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Smolenice
(SLOVAKIA)

FIELD TRIP GUIDE

STRATIGRAPHY, SEDIMENTOLOGY AND PALEOGEOGRAPHY OF CRETACEOUS SEQUENCES IN WESTERN PART OF THE WESTERN CARPATHIANS

Edited by

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BRATISLAVA 1994

PROGRAM OF THE EXCURSION

Thursday, October 6th
Upper Cretaceous deposits of the Myjava Upland:

1. **Pustá Ves**, fresh-water oncolitic limestones (? Turonian - Coniacian), Brezovské Karpaty Mts
2. **Valchov Mill**, Valchov Conglomerate, Brezovské Karpaty Mts.
3. **Baranec Quarry**, Brezová, Upper Coniacian Baranec Sandstone
4. **Podbradlo**, road to the monument of gen. Štefánik, Campanian Podbradlo Formation
5. **Bradlo Hill** near Brezová, exposures near to the monument, Maastrichtian sequence the Brezová Group
6. **Hrombaba Hill**, uppermost Campanian/Maastrichtian Široké Bradlo Limestone
7. **Košariská**, road escarpment, uppermost Santonian/lowermost Campanian Košariská Formation
8. **Široké Bradlo Hill**, Široké Bradlo Limestone
9. **Priepasné**, U Kopeckých Hill, Illerdian conglomerates of the Kravárik Member

(overnight in Smolenice)

Friday, October 7th
Lower Cretaceous sequences of the Pieniny Klippen Belt and of Central Western Carpathians

10. **Strážovce**, near Čičmany, Lower Cretaceous pelagic sequence - Osnica and Mráznica Formations
11. **Zliechov valley**, special development of Berriasian Osnica Fm
12. **Butkov Quarry** - Lower Cretaceous pelagic sequence - Mráznica-, Kališčo-, Lúčkovská- and Podhorie Formations
13. **Polomec Quarry** - Strážovce Fm and Pseudothurmannia Beds

14. **Brodno (Railway station quarry)** and **Rochovica section** - Lower Cretaceous maiolica facies - Pieniny Limestone Formation

(overnight in Žilina)

Saturday, October 8th
Cretaceous deposits of the Flysch Carpathians

15. **Horní Líštná near Třinec**, Berriasian Těšín Limestone of the Silesian Unit

16. **Baška near Frýdek - Místek**, Upper Barremian part of the Těšín - Hradiště Formation of the Silesian Unit

17. **Ostravice near Frýdlant**, ?Hauterivian, Aptian - Albian complexes of the Silesian Unit and their contact with Maastrichtian deposits of the Subsilesian Unit.

18. **Štramberk near Kopřivnice**, Bioherm Lower Cretaceous Štramberk Limestone and Olivetská Hora fissure fillings

(overnight in Žilina)

Sunday, October 9th
Cretaceous sequences of the Paleoalpine Accretionary Belt

19. **Považský Chlmec - Vranie**, Upper Cretaceous sequence of the Pieniny Klippen Belt

20. **Orlové near Považská Bystrica**, neritic (?) Cenomanian - Turonian Orlové Sandstone in a deep marine flysch sequence

21. **Uhry near the Púchov Dam**, Middle Cretaceous conglomerate flysch, Klape Unit, Paleoalpine Accretion Belt

22. **Vršatec near Pruské**, classical Lower Cretaceous sequence of the Czorsztyn type, contact with Upper Cretaceous Púchov marls

23. **Krasín near Horná Súča**, Lower Cretaceous fissure fillings in Jurassic crinoidal limestones

(return to Bratislava)

UPPER CRETACEOUS SEQUENCES OF THE VESTERNMOST PART OF THE CENTRAL VESTERN CARPATHIANS

1. Pezinské Karpaty Mts (S part of Malé Karpaty Mts)

The Malé Karpaty Mountain structure consists of several superposed nappe units comprising Prealpine basement, its Mesozoic cover, superficial nappes and posttectonic cover complexes. Crustal dissection produced by long termed extensional tectonic regime controlled Alpine Tatric dismembering into individual basement sheets. The Paleoalpine superficial nappes with their Upper Cretaceous and Paleogene cover were disturbed by Neoalpine back thrust tectonics. Both the Paleogene and Lower Miocene complexes were incorporated into the Malé Karpaty horst structure during Middle Miocene, when the Vienna- and Danube Basins opened.

The nappe structure of the northernmost part of the mountains is covered by a sequence comparable with the Gosau Group of the Northern Calcareous Alps. Similar position in the structure of southernmore areas is occupated by variegated breccia bodies. They are characterized by mostly angular clasts derived from local material, filled by red argillaceous matrix. The breccias occuring in the Tatric and Fatric units and composed of several types of Mesozoic carbonate and clastic rocks (subordinately also of crystalline schists) with low content of matrix have been named as the Bartalová Breccia.

The second type of breccia occurs in the terranes built up of Triassic carbonates belonging to Ötscher (? Göller) Nappe. This type named as the Kržľa Breccia consists of angular and semirounded clasts of Triassic limestones and dolomites cemented by red argillaceous or fine sandy matrix. In several places the alternation of this breccia with dolomitic breccias has been obser-

ved. The Kržľa Breccia is covered by transgressive Late Paleocene sequence. **Činčura** (1990,1992) interpreted these sediments as the fossil products of Prae- Tertiary subaeric karstification preserved in cave cavities. **Gašparíková** et al., (1992) founded rests of Early Paleocene nannoplankton and forams in the Kržľa Formation underlying the Paleogene infilling of the Buková Depression in a borehole near the Sološnica village.

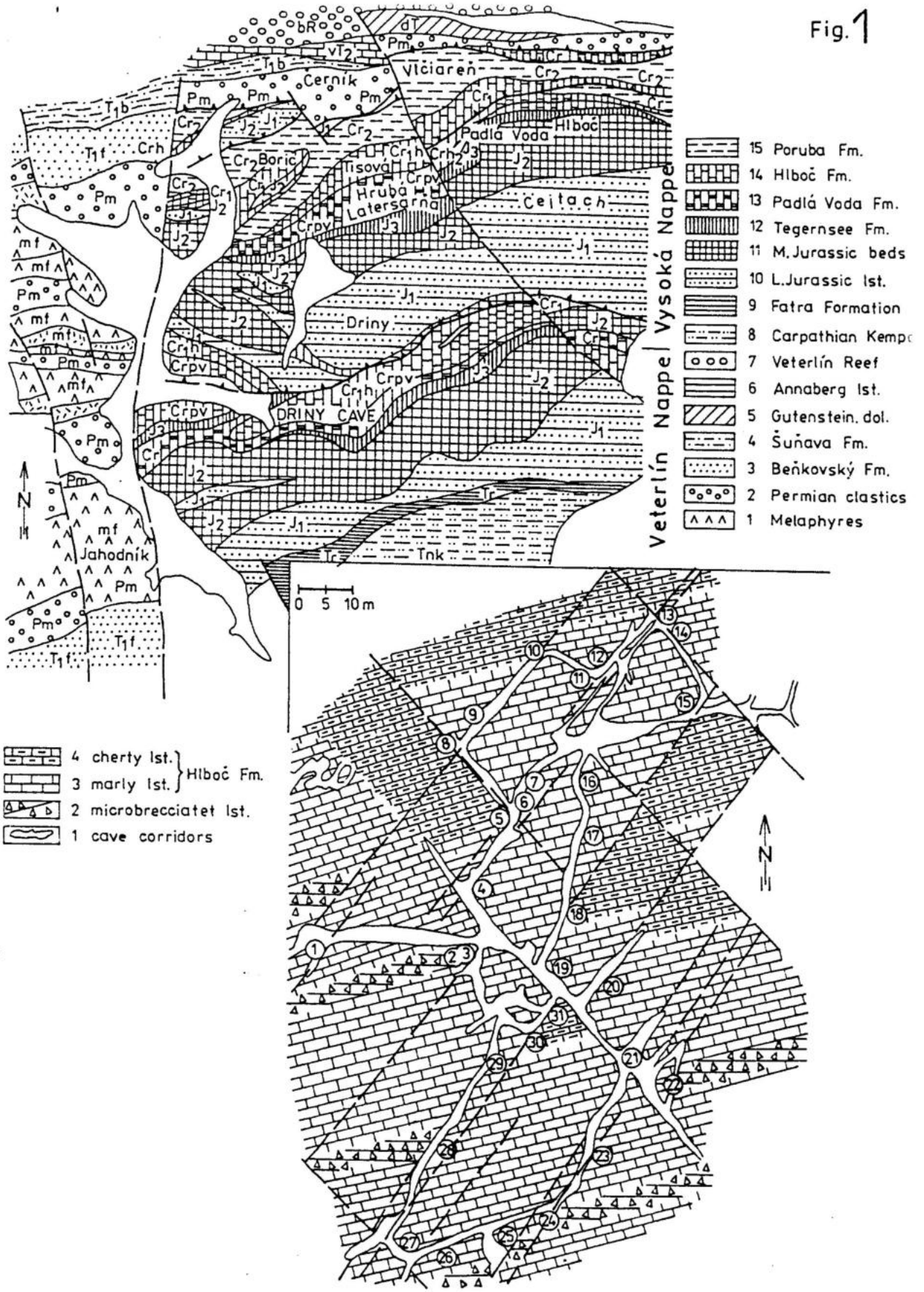
Paleogene complex rimming the northwestern part of the Pezinské Karpaty Mts is similar to the infilling of the Central Carpathian Paleogene basins. However, its base is older and the faunal associations are closer to the southernmore zones. The sequence starts with the Borové Formation consisting of conglomerates, breccias, carbonate sandstones, followed by organodetrital and organogenic (sometimes biohermal) limestones. It forms also neptunian dykes penetrating several meters deep into basement. Following Eocene Huty Formation consists of claystones with infrequent, but more-less regular intercalations of sandstones, the highermost Hrabník Formation (Oligocene in age) is built of alternating clays and aleurolite layers.

PRE - EXCURSION LOCALITIES

HLBOČ VALLEY

Jurassic and Lower Cretaceous strata in the Malé Karpaty Mts are usually affected by tectonization, being dissected into tectonic slices. However, the tectonic block of the Driny Hill yields a possibility to study these beds in mostly original mutual relations and sequence. The rock wall in the upper part of the Hlboč Valley near Smolenice exposes almost complete Upper Jurassic - Lower Cretaceous sequence.

Fig. 1


Veterlín Nappe | Vysoká Nappe
15 Poruba Fm.
14 Hlboč Fm.
13 Padlá Voda Fm.
12 Tegernsee Fm.
11 M. Jurassic beds
10 L. Jurassic lst.
9 Fatra Formation
8 Carpathian Kempe
7 Veterlín Reef
6 Annaberg lst.
5 Gutenstein. dol.
4 Šuňava Fm.
3 Beňkovský Fm.
2 Permian clastics
1 Melaphyres
Vlčiareň
Cerník
Padlá Voda
Hlboč
Boric
Tisová
Hrubá
Latersárna
Ceitach
Driny
DRINY CAVE
Jahodník
Tnk
0 5 10 m
4 cherty lst.
3 marly lst.
Hlboč Fm.
2 microbrecciatet lst.
1 cave corridors
N

Middle Jurassic (Upper Bathonian - Callovian) black shales with silicites correlable with the Ruhpolding Formation are followed by red nodular limestones of the Tegernsee Formation. The lower part of this formation represented by Oxfordian (Fibrata Zone) micrite and microsparite with Globochaete Microfacies is separated by 2-2,5 m thick siliceous limestone complex from the upper part of the "Ammonitico Rosso" beds, consisting of Kimmeridgian and Tithonian packstones and wackestones. Intraclasts occur frequently, several beds pass into limestone microbreccia. Rich association of microfossils allows to distinguish Kimmeridgian Moluccana Zone, Early Tithonian Malmica-, Tithonica- and Pulla Zones, both subzones of the Middle Tithonian Chitinoidella Zone and Late Tithonian Praetintinnopsella- and Crassicollaria Zones.

The Padlá Voda Formation consisting of almost massive pale wackestones to packstones with large cherts (Globochaete - Calpionella and Calpionella Microfacies) represents the Berriasian Calpionella Zone (with Alpina-, Remaniella- and Elliptica Subzones) (**Michalík** et al., 1990). Several layers consist of limestone microbreccia composed of clasts of Tithonian and Lower Berriasian limestones. The macrofauna occurs rarely, being represented by poorly preserved aptychi, fragments of belemnites or ammonite nuclei remnants.

The Hlboč Formation is represented by Valanginian - Lower Barremian well - bedded marly biomicrites (wackestones - packstones) with abundant cherts and marly intercalations. They contain microfossils of the Calpionellopsis- and Calpionellites Zones in the lower part (**Borza & Michalík**, 1987), the microfauna of the higher part of the sequence is mostly poorly preserved.

DRINY CAVE

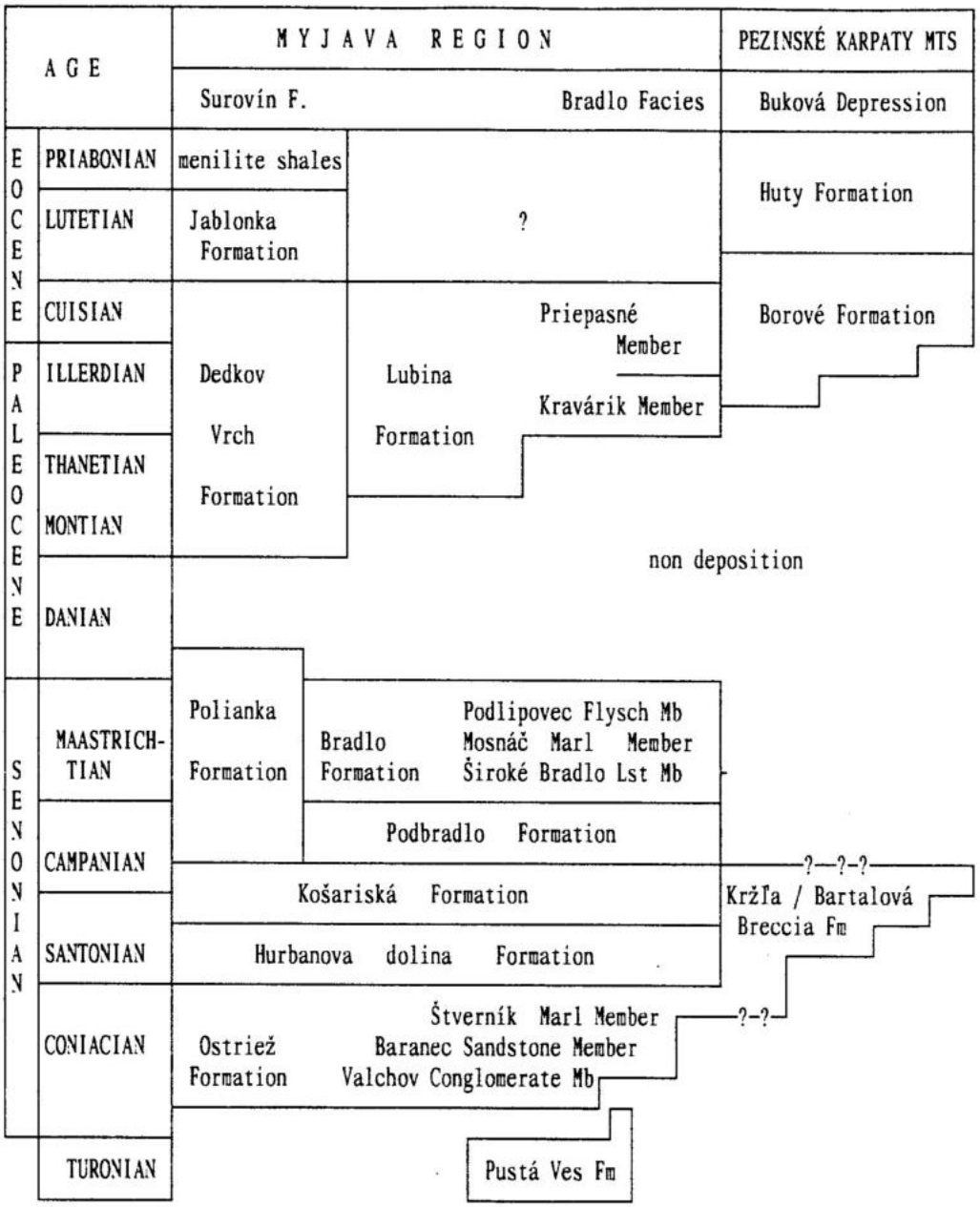
The Driny Cave originated along crossing clefts in Lower Cretaceous limestone complex of the Vysoká Nappe. Bedding plane surfaces dipping to NE played only subordinate role being closed by marly intercalations. The most frequent system of steep NW - SE right lateral strike slips comprises mostly extensional open dislocations. This system affected also the course of the main corridor dividing the cave system into two parts. The older corridors follow mormal faults of NNE - SSW direction. This open system is parallel with the Jahodník Fault, separating the Driny Block from the westernmore part of the Malé Karpaty Mountains. The entrance corridor is parallel with back thrusts separating partial slices in the Vysoká Nappe.

The substantial part of the Driny Cave formed in thick bedded wackestones of the Hlboč Formation with *Tintinnopsella carpathica, Cadosina fusca fusca* and *Colomisphaera vogleri* indicating early Hauterivian age. Several breccia intercalations contain intraclasts of Kimmeridgian (*Saccocoma* sp.), Lower Tithonian (*Parastomiosphaera malmica*), Upper Tithonian (*Crassicollaria parvula*), and Berriasian (*Calpionella alpina*) packstones.

2. Brezovské Karpaty Mts and the Myjava Upland

The Myjava upland along with the adjacent hilly mountains are considered to be a continuation of the oil-productive basement of Vienna Basin. This is why the area place an important role in the correlative studies of traditional oil-productive regions with new prognostic areas. The most important oil reservoirs in the Vienna Basin are located in Triassic carbonate com-

plexes. This fact makes from the Brezová- and the Čachtice Carpathian Mts an area attractive for oil prospection.



Lithostratigraphical division of the Upper Cretaceous / Lower Paleogene sequences in the westernmost part of the Central Carpathians

The Triassic complexes of the Brezová Carpathians have been traditionally ascribed to the Jablonica Nappe. This presumption, although not supported by geometrical analysis of the mountain structure, has been based on facies correlation. It allowes to select some affinities of this sequence with the Strážov-, Havranica- and Veterlín Nappes of the Central Western Carpathians, or with the Göller Nappe of the Northern Alps. The detailed mapping, carried several years ago has shown that several tectonic slices could be recognized in these mountains. Dobrá Voda 1 borehole (1190 m deep) penetrated a basinal Middle Triassic sequence with thick Reingraben Formation in the basement of thick Jablonica Nappe platform carbonate complexes of equivalent age.

The Brezová Carpathian Mts form an extensive horst like morphostructure emerging through the Miocene and Upper Cretaceous sedimentary cover. The higher Jablonica Nappe has a simple monoclinal structure, distorted by faults. Underlying nappe slice units crop out in two deformed elevated zones along the border of the Dobrá Voda- and Hradište Depresions. Strong tectonization and general vergence proved for back-thrusting movements of the main shallow marine Triassic carbonate blocks of the Jablonica Nappe.

Triassic complexes of the Brezová Carpathians are affected by three systems of transversal faults. The oldest system (N - S, or NNW - SSE respectively) is concentrated near Hradište pod Vrátnom or near Dobrá Voda villages, where it created a series of narrow slice bodies. The next system (E - W) divides the blocks with different elevation amplitude. Similar movements created also the Dobrá Voda Depression itself. The post- Oligocene or post-Savian age could be presumed for origin of all the disjunctive structures described. The youngest "Sudetian" system (NW-SE; probably Late Miocene in age) cuts all the structures observed.

The Upper Cretaceous - Paleogene complexes in the Myjavská Pahorkatina Upland represent an analogue of the Gosau Group of the Northern Calcareous Alps, filling the dish-shaped brachysynclinal intermountain depressions. They overlap frontal parts of the Central Carpathian nappes along inner margin of the Pieniny Klippen Belt. These complexes closely related to the Gosau facies are tectonically incorporated in the nappe structure of the Vienna Basin basement. They have been affected by the Mesoalpine orogenetic deformations, equally as the part of the Paleoalpine Accretionary Belt at the outer margin of the Central Carpathians.

Upper Cretaceous - Paleogene complexes in the western part of the Central Western Carpathians have been studied more in detail by **Salaj** (1969); **Maheľ** (1973); **Samuel, Salaj & Began** (1980); **Kysela, Marschalko & Samuel** (1982), **Salaj & Began** (1983); **Marschalko** (1986); **Salaj & Priechodská** (1987); **Plašienka, Michalík, Kováč, Gross & Putiš** (1991).

The oldest sediments of the Late Cretaceous sedimentary megacycle are represented by fresh-water oncolitic limestones (Pustá Ves Formation). They occur in two areas of the Central Carpathians: NE termination of the Malé Karpaty Mts (Brezovské and Čachtické Karpaty Mts) and in the Spiš-Gemer Ore Mts (mainly the Stratená Mts). They accompain two areas with rests of Senonian marine sequence. The distribution of these rocks is not congruent with the configuration of the successive Gosau basins.

I. Three outcrops are known in the Brezovské- and Čachtické Karpaty Mts area. The first one, Hrdlákova Skala, W from Čachtice has been erroneously attributed to the Triassic by **Hanáček** (1954). Brown oncolitic limestones overlie the Anisian Gutenstein Limestone here. The second outcrop is known near the Černík

gamekeeper's cottage N from Chtelnica, the third one is situated on the Mladé Háje Hill SE from Pustá Ves, N from Kočín (both were described by **Mello** in **Salaj** et al., 1987). Pebbles of these limestones were found in the Coniacian Valchov Conglomerate on the stratotype locality (**Borza** 1962) and in Karpatian Jablonica Conglomerate at the Prievaly, Lipovec and Mníšek localities as well (**Mišík** 1986). The limestones contain characeans, but no representatives of *Munieria*.

II. Three occurences have been found in the Spiš-Gemer Ore Mts area, Stratená Mts. Brown partly oncolitic limestones overlie the substratum with disconformity S from Betlanovce (**Maheľ** 1967), or S from Spišský Štiavnik (**Peržel** 1964 ex **Mello** 1967). Brown algal limestones cover Anisian Gutenstein Limestone in front of the Dobšiná Ice Cave entrance (**Bystrický** 1978). They contain *Munieria grambasti sarda* erroneously considered by **Bystrický** (l.c) as Early Cretaceous species. *Munieria*-containing pebbles occurs also in Upper Santonian/Lower Campanian conglomerates and in the Eggerian conglomerates near Chvalová (40 km to the S; **Mišík** & **Sýkora** 1980).

The Pustá Ves Formation is represented by brown biomicritic limestones with ostracods, gastropods, algae (*Munieria* and other characeans, as well as with several new fresh-water taxa). Cracks and desiccation pores occur frequently. Almost complete lack of terrigenous admixture indicates the sedimentation in shallow lakes on a pediplained surface. Such a conditions have arisen after Middle Cretaceous Austrian nappe transport and extensive erosion.

Fresh water origin of the Pustá Ves Limestone was indicated also by isotopic analyses of **Kantor** & **Mišík** (1992) from the Hrdlákova Skala locality ($\delta^{13}C$ = -9,49 %., $\delta^{18}C$ = -7,87 %.). Another indicator of fresh water environment, the alga *Munieria*

grambasti sarda was described from Sardinia (Mid Cretaceous: **Cherchi** et al., 1981), from Eastern Alps (Late Santonian / Early Campanian: **Schlaginweit & Wagreich** 1992), from Hungarian Transdanubian Midmountains (Late Santonian/Early Campanian: **Gellai & Toth** 1982), from Slovakian Stratená Mts (? Coniacian / Santonian: **Bystrický** 1978) and from Roumanian Borod Basin (Coniacian / Early Santonian: **Dragastan** 1978).

The Gosau-like Brezová Group sequence in the Myjava region starts with conglomerates with red matrix. Their sedimentological features point out to facies of braided rivers and subaerial deltas. This basal Valchov Conglomerate Member of the Ostrież Formation lies trangressively on an eroded surface of the Triassic carbonates of the Jablonica Nappe.

The conglomerates contain local material derived almost exclusively from carbonate rocks. In the Brezovské Karpaty Mts (Brezová province) they contain mostly the Triassic and Liassic rocks. Besides these basemental rocks, pebbles of freshwater *Schizophyta* limestones derived from the former border margin of sedimentary basin occur sporadically. The localities situated in the proximity of the Pieniny Klippen Belt (Čachtické Karpaty Mts, Bzince province) contain also some pebbles of "exotic" rocks redeposited from the "Upohlav" conglomerates: rhyolites (max. 8 %, max. diameter 25 cm), rarely basic volcanics, pebbles of grey siliceous conglomerates with clasts of vein quartz and quartzites (max. diameter 30 cm), Urgonian limestone with rare chromspinels and pebbles of Mid-Cretaceous clastic rocks with partially euhedral quartz with zonally arranged inclusions. The pebbles of Barmstein Limestone with Upper Jurassic shallow water microorganisms (*Protopeneroplis striata, Anchispirocyclina lusitanica, Clypeina jurassica*) represent an interesting local component cropping out only in the Čachtické Karpaty Mts in the Slovakian territory. The

matrix is characterized by small rock fragments (dolomitic lithoclasts being dedolomitized); echinoderm skeletal fragments and chalcedony spicules of the *Silicispongae* occur rarely.

The boundaries of the Valchov Conglomerate are heterochronous. The localities near Brezová are Early Coniacian in age (higher members contain Coniacian foraminifers), while an intercalation with Campanian microfauna has been described E of Bzince by **Borza** (1962).

The Valchov Conglomerate can be laterally substituted by a thin layer of dolomitic breccia. In other parts of the ancient dolomitic seashore lacking streams or deltas, the Baranec Sandstone lies directly on the substratum. The southernmost erosional relict of the Senonian sequence near Rozbehy contains Upper Campanian carbonate conglomerates and breccias with *Orbitoides tissoti* (**Köhler & Borza**, 1984).

The Valchov Conglomerate is an equivalent of the Kreuzgraben Formation, but probably also of the lower part of the Streiteck Formation of the Gosau Group.

The conglomerates are overlain by the Baranec Sandstone Member. The sequence, 50 - 150 m thick, consists of thick bedded (250-400 cm) coarse indistinctly graded sandstones to microconglomerates. They represent sedimentary rhythms terminated by 20 - 30 cm bed of fine grained sandstone with parallel or wavy bedding. The higher part of the sequence contains more frequent organic debris. It pass laterally into sandy limestones with *Actaeonella gigantea*. Heavy mineral spectrum (**Salaj & Priechodská** 1987) is dominated by tourmaline, magnetite and ilmenite. Zircon, rutile, chlorite, chloritoid, amphibole and limonite occur subordinately, zoisite and garnets are rare. **Oberhauser** (1968) stated

the presence of chromite.

Top part of the Ostrież Formation is formed by the Štverník Marl Member (150 m) with Late Coniacian foraminiferal fauna: *Marginotruncana angusticarinata* and *Segalia deflaensis* (**Maheľ** et al., 1987). Planktonic forms prevail (90 %) over benthic organisms (ostracods, etc).

The Hurbanova Dolina Formation is represented by 500 - 600 m thick sequence of alternating graded calcareous sandstones, sandy marls and sandy limestones. It contains foraminiferal microfauna of the *Sigalia carpathica-*, *Ventilabrella decoratissima-* and *Globotruncanita elevata - Ventilabrella alpina* Zones, rich nannoplankton assemblage of the *Tetralithus obscurus* Zone (**Began** et al., in **Gašparíková & Salaj** 1983), gastropod horizons and coal seams (**Salaj & Priechodská** 1987). Mentioned authors correlated this formation with the Grabenbach Fm of the Northern Alps. Despite of brackish/limnic character of sedimentation of its upper part they supposed sedimentary depth up to 3000 m. The association of heavy minerals is characterized by tourmaline, rutile, zircon, ilmenite, magnetite and chromite. Hyperstene, staurolite, zoisite, chlorite, chloritoid, pyrite and limonite occur subordinately, amphibole, epidote and garnets are rare.

Lower Campanian Košariská Formation is characterized by variegated (mostly red) marls with foraminiferal microfauna ("globotruncana biomicrite") dominated by planktonic forms of the *Globotruncana arca* Zone. The rich nannoplankton assemblage corespond to the Lower Campanian *Broinsonia parca* Zone (**Began** et al., in **Gašparíková & Salaj** 1983). The formation up to 50 m thick resembles the Púchov Formation (Malinowa Formation of **Birkenmajer** 1977), or the Alpine Nierental Formation. The association of heavy minerals consists of garnets and chromite.

The Upper Campanian and Maastrichtian flysch sequences have high content of carbonate. They comprise calcarenite sandstones, sandy *Orbitolina* limestones, microconglomerates with "exotic pebbles" and *Inoceramus* marlstones.

The Podbradlo Formation (500 m) consists of calcarenite sandstones and *Inoceramus* marlstones with Middle Campanian (*Globotruncana arca*) and Lower Maastrichtian (*Globotruncana falsostuarti*) foraminifers, rich nannoplankton and with microconglomerate layers. The latter contain pebbles of mica schists, phyllites and diabases. The association of heavy minerals is dominated by zircon, rutile, limonite over hyperstene, epidote, tourmaline, chlorite, chromite, ilmenite and magnetite. Zoisite, garnets, staurolite and biotite occur rarely.

The Bradlo Formation (200 m) starts with clastic limestones (Široké Bradlo Member) passing into the Mosnáč Marls Member and being terminated by the Podlipovec Flysch Member. Široké bradlo Member contains rare tourmaline, garnets and disthene. The Podlipovec Flysch is rich in tourmaline, zircon, magnetite, limonite. Epidote, zoisite, garnets, rutile, chlorite, apatite and ilmenite are rare.

The younger formations crop out in three separate facies belts:

1. The external zone of the basin (**Surovín Facies Belt**) is characterized by special marly development with fine grained sandy intercalations on the base and with rich foraminiferal microfauna called as the Polianka Formation. It is 300 - 450 meters thick. HM association is characterized by the dominance of zircon, rutile, tourmaline, chlorite, magnetite, limonite over other mine-

rals. Chromite is rare. Early Tertiary development in the mentioned zone is characterized by the Mid Paleocene Dedkov Vrch Formation (500 m) consisting of organogene sandstones and coralgal limestones alternating with marls. The Jablonka Formation starts with red clays with agglutinated microfauna and continues by fine rhythmic flysch. It is 300 - 400 m thick, passing to shales of "menilite" type. Garnets, zircon and ilmenite prevail in the HM association over hyperstene, zoisite, rutile, apatite, biotite, chlorite and chromite.

2. The Paleogene sedimentation in the **central part of the Myjava Basin** is characterized by variegated clastic sequence of the Lubina Formation (800 - 1000 m).

3. In the proper **Bradlo Facies Belt**, this formation used to be divided into the Kravárik Conglomerate Member (200 - 300 m) and the Priepasné Flysch Member (200 - 300 m). The Kravárik Conglomerate contain similar heavy mineral association as the Zwieselalm Fm of the Eastern Alps.

Fig. 2

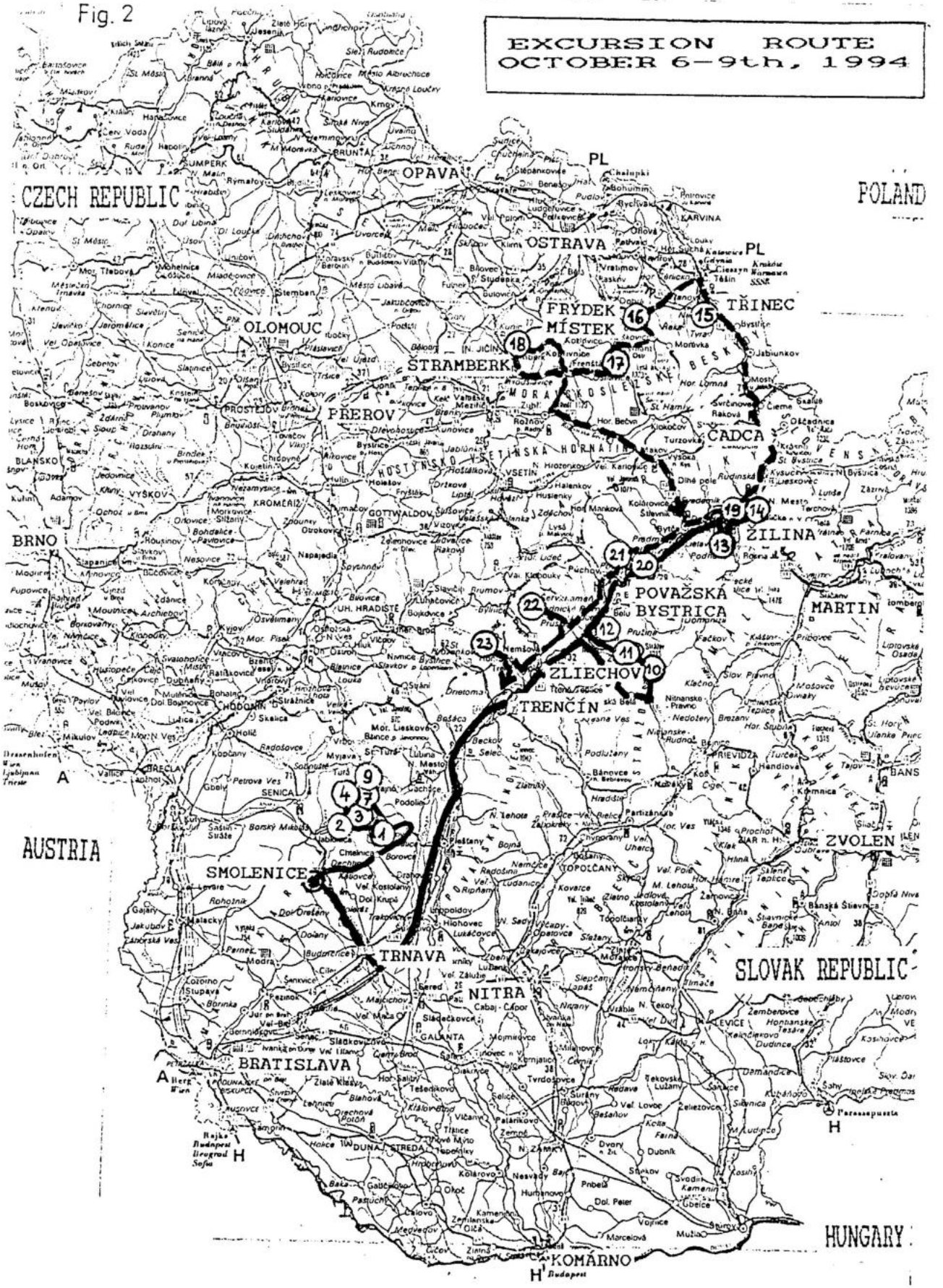

EXCURSION ROUTE
OCTOBER 6–9th, 1994
CZECH REPUBLIC
POLAND
AUSTRIA
HUNGARY
SLOVAK REPUBLIC
OPAVA
OSTRAVA
FRÝDEK MÍSTEK
TŘINEC
OLOMOUC
ŠTRAMBERK
PŘEROV
CADCA
ŽILINA
BRNO
GOTTWALDOV
POVAŽSKÁ BYSTRICA
MARTIN
ZLIECHOV
TRENČÍN
ZVOLEN
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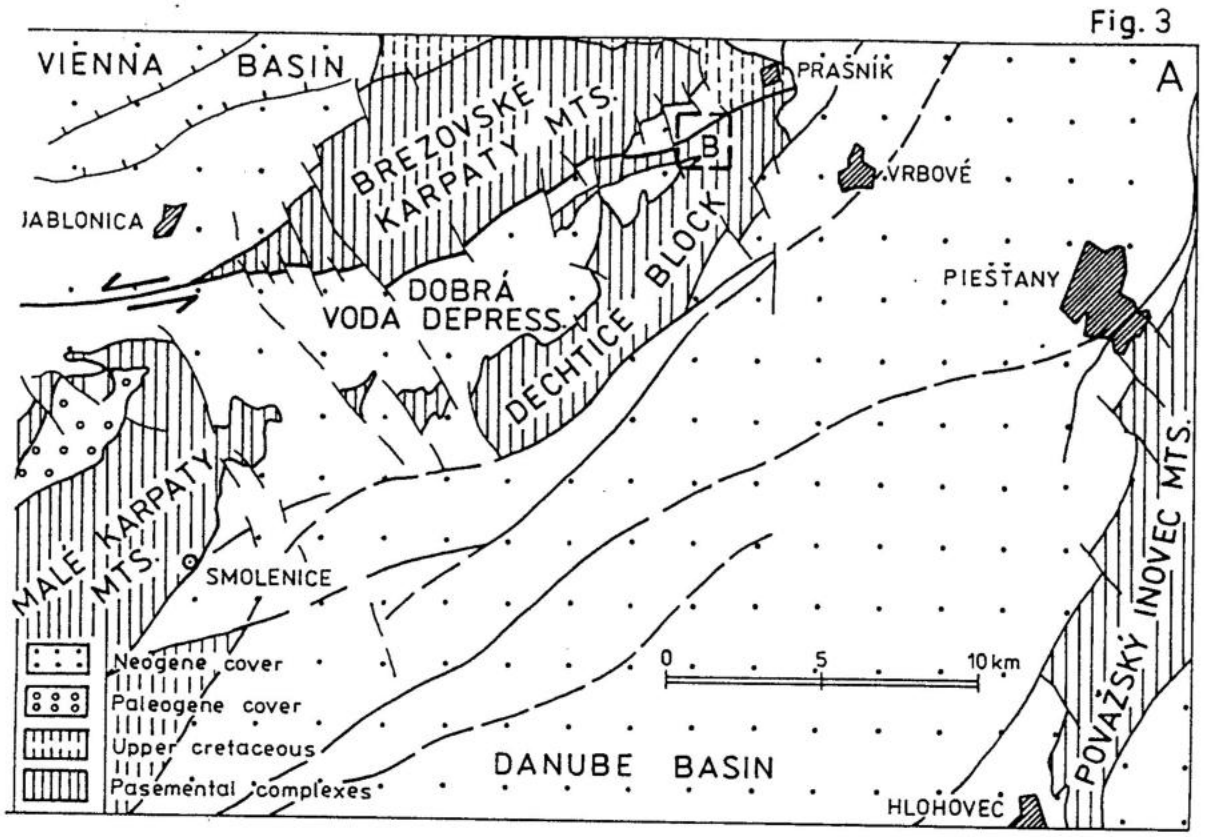
Fig. 3


VIENNA BASIN
PRAŠNÍK
A
BREZOVSKÉ KARPATY MTS.
B
VRBOVÉ
JABLONICA
DOBRÁ VODA DEPRESS.
DEXTICE BLOCK
PIEŠŤANY
MALÉ KARPATY MTS.
SMOLENICE
POVAŽSKÝ INOVEC MTS.
Neogene cover
Paleogene cover
Upper cretaceous
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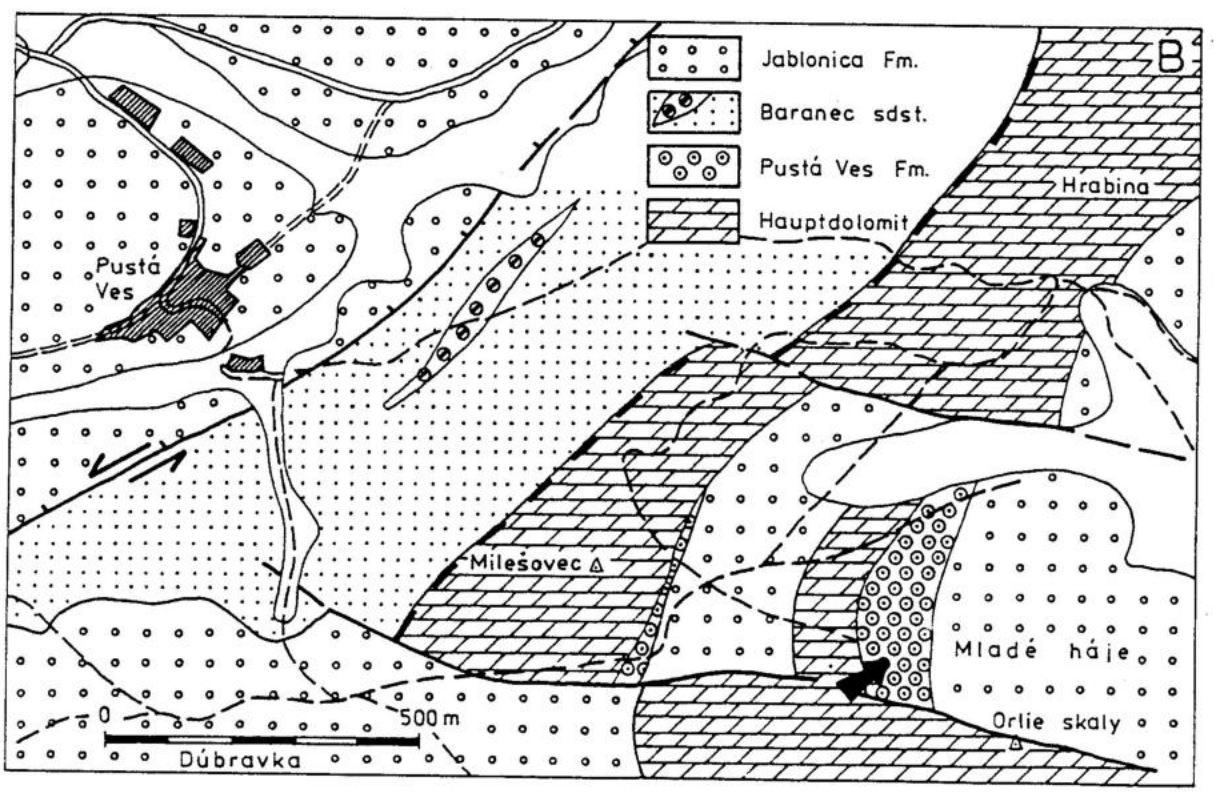
10 km
DANUBE BASIN
HLOHOVEC


Jablonica Fm.
Baranec sdst.
Pustá Ves Fm.
Hauptdolomit
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Hrabina
Pustá Ves
Milešovec
Mladé háje
Orlie skaly
0
500 m
Dúbravka

EXCURSION ROUTE

Locality No.1

PUSTÁ VES near Prašník, Brezová Mts

Small rocky outcrops in the Mladé Háje woody ridge, SE from the Pustá Ves settlement are built of brown oncolitic limestones of probably ? Turonian/Coniacian age. They contain ostracod and gastropod shells, dolomite lithoclasts, but no terigenous admixture. Algal nodules attain size of several centimeters in diameter. The limestones rest on the Triassic Vetterstein Dolomite being in tectonic contact with ? Eggenburgian clastics. The supposed age of Late Turonian - Lower Coniacian resulted from finding of pebbles of these rocks in the Coniacian Valchov Conglomerate (**Borza** 1962). The locality was described by **Mello** (in **Salaj** et al., 1987).

Locality No.2

VALCHOV MILL, near Brezová

The escarpment of the road Jablonica - Brezová exposes the contact of the Coniacian Valchov Conglomerate with the underlying Upper Triassic Hauptdolomit of the Jablonica Nappe. Dolomite cycles have fine clastic base, indistinct detrite bands and occasional pseudomorphs in the middle part, being terminated by loferitic algal mat lamination. The Valchov Conglomerate starts with unsorted dolomite breccia alternating with yellow clayey intercalations. The main part of the conglomerate body consists of well rounded clasts of local material with red matrix.

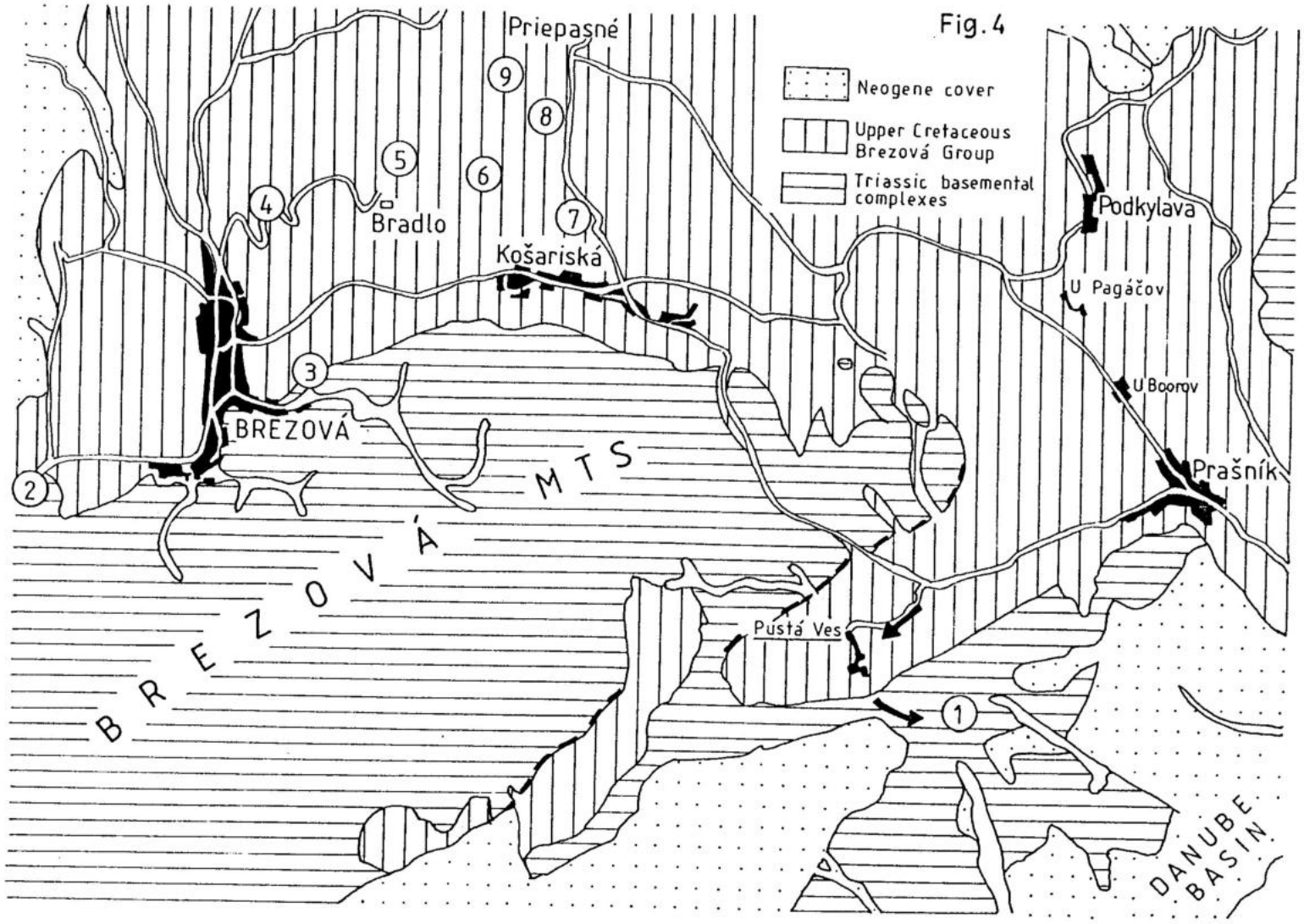


Fig. 4
Neogene cover
Upper Cretaceous Brezová Group
Triassic basemental complexes
Priepasné
Bradlo
Košariská
Podkylava
U Pagáčov
U Boorov
Prašník
BREZOVÁ
MTS
BREZOVÁ
Pustá Ves
DANUBE BASIN
1
2
3
4
5
6
7
8
9

Locality No.3

BARANEC QUARRY, near Brezová

Quarry at the foothills of the Brezovské Karpaty Mts exposes the contact of Triassic dolomite sequence of the Jablonica Nappe with the Coniacian conglomerates named as the Valchov Conglomerate Member. The conglomerate predominantly consisting of dolomite pebbles (up to several tens of cm in size) is gradually fining up to sandy marls. The conglomerates are overlain by the Upper Coniacian Baranec Sandstone Member (50 - 150 m thick). Its lower part, lacking in forams, was deposited in shallow neritic, while the higher part, rich in benthic and planktonic organisms sedimented in deeper neritic zone. Sandstones laterally pass into sandy limestones with *Actaeonella gigantea* and *A. laevis*.

The Coniacian sediments are massive, but some indications show that the beds are relatively steeply dipping, what could be explained by tectonic movements after deposition of the Coniacian sequences.

Dolomite basement is penetrated by a dense fault systemes. Shear faults of ENE - WSW direction with horizontal striation, steeply dipping to the S, are dominating. One of these dislocations cuts the Valchov Conglomerate. The striation on the slicken sides indicates left lateral character of the movements. **Marko** (1987) stated the presence of pinnate structures (i.e. generated by movements at a horizontal strike slip) in the quarry. They are mainly shear dislocations dipping to WSW with oblique striation inclined to NW. He interpreted them as a reverse faults generated by horizontal strike slip at the ENE - WSW system. Steep tensional dislocations of NE - SW direction are also discernible for-

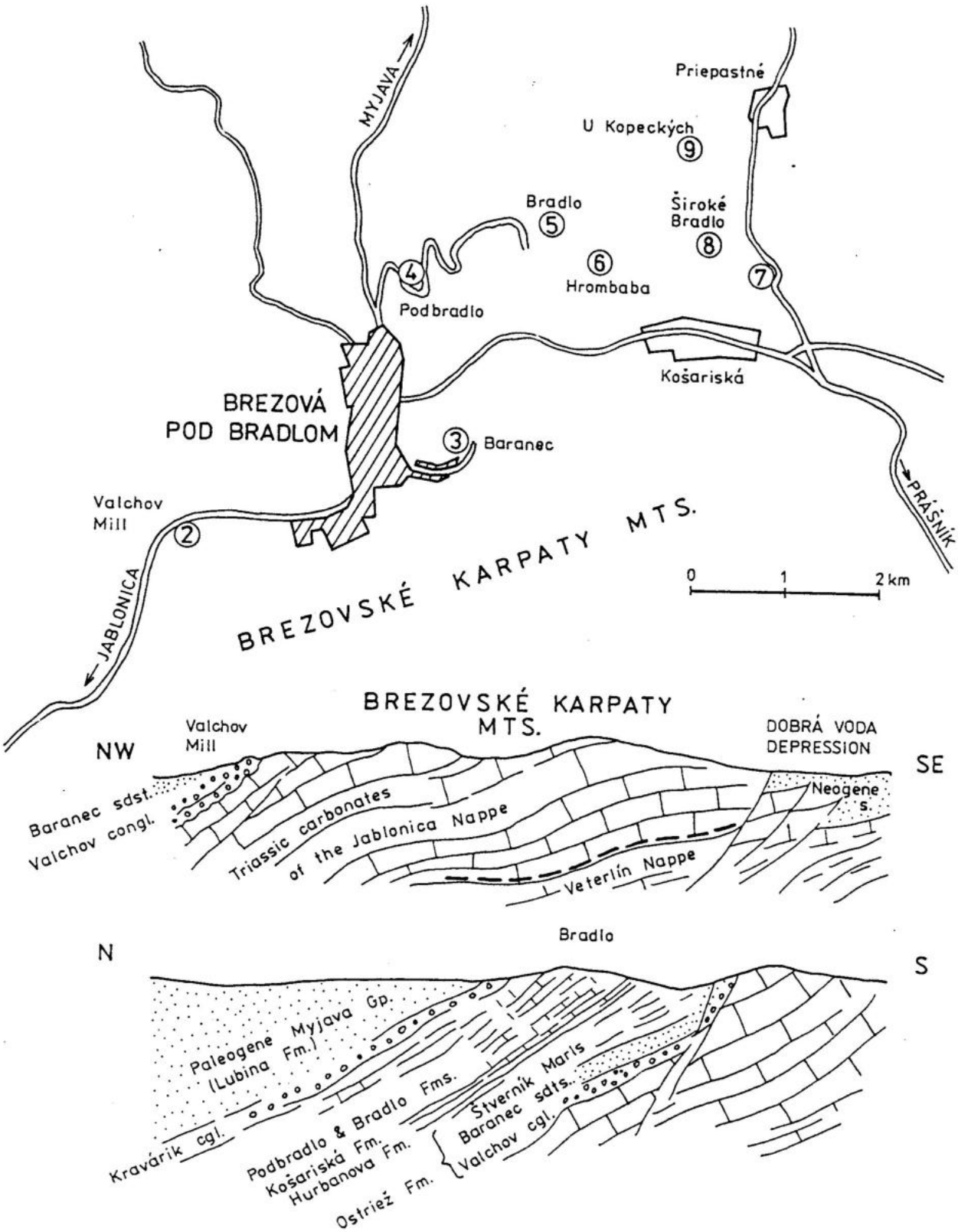
ming an angle of about 30 ^{o} with the horizontal strike slips. Thus, the original transgressive contact of the Gosau Group sequence with the dolomite basement is modified by left sided horizontal strike slip.

Locality No.4

PODBRADLO, Bradlo Hill slope

The stops 4 and 5 are situated along the road from Brezová to the monument of famous Slovakian astronomer and politician, general M.R.Štefánik, one of the founders of the Czechoslovakian State. The road cuts Santonian and Campanian shaly sequence of the Hurbanova Dolina-, Košariská- and Podbradlo Formations. However, the exposures are very poor and they not allow any possibility to study the lithology and sequence stratigraphy. The last unit mentioned above, the Podbradlo Formation, crops out in small ravine. It consists of 600 m thick gray-green marl sequence with intercalations of blue-grey calcareous sandstones and conglomerates with orbitoid foraminifers. The microfauna consisting of both planktonic and benthic foraminifers (*Globotruncana arca rugosa* Zone) and nannoplankton is extremely rich (**Began** et al., in **Gašparíková & Salaj** 1983). The formation follows after red and variegated marls of the Košariská Formation, passing upwards into the Široké Bradlo Limestone.

Fig. 5


MYJAVA
Priepastné
U Kopeckých
9
Bradlo
5
Široké
Bradlo
8
6
Hrombaba
4
Podbradlo
7
Košariská
BREZOVÁ
POD BRADLOM
3
Baranec
PRÁŠNÍK
Valchov
Mill
2
JABLONICA
BREZOVSKÉ KARPATY MTS.
0
1
2 km
BREZOVSKÉ KARPATY
MTS.
NW
Valchov
Mill
DOBRÁ VODA
DEPRESSION
SE
Baranec sdst.
Valchov congl.
Triassic carbonates
of the Jablonica Nappe
Neogene
s.
Veterlín Nappe
N
Bradlo
S
Paleogene Myjava Gp.
(Lubina Fm.)
Kravárik cgl.
Podbradlo & Bradlo Fms.
Košariská Fm.
Hurbanova Fm.
Ostrież Fm.
Štvernik Marls
Baranec sdts.
Valchov cgl.

Locality No.5

BRADLO HILL near Brezová

Flat surface of the Bradlo Hill has been formed on the biosparitic Široké Bradlo Limestone. This several tens meters thick formation consists of organodetrital and coarse clastic limestones and conglomeratic breccias. The lithoclasts were derived from older (mostly Triassic) carbonate sequences. The range of their size is from 0,3 to 30 mm. The limestone beds are 15 - 30 cm thick. The bioclasts are formed by fragments of rudists and oysters (up to 30 %).

Köhler (1962) determined Late Campanian species *Orbitoides media media, O.m. megaloformus,* and *Pseudosiderolites vidali* from the type locality. Early Maastrichtian age of the higher part of the sequence is indicated by *Orbitoides apiculata plana, O. a. gruenbackensis, O. gensacicus,* etc.

Široké Bradlo Formation is covered by the Mosnáč Marls called previously as "Inoceramus Marls". They Early Maastrichtian age is proved by the occurrence of *Globotruncana falsostuarti*. The marls fill a relief depression.

Locality No.6

HROMBABA HILL, Bradlo

Bioclastic limestones with variable amount of Triassic dolomite litoclasts and transitions to fine-grained breccias may be observed in the outcrop. The layers are to 20 cm thick. Well sorted biosparites with rare larger fragments of rudists (**Kühn and Andrusov** 1942, p. 455) quoted *Durania* cf. *austinensis* form A from here). They also contain bivalvian fragments, larger foraminifera - *Orbitoides media media*, *Pseudosiderolites vidali*, agglutinated benthonic foraminifera, sessile foraminifera (*Planorbulina cretacea*), rare *Globotruncana* sp., bryozoans, coralline algae, plates and spines of echinids, ostracods, *Pieninia oblonga* etc. Rarely partial silicification of organic remains and chert nodules may be seen.

The Široké Bradlo Limestone were interpreted as the product of temporary shallowing after the deposition of Podbradlo Flysch Formation foregoing the sedimentation of inocerams bearing Mosnáč Marls. The gradual passage from the underlying flysch and total lack of bioherms may indicate allodapic transport from destructed rudist banks (corals are not present) into relative deep water environment. On the other hand, well developed bedding, absence of gradation and lack of clayey matrix does not support it. However, poor exposition of the sequence makes the solution of this problem impossible.

Locality No.7

KOŠARISKÁ, near Brezová

The road cut N above the Košariská village exposes the sequence of red marlstones with occasional thin intercalations of fine grained sandstones named according to this locality as the Košariská Formation. Dipping of the beds is 30/30°. Rich Early Campanian foraminiferal microfauna (*Globotruncana arca, G. bulloides, G. fornicata, Globotruncanita elevata,* etc.) and nannoplankton assemblage (*Broinsonia parca, Cretarhabdus conicus, C. crenulatus,* etc.) have been described by **Gašparíková & Salaj** (1983).

Locality No.8

ŠIROKÉ BRADLO HILL, between Košariská and Polianka

Coarse grained biodetrital limestones with abundant small lithoclasts of carbonates and exotic rocks (localy even transition to microconglomerates and fine grained breccia) crop out in small abandoned quarry in the Široké Bradlo Hill. They contain abundant large Late Campanian - Early Maastrichtian foraminifers like *Orbitoides media media, O.m. megaloformis, Pseudosiderolites vidali* (**Köhler** 1962), and rudist shell fragments similar to the Hrombaba locality.

Locality No.9

PRIEPASNÉ, near Košariská

Polymict conglomerates with exotic pebbles alternate with coarse grained sandstones in a small bushy ridge above the "U Kopeckých" settlement. The conglomerates contain well rounded pebbles of Mesozoic carbonates, clastic rocks, rhyolites, basic vulcanics of various structures etc. Blocks of Paleocene biohermal limestones containing *Discocyclina seunesi* attain maximum of size. This lithotype, similar to the Kambühel Limestone, represents an index for distinguishing of Upper Cretaceous and Paleogene limestone sequences in this area.

Quantitative evaluation done by **Mišík & Sýkora** shows that the carbonates form 47,1 % of the pebble association (34,9 % of limestones, 21,7 % of dolomites); clastic rocks present 40,1 % (19,8 % of quartzites, 17,5 % of sandstones and greywackes, 0, 9 % of conglomerates); volcanics form 10,9 % (8,5 % of basics, 2, 4 % of acid types); vein quartz is represented by 1,9 %. No granitoids nor metamorphic rocks were found.

2nd day: CENTRAL WESTERN CARPATHIANS

Geological structure of the Strážovské Vrchy Mts

This extensive, dissected mountains range fringes the left side of the Váh River Valley between the towns of Žilina and Trenčín. The Jastrabie Saddle separates this mountains from the Považský Inovec on the south, while the Fačkov Saddle divides it from the Lúčanská Fatra on the east. The relief of the mountain range is moderate, its altitude attains 250 to 1014 m above the sea level. The streams issuing in the Strážovské Vrchy Mts (Rajčianka, Pružinka, Mojtín, Podhradie and Teplička brooks) are drained mostly into the Váh River. The streams issuing on their southern slopes (Nitra, Nitrica, Tužinka, Belanka, Radiša, Bebrava brooks) flow through the Bánovce and Horná Nitra Basins.

The Strážovské Vrchy Mts is a typical Central Carpathian ("core") mountain. Its geological structure may be traced in a large area (almost 3000 km^2). The Strážovské Vrchy Mts exposes frontal parts of Central Carpathian nappe units. Substantial part of these superficial nappes consists of the highest parts of Mesozoic sedimentary sequences, which slided gravitationally forward during last stage of the nappe movement. This is why the Cretaceous sequence is mostly well represented in many units. Moreover, digitated structure of the nappes enables to follow lateral changes of Cretaceous sediments more widely.

The deepest structural levels are exposed assymetrically in the southeastern periphery of the mountains (although Mesozoic masses are exposed also along very southern margin of the crystalline in the mountain range of Rokoš and Drieňový Vrch). External NW margin comprises imbricated Mesozoic masses of almost all Central Carpathian tectonic units from the Tatric cover through

the Belá- and Krížna nappes of the Fatric, the Manín Unit, the Čierny Váh-, Biely Váh- and the Bebrava sequence of the Hronic Choč Nappe, to the Strážov Nappe, equivalent to the high Austroalpine units.

The Austrian nappe structure characterized by many partial imbrications and digitations in the frontal part of the nappes was repeatedly deformed into moderate synclines after post-Paleogene folding, the masses of the Choč- and Strážov nappes being affected by back overthrusts. In the latest stage, the area was dissected by a system of NW-SE and NNW-SSE transversal normal faults and strikes concealing the course of original zonal structures. The mountains structure is rimmed on NW by Paleoalpine Accretion Belt, composed of imbricated thick Upper Cretaceous and Paleogene "wildflysch" complexes with olistolites and tectonic slices of older rocks. On the northeast, north and west, the mountains is rimmed by Rajec-, Žilina-, Púchov- Ilava- and Trenčín Basins, filled by Tertiary sediments.

The Tatric Malá Magura sequence commences with the Scythian Lúžna Formation covered by a huge complex of the Triassic limestones, dolomites and terrigene clastics. Jurassic complex of dark limestones, shales and silicites is followed by Berriasian - Valanginian cherty limestones. It is presumed that the Hauterivian - Aptian beds underwent Early Albian erosion. Albian shaly sequence of the Poruba Formation contain large bodies of paraconglomerates.

The Manín Unit, is regarded either as a marginal Tatric element detached from its basement and affected again by the Laramian orogeny, or as the proximal part of the Krížna (Fatric) Unit. Its Lower Cretaceous sequence in Neocomian facies development is lying on Upper Jurassic Ammonitico Rosso limestone com-

plex. Berriasian - Barremian pelagic limestones are covered by products of Upper Barremian - Aptian - Lower Albian "Urgonian" platform carbonates. Limestone sequence is terminated by hard ground, followed by pelagic Butkov Marls. These marls are the first member of a thick Upper Cretaceous flysch sequence, which has been probably already deposited on a mobile substrate thrust into the Paleoalpine Accretionary Belt.

The Belá Unit represents a zone of nappe slices at the margin of Fatric Superunit. It comprises a continuous sequence of Triassic and Jurassic sediments. The Neocomian sequence is interrupted by sedimentary gaps during Late Tithonian and Valanginian / Early Hauterivian. Dark marlstones with pyrite concretions and Late Hauterivian belemnite fauna and microfauna are overlain by "Urgonian" slope limestone complex, penetrated by a system of neptunian dykes. It is followed by black Lower Albian limestones, followed by Butkov marls.

The Zliechov Sequence forms the substantial part of the Krížna Nappe Unit. Triassic sequence is usually tectonically reduced in frontal part of the nappe body. Thick Jurassic sequence is represented by hemipelagic and eupelagic facies. Berriasian biancone-type Osnica Limestone is covered by thick Valanginian - Barremian marly limestone complex of the Mráznica Formation. Aptian - Lower Albian black Párnica Formation contains intercalations of paraconglomerates, slumped bodies, basic volcanics and tuffites. It it overlain by Albian - Cenomanian flysch - like Poruba Formation.

Choč Nappe sequence consists mostly of Triassic carbonate sequence. However, the frontal parts of the nappe exposed here contain also preserved Jurassic and Lower Cretaceous sediments. They are represented by Tithonian - Berriasian biancone - type

limestones, followed by Valanginian well bedded cherty limestones and then by Hauterivian marls with aleurolitic intercalations.

Higher (Strážov) Nappe forming the highest (Triassic limestone) peaks of the mountains, does not contain any Jurassic and Cretaceous rocks.

Locality No. 10

STRÁŽOVCE SECTION

The section exposed by road escarpment between the villages Zliechov and Čičmany in the central part of the Strážovské Vrchy Mts well documents relatively deep pelagic development of Upper Jurassic and Lower Cretaceous carbonates. Upper Jurassic deposits in the Zliechov type sequence are represented mostly by the Steinmühl Formation, consisting of reddish nodular limestones of Ammonitico Rosso Facies.

In contrary, the Jasenina Formation represents Upper Jurassic deposits in the Strážovce section. It is built of schistose marly limestones and marlstones, belonging to the *Moluccana-*, *Malmica-* and *Crassicollaria* Zones. On the other hand, both the mid Tithonian *Chitinoidella-* and early late Tithonian *Praetintinnopsella* Zones have been not proved.

The Berriasian sediments are represented by thick- bedded micrite limestones with scarce, poorly preserved macrofauna (berriasellid ammonites, lamellaptychi and indeterminable belemnites) and with abundant calpionellids of the *Calpionella-* and *Calpionellopsis* Zone. This "biancone" limestones, partially equivalent to the Pieniny Fm, was named here as the Osnica Formation.

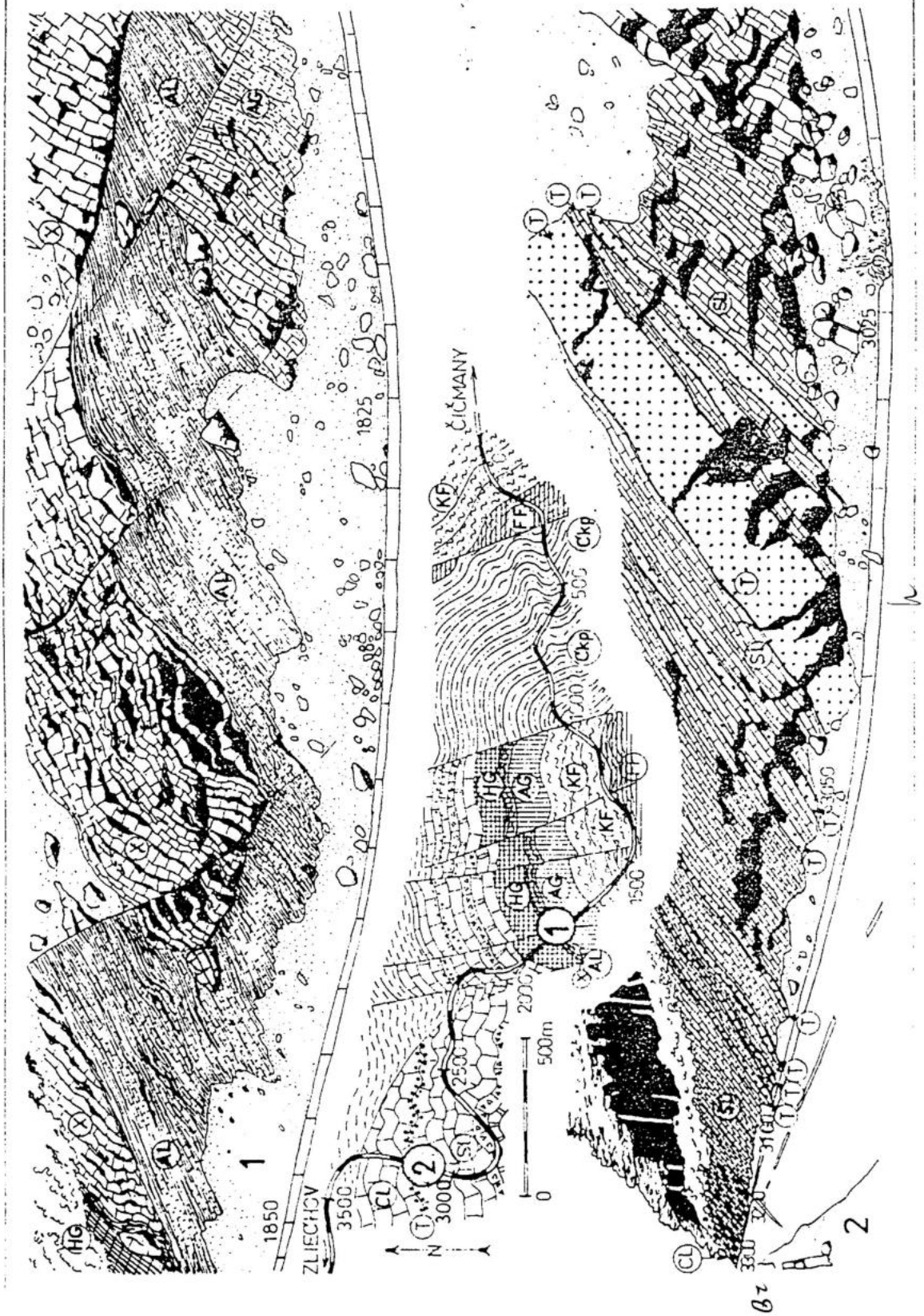


Figure 6.: A sketch of the Strážovce section (in the middle): Ckp - Carpathian Keuper, FF- Rhaetian Fatra Formation, KF- Hettangian Kopieniec Formation, AG- spotted limestones of the Janovky Formation. The other abbreviations explained below.

Detail 1: Slump character of the boundary between Adnet Fm (AL) and Aalenian thick bedded limestones (X) covered by the Ruhpolding Fm (HG).

Detail 2: Hauterivian sequence of the Mráznica Fm (SL) with intercalations of the Strážovce turbidites (T). The sequence is covered by Barremian cherty limestones (CL).

The Mráznica Formation is composed of well bedded argillaceous limestones with characteristic bioturbation and thin marly intercalations. Beds of the Nozdrovice Breccia contains limestone clasts derived from the underlying Berriasian limestones. Mráznica limestones contain Valanginian and Hauterivian nannofossils and microfossils of the *Calpionellites-* and *Tintinnopsella* Zones, abundant aptychi, ammonites and belemnites enabling zonal division (*Lamellaptychus mortilleti, L. didayi, L. seranonis, Crioceratites sp., Duvalia dilatata, D.lata*, etc.).

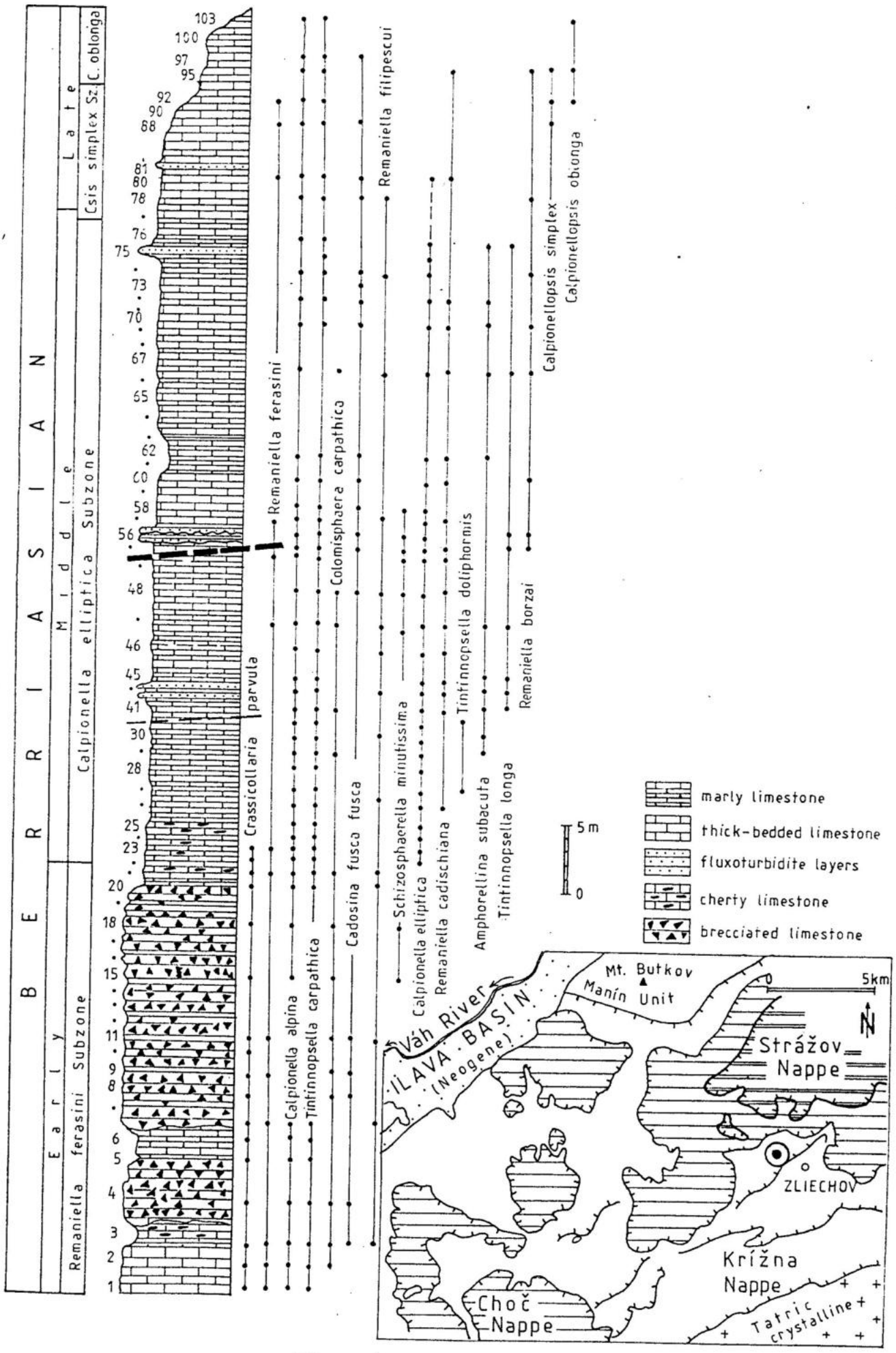
A distinct complex of rhythmical builded organodetrital, cherty and marly spotted limestones with marly intercalations is called the Strážovce Formation. Calciturbidite beds are indistictly graded, often accompanied by chert horizons. They attain thickness 15 - 200 cm. Clasic quartz grains and authigene quartz and feldspar crystals occur seldomly. Reworked organic remnants form the major constituent of the rock: crinoid ossicles, bivalve shells, echinoid spines, uniserial bryozoans, solenoporaceans, forams and rare *Cadosina fusca cieszynica* and *C. semiradiata olzae*. The age of calciturbidites has been estimated as early late Hauterivian.

Overlying well bedded marly limestone with Upper Hauterivian belemnites and spotted cherty limestones with barremitid ammonites belong to the higher part of the Mráznica Formation.

The sequence is cut by fault, dividing it from the marly complex of the Albian Poruba Formation.

ZLIECHOV SECTION

Fig.7



Locality No. 11

ZLIECHOV VALLEY

Rock walls in the right slope of the Zliechov Valley approximately 0.5 km below the Zliechov village expose lower part of the Lower Cretaceous sequence of the Vápenica digitation of the Zliechov Unit (Krížna Nappe). The major part of this rocks is formed by special development of the Berriasian Osnica Formation.

The base of the exposed sexuence consists of grey thick bedded micritic limestones. Brecciated limestone with micritic matrix crops out in the steep wall. The clasts attain diameter of 5 to 500 mm. Thickness of the breccia body is 12 meters, higher breccia beds are disturbed by synsedimentary slumping. Both the limestone clasts and their matrix contain the same microfossil association dominated by *Calpionella alpina*. The breccia body represents probably a channel filling in deep slope environment.

Gray thin bedded cherty micritic limestones (wackestones) with occasional oblique and cross laminated layers follow above it. They are several tens (up to hundred) of meters thick. The higher part of the sequence contains intercalations of microbreccia limestones (sometimes with indistinct gradation). One of them consists of flat clasts and contain sole coral fragments. Badly preserved ammonites (probably *Berriasella sp.*) have been found in the topmost layers of the section.

Breccia beds with similar composition, named as the Nozdrovice Breccia occur in several sections of the Zliechov Unit in the Strážovské Vrchy Mts. Their age is Berriasian to lower Valanginian. The clasts are mostly derived from the underlying or con-

temporaneous limestone beds, clasts of shallow marine limestones are extremely rare (if compared with Valanginian and Hauterivian turbidite layers composed mostly of the fragments of shells of shallow marine organisms and terrigenous detrite).

Equivalent rock type has been found also in other areas and units (Vysoká Unit of the Malé Karpaty Mts., Butkov section of the Manín Unit) of central Western Carpathians, but also in Outer Carpathian Klippen Belt (Kysuca Unit) and in other mountains ranges (Mecsek Mts in Hungary, Ybbsitz Zone of Eastern Alps in Austria). Peculiar type of Berriasian breccia has been observed in the Inovec Unit of the Považský Inovec Mts., which contains not only limestone clasts but also fragments of crystalline rocks in biomicrite matrix with calpionellids.

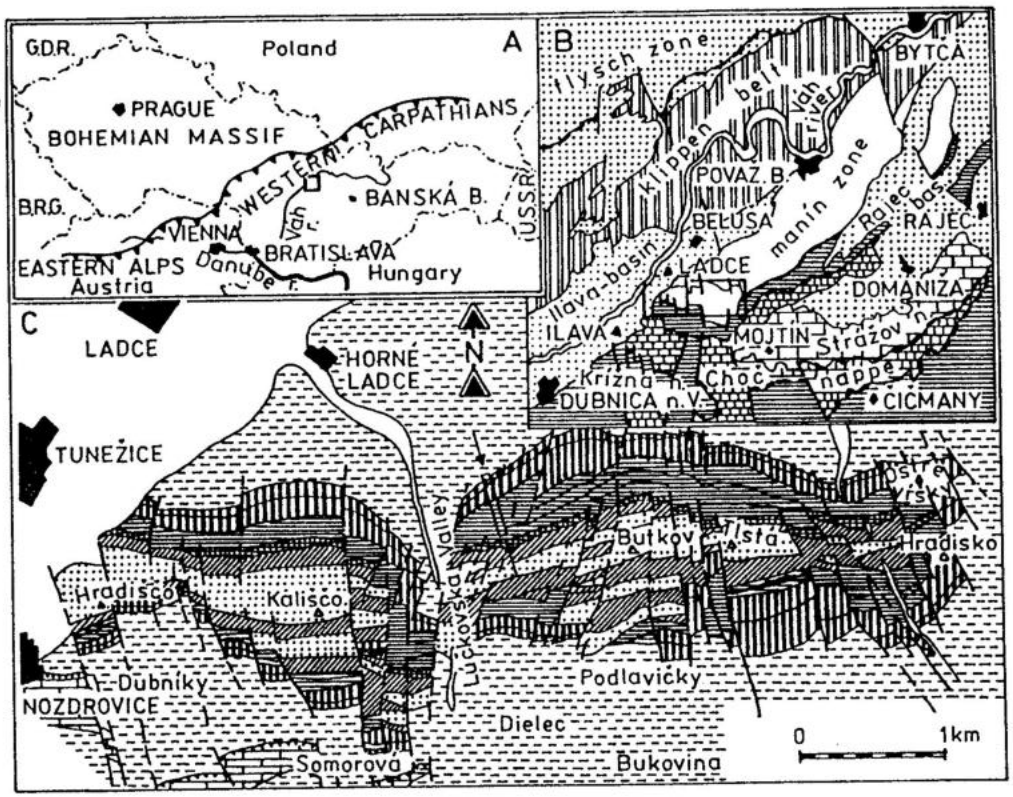
The Nozdrovice Breccia documents denivelation of the sea bottom due to Late Cimmerian tectonic activity and subsequent erosion of edges of faulted blocks.

Locality No. 12

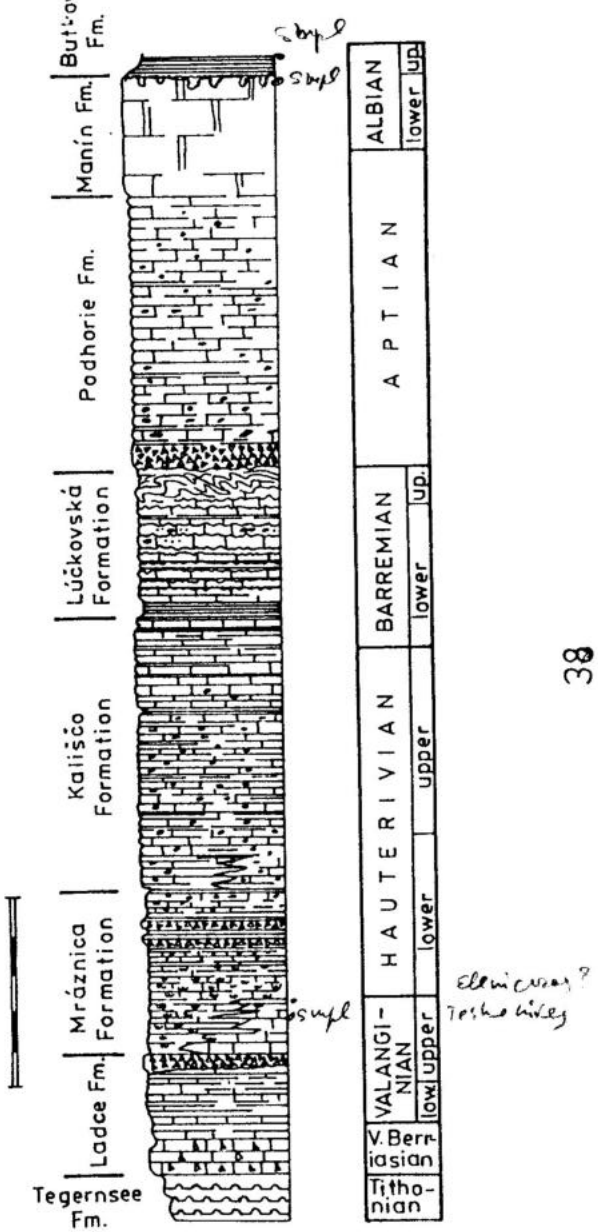
BUTKOV QUARRY

Butkov- and Kališčo Hills form expressive dominants, mounting over the Neogene Ilava Basin in the middle Váh Valley. They are build up of the Manín Unit strata, forming the very margin of the central Western Carpathian block in this area. Lower Cretaceous sequence is exposed here by a big quarry of the Ladce cement factory in NW slope of the Mt. Butkov. Reference sections of four lithostratigraphic units (Ladce-, Kališčo-, Lúčkovská- and Pohorie Formations) are localized here.

Fig. 8



1 - Urbanized region
2 - Quaternary deposits
3 - Križna Nappe
4 - Butkov & Belušské Slatiny Formations
5 - Manín Formation & Podhorie Formation
6 - Lučkovská Formation & Kališčo & Ladce & Mráznica Formation
7 - Tegernsee Formation
8 - Ruhpolding Formation
9 - Trlianska Formation



Upper Jurassic complex of red nodular limestones is divided by an intercalation of Oxfordian yellowish green ("banana") radiolarites onto two formations. The Niedzica Formation contains globuligerinid forams, globochaetes, abundant filaments and poorly preserved belemnite and ammonite fragments. The Czajakowa Radiolarite Formation yielded rich association of Oxfordian radiolarians. The microfossil content of the upper part of the "Ammonitico Rosso", Czorsztyn Formation allowed to recognize the Kimmeridgian *Moluccana-*, early Tithonian *Malmica-*, *Pulla-*, *Tithonica*, mid Tithonian *Dobeni-*, *Boneti*, and late Tithonian *Praetintinnopsella- and Crassicollaria* Zones within it.

The Ladce Formation represents late Berriasian (*Remaniella-* and *Elliptica* Subzones) and early Valanginian (*Calpionellopsis* and *Calpionellites* Zones). This fact, as well as the presence of frequent Tithonian and Lower Berriasian clasts in the basal breccia indicates important erosion of underlying rock strata and stratigraphic gap prior to the sedimentation of this formation. Well bedded pale grey nannocone biomicrites were named as "sublithographic limestone" by local geologists.

Gray inconspicuously spotted limestones with disseminated tiny cherts form the lowermost beds of the Mráznica Formation. Predominant lithotype of this units consists of brown gray and gray marly heavily bioturbated bimicrite wackestones with *Cadosina fusca*, *C. semiradiata*, *Stomiosphaera echinata*, *S. wanneri*, *Colomisphaera vogleri*, *C. heliosphaera* and *Tintinnopsella carpathica*. Hedbergellid forams occur sporadically, radiolarians are calcified, the composition of nannoplankton association is similar to the Ladce Fm. Rich ammonite, belemnite and aptychi fauna date late Valanginian to lower Hauterivian age of the Mráznica Formation.

The lower part of the Kališčo Formation consists of well bedded biomicrite wackstones with countour cherts. They contain rich and diversified radiolarian association of late early Hauterivian *Mirifusus chenodes* Zone. The macrofauna is represented by well preserved belemnites, and ammonites. The upper part of the formation is formed by brownish grey limestones with diffuse dark cherts. Typical late Hauterivian nannoconid association, ammonites and aptychi occur in these beds.

The Lúčkovská Formation is build of yellowish weathering well bedded brownish gray marly biomicrites (wackestones) with big loaf like chert nodules and marly intercalations. They contain rich association of belemnites, sponges, echinoids, brachiopods, ammonites and fish teeth. Microfauna is represented by hedbergellid forams, radiolarians, *Stomiosphaera wanneri*, nannoconids, siliceous and sponge spicules. Limestone clasts occur frequently, the higher beds are locally deformed by slumping. Belemnite and sporadic ammonite fauna permits to range these beds with Lower and upper Barremian. On the other hand, radiolarian microfauna is closer to the Hauterivian association.

The Podhorie Formation begins with limestone breccia arranged in graded strata. Clasts consist of organodetritic as well as Barremian to middle Aptian micritic limestones, cherts, rarely of fragments of basic extrusives and tuffs. The erosive boundary with the Lúčkovská Formation indicate progradation of slope sediments of the originating carbonate platform through a pelagic carbonate ramp. The formation reaches thickness of 65 - 75 m. The upper member, consisting of bedded bituminous organodetritic limestones with blackish gray cherts (arranged sometimes in *Thalassinoides*- type galleries), is locally silicified. Fragment of bivalve shells, crinoid ossicles, hedbergellid, mioliolid and orbitolinid forams are frequent. These limestones pass upwards into

organodetritic limestones of Urgonian carbonate platform of Aptian - Lower Albian age. The carbonate sequence is terminated by hard ground with numerous borings of benthic organisms and covered by ferrugineous and stromatolitic crust.

Upper Albian - Cenomanian Butkov Formation is formed by thick pile of brownish glauconitic marls and marlstones with sporadic thin aleurolitic intercalations. They contain Late Albian nannocones of the *Eiffelithus turriseiffeli* Zone and mid Albian - mid Cenomanian planktonic foraminifers *Thalmaninella ticinensis*.

Locality No. 13

POLOMEC QUARRY

Abandoned quarries at the Polomec Hill near Lietavská Lúčka village (now part of Žilina) occur at the very margin of the Strážovské Vrchy Mts. The exposed Lower Cretaceous carbonate sequence belongs to the Zliechov Unit of the Krížna Nappe. The sequence studied can be divided into four lithostratigraphic units, as follows.

Turbiditic complex similar to the Strážovce Formation consists of grey and brownish, fine grained sandy limestones (microsparite to sparite with micritic intraclasts). Quartz grains, feldspars (also authigenic), fine muscovite flakes, biotite and chlorite are less common. Accessory zircon and tourmaline occur sporadically. Organic remains are represented by crinoid columnals, broken bivalve shells and bryozoan fragments. *Tintinnopsel-*

la carpathica, Stomiosphaera echinata and ostracods occur in micrite matrix. The upper part of turbidite cycles is formed by pelmicrite and pelmicrosparite with glauconite and pyrite. This complex is probably of early late Hauterivian age.

Violet- grey marly biomicritic limestones of the Ptychoceras Beds with spotted nannocone biomicrite intercalations frequently contain radiolarians and nannoflora. Foraminifers (*Lenticulina, Nodosaria, Patellina, Spirillina*), globochaetes, crinoids, bivalve and aptychus fragments, ostracods, echinoid spines, sponge and ascidian spicules and "short filaments" are infrequent. Microplankton is represented by *T. carpathica, Cadosina fusca fusca, Colomisphaera heliosphaera*: associated nannoflora is very scarce, represented by *Ellipsagelosphaera, Cyclagelosphaera* and *Parhabdolithus*. Clastic admixture consists of rare silt-sized quartz grains, muscovite and clay minerals: limonitized pyrite prevails over phosphate and rare dolomite rhombs in the authigenic minerals. Throughout the sequence (except of its base) fragments and more complete shells of *Euptychoceras meyrati, E. borzai, Haploceras* and *Barremites* occur, accompanied by more rare *Paraspinoceras puzosianum* and true crioceratitid ammonites. Aptychi (*Lamellaptychus angulicostatus*) occur mostly as fragments. This part of the sequence can be placed in the late Hauterivian *Meyrati* Zone.

The upper part of the violet gray limestones consists of nannocone biomicrites still with the *Tintinnopsella* association. In the topmost part, the first hedbergellid foraminifers have been recorded. The nannofloral association is substantionally enriched (*Ellipsagelosphaera* ex gr. *britannica, E.coronata, E.ovata, Braarudosphaera bigelowi* dominate over *Cyclagelosphaera rotaclypeata, C.mergereli, Podorhabdus* and *Discorhabdus ignotus*).

The yellowish brown, reddish-grey or greenish grey biomicri-

tes of the Pseudothurmannia Beds with marly admixture are remarkable for the presence of synsedimentary slumping and brecciated beds. *Tintinnopsella* no longer occurs, but hedbergellid foraminifers are fairly abundant. Representatives of *Pseudothurmannia* and *Crioceratites* dominate over other ammonite genera in the macrofauna. Aptychi (*L. angulicostatus angulicostatus*), belemnites (*Duvalia dilatata*), brachiopods (*Terebratulina, Pygites*) are locally abundant. Nannocone biomicrites contain rare silt-sized quartz grainsand the "usual" spectrum of accessory and authigenic minerals, plus frequent brachiopod, bivalve, aptychus and ostracod fragments: radiolarians, stomiosphaerids and colomisphaerids are less frequent. *Ellipsagelosphaera* is represented sporadically in the nannofloral association, *Cretarhabdus, Zygolithus* and *Braarudosphaera* dominate over *Cyclagelosphaera, Parhabdolithus* and *Manivitella*. Pseudothurmannia beds are regarded as basal Barremian.

Both *Pseudothurmannia* and *Crioceratites*, together with the last aptychi, disappear suddenly at the base of the sequence of well bedded spotted limestones with *Barremites difficilis, Hamulina lorioli, Hamulinites, Karsteniceras, Holcodiscus* and other ammonites. The composition of microfauna is similar to the assemblage mentioned earlier. However, the nannoplankton assemblages are characterized by a sudden increase in the proportion of thick- walled forms (*Parhabdolithus*). This part of the sequence is of early Barremian age. The lithology of upper Barremian limestones is unchanged. They contain ammonite indexes *Silesites seranonis* and *S. vulpes*.

Aptian strata consist of dark grey marls with sporadic intercalations of black limestones. They contain planktonic foraminifers (*Caucasella*). Above lying Albian shales belong to the Poruba Formation.

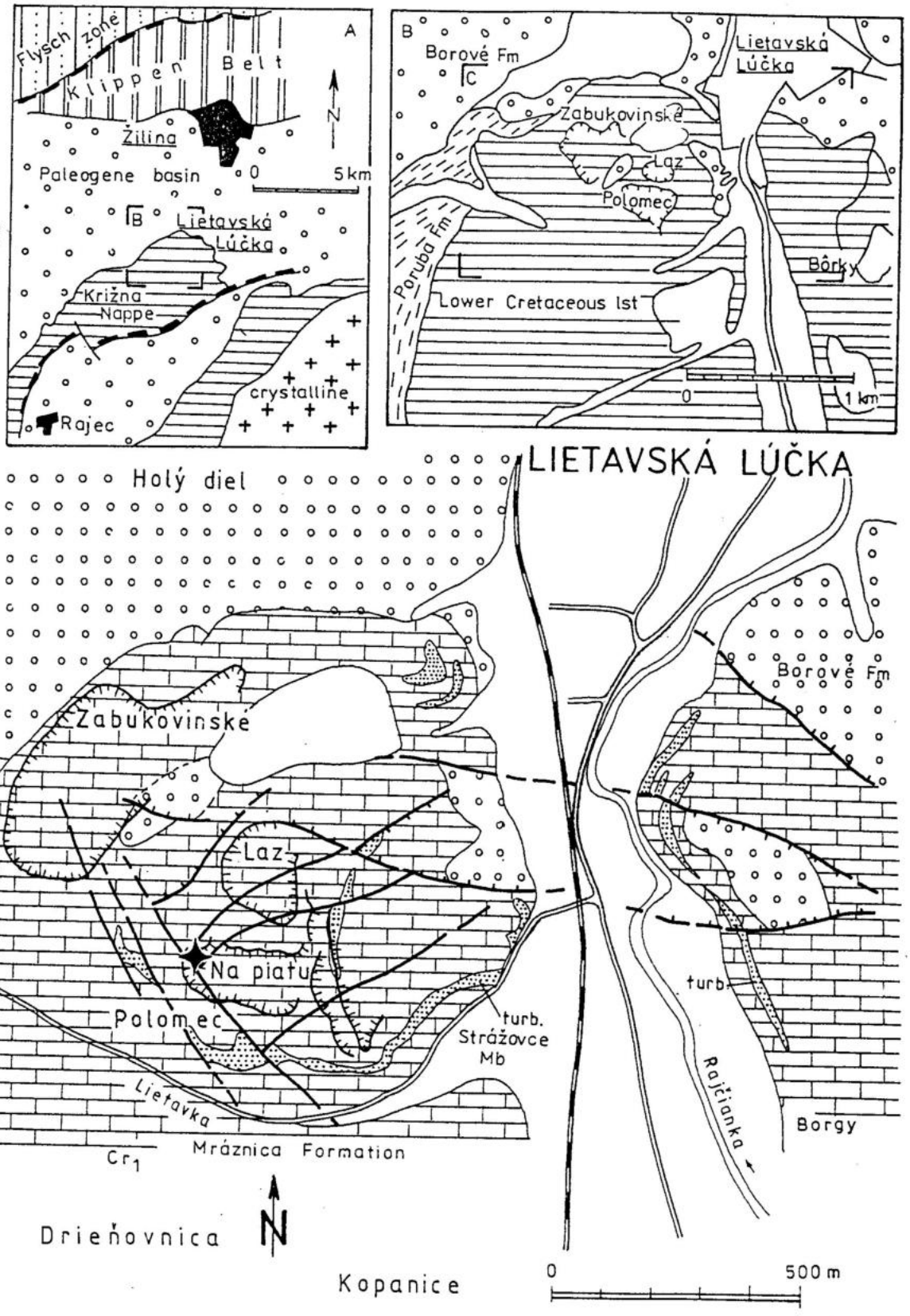

A
Flysch zone
Klippen Belt
Žilina
N
Paleogene basin
0
5 km
B
Lietavská Lúčka
Križna Nappe
crystalline
Rajec
B
Borové Fm
C
Lietavská Lúčka
Zabukovinské
Laz
Polomec
Poruba Fm
Lower Cretaceous lst
Bôrky
0
1 km
LIETAVSKÁ LÚČKA
Holý diel
Zabukovinské
Laz
Na piatu
Polomec
turb. Strážovce Mb
Lietavka
Mráznica Formation
Cr1
Borové Fm
turb.
Rajčianka
Borgy
Drieňovnica
N
Kopanice
0
500 m

Fig. 9

Polomec section has been suggested as national reference section of the Hauterivian/Barremian boundary. The study of its biostratigraphy and sedimentology is in progress.

Locality No. 14

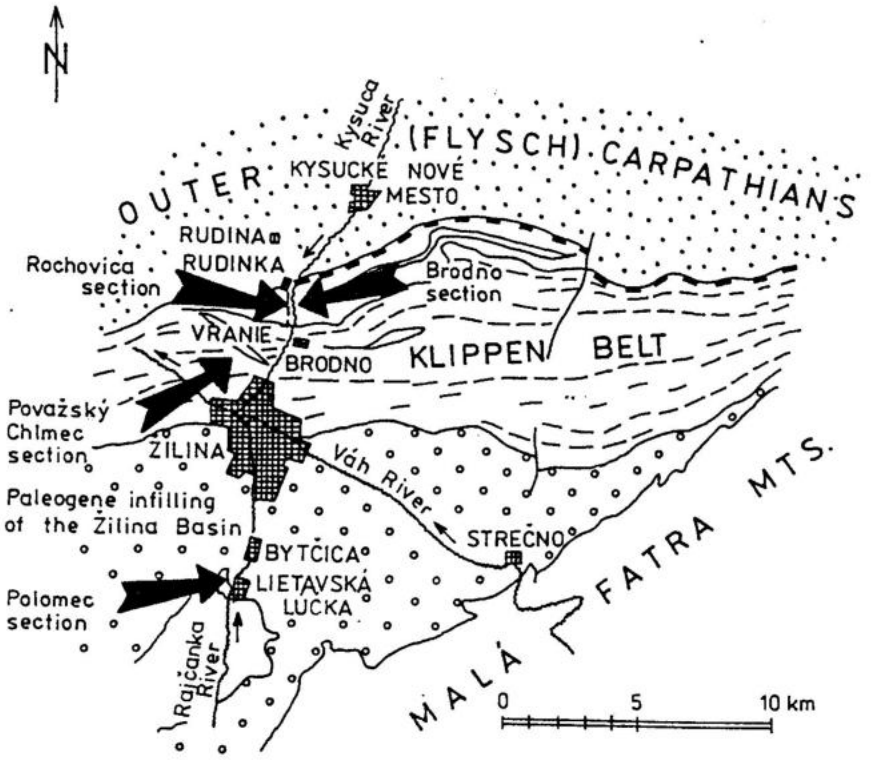
BRODNO - Railway station quarry- and Rochovica sections

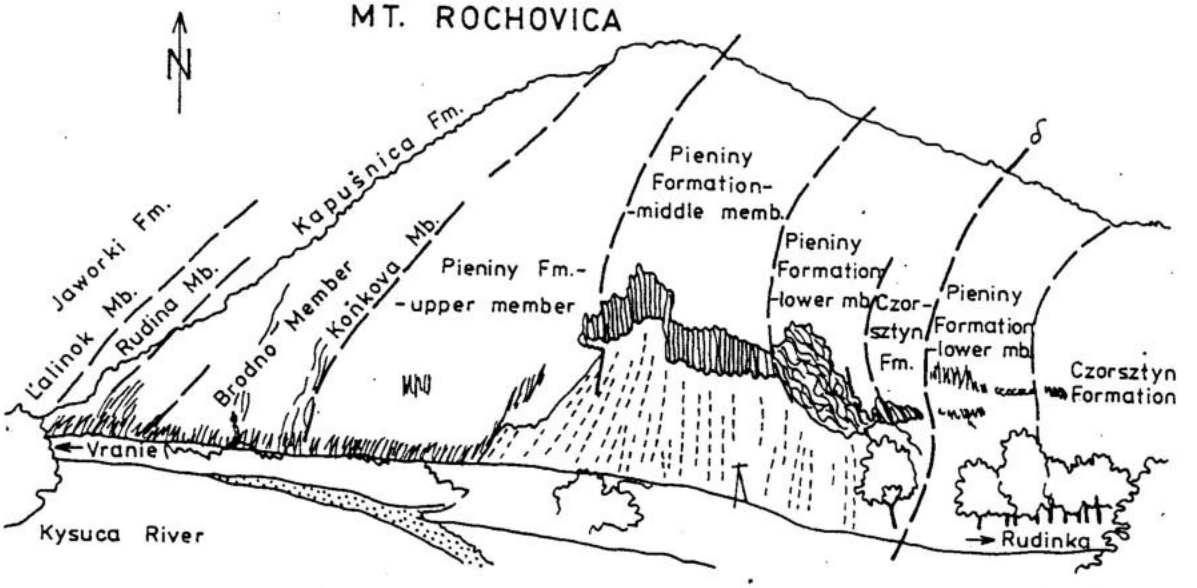
This locality is situated in the Pieniny Klippen Belt belonging already to the Paleoalpine Accretionary Belt (see introduction to the fourth day of the excursion). Classical section in the "Kysuca Gate" (narrow straits of the Kysuca River between villages Brodno, Rudinka and Vranie north of the town of Žilina) yielded important informations on relatively deep marine sedimentation in contact zone of the Outer- and the Central Western Carpathians, which has been substantionally reduced during later Alpine tectogenesis.

Late Jurassic sedimentation rate has been low, condensed sediments received only limited terrigene clastic support, similarly as in other Western Carpathian areas. Extensive areas were characterized by red nodular calcareous ooze of the "Ammonitico Rosso Facies". The Czorsztyn Formation represents Kimmeridgian and Tithonian sediments of the Kysuca succession.

Biomicrite packstones of *Saccocoma - Globochaete-* and *Saccocoma - Radiolaria* Microfacies contain *Colomisphaera pieninìensis, C. fibrata, Carpistomiosphaera borzai* and *Stomiosphaera moluccana* indicating Kimmeridgian age.

Fig. 10


N
Kysuca River
OUTER (FLYSCH) CARPATHIANS
KYSUCKÉ NOVÉ MESTO
RUDINA
RUDINKA
Rochovica section
Brodno section
VRANIE
BRODNO
KLIPPEN BELT
Považský Chlmec section
ŽILINA
Váh River
Paleogene infilling of the Žilina Basin
BYTČICA
STREČNO
MALÁ FATRA MTS.
Polomec section
LIETAVSKÁ LUCKA
Rajčanka River
0
5
10 km


MT. ROCHOVICA
N
Kapušnica Fm.
Jaworki Fm.
Ľalinok Mb.
Rudina Mb.
Brodno Member
Kaňkova Mb.
Pieniny Fm.- -upper member
Pieniny Formation- -middle memb.
Pieniny Formation lower mb.
Czor-sztyn Fm.
Pieniny Formation lower mb.
Czorsztyn Formation
Vranie
Kysuca River
Rudinka

Reddish nodular cherty and indistinctly nodular biomicrite packstones are rich in *Saccocoma*, radiolarians and globochaetes. Ostracods, foraminifers, filaments, crinoids are common. *Parastomiosphaera malmica, Carpistomiosphaera tithonica* and *Colomisphaera pulla* indicate early Tithonian age of the limestones.

Grey indistinctly nodular micrites contain microfossils of the middle Tithonian *Chitinoidella* Zone (only *Boneti* Subzone being documented). The assemblage is represented by *Ch. tithonica, Ch. slovenica, Ch. boneti* and *Cadosina fusca*.

Late Tithonian *Praetintinnopsella-* and *Crassicollaria* Zones were identified in indistinctly nodular- and in well - bedded wackestones with *Crassicollaria intermedia, C.brevis, C. massutiniana, C. parvula, Tintinnopsella remanei, T. carpathica, Cadosina fusca, C. semiradiata*, foram fragments, ostracods, bivalve shells, aptychi (*Lamellaptychus beyrichi*) and ammonites (*Ptychophylloceras ptychoicum*).

The change between the Late Jurassic and the Early Cretaceous limestone formations is isochronous not only in the Klippen Belt (Kysuca- and Czorsztyn Units), but also in the Central Carpathian units. This fact proves for expressivity and spatial extension of environmental changes, which happened during the boundary of both the *Crassicollaria-* and *Calpionella* Zones not only in the Western Carpathians.

Berriasian formations were characterized by strong subsidence but mainly by great acceleration of "planktic rain" of organic matter and calcareous microskeletons. This change detectable in the majority of Western Carpathian successions (Padlá Voda-, Ladce- and Osnica Formations) created the "majolica" pattern of pelagic sedimentation (Pieniny Limestone Formation) in the Pieniny

sedimentary basin. This sedimentation survived here until early Aptian.

Lower Berriasian part of this succession is represented by well bedded pale biomicritic wackestones with *Calpionella - Globochaete* and *Radiolaria - Calpionella* Mikrofacies. *Calpionella alpina* and *Globochaete alpina* are dominating, foram fragments, radiolarians, ostracods, aptychi, ophiuroids, bivalves, juvenile ammonites (*Pseudosubplanites (P.) sp.*), *Crassicollaria parvula, Tintinnopsella carpathica, Cadosina fusca, C. semiradiata* are common. Microbreccia layers contain limestone clasts with Tithonian microfossils. *Remaniella cadischiana* and *R.ferasini* characterize the middle Berriasian part of the formation. *Calpionella elliptica* and *Cadosina minuta* typical for the late Berriasian *Elliptica* Subzone occur in thick bedded cherty limestones with *Calpionella* and *Radiolaria* Microfacies.

Biomicrite wackestones and packstones (in the Rochovica section) contain *Calpionellopsis simplex, Calpionellopsis oblonga, Lorenziella hungarica* and *Carpistomiosphaera valanginiana*. Calpionellid abundance decreases in the *Cadosina - Calpionella - Radiolaria* Microfacies belonging to late Berriasian and early Valanginian *Calpionellopsis* Zone. *Calpionellites darderi, C. caravacaensis, Tintinnopsella longa, Amphorellina subacuta, Colomisphaera vogleri, C.heliosphaera* and abundant nannoconids are typical for late Valanginian *Calpionellites* Zone. The beds belonging to the top Valanginian to Hauterivian *Tintinnopsella* Zone yielded ammonites *Bochianites neocomiensis, Eristavites platycostatus* and aptychi *Lamellaptychus excavatus*. Late Hauterivian part of the sequence contains abundant nannoplankton (*Calcicalathina oblongata, Conusphaera mexicana, Nannoconus steinmanni, N.globulus, N.boneti*), radiolarians (*Acaeniotyle umbilicata, Archaeodictyomitra rigida, Podobursa triacantha*, etc.) and aptychi

(*Lamellaptychus angulocostatus*).

Dark grey spotted biomicrite wackestones and packstones characterized by *Hedbergella - Radiolaria* and *Hedbergella* Microfacies contain *Hedbergella infracretacea, H.cretacea, Colomisphaera heliosphaera, C. vogleri, Stomiosphaera echinata, Stomiosphaera wanneri*. They indicate Barremian age.

The Koňhora Formation is represented by black marls with intercalated micritic limestones and Aptian forams *Hedbergella trochoidea, H. infracretacea, Planomalina cheniourensis*.

The Brodno Beds consist of 16 m of pale greenish gray limestones with dark contour cherts and dark gray marly intercalations. They contain low diverse nannoplankton assemblage (*Nannoconus globulus, Ellipsagellosphaera britannica, E. ovata, Cyclagelosphaera mergereli* and *Watznaueria barnesae*).

Monotonous shaly complex of the Rudina Beds contain Albian foraminifers *Hedbergella roberti* and *Thalmaninella ticinensis* and radiolarians.

3rd day: LOWER CRETACEOUS FORMATIONS IN OUTER CARPATHIANS

Outer Western Carpathians (called also "Flysch Carpathians") represent the most external allochtonous nappe system of the Carpathian Mountain Range in contact with the Bohemian Massif.

Outer Carpathian units were formed on a Variscan foreland in direct neighbourhood of the Bohemian Massif. During Late Paleogene and Miocene, thick Jurassic - Middle Miocene sedimentary cover was folded and thrusted over the southeastern margin of the North European Epivariscan Platform.

Two groups of nappes could have been distinguished on the basis of the lithofacies, structural development and tectonic style. The outer group consists of Pouzdřany, Ždánice, Subsilesian and Silesian Units (Nappes). The last one is formed also by thick Cretaceous sequence, lateral facies changes of which enabled recognition of three: Godula, Baška and Kelč developments.

Lower Cretaceous Těšín-Hradiště Formation (black shales with iron (pelosideritic) concretions, on the base with Berriasian allodapic limestones, and flysch-like alternating shales and clastics development) characterize the Silesian Basin. The formation containts famous Valanginian ammonite and belemnite fauna (**Uhlig** 1902). The upper part is rich in Barremian and Early Aptian ammonites, accompanied by bivalves and rests of terrestrial plants (**Uhlig** 1883, **Vašíček** 1972). Thick (above 1 km) sediments are penetrated by Lower Cretaceous bodies of the "teschenite" volcanics.

Stratigraphy of the Outer Flysch Carpathians (in the area discussed)

				SUBSILESIAN UNIT	SILESIAN UNIT		MAGURA FLYSCH
					BAŠKA FACIES	GODULA FACIES	RAČA UNIT
TERTIARY	PALEOGENE		Oligocene	Equivalents of Ždánice-Hustopeče Formation		Krosno Formation	
			Eocene	Menilitic Complex		Menilitic Complex	------?--------
				Frýdlant Formation		Submenilitic Complex	Zlín Formation
			Paleocene	Třinec Mb / Variegated Mb			Beloveža Fm
			Danian		----------		Soláň Formation
MESOZOIC	CRETACEOUS	L	Senonian	Frýdek Formation	Palkovice Formation	Istebna Formation	------?--------
		MID	Turonian	---------?---------	Baška Formation	Godula Formation variegated beds	
			Cenomanian			Lhoty Formation	
			Albian			Veřovice Fm	
		EARLY	Aptian		Chlebovice Facies	Těšín-Hradiště Formation	
			Barremian				
			Hauterivian				
			Valanginian			Těšín Limestone	
	Late Jurassic				-------?---------	---------?--------	

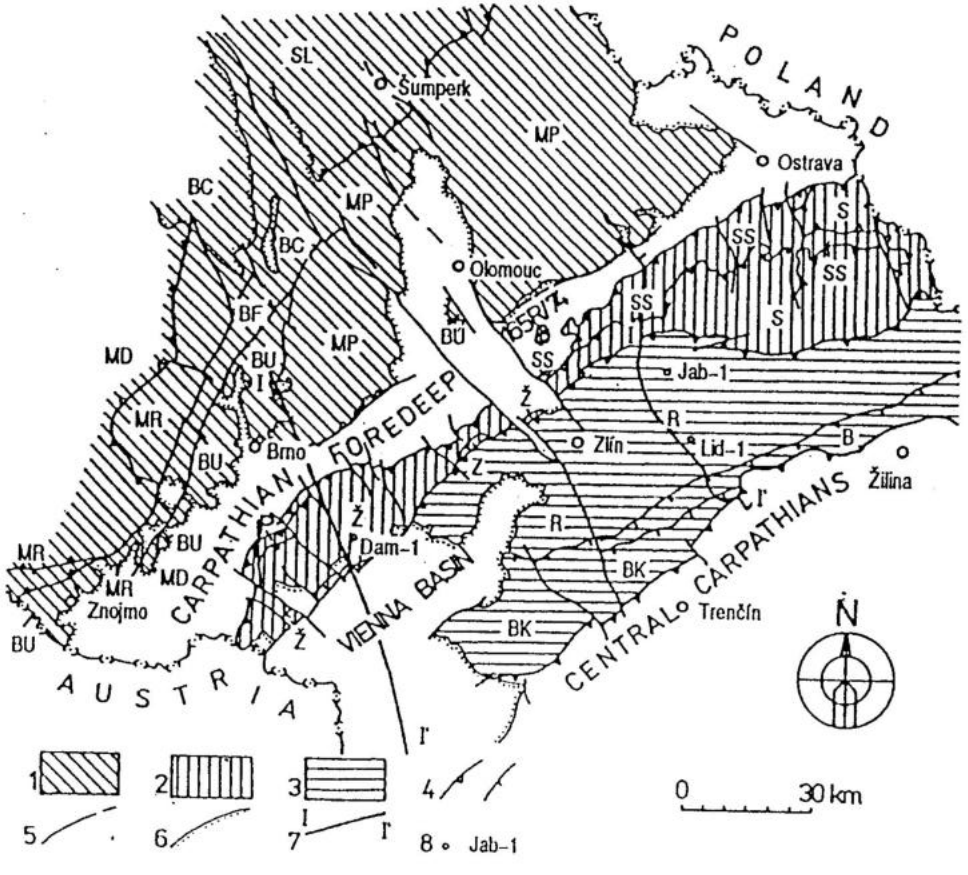


Fig. 1. Geological map of the contact between Bohemian Massif and Carpathians
1 – Bohemian Massif (BU – Brno unit, MR – Moravicum, SL – Silesicum, MD – Moldanubicum, MP – Moravo-Silesian Paleozoic, BF – Boskovice Graben, BC – Bohemian Cretaceous); *2* – Carpathian Flysch Belt, Outer units (P – Pouzdřany, Ž – Ždánice, SS – Subsilesian, S – Silesian, Z – Zdounky); *3* – Carpathian Flysch Belt, Magura group of the nappes (R – Rača unit, B – Bystrica unit, BK – Bílé Karpaty unit); *4* – Thrust faults; *5* – Fault; *6* – Transgression; *7* – Line of geological cross-sections; *8* – Deep borehole

Locality No.15

HORNÍ LÍŠTNÁ, near Třinec

The abandoned quarry in a valley near Horní Líštná village (near to Polish frontier, 2 km east of Třinec) exposes Berriasian Těšín Limestone. Thick to massive, often graded limestone beds contain intercalations of dark, yellowish weathering marls and local thin beds of sandstones and crumbling detritic marlstones.

Detrital limestone layers contain debris of oysters, brachiopods and other macrofaunal shells on their base. Reworked fragments of small gastropods, crinoid columnalia, echinoid spines, oysters and bryozoans are a common component of detritic marlstones, as well. On the other hand, only rare aptychi (*Lamellaptychus studeri* (Ooster)) can be found in claystone beds. Bifurcated traces of *Chondrites* Sternberk occur frequently on bedding planes of sandy intercalations.

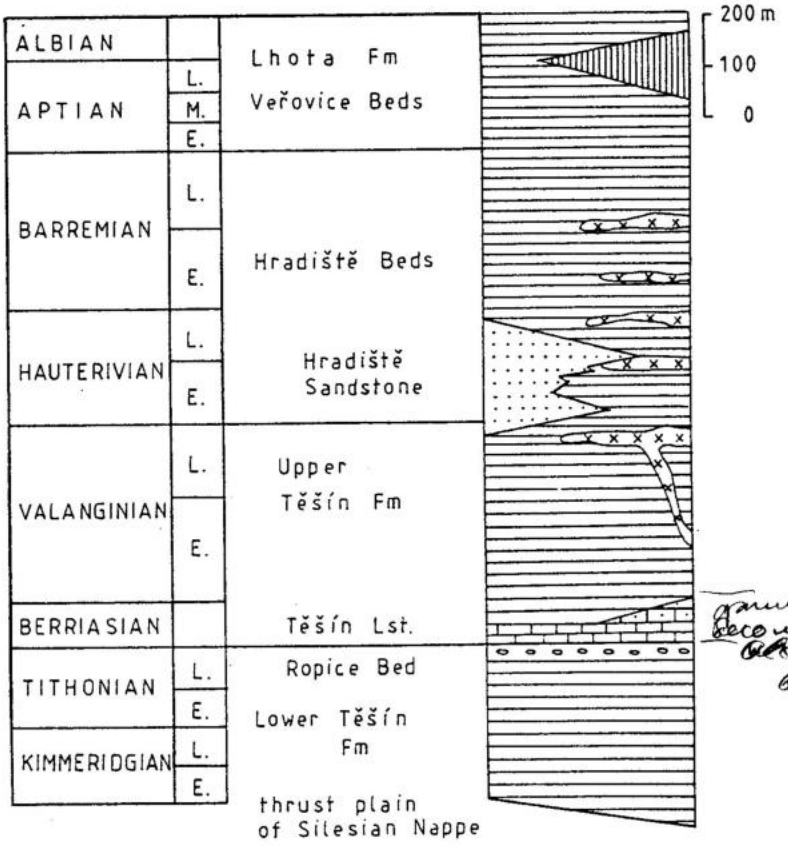
Locality No.16

BAŠKA, near Frýdek-Místek

Rocky bottom of the Ostravice River near the Baška village about 2 km south of Frýdek-Místek exposes higher (Upper Barremian) part of the Těšín- Hradiště Formation. Dark-grey marlstones and siltstones are penetrated and metamorphosed by intruding rocks of so-called těšínite association (here: těšínite pyroxenite). Mandelstones with cavity diameters up to 15 cm, filled by calcite, analcime and harmotome, occur locally near the contacts with the sediments.

Fig. 12

SILESIAN UNIT – GODULA DEVELOPMENT



The pelites contain seldom, frequently incomplete ammonite and small gastropod shells. According to P. Skupien, small collection from these beds comprises ammonites *Costidiscus rakusi* (Uhlig), *Partschiceras infundibulum* (D'Orbigny) and gastropod *Confusiscala* Boury.

Locality No.17

OSTRAVICE, near Frýdlant

The Ostravice River channel near the Ostravice village (about 4 km SE of Frýdlant upon Ostravice) cut Lower Cretaceous (?Hauterivian, Aptian - Albian) formations of the Silesian nappe with the contact with the Maastrichtian deposits of the deeper, i.e. Subsilesian nappe.

The Maastrichtian Frýdek Formation represents the lowermost (the only preserved here) part of the Subsilesian nappe. It is built of grey calcareous claystones with light mica and frequent intercalated laminae- up to thin beds (4 cm) of fine to medium - grained sandstones. The sequence yielded a poor assemblage with *Rugoglobigerina rugosa* (PLUM.), *Globigerina cretacea* (D'ORB.), *Bathysiphon* sp.

The Silesian nappe is represented by the partial (Godula) slice. The contact of both the units is accompanied by lensoidal tectonic breccia zone, up to 2 m thick. Lower part of the unit is built of Aptian (60 m thick) part of the Těšín - Hradiště Formation. It consists of claystone sequence more or less regularly alternating with sandstone beds. Dark grey- to black calcareous claystones are up to several tens of cm thick.

Subsilesian Nappe (left) thrust by the Silesian Nappe Unit
along the right bank of the Ostravice River

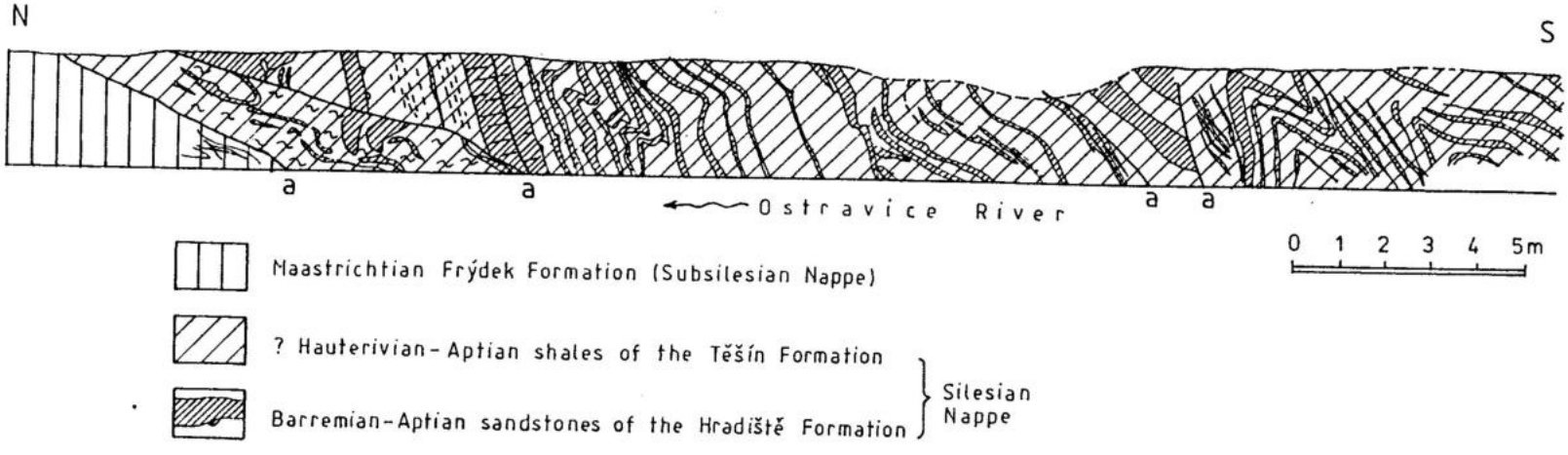


Fig. 13

Medium to coarse-grained (greywackeous) calcareous sandstones are thickly (even more than 1 m) bedded. Siltstones form occasional corrugated laminae. Lower bedding planes of sandstone layers are covered with numerous flute cast and load casts. The sediments can be classified as distal turbidites deposited in a reducing alkaline enviroment. Pelites yield radiolarians and foraminifers. Rare ammonites have been found in other localities. The frequence of sandstone intercalations diminishes upwards up to passage into dark non-calcareous pelites (Veřovice Member) and Albian spotted pelites (Lhoty Formation) and successively into Cenomanian variegated pelites of the Godula Formation. The Mesozoic complexes are covered by Lower Holocene river gravels.

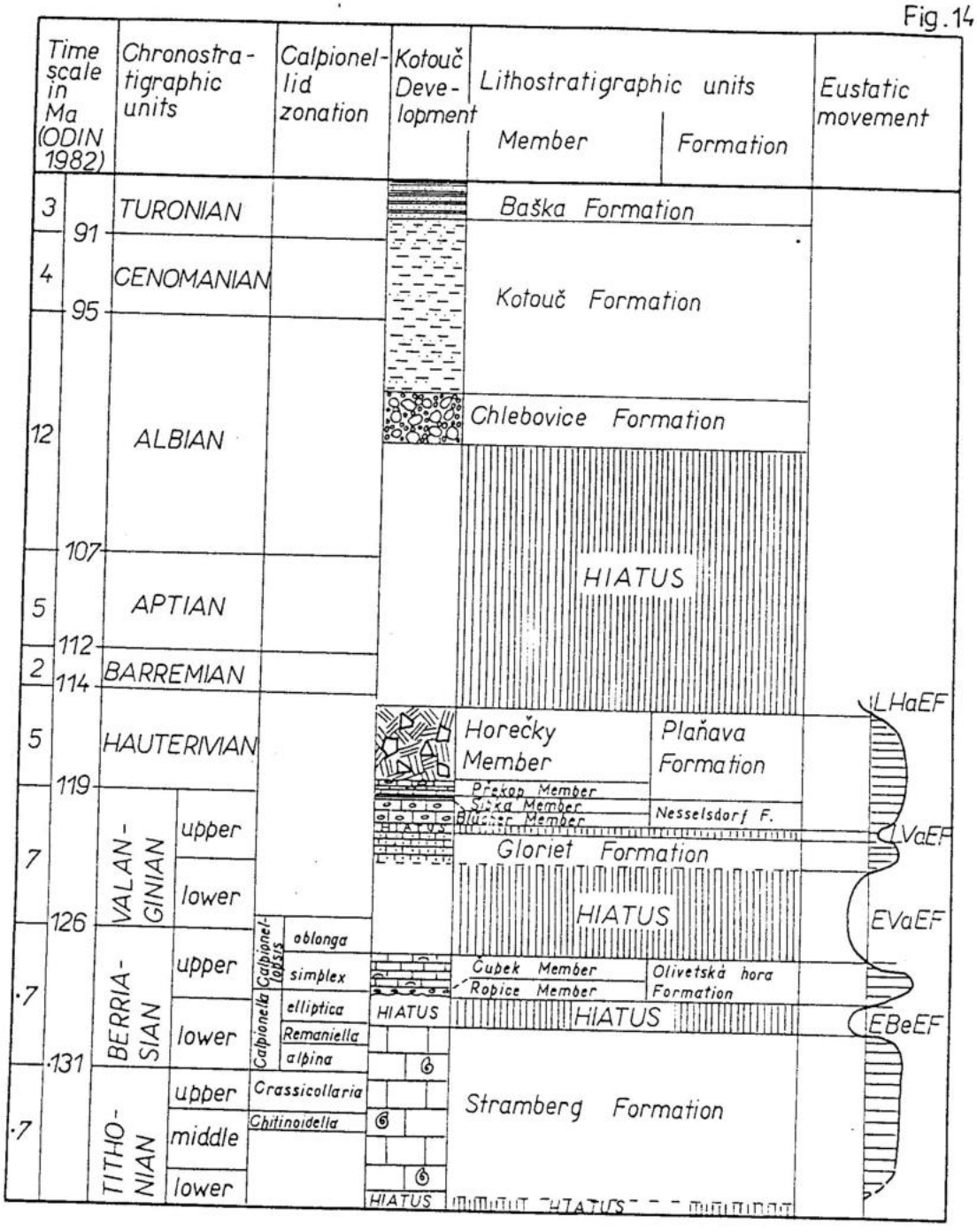
Locality No. 18

ŠTRAMBERK near Kopřivnice

In the nearest vicinity of Štramberk, several tectonic bodies of Tithonian and Berriasian limestones (Štramberk and Olivetská hora Formations) protrude through the flysh envelope. Various younger (Valanginian up to Cenomanian) rocks, which are connected genetically with the limestone bodies, are preserved on the surface and/or penetrate into deep fissures (forming sedimentary dykes or infillings of carst cavities) of these limestone bodies.

The limestone bodies form three main morphological units in the vicinity of Štramberk, which are: Trúba (Castle Hill), Skalky and Kotouč (Ölberg). Each of them is exposed by one or several abandoned quarries. Only the Kotouč hill quarry is still working. We shall visit its 6th floor, where 600 m long profile through the Stramberg limestone was studied both magnetostratigraphically and biostratigraphically by **Houša, Krs, Krsová** and **Pruner**.

Fig. 14



Stratigraphical scheme of the Tithonian and Lower Cretaceous beds of the Kotouč development on the top part of the Baška elevation in the Štramberk section.

EBeEF - early Berriasian eustatic fall
EVaEF - early Valanginian eustatic fall
LVaEF - late Valanginian eustatic fall
LHaEF - late Hauterivian eustatic fall

The Stramberg Limestone is mostly grey, light to whitish-grey, biofragmental to micrito-biofragmental one. It consists of layers, lenses or nests of detritus of different grain size, mostly about 0,5 to 1 mm. The layers of coarse detritus composed mainly of shells of diceratids, corallites or their fragments or the clasts of biofragmental Stramberg limestone occurs frequently. Boulders and clasts of the Stramberg limestone are infrequent.

The composition of fauna, i.e. numerous remains of hermatypical *Scleractinia*, the majority of thick-shelled bivalves of diceratids and many species that belong to other faunal groups suggest biohermal origin of the Stramberg Limestone. Its lithology reveal that the majority of sediments belong to talus of reef organisms which was acumulated in the vicinity of the bioherms.

The Stramberg limestone is massive, without visible traces of its original stratification. Relatively frequent layers of debris of various grain-size were ascertained on the fresh broken walls of the quarry Kotouč only. The orientation of these layers correspond to the stratification ascertained in the of cavity fillings of organic shells, in the fillings of primary sedimentary cavities in the Stramberg limestone and also with the boundaries of calpionellid biozones ascertained in the limestone bodies.

The Stramberg limestone is famous especially in its rich macrofauna described in classic monographies of **Oppel**, **Zittel**, **Bohem**, **Ogilvie**, **Remeš**, **Blaschke** and others. However, there is hardly possible to find in Štramberk well preserved Tithonian fossils today. All the shells and skeletons break across in the fresh rock in quarries. The majority of classic Stramberg fauna, especially ammonites) were collected in abandoned Castle Quarry, where moderately altered superficial parts of these limestones

were quarried. The fauna described by **Blaschke** from the old Guttman's quarry, which was opened in the oldest part of the Kotouč limestone body, represents a similar case.

Calpionellids are present in all main bodies of the Stramberg Limestone. According to their occurrence, the Stramberg limestone may be divided into two parts: younger one, containing calpionellids of the *Chitinoidella-* (youngest middle Tithonian), *Crassicollaria-* (late Tithonian) and *Calpionella* (early Berriasian) Zones, and the older one, in which calpionellids are absent. Early Tithonian index species of microfauna (**Řehánek**, personal communications) was ascertained in the this older part, and even the latest Kimmeridgian microfauna (**Houša and Řehánek** 199.) was proved in several boulders of Stramberg limestone. This older part of Stramberg limestone in the Kotouč quarry is 350 m thick.

The *Chitinoidella* Zone is the oldest calpionellid zone determined in the Stramberg limestone. Its latest part, which represents the acme of *Chitinoidella boneti*, is very well expressed, having a thickness from 20 to 50 m.

The standard *Crassicollaria* Zone is well developed in the Kotouč body reaching a thickness of 140 m.

The *Calpionella* Zone is the youngest calpionellid zone in the Stramberg Limestone. The provisional Jurassic/Cretaceous boundary in the Tethyan Region is situated at the base of the *Pseudosubplanites euxinus* Zone (i.e. former Jacobi-Grandis Zone), which is considered as identical with the base of the *Calpionella* Standard Zone. Therefore the *Calpionella* Zone belongs to the earliest Berriasian. This boundary is discernible in the Stramberg Limestone only on the basis of calpionellids. No other change (e.g. lithological or paleontological) is here perceptible. The Stramberg

limestone representing the Calpionella Zone reaches about 200 m thickness. This zone is represented by its older Alpina Subzone and by the middle Remaniella Subzone only. The latest Elliptica Subzone has not been estimated, its time span probably represents a short gap (so called early Berriasian eustatic fall of **Hoedemaeker**) expressed by conglomeratic parts in limestones of the Olivetská hora Formation.

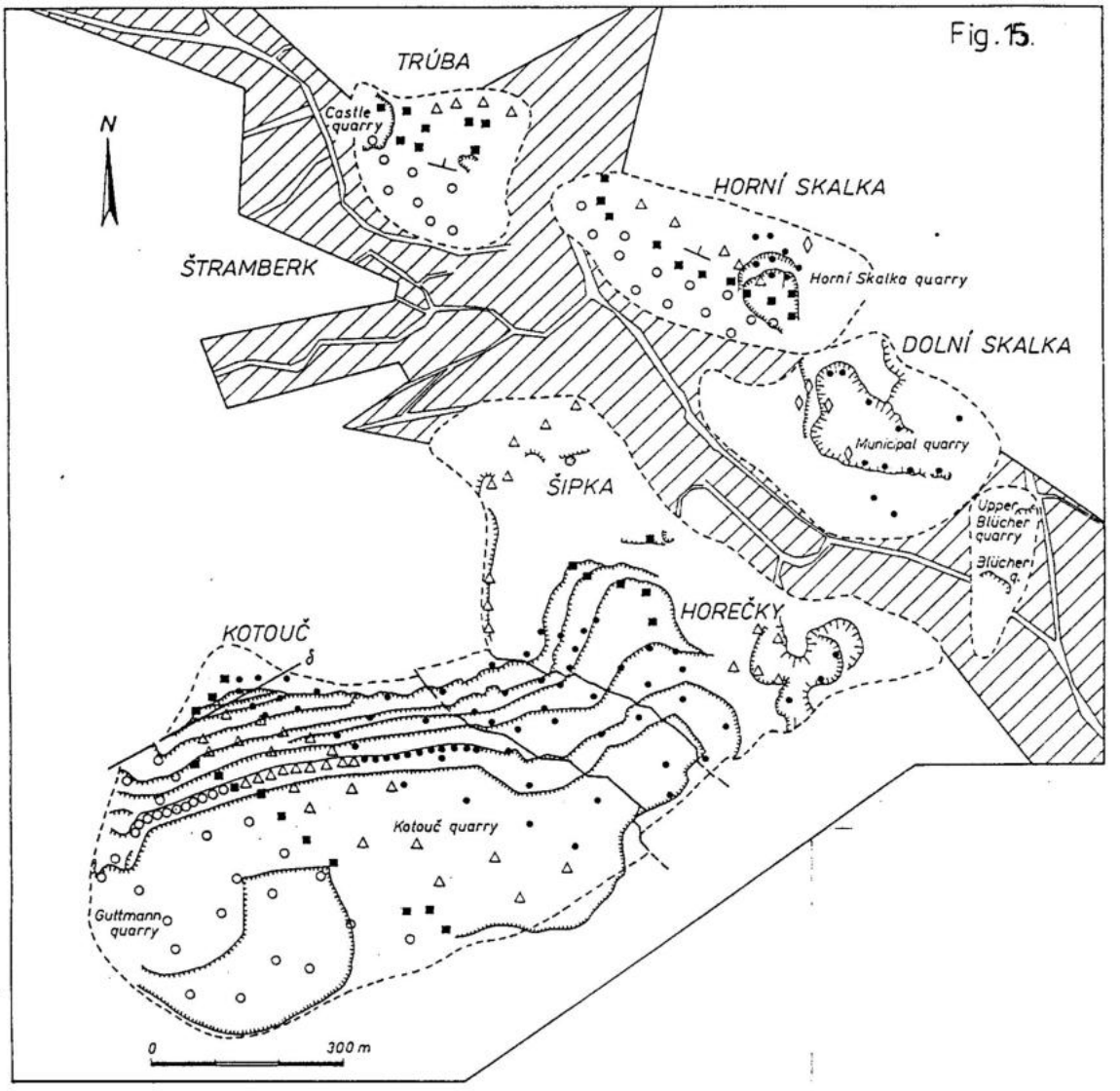
The magnetostratigraphic profile at the 6th level of the Kotouč quarry starts in the section of the Stramberg limestone without calpionelids, i.e in the middle Tithonian. The position of acme of *Chitinoidella boneti* (latest Middle Tithonian) identifies with confidence the normal interval of M 20. Therefore the reverse interval below it is interpreted as reverse part of the M 20. The complete older magnetozone on the basis of the profile is most probably M 21. The first (oldest) sample of the profil studied shows the sure normal paleomagnetization and therefore it is not excluded, it may represent the youngest part of normal interval of M 22.

In the very long normaly magnetized interval in the central part of the profile studied lie two important biostratigraphical horizons, which caracterize two different magnetozones. One is The acme of *Chitinoidella* (latest middle Tithonian) represents the first one, which identifies, as mentioned above, the normaly magnetized interval of M 20 and in the profile studied. It is situated in the older part of this long normaly magnetized interval. Stratigraphically above it, an another important biohorizon occurs, which is represented by the boundary between both the *Crassicollaria* and *Calpionella* Zones, i.e. provisional J/C boundary. This horizon, as we know from other localities, lies in normal interval of M 19. As both biohorizons mentioned lie in the profile studied in one long normaly magnetized interval, it is

therefore necesary to interpret this long interval as united normal intervals of M 19 and M 20. The reverse interval of M 19, which necessarily must exist between M 19n and M 20n, is missing or is represented in very reduced form (by 1 sample only in the nearest vicinity of calpionellid sample site KV-1446).

A prominent reverse interval, which we interprete as the reverse interval of M 18, is situated in the Berriasian part of the profile studied. It is followed by normal interval of this zone, to which the latest samples of the profile are related. The inverse interval of M 17 is not proved.

The Olivetská hora Limestone occurs in situ in the Skalky bodies. Elsewhere, it forms filling of fissures only. It is represented by grey to grey-green or reddish-brown micritic to biofragmental limestones, which contain very often clasts of the Stramberg limestone. Its calpionellid fauna gives evidence of the end of the *Calpionella* Zone (*Elliptica* Subzone) and to Standard *Calpionellopsis* Zone (the *Simplex* Subzone only). *Calpionellopsis oblonga* has so far been recovered neither in the apparently youngest parts of the Čupek Limestone nor in pebbles of this limestone in younger formations.



Scheme of occurrence of calpionellid zones in individual bodies of the Stramberg Limestone in the vicinity of Štramberk.

- ○ - limestone without calpionellids (Middle Tithonian and older)
- ■ - acme of *Chitinoidella boneti*
- △ - standard *Crassicollaria* Zone
- • - standard *Calpionella* Zone
- ◊ - principal occurrences of *Calpionellopsis simplex*

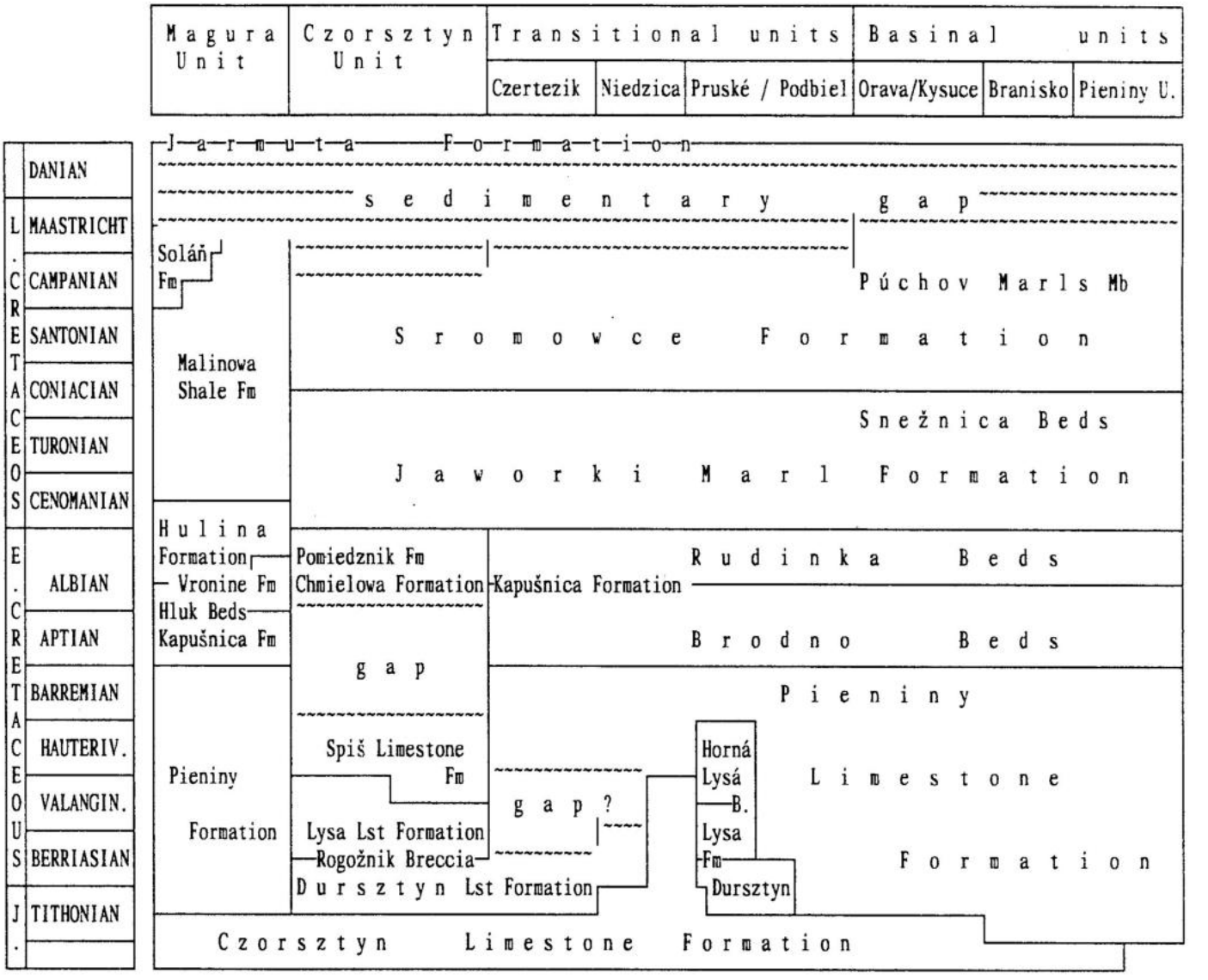
4th day:
WEST CARPATHIAN PALEOALPINE ACCRETIONARY BELT

Since the beginning of shortening in the Penninic area by gradual convergence of the Alpine - Carpathian microcontinent, the subduction zone between them was the site of tectonic accumulation of obducted sedimentary prisms. These masses comprised sedimentary cover of deep oceanic bottom, fan and slope deposits of adjacent elevations, as well as detached small intraoceanic ridges. Olistostromes and frontal slices of superficial nappes were incorporated into this complex during Alpine - Carpathian tectogenesis. During peak of tectonic shortening, the border of North European shelf turned into zone of superposed tectonic slices. Moreover, as the collision in this Alpidic segment was of "Californian type" (connected with oblique left-lateral strike slip movement), these slices formed in a zone of lateral shear.

This was a cause of origin of the Pieniny Klippen Belt - more than 600 km long zone of sheared subvertically dipping slices of Jurassic and Cretaceous sedimentary rocks surrounded by Upper Cretaceous shales.

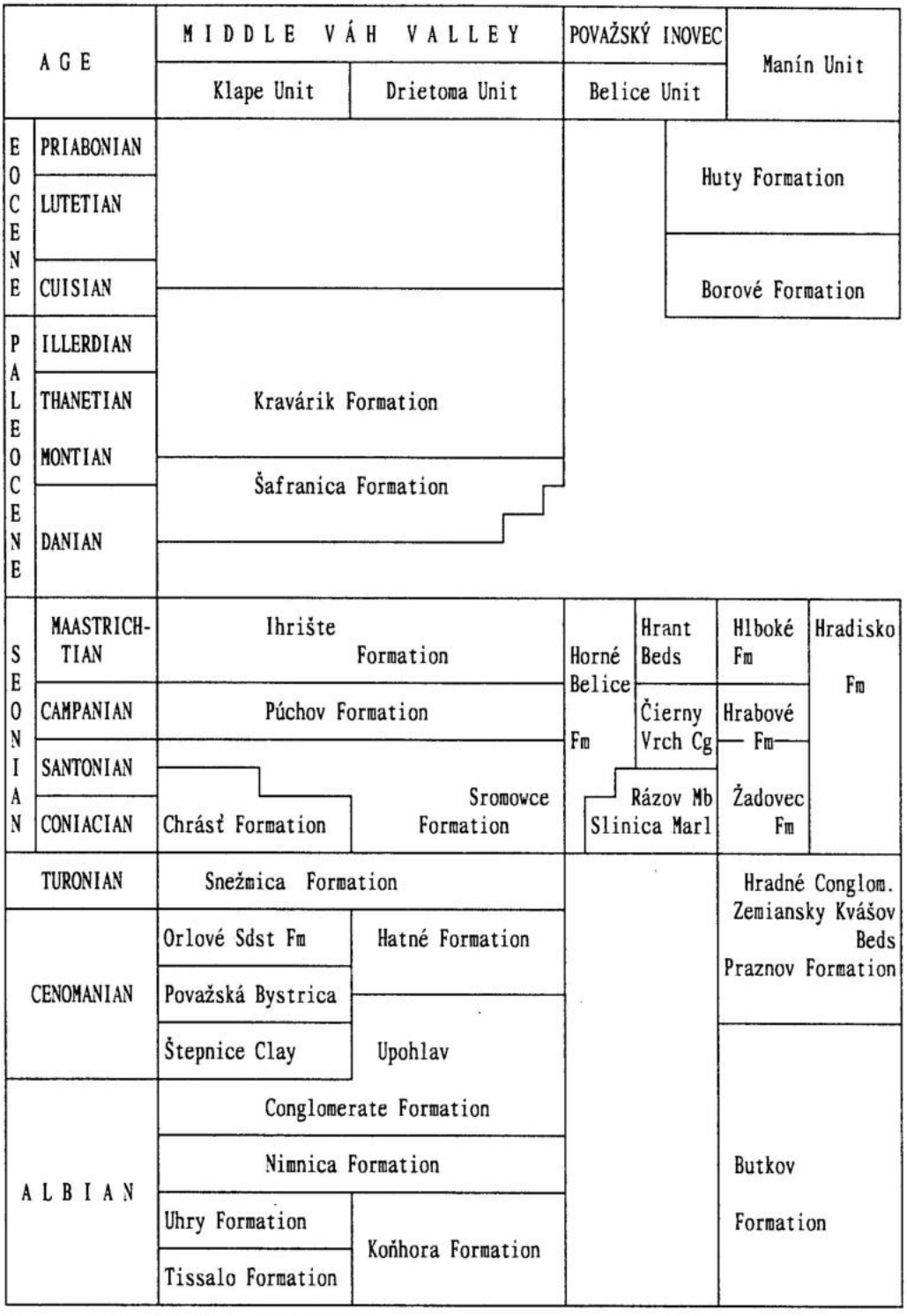
The zone reflects Late Cretaceous - Early Tertiary processes along the Paleoalpine suture (**Maheľ** 1980). The course of this belt is more - less congruent with the sudden change in thickness of the crust ("Peri - Pieninic Lineament") indicated by geophysical methods (**Plašienka** et al., 1991).

Lithostratigraphic division of the Cretaceous sequence of the Pieniny Klippen Belt



The Pieniny Klippen Belt consists of sedimentary products which have arisen in several paleogeographic units of ridge-and-basin system at the margin of the European Plate. The most important representative of the basinal sequences visited during our excursion will be the Kysuca Unit (similar to the Pieniny and Branisko Units), while the Czorsztyn Unit is a typical representative of the ridge sequence. Several transitional sequences were described comprising the Pruské-, Podbiel-, Orava-, Czertezik- and the Niedzica Unit.

The Peri-Klippen Belt comprises mostly Middle and Upper Cretaceous flysch like sequences with olistostromes and tectonic bodies of older rocks. The most typical element of this zone is formed by the Klape Unit. The Manín Unit has a more problematic position due to more-less continual transition of Jurassic and Lower Cretaceous sequence into younger flyschoid sediments. This is the argument for supposition of "home-position" of this unit in the Periklippen Zone prior to Mid Cretaceous. However, other authors suppose that Middle and Upper Cretaceous sediments were laid down on mobile substrate during- and post Austrian transport of this unit from more southern zones.



Lithostratigraphic division of the Middle Cretaceous - Lower Paleogene sequences in the western part of the Accretionary Belt of the Central Vestern Carpathians

Locality No. 19

POVAŽSKÝ CHLMEC near Žilina

On the right side of the Kysuca River bed, the road escarpment near Považský Chlmec - Vranie exposes the flysch sequence of the Pieniny Unit of the Klippen Belt. The sequence is divided into two formations.

The lower, 100 - 400 m thick part, called as the Jaworki Formation consists of sandstones (its thickness is 5 - 60 cm), pelites and aleurites (with the beds up 1 to 40 cm thick), in which Ta intervals of the Bouma's cycle are frequent, as well as of the coarser non-structured layers. Tb and Tc intervals are frequently visible into the marl sequence of the section. **Marschalko** (1986) supposed that the turbidites of the Snežnica Member belonged to the C and D facies of the middle and outer part of the fan. Its Turonian age is proved by foraminifers.

The upper part of sequence belonging to the Sromowce Formation contains Coniacian to Santonian polymict conglomerate layers with inverse gradation. Their thickness is 2-12 m. Conglomerates belong to simmictites, slumps and olistostromes, proving unsteady slope conditions during the source zone extinction. According to **Marschalko** (1.c), the conglomerate flysch sequence belongs to the upper part of the fan. Considerable lenght of the lithosome points to conclusion that the material of the fan was transported through a large canyon. Conglomerates contain occasionaly calcarenite pebbles and blocks of the Orlové Sandstone Formation with *Rhynchostreon suborbiculatum* (previously named as *Exogyra columba silicea)* as well as the small lithoclasts of the Albian marls. It proves that not only the hypothetic Andrusov Ridge, but uplifted

sedimentary complex of the Klape Unit was eroded at the beginning of the Late Cretaceous as well.

Carbonate pebbles dominate, they present about 45 - 50 % of the conglomerate material. **Mišík & Sýkora** (1981) distinguished: pebbles of Triassic dolomites, Middle and Upper Triassic Wetterstein Limestone, Carnian algal limestones, Liassic sponge limestones, Upper Jurassic shallow marine limestones with *Protopeneroplis striata, Conicospirillina basiliensis, Cladocoropsis mirabilis, Clypeina jurassica*, and shallow marine limestones with *Orbitolina* sp.

Acid and intermedial volcanites are abundant (33 - 35 %), too. Paleorhyolites and porphyric paleoandesites (with large crystals of plagioclases) are typical for the Považský Chlmec area.

Clastic rocks (sandstones, quartzites, conglomerates) represent about 15 %, while the intrusive rocks (mostly subvolcanic facies of the rocks mentioned above) attain 5 % of the sediment volume. Metamorphic rocks, quartzite metaconglomerates, quartzites and vein quartz are rare (3 %).

Locality No. 20

ORLOVÉ near Považská Bystrica

Thick (200-700 m) body of massive sandstones containing Cenomanian oyster coquinas (*Rhynchostreon suborbiculatum*

(Lamarck) incorporated in a huge sequence of Upper Cretaceous flysch is an example of unexplained geological paradox for almost two hundred years.

The locality in the forest path below the Považský Hrad castle ruine exposes the upper part of this lithostratigraphical unit called as the Orlové Sandstone by **D. Štúr** (1860).

Sedimentological, lithological and biostratigraphical research (**Marschalko & Samuel**, 1980) showed that the Orlové Sandstone represent various genetic types with different stratigraphic position. Great part of the sandstones display a flysch character and are Middle and Upper Albian in age, whereas the other part of the sandstones are turbidites formed in submarine fans of deep sea plains. On the other hand, the beds with accumulations of oysters possess typical shallow water sedimentary structures. **Marschalko & Kysela** (1980) regarded this shallow marine event as a typical phenomenon of the Klape Unit development.

Fig.16

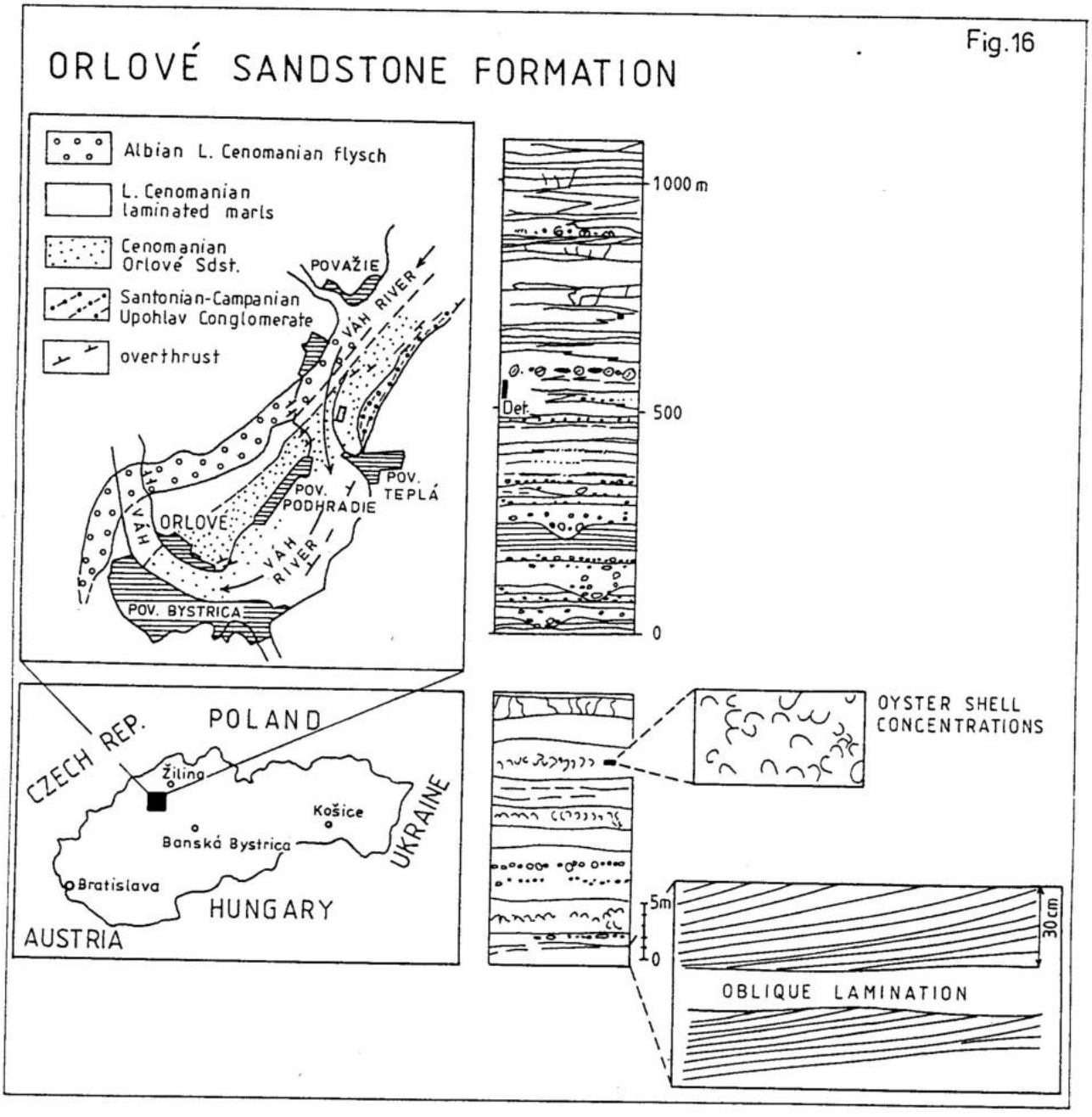
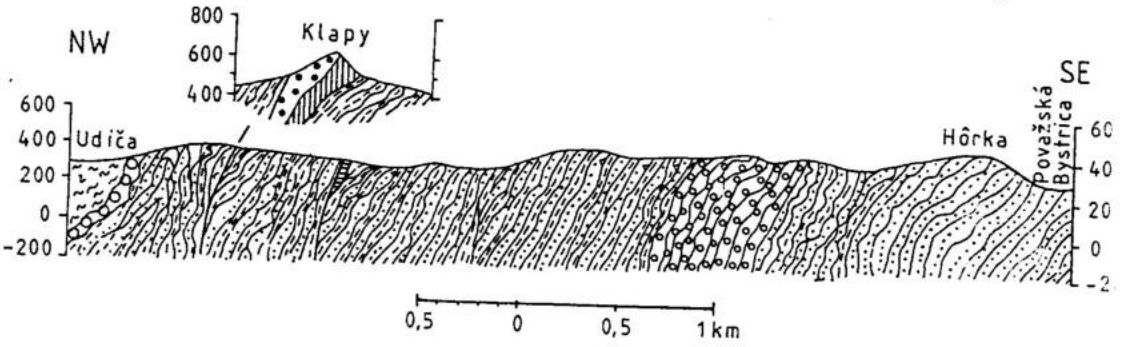
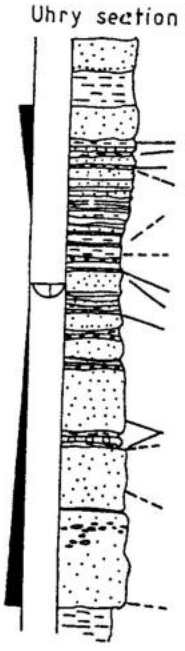

ORLOVÉ SANDSTONE FORMATION
Albian L. Cenomanian flysch
L. Cenomanian laminated marls
Cenomanian Orlové Sdst.
Santonian-Campanian Upohlav Conglomerate
overthrust
POVAŽIE
VÁH RIVER
ORLOVE
POV. PODHRADIE
POV. TEPLÁ
POV. BYSTRICA
1000 m
Det.
500
0
CZECH REP.
POLAND
UKRAINE
HUNGARY
AUSTRIA
Žilina
Košice
Banská Bystrica
Bratislava
OYSTER SHELL CONCENTRATIONS
5m
0
30 cm
OBLIQUE LAMINATION

Fig. 17





Santonian - Campanian variegated marls

Coniacian conglomerates

Midlle / Upper Cenomanian Orlové Sandstone

Lower Cenomanian flysh

Upper Albian exotic conglomerates

Albian flysh

Jurassic crinoidal limestones

Lias cherty crinoidal limestones

Lower Cretaceous marly limestones

Dogger spotted limestones

thrusts

bed dipping

Locality No. 21

UHRY near the Púchov Dam

The road cut between Udiča and Orlové - Považská Bystrice at the shore of the Nosice dam lake exposes mid Cretaceous flysch sequence with olistolites of Jurassic shallow- water limestones.

Albian - Lower Cenomanian conglomerate flysch sequence consists of blue - gray to yellowish gray, medium grained- to coarse grained calcareous sandstones. They belong to the lithic sandstones according to their modal composition. The sandstone layers alternate with blue gray and greenish calcareous claystone intercalations. Thicker sandstone beds contain dispersed marlstone intraclasts, without any (or only rare) indications of gradation. On the other hand, the base of thinner sandstone beds with well developed flute - casts is graded, higher-up being followed by parallel- and cross - bedded intervals.

The pelites and aleurites contain Albian ammonites and belemnites comprising *Phylloceras (Holcophylloceras) sp.*, *Puzosia sp.*, *Kosmatella sp.*, *Neohibolites sp.*, as well as foraminiferal microfauna (*Hedbergella sp.*, *Ticinella* ex gr. *roberti*).

The successive member of the sequence is the Nimnica Formation. It is followed by the Upohlav Conglomerate Formation containing fine- to coarse conglomerate layers alternating with calcareous sandstones and claystones. The pebbles derived from Triassic - to Lower Cretaceous sequences consist of clastic rocks (19 - 29 %), limestones (42 - 48 %), dolomites (8 - 11 %), cherts (1 - 3 %), igneus and metamorphic rocks (6 - 10 %). Transport direction was from S - SE to NW (in present orientation). Both

the Upper Albian formations, similarly as the successive Cenomanian Štepnica Clay and the Považská Bystrica Formation, were deposited in deep-marine clastic fans. In contrast, the shallow water origin of higher-lying Upper Cenomanian Orlové Sandstone is supported by the occurrence of oyster (*Rhynchostreon suborbiculatum)* biostromes.

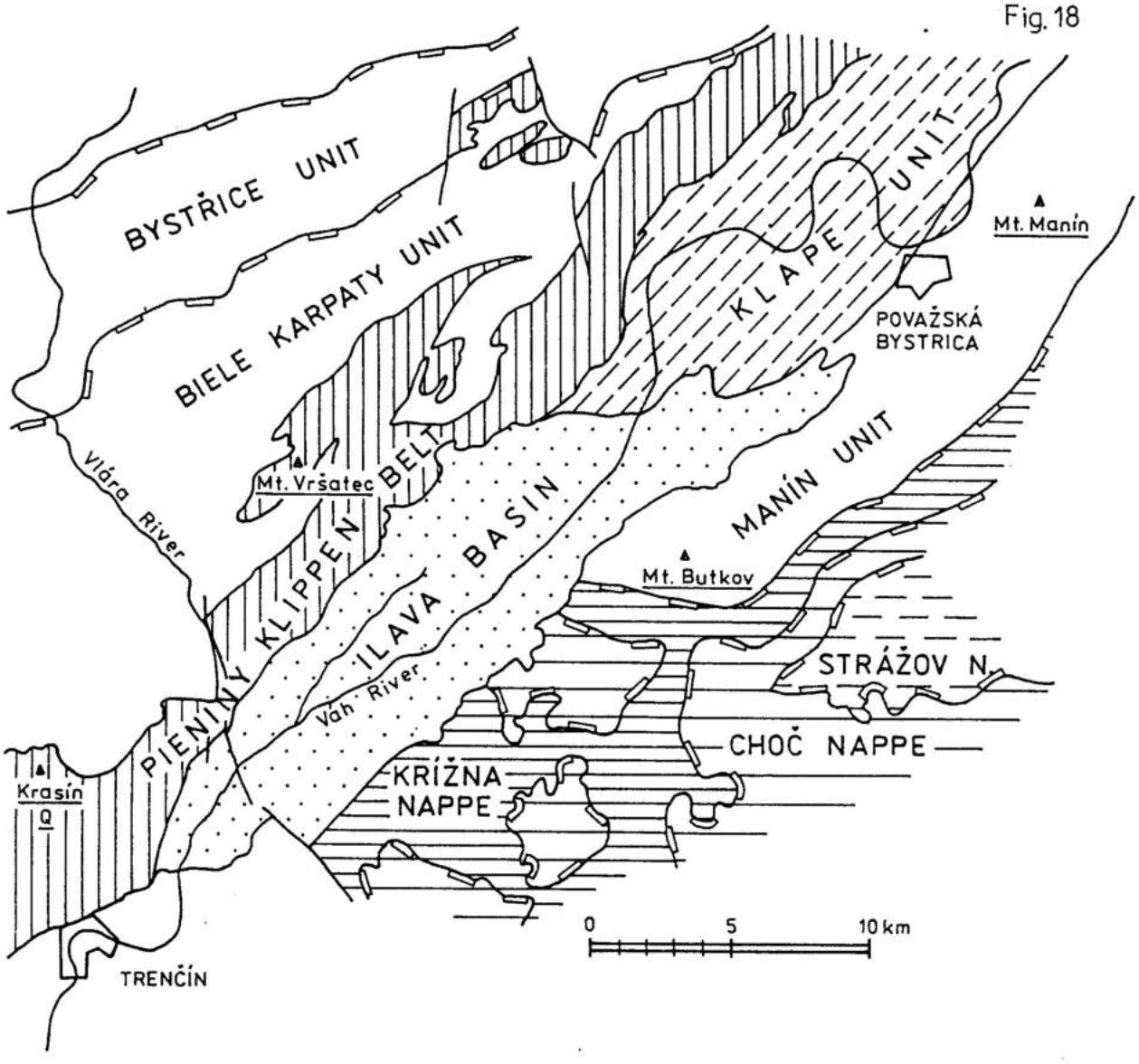
Locality No. 22

VRŠATEC

The castle rock of the Vršatec mountain group (7 km NW from Pruské in the middle Váh Valley) belongs to the threshold-type Czorsztyn Succession. It is characterized by Middle- to Upper Jurassic crinoidal- (Smolegowa- and Krupianka Formations) and Ammonitico Rosso (Niedzica- and Czorsztyn Formations) limestones with Oxfordian reef development (Vršatec Limestone), followed by shallow marine Lower Cretaceous deposits. The succession is penetrated by numerous (Oxfordian, Albian) fissure fillings.

On the other hand, the neighbouring row of klippes exposes more pelagic succession, represented by green radiolarites of the Czajakowa Formation, Lower Tithonian - Upper Berriasian Ammonitico Rosso (Upszar Limestone of the Czorsztyn Formation) and Valanginian - Lower Barremian limestones of the Horná Lysá Formation. The last unit consists of well bedded (5-20 cm) light gray (rarely rose- to violetish red) micritic limestones with dispersed crinoidal ossicles and small lithoclasts. Black and brown nodular cherts occur in upper part of the sequence. Berriasian brachiopods were found in the lower part, while radiolarian association indicate the Hauterivian (to Early Barremian ?) age of the topmost part of the sequence.

Fig. 18


BYSTŘICE UNIT
BIELE KARPATY UNIT
KLAPE UNIT
Mt. Manín
POVAŽSKÁ BYSTRICA
Mt. Vršatec
Váh River
PIENINY KLIPPEN BELT
ILAVA BASIN
MANÍN UNIT
Mt. Butkov
STRÁŽOV N.
CHOČ NAPPE
KRÍŽNA NAPPE
Krasín
Q
TRENČÍN
0
5
10 km

Locality No. 23

KRASÍN QUARRY, Horná Súča

Abandoned quarry in the Krasín Hill above the Horná Súča village exposes shallow water complex of Jurassic crinoidal limestones belonging to the Czorsztyn Unit. It is penetrated by system of Lower Cretaceous dykes filled by Berriasian to Hauterivian sediments.

Bajocian white crinoidal limestones of the Smolegowa Formation with *Teloceras* ex gr. *blagdeni* represent the oldest exposed part of the sequence.

They are followed by Bathonian and Callovian Krupianka Formation formed by grey pink and red brecciated crinoidal limestones. It locally attains character of cliff- breccia with clasts of crinoidal limestones of various colours and structures, up to 1 m in diameter. Frequent laminated void fillings and neptunic dykes are filled with synchronneous red micrite. Hard - grounds has been observed at point 7.

Bathonian - Callovian member of the Krupianka Formation consisting of grey and red fine grained crinoidal limestones with brown chert nodules crops out in small old quarry.

Red and rose-red crinoidal limestones with small fragments of white micritic limestones (Dursztyn Formation) is late Berriasian - late Valanginian in age (points 4,6, between 7-8, 8, 17-18 and 20). They fill three deep fractures (splits). The rock is very similar to those of the Middle Jurassic Krupianka Formation. However, according to microscopic observation, crinoidal

ossicles limited by microstylolites possess abundant pressure-twinning lamellae which are mostly absent in mid Jurassic rocks. Dolomite clasts are more abundant. Larger and fragmented grains of clastic quartz, phosphatic intraclasts, and, especially, lithoclasts of biomicrite with *Crassicollaria* and *Calpionella alpina* are present almost in all thin sections. Besides them, fragments of Kimmeridgian - Lower Tithonian *Saccocoma* limestones and Oxfordian (?) filament limestones were found.

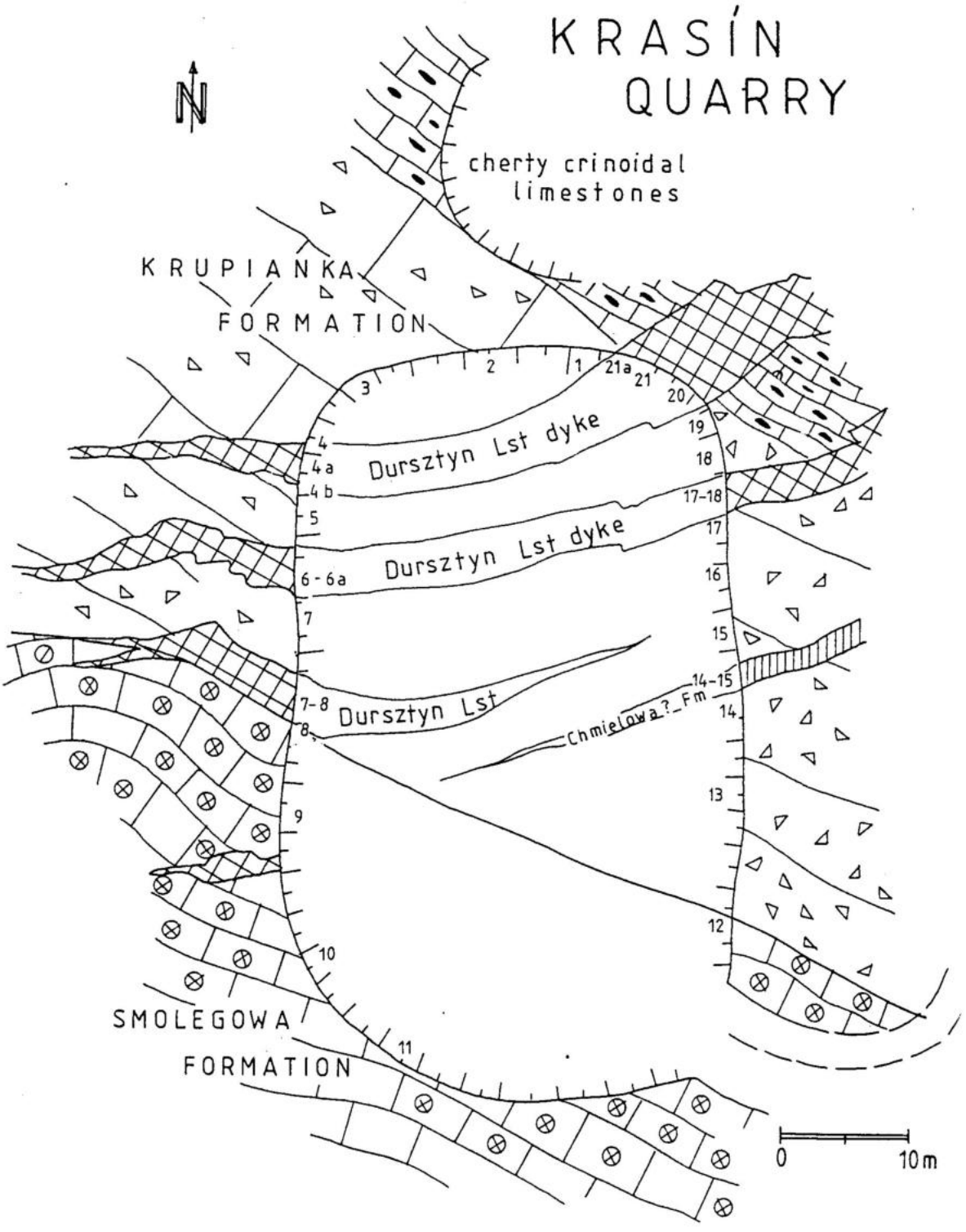
Heavy mineral association from the Lower Cretaceous Dursztyn Fm

garnet.....58 %	staurolite.....1 %
zircone.....15 %	titanite.....1 %
rutile.....15 %	apatite.....++
tourmaline.....10 %	

Dyke filled by red fine-grained biodetrital limestones (in red marly shales) with Hedbergella - echinoderm microfacies occurs between point 14-15 only. This lithotype determined as Hauterivian by **Mišík** et al. (in press) is similar to the Chmielowa Formation.

From the standard Czorsztyn Succession, the Krasín Klippe sequence differs by the presence of Dogger scarp breccias, and by the erosion of Upper Jurassic strata, as well. Mid Jurassic to Early Cretaceous synsedimentary faulting lead to the scarp breccia formation and, later, to the origin of Lower Cretaceous neptunian dykes penetrating the mid Jurassic limestone basement.

Fig. 19


KRASÍN
QUARRY
N
cherty crinoidal
limestones
KRUPIANKA
FORMATION
Dursztyn Lst dyke
Dursztyn Lst dyke
Dursztyn Lst
Chmielowa? Fm
SMOLEGOWA
FORMATION
1
2
3
4
4a
4b
5
6-6a
7
7-8
8
9
10
11
12
13
14
14-15
15
16
17
17-18
18
19
20
21
21a
0
10m

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