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NEW MICROBIOSTRATIGRAPHICAL DATA FROM SEVERAL LOWER CRETACEOUS PELAGIC SEQUENCES OF THE NORTHERN CALCAREOUS ALPS, AUSTRIA (PRELIMINARY RESULTS)

Daniela Reháková, Jozef Michalík & Ladislava Ožvoldová

With 7 figures and 5 plates

Abstract:
The article gives a survey of results of microfacies and microbiostratigraphic investigation of Lower Cretaceous pelagic limestone sequences of six selected sections in Eastern Alps. The study contributes to the more widely oriented correlation IGCP Project No. 362, as well as to ALCAPA Project. Attention was focused on distribution of the calpionellid microfauna in Texing, Reidl, Hohenberg, Großer Flösselberg, Anzenbach and Gartenau sections as well as on radiolarian associations in the Hohenberg and Gartenau sections. The correlation of lithostratigraphic units coming from different paleotectonic environments was enabled by combined utilization of various biostratigraphic markers (calpionellids, radiolarians, but also ammonites, etc.) and of several parallelly developed biostratigraphic scales. Preliminary results of this complex study indicate possible calibration of variations in index microfossil distribution in individual sedimentary basins often affected by local factors.

Zusammenfassung:
In dieser Studie werden die Ergebnisse der mikrofaziellen und mikrobiostratigraphischen Untersuchungen pelagischer Karbonatgesteinsfolgen anhand von sechs Profilen der Nördlichen Kalkalpen dargestellt. Die Untersuchungen stellen sowohl einen Beitrag zum IGCP-Projekt Nr. 362, als auch zum ALCAPA-Projekt dar. Besonderes Augenmerk wurde auf die Verbreitung der Calpionellen in den Profilen Texing, Reidl, Hohenberg, Großer Flösselberg, Anzenbach und Gartenau gelegt. Aber auch die Erfassung der Radiolarienfauna in den Profilen Hohenberg und Gartenau war ein besonderes Anliegen. Durch den kontinuierlichen Einsatz verschiedener biostratigraphischer Marker (Calpionellen, Radiolarien, aber auch Ammoniten etc.) war es möglich, die lithostratigraphischen Einheiten aus den verschiedensten paläotektonischen Ablagerungsräumen zu korrelieren. Die vorläufigen Ergebnisse der Studie zeigen auf, daß die Eichung von Index-Mikrofossilien in den jeweiligen Becken oft stark von lokalen Faktoren beeinträchtigt wird.

Introduction

In the frame of the ALCAPA partial project "Cretaceous and Paleogene paleogeography and geodynamics of the Alpine-Carpathian-Pannonian Region", led by Prof. Dr. F. Faupl from the Geological Department of the University of Vienna, field works were organized with aim to establish a basis for detailed lithostratigraphic correlation and interpretation of sedimentary regime in Lower Cretaceous Alpine-Carpathian basins. Samples from six selected sections (Figs. 1, 2) representing Lower Cretaceous sequences of several Penninic, Bajuvaric and Tirolic units of the Eastern Alps were collected during field season in summer 1992.

The investigation of Lower Cretaceous microplankton is closely connected with orientation of the IGCP Project 362 (Tethyan and Boreal Cretaceous Correlation). In the last few years, biostratigraphical scales based on different organisms were correlated (ONDREJÍČKOVÁ et al., 1993; VAŠÍČEK et al., 1992, 1994 a, 1994 b). Special attention was focused on local variations of microplankton associations in various Tethyan regions (REHÁKOVÁ & MICHALÍK, 1992, 1993, 1994).

The study of Upper Jurassic and Lower Cretaceous sequences stressed the need of more precise lithologic and biostratigraphic calibration, enabling more reliable correlation of neighbouring sedimentary basins. In this aspect, several widely used lithostratigraphic terms (e. g. "Aptychen-

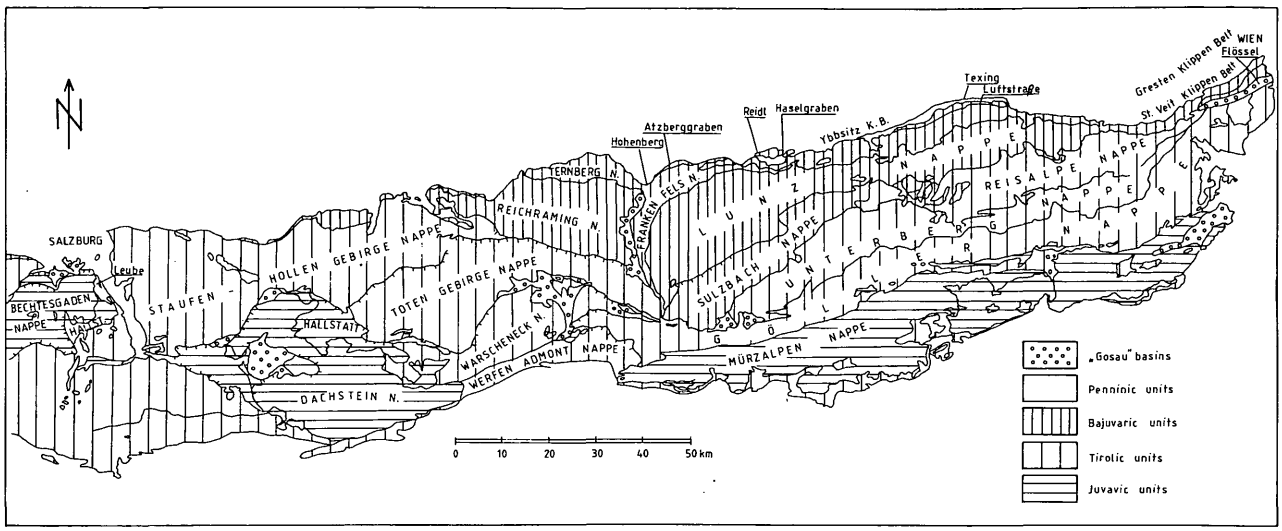

Fig. 1: Microbiostratigraphically investigated sections in Upper Jurassic and Lower Cretaceous sequences in the Austrian Eastern Alps.

kalk") do not answer to modern lithostratigraphic classification.

Calpionellid microbiostratigraphy was developed by authors working in Jurassic Cretaceous sequences of Western Alps footmountains (REMANE, 1964; REMANE, in BOLLI et al., 1985). A few years later, the calpionellid zonation was applied and refined in the Carpathians, too (NOWAK, 1970; POP, 1974; BORZA, 1984; BORZA & MICHALÍK, 1986). Simultaneously, several pecularities in calpionellid distribution became more pronounced. Unfortunately, Upper Jurassic – Lower Cretaceous calpionellid associations in the East Alpine pelagic limestone sequences which could fill the gap between the two areas mentioned were inadequately investigated only (KRISTAN-TOLLMANN, 1962; FLÜGEL & FENNINGER, 1966; GARRISON, 1967; HOLZER, 1968; FENNINGER & HOLZER, 1970; WIDDER, 1988).

The Jurassic and Lower Cretaceous radiolarian biostratigraphy was used for correlation of deep-sea deposits (PESSAGNO, 1977). It was adapted by BAUMGARTNER et al. (1980, 1984, 1987) and SCHAAF (1984, 1985) for the Mediterranean Tethys. Interest of stratigraphers is concentrated on its correlation with the calpionellid and ammonite zonations.

1.1. Setting

1. The Texing section in the Penninic Gresten Klippen Belt is exposed by a road cut to the Plankenstein Castle southwest of St. Pölten (Fig. 1). Upper Jurassic fluxoturbidites (Scheibbsbach and Konradsheim Fms) and pelagic limestones (Arzbergkalk) crop out above Middle Jurassic cherty sequence (Lampelsberg Fm). 22 samples were taken from the Lower Cretaceous rhythmical limestone- and marly complex belonging to the Blassenstein Fm. It is overlain by Middle Cretaceous variegated marls (Buntmergel Gp, Fig. 2).

2. The Penninic Ybbsitz Zone is represented by the Reidl section, exposed by a small quarry WSW of Ybbsitz and southward from Amstetten (OŽVOLDOVÁ & FAUPL, 1993). Middle Jurassic silicites (Rotenberg Fm) are followed by pelagic limestones (Fasselgraben Fm, nine samples) with breccia and turbidite beds. Valanginian to Coniacian turbidite sequence of marly siltstones to sandstones with breccia and claystone intercalations (Glosbach, Haselgraben and Ybbsitz Formations) forms its overlying.

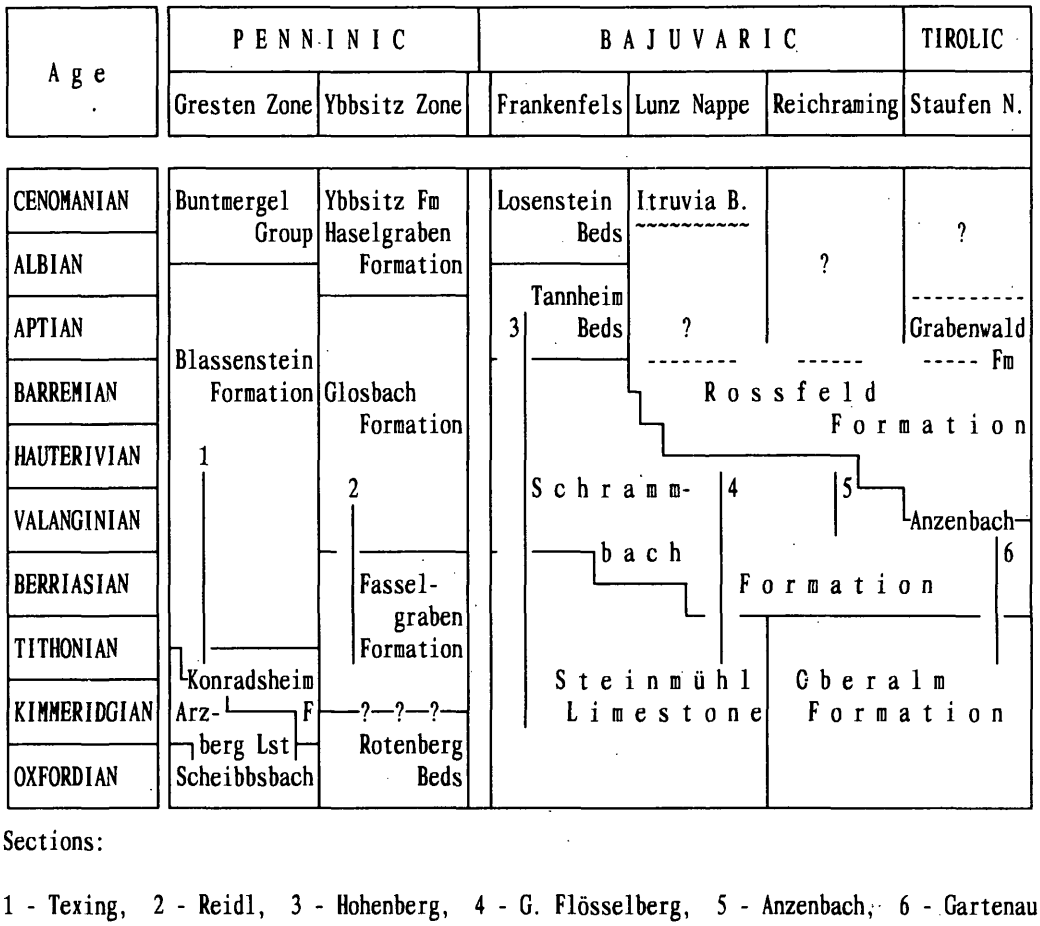

Fig. 2: Lithostratigraphy of Upper Jurassic and Lower Cretaceous formations in selected Austroalpine units.

3. The Hohenberg section in a forest road cut above Anzenbach south from Steyr represents Frankenfels Nappe development (Rettenbach Mulde) of the Bajuvaric. Upper Jurassic to Berriasian nodular Steinmühl Limestone is covered by Schrambach Formation built of thin-bedded spotted marly limestones intercalated by marls. The latter pass into blackish marlstones with marly limestone intercalations belonging to the Tannheim Fm (Fig. 2). Albian to Cenomanian Losenstein Fm is formed by a shaly complex with rhythmic sandstone intercalations.

4. Lunz Nappe of Bajuvaric is represented by a section in the Perlmooser Zementwerke Quarry on the Großer Flösselberg near Kaltenleutgeben (Wienerwald) at the southwestern periphery of Vienna. There is a complex of nodular limestones (Steinmühl Fm) covered by cement marls and well-bedded grey spotted limestones with allodapic intercalations (Schrambach Fm). Turbidites of the Roßfeld Formation follow with erosional unconformity above it.

5. Tirolic Lower Cretaceous pelagic sequence has been studied in Leube brothers cement quarry

in Gartenau near St.Leonhard southward from Salzburg. Upper Jurassic Oberalm Fm comprising slumped bodies of Permian, Triassic and Lower Jurassic rocks (PLÖCHINGER, 1974; MATURA & SUMMESBERGER, 1980) are covered by a thick complex of well-bedded spotted marly limestones of Schrambach Fm, capped by reddish marly Anzenbach Limestone. The sequence it terminated by sandy marly and conglomeratic (olisthostrome- rich) Roßfeld Fm.

2. Lithostratigraphy and microfacies

2.1.Penninic units

These sequences represent the record of a synrift sedimentation in the Penninic Ocean, which has been spreading during Jurassic and Lower Cretaceous. The rests of their sediments were mostly subducted during Alpine orogenesis, only being preserved in two zones of tectonic slices. The Gresten Klippen Belt is characterized by fluviatile to shallow-marine Lower and Middle Jurassic Gresten Beds, followed by pelagic cherts (Lampelsberg Fm) and limestones (Blassenstein Fm), and then by the Buntmergelserie of Cretaceous to Eocene age (Fig. 2). On the other hand, the Ybbsitz Klippen Belt contains an ophiolite sequence (HOMAYOUN & FAUPL, 1992), represented by ultrabasics and basic rocks, Mn cherts, radiolarites (Rotenberg Fm) and pelagic limestones (Fasselgraben & Glosbach Fms). The sedimentation continued by Cretaceous flysch (Haselgraben Fm).

2.1.1. Gresten Zone (Texing section)

Bedded dark-gray silicified mudstone contains sporadic pyritized radiolarians, sponge spicules and *Colomisphaera tenuis* (NAGY). Overlying variegated marly pelbiosparites contain *Textularia* sp., *Cadosina semiradiata semiradiata* WANNER, *Cad. fusca fusca* WANNER, *Cad. parvula* (NAGY), *Colomisphaera radiata* (VOGLER), *Schizosphaera minutissima* (COLOM), *Carpistomiosphaera tithonica* NOWAK, bivalve shell fragments, crinoids, aptychi, pellets with silicified nuclei, rhombs of authigene feldspars, silt quartz and glauconite grains. The association of microfossils (Fig. 3) is typical of Early Tithonian Tithonica Zone.

Overlying indistinctly nodular limestones contain microfossils of the Early Tithonian Malmica Zone: *Parastomiosphaera malmica* BORZA, *Cadosina fusca fusca, Colomisphaera carpathica* (BORZA), *Globochaete alpina* LOMBARD, *Saccocoma* sp., foraminifer fragments, crinoids and aptychi. Slightly silicified sediment contains silty admixture of quartz, mica and glauconite.

A few fluxoturbidite intercalations (up to 25 cm thick) are built of gray fine-grained organodetrital limestone with biopelmicrosparite texture. It contains *Carpistomiosphaera tithonica, Cadosina semiradiata semiradiata, Cadosina fusca fusca, Pieninia oblonga, Textularia* sp., *Quinqueloculina* sp., *Parastomiosphaera malmica,* foraminifer fragments, crinoids, aptychi, bivalves and ostracods. The presence of fluxoturbidite intercalations in the described part invokes a comparison with the upper member of the Konradsheim Formation.

Pale micrites of the Majolica type belong to calpionellid, calpionellid-radiolarian and radiolarian wackestone to mudstone. Bed thickness decreases upwards. The lower part of the complex contains microfossils of the Late Tithonian Crassicollaria Zone: *Crassicollaria intermedia* (D. DELGA), *Cr. colomi* DOBEN, *Cr. parvula* REMANE, *Calpionella alpina* LORENZ, *Tintinnopsella carpathica* (MURGEANU et FILIPESCU), *Schizosphaerella minutissima, Cadosina fusca fusca, Globochaete alpina,* calcified radiolarians, foraminifer fragments, crinoids and bivalves. While the lithology of Berriasian limestones remains unchanged, microfossil association (Fig. 3) is dominated by sphaerical form of *Calpionella alpina,* later accompanied by *Remaniella ferasini, R. cadischiana* (COLOM) and *Calpionella elliptica* CADISCH.

Thin-bedded pale gray-spotted limestone with rhythmic marly intercalations (biomicrite of mudstone/wackestone type) is the most typical member of the Blassenstein Formation. It contains mi-

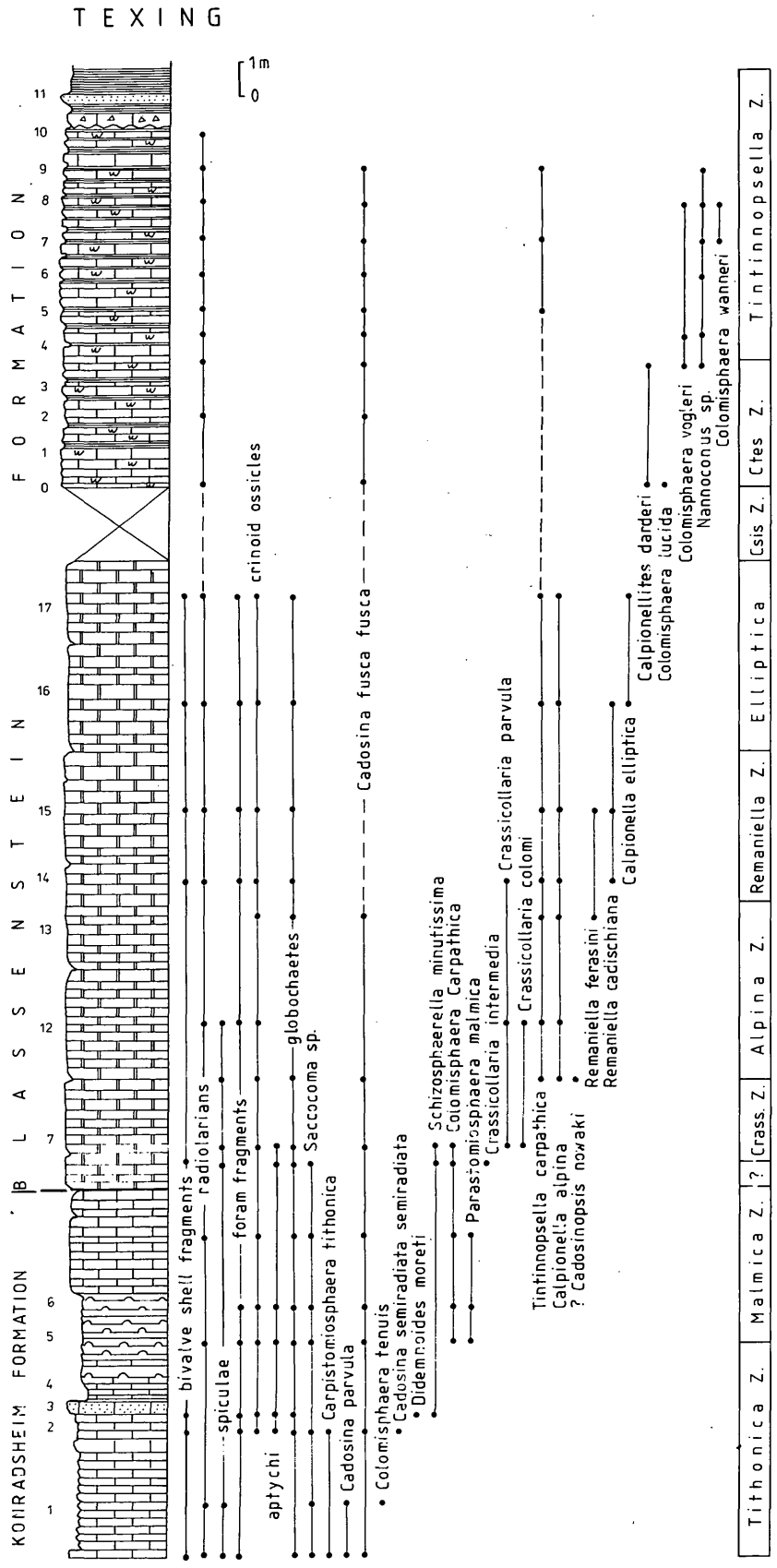

Fig. 3: Microbiostratigraphic evaluation of the Texing section, Gresten Klippen Belt, Penninic, Eastern Alps.

crofossils of Late Berriasian to Early Valanginian Calpionellites Zone: *Calpionellites darderi* (COLOM), *Cadosina fusca fusca, Colomisphaera lucida* BORZA, *Col. vogleri* (BORZA), *Col. wanneri* BORZA, accompanied by abundant nannoconids. Substantially reduced composition of microfossil association in the upper part of the sequence indicates Valanginian Tintinnopsella Zone.

2.1.2. Ybbsitz Zone (Reidl section)

Radiolarian associations of the Rotenberg Formation were evaluated in detail by OŽVOLDOVÁ & FAUPL (1993). They indicate middle Callovian to late Oxfordian age of the chert sequence.

The lower member of the Fasselgraben Formation consists of indistinctly nodular limestone. The samples taken from its base contain microfossils (Fig. 4) of late Tithonian Crassicollaria Zone: *Crassicollaria parvula, Cr. massutiniana,* both elongated and sphaerical forms of *Calpionella alpina, Tintinnopsella carpathica, Globochaete alpina, Schizosphaerella minutissima.* The problem concerning indentification of the Kimmeridgian interval in this sequence (cf. DECKER, 1990) remains unsolved.

Higher-up lying well-bedded pale "Majolica" type micrite limestone comprises allodapic intercalations (distal turbidites, cf. HOMAYOUN & FAUPL, 1992). Microfossil content (Fig. 4: *Calpionella alpina, C. minuta, Remaniella ferasini* (CATALANO), *R. filipescui* POP, *Tintinnopsella carpathica, Crassicollaria parvula, Cadosina fusca fusca, Colomisphaera carpathica, Schizosphaerella minutissima, Didemnum carpaticum, Globochaete alpina, Nannoconus sp.,* accompanied by aptychi fragments, foraminifers, ostracods, bivalves, crinoids and belemnites) indicates early/middle Berriasian age.

The clasts in breccia beds were derived from Kimmeridgian Saccocoma-Globochaete packstone with *Colomisphaera pieniniensis, Cadosina parvula*; lower Tithonian Saccocoma wackestone with *Parastomiosphaera malmica, Cadosina fusca fusca, Globochaete alpina,* radiolarians, aptychi and juvenile ammonites: Berriasian Calpionella wackestone with *Calpionella alpina, Tintinnopsella carpathica, Colomisphaera carpathica*; pelbiosparites with foraminifer fragments; sucrosic dolomitic and siliceous limestones; cherts and shales. Matrix of the breccias contains dispersed quartz (up to 2 mm in diameter) and glauconite grains.

2.2. Bajuvaric units

Upper Jurassic and lower Cretaceous sediments of these units have been deposited in a system of subsiding basins and elevations in the western part of the Alpine-Carpathian microcontinent (Fatric and Hronic units of the Central Western Carpathians form their eastward continuation, cf. MICHALÍK, 1994). Microfacies of pelagic elevations of this age (as well as their calpionellid microfauna) in the Frankenfels Nappe (Pechgraben area) have been described by KRISTAN-TOLLMANN (1962) and HOLZER (1968).

2.2.1. Frankenfels Nappe (Hohenberg section)

Red nodular biomicrite limestone – called the Steinmühl Limestone – forms a considerable part of the Kimmeridgian/Lower Valanginian sequence in the Rettenbach Mulde of the Frankenfels Nappe (FLÜGEL, 1967). Despite several problems caused by expressive condensation of this sequence, the following microfacies units could be distinguished:

a. The lowermost, Kimmeridgian member is built of Globochaete packestone with microfauna of *Lenticulina* sp., radiolarians, ostracods, "filaments" of juvenile bivalves and crinoids. Its uppermost part, belonging to the mid-Tithonian Chitinoidella Zone contains *Chitinoidella boneti, Ch. slovenica, Schizosphaerella minutissima, Cadosina fusca fusca, Colomisphaera carpathica,* phosphatized fish teeth, aptychi, crinoid columnalia, radiolarians and foraminifers, as well (Fig. 5).

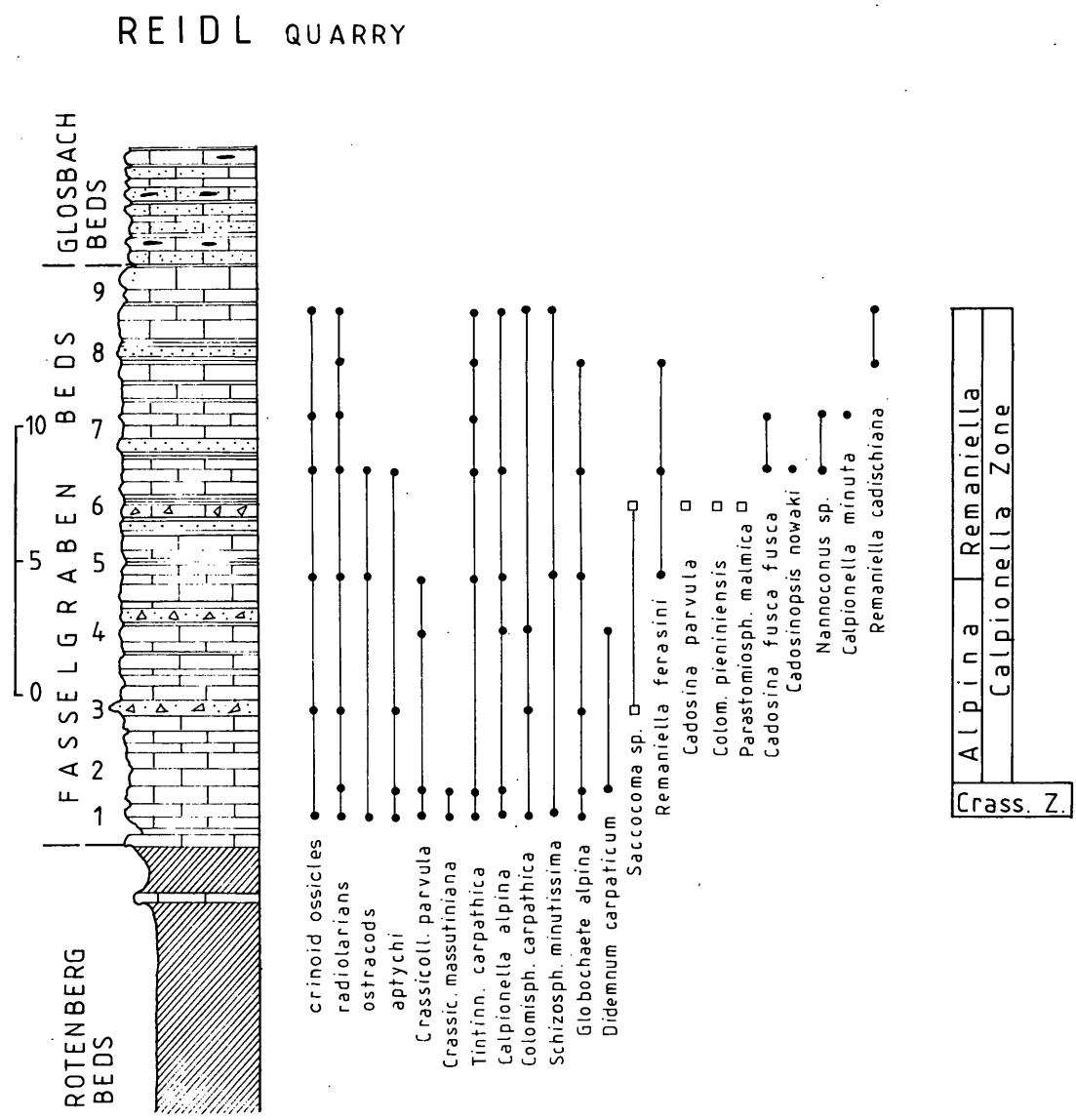

Fig. 4: Microbiostratigraphic evaluation of the Reidl section, Ybbsitz Klippen Belt, Penninic, Eastern Alps.

b. Crassicollaria-Globochaete wackestone of the late Tithonian Crassicollaria Zone encloses *Crassicollaria brevis, Cr. colomi, Cr. parvula, Calpionella alpina, Globochaete alpina, Tintinnopsella carpathica,* aptychi, crinoid columnalia and foraminifers.

c. Lower Berriasian Calpionella wackestone with *Tintinnopsella carpathica, Calpionella alpina, C. elliptica, Remaniella ferasini, R. filipescui, R. cadischiana* (COLOM), *Globochaete alpina, Schizosphaerella minutissima, Lenticulina* sp., radiolarians and crinoids pass upwards into biomicrite with less abundant microfossil association of the late Berriasian Calpionellopsis Zone (Pl. 1) *C. simplex, C. oblonga, T. carpathica, R. cadischiana, R. borzai* POP, *Cadosina fusca fusca, Calpionella alpina, Globochaete alpina, Textularia* sp., crinoids and foraminifers.

Thin-bedded gray-spotted marly limestone with laminae and intercalation of marl belongs to the Schrambach Formation. Nannoconid and radiolarian-nannoconid wackestone to mudstone contains *Colomisphaera heliosphaera, Col. lucida, Col. vogleri, Cadosina fusca fusca, Stomio-*

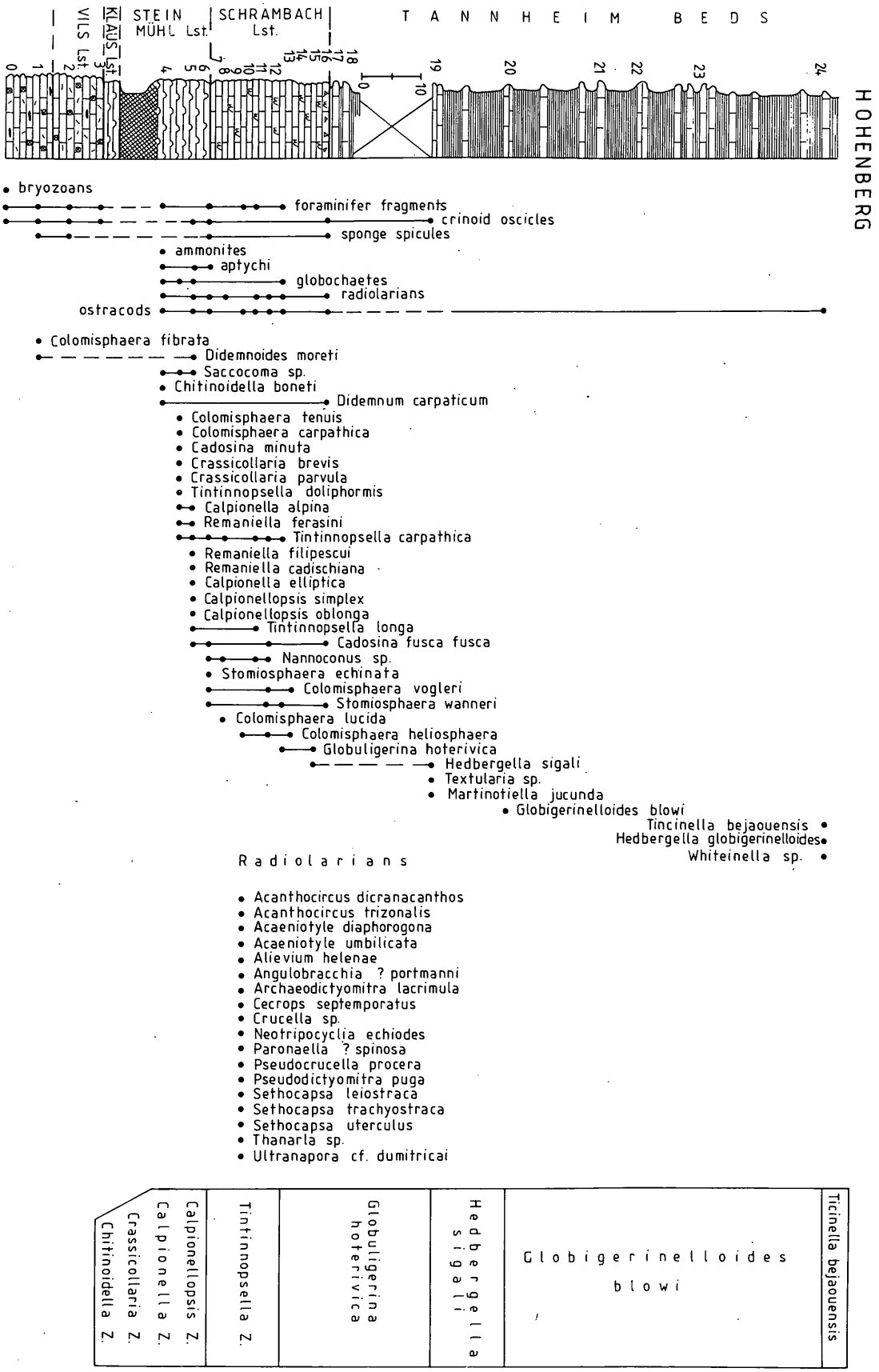

Fig. 5: Microbiostratigraphic evaluation of the Hohenberg section, Frankenfels Nappe of the Bajuvaric, Northern Calcareous Alps.

sphaera wanneri, *Tintinnopsella carpathica*, *T. longa*, radiolarians (Pl. 2), *Acanthocircus dicranacanthos* (SQUINABOL), *A. trizonalis* (RÜST), *Acaeniotyle diaphorogona* FOREMAN, *Ac. umbilicata* (RÜST), *Alievium helenae* SCHAAF, *Angulobracchia* (?) *portmanni* BAUMGARTNER, *Archaeodictyomitra lacrimula* (FOREMAN), *Cecrops septemporatus* (Parona), *Crucella* sp., *Suna echiodes* (FOREMAN), *Paronaella* (?) *spinosa* (PARONA), *Pseudocrucella procera* OŽVOLDOVÁ, *Crucella lipmanae* JUD, *Sethocapsa leiostraca* FOREMAN, *S. trachyostraca* FOREMAN, *S. uterculus* (PARONA), *Ultranapora* cf. *dumitricai* PESSAGNO, *Wrangelium medium* WU, ostracods and sponge spicules. Clastic admixture is represented by quartz grains and muscovite flakes. Calpionellids disappear upwards, being substituted by the planktonic foraminifers *Globuligerina hoterivica* and *Hedbergella sigali*.

Aptian association of planktonic foraminifers belonging to the Globigerinelloides blowi Zone (Pl. 3) was documented in a black marly complex with limestone intercalations (Tannheim Formation). A sample with early Albian plankton foraminifer association *Hedbergella globigerinelloides*, *Ticinella* sp. and *Whiteinella* sp. has been taken from the top part of the sequence.

2.2.2. Lunz Nappe (G. Flösselberg section)

Pink to pale brown micritic Steinmühl Limestone is characterized by Calpionella-radiolarian to radiolarian wackestone texture. It contains the microfossil association of the Remaniella Subzone (Fig. 6, Pl. 4): *Calpionella alpina*, *Tint. carpathica*, *Remaniella cadischiana*, *Rem. ferasini*, *Crassicollaria parvula*, *Cr. colomi*, *Nannoconus* sp., *Globochaete* sp., foraminifers, aptychi fragments and bivalves.

The Schrambach Formation consists of a rhythmic sequence of gray-spotted marly limestones (biomicritic mudstone to wackestone). VAŠÍČEK et al. (in print) described the microfossil association of the Tintinnopsella Zone from this section: *Tintinnopsella carpathica*, *Tintin. subacuta* (COLOM), *Cadosina semiradiata semiradiata*, *C. semiradiata cieszynica* NOWAK, *C. semir. olzae* NOWAK, *C. fusca fusca*, *Colomisphaera vogleri*, *Cadosinopsis nowaki* BORZA, *Stomiosphaera echinata* NOWAK, *St. wanneri*, *Carpistomiosphaera valanginiana* BORZA, *Didemnoides moreti*, *Globochaete alpina* with abundant nannoconids, radiolarians, foraminifers, aptychi fragments, crinoids, ostracods. This micro- and macrofossil (ammonites, aptychi) association indicates early Hauterivian age.

The formation comprises several fine-grained detrital limestone beds of fluxoturbidite origin. They are built of siliceous bioclastic packestone with mass accumulation of sponge spicules, accompanied by *Cadosina fusca cieszynica*, radiolarians, foraminifers and crinoid columnalia. Clasts of biomicrite wackestone with *Calpionella alpina* occur sporadically. Clastic quartz and glauconite grains are frequent, being accompanied by less abundant mica flakes.

2.2.3. Reichraming Nappe (Anzenbach section)

Small quarry near the road from the Anzenbach Valley to Brennhöhe exposes upper member of the Schrambach Formation, built of dark gray marlstones/marly limestones. It yielded an early Hauterivian macrofauna of ammonites and belemnites (VAŠÍČEK et al., in print). Nannocone mudstone comprises microfossil association of the Tintinnopsella Zone: *Cadosina fusca fusca*, *Cad. semiradiata olzae*, *Stomiosphaera echinata*, *Tintinnopsella carpathica* (P1.4).

2.3. Tirolic units

They represent the main structural element of the Northern Calcareous Alps (JANOSCHEK & MATURA, 1980). They comprise several partial tectonic units (Inntal-, Staufen-Höllengebirge-, Totes Gebirge-, Ötscher nappes). Upper Jurassic and Lower Cretaceous sedimentary record is represented by products of a basin (pelagite limestones of the Oberalm- and Schrambach formations; tur-

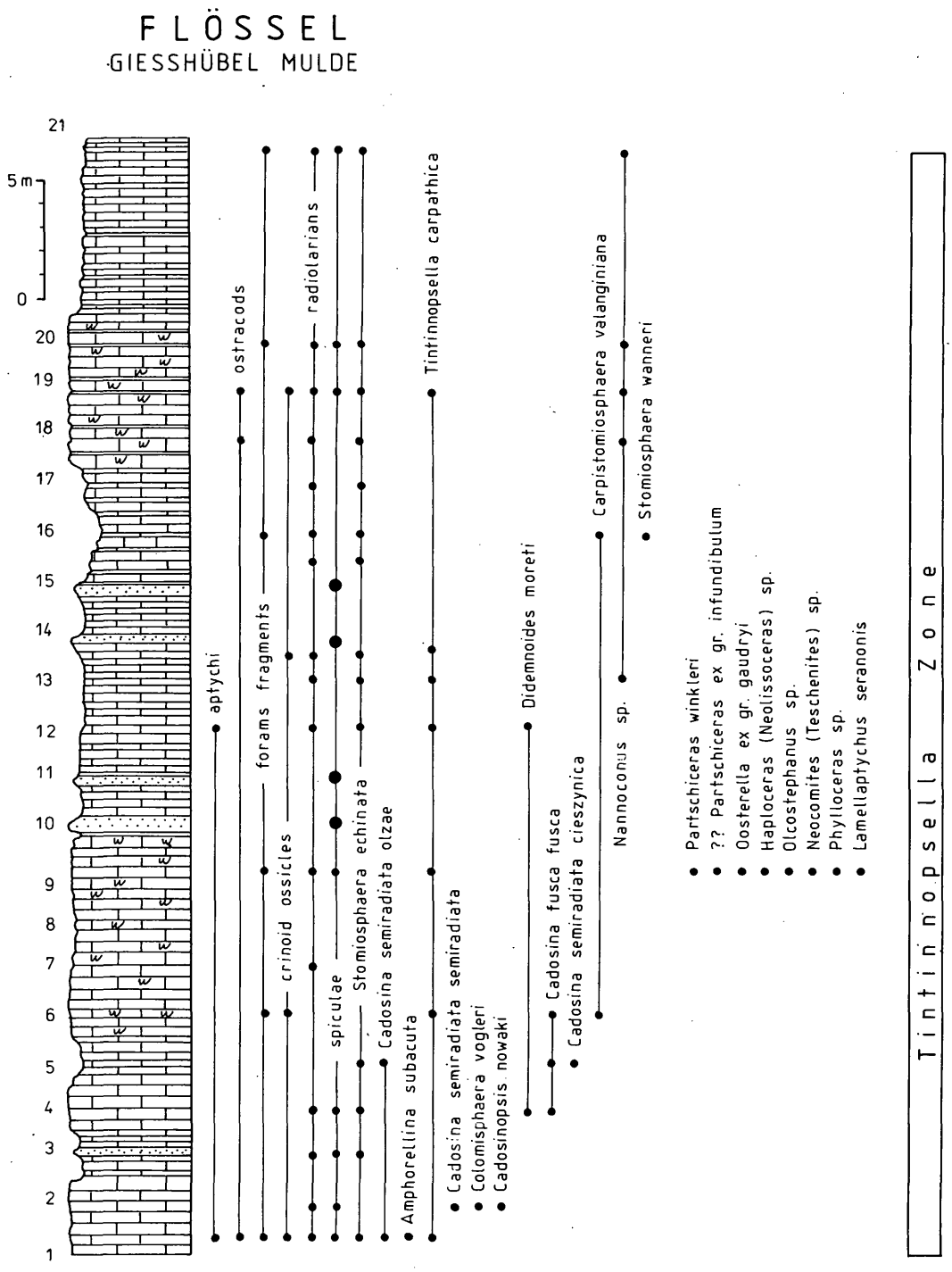

Fig. 6: Microbiostratigraphic evaluation of the Flössel section, Lunz Nappe of the Bajuvaric, Northern Calcareous Alps.

bidites of the Barmstein Formation) rimmed from the south and east by a shallow-marine carbonate platform (Plassenstein- and Tressenstein formations). During Hauterivian and Barremian the basin was filled by clastic sediments derived from emerging zones in the south (Roßfeld Formation).

2.3.1. Staufen-Höllengebirge Nappe (Gartenau section)

Well-bedded gray cherty micrites with aptychi fragments (Oberalm Fm) were interpreted as deep basinal deposits (FLÜGEL & FENNINGER, 1966).

They are characterized by Saccocoma wackestone structure with *Colomisphaera carpathica, Globochaete alpina,* foraminifers, ostracods and crinoid columnalia of Kimmeridgian age. Upwards, these rocks pass into Saccocoma-Globochaete wackestone (Pl. 4) with *Praetintinnopsella andrusovi* BORZA, *Colomisphaera carpathica* and radiolarians representing lower Tithonian strata. The topmost Crassicollaria-Globochaete wackestone with *Crassicollaria intermedia, Cr. parvula, Calpionella alpina, Tintinnopsella carpathica* accompanied by radiolarians (Pl. 5): *Acanthocircus dicranacanthos, Archaeodictyomitra apiaria, Emiluvia chica* FOREMAN, *Emiluvia ordinaria* OŽVOLDOVÁ, *Pantanellium squinaboli* (TAN), *Pseudodictyomitra carpatica* (LOZYNYAK), *Thanarla sp.* B. *Tritrabs ewingi* (PESSAGNO), foraminifers, crinoids, sponge sclerites and ostracods represents upper Tithonian. The Oberalm Formation contains calciturbidite layers of fine-detrital packestones and grainstones (Barmstein Fm).

FENNINGER & HOLZER (1972), relying on calpionellid zonation applied here by GARRISON (1967), regarded higher-lying well-bedded gray marly, locally bioturbated limestones with laminae or intercalations of marl as upper member of the Oberalm Beds. However, different lithology and microfauna of these beds lead us to the conclusion to consider them as part of the Schrambach Formation. It is represented by radiolarian wackestone and nannoconid mudstone. Dominating radiolarians *Archaeodictyomitra apiaria* (RÜST), *Archaeodictyomitra excellens* (TAN SIN HOK), *Holocryptocanium barbui* DUMITRICĂ, *Mirifusus dianae* (KARRER), *Pantanellium squinaboli* (PARONA), *Parvicingula cosmoconica* (FOREMAN), *Podobursa triacantha* (FISCHLI), *Pseudodictyomitra carpatica* (LOZYNYAK), *Sethocapsa* cf. *pseudouterculus* AITA, *Thanarla conica* (ALIEV), *Thanarla* sp. A, are accompanied by microfossils of Berriasian Calpionella- and Calpionellopsis Zones (Pl. 4): *Calpionella alpina, Tintinnopsella carpathica, Calpionella elliptica, Remaniella cadischiana, Calpionellopsis simplex, Cadosina fusca fusca, Schizosphaerella minutissima,* sponge spicules, ostracod tests, foraminifer fragments.

3. Discussion

Six sections representing Lower Cretaceous pelagic limestone sequences of selected units of the Eastern Alps have been evaluated microbiostratigraphically.

Majolica type limestones of the Penninic units (Texing section in the Gresten Zone; Reidl section in the Ybbsitz Zone) yielded rich associations of Berriasian calpionellid comparable with those in the Pieniny Klippen Belt of the Western Carpathians. The occurrence of limestone breccias in the southern Penninic Ybbsitz Zone is remarkable. They resemble the Nozdrovice Breccia, studied in the Western Carpathians by REHÁKOVÁ & MICHALÍK (1995). The clasts from this breccia were derived from underlying Upper Jurassic strata as well. However, in addition, they also contain abundant clastic quartz and glauconite grains, and even crystalline schist fragments, similar to equivalent breccias described by REHÁKOVÁ et al. (1995) from the Outer Carpathian Magura Basin, or by PLAŠIENKA et al. (1994) from the southern margin of the Penninic Basin in the Považský Inovec Mts (Central Western Carpathians).

The Hohenberg section (in the Frankenfels Nappe) well illustrates the persistence of limestone facies of the "Ammonitico Rosso" type (here represented by the Steinmühl Formation with Tithonian and Berriasian calpionellid associations) until the earliest Valanginian. Calpionellid loricas from these associations are larger and their excellent preservation proves more rapid lithification of the sediment if compared with their basinal counterparts. The persistence of Upper Jurassic elevation facies is unusual in the majority of Alpine and Carpathian Lower Cretaceous sequences. Noteworthy, a similar habitus of calpionellid loricas has been described in peripheral parts of the Fatric area in the central Western Carpathians by BORZA (1969, from the Manin Unit) or by MICHALÍK et al. (1994, MLS-1 borehole, northern margin of the Humenné Mts).

The Valanginian-Hauterivian part of the Lower Cretaceous pelagic sequence of the Frankenfels Nappe is represented by the basinal Schrambach Formation. In several units of the Bajuvaric

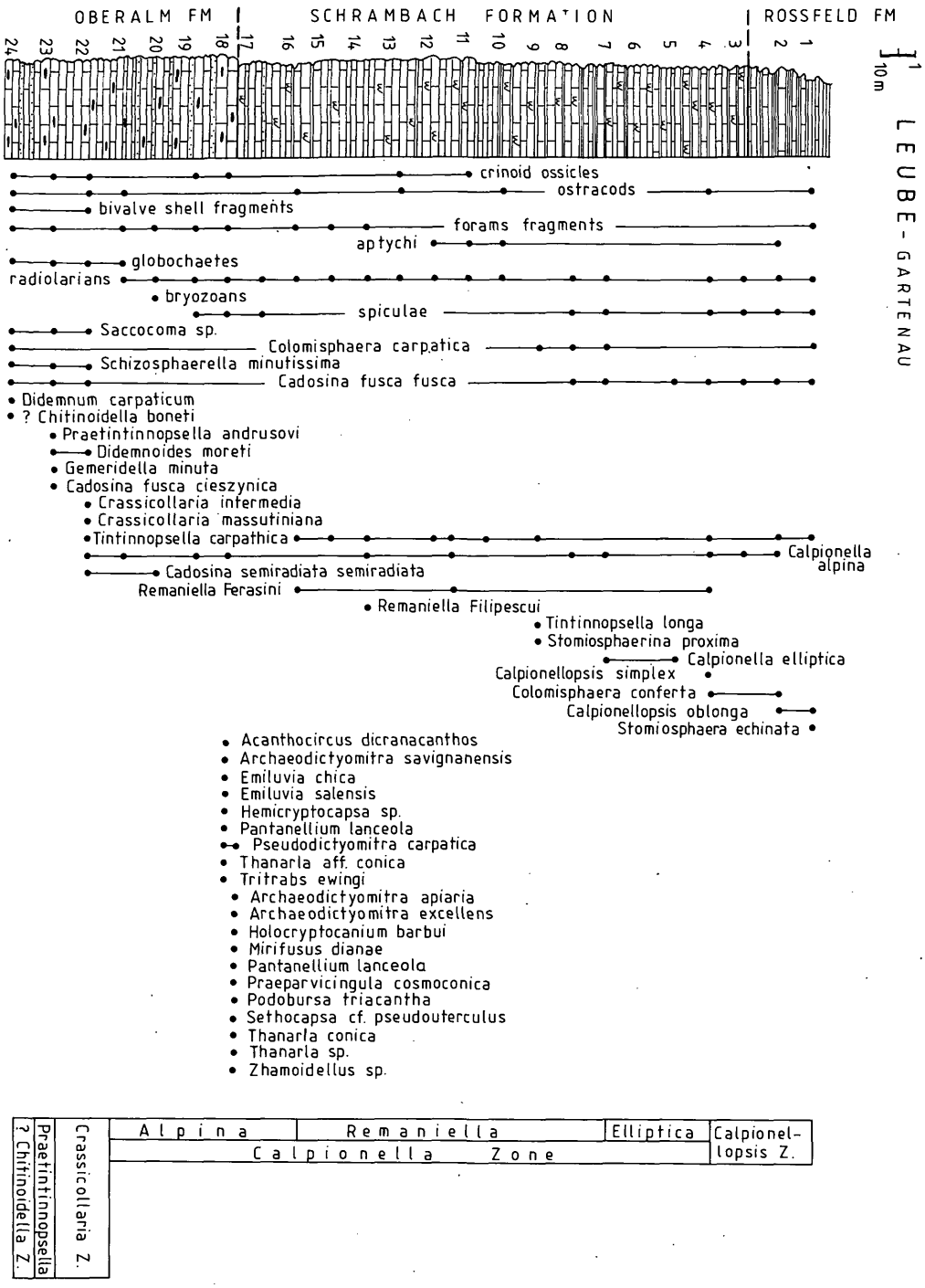

Fig. 7: Microbiostratigraphic evaluation of the Gartenau section, Staufen-Höllengebirge Nappe of the Tirolic, Northern Calcareous Alps.

(Lunz-, Reichraming Nappes) and of the Tirolic (Staufen-Höllengebirge Nappe), basinal development started as early as in the Berriasian. Besides calcareous microplankton, stratigraphically important ammonites and radiolarians helped to establish the age of this formation. *Cecrops septemporatus* and *Crucella lipmanae* indicate late Valanginian to early Hauterivian age of the radiolarian association (cf. BAUMGARTNER, 1984, 1987; JUD, 1994; GORIČAN, 1994), occurring in the Schrambach Formation of the Hohenberg section (Bed No. 9; Fig. 5, Pl. 2) along with calcareous mi-

croplankton of the Tintinnopsella Zone. Early Hauterivian age of the Schrambach Fm in the G. Flösselberg section is (besides microplankton of the Tintinnopsella Zone) also evident by finding of *Spitidiscus* sp. and *Lamellaptychus* cf. *serranonis* (VAŠÍČEK et al., 1994 a).

Occurrence of the radiolarian Unitary Association U.A. 11 (according to BAUMGARTNER, 1984, 1987) in the sample No. 18 from the Gartenau (Leube) section (Staufen Nappe of Tirolic) corresponds quite well to the lower Berriasian calpionellid association characterizing the Alpina Subzone.

If compared with the sample mentioned, the association of the Bed No. 17 (Fig. 7), although more abundant, comprises species with wider stratigraphic span. According to BAUMGARTNER (l.c.), *Holocryptocanium barbui* DUMITRICĂ should appear during the late Berriasian. However, it occurs in association of lower Berriasian calpionellids. A similar case (the occurrence of "stratigraphically younger" *Pseudodictyomitra lilyae* and *Archaeodictyomitra nuda* in the lower Berriasian association 11 U.A.) was recorded by ONDREJÍČKOVÁ et al. (1993).

Radiolarian biostratigraphic scale is still in progress now. We hope that new data on the stratigraphic range of radiolarian taxa from detailed Berriasian key sections supported by other index fossils will lead to a more precise view in proximal future.

4. Acknowledgements

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Authors' addresses:

RNDr. Jozef Michalík, DrSc. , RNDr. Daniela Reháková CSc., Geological Institute of the Slovakian Academy of Sciences, Dúbravská cesta 9, SK-842 26 Bratislava, Slovakia;
RNDr. Ladislava Ožvoldová, CSc., Comenius University, Faculty of Sciences, Department of Geology and Paleontology, Mlynská dolina G-1, SK-842 15 Bratislava, Slovakia.

Plate 1

Calcareous microplankton from the Steinmühl Formation in the Hohenberg section (Frankenfels Nappe of the Bajuvaric), Northern Limestone Alps. The specimens were derived from beds No 4 (Figs. 7–8, 10–11, 13), 5 (Fig. 12) and 6 (Figs. 1–6, 9). Magnification: 155 x (Figs. 1–3, 6, 10, 12) and 265 x (Figs. 4–5, 7–9, 11, 13), respectively.

Fig. 1: *Textularia* sp.
Fig. 2: *Permodiscus* sp.
Fig. 3: *Calpionellopsis oblonga* (CADISCH)
Fig. 4: *Calpionellopsis simplex* (COLOM)
Fig. 5: *Remaniella filipescui* POP
Fig. 6: *Calpionellopsis oblonga* (CADISCH)
Fig. 7: *Colomisphaera carpathica* (BORZA)
Fig. 8: *Chitinoidella boneti* DOBEN
Fig. 9: *Tintinnopsella carpathica* (MURGEANU et FILIPESCU)
Fig. 10: *Saccocoma* sp.
Fig. 11: *Chitinoidella boneti* DOBEN
Fig. 12: *Calpionella elliptica* CADISCH and *Tintinnopsella carpathica* (MURG. et FILIP.)
Fig. 13: *Cadosina semiradiata* WANNER

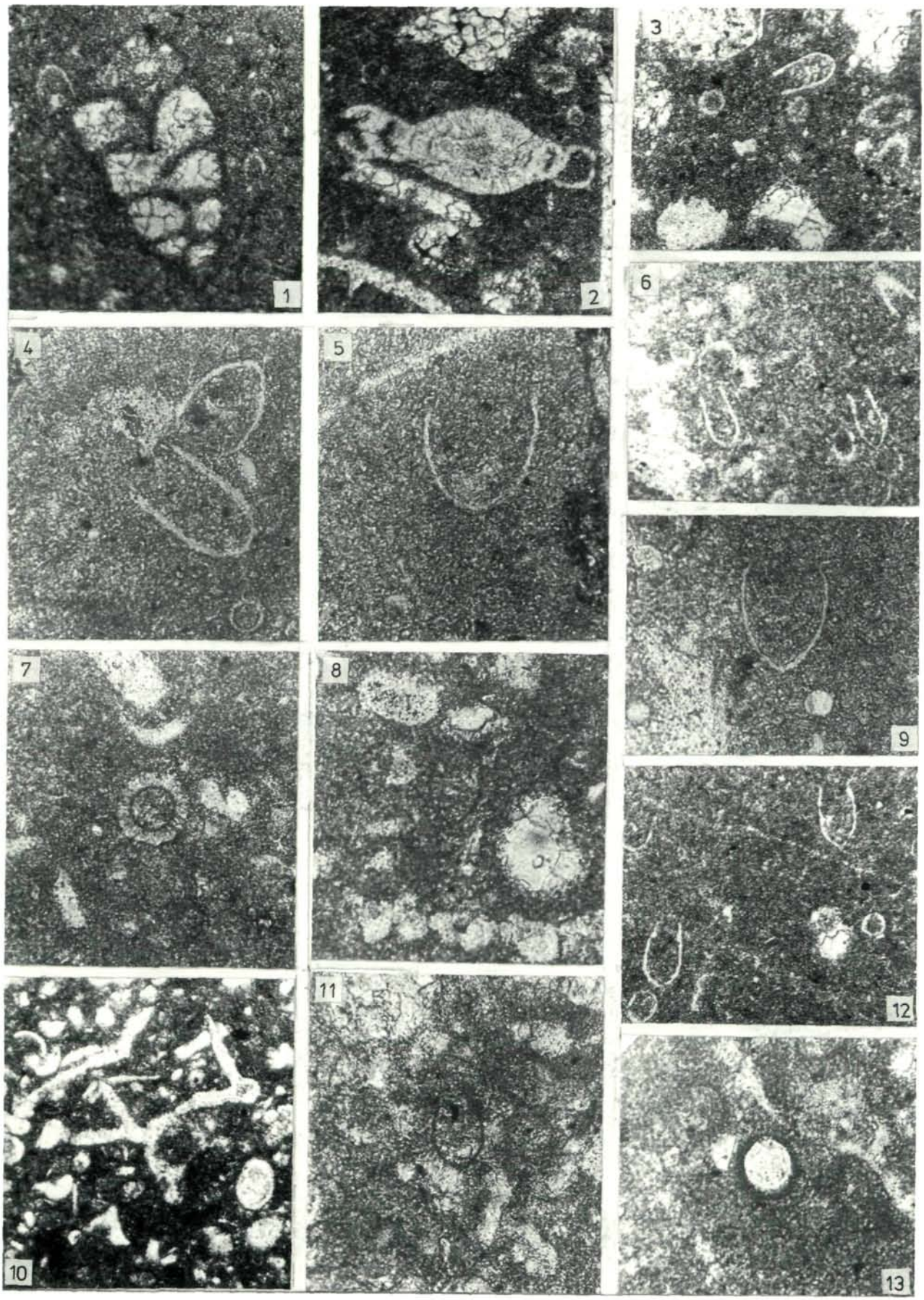
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Plate 2

Radiolarian association from the Hohenberg section, Frankenfels Nappe of the Bajuvaric, Northern Limestone Alps, sample 21.

Fig. 1: Foraminifer *Anomalinidae* gen. indet., 115 x
Fig. 2: *Suna echiodes* (FOREMAN), 200 x
Fig. 3: *Crucella lipmanae* JUD, 130 x
Fig.: *Acanthocircus dicranacanthos* (SQUINABOL), 240 x
Fig. 5: *Sethocapsa uterculus* (PARONA), 300 x
Fig. 6: *Archaeodictyomitra lacrimula* (FOREMAN), 240 x
Fig. 7: *Angulobracchia* (?) *portmanni* BAUMGARTNER, 150 x
Fig. 8: *Wrangellium medium* WU, 280 x
Fig. 9: *Pseudocrucella procera* OŽVOLDOVÁ, 175 x
Fig. 10: *Alievium helenae* SCHAAF, 195 x
Fig. 11: *Ultranapora* cf. *dumitricai* PESSAGNO, 240 x
Fig. 12: *Cecrops septemporatus* (PARONA), 215 x
Figs. 13,15: *Crucella* sp., 240 and 350 x, proximal and lateral view
Fig. 14: *Paronaella* (?) *spinosa* (PARONA), 160 x

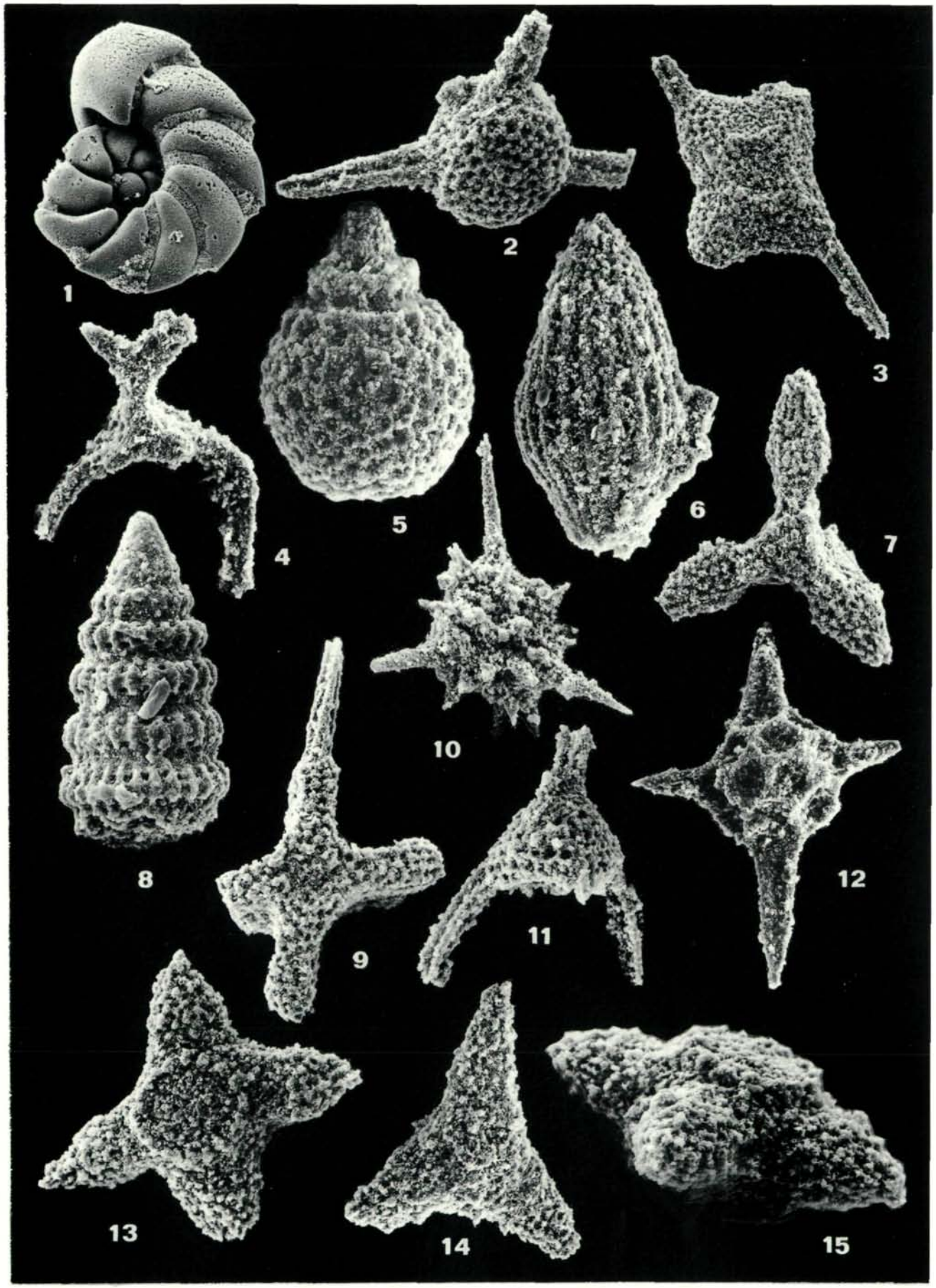
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Plate 3

Calcareous microplankton from the Tannheim- (Figs. 1–4), Schrambach- (Figs. 5–15) and Oberalm (Figs. 16–19) formations in both the Hohenberg- (Frankenfels Nappe of Bajuvaric) and Gartenau (Staufen-Höllengebirge Nappe of the Tirolic) sections, Northern Limestone Alps. Magnification 155 (Fig. 5) and 265 x (Figs. 1–4, 6–19), respectively.

Fig. 1: *Hedbergella sigali* MOULLADE, Hohenberg No. 15
Fig. 2: *Globigerinelloides blowi* (BOLLI), Hohenberg No. 21
Fig. 3: *Hedbergella globigerinelloides* (SUBB.), Hohenberg No. 23
Fig. 4: *Ticinella sp.*, Hohenberg No. 24
Fig. 5: radiolarian wackestone, Hohenberg No. 9
Fig. 6: *Tintinnopsella carpathica* (MURG. et FIL.) Hohenberg No. 11
Fig. 7: *Calpionella elliptica* CADISCH, Gartenau No. 7
Fig. 8: *Schizosphaerella minutissima* (COLOM), Gartenau No. 7
Fig. 9: *Colomisphaera heliosphaera* (VOGLER), Hohenberg No. 14
Fig. 10: *Colomisphaera vogleri* (BORZA), Hohenberg No. 11
Fig. 11: *Stomiosphaera wanneri* BORZA, Hohenberg No. 23
Fig. 12: *Calpionella alpina* LORENZ, Gartenau No. 2
Fig. 13: *Calpionella elliptica* CADISCH, Gartenau No. 4
Fig. 14: *Remaniella cadischiana* (COLOM), Gartenau No. 4
Fig. 15: *Cadosina semiradiata semi radiata* WANNER and *Cadosina fusca fusca* WANNER, Gartenau No. 1
Fig. 16: *Praetintinnopsella andrusovi* BORZA, Gartenau No. 23
Fig. 17: *Crassicollaria intermedia* (DUR. DELGA), Gartenau No. 22,
Fig. 18. *Schizosphaerella minutissima* (COLOM), Gartenau No. 22
Fig. 19: *Colomisphaera carpathica* (BORZA), Gartenau No. 24

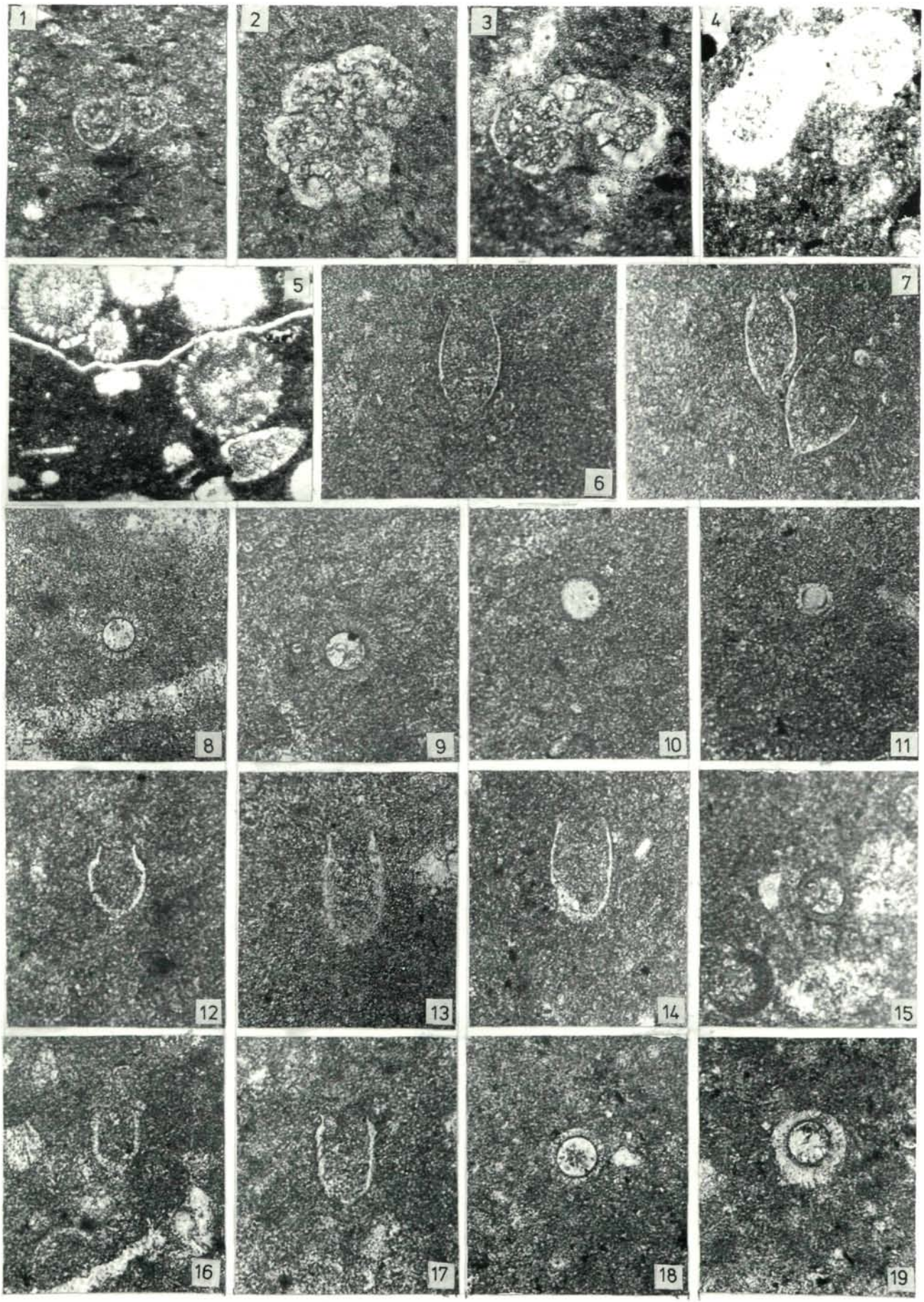
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Plate 4

Calcareous microplankton from the Schrambach Formation, Lunz (G. Flösselberg section, Figs. 2–3, 5–13), and Reichraming (Anzenbach section, Figs. 1,4) nappes of the Bajuvaric, Northern Limestone Alps. Magnification 265 x.

Figs. 1–2: *Cadosina fusca fusca* WANNER
Fig. 3: *Schizosphaerella minutissima* (COLOM)
Figs. 4–5: *Cadosina semiradiata olzae* NOWAK
Fig. 6: *Cadosinopsis nowaki* BORZA
Fig. 7: *Colomisphaera conferta* ŘEHÁNEK
Fig. 8: *Colomisphaera vogleri* (BORZA)
Fig. 9: *Carpistomiosphaera valanginiana* BORZA
Fig. 10: *Stomiosphaera echinata* NOWAK
Figs. 11–12: *Tintinnopsella carpathica* (MURGEANU et FILIPESCU)
Fig. 13: *Remaniella borzai* POP

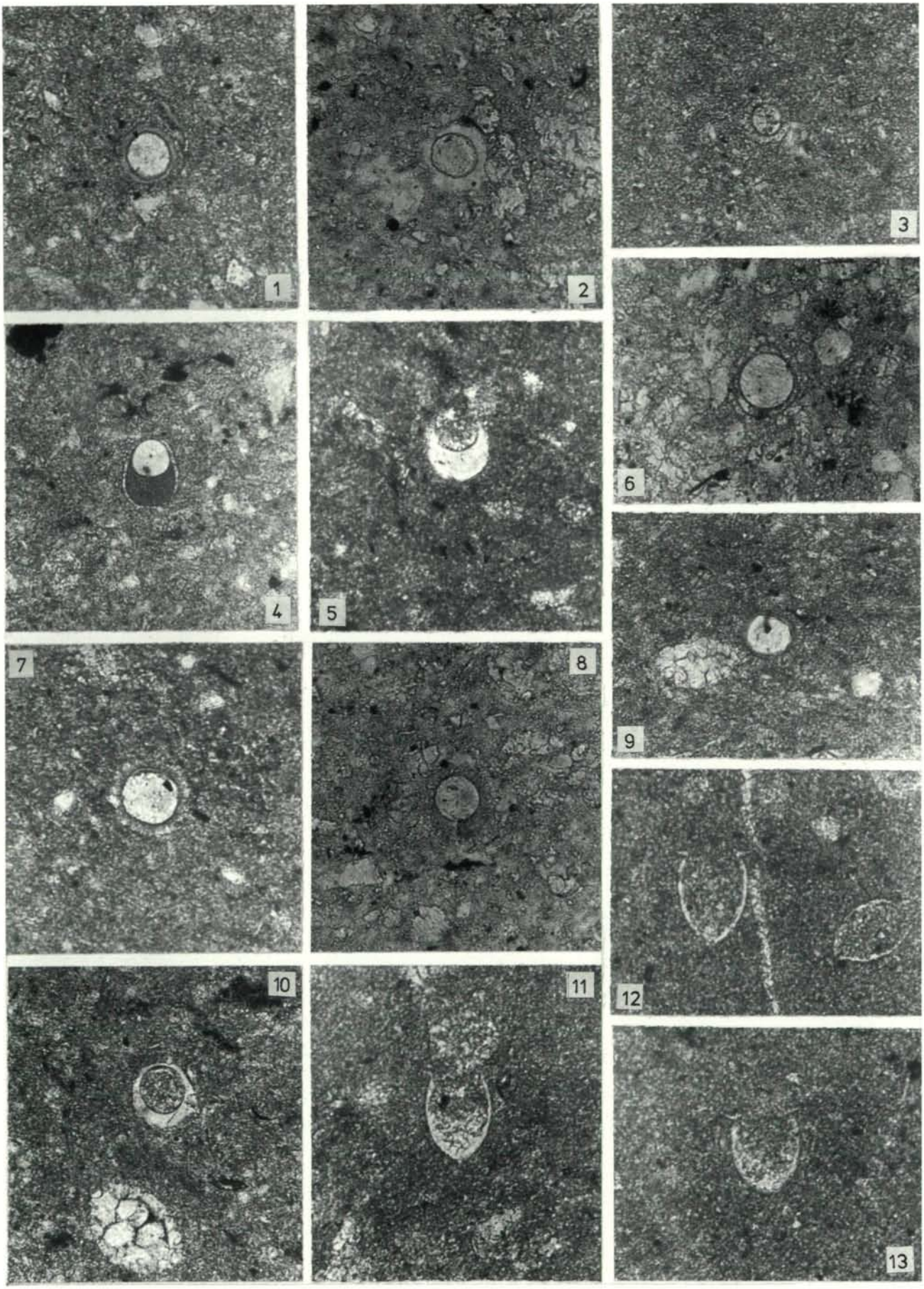
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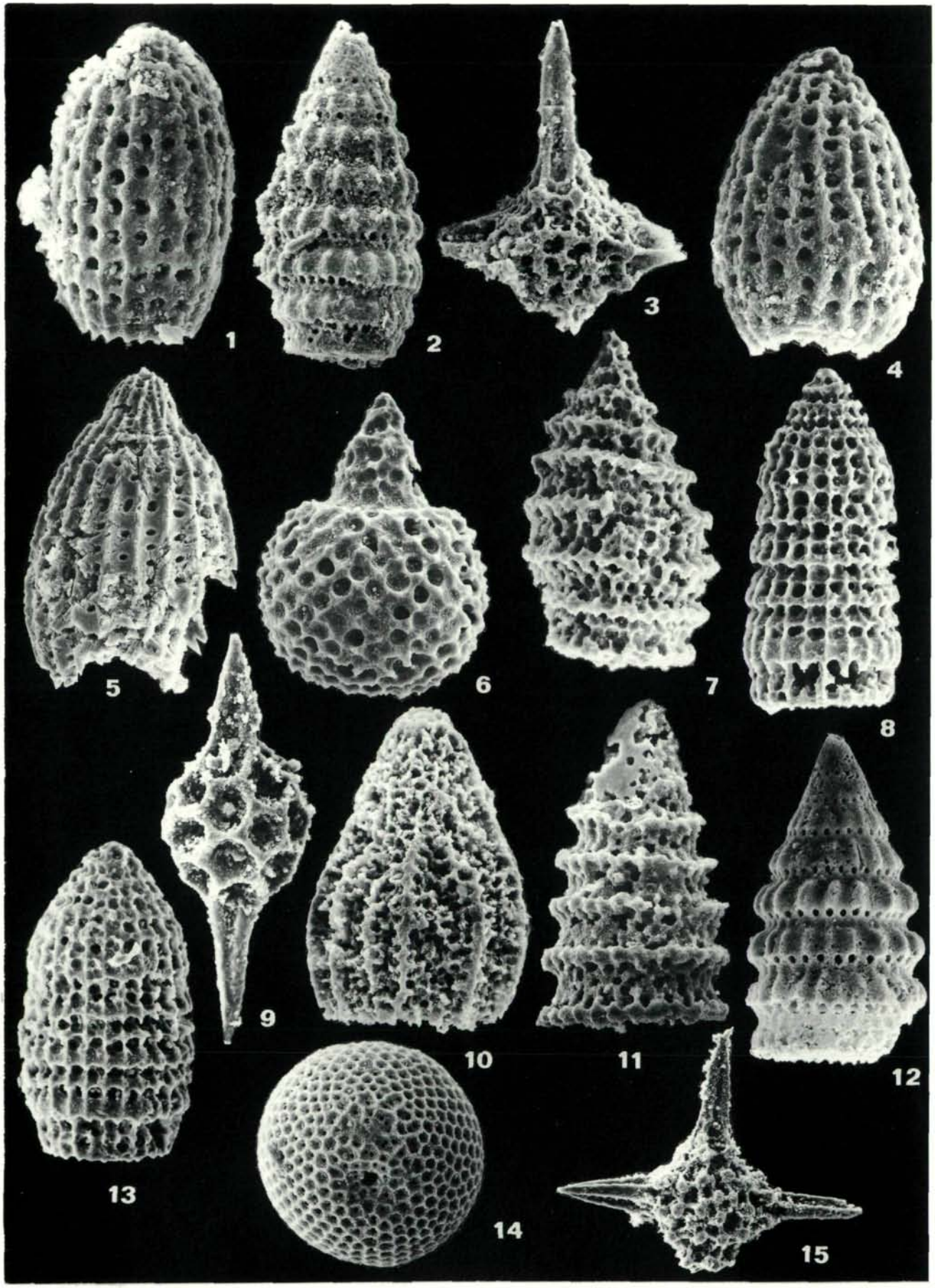
Plate 5

Late Tithonian / Berriasian radiolarian association from the Gartenau (Leube) section, Staufen-Höllengebirge Nappe of the Tirolic, Northern Limestone Alps. Specimens 1–4, 9–10, 15 came from sample L-18, specimens 5–8, 11–14 were yielded from sample L-17.

Fig. 1: *Archaeodictyomitra apiaria* (RÜST), 450 x
Fig. 2: *Pseudodictyomitra carpatica* (LOZYNYAK), 280 x
Fig. 3: *Emiluvia ordinaria* OŽVOLDOVÁ, 200 x
Fig. 4: *Thanarla conica* (ALIEV), 400 x
Fig. 5: *Thanarla* sp. A, 400 x
Fig. 6: *Sethocapsa* cf. *pseudouterculus* AITA, 300 x
Fig. 7: *Parvicingula boesii* (P), 300 x
Fig. 8: *Archaedictyomitra exceltens* (TAN SIN HOK), 240 x
Fig. 9: *Pantanellium squinaboli* (TAN), 300 x
Fig. 10: *Thanarla* sp. B., 300 x
Fig. 11: *Parvicingula cosmoconica* (FOREMAN), 330 x
Fig. 12: *Pseudodictyomitra carpatica* (LOZYNYAK), 300 x
Fig. 13: *Archaedictyomitra apiaria* (RÜST), 280 x
Fig. 14: *Holocryptocanium barbui* DUMITRICĂ, 280 x
Fig. 15: *Emiluvia chica* FOREMAN, 160 x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