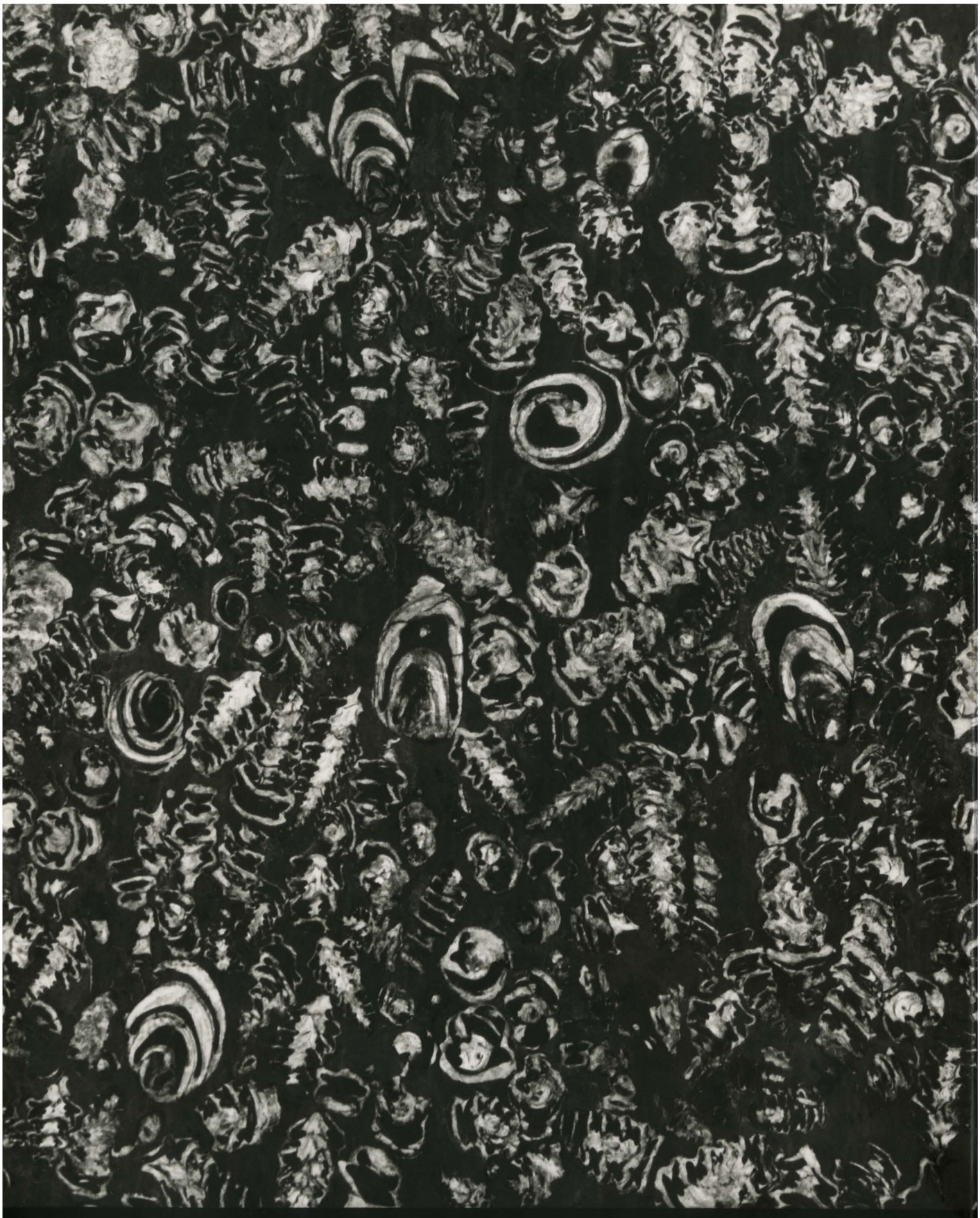

WGCM – 4th Meeting (1982)
Gosau Basins in AUSTRIA

WORKING GROUP ON THE CONIACIAN - MAASTRICHTIAN STAGES

FOURTH MEETING

EXCURSIONS TO CONIACIAN - MAASTRICHTIAN IN THE AUSTRIAN ALPS

by

Heinz A. KOLLMANN and Herbert SUMMESBERGER

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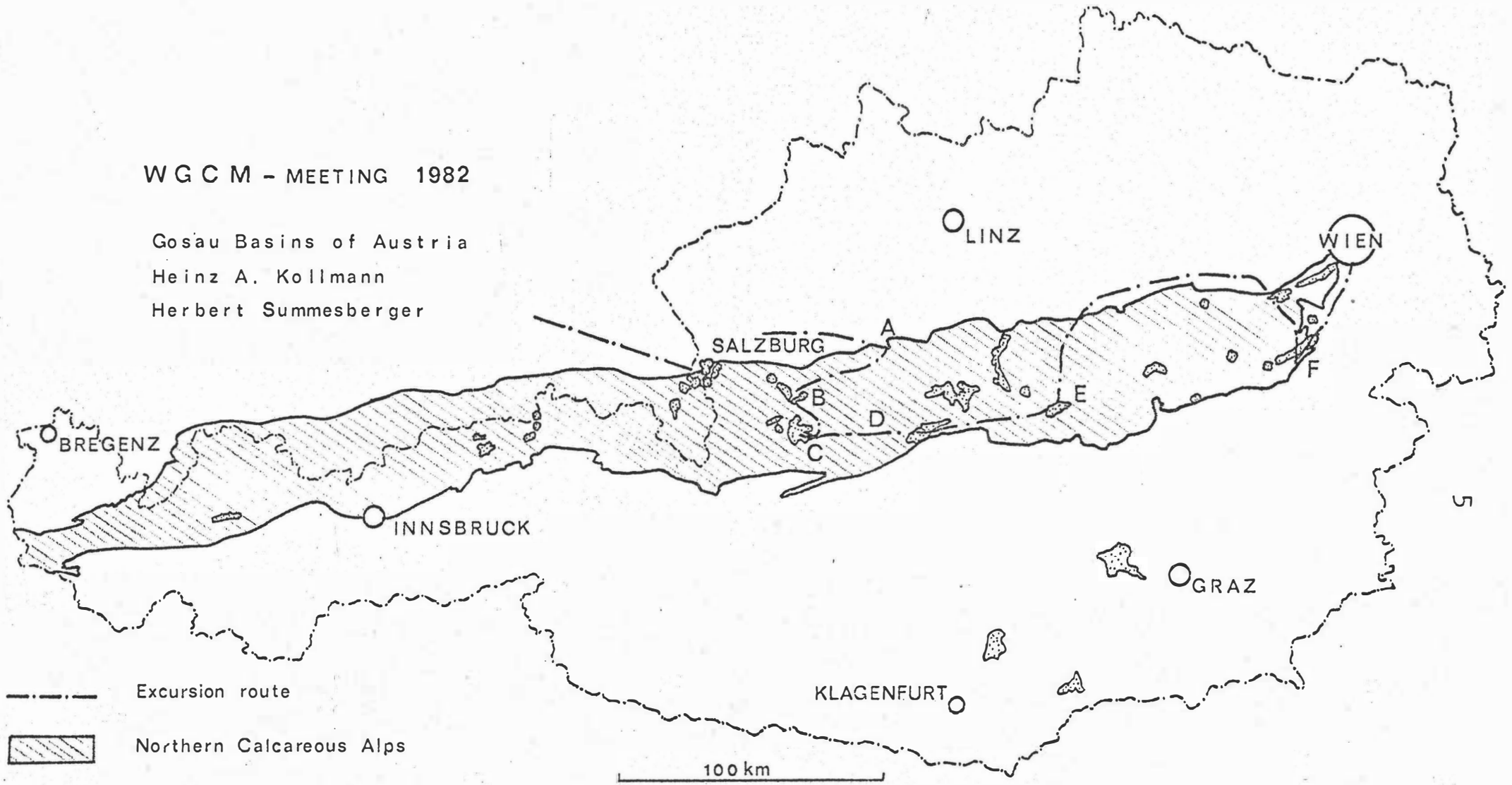
WGCM - MEETING 1982
Gosau Basins of Austria
Heinz A. Kollmann
Herbert Summesberger
LINZ
WIEN
SALZBURG
A
B
C
D
E
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BREGENZ
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KLAGENFURT
100 km
Excursion route
Northern Calcareous Alps
Gosau basins
A Rehkogelgraben
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THE UPPER CRETACEOUS IN AUSTRIA

In Austria non metamorphic Upper Cretaceous rocks are occurring in the following tectonic units (from North to South):

1. In the autochthonous Mesozoic cover on the southern slope of the Bohemian Massif. Cretaceous rocks have been recorded only from boreholes in Upper Austria and Northern Lower Austria. The tectonic position of these occurrences is comparable with the outcropping Cretaceous of the Regensburg area in Bavaria.

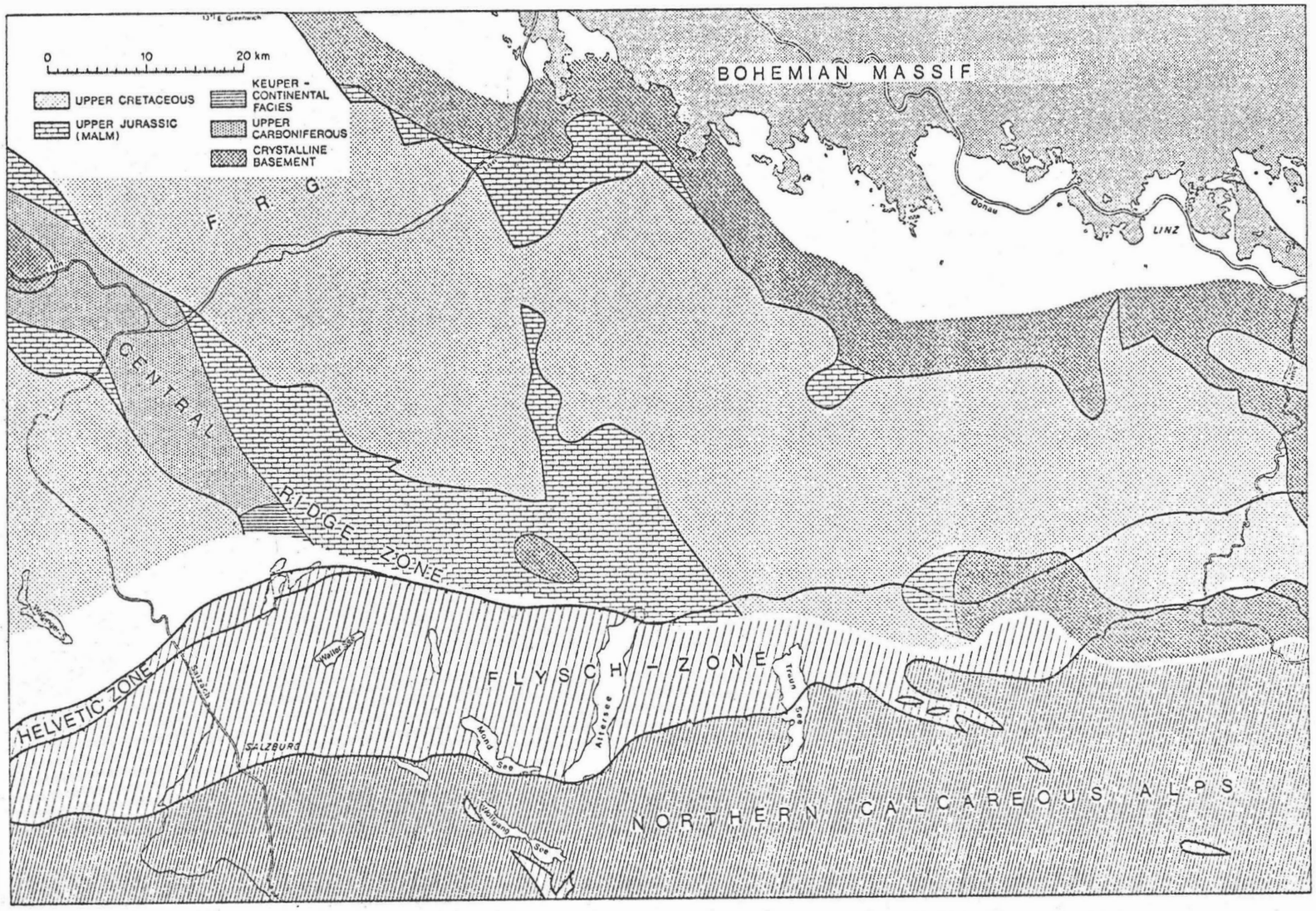
2. In the Helvetic zone.

3. In the Rheno- Danubian Flysch units.

4. In the Northern Alps, mainly in the Northern Calcareous Alps. Here the rocks are called "Gosauschichten" (Gosau group). Their occurrence is restricted to the Gosau basins.

PALEOGEOGRAPHY OF THE UPPER CRETACEOUS IN AUSTRIA

There is hardly any other part of the world which has been as much discussed in the geological literature and which has been interpreted geologically in such different ways as Central Europe. Especially geological literature on the Alps represents collisions of opinions but also of opinion leaders and their followers. This has its reason in the fact that for a long time observations on highly complicated structures have only been possible by surface geology.



Subsurface map of the pre-Tertiary basement of the Molasse zone between the rivers Salzach and Enns (after K. KOLLMANN, 1977)

Tectonic structures and the dating of geological events has been to a high degree guess work.

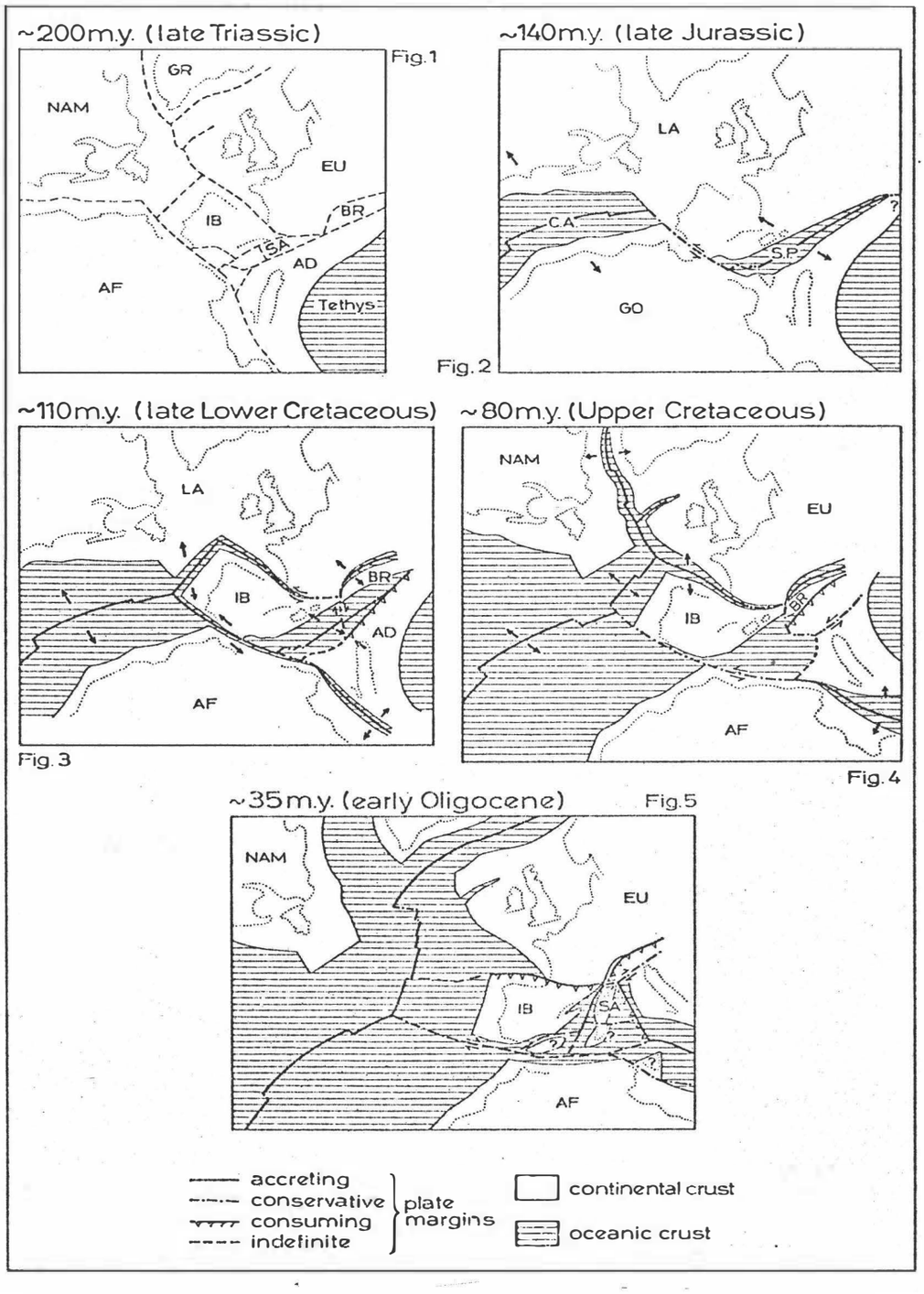
Although there is still a discussion about many details it is now generally agreed that the geological structure of Austria is due to the collision of two plates in Cretaceous and Tertiary time. These are the Eurasian plate and the Adriatic plate. The Adriatic plate had separated from the bulk of the Eurasian plate in middle Jurassic time as we may see from W.FRISCH's maps. Between the two plates the Penninic ocean was spreading. The sediment cover which has been deposited on the outer shelf of the Eurasian plate is called the Helvetic zone.

Beginning with the Lower Cretaceous another microplate was separating from the Eurasian plate and in the newly formed ocean basin the Rheno- Danubian Flysch was deposited.

In the Upper Albian the subduction of the crust of the Penninic ocean under the Adriatic Plate began and by Santonian time the ocean has vanished. While the sedimentation ceased in the southern parts of the Northern Calcareous Alps within the lower Cretaceous, it continued in the northern part into the Middle Turonian. Upper Turonian sediments are not known throughout the Eastern Alps which may have its reason in a general regression during this time. In the Helvetic zone and in the Flysch zone the sedimentation continued into the Lower Tertiary.

In the Eastern Alps the next transgression began in the Lower Coniacian. This is the transgression of the Gosau sea which lasted until the Lower Eocene.

One of the most striking facts about the distribution of the Gosau sediments is their occurrence in isolated areas of varying size with sequences having a thickness of two



Palaeogeographic sketches of the Western Mediterranean and the North Atlantic from late Triassic to lower Tertiary times (after W. FRISCH, 1980)
The plate motions are approximate (semiquantitative) and so are the arrows indicating relative motions between two plates. Dashed lines in fig. 1 are lines of later disintegration of plates.

Plates: GO, Gondwana. LA, Laurasia. AF, Africa. EU, Eurasia. NAM, North America. GR, Greenland. IB, Iberia. BR, Brianconia. AD, Adriatica. SA, Sardegna-Corsica. Small plates between IB, AF and AD include the Betics, Calabria and Sicily. They are not well defined. Oceans (in fig. 2): C.A., Central Atlantic. S.P. South Penninic Ocean.

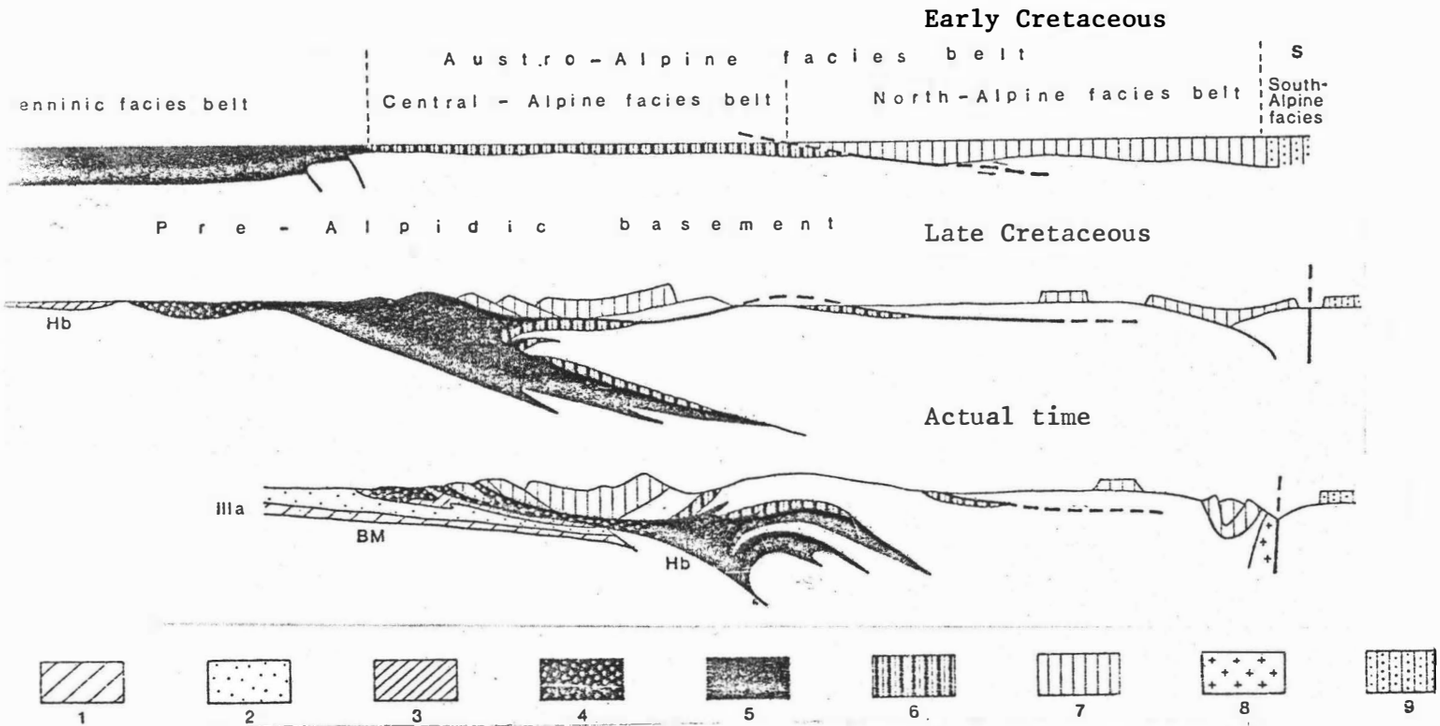
thousand meters and more and last not least having different stratigraphic ranges. Most of these basins, as they are called, are situated within the Northern Calcareous Alps, a few of them also in metamorphic rocks in the Central Zone of the Alps. The sea, of course, covered much larger areas. It is only in the basins that sediments of considerable thickness have been accumulated. This means that the Gosau basins have been local areas of subsidence in which sediments have been trapped.

This is a very special tectonic featurecaused by the gravitational gliding of the large East Alpine nappe towards north during the Upper Cretaceous and Lower Tertiary. Within this nappe fracture zones of partly wide lateral extension developed. It was in these zones that the basement was subsiding along faults as we know from all Gosau basins. Here the Gosau sediments have been deposited. In the further course of the gravitational movement the subsiding parts have been overthrusted from the south in many cases.

The basal beds of most Gosau basins show an equilibrium between the subsidence and the sedimentation rate. The sequences which were deposited are partly of a enormous thickness and a shallow water fauna of high diversity was living on and within the bottom. In some cases also a fresh water influence is recognizable from the fossil faunas. Only in a few places the Cretaceous sediments deposited on the stable platform are preserved. These are highly energetic sediments consisting mostly of rudists and reworked local limestones. This is the facies of the Untersberg limestone which has been widely shipped as a decoration stone in Europe.

Beginning with the Campanian the water depth of the Gosau sea was increasing considerably. The sea floor was partly even below the CCD. Flysch sediments and the Nierental

formation, a series of variegated pelagic marlstones have been deposited. From the Upper Maastrichtian on basins with sediments in Nierental facies show an increasing number of turbiditic layers. The clastic components are not only derived from denudated parts of the Northern Calcareous Alps but also from the Paleozoic mica schists on which the

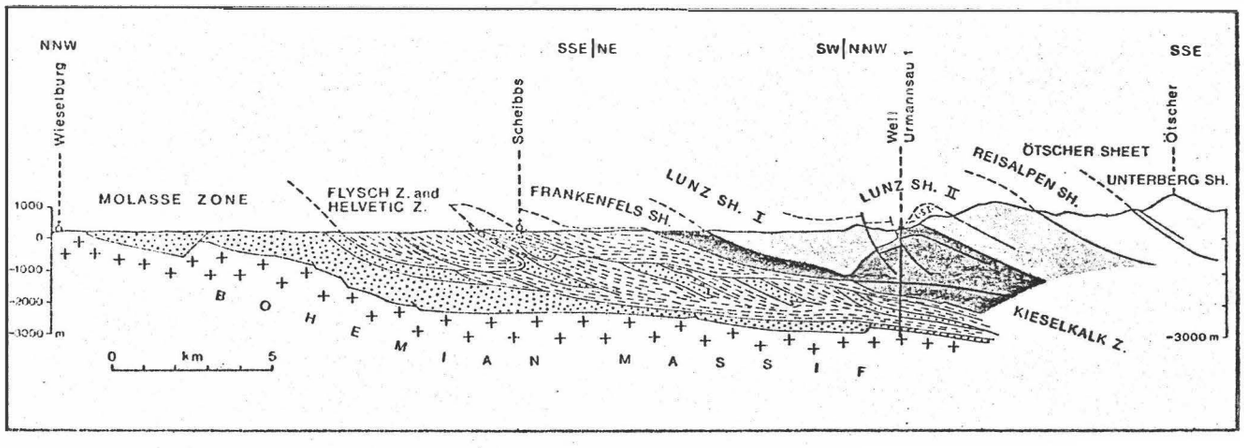


The tectonic evolution of the Eastern Alps (after E.CLAR, 1973)

Legend for the sections: 1 = Tertiary rocks of the Molasse zone. 2 = Extra-Alpine post-Variscian sedimentary rocks. 3 = Helvetic zone and Klippen zone. 4 = Flysch zone. 5 = Permomesozoic of the Penninic zone. 6 = Permomesozoic of the Central Alpine facies belt. 7 = Permomesozoic of the North Alpine facies belt. 8 = Periadriatic intrusion. 9 = South Alpine facies. BM = Bohemian Massif. Hb = Basement of the Helvetic zone

Northern Calcareous Alps have been originally deposited. This is an indication that the Northern Calcareous Alps and the Paleozoic schists have not only been sliding North wards together on their common crystalline basement but that the Northern Calcareous Alps were also moving independently uncovering their primary basement. This is also evident

from the fact that in the Kainach basin close to the Styrian capital Graz Cretaceous sediments were deposited on the Paleozoic series. Besides of this, an increasing number of areas within the Alps must have been again above sea level or very shallow to be the source for the turbidites. The sedimentation of the Gosau cycle ends in the Lower Eocene. The later Eocene sedimentation ceased in the Rheno-Danubian Flysch zone and finally in the Helvetic zone. These zones were tectonically removed from their basements by the north moving Alpine nappes and were migrating northwards too.



Cross section through the Molasse zone, the Ultrahelvetic zone, the Rheno-Danubian Flysch zone and the Northern Clacareous Alps. The cecti-on is drawn through the ell Urmannsau 1 which was the first to drill through the Northern Calcareous nappes into the underlying and over-thrusted tectonic zones which are intensively tectonized (W. JANOSCHEK, after A. KROELL & G. WESSELY)

THE STATUS OF THE TERM GOSAUSCHICHTEN: A GROUP OF FORMATIONS

The term Gosauschichten (Gosau beds) has been used first by Paul PARTSCH (1844) and has been applied later to all rocks of presumably Upper Cretaceous age in the Northern Alps. Still later, it has been used for all transgressive Upper Cretaceous throughout the Austro-Hungarian Empire.

Besides of Austria, it is still used today by geologists working in the Carpathian mountains of Tschechoslovakia and by Romanian geologists. It is evident that "Gosauschichten" in this sense is a tectonic term for a stratigraphically undivided series lying transgressive on older rocks. It should be mentioned as a curiosity that the term "Gosau-facies" has been applied to Cretaceous sediments of Tethyan origin containing Actaeonellids, Nerineids, and Rudists all over the world. E. BOESE, for example, used it in his monographs on the Mexican Cretaceous.

As the stage of the Gosau sedimentation has always been considered as one of the keys for understanding Alpine tectonic movements biostratigraphical data have been used since the middle of the last century to date the sequences. Primarily of a tectonic background is the subdivision of the Gosau sequences in a lower, middle, and upper Gosau by BRINKMANN which has been applied by his students with varying success to different basins in the 1930ies. After BRINKMANN (1935) each of these three sections was a sedimentary cycle beginning with a transgression and ending with a regression. He believed that events were caused by orogenetic phases according to STILLE. It is a basical misunderstanding that his concept has been used by KÜHN (1947) and others in a stratigraphical way.

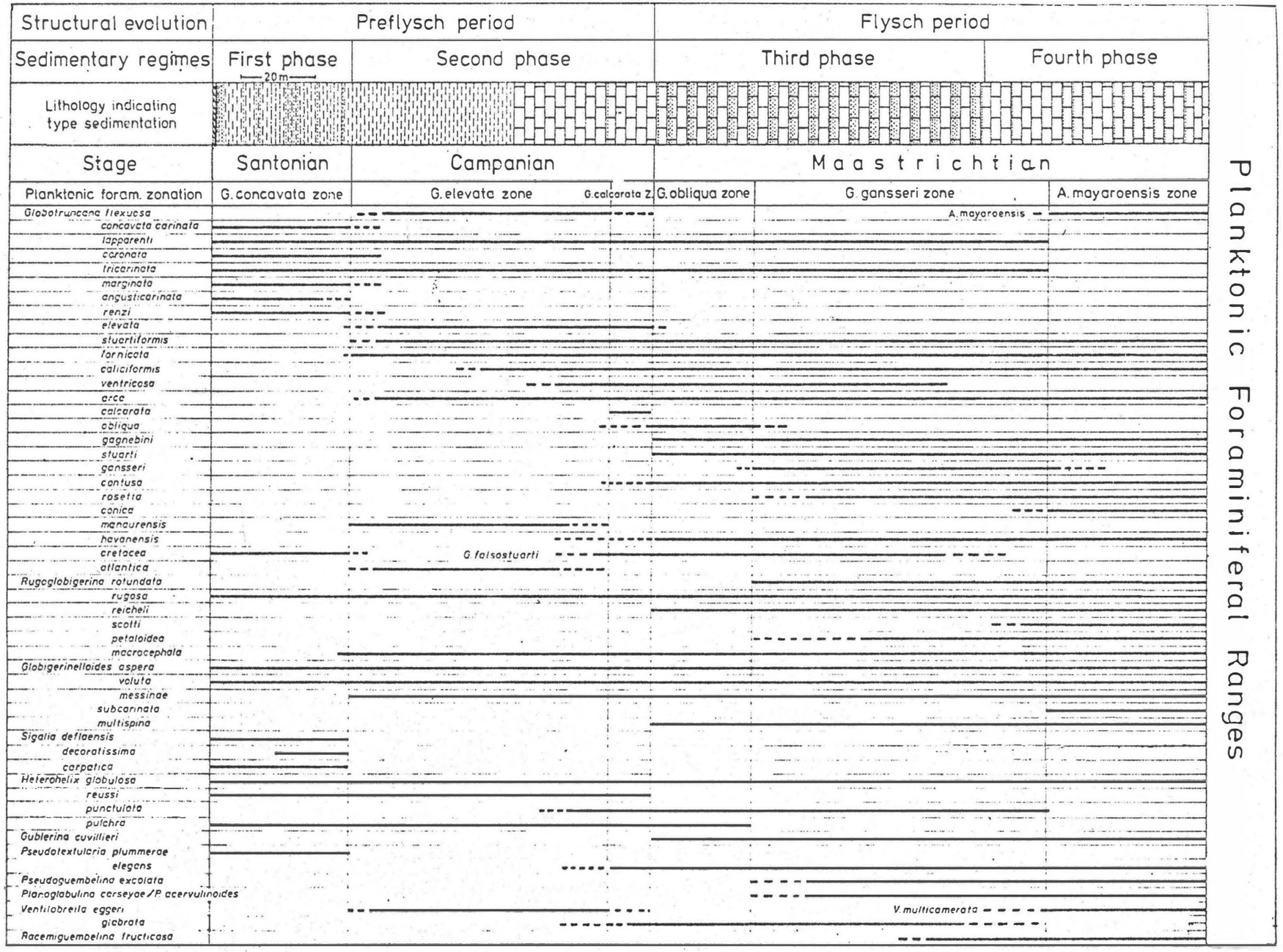
As mentioned before, the Gosau sequences of the different basins are varying to a great extent. Therefore, no general lithostratigraphy has been established for the Gosau basins unlike to the Triassic and the Jurassic of the Eastern Alps. The Nierental formation is an exception as this widely distributed series of pelagic limestones and shales is easily recognizable. In fact, the differences in the sequences have been used as an argument against lithostratigraphic subdivisions. For most basins general terms as inoceramus shales, grey shales, basal conglomerates have been used by field geologists. Only for the Gosau area WEIGEL (1937) has established a lithostratigraphic subdivision. This has been used in a new geological map of the Gosau area by KOLLMANN (1981) and in recent papers by KOLLMANN (1980) and SUMMESBERGER (1979, 1980) with some modification. All the lithostratigraphic units are used in the sense of formations although most of them are not yet defined formally with type sections. This is the reason why they are not called formations in the charts. The names of these units are formed by the geographic name with the informal suffix "-schichten" which will be replaced by the term "formation" when the name is formalized. This work is in progress. If we use the term "Gosauschichten" according to this lithostratigraphical sense it should be called Gosau group.

BIOSTRATIGRAPHY OF THE GOSAU GROUP

Besides of marine shallow water environments with reduced salinity or even of fresh water were widespread in the Upper Cretaceous of the Alps. As sediments deposited in such environments contain mostly fossils of a wide stratigraphic range there are still many problems about the stratigraphic correlation between the different basins and the chronostratigraphic dating of sediments.

A first biostratigraphic correlation with molluscs has been tried by K.ZITTEL (1966) who had finished a monograph on the Gosau pelecypods while he was a curator at Imperial collections in Vienna. In later papers FELIX (1908) and KÜHN (1947) tried to apply a biostratigraphic subdivision to the Gosau sequences on the base of rudists. With little success, as we know today. Nevertheless, rudists were for a long time the major source for biostratigraphic dating of the Gosau sediments. Later it was BRINKMANN (1935) who examined the ammonites from the Gosau sediments which were scattered in collections of Austria and Germany. Although this is an important work the locality data available to BRINKMANN were mostly too vague to be of biostratigraphic use and in some cases certainly wrong, as new examinations of the material by KENNEDY and SUMMESBERGER have shown.

Micropalaeontology had a strong impact on the Gosau biostratigraphy. It was with foraminifera that the pelagic series could first be dated precisely. The stratigraphic range could be extended into the Lower Tertiary by GANSS & KNIPSCHEER in 1954. In later papers by KÜPPER (1956), WICHER & BETTENSTAEDT (1956), HERM (1962), v.HILLEBRANDT (1962), VAN HINTE (1963), KOLLMANN (1964), WILLE-JANOSCHEK (1966), WEISS (1977), BUTT (1981) and others, a subdivision of the pelagic Campanian to Eocene parts of the sequences was accomplished.



Planktonic Foraminiferal Ranges

Planctonic foraminiferal ranges in the Reichenhall Gosau basin (A. BUTT, 1981)

Recent biostratigraphic work by HERM, KAUFFMAN, and WIEDMANN (1979), KOLLMANN and SUMMESBERGER (unpublished) is therefore again concentrating on the basal beds and their megafauna which has been neglected since a long time. It has to be notified that especially the number of ammonites collected in sections could be multiplied in the last few years. Further systematic work on the megafauna and also on the megaflora is in progress.

EXCURSION GUIDE

DAY 1

Leave Munich by bus on Autobahn E 11 to Salzburg. Leave E11 and drive on E 14 east. Leave Autobahn at Vorchdorf. Drive south over Eggenberg, Eichham, Hagenmühle to Edlbach. Leave mainstreet, drive south along the river Dürre Laudach on agricultural road until third bridge and the forest road "Bachwiese".

STOP 1.:REHKOGEL SECTION IN THE CRETACEOUS OF THE HELVETIC ZONE (Sampled by Fred RÖGL and Hedi LANGENEGGER, 1972. Micropaleontology: Fred RÖGL, 1982)

The section is one of the most complete in the Cretaceous of the Helvetic zone and has been first described by S.PREY (1951).

The sediments have been deposited in the southern part of the Helvetic zone (the Ultrahelvetic zone of the Alpine Geologists) which was the outer shelf of the Eurasian plate. In contrary to the Gosau sedimentation it shows a pelagic facies from the Albian on throughout the Upper Cretaceous and the Lower Tertiary. As the Helvetic zone has been scratched off from its basement by the north moving Alpine nappes the sediments are intensively faulted.

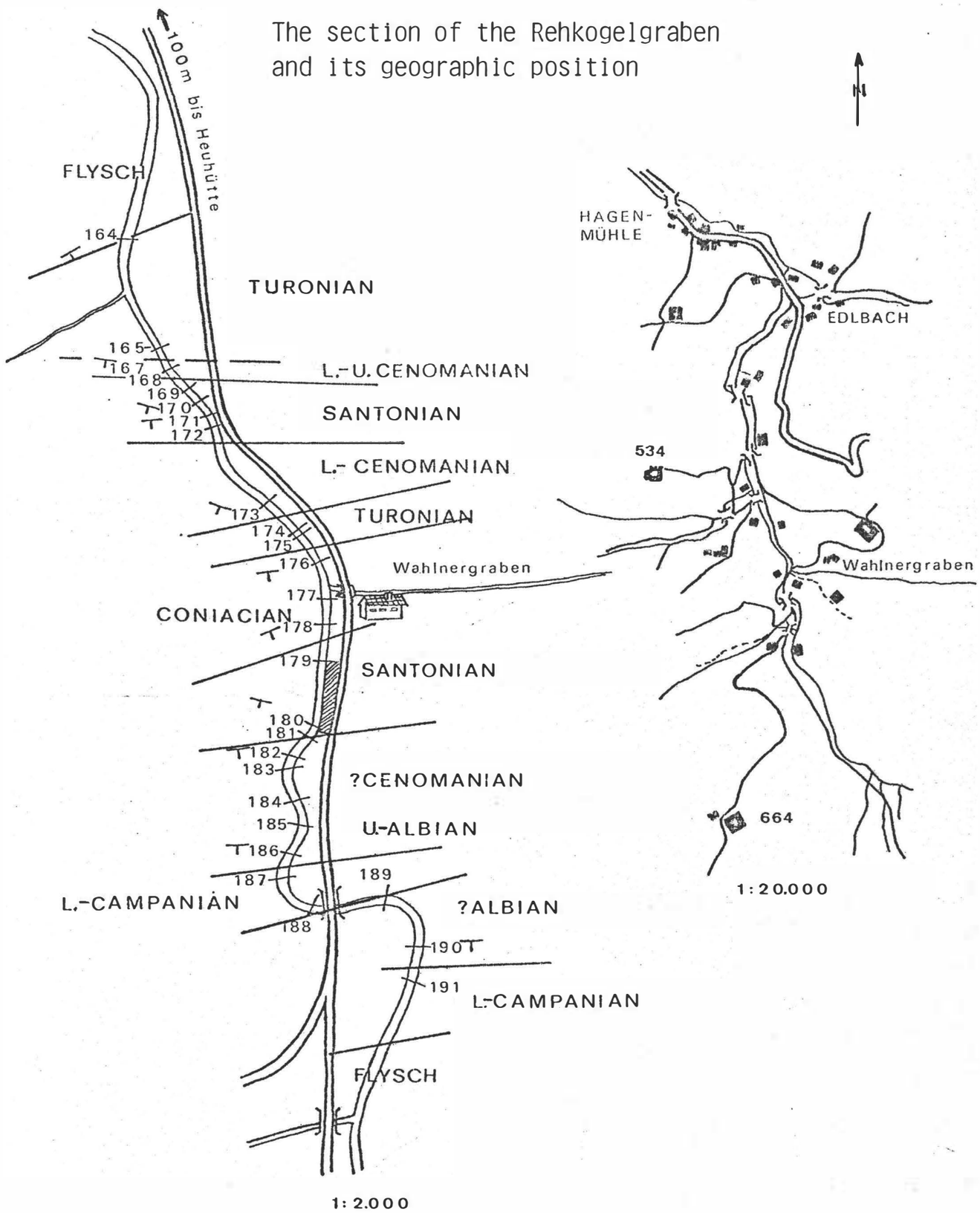
The section is exposed in a tectonic window within the Austro-Alpine Flysch. It begins SSW of a small hay cabin.

Sample number:

165 43 meters (23 meters above small ditch). Light grey solid shales with rich planctonic fauna:

Praeglobotruncana stephani (GANDOLFI)
Dicarinella imbricata (MORNOD)
D. hagni (SCHEIBNEROVA)
Marginotruncana cf.*pseudolinneiana* (PESSAGNO) 188/82

? Lower Turonian


The section of the Rehkogelgraben
and its geographic position
100 m bis Heuhütte
FLYSCH
164
TURONIAN
165
167
168
169
170
171
172
L.-U. CENOMANIAN
SANTONIAN
L.- CENOMANIAN
173
174
175
176
TURONIAN
Wahlnergraben
177
CONIACIAN
178
179
SANTONIAN
180
181
182
183
?CENOMANIAN
184
185
U-ALBIAN
186
187
189
L.-CAMPANIAN
?ALBIAN
188
190
191
L.-CAMPANIAN
FLYSCH
1:2.000
HAGEN-
MÜHLE
EDLBACH
534
Wahlnergraben
664
1:20.000

166 Black layer, silty shales with poor, unfavourably preserved fauna:

Dicarinella imbricata (MORNOD)
Praeglobotruncana helvetica (BOLLI)?
Marginotruncana pseudolinneiana PESSAGNO — 2 meters above 165

Lower to Middle Turonian

167 White argillaceous shales. ? *Dicarinella imbricata* in thin section — 1 meter above 166

168 50.5 meters. Dark grey foliated shales with rich *Rotalipora* fauna:

Rotalipora cushmani (MORROW)
Hedbergella simplex (MORROW)

Middle to upper Cenomanian

169 60 meters. Reddish brown, soft shales as an intercalation in solid, light grey shales. Rich but not very well preserved fauna containing much benthos:

Marginotruncana coronata (BOLLI)
Globotruncana lapparenti BROTZEN

Santonian

170 66 meters. Red soft and thinly splitting shales with rich plantonic fauna and benthos.

Marginotruncana coronata (BOLII)
Marginotruncana marginata (REUSS)
Globotruncana lapparenti BROTZEN — 196/80

Santonian

171 71 meters. Light grey to whitish calcareous shales from an succession of red and grey shales. Very rich fauna:

Marginotruncana coronata (BOLLI)
Globotruncana lapparenti BROTZEN — 178/54

Santonian

172 74.5 meters. Light grey splitting shales, residue white with fragments of fine grained limestones. Fauna rich but rather small:

Marginotruncana coronata (BOLLI)
Dicarinella cf.*concavata* (BROTZEN)
Globotruncana tricarinata (QUEREAU)
Globotruncana lapparenti BROTZEN
Globotruncana bulloides VOGLER
Pseudotextularia sp.

Upper Santonian?

173 108 meters. Elephant grey spotty shales, slightly silty, containing a rich but mostly small planctonic fauna including Radiolarians and remains of thin shelled Pectinids.

Hedbergella
Praeglobotruncana stephani (GANDOLFI)
Rotalipora appenninica (RENZ) 200/56

Lower Cenomanian

174 123 meters. Light grey solid limestone bedded in a 10 to 15 centimeter rhythm. *Hedbergella* and forms with two keels (*Mt.coronata* ?) 170/56

175 124 meters. Soft reddish shales between the limestone. Rich fauna with

Praeglobotruncana helvetica (BOLLI)
Praeglobotruncana stephani (GANDOLFI)
Praeglobotruncana turbinata (REICHEL)
Praeglobotruncana gibba (KLAUS

Turonian, Helvetica-Zone

176 136 meters. Reddish grey soft shales with rich fauna of large Globotruncanids.

Marginotruncana coronata (BOLLI)
Marginotruncana sigali (REICHEL)
Marginotruncana sinuosa (PORTHAULT)
Marginotruncana pseudolinneiana PESSAGNO 170/60

Coniacian

145 meters: Ditch from the right side, bridge above and drive to house. Reddish foliated shales with intercalating solid layers in a 10 to 20 centimeter rhythm.

177 152 meters. Light reddish foliated shales with little and badly preserved fauna:

Marginotruncana coronata (BOLLI)
Mt. pseudolinneiana ?

? Coniacian

178 161 meters. Light reddish, soft argillaceous shales with rich fauna:

Marginotruncata coronata (BOLLI)
Mt. pseudolinneiana PESSAGNO
Dicarinella primitiva (DALBIEZ) 158/80

Coniacian

179 Light grey, foliated argillaceous shales, beginning at the stone wall on riverside. Fauna not rich and unfavourably preserved.

Marginotruncana coronata (BOLLI)
Mt. sinuosa PORTHAULT
Globotruncana lapparenti BROTZEN
Pseudotextularia sp.

Upper Santonian ?

180 200 meters. End of wall. Reddish calcareous shales with not very rich fauna. In thin sections

Marginotruncana coronata (BOLLI) and
Globotruncana lapparenti BROTZEN 190/76

Santonian

181 204 meters. Reddish soft calcareous shales with extremely rich fauna of partly large grown Globotruncanidae.

Marginotruncana coronata (BOLLI)
Mt. sinuosa PORTHAULT
Mt. marginata (REUSS)
Mt. paraconcavata PORTHAULT
Globotruncana lapparenti BROTZEN

Santonian

182 214.5 meters. Silty shales, soft, gray like elephant, with fragments of thin Pecten shells (like sample 173). Rare and unfavourably preserved fauna, mostly benthos, a few radiolarians and small planctonic foraminifera: *Hedbergella cf. planispira* (TAPPAN), *Hedbergella cf. delrioensis* (CARSEY), *Globigerinelloides* sp. 170/35
? Cenomanian

183 218 meters. On west bank of river. Solid, light gray limestone layer in gray shale with dark bioturbations. In thin sections recrystallized radiolaria

184 230 meters. Elephant gray soft shale, silty, with rich recrystallized fauna of small *Hedbergella* and Radiolaria
? Lower Cretaceous

185 240 meters. Elephant gray shales as above but calcareous. Fauna badly preserved: Small *Hedbergella* and a few Radiolaria.
? Lower Cretaceous

186 251.5 meters. Elephant gray, foliated silty shales. Comparatively rich large grown fauna containing also Radiolaria and benthos.
Biticinella breggensis (GANDOLFI)
Hedbergella planispira (TAPPAN)
Clavihedbergella subcretacea (TAPPAN)
Globigerinelloides sp. 176/60
Upper Albian

255 meters. More solid layers of limestone with intercalations of black, foliated shale

From 258 meters upwards light grey and reddish foliated shales

187 260 meters. Red, foliated silty shales with a rich fauna of Globotruncanidae and agglutinated foraminifera.
Marginotruncana coronata (BOLLI)
Marginotruncana marginata (REUSS)
Globotruncana lapparenti BROTZEN
Globotruncana bulloides VOGLER
Globotruncana elevata (BROTZEN)
Lower Campanian

188 274.5 meters. Black, foliated shales containing solid concretions. Not in place

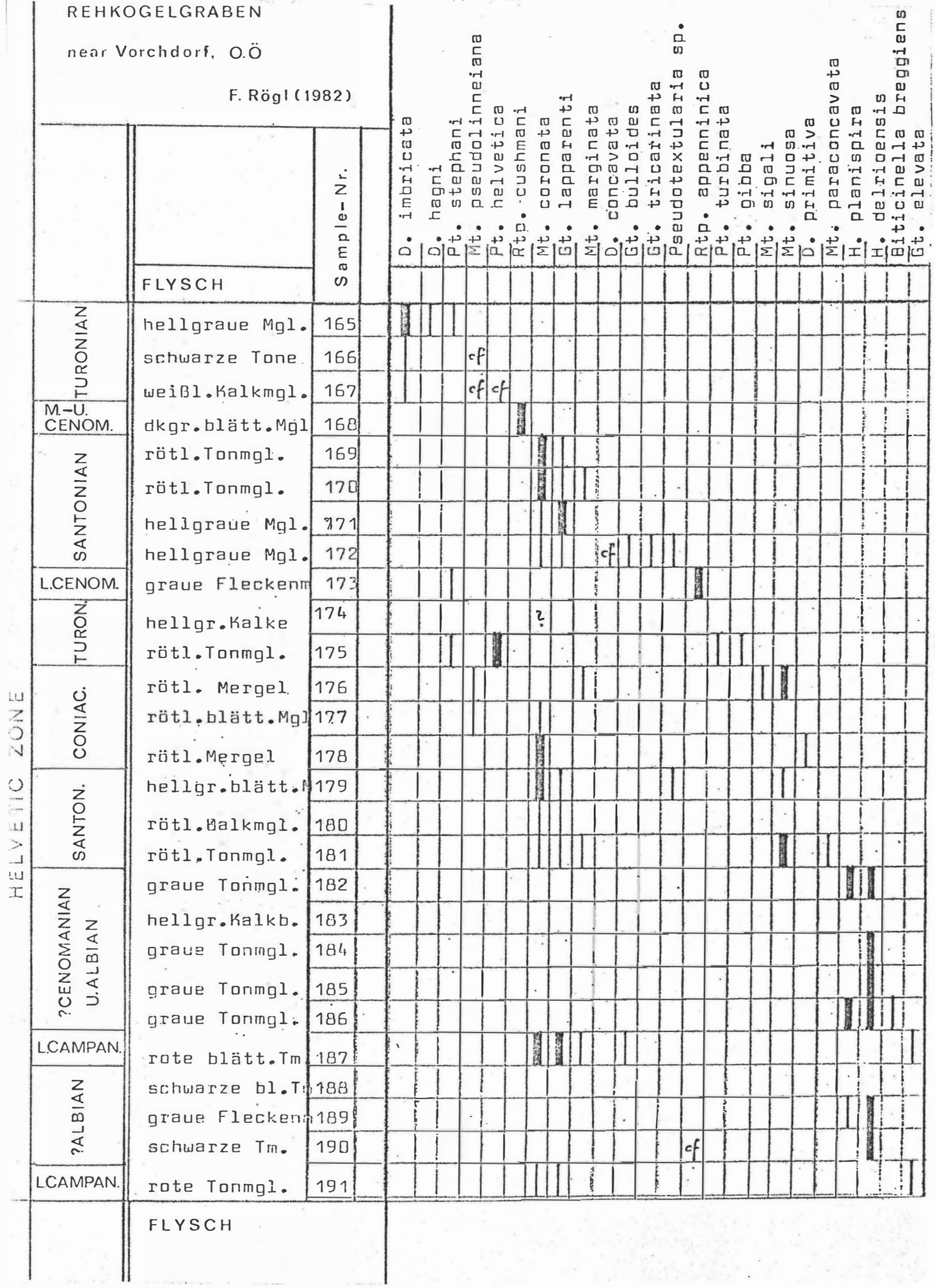
189 301 meters. Grey, silty to calcareous spotted shales. Fauna not very rich. Benthos and Radiolaria more abundant, planctonic foraminifera small.
Hedbergella delrioensis (CARSEY)
Hedbergella planispira (TAPPAN)
Globigerinelloides sp.
? Lower Cretaceous

190 324.5 meters. Black, foliated silty shales with rich benthos, Radiolaria. Small Hedbergella as in sample 189
Rotalipora cf.*appenninica* (RENZ) 176/60
? Upper Albian

REHKOGELGRABEN

near Vorchdorf, O.Ö

F. Rögl (1982)



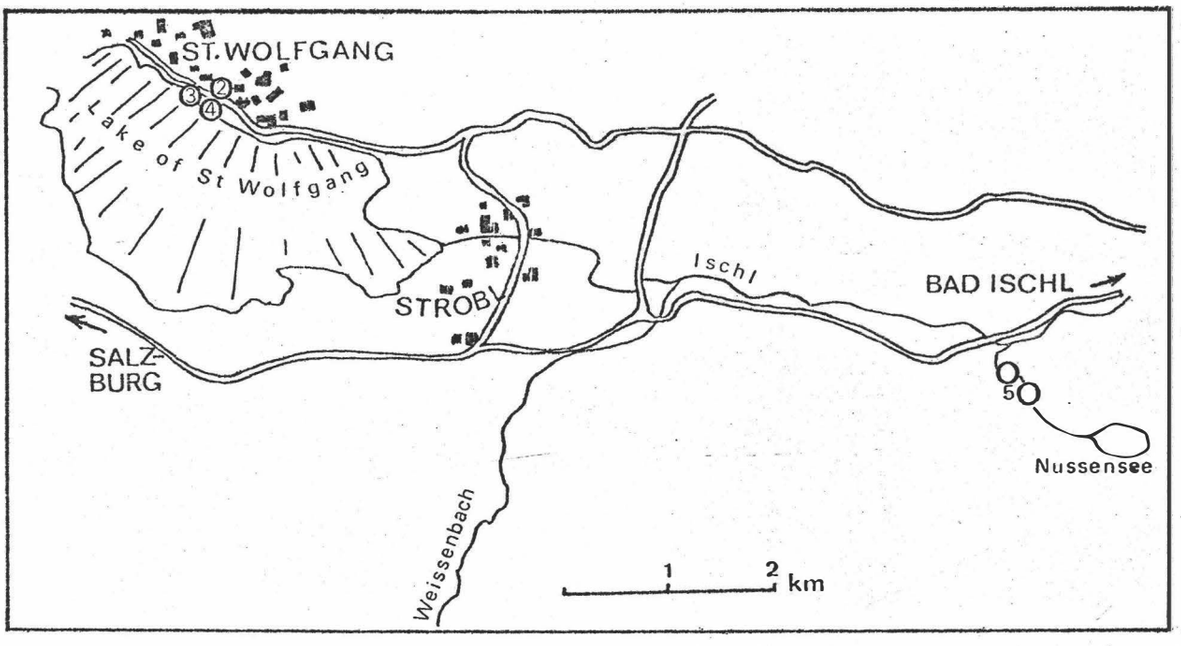
191 337.5 meters. Red, calcareous shales with moderately preserved fauna of Globotruncanidae and benthos, similar to sample 187.
Marginotruncana coronata (BOLLI)
Globotruncana lapparenti BROTZEN
Globotruncana elevata (BROTZEN)
Lower Campanian

No outcrops in stream until flysch

Drive on local roads to Kirchham. From Kirchham to the beautiful town if Gmunden the route passes four Pleistocene terraces. Route follows the lakeside of Traunsee to the south. The high mountain to the left is the Traunstein which forms the northern margin of the Northern Calcareous Alps. We drive further southward the Traun valley upstream to the historic town of Bad Ischl. Now we turn to the north west. The Gosau basin of St. Wolfgang extends around the St. Wolfgang lake and is divided by it into a number of isolated Cretaceous areas.

The Gosau basin of St. Wolfgang

The Gosau basin of St. Wolfgang comprises a number of classical sites mentioned by HAUER (1858, 1866) and REDTENBACHER (1873) in their descriptions of the cephalopods of the "Gosauschichten". The localities Weißenbachtal, Schmolnauer Alpe, Ofenwand, Leiner Alpe, St. Wolfgang bore rich faunas.

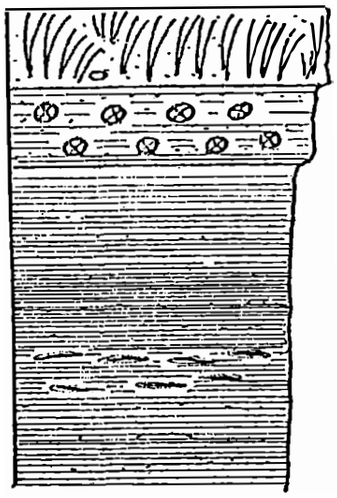


First investigations in the area in 1981 led to the conclusion that unfaulted sections are rare and rather short. A short profile (St. Wolfgang) was drawn after PLOECHINGER (1964, 1973).

Most fossil bearing localities are isolated. The locality Schmolnauer Alpe is situated within a faulted sequence probably lying above the sequence of several hundreds of meters of conglomerates and sandstones of the Fahrenberg. REDTENBACHER's (1873) Tissotias - he has mentioned 51 specimens - seem to come from a level which is separate from the horizon containing Peroniceras. Both localities are very close in the sequence and probably of Upper Coniacian age. The level with Tissotia is tentatively located above the Peroniceras level.

The visited section of St. Wolfgang with shales containing abundantly Muniericeras and with an overlying rudist bioherm is comparable to the basal Hochmoos formation of the Gosau area and of Santonian age.

STOP 2. ST. WOLFGANG, PARKING AREA NUMBER 3.
Sandy shales with common Muniericeras, dipping SW. The fauna contains
Ostracoda
Muniericeras gosauicum (HAUER)
Barroisiceras sp.
Age: Santonian (probably middle Santonian)



Rudist breccia (stop 4)

Coral marls (stop 3)

Muniericeras bearing shales (stop 2)

Stop numbers 2,3,4. Sequence of St. Wolfgang (Santonian) Tentative section, out of scale.

STOP 3. ST. WOLFGANG, FOOTPATH FROM THE PARKING AREA TO THE ST. WOLFGANG LAKE

Calcareous marls with abundant corals. OPPENHEIM (1930) records the following species from here:

Haplarea pratzi (FELIX)
Mesomorpha mammilata REUSS
Heliastraea lilli REUSS
Heliastraea exsculpta REUSS
Heliastraea lepida REUSS
Mycetophyllopsis antiqua REUSS
Placosmilia cuneiformis MILNE EDWARDS & HAIME
Polytremacis partschi REUSS

STOP 4. ST. WOLFGANG, FOOTPATH ALONG THE LAKESIDE.
Rudist breccia, extending over several hundred meters along the lakeside. After KUEHN (1965) the following rudists are ocurring here:

Hippurites (Vaccinites) gosaviensis DOUVILLE
Hippurites (Vaccinites) sulcatus DEFRANCE

OPTIONAL STOP : A short visit to the famous gothic altar of the church is planned if time allows. The altar dates from 1481 and has been carved by Michael PACHER.

The excursion route leads back towards south east. We follow a small road to the Nussensee on the half way to Bad Ischl. Stop near the hotel and walk to the outcrops in the Nussenseebach valley. The section exposes two sedimentary cycles of the Upper Cretaceous which are in a tectonic contact.

STOP 5. NUSSENSEEBACH VALLEY, AT HOUSE LINDEN NR. 53
Nierental formation. Reddish coloured calcareous shales containing the following planctonic fauna:
Globotruncana tricarinata QUEREAU
Globotruncana fornicata PLUMMER
Globotruncana arca CUSHMAN
Globotruncana stuartiformis DALBIEZ

The fauna indicates an Upper Campanian age

NUSSENSEEBACH VALLEY, APPROXIMATELY 150 METERS ABOVE THE FIRST BRIDGE.
The area is known since historic times as an excellent site for collecting ammonites. The following species have been recorded from here (revised by KENNEDY & SUMMESBERGER, in preparation):

Tetragonites cf. *epigonus* (KOSSMAT)
Scaphites meslei de GROSSOUVRE
Scaphites lamberti de GROSSOUVRE
Otoscaphites arnaudi (de GROSSOUVRE)
Otoscaphites sp.
Sornayiceras propoetidum (REDTENBACHER)
Peroniceras czoernigi (REDTENBACHER)
Ishikariceras ? sp.
Fraudatoroceras eugnatum (REDTENBACHER)
The microfauna is poor and contains only smooth ostracodes and *Robulus*.

NUSSENSEEBACH VALLEY: EXPOSURE AT THE FOOTPATH, APPROXIMATELY 100 METERS ABOVE AMMONITE LOCALITY.
Sandy shales with a diverse shallow water mollusc and coral fauna:
Solitary corals *(Cyclolites sp.)*
Naticidae
Anomia sp.
Pinna sp.
Gervillia sp.
Avicula sp.
Baculites sp.

Route description: Drive through Bad Ischl and follow Traun valley upwards. At Bad Goisern we leave Bundesstraße Nr. 145 and follow Bundesstraße 166. Overnight stop at Gosaumühle (Hotel Gosaumühle, A - 4823 Steeg am Hallstättersee; Telefone 06/=6134/242).

The Gosau Basin (General)

The type area of the Gosau group covers an area approximately 40 square kilometers large in an altitude of 400 to 1500 meters. It extends over the boundary between Upper Austria and Salzburg.

First reports on the fossils of the area date back until the 18th century. The scientific investigation began when SEDGWICK & MURCHISON, at this time still friends, passed through Gosau on their field trip through the Eastern Alps in 1829. The results of their investigations have been published in 1832. This was not only a monograph about the structural geology of the Alps. They had also picked up a number of fossils and these were figured without a description by J.D.C. SOWERBY in the same monograph.

Here we are for the first time confronted with a problem which many other palaeontological papers about the Gosau area give us to solve: Fossils have been collected in the float of the streams, not only by the authors themselves but also by local collectors. The locality data are mostly vague but may be reconstructed in some cases from the lithology of the substratum and the actual occurrence of the fossils.

Besides of this an extraordinary large number of fossils has been described from the Gosau area. The following list of papers and monographs is arranged after their main emphasis and gives only a selection:

Foraminifera: HAGN (1957), K.KUEPPER (1956), WEISS (1975, 1977), WILLE-JANOSCHEK (1966)
ANTHOZOA: FELIX (1903), OPPENHEIM (1930), REUSS (1854)
ECHINOIDEA : LAMBERT (1907), KUEHN (1925)

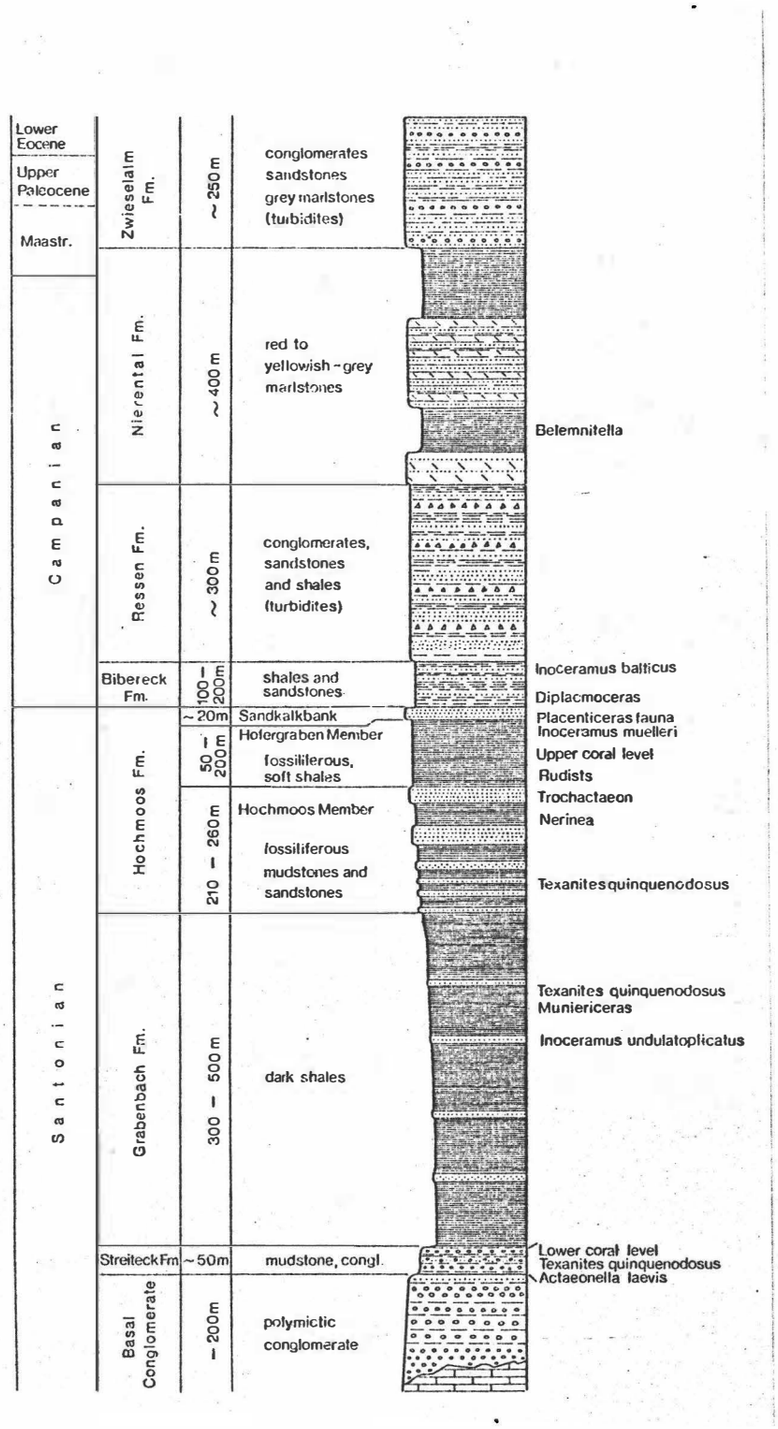
PELECYPODA: DOUVILLE (1890-97), FELIX (1908), KUEHN (1965), ZITTEL (1860-66)
GASTROPODA: KOLLMANN (1965, 1967, 1980), POKORNY (1956), STOLICZKA (1860), TIEDT (1958), ZEKELI (1852)
CEPHALOPODA: BRINKMANN (1935), GERTH (1956, 1959), v.HAUER (1858, 1866), REDTENBACHER (1873), REYMENT (1959), SUMMESBERGER (1979, 1980), WIEDMANN (1978)
GEOLOGICAL AND STRATIGRAPHICAL WORK: FELIX (1908), KOLLMANN (1981), SPENGLER (1919), WEIGEL (1937)

GEOLOGY AND LITHOSTRATIGRAPHICAL UNITS OF THE GOSAU BASIN

Like all other basins in the Eastern Alps formed contemporaneously the Gosau basin is surrounded by faults. Due to the subsidence of the basement 2600 meters of sediments have been trapped during approximately 30 million years. This sequence is by far not uniform. As mentioned before WEIGEL (1937) was the first to subdivide it into a number of lithostratigraphical units which were defined by him. Other units which are partly synonymous with WEIGEL's have been created by WEISS (1975, 1977). The units are described here from the base to the top of the succession as they have been used in the new geological map of the Gosau area by KOLLMANN (1981).

Kreuzgraben formation

This term has been used by WEIGEL (1937) for the basal conglomerates. They consist of well rounded and unsorted pebbles derived from the Triassic and Jurassic rocks of the surroundings. Well cemented layers having a calcareous



Generalized stratigraphical column of the Gosau group in the vicinity of Gosau and Abtenau (after WEIGEL, WEISS, WILLE-JANOSCHEK, SUMMESBERGER and KOLLMANN)

matrix alternate with badly cemented layers with silty matrix. Sandstones are primarily occurring in the uppermost part of the sequence.
Fossil content and age. STOLICZKA (1860) has described from an abandoned coal mine near Russbach a gastropod fauna with the following genera: *Melanopsis*, *Pyrgulifera*, *Tanaliopsis*. A reptil tooth from the same locality has been determined as belonging to an Aligatoridae by BUFFETAUT (1979). The fauna of the Neualm indicates a reduced salinity.

Streiteck formation

Synonymous with WEIGEL's Streiteck formation are WEISS's Iglmoos- and Edelbachschichten which could not be separated after their lithology. The series consists of more or less sandy shales, sandstone and conglomerates with well rounded mostly small pebbles. The main distribution is in the Randograben and in the Edlbachgraben.
Fossil content and age. Well known fossil localities within this formation are situated in the Zimmergraben and in the Stöckelwaldgraben, both subsidaries of the Randograben, and in the Edelbachgraben close to the village of Gosau. The small *Actaeonella laevis* (SOWERBY) occurs in large numbers in the Streiteck formation. Other gastropods and pelecypods are diverse. The colonial coral groups are noteworthy as they occur otherwise in the Gosau basin only in the Hochmoos formation. *Texanites quinquenodosus* (REDTENBACHER) has been found recently close to the base of the Streiteck formation and dates at least most of it as Santonian. By means of microfossils an Upper Coniacian age could not be excluded by WILLE-JANOSCHEK (1966) and WEISS (1977).

Grabenbach formation

A series of dark grey monotonous shales has been named Grabenbach-Schichten by WEIGEL. Intercalating sandstone layers are only common in the area around Russbach.

Fossil content and age. The megafauna is extremely poor in individuals and in species. Occasionally, small solitary corals and echinoids may be found. The gastropods are represented by the genera *Exechocirsus* and *Calliomphalus*, the pelecypods by Nuculidae and Inoceramidae. The marine microfauna indicates after WEISS (1975, 77) an Upper Santonian age.

Hochmoos formation

The Hochmoos formation of WEIGEL is the most complex in the Gosau area and includes the Wegscheidschichten and the Finstergrabenschichten of WEISS. They consist of grey generally fossiliferous more or less sandy shale, limestone and sandstone which may pass laterally into conglomerate. The higher parts of the formation are formed by the soft shales of the Hofergraben member ("shales with fossils" of WEIGEL's Stöckelwaldschichten) and of a 10 to 15 meter thick calcarenite, which has been called Sandkalkbank by WEIGEL. It forms a marker horizon on top of the Hochmoos formation in the Gosau basin.

Fossil content and age. In the contrary to the underlying Grabenbach formation the Hochmoos formation is very diverse in its lithology and fossil fauna. All famous rudist bioherms of the Gosau area are part of the Hochmoos formation. The mass occurrences of *Trochactaeon conicus* and of *Trochactaeon giganteus* are also confined to this formation. The most famous fossil locality of the Hofergraben member besides of the Hofergraben itself is a small tributary stream of the Nefgraben system called Elliptica Graben by GERTH (1959). Here, a coral-rudist facies is exposed. Solitary rudists occur here together with a diverse coral fauna of more than 100 species after OPPENHEIM (1930).

From the calcarenite on top of the Hochmoos formation SUMMESBERGER (1979, 1980) recorded a diverse ammonite fauna of Uppermost Santonian age. The calcarenite is also extremely

rich in pelecypods preserved with both valves and in corals which form flat colonies. All together, the Hochmoos formation has been deposited in shallow water with non marine influence in the northwestern part of the basin. After WEISS (1975) the microfauna is dominated by benthic families which do not allow a precise dating of the deposits.

Bibereck formation

WEISS (1975, 1977) named a series of light grey to yellow sandy shales with thin sandstone intercalations Bibereck-Schichten. They are overlying the Hochmoos formation in the whole Gosau basin and represent the upper part of the Randoschichten of WEIGEL (1937).
*Fossil content and age.*The shales of the Bibereck formation are highly bioturbate. In the contrary to the Hochmoos formation the mollusc fauna is not diverse. Dominant bivalves are the Inoceramidae and *Gervillia solenoides* DEFRANCE. All echinoids described by LAMBERT (1907) and KUEHN (1925) from the Gosau area have been collected in the Bibereck formation. The microfauna is rich in planctonic foraminifera. After WEISS (1975, 1977) *Globotruncana elevata* BROTZEN has its first appearence within the Gosau sequence at the base of the Bibereck formation which indicates a Lower Campanian age.

Ressen formation

The lithostratigraphic term has its origin in the "Ressen sandstone" of SPENGLER (1914). It contains flysch sediments with sandstones and greenish to brown shales. The sandstones have been quarried on the Ressen east of Gosau for making grinding stones. Occasionally, breccias containing lydite quartz and limestone components are developed.
*Fossil content and age.*With the exception of trace fossils no megafossils occur in the Ressen formation. KUEPPER (1956) has already reported that the microfauna is dominated by

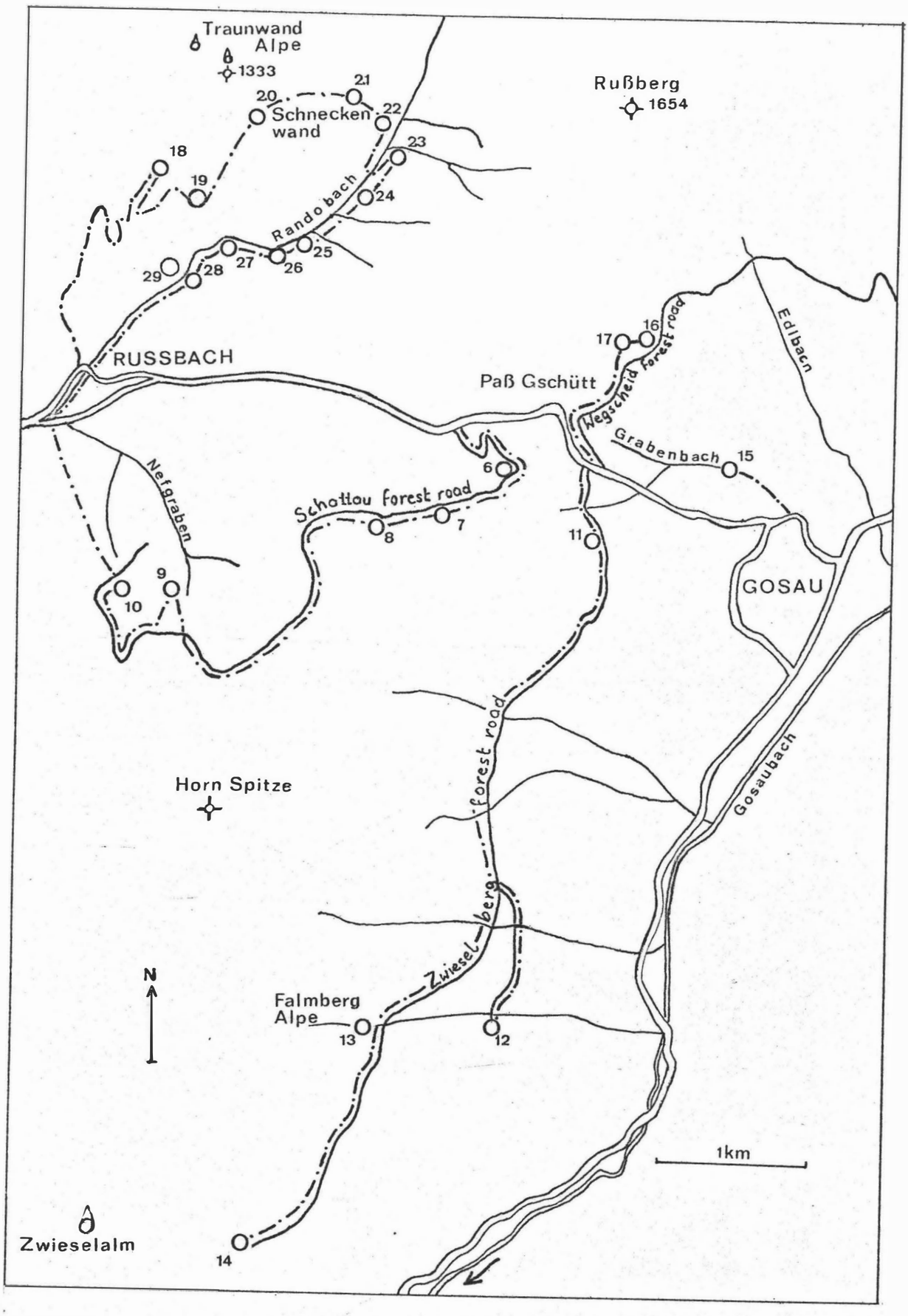
agglutinated foraminifera. WILLE-JANOSCHEK (1966) and WEISS (1975, 1977) have found only a few Globotruncanidae which indicate a Lower Campanian age. From the poor preservation and from the composition of the fauna it may concluded that the Ressen formation has been deposited below the CCD.

Nierental formation

The Nierental formation is a series of variegated calcareous shales and argillaceous limestones. The basal Nierental formation consists of 120 meters of red calcareous shales. They are overlain by 150 meters of white argillaceous limestones with occasional sandstone layers which show large scale slumpung structures. The formation is terminated by red argillaceous limestones.
Fossil content and age.The Nierental formation contains a rich planctonic microfauna which has been described in detail by WILLE-JANOSCHEK (1966). A stratigraphic range from the Upper Campanian to the Lower Maastrichtian has been proved.

Zwieselalm formation

KUEHN (1930) was the first to describe the clastic series with intercalated grey shales on top of the Gosau group. The beds are graded, the breccia layers contain phyllite, well rounded quartz pebbles, crystalline and limestone components.
Fossil content and age.At the ski slope close to the Liesenhütte grey shales containing large boulders of a laminated algal limestone together with colonial corals are exposed. These are of shallow water origin and have been gliding into the deep basin. The microfauna described by WILLE-JANOSCHEK (1966) has a high pelagic character and indicates a stratigraphic range between the Upper Maastrichtian and the Higher Paleocene. The megafauna has been described by KUEHN (1930).



Location of the stops in the Gosau area

DAY 2

Drive to Gosau. Turn right, follow Bundesstraße 166. Stop 500 meters after top of Pass Gschütt at the beginning of the Schattau forest road. Walk up Schattau forest road.

STOP 6.: SMALL DITCH AT THE THIRD TURN OF THE FOREST ROAD:

Grey, sandy shales of the Hochmoos formation containing a rich shallow water fauna. Most abundant are

Ceratostreon spinosum (MATHERON), occurring in a hard layer
Neithea coquandi (PERON)
Plagiostoma striatissima (REUSS)
Pinna cretacea ZITTEL
Exechocirsus reticosus (ZEKELI)
Lunatia semiglobosa (ZEKELI)
Placosmilia sp.

Proceed on Schattau forest road.

STOP 7.: ROAD CUT SHOWING LIGHT GREY SHALES WITH CALLIANASSID BURROWS OF THE HOFERGRABEN MEMBER OF HOCHMOOS FORMATION:

Most abundant are

Placosmilia cuneiformis MILNE EDWARDS & HAIME
Small Cyclolites
Exechocirsus reticosus (J.D.C. SOWERBY)
Helicaulax gibbosus (ZEKELI)
Lipodesthes costatus (J.D.C.SOWERBY)
Lunatia semiglobosa (ZEKELI)
Pseuadamaura bulbiformis (J.D.C. SOWERBY)

The Hofergraben member consists of light grey, usually soft shales and may be distinguished by this lithology from the darker grey and more silty portions of the Hochmoos formation. They are especially rich in gastropods in most outcrops. Among these the deposit feeding groups and the carnivorous Naticids are dominant. A special development is the rudist-coral shale of the Nefgraben which will be visited later.

Proceed on forest road. Pass nodular calcarenite.
This is the Sandkalkbank of WEIGEL (1937) which is nearly unfossiliferous in this part of the basin but has yielded closer to Gosau many fossils. It forms the top of the Hochmoos formation.

STOP 8.: ROAD CUT OF FOREST ROAD.

Bluish grey shales and thinly bedded sandstones of the Bibereck formation.

The molluscfauna is dominated by *Inoceramus* and *Gervillia solenoides* DEFRANCE. SEITZ (unpublished) has determined the Inoceramids from the Bibereck formation of the Schattau area and recognized the following species:

Inoceramus muellleri PETRASCHECK
Inoceramus balticus J.BOEHM
Inoceramus cf. *cycloides* WEGNER.

The foraminifera of the Bibereck formation have been determined by WEISS (1975, 77). The microfauna contains abundantly planctic foraminifera and indicates therefore an environmental change against the underlying Hochmoos formation in which agglutinated foraminifera are dominating. WEISS (1975) gives the following list of foraminifera from the Bibereck formation.

Haplophragmoides, Ammobaculites and related agglutinated foraminifera
Triplasia murchisoni REUSS
Spiroplectammina baudouiniana (D'ORBIGNY)
Gaudryina pyramidata CUSHMAN
Gaugryina rugosa D'ORBIGNY
Dorothia conulus (REUSS)
Dorothia pupa (REUSS)
Dorothia pupoides (D'ORBIGNY)
Dorothia oxycona (REUSS)
Spiroloculina cretacea (REUSS)

Quinqueloculina sp.

Nodosaria div.sp.

Dentalina div.sp.

Frondicularia div.sp.

Lagena div.sp.

Lenticulina div.sp. and related forms

Neoflabellina laterocompressa TOLLMANN

Neoflabellina ?suturalis (CUSHMAN)

Bulimina sp.

Buliminella sp.

Transition forms of *Reussella szajnochae praecursor* DE KLASZ & KNIPSCHEER to *Reussella szajnochae szajnochae* (GRZYBOWSKI)

Allomorphina trochoides (REUSS)

Quadrimorphina allomorphinoides (REUSS)

Globorotalites micheliniana (D'ORBIGNY)

Goupillaudina sp.

Gyroidinoides nitida REUSS

Gavelinella stelligera (MARIE)

Gavelinella lorneiana (D'ORBIGNY)

Stensiöina exsculpta (REUSS)

Epistomina sp.

Höglundina stelligera (REUSS)

Globotruncana lapparenti lapparenti BROTZEN

Globotruncana lapparenti tricarinata (QUEREAU)

Globotruncana concavata (BROTZEN)

Globotruncana elevata elevata (BROTZEN)

Globotruncana lapparenti coronata BOLLI

Globotruncana fornicata PLUMMER

Globotruncana marginata (REUSS)

Sigalia deflaensis (SIGAL)

Pseudotextularia carseyae (PLUMMER)

Ventilabrella eggeri CUSHMAN

Planoglobulina ornatissima (CUSHMAN & CHURCH)

Heterohelix globulosa (EHRENBERG)

Heterohelix striata (EHRENBERG)

With the first occurence of *Globotruncana elevata elevata* (BROTZEN) and the transition forms between *Reussella szajnochae praecursor* DE KLASZ & KNIPSCHEER and *Reussella szajnochae szajnochae* (GRZYBOWSKI) the Bibereck formation may be dated as lower Lower Campanian. In the samples of the lowermost part of the Bibereck formation *Globotruncana concavata* (BROTZEN) and *Sigalia deflaensis* (SIGAL) which are otherwise typical for the Santonian occur together with *Globotruncana elevata elevata*. This shows that the stratigraphic ranges of these species overlap slightly.

Most Echinoids known from the Gosau originate from the Bibereck formation. One of the main localities lies about 250 meters east of the visited point in a steep and slippery ditch. This is the locality which is called "Schattau" by KÜHN (1925). From here the following Echinoids have been described:

Epiaster variabilis KUEHN
Epiaster trauthi KUEHN
Micraster corbaricus LAMBERT
Micraster gappi KUEHN

Proceed on forest road. Pass boundary between Ressen formation and Nierental formation. Take northern (lower) branch of forest road at bifurcation. Walk down ditch into westernmost branch of Nefgraben (=Elliptica-Graben after GERTH, 1959).

STOP 9.: WESTERNMOST BRANCH OF NEFGRABEN.

Bluish grey shales with abundant corals and rudists. Coral-rudist facies of the Hofergraben member. The rudist species occuring here are after KUEHN (1965):

Hippurites (Vaccinites) boehmi DOUVILLE
Hippurites (Vaccinites) oppeli DOUVILLE
*Plagioptychus aguilloni d'*ORBIGNY

Besides of the rudists, FELIX (1908) recorded over 100 species of corals from this locality, among them the large *Cyclolites elliptica* LAMARCK and a great number of colonial forms. ZAPFE (1937) has made an analysis of rudist growth forms. Because of the Cyclolites GERTH (1959) has named the ditch which extends from the lower Hochmoos formation upwards "Elliptica-Graben". The uppermost portions of the ditch are formed by the calcarenite we have already met before and the lower parts of the Bibereck formation.

Proceed through dense forest westwards (Please, keep together) to forest road at ski slope.

STOP 10.: LARGE OUTCROP IN THE HOCHMOOS FORMATION, JUST BELOW MIDDLE STATION OF SKI LIFT:

Grey, shaly sands with callianassid burrows. The fauna contains

Texanites quinquenodosus (REDTENBACHER)
Ceratostreon spinosum (MATHERON)
Neithea coquandi (PERON)
Turritella rigida J.D.C.SOWERBY
Diploctenium angusterimatum OPPENHEIM

The fossils may be collected best in the boulders which have been removed from the outcrop.

Walk down over ski slope to Russbach. You certainly find some money which skiers have lost in the winter. Take the chance to reduce the costs for the field trip!
Mount bus and drive back over Pass Gschütt to the beginning of Zwieselberg forest road.

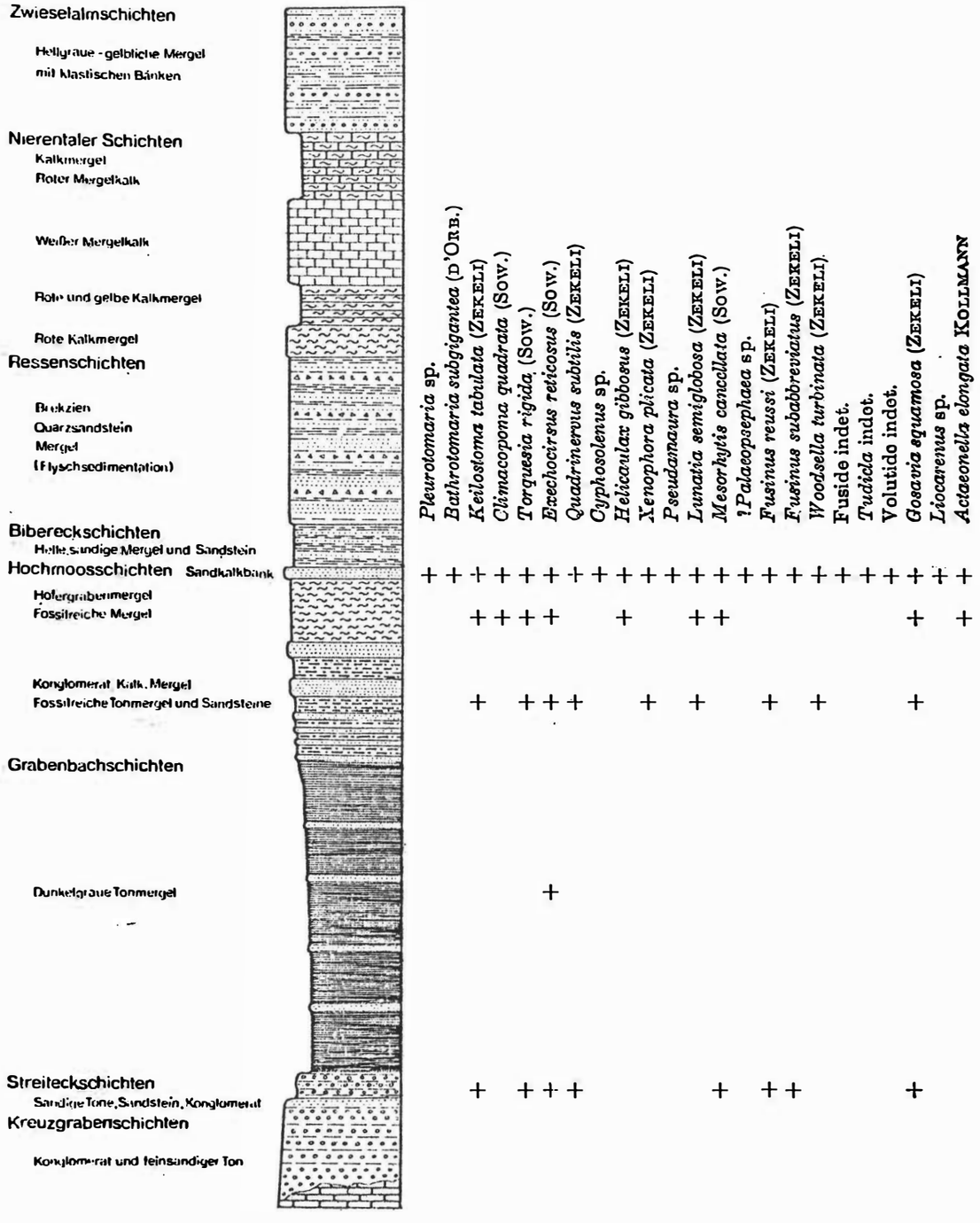
STOP 11.: FINSTERGRABENWANDL at the ZWIESELBERG FOREST ROAD. Member "Sandkalkbank" of the Hochmoos Formation. Upper Santonian.

The "Sandkalkbank" (WEIGEL, 1937) is a calcarenitic member of considerable thickness of the Hochmoos formation. Approx. 20 meters have been measured in the Zwieselberg road sequence. Other localities are of minor thicknesses. The diverse megafauna consists of pelecypods, corals, gastropods, nautiloids, ammonoids, brachiopods, bryozoans. The preservation of bivalves in living position (*Pinna* sp.) and well preserved apertures of ammonites show that even energetic level was very low. The ammonite fauna recently studied by SUMMESBERGER indicates an upper Santonian age. The overlapping Bibereck Schichten are by evidence of *Globotruncana elevata elevata* (BROTZEN) of Campanian age (WEISS 1977). H.A. KOLLMANN (1980) described 23 taxa of the gastropod fauna of the Sandkalkbank. 7 of 16 determinable species were restricted to the Hochmoos formation. The composition of the fauna indicates a high sedimentation rate and sufficient phytoplancton in the water and within the sediment. The first description of a pleurotomariid gastropod gives an evidence for the boreal influence into the Tethyan realm in upper Santonian times. The lack of Scaphitids and dominating ammonite genera of the circum-pacific realm make sure that the Gosau basin in Upper Santonian times was a marginal part of the circumpacific realm with connections to the North and West (Westfalia, Gulf coast of Texas and Mexico).

Fauna: Gastropods after H.A.KOLLMANN (1980),ammonites after H.SUMMESBERGER (1979, 1980):

Nautilus sp.
Gaudryceras mite (HAUER)
Baculites fuchsi REDTENBACHER
Baculites cf. *fuchsi* REDTENBACHER
Baculites cf. *tanakai* MATSUMOTO & OBATA
Baculites sp.

Böehmoceras krekeleri (WEGNER)
Boehmoceras loescheri RIEDEL
Hyphantoceras (Madagascarites?) amapondense (VAN HOEPEN)
Nostoceratide indet.
?Diplomoceras (Subgenus?) *tenuisulcatum* (FORBES)
?Diplomoceras (Subgenus?) *largesulcatum* (FORBES)
Damesites compactus (VAN HOEPEN)
?Parapuzosia cf.*seppenradensis* (LANDOIS)
Kitchinites stenomphalus SUMMESBERGER
Hauericeras (Gardeniceras) gardeni (BAILY)
Eupachydiscus isculensis (RĘDTENBACHER)
Nowakites draschei (REDTENBACHER)
Skoumalia austriaca SUMMESBERGER
Stantonoceras depressum (HYATT)
Placenticeras paraplanum WIEDMANN
Placenticeras maherndli SUMMESBERGER
Reginaites gappi WIEDMANN
bryozoans
corals, mostly solitary corals
boring animals (possibly porifera)
gastropods (Fig.)
pelecypods:
Pycnodonte sp.
Barbatia sp.
Inoceramus sp.
Lima sp.
Neithea coquandi PERON
Gervillia sp.
Pinna sp.
Ambocardia planidorsata (ZITTEL)
Pterocardium productum (SOWERBY)



The distribution of the gastropods occurring in the "Sandkalkbank" in the Gosau sequence (after KOLLMANN, 1980)

Drive forest road towards south west. Take lower branch until bridge over Aster Graben.

STOP 12.: BRIDGE OVER ASTER GRABEN.

Sandstone with greenish shales of the Ressen formation. The Ressen formation is turbiditic and contains only occasionally

Ammobaculites sp.
Textularia sp.
Bigenerina sp.
Spiroplectammina baudouiniana (D'ORBIGNY)
Nonionella sp.
Gyroidina sp.
Valvulineria sp.
Globorotalites micheliniana (D'ORBIGNY)
Gavelinella stelligera (MARIE)
Stensiöina exculpta var.*aspera* HOFKER
Stensiöina pommerana BROTZEN
Stensiöina sp.

The underlying lower Lower Campanian Bibereck formation and the beginning of the Nierental formation in the Upper Campanian (Zone KC of WILLE-JANOSCHEK, 1966) confine the age of the Ressen formation to the Lower to Upper Campanian.

Drive back lower branch of forest road to bifurcation. Take upper branch to Falmberg Alm house.

STOP 13.: BEHIND FALMBERG ALM HOUSE (If snow allows!)

Boundary between the Ressen formation and the Nierental formation. The basal Nierental formation consists of variegated calcareous shales with a rich pelagic microfauna. The fauna contains after KUEPPER (1956) and WILLE-JANOSCHEK (1966) the following Globotruncanids:

Globotruncana arca (CUSHMAN)
globotruncana elevata elevata (BROTZEN)
globotruncana stuartiformis DALBIEZ
Globotruncana fornicata PLUMMER
Marginotruncana coronata BOLLI
Globotruncana lapparenti BROTZEN
Globotruncana lapparenti tricarinata (QUEREAU)

After WILLE-JANOSCHEK the sedimentation of the Nierental formation begins in the Gosau basin in the Upper Campanian (zone KC after WILLE-JANOSCHEK).

Proceed to Liesenhütte.

STOP 14.: SKI SLOPE ABOVE LIESENHÜTTE.

Grey shales containing boulders of laminated algal limestone, partly incrusted quartz pebbles, corals and echinoid spines. The shales are underlain by breccias containing mostly coarse components of phyllite and quartz.

The microfauna is a pelagic one as in the Nierental formation. *Abathomphalus mayaroensis* has its first occurence in the section which indicates an Upper Maastrichtian age for the Zwieselalm formation. Other Globotruncanids are (after WILLE-JANOSCHEK, 1966):

Globotruncana arca (CUSHMAN)
Globotruncana contusa (CUSHMAN)
Globotruncana elevata stuartiformis DALBIEZ
Globotruncana fornicata PLUMMER
Globotruncana gansseri BOLLI
Globotruncana rosetta rosetta (CARSEY)
Globotruncana falsostuarti SIGAL
Globotruncana stuarti (de LAPPARENT)
Rugoglobigerina rugosa (PLUMMER)

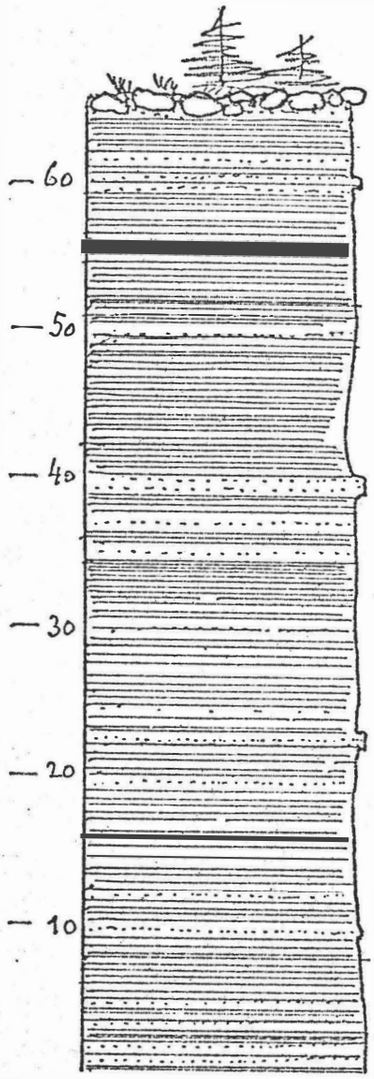
As mentioned before, the megafauna consists of calcareous algae, corals and mollusc fragments. It has been described by KUEHN (1930) who had dated the whole Zwieselalm formation as Danian.

Drive back to beginning of Zwieselberg forest road. Change bus and drive on Bundesstraße 166 in the direction of Gosau. Stop at the restaurant "Koller's Heurigen" and walk on small road into Grabenbach. After 500 meters we pass a dam and walk further on the ground of the stream.

STOP 15. GRABENBACH (Grabenbach formation)

Description: Dark grey shales with rare intercalations of arenites. In the Grabenbach a sequence of approximately 180 meters thickness is exposed. Fossils are rare. Most common are Nuculids, Inoceramids, and small Pectinids. Gastropods are represented by *Calliomphalus* and *Exechocirsus* but are extremely rare. After KAUFFMAN (1967) this fauna may represent a level bottom community which is most closely related to the soft mud bottom communities occurring between 30 and 150 meters depth in the Atlantic.

Texanites in the sequence and in the underlying Streiteck formation indicate a Santonian age. Themicrofauna is much more diverse than in the Streiteck formation but contains the same foraminifera of stratigraphic importance.



Texanites quinquenodosus

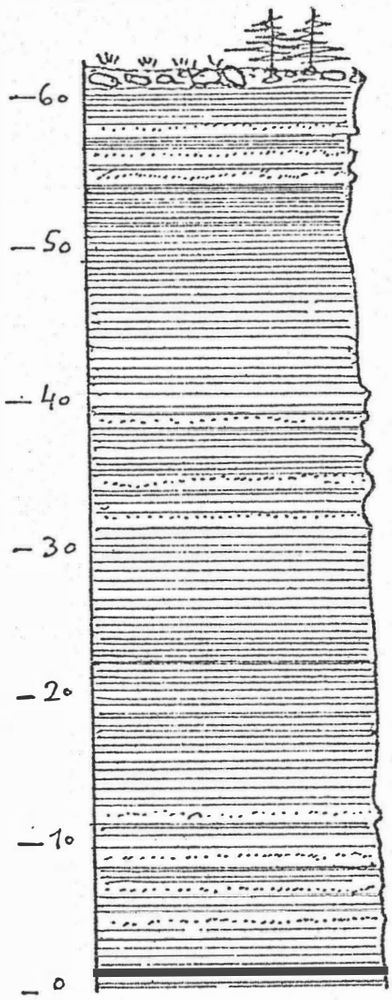
Plant debris

Inoceramus

Baculites
Muramotoceras
Tissotia

Inoceramus

Stop 15. Grabenbach. Section I in the Grabenbach formation



Stop 15. Grabenbach. Section II in Grabenbach formation (not visited)

Microfauna (after WEISS, 1975):

Globotruncana lapparenti lapparenti BROTZEN
Globotruncana lapparenti coronata BOLLI
Globotruncana lapparenti tricarinata (QUEREAU)
Globotruncana concavata (BROTZEN)
Globotruncana fornicata PLUMMER
Heterohelix globulosa (EHRENBERG)
Heterphelix striata (EHRENBERG)
Pseudotextularia plummerae (LOETTERLE)
Pseudoguembelina costulata (CUSHMAN)
Sigalia deflaensis (SIGAL)
primitive agglutinated foraminifera
Ammodiscus gaultinus BERTHELIN
Arenobulimina d'orbigny REUSS
Pseudogaudryinella sp.
Spiroplectammina praelonga (REUSS)
Verneuilina münsteri REUSS
Gaudryina pyramidata CUSHMAN
Tritaxia tricarinata (REUSS)
Marssonella turris (D'ORBIGNY)
Dorothia conulus (REUSS)
Dorothia pupa (REUSS)
Dorothia oxycona (REUSS)
Ophtalmidium cretaceum (REUSS)
Nodosaria div.sp.
Dentalina div.sp.
Frondicularia div.sp.
Lagena sp.
Lenticulina marcki (REUSS)
Lenticulina subalata (REUSS)
Lenticulina div.sp.
Planularia complanata (REUSS)
Neoflabellina suturalis (CUSHMAN)
Saracenaria ?jarvisi BROTZEN
Vaginulina gosae (REUSS)

Bulimina sp.
Buliminella sp.
Valvulineria lenticula (REUSS)
Rugoglobigerina rugosa (PLUMMER)
Rugoglobigerina sp.
Globigerina infracretacea GLAESSNER
Globigerinalle aequilateralis (BRADY)
Loxostomum eleyi (CUSHMAN)
Quadrimorphina allomorphinoides (REUSS)
Globorotalites micheliniana (D'ORBIGNY)
Globorotalites multisepta BROTZEN
Gyroidinoides nitida REUSS
Gavelinella lorneiana (D'ORBIGNY)
Gavelinella stelligera (MARIE)
Stensiöina exsculpta (REUSS)
Stensiöina gracilis (BROTZEN)
Epistomina div.sp.
Höglundina stelligera (REUSS)

Megafauna:

rare echinoids,

gastropods:

Calliomphalus sp.
Exechocirsus sp.

pelecypods:

Inoceramus sp.
small Nuculidae (common)
Gervillia sp.
Syncyclonema sp.

ammonoids:

Muramotoceras n.sp.
Baculites sp.
Muniericeras cf.*gosauicum* (HAUER)
Placenticeras sp.
Tissotia sp.
Texanites quinquenodosus (REDTENBACHER)

crustaceans:

Callianassa sp.

Age: Santonian,possibly Lower Santonian

Drive back to Hotel Gosaumühle. Overnight stop.

The Ammonite Distribution in the Santonian of the Basin of Gosau, Austria

	Desmoceratidae	Muniericeratidae	Placenticeratidae	Tissotiinae	Texanitinae	Barroisiceratinae	Heteromorphs
HOCHMOOS FM.	Hauericeras Parapuzosia Nowakites Eupachydiscus	Muniericeras	Placenticeras Stantonoceras Placenticeras		Texanites	Barroisiceras	Boehmoceras Madagascarites Diplomoceras Baculites Euhomaloceras
GRABENBACH FM.	Nowakites Parapuzosia	Muniericeras	Placenticeras	Tissotia Hemitissotia	Texanites		Baculites Muramotoceras Muramotoceras Baculites
STREITECK FM.					Texanites	Barroisiceras	

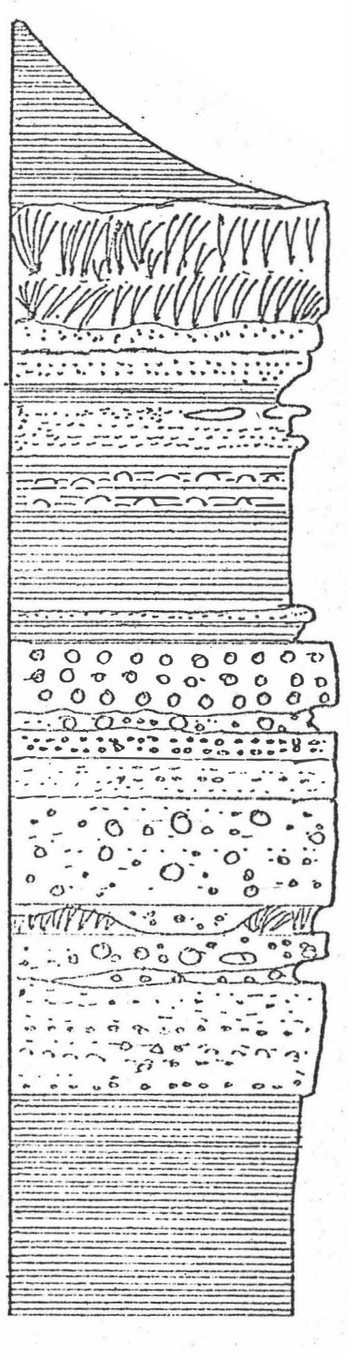
DAY 3

Drive to Gosau. Turn right to Bundesstraße 166 and drive 2 kilometers towards Paß Gschütt. Stop at junction with Zwieselberg forest road and walk down over meadow to Wegscheid forest road. Follow forest road 800 meters uphill. Walk up to small wall of rocks.

STOP 16. WEGSCHEIDGRABEN - BRUNFTLOCH

Description of the section:

1. Dark grey shales (Grabenbach formation)
2. Porous sandstone with limestone pebbles (diameter up to 1 centimeter)
3. Unconsolidated conglomerate with large pebbles
4. Unsorted well cemented conglomerate
5. Patches of rudist bioherms within conglomerate
6. Conglomerate, well cemented, with pebble size up to 4 centimeters
7. Sandstone with pebbles
8. Light brown fine grained conglomerate, well cemented
9. Unconsolidated conglomerate with large pebbles (up to 7 centimeters)
10. Well cemented conglomerate, components of medium size
11. Grey, solid shales
12. Yellowish sandstone
13. Grey shaly marls with layers of mollusc debris
14. Sandstone and shales
15. Solid sandstone with fossil debris
16. Dark grey shale
17. Solid calcarenite
18. Rudist bioherm with *Hippurites (Batolites) tirolicus* DOUVILLE, *Hippurites (Vaccinites) gosaviensis* DOUVILLE and *Plagioptychus aguilloni* d'ORBIGNY



19. Grey shales (Naticidae, pelecypods)

18. *Hippurites* bioherm

17. Sandstone with shaly intercalation

14. Sandstone lenses in soft shale

Shell debris

13. Grey shales

12. Yellow sandstone

10. Well cemented conglomerate
9. Badly cemented conglomerate (coarse)
8. Light brown fine conglomerate
7. Sandstone with pebble layers

6. Well cemented conglomerate

5. *Hippurites* patches in badly sorted congl.

3. Badly cemented,badly sorted conglomerate

2. Porous sandstone with pebble layers

1. Grey shales; Grabenbach formation (top)

Stop 17, Brunftloch. Base of Hochmoos formation (Santonian)
Scale 1 : 100

19. Exposed in small excavations: Bluish grey shale. Pelecypods and Naticidae abundant

STOP 17. UPPER PART OF SECTION OF STOP 16, Exposed at the forest road. The fauna of the bluish grey shale overlying the rudist bioherm may be collected here.

Remarks to stop 16 and 17

The locality Brunftloch (which has also been called Brunsloch and Brunnsloch in the literature) has already been mentioned by REUSS (1854) in the first comprehensive description of the Gosau valley. For WEIGEL (1937) this has been one of the keypoints in the geologic history of the Gosau area. He was thefirst to show the difference in lithology and facies between the Grabenbach formation and the Hochmoos formation. He demonstrated that the Hochmoos formation was deposited in shallower water than the Grabenbach formation. This is shown by the deposition of clastic sediments, by the rudist bioherms and the shallow water molluscs of the shales overlying the bioherms.

From the shales, FELIX (1908) has recorded the following molluscs (partly revised):

Pterocardium productum (SOWERBY)
Crassatella macrodonta SOWERBY
Cucullaea chiemensis ZITTEL
Neithea coquandi (PERON) after DHONDT, 1973
Limopsis calvus (SOWERBY)
Liopistha (Psilomya) frequens ZITTEL
Modiola flagellifera FORBES
Perna falcata ZITTEL
Pinna cretacea ZITTEL
Solen sp.
Pseudamaura bulbiformis (SOWERBY)
Lunatia semiglobosa (ZEKELI)
Climacopoma quadrata (SOWERBY)

Rudists from here have been described by ZITTEL (1864-66), DOUVILLE (1890 - 97), FELIX (1908) and ZAPFE (1937). After KUEHN (1947, 1965) the Brunstloch was representing the widespread rudist development of the Upper Santonian in the Alps.

Walk back to bus. Drive over Paß Gschütt to Russbach (Salzburg).
The following localities are only accessible by walking. Prepare for a long walk. Don't forget your raincoat even if weather looks perfect to you.
Walk up towards farmhouse Falleneck. Take dirt road towards north east. Walk up hill along the fence to hill crest. Follow hill crest to north east to an altitude of 1100 meters.

STOP 18. RUDIST BIOHERM OBERSTOECKL

The rudist bioherm Oberstöckl is one of the largest and best preserved in the Northern Calcareous Alps. DOUVILLE (1890 - 97), FELIX (1908) and KUEHN (1965) described from here

Hippurites (Vaccinites) oppeli felixi KUEHN
Hippurites exaratus ZITTEL
Hippurites (Vaccinites) gosaviensis DOUVILLE
Radiolitidae
The gastropod *Nerinea (Simploptyxis) buchi* MUENSTER

FELIX (1908) who certainly has seen many rudist localities called the bioherm Oberstöckl "the most impressive he had hitherto seen in the Gosau beds". He thought it was the oldest in the Gosau basin and dated it as Coniacian. He was followed in this by KUEHN (1947, 1965).

The bioherm Oberstoeckl begins at the farm house of the same name and ends near the Traunwand Alm in an altitude

of 1333 meters. The main development is about 350 meters long but further patches in the same position occur also close to the log cabins of the Alpine pasture. The bioherm is overlain by yellowish limestones containing rudist fragments and conglomerates in a solid matrix of limestone.

Walk through forest to door in fence north of the farmhouse Oberstöckl. Cross meadow towards path. Follow path eastwards.

STOP 19. PATH EASTNORTHEAST OBERSTOECKL,JUST BEHIND FENCE. Grey shales with coal fragments of the Hochmoos formation. Diverse pelecypod fauna with *Pycnodonte*, *Neithea*, *Pinna*,and the single corals *Placosmilia arcuata* MILNE EDWARDS & HAIME, *Cyclolites sp.* which are both characteristic for the Hochmoos formation.

Stop 19 is situated directly above the well known locality Oberstöckl which is not as easily accessible. FELIX (1908) reports the following fauna from Oberstöckl (partly revised):

Cyclolites sp.
Diploctenium coniugens REUSS
Placosmilia arcuata MILNE EDWARDS & HAIME
Pterocardium productum (SOWERBY)
Cucullaea chiemensis ZITTEL
Modiola flagellifera FORBES
Actaeonella crassa (DUJARDIN)

Follow path to Schneckenwand

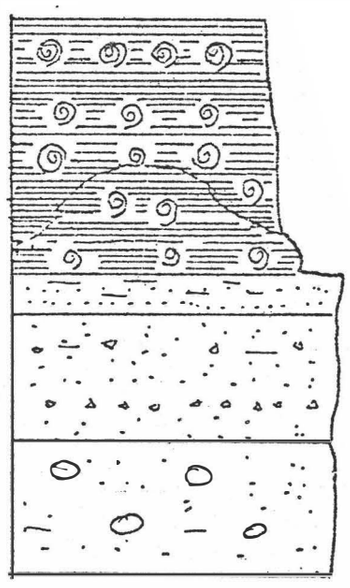
STOP 20. SCHNECKENWAND. DEPOSITS OF ENVIRONMENT WITH REDUCED SALINITY IN THE HOCHMOOS FORMATION

Section through the Schneckenwand (from top to base):

1. Grey marlstone containing *Trochactaeon conicus* (MUENSTER) and *Trochactaeon giganteus giganteus* (SOWERBY)
2. Lens of soft grey shale containing the gastropods
   Tanaliopsis zekelii KOLLMANN
   Cassiope kefersteini (MUENSTER)
   Neritopsis goldfussi (KEFERSTEIN)
   Pirenella muensteri (KEFERSTEIN)
   Pseudomelania sp.
   Trochactaeon conicus (MUENSTER)
   Actaeonella laevis (SOWERBY)
   The composition of the fauna indicates a reduced salinity.
3. Shales with large *Trochactaeon conicus*, *Trochactaeon giganteus giganteus*, *Neritopsis* and small Cerithidae
4. Solid grey sandstone
5. Sandstone with breccious zones. Component size up to 5 millimeters
6. Sandstone with large quartz pebbles

Large Trochactaeon can be found in different localities in the Hochmoos formation but nowhere in the other part of the Gosau basin such a concentration of shells exists as in the Schneckenwand ("snail wall"). This large number of shells, together with the accompanying fauna in the beds 2 and 3 indicates a strongly reduced salinity (Meiomesohalinikum) after KOLLMANN (1967).

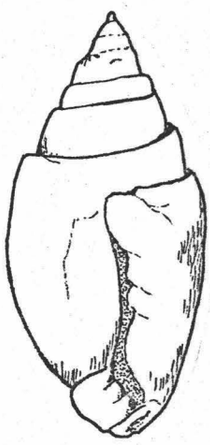
The Schneckenwand is the type locality for *Trochactaeon conicus* (MUENSTER).



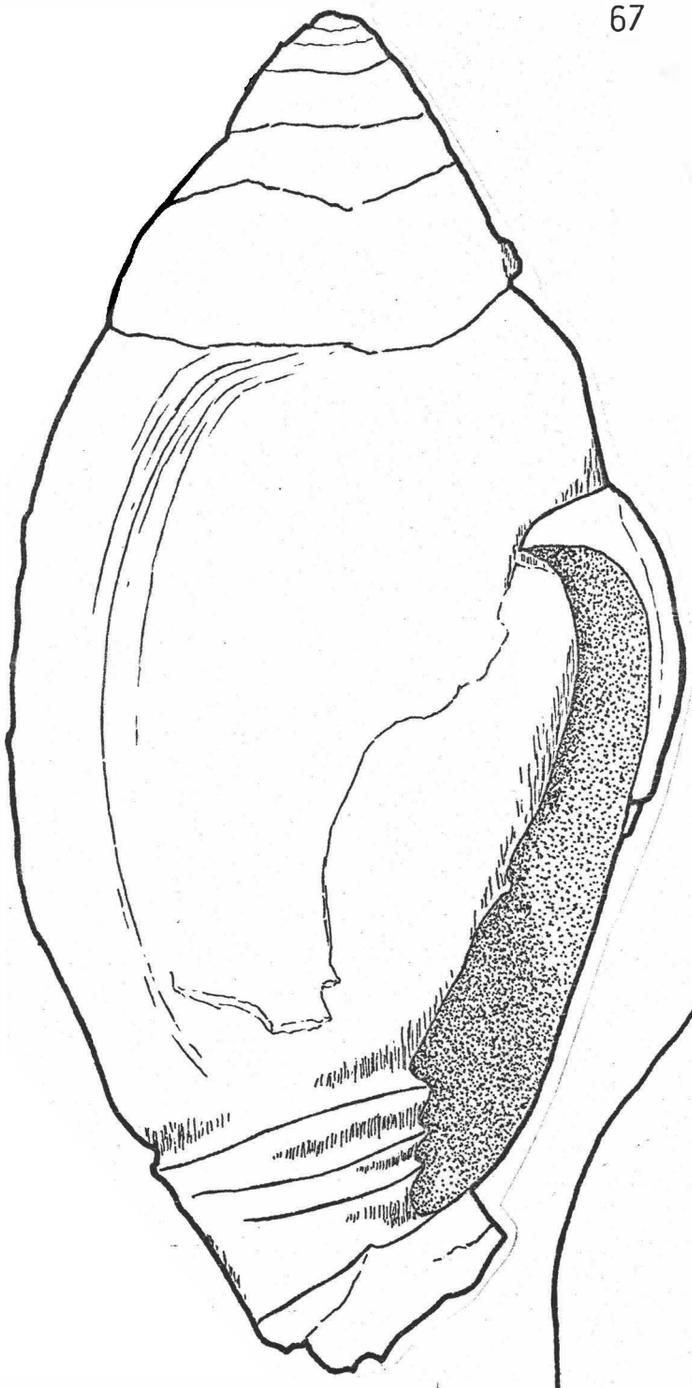
1. Grey marlstone with *Trochactaeon* and small Neritaceans, Cerithiids
2. Lens of soft grey shales (bioturbate) with *Trochactaeon*, *Actaeonella*, *Cassiope*
3. Shales with *Trochactaeon*
4. Sandstone with breccious layers components up to 5 mm
5. Sandstone with large quartz and flint pebbles

Stop 20. Schneckenwand; Hochmoos formation; scale 1 : 50

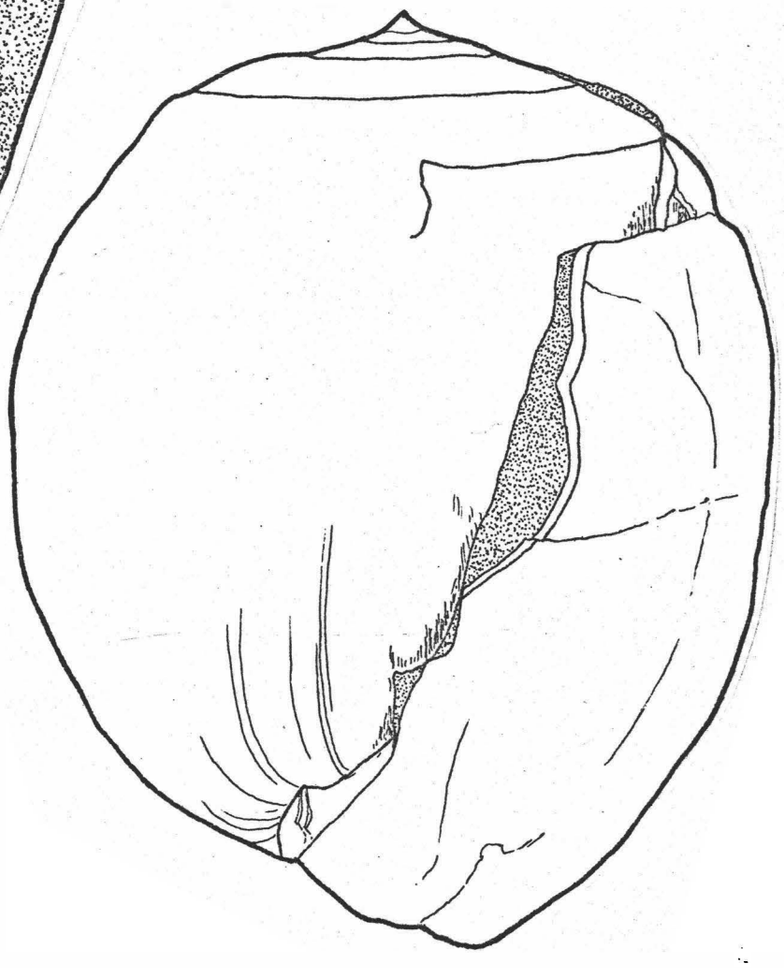
Actaeonella laevis (SOWERBY)
Gosau



Trochactaeon lamarcki (SOWERBY)
Gams



Trochactaeon conicus
(MUENSTER)
Schneckenwand



Trochactaeon giganteus (SOW.)
Gosau

Actaeonellidae of the
Eastern Alps

Walk through a pretty forest towards Stöckelwaldgraben. You know everything about the condition of the outcrop when you hear that the local collectors call it Dreckmaschin' which means dirt machine. Its upper part is a large landslide area of mobilized Hochmoos formation. WATCH YOUR RUBBER BOOTS !

STOP 21. STOECKLWALDGRABEN. UPPER PART: GRABENBACH FORMATION

This part of the section is important for the local stratigraphy. Beds with *Hemitissotia randoi* GERTH are overlying without any doubt parts of the section containing *Texanites*. *Texanites* has actually been found twice in the section: Once in the Grabenbach formation, once in the Streiteck formation. The transition from the underlying Streiteck formation to the Grabenbach formation is a gradual one. The distinction between the formations is based on the disappearance of coarse intercalations and of the concentrations of *Actaeonella laevis*. Fossils occur in layers of debris. The following groups have been determined:

Calliomphalus sp. which is the most abundant gastropod
and the ammonoids
Hemitissotia randoi GERTH (common)
Baculites sp.
The Grabenbach formation is of Santonian age.

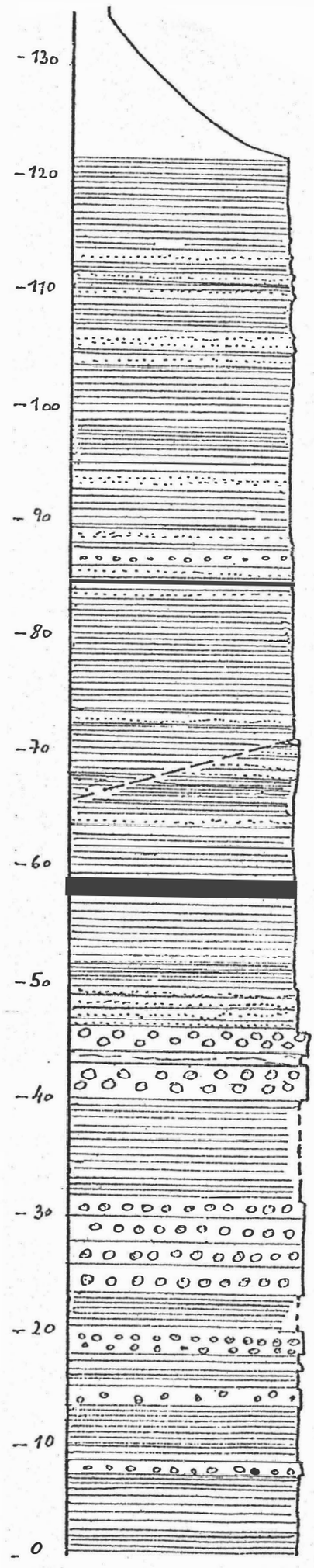
Walk down Stöcklwaldgraben to top of Streiteck formation

STOP 22. STOECKLWALDGRABEN. LOWER PART: STREITECK FORMATION

The Streiteck formation comprises sandy shales with thick intercalations of conglomerates containing well sorted and rounded components. Near the branching-off of a small ditch and around the conglomerates the following fauna may be collected:

GRABENBACH FORMATION

Stop 21



Hemitissotia randoi
Inoceramus, Cerithium

Texanites quinquenodosus
Pecten;Nucula, Aporrhaidae,
Dentalium

Neithea

Actaeonella laevis

Texanites quinquenodosus
Tympanotonus, Cyclolites

Cyclolithes, Placosmilia

Cyclolites
Actaeonella laevis,Nerinea flexuosa
Aporrhaidae, pelecypods

Actaeonella laevis

STREITECK FORMATION

Stop 22

Cyclolites, A.laevis
Phelopteria caudigera

Corals:	*Placosmilia sp.*
	Cyclolites sp.
Scaphopods	
Gastropods:	*Actaeonella laevis* (SOWERBY)
	Nerinea flexuosa SOWERBY
	Turritella "eichwaldiana" after ZEKELI
	Exechocirsus reticosus (SOWERBY)
	Torquesia rigida (SOWERBY)
	Quadrinervus subtilis (ZEKELI)
	Aporrhaidae
Pelecypods:	*Barbatia sp.*
	Anatina sp.
	Pectinidae
Ammonoids:	*Texanites quinquenodosus* (REDTENBACHER)

The fauna indicates shallow water conditions.

A small outcrop below the conglomerate bears an interesting fossil content:
Seaweed
Cyclolites sp.
Actaeonella laevis
Pileolus sp.
Phelopteria caudigera (ZITTEL)
Pectinidae
It is supposed that *Phelopteria* has been attached on the seaweed by byssal threads.
Age: After WEISS (1975, 1977) the microfauna of the Grabenbach formation and the Streiteck formation (his Edlbachschichten) is nearly identical. This is also the case for levels which must be below the occurrence of *Texanites quinquenodosus* in the section. In the contrary to the opinion of FELIX (1908), WEIGEL (1937) and GERTH (1959), there is no evidence for Coniacian sediments in the Gosau area.

Walk on right side of Randobach to next bridge. Cross river. At the forest road on the other side of the river the Kreuzgraben formation is exposed. It consists of coarse conglomerates, often with a red matrix.

STOP 23. ROAD CUT OF FOREST ROAD,AT JUNCTION WITH ROAD TO ZIMMERGRABEN. KREUZGRABEN FORMATION

The outcrop shows intercalations of green shales with coal seams in the conglomerates of the Kreuzgraben formation. The coal seam contains crushed gastropods which can be determined as

Deianira sp.

The archaeogastropod genus *Deianira* is a fresh water faunal element. It has first been described by STOLICZKA (1859) from the dump of an abandoned coal mine close to the Neualm, about 2.5 kilometers northeast of stop 23. The fauna of the Neualm contained *Deianira bicarinata* STOLICZKA, *Deianira hoernesi* STOLICZKA, *Melanopsis pichleri* (HOERNES), *Melanopsis spiniger* (J.D.C.SOWERBY) and other fresh water gastropods. A single reptile tooth of the same locality has been determined by BUFFETAUT (1979) as the tooth of an alligator.

Follow Randobach forest road along river to South west. After the road bifurcation the boundary to the Streiteck formation will be passed. 300 meters after stop 23 follows

STOP 24. RANDOBACH FOREST ROAD. STREITECK FORMATION

In a small ditch on the left side of the forest road dark coloured silty shales are exposed. They bear abundantly *Actaeonella laevis* (SOWERBY).

Walking the Randobach river downstream we are moving up the section stratigraphically.
After passing the next bridge the next exposure is visible on the other side of the river. Examination depends on water conditions.

STOP 25. RANDOBACH RIVER. GRABENBACH FORMATION

Dark grey shales with arenitic intercalations. A few years ago a large *Parapuzosia daubreei* (de GROSSOUVRE) has been found in this locality. It is on display in the Oberösterreichisches Landesmuseum in Linz, the capital of Upper Austria. After de GROSSOUVRE the species appears together with *Texanites texanum* in southern France. In a site in the nearby situated Zimmergraben which is stratigraphically very close to stop 25, *Texanites quinquenodosus* has been found.

Other fossils in stop 25 are *Calliomphalus sp.* and *Baculits sp.*

The sediments are of Santonian age.

STOP 26. RANDOBACH RIVER.GRABENBACH FORMATION

About 20 meters from Stop 25 is the type locality of *Hemitissotia randoi* GERTH.

It depends on water conditions whether this locality can be visited or not.

Walking downstream a large exposure of Grabenbach formation is visible on the left side. We pass it and cross the river on the next bridge. The next stop is directly after the bridge.

STOP 27. RANDOBACH FOREST ROAD. HOCHMOOS FORMATION

In a large outcrop dark grey silty shales and sandstones of considerable thickness are exposed. In the soft layers bifurcated callianassid burrows are visible.

The Hochmoos formation is dislocated against the Grabenbach formation on a dislocation line of large lateral extension.

Walking further downstream we see outcrops of tectonically disturbed Hochmoos formation in the river and on the roadside. After 250 meters a large outcrop of Hochmoos formation follows in a river bend. Visiting this outcrop depends again on water conditions.

STOP 28. RANDOBACH RIVER. 70 METERS UPWARDS FROM THE FIRST BRIDGE OF FOREST ROAD

Thickly bedded, dark grey,fine bedded sandstone with high calciumcarbonate content. The sandstone forms the centre of a north west dipping anticline. The core of the anticline is overlain by conglomerate and rudist limestone.
In the sandstone *Muniericeras gosauicum* (HAUER) is common together with a *Baculites* sp.

Only a few meters downstream rudist limestone crosses the forest road.

STOP 29. RANDOBACH FOREST ROAD. HOCHMOOS FORMATION

In a small outcrop on the right side, about 20 meters above the river, the rudist bioherm "Randograben" of FELIX (1908) and KUEHN (1965) is exposed. It is in the same stratigraphic position as the bioherm Oberstöckl. The fauna is the same as in Stop 18.

Walk along river to the village Russbach. On the way back to the hotel Gosaumühle you may relax in the bus. Overnight stop in the hotel Gosaumühle.

OPTIONAL STOP. Panoramic view at the Gosau lake

The point of view is situated on the end moraine of the Late Wuermian Gschnitz stadium. The lake behind is located in a large fault system with lateral displacement. The valley flanks are oversteepened by glacial erosion.

When weather is good we may see on the right side the Upper Triassic reef complex of the Gosaukamm. The Hoher Dachstein (altitude 3004 meters) in the background is built up by contemporaneous lagoon sediments which are called the Dachsteinkalk (Dachstein limestone). In the northwestern edge of the Gosaukamm which is unvisible from our standpoint the reef sediments are interfingering with the shales of the Hallstatt facies (Zlambach shales). But also Cretaceous rocks are visible from this point of view. To the north you may see a large natural wall. It is the Rote Wand which consists entirely of rocks belonging to the Nierental formation. This is the largest outcrop of these rocks in the Gosau area.

In the Pleistocene the glacial system of the Gosau valley was connected with that of the Salzach valley. The glacier took its way over the Pass Gschütt through the Lammer valley and met the Salzach glacier at Golling.

DAY 4

Drive from Gosaumühle to Bundesstraße 145 and follow it over the Pötschen pass. Leave the road at Bad Aussee and follow a small road to Grundlsee. Near Grundlsee drive on local roads to the forest road Weissenbachalm. Follow road until it ends in the Weissenbach Alm area.
Visiting the following localities depends on snow conditions !

STOP 30. WEISSENBACH ALM. RUDIST - CORAL - BRACHIOPOD Facies

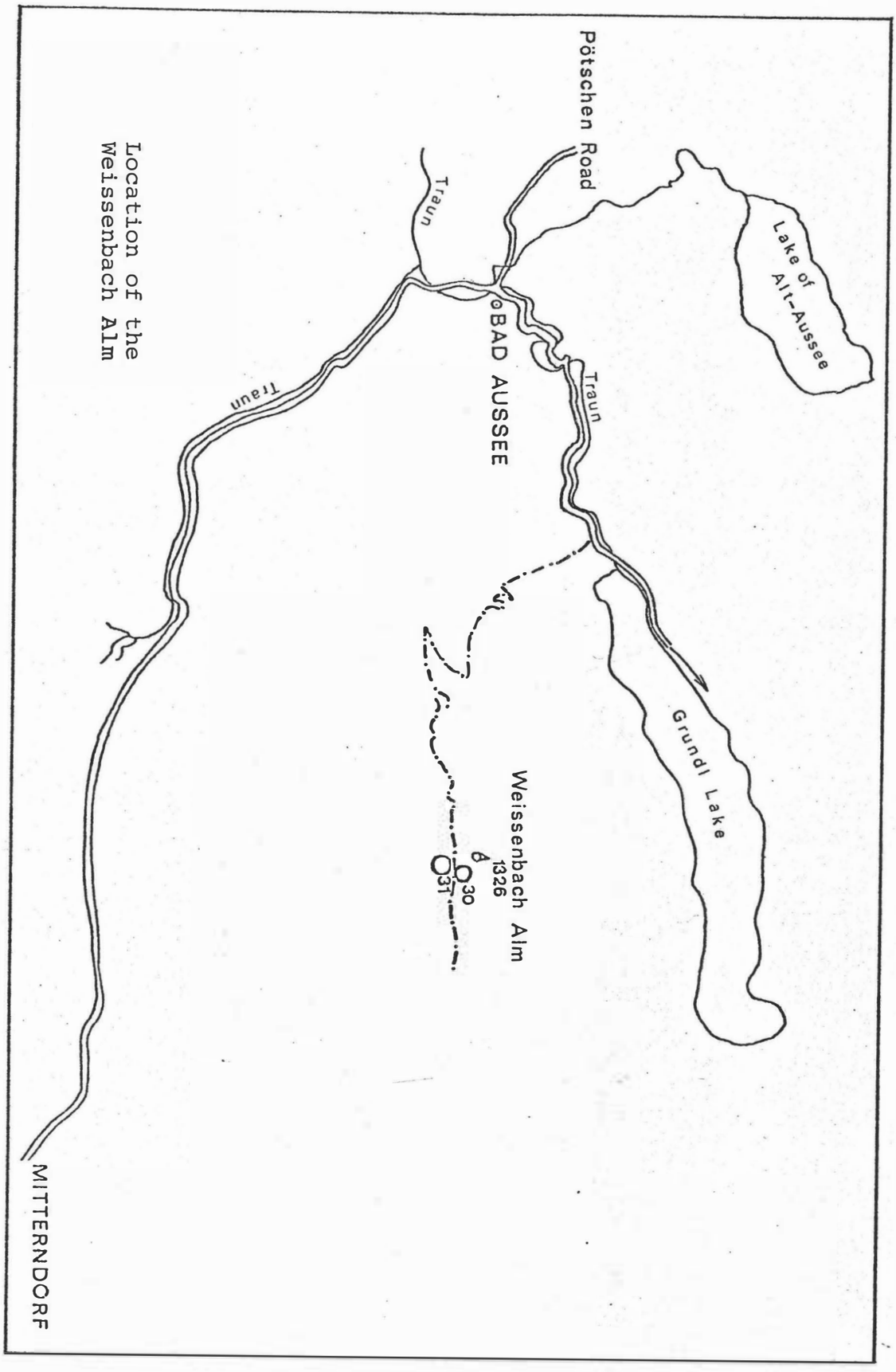
The outcrop shows one of the most beautiful occurrences of the rudist-coral facies in the sense of ZAPFE (1937) in the Eastern Alps. The forest road has been built in 1972. With the road construction the shales with rudists corals and brachiopods became exposed. The rudists are solitary forms. Especially the small Hippurites sulcatus is extremely variable in shape. The following fossils are occurring in this outcrop:

Colonial corals
Brachiopods
Radiolitidae
Hippurites (Vaccinites) sulcatus DEFRANCE
Hippurites (Vaccinites) inaequicostatus MUENSTER
Plagioptychus aguilloni d'ORBIGNY

Following the Weissenbach stream to the west we arrive at the outcrops with dark grey shale from which TOLLMANN (1960) has described a large microfauna.

STOP 31. WEISSENBACH ALM. DARK GREY SHALES

The shales overly the beds with rudists visited in Stop 30. and basal congomerates which we have seen on our way up around the road. After TOLLMANN (1960) the microfauna


Location of the
Weissenbach Alm
Pötschen Road
Traun
BAD AUSSEE
Traun
Traun
Lake of
Alt-Aussee
Grundl Lake
Weissenbach Alm
1326
30
37
MITTERNDORF

of the shale indicates an Upper Coniacian age. He was argueing that this was proved by the occurrence of *Barroisiceras haberfellneri*. Besides that the stratigraphic range of this species is still discussed it turned out after a re-examination of the single ammonite fragment which he had found that it was the outer mould of a Scaphites.

TOLLMANN compared the Weissenbach fauna with the foraminifera assemblages of the Streiteck formation and the Grabenbach formation which was supposed at that time to be of Coniacian age. Recent discoveries of *Texanites quinquenodosus* in both of these formation confirm the micropaleontological dating by WEISS (1975, 1977) into the Santonian.

The following Globotruncanidae have been recorded by TOLL-
Rotalipora schneegansi (SIGAL)
Marginotruncana marginata (REUSS)
Marginotruncana angusticarinata (GANDOLFI)
Marginotruncana coronata (BOLLI)
Marginotruncana globigerinoids (BROTZEN)
Globotruncana linneiana (d'ORBIGNY)
Globotruncana ventricosa WHITE
Globotruncana spinea KIKOINE
Hedbergella infracretacea (GLAESSNER)
Hedbergella aequilateralis (BRADY)

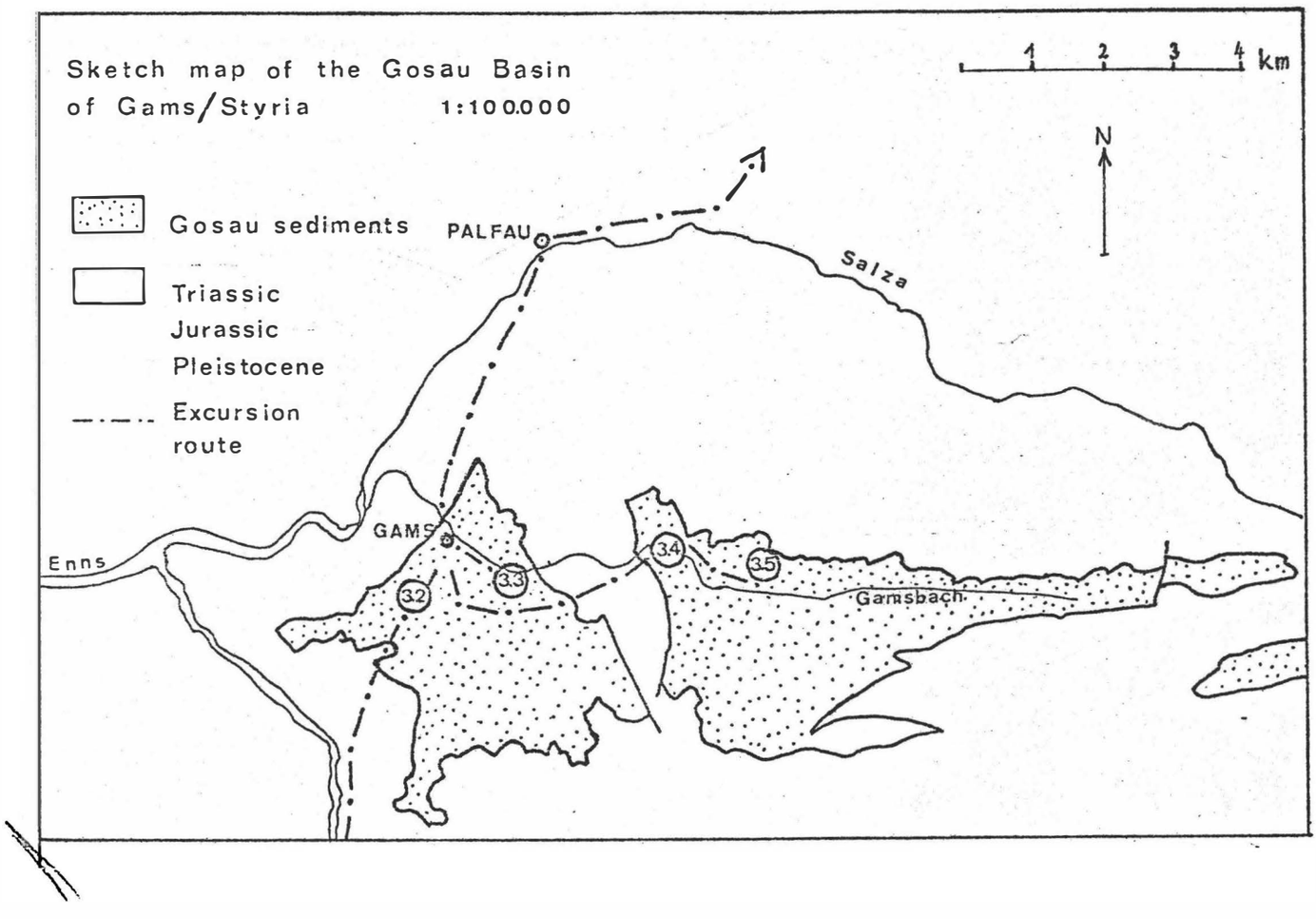
Route description: Drive back the same way to Bundesstraße 145. Drive the Traun valley upstream towards south east. Near the village of Steinach we come into the Enns valley. The road follows now the river Enns downstream until the small town of Admont which is famous by its large monestary. On the left side escarpments of the southern margin of the Northern Calcareous Alps are visible. On the right side we may see the Niedere Tauern which are a part of the Central zone of the Alps.

The road enters the scenic gorge of the Gesäuse where a large Triassic sequence is exposed. After Hieflau the route follows Bundesstraße 115 until Gams.

The Gams Basin (General)

Situated in northern Styria close to the Enns valley the Gams basin extends about 12 kilometers from west to east and is maximally 5 kilometers broad. It is separated into two parts by Triassic and Jurassic rocks. Both of these parts have a different geological history.

The scientific investigation of the Gams area began in early pioneer time with works by MORLOT (1850), PETERS (1852), REUSS (1854). In these early papers only the fossil bearing sediments of the western basin have been treated. An investigation of the eastern basin began with micropaleontological work by WICHER & BETTENSTAEDT (1956) who described a section passing the Cretaceous-Tertiary boundary.



A litho- and biostratigraphical subdivision of the whole sequence has been established by KOLLMANN (1964) who produced a geological map of the area.

The Western Basin

In the western basin sedimentation begins with sandstones and conglomerates. The coal bearing series which follows above consists of sandstones, sands and shales. From these beds microfaunas with *Marginotruncana angusticarinata*, *Marginotruncana concavata*, *Marginotruncana coronata*, *Marginotruncana marginata*, *Globotruncana linneiana*, *Globotruncana tricarinata* have been recorded by KOLLMANN (1964). They indicate a Santonian age but uppermost Coniacian cannot be excluded.

The coal bearing series in which jet for rosaries has been mined until 1559 is overlain by sands and sandstones with Actaeonellids, Nerinea and rudist bioherms. A section within this series is described with stop 33.

Dark grey shales and sands form the major part of the sequence in the western basin of Gams. The sequence has a thickness of approximately 750 meters. The microfauna is uniform and consists of the same planctonic species which have been mentioned below. The megafauna is dominated by infaunal species of gastropods and pelecypods (Turritella, Nucula).

Lower Campanian has not been recorded in the western Gams basin. The upper Campanian consists of grey more or less silty shales. The planctonic microfauna is characterized by *Globotruncana linneiana*, *Globotruncana fornicata*, *Globotruncana arca*, *Globotruncana elevata*, *Globotruncana bulloides* and others. In the south of the basin the shales are overlain by conglomerates.

Eastern Gams basin

The eldest sediments of the eastern basin are comparable in their lithology to the basal beds of the western basin. These are dark grey sands and conglomerates which are preserved only in a narrow zone in the north.

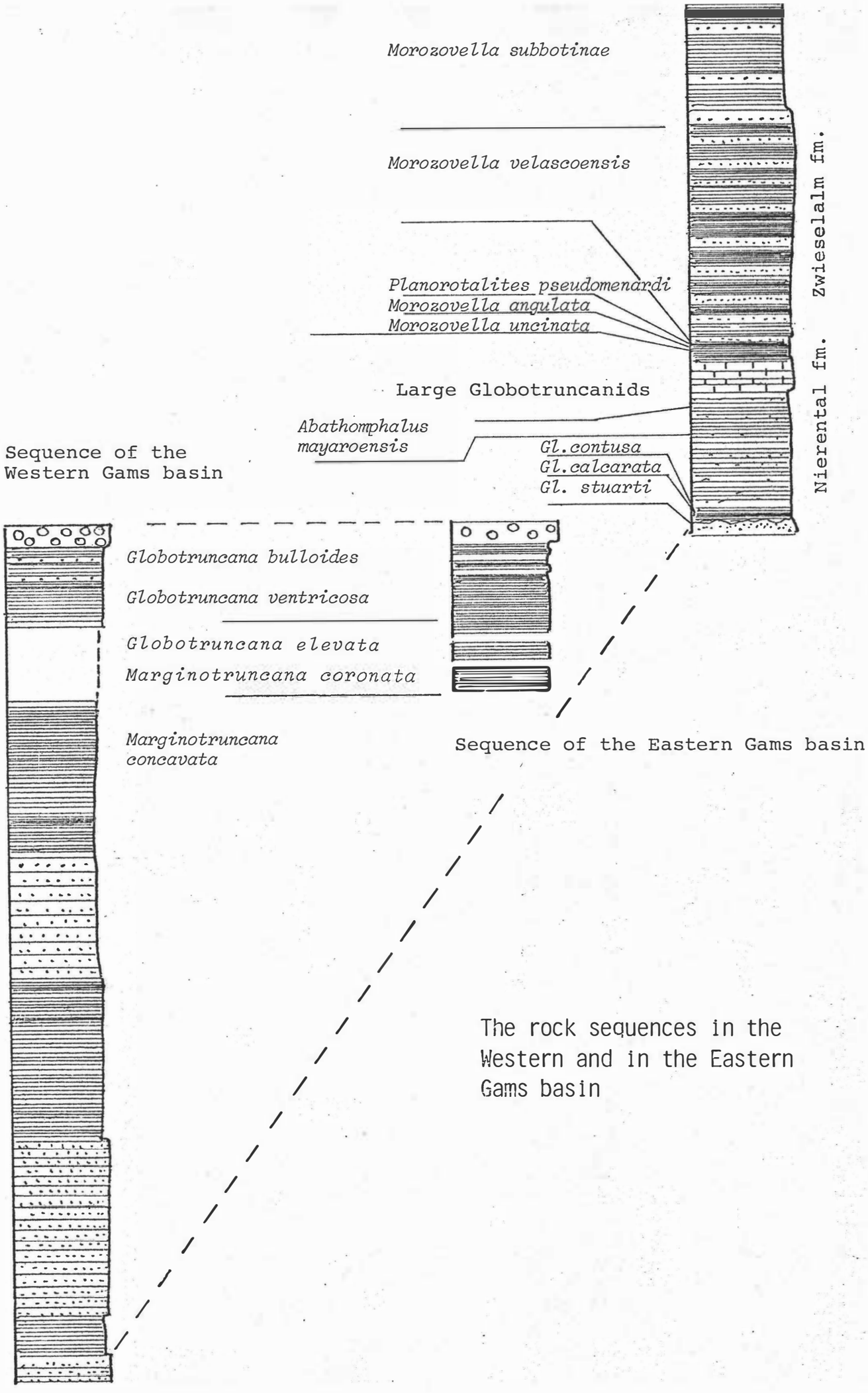
Shales and sandstones of the Lower and Upper Campanian are wider distributed than in the western basin. The lower Campanian consists of shales and sandstone. The microfauna is characterized by *Marginotruncana coronata*, *Globotruncana fornicata*, *Globotruncana elevata*. The sedimentation goes on without interruption into the higher Campanian shales which are the same as in the western basin.

The conglomerate of the Upper Campanian is widely distributed along the southern boundary of the basin.

The sedimentation of the Nierental formation begins in the Upper Campanian and lasts into the Paleocene. The Upper Campanian portion is characterized by *Pseudotextularia elegans*, *Globotruncana stuarti*, *Globotruncana rosetta*, *Globotruncana forniacata* , *Globotruncana linneiana*. The further succession will be discussed with the description of the visited section.

In Gams, the Nierental formation ranges up into the *Planorotalites pseudomenardii* zone. As in Gosau, it is followed by the Zwieselalm formation which begins in the *Morozovella velascoensis* zone and extends up into the *Morozovella subbotinae* zone of the Eocene.

Comparing the Gams section with the Gosau section it is evident that the same depositional character appeared at different times in the Gosau basins. The Gams area is further a good example that sedimentation may even differ in areas which are close together.



The rock sequences in the Western and in the Eastern Gams basin

STOP 32. RADSTATT, AT HIGHWAY SOUTH OF GAMS

Dark grey shales containing the following planctonic microfauna:

Marginotruncana concavata (BROTZEN)
Marginotruncana angusticarinata (GANDOLFI)
Marginotruncana coronata (BOLLI)
Marginotruncana marginata (REUSS)
Globotruncana linneiana (d'ORBIGNY)

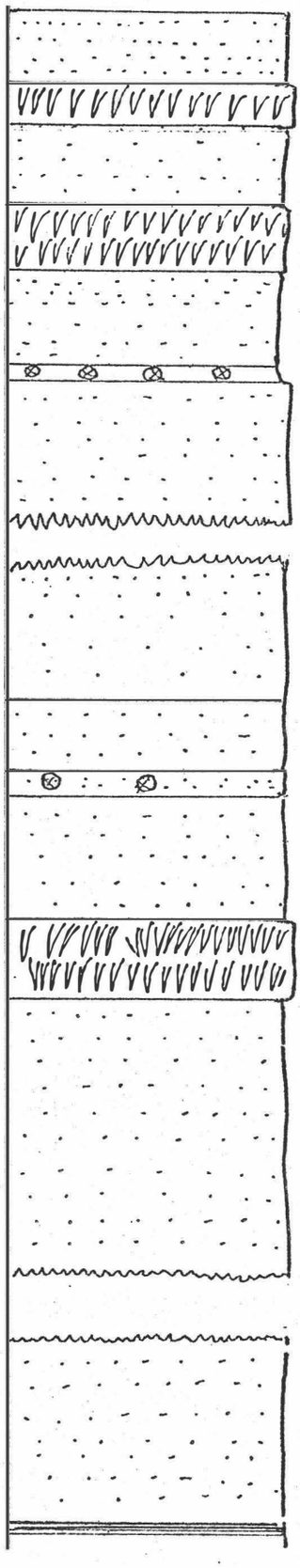
HAUER (1858) has described the ammonite *Barroisiceras haberfellneri* from the Gams basin. In a later paper STUR (1871) mentioned that he had collected together with Josef Haberfellner who had sent the ammonite material to HAUER in the Gams area. STUR limited the locality where *Barroisiceras haberfellneri* had been found with "Radstatt". From the holotype it is evident that it had been collected in a dark grey shale as we see it in the visited locality. This is of Santonian age.

Drive through Gams, turn right and take small road in the direction of "Krautgraben". Stop at old forester's house and walk to the section "NOTH".

STOP 33. NOTH, SANDS WITH GASTROPODS AND RUDIST BIOHERM

The locality "Noth" is the type locality of *Trochactaeon lamarcki* SOWERBY which occurs here in large numbers and has been collected by SEDGWICK & MURCHISON.

In the road cut a section of the sands and sandstones overlying the coal bearing series of the Gams basin is exposed. The section is especially interesting from a ecological point of view as it shows the occurrence of *Trochactaeon* in a marine environment. This deduced from



2,5 m dark grey sandstone

1,5 m rudist bioherm

2,8 m sandstone

2 m bioherm with
Hippurites (Vaccinites)sulcatus

3,5 m dark grey sandstone

andy shales with corals

32 metres (not in scale)
dark grey sand with
Trochactaeon lamarcki

dark grey sand with
Nerinea (S.)pailletteana,T.lamarcki
o,9 m dark grey sand with
Trochactaeon lamarcki,Nerinea (Simploptyxis) pailletteana,Cladocora
6 m dark grey sandstone with
Trochactaeon lamarcki

3 m rudist bioherm with
Hippurites (V.) sulcatus
Hippurites (V.) gosaviensis

4o metres (not in scale)
sandstone and dark grey
shale with abundant
Trochactaeon lamarcki

sandstone

soft brown coal
sandstone

Section of the locality "NOTH" near Gams, Styria (Stop 33)

the destruction of the shells by boring sponges which live in a shallow marine water. Another indication is the common occurrence of *Trochactaeon lamarcki* and the branching coral *Cladocora tenuis* (REUSS).

The rudist bioherms contain

Hippurites (Vaccinites) sulcatus DEFRANCE
Hippurites (Vaccinites) gosaviensis DOUVILLE

Walk back to bus. Drive into Krautgraben valley of the Gams river. Stop at small pub. Walk back a few meters towards west, pass road bridge over river north.

STOP 34. CURVE OF GAMS RIVER NEAR PUB

Grey silty shales containing an Upper Campanian microfauna with the following foraminifera:

Stensiöina pommerana BROTZEN
Pleurostomella subnodosa gigantea WHITE
Globotruncana linneiana (d'ORBIGNY)
Globotruncana fornicata PLUMMER
Globotruncana globigerinoides BROTZEN
Globotruncana thalmanni GANDOLFI
Globotruncana elevata DALBIEZ
Globotruncana caliciformis (d'ORBIGNY)
Globotruncana bulloides VOGLER
Globotruncana ventricosa WHITE

Walk westwards on road until bifurcation with forest road to North. At the bifurcation fine breccias containing small Paleocone nummulitids and bryozoans are exposed.
Walk up forest road to the farmhouse "Summerauer" and into the gorge behind farm house on dirt road. Follow gorge when road ends.

STOP 35. SECTION THROUGH THE NIERENTAL FORMATION AND THE BASAL ZWIESELALM FORMATION

The section has been sampled by KOLLMANN (1964) and by KRISTAN-TOLLMANN & TOLLMANN (1976). The outcrop conditions are changing steadily.

The basal beds of the section which are comparable to the basal beds of the western basin in their lithology are greenish grey sandstones containing coarse pebbles of "Exotic origin". The Nierental formation is lying with an inconformity above the basal sediments. At the boundary coarse unrounded slabs of Upper Jurassic Plassen limestone which forms the northern rim of the basin has been deposited.

The basal greenish grey shales of the Nierental formation contain the following microfauna:

Gaudryina cretacea (KARRER)
Neoflabellina numsimalis WEDEKIND
Globotruncana linneiana (d'ORBIGNY)
Globotruncana fornicata PLUMMER
Globotruncana elevata (BROTZEN)
Globotruncana stuartiformis DALBIEZ
Globotruncana bollii GANDOLFI
Globotruncana arca (CUSHMAN)
Globotruncana rosetta pembergeri PAPP & KUEPPER
Globotruncana rosetta rosetta (CARSEY)
Globotruncana stuarti (d'ORBIGNY)
Globotruncana falsostuarti SIGAL
Pseudotextularia elegans RZEHAK

This microzone has a thickness of approximately 20 meters in the section. It differs from the earlier Upper Campanian of stop 34 by the occurrence of *Globotruncana stuarti* and *Globotruncana rosetta rosetta*.

Uppermost Campanian: Zone of *Globotruncana calcarata* CUSHMAN. The zone has a thickness of approximately one meter. It covers the vertical range of
Globotruncana calcarata CUSHMAN
The lithology is the same as in the zone described before.

Lowermost Maastrichtian. Greenish grey and reddish brown shales with a thickness of 85 meters. The microfauna is rich and contains
Stensiöina pommerana BROTZEN
Globotruncana tricarinata (QUEREAU)
Globotruncana linneiana (d'ORBIGNY)
Globotruncana fornicata PLUMMER
Globotruncana stuartiformis DALBIEZ
Globotruncana bollii (GANDOLFI)
Globotruncana caliciformis (d'ORBIGNY)
Globotruncana flexuosa v.d.SLUIS
Globotruncana ventricosa WHITE
Globotruncana arca (CUSHMAN)
Globotruncana rosetta rosetta (CARSEY)
Globotruncana rosetta pembergeri PAPP & KUEPPER
Globotruncana stuarti (de LAPPARENT)
Globotruncana contusa (CUSHMAN)
Globotruncana citae (GANDOLFI)
Globotruncana gansseri BOLLI
Globotruncana gagnebini TILEV
Rugoglobigerina rugosa BOLLI

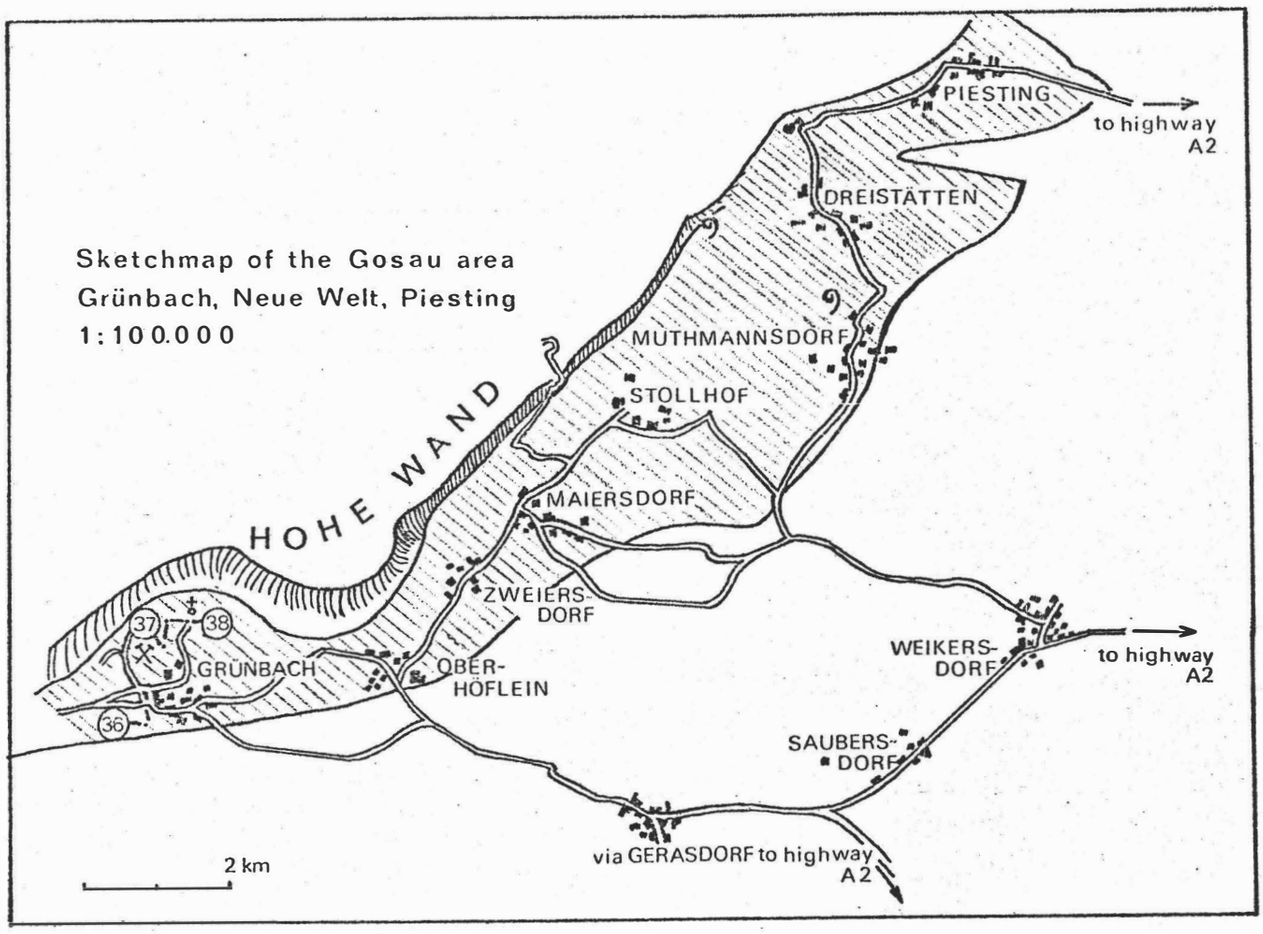
Most important is the first occurrence of *Globotruncana contusa* CUSHMAN and *Globotruncana gansseri* BOLLI at the base of this zone.

In the Upper Maastrichtian 100 meters of dark grey silty shales and 30 meters of solid light grey calcareous limestone have been deposited. The basis is characterized by the first occurrence of *Abathomphalus mayaroensis* (BOLLI). The following Globotruncanidae have been determined:
Globotruncana stuartiformis DALBIEZ
Globotruncana arca (CUSHMAN)
Globotruncana stuarti (d'ORBIGNY)
Globotruncana citae BOLLI
Globotruncana gansseri BOLLI
Globotruncana conica WHITE
Globotruncana contusa (CUSHMAN)
Abathomphalus mayaroensis (BOLLI)

Approximately 80 meters above the base of this zone *Globotruncana contusa* shows an enormous encrease in size. Some meters above also *Globotruncana conica*, *Abathomphalus mayaroensis*, *Globotruncana rosetta*, show a similar increase in size. In the highest layers of the Maastrichtian sequence an increase in the number of agglutinated foraminifera is remarkable. The Lower Tertiary begins with reddish brown shales, partly with green spots. The lowermost Tertiary planctonic zone which has been recorded in the section is the *Subbotina trinidadensis* zone. Lower planctonic zones are missing in the whole Gams area.

Walk back to bus. Drive to Bundesstraße 25. Follow Bundesstraße 25 northwards. On the way, the famous Triassic localities of Lunz will be passed. At Scheibbs we leave the Northern Calcareous Alps and come into the Rheno Danubian Flysch zone which we leave again after a short while. It is followed to the north by the Molasse zone with Tertiary sediments. At Ybbs we cross the Danube. The mountains on the other side of the Danube are higher again. These are the southern parts of the Bohemian Massif.

Stay overnight in the hotel Weißes Rössl in Ybbs.



DAY 5

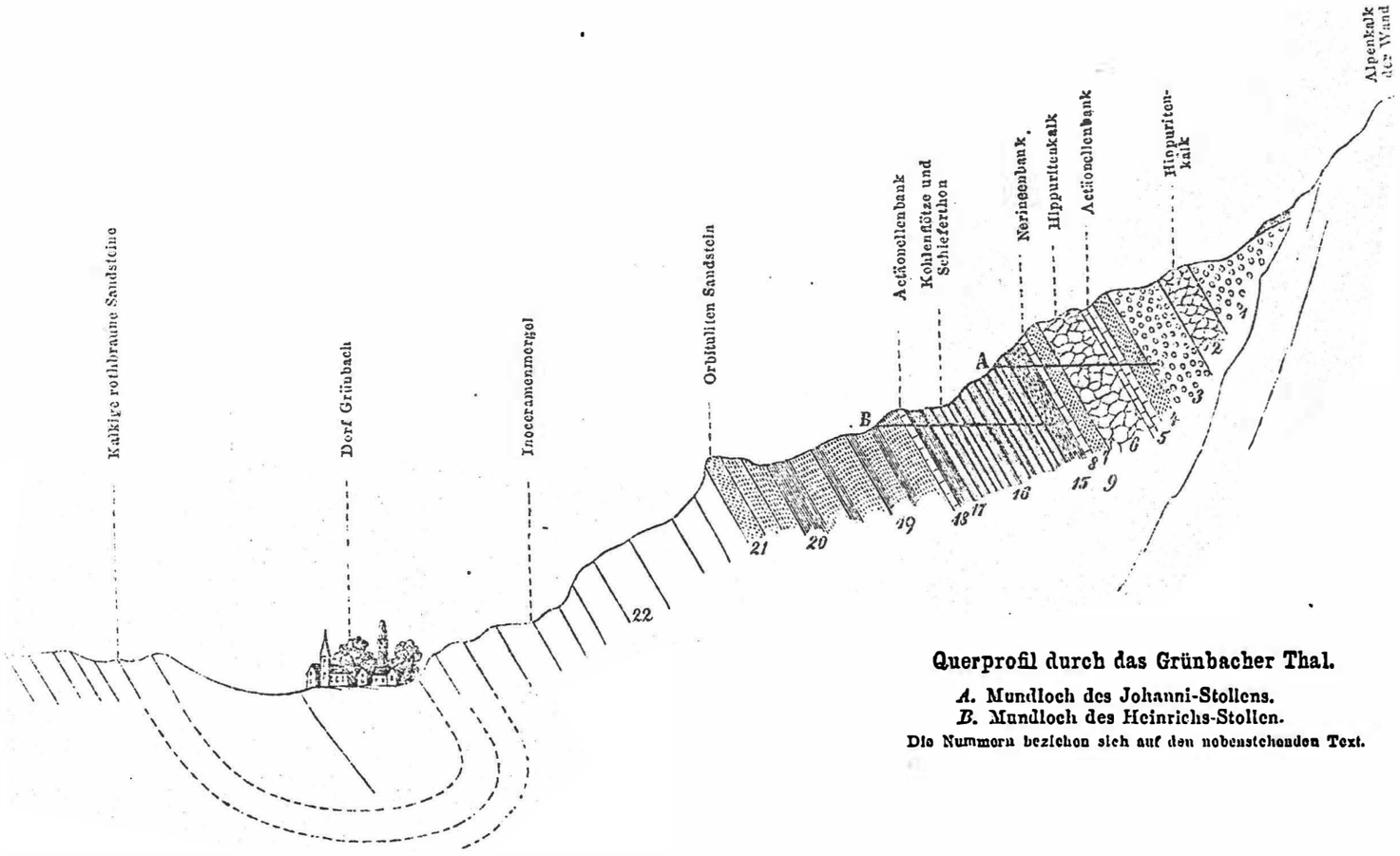
Leave Ybbs in the morning,cross the Danube and follow the Molasse basin eastward using the Autobahn A 1. We leave the A 1 at the highway junction of Steinhäusl with direction to Baden. On this route we cross again the Flysch zone and enter the Northern Calcareous Alps at Alland. From here we follow the Schwechat river downstream. At Baden the eastern margin of the Northern Calcareous Alps is reached and we enter into the Vienna basin which is filled by a sequence of Younger Tertiary rocks with a thickness up to 6000 meters.

We drive southward on the Autobahn A 2 which we leave close to the city of Wiener Neustadt. Soon after we have entered the Northern Calcareous Alps again we are coming into the large synclinal system of the Grünbach basin. The prolongation of the large escarpment of Triassic rocks in the background, the Hohe Wand, is the basement of the Upper Cretaceous transgressional series.

THE BASIN OF GRUENBACH (GENERAL)

The basin of Grünbach strikes east-west and turns southwest-northeast in an area which is called the Neue Welt. The geological knowledge about the basin is not only based on surface investigation but also on subsurface exposures in the coal mines of Grünbach, Höflein, Zweiersdorf, Muthmannsdorf and Dreistätten.

Since ZITTEL (1864-66) the basin is interpreted as a large syncline with an inverted northwestern limb. All parts of the basin bear fossiliferous sites. Especially mentioned shall be the Scharrergraben near Piesting which has yielded a large fauna of corals described by REUSS (1854), FELIX (1903) and OPPENHEIM (1930). F. ZITTEL (1860-66) has treated the pelecypods. Gastropods have been described by ZEKELI (1852). This famous outcrop is hardly visible today.



Querprofil durch das Grünbacher Thal.

A. Mundloch des Johanni-Stollens.
B. Mundloch des Heinrichs-Stollen.
Die Nummern beziehen sich auf den nebenstehenden Text.

K. A. ZITTEL's section through the Gosau basin of Grünbach

Legend:

A,B, Coal mines, 1. conglomerate, 2. rudist limestone, 3. conglomerate, 4. greenish grey sandstone with plant remains, 5. limestone with Actaeonellids, 6. rudist limestone, 7. sandstone with single rudists, 8. limestone with Nerinea bicincta, 9. shale, 10. sandstone, 11. coal shale, 12. shale with Pyrgulifera acinosa, 13. coaly shale, 14. shale, 15. coal, 16. 22 thin coal layers, in between dark grey shales with Cyclas gregaria and Cyclas ambigua, 17. sandstone with marine gastropods and Limopsis calvus, 18. limestone with Actaeonellids, 19. sandstone with non marine gastropods and pelecypods, 20. sandstone, 21. sandstone with Orbitoides

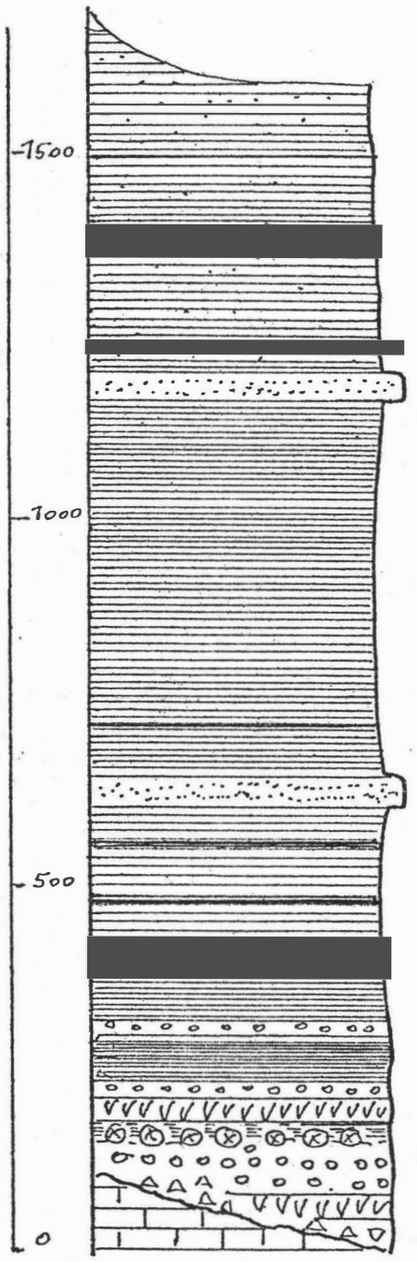
Another well known locality is the Schneckengartl. This is the type locality of *Trochactaeon giganteus* (SOWERBY). A number of molluscs from here has also been described by MUENSTER in GOLDFUSS (1844).

Recently, the basin has been investigated geologically by PLOECHINGER (1961). The subdivision of the sequence is based to a great extent on micropalaeontological work by OBERHAUSER and PAPP in PLOECHINGER's paper. According to our present knowledge Upper Santonian to Paleocene rocks are represented in the basin of Grünbach. Only from the Scharrergraben north of the Piesting river BRINKMANN (1935) quotes an ammonite fauna which he considers as being of Coniacian age. This may be the case with *Tissotoides haplophyllus* REDTENBACHER. But on the other hand BRINKMANN's *Barroisiceras haberfellneri* is a mis-identification. After KENNEDY & SUMMESBERGER (in preparation) it is a placenticeratid while all of BRINKMANN's placenticeratids from the Scharrergraben belong to *Stantonoceras* and confirm an Upper Santonian age.

The sequence of the basin has been subdivided by PLOECHINGER into the following strata:

Transgressive series. Conglomerates, breccias and sandstone with rudist bioherms. From the bioherm close to Grünbach KUEHN (1947, 1965) has mentioned a number of rudists which he dates as Upper Santonian. A list will be given with the description of stop 37.

Coal bearing series. The coal bearing series is up to 700 meters thick and consists mostly of shales. It does not only contain coal and other plant remains together with fresh water molluscs but also marine molluscs which indicate an oszillating sea shore. The coal bearing series of the Grünbach basin has yielded also the largest Cretaceous reptile fauna of the Eastern Alps. It had first been described by



DANIAN — Zweiersdorfer Beds

Globigerina triloculinoides
Gl. pseudobulloides

MAASTRICHTIAN — Inoceramus Beds

Orbitoides - sandstone

Globotruncana div.sp.

Sandy shales

Orbitoides - sandstone

Ammonite fauna with *P.neubergicus*
Pseudokossmatic.

Plant fossils

SANTONIAN CAMPANIAN — Transgress.Coalbearing Series

Conglomerates with *Trochactaeon*

Rudist bioherms

Conglomerates

Rudist bioherms

Breccias

Generalized column of the Gosau basin Grünbach (Lower Austria)
(after PLOECHINGER, 1961)

BUNZEL (1871) and was revised later by SEELEY (1881), BUFFETAUT (1979) and WELLNHOFER (1980). Dinosaurs, crocodilians, turtles, lizards and pterosaurs have been recorded from here.

The fossil flora of Grünbach is one of the largest known Cretaceous floras. A first description of the material is in progress.

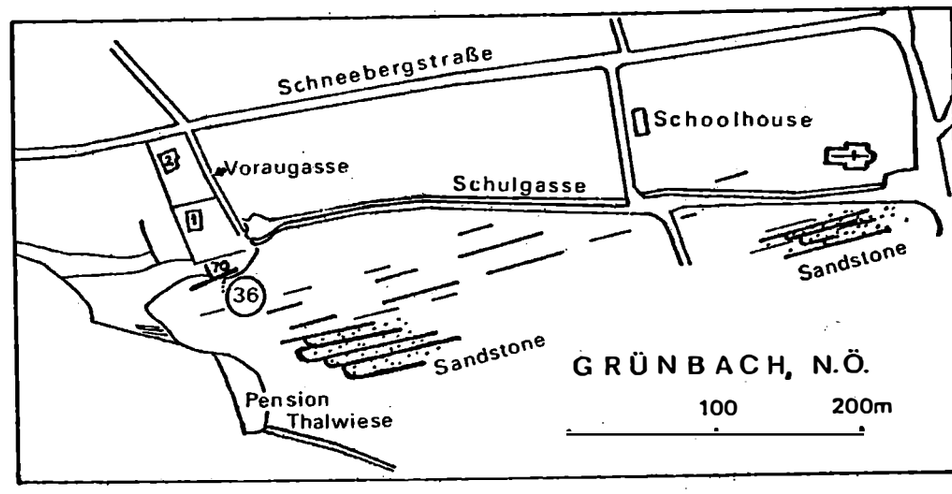
Considering the age determination of the basal rudist bioherm of Grünbach by KUEHN (1947, 1965) and the age of the overlying sequence of orbitoid sandstone and inoceramus shales the coral bearing series has been dated as Campanian by PLOECHINGER (1961)

Inoceramus shales and Orbitoides sandstone. After the nearshore to freshwater environment of the coal bearing series followed a timespan of subsidence. In this time the silty inoceramus shales with intercalated orbitoides sandstones have been deposited. The latter are yellowish brown and bear tests of the large foraminifera *Orbitoides* and of related genera in large quantities. They greatly resemble the Zwieselalm formation of the western Gosau basins. In the shales the trace fossil *Zoophycos* is found which indicates deep water conditions.

The thickness of the whole series does not exceed 400 meters. It can be dated by foraminifera as Upper Campanian to Maastrichtian. Of Maastrichtian age is the ammonite *Pseudokossmaticeras brandti* (REDTENBACHER) which has been found in the Orbitoides sandstone close to Grünbach. *Orbitoides apiculata grünbachensis* PAPP which has been described from the same limestone has to be dated after PAPP in PLOECHINGER (1961) as Lower Maastrichtian after the evolutionary stage of this subspecies.

Zweiersdorf formation. This formation is characterized by grey silty shales with plant debris and layers with debris of calcareous algae and mollusc fragments. Lithologically it is very close to the Zwieselalm formation of the Gosau and Gams area but the clastic layers are not as consolidated.

Besides of the fossil debris which is on secondary deposit the Zweiersdorf formation has yielded planctonic and benthonic foraminifera of the Paleocene *Subbotina pseudobulloides* to *Morozovella angulata* zones.



Location of stop 36 (Grünbach, Voraugasse)

STOP 36. SHALES WITH THE LARGE FORAMINIFERA LITUOLA GRANDIS

In a pine wood at the south end of the Voraugasse in Grünbach solid grey silty shales are exposed. These shales which are part of the inoceramus shale contain the large foraminifera
Lituola grandis (REUSS)
in great numbers. After OBERHAUSER in PLOECHINGER (1961) they are accompanied by the foraminifera
Bolivina cf. incrassata REUSS
Spiroplectammina roemeri LALICKER
Spiroplectammina senonana LALICKER
and others. The microfauna is badly preserved and does not allow a more precise dating than Upper Campanian to Maastrichtian.

Lituola grandis has been described by REUSS (1854) from the area of Grünbach. It has been revised systematically by ZIEGLER (1959).

STOP 37. SECTION AROUND THE ABANDONED COAL MINE SEGEN GOTTES.

Next to the coal mine Segen Gottes a section showing the basal beds, the coal bearing series and the Orbitoides limestone is exposed with some gaps. It is visited from the top to the base.

The Orbitoides limestone forms a small hill which is topped by a few pines. It is a quartz rich yellowish sandstone which contains larger foraminifera in great numbers. PAPP in PLOECHINGER (1961) gives the following list.
Orbitoides apiculata gruenbachensis PAPP
Lepidorbitoides cf. minor (SCHLUMBERGER)
Siderolites sp.

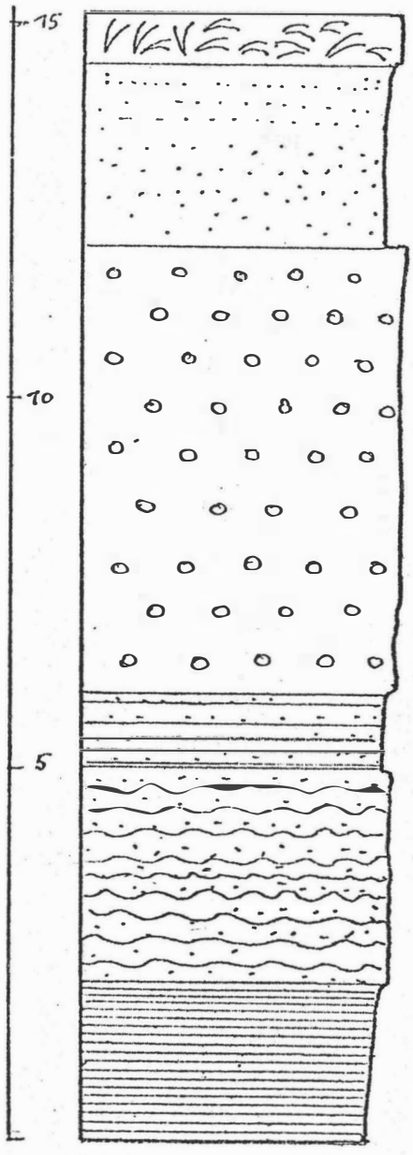
The age is Lower Maastrichtian.

The nearby situated dump of the coal mine Segen Gottes bore in former time a rich flora which contained the following plant groups:

Equisetites
Matonia
Goniopteris
Thinnfeldia
Protozamites
Geinitzia
Ginkgo
Brasenia
Flabellaria
Pandanus

Unfortunately, the rich flora has never been described. Only KRASSER has identified the material of the Museum of Natural History in Vienna. A new effort is made now by H. WALTHER and F. SCHAARSCHMIDT to make a scientific investigation of the beautifully preserved flora.

We follow a footpath to north east with some small outcrops in the coal bearing series.
Behind a fence and unaccessible to us the main rudist reef of Grünbach is visible. After KUEHN (1947, 1965) the following rudists are occurring here:
Hippurites (Vaccinites) sulcatus DEFRANCE
Hippurites (Batolites) gosaviesis DOUVILLE
Hippurites (Vaccinites) oppeli santoniensis KUEHN
Radiolites cf. angeiodes LAPEIROUSE
Plagioptychus aguilloni d'ORBIGNY



0,7 m limestone with rudist debris passing laterally into limestone with *Nerinea buchi*, *Trochactaeon giganteus*

3,5 m sandstone

6 m well cemented conglomerate containing many siliceous pebbles

1 m calcareous sandstone to marlstone with Aporrhaidae, *Corbula*, " *Mactra*"

3 m light brown nodular calcareous sandstone with *Ostrea*

2 m calcareous marls with few quartz pebbles. Burrows of *Callianassa*

Lupat, Grünbach. Quarry behind house with shrine (Stop 38)

KUEHN has dated all alpine bioherms with this fauna as Upper Santonian.

We walk on an asphalt road towards east. Behind a fence well guarded by wild boars we notice large numbers of large actaeonellids. Finally we come to the group of houses called Lupat.

STOP 38. LUPAT, QUARRY BEHIND HOUSE WITH SHRINE.

In a small quarry and on the road above the inverted basal series of the Grünbach basin is exposed. The section begins with calcareous marls with callianassid burrows and passes into rudist limestone which is of the same stratigraphic position as the rudist bioherm we were unable to see closer.

After this last stop we walk back to the bus and drive to the Autobahn A 2 which we follow to Vienna.

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