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### Introduction

Upper Triassic (Norian and Rhaetian) reefs of the Calcareous Alps are located in southern Bavaria and northern Austria. According to the position of the reefs on the platform three types of buildups may be recognized (fig. 1, A, B, C):

**A)** large "Dachstein-type reefs" on the platform margin;

**B)** small "Upper Rhaetian" reefs (e. g. the reef near Adnet, see stop 3) formed on a carbonate platform, and

**C)** small "Upper Rhaetian" reefs (e. g. Rötélwand) formed on shoals within the Kössen basin.

For more detailed information about facies, palaeoecology and palaeontology of the Norian-Rhaetian reefs see FLÜGEL (1981) and STANTON & FLÜGEL (1989).

From both Dachstein-type and Upper Rhaetian reefs a lot of algae have been reported which are listed in tab. 1. Some of these algae already can be recognized in the field, but most of them in thin section.

Calcareous algae of the Norian-Rhaetian reefs are represented by spongiostromate and porostromate cyanophyceans, red algae (solenoporaceans and gymnocodiaceans), green algae (abundant dasyclads, questionable codiaceans) and endolithic algae. In addition to these groups some problematic organisms, probably algae of uncertain systematic position, are described as a separate group.

### Spongiostromate cyanophyceans

As stabilizing organisms in the buildups the spongiostromate cyanophyceans are characterized by crusts of several mm thickness (up to 20 mm thick) and composed of thin micritic and microsparitic layers occurring only in the central reef area (comp. pl. 12, fig. 2.). Here they are associated with sponges, "hydrozoans" and so-called "tabulozoans" (mostly sclerosponges). Spongiostromata do usually not occur in association with dendroid corals (*Retiophyllia*). The spongiostromate cyanophyceans occurring in Norian-Rhaetian reefs are restricted to the Dachstein-type and Upper-Rhaetian reefs. They are not known from Carnian or other Middle Triassic reefs.

### Porostromate cyanophyceans

The porostromate cyanophyceans are characterized by filaments exhibiting a distinct branching pattern. They are represented by different genera. The most abundant genera are *Cayeuxia*, *Ortonella* and *Garwoodia*. The porostromate algae occur usually in the lagoonal facies. They are associated with heteroporellid dasycladaceans, oncolites and foraminifera dominated by involutinid, autotortid and glomospirid types.

### Red algae


Two groups of red algae (solenoporaceans and rarely gymnocodiaceans) are known from the Norian-Rhaetian reefs in the Alps. The solenoporaceans are represented by the genera *Solenopora* and *Parachaetetes*, whereas *Solenopora* is more common than the latter (tab. 1.; pl. 11, fig. 1).

The gymnocodiaceans are rare. *Abatea culleiformis* SENOWBARI-DARYAN & SCHÄFER (1980) is the only taxon known from Norian-Rhaetian reefs in the Alps (pl. 11, fig. 2).



Tab. 1 : List of calcareous algae in Upper Triassic reef limestones of the Northern Calcareous Alps (from FLÜGEL 1981). Asterisk marks the data for Adnet locality.



Calcareous Algae	Dachsteinkalk Reefs					Upper Rhaetian Reefs			
	Göll	Gosau- kamm	Gesäuse	Sau- wand		Adnet	Rötel- wand	Feich- tenstein	Gruber- alm
Dasycladaceae									
<i>Acicularia</i> sp.		x						x	
<i>Clypeina</i> sp.					x	x	x	x	
<i>Diplopora adnetensis</i> FLÜGEL					x	x	x	x	
<i>Diplopora phanerospora</i> PIA		x					x		
<i>Diplopora tubispora</i> OTT	x	x					x		
<i>Griphoporella curvata</i> (GÜMBEL)		x	x	x		x	x	x	
<i>Gyroporella vesiculifera</i> GÜMBEL			x						
<i>Heteroporella crosi</i> (OTT)		x					x		
<i>Heteroporella zankli</i> (OTT)	x	x	x		x	x	x		x
<i>Macroporella</i> sp.		x		x					x
<i>Pentaporella rhaetica</i> SENOWBARI-DARYAN								x	
Solenoporaceae									
<i>Parachaetetes maslovi</i> FLÜGEL		x	x	x		x	x	x	
<i>Solenopora alcornis</i> OTT	(x)	(x)			x	x	x		x
<i>Solenopora endoi</i> FLÜGEL		x	x	x	(x)				
<i>Solenopora styriaca</i> FLÜGEL	x					(x)			
<i>Solenopora</i> sp. 1 ZANKL	x		x		x	x	x		
<i>Solenopora</i> sp.		x		x					x

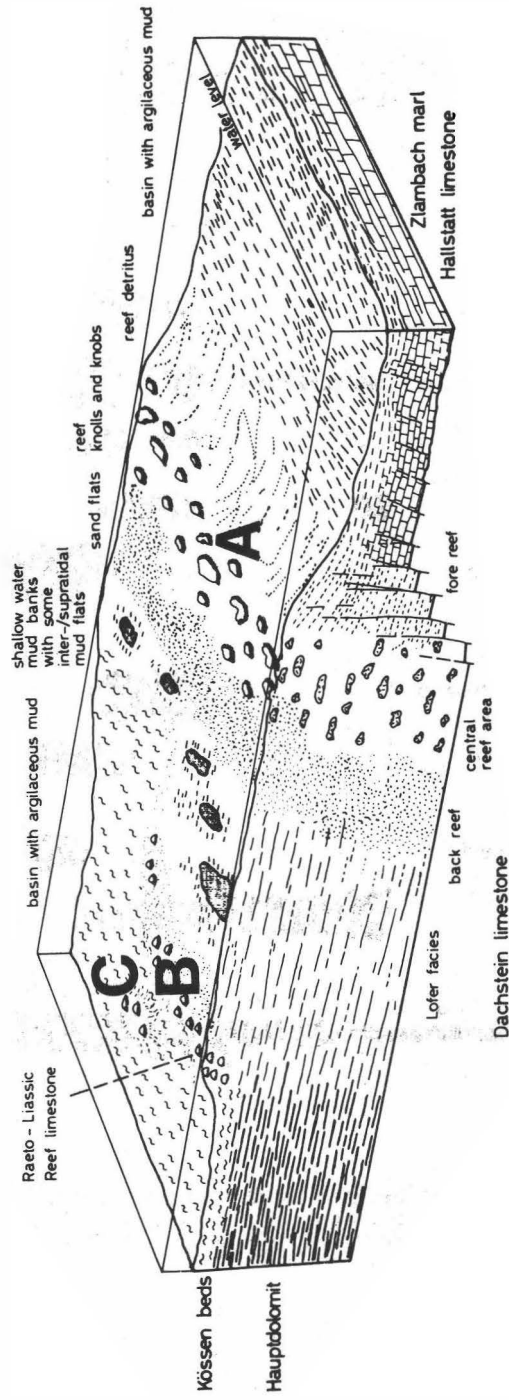


Fig. 1 : Palaeogeographic interpretation of the depositional environment during the Late Rhaetian (from ZANKL 1971). For explanation see text.





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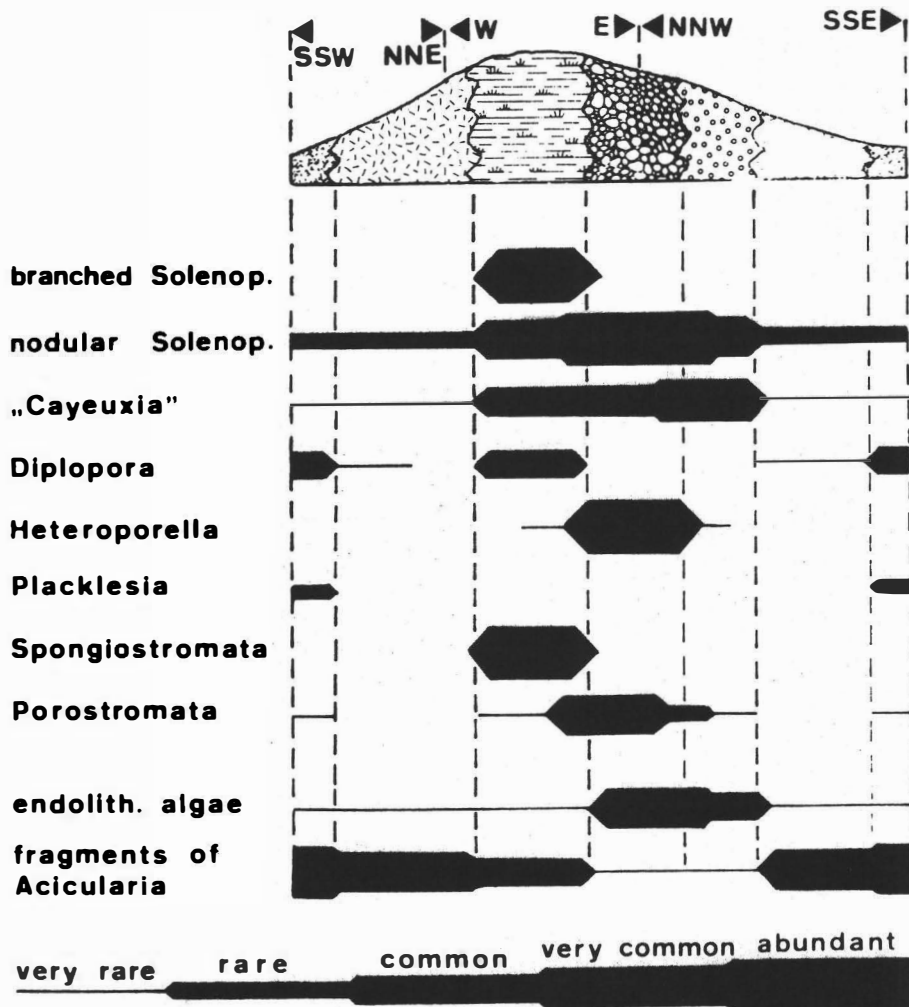


Fig. 2a: Diagram showing the distribution patterns of the main groups of the calcareous algae in Feichtenstein reef – complex near Hintersee as representative of Late Triassic reefs (from SCHÄFER & SENOWBARI - DARYAN 1981).

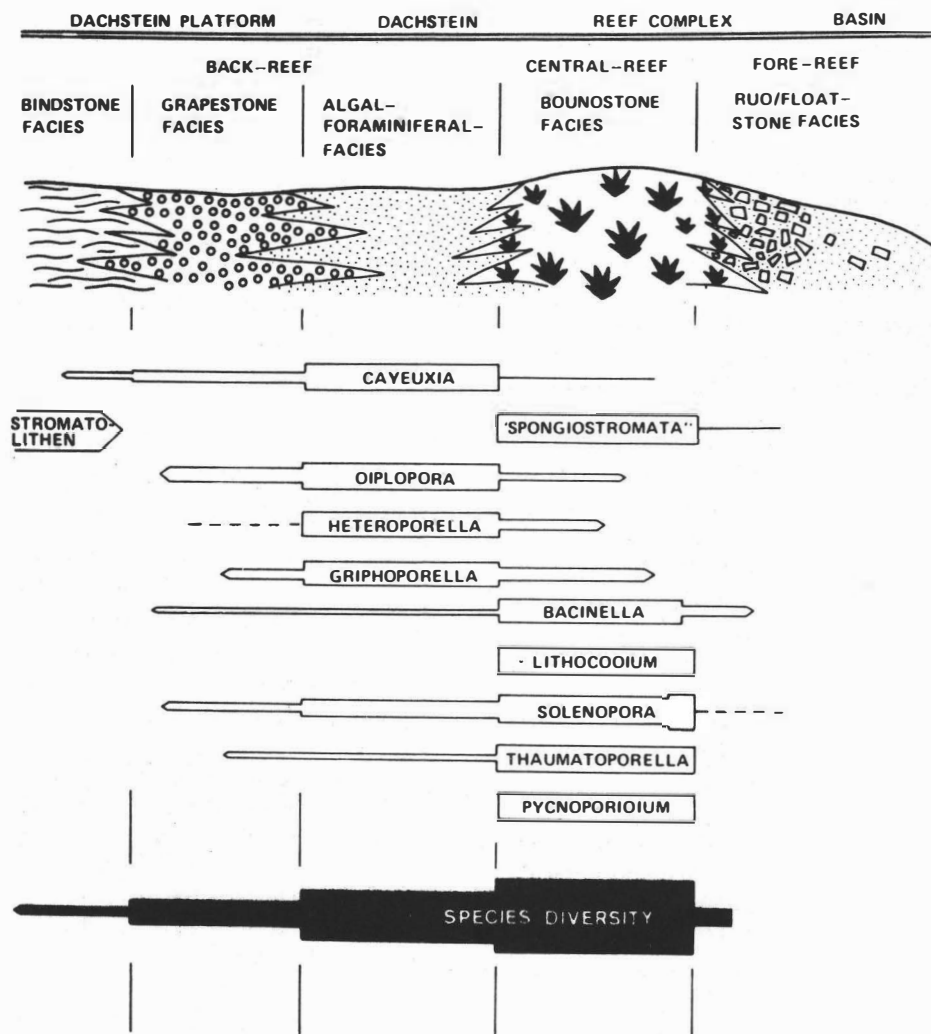


Fig. 2b: Depositional pattern of algae in Dachstein reef complex (from FLÜGEL 1979).



### Green algae

The green algae are represented by dasyclads and questionable codiaceans. The dasyclads are represented by the genera *Heteroporella*, *Diplopora*, *Griphoporella* and the rare genera *Macroporella*, *Pentaporella* and *Acicularia* (pl. 8, 9). *Heteroporella* and *Diplopora* are the most common genera occurring with several species both in Dachstein and Upper Rhaetian reefs. While *Heteroporella* occurs predominantly in the back reef area of Dachstein-type reefs and within the oncolite facies of Upper Rhaetian reefs, the species of *Diplopora* are usually found in the reef-core facies. For example, in Upper Rhaetian reefs exposed in the Tropfbruch quarry near Adnet (see stop 3) *Diplopora adnetensis* FLÜGEL (pl. 10, fig. 4) is an abundant alga in bioclastic limestones between the reef constructors. *Griphoporella* is another alga, common in the reef-core facies.

Codiaceans have not been found so far in Norian-Rhaetian reefs of the Alps. However, some genera, like *Lithocodium*, are discussed among the problematic algae.

Endolithic algae (or fungi) are represented by micritic envelopes, usually in depositions of lagoonal facies.

Some systematically uncertain algae, like *Lithocodium*, *Bacinella*, *Baccanella*, and the questionable *Pycnoporidium* (pl. 12, fig. 1) have been reported from Norian-Rhaetian reefs. However, *Lithocodium* or/and *Bacinella* are the most important types growing around the biogenic and abiogenic components forming oncolites characterizing a different facies type of the reef complex (pl. 10). *Baccanella* and *Pycnoporidium* are limited to protected areas in the reef facies and are reliable facies fossils. The

affiliation of *Pycnoporidium* to algae is very uncertain.

The algae show a distinct distribution within the reef complex, both in Dachstein and Upper Rhaetian reefs. An exemplary distribution of different algae in the Upper Rhaetian Feichtenstein reef (near Hintersee, SE Salzburg) is shown in fig. 2a. The algal distribution in the Dachstein reefs is quite similar (fig. 2b).

### Stops

The stops of the field - trip containing Norian-Rhaetian platform carbonates, exposed mostly in SE area of Salzburg, are shown in fig. 3.

#### Stop 3

##### Locality

Tropfbruch Quarry near the village of Adnet, SE Salzburg (fig. 3).

##### Stratigraphy

Upper Rhaetian reef facies. The sawed and polished walls and floors of the Tropfbruch quarry near the village of Adnet reveal an impressive insight into an Upper Rhaetian reef with reef organisms and the paleocological zonation of reef constructors.

The reef complex consists of isolated, very dense reef patches exhibiting an internal zonation of constructing organisms. The growth direction of the patches is pointing towards the palaeocurrents. (see fig. 4 for the facies distribution of the Adnet reef complex).

##### Algae

The reef patches of the Adnet complex, exposed in Tropfbruch Quarry are completely surrounded by oncolite facies consisting of large oncoides (up to several centimeter) formed by the problematic algae *Lithocodium* / *Bacinella*.

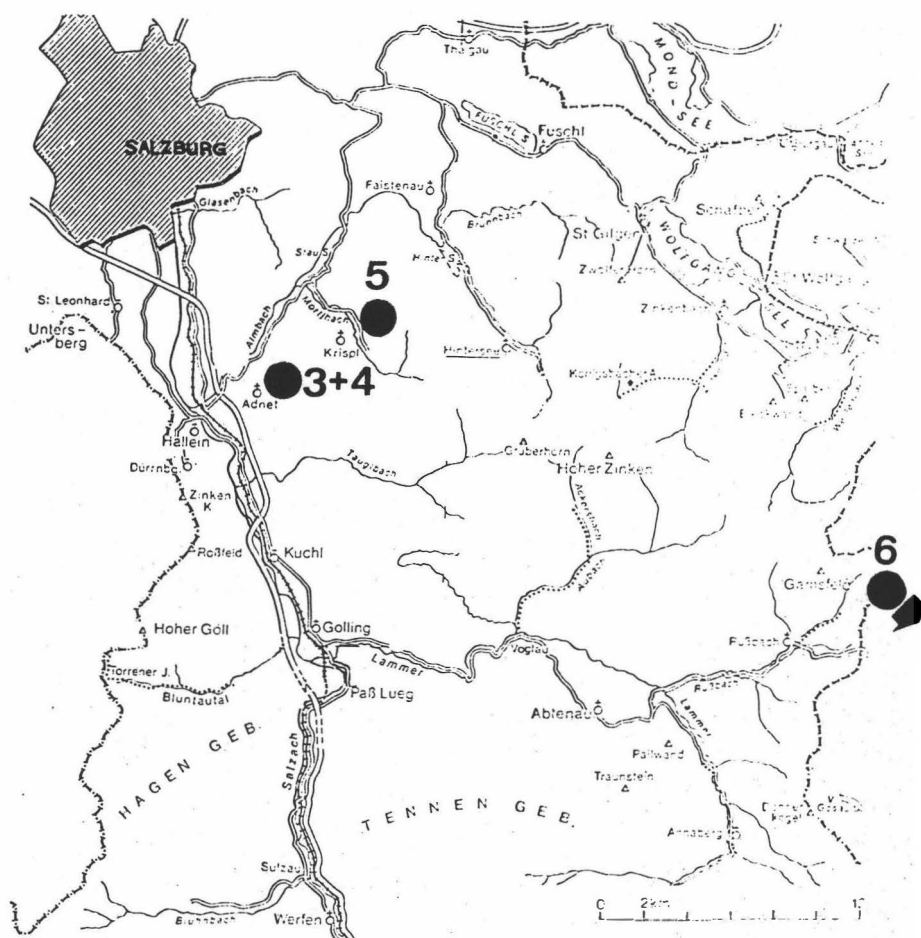
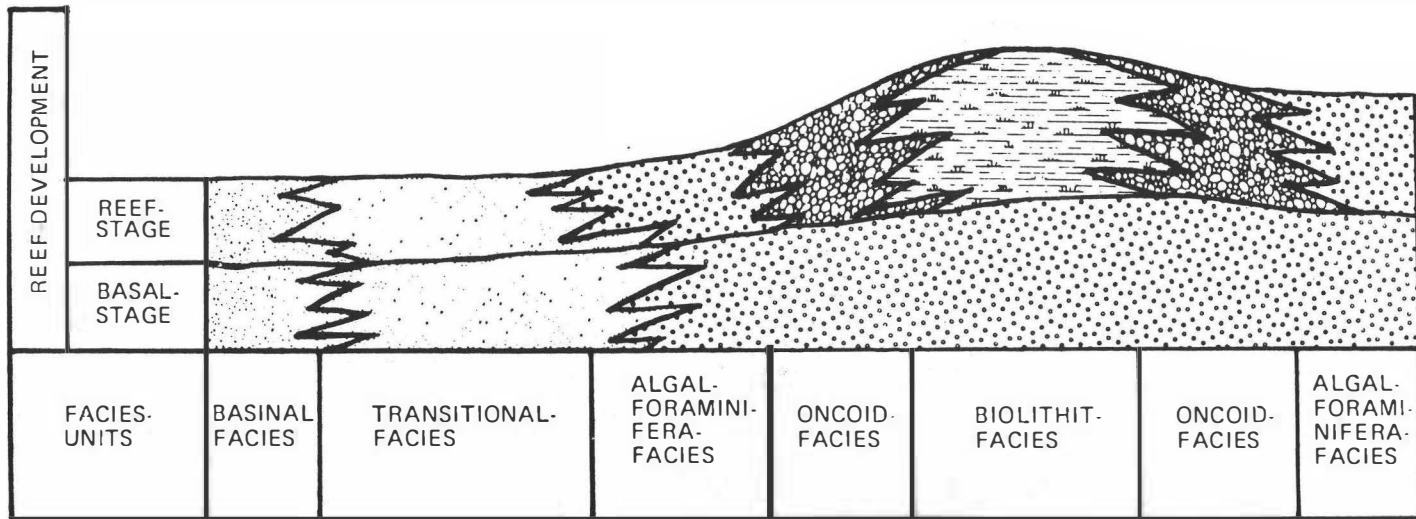


Fig. 3 : Stops in the area SE of Salzburg.



Fig. 4 : Vertical section through the Adnet reef-complex exhibiting the different facies units.

The diploporid algae (e. g. *Diplopore adnetensis* FLÜGEL), branched solenoporaceans and spongiostromate cyanophyceans are abundant in the biolithitic facies. The oncoid facies is characterized by the dominance of *Lithocodium/Bacinella* and heteroporellid greens. The nodular solenoporaceans and porostromate cyanophyceans (e. g. *Cayeuxia*) occur usually in the algal - foraminiferal facies (from SCHÄFER & SENOWBARI - DARYAN 1981).







The walls and the floor in the right part of the quarry exhibit some large onco-ids. Dendroid and branched solenopora-cean algae are relatively abundant but most of them are recrystallized and hardly to recognize. Between the reef constructing organisms small thalli of the dasyladacean alga *Diplopora adnetensis* FLÜGEL (pl. 10, fig. 4) occurs commonly in accumulations and may be recognized very easily by a hand-lense. The spongiostromate cyanophy-ceans are usually recognizable by their encrusting growth forms, commonly around sponges and massive corals.

#### Other fossils

Corals (diverse species of dendroid types, mostly *Retiophyllia*, massive *Thamnasteria* and others, solitary *Montlivaltia*), sponges (mostly *Paradenigeria* and the large *Cinnabaria? adnetensis* SENOWBARI-DARYAN), some spongiomorphids, bivalves, gastropods.

The Rhaetian reef is overlain by Liassic red, nodular limestones exposed in numerous localities and quarries in the area around the villigae of Adnet. One of them is the following stop, called Lienbacher quarry.

### Stop 4

#### Locality

Lienbacher Quarry near the village of Adnet, SE Salzburg (fig. 3).

#### Stratigraphy

Liassic (Sinemurian-Domerian?)

The red, nodular and well-bedded Liassic limestones are deposited in marginal position overlying the algae-foraminiferal-detrital-facies of the Upper Rhaetian reef-complexes.

#### Algae

The upper part of the quarry wall displays a vertical and upright growing deep-water stromatolite horizon howing

an angle of 15-20 degrees to the bedding plane (BÖHM & BRACHERT 1993).

#### Other fossils

Macroorganisms are represented mainly by ammonites, microfossils by diverse foraminifera.

### Stop 5

#### Locality

Roadcut near Gaißau, Mörtelbach Valley, NE Hallein, SE Salzburg (fig. 3).

#### Stratigraphy

Norian Hauptdolomit.

#### Facies

The bedded Dachstein limestone of the Lofer facies (see stop 6) grades northward into a facies-type called Hauptdolomit, which was deposited in a restricted environment, named "ultra-back-reef" by FISCHER (1964), reaching a maximum thickness of 2000m.

The main part of the Hauptdolomit is built by thin-laminated beds, up to 1 m thick, formed by algal films (preservation because of incomplete decomposition of the organic matter) pointing to subtidal formation, or by algal stromatolites indicating an intertidal to very shallow subtidal environment (see figs.6- 7).

#### Algae

Algal films and stromatolites.

#### Other fossils

Rare gastropods, bivalves, foraminifers, ostracods.

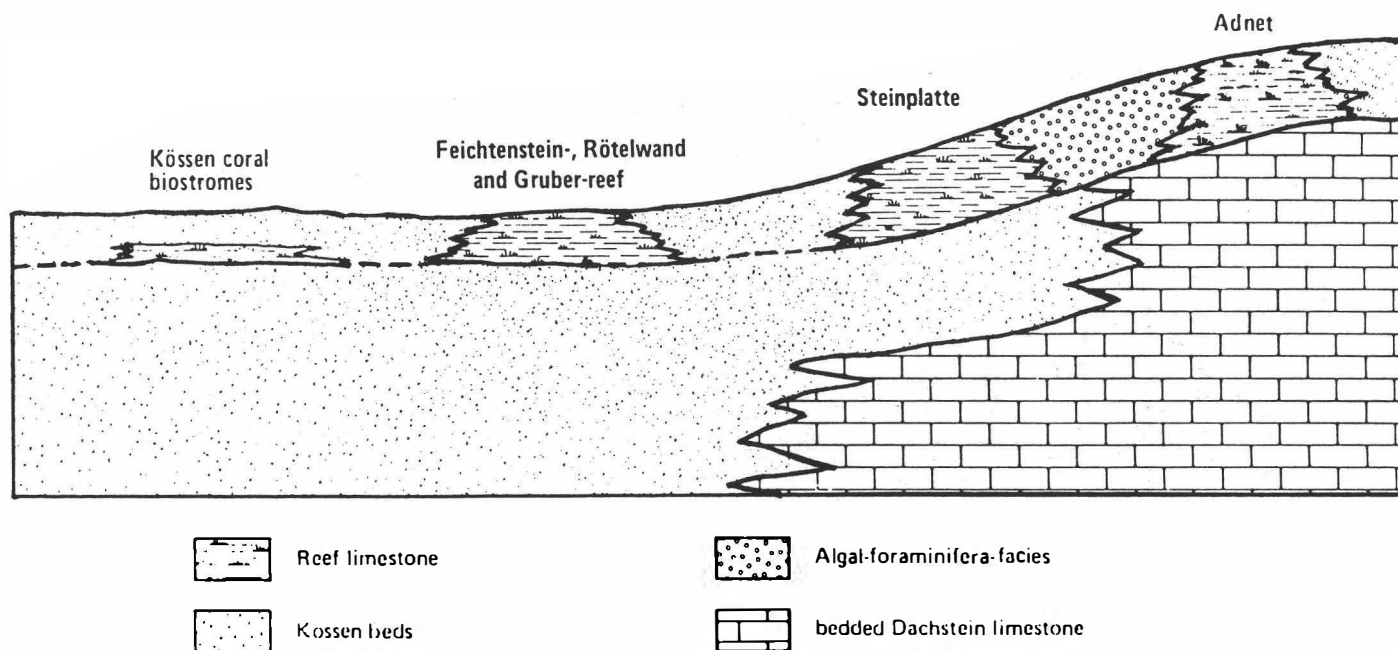
Fig. 5 : Palaeogeographic setting and palaeoenvironmental model of some Late Rhaetian reefs (bioherms) and biostromes (from SCHÄFER & SENOWBARI – DARYAN 1981).

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INFLUENCE OF KÖSSEN BASIN

INFLUENCE OF DACHSTEIN PLATFORM



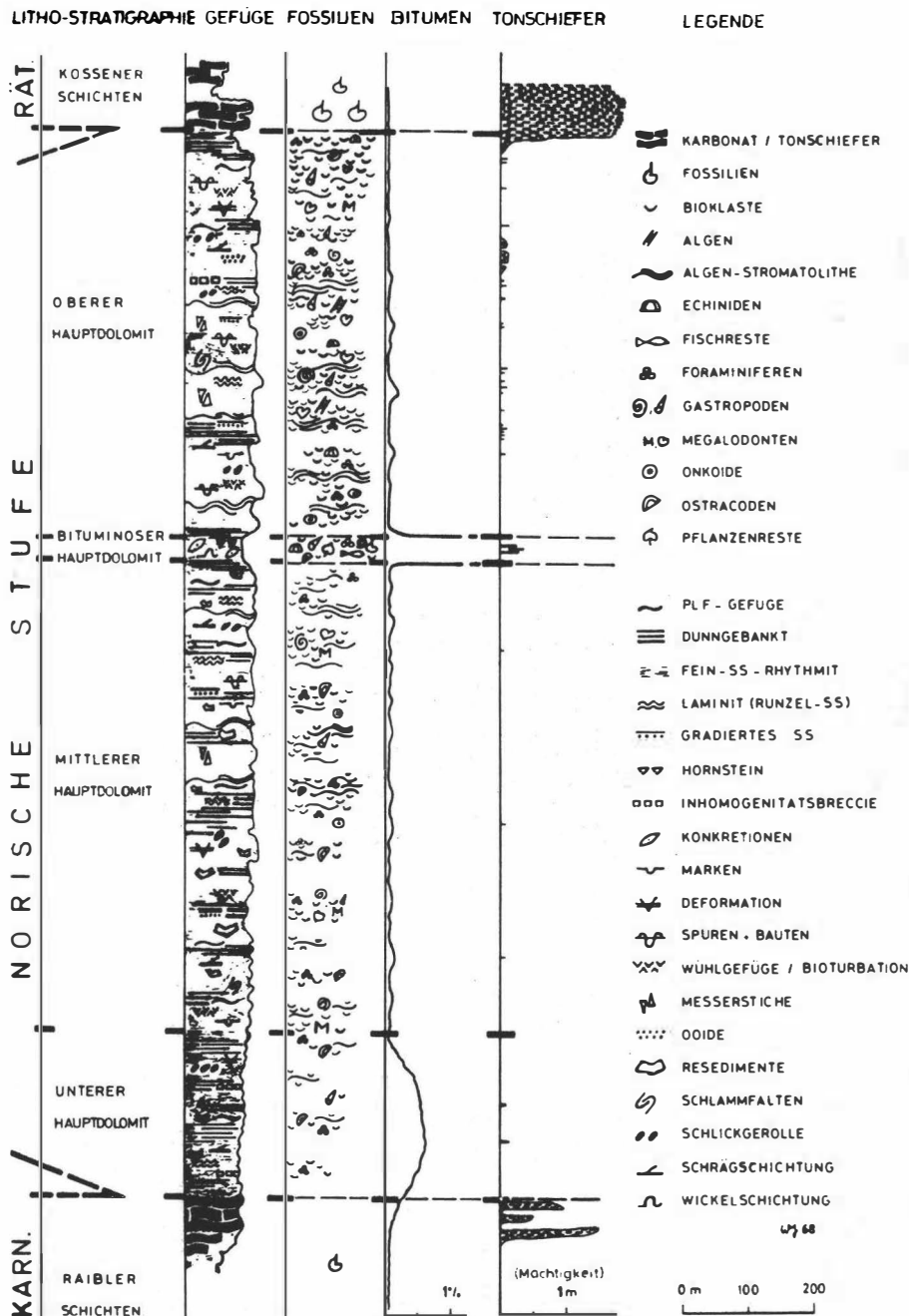
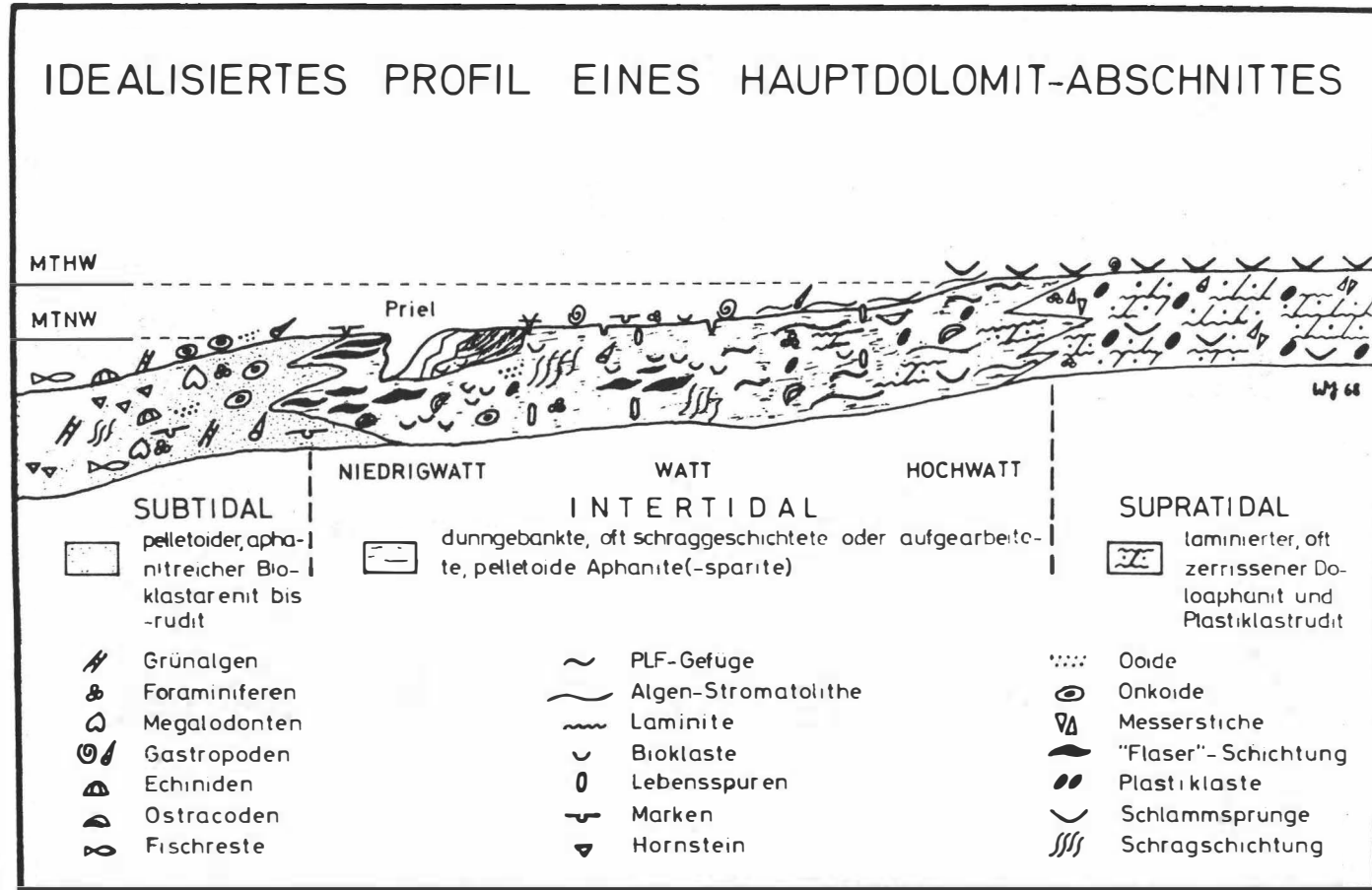


Fig. 6 : Generalized vertical section of the Alpine Hauptdolomit (from MÜLLER – JUNGBLUTH 1970).

Fig. 7 : Depositional environment of Alpine Hauptdolomit (from MÜLLER – JUNGBLUTH 1970).



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