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Biostratigraphy and Facies of Upper Jurassic–Lower Cretaceous pelagic carbonate sediments (Oberalm-, Schrambach- and Roßfeld-Formation) in the Northern Calcareous Alps, South of Salzburg

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4 Text- Figures, 3 Tables, 14 Plates

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Pelagic Carbonates
Oberalm-Formation
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Biostratigraphie und Fazies der pelagischen Oberjura/Unterkreide-Sedimente (Oberalmer, Schrambach- und Roßfeld-Formation) der Nördlichen Kalkalpen südlich von Salzburg

Zusammenfassung

Im Rahmen einer interdisziplinären Studie wurden einige Schlüsselprofile von oberjurassisch-unterkretazischen pelagischen Kalksteinen (Oberalmer, Schrambach- und Roßfeld-Formation) südlich von Salzburg im Hinblick auf ihren biostratigraphischen Umfang und hinsichtlich ihrer Mikrofazies untersucht. Calpionelliden erwiesen sich dabei für die oberjurassischen bis berriasischen Sedimente als bestens geeignet, während Dinoflagellaten-Zysten sich ab dem Ober-Berrias und im Valangin als biostratigraphisch sehr wertvoll erwiesen, unterstützt auch durch die gar nicht so seltenen Aptychenfunde.

Das bemerkenswerteste Ergebnis unsere Untersuchungen ist, daß die oben erwähnten "typischen" lithofaziellen Einheiten pelagischer Kalksteine in ihrem stratigraphischen Umfang signifikante Unterschiede aufweisen. So zeigen etwa lithostratigraphisch "typische" Oberalmer Schichten in den Steinbrüchen am Gutrathsberg oder Mathias Wallinger ein Ober-Tithon-Alter, im Woerndl-Bruch repräsentieren sie Sedimente des Unter- (bis ?Mittel-) Berrias, während sie im Rettenbacher Steinbruch von Obertithon bis ins jüngste Berrias – hier mit charakteristischen Lagen von allodapischem Barmsteinkalk – reichen, eventuell sogar ins frühe Valangin. Hingegen setzt die Sedimentation von dünnplattigen pelagischen Kalken vom Typ der Schrambach-Schichten im Steinbruch Gutrathsberg bereits im Obertithon ein und reicht bis ins obere Berrias, wo sie über rosarote fleckige Mergelkalke vom Typ der Anzenbach-Schichten allmählich in die Kalkmergel bzw. Mergel der Unteren Roßfeld-Formation des frühen Valangin übergehen, wie die Ergebnisse des Studiums der Dinoflagellaten-Zysten und der Aptychen belegen. Die Sedimentation der Oberen Roßfeld-Formation wird von verschiedenen Sandsteinen und von Wildflysch-artigen olistholithischen Breccien dominiert, wobei der eine Wildflysch-Typ durch mergelige Grundmasse – z. T. als "Rosinenmergel" ausgebildet – charakterisiert ist, die sich mit Hilfe von Dinoflagellaten-Zysten ins späte Valangin einstufen ließen. Der andere Wildflysch-Typ liegt in Form einer chaotischen, schlecht sortierten Korn-unterstützten Breccie vor, die bislang stratigraphisch nicht eindeutig eingestuft werden konnte; Dinoflagellaten-Zysten in den mergeligen Zwischenmitteln deuten jedoch auf ?Hauterive-Alter. Weiters sind verschiedene Sandstein-Typen ein charakteristisches Element für die "distal fan channel"-Sedimentation der Oberen Roßfeld-Formation.

Abstract

An interdisciplinary study of some key sections of Late Jurassic-Early Cretaceous pelagic carbonate sediments (Oberalm-, Schrambach- and Roßfeld-Formation) south of Salzburg was carried out with particular focus on biostratigraphy and microfacies. Calpionellids prooved to be most useful for the Late Jurassic-Berriasian sediments, while dinoflagellate cysts take over this role in sediments of Late Berriasian-Valanginian age, supplemented by occasional findings of aptychi. The most remarkable result of our study is, that the "typical" lithofacies-types of the above mentioned pelagic limestones show considerable different stratigraphic age. "Typical" limestones of Oberalm-type show for instance a Late Tithonian age in the Gutrathsberg and Mathias Wallinger Quarries, while in the Woerndl Quarry they comprise the early-(?middle) Berriasian. In the Rettenbacher Quarry pelagic limestones of Oberalm-type are intercalated by allodapic Barmstein-Limestone beds, comprising a stratigraphic interval from the latest Tithonian to the latest Berriasian, maybe even to the early Valanginian. On the contrary the sedimentation of thin-bedded Schrambach-type limestones commenced in the Gutrathsberg Quarry already in the Late Tithonian and persisted till the Late Berriasian. In the Gutrathsberg Quarry variegated coloured marlstones ("Anzenbach-Member") are considered to mark the boundary between the Schrambach- and the Lower Roßfeld-Formation, the latter of Early Valanginian age – as prooved by the study of dinocysts and aptychi - while the marls accompanying the "wildflysch" olistolithic breccia of the Upper Roßfeld-Formation can be dated by dinoflagellate cysts as Late Valanginian. Another type of "wildflysch" breccias of the Upper Roßfeld-Formation is represented by an extremly poorly sorted clast-supported breccia without any marly matrix. However, in between the olistolithic clast supported grainflows, also marly pockets can be observed, which yielded dinoflagellate cysts of ?Hauterivian age. Also various sandstones are a characteristic element for the distal fan channel-sedimentation of the Upper Roßfeld-Formation.

1. Introduction

In 1997-98 we started to carry out a detailed biostratigraphic research of several already well known localities, in which fossiliferous Lower Cretaceous deposits are favourably exposed as a result of quarrying. Thus we wanted, especially from the macrofaunistic point of view, to go back to the successful results achieved in the area of Grossraming and Hollenstein a. d. Ybbs (VAŠÍČEK & FAUPL, 1996, 1999a; VAŠÍČEK et al., 1999b). However, already in the first year of our field work it was clear that in some localities, deposits older than the Lower Cretaceous outcropped and that the majority of deposits were poor in macrofossils. In spite of this finding we documented in detail the two most favourable quarry sections and explored several other localities, among others the Rieger, Wallinger and Woerndl Quarries (Text-Fig. 1). In addition to the macrofaunistic collections done in all the localities, we documented in detail the lithology and the depositional conditions of sections traced in the Gutrathsberg and Rettenbacher Quarries. We supplemented the basic macropetrographic investigation by systematic sampling for thin sections and by systematic sampling of marly intercalations for testing on and determination of non-calcareous dinocysts. The thin sections were evaluated from the microfacial and micropalaeontological point of view.

Of all the studied localities a basic lithological description including a detailed microfacial and micropalaeontological description and a biostratigraphic analysis based on calpionellids, dinoflagellates and macrofauna is given. After the description of all localities, a systematic palaeontological part is presented, in which the most important findings of cephalopods are described.

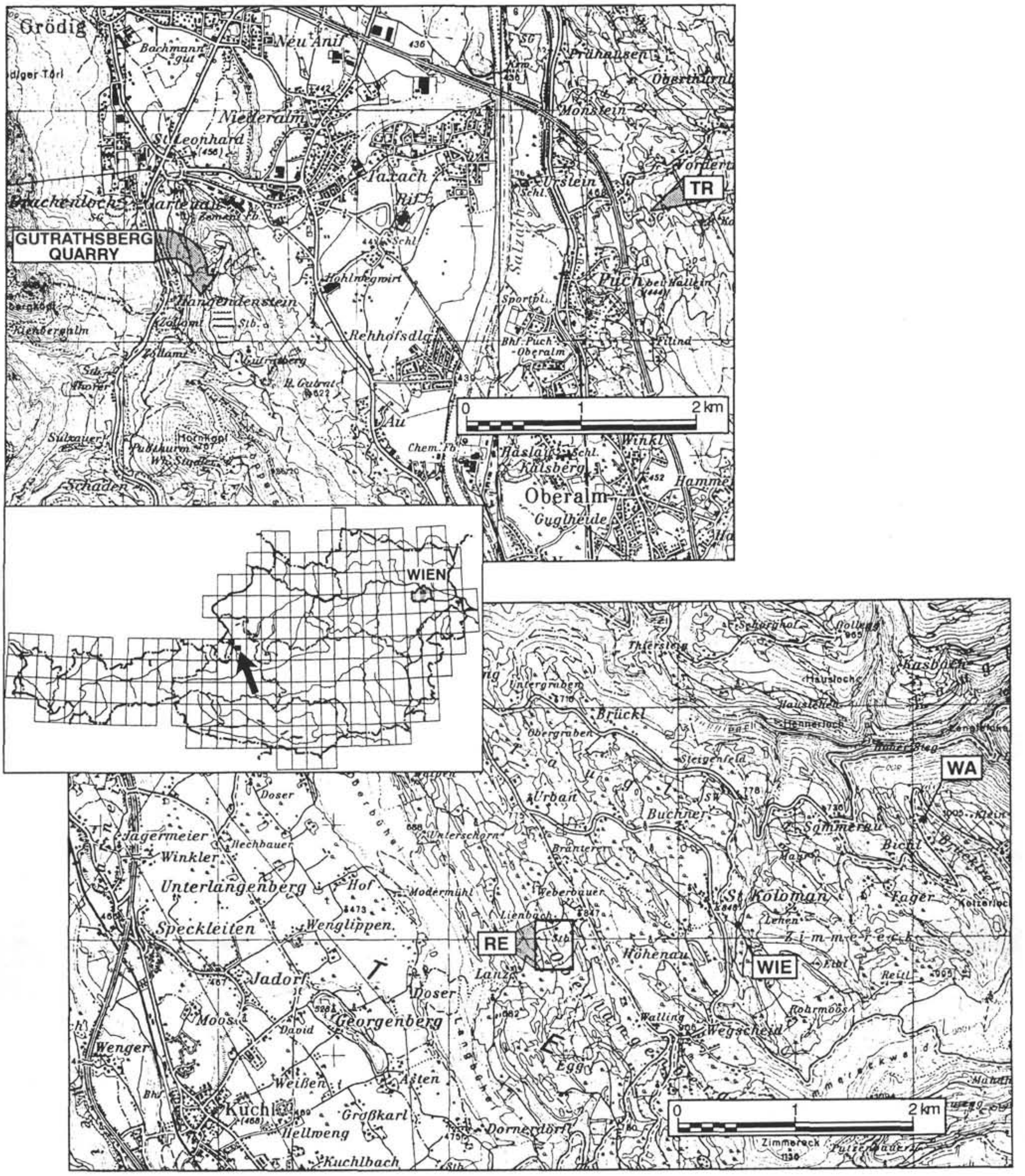
A short review on previous research on Late Jurassic-Early Cretaceous pelagic sedimentation in the region concerned was given by LOBITZER et al. (1994a).

2. Studied Localities

2.1. Gutrathsberg Quarry of Leube Cement Co. Ltd. at Gartenau

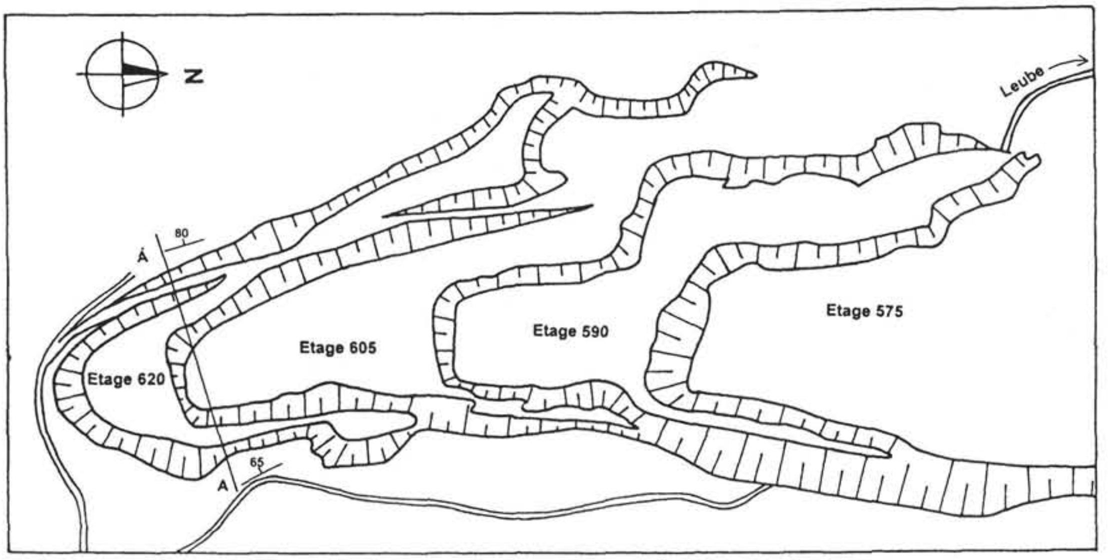
2.1.1. Geological Setting

The geological structure of the set of quarry faces at Gutrathsberg and the complex of deposits outcropping there have been already studied several times in the previous years. It was primarily PLÖCHINGER (1974) who studied the



Text–Fig. 1.
Topographic situation of the studied localities. The upper map (ÖK 93) shows topographic situation of Gutrathsberg Quarry of Leube Cement Co. Ltd. Toni Rieger Quarry: TR; the lower map (ÖK 94) shows topographic situation of Rettenbacher Quarry: RE, Wieser (Woerndl) Quarry: WIE and Mathias Wallinger (Schorn) Quarry: WA.

whole geological structure on the lower quarry levels. In the Oberalm-Formation, which he assigned to the Tithonian, he distinguished 4 cyclothems. It follows from his illustration in Plate 1 that the section studied by us starts only with the third cyclothem. The fourth cyclothem, which is - as can be judged from the photo - lithologically different, corresponds to the lower part of the marly Schrambach-Formation. The uppermost, siliceous part of the marly formation, is included by PLÖCHINGER (1974) into the Lower Roßfeld-Formation. In 1980 PLÖCHINGER designated these deposits as the Anzenbach-Member. They are characterized especially by layers of red marlstones. As stated then by WEIDICH (1990), in the type area at Anzenbach belonging, however, to the geological unit of the Bajuvaricum, he failed in verification of



Text–Fig. 2.
Scheme of the existing mining area of the Gutrathsberg Quarry (A – A'= ideal line of the orientation of section).

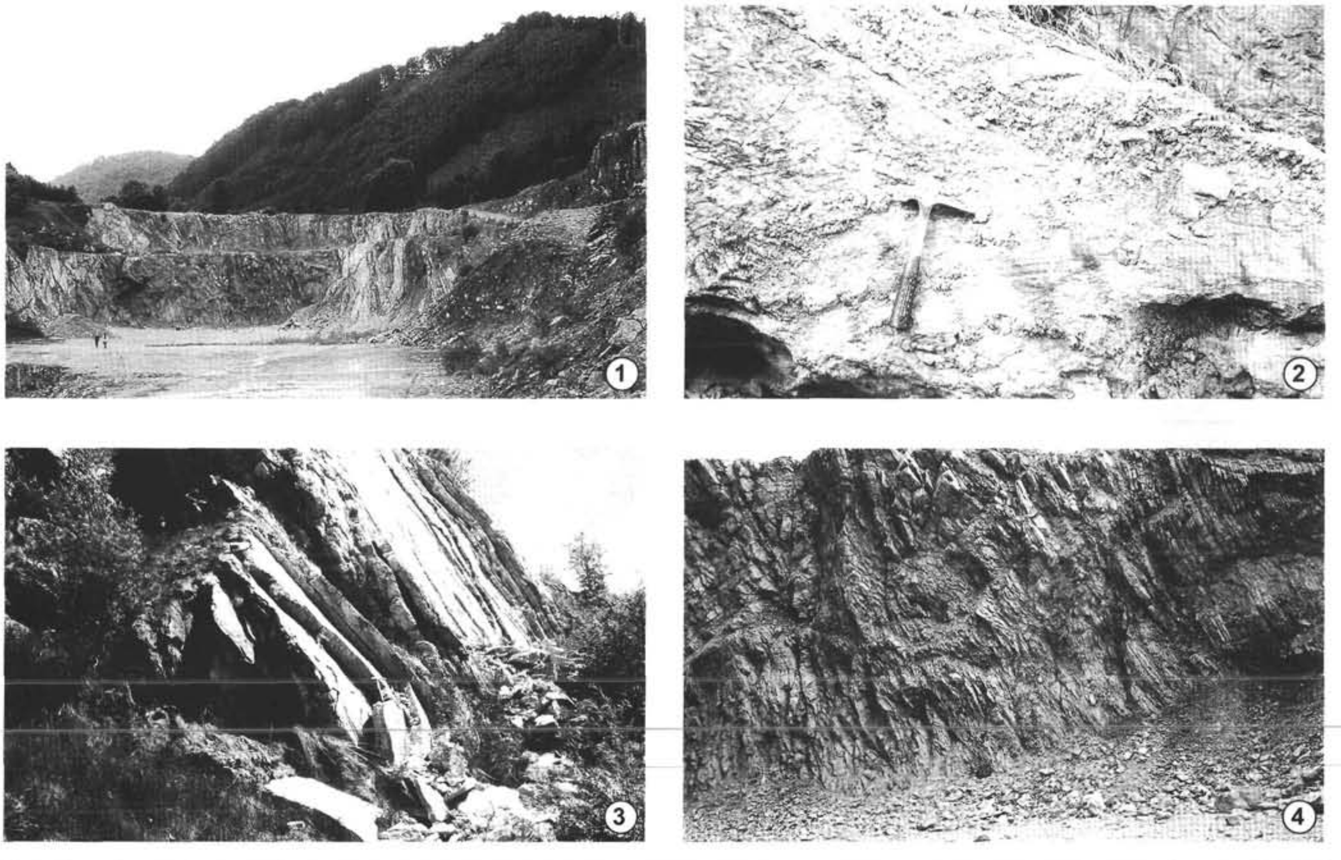


Plate 1

Gutrathsberg Quarry of Leube Cement Co. Ltd. in Gartenau.

Fig. 1: View of quarry levels 605m and 620m. Profile section runs from left to right. On the left exposures of Oberalm-Formation with "recultivated" outcrop of Oberalm basal breccia (meadows on the left). In the center tectonized slabby ±vertical Schrambach-Formation transient to the Lower Roßfeld-Formation. On the right side of quarry levels 620m respectively 635m (top of quarry) the Upper Roßfeld-Formation is exposed, showing "wildflysch"-type olistolithic sediments.

Fig. 2: Oberalm basal breccia on quarry level 620m; Late Tithonian; Poor sorting of components; cross-bedding.

Fig. 3: Basal Oberalm-Formation, Late Tithonian; about 20cm thick bedded limestone with chert.

Fig. 4: Tectonized slabby limestones of Schrambach-Formation, Late Tithonian-Late Barriasian; quarry level 620m.

the type locality of Anzenbach-Schichten with variegated deposits and did not use this rock unit name in the Gutrathsberg section.

Recently, the section of Gutrathsberg has been also studied by REHÁKOVÁ et al. (1996). As can be judged by to their results, their section begins in the uppermost part of the Oberalm-Formation, includes the lower part of the Schrambach- Formation and ends at the base of variegated marly deposits. They regard the latter marly deposits as the base of the Roßfeld-Formation. The section was sampled probably along one of the lower levels of the set of quarry-faces.

In the large system of several levels of quarry faces we documented suitably exposed sections of the two uppermost levels at 605m and 620m situated in the zone at the southern boundary of the existing mining area (Text-Fig. 2). The studied section begins in the uppermost level (620m-level) in an abandoned east face of the quarry complex. In this face, the oldest deposits outcrop. The bedding roughly corresponds to the orientation of the face. The section from the given face after short intermission corresponding to the overgrown base of the face passes to the lower quarry level at 605m. The documented face is orientated here approximately normally to the strike of strata. With reference to the fact that this face is in its second (western) half covered with debris, the subsequent documentation had to be shifted to an equivalent section in the central part of the uppermost quarry level. There the overlying deposits are exposed favourably up to the highest part of the sequence of strata in the west. The obtained section through the whole sequence of strata corresponds to the marked ideal line of the section A – A' (Text-Fig. 2). The axis of the section (SE–NW) correspond to the direction of the quarry face No. 605. On it, all the remaining documented partial sections of faces deviating from the ideal direction, are projected. By suitable combining the documented partial sections of both the uppermost levels, an overall section of the total thickness of deposits of about 100 m was created (Text-Fig. 3).

From bottom to top, three rather steeply inclined formations are exposed in the studied levels: the Oberalm-Formation, the Schrambach-Formation and the Roßfeld-Formation. In between the lithologically typical Oberalm- and Schrambach-Formation uncharacteristic Late Tithonian pelagic limestones are intercalated, which we call "Transitional Facies of Oberalm-/Schrambach-Formation". These are thin-

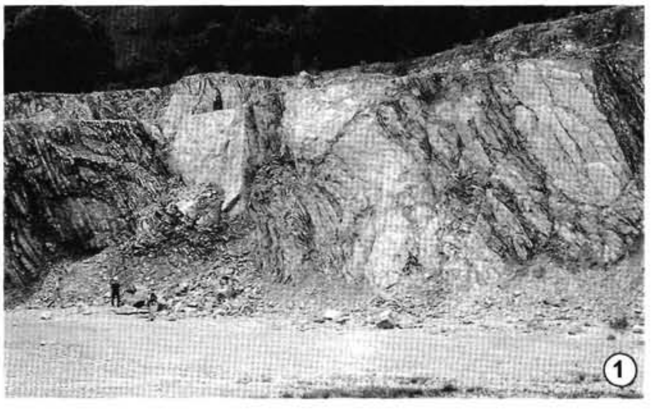


Plate 2

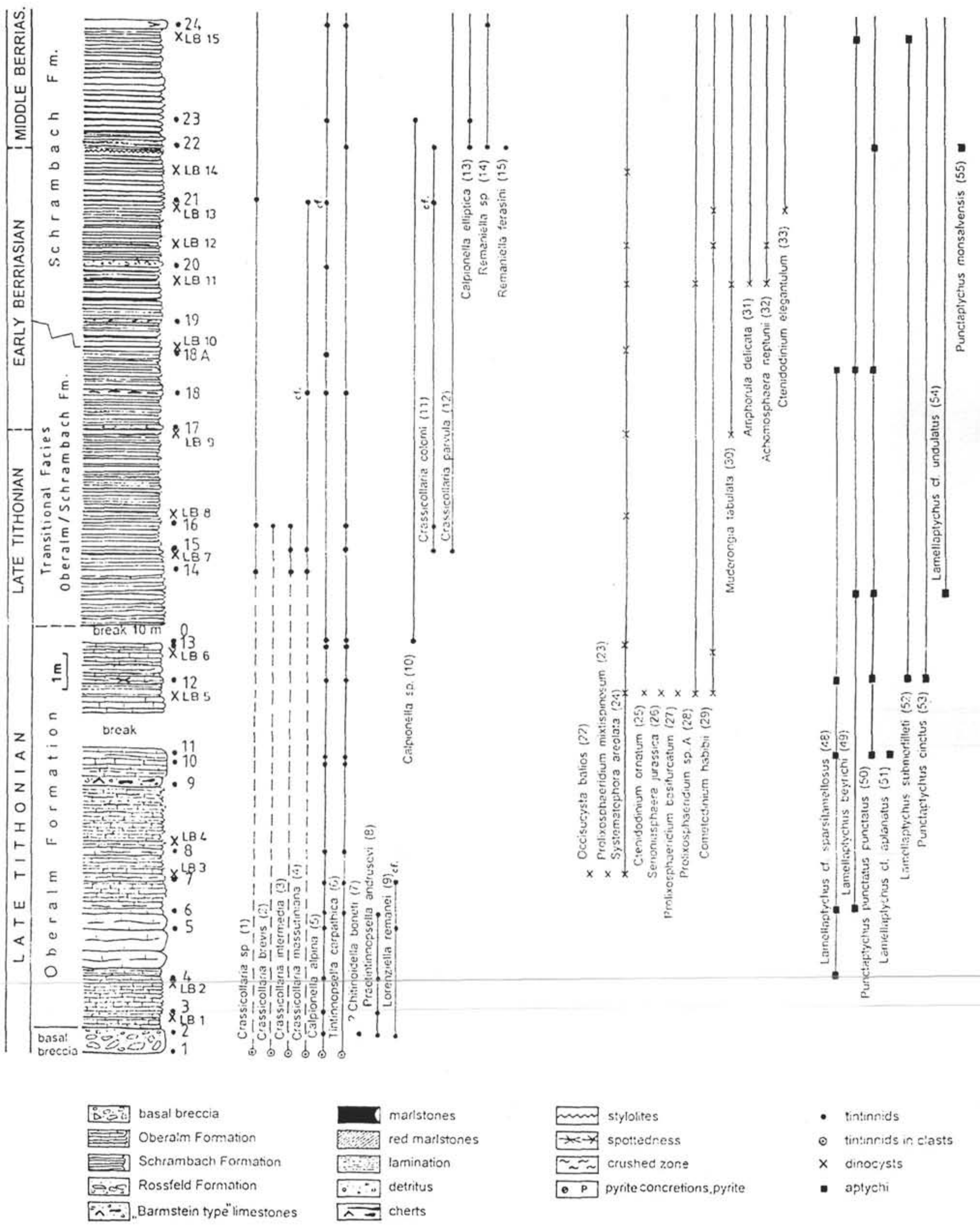
Gutrathsberg Quarry of Leube Cement Co. Ltd. in Gartenau.

Fig. 1: Transition from slabby limestones of Schrambach-Formation (Late Berriasian) towards the right into coarser bedded marlstones of the Lower Roßfeld-Formation (Early Valanginian), close to the Formation boundary with conspicuous pink layers of "Anzenbach-Member".

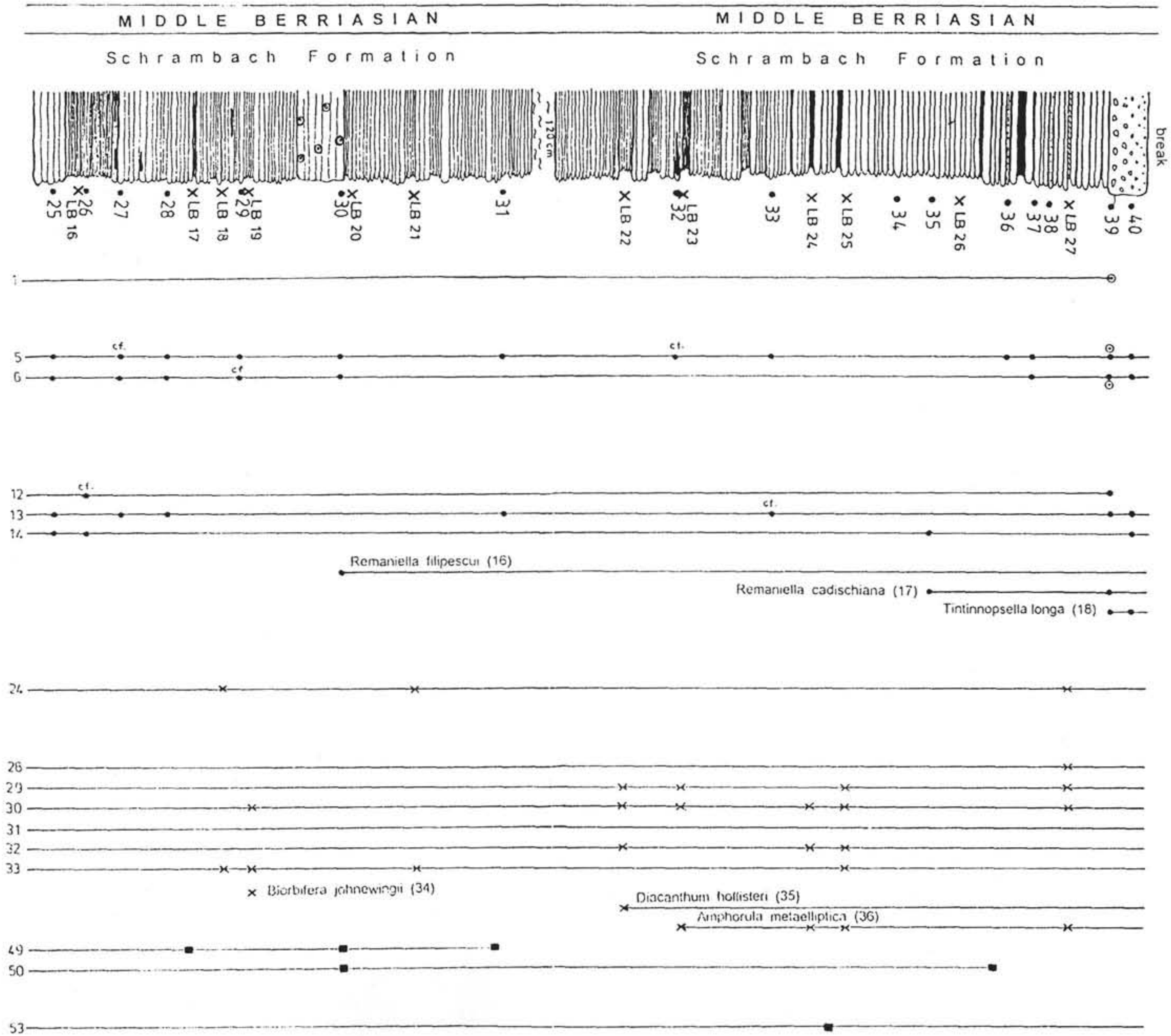
Fig. 2: Cross-bedded, coarse-grained glauconitic sandstone of the Upper Roßfeld-Formation (?Valanginian or Hauterivian).

Fig. 3: Olistolithic "wildflysch" sediment of the Upper Roßfeld-Formation. The matrix consists of soft to brittle marls, which yielded upper most Valanginian to Hauterivian foraminifers (det. L. HRADECKÁ, Praha) and dinoflagellate cysts. The limestone boulders are extremly poorly sorted, showing grain-sizes from the cm - to the m³ - range.

Fig. 4: On the bases of the "wildflysch" occasionally marls with marl concretions and components in gravel size can be seen ("Rosinenmergel", "plum cake marls"); they yielded a foraminifera assemblage of Hauterivian age (det. HRADECKÁ, in EGGER et al., 1997).

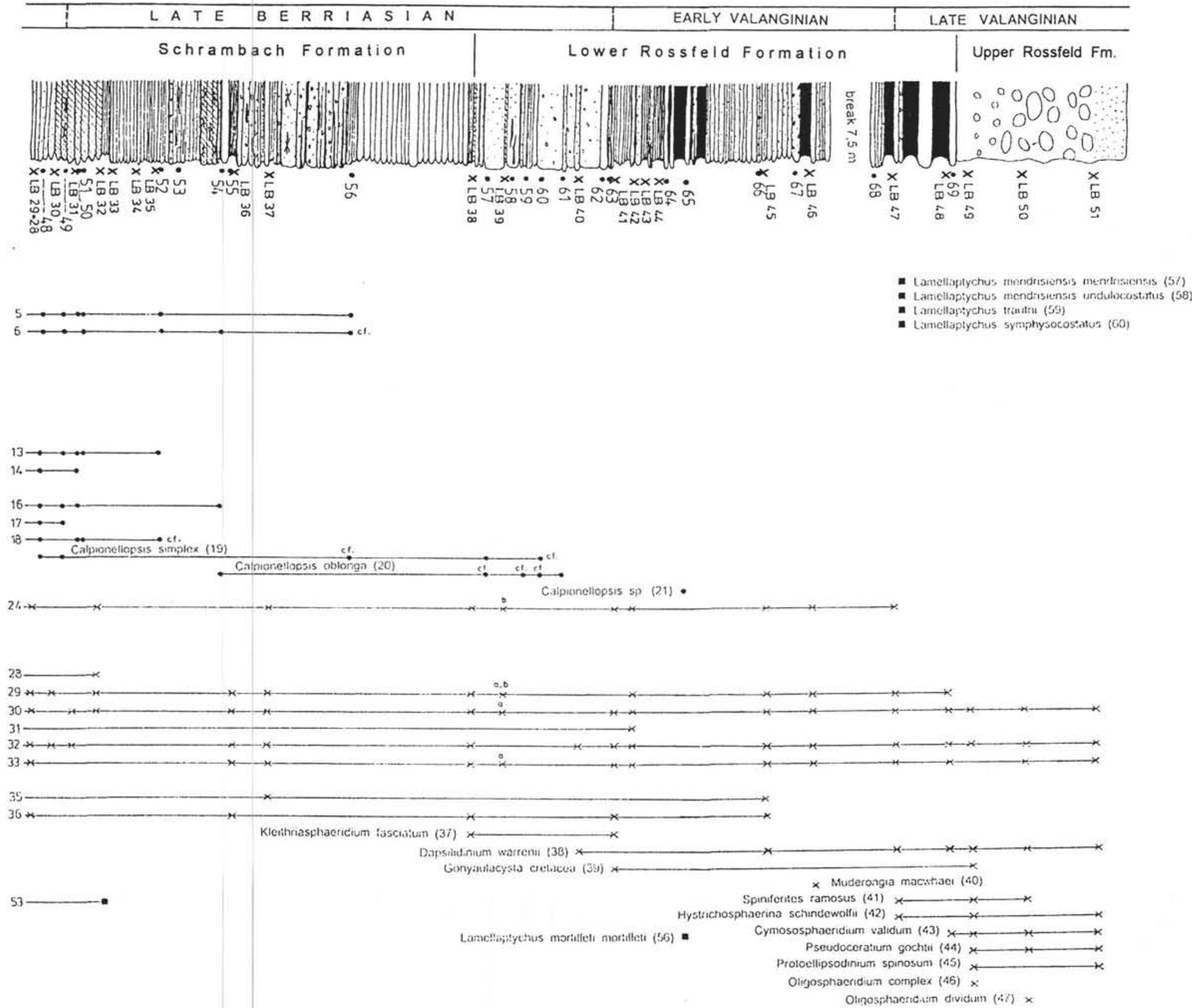


Text–Fig. 3: Stratigraphy and lithology of the Gutrathsberg Quarry.



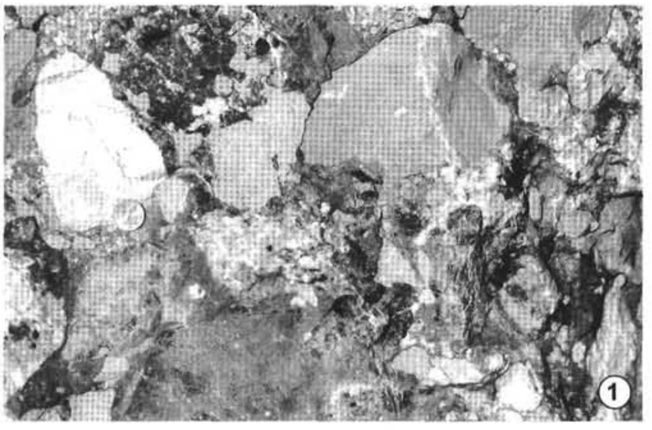
Text–Fig. 3: Stratigraphy and lithology of the Gutrathsberg Quarry (etage 605).

II



Text–Fig. 3: Stratigraphy and lithology of the Gutrathsberg Quarry (etage 620).

III



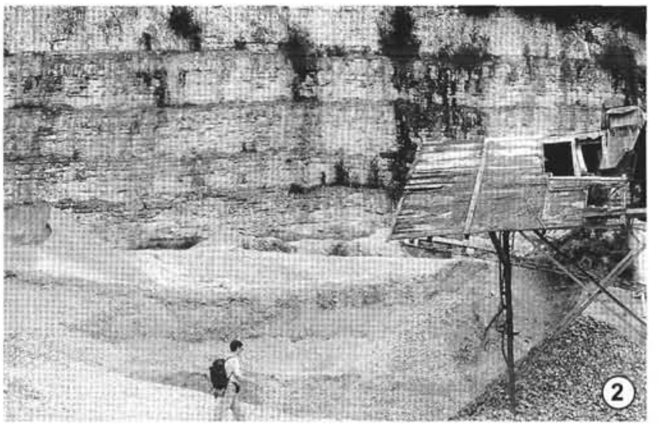


Plate 3

Fig. 1: Clast supported, very poorly sorted olistolithic breccia/conglomerate of the Upper Roßfeld-Formation; Gutrathsberg Quarry, 620m level.

Fig. 2: Toni Rieger Quarry in Puch exposing pelagic limestones of the Oberalm-Formation (starting in the Middle Tithonian) with frequent intercalations of allodapic Barmstein Limestones. The top-layer consists of Barmstein Limstones of Berriasian age (BODROGI in LOBITZER et al., 1994b).

Fig. 3: Rettenbacher Quarry west of St. Koloman. Pelagic limestones of the Oberalm-Formation (Upper Tithonian-Late Berriasian) with intercalations and toplayer of allodapic Barmstein-Limestone; the latter of uppermost Berriasian, maybe even of Early Valanginian age.

Fig. 4: Mathias Wallinger (previously Schorn) Quarry. About 3dm thick bedded pelagic limestones of uppermost Tithonian Oberalm-Formation, partly with chert and brittle diagenetic marlstone intercalations.

bedded limestones without marly intercalations, which resemble more the slabby limestone beds of the Schrambach-Formation, however, without the otherwise characteristic marly intercalations. The orientations of bedding planes in the lower parts of the sequence of strata reach mean values of about 250/60-70°. It is, in principle, equal to the course of the majority of faces in the eastern part of the quarry complex. In the uppermost part of the sequence of strata in the western part of the quarry, beds become steeper up to 80° at almost the same dip direction. The continuity of the sequence of strata is complicated by a system of overthrusts and fault dislocations. The first type of dislocations moving in the range of measured values of 260-290/60-70° is subparallel to the bedding. It has a character of overthrusts to slips between layers. Values of the second type of dislocations are about 320-340/55-80°. Their dislocation planes show subvertical grooving. These faults show usually an insignificant dislocation in the decimetre to several meters in order. The third, least numerous system having the value of 40-60/70-80° plays partially a role in the orientation of the western faces. The continuity of the whole sequence of strata is interrupted by two covered sectors inaccessible to documenting. The eastern interruption, situated in the Oberalm-Formation, belongs to the overgrown base of the highest quarry face. The western interruption, located in the uppermost part of the Schrambach-respectively Lower Roßfeld-Formation, corresponds to the road bottom from the lower part to the uppermost part of the quarry.

The Oberalm-Formation outcrops at the highest quarry level at 620m in the abandoned eastern part of the level. The examined section starts with the basal breccia that reaches a thickness of about 70 cm (Plate 1, Fig. 2). On its base, there are coarser clasts becoming more and more smaller towards the overlying rocks and gradually passing into a fine-grained sediment. In the breccia, beige to pink clasts prevail with a tinge of brown; they are rarely also grey, or light grey. The matrix is brownish, or grey. The material is unsorted. The size of the clasts varies from about 1 mm to several cm. It contains fragments of brown-grey cherts.

On top of the breccia follow light grey limestones which are thin bedded, slab-like. About 8 m above the base, a 30 cm thick layer of allodapic limestone of the "Barmstein type" is exposed in the section. Behind the dislocation, in the immediate overlying rocks, further slabby limestones follow. They contain no longer any other intercalations of limestone of the "Barmstein type".

The uppermost part of the Oberalm-Formation and the transition to or the contact with the overlying Schrambach-Formation in the thickness of about 10 m is not accessible to direct observation, because as mentioned, it is located on the overgrown bottom of the highest quarry face.

On bedding planes, aptychi occur rather abundantly in places. At the whole upper level of the quarry, 30 valves of aptychi have been found in all. Only very sporadically occur imprints of very poorly preserved perisphinctid ammonites, exceptionally the remnants of rhyncholites and belemnites. Rarely poorly preserved trace fossils of the *Ophiomorpha/Thalassinoides*-type can be observed on the bedding planes.

The Schrambach-Formation is favourably exposed at the lower quarry level, whereas their upper part and the Roßfeld-Formation are exposed only in the west of the highest level. The lower part of the Schrambach-Formation – in the section (Text-Fig. 3) designated as "transitional facies Oberalm/Schrambach-Formation", because marly intercalations are missing - consists of greenish-grey, slabby, marly limestones. The limestones are rarely inexpressively spotty. Rather usually they are tectonically affected - shaly, and on the bedding planes there is a faulting polish. The limestones are sporadically cherty; grey, or black cherts of various shape occur - lenticularly elongated, parallel to the bedding. Some layers are laminated. Only scarcely graded bedding can be observed. Rarely rusty-brown coatings caused by Fe-oxides are present. In the lowest part of the section, an abut 10 cm thick slab of allodapic Barmstein type limestone occurs at the level of about 5 m and one meter higher, a layer of cherty limestone. Similar slabby layers with cherts appear then several times also in the overlying rocks upsection to the level of about 33 m. At the level of about 10 m, a layer with conspicious pyrite can be seen as a speciality as well. In the higher part of the section, from about 35 m, limestone slabs become thicker. Regularly they are interbedded with thin but distinct intercalations of marlstones. They reach exceptionally a thickness of 12 - 15 cm. At the level of about 39 m, a pink - it means differently coloured very thin layer of marl emerges. At 42.34 m, a 6 cm thick layer of red-coloured marl can be observed. In the mentioned interval, two sandy layers have been found too, even though merely several centimeters thick. The sequence of strata in this part of lower level is ended with a 1 m thick bed of organodetrital limestone (44.35 m in the section).

In the just described sequence of strata at the lower level, namely especially in parts richer in marl, valves of aptychi occur (about 35). The number of aptychi decreases gradually towards the overlying strata.

After the monoclinally deposited sequence of strata at the lower level as well as in the section roughly equivalent also in the upper level a zone about 15 m thick follows with a different strike. The contact of both these parts is covered with a dislocation plane (40/80°) that is congruent with a partial course of the quarry face. That is followed by a younger formation of deposits lithologically different from the underlying rock that obtains the original strike in a short time. Whereas in the lower level the

Tab. 1.
Correlation scheme of ammonite and calpionellid zonation.

			Hoedemaeker, Company et al., 1993 Wright et al., 1996	Borza, 1984 Pop, 1989, 1994 a, b, 1998
Valanginian	Late (pars)		*Himantoceras trinodosum*	
			Saynoceras verrucosum	*Tintinnopsella* ssp.
	Early		*Busnardoites campylotoxus*	*Calpionellites major*
			Thurmanniceras pertransiens	*Calpionellites darderi*
Berriasian	Late		*Tirnovella otopeta*	*Praecalpionellites murgeanui*
		Fauriella boissieri	*Tirnovella alpillensis*	
			Picteticeras picteti	*Calpionellopsis oblonga*
			Malbosiceras paramimounum	*Calpionellopsis simplex*
	Middle	*Tirnovella occitanica*	*Dalmasiceras dalmasi*	*Tintinnopsella longa*
			Berriasella privasensis	
			Tirnovella subalpina	*Calpionella elliptica*
	Early	*Berriasella jacobi*	*Pseudosubplanites grandis*	*Remaniella ferasini*
			Berriasella jacobi	*Calpionella alpina*
Tithonian	Late		*Durangites* ssp.	*Crassicollaria colomi*
				Crassicollaria intermedia
			Micracanthoceras microcanthum	*Lorenziella remanei*
				Praetintinnopsella andrusovi
	Middle pars		*Micracanthoceras ponti*	*Chitinoidella boneti*
				Chitinoidella dobeni

mentioned higher sequence of strata is shortly covered with debris and inaccessible, all this section is favourably exposed at the highest level. It is a formation of deposits designated in the literature differently as the Lower Roßfeld-Formation (PLÖCHINGER, 1976), the Anzenbach-Member (PLÖCHINGER, 1980) or the Schrambach-Formation (WEIDICH, 1990). What is conspicuous here is mainly the presence of red-coloured marly layers. The first of them tectonically recurs in the lowermost part of the sequence of strata at the highest level.

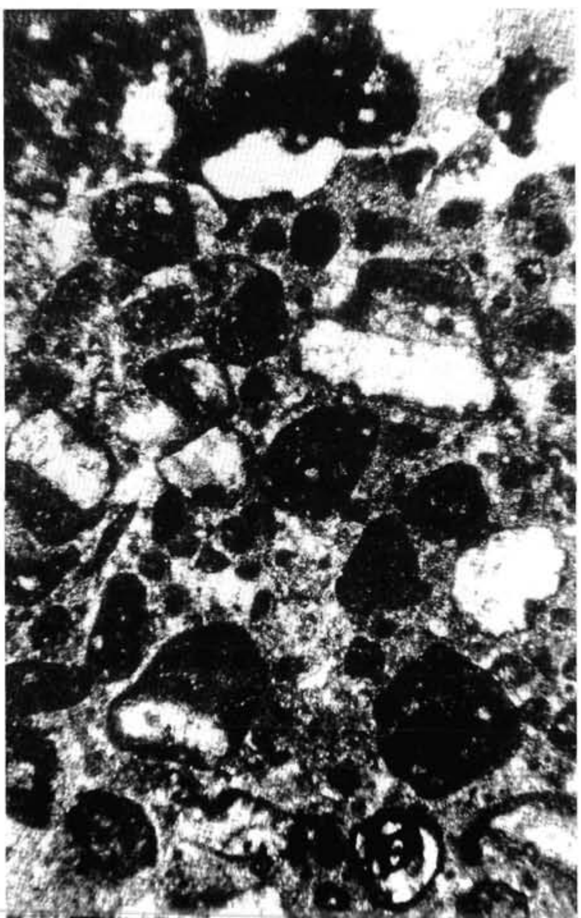
In the overlying marls development, a different formation of sandy deposits follows. Moreover, a formation of cherty limestone several meters thick is marked here that manifests itself morphologically. An even higher part of the sequence of strata is formed by more marly limestones intercalated with beds of sandy to detrital limestones. Sandy components are present in a greater amount also in the marly parts of the section. In our profile Text-Fig. 3 this part of the sequence is assigned to the **Lower Roßfeld-Formation**.

Macrofauna in the upper level occurs in the whole formation only very rarely: two valves of aptychi and one belemnite at the level of the lowermost red-coloured marly layer and 4 valves of aptychi in the uppermost part of the sequence of strata in a position under the road leading from the bottom to the southern uppermost margin of the quarry. Sometimes trace fossils of the *Chondrites*-type can be observed on the bedding planes.

Plate 4

Basal breccia - lower part. Thin section Leu 1, Gutrathsberg Quarry, late Tithonian. Oberalm-Formation

Fig. 1: Matrix, intrabiopelmicrosparitic/intrabiopelsparitic (intraclast-biogenic-peloid wackestone/packstone/grainstone).
Fig. 2: *Bacinella irregularis* RADOIČIĆ.
Fig. 3: Hydrozoa. On the right a clast with calpionellids.
Fig. 4: Siphonal alga from the order Bryopsidales.
Fig. 5: Clast with *Clypeina jurassica* FAVRE.



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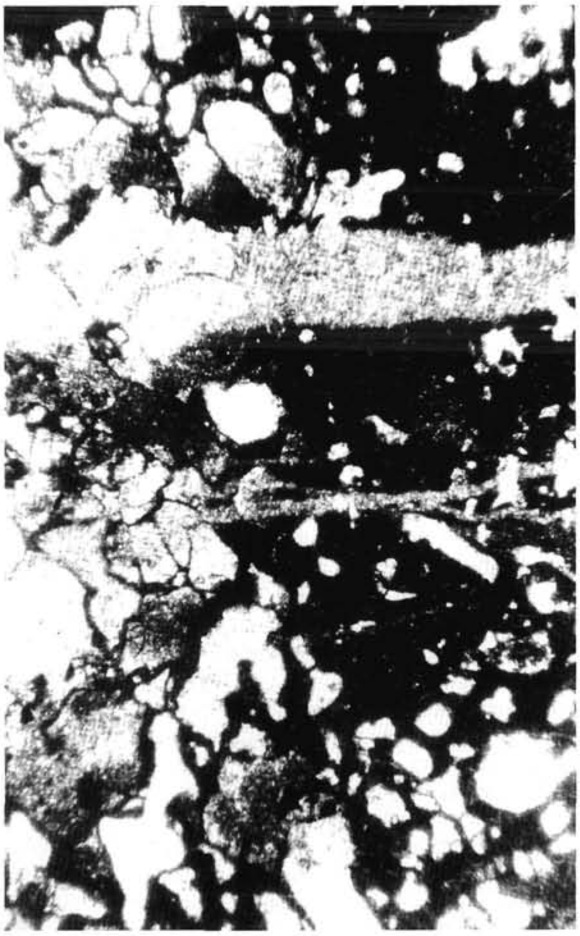

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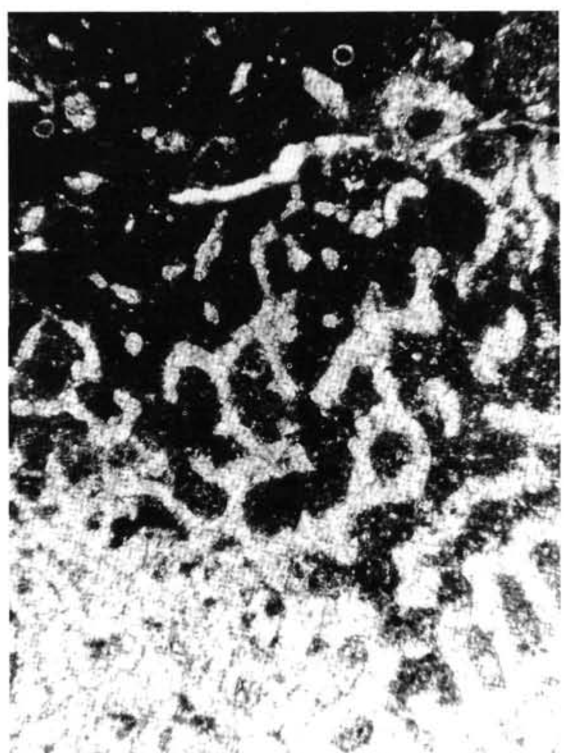

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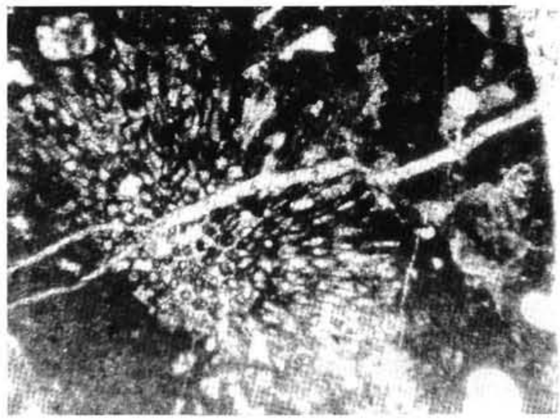

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Above the mentioned road, that causes the interruption of the continuous sequence of strata by more than 7 m, a light grey formation of deposits is there farther towards the overlying strata that we consider as part of the Lower Roßfeld-Formation. It is composed of an about 2 m thick light coloured deposits of silty to sandy marlstones and claystones alternating with silty-marly limestones. In the latter, aptychi not in great numbers occur for the last time. In addition, one remnant of an oyster and one of an inoceramid bivalve were found.

In the immediate overlying strata, a different formation of grey to dark grey deposits appears suddenly. It is the true Upper Roßfeld-Formation. It begins with sandy dark grey claystones, in which smaller pebbles and fragments of various rocks with diameters of even 10 cm, then coarser pebbles of various sizes to blocks of the olistolith type emerge. In some places at the base, the pebbles are missing so that merely a clayey matrix is present. In this formation no macrofauna has been found.

Above the mentioned deposits that can be designated as "wildflysch", breccias to fine-grained conglomerates follow a thick formation of dark coloured sandstones.

2.1.2. Microfacies and Micropalaeontological Evaluation

For the detailed study of deposits samples were regularly taken for thin sections (70 altogether) and from suitable marly layers also samples were taken for studying non-calcareous dinoflagellates (53 in all, designated as LB), and simultaneously also macrofaunal collections were made.

For stratigraphic purposes, the determined associations of fossils were evaluated, as far as possible, on the level of ammonite and calpionellid zones, or subzones. For this end and for better illustration, we tried to create a correlation scheme of zonation of both the mentioned faunistic groups (Tab. 1). It was formed on the basis of combination of data of authors given in the head of the table. The boundaries and conception of zones and subzones cannot be absolute, because underlying data of particular authors differ in many places.

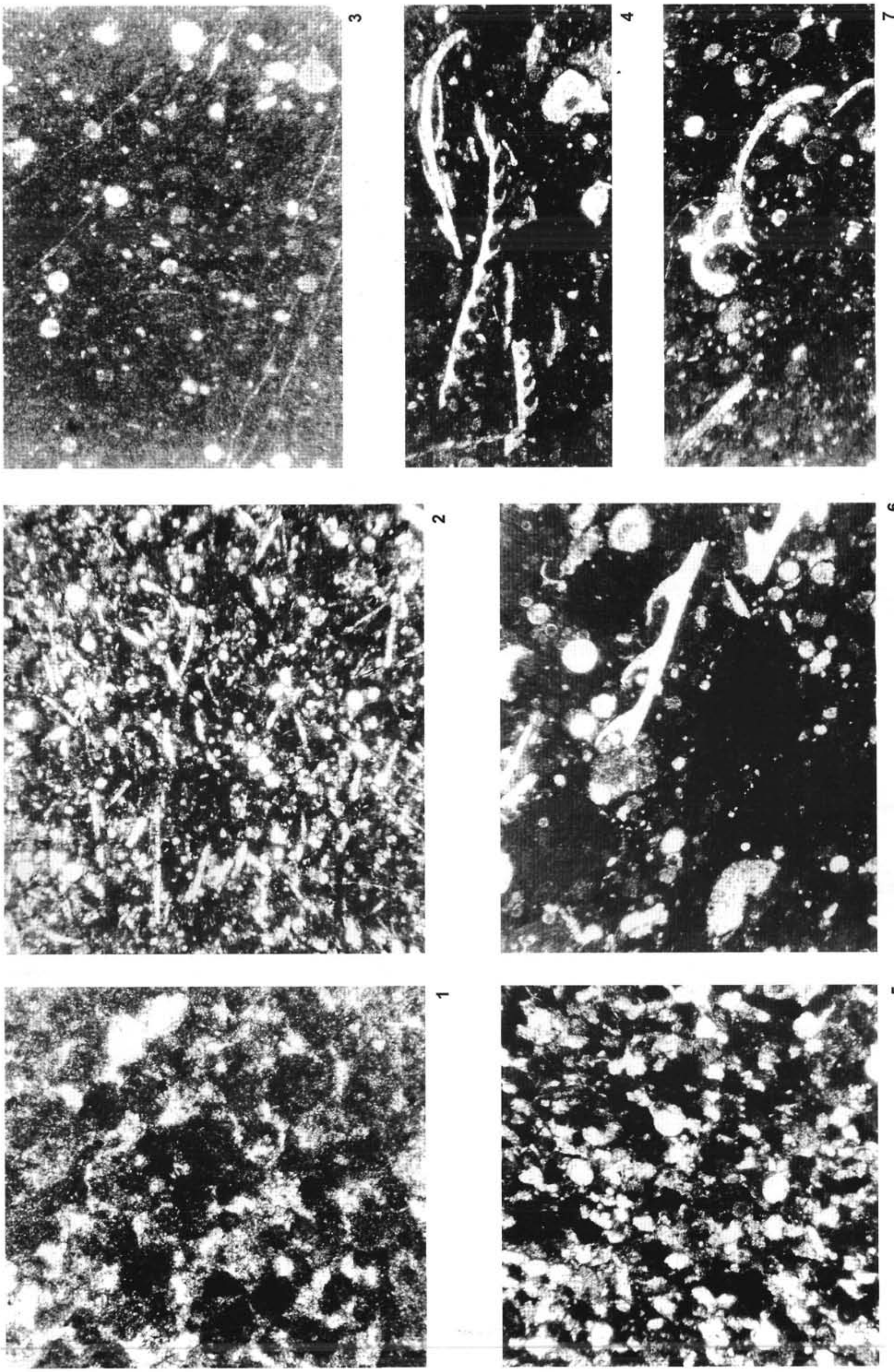
2.1.2.1. Oberalm-Basal Breccia

Three samples for thin sections were taken from the breccia. Two thin sections were analyzed from the coarse, basal part of the breccia. It is intrabiopelmicrosparrudite/intrabiopelsparrudite (trend to rudstone and floatstone) from the standpoint of texture. In the intrabiopelmicrosparite/intrabiopelsparite (intraclast-biogenic-peloid wackestone/packstone/grainstone) matrix (Pl. 4, Fig. 1), densely packed allochems of various composition occur. Their size varies within the limits of the rudite grain fraction. Because of the grain-supported fabric it is possible to study the matrix merely in places. It mainly contains micritic intraclasts and locally also peloids. The rather rare biogenes are represented by foraminifers, especially miliolids and/or *Valvulina* sp.), fragments of echinoderms - sometimes with syntaxial rims of calcite - and spines of echinoids. Calcareous sponges, hydrozoans (Pl. 4, Fig. 3), ?bryozoans, *Thaumatoporella parvovesiculifera* (Raineri), *Bacinella irregularis* Radoičić (Pl. 4, Fig. 2), *Tubiphytes* sp., siphonal alga of the order Bryopsidales (Pl. 4, Fig. 4) are also present. Various clasts occur, e. g. of the intrabiomicrite texture (wackestone) with well rounded micritic clasts, recrystallized fragments of echinoderms, benthic foraminifers, biodetritus, or biointrapelmicrite with micrite clasts. Recrystallized fossils are represented by shallow-water organisms without any nearer identification of clasts of the intrabiopelmicrite/intrabiopelmicrosparite texture (intraclast-calpionellid-peloid wackestone/packstone). Sporadic remains of organisms are represented by stratigraphically significant calpionellids as *Crassicollaria brevis* (Remane), *Cr. intermedia* (Durand Delga) (Pl. 7, Fig. 10), *Cr. massutiniana* (Colom) (Pl. 7, Fig. 11), *Crassicollaria* sp., *Calpionella alpina* Lorenz, *Tintinnopsella carpathica* (Murgeanu & Filipescu). Fragments of echinoderms, *Globochaete alpina* Lombard, benthic foraminifers, filaments, recrystallized biodetritus, clasts of biomicrite/biopelmicrosparite (wackestone/packstone) with *Clypeina jurassica* Favre (Pl. 4, Fig. 5), scarce clasts of the pelintrasparite/pelintramicrosparite texture with rare biogenes (peloid-intraclast grainstone), pyritized fragments of detritic limestone were determined. Some allochems (especially biogenes) are coated, by cyanophytes, others are silicified, what makes their identification impossible.

From the upper, more fine-grained part of the breccia, one thin section has been evaluated. It shows intrabiopelmicrosparite/intrabiopelmicritic texture (intraclast-biogenic-peloid packstone; Pl. 5, Fig. 1). Locally the matrix is sparitic. Allochems are packed, rather well sorted. Prevailingly well rounded allochems of micrite are dominant. Recrystallized organic remains are represented mainly by fragments of echinoderms, benthic foraminifers (*Lenticulina* sp.), radiolarians of the spumellarian type (filled usually with one grain of calcite), calcareous dinoflagellates [*Colomisphaera carpathica* (Borza), *Schizosphaerella minutissima* (Vogler)], Ostracoda div. sp., ?fragments of bivalves, biodetritus and of aptychi. Moreover, representatives of tintinnids can be found sporadically. Sometimes it is difficult to determine whether they occur in clasts or in the matrix. *Calpionella alpina* Lorenz (Pl. 8, Fig. 6), *Lorenziella remanei* Borza, cf. *Tinntinopsella carpathica* (Murgeanu & Filipescu), *Praetintinnopsella andrusovi* Borza, and also one problematical section of ?*Chitinoidella boneti* Doben have been identified. The mixed assemblage of tintinnids shows elements of the early and late part of the late Tithonian. In contrast to the specimens from coarser layers of breccia, crassicollarians have been found neither in the clasts, nor in the matrix.

Plate 5

Fig. 1: Intrabiopelmicrosparite (intraclast-biogenic-peloid packstone). Nearly in the middle *Calpionella alpina* Lorenz. Thin section Leu 2, upper part of the basal breccia, late Tithonian.
Fig. 2: Intrabiopelmicrosparite (intraclast-sponge-radiolarian-peloid packstone). Thin section Leu 38, Schrambach-Formation, middle Berriasian.
Fig. 3: Biomicrite (radiolarian wackestone). Thin section Leu 40, Schrambach-Formation, middle Berriasian.
Fig. 4: Directed aptychi. Thin section Leu 39, Schrambach-Formation, middle Berriasian.
Fig. 5: Intrabiopelmicrosparite/intrabiopelsparite (packstone/grainstone). Sandy limestone. Thin section Leu 67, Lower Roßfeld-Formation, early Valanginian.
Fig. 6: Lamina with intrabiomicrite texture (intraclast-radiolarian-aptychus-calpionellid packstone). Thin section Leu 39, Schrambach-Formation, middle Berriasian.
Fig. 7: Cross section of secundibrachial *Saccocoma* sp. Thin section Leu 39, Schrambach-Formation, middle Berriasian.
All thin sections from the Gutrathsberg Quarry.



The mineral impurities are represented by pyrite, sometimes emphasizing microstylolites, together with Fe-oxides, hydromicas, or flakes of muscovite and rare detrital quartz of the sandy grain fraction. In addition, rhombohedra of carbonate have been found rarely.

In the basal part of the Oberalm-breccia also clasts occur showing a late Tithonian calpionellid fauna (Crassicollaria Biozone, Intermedia Subzone in the sense of POP, 1994b) that fade towards the overlying strata and with tintinnids that appear in about the ?middle, or basal and upper parts of the late Tithonian (mixed association).

2.1.2.2. Oberalm-Formation

Above the basal breccia, the sedimentation of the pelagic limestones of the Oberalm-Formation was taking place. In the lower horizons, thin platy light grey, more or less marly limestones of a thickness of 3-5 cm occur that pass, towards the overlying strata, into several thin to thick bedded layers (50-60 cm). Above them, layers of thick platy limestones appear again, whose thickness varies in the range from 9 to 22 cm. Limestones of the Oberalm type are rather commonly tectonized and are of shaly disintegration. On some bedding planes rusty coatings of Fe-oxides occur. In the limestone, from which 12 samples for thin sections were taken, a spottedness was observed. Less than 8 m above the base of the section, a 30 cm thick layer of grey cherty limestone with clasts occurs. The cherts are of various shape (lenticular, continuous). The limestone is of the "Barmstein type s. l.".

The texture of the Oberalm-Formation shows biomicrites (mainly radiolarian-, or radiolarian-tintinnid wackestone). Allochems are irregular, streaky, recrystallized. Microlamination with indications of grain orientation was observed very sporadically as a result of the denser accumulation of biogenes, or – as in thin section 4 - a thin pyritized lamina occurred. Radiolarians, especially spumellarians, are filled mainly by sparry calcite and are sporadically elongated in a spindle manner. Besides sponge spicules, infrequently to rarely there are filaments, fragments of echinoderms, *Globochaete alpina* LOMBARD, shells of ostracods, aptychi, calcareous dinoflagellates [*Schizosphaerella minutissima* (VOGLER), *Cadosina fusca* WANNER], benthic foraminifers (*Spirillina* sp., *Lenticulina* sp.), a spine of echinoid, *Saccocoma* sp. and biodetritus indet. Tintinnids can be found sporadically to rarely. Part of them is more or less deformed and poorly preserved. *Calpionella alpina* LORENZ, occurs among the tintinnids most frequently, but also *Praetintinnopsella andrusovi* BORZA, *Tintinnopsella carpathica* (MURGEANU & FILIPESCU), *Lorenziella remanei* BORZA and cf. *L. remanei* BORZA.

Pyrite emphasizes sometimes microstylolites. Also authigenic and clastic quartz of the sand fraction, micas and rhombohedra of carbonate can be observed. Seldom cherts are present.

The sedimentation of the Oberalm Limestones terminated in all probability in the course of the upper part of the late Tithonian, probably during the Intermedia Subzone in the sense of POP, 1994b, although any crassicollarians have not been found in the Oberalm-Formation. Maybe in this area most likely there were no conditions suitable to their optimum development. This would confirm a new knowledge concerning the mixed association of tintinnids. Redeposition is also supported by their partial deformation. It would follow from above mentioned that the source that had supplied the material to the underlying Oberalm-breccia (first the upper part of the late Tithonian was eroded and then subsequently the lower part of the late or the uppermost part of the middle Tithonian), stopped supplying the material in the late Tithonian, when a gradual continuous sedimentation of overlying complexes of rocks took place.

The relatively monotonous sedimentation of the Oberalm-Formation is interrupted by a bed of limestone of the "Barmstein type", from which the sample for thin section 9 was taken. This sediment can be characterized as radiolarian-sponge microfacies with packed allochems. Indications of grain orientation are obvious. The texture is intrabiopelmicritic/intrabiopelmicrosparitic (intraclast-biogenic-peloid packstone). Intraclasts are micritic. Sometimes it is problematic to decide, whether there are intraclasts, or peloids, or whether it is a result of partial recrystallization. Fossils are represented by dominant, rather unsorted radiolarians of the spumellarian type and sponge spicules of many morphotypes with substantially the same filling. Nassellarians (radiolarians) show - in addition to the micritic and microsparitic fillings - sometimes rims of sparite, also siliceous filling is common or partial pyritisation. Filaments, fragments of aptychi, echinoderms, sporadic benthic foraminifers are also rare. Immature cherts, in principle with the same faunistic content, pyrite and hydromica are also present.

2.1.2.3. Schrambach-Formation

The limestones of the lowermost Schrambach-Formation belong to the calpionellid biomicrites (calpionellid wackestone/packstone). The crassicollarians are represented by *Crassicollaria* sp., *Crassicollaria intermedia* (DURAND DELGA), *Cr. massutiniana* (COLOM), *Cr. brevis* REMANE, *Cr. colomi* DOBEN, *Cr. parvula* REMANE and occur in a higher number only in a short interval and fade away rather quickly (see Text-Fig. 3). Probably the ecological conditions were not suitable for their optimum development. The assemblage of crassicollarians corresponds to the standard late Tithonian Crassicollaria Biozone (Intermedia Subzone, or Colomi Subzone) in the sense by POP (1994b), together with *Calpionella* sp., *C. alpina* LORENZ and *Tintinnopsella carpathica* (MURGEANU & FILIPESCU). Towards the overlying strata, a change in the microfacies to the radiolarian (radiolarian wackestone (Pl. 5, Fig. 3)/packstone), or radiolarian-sponge (radiolarian-sponge biomicrite - wackestone/packstone) - namely from thin section 18A comes about. In the course of sedimentation of limestones with the radiolarian and radiolarian-sponge microfacies were several periods, during which

Plate 6

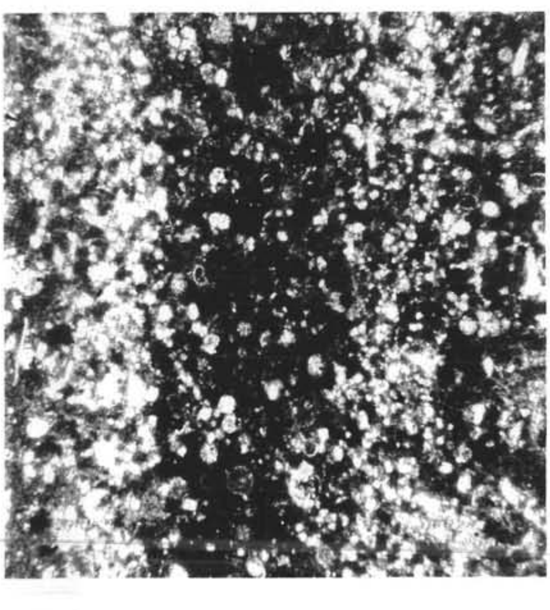
Fig. 1: Laminated limestone. Thin section W 2, Wieser (Woerndl) Quarry, Schrambach-Formation, middle Berriasian.

Fig. 2: Pyritized lamina with well preserved structure of radiolarian test walls. Thin section Leu 21, Gutrathsberg Quarry, Schrambach-Formation, early Berriasian.

Fig. 3: Laminated limestone. In the lower part a silicified lamina. Thin section Leu 63, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.

Fig. 4: Laminated limestone. Thin section Re 16, Rettenbacher Quarry, Oberalm-Formation, late Berriasian.

Fig. 5: Intrabiopelmicrite/intrabiopelmicrosparite (intraclast-radiolarian-sponge-peloid packstone). Indications of orientation. Thin section Re 6, Rettenbacher Quarry, Oberalm-Formation, early Berriasian.



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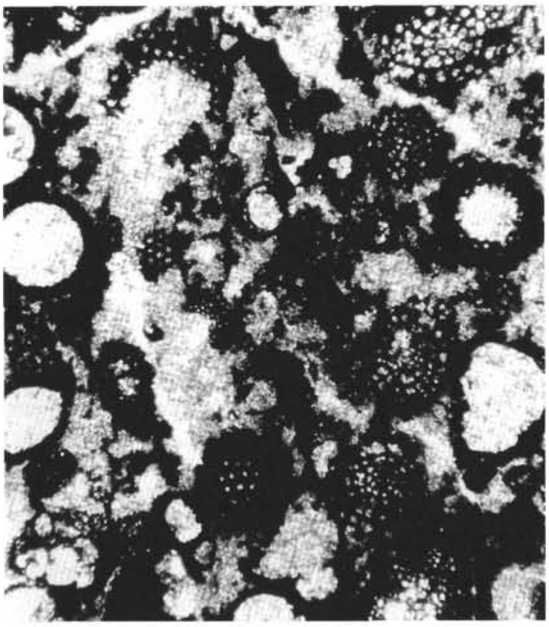

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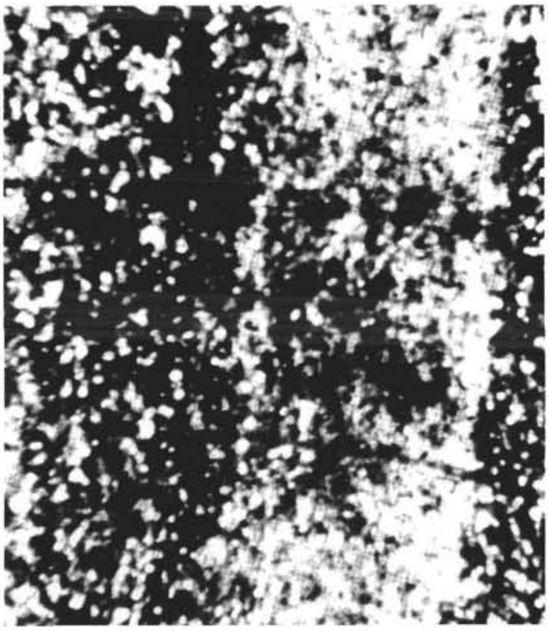

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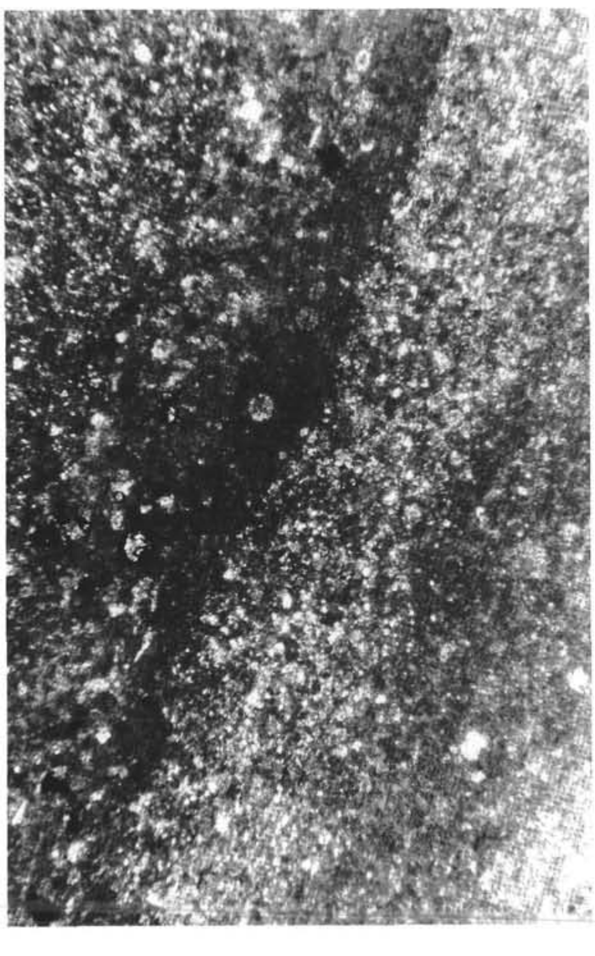

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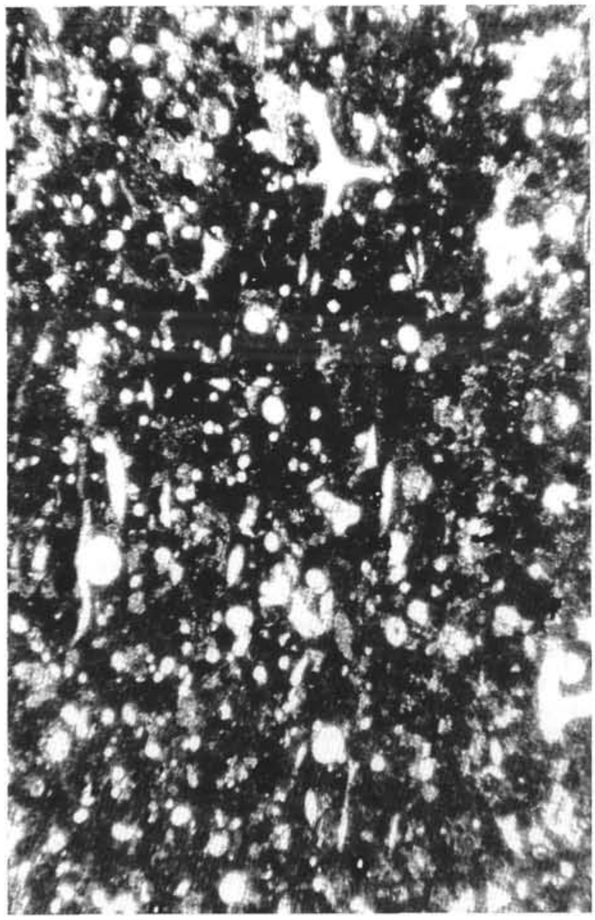

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a marked retreat of radiolarians occurred, but they never again appeared in the previous quantity.

In thin sections 38 and 45, an onset especially of uniaxial sponge spicules was recorded (intrabiopelmicrosparite - intraclast-sponge-radiolarian-peloid packstone; Pl. 5, Fig. 2). Allochems are usually irregularly arranged and show up as "nests" rich in organic remains. In other places the micritic matrix is devoid of fossils, or shows rare biogenes only. Indications of orientation were observed. Radiolarians that previously had occurred in a subordinate number and also sponge spicules of diverse morphological types (rhaxes, uniaxial, biaxial, triaxial, tetraaxial, etc.) became dominant organic remains. Poorly sorted radiolarians are filled with fine sparry calcite, micrite or microsparite. They show combined calcite/siliceous and/or siliceous fillings. Other fossils, which are found in all sediments of the Schrambach- and Lower Roßfeld-Formation, occur more or less rarely. Present are filaments, *Globochaete alpina* LOMBARD, calcareous dinoflagellates *Schizosphaerella minutissima* (VOGLER) (Pl. 7, Fig. 12), *Calpionella carpathica* (BORZA), *Cadosina fusca* WANNER, *Cadosina semiradiata* WANNER, *Colomisphaera conferta* ŘEHÁNEK, fragments of echinoderms, shells of ostracodes, fragments of thick-walled bivalves, aptychi (first they were identified in thin section 18; they occur more frequent in thin section 25), benthic foraminifers (*Gaudryina* sp., *Lenticulina* sp., *Spirillina* sp., *Permodiscus* sp.), a ?fragment of a bryozoan and a section of a belemnite. Tintinnids, which are important for the age assignation, are mostly, with rare exceptions, present only modestly. Their partly poor preservation enables their precise determination not in all cases. With regard to this fact, the **definition of the Jurassic/Cretaceous boundary** on the basis of thin sections is problematical. In thin section 22 (laminated limestone - description is presented below) a form of *Calpionella elliptica* CADISH (Pl. 8, Fig. 7) appears for the first time. According to POP (1994a, b) it indicates the middle Berriasian (index fossil of the highest part of the Elliptica Subzone of the standard Calpionella Biozone). Also *Tintinnopsella longa* (COLOM) is found, which appears in thin section 39 for the first time. In the middle Berriasian the first representatives of remaniellids were recorded too. *Remaniella ferasini* (CATALANO) that should appear already in the higher part of the early Berriasian (POP, 1994a, b) was identified, for the first time, only in the association with *Calpionella elliptica* CADISH. In the studied section, remaniellids are represented further by *Remaniella* sp., *R. filipescui* POP (Pl. 7, Fig. 8), *R. cadischiana* (COLOM). In the middle Berriasian, redeposited crassicollarians appear in places as well.

Richer associations of calpionellids occur in thin sections 48, 49, and 51 (calpionellid wackestone/packstone) – the last from the thin layer of red marlstones. Calpionellids of the standard Calpionellopsis Biozone (the uppermost part of the middle Berriasian - late Berriasian) begin with a form of *Calpionellopsis simplex* (COLOM) in thin section 48 and *C. oblonga* (CADISH) (Pl. 7, Fig. 9) in thin section 54. Younger calpionellid elements have not been found. [The last sporadic calpionellids occur in thin section 65 of the Lower Roßfeld-Formation. Their precise identification is not possible owing to unsuitable preservation (?*Calpionellopsis* sp.)]. In the higher horizons of the Schrambach-Formation (from thin section 49), the radiolarian, or radiolarian-sponge microfacies fades away. In thin section 54 uniaxial sponge spicules occur most commonly.

In the Schrambach- similar as in the overlying Lower Roßfeld-Formation also intercalations of laminated limestones occur [thin sections 19, 21, 22, 36, 52, 53, 56, 59, 63 (Pl. 6, Fig. 3), 66 - for their age see Text-Fig. 3]. Lamination is largely a result of concentrated allochem accumulations, dominantly of biogenes, which are unsorted and whose size is also variable in particular laminae sometimes. Also silicification (Pl. 6, Fig. 3) of individual laminae can be observed. Laminae of radiolarian biomicrite (radiolarian wackestone) are also present. As for them, radiolarians of the spumellarian type, filled mainly with crystallized calcite, or microsparite, micrite or combined, or siliceous filling, play an important role. Sponge spicules are also more or less common. Infrequent to rare are filaments, shells of ostracodes, *Schizosphaerella minutissima* (VOGLER), ?aptychi, calpionellids represented by *Crassicollaria* sp., *Cr. massutiniana* (COLOM), cf. *Cr. colomi* DOBEN in thin section 21, *Tintinnopsella carpathica* (MURGEANU & FILIPESCU), *Remaniella ferasini* (CATALANO) in thin section 22, or a small form of *Calpionella alpina* LORENZ in thin section 36 and recrystallized detritus that is sometimes cumulated into "nests".

Rhombohedra of carbonates and quartz of the sandy fraction occur sporadic. Other laminae, in which biogenes are densely-packed, are characterized by textures of radiolarian biomicrite (radiolarian packstone), radiolarian-sponge biomicrite (radiolarian-sponge packstone), intrabiopelmicrosparite/intrabiopelsparite (intraclast-radiolarian-peloid packstone/grainstone; thin section 22), intrabiopelmicrite/intrabiopelmicrosparite (intraclast-radiolarian-sponge-peloid packstone in thin sections 53, 56, 59). In thin section 36, laminae thinning away and "nests" of intrabiopelsparite/intrabiopelmicrosparite (intraclast-biogene-peloid grainstone) are present together with more frequently occurring quartz and pelintransparite/pelintramicrosparite (peloid-intraclast grainstone) with partially silicified matrix, where radiolarians have not, in contrast with the other laminae, any dominant position. Especially laminae, in which organic remains, or partially the matrix, are pyritized, are conspicuous. In addition, in laminae

Plate 7

Fig. 1: Biomicrite (crassicollarian-calpionellid-radiolarian-sponge wackestone/packstone). Thin section Re 22, Rettenbacher Quarry, late Tithonian Oberalm-Formation.

Fig. 2: Cross section of aptychus. Thin section Re 8C, Rettenbacher Quarry, middle Berriasian Barmstein-type Limestone.

Fig. 3: *Chitinoidella boneti* DOBEN.
Thin section O-P 3, Toni Rieger Quarry at Puch, Oberalm-Formation, higher part of the middle Tithonian.

Fig. 4: *Tintinnopsella carpathica* (MURGEANU & FILIPESCU). Thin section W 1, Wieser (Woerndl) Quarry, Schrambach-Formation, middle Berriasian.

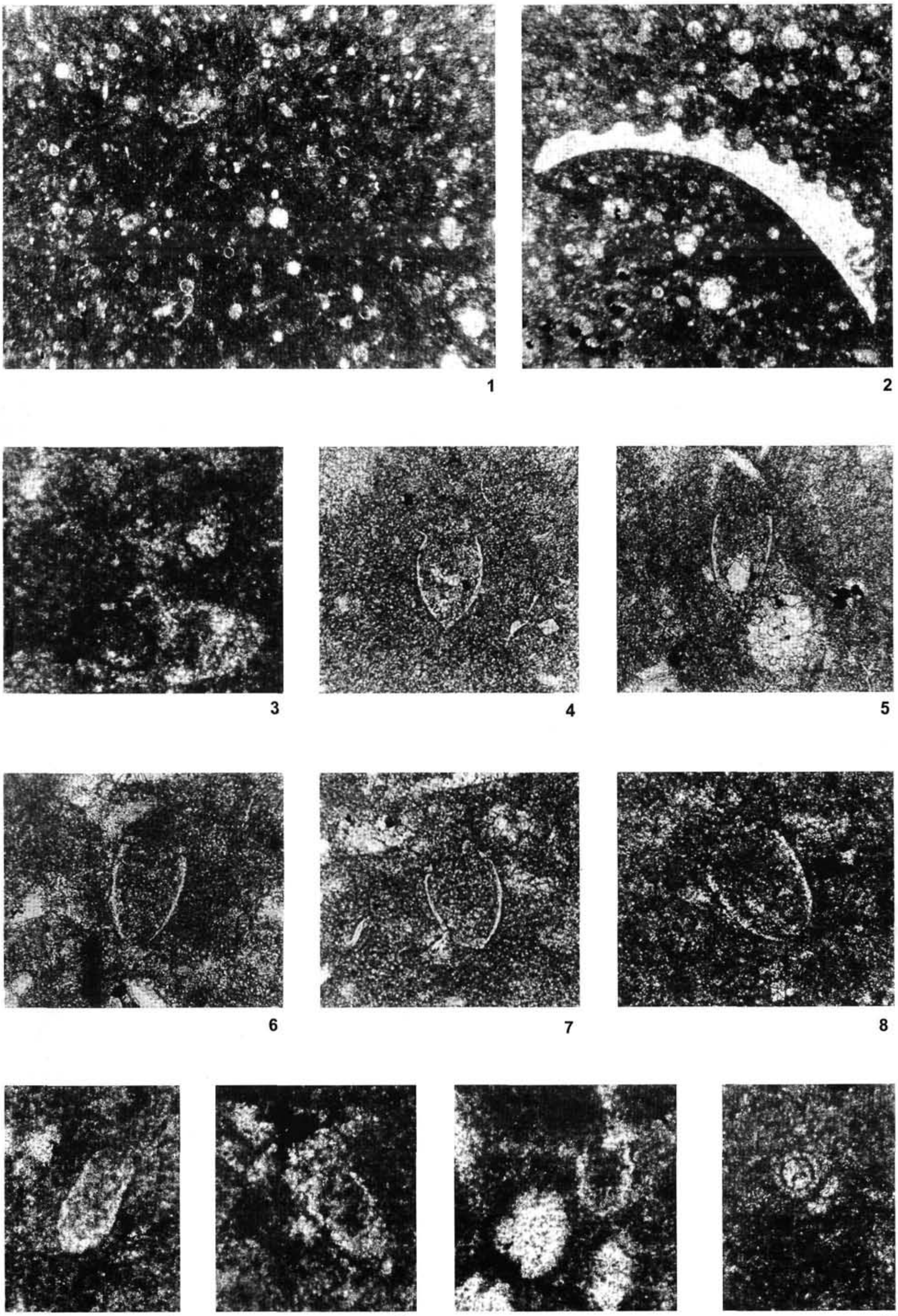
Figs. 5, 6: *Remaniella cadischiana* (COLOM). Thin section W 2, Wieser (Woerndl) Quarry, Oberalm-Formation, middle Berriasian.

Figs. 7, 8: *Remaniella filipescui* POP. Fig. 7 – thin section W 2, Wieser (Woerndl) Quarry, Oberalm-Formation, middle Berriasian. Fig. 8 – thin section Leu 50, Gutrathsberg Quarry, Oberalm-Formation, late Berriasian.

Fig. 9: *Calpionellopsis oblonga* (CADISCH). Thin section 54, Gutrathsberg Quarry, Schrambach-Formation, late Berriasian.

Figs. 10, 11 – thin section Leu 1, Gutrathsberg Quarry, clast, basal breccia - lower part, late Tithonian. Fig. 10: *Crassicollaria intermedia* (DURAND DELGA). Fig. 11: *Crassicollaria massutiniana* (COLOM).

Fig. 12: *Schizosphaerella minutissima* (VOGLER). Thin section Leu 44, Gutrathsberg Quarry, Lower Roßfeld-Formation, Early Valanginian.



with packed fossils, radiolarians mostly dominate that have a well preserved texture of the test walls in the pyritized layers (Pl. 6, Fig. 2). Besides the pyrite fillings, they are filled with micrite, microsparite and sparry calcite, sometimes with rims of pyrite. Mainly in the upper layers, a siliceous filling is typical; they rarely show geopetal fabrics. Spicules, in addition to radiolarians, are the most common fossils in some samples. This is valid mainly in the upper horizons. Filaments, fragments of echinoderms, benthic foraminifers (*Spirillina* sp.), calcareous dinoflagellates [*Colomisphaera* cf. *carpathica* (BORZA), *Cadosina fusca* WANNER], *Globochaete alpina* LOMBARD, recrystallized detritus and tintinnids (see Text-Fig. 3) are rare, however. *Calpionella alpina* LORENZ (thin sections 21, 52, 56), *C. elliptica* CADISH (thin sections 22, 52), *Crassicollaria parvula* REMANE (thin section 22), *Tintinnopsella carpathica* (MURGEANU & FILIPESCU; thin sections 52, 56), *T.* cf. *longa* (COLOM) (thin section 52), cf. *Calpionellopsis simplex* (COLOM) (thin section 56), *C.* cf. *oblonga* (CADISCH) (thin section 59) were identified. In some of the specimens, calpionellids do not occur at all. Corroded quartz, micas, hydromicas and rare glauconite are present. Smaller intraclasts are of micritic texture. In several samples, indications of grain orientation and graded bedding are observable.

It is thin section 39 (allodapic limestone) that does not fit into the framework of the basic characteristic of a rock of middle Berriasian age, in which laminae with more or less packed allochems occur. Biogenes are orientated (subparallel structure due to the orientation of fossils), which can be seen best in the commonly occurring aptychi, or sporadic filaments. Laminae with intrabiomicritic texture (intraclast-calpionellid-aptychi-echinoderm packstone/wackestone) are present. Already in the framework of microlaminae, clusters prevailingly of biogenes can be found. The intraclasts show micritic, biomicritic, or biomicrosparitic texture (calpionellid-radiolarian wackestone) with radiolarians of the spumellarian type, that are mostly filled by sparry calcite and also tintinnids represented by *Calpionella alpina* LORENZ and *Crassicollaria* sp. In one clast, cf. *Remaniella cadischiana* (COLOM) and *Crassicollaria parvula* REMANE were found. Fossils are represented above all by aptychi (Pl. 5, Fig. 4), fragments of echinoderms, sometimes with the preserved net scructure, rather sporadically sections of ramuli and secundibrachials of *Saccocoma* sp. (Pl. 5, Fig. 7), filaments, radiolarians of the group of spumellarians, fragments of thick-walled bivalves, benthic foraminifers (*Lenticulina* sp.), *Globochaete alpina* LOMBARD, calcareous dinoflagellates (*Colomisphaera conferta* ŘEHÁNEK), rarely spines of echinoids and recrystallized biodetritus. Tintinnids are deformed sometimes, or partially amputated. Representatives of a small and a larger form of *Calpionella alpina* LORENZ, *C. elliptica* CADISH, *Crassicollaria parvula* REMANE, *Tintinnopsella carpathica* (MURGEANU & FILIPESCU) and one specimen of a partially deformed *Remaniella cadischiana* (COLOM) were identified. Another type of lamina, in which allochems are more markedly packed, can be characterized by a dominance of unsorted radiolarians of the spumellarian type. The rather irregular, finer lamination originates as a result of alternation of layers of radiolarians with calcitic, or siliceous fillings. Intrabiomicrite (intraclast-radiolarian-aptychi-calpionellid packstone; Plate 5, Fig. 6) with intraclasts of micritic, or biomicritic texture (calpionellid-radiolarian wackestone) can be observed in the rudite fraction. With the exception of different frequency of biogenes, the other faunistic content remains, in principle, unchanged.

2.1.2.4. Lower Roßfeld-Formation

Monotonous marly deposits of the Schrambach-Formation (in the uppermost part with red layers) are followed by a set of different deposits. They are favourably exposed at the highest quarry level. Their contact with the underlying Schrambach-Formation is, however, complicated with a face of fault in the critical part of the section. These deposits – assigned to the Lower Roßfeld-Formation – are characterized by an increased content of sand, layers of cherts, sandy and detrital limestone, etc.

In the thin sections, recrystallized, most probably biodetritus is more common and quartz of the silty and sandy fractions occurs in greater amount. "Nests" with clusters of radiolarians (thin sections 57 and 64) are present only locally. Thin sections 61 and 62 show only poorly preserved organic remains. The matrix is partially silicified. More or less significant accumulations of recrystallized biodetritus are formed also by sponge spicules, calcareous dinoflagellates (*Cadosina fusca* WANNER) and clastic quartz of the arenaceous fraction shows undulatory extinction.

Thin section 67 of the Lower Roßfeld-Formation represents arenaceous limestone of the intrabiopelmicrosparite/intrabiopelsparite texture (packstone/grainstone; Pl. 5, Fig. 5). Rather sharply angular quartz of the sandy fraction with undulatory extinction (5-7%) occurs. Clasts are micritic (mudstone). Organic remains are represented by radiolarians (spumellarians) showing siliceous or calcitic filling, fragments of echinoderms, ?thick-walled bivalves, benthic foraminifers, or parts of their shells (*Lenticulina* sp.), axisless sponge spicules, a fragment of a partially silicified aptychus, a bryozoan and calcareous dinoflagellates. One specimen occurred resembling *Calpionella* sp. in a clast. The rock is silicified in places. Pyrite, lamellae of muscovite, glauconite, authigenic quartz, heavy minerals - most probably zircon - and fragments of crystalline schists occur.

▶

Plate 8

Fig. 1: Deformed calpionellids. Right at the top *Crassicollaria intermedia* (DURAND DELGA). Thin section Sch 1, Mathias Wallinger Quarry, Oberalm-Formation, uppermost Tithonian.

Fig. 2: Deformed calpionellids. On the right nearly in the middle *Calpionella alpina* LORENZ. Thin section Sch 2, Mathias Wallinger Quarry, Oberalm-Formation, uppermost Tithonian.

Figs. 3–6: *Calpionella alpina* LORENZ. Fig. 3 – thin section W 1; Fig. 4 – thin section W 2, Wieser (Woerndl) Quarry, Oberalm-Formation, middle Berriasian; Fig. 5 – thin section Re 21, Rettenbacher Quarry, Oberalm-Formation, late Tithonian; Fig. 6 – thin section Leu 2, Gutrathsberg Quarry, upper part of the basal breccia, late Tithonian.

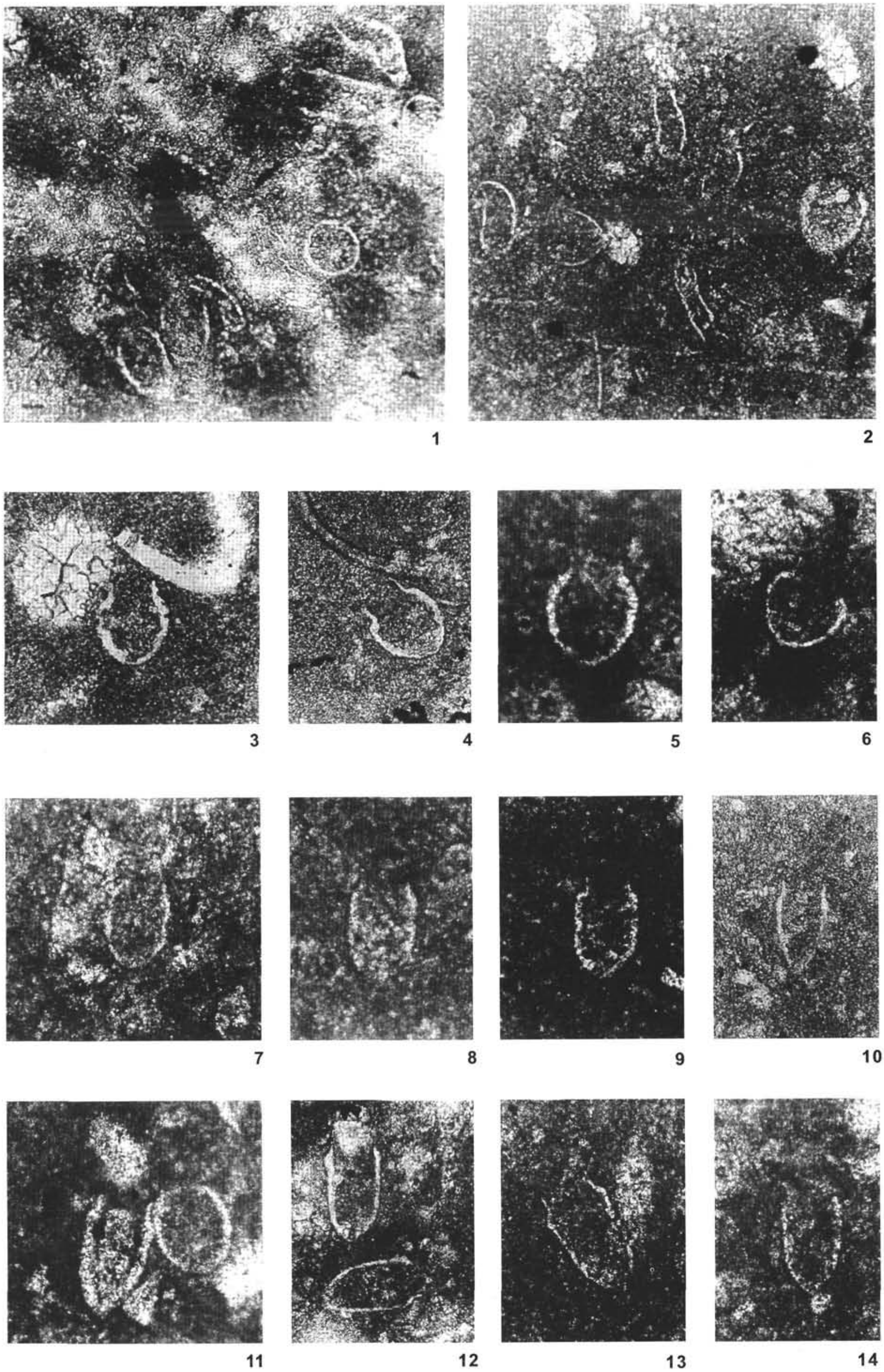
Fig. 7–9: *Calpionella elliptica* CADISCH. Fig. 7 – thin section Leu 48, Gutrathsberg Quarry, Schrambach-Formation, middle Berriasian, Fig. 8 – thin section Re 18A, Fig. 9 – thin section Re 20, Rettenbacher Quarry, Oberalm-Formation, late Berriasian.

Fig. 10: *Crassicollaria colomi* DOBEN. Thin section Sch 2, Mathias Wallinger Quarry, Oberalm-Formation, uppermost Tithonian.

Fig. 11: *Crassicollaria parvula* REMANE. Thin section Re 21, Rettenbacher Quarry, Oberalm-Formation, late Tithonian.

Figs. 12, 13: *Crassicollaria massutiniana* (COLOM). Fig. 12 – thin section Sch 1, Mathias Wallinger Quarry, Oberalm-Formation, uppermost Tithonian; Fig. 13 – thin section Re 22, Rettenbacher Quarry, Oberalm-Formation, late Tithonian.

Fig. 14: *Crassicollaria intermedia* (DURAND DELGA). Thin section Re 21, Rettenbacher Quarry, Oberalm-Formation, late Tithonian.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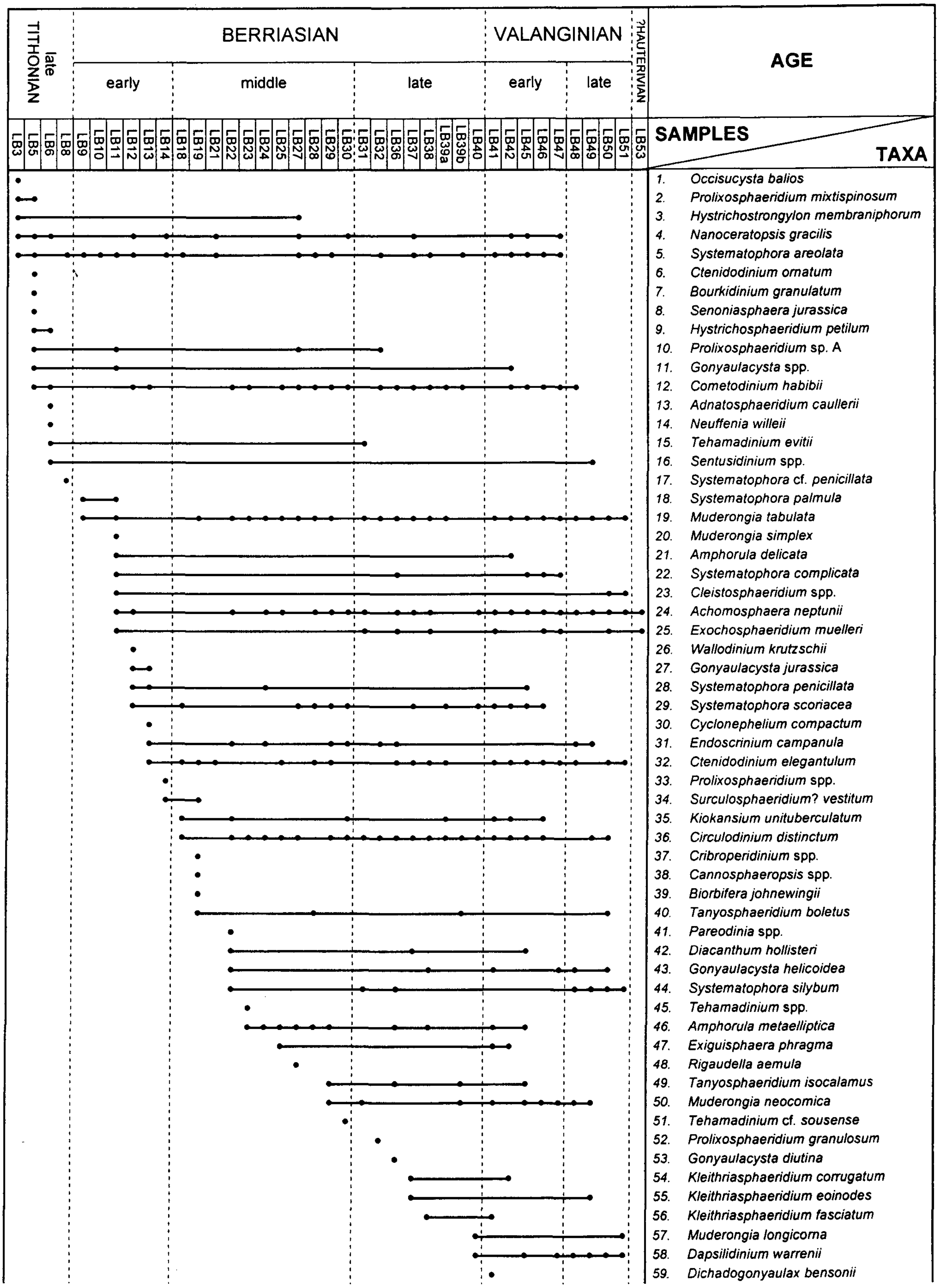
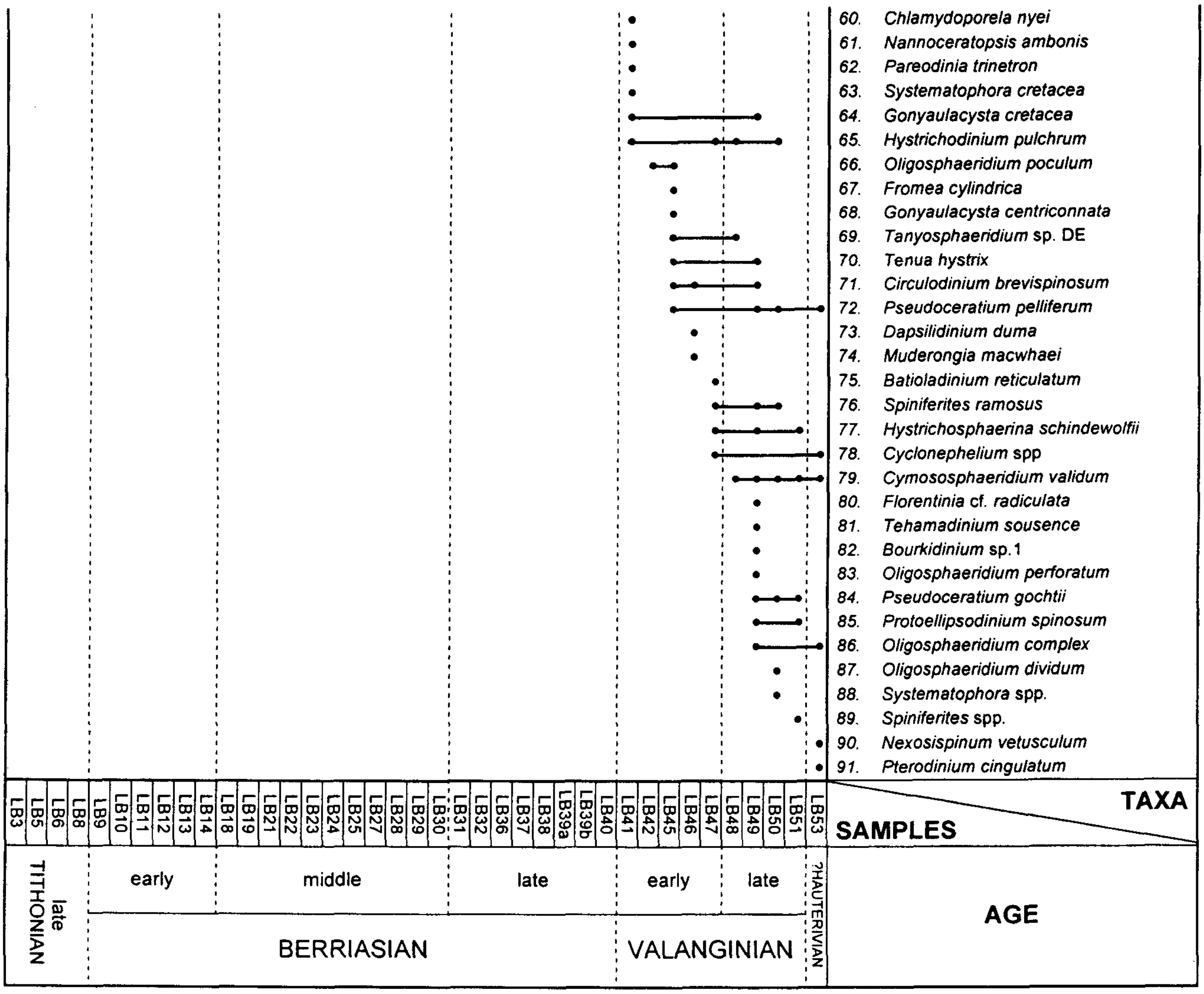
Tab. 2.
Qualitative distribution-chart of dinoflagellate cyst taxa of the Gutrathsberg Quarry arranged in order of first occurrences.





2.1.3. Dinoflagellate Cysts

35 samples (of 48 taken from the Oberalm-, Schrambach- and Lower Roßfeld-Formation) yield noncalcareous dinoflagellate cysts. Their assemblages are relative poor, but well preserved. The palynological assemblages are mainly composed of dinocysts, only in few samples were found few representatives of sporomorphs and foraminifera linings. In addition, dark amorphous particles, plant debris (light and dark brown in colour) occur in the samples. Results of qualitative analysis of dinoflagellate cysts are presented in Tab. 2.

Samples from the Oberalm-Formation (LB3, LB5 and LB6) contain dinocysts, such as *Ctenidodinium ornatum, Occisucysta balois, Prolixosphaeridium mixtispinosum, Senoniasphaera jurassica, Systematophora areolata, Tehamadinium evittii* etc., which are typical of Tithonian to lower Berriasian age (Habib & Drugg, 1983; Monteil, 1992; Stover et al., 1996).

The lowermost part of the Schrambach-Formation (samples LB7 and 8) are palynologically very poor. Only sample LB8 contains few species without stratigraphic importance. As far as the recovered dinocyst species are concerned, the early Berriasian age is proposed for the interval from sample LB9 to sample LB14. Stratigraphically the most important species *Muderongia tabulata* occurs firstly in sample LB9 and *Achomosphaera neptunii* in sample LB11. The first appearance of these species has been reported from the early Berriasian (Jacobi Zone) of southeastern France (Monteil, 1992). Simultaneously this interval includes *Amphorula delicata, Circulodinium distinctum, Ctenidodinium elegantulum, Endoscrinium campanula, Systematophora areolata, S. complicata, S. scoriacea, Wallodinium krutzschii,* etc., so species well known from the Berriasian.

Sample interval LB15-17 is palynologically barren. The next sample (LB18) is without stratigraphically significant dinocysts species. The stratigraphically important species *Biorbifera johnewingii* occurs in sample LB19. Jardine et al. (1984) found out the first occurrence of *B. johnewingii* at the base of the Occitanica Zone of the middle Berriasian. Habib & Drugg (1983) considered the first occurrence of this species in the Privasensis Subzone. *Diacanthum hollisteri,* which occurs in sample LB22, appears in the middle Berriasian (Subalpina Subzone; Leereveld, 1995; Monteil, 1992). Therefore, sample LB19 can be considered as the base of the middle Berriasian. With reference to the occurrence of stratigraphically significant calpionellids in the overlaying strata of the place of taking sample LB14, samples LB 15 - 18 are also assigned to the middle Berriasian.

The next samples (LB23 - LB37) contain merely dinocysts without stratigraphic importance.

The interval from sample LB38 to sample LB40 is of late Berriasian age. The presence of *Kleithriasphaeridium fasciatum* is significant. The first occurrence of this species is indicative of the uppermost Berriasian Otopeta Zone (Leereveld, 1995). Monteil (1992) considered the occurrence of this species only in this zone of southern France. Samples LB 39-40 belong already to the Lower Roßfeld Formation.

From sample LB41 come new species, e. g. *Gonyaulacysta cretacea, Hystrichodinium pulchrum, Oligosphaeridium poculum, Systematophora cretacea,* and simultaneously *Kleithriasphaeridium fasciatum* occurs for the last time. According to data in the literature (LEEREVELD, 1995), sample LB41 can be assigned to the early Valanginian; the conventional boundary between the Berriasian and the Valanginian being put here. Sample LB48 we can assign to the lower part of the late Valanginian based on the first occurrence of *Cymososphaeridium validum,* which LEEREVELD (1995) considered in the Verrucosum Zone.

The reworking of older species to the Lower Cretaceous sediments is documented by the presence of Jurassic representatives of dinoflagellates (such as *Nannoceratopsis ambonis, N. gracilis, Rigaudella aemula, Systematophora penicillata*) in the Berriasian-Valanginian samples. The reworking of Lower Cretaceous species is determined in virtue of the comparison of their occurrences in the section of Gutrathsberg Quarry with occurrences in southeastern Spain and southeastern France. In this case, the species *Amphorula metaelliptica* in samples LB38, LB41, LB45, *A. delicata* in sample LB42 and *Systematophora areolata* in sample LB47 can be taken as reworked. The species *A. metaelliptica* and *A. delicata* as typical representatives of the Berriasian appear here also in the Valanginian. The species *S. areolata* with the latest described occurrence in the lower part of the early Valanginian appears in the Gutrathsberg Quarry in the uppermost part of the early Valanginian as well.

Deposits of the Upper Roßfeld-Formation differ, among other things (see the introduction part), from the underlying rocks especially by the grey to dark grey colouring of the deposits.

From the Upper Roßfeld-Formation 5 samples were taken for dinoflagellate cyst content. Samples LB 49 – LB51, which were taken from the sandy dark grey claystones of the "wildflysch" are of late Valanginian age. Especially sample LB50 contains a rich assemblage with taxa such as *Cymososphaeridium validum, Bourkidinium* sp. 1 sensu LEEREVELD (1995), *Hystrichosphaerina schindewolfii, Oligosphaeridium complex, O. perforatum, Protoellipsodinium spinosum, Pseudoceratium gochtii,* of which *C. validum* and *H. schindewolfii* predominate. In addition to the dinocysts, the sample yields plant debris.

Samples LB52, LB53 were taken from dark fine-grained sandstones of the Upper Roßfeld-Formation at 30 and 60 m in the overlying strata of "wildflysch". Both the samples are very rich in plant debris. In contrast to the previous specimens, they contain more microforaminifers and sporomorphs; sample LB53 containing several dinocysts without stratigraphic importance. Only on the evidence of the presence of the species *Nexosispinum vetusculum* that appears in the early Hauterivian in south-east Spain for the first time (LEEREVELD, 1995), it is possible to suppose the Hauterivian age of this sandstone part of the Upper Roßfeld-Formation.

2.1.4. Macrofaunistic Evaluation

Macrofauna, as already stated, is represented especially by aptychi. In the whole section about 80 valves have been found in all, of which, however, only more than a half can be determined. Although several tens of aptychi were found in the Oberalm-Formation as well as in the lower part of the Schrambach-Formation, it is necessary to state that, as far as species are concerned, it is a case of associations poor in aptychi. Those associations are represented merely by a few species.

The Oberalm-Formation is characterized especially by the presence of small to juvenile valves of *Lamellaptychus* cf. *sparsilamellosus* (GUEMBEL) - Pl. 13, Figs. 9-11, *L. beyrichi* (OPPEL) together with larger valves of *Punctaptychus punctatus punctatus* (VOLTZ). *P. cinctus* TRAUTH and *L.* cf. *aplanatus* (GILLIÉRON) occur sporadically. Discussion on difficulties in the determination of some of them is more specified in the systematic part of this contribution. The given association corresponds, from the stratigraphic point of view, to a considerably poor late Jurassic aptychi association with the dominance of *L.* cf. *sparsilamellosus.* The other determined representatives usually occur in both the Tithonian and the early Berriasian deposits. It is only *P. p. punctatus* and *P. cinctus* that reach as far as the middle/late Berriasian boundary.

The aptychi association of the lowermost part of the Schrambach-Formation is similar to the previous one. *Punctaptychus monsalvensis* TRAUTH (Pl. 14, Fig. 3) and *L. submortilleti* TRAUTH appear as new elements but are represented always by a single valve.

The upper part of the Schrambach- and the Lower Roßfeld-Formation-Formation are, in the prevailing part, very poor in macrofauna. In the vicinity of red-coloured deposits (Anzenbach-Member), a single determinable valve of *Punctaptychus cinctus* (Pl. 14, Fig. 5) was found. According to the maximum stratigraphic range of the given species, we can consider the age as of the middle/late Berriasian.

In the uppermost part of the Schrambach- respectively Lower Roßfeld-Formation, two horizons with the occurrence of aptychi have been hit. The lower one contains merely several valves of *Lamellaptychus mortilleti mortilleti* (PICTET & LORIOL) - Pl. 14, Fig. 10. The upper horizon, belongs already to the Lower Roßfeld-Formation, includes *L.* ex gr. *mortilleti, L. mendrisiensis mendrisiensis* RENZ & HABICHT (Pl. 14, Figs. 11, 12), *L. m. undulocostatus* n. ssp. (Pl. 14, Fig. 13), *L. trauthi* RENZ & HABICHT (Pl. 14, Fig. 9) and *L. symphysocostatus* TRAUTH (Pl. 14, Fig. 14). Whereas *L. m. mortilleti* (in the first horizon) has a considerable stratigraphic range from the late Berriasian to the late Valanginian, *L. mendrisiensis* and *L. symphysocostatus* yet less known from the highest aptychi horizon are stated in the literature as coming only from the Valanginian. Of them, *L. mendrisiensis* probably occurs merely in the late Valanginian (RENZ & HABICHT, 1985). On the basis of the latter mentioned association, we assign the uppermost section of the Lower Roßfeld-Formation to the lower part of the late Valanginian.

2.1.5. Stratigraphic Conclusions

The oldest deposits studied by us in the Gutrathsberg section pertain to the upper part of the Oberalm-Formation. The section begins with the basal breccia. The breccia having only a thickness of 70 cm is interesting owing to the occurrence of crassicollarians of the late Tithonian in the clasts in the lower part. In the higher part of the breccia, the calpionellid association of the higher middle Tithonian is present. It documents, that the source area must have been denuded down to a rather deep level. The overlying non-clastic light grey limestones do not contain any favourably preserved calpionellids. A monotonous character of calcareous deposits is disturbed by a 30 cm thick layer of macroscopically different limestone that resembles limestones of the allodapic "Barmstein type". Above this layer, limestones of the previous type are there in the section. Their thickness cannot be precisely determined because the face is affected by two partial dislocations. The first has probably a fault character, the other is only of the shift character. However, we do not suppose any more significant movements along them. The uppermost part of the Oberalm-Formation is not accessible to direct observing, because it is hidden in the overgrown base of the uppermost level.

In the inaccessible part, deposits of transition to the next member of strata belonging to the Schrambach-Formation seem to be situated. Its lower monotonous part consists primarily of greenish grey deposits that are shaly marly-calcareous in places. Moreover, the oldest exposed deposits contain crassicollarians documenting the late Tithonian age. The underlying deposits, including the basal breccia indicate then the late Tithonian age corresponding to the lower part of the Crassicollaria Zone (Intermedia Subzone).

The Jurassic/Cretaceous boundary is not defined unambiguously in the Oberalm-, respectively Schrambach-Formation. Basal Cretaceous deposits corresponding to the lowermost subzones of the Calpionella Zone are not very thick. They do not contain any stratigraphically significant fossils. Only the Elliptica Subzone is then well documented (Calpionella Zone) that evidenced the middle Berriasian. Deposits of this subzone are unexpectedly thick (Text-Fig. 3). It can be supposed that their lower part is repeated tectonically. This tectonic repetition can be expected because of the presence of a crushed zone about 120 cm wide, that outcrops on the level of about 30 m in the lower quarry level. In the section stated by REHÁKOVÁ et al. (1996), deposits of the Elliptica Subzone reach, on the contrary, merely a negligible thickness. We suppose that the sequence is tectonically considerably reduced here.

In the uppermost part of deposits of the Elliptica Subzone with the subsequent Longa Subzone, the lithology changes. Layers of limestone are more slabby and the first two variegated (pink and red) thin layers of marlstones ("Anzenbach-Member") appear here. The section of the lower level ends with a dislocation plane (at 44.35 m). In its underlying bed a lithologically different 1 m thick layer of allodapic organodetritic limestone has been found. From the standpoint of macrofaunistic content, the whole previous sequence of strata of the Schrambach Formation can be designated as aptychus limestones.

The continuation of the next sequence of strata in the transition to the Lower Roßfeld-Formation is exposed favourably on the upper level of the quarry. What is conspicuous here is an approximately 70 cm thick layer of red marlstones (that are, after all, clear also on the lower level). This layer is tectonically repeated by an overthrust fault inclining conformably with the direction of the dip of strata, as directly seen in the face. In this way the mechanism similar to that of another overthrust dislocation twinning the underlying deposits on the lower level (in the middle Berriasian) is directly evidenced here.

In the underlying bed of the red layer, deposits of the uppermost part of the Elliptica Subzone outcrop (1 m layer of organodetritic limestone from the lower level, however, has not been found), as confirmed by thin sections 40A, 41-47 (that are not, for the reason of repetition, included into the drawing part of the section in Text-Fig. 3). Above the Calpionella Zone, there is the Calpionellopsis Zone evidenced by the first occurrence of *Calpionellopsis simplex* (late Berriasian) in the underlying red marker bed. In the overlying deposits, in which fine sandy components gradually increase in number, the Oblonga Subzone follows the Simplex Subzone. The last calpionellids fade away at 42 m in the section on the upper level. In the immediate overlying rocks, the Berriasian/Valanginian boundary is supposed only on the basis of dinocysts. According to the dinocysts, deposits of the early Valanginian (Lower Roßfeld-Formation) continue above it. Almost up to the highest part of the early Valanginian, the whole studied section of the upper level can be designated, from the macrofaunistic standpoint, as sterile.

Only in marly deposits situated under the way out (traffic road for quarry cars) from the lower level to the uppermost level, some stratigraphically little significant lamellaptychi were found. Other findings of aptychi then come from the deposits of the Lower Roßfeld-Formation. According to their species composition, they correspond to the lower part of the late Valanginian. In accordance with the association of dinocysts it can be judged that about 2 m of the uppermost sequence of strata of the Lower Roßfeld-Formation can be assigned to the late Valanginian. Then deposits of the Upper Roßfeld-Formation follow that can be designated as "wild-flysch".

In the whole examined section we have found repeated and substantial redepositions of both microfauna and non-calcareous dinocysts.

2.2. Rettenbacher Quarry at St. Koloman

2.2.1. Geological Setting

An active quarry (Plate 3, Fig. 3) founded in subhorizontally deposited strata (175/5°). The main quarry face is about 12 m high. Under the base of the main quarry level, a partial deeper level of a substantially lesser extent is situated that exposes the underlying sequence of strata with a thickness of 3.6 m. Under its base, a small depression quarried out is located that is flooded, in a greater part, with underground water.

In the sequence of strata (Text-Fig. 4), thin and mainly thick slab-like-bedded limestones of the Oberalm-Formation of several shades of grey prevail. In places, grey-brown, or grey-black cherts are there that are usually parallel to the bedding and occur in several coarse more or less 1-2 cm thick regular layers. Often in the framework of the single layers, a change in colour from dark grey to light grey, or light brown-grey comes about. What is a characteristic feature of the limestones is their spotting, which in the upper parts of the section fades out. In some layers, lamination can be seen mostly at the base. In other layers, a markedly increased content of detritic fraction is there (usually also in the lower parts of slabs). Only seldom the limestones are shaly breaking in the upper parts of the section. In the uppermost horizons, rust-brown covers were observed. The limestones are interbedded with dark grey, in the higher horizons grey-green spotted shales, the thickness of which ranges from several mm to 3 cm, sporadically 6 cm as a maximum. In the higher part of the sequence of strata, conspicuous thick-bedded layers (max. 175 cm) of beige (or pink-brown) Barmstein-Limestones occur as a new element. Grey-brown, or black cherts in the forms of nodules, lenses and bands that reach the thickness of 6-7 cm as a maximum and are parallel to the bedding are placed in them.

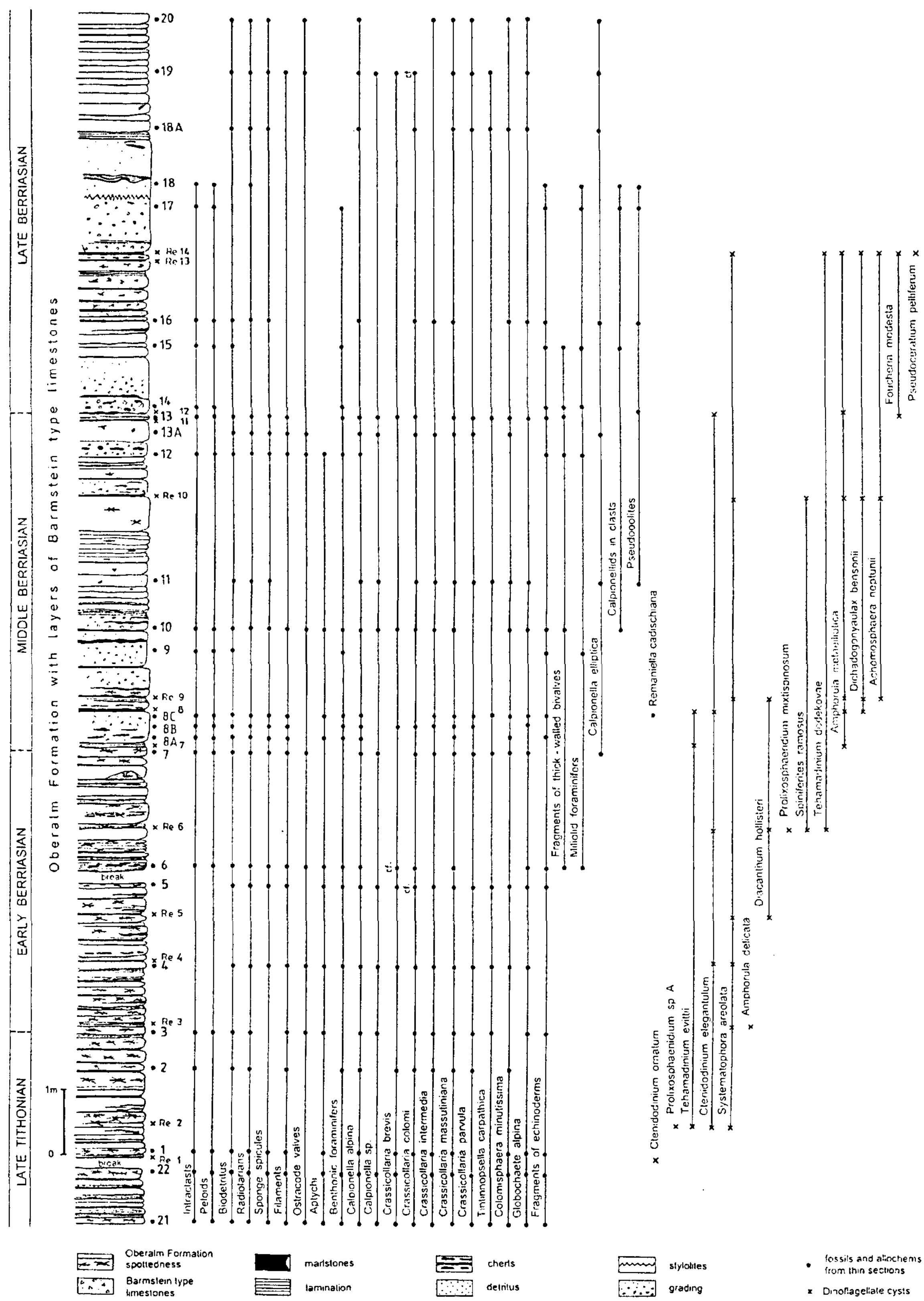
In the documented section having the thickness of 17 m in all (with two insignificant interruptions on the base corresponding to the thickness of about 0.5 m) altogether 22 samples were taken for thin sections and 14 samples (designated as Re) for dinoflagellate content. With regard to unfavourably uncovered bedding planes in the quarry, macrofaunas could be collected only from the debris.

In the debris, more than 70 macrofaunal remnants (designated Rt or Re) were collected altogether. Aptychi dominate but

LITHOLOGICAL AND MICROBIOSTRATIGRAPHICAL

SECTION OF RETTENBACHER QUARRY

1998



Text–Fig. 4:
Stratigraphy and lithology of the Rettenbacher Quarry.

at a considerable share of juvenile valves. Further, 8 ammonite moulds (partly juvenile and smooth ones belonging to the range of the genus *Haploceras* ZITTEL), 3 guards of belemnites, 3 rhyncholites and one minor theca of a crinoid were found.

2.2.2. Microfacies and Micropalaeontological Evaluation

2.2.2.1. Oberalm-Formation

The beginning of the section (Text-Fig. 4) is represented by sediments belonging, from the standpoint of microtexture, to the biomicrite (crassicollarian-calpionellid-radiolarian-sponge wackestone/packstone; Pl. 7, Fig. 1). Allochems are usually recrystallized, distributed irregularly, sometimes concentrated into laminae (laminated limestone; Pl. 6, Fig. 4), of which several are partially silicified, or they form "nests" with a more recrystallized matrix. In the "nests" there are micrite intraclasts and peloids. However, it cannot be unambiguously eliminated that their presence is of secondary origin - caused by recrystallization. In places, indications, or uniform orientation of particular components of rocks are observable.

Organic remains are represented by rather unsorted radiolarians, dominantly of the spumellarian type (only sporadically nassellarians) with a various type of filling (siliceous, sparry calcite, microsparite, or micrite with the rim of sparite, or they have combined fillings), spicules of sponges of more morphotypes with a siliceous or calcite filling, filaments, valves of ostracodes, benthic foraminifers (*Spirillina* sp., *Lenticulina* sp.), *Globochaete alpina* LOMBARD, aptychi (Pl. 7, Fig. 2), rare fragments of echinoderms, calcareous dinoflagellates - *Schizosphaerella minutissima* (VOGLER). The stratigraphic assignation is possible thanks to common to numerous calpionellids deformed seldom. There are representatives of a large form of *Calpionella alpina* LORENZ (Pl. 8, Fig. 5), *Crassicollaria intermedia* (DURAND DELGA) (Pl. 8, Fig. 14) and *Cr. massutiniana* (COLOM) (Pl. 8, Fig. 13), scarcely *Cr. brevis* REMANE, *Cr. colomi* DOBEN, *Cr. parvula* REMANE (Pl. 8, Fig. 11), *Tintinnopsella carpathica* (MURGEANU & FILIPESCU) and *Calpionella* sp. that occur most often. The association of calpionellids corresponds with the late Tithonian standard Crassicollaria Biozone and the Colomi Subzone (POP, 1994b). A mineral impurity is represented by pyrite. Neomorphic rhombohedra of carbonates also appear.

A change in the character of sediment comes about in thin section 3. Intervals exist, in which identifiable biogenes occur only very rarely. It is, substantially, the case of fine recrystallized detritus with rhombohedra of carbonate. Irregular laminae are present, or intervals of the intrabiopelmicrosparite texture (intraclast-calpionellid-peloid packstone). The intraclasts are of the micrite texture. Although the faunistic content remains, in principle, without any change, a marked change is there in the quantitative representation of microfossils, which is reflected primarily in a decrease in the amount of radiolarians and spicules of sponges; calpionellids are commonly deformed and crassicollarians decrease in number. *Crassicollaria intermedia* (DURAND DELGA) and *Cr. massutiniana* (COLOM) fade, *Calpionella alpina* LORENZ - a small and large forms appear in an increased degree. We regard thin section 3 to be transient and put the conventional Jurassic/ Cretaceous (Tithonian/Berriasian) boundary at its level. What is meant is, in all probability, the base of the Alpina Subzone, Calpionella Zone (POP, 1994a, b).

Berriasian sediments (Calpionella Zone) are characterized again by the biomicrite texture (wackestone/packstone); the microfacies being calpionellid-crassicollarian-radiolarian-spongine in the lower horizons. Of the crassicollarians, *Crassicollaria parvula* REMANE gradually achieves superiority. With some exceptions the composition and the manner of preservation of organic remains and also the distribution of allochems [("nests", indications, or lamination, orientation, and/or indications of orientation (Pl. 6, Fig. 5)] correspond, taking into account their qualitative variability, with limestones of the uppermost Tithonian (Colomi Subzone). In some of the thin sections micrite intraclasts and peloids appear: intrabiopelmicrite/intrabiopelmicrosparite [packstone (Pl. 6, Fig. 5)/wackestone; see Text-Fig. 4].

In thin section 7, the first occurrence of *Calpionella elliptica* CADISCH (Pl. 8, Figs. 8, 9) has been recorded that appears at the beginning of the middle Berriasian. It is a zone fossil of the middle Berriasian Elliptica Subzone of the Calpionella Zone (POP, 1994a, b). The Ferasini Subzone (the upper part of the early Berriasian), which was defined below the Elliptica Zone, has not been found. In the whole section of the Rettenbacher Quarry, representatives of remaniellids are very rare. *Remaniella cadischiana* (COLOM) that was discovered at the base of the middle Berriasian (POP l. c.) was identified in thin section 8C. Moreover, some other problematic sections probably belong to remaniellids, although with regard to the unsuitable preservation any unambiguous interpretation is not possible. For example, in thin section 11 a form of cf. *Remaniella filipescui* POP occurs.

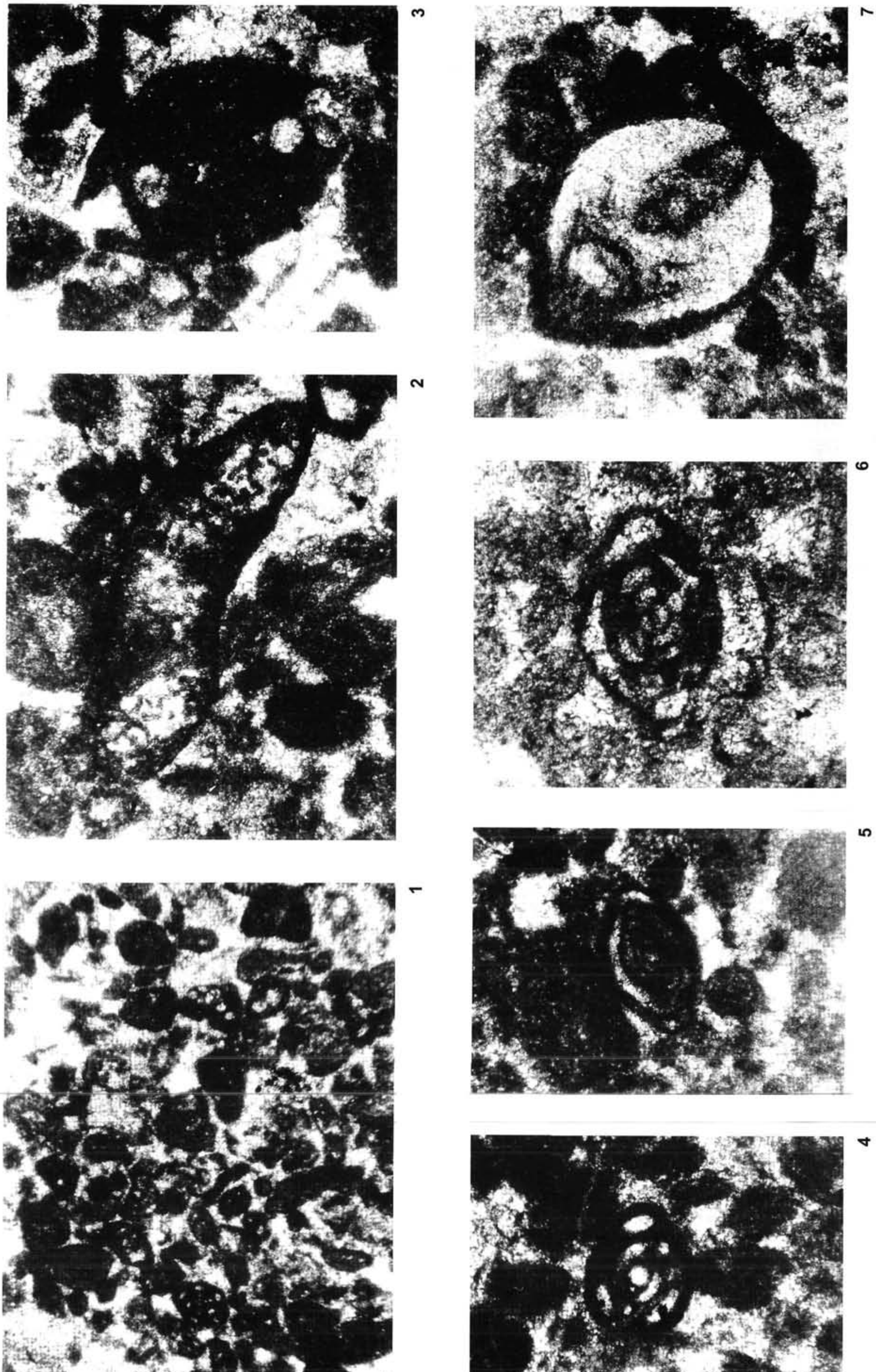
Towards the overlying strata, calpionellids and, with some exceptions, also other biogenes fade out. Representatives of crassicollarians are there continuously in the whole section, mainly in upper horizons. Several of them must be redeposited. This is valid for a proportion of representatives of calpionellids too - a large form of *Calpionella alpina* LORENZ as well as other fossils or their fragments.

Index fossils, by means of which upper middle Berriasian and late Berriasian biozones were divided (Longa Subzone of the Calpionella Zone, or the Simplex and Oblonga Subzones of the Calpionellopsis Zone) have not been recorded.

The association of calpionellids assigns sediments of the Oberalm-Formation in the Rettenbacher Quarry to the uppermost Tithonian to the middle Berriasian. However, it is necessary to note that *Calpionella elliptica* CADISCH (the latest occurrence of which was recorded according the data from literature in the lower part of the Oblonga Subzone) and remaniellids occur in the assemblage together with upper Berriasian forms, which does not rule out a late Berriasian age determined in virtue of non-calcareous dinocysts.

2.2.2.2. Barmstein-Limestone

Allodapic limestones of the Barmstein type are characterized by the intrabiopelsparite texture (intraclast-biogenic-peloid grainstone; Pl. 9, Fig. 1). Allochems are packed. More or less sorted, usually well rounded (up to gravels) clasts of the micrite texture dominate. Fragments of biomicrite, or sparite with the rims of micrite and detrital limestone are rare. Attention should primarily be paid to clasts that contain calpionellids. In a prevailing degree it is the case of *Calpionella alpina* LORENZ, only sporadically *Crassicollaria* sp., or *Cr. colomi* DOBEN was found, however, it is not clear if they occur in clasts or in the matrix. As far as the other fossils are concerned, filaments, benthic foraminifers are there in the clasts. Recrystallized biogenes are represented above all by foraminifers. Sometimes considerably common miliolid (Pl. 9, Figs. 4, 5, 6), more rarely textularoid forms are present, or *Dorothia* sp., cf. *Nautiloculina pseudoolithica* MOHLER (Pl. 9,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Tab. 3.
Qualitative distribution-chart of dinoflagellate cyst taxa of the Rettenbacher Quarry arranged in order of first occurrences.

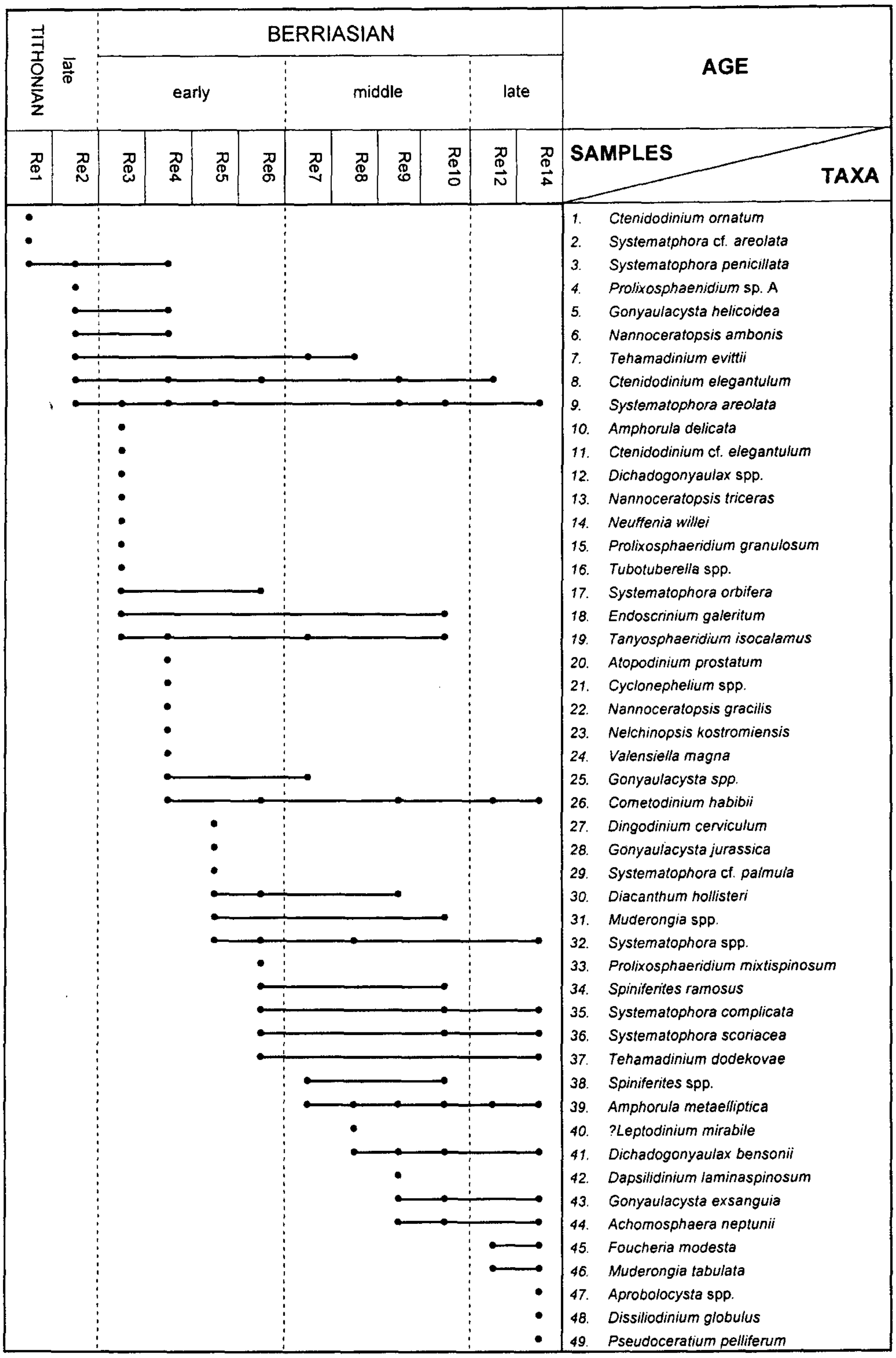


Plate 9

Rettenbacher Quarry, Barmstein-Limestone.

Fig. 1: Intrabiopelsparite (intraclast-biogenic-peloid grainstone). Thin section Re 14, late Berriasian.
Fig. 2: Fragment of bivalves with traces of boring organisms. Thin section Re 15, late Berriasian.
Fig. 3: cf. *Nautiloculina pseudoolithica* MOHLER. Thin section Re 15, late Berriasian.
Figs. 4, 5, 6: Miliolid forams. Fig. 4 thin section Re 15, Fig. 5 thin section Re 17, Fig. 6 thin section Re 14, late Berriasian.
Fig. 7: *Protopeneroplis striata* WEYNSCHENK. Thin section Re 15, late Berriasian.

Plate 10

Dinoflagellate cysts. The species name is followed by the size of the specimens, preparation slide numbers, England Finder coordinates (for the localization of specimen in slide), sample location and stratigraphic position.

Fig. 1, 2: *Nannoceratopsis gracilis* ALBERTI, 1961. Body length 80 μm; LB5/a, Q 16/4, Gutrathsberg Quarry, Oberalm-Formation, late Tithonian.
Fig. 3: *Achomosphaera neptunii* (EISENACK, 1958) DAVEY & WILLIAMS, 1966. Length 65 μm; LB 25/b, T 34/1, Gutrathsberg Quarry, Schrambach-Formation, middle Berriasian.
Fig. 4: *Systematophora complicata* NALE & SARJEANT, 1962. Body width 45 μm; LB11/b, R 33/4, Gutrathsberg Quarry, Schrambach-Formation, early Berriasian.
Fig. 5: *Ctenidodinium elegantulum* MILIOUD, 1969. Body width 60 μm; LB27/a, O 44/1, Gutrathsberg Quarry, Schrambach-Formation, middle Berriasian.
Fig. 6: *Dichadogonyaulax bensonii* MONTEIL, 1992. Body width 62 μm; Re14/c, Y 39, Rettenbacher Quarry, Oberalm-Formation, late Berriasian.
Fig. 7: *Dapsilidinium warrenii* (HABIB, 1976) LENTIN & WILLIAMS, 1981. Body diameter 35 μm; LB47/a, F 43, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.
Fig. 8: *Tehamadinium evittii* (DODEKOVA, 1969) JAN du CHÊNE et al. in JAN du CHÊNE et al., 1986.
Body length 90 μm; LB31/a, V 48, Gutrathsberg Quarry, Schrambach-Formation, middle Berriasian.
Fig. 9: *Circulodinium distinctum* (DEFLANDRE & COOKSON, 1955) JANSONIUS, 1986. Body width 60 μm; LB13/a, G 44, Gutrathsberg Quarry, Schrambach-Formation, early Berriasian.
Fig. 10: *Tanyosphaeridium boletus* DAVEY, 1974. Body length 48 μm; LB18/a, J 34, Gutrathsberg Quarry, Schrambach-Formation, middle Berriasian.
Fig. 11: *Muderongia tabulata* (RAYNAUD, 1978) MONTEIL, 1991. Inner body width 60 μm; LB11/b, Y 35, Gutrathsberg Quarry, Schrambach-Formation, early Berriasian.
Fig. 12: *Cometodinium habibii* MONTEIL, 1991. Body diameter 54 μm; LB45/c, M 35, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.

Fig. 3), *Protopeneroplis striata* WEYNSCHENK (also in clasts; Pl. 9, Fig.7), *Protopeneroplis* cf. *trochangulata* SEPTFONTAINE, *Protopeneroplis* sp., *Pseudoeggerella* sp. were identified more closely. In addition, fragments of echinoderms occur (in places with syntaxial rims of calcite), spines, fragments of thick-walled bivalves (in thin section 15 a fragment with traces of boring organisms occurs (Pl. 9, Fig. 2), bryozoans, aptychi, rare radiolarians (spumellarians), sponge spicules, filaments, Ostracoda div. sp. and also sessile foraminifers. Scarcely occurrences of pseudo-ooliths were observed. Pyrite, quartz of the sandy fraction, hydromica, rhombohedra of carbonates are present. A small number of the samples represent a transient type of the Oberalm Limestones to limestones of the Barmstein type. Calpionellids are sporadic in them.

2.2.3. Dinoflagellate Cysts

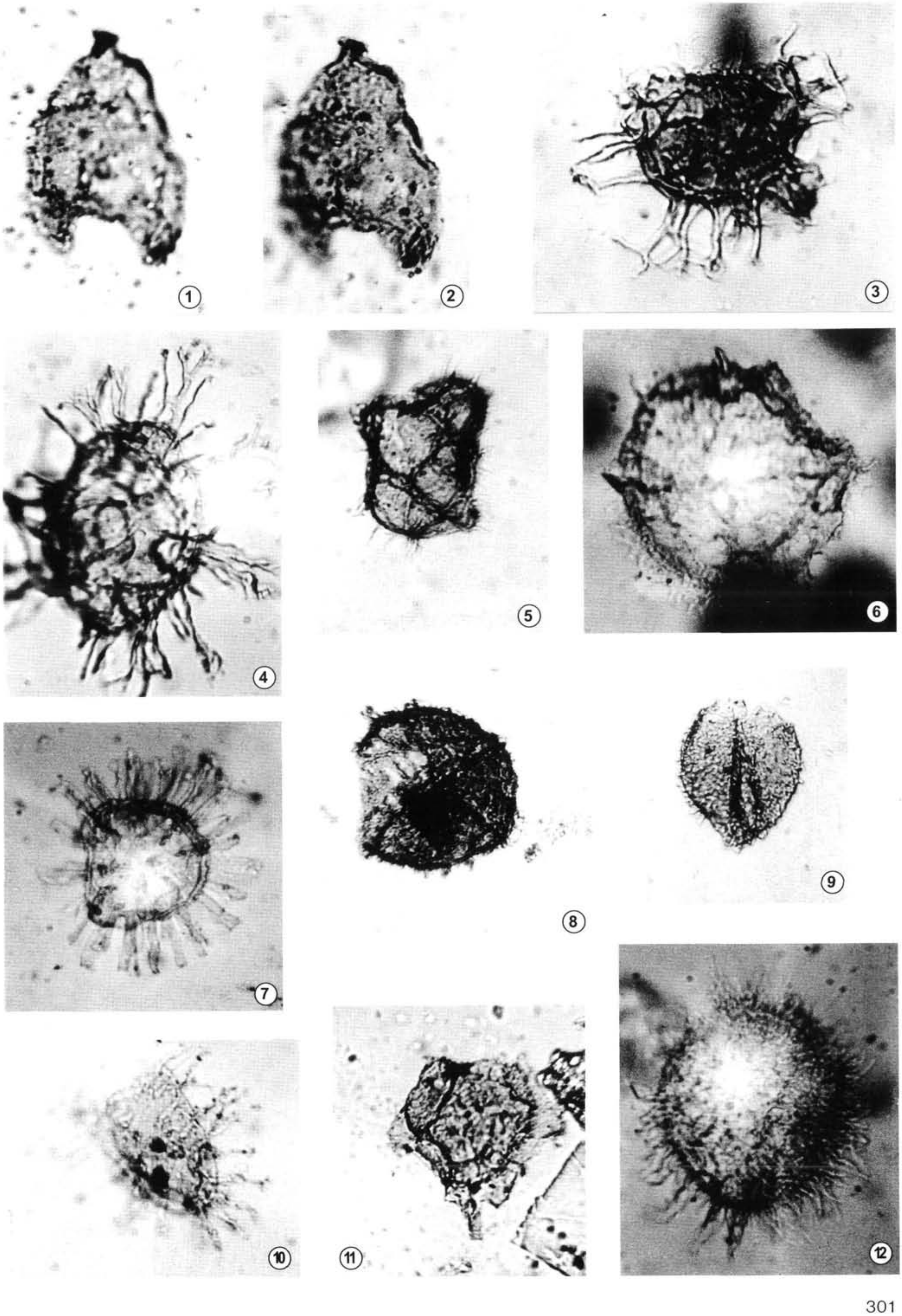
Of the samples being 14 in the total number, only 12 contain determinable dinoflagellate cyst assemblages with few individuals well preserved. Diversity is low (15 species in sample Re14 as a maximum). In addition to dinoflagellate cysts, the samples yield black amorphous material. Results of the qualitative analysis of dinoflagellate cysts are presented in Tab. 3.

The observed assemblages are typical of the late Tithonian to Berriasian. They are *Achomosphaera neptunii, Amphorula delicata, A. metaelliptica, Cometodinium habibii, Ctenidodinium elegantulum, C. ornatum, Diacanthum hollisteri, Dichadogonyaulax bensonii, Foucheria modesta, Prolixosphaeridium* sp. *A* sensu MONTEIL (1993), *Pseudoce-*

Plate 11

Dinoflagellate cysts. The species name is followed by the size of the specimens, preparation slide numbers, England Finder coordinates (for the localization of specimen in slide), sample location and stratigraphic position.

Fig. 1: *Amphorula metaelliptica* DODEKOVA, 1969. Body width 70 μm; LB36/a, Q 42/1, Gutrathsberg Quarry, Schrambach-Formation, late Berriasian.
Fig. 2: *Circulodinium brevispinosum* (POCOCK, 1962) JANSONIUS, 1986. Body width 75 μm; LB45/a, Q 35, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.
Fig. 3: *Tanyosphaeridium* sp. DE of BRIDEAUX (1977). Body length 50 μm; LB45/a, Z 43, the same localization as with Fig. 2.
Fig. 4: *Hystrichosphaerina schindewolfii* ALBERTI, 1961. Body diameter 40 μm; LB47/a, J 34, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.
Fig. 5: *Pseudoceratium pelliferum* GOCHT, 1957. Body width 70 μm; LB53/c, P 46, Gutrathsberg Quarry, Upper Roßfeld-Formation, ? Hauterivian.
Fig. 6: *Amphorula delicata* VAN HELDEN, 1986. Body width 45 μm; LB42/a, N 46, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.
Fig. 7: *Prolixosphaenidium* sp. A of MONTEIL (1993). Body length 85 μm; LB32/b, F 43, Gutrathsberg Quarry, Schrambach-Formation, late Berriasian.
Fig. 8, 9: *Muderongia longicorna* MONTEIL, 1991. Inner body width 60 μm; LB40/a, H42, Gutrathsberg Quarry, Lower Roßfeld-Formation, late Berriasian.
Fig. 10: *Muderongia tabulata* (RAYNAUD, 1978) MONTEIL, 1991. Inner body width 55 μm; LB36/a, N 43/44, Gutrathsberg Quarry, Schrambach-Formation, late Berriasian.
Fig. 11: *Nannoceratopsis ambonis* DRUGG, 1978. Length 65 μm; LB41/a, V 45, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.
Fig. 12: *Cymososphaeridium validum* DAVEY, 1982. Body diameter 50 μm; LB53/e, R 39, Gutrathsberg Quarry, Upper Roßfeld-Formation, ? Hauterivian.
Fig. 13: *Amphorula metaelliptica* DODEKOVA, 1969. Body width 52 μm; LB27/b, O 44/1, Gutrathsberg Quarry, Schrambach-Formation, middle Berriasian.
Fig. 14: *Oligosphaeridium poculum* JAIN, 1977. Body width 61 μm; LB41/a, S 33, the same localization as with Fig. 11.
Fig. 15: *Systematophora areolata* KLEMENT, 1960. Body width 65 μm; LB5/c, N 44/45, Gutrathsberg Quarry, Oberalm-Formation, late Tithonian.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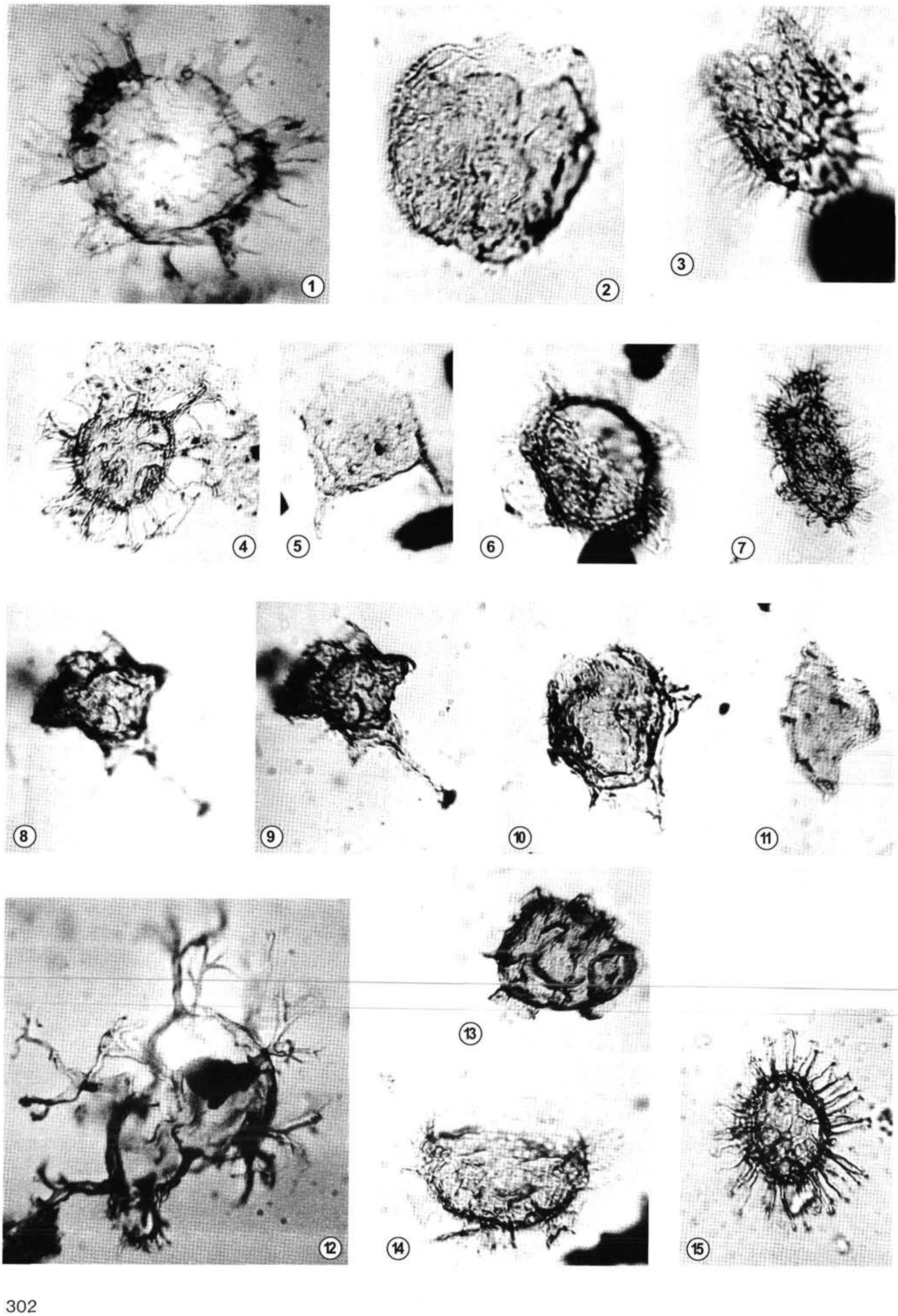
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ratium pelliferum, Spiniferites ramosus, Systematophora areolata, S. complicata, S. orbifera, S. penicillata, Tehamadinium dodekovae, T. evittii, etc.

From the recovered dinocyst species, the late Tithonian to early Berriasian is proposed for the lower part of the profile (samples Re1 to Re6). This part contains *Ctenidodinium ornatum, Endoscrinium galeritum, Gonyaulacysta jurassica, Nannoceratopsis ambonis, N. gracilis, N. triceras* and *Systematophora penicillata,* which are typical of the middle and late Jurrasic (STOVER et al., 1996) and therefore they can be considered to be redeposited. It is necessary to note that representatives of the genus *Nannoceratopsis* are numerous in this part. The last occurence of *Prolixosphaeridium mixtispinosum* and the first occurrence of *Ctenidodinium elegantulum, Diacanthum hollisteri, Spiniferites ramosus, Tehamadinium dodekovae* are well known in the early Berriasian of southeastern France at the Jacobi Zone (MONTEIL, 1992, 1993). HABIB & DRUGG (1983) reported that representatives of the *Ctenidodinium elegantulum* had first occurred at the upper part of the early Berriasian. Because in sample Re2 the only representative of the species *C. elegantulum* was found, which is of frequent occurrence even with sample Re4, it is possible to incline to the conventional Jurassic/Cretaceous boundary determined according to calpionellids.

The presence of *Dichadogonyaulax bensonii* in sample Re8 is significant. MONTEIL (1992, 1993) recorded the first occurrence of *D. bensonii* in the uppermost part of the Jacobi Zone. LEEREVELD (1995) considers the first occurrence of this species as marker for the middle Berriasian. In the higher sample (Re9), representatives of the species *Achomosphaera neptunii* occur for the first time as well, namely in numbers. *Foucheria modesta,* which occurs in sample Re12, is significant for the late Berriasian. On the basis of the content of dinocysts, the middle part of the section (samples Re8-10) can be assigned to the middle Berriasian. With reference to the occurrence of stratigraphically significant calpionellids in the underlying strata of the place of taking sample Re7, this is also assigned to the middle Berriasian. Therefore, the middle Berriasian can be assigned to the samples interval Re7-Re10.

The upper part of the section (interval of samples Re12-Re14) is of late Berriasian age. The presence of *Amphorula metaelliptica, Foucheria modesta* and *Pseudoceratium pelliferum* is significant. *Foucheria modesta* is known in the late Berriasian (Boissieri Zone; MONTEIL, 1992, 1993; LEEREVELD, 1995). *Pseudoceratium pelliferum* was described from the uppermost part of the Boissieri Zone (Alpillensis Subzone; MONTEIL, 1992). Similarly, the last occurrence of *A. metaelliptica* is well known in the late Berriasian of southeastern France (at the top of Boissieri Zone).

The uppermost part of the section has not been sampled, because intercalations of shales are missing here and limestones are not suitable for obtaining non-calcareous dinocysts.

2.2.4. Macrofaunistic Evaluation

In the collected material one of the ammonites has been successfully determined on the species level as *Pseudosubplanites* cf. *ponticus* (RETOWSKI) - Pl. 13, Fig. 1, the other as *Haploceras* sp. and the following association of aptychi as well: *Punctaptychus punctatus punctatus* (VOLTZ), *P. p. rectecostatus* CUZZI, *P. p.* cf. *angustus* KHALILOV, *P. cinctus* TRAUTH, *Lamellaptychus* cf. *submortilleti* TRAUTH and *L. beyrichi* (OPPEL).

According to the determined ammonite and the aptychi association that, however, could not be collected using the layer by layer method, marly deposits in the quarry correspond stratigraphically to the deposits in the vicinity of the Jurassic/Cretaceous boundary.

The submitted stratigraphical results differ substantially from the data by LOBITZER et al. (1994a). In addition to the Late Tithonian stated in the cited study, we have succeeded, on the basis of calpionellids, in the specification concerning the assignation of the oldest deposits exposed in the Rettenbacher Quarry to the Colomi Subzone (Crassicollaria Zone).

The largest proportion of deposits pertain to almost the whole of Calpionella Zone (however, for the Ferasini Subzone the occurrence of the index species is missing). In virtue of the non-calcareous dinocysts, the Late Berriasian, in addition to the Middle Berriasian, has been successfully demonstrated (the whole ammonite Boissieri Zone).

2.3. Toni Rieger Quarry at Puch

The large active quarry called Toni Rieger is situated nearby the village of Puch having several levels. The main face has the height of several tens of meters and is inaccessible. Beds are deposited subhorizontally. In the lowermost part of the quarry limestones are intercalated with numerous layers of non-schistose greenish-grey marlstones even 1 dm thick. Towards the overlying strata, marlstones disappear. Limestones are grey, grey-brown, usually spotted. Grey-brown cherts occur in them in places. A lamination has been observed, or the signs of it and gradation (detritic limestone on the base passes gradually to the mud limestone). In the upper part of the sequence of strata, the Barmstein-Limestone dominates.

In the quarry, 4 samples for thin sections were taken from lowermost horizons in the right side of the face exposure. In thin sections 1 and 2, a streaked pattern of allochems can be observed, even indications of lamination. Intervals of intrabiopelmicrite/intrabiopelmicrosparite (intraclast-biogenic-peloid packstone) are there. These parts of the sediment contain more or less sorted material comprising micrite intraclasts, sporadic radiolarians of the spumellarian type that are filled with crystalline calcite, or partially with pyrite, sponge spicules, *Globochaete alpina* LOMBARD, filaments, several chambers of benthic foraminifers (*Dorothia* sp., *Spirillina* sp.), *Gemeridella minuta* BORZA & MIŠÍK, calcareous dinoflagellates, fragments of echinoderms, shells of ostracodes, a problematic fragment of ?bryozoan, recrystallized biodetritus. Pyrite, rhombohedra of carbonate and chert are present.

In places with a significantly lower content of allochems (biomicrosparite-wackestone) recrystallized biodetritus mainly occurs. From the standpoint of stratigraphic assignation of the rock, the occurrence of the very rare form of *Chitinoidella boneti* DOBEN that is an index fossil of the Subzone of the same name subdivided in the higher part of the middle Tithonian (BORZA, 1984) is very important.

Two types of texture also occur in thin section 2A. Intrabiopelsparite (intraclast-biogenic-peloid grainstone) contains rather sorted, well rounded intraclasts of the micrite texture, or peloids, an organic component represented mostly by fragments of benthic foraminifers (*Dorothia* sp., miliolid forms), *Globochaete alpina* LOMBARD, radiolarians of the spumellarian type with the filling of sparry calcite, sponge spicules, filaments, aptychus, *Ostracoda* div. sp., fragments of echinoderms, a fragment of (?)alga. No presence of calpionellids has been found out. Pyrite, very rare quartz of the sandy fraction, small chert are present. This part of the sediment represents limestones of the Barmstein type.

The texture of radiolarian-sponge-chitinoidellid biomicrite, or intrabiopelmicrite/intrabiopelmicrosparite (packstone) is typical for thin section 3. Micrite intraclasts and peloids are not observable in all cases. Allochems are irregularly distributed and are rather unsorted. The matrix is partially recrystallized. Radiolarians, dominantly spumellarians, are filled with crystalline calcite as well as sponge spicules. From the biostratigraphical point of view, the occurrence of *Chitinoidella boneti* DOBEN (Pl. 7, Fig. 3) is important that assigns the sediment to the higher part of the middle Tithonian (in the sense of BORZA, 1984, Chitinoidella Biozone, Boneti Subzone). Microfossils are represented further by benthic foraminifers, or parts of their tests [*Dorothia oxycona* (REUSS), miliolid forms], filaments, *Globochaete alpina* LOMBARD, fragments of echinoderms, shells of ostracodes, calcareous dinoflagellates; also recrystallized biodetritus occurs. Pyrite in biogenes, rare quartz of the sandy fraction, authigenic quartz and rhombohedra of carbonate are present.

In view of depositional conditions, macrofaunas could be collected only in the debris. Altogether 80 findings (designated Pu) have been accumulated. For the most part, they belong to not very well-preserved aptychi. Merely 3 findings belong to belemnites; one remnant of a perisphinctid ammonite, one of a rhyncholite and one remnant of a small crinoidal theca.

In the material wholly dominate representatives of the genus *Punctaptychus*, namely: *P. p. punctatus* (VOLTZ) - Pl. 13, Fig. 7, *P. p. seranonoides* TURCULET (Pl. 13, Fig. 4), *P. p. angustus* KHALILOV (Pl. 13, Fig. 3), *P. p. divergens* TRAUTH (Pl. 14, Fig. 2) and *P.* cf. *cinctus* TRAUTH. Together with them, *Lamellaptychus beyrichi* (OPPEL) occurs sporadically. According to the complex composition of the fossil association, the middle/late Tithonian age of deposits can be supposed in all probability.

The further characteristics of the sequence of strata in the quarry and the Late Tithonian age of the Oberalm-Formation on the evidence of microfauna in thin sections are proved by LOBITZER et al. (1994a).

2.4. Mathias Wallinger (Schorn) Quarry at St. Koloman

An active quarry at St. Koloman is owned by Mathias Wallinger. In the quarry, subhorizontally deposited beds outcrop in the quarry face having the height of more than 12 m. Slabby limestones with cherts dominate here that are interbedded with greenish-grey marlstones. Grey, grey-brown, more or less spotted limestones dominate here with black continuous layers of cherts. In some layers lamination can be observed. Trace fossils are numerous as well (LOBITZER et al., 1994a).

In the quarry, 4 point samples of limestones were taken for the analysis of thin sections. Their matrix is partially recrystallized (mainly thin section 3). The crassicollarian, or crassicollarian-radiolarian-sponge microfacies is characteristic for all of them. As for the texture, they pertain to biomicrites/biomicrosparites (wackestone/packstone), with the exception of thin section 3 (thin section contains in part chert), in which micrite intraclasts and peloids (intrabiopelmicrite - packstone) appear in contrast with other studied samples, allochems are more densely packed and radiolarians of the spumellarian type and sponge spicules occur in an increased degree. Of common to numerous, sometimes deformed calpionellids (Pl. 8, Figs. 1, 2), whose quality varies in the framework of particular samples, crassicollarians begin to flourish. They are represented above all by *Crassicollaria intermedia* (DURAND DELGA) (Pl. 8, Fig. 1), *Cr. massutiniana* (COLOM) (Pl. 8, Fig. 12), less numerous are *Cr. brevis* REMANE, *Cr. colomi* DOBEN (Pl. 8, Fig. 10) and *Cr. parvula* REMANE. Calpionellids are represented especially by a large form of *Calpionella alpina* LORENZ and *C. grandalpina* NAGY. The association of calpionellids corresponds to the standard Crassicollaria Biozone and the Colomi Subzone (its lower part – POP, 1994b) and indicates the uppermost Tithonian. As for other biogenes, radiolarians (spumellarians are dominant) are present with calcite filling of cavities after solved radiolarians, or partially pyrite filling (only in thin section 3 also silicified forms are there), sponge spicules, *Globochaete alpina* LOMBARD, calcareous dinoflagellates [*Schizosphaerella minutissima* (VOGLER)], filaments, shells of ostracodes, very rare benthic foraminifers (*Spirillina* sp.) and fragments of echinoderms. Recrystallized biodetritus occurs. Pyrite and rhombohedra of carbonates are present.

With reference to the quarry conditions, collections of macrofauna could be executed only in the debris. More than 30 macrofaunal findings (designated Kol) belong especially to aptychi. Two imperfectly preserved remnants belong to indeterminable fragments of perisphinctid ammonites. Further, a single rhyncholite and a belemnite guard have been found.

The aptychi belong to *P. p. punctatus, P. p. seranonoides* (Pl. 14, Figs. 1, 6), *P. p. angustus, P. p. fractocostatus* TRAUTH (Pl. 13, Fig. 6) and *?L. beyrichi* (Pl. 14, Fig. 8). The whole assemblage is very close to the preceding locality. The locality in accordance with calpionellids pertains to the uppermost Tithonian.

Plate 12

Dinoflagellate cysts. The species name is followed by the size of the specimens, preparation slide numbers, England Finder coordinates (for the localization of specimen in slide), sample location and stratigraphic position.

Fig. 1: *Endoscrinium campanula* (GOCHT, 1959) VOZZHENNIKOVA, 1967. Body length 90 µm; LB48/a, U36/4, Gutrathsberg Quarry, Lower Roßfeld-Formation, late Valanginian.

Fig. 2: *Oligosphaeridium complex* (WHITE, 1842) DAVEY & WILLIAMS, 1966. Body width 50 µm; LB49/a, T31 Gutrathsberg Quarry, Upper Roßfeld Formation, late Valanginian.

Fig. 3: *Kleithriasphaeridium eoinodes* (EISENACK, 1958) DAVEY, 1974. Body width 50 µm; LB49/a, Z43, the same localization as with Fig. 2.

Fig. 4, 7: *Hystrichodinium pulchrum* DEFLANDRE, 1935. Body width 52 µm; LB41/a, H42, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.

Fig. 5: *Gonyaulacysta cretacea* (NALE & SARJEANT, 1962) SARJEANT, 1969. Body width 53 µm; LB41/a, W39, the same localization as with Fig. 4.

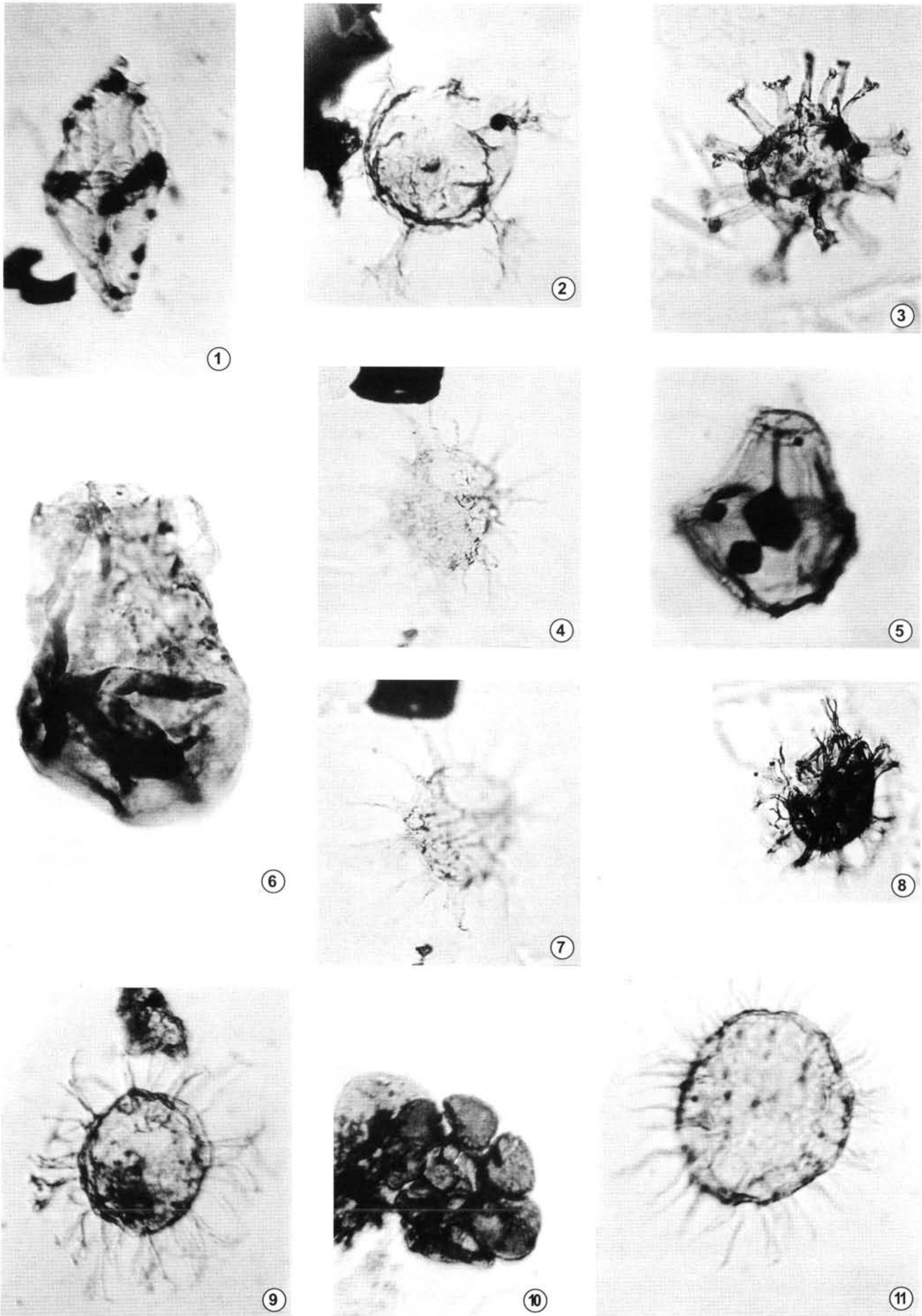
Fig. 6: *Fromea cylindrica* (COOKSON & EISENACK, 1960) STOVER & EVITT, 1978. Body length 80 µm; LB45/a, N43/44, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.

Fig. 8: *Spiniferites ramosus* (EHRENBERG, 1838) MANTELL, 1854. Body width 43 µm; LB47/b, J30, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.

Fig. 9: *Systematophora silybum* DAVEY, 1979. Body width 60 µm; LB51/b, N 44, Gutrathsberg Quarry, Upper Roßfeld-Formation, late Valanginian.

Fig. 10: Chitinous foraminifera lining. Diameter 62 µm; LB51/b, J31/3, the same localization as with Fig. 9.

Fig. 11: *Exochosphaeridium muelleri* YUN, 1981. Body width 50 µm; LB47/b, M40, Gutrathsberg Quarry, Lower Roßfeld-Formation, early Valanginian.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2.5. Wieser (Woerndl) Quarry at St. Koloman

In the quarry that is mined only ocassionally, light grey, grey to brown-grey slab-like, more or less spotted limestones of an atypical Oberalm-Formation without cherts occur. In some layers, lamination can be seen, especially at the base. The layers of shales in the limestones are rarer than in the Rettenbacher Quarry and reach a small thickness (usually only several mm). The limestones are exposed in the thickness of several meters. The intercalations of marlstones in the limestones are not abundant and are of small thickness.

In the quarry, 5 samples were taken for thin sections. What is of interest is primarily sample No. 2 that represents a laminated limestone (Pl. 6, Fig. 1). The laminae have irregular courses, are of various thickness, variable quantity of organic remains and are characterized by several types of texture. The laminae of biomicrite/biomicrosparite (radiolarite-sponge-calpionellid packstone, seldom wackestone) alternate with thin laminae of intrabiopelsparite (intraclastic-biogen-peloid grainstone), or thicker laminae of intrabiopelmicrosparite (intraclastic-biogen-peloid packstone). Allochems show some signs of preferential orientation, are usually numerous with dominant microfossils represented by radiolarians (mainly of the spumellarian type, nassellarians are only sporadic) filled with sparry calcite (siliceous filling is rare), spicules of sponges of many morphotypes, filaments, *Globochaete alpina* LOMBARD, sporadic benthic foraminifers (*Dorothia* sp.), calcareous dinoflagellates [*Colomisphaera carpathica* (BORZA), *Schizosphaerella minutissima* (VOGLER)], and especially calpionellids, of which some are deformed. The mixed association of calpionellids was found represented by a large and a small form of *Calpionella alpina* LORENZ, *Crassicollaria colomi* DOBEN, *Cr. intermedia* (DURAND DELGA), *Cr. massutiniana* (COLOM), *Cr. parvula* REMANE, *Tintinnopsella carpathica* (MURGEANU & FILIPESCU), *Remaniella cadischiana* (COLOM) (Pl. 7, Figs. 5, 6), *R. filipescui* POP (Pl. 7, Fig. 7). The latter mentioned species has, according to POP (1994b), a stratigraphic range from the middle Berriasian to the early Valanginian. Because no younger faunistic elements have been found out, we can assign the studied sediment to the middle Berriasian. Intraclasts show micritic texture. Rhombohedra of carbonate, authigenic quartz and pyrite are present. The clastic quartz of the sandy fraction occurs mainly in laminae with the texture of grainstone.

The lamination can be seen also in thin sections 5 and 3. Mainly in thin section 5 laminae with dense allochems occur. From the standpoint of texture and faunistic content, in all specimens described below any more marked change in comparison with thin section 2 does not substantially come about. A difference consists in the quantitative representation of allochems and the composition of species of calpionellids. The calpionellids, with which a decrease in their number took place, provided an association without crassicollarians and with the presence of *Tintinnopsella carpathica* (MURGEANU & FILIPESCU) in a greater extent. *Calpionella alpina* LORENZ is common, *Calpionella elliptica* CADISH, *Remaniella filipescui* POP, *Remaniella* sp., are rare. The thin section from sample 3 recorded a lamina of intrabiopelmicrite, locally intrabiopelmicrosparite texture (packstone). The surrounding sediment is characterized by the biomicrite, or biomicrosparite structure (wackestone). Calpionellids are rare and, with some exceptions, poorly preserved. *Calpionella alpina* LORENZ and *Tintinnopsella carpathica* (MURGEANU & FILIPESCU) were identified.

From the point of view of texture thin section 1 belongs to biomicrite (*Tintinnopsella*-radiolarian-sponge wackestone). The biogenes are irregularly, schlieren-like order form clusters (packstone) where mainly fine recrystallized detritus and rhombohedra of carbonate accumulate. Calpionellids are represented, as in thin section 3, by *Calpionella alpina* LORENZ (Pl. 8, Fig. 3) and *Tintinnopsella carpathica* (MURGEANU & FILIPESCU) (Pl. 7, Fig. 4). Hydromicas and minor cherts are scarce. The calpionellids correspond with the Berriasian Calpionella Zone (POP, 1994a, b). With reference to the absence of index fossils, subzones cannot be specified reliably. However, it follows from the total faunistic content that the earliest sediments prove the middle Berriasian age.

In the quarry, some imperfectly preserved imprints of prevailingly perisphinctid ammonites and 15 valves of aptychi (designated Woe) have been found. One of the ammonites was determined as *Pseudosubplanites* cf. *lorioli* (ZITTEL) - Pl. 13, Fig. 2. The valves of aptychi belong to *Punctaptychus punctatus punctatus* (VOLTZ), *P. p. rectecostatus* CUZZI, *Lamellaptychus* cf. *sparsilamellosus* (GUEMBEL) and *L. submortilleti* TRAUTH (Pl. 13, Fig. 8).

For the purpose of correlation, 2 thin sections from the same piece of limestone, on which an ammonite *Pseudosubplanites* cf. *lorioli* occurred, were evaluated. From the standpoint of texture, there is calpionellid-radiolarian-sponge biomicrite (calpionellid-radiolarian-sponge wackestone/packstone). In one part of the thin sections, two more or less thin laminae of intrabiopelmicrosparite (intraclast-biogenic-peloid packstone) with an increased concentration of allochems occur, the biogenes consist mainly of calpionellids. The intraclasts are micritic. Indications of uniform orientation of particular components of the rock can be found. Microfossils are represented by unsorted radiolarians, primarily of the spumellarian type filled with crystalline calcite, microsparite with a rim of crystalline calcite, or partially with pyrite. Also sponge spicules, *Globochaete alpina* LOMBARD, filaments, benthic foraminifers, or parts of their test (*Spirillina* sp.), calcareous dinoflagellates (*Schizosphaerella minutissima* (VOGLER), cf. *Cadosina fusca* WANNER were identified), valves of ostracodes and recrystallized biodetritus occurs. Calpionellids also commonly occur, they are only seldom deformed and are represented by dominant *Calpionella alpina* LORENZ (Pl. 8, Fig. 4; in the lamina not only a small form but also a large form is present), rare *Calpionella elliptica* CADISCH, *Tintinnopsella carpathica* (MURGEANU & FILIPESCU), cf. *Tintinnopsella subacuta* (COLOM), *Remaniella filipescui* POP, cf. *Remaniella cadischiana* (COLOM), *Crassicollaria parvula* REMANE and by one specimen of redeposited *Crassicollaria massutiniana* (COLOM) as well. The association corresponds to the Calpionella Zone, i. e. middle Berriasian Elliptica Subzone (after POP, 1994a, b). Pyrite, hydromicas, authigenic quartz, rare rhombohedra of carbonates are present.

With reference to the determined faunistic assemblage we can conclude, that deposits of the early/middle Berriasian outcrop in this locality. LOBITZER et al. (1994a) arrive at similar stratigraphical results.

3. Palaeontological Part

3.1. Ammonoidea

Superfamily Perisphinctaceae STEINMANN 1890
Family Berriasellidae SPATH 1922
Genus *Pseudosubplanites* LE HÉGARAT 1973
Pseudosubplanites cf. *ponticus* (RETOWSKI 1893)
Pl. 13, Fig. 1

1893 *Perisphinctes ponticus* n. sp.; RETOWSKI, p. 256, pl. 10, fig. 9
1982 *Pseudosubplanites (Pseudosubplanites) ponticus* RETOWSKI; NIKOLOV, p. 42, pl. 2, fig. 6, pl. 6, figs. 1, 2 (cum syn.)

Material: The only incomplete shell (spec. Rt-2) heavily deformed into the plane of the bedding surface. According to the deformation gradient, the terminal quarter of the shell belongs probably to the living chamber. The siphonal area is not accessible to observing.

Description: The half-evolute shell of medium size. Slightly flexuous ribs bifurcate approximately in the half of the whorl height. Sporadically simple ribs occur among them.

Measurement: Values are considerably influenced by deformation. At D = 65 mm, where H = 27.00 (0.41) and lies on the living chamber, U = 23.00 (0.35). At D = 56 mm, where H = 20.5 (0.37) and lies on the phragmocone, U = 20.5 (0.37). The shell reaches the maximum diameter that is a little more than 70 mm.

Remarks: The size of the shell, the character and density of ribbing correspond most to *P. ponticus*. The unambiguous determination of the deformed and incomplete shell is not, however, possible.

Distribution: According to NIKOLOV (1982), typical representatives of the mentioned species occur in the uppermost Tithonian and the early Berriasian in the Crimea, in Rumania, Bulgaria, France, Spain and Tunis.

Occurrence: The ammonite shell was found in debris of the Oberalm-Formation at the bottom of the Rettenbacher Quarry, most probably in the deposits of the uppermost Tithonian (Crassicollaria Zone, Colomi Subzone). The age was derived according to the calpionellid association in the thin section made of the same piece of limestone, on whose bedding plane *Pseudosubplanites* cf. *ponticus* was there. The association of calpionellids consists of *Crassicollaria massutiniana, Cr. parvula, Cr. colomi, Tintinnopsella carpathica* and *Calpionella alpina* (both - small and large forms).

Pseudosubplanites cf. *lorioli* (ZITTEL 1868)
Pl. 13, Fig. 2

1868 *Ammonites lorioli;* ZITTEL, p. 103, pl. 20, figs. 6, 8, non fig. 7
1982 *Pseudosubplanites (Pseudosubplanites) lorioli* ZITTEL; NIKOLOV, p. 42, pl. 2, fig. 2, pl. 5, figs. 5-8 (cum syn.)
1985 *Berriasella (Pseudosubplanites) lorioli* ZITTEL; TAVERA, p. 261, pl. 36, fig. 10, fig. 20/I

Material: The only specimen (spec. Woe-2) preserved as an imprint of which a plaster positive was cast. The siphonal area is not preserved.

Description: A small, subevolute coiled shell with slightly vaulted, not very high whorls. On the last whorl, rather sparse, thin slightly flexuous ribs are preserved. All those ribs, with the exception of the sole simple rib, bifurcate in the upper third of the height.

Measurement: An imperfectly preserved periphery of the shell does not enable any total precise measurement. At D = 41.5 mm, H = 15.5 (0.37), U = 13.9 (0.33). At the mentioned diameter, 22 ribs at the umbilicus and 43 ribs at the periphery fall on a half-whorl.

Remarks: A small diameter of the shell, the type of bifurcation and the density of ribs indicate the species *P. lorioli.* However, the ignorance of the outer side and bed preservation obstructs the unambiguous genus, or species determination.

Distribution: According to NIKOLOV (1982), the typical representatives of this species is known from the uppermost Tithonian and basal Berriasian of France, Spain, Tunis, Rumania, Bulgaria and the Caucasus. ZITTEL's (1868) type specimen comes from limestones of the Štramberk type from the limestone block probably redeposited that had been exploited at Koňákov (Silesian unit, Czech Republic) long time ago and that is of non-unambiguous stratigraphic position.

Occurrence: Woerndl Quarry at St. Koloman, Schrambach-Formation (early/middle Berriasian).

3.2. Aptychi

Aptychi are classified according to an artificial system because their valves arranged originally in pairs occur only seldom together with the parent shells of ammonites. The artificial systematic classification as well as the morphological nomenclature created for aptychi by TRAUTH (1927, 1935, 1938) and rather supplemented by GASIOROWSKI (1959, 1962) has been used, with few modifications, up to now (see e. g. VAŠÍČEK et al., 1994). The basis of the taxonomy of aptychi is formed by several genera that divide into many artificial species and subspecies. As far as the aptychi are concerned, in the deposits of the uppermost Jurassic and the Lower Cretaceous only two genera presented below occur.

However, the genus classification of small valves of aptychi can be, in some cases, complicated owing to the eventual corrosion of a so-called punctate layer on the surface of valves of the genus *Punctaptychus*. Sometimes its dissolution takes place and on the surface of valves the ribbing of the calcareous underlayer manifests itself secondarily that corresponds to the genus *Lamellaptychus*. This unpleasant fact was already pointed out by POZZI (1965, p. 862).

Genus *Punctaptychus* TRAUTH 1927
Punctaptychus punctatus (VOLTZ 1837)

From the morphological point of view, the presented species is extraordinarily variable, which reflects in a great number of distinguished subspecies into which the species can be divided. Among all the subspecies, continuous transitions can be found in the case of sufficiently rich material. In addition to subspecies occurring commonly and most frequently, among which primarily the typical subspecies *P. p. punctatus* (VOLTZ) and also *P. p. rectecostatus* CUZZI 1962 can be ranked, other subspecies occur less frequently in the studied area as well. The most interesting species of them are described briefly below.

Punctaptychus punctatus divergens TRAUTH 1935
Pl. 14, Fig. 2

1935 *Punctaptychus punctatus* (VOLTZ) var. n. *divergens;* TRAUTH, p. 321, text-fig. 1 (cum syn.)
1996 *Punctaptychus punctatus divergens* TRAUTH; ELIÁŠ et al., pl. 4, fig. 5
1997 *Punctaptychus punctatus divergens* TRAUTH; VAŠÍČEK & HOEDEMAEKER, p. 32, pl. 1, fig. 4

Material: The only complete valve (spec. Pu-1/3).

Description: A large valve with ribs that are slightly arcuated in the whole course. More juvenile ribs converge towards the harmonic margin, following ribs that end at the outer margin, diverge more and more to the opposite side.

Remarks: The shape of valves with a wide, rounded outer margin reminds a typical subspecies; however, the difference being that it has a fanlike arrangement of adult ribs.

Distribution: TRAUTH's valves (1935) from the Alps miss the more precise stratigraphic assignation. In the Outer Carpathians in the Czech Republic (ELIÁŠ et al., 1996), the given subspecies occurs in the early Tithonian and redeposited specimens in the early Berriasian. In the section of Río Argos, *P. p. divergens* occurs in the basal Berriasian (Jacobi ammonite zone).

Occurrence: The sole specimen was found in the Toni Rieger Quarry at Puch, Oberalm-Formation, middle/late Tithonian.

Punctaptychus punctatus seranonoides TURCULET 1995
Pl. 13, Fig. 4, Pl. 14, Figs. 1, 6

1995 *Punctaptychus (Beyrichipunctaptychus) punctatus seranonoides* n. pssp.; TURCULET & AVRAM, p. 98, pl. 6, figs. 1, 1a

Material: Four valves of large dimensions (spec. Kol-11, 19, Pu-98/13).

Description: A more detailed description can be found in the contribution by VAŠÍČEK et al. (in press), namely in the same proceedings.

Remarks: The back bend of ribs, which is characteristic of the subspecies, occurs only on large valves that reach the length more than 30 mm. At the 30 mm length, this bend is, however, still indistinct. Adult ribs resemble, thanks to their divergent arrangement, *P. p. divergens*. In addition to the mentioned specimens, the only incomplete related valve was found, with which the back bend of ribs on the harmonic margin was more complicated, double (see Pl. 13, Fig. 5).

Distribution: The author of the species states the Tithonian of Rumania; VAŠÍČEK et al. (in press) the uppermost Tithonian in the Eastern Alps.

Occurrence: Valves were found merely in the active quarries named M. Wallinger at St. Koloman and T. Rieger at Puch, Oberalm-Formation (late Tithonian).

Punctaptychus punctatus angustus KHALILOV 1978
Pl. 13, Fig. 3

1978 *Punctaptychus punctatus angusta* A. KHALILOV subsp. nov.; KHALILOV, p. 57, pl. 2, figs. 23, 24
1979 *Punctaptychus triangularis* n. sp.; KÄLIN et al., p. 754, fig. 11 e, figs. 12 m, n
1988 *Punctaptychus punctatus angusta* A. KHALILOV; CHALILOV, p. 374, pl. 20, figs. 5, 6

Material: Almost twenty valves of various quality of preservation (e. g. spec. Pu-1/4, 6, 12, Pu-98/16, 21, 23, 35, Kol/22, 25).

Description: Valves of the triangular outline due to narrowing the terminal area. In the vicinity of the harmonic margin the valves are strongly vaulted.

Measurement: Spec. Pu-98/16 reaches the total length of 32.5 mm. The length of the harmonic margin is 28.0 mm, the length of the valve is 17.5 mm.

Remarks: As follows from synonymy, the subspecies was described as a new form twice in a short time. Ribs have the course similar to that of subspecies *P. p. punctatus* and *P. p. rectecostatus*. The different outline of the valves is caused by a considerably vaulted and concave frontal margin and thus by a relative small length of the harmonic margin, and especially by the marked narrowing of the terminal area of the valve.

Distribution: KHALILOV (1978) states the Berriasian of the southeastern Caucasus, KÄLIN et al. (1979) state the Tithonian of Italy (Southeastern Tuscany).

Occurrence: *P. p. angustus* occurs in the M. Wallinger Quarry at St. Koloman and T. Rieger Quarry at Puch, Oberalm-Formation (late Tithonian).

Punctaptychus monsalvensis TRAUTH 1935
Pl. 14, Fig. 3

1880 *Aptychus* sp. ind.; FAVRE, p. 43, pl. 3, fig. 16 a
1935 *Punctaptychus monsalvensis* n. n.; TRAUTH, p. 324, textfig. 2 (cum syn.)

Material: The only almost complete valve (spec. LB98-b/11.85).

Description: A flat medium-sized valve with a wide outer margin. Ribs run almost straightly through the whole length of the valves in an oblique way to the harmonic margin. Ribs along the harmonic margin are thinner and denser than following ribs. The majority of the ribs end at the outer margin. Close to it, the ribs deflect towards the terminal apex.

Measurement: The length of the valve reaches 27.5 mm, the height is 14.5 mm and the length of the harmonic margin reaches 25.0 mm.

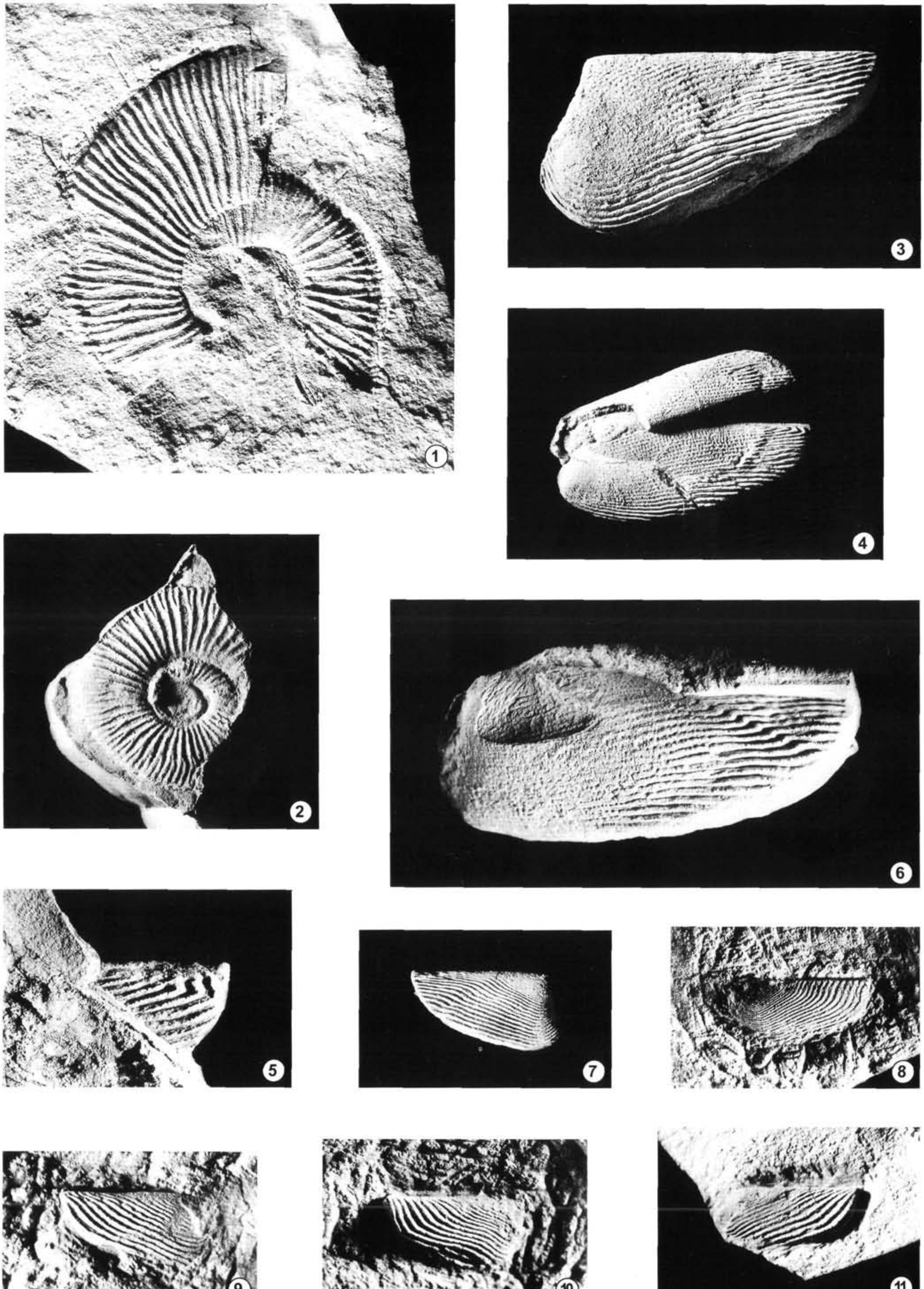
Remarks: The found valve is comparable well with FAVRE's valve (1880), which acquired, thanks to TRAUTH's illustration (1935), the character of a type specimen. The only small difference consists in the more arcuated course of ribs with the Alpine specimen.

Distribution: According to TRAUTH (1935), historical specimens occur in the Tithonian of the Outer Carpathians and Switzerland.

Occurrence: The single finding comes from the position at 11.85 m in the section at the lower level in the Gutrathsberg Quarry, Schrambach-Formation (early/middle Berriasian).

Plate 13

Fig. 1: *Pseudosubplanites* cf. *ponticus* (RETOWSKI) 1x; specimen Rt-2, Rettenbacher Quarry, Oberalm-Formation, uppermost Tithonian.
Fig. 2: *Pseudosubplanites* cf. *lorioli* (ZITTEL) 1x; spec. Woe-2, Woerndl Quarry at St. Koloman, Oberalm-Formation, early/middle Berriasian.
Fig. 3: *Punctaptychus punctatus angustus* KHALILOV 2x; spec. Pu98/16, Rieger Quarry at Puch, Oberalm-Formation, middle/late Tithonian.
Fig. 4: *Punctaptychus punctatus seranonoides* TURCULET 1x; spec. Pu98/13, the same localization as with Fig. 3.
Fig. 5: *Punctaptychus punctatus* cf. *seranonoides* TURCULET 2x; spec. Pu98/9, the same localization as with Fig. 3.
Fig. 6: *Punctaptychus punctatus fractocostatus* TRAUTH 2x; spec. Kol-7, Wallinger Quarry at St. Koloman, Oberalm-Formation, uppermost Tithonian.
Fig. 7: *Punctaptychus punctatus punctatus* (VOLTZ) 2x; juvenile spec. Pu-1/10, Rieger Quarry at Puch, Oberalm-Formation, middle/late Tithonian.
Fig. 8: *Lamellaptychus submortilleti* TRAUTH 2x; spec. Woe98/5, Woerndl Quarry at St. Koloman, Oberalm-Formation, early/middle Berriasian.
Figs. 9–11: *Lamellaptychus* cf. *sparsilamellosus* (GUEMBEL) 3x; 9 – spec. LBa98-II/10, 10 – spec. LBa98-I/2, 11 – spec. LBa98-III/5, Gutrathsberg Quarry, uppermost level, Oberalm-Formation, late Tithonian.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Punctaptychus cinctus TRAUTH 1935
Pl. 14, Figs. 4, 5

1994 *Punctaptychus cinctus* TRAUTH; VAŠÍČEK et al., p. 70, pl. 23, fig. 2 (cum syn.)
1997 *Punctaptychus cinctus* TRAUTH; VAŠÍČEK & HOEDEMAEKER, p. 34, pl. 1, fig. 6

Material: Four incomplete valves with imperfectly preserved punctate layers (spec. Re98/22, LB98-Abs/1, LB98-III/3, LB98-Sch/1).
Description: Small valves. Straight, thin juvenile ribs are densely clustered and lead subparallelly to the harmonic margin. The following ribs are stronger, less dense, goose-necked in the terminal part. The last adult ribs follow the outline of the valve.
Remarks: *P. cinctus* has also probably its own morphologic parallel to *L. cinctus* Turculet.
Distribution: TRAUTH (1935) states the Tithonian. In the Outer Carpathians, *P. cinctus* has been found in the deposits at the early/middle Berriasian boundary, in the Río Argos section (Spain) in the middle Berriasian (Privasensis ammonite subzone).
Occurrence: The Gutrathsberg Quarry, upper level, in the Oberalm-Formation (late Tithonian); upper and lower levels, debris at 56 m (where zone of red-coloured deposits occurs here), Schrambach-Formation (middle and late Berriasian). Debris in the Rettenbacher Quarry, Oberalm-Formation (uppermost Tithonian or early Berriasian).

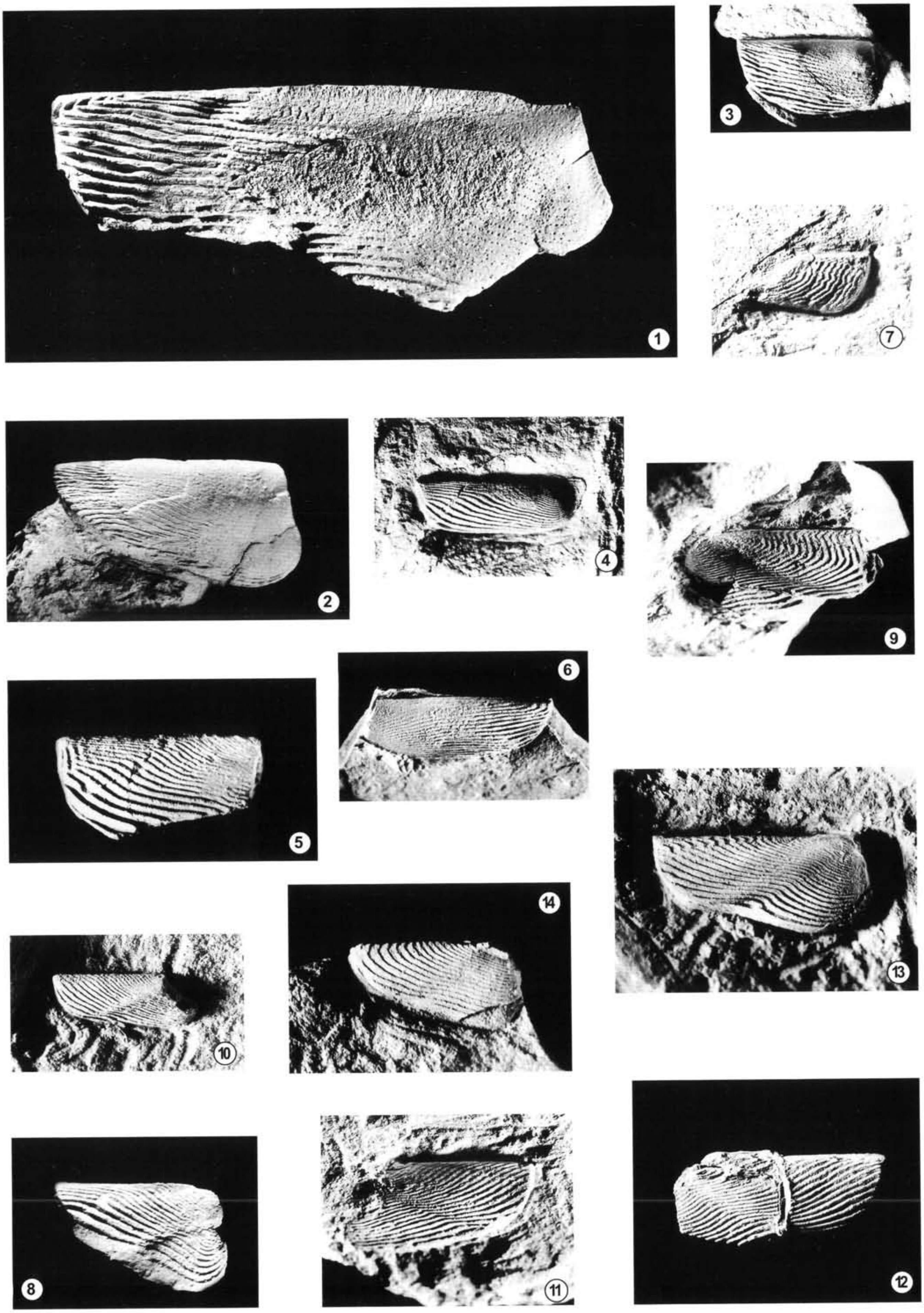
Genus *Lamellaptychus* TRAUTH 1927
Lamellaptychus cf. *sparsilamellosus* (GUEMBEL 1861)
Pl. 13, Figs. 9-11

1870 *Aptychus exsculptus* SCHAUR.; ZITTEL, p. 150, pl. 25, fig. 10
1938 *Lamellaptychus sparsilamellosus* (GUEMB.) f. typ.; TRAUTH, p. 165, pl. 11, figs. 23-27 (cum syn.)

Material: More than 10 imperfectly preserved, incomplete, prevailingly juvenile valves (e. g. spec. LBa98-I/2, LBa98-II/10, LBa98-III/5, Rt-31).
Description: Small vaulted valves with an indicated keel. At first, thin juvenile ribs run obliquely on the valves, almost straightly, roughly subparallelly to the outline of the valves. They end at the harmonic margin at the angle approximately less than 30°. In the course of growing, the ribs become more arcuated; slightly on flanks but more and more apparently in the terminal area. First feeble, later even more sigmoidally between the keel and the harmonic margin. The bend of ribs becomes still more marked there, so that the angle, at which the ribs intersect the harmonic margin, continuously increases to 60-70°. The latter mentioned changing bend is accompanied by a rise in the width of intercostal furrows that is maximum in the axis of the largest bend of the ribs. On smaller valves, terminal marginal ribs concentrate in the terminal apex. On larger valves, this trend is rather disturbed because adult ribs at the outer margin more and more accommodate to the outline of valves. The majority of valves do not reach the length of 10 mm.
Remarks: According to TRAUTH's diagnosis (1938) as well as according to GASIOROWSKI's pen-and-ink drawings (1962), right *L. sparsilamellosus* should be characterized by the presence of a narrow smooth border along the harmonic margin. Because we have not succeeded in finding it with the material under study, the species assignation is not unambiguous.
What is a characteristic feature of valves that are at our disposal is a variability in the course of ribs at juvenile and adulter stages of growth and an apparently less dense ribbing in the area of the bend of ribs as a result of widening the intercostal furrows. Moreover, the convergency of terminal ribs into the terminal apex very often occurs as seen especially in ZITTEL's illustration (1870, pl. 25, fig. 10). TRAUTH (1938) assigns ZITTEL's valve into the synonymy of *L. sparsilamellosus*.
Distribution: According to TRAUTH (1938), the typical representatives of *L. sparsilamellosus* occur in the whole Upper Jurassic of the Alpine area and in the deposits of the adjacent Jura platform as well.
Occurrence: Valves are characteristic of the Oberalm-Formation in the Gutrathsberg section (late Tithonian) and partially of the deposits in the Woerndl Quarry (early/middle Berriasian). They occur only sporadically in the Rettenbacher Quarry.

Plate 14

Fig. 1: *Punctaptychus punctatus seranonoides* TURCULET 2x; spec. Kol-11, Wallinger Quarry at St. Koloman, Oberalm-Formation, uppermost Tithonian.
Fig. 2: *Punctaptychus punctatus divergens* TRAUTH 1x; spec. Pu-1/3, Rieger Quarry at Puch, Oberalm-Formation, middle/late Tithonian.
Fig. 3: *Punctaptychus monsalvensis* TRAUTH 1x; spec. LB98-b/11,85, Gutrathsberg Quarry, lower level, Schrambach-Formation, early/middle Berriasian.
Figs. 4, 5: *Punctaptychus cinctus* TRAUTH Fig. 4 – 2x, spec. LB98-Sch/1, Gutrathsberg Quarry, uppermost level, debris of the Schrambach-Formation, middle Berriasian; Fig. 5 – 3x, spec. LB98-Abs/1, Gutrathsberg Quarry, lower level, debris of the Schrambach-Formation, late Berriasian.
Fig. 6: *Punctaptychus punctatus seranonoides* TURCULET 1x; spec. Kol-19, Wallinger Quarry at St. Koloman, Oberalm-Formation, uppermost Tithonian.
Fig. 7: *Lamellaptychus* cf. *undulatus* (STOPP.) 2x; spec. LB98-Ob/1, Gutrathsberg Quarry, Oberalm-Formation, uppermost Tithonian.
Fig. 8: *?Lamellaptychus beyrichi* (OPPEL) 3x; spec. Kol-28, Wallinger Quarry at St. Koloman, Oberalm-Formation, uppermost Tithonian.
Fig. 9: *Lamellaptychus trauthi* RENZ & HABICHT 2x; spec. LB-r/4, Gutrathsberg Quarry, upper level, uppermost part of the Lower Roßfeld-Formation, late Valanginian.
Fig. 10: *Lamellaptychus mortilleti mortilleti* (PICTET et LORIOL) 2x; spec. LB98-ro/1, Gutrathsberg Quarry, upper level, Lower Roßfeld-Formation, early Valanginian.
Figs. 11, 12: *Lamellaptychus mendrisiensis mendrisiensis* RENZ & HABICHT Fig. 11 – 2x, spec. LB-r/3; Fig. 12 – 3x, spec. LB-r/1, the same localization as with Fig. 9 .
Fig. 13: *Lamellaptychus mendrisiensis undulocostatus* n. ssp. 3x; spec. LB98-ros/2, the same localization as with Fig. 9.
Fig. 14: *Lamellaptychus symphysocostatus* TRAUTH 3x; spec. LB-r/6, the same localization as with Fig. 9.
Photos: K. Mezihoráková, Ostrava University. All figured specimens were coated with ammonium chloride before photographing.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Lamellaptychus submortilleti TRAUTH 1938
Pl. 13, Fig. 8

1938 *Lamellaptychus sub-mortilleti* n. n. f. typ.; TRAUTH, p. 143, pl. 10, fig. 23, non figs. 24, 25
1994 *Lamellaptychus submortilleti* TRAUTH; VAŠÍČEK et al.; p. 71, pl. 23, fig. 5 (cum syn.)

Material: Three incompletely preserved valves (spec. Woe98/5, 9, Woe-1).
Description: Valves of small to medium size, flat or vaulted, or with an indicated keel but without any lateral depression. All ribs run subparallelly to the outline of valves so that the prevailing majority of them end at the harmonic margin. Closely to the harmonic margin, the ribs deflect suddenly to the terminal apex.
Remarks: This, to a considerable degree variable, species is usually conceived considerably non-uniformly. The valve illustrated by TRAUTH (1938, pl. 10, fig. 23) is regarded as a type specimen, whereas the other specimens illustrated by TRAUTH can be assigned rather to the group of *L. sparsilamellosus* (GUEMBEL). Mostly small valves depicted in KÄLIN et al. (1979) that are designated, with regard to the course of juvenile ribs that are subparallel to the harmonic margin, as *L. submortilleti* do not belong to the mentioned species either.
Distribution: According to occurrences in the Western Carpathians (VAŠÍČEK et al., 1994; ELIÁŠ et al., 1996), *L. submortilleti* occurs primarily in the early Berriasian.
Occurrence: *L. submortilleti* is reliably known merely from the abandoned Woerndl Quarry at St. Koloman, Oberalm-Formation (early/middle Berriasian).

Lamellaptychus symphysocostatus TRAUTH 1938
Pl. 14, Fig. 14

1994 *Lamellaptychus symphysocostatus* (TRAUTH); VAŠÍČEK et al., p. 77, pl. 24, figs. 2, 3 (cum syn.)

Material: The only, rather corroded valve (spec. LB-r/6).
Description: A small valve with an indicated keel. Ribs subparallel to the outline of the valve, are, closely to the harmonic margin, bent back to the apex. The harmonic facet is denticulated.
Remarks: In addition to the back bend of ribs, a speciality of the given species is a crenulate harmonic facet.
Distribution: RENZ & HABICHT (1985) state the Valanginian without closer specification from southern Switzerland. VAŠÍČEK et al. (1994) state the upper part of the early Valanginian of the Central Carpathians in Slovakia (Campylotoxus ammonite zone).
Occurrence: Upper level of the Gutrathsberg Quarry, uppermost part of the Lower Roßfeld-Formation (late Valanginian).

Lamellaptychus cf. *undulatus* (STOPP.)
Pl. 14, Fig. 7

1938 *Lamellaptychus undulatus* (STOPP.); Trauth, p. 175, pl. 12, fig. 16

Material: The single, considerably incomplete and rather corroded valve (spec. LB98-Ob/1).
Description: Slightly vaulted valve of medium size without any keel and lateral depression. Very thin ribs probably run subparallelly to the outline of the valve. In the whole area that is closer to the harmonic margin, ribs are finely undulated.
Remarks: By the total course of ribbing, the studied valve is most related to *L. aplanatus* (GILLIÉRON) that, however, has non-undulated, smooth ribs. The undulation of ribs is close to that of *L. undulatus*. The type specimen of this rare, little known and problematic species, however, is about five-times larger than the imperfectly preserved Alpine valve. Ribs of the former valve, however, tend to the harmonic margin at a smaller angle (about less than 60°).
Distribution: TRAUTH (1938) states the late Jurassic limestones from the Lombardian Alps.
Occurrence: Lower level of the Gutrathsberg Quarry, Schrambach-Formation (uppermost Tithonian).

Lamellaptychus mendrisiensis undulocostatus n. ssp.
Pl. 14, Fig. 13

Material: The single complete valve that is a holotype of the above mentioned subspecies (spec. LB98-ros/2).
Diagnosis: The valve with a keel and a lateral depression. Ribs between the keel and the harmonic margin converge obliquely to the harmonic margin. Close before reaching it, the ribs undulate severalfold.
Description: The valve of medium size with a well developed keel and a lateral depression. In the depression, ribs distinctly bend in an inflectional way. In the area between the keel and the harmonic margin ribs are slightly arcuated to sublinear in the long section. In the vicinity of the harmonic margin, the ribs then severalfold undulate, namely in combination with radial lines that run obliquely from the apex. The higher number of adult ribs (5-6) end at the outer margin.
Measurement: The valve reaches the length of 14 mm and the height of 6.8 mm.
Remarks: The basic course of ribs corresponds to that of typical representatives of *L. mendrisiensis* RENZ & HABICHT 1985. However, a complicated course of ribs in the surroundings of the harmonic margin represents a subspecies difference.
Distribution: *L. mendrisiensis*, more specifically, *L. m. mendrisiensis* is, according to RENZ & HABICHT (1985), known from the late Valanginin of Switzerland. According to VAŠÍČEK et al. (1994) it is known from the Western Carpathians of Slovakia from the late Valanginian and maybe also from the early Hauterivian (?). In the Outer Carpathians (Czech Republic) it occurs in the deposits at the early/late Valanginian boundary.
Occurrence: Gutrathsberg Quarry, Lower Roßfeld-Formation - underlying bed of the dark Upper Roßfeld-Formation (late Valanginian).

3.3. Dinoflagellate Cysts

3.3.1. Methods

Mineral components of samples were removed using concentrated HCl and HF. The residue was sieved in the ultrasonic apparatus by means of a 15 µm sieve. When it was necessary, heavy liquid separation was used to remove remaining mineral components. Microscopic slides were prepared by embedding the material in glycerine jelly. The samples were qualitatively analysed for their dinocyst content. All materials are stored at the Institute of Geological

Engineering, VŠB-Technical University of Ostrava (Czech Republic).

3.3.2. Taxonomic Section

For author's references of the taxa mentioned in the present study, see LENTIN & WILLIAMS (1993). A selection of taxa is depicted on Plates 10-12. Sizes of the specimens, preparation slide numbers (LB – Gutrathsberg Quarry, Re – Rettenbacher Quarry; numbers represent sample codes) and England Finder coordinates are indicated.

The following taxa are determined. Numbers in parentheses refer to the position of the species in the distribution chart of the Gutrathsberg Quarry or Rettenbacher Quarry. A zero indicates that the species is absent from that particular locality.

Achomosphaera neptunii (EISENACK, 1958) DAVEY & WILLIAMS, 1966 (24, 44; Plate 10, Fig. 3)
Adnatosphaeridium caullerii (DEFLANDRE, 1938) WILLIAMS & DOWNIE, 1969 (13, 0)
Amphorula delicata VAN HELDEN, 1986 (21, 10; Plate 11, Fig. 6)
Amphorula metaelliptica DODEKOVA, 1969 (46, 39; Plate 11, Figs. 1, 13)
Aprobolocysta spp. DUXBURY, 1977 emend. DUXBURY, 1980 (0, 48)
Atopodinium prostatum DRUGG, 1978 emend. MASURE, 1991 (0, 20)
Batioladinium reticulatum STOVER & HELBY, 1987 (75, 0)
Biorbifera johnewingii HABIB, 1972 (39, 0)
Bourkidinium granulatum MORGAN, 1975 (7, 0)
Bourkidinium sp.1 of LEEREVELD, 1995 (82, 0)
Cannosphaeropsis spp. O. WETZEL, 1932 (38, 0)
Chlamydoporela nyei COOKSON & EISENACK, 1958 (60, 0)
Circulodinium brevispinosum (POCOCK, 1962) JANSONIUS, 1986 (71, 0; Plate 11, Fig. 2)
Circulodinium distinctum (DEFLANDRE & COOKSON, 1955) JANSONIUS, 1986 (36, 0; Plate 10, Fig. 9)
Cleistosphaeridium spp. DAVEY et al., 1966 (23, 0)
Cometodinium habibii MONTEIL, 1991 (12, 26; Plate 10, Fig. 12)
Cribroperidinium spp. NEALE & SARJEANT, 1962 (37, 0)
Ctenidodinium cf. *elegantulum* MILIOUD, 1969 (0, 11)
Ctenidodinium elegantulum MILIOUD, 1969 (32, 8; Plate 10, Fig. 5)
Ctenidodinium ornatum (EISENACK, 1935) DEFLANDRE, 1938 (6, 1)
Cyclonephelium compactum DEFLANDRE & COOKSON, 1955 (30, 0)
Cyclonephelium spp. DEFLANDRE & COOKSON, 1955 (78, 21)
Cymososphaeridium validum DAVEY, 1982 (79, 0; Plate 4, Fig. 12)
Dapsilidinium duma (BELOW, 1982) LENTIN & WILLIAMS, 1985 (73, 0)
Dapsilidinium laminaspinosum (DAVEY & WILLIAMS, 1966) LENTIN & WILLIAMS, 1981 (0, 42)
Dapsilidinium warrenii (HABIB, 1976) LENTIN & WILLIAMS, 1981 (58, 0; Plate 10, Fig. 7)
Diacanthum hollisteri HABIB , 1972 (42, 30)
Dichadogonyaulax bensonii MONTEIL, 1992 (59, 41; Plate 10, Fig. 6)
Dichadogonyaulax spp. SARJEANT, 1966 emend. SARJEANT, 1975 (0, 12)
Dingodinium cerviculum COOKSON & EISENACK, 1958 emend. MEHROTRA & SARJEANT, 1984 (0, 27)
Dissiliodinium globulus DRUGG, 1978 (0, 49)
Endoscrinium campanula (GOCHT, 1959) VOZZHENNIKOVA, 1967 (31, 0; Plate 12, Fig. 1)
Endoscrinium galeritum (DEFLANDRE, 1938) VOZZHENNIKOVA, 1967 (0, 18)
Exiguisphaera phragma DUXBURY, 1979 (47, 0)
Exochosphaeridium muelleri YUN, 1981 (25, 0; Plate 12, Fig. 11)
Florentinia cf. *radiculata* (DAVEY & WILLIAMS, 1966) DAVEY & VERDIER, 1973 (80, 0)
Foucheria modesta MONTEIL, 1992 (0, 46)
Fromea cylindrica (COOKSON & EISENACK, 1960) STOVER & EVITT, 1978 (67, 0; Plate 12, Fig. 6)
Gonyaulacysta centriconnata RIDING, 1983 (68, 0)
Gonyaulacysta cretacea (NALE & SARJEANT, 1962) SARJEANT, 1969 (64, 0; Plate 12, Fig. 5)
Gonyaulacysta diutina DUXBURY, 1977 (53, 0)
Gonyaulacysta exsanguia DUXBURY, 1977 (0, 43)
Gonyaulacysta helicoidea (EISENACK & COOKSON, 1960) SARJEANT, 1966 (43, 5)
Gonyaulacysta jurassica (DEFLANDRE, 1938) NORIS & SARJEANT, 1965 (27, 28)
Gonyaulacysta spp. DEFLANDRE, 1964 (11, 25)
Hystrichodinium pulchrum DEFLANDRE, 1935 (65, 0; Plate 12, Fig. 4, 7)
Hystrichosphaeridium petilum GITMEZ, 1970 (9, 0)
Hystrichosphaerina schindewolfii ALBERTI, 1961 (77, 0; Plate 11, Fig. 4)
Hystrichostrongylon membraniphorum AGELOPOULOS, 1964 (3, 0)
Kiokansium unituberculatum (TASCH, 1964) STOVER & EVITT, 1978 (35, 0)
Kleithriasphaeridium corrugatum DAVEY, 1974 (54, 0)
Kleithriasphaeridium eoinodes (EISENACK, 1958) DAVEY, 1974 (55, 0; Plate 12, Fig. 3)
Kleithriasphaeridium fasciatum (DAVEY & WILLIAMS, 1966) DAVEY, 1974 (56, 0)
?Leptodinium mirabile KLEMENT, 1960 (0, 40)
Muderongia longicorna MONTEIL, 1991 (57, 0; Plate 11, Figs. 8, 9)
Muderongia macwhaei COOKSON & EISENACK, 1958 (74, 0)
Muderongia neocomica (GOCHT, 1957) LENTIN & WILLIAMS, 1993 (50, 0)
Muderongia simplex ALBERTI, 1961 (20, 0)
Muderongia spp. COOKSON & EISENACK, 1958 (0, 31)
Muderongia tabulata (RAYNAUD, 1978) MONTEIL, 1991 (19, 47; Plate 10, Fig. 11; Plate 11, Fig. 10)
Nannoceratopsis ambonis DRUGG, 1978 (61, 6; Plate 11, Fig. 11)
Nannoceratopsis gracilis ALBERTI, 1961 (4, 22; Plate 10, Figs. 1, 2)
Nannoceratopsis triceras DRUGG, 1978 (0, 13)
Nelchinopsis kostromiensis (VOZZHENNIKOVA, 1967) WIGGINS, 1972 (0, 23)
Neuffenia willeii BRENNER & DÜRR, 1986 (14, 14)
Nexosispinum vetusculum (DAVEY, 1974) DAVEY, 1979 (90, 0)
Occisucysta balios GITMEZ, 1970 (1, 0)
Oligosphaeridium complex (WHITE, 1842) DAVEY & WILLIAMS, 1966 (86, 0; Plate 12, Fig. 2)
Oligosphaeridium dividuum WILLIAMS, 1978 (87, 0)
Oligosphaeridium perforatum (GOCHT, 1959) DAVEY & WILLIAMS, 1969 (83, 0)
Oligosphaeridium poculum JAIN, 1977 (66, 0; Plate 11, Fig. 14)
Pareodinia spp. DEFLANDRE, 1947 (41, 0)
Pareodinia trinetron (SARJEANT, 1966) BELOW, 1990 (62, 0)
Prolixosphaeridium granulosum (DEFLANDRE, 1937) DAVEY et al., 1966 (52, 15)
Prolixosphaeridium mixtispinosum (KLEMENT, 1960) DAVEY et al., 1969 (2, 33)
Prolixosphaenidium sp. A of MONTEIL (1993) (10, 4; Plate 11, Fig. 7)

Prolixosphaeridium spp. DAVEY et al., 1966 (33, 0)
Protoellipsodinium spinosum DAVEY & VERDIER, 1971 (85, 0)
Pseudoceratium gochtii NEALE & SARJEANT, 1962 (84, 0)
Pseudoceratium pelliferum GOCHT, 1957 (72, 50; Plate 11, Fig. 5)
Pterodinium cingulatum (O. WETZEL, 1933) BELOW, 1981 (91, 0)
Rigaudella aemula (DEFLANDRE, 1938) BELOW, 1982 (48, 0)
Senoniasphaera jurassica (GITMEZ & SARJEANT, 1972) LENTIN & WILLIAMS, 1973 (8, 0)
Sentusidinium spp. SARJEANT & STOVER, 1978 (16, 0)
Spiniferites ramosus (EHRENBERG, 1838) MANTELL, 1854 (76, 34; Plate 12, Fig. 8)
Spiniferites spp. MANTELL, 1850 (89, 38)
Surculosphaeridium ?vestitum (DEFLANDRE, 1938) DAVEY et al., 1966 (34, 0)
Systematophora areolata KLEMENT, 1960 (5, 9; Plate 11, Fig. 15)
Systematphora cf. *areolata* KLEMENT, 1960 (0, 2)
Systematophora complicata NALE & SARJEANT, 1962 (22, 35; Plate 10, Fig. 4)
Systematophora cretacea DAVEY, 1979 (63, 0)
Systematophora orbifera KLEMENT, 1960 (0, 17)
Systematophora palmula DAVEY, 1982 (18, 0)
Systematophora cf. *palmula* DAVEY, 1982 (0, 29)
Systematophora penicillata (EHRENBERG, 1843) SARJEANT, 1980 (28, 3)
Systematophora cf. *penicillata* (EHRENBERG, 1843) SARJEANT, 1980 (17, 0)
Systematophora scoriacea (RAYNAUD, 1978) MONTEIL, 1992 (29, 36)
Systematophora silybum DAVEY, 1979 (44, 0; Plate 12, Fig. 9)
Systematophora spp. KLEMENT, 1960 (88, 32)
Tanyosphaeridium boletus DAVEY, 1974 (40, 0; Plate 10, Fig. 10)
Tanyosphaeridium isocalamus (DEFLANDRE & COOKSON, 1955) DAVEY & WILLIAMS, 1969 (49, 19)
Tanyosphaeridium sp. DE of BRIDEAUX (1977) (69, 0; Plate 11, Fig. 3)
Tehamadinium dodekovae JAN du CHèNE et al., 1986 (0, 37)
Tehamadinium evittii (DODEKOVA, 1969) JAN du CHèNE et al. in JAN du CHèNE et al., 1986 (15, 7; Plate 10, fig. 8)
Tehamadinium sousence (BELOW, 1981) JAN du CHèNE et al. in JAN du CHèNE et al., 1986 (81, 0)
Tehamadinium cf. *sousense* (BELOW, 1981) JAN du CHèNE et al. in JAN du CHèNE et al., 1986 (51, 0)
Tehamadinium spp. JAN du CHèNE et al. in JAN du CHèNE et al., 1986 (45, 0)
Tenua hystrix EISENACK, 1958 (70, 0)
Tubotuberella spp. VOZZHENNIKOVA, 1967 (0, 16)
Valensiella magna (DAVEY, 1974) COURTINAT, 1989 (0, 24)
Wallodinium krutzschii (ALBERTI, 1961) HABIB, 1972 (26, 0)

The following species require further comments:
Aprobolocysta spp. DUXBURY, 1977, p. 52; emend. DUXBURY, 1980, p. 721

Remarks: The single and badly preserved specimen does not allow a definite assignment of species.

Bourkidinium sp. 1 of LEEREVELD (1995), p. 412

Remarks: Forms here assigned to this species are comparable to the specimen depicted as *Bourkidinium* sp. 1 in LEEREVELD, 1995 (pl. 10, fig. d). The observed species are characterized by a smooth body surface, 10-30 hollow, slender, distally open processes which are distally flared or simple.

Cribroperidinium spp. NEALE & SARJEANT, 1962, p. 443

Remarks: No attempt has been made to distinguish forms of *Cribroperidinium* because of the strong integrading nature of the characteristic features.

Ctenidodinium cf. *elegantulum* MILIOUD, 1969, p. 427

Remarks: This form differs from *Ctenidodinium elegantulum* by having reticulate surface ornamentation.

Dichadogonyaulax spp. SARJEANT, 1966, p. 153; emend. SARJEANT, 1975, p. 50

Remarks: Apart from identifying *D. bensonii* no attempt has been made to distinguish *Dichadogonyaulax* species, because of the strong integrading nature of the characteristic features.

Gonyaulacysta spp. DEFLANDRE, 1964, p. 5030

Remarks: This group include a few representatives, which are however too badly preserved for identification of species.

Florentinia cf. *radiculata* (DAVEY & WILLIAMS, 1966) DAVEY & VERDIER, 1973, p. 191

Remarks: The single specimen does not allow a definite assignment to the species.

Muderongia spp. COOKSON & EISENACK, 1958; emend. MONTEIL, 1991, p. 470-471

Remarks: This group includes the few representatives, which are however too badly preserved for identification of species.

Pareodinia spp. DEFLANDRE, 1947, p. 4

Remarks: The single and badly preserved specimen does not allow a definite assignment to the species.

Prolixosphaeridium sp. A of MONTEIL (1993) (Plate 11, Fig. 7)
Remarks: Dinocysts included into this species have features comparable with the species described as *Prolixosphaeridium* sp. A in MONTEIL 1993 (pl. 1, fig. 6). The observed species are characterized by large size (80-95 µm in length), numerous and relatively short processes (approx. 1/3 of the body) which are equal in length.

Prolixosphaeridium spp. DAVEY et al., 1966, p. 171

Remarks: Apart from identifying *Prolixosphaeridium granulosum, P. mixtispinosum* and *P.* sp. A no attempt has been made to distinguish *Prolixosphaeridium* species, because of the strong integrading nature of the characteristic features.

Spiniferites spp. MANTELL, 1850, p. 191

Remarks: Apart from the identification of *S. ramosus* no attempt has been made to distinguish morphologically closely related and highly variable species of *Spiniferites.*

Systematophora cf. *areolata* KLEMENT, 1960, p. 62-65

Remarks: The specimens from the Rettenbacher section differs from *S. areolata* by having shorter processes.

Systematophora cf. *palmula* DAVEY, 1982, p. 11-12

Remarks: The single specimen found does not show clearly the processes composition. They are damaged in many cases.

Systematophora spp. KLEMENT, 1960, p. 61-62

Remarks: This group include a few representatives, which are however too badly preserved for the identification of species.

Tanyosphaeridium sp. DE of BRIDEAUX (1977) (Plate 11, Fig. 3)

Remarks: Forms here assigned to this species are comparable to the specimen depicted as *Tanyosphaeridium* sp. DE in BRIDEAUX, 1977 (pl. 14, fig. 5). This type is a thin-walled with granular surface and smooth processes up to 55 or more in number. The processes are 10–15 μm long, tubiform, hollow, open distally and with slightly flared margins.

Tehamadinium cf. *sousense* (BELOW, 1981) JAN du CHèNE et al. in JAN du CHèNE et al., 1986, p. 353

Remarks: Forms assigned to this taxon only resemble *T. sousence* in their overall morphology (archeopyle type, position, paratabulation, surface morphology). The few specimens encountered in this study are poorly preserved and do not allow a definite species assignment.

Tehamadinium spp. JAN du CHèNE et al. in JAN du CHèNE et al., 1986, p. 352

Remarks: The single and badly preserved specimen does not allow a definite assignment of species.

Tubotuberella spp. VOZZHENNIKOVA, 1967, p. 179-180

Remarks: The single and badly preserved specimen does not allow a definite assignment of species.

4. Conclusions

Two sections and three other localities are described in detail that, in many directions, broaden the hitherto known facts concerning the lithology, facies, content of fossils and biostratigraphy of deposits of the uppermost Jurassic and Lower Cretaceous in the southern surroundings of Salzburg. Stratigraphic data rest mainly upon the content of calpionellids. Only in the Valanginian deposits, or the deposits of the late Berriasian, i. e. where calpionellids are missing, their role is taken over by non-calcareous dinocysts. The dinocysts were studied in the given region probably for the first time. As far as macrofaunas are concerned, ammonites are almost wholly missing and aptychi usually form only a supplementing stratigraphical component.

The most complete section through the Lower Cretaceous deposits that follow the Upper Jurassic deposits having the thickness of almost 100 m we obtained on the uppermost two levels in the Gutrathsberg Quarry at Gartenau. The Oberalm-Formation, the Schrambach-Formation and the Roßfeld-Formation outcrop here. The upper part of the Oberalm-Formation begins with the basal breccia that indicates a rapid commencement of sedimentation. The breccia and calcareous deposits of the mentioned formation belong to the late Tithonian (Crassicollaria Zone, Intermedia Subzone). Deposits of the Oberalm-Formation are considerably poor in stratigraphically significant fossils. The boundary between the Oberalm-Formation and the overlying Schrambach-Formation is lithologically and stratigraphically difficult to determine. The increasing share of the marly component in the uppermost part of the Oberalm-Formation is continuous; stratigraphically significant calpionellids continue to be very sporadic. According to our results, we place the base of the overlying Schrambach-Formation taking the greatest part of the examined sequence of strata into the Late Tithonian, into the underlying layers of the first more numerous occurrence of representatives of the genus *Crassicollaria.* Pelagic marly-calcareous deposits of the Schrambach-Formation then start in the Crassicollaria Zone, most probably in the upper part of the Intermedia Subzone. REHÁKOVÁ et al. (1996) put the boundary between both the formations merely to the upper parts of the Alpina Subzone (Calpionella Zone).

Overlying layers of the deposits with crassicollarians have again no stratigraphically significant fossils. The situation changes only in the upper Berriasian, when *Calpionella elliptica* appears. It indicates the Middle Berriasian, the subzone of the same name in the framework of the Calpionella Zone.

The Upper Berriasian is evidenced by calpionellids of the Calpionellopsis Zone (Simplex and Oblonga Subzones). Along the boundary between the middle and late Berriasian, a lithologically very conspicuous layer of red marlstones occurs in the sequence of strata. Some authors (PLÖCHINGER, 1980, REHÁKOVÁ et al., 1996) designate the upper part of the Schrambach-Formation as the Anzenbach-Schichten or the lower Roßfeld-Formation. Variegated deposits on the base of them belong to the late Berriasian, Calpionellopsis Zone. REHÁKOVÁ et al. (1996) arrive at similar conclusions.

From the Berriasian, sedimentation continues as the Lower Roßfeld-Formation (from early Valanginian up to the base of the late Valanginian). The age of this part of the sequence of strata is evidenced by non-calcareous dinocysts and partially by aptychi. WEIDICH (1990) presents, based on KAISER-WEIDICH's determination (p. 53), the Calpionellites Zone.

From the microfacial point of view, the oldest part of the Schrambach-Formation pertains to crassicollarian-calpionellid biomicrite. The lower Berriasian is represented by the radiolarian and radiolarian-sponge microfacies. In the upper part of the Schrambach-Formation, the presented microfacies fade out and silty and sandy fractions of quartz occur increasingly in the Lower Roßfeld-Formation.

In the beginning of the late Valanginian, the sedimentation of the Lower Roßfeld-Formation was suddenly ended by the emergence of wildflysch of the Roßfeld-Formation, in which, with the exception of stratigraphically significant dinocysts, no fossils were found. WEIDICH (1990) states a rich occurrence of foraminifers in sandy marlstones of the Upper Roßfeld-Formation. In his opinion, the foraminifers prove, at least partly, the Hauterivian age. HRADECKÁ (in EGGER et al. 1997) comes to similar conclusions.

The whole studied sequence of strata in the Gutrathsberg Quarry is tectonically strongly affected. A part of the deposits shows shaly character; three main dislocation systems can be recognized. Dip-slip thrust faults inclining conformably with the direction of the dip of strata manifest themselves most markedly here. By repetition of the sequence of strata they increase apparently the thickness of pelagic deposits of the Schrambach-Formation, namely especially of the middle and late Berriasian. Dislocations normal to the bedding are primarily faults with a negligible length of movement. This is above all obvious in the western part of the quarry, where a lithologically varied contact of the Lower Roßfeld-Formation with the Upper Roßfeld-Formation is exposed in the face.

The Oberalm-Formation was studied in detail in the section in the Rettenbacher Quarry supplemented by the study of localities at St. Koloman and Puch (Mathias Wallinger and Toni Rieger Quarries). In these localities, the Oberalm-Formation is morphologically markedly different from deposits outcropping in the Gutrathsberg Quarry. Marly deposits interbedding marly limestones are greenish grey. Intercalations of calciturbidites designated as Barmstein-Limestones are another different component.

The uppermost part of the Oberalm-Formation is well exposed in the Toni Rieger Quarry at Puch. The basal parts of the quarry correspond to the Chitinoidella biozone (Boneti Subzone), i. e. the higher part of the middle Tithonian. In the higher part of the sequence, the Barmstein-Limestones dominate. BODROGI (in LOBITZER et al., 1994b) states rich foraminifers, calcareous algae and microproblematics in the Barmstein-Limestone of the T. Rieger Quarry and assigns them as of Berriasian age.

In the Mathias Wallinger Quarry, similar deposits outcrop. The study of Calpionellid proves the Crassicollaria biozone, Colomi Subzone of uppermost Tithonian age.

Almost in the same stratigraphic position as in the Wallinger Quarry, deposits are exposed also in the section of the Rettenbacher Quarry. Dinocysts were studied here as well that yielded results in accordance with conclusions obtained by studying the calpionellids. The Jurassic deposits in the studied section pass continuously into the Lower Cretaceous Calpionella Zone, Alpina Subzone. The following Ferasini Subzone has not been proved (as in the equivalent deposits of the Gutrathsberg section). The middle Berriasian is documented by the zone species *Calpionella elliptica*. The highest part of the Calpionella Zone, i. e. Longa Subzone, is not documented by calpionellids. With the emergence of Barmstein-Limestones, the calpionellids fade away, however, dinocysts provide additional stratigraphic data. According to them, the upper part of the section pertains to the late Berriasian (Boissieri ammonite zone that is equivalent to the Calpionellopsis calpionellid zone). The uppermost part of the section is formed by the Barmstein-Limestones. It means that these limestones reach, from the stratigraphical point of view, considerably higher up in the Rettenbacher Quarry than was expected, i. e. even to the uppermost Berriasian, maybe even to the early Valanginian.

In the Woerndl Quarry, marly-calcareous deposits are not accompanied by any Barmstein-Limestone intercalations. Their lithological composition indicates an other type of the Oberalm-Formation. The calpionellid association indicates the Berriasian Calpionella Zone. As far as index fossils are concerned, only *Calpionella elliptica* is present seldom in the thin sections, which indicates the middle Berriasian. However, according to aptychi, it can be also judged that the early Berriasian is present as well, so that most probably deposits of the early/middle Berriasian boundary outcrop in this quarry.

The Oberalm-Formation in the area of St. Koloman shows in contrast to the locality of Gutrathsberg, a different lithological development and a different stratigraphic span. Whereas in the Gutrathsberg section, deposits of the Oberalm-Formation pass continuously to the marly Schrambach-Formation already in the upper part of the late Tithonian, the Oberalm-Formation in the surroundings of St. Koloman with numerous layers of Barmstein-Limestones unambiguously continue even to the late Berriasian.

Altogether, it can be summarized that in the submitted contribution occurrences of calpionellids are correlated with those of non-calcareous dinoflagellates and partially with those of aptychi. In the deposits in which no calpionellids have been preserved, non-calcareous dinocysts play a guide role. However, it follows from the detailed observation that considerable redeposition of calpionellids and as well of dinocysts is obvious in many places in the deposits studied. This fact has to be kept in mind studying pelagic limestones of Upper Jurassic-Lower Cretaceous age.

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