelserie** olive-grey marl	**F:** *Marssonela oxycona*, *Triloculina sp.*, *Morozovella aequa*, *Subbotina triloculinoides*, *Pullenia* sp.	Late Paleocene
6/04	**Buntmergelserie** green marl	**F:** *Ammobaculites* sp., *Trochammina* sp., *Trochamminoides* sp., *Haplophragmoides* sp., *Recurvoides* sp., *Karrerulina* sp., *Hormosina ovulum*, *Spiroplectammina* cf. *navarroana*, *Lenticulina* sp., *Neoflabellina* sp., ?*Globigerina* sp.	Paleogene

Fig. 6. Samples lithology, selected microfossils and approximate age based on foraminiferids and radiolaria from the studied formations: **F** — foraminiferida, **R** — radiolaria. Stratigraphic ranges of agglutinated foraminiferids after Geroch & Nowak (1984) and planktonic species after Caron (1985), Robaszynski & Caron (1995), Premoli-Silva et al. (2002, 2004). Radiolarian stratigraphic ranges are based on Baumgartner et al. (1995).

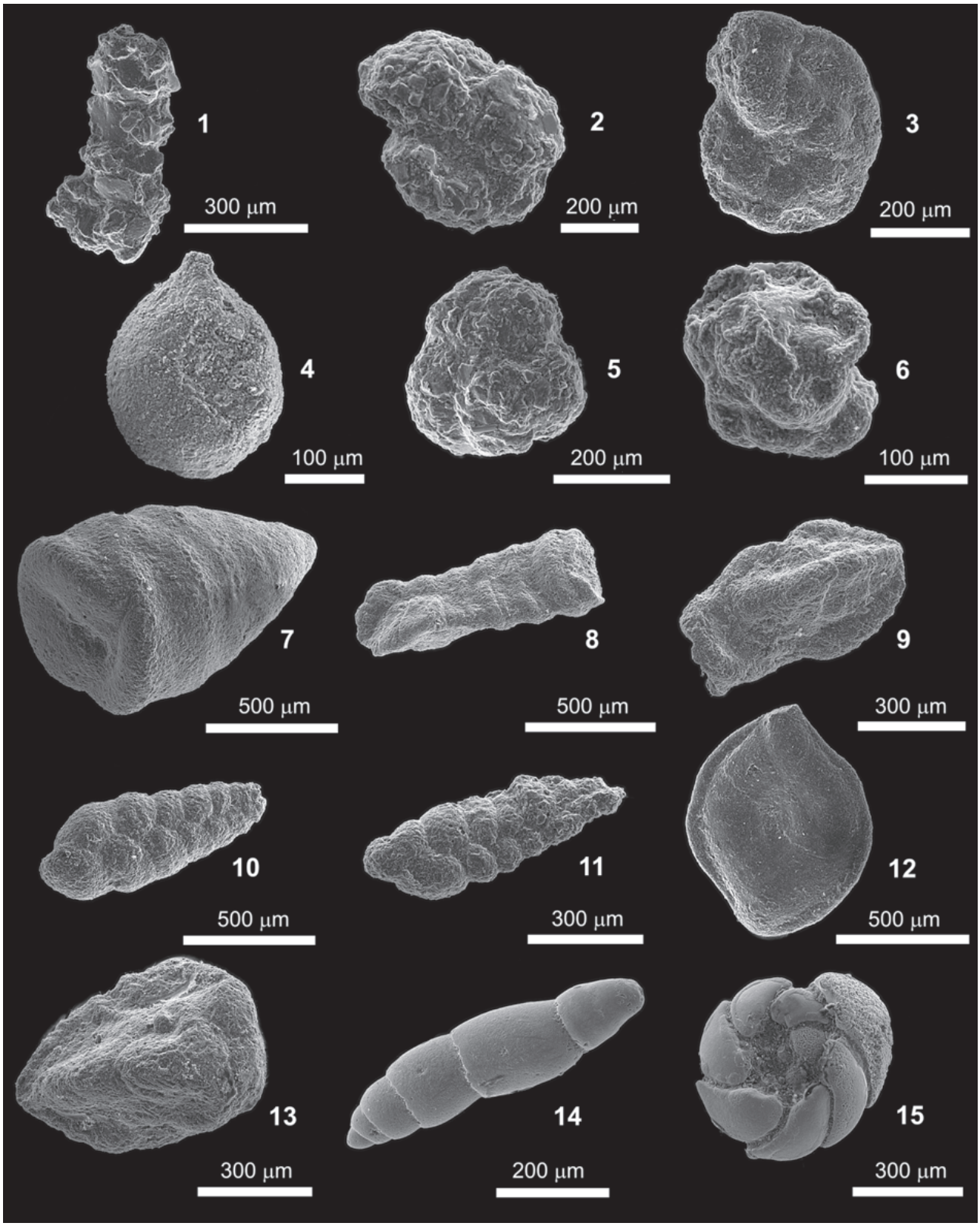

Fig. 7. (Bars have different values.) **1** — *Ammobaculites* sp., sample 4/03; **2** — *Haplophragmoides* sp., sample 4/03; **3** — *Haplophragmoides* sp., sample 7/03; **4** — *Caudammina ovulum* (Grzybowski), sample 15/03; **5** — *Trochammina* sp., sample 4/03; **6** — *Trochamminoides* sp., sample 4/03; **7** — *Marssonella oxycona* (Reuss), sample 18a/03; **8, 9** — *Tritaxia* ex gr. *gaultina* (Morozova), sample 11/03; **10** — *Karrerulina* sp., sample 11/03; **11** — *Karrerulina* sp., sample 6/04; **12** — *Triloculina* sp., sample 18a/03; **13** — *Gaudryina* sp., sample 11/03; **14** — *Dentalina* sp. (internal mould), sample 16/03; **15** — internal mould of *Cibicides* s.l., sample 16/03.

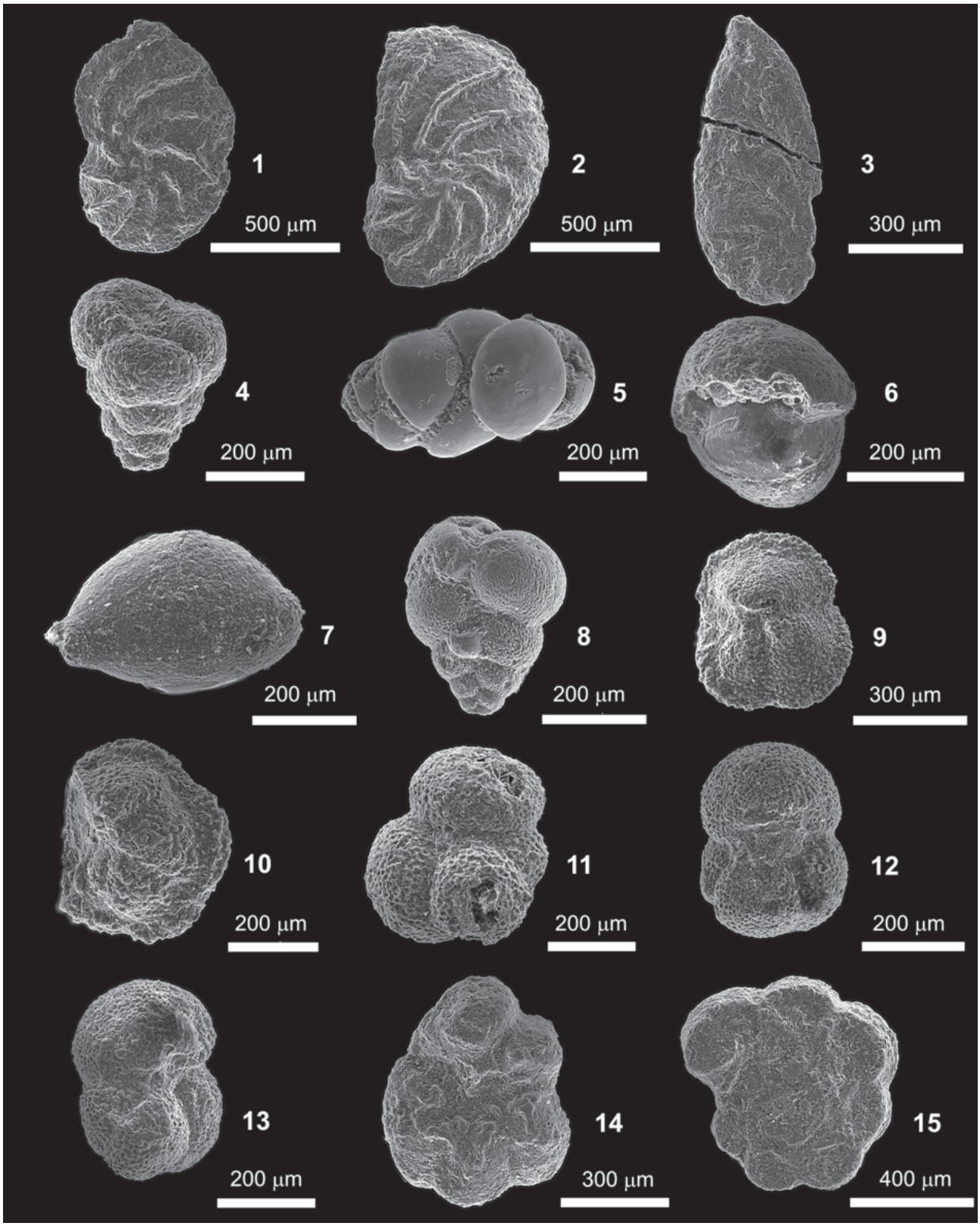

Fig. 8. (Bars have different values.) **1, 2** — *Lenticulina* sp., sample 4/03; **3** — *Astacolus* sp., sample 7/03; **4** — *Guembelitria* sp., sample8/03; **5** — *Bulimina* sp. (internal mould), sample 8/03; **6** — *Pullenia* sp., sample 18a/03; **7** — *Ramulina* sp., sample 7/03; **8** — *Heterohelix striata* (Ehrenberg), sample 8/03; **9** — *Morozovella aequa (*Cushman & Renz), sample 18a/03; **10** — *Morozovella* sp., sample 17a/03; **11** — *Subbotina triloculinoides* (Plummer), sample 18a/03; **12, 13** — *Subbotina* cf. *triloculinoides* (Plummer), sample 18a/03; **14** — *Rotalipora* cf. *appenninica* (Renz), sample 14a/03; **15** — *Globotruncana* ex gr. *lapparenti* (Brotzen), sample 14a/03.

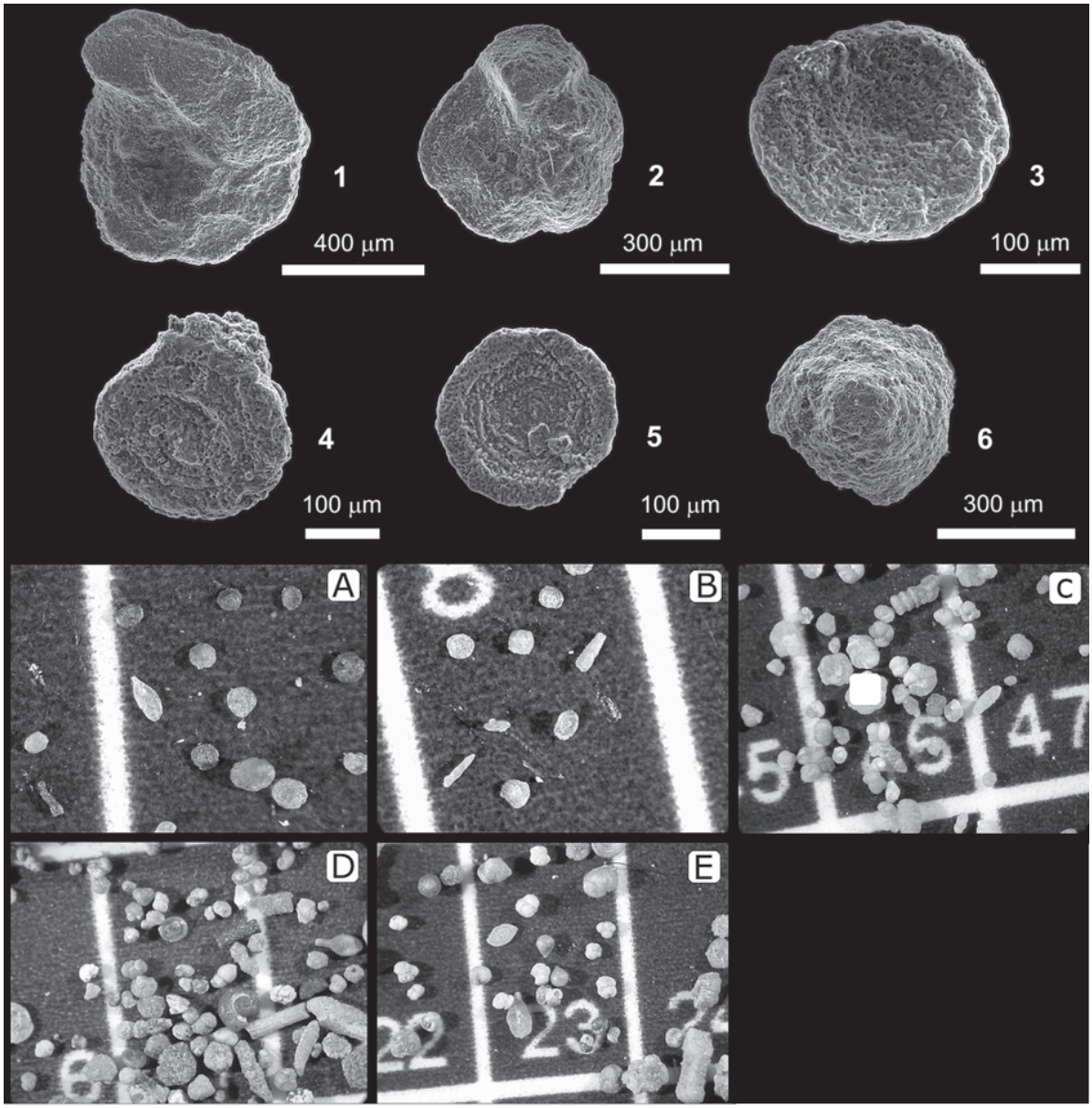

Fig. 9. (Bars have different values.) **1** — *Globotruncana bulloides* Vogler, sample 14a/03; **2** — *Rotalipora appenninica* (Renz), sample 14a/03; **3, 4** — *Sprillina* sp., sample 9/03; **5, 6** — *Spirillina* sp., sample 22a/03. Foraminiferal assemblages: **A** — sample 9/03 (Jurassic–Early Cretaceous); **B** — sample 22a/03 (Jurassic–Early Cretaceous); **C** — sample 14a/03 (mixed mid-Late Cretaceous–Paleogene microfauna); **D** — sample 17a/03 (Paleocene); **E** — sample 18a/03 (Late Paleocene).

syringium fossile (Squinabol) are particularly important as they allow correlation with the radiolarian *costata* Subzone of *Turbocapsula*.

The radiolarian assemblages listed by Ožvoldová & Faupl (1993) from Jurassic chert formations of the Gresten and Ybbsitz Klippen Belt (Eastern Alps, Lower Austria) are different in composition from the above mentioned assemblages.

Nannoplankton

Eight samples numbered as Kg 1–8 from dark grey clasts of the Konradsheim Formation were treated for nannoflora by Stjepan Coric (Austrian Geological Survey). All of them except sample Kg 4 which was barren, were generally rich in *Watznaueria* species:

Kg 1: *Watznaueria fossacincta* (Black, 1971), *W. britannica* (Stradner, 1963) Reinardt, 1964, *W. manivitae* Bukry, 1973, *W. barnesae* (Black, 1959), Perch-Nielsen, 1968. Kg 2: *Watznaueria fossacincta* (Black, 1971), *W. britannica* (Stradner, 1963) Reinardt, 1964, *W. manivitae* Bukry, 1973. Kg 3: *Watznaueria fossacincta* (Black, 1971), *W. britannica* (Stradner, 1963) Reinardt, 1964. Kg 5: *Watznaueria fossacincta* (Black, 1971), *W. barnesae* (Black, 1959), Perch-Nielsen, 1968. Kg 6: *Watznaueria fossacincta* (Black, 1971), *W. britannica* (Stradner, 1963) Reinardt, 1964, *W. manivitae* Bukry, 1973, *W. barnesae* (Black, 1959), Perch-Nielsen, 1968. Kg 7:

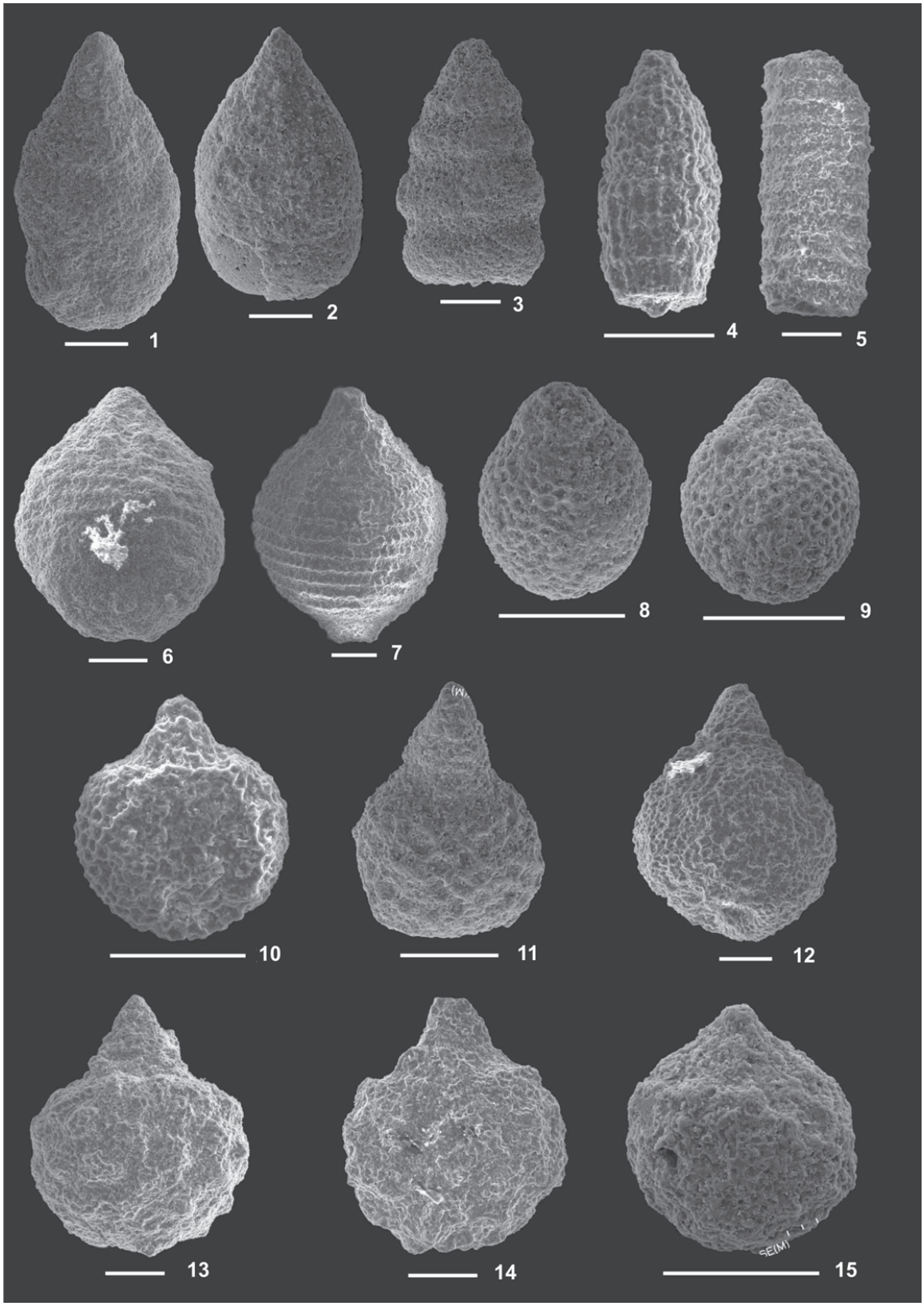

Fig. 10. **1, 2** — *Spongocapsula perampla* (Rust), sample 23b/03; **3** — *Spongocapsula palmerae* Pessagno, sample 23b/03; **4** — *Parahsuum stanleyense* (Pessagno), sample 25b/03; **5** — *Parvicingula altissima* (Rust), sample 21/03; **6, 7** — *Mirifusus dianae minor* Baumgartner, sample 23b/03; **8, 9** — *Stichocapsa robusta* Matsuoka, sample 25b/03; **10** — *Williriedellum carpathicum* Dumitrica, sample 25b/03; **11** — *Sethocapsa* sp., sample 23b/03; **12** — *Obesacapsula bullata* Steiger, sample 23b/03; **13, 14** — *Sethocapsa funatoensis* Aita, sample 25b/03; **15** — *Sethocapsa* aff. *S. trachyostraca* Foreman, sample 23b/03. Scale bar 100 micrometers.

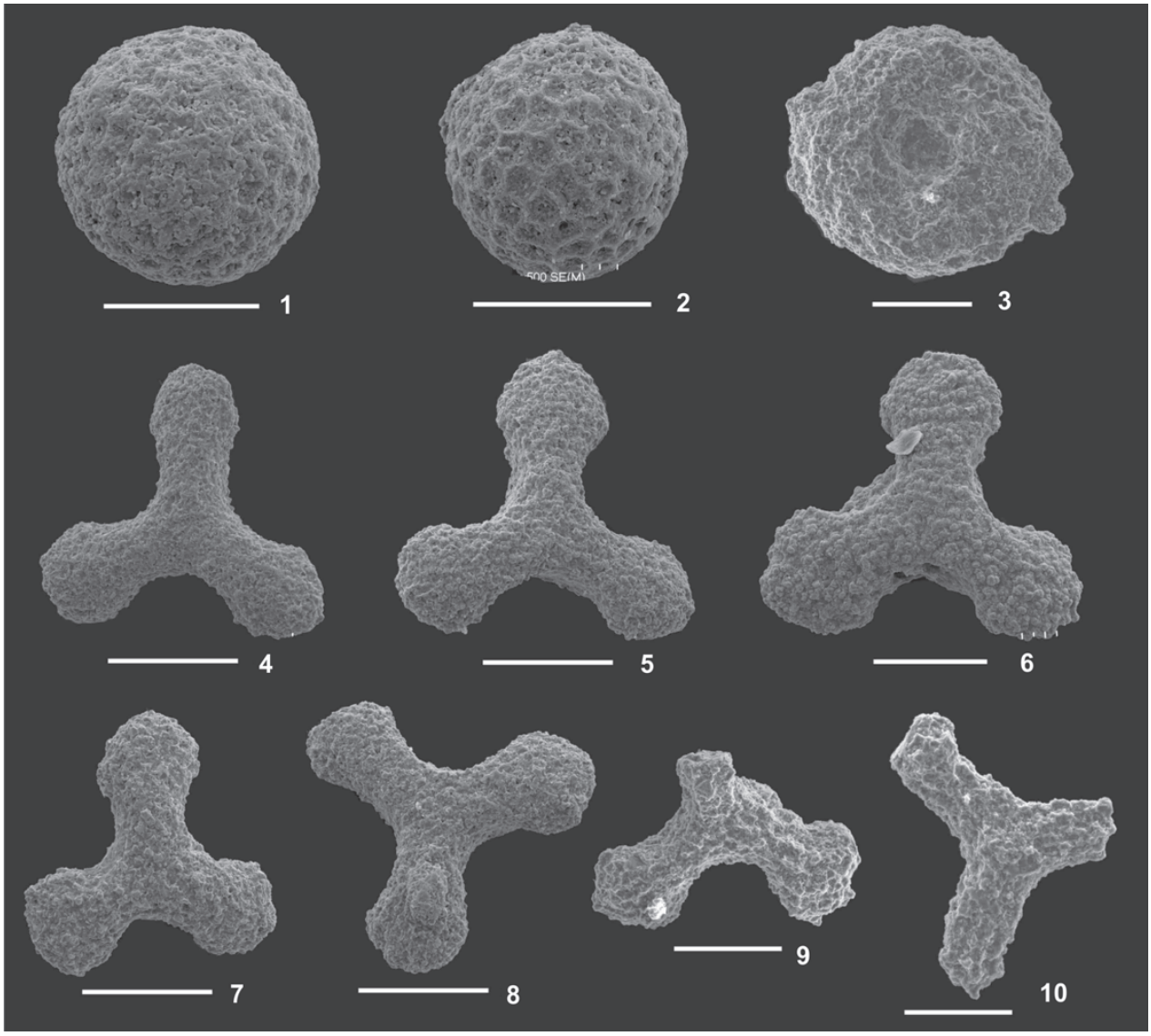

Fig. 11. **1, 2** — *Gongylothorax favosus* Dumitrica, sample 23b/03; **3** — *Orbiculiforma* sp., sample 25b/03; **4–6** — *Homoeoparonaella*(?) *gigantea* Baumgartner, sample 19b/03; **7–9** — *Paronaella broennimanni* Pessagno, samples: 19b/03, 25b/03; **10** — *Halesium* sp., sample 25b/03. Scale bar 100 micrometers.

Watznaueria fossacincta (Black, 1971), *W. britannica* (Stradner, 1963) Reinardt, 1964. Kg 8: *Watznaueria fossacincta* (Black, 1971), *W. britannica* (Stradner, 1963) Reinardt, 1964, *W. manivitae* Bukry, 1973, *W. barnesae* (Black, 1959), Perch-Nielsen, 1968.

These species are typical of the Middle–Late Jurassic. However, zonal marker species were not found, and they have a wide stratigraphic range: *Watznaueria barnesae* and *W. britannica* were also found in mid-Cretaceous deposits and *W. fossacincta* and *W. manivitae* from Lower Hauterivian deposits (e.g. Bown 1982).

Mollusca

One of the clasts of black shale (sample 19B/03) contains abundant tiny molluscs similar to *Bositra* sp. This clast also contains radiolarians of Middle Callovian–Tithonian age (sample 19B/03).

Discussion

The radiolarian assemblages in the grey turbiditic siliceous limestones which can be correlated with Scheibbsbach Formation display a broad stratigraphic range from Middle Callovian to Early Tithonian.

The majority of samples from the redeposited clasts within the conglomerates of the Konradsheim Formation in the Pöchlau klippe contain foraminifers and radiolarians characteristic of the upper part of the Early Cretaceous, only a few of the redeposited clasts contains assemblages of the Middle–Late Jurassic. The one sample which contains the Late

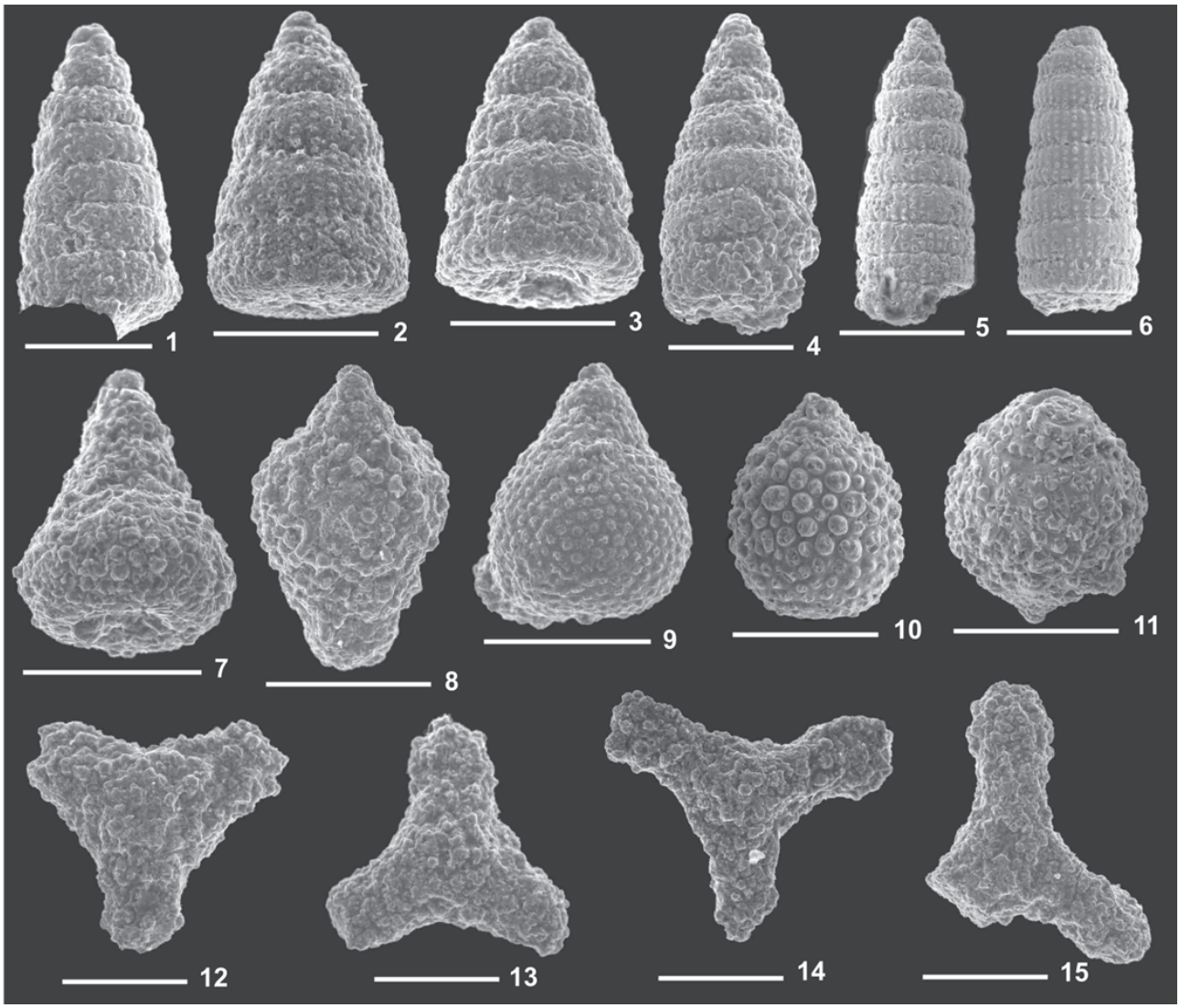

Fig. 12. **1–3** — *Dictyomitra communis* (Squinabol), samples: 5/2, 4/02; **4–6** — *Pseudodictyomitra lodogaensis* Pessagno, samples: 5/02, 4/02; **7** — *Obeliscoites* cf. *O. vinassai* (Squinabol), sample 5/02; **8** — *Pseudoeucyrtis hanni* (Tan), sample 5/02; **9** — *Hiscocapsa asseni* (Tan), sample 5/02; **10–11** — *Rhopalosyringium fossile* (Squinabol), sample 5/02; **12–14** — *Paronaella trifoliacea* Ožvoldová, sample 5/02; **15** — *Angulobracchia portmanni* Baumgartner, sample 5/02. Scale bar 100 micrometers.

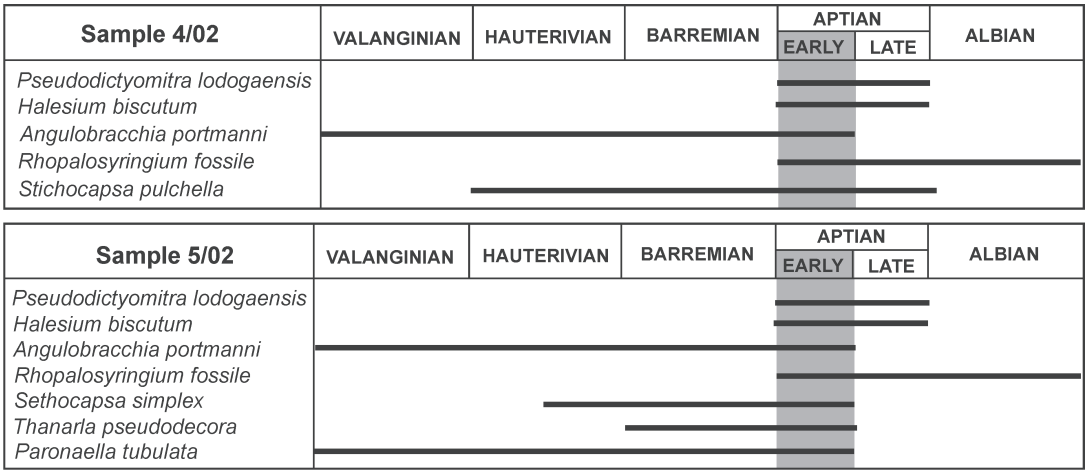

Fig. 13. Ranges of radiolarian species found in samples: 4/02 and 5/02.

Cretaceous was taken from the brecciated block of greenish marl situated in vicinity of the fault, which cut the lower quarry, therefore it probably represents a tectonic block of younger sediments incorporated into the conglomerates of the Konradsheim Formation during younger tectonic movements. Therefore, the sampled part of the conglomerates of the Konradsheim Formation within the Pöchlau klippe cannot be older than Barremian-Aptian and, most probably, their age is mid-Cretaceous. The existence of conglomeratic deposits of similar age is known from the Calcareous Alps (e.g. synorogenic conglomerates of the Rossfeld Formation— Decker et al. 1987; Losenstein Formation—Schnabel ed. 2002) and recently described by Józsa & Aubrecht (2008), from the western part of the Pieniny Klippen Belt (Tvrdošín Breccia Member). The position of the unique, Upper Cretaceous-Paleogene mainly pelitic sequence above the conglomerates of the Konradsheim Formation, exposed at the entrance to the higher quarry is not clear. The conglomeratic sandstones could correspond to the conglomerates described by Faupl & Schnabel (1987) from the vicinity of Scheibbs. However, if this sequence is the primary cover of the conglomerates of the Konradsheim Formation, this confirms its Early Cretaceous age.

The similar, mid-Cretaceous age of the conglomerates of the Konradsheim Formation was found in the *locus typicus* near the Konradsheim village as well as in Kohlgraben (Höck et al. 2005). The existence of conglomeratic limestone complexes within the Upper Jurassic sediments (Decker 1987; Widder 1988) similar to those from the vicinity of the *locus typicus*, show that sedimentation of the conglomeratic limestones of the Konradsheim Limestone type started already during the Late Jurassic and was repeated several times. As a result several separated lenses of conglomeratic sediments existed within the Upper Jurassic–Lower Cretaceous sediments of the Gresten Klippen Zone. Observed erosional surfaces below some complexes of these deposits in the Pöchlau klippe as well as near Arthof (Höck et al. 2005) imply that intercalated, probably more pelitic sediments dividing the conglomeratic ones were eroded by dense turbiditic currents which deposited the conglomeratic limestones and/or were squeezed out during the tectonic movements. The existence of the erosion during the sedimentation of the conglomeratic limestones is also confirmed by the co-existence of clasts of different age, from Jurassic to Early Cretaceous, in the conglomerates of the Konradsheim Formation.

The repeated sedimentation of conglomeratic limestones similar to the conglomerates of the Konradsheim Formation from the Late Jurassic up to the Early Cretaceous can give a new insight into the paleogeography (see Höck et al. 2005) of the discussed area and show the recurrent activity of the source area for the conglomeratic limestone during that time.

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