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Early Norian Scleractinian Corals and Microfacies Data of the Dachstein Limestone of Feisterscharte, Southern Dachstein Plateau (Northern Calcareous Alps, Austria)

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Steiermark
Nördliche Kalkalpen
Trias
Norium
Korallen
Mikrofazies

Contents

Unternorische Korallen (Scleractinia) und Mikrofaziesdaten aus dem Dachsteinkalk der Feisterscharte (Südliches Dachsteinplateau, Nördliche Kalkalpen, Österreich)

Zusammenfassung

Zum ersten Mal wird über eine unternorische Korallenfauna aus den Nördlichen Kalkalpen berichtet. Die Korallen führenden Kalke stammen aus dem Umfeld der Feisterscharte am südlichen Dachstein-Plateau. Unternorische Korallen wurden auch auf der Nordostseite des Gosaukammes gefunden. Das Vorkommen der Feisterscharte zeigt nun eine der bisher taxonomisch diversesten unternorischen Korallen-Vergesellschaftungen. Karnische Gattungen herrschen zahlenmäßig vor, die unternorischen Index-Arten *Pachysolenia cylindrica* und *Pachydendron microthallos* sind häufig. Das unternorische Alter ist durch mehrere Conodontenfaunen gut belegt.

Ergänzend werden einige Daten zur Mikrofazies und zu den Foraminiferen des Riffkalkes und begleitender Gesteine präsentiert. Die Gesteine der Feisterscharte repräsentieren das initiale Wachstumsstadium der norisch-rhätischen Dachsteinkalkplattform.

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Abstract

This is the first report concerning an Early Norian coral fauna from the Northern Calcareous Alps. The coral-bearing limestones outcrop in the vicinity of the Feisterscharte, in the southern Dachsteinplateau. In this Alpine region, aside from the Dachsteinplateau, Early Norian corals have been recorded only from the Gosaukamm range, which is also part of the Dachstein massif. The exposures at Feisterscharte show one of the most taxonomically diversified Early Norian coral assemblages known so far. In the assemblage, Carnian genera are prevailing in number, and Early Norian index species, *Pachysolenia cylindrica* and *Pachydendron microthallos*, are frequent. The Early Norian age is proofed by conodonts.

Some remarks on microfacies and foraminifera content of the reef and associated limestones are given. The rocks represent the initial growth stage of the Norian to Rhaetian Dachstein carbonate platform.

1. Introduction

In the Dachstein area Upper Triassic Dachstein reef limestone is well known from the Gosaukamm (SCHLAGER, 1967; WURM, 1982) and from the Grimming (BÖHM, 1986, 1988); see also FLÜGEL et al. (1996). These spectacular mountains represent remnants of the reef rim of the huge Dachstein carbonate platform. Deep erosion reveals at a few localities reef limestones below a thick sequence of lagoonal carbonates of the platform interior. These reefs and associated limestones represent the early growth stage of the Dachstein platform following the intra-Carnian regression. They have been found in the course of the geological mapping of map sheet GÖK 127 Schladming (MANDL & MATURA, 1995).

The material was collected by Harald LOBITZER and Gerhard W. MANDL in the years 1987 and 1989. The bulk of samples were collected in outcrops located 50–100 m around the Feisterscharte.

The collection contains 33 rock fragments with corals. Coral skeletons are completely recrystallized, but faint traces of original microstructure are preserved in places.

The collection is housed in the collections of the Geologische Bundesanstalt in Vienna, Austria under the inventory number 2007/152/0001 ff.

2. Geological Overview

The karstified Dachstein plateau represents a part of the Austrian sector of the Triassic shallow shelf, bordering the deep Hallstatt shelf of the Tethys Ocean. Along the southern platform margin transitions from the thick sequence of Middle to Late Triassic platform carbonates into slope and basinal limestones are locally preserved (SCHLAGER, 1966, 1967a,b; LEIN, 1976; WURM, 1982; MANDL, 1984a,b, 2001; REJMER, 1991).

Carbonate sedimentation has started in the Anisian, after the siliciclastic Lower Triassic Werfen Formation – see Text-Fig.1. Wetterstein platform carbonates became widespread in Middle Triassic times, prograding over adjacent basins during Ladinian to Early Carnian. Typical sedimentary features are reef breccias, platform derived massive to bedded allodapic limestones and distal carbonate turbidites. Secondary dolomitization has affected large parts of the platform carbonates, especially the lagoonal interior. Resedimentation of dolomitic components within the slope sediments indicates a very early dolomitization.

During the Early Carnian sea level drop ("Reingraben event" [SCHLAGER & SCHÖLLNBERGER, 1975; HORNUNG et al., 2007]) the platform emerged. Frame building organisms (mainly calcisponges) became restricted to a narrow belt (Leckkogel facies of the Reingraben Group) along the former Wetterstein platform slope, their detritus can be found within adjacent dark limestones and shales (FLÜGEL et al., 1978.) As suggested by facies distribution and age data of superimposing strata the emerged platform has been exposed to remarkable erosion, creating a relief of several 10 meters.

Sea level rise in the Late Carnian led at first to lagoonal conditions (Waxeneck Limestone) in local depressions of the eroded Wetterstein platform. Local coeval reefs seem to be hidden in recrystallized dolomites with a few „ghosts" of frame building organisms, e.g. at the lower part of Mt. Bischofsmütze – Gosaukamm.

In the latest Tuvalian a distinct transgressive pulse led to widespread pelagic conditions, covering the drowning platform. The persisting seafloor relief caused a complex pattern of local reef patches, separated by depressions, where massive, often micritic limestones have been deposited. They exhibit a mixture of components from the platform interior (ooids, oncoids, porostromate algae and dasycladaceans), of reef debris, crinoids and pelagic biogenes (ammonoids, halobiids and "filaments", radiolarians and conodonts); microfacies see next chapter.

This initial stage of Dachstein platform growth has been terminated by rapid progradation of lagoonal limestones, the reefs became concentrated at the platform margin. The open platform situation changed into a rimmed platform configuration, characteristic for the Dachstein facies during Middle Norian to Rhaetian and exposed e.g. at Gosaukamm and Grimming.

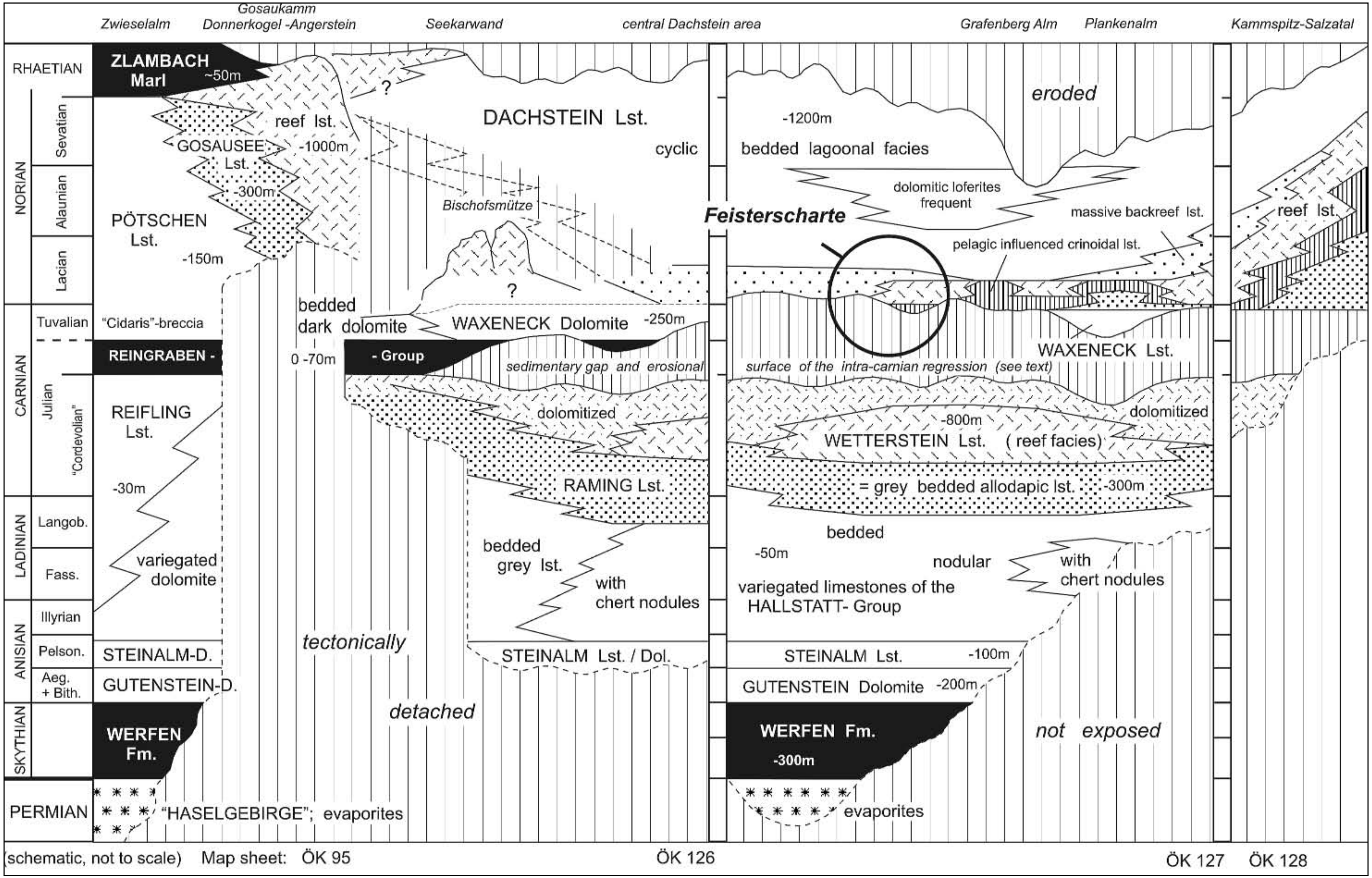
Pelagic intercalations within the reef debris enables dating by conodonts; see Text-Fig. 2:

A few reddish dolomite beds at the base of the Dachstein limestone northeast of Guttenberghaus have yielded the Carnian species *Metapolygnathus polygnathiformis* (BUD. & STEF.). About 60 meters higher according to LEIN (1987) the samples L81, L82 have yielded *Epigondolella primitia* MOSHER, indicating an Earliest Norian age (Lacian 1). A sample about 130 meters higher on the path to Mt. Sinabel summit contains an association of *Epigondolella triangularis* (BUDUROV) and *Norigondolella navicula* (HUCKRIEDE), indicating Lacian 2. The same fauna was found in similar position on the NE side of Mt. Eselstein (D 10, M. SCHAUER, pers. comm.). Near to the transition into a massive backreef facies *Epigondolella* cf. *multidentata* MOSHER (sample 89/03) indicates Middle Norian (Early Alaunian).

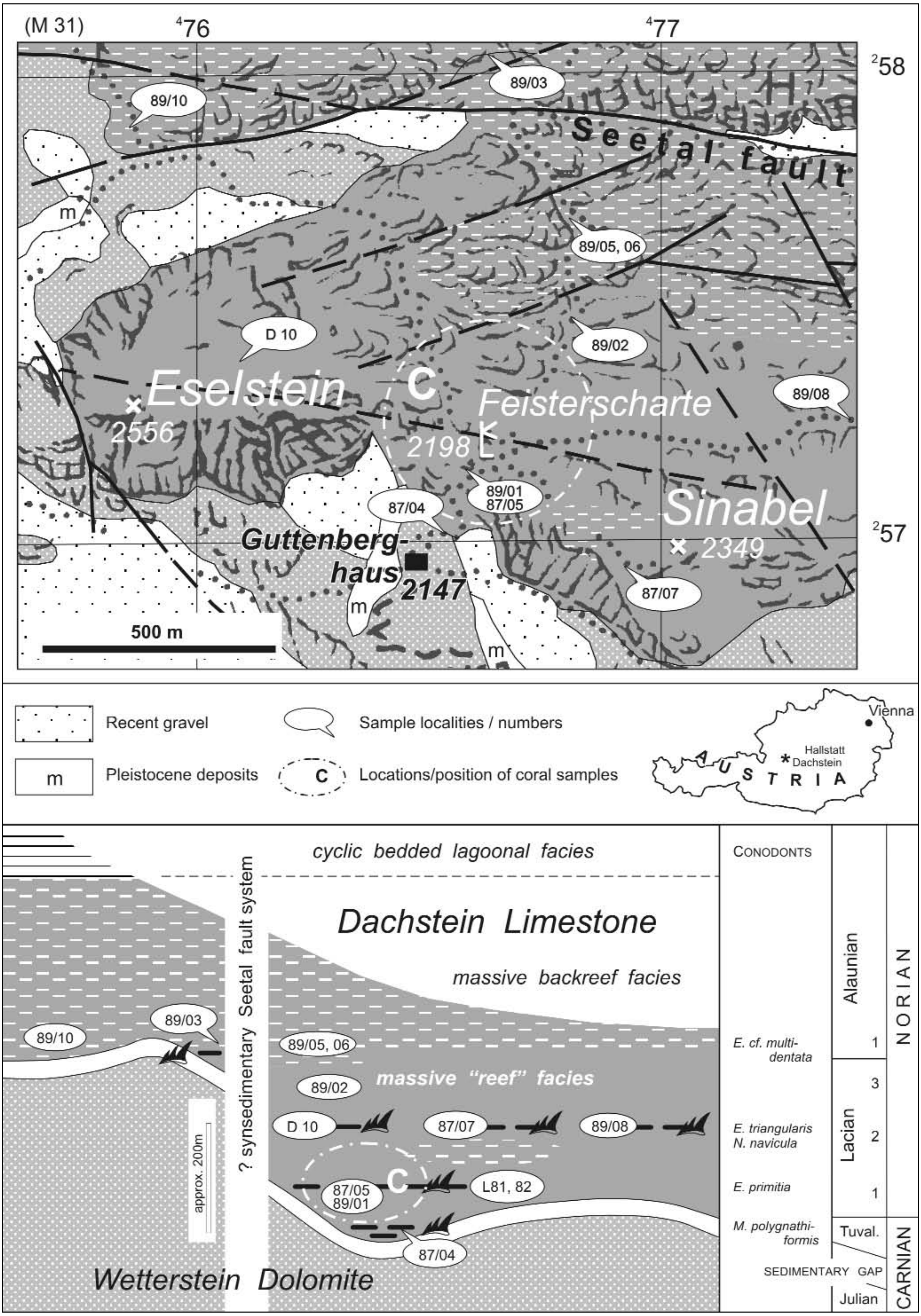
3. Microfacies

Although sampling concentrated on the massive „reef-facies", thin section analysis revealed the very inhomogenous character of these sediments. But due to the massive character of the rocks under consideration it is impossible to elaborate a detailed sedimentological scheme in terms of facies progradation/retrogradation. In our material sediments of the reef-detritus facies are dominant, followed by those of the proximal back-reef facies, whereas representatives of the biolithit-facies are rare. The most scarce, but nevertheless most interesting facies is represented by the intercalations of pelagic sediments. Due to the short duration of these intervals and their transgressive character they are predominantly mixed with "reef"-derived components.

This fits to the field observations of small scaled coral patches within limestones with mixed lagoonal to pelagic components.



Text-Fig. 1.
Triassic stratigraphy of the Dachstein nappe, according to MANDL (2000).



Text-Fig. 2.
Geological sketch map and stratigraphic scheme of the Feisterscharten area.

3.1. Transgressive Facies (T)

T1 – Pelagic Sediment

T1.1. Filament Biomicrite (Wackestone)
(Plate 1, Fig. 1)

The pure pelagic sediment consists of very finegrained biomicrites rich in tiny filaments, whereas also echinodermal remains, ostracodes, microproblematica (*Muranella sphaerica*) and foraminifera occure. The latter exhibit very small involutinid foraminifera (see below). The matrix containes small globular bodies (up to 30 micron in diameter) that could represent calcareous nannoplancton (? *Prinsiosphaera* sp.).

T2 – Mixed Types

T2.1. Coquina Facies
T2.1.1. Pelecypod Biosparite (Rudstone)

Up to several cm long, thick shells of Pelecypods are more or less densely packed. The strongly winnowed umbrella-porosity is filled by radiaxial-fibrous cements, sparry calcite or an micrite-calcite alternation.

STANTON & FLÜGEL (1989, p.125 f.) report similar shell-beds from the Rhaetian Steinplatte "Reef" in a slope environment.

T2.1.2. Halobiid Biomicrite/-sparite (Floatstone)
(Plate 1, Fig. 2)

In this facies-type the mollusc shells are set in a micritic to microsparitic matrix. Cementation of the intraparticle porosity is by far not so intensive as in the above mentioned facies-type.

In sample 89-08 the matrix (pelagic sediment, see above) consits of tiny shell debris, pelecypod debris, echinodermal remnants, sponge-spicula, foraminifera and abundant microproblematica (*Muranella sphaerica*). The latter are up to 1mm in diameter and are built of a mostly micritic nucleus followed by up to 3 generations of radial calcite fibres. Further hints for a syn- or early postdepositional supersaturation with respect to calciumcarbonate is given by miliolid foraminifera that are encrusted by tiny radial cement or thick cemented seams.

Allochthonous microproblematica are further represented by *Baccanella floriformis, Thaumatoporella parvovesiculifera, Aeolisaccus dunningtoni* and broken specimen of *Radiomura cautica* and *Baccanella irregularis*.

The foraminifera-fauna contains *Textularia* sp., *Tetrataxis* sp., *Palaeolituonella meridionalis* (LUPERTO, 1965), *Planiinvoluta carinata, Ophthalmidium carinatum, O. leischneri, O. triadicum, Aulotortus sinuosus*, very small individuals of *Trocholina multispira, Semiinvoluta clari* and *Planispirillina* sp. Of special interest is the finding of *Praepatellina pilleri* and *Licispirella bicarinata*. Both species are up to now only known from the Lower Liassic (e.g. BLAU, 1987a, b).

In sample 89/01/5 the foram- and microproblematica content is strongly reduced, whereas peloids, strongly recrystallized mollusc and echinoderm debris are more common as above.

T2.2. Allodapic Limestones
T2.2.1. Bioclastic Biosparite with Lithoclasts (Rudstone)
(Plate 1, Fig. 3)

This facies type comprises rudstones, embedded in sediments (filament biomicrite) typical for the transgressive pulses. Lithoclasts derived from the pellet-mud- and grapestone-facies are rare, but prove the erosion of distal backreef areas. These regions must have been in contact to the deeper water environment, probably via channels. More common are bioclasts, (echinoderms, thick shelled bivalve debris, foraminifera, dasyclad algae, framebuilders derived from the reef, and very rare ammonoidea). The depositional upper surfaces of the shedding events are irregular. Their texture is characterized by coarse-tail grading, due to different hydrodynamic behavior of the bioclasts.

T2.2.2. Echinoderm-Mollusc Biomicrite with Lithoclasts (Floatstone)

Up to 3 cm large angular to subangular lithoclasts (Biopelmicrites/-sparites, Grainstones, Packstones) are embedded together with coral and sponge debris in a reddish-yellowish matrix rich in Halobiids, echinoderm and tiny shelled bivalve debris.

This facies type is connecting the densely packed allodapic limestones (see above) and the coquina facies.

3.2. "Reef"- and "Reef"-Detritus Facies (R)

R1 – Coral Biomicrite to -sparite (Bafflestone)

(Plate 1, Figs. 4,5)

The porosity between densely spaced corals is mostly filled by a biopelsparitic to -micritic, partly graded sediment. Large cavities are filled by several generations of radiaxial and/or blocky calcite cements. The degree of encrustation is intermediate to high. Besides rarer microbial ("spongiostromate") crusts, Bryozoa and foraminifera (*Alpinophragmium perforatum, Tolypammina* sp., *Calcitronella, Planiinvoluta carinata* sp.), the microproblematica *Tubiphytes*, ? *Pycnoporidium eomesozoikum, Radiomura cautica* and *Lamellitubus cauticus* are rather common. The latter, together with *A. perforatum* may be dominant.

R2 – Coral, Sponge Biomicrite to -sparite (Floatstone)

(Plate 1, Fig. 6)

This MF-type is characterized by the frequent detritus of frame-building organisms (corals, calcisponges, Hydrozoa).

Encrusting organisms are serpulid worms, *Bacinella* sp., *Pycnoporidium eomesozoikum, Tubiphytes* sp., *Lamellitubus cauticus* and rare ataxophragmiid foraminifera. The matrix contains echinodermal remains, *Microtubus communis, Baccanella floriformis*, gastropods, pelecypods, *"Cayeuxia"* sp., and broken Dasycladales. In some samples several cm long and thick voids are filled by radiaxial-fibrous and sparry calcitic cement.

3.3. Backreef facies (B)

B1 – Biosparite with Grapestone Lumps (Rudstone, Rarely Grainstone)

(Plate 1, Fig. 7)

The poorly sorted bioclasts and grapestones are embedded in a blocky calcite. The porostromate algae of the *"Cayeuxia"*-typus together with specimen of the *Epimastopora/Epimastoporella*-group are common. Thick-shelled bivalve debris, gastropods and echinoderms are also characteristic. Bryozoans, microproblematica (*Lamellitubus cauticus, Pycnoporidium ? eomesozoicum*) and rare debris of calcicponges also occures and document a near-reef position. Duostominid foraminifera as well as the genera *Agathammina, Trochammina* and *Reophax* together with encrusting forms (*Tolypammina gregaria, Nubecularia* sp.) are common. Involutinids (*Aulotortus sinuosus*) are rare.

Of special interest are subangular, partly dolomitized micritic lithoclasts.

Fine-grained types of this sediment (grainstones with pellets) lack reefal influence and are therefore deposited in a more distal environment (e.g. sample 89-01-7).

B2 – Biopelmicrite with Rivualriaceans
(Plate 1, Fig. 8)

Colonies of *"Cayeuxia"* sp. with a size up to 2 cm are growing in a biopelmicritic sediment with abundant birdseyes and shrinkage pores. Biomolds are abundant. The rare foraminifera are represented by the genera *Aulotortus* and *Quinqueloculina*.

These sediments seem to have been deposited in very shallow water.

3.4. Remarks on the Foraminifera Fauna

Foraminifera of the Norian Dachstein reefs have been investigated in detail by WURM (1982; Gosaukamm) and BÖHM (1986; Grimming). Unfortunately the stratigraphic control of their samples is only very general. The bulk of the Gosaukamm reef limestone is of Middle Norian to Rhaetian age, dated by conodonts (SCHAUER, 1983). Later on at a few places Early Norian fauna have been found (M. SCHAUER, pers. comm.) in RONIEWICZ (1996). The Grimming is also dated as Middle Norian to Rhaetian (BÖHM, 1986).

Our material from Feisterscharte/Dachstein is well dated by conodonts as exclusively Early Norian. Most foraminifera taxa reported from Gosaukamm and Grimming have been found in our samples too. Only the characteristic genera *Galeanella* and *Lituosepta* are missing here till now. They are reported as common to frequent in association with S*igmoilina, Quinqueloculina* and *Ophthalmidium* in cavities of the central reef facies. They can be also found as allochthonous components in carbonate turbidites of the adjacent distal slope (MANDL, 1984a). Their missing in the Early Norian samples may indicate a stratigraphic restriction to Middle and Late Norian. Further research of Late Triassic reefs should take into account this possibility.

Triasina hantkeni MAJZON, in general used as an indicator for Rhaetian age, has also been found in one of our samples. This finding together with Early Norian rocks has to be seen carefully. The sample may origin from an erratic block of Rhaetian Dachstein limestone, ice-transported during the Pleistocene glaciation.

4. General Features of the Coral Fauna

The assemblage is constituted of corals of various morphology: lamellate, massive, and branched built of parallel corallites, i.e., of phaceloid type. Colonies of the two former types do not attain considerable size, their height and diameters being limited most frequently to few centimeters. The dimensions of the latter, in contrast, frequently may be estimated in decimeters. The phaceloid corals show epithecal walls. In same rocks, colonies are crumbled, in others, even phaceloid corals are complete.

The term "assemblage" as used in the text has no ecological connotations. It corresponds to the term 'fauna', and embraces all coral taxa found in the limestones fragments.

The estimated number of coral taxa is 26, the majority having been identified to the generic level (Table 1) and some to species level. Despite recrystallization, the skeletons show enough traces of the original microstructure to be classified into three microstructural groups from the four groups known in the Triassic. The groups are diagnosed by the particular microstructure of septa and wall, and are named after their diagnostic features as follows:

I. pachythecal corals.
II. minitrabecular corals.
III. thick-trabecular corals.
IV. fascicular or non-trabecular corals (for characteristics see Appendix).

The microstructural groups answer to the following suborders, respectively:

I. Pachythecaliina ELIÁSOVÁ, 1975
II. Caryophylliina VAUGHAN & WELLS, 1943
III. a group containing families from the Archaeocoeniina ALLOITEAU, 1952 and Microsoleniina MORYCOWA & RONIEWICZ, 1994 (earlier Fungiina VERRIL, 1865)
IV. Stylophyllina BEAUVAIS, 1981. In the examined fauna, the stylophylline corals are missing. This is a group, which is poorly represented in the Carnian (VOLZ, 1896), not recorded in the Early Norian, but flourishing in marly facies of the Rhaetian (RONIEWICZ. 1989).

Stratigraphical distribution of genera which have been identified

Table 1.
Coral genera from the Early Norian Dachstein limestone of Feisterscharte, and their distribution in the Tethyan domain.
Large characters + mark genera of a dominating role; small + mark a minor role of the taxon.
Geographical distribution of genera after CUIF, 1975a,b,c, 1976; MELNIKOVA, 1986, 1996; RAMOVS & TURNSEK, 1984, 1991; RONIEWICZ, 1989, 1992, 1996; TURNSEK & BUSER 1989; TURNSEK & RAMOVS 1987; TURNSEK et al., 1982; VOLZ, 1896.

Coral genera at Feisterscharte/Dachstein	Number of species	Localities					Stratigraphic Age			
		Dolomites	Taurus	Julian Alps	Gosaukamm	Pamirs	Carnian	Early Norian	Late Norian	Rhaetian
I. Pachythecal group										
1. *Pachydendron*	1	-	+	+	-	+	-	**+**	+	-
2. *Pachysolenia*	1	-	+	-	-	+	-	**+**	-	-
II. Minitrabecular group										
3. *Volzeia*	1	+	-	+	?	+	+	-	-	-
4. *Retiophyllia*	3	-	+	+	+	+	+	+	**+**	**+**
5. *Cuifia*	1	-	-	-	+	+	-	+	+	+
6. *Margarophyllia*	1	+	-	+	-	-	**+**	-	-	-
7. *Margarosmilia*	3	+	+	+	+	-	**+**	+	-	+
8. *Thamnomargarosmilia*	1	-	-	-	-	+	-	+	-	-
9. *Craspedophyllia*	1	+	-	+	-	+	**+**	-	-	-
10. *Procyclolithes*	1	-	-	+	+	-	-	-	-	+
11. *Astraeomorpha*	1	+	-	+	+	+	+	+	**+**	**+**
III. Thick-trabecular group										
12. *Tropiphyllum*	1	-	+	-	-	-	-	+	-	-
13. *Thamnasteriamorpha*	4	+	-	-	-	+	+	-	+	+
14. *Conophyllia*	1	+	-	+	-	+	**+**	-	-	-

in the Dachsteinplateau (Table 1) point to the particular feature of this assemblage, i.e., its transitional character between Carnian and Late Norian-Rhaetian faunas.

In the assemblage, the only so far determined species, i.e., *Pachydendron microthallos* CUIF, 1975 and *Pachysolenia cylindrica* CUIF, 1975, have been known exclusively from the Lower Norian (CUIF, 1975; MELNIKOVA, 1986). Due to their distribution in distant geographical points: the Alps, the Taurus Mountains and the Pamirs, the both species may be considered as index fossils for the Lower Norian, at least in the Tethyan province. Typical Carnian genera are *Margarophyllia, Margarosmilia, Craspedophyllia* and *Conophyllia* (compare VOLZ [1896], MELNIKOVA [1986], TURNSEK et al. [1982], RAMOVS & TURNSEK [1984], TURNSEK & BUSER [1989]), besides, recorded also in the Carnian/Lowermost Norian beds in Hydra Island (TURNSEK & SENOWBARI-DARYAN, 1994). From among mentioned genera only *Margarosmilia*, the most diversified in the Carnian (3 species), continued to the Rhaetian (1 species: RONIEWICZ [1989]); the whole stratigraphic range of similar *Thamnomargarosmilia* MELNIKOVA, 1996 rest unknown. In contrast, Astraeomorpha is known throughout the whole Upper Triassic, while Cuifia have been recorded only in the Norian and Rhaetian. The earliest and so far a unique Carnian find of Retiophyllia was described from the Tuvalian of Perbla, NW Slovenia (TURNSEK et al. 1987); the genus is typical of the Norian–Rhaetian interval (RONIEWICZ, 1989).

5. Early Norian Coral Assemblages in the World

In the Tethyan ocean realm, Early Norian coral finds are rare, in contrast to the Late Norian. Paleontological literature records only four regions with well documented stratigraphically Early Norian corals. These are the Taurus Mountains in Turkey, the Julian Alps, Hydra Island, the Pamir Mountains, and the Koriak Uplands (Koryakskiy Khrebet) at the North East of Russia. To this list, the present report adds two localities in the Dachstein region, Northern Calcareous Alps, i.e., southern Dachsteinplateau and Gosaukamm.

In the eastern Pacific region, Early Norian corals are known in a number of the North American terranes. That fauna, different from the Tethyan one, will be characterized in brief.

❍ **Taurus Mountains, Turkey**
The Turkish coral fauna, with its 21 species belonging to 19 genera, has been the only well preserved Early Norian assemblage described so far (CUIF, 1975a, b, c, 1976). It origins from the Alakir Çay Valley, between villages Karash and Dereköy (CUIF, 1977). This find is of special value as the skeletons are preserved in the original aragonite mineralogy. The corals appear in reefal boulders („Cipitkalk“ type), embedded in marly and silty deposits. The age of the finds was determined to be Kerri zone, based on cephalopods and *Halobia* (KRYSTYN [1986] in MARCOUX et al. [eds.]).
This Norian coral fauna is composed predominantly of Carnian genera and new short-liveing genera, *Pachythecalis, Pachysolenia* and *Pachydendron*. Specifically, it is completely different from the Carnian fauna. The growth forms are highly differentiated: more than a half of taxa represent massive colonies of all types, among them colonies of a high degree of integration (cerioid, meandroid, astreoid, thamnasterioid: compare COATES & OLIVER [1974], COATES & JACKSON [1987]), in the majority representing thick-trabecular Carnian genera. The remaining corals are phaceloid and solitary, mostly representing new genera. This fauna is microstructurally diversified, but non-trabecular corals are lacking.

❍ **Julian Alps**
Early Norian corals were found in two neighbouring mountain massives, Planja and Razor, and from the lower part of the reefal complex of the Tomiškova pot – Rusnata Mlinarica – Kot (TURNSEK & RAMOVS, 1987; RAMOVS & TURNSEK 1991). The fauna contains thirteen species showing an insignificant number of taxa in common with the Taurus Mountains (common nominal taxa, without formal revision). From Carnian genera, there are represented *Tropidendron, Craspedophyllia, Margarosmilia* and others. The assemblage contains chiefly minitrabecular corals, in the first place phaceloid. The skeletons are intensively recrystallized.

❍ **Gosaukamm**
Early Norian coral-bearing limestones crop out at the NE slopes of the Gosaukamm range. The corals, being at present under examination, were collected at the foot of Grosswand (site Eisgrube at Armkar) by M. SCHAUER, who also determined their stratigraphical position as the Lacian (published with permission in RONIEWICZ [1996: fig. 1], marked also in the collection). Only 6 coral species from 5 genera have been here differentiated (among others *Retiophyllia*, ? *Volzeia*), all phaceloid, mostly minitrabecular. Some of them are typical Carnian taxa, others are common taxa of Late Triassic range in general. In the Gosaukamm, like as in the southern Dachsteinplateau, the skeletons are intensively recrystallized.

❍ **Hydra Island**
Corals of Pantokrator limestone in the Hydra Island, of an age estimated as Carnian-Lowermost Norian, constitute a rich assemblage (TURNSEK & SENOWBARI-DARYAN [1994]: 24 species, 14 genera) showing strong Carnian relationships on the generic level, while problematic on the species level. Typical Norian-Rhaetian genera, such as *Coryphyllia* (or *Cuifia*), and *Palaeastraea*, co-occur with Carnian *Protoheterastraea, Margarophyllia* and so on. The fauna doesn't show any relationship with the Turkish one. The majority of taxa represents minitrabecular corals.

❍ **Pamirs**
In the South East Pamirs, Early Norian corals are known in the region of the Aktash Mountain, at the mouth of the Djilgakochusu Valley and at the mouth of the Karauldyndala Valley (MELNIKOWA, 1986, 1996). Only seven species of 6 genera have been described so far (*Pachysolenia, Pachydendron, Lubowastraea, Cerioheterastraea, Protoheterastraea, Thamnomargarosmilia*). Among them, at least two may be indicated as Early Norian index taxa (*Pachysolenia cylindrica* and *Pachydendron microthallos*). The assemblage contains phaceloid and lamellate corals of Carnian and/or Norian relationships, and pachythecal, minitrabecular and thick-trabecular microstructure. Surprisingly, the state of preservation is good enough for tracing general microstructural features, although the skeletons are recrystallized.

❍ **Koriak Uplands**
In the Kenkeren mountain range in Koriak Uplands, corals have been found on the bank of Triasovyi Stream falling into the Nutekingenkyveem River. Coral-bearing beds are situated at the top of Nutekinskaya series, in limestones estimated to be late Early Norian–early Middle Norian in age (MELNIKOWA & BYCHKOW, 1986). Nine coral genera represent two microstructural groups: minitrabecular (4 taxa) and thick-trabecular (5 taxa). Three genera are known to be typically Carnian: *Stuoresia, Thamnotropis* and *Beneckastraea*, the others range to the Rhaetian. Despite assignement of two forms to American species *Retiophyllia dawsoni* (CLAPP & SHIMER, 1911) and *Kuhnastraea cowichanensis* (CLAPP & SHIMER, 1911), and one to the Turkish species, *Palaeastraea granulata* CUIF,

1976, the actual relationships of the fauna is difficult to be established due to its poor state of preservation.

- **North America**
  Early Norian corals have been recorded in the Pilot Mts., Nevada; around the Lake Shasta region, California; in the Wallowa Mts. Oregon; on Gravina Island, Alaska (STANLEY, 1979). Corals are considered to be significant members of reefal associations and important rock-building elements. Taxonomical descriptions were given by SMITH (1927), MONTANARO-GALLITELLI et al. (1979), STANLEY (1979, 1986), STANLEY & WHALEN (1989). Unfortunately, destructive silicification makes examination of the skeleton structure and detailed taxonomical comparison with Tethyan fauna difficult. American assemblages, comprising more than 40 species, contain no Carnian elements and judging from their morphological and microarchitectural features, are similar to Late Norian corals from European assemblages (compare MONTANARO-GALLITELLI et al. [1979], STANLEY & WHALEN, 1989).

6. Conclusions

This brief review shows that the coral assemblage from the southern Dachsteinplateau belongs taxonomically to the most diversified finds in the western Tethys. It equals that from the Taurus Mountains, differing from it in ecological type. On Dachsteinplateau, as in the whole Alpine region and on Hydra Island, phaceloid and solitary growth forms prevail, while massiv colonies (cerioid, thamnasterioid) are of a minor significance: In the Taurus Mountains the situation is completely different (compare CUIF [1975a,b,c; 1976]).

Norian crisis

European and central Asian Early Norian assemblages comprise Carnian genera, differing in this from the Late Norian-Rhaetian assemblages (coral fauna of the Middle Norian have not been discriminated as a faunal entity as yet). This difference is a manifestation of the crisis the corals passed through in their history between Early Norian and later times in the whole Tethys. Lower Norian and Middle-Upper Norian coral-bearing limestones do not show any lithological difference that could justify the crisis by any changes in sea level. It is not the only catastrophic episode that has been marked in the Late Triassic, as a crisis somewhere in the Carnian is documented by collapses in the occurrence of other sea and land organisms (BENTON, 1986).

Same environmental changes must have influenced Late Triassic life in the sea and land by steps, and the reaction of different organic groups was different. Even among corals, not all genera were equally sensitive to the changes and a lot of genera survived and flourished in the Late Norian and Rhaetian. These are some opportunistic minitrabecular genera (*Retiophyllia, Distichophyllia, Cuifia, Astraeomorpha*), which, with non-trabecular stylophyllids, and few thick-trabecular corals (e.g., *Pamiroseris*), flourished up to the next crisis marking the Triassic/Jurassic boundary.

Early Norian Tethyan assemblages are so distinctive, as to have a stratigraphical value. The mentioned above difference between Early Norian Tethyan and East Pacific faunas, lying in a lack of Carnian elements in the East Pacific, is worthy of notice. This lack causes no distinct taxonomical difference between Early Norian and later North American coral faunas. In consequence, the stratigraphical role of North American Early Norian corals is not comparable to that of the Tethyan faunas.

Plate 1

Microfacies of investigated sediments

Fig. 1: Pelagic sediment, Microfacies T1.
Filament Biomicrite (Wackestone). The sediment consists of tiny filaments.
Sample 89/10; Scale bar: 0,5 mm.

Fig. 2: Coquina facies, Microfacies T2.1.2.
Halobiid-Biomicrite/ -sparite (Floatstone).
Sample 89/08; Scale bar: 2 mm.

Fig. 3: Allodapic limestone, Microfacies T2.2.
Shallow water derived detritus forms an irregular depositional surface and is overlain by filament biomicrites.
Sample 89/03-1; Scale bar: 5 mm.

Figs. 4,5: Reef facies, Microfacies R1.
Coral Biomicrite to -sparite (Bafflestone). Densely spaced corals baffle finegrained peloidal sediment, in which also microproblematica (*Radiomura cautica*; Fig. 4 center) occur. Large voids (Fig. 4) are filled by several generations of radiaxial fibrous to sparry calcite.
Fig. 4: Sample 89/02-1; Scale bar: 2 mm.
Fig. 5: Sample 89/8; Scale bar: 2 mm.

Fig. 6: Reef-detritus facies, Microfacies R2.
Coral-sponge-biomicrite to -sparite (Packstone, Floatstone). Coral detritus is encrusted by a bryozoa and a consortium of ? *Pycnoporidium eomesozoicum, Lamellitubus cauticus*, and *Tubiphytes morroensis*. Grapestones in the surrounding sediment reveal a backreef position.
Sample 87B/8; Scale bar: 2 mm.

Fig. 7: Backreef facies, Microfacies B1.
Biosparite with grapestone lumps (Rudstone/Grainstone). Besides diagnostic grapestone lumps Involutinids (*Aulotortus sinuosus*) and calcareous algae (*Epimastopora/Epimastoporella* and *Heteroporella*) occur.
Sample 87/8M; Scale bar: 1 mm.

Fig. 8: Backreef facies, Microfacies B2.
Biopelmicrite with Rivulariaceans. Mass occurrence of *"Cayeuxia"* sp.
Sample 89/10; Scale bar: 5 mm.

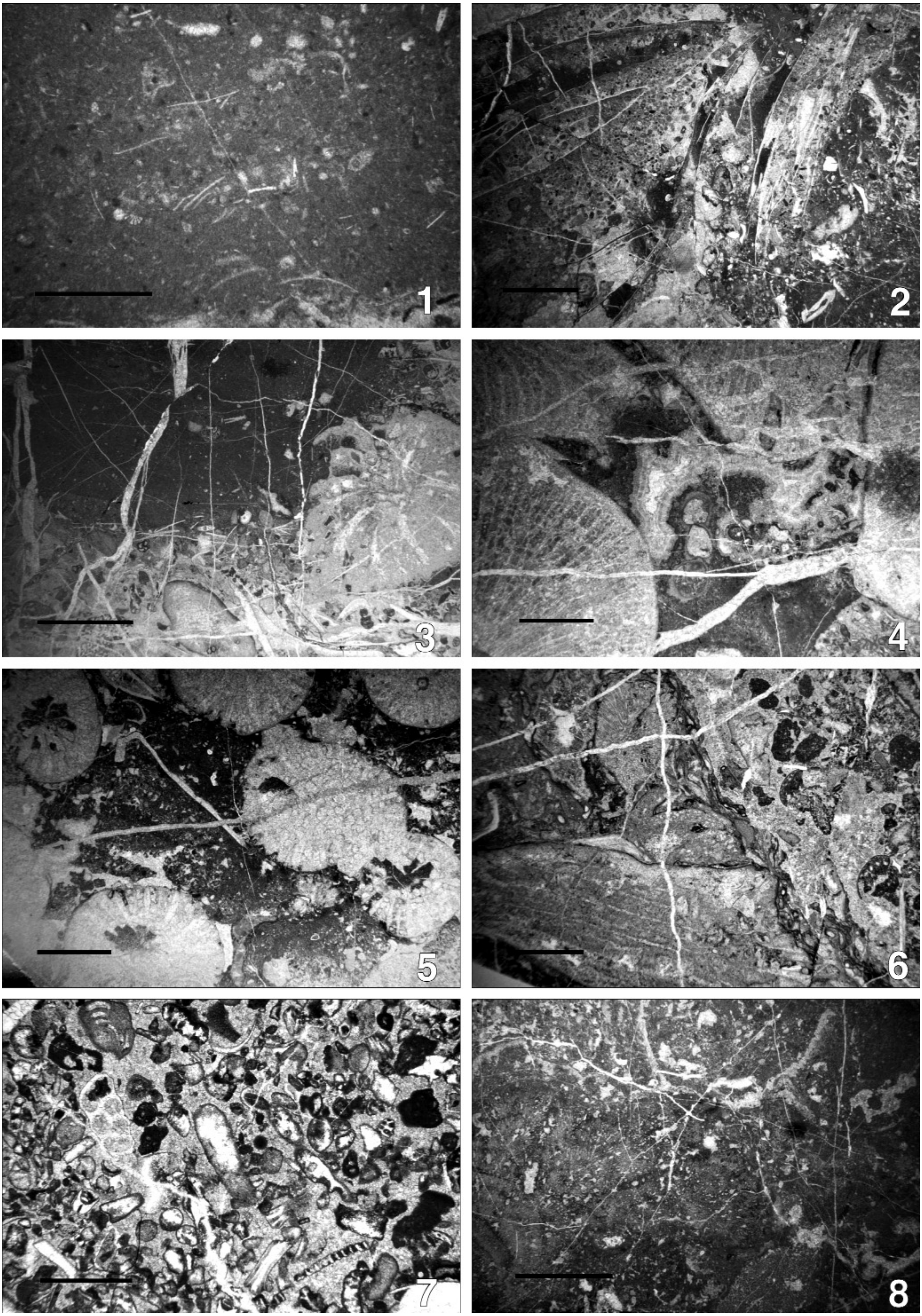

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Plate 2

Foraminifera and microproblematica of the Dachstein limestone

Fig. 1: *Reophax* sp, agglutinating other forams as *Quinqueloculina* sp.
Sample 89/03-1-4.
Scale bar: 0,1 mm.

Fig. 2: Mass occurrence of *Alpinophragmium perforatum* FLÜGEL.
Sample 87 A.
Scale bar: 2 mm.

Fig. 3: *Palaeolituonella meridionalis* (LUPERTO).
Sample 89/03-1-6.
Scale bar: 0,5 mm.

Fig. 4: *Triasina hantkeni* MAJSON.
Sample 87/A-2.
Scale bar: 0,2 mm.

Fig. 5: *Aulotortus sinousus* WEYNSCHENK.
Sample 127/6.
Scale bar: 0,2 mm.

Fig. 6: *Trocholina multispira* OBERHAUSER and *Trocholina* sp.
Sample 89/03-1-7.
Scale bar: 0,2 mm.

Fig. 7: *Trocholina gracilis* BLAU.
Sample 87/8-2.
Scale bar: 0,2 mm.

Fig. 8: ? *Turrispirillina altissima* PIRINI.
89/03-1-2.
Scale bar: 0,1 mm.

Fig. 9: *Bacanella floriformis* PANTIC.
Sample 89/8-1.
Scale bar: 0,2 mm.

Fig. 10: *Halocoryne* sp.
Sample 89/01-2.
Scale bar: 0,1 mm.

Fig. 11: *Pycnoporidium eomesozoicum* FLÜGEL and *Radiomura cautica* SENOWBARI-DARYAN & SCHÄFER.
Sample 89/09-1.
Scale bar: 1 mm.

Fig. 12: *Lamellitubus cauticus* OTT.
Sample 89/01-12.
Scale bar: 0,5 mm.

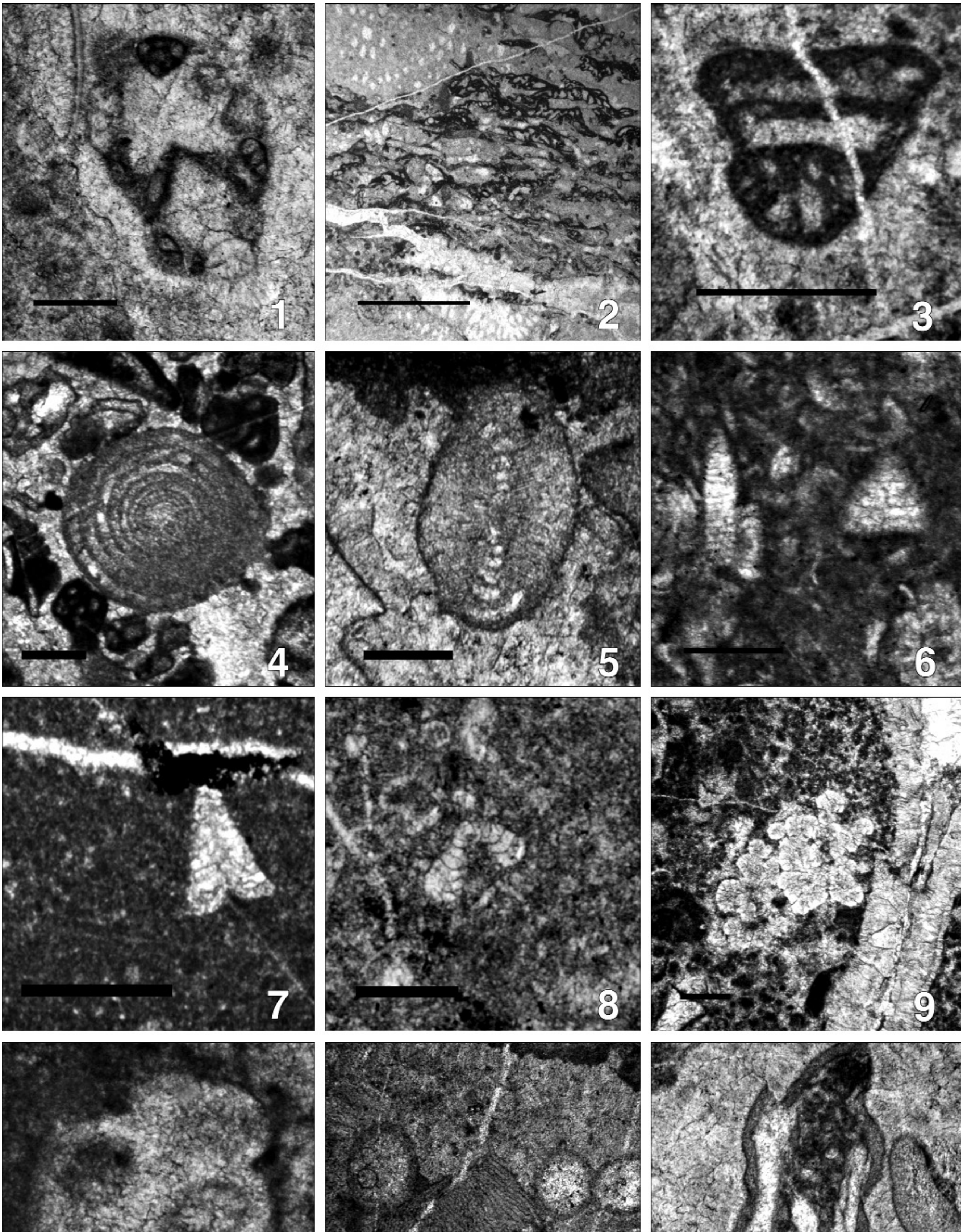
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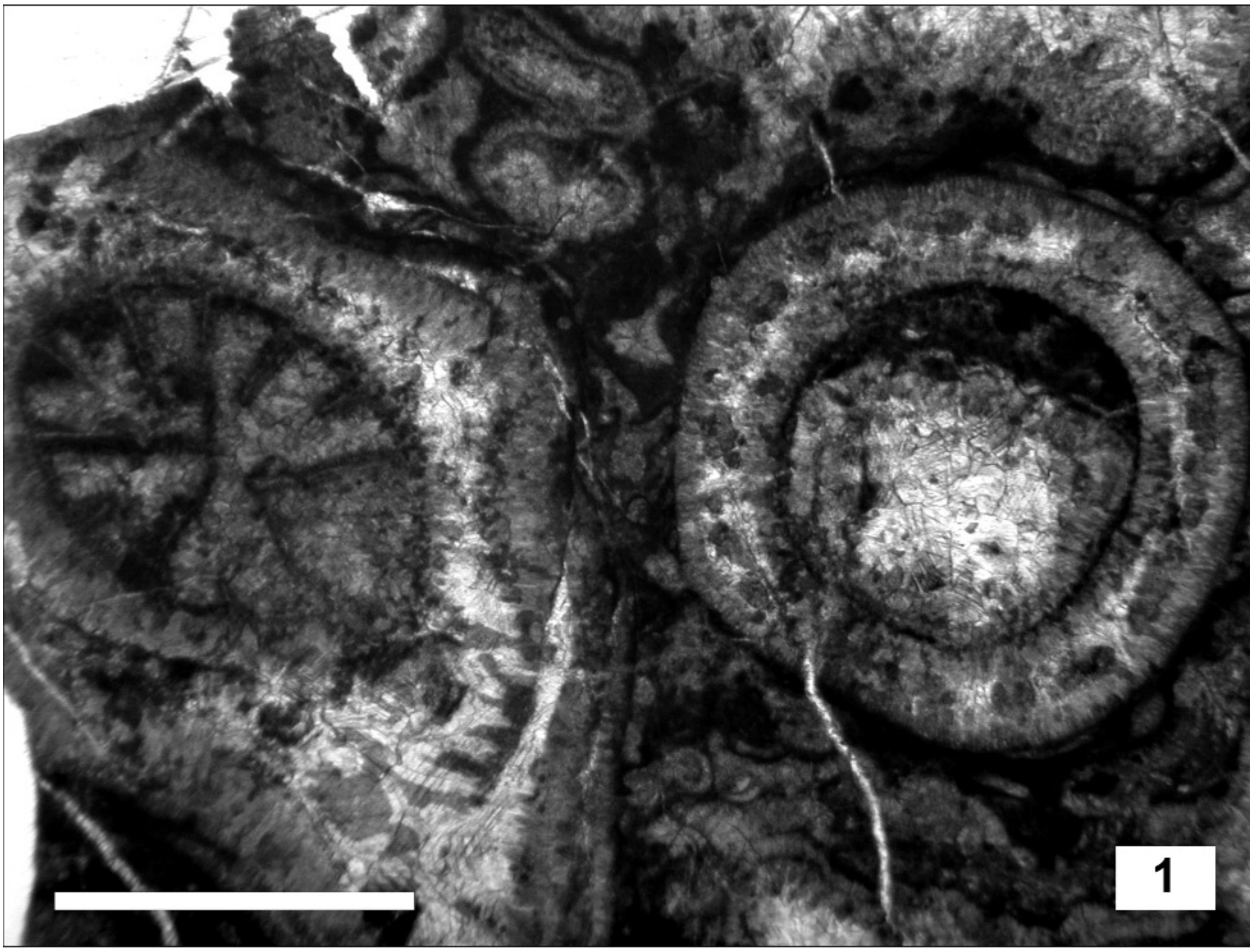
Plate 3

Early Norian index corals.

Fig. 1: *Pachysolenia cylindrica* CUIF, 1975.
Fragment of phaceloid corallum in transverse section; left corallite with thick, folded wall (pachytheca), and scanty septa, right corallite empty because the section pass through the distalmost part of the calice, lacking septa. Traces of modular wall microstructure recognizable as radial striation.
Feisterscharte, Dachsteinplateau, sample 89/01/14; leg. G.W. MANDL 1989.

Fig. 2: *Pachysolenia cylindrica* CUIF, 1975 and *Retiophyllia* sp (at lower right corner).
Transverse, slightly oblique section of the corallite showing well preserved modular microstructure of the wall; the modules are recognizable as striation when cut along their axes, or dots, when cut perpendicularly to the axes.
Early Norian, Alakir Çay, Turkey. ZPAL H XXI/2. Coll. Cuif.

Scale bars: 3mm.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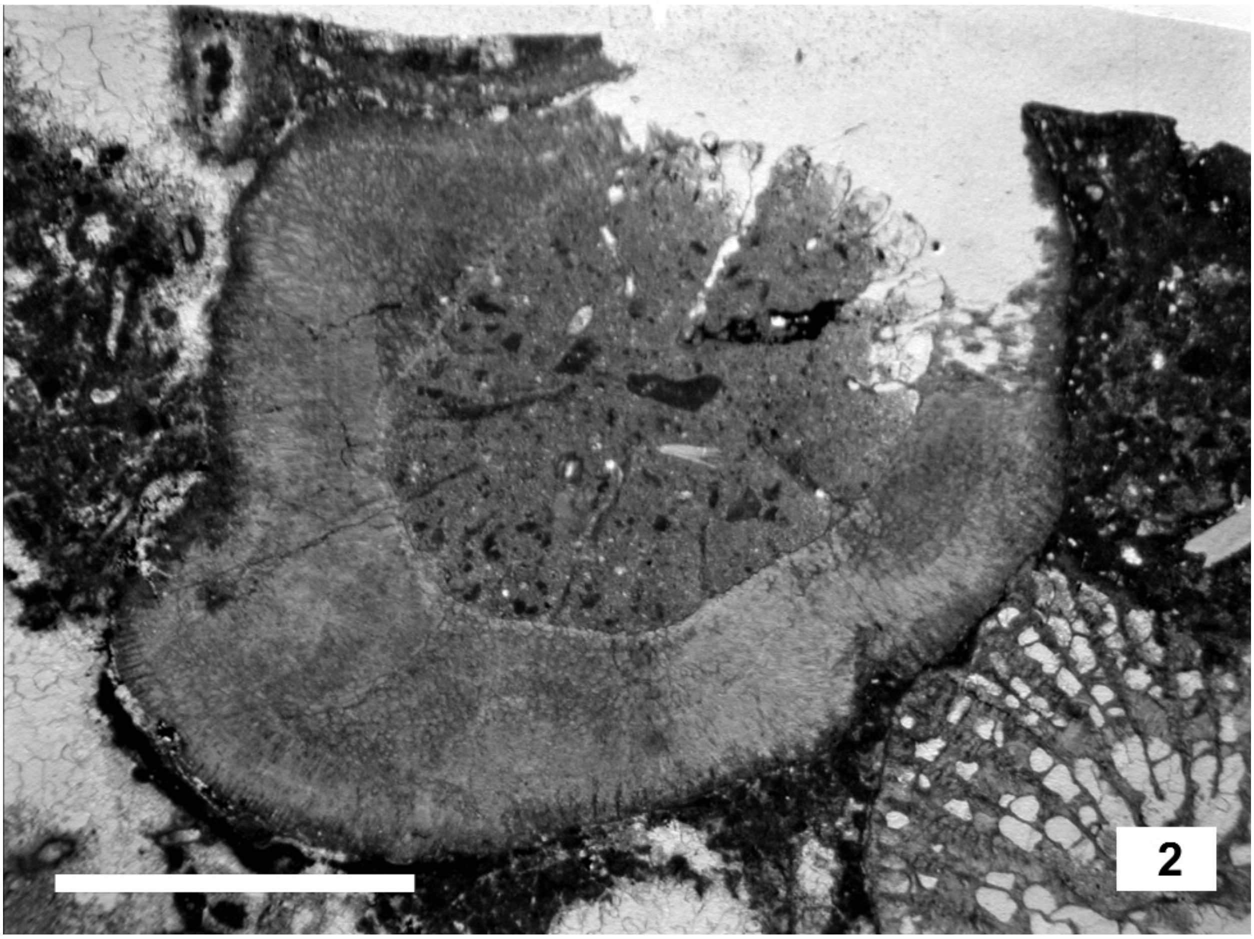
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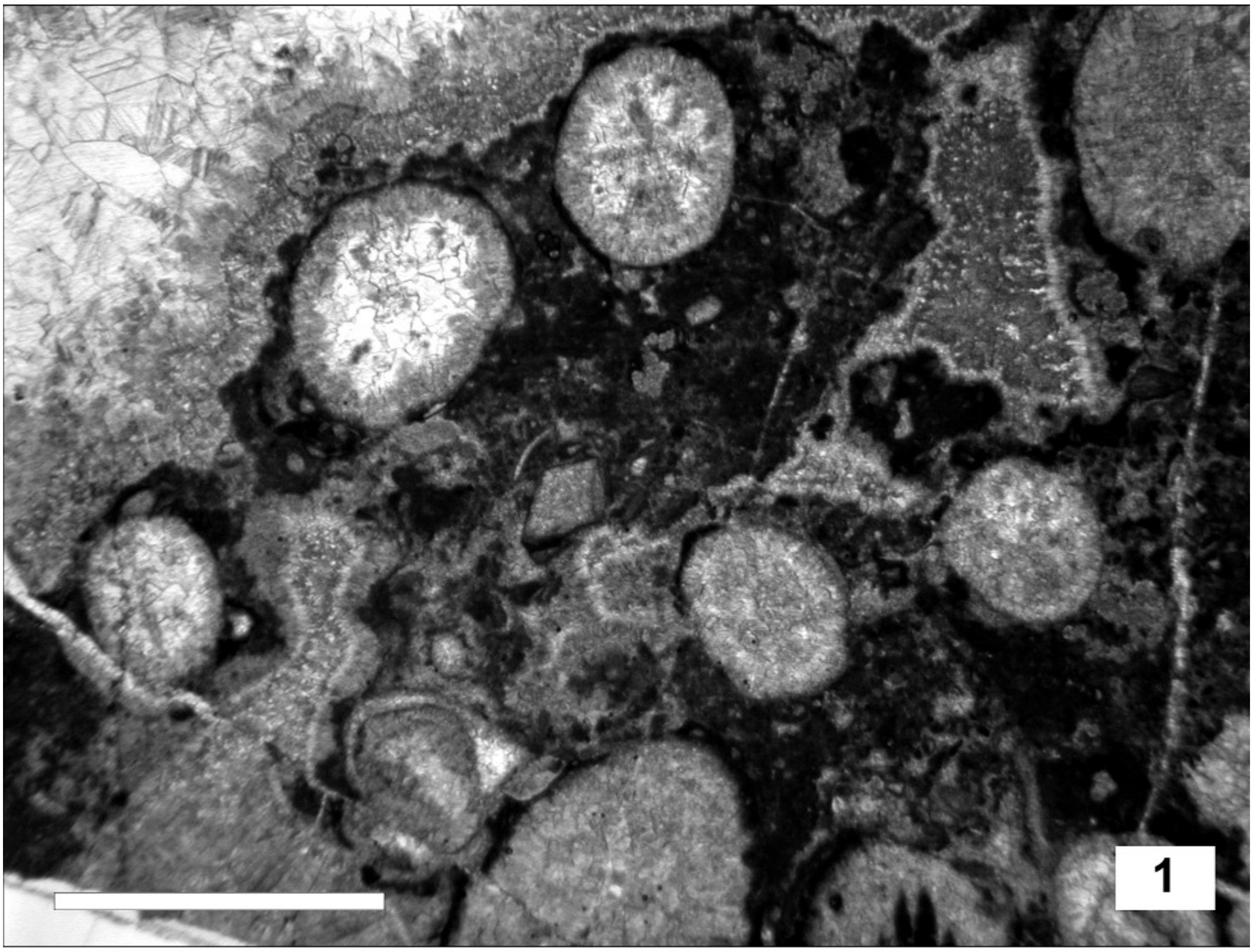
Plate 4

Early Norian index corals.

Fig. 1: *Pachydendron microthallos* CUIF, 1975.
Fragment of phaceloid corallum in transverse section; thick wall and septa recognizable.
Feisterscharte, Dachsteinplateau. sample 89/F3, leg. H. LOBITZER 1989.

Fig. 2: *Pachydendron microthallos* CUIF, 1975.
Fragment of phaceloid colony in transverse section. Corallite pachythecal wall shows well preserved modular microstructure (radial striation).
Early Norian, Alakir Çay, Turkey. ZPAL H/xx (for the moment without number). Coll. CUIF.

Scale bars: 3mm.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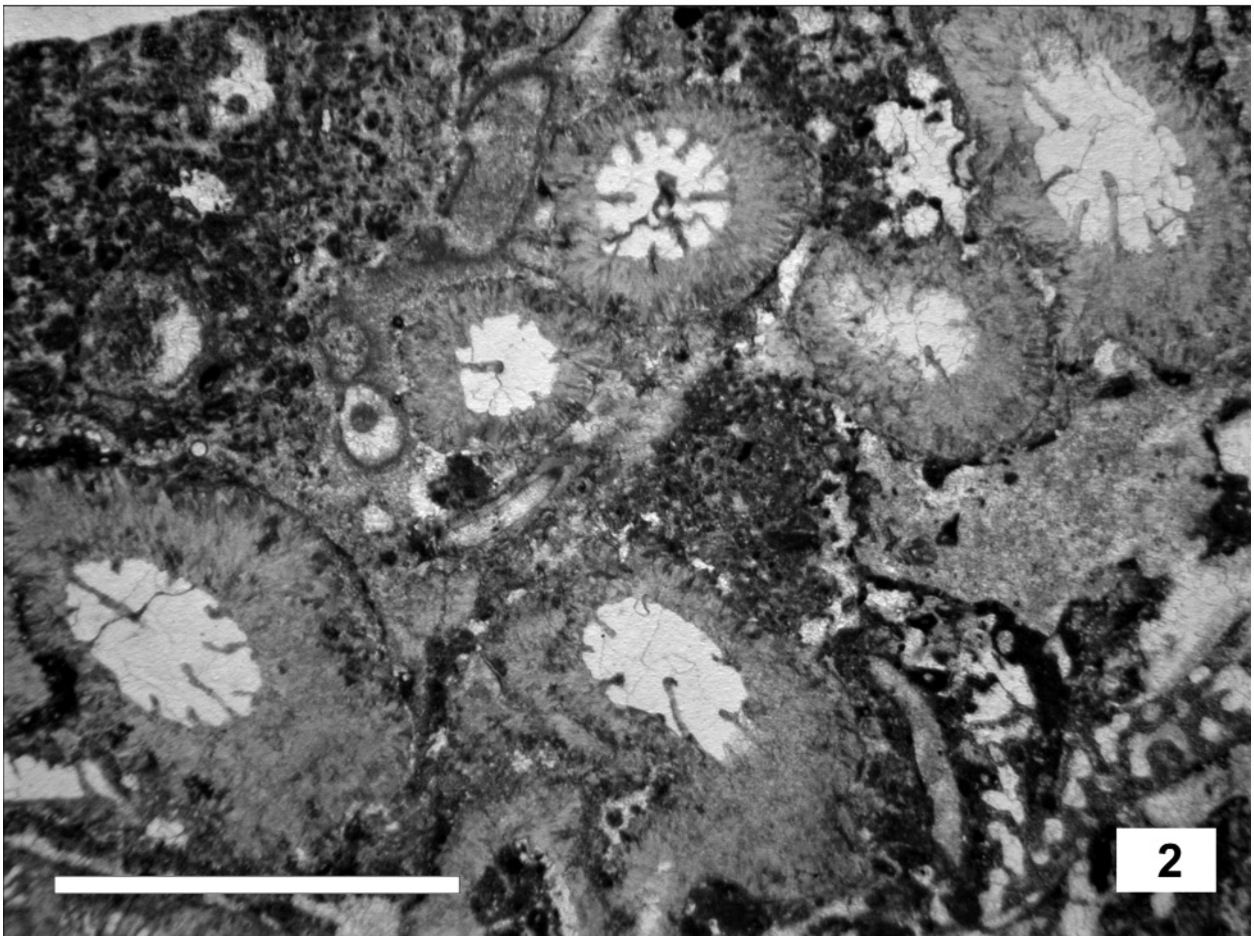
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Plate 5

Early Norian index corals.

Fig. 1: *Pachysolenia* cf. *cylindrica* CUIF, 1975.
Fragment of phaceloid corallum in transverse section; the corallite shows a thick, folded wall and numerous thin septa. A modular, radial structure of wall is recognizable.
Dachsteinplateau, Feisterscharte, sample 87/23; leg. LOBITZER 1987.

Scale bar: 3mm.

Appendix

The characteristics of coral microstructural groups recognized in the Triassic (after RONIEWICZ [1989] and RONIEWICZ & MORYCOWA [1993], completed with data on epithecal wall after RONIEWICZ & STOLARSKI [1999]):

I. Pachythecal coral group
Wall epithecal, thick and modular in structure; septa thin and built of centripetally growing trabeculae, or septal microstructure fibronormal (in relation to the midseptal plane); septal faces not ornamented.

II. Minitrabecular coral group
Wall epithecal; thin trabeculae form a midseptal plane (=Urseptum of the nineteenth century authors) associated with lateral sclerenchyme thickening the septa from both sides; lateral sclerenchyme is fibronormal or organized into short lateral trabeculae perpendicular to the midseptal plane; septal faces are ornamented with granulations or with ledges paralleling the upper septal margin and named pennulae.

III. Thick-trabecular coral group
Wall epithecal; septa built exclusively from subvertical or fan-wise ordered thick trabeculae; septal faces ornamented with granulations which may coalesce into ledges (=pennulae).

IV. Nontrabecular, or fascicular coral group
Wall epithecal; septa consisting of septal spines that are free or coalesced into septal blades; septal spines are formed of well individualized thick fascicles of fibres that are arranged in fountain-like manner; septal faces are coarse, lacking regular ornamentation.

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