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Guide to Excursion 33 C
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Neogene Basins and Sedimentary Units of the Eastern Alps near Vienna

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(First day)

Vienna Basin and Molasse Region north of the Danube

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With 2 plates and 2 tables

Introduction

This excursion leads through a region of complicated geological pattern. The point of departure is in the Inner-Alpine Vienna Basin north of the Danube. Its Neogene filling as well as the basement will be shown at selected exposures and by means of core-profiles from deep drillings. The Steinberg near Zistersdorf offers an excellent view of the basin and its boundaries. Later on, after leaving the Vienna Basin, the Molasse region to the west of it will be visited. The Molasse can be divided into a tectonically disturbed interior part, called Waschberg Zone and an undisturbed exterior part. On the way back to Vienna, the small Tertiary Korneuburg Basin will be passed en route.

The Danube is regarded by geographers as the boundary between Alps and Carpatians. This is also valid for the geology. The Flysch Zone as well as other Alpine units south of it, when turning from the Alpine W-E direction into the Carpatian SW-NE direction, undergo some changes in their composition. Even within the Tertiary basins, differences exist between their portions south and north of the Danube. This is especially remarkable in the Molasse Zone. The undisturbed Molasse of the foreland north of the Danube consists mainly of Miocene only, the disturbed part along the front of the Flysch Zone north of the Danube forms a distinctive and separate unit. Its continuation beyond the Austrian—Czechoslovakian boundary, the so-called Steinitzer Zone, was originally regarded as outermost part of the Flysch Zone. The Korneuburg Basin is faulted-down between two horsts of the Flysch Zone. The southern boundary of the Basin is the Danube valley. The great down-faulted part of the Alpine—Carpatian arc, the Vienna Basin, shows considerable differences between its southern and northern sections. The Vienna Basin south of the Danube therefore will be visited by another excursion.

The oldest of the three Tertiary basins is the Molasse trough. In Upper Austria, the sedimentation begins in the Upper Eocene with marine, brackish and limnic sediments. East of the Enns river, the oldest beds are marls of the Rupelian. In the Tulln area south of the Danube, marine sedimentation begins with the Upper Oligocene. North of the Danube, Aquitanian strata exist only locally; mostly, the crystalline or Mesozoic basement is overlain directly by Burdigalian beds. Those richly fossiliferous sediments are present near Eggenburg at the margin of the Bohemian Massif and also as a relatively thin layer within the Molasse trough. They are "Lower" Burdigalian in age. J. Kapounek, A. Papp and K. Turnovsky (1960) have introduced the name Eggenburg series. The authors wished to establish local series in agreement with the sedimentary sequences in the Tertiary basins visited by the excursion. The exclusive use of the generally adopted stage names could lead to errors, moreover since a general agreement on European Tertiary stratigraphy has not been reached so far.

Overlying the Eggenburg series there exists in the undisturbed Molasse a non fossiliferous sequence of marls and clays of about 1000 ms thickness, changing gradually into the brachyhaline Oncophora beds (Rzehakia-beds). These equivalents of the "Luschitz series" which was originally established in the Inner-Alpine Vienna Basin may belong to the "Upper Burdigalian" to "Lower Helvetian".

Transgressively overlying this older Neogene cycle follows a succession of marine marls and sands, called Laa series by Austrian geologists, whilst the CSSR-geologists introduced the name Carpatian formation. It corresponds approximately to the Upper Helvetian of the general stratigraphy. Type locality are Laa brickworks near the road east of Laa; it will be visited by the excursion. Formerly, those sediments were called "Grunder Schichten". They include, however, also beds of "Tortonian" age. The type locality Grund belongs to the Lower Lagenid zone.

The most important stratigraphic unit of the disturbed Molasse north of the Danube (Waschberg Zone) are shaly marls of Burdigalian age. Locally, equivalents of the Oncophora beds and the Laa series are present. The older strata of the Neogene sequence are included into imbricated structures, together with strata from the former basement. Widely distributed are the Upper Jurassic Klentnitz beds and the Ernstbrunn limestone, frequently appearing as topographically prominent "Klippen". One of them, the klippe of Staatz and its big quarry will be visited by the excursion. The Lower Cretaceous is known from drillings; marly and sandy sedimentary rocks, rich in Foraminifera of Upper Cretaceous age, are widely distributed. *Pseudotextularia varians* was described for the first time in 1895 by Rzehak from the Waschberg Zone. The Eocene of Waschberg Zone shows several different facies. Deep drillings of the Österreichische Mineralölverwaltung Aktiengesellschaft have made it possible to clarify the details of the imbricated (Schuppen-)structures and of the autochthonous basement.

	TIME UNITS	MOLASSE ZONE NORTH OF THE DANUBE AND BASEMENT OF MOLASSE TROUGH	WASCHBERG ZONE	NORTHERN PORTION OF VIENNA BASIN
PLIO-CENE	PANNONIAN	Talus-fan of Hollabrunn Clay marls with Ostracoda (loc.)		Typical PANNONIAN
MIOCENE	SARMATIAN	Clays and sands (locally)		Typical SARMATIAN
	TORTONIAN	Baden series		Baden series
	HELVETIAN	Lea series (Carpatian Formation) Oncophora sands	Limonitic sands and clays	Laa series Luschitz series
	BURDIGALIAN	Marl Facies Eggenburg series	Shaly marls Shaly marls	Eggenburg series(locally)
OLIGOCENE	UPPER OLIGOCENE (AQUITANIAN, CHATTIAN)	Melk series (Absdorf, Porrau)	Michelstetten beds	P a l e o g e n e
	MIDDLE-LOWER OLIGOCENE		not present	
EOCENE	UPPER-EOCENE (WEMMELIAN, LEDIAN)		Globigerina beds, Reingrub series	
	MIDDLE-EOCENE (LUTETIAN)		Haidhof beds	and
	LOWER-EOCENE (CUIS)		Waschberg limestone	
PAL-EOC	DANIAN		Sands from Reingruberhöhe Bruderndorf beds	
CRETACEOUS	MAASTRICHTIAN CAMPANIAN SANTONIAN CONIACIAN TURONIAN CENOMANIAN	Glauconitic sands and marls beneath the Waschberg-Zone	Marls and glauconitic sands in thrust sheets	M e s o z o i c of Alpine nappes
	APTIAN-ALBIAN BARREMIAN HAUTERIVIAN VALANGINIAN BERRIASIAN	not present Clay marls and clay stones	not present KORNEUBURG 2 (850-923 m)	(Flysch and Limestone Alps)
JURASSIC	UPPER JURASSIC (MALM)	Clay marls, bright coloured reef Oolitic limestones limestones	Ernstbrunn limestone and Klentnitz beds	
	MIDDLE JURASSIC (DOGGER)	Sandstones, shales dolomitic sandstones		
	LOWER JURASSIC (LIASSIC)	Claystones, coal bearing clays		

Table 1: Stratigraphic sequences in the excursion area. By A. Papp.

TIME UNITS			MOLASSE north of Danube	WASCHBERG ZONE	VIENNA BASIN
PLIOCENE			Gravels		Gravels, red clays
PLIOCENE	PANNONIAN	MESSINIAN	Talus-fan of Hollabrunn Clay marls with Ostracoda (Zone B) locally at Maria Thal		PANNONIAN: UPPER- Zones F,G,H MIDDLE- Zone E LOWER- Zones A,B,C,D
MIOCENE	SARMATIAN	MESSINIAN / TORTONIAN	locally at: Hollabrunn, Ziersdorf Langenlois		JOUNGER: Zone with deteriorated fauna — Nonion granosum Mactra, Ervilia } beds OLDER: Rissoa beds — Elph. hauer. Elphidium reginum
MIOCENE	BADEN SERIES	TORTONIAN	Lower Lagenid zone	Lower Lagenid zone (transgressiv)	Upper-: Rotalia zone Bulimina-Bolivina zone Zone with arenaceous forams Lower-: Lagenid zone
MIOCENE	LAA SERIES (CARPATIAN FORMATION)	HELVETIAN	Zone with Globigerinoides sicanus (=bisphaericus) Sand and Schlier facies of Laa series	Laa series	Laa series
MIOCENE	LUSCHITZ SERIES	HELVETIAN	Oncophora sands Marl Facies	Limonitic sands and clays Shaly marls ~~~Tectonic Phase~~~	Poorly fossiliferous Schlier, Oncophora beds Schlier with Elphidium and Cibicides Schlier with Cyclammina and Bathysiphon
MIOCENE	EGGENBURG SERIES	BURDIGALIAN	Typical outcrops of Eggenburg series at Eggenburg, Horn, Fels a. Wagram	Shaly marls	Equivalents of Eggenburg series locally in deep drillings

Table 2: The Neogene in the excursion area. By A. PAPP.
(Elph. hauer. means Elphidium hauerinum)

The wells Staatz 3 and Hagenberg 1 penetrated the Waschberg Zone and the underlying strata down to the crystalline basement.

The horizontal tectonic movements caused by the forward thrust of the Flysch-nappe cease with the Laa series; the Baden series overlies the entire system transgressively. Faulting replaces horizontal movements: the Korneuburg Basin, filled by younger horizons of the Laa series, subsided along syngenetic faults, striking SW-NE. The main faults, bordering and dividing the Inner-Alpine Vienna Basin, generally striking SW-NE, are mostly not older than the Baden series. They determine the younger history of the basin, meaning the sedimentation of a thick succession of strata from the marine Baden series to the brachyhaline Sarmatian and the brackish to limnic Pannonian. The older history of the basin region is represented by Burdigalian—Helvetian strata, whose distribution, however, shows no connection with the final contours of the basin.

Lower Burdigalian only exists in small relics in the depth of the basin. North of the Danube, the Luschitz series is widely distributed, consisting of thick, well stratified marls with a basal conglomerate (Flyschschutt, debris of Flysch). Locally, the higher parts of the Luschitz series are developed as Oncophora sands. As in the Molasse, those older series are transgressively overlain by marls and sands of the Laa series, in the northern parts of the basin in marine, in the southern parts in limnic facies.

The Excursion

(Stop I/1 — stop I/7)

The route passes first the quaternary gravel fields of the Danube (Marchfeld); then, travelling on Brünner Straße we reach the hill country of the Weinviertel (Tertiary, covered in parts by Loess) near Eibesbrunn. The "Weinviertel" comprises the region north of the Danube between the Bohemian Massif and the March river. Geologically this geographical unit includes parts of the Molasse trough and of the Inner-Alpine Vienna Basin together with outliers of the Flysch separating them.

North of Wolkersdorf, west of the road, a big sand pit is visible (sand of Upper Pannonian age) forming the surface of the downthrown block east of the Steinberg fault. Several kilometers further to the north, the road crosses the Steinberg fault. Strata of Lower Pannonian and Sarmatian age are forming here the hill country on both sides of the road until Hobersdorf.

Here, the excursion leaves the Brünner Straße, turning eastward through Maustrenk to the Steinberg (317 m) near Zistersdorf.

Stop I/1: View from the Steinberg.

The crossroad point above Windischbaumgarten offers an impressive view of the Inner-Alpine Vienna Basin north of the Danube and its frame.

Near Vienna, the basin is faulted down along the straight-running Bisamberg fault. Further to the north, the limestone Klippen of the Waschberg Zone form the approximate boundary of the basin. The Leiser Berge with the Buschberg (492 m), the highest point oft the Weinviertel are well visible. The Ernstbrunn limestone (Tithonian) is extensively exploited in a big quarry. Further to north, the "Jura-klippen" of Falkenstein and the Pollau hills beyond the Austrian boundary can be seen. The Staatz Klippe, however, is hidden by a line of hills. The actual western limit of the basin in this northern regions is formed by the Falkenstein fault which displaces Baden series against rocks of the Waschberg Zone. The part of the basin between Falkenstein fault and Schrattenberg fault to the east is called "Poysbrunner Scholle (Block)". The hill country of the "Mistelbach Block" between Schrattenberg fault and Steinberg fault is well visible. To the east we see the range of the Minor Carpatians (Kleine Karpaten). They form the eastern limit of the Vienna Basin. The Upper Pannonian of the downfaulted area east of the Steinberg fault is peneplained by a system of terraces caused by the March river.

The Steinberg region itself is one of the best known parts of the Vienna Basin. The outcrop of Baden series in the midth of younger beds has been noticed by geologists since a long time.

The exposed Lithothamnium limestone (Leithakalk) is morphologically prominent and has a thickness of about 20—30 ms. According to its microfauna, it corresponds to the middle Baden series. It is underlain by marls and sands, rich in microfauna of the lowermost Baden series (Lower Lagenid zone). The latter is underlain by Schlier and basal conglomerate of Luschitz series. The Flysch basement shows a prominent relief; therefore, it has been reached by drillings at different depths ranging from a few 100 ms down to 1500 ms.

The Sarmatian and Lower Pannonian on the eastern flank of the Steinberg may either represent an intermediate downfaulted block or may lay conformably upon the "Tortonian".

Using the top of the Baden series as level of comparison, the Steinbergbruch (fault) has a total displacement of about 2000 ms. The drilling Zistersdorf 3 is till now the deepest well on the eastern flank of the Steinberg Dome, where typical drag structures exist in the downfaulted block. The well met the fault at a depth of 3308 ms and was abandoned at 3407.5 ms in the Flysch of the high block. Further east, the well Ringelsdorf 2 did not reach the basement and was abandoned at 4298 ms in a series which may be lowest Baden or uppermost Laa.

The oil fields in the Steinberg region, the "Zistersdorf area" are now more or less depleted. From our vantage point we see the oldest oil field in the Vienna area, the Gösting Field north of Zistersdorf, and the RAG Field, immediately south of Gösting Field. These fields produce mainly from Sarmatian and "Tortonian" reservoirs in drag structures along the Steinberg fault. West of it, we have oil fields on the high block. The small field Maustrenk north of the Steinberg produces from the basal conglomerate (Flysch debris) of the Schlier. The larger part of the field St. Ulrich—Hauskirchen—van Sickle produces from a burried Flysch hill and porous layers of the overlying Schlier.

Stop I/2: Core depot of ÖMV AG Neusiedl.

Demonstration and explanation of material and data on the subsurface geology.

Stop I/3: Sarmatian outcrop in the northern area surrounding the Steinberg (Hauskirchen).

Sands, sandstones and clay marls of this section belong to the Upper Sarmatian which apparently immediately overlies the Leithakalk of the Baden series, as proved south of the Steinberg by shallow drillings. Lower Sarmatian appears further towards the flanks in the Steinberg Dome; the "Tortonian" as well as the Sarmatian are reduced. The defile N Hauskirchen shows Sarmatian in marginal facies. Sands and sandstones, locally disturbed, contain a characteristic fauna with *Pirenella picta picta, Cerithium (T.) rubiginosum subtypicum, Pirenella disjuncta disjuncta* and also small specimens of *Ervilia dissita dissita, Drus (P.) gregarius gregarius, Cardium vindobonense, Cardium latisulcum, Modiolaria, Donax, Calliostoma* a. o. The microfauna is rich and contains *Nonion, Elphidium, Ammonea*, Bryozoa, Ostracods and small Molluscs. This fauna is typical for the Upper Ervilia beds/zone of Nonion granosum (Upper Sarmatian).

The excursion route passes through Großkrut to Poysdorf where it crosses the Schrattenberg fault. Then it leads westward across the Poysbrunn Block, and, after crossing the Falkenstein fault system, to Staatz, in the Waschberg Zone and then to the SE back into the Vienna Basin to the brickworks near Frättingsdorf railway station.

Stop I/4: L o w e r B a d e n s e r i e s, L o w e r L a g e n i d z o n e (B a d e n c l a y s, B a d e n e r T e g e l), F r ä t t i n g s d o r f, b r i c k w o r k s.

Around Vienna, all Tertiary plastic pelitic materials are called "Tegel". The Badener Tegel is, together with the Leithakalk, one of the most typical sediments of the Baden series and is found only in it's lower part (Lagenid zone). It was deposited predominantly in shallow parts of the basin, presumably in well oxygenized regions of quiet sedimentation. In the interior sections of the Vienna Basin the lithology and fauna of clay marls differs somewhat. The blue greyish "Tegel" of Frättingsdorf shows hardly signs of bedding and the microfauna indicates the age of Lower Lagenid zone, just the same as marls and sands underlying the Leithakalk of the Steinberg. The "Tegel" from the type locality near Baden is somewhat younger and belongs into the Upper Lagenid zone.

In Frättingsdorf, macrofossils are relatively rare, mostly siphonostome gastropods (*Fusidae, Pleurotomidae*). Most important are the microfossils. The fauna is typical for the Lower Lagenid zone with high frequency of *Lagenidae (Robulus, Nodosaria), Stilostomella, Guttulina, Glandulina, Nonion, Bulimina, Bolivina, Uvigerina, Epistomina, Pullenia* and *Cibicides*. The planctonic forms show Globigerinids with large aperture of the type of *G. diplostoma* Reuss, *Orbulina suturalis* Bronnimann, rarely *O. glomerosa* (Blow), *Globigerinoides trilobus* Reuss and *Globorotalia mayeri* Cushm. & Ellisor.

The clays of Frättingsdorf also contain many silica-shelled forms, excellently preserved. Diatoms are abundant, also Radiolaria and Silicoflagellates. Remarkable are also Hystrichospaera and the nannofossils *Coccolithus pelagicus* (Wallich) and *Discoaster challengeri* Bramlette & Riedel.

Besides *Orbulina suturalis* and *Orbulina glomerosa, Uvigerina macrocarinata* Papp & Turnovsky is a characteristic fossil for the Lower Lagenid zone in Vienna basin and adjacent areas. This zone is underlain by the Laa series with *Globigerinoides sicanus (= bisphaericus).*

The excursion returns to Staatz by way of Ernsdorf.

Stop I/5: E r n s t b r u n n l i m e s t o n e, T i t h o n i a n, S t a a t z.

At Ernsdorf north of Frättingsdorf, the excursion crosses again the western digitation of the Falkenstein fault and leaves the Vienna Basin. At first it leads along the Waschberg Zone which is locally rather narrow. The Jurassic Klippe of Staatz appears topographically dominant and impressive. It consists of white, firm but brittle "Ernstbrunner" Kalk", extensively fractured. Fossils are rare here but are locally common in the Leis hills, showing that the limestone was originally deposited as a coral reef.

Towards NW, the limestone of Staatz is followed by a narrow zone of Upper Cretaceous and Lower Tertiary marls and clays. Towards SE, Burdigalian clay marls and sands are present.

The deep drilling Ameis 1 of the ÖMV, about 5 kms to the east has encountered this part of the entire stratigraphic column at a depth of about 1850 ms. This is approximately the base of the zone of thrust sheets where it overlies autochthonous Burdigalian and Mesozoic. Crystalline was reached by Staatz 3 at 3355 ms.

Going on towards Laa brickworks, we pass the well site of Staatz 1, drilled 1959 by ÖMV AG. The profile of this well at the exterior margin of the disturbed Molasse proved the existence of a deep Mesozoic trough in the foreland.

Stop I/6: Laa series, brickworks of Brandhuber east of Laa/Thaya.

In the big pit of the brickworks east of Laa/Thaya, the Laa series belonging to the undisturbed horizontal Molasse region is exposed in a thickness of about 15 ms.

The deeper layers are composed of finely bedded, bluish grey clay marls, overlain by yellow, fine grained sands. In the marls macrofossils are rare, in the fine grained sands good faunas of the marginal facies are found.

Pirenella bicincta turritogracilis (Sacco) occurs frequently and is a rather variable species. *Turritella terebralis gradata* Menke, *Clithon (Vittoclithon) pictus pachii* (M. Hörn.), *Ostrea, Cardium, Ocenebrina, Dorsanum ternodosum* (Hilber) a. o. They prove a near-shore biotope with somewhat reduced salinity. This is also shown by the occurence of *Melanopsis impressa impressa* Krauss, *Congeria neumayeri* Andr. and land snails. Within concretions plant remains (mainly *Cinnamomum*) can be found.

The foraminiferal fauna of the clay marls shows Globigerinids with large aperture similar to *G. diplostoma* Reuss and the five-chambered form *G. concinna* Reuss in large and typical specimens. In some beds small *Globigerinas* predominate. *Orbulina* or *Praeorbulina* are not present. Frequently *Bulimina, Loxostomum, Valvulineria* and *Uvigerina* are found. In the fine sands *Ammonea, Nonion* and other genera typical for near- shore facies predominate. Typical for the sediments from Laa are *Uvigerina parkeri breviformis* P. & T. and *Uvigerina bononiensis primiformis* P. & T.

The Laa series in general including the type locality is considered to be deeper Middle Miocene, i. e. Upper Helvetian in age. At the top of the series a horizon with *Globigerinoides sicanus (= bisphaericus)* exists. Separated by an unconformity follows the Baden series with *Orbulina* (or Praeorbulina) *glomerosa.*

After having passed the historically interesting town of Laa/Thaya, the excursion route leads at first directly southward. South of Eichenbrunn the external margin of the Waschberg Zone is reached, however, mostly covered by gravels of the Lower Pliocene ("Pre-Danube"). The river course was situated along the present valley of the Zaya north of the Leis hills. Passing the Leiser Berge and the "Tortonian" embayment of Niederleis, the excursion reaches the small Korneuburg basin SE Ernstbrunn.

Stop I/7: Laa series, Sand-pit Kleinebersdorf in the Korneuburg Basin.

Clay marls and sands filling the Korneuburg Basin in a thickness of about 600 ms belong into the Laa series, as shown by their fauna. Probably they correspond to the upper part only which, in the undisturbed Molasse, shows smaller thickness. A good outcrop is behind the schoolhouse of Kleinebersdorf. Certain sandlayers contain abundant fossils, about the same fauna as in the sands from Laa/Thaya.

Continuing the excursion to the south, the western boundary fault is well recognizable topographically, whilst the east flank of the basin floor rises gradually. In Korneuburg the southern margin of the basin is reached. The Danube fault (NW-SE) displaced Laa series against Flysch. The fault line itself is covered by river gravels.

Passing through the Danube valley the excursion reaches Vienna on the Prager Straße.

Basement of the Tertiary basins according to latest results of geophysics and deep drillings

The entire Mesozoic complex underlying the undisturbed and disturbed Molasse, which was reached and penetrated by a considerable number of deep drillings comprises Jurassic, Lower Cretaceous (Hauterive) and Upper Cretaceous. Maastrichtian and older Tertiary have not yet been discovered in undisturbed position. Triassic is missing, Paleozoic is present in erosional relics. Lower Neocomian (Valanginien, Berriasien) is not present nor was any Aptian — Lower Turonian found. Therefore unconformities exist between Upper Jurassic and middle Lower Cretaceous and also within the time-equivalent: high Lower Cretaceous — deeper Upper Cretaceous.

The maximum thickness of autochthonous sediments amounts to about 2700 ms. The subsurface outcrop line of the Mesozoic in the west towards the Bohemian Massif under cover of the Molasse seems to be due to erosion. Going from West to East, successively younger sedimentary series are encountered. Thus Staatz 1 met Lower Cretaceous (Hauterive) as the youngest horizon, whilst the profile of Staatz 2 already includes Upper Cretaceous (Upper Turonian—Coniac).

It seems that the Mesozoic sediments extend considerably further east beneath the nappes of the Flysch and Limestone Alps which, in their turn, form the basement of the Vienna Basin. Highest Upper Cretaceous (Maastrichtian) and older Tertiary should occur there too, because they are present in the thrust sheets of the disturbed Molasse (Waschberg Zone).

The tectonic elements comprise ancient post-Variscan fault lines in the crystalline basement which also influence the Jurassic rocks (Mailberg—Steinabrunn—Wollmannsberg faults). This causes relatively strong variation in thickness of the Jurassic sediments. The ancient tectonic lines intersect the strike of the Alpine-Carpatian thrusts at an acute angle. Those younger horizontal movements influence beds from Tithonian to Lower Miocene age, they last until the end of Lower Miocene and cause the imbricated structures of the Waschberg Zone, whose oldest sediments are the Tithonian limestones of the Ernstbrunner Klippen.

Yet later faulting from Middle Miocene to Pliocene causes the downthrow of the Vienna Basin. The young fault lines show the same strike as the old ones mentioned above (SW-NE), suggesting that they are a reactivation of those.

The following details should be noted: Staatz 1 penetrated Lower Cretaceous, Upper and Middle Jurassic. It was abandoned in coal-bearing Liassic beds. The facies is strongly reminiscent of the Gresten beds in the Klippenzone between Flysch and Limestone zone.

In Wildendürnbach 4, west of Staatz 3, the Mesozoic has smaller thickness. The well encountered the Granite of the Bohemian Massif beneath the Jurassic.

Staatz 2 has encountered autochthonous Upper Cretaceous, Staatz 3 drilled through the entire disturbed complex as well as through the autochthonous series down to the crystalline basement.

Ameis 1, Poysdorf 2 have met Upper Cretaceous in the form of thrust sheets as well as in autochthonous position. The thrust sheets also contain Eocene and Michelstetten beds (Chattian—Aquitanian).

Ameis 1 which did not reach the Crystalline but was abandoned in autochthonous Lower Cretaceous, encountered two Upper Cretaceous thrust sheets, of which the upper one contained Campanian—Maastrichtian, the lower Upper Turonian—Campanian. Ameis 3 only reached the upper thrust sheet.

Poysdorf 2 encountered beneath the disturbed Neogene also disturbed strata of Upper Cretaceous (Turonian—Campanian) age, and beneath those autochthonous strata of the same stratigraphical position.

Linenberg 2 met a great thickness of Flysch (more than 4000 ms) which can be explained to be an imbricated structure caused by fourfold thrusting. The well was finally abandoned within the Flysch.

The drilling Hagenberg 1 is of special interest. At a depth of 300 ms it penetrated an overthrust plane; there, Eggenburg/Michelstetten beds are thrust on beds of the Laa series. At about 1800 ms it reached autochthonous Upper Cretaceous, rich in Glauconite. From 1935 to 2694 ms it penetrated Lower Cretaceous, then Jurassic until 3113 ms. The deeper part of the Liassic is coal-bearing. The Liassic is underlain by Crystalline debris (? Paleozoic) and then Crystalline rocks of the Bohemian Massif itself. Tectonic disturbance has been observed within the Mesozoic and the Neogene series (Eggenburg series) at about 1600—2090 ms and again at 2360—2500 ms. From 2500 ms down wards there is no more indication of tectonic disturbance. The higher part of the sediments in the profile of this drilling has, therefore, been influenced by Alpidic tectonics.

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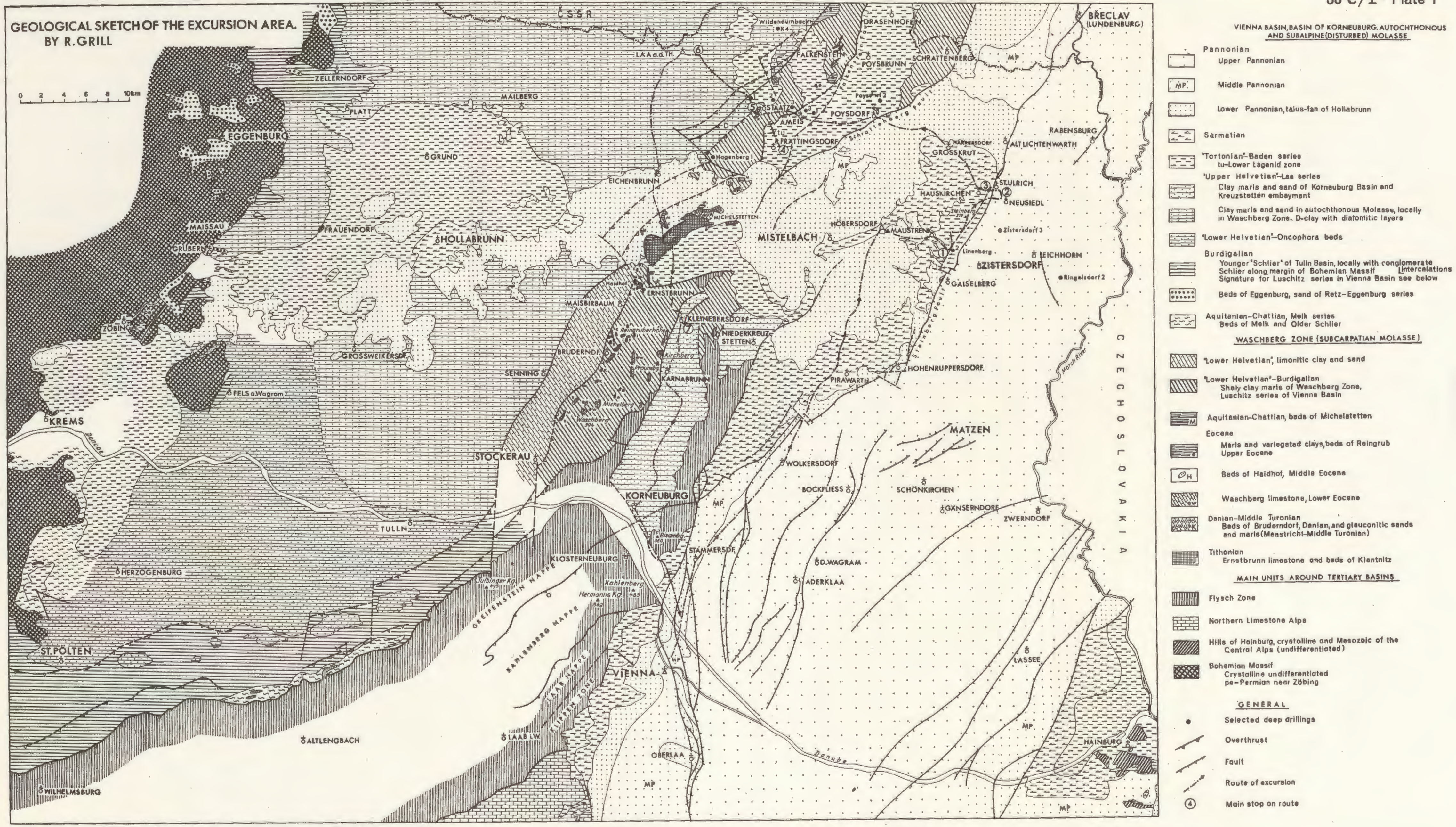
R. GRILL, J. KAPOUNEK & A. PAPP: Vienna Basin and Molasse Region north of the Danube



SECTION THROUGH THE NORTHERN PART OF MOLASSEZONE AND VIENNA BASIN

BY J. KAPOUNEK AND A. KRÖLL

0 1 2 3 4 kms

II

(Second day)

Border Area between the southern Vienna Basin and the Pannonian Plain

(Including a visit to the burial place of J. Barrande)

By H. Küpper

With 6 figures

General aspect

The area of our excursion consists of low hills, which by their NE-SW trend form the barrier between the basin of Vienna and the Hungarian plain (fig. 1).

During the Upper Tertiary about the same situation prevailed insofar as patches of crystalline rocks, cropping out in a similar pattern, acted as litoral or near-shore ridge between the strongly subsiding basin of Vienna and the Pannonian regions of less pronounced tendency of subsidence.

Late Tertiary sedimentation, synsedimentary tectonics and, on the surface of the near-shore area, morphological features merge into a relatively well documented, overall palaeogeographical picture, in which low elevations are surrounded by shallow, partly more, partly less subsiding marine basins.

These features, beyond their local interest, are of general importance insofar, as they indicate, that soon after the latest thrust-like movements took place on the outer margin of the Alpine—Carpathian thrust belt, in the inner sections of this belt, subsiding basins and low-energy relief features were predominant. As this situation can be observed over large areas between the eastern end of the Eastern Alps and the southwestern end of the higher parts of the Carpathians in Slovakia, we believe that this might support the following conception, namely, that tectonical thrust features in the outer-(marginal) parts of a mountain belt must not necessarily be connected with high elevations in the inner (more central) regions.

The sum total of the features worked out during the last twenty years by Austrian, Czechoslovakian and Hungarian geologists seems to indicate, that the latest thrust movements in the marginal region are to be dated here as late Burdigalian to early Helvetian, whereas the partly unstable low-energy relief of the hinterland, in which sedimentation continued, is to be dated as late Helvetian, Tortonian and younger.

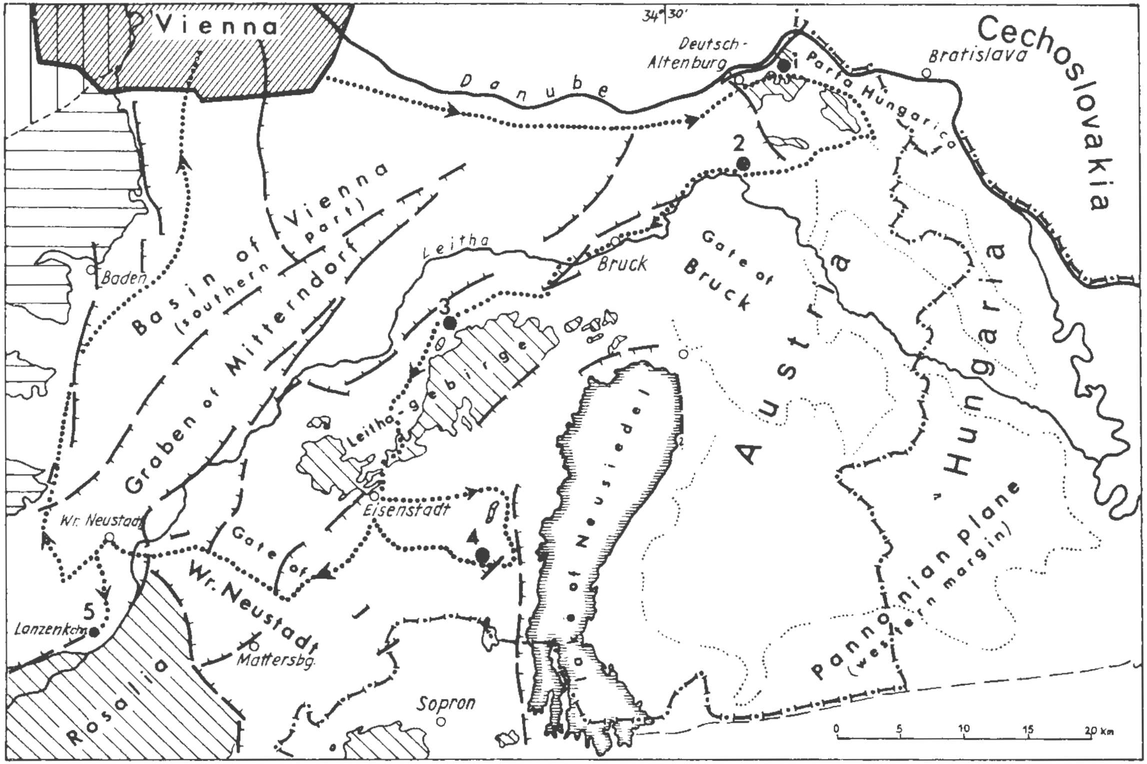


Fig. 1. Situation Excursion 33 C/II.

These facts, in our opinion, are not in favour of an overall validity of a notion, which motivates thrusting tectonics by gliding (decollement-) mechanics only.

Regional features

The excursion starts in an area, where in Roman times the intersection of W-E military roads with N-S trade routes gave rise to a densily inhabited region with mixed population elements. Marc Aurel, emperor and philosopher, wrote his memoirs and died here (March 17th, 180 A. D.).

The region which separates the basin of Vienna from the western margin of the Hungarian plain, consists of NNE-SSW trending hills alternating with shallow depressions, along which our route is laid out. The respective geographical terms are, arranged from NNE to SSW, the following:

Porta Hungarica	Hungarian Gate
Hainburger Berge	mountains of Hainburg
Brucker Pforte	Gate of Bruck
Leithagebirge	Leitha-"mountains"
Ruster Hügelland	hills of Rust
Wiener Neustädter Pforte	Gate of Wiener Neustadt.

The overall geological situation of this area can be summarized as follows:

firstly, as a whole, near-shore conditions prevailed during the Upper Tertiary; the region consisted of an alternation of more stable islands with shallow depressions of limited subsidence tendency;

secondly, our region is bounded towards west by the basin of Vienna and towards east by the westernmost margin of the Pannonian basin; in both basins Tertiary sedimentation attained considerable thickness by synsedimentary subsidence.

These features are summarized on table a, which is derived from numerous deep wells, mostly carried out by ÖMV-AG. during the latest years.

Table a. Thickness of Upper Tertiary

	Basin of Vienna	Leitha-"mountains" (area of excursion)	western margin of Hungarian plain
Pannonian	abt. 600 m	0— 50 m	400—1200 m
Sarmatian	abt. 450 m	0—100 m	0— 100 m
Tortonian	abt. 1200 m	0—100 m	0— 100 m

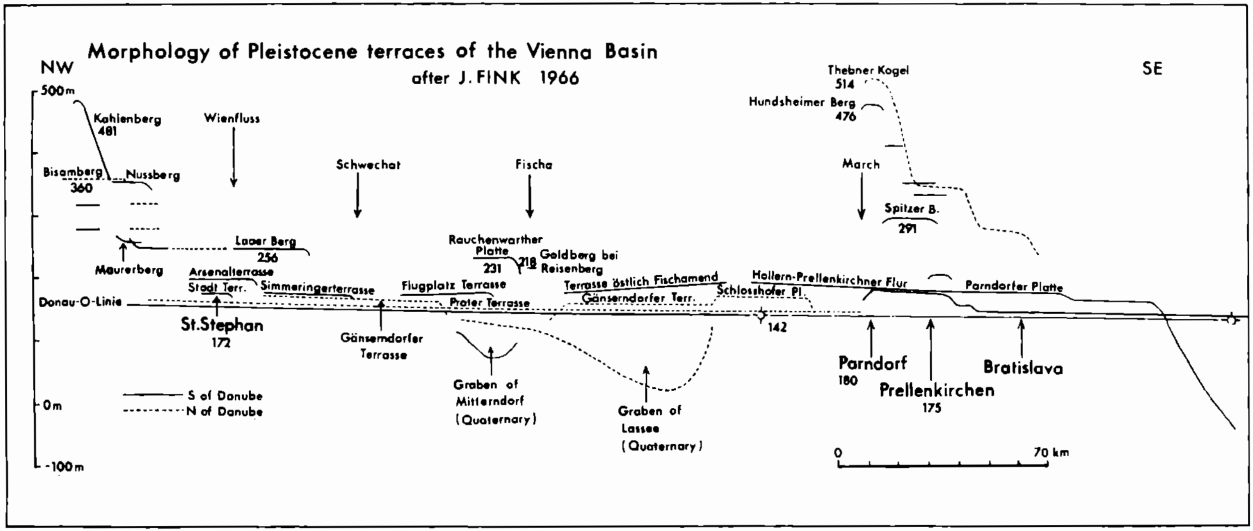

Morphology of Pleistocene terraces of the Vienna Basin
after J. FINK 1966
NW
SE
500 m
0 m
-100 m
Kahlenberg
481
Wienfluss
Bisamberg
360
Nussberg
Schwechat
Fischa
March
Thebner Kogel
514
Hundsheimer Berg
476
Spitzer B.
291
Laaer Berg
256
Maurerberg
Rauchenwarther Platte
231
218
Goldberg bei Reisenberg
Arsenalterrasse
Stadt Terr.
Simmeringerterrasse
Flugplatz Terrasse
Prater Terrasse
Terrasse östlich Fischamend
Gänserndorfer Terr.
Schlosshofer Pl.
Hollern-Prellenkirchner Flur
Parndorfer Platte
Donau-O-Linie
St.Stephan
172
Gänserndorfer Terrasse
142
Graben of Mitterndorf (Quaternary)
Graben of Lassee (Quaternary)
Parndorf
180
Prellenkirchen
175
Bratislava
S of Danube
N of Danube
0
70 km

Fig. 2.

Morphology of Pleistocene terraces of the Vienna Basin is summarized on fig. 2 by J. Fink.

The excursion ends by turning towards SW into the center part of the southern Vienna basin, visiting at Lanzenkirchen the burial place of J. Barrande († Oct. 5th, 1883).

The Excursion

(Stop II/1 — Stop II/5)

Stop II/1: Braunsberg 346 m, Porta Hungarica.

The Danube passes through Porta Hungarica (138 m) towards Bratislava. The depression existed in well accentuated form already during late Tertiary times. Middle Tortonian marls were found between Schloßberg and Braunsberg. Sarmatian oolithic limestones overlie granite in a wide, but shallow depression east of Braunsberg. Pannonian near-shore sandstones and conglomerates are exposed on the slopes of the Hundsheimer Berg 480 m in the SW, and on Thebener Kogel 515 m in the NE. Oldest Pleistocene gravels were found on the road to the summit of the Braunsberg at abt. 230 m in a morphologically protected position; younger Pleistocene terraces enter, partly as well preserved forms, the narrow section of the valley between Hainburg and Bratislava (fig. 3).

The pre-Tertiary basement is exposed and consists of a steep dipping sequence of lower to upper Mesozoic rocks.

Middle Triassic and Cretaceous is proven by fossils.

Thickness and facies differs from that of the northern Limestone Alps. The series are relatively thin and rest upon a presumably pre-Permian granitic to crystalline basement; this basement however, together with its mesozoic cover, is strongly influenced by Alpine tectonics.

Literature:

WESSELY, G.: Geologie der Hainburger Berge. Jb. Geol. B.-A. Bd. 104, Wien 1961, S. 273.

Stop II/2: Schönbrunn 186 m, Gate of Bruck.

Looking north-northeast one sees the southern edge of the mountains of Hainburg modelled by Miocene terraces; toward southwest the faint contours of the Leitha-"mountains" are just visible. The purpose of this (short) stop is to give an impression of the Gate of Bruck, where relatively shallow upper Tertiary rests upon crystalline schists. During the middle Pleistocene, through this gate a wide connection existed

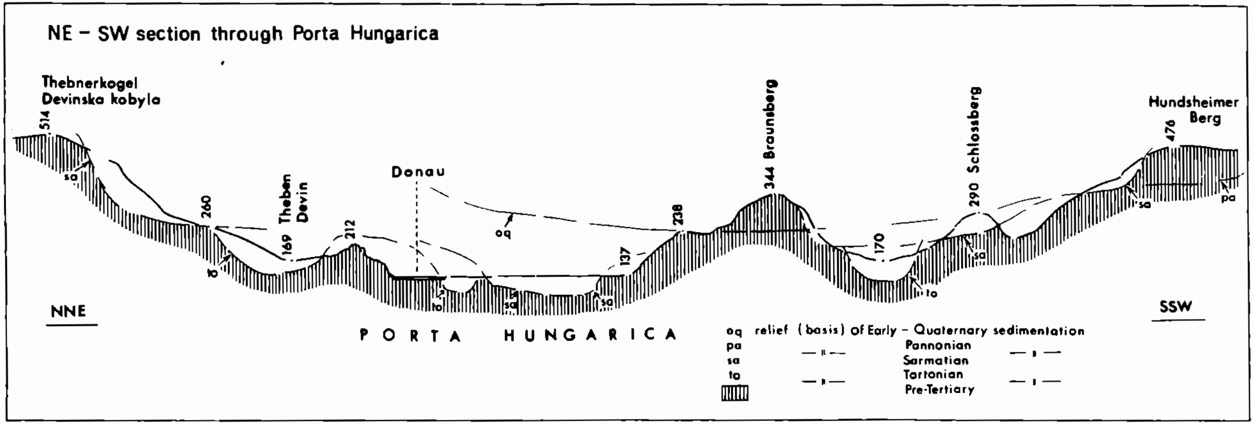


Fig. 3 (abt. 1 : 50.000, horizontal).

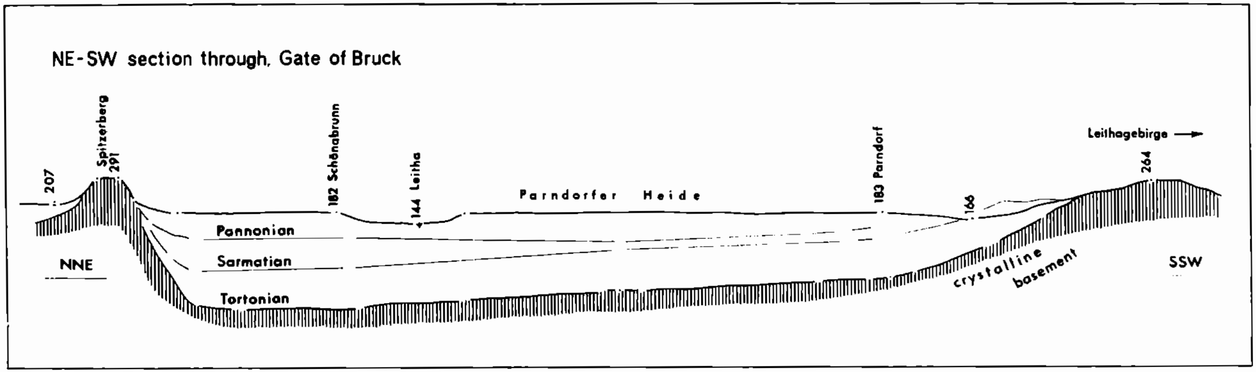


Fig. 4 (abt. 1 : 100.000, horizontal)

between the basin of Vienna and the Hungarian plain, documented by broad gravelfans covering the Upper Tertiary. The present course of the Leitha river is cut epigenetically into the Pleistocene and Pliocene fillings of the gate (fig. 4).

(Note: between this and the next stop, the route passes the birth place of the famous composer J. Haydn (1732—1809) at Rohrau, 148 m).

Stop II/3: Mannersdorf an der Leitha 212 m.

Upper quarry 260 m: Tortonian algal limestones.

Lower quarry 196 m: Pannonian clays.

Upper Tertiary near-shore sediments, on the west-slope of the Leitha-"mountains" towards the basin of Vienna are shown; the Lithothamnium limestones and clastic facies types of Miocene overlying directly the pre-Tertiary basement, partly crossed by faults subparallel to the edge of the basin of Vienna, are exposed in the upper quarry. The lower quarry shows gently dipping clays of Pannonian age, rich in ostracods.

Fig. 5 gives a section through this part of the edge of the basin of Vienna.

(Note: between this and the next stop the route crosses the Leitha-"mountains" and, after passing Eisenstadt (182 m) proceeds eastward to the hills of Rust).

Literature:

Excursion 9. Juni 1963; H. Küpper, H. Schmid, F. Sohs. Mitt. Geol. Ges. Wien. Bd. 56, Wien 1963, S. 743.

Stop II/4: Hills of Rust, Chapel 224 m and quarries.

The hills of Rust are an "en miniature"-replica of the Leitha-"mountains"; upper Tertiary sedimentation and tectonics of an area, remaining relatively stable and elevated between subsiding basins east and west of it can be well shown in quarries, which themselves are famous for their algal-limestone, used since Roman times for building and sculptural purposes (main building stones for St. Stephan's Cathedral, Vienna).

The details of the geology are summarized in the north-south and east-west sections enclosed (fig. 6). The quarries show a slightly uplifted western margin of a small platform-like unit, which during the Upper Tertiary seems to have been marked by reduced sedimentation as compared with the region of the lake of Neusiedel (115 m) in the east and the axis of the basin of Eisenstadt (140 m) in the west.

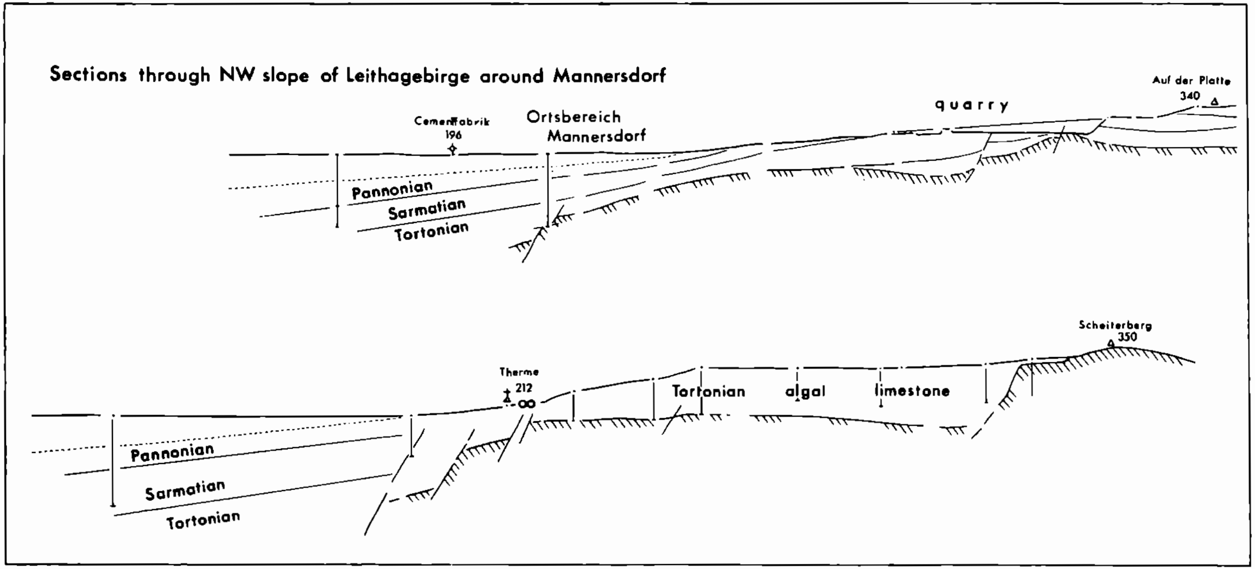


Fig. 5 (abt. 1 : 16.000, horizontal).

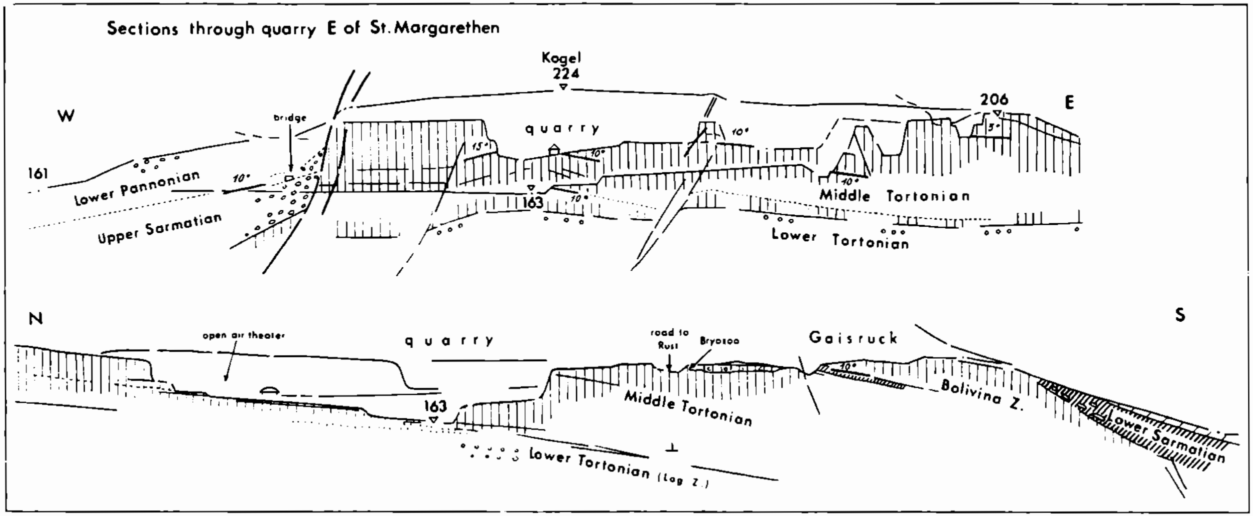


Fig. 6 (abt. 1 : 5000, horizontal)

Literature:

FUCHS, W.: Geologie des Ruster Berglandes. Jb. Geol. B.-A. Bd. 108, Wien 1965, S. 155.

GROBAUER, F. J.: St. Margarethen, Steine, Menschen, Zeiten. Wien 1965, Selbstverlag.

(Note: after this stop the route turns west and enters the southern part of the basin of Vienna via the Gate of Wiener Neustadt).

Stop II/5: Lanzenkirchen 302 m, Burial place of J. Barrande.

When travelling in the morning from Vienna to Hainburg we had to cross the basin of Vienna at its full width (40 km); here, south of Wiener Neustadt (265 m altitude), the western and eastern flanks of the basin are only 10 km distant, the western mountains rise to 1500 m and finally to 2035 m (Schneeberg). This southernmost part of the basin has a smoothly NE dipping surface of partly well cemented middle Pleistocene gravels. The thickness of these gravel-fans is more than 50 m in the center part, indicating intra-Pleistocene subsidence — which, as a matter of fact, continues even today, as is shown by historical and present day earthquakes, arranged along the SW-NE axis of the basin of Vienna. The surface of the gravels is but slightly modelled by young erosion, soil cover is scarse.

The highway back to Vienna follows the western flank of the Vienna Basin. For this region, E. Sueß in 1864 gave a tectonical interpretation, by which the position of the thermal springs of this zone were considered as surface indications for the western marginal faults. This, by subsequent work, has been confirmed and corroborated in detail.

Note: Barrande Joachim (1799—1883), geologist and palaeontologist, was born at Saugues, Haute Loire, France, on August 11, 1799 and educated an the École Polytechnique at Paris. He was Tutor to the duc de Bordeaux (afterwards known as the comte de Chambord), grandson of Charles X, and when the king abdicated in 1830, Barrande accompanied the royal exiles to Prague.

The first volume of his important work, Système silurien du centre de la Bohême (dealing with trilobites), appeared in 1852; and from that date until 1881 he issued 21 quarto volumes of text and plates. Two other volumes were issued after his death in 1887 and 1894.

Barrande died at Frohsdorf on October 5, 1883. (Quotation from Encyclopaedia Britannica, 1962, Vol. 3).

L i t e r a t u r e :

GATTINGER, T. & H. KÜPPER: Trinkwasser, Thermen und Tektonik im südlichen Wiener Becken. Exkursion II/7, Mitt. Geol. Ges. Wien, Bd. 57, Wien 1964, H. 1, S. 205.

Note: after this text has been completed, the following important publication came out: T. BUDAY and V. ŠPICKA: Einfluß des Untergrundes auf den Bau und Entwicklung der intramontanen Depressionen unter Berücksichtigung der Verhältnisse im Donau-Becken. Sbornik Geologickych Vied-Rad Západné Karpaty ZK-zväzok 7, Bratislava 1967 — it is a modern summary on the geology of the basin area N of the Danube and E of Bratislava on the basis of recent drilling results, giving an outline of the developement of this region during the Tertiary.

III

(Third, fourth and fifth day)

Flysch Zone and Northern Limestone Alps near Vienna

With 10 figures and 2 tables

A. The Flysch Zone near Vienna

By S. PREY

Introduction

1. The sequences of the Flysch Zone near Vienna

The sequences of strata and their composition is shown in detail on table. Only a few supplementary explanations seem to be necessary.

a) The sequences of the Flysch (see table 1)

The facies of the Flysch is basically different from the Ultrahelvetic (in our area connected with klippes) of the Main Klippen Zone of the Vienna Woods, and from the sequences of the Klippen Zone of St. Veit. One can observe everywhere in the Flysch the typical alternation of marls and shales with sandstones, which mostly show the characteristics of turbidites. The best explanation for the origin of the Flysch is given by H. P. Kuenen. According to Kuenen the Flysch sediments were deposited under deep sea conditions and under the influence of turbidity currents. In the Neocomian Flysch, those phenomena are less distinct than in the rest of the sequence. The thickness of the Flysch sediments near Vienna is estimated to be several thousand meters.

It is an interesting fact, that in the Vienna Woods the Reiselsberg sandstone with its accompanying, partly multicolored beds of the Cenomanian — Turonian so far has not been proved. However, equivalent series (Cenomanian — Turonian) seem to exist in the Lainzer Tiergarten area. In the Greifenstein nappe, the gap seems to reach from the Cenomanian into the Campanian.

Another peculiarity of the Flysch of the Vienna Woods is, that the Kahlenberg beds, together with the multicolored slates, underlying and overlying them in the west, are replaced by the predominantly variegated series of the Kaumberg beds in the south, in the Laab nappe. There are also lithological differences in the Paleogene.

The beds of the Flysch Zone of the Vienna Woods were characterized according to lithologic viewpoints, to their microfaunas and, in places, also to their macroforaminifera (G. Götzinger, 1951, 1954; A. Papp,

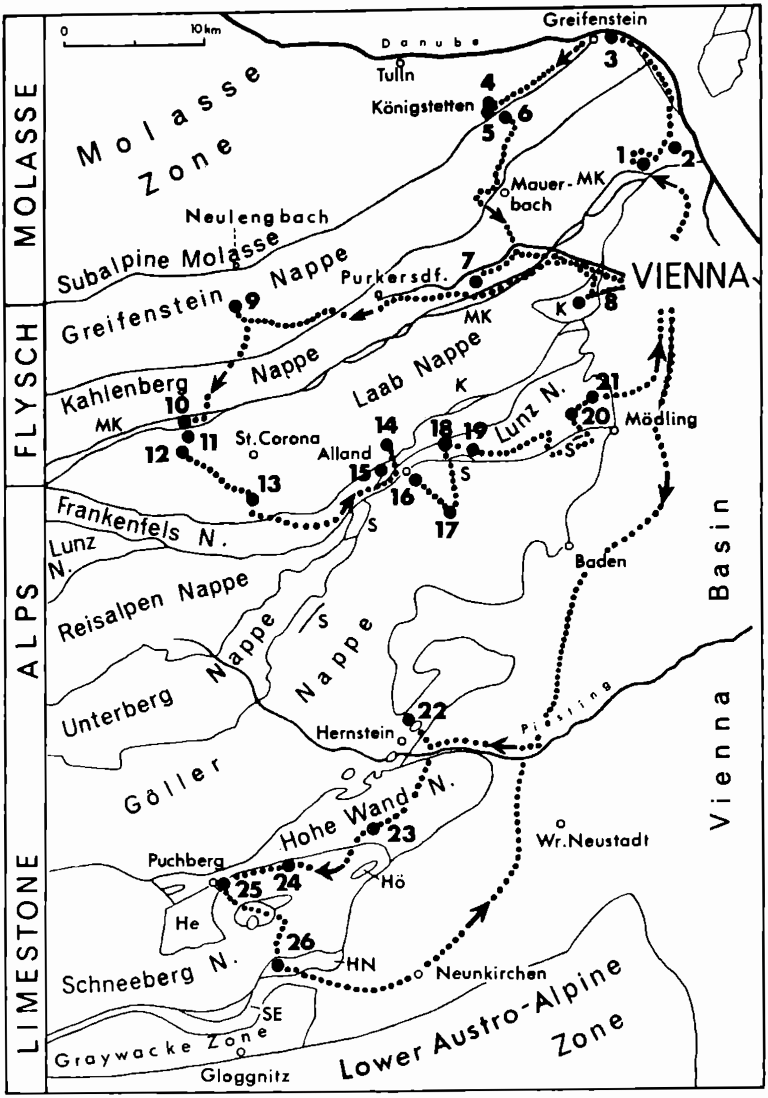


Fig. 1. Tectonic sketch map showing excursion route and stops in the Flysch Zone and Limestone Alps (Upper Austro Alpine Zone) near Vienna.

He = Hengst window, HN = Hohe Wand nappe, Hö = Höflein window, K = Klippen Zone of St. Veit, MK = Main Klippen Zone, s = thrust slices on the border of Göller nappe, SE = Südrandelement.

		Northern zone Greifenstein nappe	Middle zone Kahlenberg nappe
Tertiary	Middle - Lower Eocene	Greifenstein sandstone accompanied by often sandy shales, alternating with glauconitic sandstones (current bedding,convolut bedding,hieroglyphs)	Gablitz beds: Shales,sandstones(often siliceous),sandstones of Greifenstein type
	Paleocene - Danien	Altlengbach beds: Calcareous sandstones with graded bedding,coárser grained micaceous sandstones, partly with clayey cement and softly weathering("Mürbsandsteine")alternating with gray marls and gray or black shales (rarely Fucoids and Helminthoids)	Variegated shales Alt-
Cretaceous	Maastr.		lengbach beds Sievering beds are a facies of Altlengbach beds,more rich of marls
	Campanian	Interruption	Traces of variegeted shales Kahlenberg beds: Gray marls(partly with Fucoids, Helminthoids),marly shales,greenish shales; mainly fine grained calcareous sandstones and sandy limestones (current bedded)
	Santonian		
	Coniacian		
	Turonian		Variegated shales ?
	Cenomanian		Black and green,locally also red shales with quartzitic layers
	Lower Cretaceous	Gault Flysch: Black and green,locally red shales with beds of dark sandstones,often siliceous and glauconitic. Neocomian Flysch: Detritic or sandy limestone beds and layers of shaly marls	
Jurassic	Malm	Basement unknown	Basement unknown
	Dogger		
	Liassic		
Trias	Rhaetic		

Table 1. Stratigraphy of the Flysch Zone

Main Klippen Zone	Southern zone Laab nappe	Klippen Zone of St.Veit	
	Laab beds: Agsbach beds: Hard dark shales, scarcely marls, siliceous sandstones		Middle - Lower Eocene
Buntmergelserie: Series of variegated marls and clays with few agglutinating, sometimes also calcareous foraminifera	Hois beds: Numerous fine to coarse grained partly siliceous sandstones, shales; Black shales, dark glauconitic quartzites	Yellowish-reddish marls ?	Paleocene - Danien
	Thin bedded quartzites, thin shales (seldom Rzehakina)		Maastr.
	Kaumberg beds: Greenish-gray, red and gray shales and marls with thin layers of calcareous sandstones		Campanian
		Reddish and yellowish marls and sandstones	Santonian
		Sandstones with Orbitolina	Coniacian
		Sandstones with Inoceramus?	Turonian
		Variegated beds	Cenomanian
Stollberg beds: Marls, Marly limestones, Aptychus limestone		Variegated beds ? Aptychus limestone	Lower Cretaceous
Variegated limestones Radiolarite Siliceous clays	Basement unknown	Cherty limestone Crinoidal limestone	Malm
Micaceous sandy marls and sandy limestones, marly sandstones Black clay ?		Gray-green clays and siliceous clays Siliceous limestone Marls and marly limestones	Dogger
Gresten beds		Gresten beds: Arcose, shales, sandy limestones etc.	Liassic
		Kössen beds: Marls and limestones	Rhaetic

in the Vienna Wood area. S. PREY 1967

1956, 1960); Recently, the method of studying the nannoplancton (H. Stradner; F. Brix, 1961) was employed with much success. In comparison, megafossils are rare.

The Flyschsequence reaches from Lower Cretaceous to Middle Eocene. Upper Eocene could not be proved until now.

b) The beds of the Klippen Zones (see table 1)

The sequence of strata — mainly Jurassic to Neocomian — of the Klippen series is fairly similar, both in the Main Klippen Zone (G. Götzinger, 1954; H. Küpper, 1962, 1965; P. Gottschling, 1966) and in the Klippen Zone of St. Veit (G. Götzinger, 1954; R. Janoschek et al., 1956; H. Küpper, 1965). However, the tectonic disruption of the sequence in the Main Klippen Zone has been very intense, whereas at St. Veit major stratigraphic complexes are preserved of places. Different, however, are the mantle rocks of the klippes (S. Prey, 1960): In the Main Klippen Zone, they are multicolored shales of Upper Cretaceous to Eocene age, which must be assigned to the Buntmergelserie of the Ultrahelvetic of the western Flysch Zone. On the other hand, under the multicolored shales of the St. Veit Klippen Zone, so far only Cenomanian and Middle Cretaceous have definitely been proved (R. Noth; R. Janoschek et al., 1956; S. Prey, 1960); A. F. Tauber described sandstones of Cenomanian and Senonian age. Most recently indications of marls and sandstones of Senonian and (?) Eocene age have been reported (H. Küpper, 1965). Sufficient details are given on table 1.

2. The tectonics of the Flysch Zone near Vienna

Based on the tectonical division by G. Götzinger (1954), but making allowance for more recent informations (S. Prey, 1960, 1962, 1965), the following scheme may be set up (see also fig. 1 and fig. 2):

Greifenstein nappe
Kahlenberg nappe
Main Klippen Zone
Laab nappe
Klippen Zone of St. Veit.

The Greifenstein and the Kahlenberg nappe (G. Götzinger speaks of "part-nappes") differ somewhat in their facies of the Paleogene. Moreover, the bulk of Lower Cretaceous lies in the Greifenstein nappe, whereas the Upper Cretaceous Kahlenberg beds are characteristic of the Kahlenberg nappe. The Laab nappe is distinctly different from both other two nappes (S. Prey, 1965).

The Main Klippen Zone as described by G. Götzinger is now regarded as a complex mass (S. Prey, 1965) for it consists, on one hand, of Kaum-

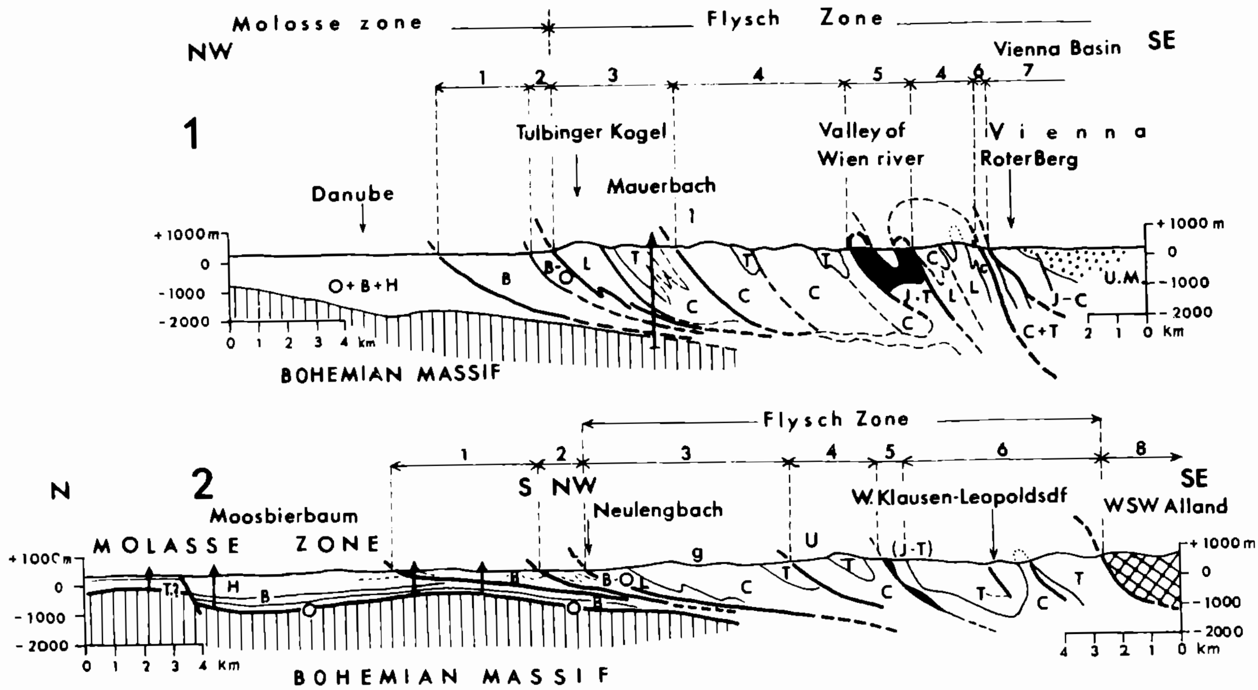


Fig. 2. Geological cross sections through the Flysch Zone west of Vienna (according to G. Götzinger, F. Brix und K. Götzinger, J. Kapounek a. os.) by S. Prey 1967.

Legend: 1, 2 = Molasse (1 = Disturbed Molasse, 2 = Subalpine Molasse); 3—7 = Flysch Zone (3 = Greifenstein nappe, 4 = Kahlenberg nappe, 5 = Klippen Zone, Ultrahelvetic, 6 = Laab nappe, 7 = Klippen Zone of St. Veit, Pieninic); 8 = Limestone Alps. J = Jurassic; L = Lower Cretaceous; C = Upper Cretaceous; T = Lower Tertiary; O = Oligocene; B = Burdigalian; H = Helvetian; UM = Upper Miocene.

berg beds belonging to the northern border of the Laab nappe, on the other hand of imbricated Mesozoic klippes with a mantle of Buntmergelserie of the Ultrahelvetic unit (see table 1).

The Klippen Zone of St. Veit, according to its position and structure, is an equivalent to the Pieninic Klippen Zone of the Carpathian mountains.

Within the Flysch nappes, folds and imbricate structures are frequent. The Laab nappe may roughly be divided into a large syncline zone in the north and east, and into an anticline zone in the southwest, where Kaumberg beds are widely exposed.

At the outer rim, the Flysch nappes are thrust far over the Molasse Zone of the Alpine Foreland; in our area, this has been confirmed by ÖMV AG's well near Mauerbach. Likewise, the Northern Limestone Alps are thrust very far over the Flysch Zone, as proved by tectonic windows and by the well Urmannsau (ÖMV AG).

From an overall tectonic view point the author distinguishes the following tectonic units (from base to top) (see Fig. 2):

1. The autochthonous Molasse with the Bohemian Massif as base,
2. the subalpine Molasse (disturbed, transported),
3. the Ultrahelvetic with Buntmergelserie and klippes,
4. the Flysch nappes,
5. the Klippen Zone of St. Veit, and
6. the Northern Limestone Alps.

The well Urmannsau has largely confirmed the above sequence of tectonic units underneath the Limestone Alps.

3. The paleogeography of the Flysch Zone

The original setting of the areas of sedimentation is reflected by the grouping of the tectonic units mentioned above. The long-stretched extremely deep marine, Flysch trough had on either side slightly shallower marine areas with pelagic sedimentation (often in foraminiferal facies). — The Cretaceous-Paleogene series of the Ultrahelvetic and Helvetic units have been deposited north of the Flysch trough, south of it originated the mantle rocks of the Pieninic Klippen Zone, having the same age. In these mantle rocks parts of the Mesozoic basement are tectonically intercalated in the form of klippes.

The sediments of the Flysch trough between these two areas are deep sea deposits, with turbidity currents playing their part.

In the west (Swiss-Austrian border area) there is evidence for a close relation between the Flysch Zone of the Eastern Alps and the Penninic area. However, the distance between the deposition area of the Flysch and that of the Upper Cretaceous and Paleogene sediments of the

Limestone Alps must be assumed to be rather large, because of the differences in facies and in the composition of the sedimentary rocks; this points to different source areas for the sediments. In the Flysch trough, the source areas have changed approximately at the beginning of the Paleogene which is evident from a change in the heavy mineral spectra: change from a preponderance of garnet to a preponderance of zircone (G. Woletz, 1962). The original basement of the Flysch sediments is not known, whereas the Cretaceous-Paleogene sediments of the Limestone Alps rest on Mesozoic rocks.

The most important tectonic events in the Flysch Zone took place in late Eocene to Oligocene times.

The Excursions

(Stop III/1 — stop III/14)

(See sketch map Fig. 1)

1. Vienna — Sievering — Kahlenberg — Höflein — Königstetten — Dopplerhütte — Purkersdorf — Roter Berg — Vienna

Third day. Guide S. Prey (Stop III/1 — stop III/8)

The tour leads to the 19th district of Vienna and the suburb of Sievering, to

Stop III/1: Sievering, quarry west of Gspöttgraben.

Outcropping beds: Flysch, Sievering beds. Upper Cretaceous, Maastrichtian.

The center of the quarry exposes a group of about 1—7 m thick, graded, at the base fine-brecciated layers of sandstone, less frequently micaceous marly coarser sandstones (friable sandstones = "Mürbsandstein") with shale fragments, and intercalations of dark grey and greenish shales to marls. On either side of this group there are exposed grey to greenish shales, marly layers (often with fucoids and helminthoids), calcareous sandstone and several friable sandstone layers. Good sole markings and other "Lebensspuren" can be seen at the base planes (in overturned position).

Microfauna: A fairly large agglutinating foraminiferal fauna with big *Dendrophryae* and *Trochamminoidae* and partly *Rzehakina epigona.* The sandstones contain orbitoids: *Orbitoides apiculata tenuistriata,* O. *media, Lepidorbitoides socialis* (A. Papp, 1956). Also the nannoflora (H. Stradner, F. Brix, 1961) indicates high Upper Cretaceous.

Regarding the sedimentary lithology, see G. Niedermayer (1966).

The tour continues via the Höhenstraße to

Stop III/2: Kahlenberg, terrace of the hotel.

View of the margin of the Flysch Zone and of the Limestone Alps towards the Vienna Basin which is an over 5000 m deep Neogene basin (shown to the excursion on the days before). Good visibility provided, the southeastern boundary of the Vienna Basin (Leitha Mountains, Little Carpathians) can be seen.

The tour leads now to the Danube valley and to Klosterneuburg (famous abbey) and follows that valley across the Flysch Zone to its outer rim. Here is

Stop III/3: Höflein, quarry, run by Strombauamt (formerly "Hollitzer" quarry).

Outcropping beds: Flysch, Greifenstein sandstone, older Cuisien (A. Papp, 1962).

The several hundred meters long face of the quarry consists in its lower part of massive, thick-bedded Greifenstein sandstones which are glauconite-bearing quartz sandstones, rather coarse-grained, in their lower section with irregularly distributed conglomeratic parts (main components: Quartz, granite, metamorphic rocks, shales and sandy shales, sandstone, further some limestone and chert, and frequently also fossil fragments in the coarser sandstone). On top there is a sequence of thinner-layered, often intensely-bedded glauconitic sandstones, with frequent sole markings and "Lebensspuren", separated by shale layers.

The shales contain faunas of agglutinating foraminifera. In the sandstones, nummulites have long been known (G. Götzinger, 1951, 1954). A. Papp (1962) determined: *Nummulites globulosus, N. praecursor, N. atacicus, N. pernotus, N. planulatus sparsiseptatus, N. aff. planulatus, N. ficheuri.*

The dip is towards southeast.

Regarding the petrology of the sediments, see H. Wieseneder (1962) and G. Niedermayer (1966).

Continuing the tour, the route leads via St. Andrä-Wördern along the mountain border to southwest as far as Königstetten. At St. Andrä, the marginal strip of Lower Cretaceous Flysch — hidden farther in the northeast under the gravel-covered Danube plain — emerges and forms now the outermost part of the Flysch Zone for a long distance towards west. At Königstetten, begin the Molasse hills widening towards west because of the recession of the Danube plain

(Tullner Feld) from the Alpine border. The Molasse hills are situated northwest of the Flysch overthrust.

For stop III/4 — stop III/8 see also fig. 2.

Stop III/4: Königstetten, track cut southwest of the church.

Outcropping beds: Molasse, so-called "Sandstreifenschlier" (sand-streaked schlier). Miocene, Burdigalian.

Shortly after passing the entrance of the track cut, there is a larger exposure of fine-sandy, micaceous, thin bedded marly shales, alternating intensely with layers richer in sand (thus the term "sand-streaked schlier"). A few benches are visible, somewhat more consolidated which are up to 15 cm thick.

The poor dwarfish microfauna is characterized by *Cibicides lobatulus*, *C. boueanus*, *Rotalia beccarii*, *Elphidia* and others, numerous spicules and remains of *Spongiae* (det. W. Fuchs).

Dip about 15° SE, thus towards the Alps.

From the eastern end of Königstetten, the tour is continued about 1 km into a side valley towards SSW, to

Stop III/5: Creek bank near the Sanatorium south of Königstetten.

Outcropping beds: Molasse, bouldery sands of Königstetten (G. Götzinger, 1954). Miocene, Burdigalian.

Gray, brown weathering, somewhat marly sands, with individual layers or lenses rich in pebbles and boulders (frequently sized up to about 10 cm, in rare cases up to 70 cm), which consist almost exclusively of Flysch rocks. In addition, small quartz pebbles are scarcely found. The heavy mineral spectrum of the sands (det. G. Woletz) is characterized by abundant garnet together with staurolite and apatite, rarely zircone, rutile, tourmaline and, in places, chloritoide. The spectrum of the "Schlier", embedding the bouldery sands, is very similar.

Dip about 15° SSE (as in stop 4).

Progressing in the valley, one could reach after about 200 m the poorly exposed Flysch overthrust.

From the entrance of the valley, the road, crossing the edge of the Flysch Zone, winds upwards to

Stop III/6: Quarry at Dopplerhütte.

Outcropping beds: Flysch, Neocomian limestones.

Exposed are: Fine-grained, organodetritic to quartz-sandy limestone benches, maximal 40—50 cm thick, which are only poorly graded but in their upper part often become thin-bedded; on their bedding planes, small gray marl-plates are frequently found. In the upper part of the benches, in some places some gray chert occurs. Towards the top several benches show transition into intermediate layers of dark gray, ash-gray weathering marly shales.

The badly preserved, poor, dwarfish microfauna contains among others *Globigerinae*, rotaloid calcareous-tested forms, *Trocholinae* and *Radiolariae*. The nannoflora (H. Stradner) corresponds to Lower Cretaceous (F. Brix, 1961).

The beds are strongly folded, but in most cases dip SSE-SE.

The Gault Flysch which forms the bulk of the Lower Cretaceous Flysch in that area, unfortunately is very poorly exposed everywhere and therefore cannot be shown.

The general geological situation is well visible from the parking lot near Dopplerhütte: The front of the Flysch, overthrust towards N, is morphologically quite different from the piedmont Molasse hills — the southern part of the latter still tectonically disturbed (Subalpine Molasse). The Flysch-edge is also morphologically different from the Danube plain of Tullner Feld, and from the Molasse basin in general (called also "Outer Alpine Vienna Basin") behind which the Bohemian Massif rises gently. In the "disturbed Molasse" there is a conspicuous mountain crest in the southwest, consisting of the Burdigalian Buchberg conglomerate (equal to the bouldery sands, but consolidated). Easy to recognice are the Flysch-outliers north of the Danube gap and the Waschberg the latter consisting of folded and imbricated Molasse beds with various intercalations (e. g. granitic boulders, bouldery beds, nummulite limestones), called „Waschberg Zone".

From the Dopplerhütte, a larger part of Flysch Zone is now traversed southward, touching also the location in the southernmost part of the Greifenstein nappe, where ÖMV AG's well M a u e r b a c h 1 had been drilled. To a depth of 2364 m, this well drilled through the repeatedly tectonically divided Flysch nappe, then entered the Molasse Zone down to 3038 m, and finally penetrated about 400 m of autochthonous Jurassic on the Crystalline of the Bohemian Massif — a splendid confirmation that the Flysch Zone is overthrust over the Molasse Zone.

Already within the Kahlenberg nappe lies the former Carthusian monastery of Mauerbach, since long secularized. At Purkersdorf we reach the valley of the Wien river. There, about 2 km farther to west, is the

Stop III/7: Quarry in the Dammbachgraben WSW of Purkersdorf.

Outcropping beds: Flysch, Kahlenberg beds. Upper Cretaceous, Campanian, Kahlenberg nappe.

Benches of characteristic, gray to bluish-gray, mostly graded sandy limestones to calcareous sandstones, predominantly rather fine-grained, and frequently 0.5—1.0 m to only few centimeters thick, alternate with gray, usually slaty marls (often fucoids, helminthoids) and greenish-gray shales.

The microfauna is a poor agglutinating fauna with *Dendrophryae* et al., less frequently two-keeled *Globotruncanae* and small *Rzehakinae.* The nannoflora is Upper Cretaceous (det. H. Stradner).

The slightly bent beds dip about 20—35° NE.

Concerning the sedimentary petrography, see H. Wieseneder (1962).

On the further tour through the Wien valley in direction to Vienna, one can see exposures of the Upper Cretaceous Flysch. The conspicuous widening of the valley at Weidlingau is caused by the Main Klippen Zone with its soft mantle rocks, and the following narrow passage east of Auhof (between Lainzer Tiergarten and Satzberg) by another range of Upper Cretaceous Flysch. Behind those hills, within the 13th district of Vienna, we turn to south and reach Tolstoigasse:

Stop III/8: Vienna 13., Ober St. Veit, Roter Berg.

Outcropping beds: Examples of Jurassic rocks of the Klippen Zone of St. Veit; general view of the area. About half an hour's walk.

From Tolstoigasse a promenade leads to the Roter Berg. At its foot, outcrops of grayish-green clays and siliceous clays (Upper Dogger to Lower Malm) can be seen. Soon, however, the red, platy limestones (Malm), with chert and aptychi, become predominant, building also the summit of this hill.

The Roter Berg offers a good view of the neighbouring Klippen mountains, comprising beds ranging from Rhaetian to Lower Cretaceous and a varicolored Klippen mantel with proved Cenomanian, further the Flysch mountains of Lainzer Tiergarten in the western background; on the other side, one can see the Vienna Basin and its borders.

About 100 m west-northwest of the summit, light coloured aptychus beds (Malm) and traces of arkoses of the Liassic Gresten beds, possibly also of picrite are poorly exposed. If the Klippen mantle is visible at all, then only in case of recent excavations.

Now we retourn to the buses which take us back to town.

2. Vienna — Altlengbach — Klamm — Altenmarkt — Alland

Fourth day, morning. Guide S. Prey (Stop III/9 — stop III/14).

First we drive into the valley of the Wien river and onto the Autobahn. At its beginning, the Autobahn uses the wide parallel depression south of the Wien valley along the Main Klippen Zone which, on one hand, consists of Kaumberg beds of the Laab nappe, on the other hand, of emerged klippes (Dogger—Lower Cretaceous) with a mantle of Buntmergelserie (Upper Cretaceous — Eocene). At Wolfsgraben, i. e. near the Vienna Wood storage lake, we enter the area of Kahlenberg nappe with predominantly Altlengbach beds. In the defile about 1 km W of the storage lake, an exposure of Middle Cretaceous rocks was observed (black and greenish-gray slates, quartzites; S. Prey, 1965). Towards north-west, the Middle Cretaceous is pressed against an anticline of the Bihaberg, visible in particularly deep cutting. The core of this anticline consists of Kahlenberg beds, accompanied by traces of varicolored shales and Altlengbach beds, with thicker sandstones at the base.

After having moved for a longer distance through Altlengbach beds, we reach the northwestern edge of the Kahlenberg nappe at the Steinhartberg. There, in the deep cutting at the time of construction of the Autobahn, one could see the overthrust of Altlengbach beds (of the Kahlenberg nappe) over Greifenstein sandstones (of the Greifenstein nappe). The latter, lying on the right side of our passage, are particularly conspicuous for their light color.

At Altlengbach we leave the Autobahn and drive about 2 km to northwest.

Stop III/9: Quarry at Nest.

Outcropping beds: Flysch, Altlengbach beds. Maastrichtian. This place is now considered as a type locality of the Altlengbach beds.

Alternation of calcareous sandstones (graded bedding, convolute bedding, lamination, etc.), mostly crumbly-weathering, coarser-grained, micaceous, marly cemented sandstones ("friable sandstones", often with plant detritus and shale fragments), further infrequent light gray, hard marl layers with gray marly shales (very often with fucoids, helminthoids) and dark gray shales to marly shales. Typical Flysch facies.

The microfauna consists of partly large agglutinating foraminifera with *Dendrophryae* and large *Trochamminoidae* along with other forms. Samples collected in the vicinity contained *Rzehakina epigona.* The nannoplankton (det. H. Stradner) indicates higher Upper Cretaceous.

Dip of the beds: 45° S.

We now proceed southward. At Neustift we cross again the edge of the Kahlenberg nappe which consists here likewise of Altlengbach-, partly also of Sievering beds and of Greifenstein sandstone. At Klamm, we reach the Main Klippen Zone. After the floods of 1966, a Malm Klippe with a thin mantle of Buntmergelserie was exposed in the creek-bed at the base of outcropping Kaumberg beds (Laab nappe).

Slightly more than 1 km west of Klamm is

Stop III/10: Quarry at Gern, about 1.2 km west of Glashütte Inn, about 100 m south of the road to Stollberg.

Outcropping beds: Klippe of light Malm limestone. Tithonian. Main Klippen Zone.

The partly overgrown face of the quarry consists of grayish-white, dense, partly bedded limestones which show frequently short, dark gray sutures. The limestones, dipping about 70° SSE, are particularly fractured along a fault, and rich in calcite veinlets. Aptychi. In thin sections, *Calpionella alpina* is frequent, *Tintinnopsella carpathica* is rare.

The klippe rocks, frequently exposed in this area, comprise mottled limestones and mottled marls of the Neocomian.

From Klamm, we first proceed on the road in direction to Hainfeld. Where the valley becomes conspicuously narrow, there it crosses the Laab beds.

For stop III/10 — stop III/13 see fig. 3.

Stop III/11: Roadside exposures at Klamm, south of Glashütte. (That point is an alternative of stop 14.)

Outcropping beds: Flysch, Hois beds (S. Prey, 1965), a subdivision of the Laab beds. Upper Paleocene — deep Lower Eocene.

Sandstones, densely bedded, partly fine-grained, partly coarser-grained, frequently also siliceous, often with coarse-grained basal layers (quartz grains, feldspars to about 3 mm), mica-bearing, with graded bedding, occasionally also with shale fragments. Between the benches, blackish and greenish-gray shales and rare marl layers which also may contain fucoids.

The microfaunas are occasionally reather rich, but mostly there are only extremly poor agglutinating faunas. Some distance northward and thus deeper in the sequence of strata, there was found *Rzehakina epigona*. Nannofloras are mostly absent; Upper Cretaceous nannofossils, occasionally found in those beds, were certainly resedimented.

Dip of the beds: very steep S-SSE.

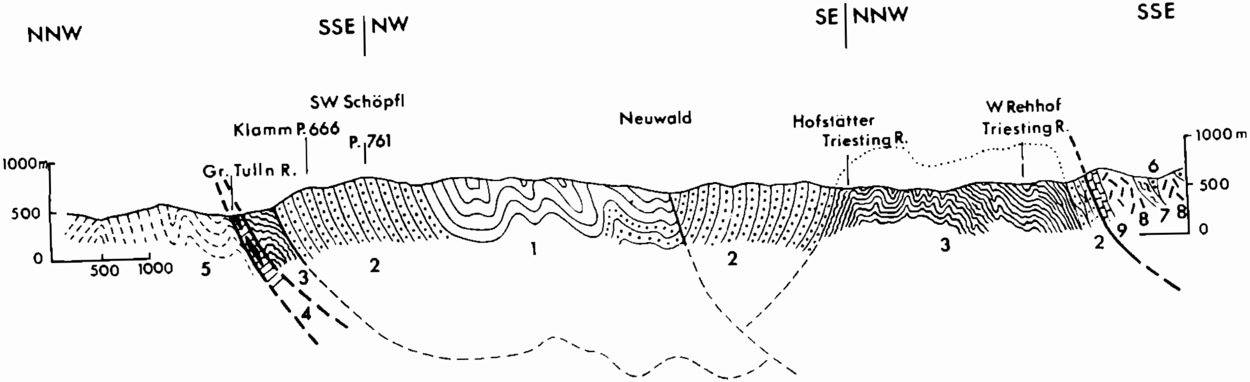


Fig. 3. Geological cross section through the Main Klippen Zone and the Laab nappe in the Klamm — Triesting river area (S. Prey).

Laab nappe: 1 = Agsbach beds, 2 = Hois beds, 3 = Kaumberg beds. Main Klippen Zone: 4 = Buntmergelserie with Jura Klippes. Kahlenberg nappe: 5 = Altlengbach beds.

Limestone Alps: 6 = Gosau beds, 7 = Liassic spotted marls, 8 = Hauptdolomit, 9 = Gutenstein dolomite.

Towards south, the sandstone complexes recede in favor of shales; the topographic relief becomes more gentle.

Stop III/12: Roadside exposure at the northern bend of the road NE of Klammhöhe.

Outcropping beds: Flysch, Agsbach beds (higher parts of the Laab beds; S. Prey, 1965). Lower Eocene.

Greenish-gray to blackish, brownish-gray weathering, hard shales with rare marl layers and thin, fine-sandy, siliceous benches and individual thicker siliceous glauconite-bearing sandstone layers.

Microfauna: Very poor agglutinating fauna. The nannoflora (det. H. Stradner) indicates higher Paleocene — Eocene.

The beds dip steeply approximately towards S.

The place in question is situated in the south-dipping northern flank of the large shale syncline of the Laab nappe, which is crossed on the way via Klammhöhe to Untertriesting in direction to southeast. When entering the wider Triesting valley, we see that, in the Weinhof area, the sandstones at the southern flank increase again and join once more the Hois bed complex, which is rich in sandstones and causes a more accentuated relief. Suddenly, the relief becomes gentler again, and the river forms a major bend, caused by the Kaumberg beds which are now widely outcropping as core of a big anticlinal structure.

Stop III/13: Left-hand concave bank of the Triesting river near the Hofstätter farm.

Outcropping beds: Flysch, Kaumberg beds of the Laab nappe. Lower Senonian.

Red, greenish-gray and gray shales and slates with often numerous, 2—10 cm thick benches of sandy limestone to fine-grained calcareous sandstone, frequently somewhat bedded, and bearing small sole markings. There occur also fine-bedded, grayish-green siliceous mud stone benches. Sections with plenty of red material alternate with those containing only green and gray material, grading one into another.

Microfauna: Rather poor agglutinating fauna with numerous *Dendrophryae* and, occasionally, few two-keeled *Globotruncanae*.

The formations are very strongly folded.

Crossing the Kaumberg anticlinal structure, the road west of Rehhof turns more towards east. Only a narrow band of Hois beds accompanies the Kaumberg beds on their southern border, immediately before the overthrust front of the Limestone Alps, which is crossed east of Rehhof. The road now leads through marginal parts of the Northern

Limestone Alps via Altenmarkt (zone with Cretaceous Gosau beds) to Hafner Berg (at the road, Gutenstein dolomite with fissures infiltrated by bauxitic material of the Gosau basement), and, finally, through Gosau beds with uplifts of Triassic and Jurassic rocks to Alland.

From here on, the following is an alternative to stop 11.

In the valley of the Schwechat river, we now proceed for about 3 km to northwest, crossing once again the edge of the Limestone Alps towards the Flysch Zone.

Stop III/14: Exposure at the excavations of the Autobahn route SW of Saagberg.

Outcropping beds: Flysch. Hois beds of the Laab nappe. Upper Paleocene — deep Lower Eocene.

Gray, brownish-gray, dark gray, sometimes also greenish, mostly hard shales and rare gray marl layers alternate with thick, hard, partly slightly siliceous sandstone benches with graded bedding, often coarse basal layers and often large sole markings, towards top becoming fine-grained and sometimes grading into the overlying shales. Frequently they show assorted shale fragments and slide marks.

The microfauna is extremly poor and consists only of agglutinating forms which do not furnish any clues in respect of their age. The nannoflora (det. H. Stradner) consists only of Cretaceous forms which have certainly been re-sedimented because, farther northeast in the direction of strike, there is a nummulite bearing locality (G. Götzinger, 1951) and, a little south of it, a nannoflora of Lower Eocene has been found.

The beds dip about 30° SSE.

Regarding the sedimentary petrography, see H. Wieseneder (1962).

At Alland, B. Plöchinger now takes over to lead the excursion into the Northern Limestone Alps.

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B. The Northern Limestone Alps near Vienna

By B. Plöchinger

Introduction

The Northern Limestone Alps, which belong to the Upper Austro-Alpine tectonic unit are situated between the Paleozoic Grauwacke Zone in the S and the Flysch Zone and Klippen Zone (Helveticum) in the N. In the excursion area, the general W-E strike changes into the Carpathian SW-NE trend. Interrupted by the Mio-Pliocene Vienna Basin, the Limestone Alps continue into the Carpathians.

1. Stratigraphy
(Compare table 2)

The Mesozoicum of the Northern Limestone Alps begins with the Skythian Werfen beds, stratigraphically connected with the Paleozoicum of the Grauwacke Zone by the Upper Permian Prebichl beds (Verrucano conglomerate). To the Werfen beds belong mottled, micaceous shales and sandstones, quarzites, clays, anhydrite and gypsum. In the Middle Triassic follow the yellow Reichenhall Rauhwacke and breccia, dark limestones and dolomites (Gutenstein beds), the cherty Reifling limestone and the finegrained Wetterstein limestone and dolomite. Remarkable are the diabase-occurences in the Werfen beds and the serpentine in the deepest Anisian layers. Clayey shales and clayey sandstones of the Lunz nappe characterize the Lower Carnian regression. In the Hallstatt facies of the Hohe Wand nappe instead of Lunz beds, which are coal-bearing at the type locality, the high marine Halobia shales are developed. Of Upper Carnian age are the Opponitz limestones with their occasional transition into dolomite, Rauhwacke and the Cidaris limestone. To the Norian belong the Hauptdolomit and the Dachstein limestone, which, in our area, are important elements of the Ötscher nappe. In the Hohe Wand nappe, the mottled fossil-rich Norian Hallstatt limestone replaces the Dachstein limestone. Together with the accompanying Norian and Rhaetian marls this limestone characterizes the Hallstatt facies.

The thin sequence of the northernmost tectonic unit (Frankenfels nappe) begins with Rauhwacke and Hauptdolomit; in it the Rhaetian layers show a resemblance to those of the Germanian facies. Corresponding to the changed conditions of sedimentation the Jurassic rocks of the Limestone Alps show different lithologic developments. Remarkable for the Liassic are the mottled, partly nodular limestones (Enzesfeld limestone, Adnet limestone) and the usually reddish crinoid limestone, for the Dogger the cherty limestone (Jurahornsteinkalk), for the Kimmeridgian the brick-red, thin-bedded nodular limestone, for the Tithonian and Neocomian the Aptychus limestones and — marls. In the Frankenfels nappe the crinoid limestone facies also occurs in the Dogger (Vils limestone) and in the Malm (Mühlberg limestone). The highest sediments of the Lower Cretaceous, of the Cenomanian and of the Coniacian to Paleocene (Gosau beds) are coarse or fineclastic.

Nearly all Mesozoic beds are fossiliferous. Remarkable megafossils were found in the Norian, Rhaetian, Liassic and Senonian sediments. Microfossils were described as well from the Carnian, Norian and Rhaetian sediments as from the Upper Cretaceous — Paleocene sediments.

2. Tectonics

(Compare sketch-map figure 1)

Together with the underlying Paleozoic rocks of the Grauwacke Zone the Mesozoic Limestone Alps moved as nappes from south to north over the Penninicum of the Tauern and the sequences of the Lower and Middle Austro-Alpine units. Thus the Limestone Alps slipped over the Flysch Zone and, together with Flysch and Klippen Zone over the Molasse Zone (E. Clar, 1963, S. 17, P. Beck-Mannagetta, R. Grill, H. Holzer & S. Prey, 1966).

This movement of nappes took place before and during the deposition of the Senonian to Eocenian Gosau-sediments and was reactivated in "post-Gosau" time. There is evidence for a "pre-Gosavian" transport of the nappes shown by the Gosau sediments unconformably overlying the overthrust-lines of the Hohe Wand nappe and the Schneeberg nappe.

The Tithonian-Neocomian sediments, which unconformably overlie Triassic rocks of the Lunz nappe, may be seen as a result of a Kimmeridgian movement. The break between the Valanginian and the Gargasian without doubt permits to speak of affects of a "Pre-Austrian phase" (Austroalpine phase according to A. Tollmann, 1963, 1964). The Austrian phase is characterized by the Cenomanian sediments, which overlie unconformably the Triassic to Lower Cretaceous rocks of the folded Frankenfels- and Lunz nappe. The Turonian break is a result of the pre-Gosavian phase. Only small deposits of bauxit filling fissures can be observed as terrestic Turonian sediments.

Coniacian, till now, has not be found in this region. The unconformable overlying of the Upper Santonian to Maastrichtian sediments corresponds to a pre-Gosavian to inter-Gosavian phase. The movements during the Campanian changed the territory from which the sediments were brought (G. Woletz, 1954). The break before the deposition of the Paleocene, which may be observed only in few places, gives an indication for the existence of a Laramian uplift.

		Frankenfels nappe	Lunz nappe
TERT.	PALEOCENE		mottled shales,flysch-like sandstones and microbreccias (Gießhübl beds)
	DANIAN		horizon with agglutinated foraminifera
UPPER CRETACEOUS	MAASTRICHTIAN		Inoceramus beds
	CAMPÁNIAN		sandstones,partly with carbonaceous pebbles
	SANTONIAN		grey cherty limestones and mottled marls
	CONIACIAN		
	TURONIAN		
	CENOMANIAN	Exotica-bearing breccia, Orbitolina sandstone and marl	
LOWER CRETACEOUS		breccia,dark clayey marls (Alb-Apt) Aptychus marls(Valanginian)	grey sandy marls and marly sands (Upper Aptien-Albian) Aptychus marls and sandstones (Valanginian-Hauterivian)
UPPER JURASSIC (MALM)		Aptychus marls,grey cherty Ls (Steinmühl Ls), red diphya Ls (Mühlberg Ls), Acanthicus beds	Aptychus marls and sandst. mottled streaky limestone, Plassen Ls.(white) and Acanthicus beds (thin-bedded nodular Ls)
MIDDLE JURASSIC (DOGGER)		cherty limestone,light and reddish crinoidal Ls(Vils Ls),dark red,partly crinoidal Ls (Klaus Ls)	grey or reddish thin-bedded siliceous and cherty Ls (Jurahornstein Ls)
LOWER JURASSIC (LIAS)		cherty marls, grey marls with black spots,red nodular Ls (Adnet Ls), sandy, carbonaceous Gresten beds, sandy Kalksburg beds	mottled limestones (Hierlatz Ls, cephalopod Ls, Jurensis beds)
UPPER TRIASSIC	RHAETIAN	red fissile shales (Schattwald beds), clayey-sandy and oolitic limestones, siliceous Ls (Rhaetian-L. Jurassic Kiesel Ls)	pale coral-bearing bioherm Ls, dark marly Ls (Kössen beds) dark shales with vertebrate-rests (bone-bed-intercalations)
	NORIAN	Rauhwacke (Ybbsitz Rauhw.) Hauptdolomit	thin bedded limestone(Platten Ls) Hauptdolomit
	CARNIAN	Rauhwacke	Opponitz limestone -"- dolomite -"- Rauhwacke Lunz beds (dark shales of clay and clayey sandst.
MIDDLE TRIASSIC	LADINIAN		thin layer of Wetterstein Ls, Partnach marls, Reifling Ls (grey,nodular,thin-bedded, cherty limestone)
	ANISIAN		Brachiopod-layer Gutenstein Limestone -"- dolomit (thin bedded dark layers) Wurstel limestone
LOWER TRIASSIC	SKYTHIAN		Werfen beds (mottled,micaceous shales and sandstones, grey quarzite) with anhydrite and gypsum

Table 2. Stratigraphy of the Northern Limestone Alps

Göller nappe (part of Ötscher nappe after KOBER)	Hohe Wand nappe	Schneeberg nappe
grey micaceous sandy marls and marly sandstones with carbonaceous fragments, rich on microfossils (Danian-Palaeocenian Zweiersdorf beds)		
Inoceramus beds (Inoceramus marls and Orbitoid sandstone), congl. and breccia clayey marls and sandstones with conglomerate-intercalation and coal seams, brown sandy limestones, basal conglomerate brachiopod and rudist limestone, mottled marls, sandy coral marls, conglomerates, breccia Bauxit and bauxitic clay		
granular brownish Ls red, partly crinoid-rich limestone (Klaus Ls) thin-bedded, cherty Ls, nodular Ls (Adnet Ls), crinoidal Ls(Hierlatz Ls) grey spotted marls, marly shales, Enzesfeld Ls.	crinoidal Ls dark spotted marls cherty Ls, crinoidal Ls (Hierlatz Ls)	
Foraminifera Ls, Kössen bed, light Dachstein Ls with reddish intercalations (Starhemberg Ls) Dachstein limestone (light, dense Ls) Hauptdolomit Opponitz Ls(grey,silicious) Opponitz dolomit,Cidaris-Ls, Halobia shales, Aon shales,clayey sandstones, Mürztal Ls	grey marls (Plackles or Zlambach marls) Hallstatt Ls(reddish, dense,Monotis-bearing Ls) Hauptdolomit Opponitz Ls Cidaris Ls Mürztal marl Lunz-beds -"- Ls	
Wetterstein Ls and dol. (white,finegrained diplopora Ls and dol.) Reifling Ls Gutenstein Ls and dol. (thin-bedded,dark)Rauhwacke and breccia (yellow-brownish) Werfen shales (mottled, micaceous)with Anhydrite and gypsum	Wetterstein Ls and dolomite Steinalm dolomite(fine grained),Gutenstein dolomite,cherty Ls,mottled streaky Ls,Rauhwacke, breccia mottled Werfen shales and clays(Haselgebirge)	Wetterstein Ls Reifling Ls Gutenstein Ls and dol. Wurstel Ls (streaky-nodular),yellow-brownish Rauhwacke,breccia and Ls with serpentine mottled Werfen shales with brownish,thin Ls-intercalation ,Anhydrite gypsum, diabas

in the excursion area. B. PLÖCHINGER 1967.

The Frankenfels nappe is the northernmost, deepest tectonic unit of the Northern Limestone Alps. This unit is overlain by the Lunz nappe, which is overthrusted from S to N. As the third and highest pre-Alpine unit the Ötscher nappe lies overthrusted over the southern part of the Lunz nappe. The Ötscher nappe is divided into the Reisalpen-, the Untersberg- and the Göller nappe. In our section only the southernmost part of the Ötscher nappe, the Göller nappe, is present.

Thrust slices of the Frankenfels nappe, so called "Schürflinge" were brought up to the surface by the overthrust of the Göller nappe. Lying along the border of this unit they indicate that the Lunz nappe does not reach very far towards south (G. Hertweck, 1961, p. 71).

The Puchberg-Mariazell-faultline determines the separation of the just mentioned "pre-Alpine" nappes from the "high-Alpine" nappes of the Limestone Alps. To the latter belong the Hohe Wand nappe (after E. Kristan-Tollmann & A. Tollmann, 1962, part of the Mürzalpen nappe) and the Schneeberg nappe. The Hohe Wand nappe is to be compared with the Hallstatt nappe of the central part of the Limestone Alps because of its Hallstatt facies.

The windows of the Göller nappe at the Hengst mountain (Hengst window), the double-window of the Göller nappe and the Hohe Wand nappe at Ödenhof (Ödenhof window) as well as the window of the Hohe Wand nappe at Höflein (Höflein window) proof the significant movements of the nappe-masses.

The Excursion

(Stop III/15 — stop III/26)

(See sketsch map figure 1)

1. Alland — Mayerling — Grub — Gießhübl — Vienna

Fourth day, afternoon. Guide B. Plöchinger (Stop III/15 — stop III/21).

Stop III/15: At the Ölberg of Alland a steeply SSE dipping, overturned Jurassic-Neocomian sequence of the Frankenfels nappe — or possibly Lunz nappe — is unconformably overlain by a gently east dipping, grey Cenomanian *Orbitolina*-sandstone and marl (fig. 4). On the irregular transgression surface occasionally a breccia appears. Stratigraphical break and unconformity indicate the existence of the pre-Cenomanian Austrian phase (B. Plöchinger, 1960, p. 64).

The underlying sequence shows 30 meters of grey cherty limestones (Jurahornsteinkalk), about 15 meters finegrained light coloured and reddish crinoidal limestone, both presumably of Dogger-age, a few

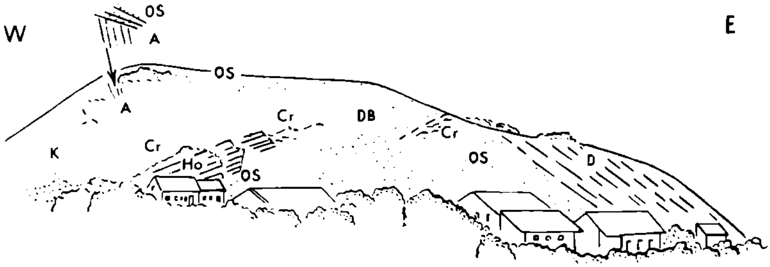

Fig. 4. View to the Ölberg in Alland with the unconformably overlying Cenomanian beds.

OS = Orbitolina sandstone (Cenomanian), DB = dolomite breccia (Cenomanian), A = Tithonian-Neocomian Aptychus marl, K = coloured limestone (Kimmeridgian), Cr = sparry limestone (? Dogger), Ho = grey, cherty limestone (Liassic), D = Hauptdolomit.

meters pale-red and grey limestone of the Kimmeridgian- ? Tithonian, about 150 meters Tithonian limestone-marls and thin-bedded Neocomian marls (Tithonian - Neocomian Cement marls or Aptychus marls). Valanginian is prooved by *Neocomites neocomiensis* and *Lamellaptychus seranonis.*

Stop III/16: On the road Alland—Mayerling, about 100 m SE of the road junction at Alland, there is a natural exposure of Maestrichtian conglomerate, which overlies a light coloured Middle Triassic limestone of the Göller nappe with an angular discordance of 60° (fig. 5). The break is the result of a pre-Gosavian movement.

Cracks on the pre-Gosavian erosion surface of the Triassic rock, which are nearly vertical to the bedding planes, are filled with a pisolitic, bauxitic clay of possibly Turonian age.

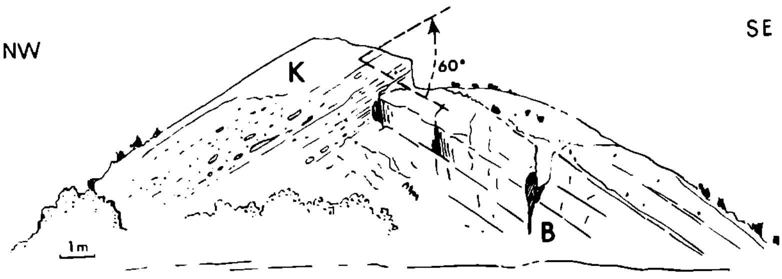

Fig. 5. Outcrop of pisplitic, bauxitic clay (B) and of unconformably overlying Maastrichtian conglomerate (K) at Alland.

The chemical and mineralogical investigations of the bauxitic clay give the possibility to compare it with the Hungarian bauxite deposits; mineralogically it consists of boehmite, hydragillite, hematite, kaolinite, rutile, prochlorite and chamosite (G. Bardossy in B. Plöchinger, 1961, p. 405).

Stop III/17: The view from the upper quarry of the Ungerstein, which is situated in the Schwechat-valley between Sattelbach and Mayerling illustrates the complicated tectonic pattern within the Göller nappe (part of the Ötscher nappe in the sense of L. Kober). The excursion-point is located on the northern border of the "Schwechat-window", which first has been interpreted as overturned wing of the pre-Alpine Ötscher nappe, reaching about 20 km to the SSW (L. Kober, 1911, table V). This structure was afterwards delimited and explained in different ways (A. Spitz, 1919, L. Kober, 1926, H. Küpper, 1951, 1952, G. Hertweck, 1964, 1965). B. Plöchinger (1965) supposes an overthrusted higher thrust slice of the Göller nappe over a deeper slice and a following transverse compression (fig. 6).

Jurassic rocks of the "window" (Tithonian Aptychus limestone, red Dogger limestone) exposed on the track to the higher quarry are overthrust by dark shales and clayey sandstones of the Lower Carnian Lunz beds, which are overlain by the Upper Carnian Opponitz limestone.

Stop III/18: The Hauptdolomit — quarry south of Grub, on the road to Heiligenkreuz exposes the unconformity between the Hauptdolomit of the Lunz nappe and the overlying marly shales of Cenomanian age. The angular unconformity of 30° and the break between the dolomite and the Cenomanian is a result of the pre-Cenomanian Austrian phase.

In thin dark shaly clay — intercalations of the dolomite, vertebrate — relies such as teeth of placoderms can be found. Towards the transgression — contact the dolomite becomes thinbedded and brecciated. The marly Cenomanian shales contain intercalations of thin calcareous *Orbitolina concava* — layers.

Stop III/19: The quarry of the Mitterwäldchen, about 1 km NW of Sittendorf, on the northwest side of the road, exposes grey, siliceous marly sands and mottled marly shales of the Gosau beds. The Santonian age of this deposit is established by the content of *Globotruncana concavata* and globotruncanids of the *lapparenti* — group in the mottled marly shales. The sandstones contain the large lamellibranchiad *Inoceramus ? undulatoplicatus,* which belongs to the zone of *Texanites texanum.*

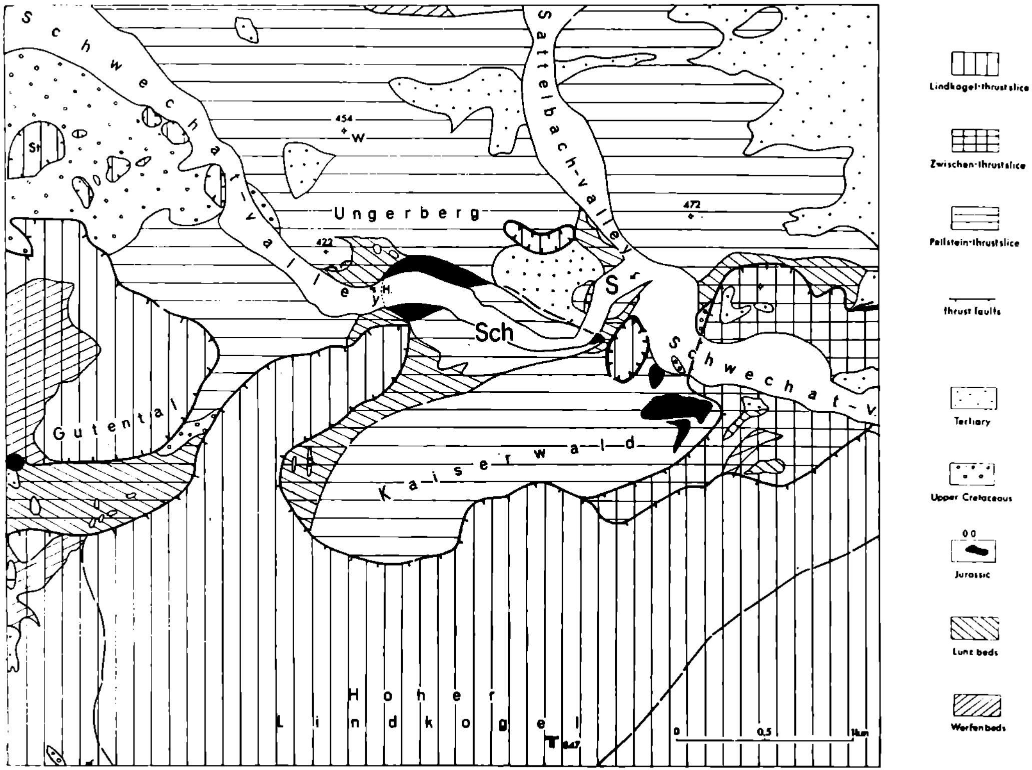

Fig. 6. Tectonic sketch map of the Schwechat "window" area.

H = Happenhofer, S = Sattelbach, Sch = „Schwechat window", St = Steinwand, W = Windhaagberg.

At the nordwestern end of the quarry the S-dipping of the siliceous marly sands is indicated by a parallel alignment of *Inoceramus* — valves. Transgreding actionellide- and echinide-bearing pebbly sands and microbreccias of the Upper Campanian are dipping gently in northern direction. The unconformity proves an inter-Gosavian movement. Between the irregulary distributed pebbles up to several centimetres in diameter there are carbonaceous pebbles, proving the preceeding regression.

The sediments of this quarry belong to the Upper Cretaceous-Paleocene beds of the Gießhübl-depression, striking between Sittendorf and Perchtoldsdorf. The transgression of these beds over a variety of rocks belonging to the Triassic, Jurassic and Lower Cretaceous begins in the western part of the depression, W of Sittendorf with the Santonian and E of this village with the Campanian — Maestrichtian (Exc. point 21). Parallel to the edge of the Vienna Basin there was probably a high-zone in Late Cretacious time.

En route from Hinterbrühl to Gießhübl there is a good view towards the front of Göller nappe, which is a part of the Ötscher nappe, according to Kober. Along the Mödlingbach valley are exposed the gypsum-bearing Skythian Werfen beds, which towards the higher terrain in the S (Anninger) are overlain by the S-dipping sequence of Middle Triassic to Liassic rocks. At the northern edge of this occourrence of Werfen beds there are overturned S-dipping tectonic slices of Middle Triassic limestones, overthrusting the Upper Cretaceous marls and conglomerates which seperate the Lunz nappe in the N from the Göller nappe in the south. They convince us, that the Werfen beds of the mentioned valley generally form the core of an overturned fold.

As components of the Maestrichtian transgression-conglomerate also pebbles of Werfen beds of the Göller nappe are found. They confirm the pre-Gosavian overthrust of this nappe over the Lunz nappe.

Stop III/20: The Gießhübl depression is filled by Upper Cretaceous and Paleocene Gosau-sediments. Good exposures of the Paleocene Gießhübl beds are to be studied south of Gießhübl church, in a cut made for the projected Autobahn.

The Gießhübl beds are about 100 m thick and rest without obvious discordance upon a 150 m thick series of predominantely reddish Globotruncana-marls, Orbitoid-sandstones and conglomerates, belonging to the Maestrichtian. Between the Gießhübl-beds and the underlying Maestrichtian there are about 20 m thick grey sands and marls, which only are occasionally exposed. The absence of *Globorotalia* suggests Danian age (R. Oberhauser in B. Plöchinger, 1963, p. 483).

The Paleocene Gießhübl beds are composed of predominantly reddish or greenish shales with intercalations of thin layers of an exotica-

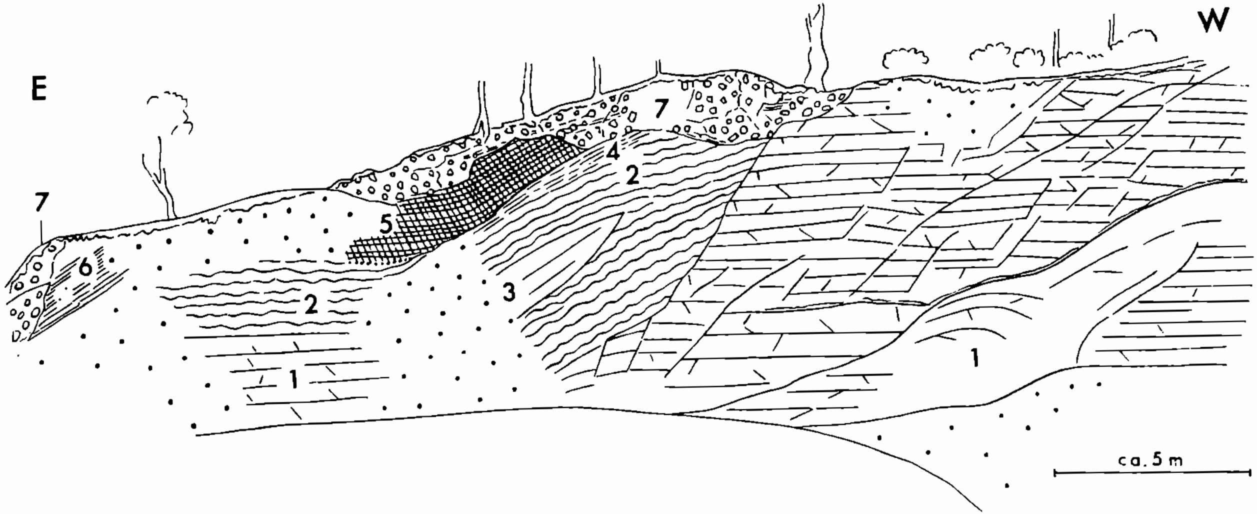

Fig. 7. The southern part of the Acanthicus quarry near Gießhübl.

1 = cherty limestone of Dogger (?) (= Jurahornsteinkalk), 2 = Acanthicus-limestone (Kimmeridgian) with a pale intercalation (3), 4 = Aptychus marl (Berriasian-Valanginian), 5 = sandy marl and sandstone (Upper Aptian to Albian), 6 = red Globotruncana marl (Maastrichtian), 7 = Maastrichtian conglomerate.

bearing breccia and meter-thick flysch-like sandstones and micro-breccias. These sedimentary rocks, apparently turbitites, are highly micaceous, rich in carbonaceous fragments and have a thick brown weathering crust. On the surface they show ripple marks, grazing trails (Helminthoides), soil markings and coprolites.

Stop III/21: The "Acanthicus-quarry" lies in a forest 0.9 km NNE of Gießhübl church, on the southern border of the Lunz nappe and the northern edge of the Gießhübl depression (fig. 7).

Above a thin bedded cherty Middle Jurassic limestone (Jurahornsteinkalk), which is about 30 m thick, the quarry exposes several meters of thick, thin-bedded, nodular and brick-red Kimmeridgian Acanthicus limestone. A. Toula (1907) collected numerous ammonites of the genus *Phylloceras, Lytoceras, Oppelia, Perisphinctes, Simoceras* and *Aspidoceras* at this locality. The index-fossil is *Physodoceras* (= *Aspidoceras*) *acanthicum.*

In a small hollow on the southern face of the quarry, above the Acanthicus limestone, one sees a one meter thick layer of marly shales, belonging to the Berriasian — Valanginian passing into about three meter thick, soft, sandy marls of the highest part of Lower Cretaceous, the Upper Aptian (Gargasian) to Albian with *Biglobigerinella barri, Globigerinelloides aff. algeriana, Epistomina colomi.*

An unconformity is shown by the fact, that in other outcrops in the vicinity the same beds of Upper Aptian — Albian lie upon older Jurassic sediments. This shows the effect of the pre-Austrian phase (Austroalpine phase).

The Lower Cretaceous sediments are overlain unconformably by Upper Cretaceous transgression — sediments, represented by a meter-thick conglomerate with thin *Globotruncana* — bearing marl-intercalations of Maestrichtian age. Thus in the Acanthicus-quarry there is evidence of two phases of tectonic movements.

2. Vienna — Hernstein — Zweiersdorf — Grünbach Pfennigbach — Puchberg — Sieding — Vienna

Fifth Day. Guide B. Plöchinger (Stop III/22 — stop III/26).

Stop III/22: East of the castle Hernstein there is a 100 m long, 70 m wide and 37 m high thrust slice, crowned by the ruin of the old castle. As F. Hauer (1848) already recognized, the rock is formed by Norian Hallstatt limestone. A. Bittner (1882) found in it *Pinacoceras (Megaphyllites) jarbas, Arcestes tornatus, Arcestes respondens, Monotis salinaria, Halobia plicosa, Halobia norica* and brachiopods, especially rhynchonellids. It is part of the northern-most dislodged slice of the Hohe Wand nappe, composed of Werfen beds and Hallstatt limestone, which rests on a ENE-trending Lias-syncline of the Göller nappe (H. Mostler, R. Oberhauser & B. Plöchinger, 1967).

The Lias is composed of red and grey, partly crinoidal limestones containing a Lower Liassic ammonite fauna, and spotted marls with intercallations of soft marls, which contain foraminifera of lower boreal Lias.

Few meters behind the eastern wall of the guesthouse there is a 20 m long, up to one meter thick lense of marl in the gently east dipping Hallstatt limestone. It is the only place in the eastern section of the Northern Limestone Alps, where marls are interbedded with Norian Hallstatt limestone. Geopetal structures as well as palaeontological data indicate that the beds are inverted.

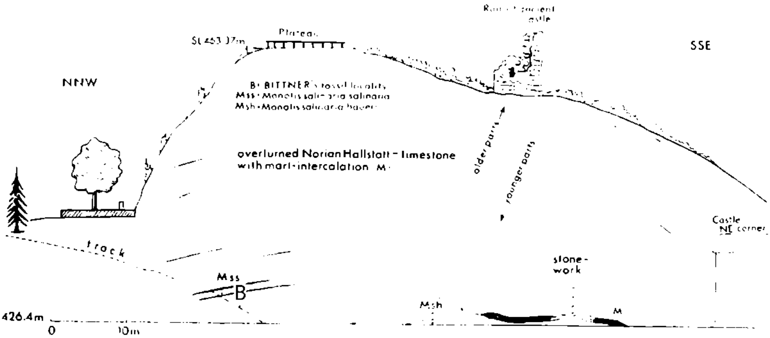

Fig. 8. Exposure at the site of the ruined castl of Hernstein.

The rock below the marl contains especially the coarse ripped form *Monotis salinaria haueri* Kittl, whilst the fine ripped *Monotis salinaria salinaria* (Schlotheim) is abundant in the overlying limestone as well as at the Bittner-locality (see fig. 8). The marls contain foraminifera, especially *Variostoma cochlea* Kristan, which has been regarded as a Norian index fossil. Marl intercalations found in recent excavations show also agglutinated forms, which are more typical of the Rhaetic.

Rich conodont assemblages containing 14 species from 10 generas from residues of limestone samples of the whole section prove Norian, partly Upper Norian (Sevatian) age.

Stop III/23: Z w e i e r s d o r f is situated in the center of a 17 km long Gosau syncline W of Wiener Neustadt (fig. 9). The northern part of the Gosau-syncline strikes SW-NE, whilst the southern part trends E-W. The Senonian to Paleocene transgression of the syncline overlaps the rocks of three nappes, the Göller-, the Hohe-Wand- and the Schneeberg-nappe. This shows, that the thrusting of these nappes occurred in pre-Senonian times.

The Upper Cretaceous transgression proceeded from W to E. In the west, Upper Santonian sediments rest on predominantly Triassic rocks of the Hohe Wand nappe, whilst Upper Campanian beds rest on Triassic rocks of the Fischauer Berge in the east. In Upper Tertiary times, the Upper Cretaceous to Paleocene beds were folded into an about 1500 m deep syncline. The flanks are slightly overthrusted towards the core of the syncline, which, in the larger soutern part, is overturned towards SE or S.

The 1400 m thick Gosau-series enclude the basal breccia and conglomerate, Hippurite- and Brachiopod limestone, the coalbearing Campanian, the Orbitoid sandstone and Inoceramus marls (Upper Campanian-Maestrichtian) and the Zweiersdorf beds. The latter have their type-locality here. The Zweiersdorf beds are a 250 m thick series of mica-rich and carbonaceous marls and marly sandstones. On the overturned NW-dipping bedding plane a gastropod trail *(Subphyllochorda)* can be seen. Lenses of marly limestone are rich in branching *Lithothamnium, Bryozoa* and lammellibranchs and contain large forams of the genus *Miscellania.*

The following forms dominate in the foram-rich marls: *Globigerina pseudobulloides, Globigerina triloculinoides, Globigerina trinidadensis, Globorotalia angulata, Globorotalia compresa.*

The nannoflora indicates a Danian to Lower Thanetian age. Besides of Upper Cretaceous foraminifera, the marls contain reworked corals and marly limestone-fragments with an Upper Cretaceous nannoflora.

The lowest 10—15 m of the Zweiersdorf beds, which are exposed in the "Johannesstollen", (main adit of a coal mine) contain a Danian, agglutinated foraminifera-fauna (R. Oberhauser, in B. Plöchinger, 1961).

At Höflein, the basal thrust of the Schneeberg nappe with the transgressive overlying Gosau deposits is crossed. The most easterly occurence of the Schneeberg nappe is exposed at Zweierwald. Below its Werfen beds and its serpentine-bearing Lower Anisian Rauhwacke and breccia, the Norian Hallstatt limestone of the Hohe Wand nappe is visible in the ENE-striking Höflein window.

Stop III/24: The Hippurite-reef of Grünbach (protected natural monument) occurs near to the Segen-Gottes-shaft at the overturned northern limb of the Grünbach syncline. The reef is 800 m long and about 5 m thick. Stratigraphically below the reef occurs a thick coarse basal conglomerate and a few meters of sandy marl with rudistids, corals and actaeonellids. Stratigraphically above, there are

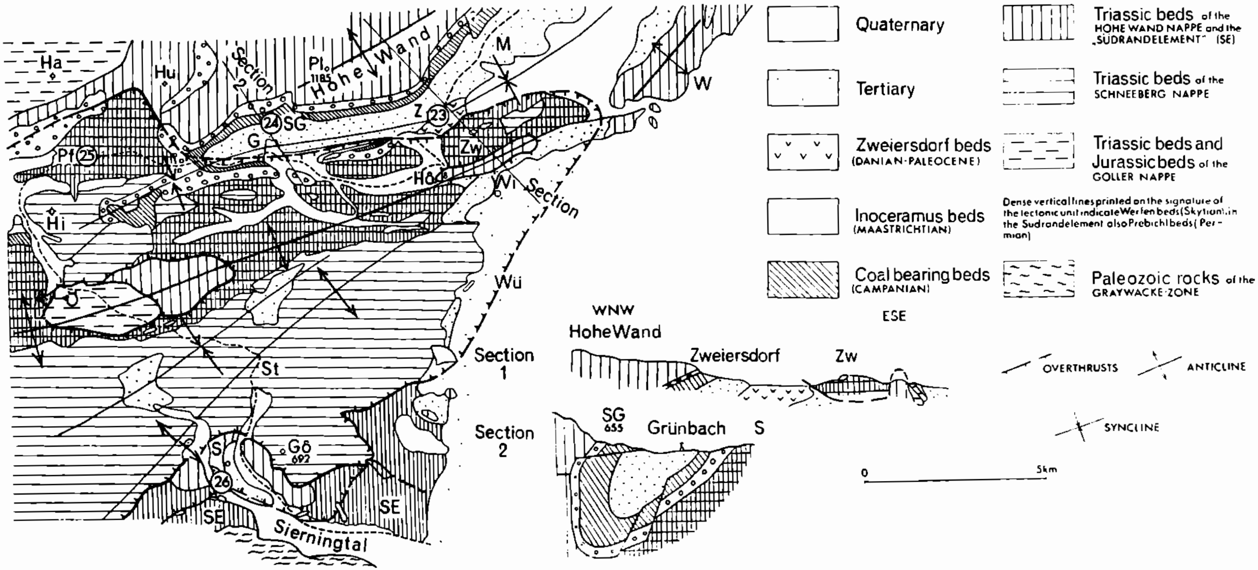

Fig. 9. The excursion area between Zweiersdorf and Grünbach (stops 23 to 26).

G = Grünbach, Gö = Gösing, Ha = Haltberg, Hi = Himberg, Hö = Höflein, Hu = Hutberg, M = Maiersdorf, Ö = Ödenhof, Pf = Pfennigbach, Pl = Plackles, S = Sieding, SG = Segen Gottes Schacht, St = Stixenstein, W = Winzendorf, W = Würflach, Z = Zweiersdorf, Zw = Zweierwald.

a few meters of *Actaeonella*-bearing conglomerate with abundant quartz and chert pebbles, which form the base of the coal-bearing Campanian marly clay-sandstone series. The Hippurite limestone which is supposed to be of Santonian age forms a prominent rocky outcrop. In this outcrop the overturned position can be demonstrated by the inverted Hippurites. The dominant species are *Hippurites* cf. *sulcatus* Defrance, *Hippurites gosaviensis* Douville and *Hippurites oppeli santoniensis* Kühn.

Until 1965, eight coalseams in a total thickness of appr. 4 meters have been worked in underground mines. The thickness of the complete coal bearing series is about 100 meters.

Stop III/25: Open-cast gypsum-mine Pfennigbach.

From the edge of the open pit there is a good view westward to the Schneeberg and Hengst. The flat top of the 2075 m high Schneeberg is an old, Miocene erosion surface, which today lies higher than that of the Hohe Wand. The Schneeberg gives its name to the highest nappe of the Northern Limestone Alps.

The ENE-striking ridge of Hengst is formed by a window, in which Hauptdolomit and Dachstein limestone of the Göller nappe appear. This window belongs to the same anticlinal zone as the Höflein window and the Ödenhof double window, which exposes both the Hohe Wand nappe and the Göller nappe.

Looking northward one sees the Haltberg, which is formed by the Göller nappe, whilst to the NE the Hutberg belongs to the Hohe Wand nappe. To the south the Himberg is part of the Schneeberg nappe. The Reichenhall Rauhwacke of the Hohe Wand nappe overlies the Upper Triassic of the Haltberg and is separated from the gypsum-bearing Werfen beds of the Pfennigbach basin by steeply dipping Gosau deposits. Because of the accompanying Middle Triassic rocks these Werfen beds can be attributed to the Schneeberg nappe.

The gypsum cap of a ENE-striking anhydrite dome is worked in a 950 m long mine. The annual production is 70,000 to 80,000 tons.

Underground the posttectonic formation of the gypsum cap can be clearly seen. Noteworthy are the NE-striking diabaseintercalation in the Werfen beds and the deep karst-weathering of the gypsum. The diabase can be attributed to the initial vulcanism in the evolution of the mesozoic geosyncline.

After Puchberg the route follows the Sierning-valley, first through the Ödenhof window and than, before reaching the Vienna Basin, along the boundary between the Northern Limestone Alps and the Grauwacke-zone. Within the window the dip of the Dachstein limestone of the Göller nappe underneath the higher nappes can be clearly seen SE of Puchberg.

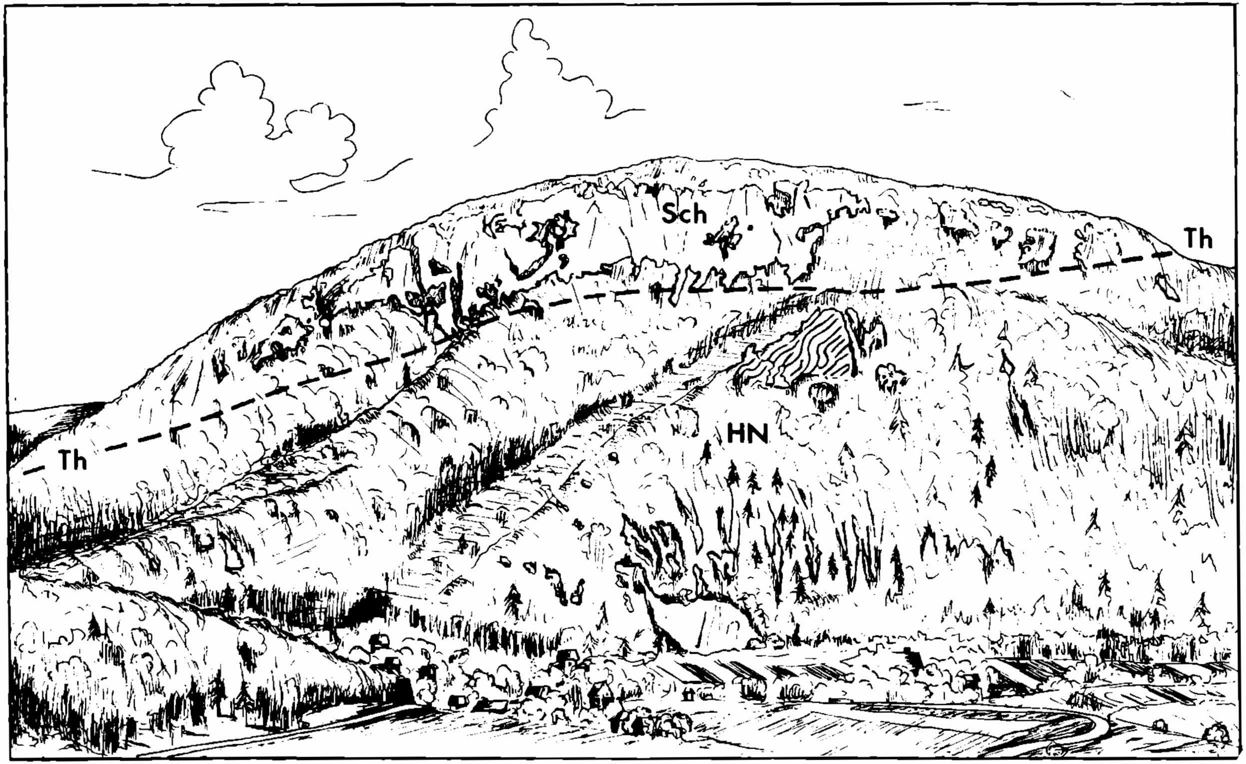

Fig. 10. The view from Sieding to the Gösing Mountain.

HN = Anisian-Carnian series of Hohe Wand nappe, Sch = Ladinian Wetterstein limestone of Schneeberg nappe, th = thrust fault.

At Stixenstein the bend-zone of an SW-NE striking anticline in the Middle Triassic of the Schneeberg nappe is crossed (look tectonic sketch figure 1).

Stop III/26: From point 455 at S i e d i n g there is a good view of the boundary between the palaeozoic Grauwacke-zone and the overlying mesozoic Northern Limestone Alps. In the southern face of the Gösing-mountain the dip of the Anisian-Carnian series of the Hohe Wand nappe underneath the Wetterstein limestone of the Schneeberg nappe can be seen (fig. 10). From here to the southern margin of Northern Limestone Alps the superposition of the Schneeberg nappe on top of the Hohe Hand nappe indicates the amount of overthrust.

Finally the transition from Werfen beds into basal beds of Gutenstein limestone will be demonstrated.

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Nr. 75 Puchberg/Schneeberg 1 : 50.000.
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IV

(Sixth day)

Mesozoic of the Central Alps in the Semmering Area

By A. Tollmann

With 2 plates, 3 figures and 1 table

Introduction

The area of the Semmering, 90 km south of Vienna, is well known for its beautiful scenery. It is within the surroundings of Vienna the nearest region where the stratigraphy of the Central Alpine Mesozoic rocks can be studied. According to the presence of nappes it played an important role in the development of the knowledge of the tectonics in the Eastern Alps.

Due to the dome-shaped uplift in the area of the Wechsel mountain, south of the Semmering, the lowest units of the Eastern Alps are here exposed. In the section from the Wechsel towards north at a distance of 10 km one can find nearly all Alpine nappe-systems from the lowest up to the highest Upper Austro-Alpine nappe — except the Alpine border units. In each case the lower tectonic system is dipping northward below the overlying one. Based on primarily north verging structures and other features it can be shown, that all units have been overthust over the Wechsel area more than dozens of kilometers from south to north. The highest tectonic nappe are derived farthest from the south.

Problems and historical review

In 1877 F. Toula found the first fossils in the Semmering limestones. In spite of their metamorphic development he showed them not to be of Paleozoic, but of Triassic age. This has given the first important impulse to a revision of the stratigraphy and to a new interpretation of the tectonics, because these Mesozoic series are dipping northward under the Paleozoic unit of the Graywacke Zone. After the concept of nappes-tectonics was introduced into the Eastern Alps by P. Termier (1903), H. Mohr (1910) and L. Kober (1912) had given a first tectonic analysis of the nappe-structures. To clarify the stratigraphy, H. P. Cornelius (1936) and E. Kristan & A. Tollmann (since 1957) have made several contributions. Finally, in 1959, A. Tollmann pointed out, that also the Tattermann thrust slice, interpreted by H. P. Cornelius (1952) as Lower Paleozoic of the Lower Graywacke Nappe, is consisting of Central Alpine Permo-Triassic rocks. The Tattermann thrust

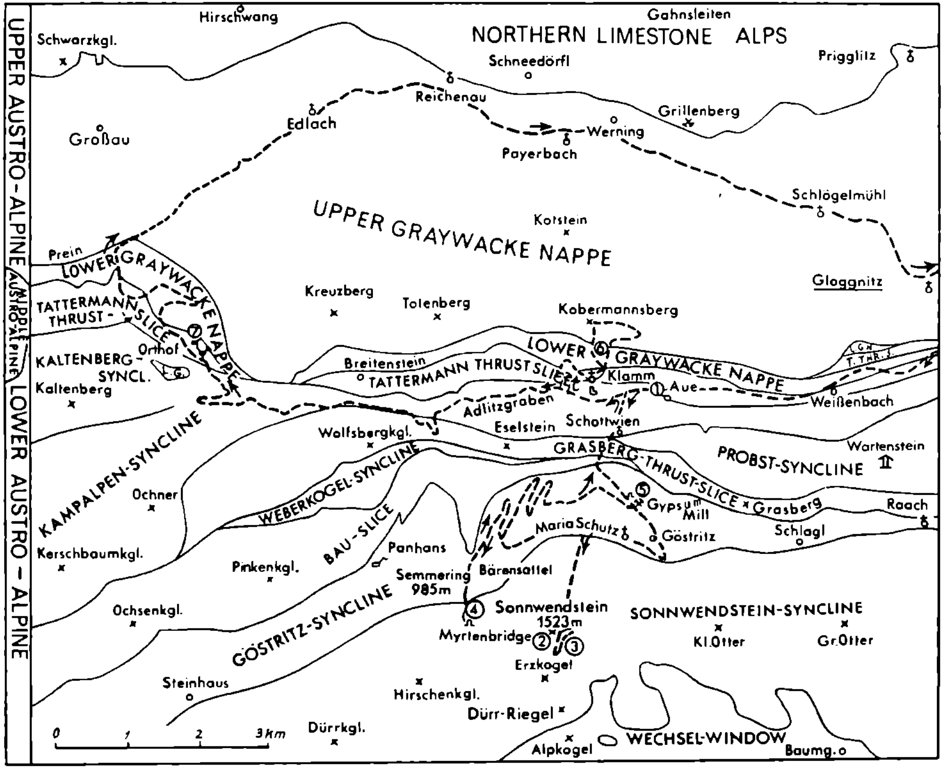


Fig. 1. Excursion route.

slice belongs to a separate nappe-system called "Middle Austro-Alpine", situated between the "Lower Austro-Alpine" Semmering system and the "Upper Austro-Alpine" Graywacke Zone plus Limestone Alps. The classification of this highest tectonic system in this area was outlined by L. Kober as early as 1909. It was essentially confirmed by the newest investigations of E. Kristan, B. Plöchinger and A. Tollmann.

Stratigraphy and tectonic units (fig. 1)

1. The Window of the Wechsel

In the Wechsel area south of the Semmering, the lowest tectonic element is exposed in a dome-shaped uplift. It is surrounded by the overlying Lower Austro-Alpine Semmering system and is dipping below it towards north. The Wechsel series consist of a monotonous sequence of albitegneisses, greenschists, phyllites, graphite-phyllites a. s. o., probably representing metamorphic Lower Paleozoic. Tectonically the series are tentatively assigned to the Penninic Zone.

The Semmering system overlies uncomformably the Wechseldome: The base of the Semmering system consists in the west of Mesozoic rocks in lower tectonic position, at the northwestern border of the Stuhleck of metamorphic rocks, in the north (Sonnwendstein-mountains) of Permo-Mesozoic rocks in higher tectonic position, beginning with the Alpine Verrucano sediments.

2. The Lower Austro-Alpine Semmering System

West and east of the Semmering area the Lower Austro-Alpine unit consists of big, north plunging, fold nappes with thick cores of metamorphic rocks (Grobgneis-series with a phyllite-mantle) and normal and overturned lying Mesozoic mantle-rocks. In the immediate surroundings of Semmering the metamorphic rocks are not so frequent. Permo-Triassic rocks prevail, representing a north dipping system of folds and thrust slices. There are no younger layers than Rhaetian. The facies of the Semmering Triassic is much more related to the northern foreland of the Alps compared with the Limestone Alps, which nowadays are situated farther in the north! For example, in the Permian of the Semmering Permo-Triassic, belonging to the Central Alpine facies, there occurs Alpine Verrucano instead of the Haselgebirge of the Limestone Alps. In the Skythian we have Semmering quartzite instead of Werfener Schichten, in the Upper Triassic Variegated Keuper (shales and sandstones) instead of the thick limestones and dolomites of the Limestone Alps. Also the biofacies of the Semmering Triassic indicates a strong influence of faunal elements of the foreland.

Stratigraphic subdivision of the Semmering-Mesozoic was improved in the last years (1957—1964) by comparison with the Lower Austro-

Table 1: Key for the sequence of the tectonic units in the meridian of the Semmering area

Top

UPPER AUSTRO-ALPINE NAPPE SYSTEM

Schneeberg nappe } Juvavikum
Mürzalpen nappe }
Göller nappe — Tirolikum
Upper Graywacke nappe (Norian nappe)
Lower Graywacke nappe (Veitsch nappe)

MIDDLE AUSTRO-ALPINE NAPPE SYSTEM

Tattermann thrust slice

LOWER AUSTRO-ALPINE NAPPE SYSTEM

Adlitz thrust slice
Probst syncline
Grasberg thrust slice
Weberkogel syncline
Bau thrust slice
Göstritz syncline
Stuhleck anticline
Sonnwendstein syncline

PENNINIC (?) NAPPE SYSTEM

Wechsel unit

Base

Alpine of the Radstädter Tauern. Fossils were found in Anisian limestone (crinoids), Anisian dolomite (gastropods), Ladinian dolomite (diploporas) and in the Rhaetian limestone (corals, crinoids, brachiopods, molluscs) still determinable in spite of rock-deformation.

The Semmering system situated above the Grobgneis and above locally thick Lower Paleozoic phyllites and remnants of a breccia of unknown age consists of:

1. more than 10 m — Alpine Verrucano (Permian): sericite-schists with layers of porphyroide.
2. more than 100 m — Semmering quartzite (Skythian) with layers of conglomerates.
3. 10 m — Röt-schists (Upper-Skythian): shales and a series with sandy Rauhwacke.
4. 100 m — Saalfeldner Rauhwacke (Lower Anisian).
5. 0—10 m — Gutensteiner basal layers (Lower Anisian): dark dolomite-shales with shale-intercalations, shales with layers of sandstones.

6. 20—200 m	— Anisian limestone (lower Middle-Anisian): white, pink, greyish-blue banded limestones and marbles, higher up dolomitic, partly rare chert nodules..
7. 300 m	— Anisian dolomite (higher Anisian): black to grey well bedded dolomite.
8. 100 m	— Wetterstein dolomite (Ladinian): light dolomite with diploporas.
9. more than 100 m	— Carnian Keuper: black shales, 100 m anhydrite and gypsum, subordinate black dolomite.
10. more than 100 m	— Variegated Keuper (Norian): violet and green shales, partly with sericite, light and dark quartzites and arkoses, brecciated layers of Rauhwacke, small lenses of yellow dolomite.
11. more than 20 m	— Rhaetian: shales and limestones, dark limestones with lumachelles, black thicklayered dolomite.

The structural geology of the "Lower Austro-Alpine" of the Semmering is rather complicated. West of the Semmering pass there are thick units of fold nappes with metamorphic rocks in the cores (Stuhleck-, Mürztal-, Drahtekogel-nappe), whereas east of it only the sedimentary units are accumulated. Here the lowest main unit is the Sonnwendstein area, consisting of a northward overturned syncline, closed in the south. The thick Keuper Zone, following in the north between the Semmering pass and Göstritz belongs already to the next higher nappe, in some parts clearly separated by a younger fault. On top of it there follow three more thrust slices with normal series, i. e. Bau-, Grasberg- and Adlitz-thrust slice (see tectonic map, A. Tollmann [1964], tab. 1).

3. The Middle Austro-Alpine Zone

A belt of sediments in normal sequence is situated upon the Lower Austro-Alpine Adlitz thrust slice and below the Upper Austro-Alpine Graywacke Zone. According to the interpretation of H. P. Cornelius (1952) this zone was the Paleozoic base of the Lower Graywacke Nappe. In 1959 A. Tollmann made a detailed stratigraphic analysis of the Mesozoic of the Semmering area; based on a comparison with the complete Semmering series, he concluded that this belt of sediments is also of Permo-Triassic age. 1967 E. Kristan-Tollmann et al. were able to describe Anisian crinoids from the Thörl-limestone belonging to the western branch of this zone.

Due to the position of this Mesozoic unit above the metamorphic rocks of the Central Alps, the latter overlying the Lower Austro-Alpine unit further west, this Mesozoic unit is considered to be a still higher tectonic system to be called Middle Austro-Alpine. In the area discussed the sequence of this unit, called "Tattermann thrust slice", is confined by tectonic reduction to Permian, Lower and Middle Triassic beds.

4. The Upper Austro-Alpine Zone

The long and narrow belt of the Lower Graywacke nappe consisting only of Upper Carboniferous sediments is overthrust over the Tattermann thrust slice. Thereupon follows the Upper Graywacke nappe built up by older Paleozoic beds. The Permian "Prebichl-conglomerate", the base of the Northern Limestone Alps, rests transgressively upon the Upper Graywacke nappe and is forming here together with a narrow belt of Lower Triassic beds the tectonically reduced lowest part of the Göller nappe (Tirolikum). The Mürzalpen nappe, lower part of High Alpine nappes (Juvavikum), is strongly reduced in the south of the Limestone Alps. The Schneeberg nappe, the uppermost tectonic unit, is marked by thick Middle Triassic limestones. The plateaulike mountains of Rax and Schneeberg, belonging to this nappe, consist mainly of Wetterstein limestone. The tectonic style of the Northern Limestone Alps is characterized by a number of tectonic windows within the Schneeberg nappe and by tectonic units of lower nappes on the southern border of the Limestone Alps.

The Limestone Alps differ strongly from the Mesozoic of the Middle and Lower Austro-Alpine (Central Alpine facies) by a lack of metamorphism and by its development in North Alpine facies.

The Excursion

(Stop IV/1 — stop IV/7)

Stop IV/1: The northern border of the Semmering system near Klamm (fig. 2): Looking from Aue towards W one can see the Semmering system (rugged rocks of Anisian limestone) dipping towards N under the Middle Austro-Alpine Tattermann thrust slice near Klamm and also under the Upper Austro-Alpine Graywacke nappe (fig. 2).

Stop IV/2: View from the top of Sonnwendstein (plate 2): The dome of the uniform Wechselschists, the lowest tectonic unit, can be seen in the south. Following the general strike the Semmering system continues towards west and east; the well rounded topography in the SW is caused by Lower Austro-Alpine metamorphic rocks, e. g. Stuhleck mountain. Towards north the strongly imbricated and folded Permo-Mesozoic beds of the Lower Austro-Alpine extend to the rock-walls along the Adlitzgraben (railway line). The meadows

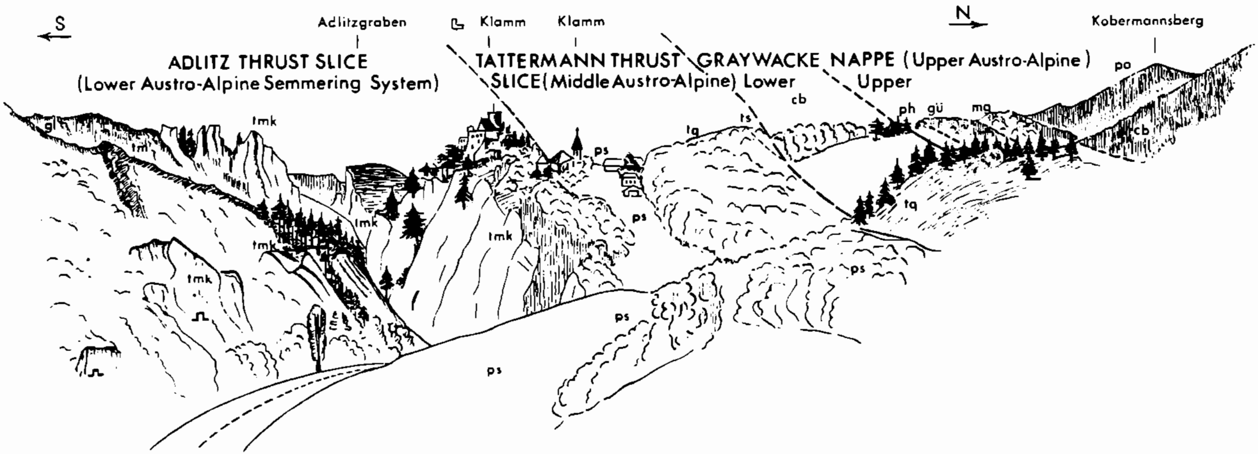
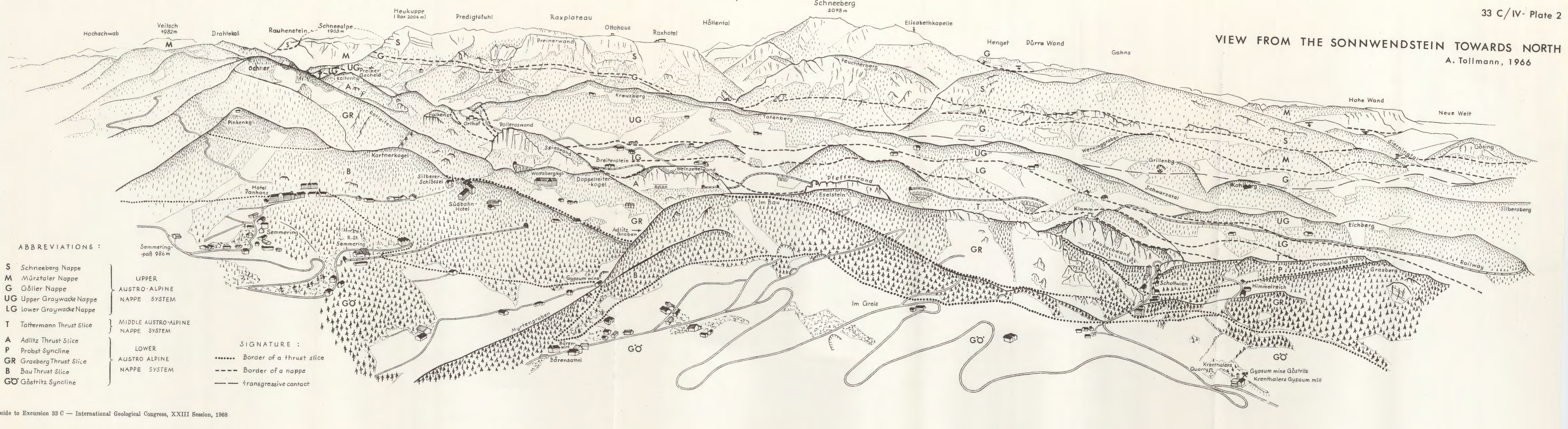


Fig. 2. View of the northern border of the Semmering system near Klamm, seen from Aue towards west (abbr. as in plate 1) (A. TOLLMANN, 1966).

A. TOLLMANN: Mesozoic of the Central Alps in the Semmering Area

VIEW FROM THE SONNWENDSTEIN TOWARDS NORTH

A. Tollmann, 1966



ABBREVIATIONS:

S	Schneeberg Nappe	UPPER AUSTRO-ALPINE NAPPE SYSTEM
M	Mürztaler Nappe	
G	Göller Nappe	
UG	Upper Graywacke Nappe	
LG	Lower Graywacke Nappe	
T	Tattermann Thrust Slice	MIDDLE AUSTRO-ALPINE NAPPE SYSTEM
A	Adlitz Thrust Slice	LOWER AUSTRO ALPINE NAPPE SYSTEM
P	Probst Syncline	
GR	Grasberg Thrust Slice	
B	Bau Thrust Slice	
GÖ	Göstritz Syncline	

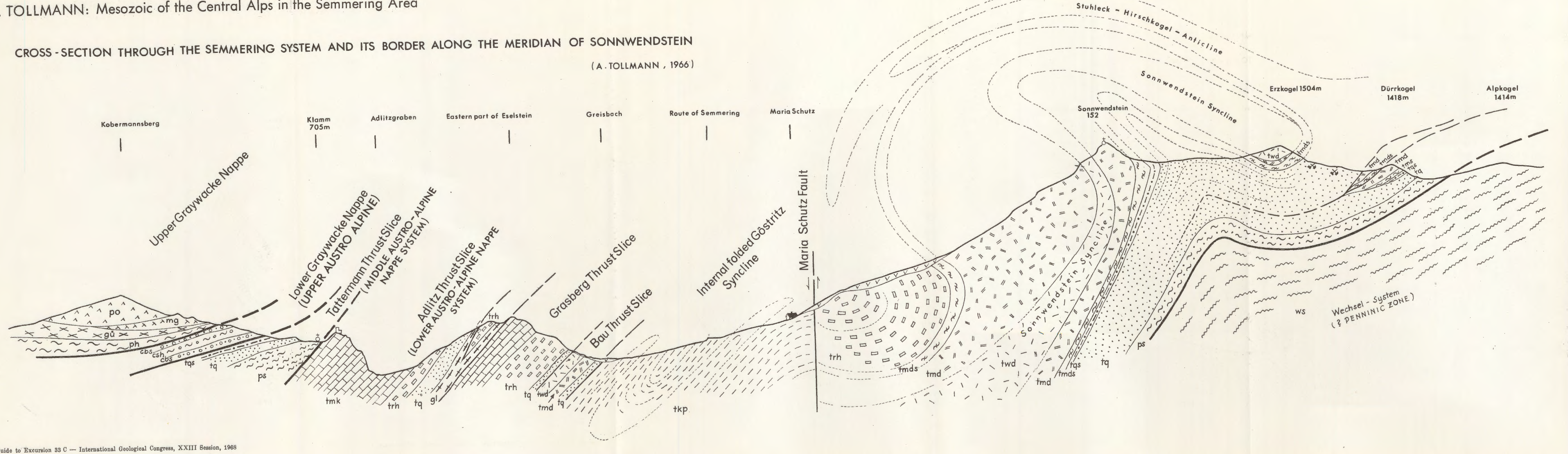
SIGNATURE:

- ······· Border of a thrust slice
- - - - - Border of a nappe
- —·— transgressive contact

A. TOLLMANN: Mesozoic of the Central Alps in the Semmering Area

CROSS-SECTION THROUGH THE SEMMERING SYSTEM AND ITS BORDER ALONG THE MERIDIAN OF SONNWENDSTEIN

(A. TOLLMANN, 1966)



UPPER AUSTRO-ALPINE

- csh Carboniferous schists } WESTFALIAN A - B
- cbs Carboniferous sandstone
- po Blasseneck porphyroid } ORDOVICIAN - LOWER SILURIAN
- mg Magnesite
- gû Green schists
- ph Silbersberg phyllite

LOWER- and MIDDLE AUSTRO-ALPINE

- tkp Keuper (CARNIAN-RHAETIAN)
- twd Diplopore dolomite (LADINIAN)
- tmd Anisian dolomite (UPPER ANISIAN)
- tmk Anisian limestone (LOWER and MIDDLE ANISIAN)
- tmds Anisian base-schists (LOWER ANISIAN)
- trh Saalfeldener Rauchwacke (LOWER ANISIAN)
- tqs Röt schists (UPPERMOST SKYTHIAN)
- tq Semmering quartzite (SKYTHIAN)
- ps Alpine Verrucano with porphyroid (PERMIAN)
- gl Phyllitic Mica-schists (OLDER PALEOZOIC)

PENNINIC ZONE ?

- ws Wechsel schists (OLDER PALEOZOIC)

schists of the Tattermann thrust slice (Middle Austro-Alpine). The higher up, south Kreuzberg—Kobermannsberg, consist of Verrucano ridge itself belongs already to the Upper Graywacke nappe, as the Lower Graywacke nappe is very narrow here. The plateaulike mountains Rax, Schneeberg and Gahns are the dominant features of the Schneeberg nappe; NW and NE of it the Mürzalpen nappe, situated tectonically below the Schneeberg nappe, is represented by Schneealpe and Hohe Wand.

Stop IV/3: Surroundings of the Sonnwendstein (plate 1): The Sonnwendstein consists mainly of Anisian and Ladinian dolomite; it is the core of a syncline, which in overturned position plunges towards north. The Lower Triassic beds can be see S and SE from the top of the Sonnwendstein: Skythian Semmering quartzite near the Sonnwendstein-hotel, Upper Skythian Röt-schists 200 m ESE from the top on a skiing route. Towards N the Röt-schists are followed by overturned Lower Anisian dolomite-schists; on the top of the Sonnwendstein occurs layered Anisian dolomite.

Stop IV/4: Quarry near Myrten bridge, Lower Anisian dolomite and Rauhwacke: Here the overturned limb of the Sonnwendstein syncline can be observed; older Rauhwacke lies upon black, layered Anisian dolomite. These beds dip steeply towards N and are folded along west-east striking axes.

Stop IV/5: Outcrops of Keuper beds of the Göstritz syncline near Bärensattel (along the road east of Bärensattel and near Krenthaler's gypsum mill near Göstritz): On the dump of the re-opened old gypsum-mine near Göstritz one can observe typical Keuper schists and quartzites as well as Carnian gypsum and dolomite. The morphological depression extending from Göstritz to Bärensattel and Semmering pass follows this soft, often folded belt of Keuper beds, tending to landslides. Outcrops of Rhaetian limestones (within the Keuper) exist in the old "Krenthaler's quarry" directly N of the gypsum mill. Here for the first time in 1877 F. Toula detected fossils in the Semmering limestone (locus classicus).

Stop IV/6: Section through the northern margin of Semmering system near Klamm (plate 1; fig. 2): The geological section through the southern ridge of Kobermannsberg shows the following units: 1. In the S the upper margin of the Mesozoic of Semmering (Anisian limestone rocks of the ruin "Klamm"). 2. The Permo-Skythian beds of the Tattermann thrust slice near Klamm (Alpine Verrucano in the defile N of the churchyard and Skythian

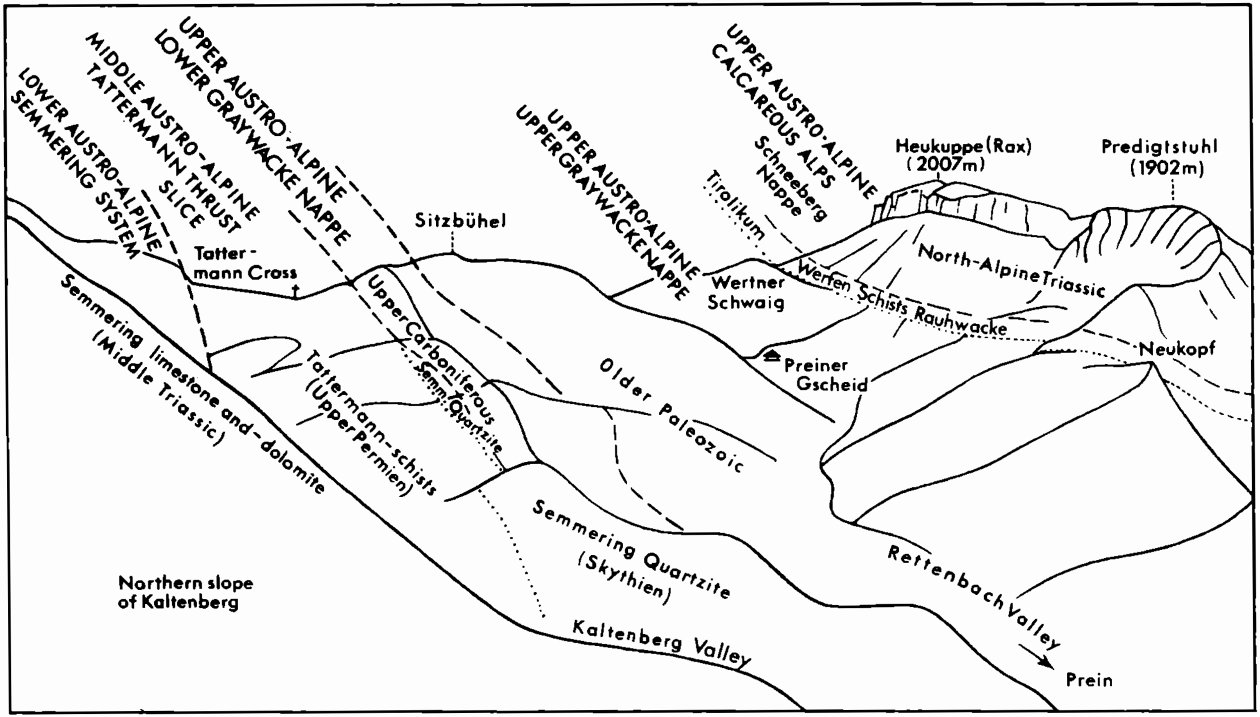


Fig. 3. View from Orthof towards west showing the structural pattern between Semmering system and the southern border of the Limestone Alps in the area of the Rax mountain (A. Tollmann, 1966).

beds in the road cut NNE of Klamm). 3. Lower and Upper Graywacke nappe on the Kobermannsberg.

Stop IV/7: Looking from Orthof towards W (fig. 3): This view shows clearly once again in a more westerly cross-section the sequence of superimposed nappes from the Lower Austro-Alpine nappe up to the highest Upper Austro-Alpine nappe, the Schneeberg nappe.

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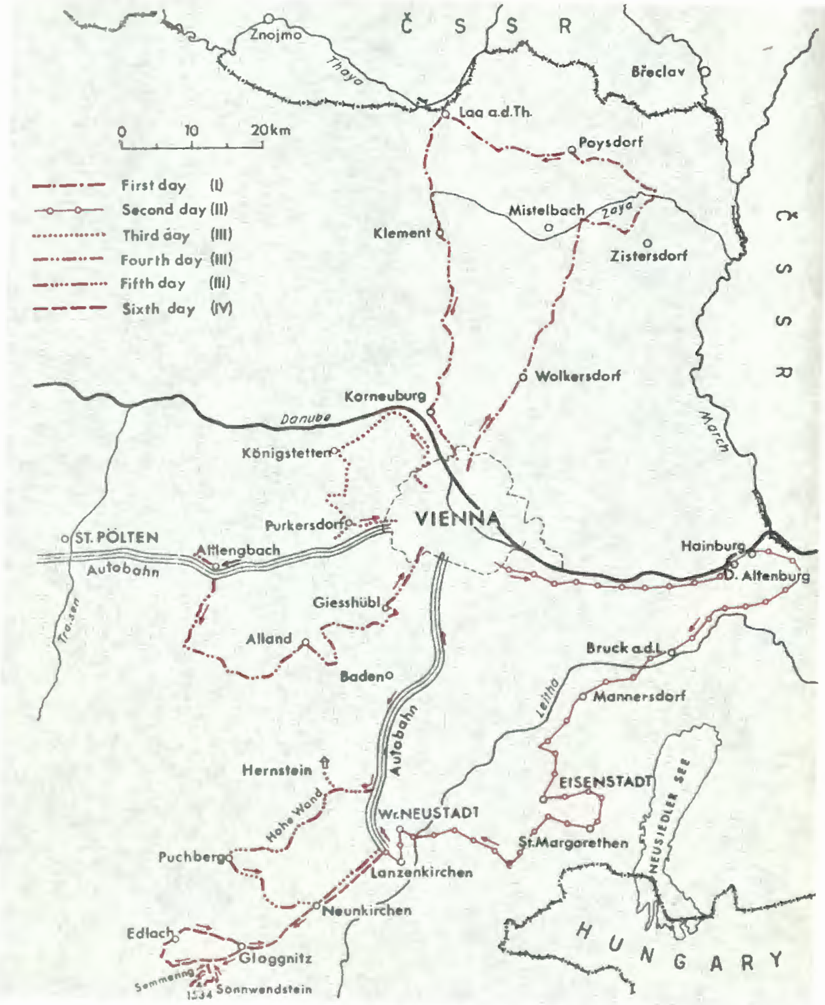
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