Field Trip D

TRIASSIC OF THE WEST CARPATHIANS

By

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with 7 figures

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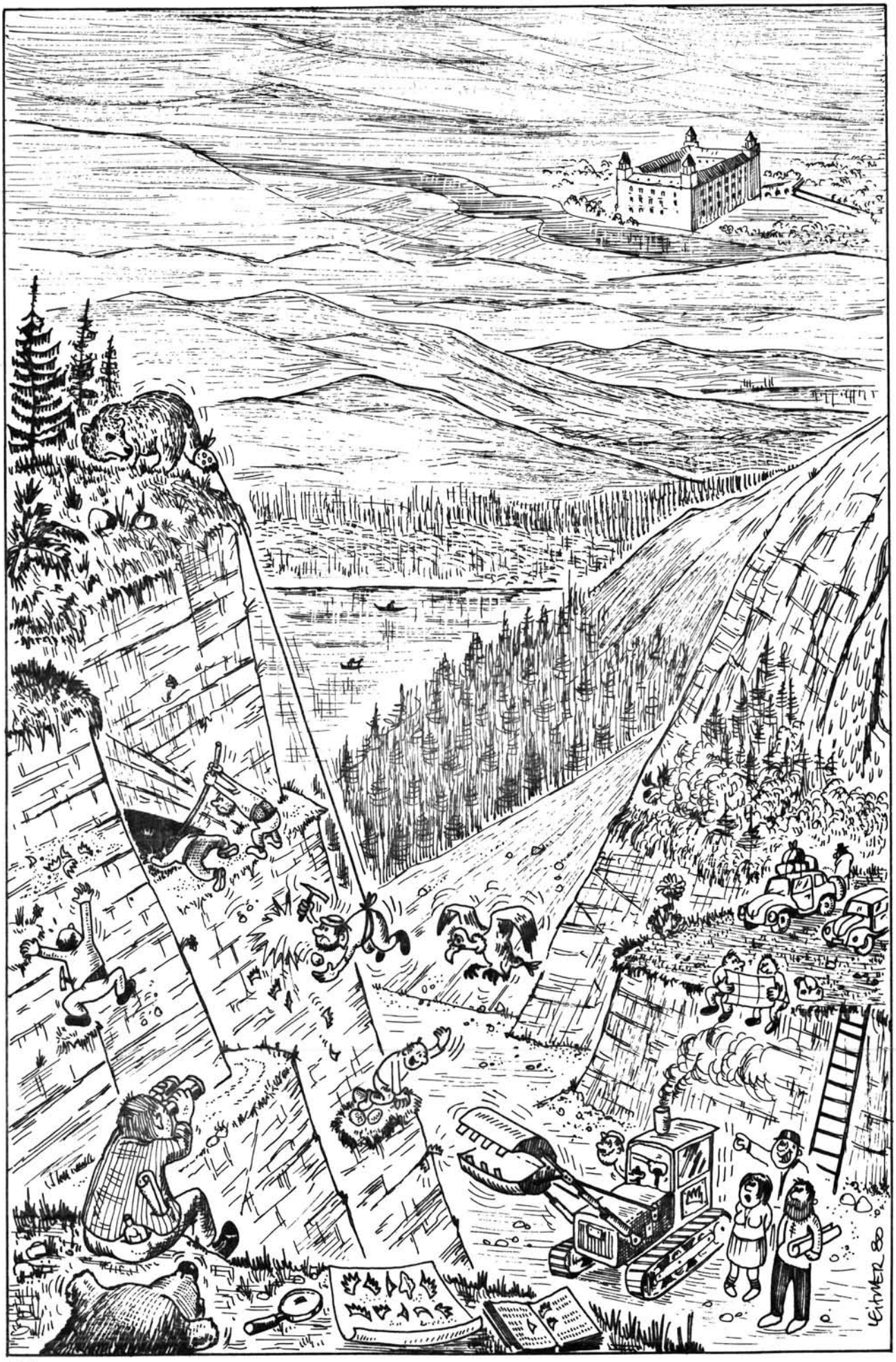

Introduction

On the occasion of the Second European Conodont Symposium (ECOS II) – organized jointly by the Geological Survey of Austria and the Geological Survey of Czechoslovakia one of the excursion (Excursion D) will take us to Slovakia.

Purpose of this excursion is visiting several typical Triassic localities, rich in conodonts, and localities where, just with the aid of conodonts, a precise stratigraphic ranging was made possible for the first time.

In Slovakia, and in the West Carpathians in general, thus also in the regions of the Polish Tatra and Northern Hungary, we could, by means of conodonts, attain convincing advances during the last ten years. Some of the stratigraphic data obtained on their grounds constituted a break-through in the true sense of the word, a revolution in understanding the geological structure and development of entire regions. In this first „10-year phase" we concerned ourselves mainly with the Triassic sequences on the whole territory of Slovakia. As a result of this we could ascertain a great number of conodont localities. Particularly valuable are finds in metamorphosed Triassic sequences of which some, until the findings of conodonts, had been considered to be Paleozoic. The Paleozoic proper of the West Carpathians is still *terra incognita* awaiting its discovery. Some of the finds of conodonts in slightly metamorphosed Paleozoic rocks are a strong impulse for future investigations (see for example H. KOZUR, R. MOCK & H. MOSTLER 1976).

The Triassic participates in a significant degree in the structure of the West Carpathians. It mainly predominates in allochthonous nappe units. It can be said that the Triassic is the „most beautiful" system of the Slovak mountains. Its development is greatly variegated. In brief, it can be characterized as follows:

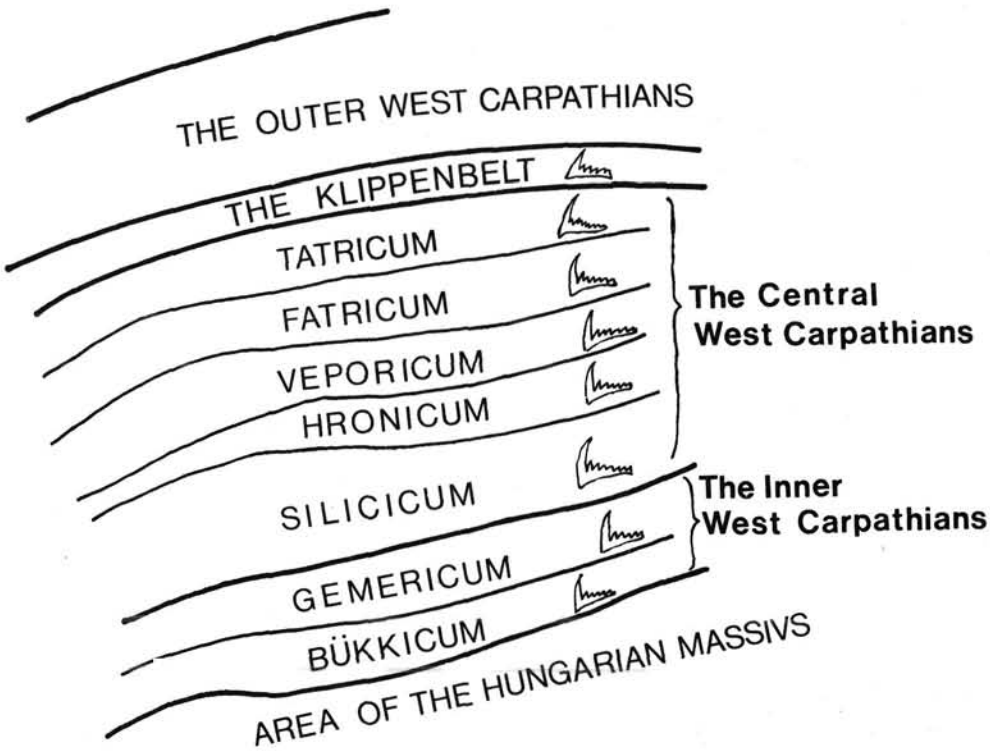

Fig. 1: Division of the West Carpathians into basic units (in palinspastic form).

In the Central West Carpathians it is a miogeosynclinal type similar to the East-Alpine, Austroalpine development, from which it differs mainly by the striking „Carpathian Keuper" in the Tatricum and Fatricum. In the Inner West Carpathians it is an entirely different, eugeosynclinal type which has a great number of signs similar to those of the development in the Southern Alps and Inner Dinarides.

The Triassic of the Pieniny Klippen Zone has a particular position. This zone forms a narrow, tectonically unusually complicated belt between the Outer and Central West Carpathians. Triassic development here has been reconstructed on grounds of a pebble analysis in Cretaceous conglomerates (with a

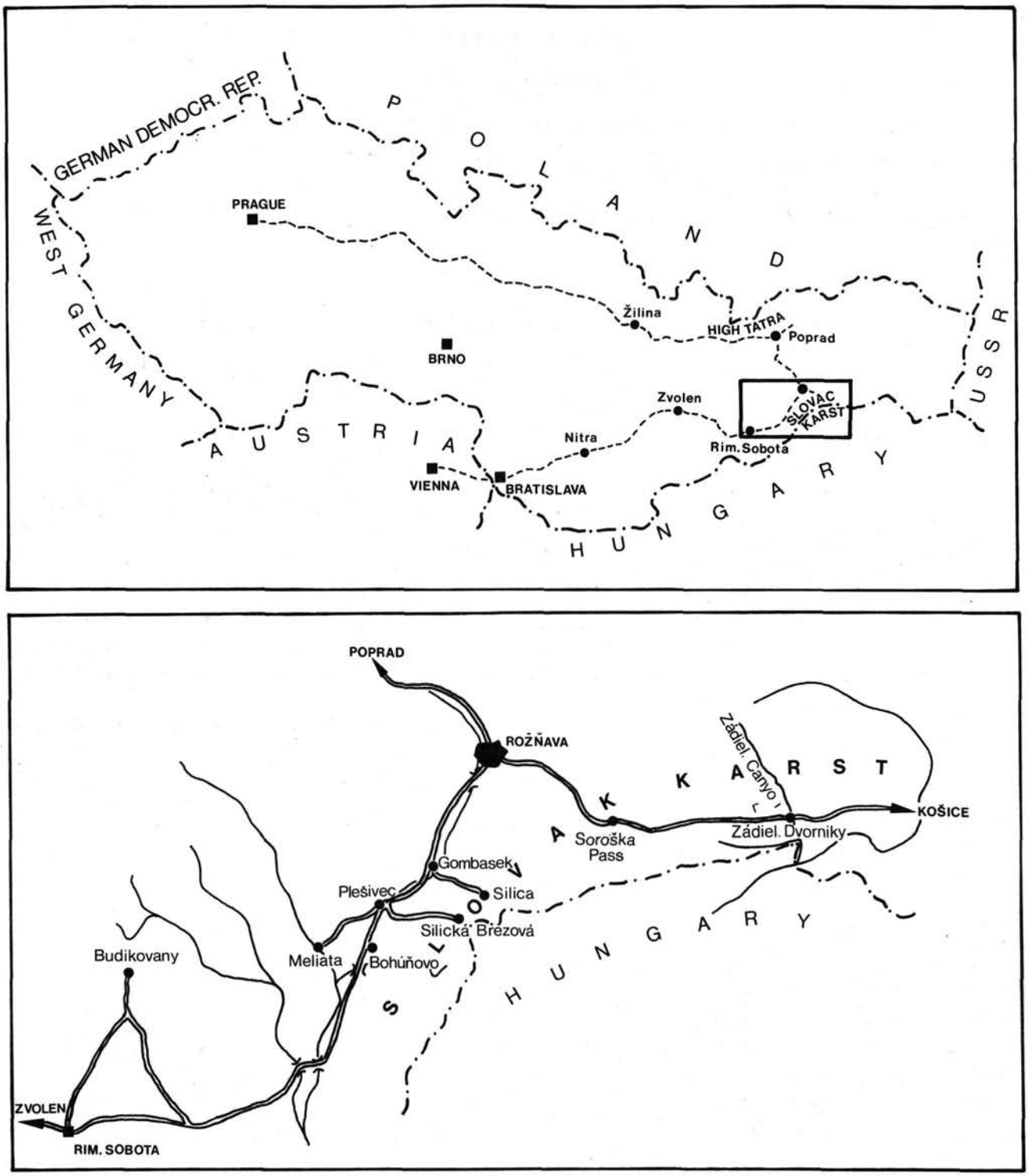

Fig. 2: Route of the excursion.

substantial aid of conodonts). In the past it was presumed that north of the Tatricum there was dry land in Triassic (the so-called Vindelic mainland). It has been shown that in the area of the Pieniny geosyncline marine sedimentation had taken place, i. e., a pelagic facies in the Middle and Upper Triassic (see M. MIŠIK, R. MOCK & M. SÝKORA 1977).

Division of the West Carpathians into basic tectonical units (in palinspastic form) is shown in fig. 1, singling out those units in which Triassic conodonts were found.

From among several areas predominantly built of Triassic we will visit the Slovak Karst, which unfortunately is very far off on the way from Vienna to Prague but it is perhaps the most interesting region with numerous important conodont localities.

On the way from the Slovak Karst to Prague by the High Tatra Mountains we will have the possibility to see, at least briefly, some more localities in another development and gain a general survey of the geology of our beautiful Slovakia. The route of our trip is shown in fig. 2.

The Excursion

STOP 1. Budikovany

Norian limestones of the Silica nappe; locus typicus of *Misikella longidentata* KOZUR & MOCK.

This locality is situated about 20 km NE of Rimavska Sobota, in the so-called Drienčany Karst. The area is built of the Triassic of the Silica nappe beneath from which the Triassic of the anchimetamorphic Meliata Group crops out in more places, and of Neogene sedimentary rocks and andesites (L. GAÁL 1980).

In the exposure we can see bedded cherty Hallstatt Limestone of grey, grey-red and pink colours, extremely rich in well preserved conodonts and other microfossils, mainly holothurian sclerites. The association *Metapolygnathus abneptis abneptis* (HUCKRIEDE), *M. abneptis spatulatus* (HAYASHI) and *M. posterus* (KOZUR & MOSTLER) point to the bottom part of the Middle Norian (*Juvavites magnus*-Zone). Besides adult specimens there often occur juvenile forms („*Parvigondolella, bidentatus, posterus*-stages") as well. Various denticulated conodonts occur frequently, on the other hand species of *Gondolella* are lacking. Here is the type locality of *Misikella longidentata* KOZUR & MOCK (see H. KOZUR & R. MOCK 1974 a). The conodont fauna practically does not change in the whole outcrop.

At the base of the exposure are bivalves determined as *Halobia* cf. *halorica* MOJS., on ground of which the Triassic, i. e., Norian age of these limestones has first been documented (K. BORZA, A. BEGAN & M. KOCHAN 1965). Formerly they were considered to be Jurassic or Tithonian-Neocomian (F. FOETTERLE 1867, M. MARKOVÁ 1959, in J. BYSTRICKÝ 1964).

From the lithological and microfacial point of view it is a remarkable facies which has no analogy in this country. Some of the banks resemble the Pötschen Limestone. The Hallstatt Limestones of the Lower Norian and Sevatian, their underlier and overlier, exposed in the Kamenný jarok valley about two km NE of this locality, likewise rich in conodonts, are mostly bedded, light grey and pink-grey in colour, containing large light coloured cherts.

Microfacially they are biomicrites and biomicrosparites, containing *Globochaete,* calcified radiolarians, sponge spicules and other microfossils.

Higher up in the exposure there are transgressive Neogene (Egerian) Lithotamnian limestones and sandstones.

STOP 2. Bohúňovo

Hallstatt Limestone and Zlambach Beds of the Silica nappe; type locality of *Parvigondolella andrusovi* KOZUR & MOCK and *Parvigondolella lata* KOZUR & MOCK (Slovak Karst).

The youngest Triassic sedimentary rocks of the Silica nappe in basin development are best preserved in the tectonic slice SE of the village Bohúňovo. This exposure is, besides the localities near Silická Brezová, the best known locality as regards occurrence of Hallstatt Limestones and Zlambach Marls in the Slovak Karst. Apart from this, it is the only locality where a gradual transition from the Upper Triassic to Jurassic is preserved. Elsewhere Jurassic sequences are denuded. This section is, unfortunately, covered in a great part with loam, and so the transitions from the Hallstatt Limestones to Zlambach Beds, and/or to Gresten Beds, Allgäu Beds and Hierlatz Limestone are not clearly visible. Structural drills have, however, shown that these are continuous transitions.

In the tectonic underlier of the Hallstatt Limestone we can see variegated sandstones and shales of the lowermost Triassic („Scythian") of the Silica nappe and even lower coarse-crystalline limestones of the Meliata Group (Lower Anisian?).

Macrofossils have so far not been found here. The Norian age of the Hallstatt Limestone was confirmed with the aid of conodonts for the first time (R. MOCK 1971).

The profile starts with thick-bedded limestones of the Lower Norian (*abneptis* Subzone of the *nodosus*-Zone). Higher up they are bedded, partly nodular red Hallstatt Limestones. From a microfacial point of view they are predominantly micrites with frequent fragments of thin-walled juvenile bivalves. These limestones are relatively poor in conodonts. In approximately the middle of the Hallstatt Limestone section starts the Sevatian with *Metapolygnathus bidentatus* (MOSHER).

First, they are typical forms, higher up very young phylogenetic forms with a greatly reduced platform, then forms with side denticle only on one side, and finally, in the topmost part of the outcrop, they are the species *Parvigondolella andrusovi* KOZUR & MOCK and *P. lata* KOZUR & MOCK (*andrusovi* A. Zone, lower part of Upper Sevatian), which were described from here from the last two expo-

sed beds of red Hallstatt Limestone (H. KOZUR & R. MOCK 1972, 1974 a).

To the *andrusovi* A. Zone also belong several banks of red limestones situated higher up (in the past exposed in an artificial groove).

From the overlying brown and grey marly limestones – the basal part of Zlambach Beds conodonts have up to now not been encountered. An Upper Sevatian and Lower Rhaetian microfauna we could, however, extract from pebbles of Zlambach marly limestones from Tertiary conglomerates (near the village of Chvalová): *Misikella hernsteini* (MOSTLER) and *Oncodella paucidentata* MOSTLER, and/or *Misikella posthernsteini* KOZUR & MOCK.

In these Hallstatt Limestone there also occur various holothurian sclerites mainly in their topmost part (H. KOZUR & R. MOCK 1974 b).

Silická Brezová

Conodont localities in Middle and Upper Triassic limestones of the Silica nappe, type localities of several stratigraphically important platform conodonts.

On the Silica plateau in the surroundings of the village Silická Brezová, near the Czechoslovak-Hungarian border, there are numerous nice and interesting exposures in the Lower, Middle and Upper Triassic. The area is built up of the Silica nappe, which has just in these surroundings well-preserved complete members of the Triassic. The younger series of strata are denuded. The Jurassic from the whole Silica plateau is only known from Bohúňovo onward. Pre-Triassic rocks of the Silica nappe are not known here.

The area has a relatively simple tectonic structure. The Silica nappe forms a moderately folded body, disturbed by a system of young faults with a vertical tendency of movements. The tectonic substratum – the Meliata Group is suspected – does not crop out anywhere here. As regards the prevailing geological conditions of the surroundings and detailed paleontological information we can learn from the studies of J. BYSTRICKÝ (1964) and J. BYSTRICKÝ et al. (1973). As regards lithology, microfacies and microfossils were studied from thin sections of Upper Triassic limestones in the area of Silická Brezová, by M. MIŠIK & K. BORZA (1976).

In the surroundings of Silická Brezová there are several localities rich in conodonts; of these we will see the most important ones, namely the quarries, in which Norian Hallstatt Limestone is gained (the so-called Brezová Marble), a long section of the Upper Triassic SW of the old quarries, Malý Mlynský vrch Hill – Hallstatt Limestone and Zlambach Beds, and the profil at Mokrá lúka – Middle Triassic in a special development with tuffites.

From the point of view of conodont stratigraphy especially significant are the sections of the Upper Triassic, starting with Lower Tuvalian *(dilleri*-Zone) and continuing up to the highest Sevatian and/or Lower Rhaetian. These limestones are rich not only in conodonts but also in other valuable microfossils, mainly sclerites of holothurians, skeletons of ophiurians, roveacrinides, etc. Owing to the fact that these profiles are both tectonically and sedimentologically uncomplicated and are relatively well exposed, it is possible to study, for the first time all over the world, the complete phylomorphogenic successions and exact relations of stratigraphically important platform and other conodonts of the Upper Triassic starting at basal Tuvalian. In view of the fact that the exposures are easily accessible, they were selected as type localities of some conodont zones (H. KOZUR & R. MOCK 1972, H. KOZUR & H. MOSTLER 1972 and H. KOZUR 1972 a).

A study of the sclerites of holothurians in these sections confirmed the succession and zonation which was worked out by H. MOSTLER (1972) and which made it possible to further precise the stratigraphy by holothurian sclerites at certain intervals of the Upper Triassic (H. KOZUR & R. MOCK 1974 b).

Research in the surroundings of Silická Brezová has not yet been completed. We intend to process in detail the unique profiles, which, unfortunately, has not been possible for technical and financial reasons so far.

STOP 3. New quarry at Silická Brezová

(About 500 m west of this village).

Approximately in the middle of the quarry there is a dislocation along which pronouncedly bedded pink and red Hallstatt Limestone tectonically contact thick-bedded up to massive dark brown-red Hallstatt Limestones from which large blocks are quarried.

The lower bedded limestones are rich in conodonts. It was K. BUDUROV & J. PEVNÝ (1970) who first described them. Based on conodonts their age is lower part of Middle Norian (*Juvavites magnus* Zone) or perhaps topmost Lower Norian (upper *Malayites paulckei* Zone). In great masses occurs *Metapolygnathus abneptis abneptis* (HUCKRIEDE) and *M. abneptis spatulatus* (HAYASHI), less *M. posterus* (KOZUR & MOSTLER), *Gondolella hallstattensis* (MOSHER) and *G. navicula* (HUCKRIEDE). Compound conodonts occur in a great variety of forms (R. MOCK 1971), namely *Chirodella dinodoides* (TATGE), *Ch. gracilis* MOSTLER, *Enantiognathus ziegleri* (DIEBEL), *Hibbardella magnidentata* (TATGE), *Metaprioniodus spengleri* (HUCKR.), *M. suevica* (TATGE), *Neohindeodella triassica* (MÜLLER), *N. triassica praecursor* KOZUR & MOSTLER, *N. triassica summesbergeri* KOZUR & MOSTLER, *N. triassica kobayashii* (IGO & KOIKE), *N. dropla* (SPASSOV & GANEV), *Ozarkodina tortilis* TATGE, *Prioniodina excavata* MOSHER, *Cypridodella muelleri* (TATGE), and others.

Macrofossils are very rare and have so far not been processed. Microfacially, they are compact micritic limestones with globochaetes, calcified radiolarians dominating, filaments of juvenile bivalves and along with other microfossils. On dissolving these limestones in acetic acid in the residuum remains perfectly preserved sclerites of holothurians.

The higher situated thick-bedded to massive Hallstatt Limestone, at places brecciated, deeply karsted, is of Sevatian age. On grounds of different phylomorphogenic stages of the species *Metapolygnathus bidentatus* (MOSHER) their age in the quarry and immediately above is the middle *bidentatus*-Zone up to the basal part of upper *bidentatus*-Zone (Lower Sevatian to basal Middle Sevatian). Besides the index species there were found among more important ones the forms *Metapolygnathus abneptis, M. abneptis spatulatus, Gondolella navicula* and *G. steinbergensis* (MOSHER). These Hallstatt Limestones are markedly poorer in conodonts than the underlying ones. Rather abundant are small ammonites, not determined up to now, and bivalves *Monotis salinaria* BRONN., forming lumachelles, *M. haueri* KITTL, *Halobia* cf. *falax* MOJS., *H.* cf. *imperialis* KITTL (see J. BYSTRICKÝ 1964, J. BYSTRICKÝ et al. 1973).

In the Sevatian Hallstatt Limestone there are remarkable fissure fillings. In the quarry itself and in its immediate surroundings one can see two generations of neptunic dykes with different filling. Their course is very irregular, and the ascertained thickness is up to 40 cm. They are partly white to light grey or pink lumachelle limestones composed mainly of small brachiopods, less frequently of bivalves, and partly wholly different, grey to dark-grey marly, micritic limestones best visible east of the border of the quarry. In both types there is approximately the same microfauna. Among conodonts we can find rare specimens of *Parvigondolella andrusovi* KOZUR & MOCK and fragments of stratigraphically not very important blade-like conodonts and a relatively rich association of holothurian sclerites (H. KOZUR & R. MOCK 1974 b): *Acanthotheelia kuepperi* MOSTLER, *Fissobractites subsymmetricus* KRISTAN-TOLLMANN, *Praeeuphronides multiperforatus* MOSTLER, *P. robustus* MOSTLER, *Th. variabilis* ZANKL, *Th. kristanae* MOSTLER, *Th. rosetta* KRISTAN-TOLLMANN, *Th. petasiformis* KRISTAN-TOLLMANN, *Th. stellifera* ZANKL, *Th. stellifera bistellata* KOZUR & MOCK.

The age of the fissure fillings in the Sevatian Hallstatt Limestone is in both cases Upper Sevatian, *andrusovi* A. Zone (= lower part of *Cochloceras suessi* Zone). Their age coincide with the transition between the Hallstatt Limestone facies and the facies of the Zlambach Marls.

Early Kimmerian germanotype movements in the uppermost Sevatian and Rhaetian caused higher relief energy and the deposition of more clastic sedimentary rocks. With them the Hallstatt Limestone facies ended.

Interestingly, at Silická Brezová in the Upper Sevatian *Parvigondolella andrusovi* has only been found in fissure fillings. The highest part of the section SW of the old quarries (see later) – where in the Hallstatt Limestone intercalations of grey limestones appear suggesting the onset of the Zlambach facies – belongs to the upper part of the *bidentatus*-Zone. At Bohúňovo, as we could see, the *andrusovi* A. Zone is still represented in the highest part of Hallstatt Limestone. The author assumes a similar situation at Malý Mlynský vrch Hill.

Detailed stratigraphic research, essentially based on conodonts and holothurian sclerites has shown that the onset of sedimentation of Zlambach Beds in the zone of the Silica nappe is diachronous.

As regards the problem of age of fissure fillings in Hallstatt Limestones of the Slovak Karst and in Salzkammergut (Austria) we refer to a separate study (H. KOZUR & R. MOCK 1973 c).

STOP 4. Old quarries

Norian Hallstatt Limestone

It is a system of several quarries, about 1,5 km west of Silická Brezová. They produce well bedded Hallstatt Limestones of pink to red colour, extremely fine-grained, with conchoidal fracture and stylolites. Remarkable are large red cherts (down to 30 cm) that invariably occur in the middle of the limestone beds. In one of the quarries in the middle of the wall one can see a striking light grey bank of a grained allodapic limestone. The conodont fauna is very rich and is practically the same as that of the bedded Hallstatt Limestone in the new quarry. There predominate *Metapolygnathus abneptis spatulatus* and *Gondolella hallstattensis (Juvavites magnus* Zone, Lower Alaunian).

STOP 5. Section southwest of the old quarries (fig. 3).

In the surroundings of Silická Brezová this is the most significant locality (fig. 3). It is a relatively well exposed clints field. Up to now, we studied about 90 samples. After artificial exposure and detailed processing this is likely to prove the most important section of the Upper Triassic in Central Europe.

The section starts with Ladinian Wetterstein Limestone in which there are remarkable fissure fillings (nests) composed of small brachiopods *Halorelloidea rectifrons* (BITTN.). Their age may be Sevatian, similar to the fillings in the new quarry (we failed to find any conodonts).

There follow Tisovec Limestone (Carnian Wetterstein Limestone) which pass into a series of light coloured massive and bedded limestones with occasional beds of crinoidal and brachiopod limestones. At this level the conodont section begins (samples M 53, M 52 etc.). Conodonts point to the Lower Tuvalian (until recently *polygnathiformis* A. Zone, *Tropites dilleri* Zone). The species *Gondolella noah* HAYASHI dominates here (formerly we put it to *G. polygnathiformis);* the multielement *Gladigondolella tethydis* is completely lacking.

Higher up it is an alternation of white, light grey, pink and red limestones; only over and above follows a series of typical red and pink Hallstatt Limestone.

Macrofossils are fairly abundant, in the lower part mainly brachiopods, in the higher part bivalves and ammonites. However, they have not been studied in detailed up to now. Well visible in the section are lumachelles with *Halobia styriaca* (MOJS.) and *Monotis salinaria* BRONN. (samples M 22 and S 16 + 24).

In the Norian there are several horizons of intraformational breccias. It is most striking at the boundary Alaunian/Sevatian. Small red cherts can be seen in several beds of Alaunian, but large cherts, such as we saw in the quarry, are lacking here. This horizon may be tectonically reduced here. However, in the succession of conodont fauna no hiatus could be observed.

In the highest part of the section in the red Hallstatt Limestone 8 thin horizons (banks) of grey micritic marly limestones are intercalated. Here the conodont fauna is much poorer than in deeper parts of the section. Phylogenetic young, highly developed specimens of *Metapolygnathus bidentatus* (MOSHER) point to the upper *bidentatus*-Zone (upper part of Lower Sevatian, *Sagenites giebeli* Zone). Zlambach Beds which original might have formed the overlier of the Hallstatt Limestone are cut by a fault. The section continues with massive organogenic limestones of the Wetterstein type which are thought to be of Ladinian or Carnian age.

Among the great number of conodonts obtained from samples of this section only those are quoted which were first described at this locality. Lists of the fauna will be presented on the premises.

From the layer S 7 H. KOZUR (1972 b) described the stratigraphically significant species *Metapolygnathus angustus* KOZUR (Tuvalian – the *subbullatus*-Zone).

Sample 169/2 (light grey limestone with crinoids and small brachiopods) yielded the holotype of *Gondolella carpathica* MOCK, in the past considered to be *Metapolygnathus communisti* HAYASHI (R. MOCK 1979). This is an important species of the Tuvalian, the zone of *Tropites subbullatus* and of the lower part of the zone of *Klamathites macrolobatus.*

Metapolygnathus parvus KOZUR (H. KOZUR 1972 b) was described from sample S 9 of the highest Tuvalian *(macrolobatus*-Zone). This species occassionally passes into the Lower Norian.

Remarkable is the occurrence of „southern elements", i. e., transitional forms between *Metapolygnathus multidentatus* (MOSHER) and *M. mosheri* (KOZUR & MOSTLER), and of *M. mosheri* in the Lower Sevatian, *Himavatites columbianus* Zone (sample S 16 and S 17).

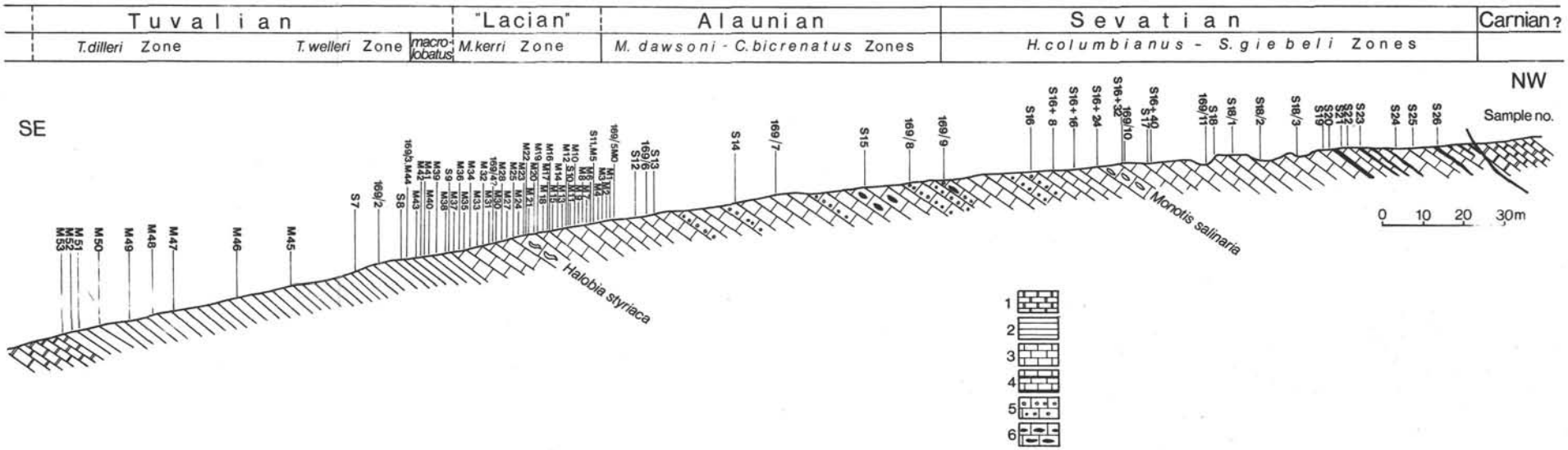

Fig. 3: Silická Brezová, section of the Upper Triassic southwest of the old quarries.
1: Wetterstein and Tisovec Lst. (Ladinian-Carnian); 2: Grey, white and pink variegated limestones (Tuvalian); 3: Pink and red Hallstatt Lst. (Norian); 4: Red Hallstatt Lst. with intercalations of grey marly limestones (Sevatian); 5: Horizons of intraformational breccias (Alaunian); 6: Red Hallstatt Lst. with small-sized red cherts (Alaunian).

STOP 6. Malý Mlynský vrch Hill

Hallstatt Limestone and Zlambach Marls of the Silica nappe; type locality of *Misikella posthernsteini* KOZUR & MOCK and *Metapolygnathus slovakensis* KOZUR.

The locality is situated about 1 km east of Silická Brezová. It is an another important conodont section concerning mainly the fauna of the Zlambach Marls. Previously, until finding the first conodonts (R MOCK 1973) they were considered as marls situated between light coloured limestones of the Carnian and Hallstatt Limestones of the Norian.

The simplified section is as follows: Red Hallstatt Limestone (based on conodonts they pass into the upper *bidentatus*-Zone) are followed by a variegated transitional facies of Hallstatt Limestones and grey Zlambach Beds. From here *Misikella hernsteini* (MOSTLER) and *Oncodella paucidentata* MOSTLER is derived. Characteristic are holothurian sclerites in this horizon too (H. KOZUR & R. MOCK 1974 b). Higher up there are typical Zlambach Marls (imposing as Liassic „Fleckenmergel") containing only few conodonts. At this locality *Misikella posthernsteini* KOZUR & MOCK, an important Lower Rhaetian index fossil was described, and the puzzling species *Metapolygnathus slovakensis* KOZUR (see H. KOZUR & R. MOCK 1974 c, H. KOZUR 1972 b). Relatively abundant ammonites occur which have not been studied so far. The highest part of the hill is formed by marly and sandy shales probably of Upper Rhaetian age.

STOP 7. Mokrá lúka (fig. 4)

Middle Triassic of the Silica nappe (?), about 2 km NW of Silická Brezová.

This locality has been known for a long time in which greenish tuffs and tuffites occur. In the Slovak Karst it is so far the only locality where such rocks have been found. The pertaining stratigraphical questions have not been elucidated up to now. J. BYSTRICKÝ (1964) regarded the series of siliceous argillites with layers of green tuffs and tuffites as part of the Lower Ladinian complex of dark bedded cherty limestones. He put the tuffs in connection with Ladinian volcanism of the Bükk Mountains.

The section which we will visit is in a partially exposed cut of a forest road in N-S direction (fig. 4). It begins with dark Gutenstein Limestone and Dolomites, well exposed by the road Silická Brezová–Ardovo. The assumed age (not proved directly) is lowermost Anisian. Higher up there are moderately recrystallized light massive Steinalm Limestone which are followed with gradual transition by grey inconspicuously bedded limestones. Already their basal part contains a Pelsonian conodont fauna (G. KALISKA 1980): *Gondolella bulgarica* (BUDUROV & STEFANOV), *Neospathodus kockeli* (TATGE) and different blade-like forms. Remarkable is the presence of *Cypridodella venusta* (HUCKR.). Accordingly, here the Steinalm Linestone is older than it had been presumed until recently. Its age is likely Bithynian; of course, they may pass into the Pelsonian.

Higher up in the section grey bedded limestones with large dark cherts are exposed. Same banks are visibly nodular. The actual thickness of the cherty limestones is at least 50 m; they built up the section up to the green tuffs. All of the 18 studied samples from this limestones contain relatively rich Pelsonian conodonts: *Neospathodus kockeli* (TATGE), *Gondolella bulgarica* (BUDUROV & STEFANOV), *G. cornuta* (BUDUROV & STEFANOV), *G. hanbulogi* (SUDAR & BUDUROV), *Neohindeodella aequiramosa* KOZUR & MOSTLER, and in four samples, also *Gladigondolella malayensis* NOGAMI (a new subspecies) and *Cypridodella venusta* (HUCKR.). In addition, there are different compound conodonts. *Neospathodus kockeli* ist still present in the substratum of green tuffs.

Cherty limestones of Pelsonian age have so far not been encountered in the Silica nappe, not even in other tectonical units of the West Carpathians. In the Silica nappe Pelsonian is represented by Steinalm Limestone and dolomite. This extraordinary facies, relatively deep, is the first argument against its belonging to the Silica nappe. The conodonts found here belong to the Dinarian faunal province sensu H. KOZUR (1973). From a microfacial point of view they are biomicrites to biosparites. Remarkable is the great participation of calcified radiolarians.

Greenish tuffs and tuffites and siliceous argillites in their overlier constitute, as already mentioned, exotic rocks in the Slovak Karst. Unfortunately, however, they are poorly exposed; hence, we ignore their thickness, neither we know their true overlyer, nor has their age been definitively established so far. However, they appear to be older than it had been presumed. On grounds of their position immediately above the Pelsonian and based on the poor conodont fauna obtained from intercalations of nodular cherty limestones in the tuffs and tuffites, they are most likely of Illyrian age. From among valuable forms I have found here several specimens of *Gondolella excelsa* (MOSHER) and *G.* cf. *hanbulogi*

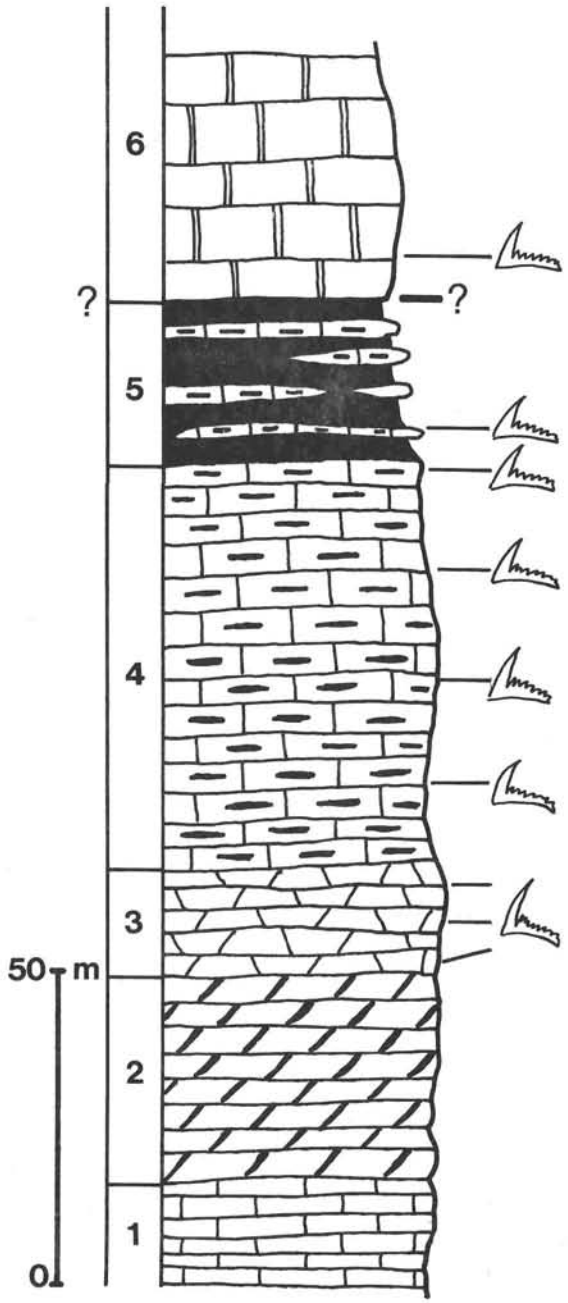

Fig. 4: Simplified lithological section of locality Mokrá lúka near Silická Brezová (Middle Triassic).
1: Gutenstein Lst. and Dolomite; 2: Steinalm Lst.; 3: Grey bedded limestones (Pelsonian); 4: Grey cherty limestones (Pelsonian); 5: Grey and green argillites and tuffs with intercalations of cherty limestone (Illyrian?); 6: Light thick bedded limestones (Illyrian ? – Ladinian ?).

(SUDAR & BUDUROV) so far.

The above described situation gave rise to express doubts whether this section actually belongs to the Silica nappe. Further northwards. beyond the wide karst sink holes with thick Quaternary, thick-bedded light grey limestones are exposed representing a transitional development between the Reifling and Wetterstein Limestones. Microfacially, they are biopel-intrasparites with different microfossils. They yielded very few conodonts. For the time being they only permit a preliminary dating (Illyrian or Ladinian).

STOP 8. Meliata (fig. 5)

Type locality of the Meliata Group

In the valley of the river Muráň, north of the village Meliata are natural rock exposures. For a length of several 100 m slightly metamorphosed sediments of the Meliata Group are exposed which was recognized here for the first time (V. ČEKALOVÁ 1954).

Stratigraphically the Meliata Group was interpreted in many different ways. They were presumed to be of Carboniferous, Permian or Triassic age. Fossils had not been known for a long time. At last the opinion became dominating that it represents an Upper Permian to basal Triassic „extraordinary development". It followed that the Meliata Group was understood as the normal stratigraphical substratum of the Triassic in the Slovak Karst (see for instance J. BYSTRICKÝ 1964, 1973).

Finding of conodonts at this locality caused a clear-cut break trough in the history of geological research of the Slovak Karst. Paleontologically it has been proved that the anchimetamorph sequences of the Meliata Group actually are of Middle to Upper Triassic age; hence, it is not the normal substratum of the Triassic of the Slovak Karst (H. KOZUR & R. MOCK 1973 a, b). The Triassic of the Meliata Group is both lithologically and paleontologically a Dinarian development. Contrary, the non-metamorphosed Triassic of the Slovak Karst proper which thus necessarily constitutes an extensive nappe (called Silica nappe) is a classical Austroalpine development. Determination of the real age of the Meliata Group at its type locality belongs among the greatest advances as regards study of conodonts in the West Carpathians. From the new stratigraphic knowledge of the Meliata Group - since the first discovery conodonts have been found at about 20 other localities – far-reaching conclusions can be drawn not only for the region of the Slovak Karst but also for the whole of the Inner West Carpathians (see also D. ANDRUSOV 1975, R. MOCK 1978, H. KOZUR 1979).

Recently we have deduced another highly important fact at this locality (1980): The thick complex of flyschoidally developed dark shales in the highest part of the section is of Jurassic age; up to now we presumed an Upper Triassic to Carnian age.

The section (fig. 5) starts with massive, monotonous crystalline limestones. Their thickness amounts

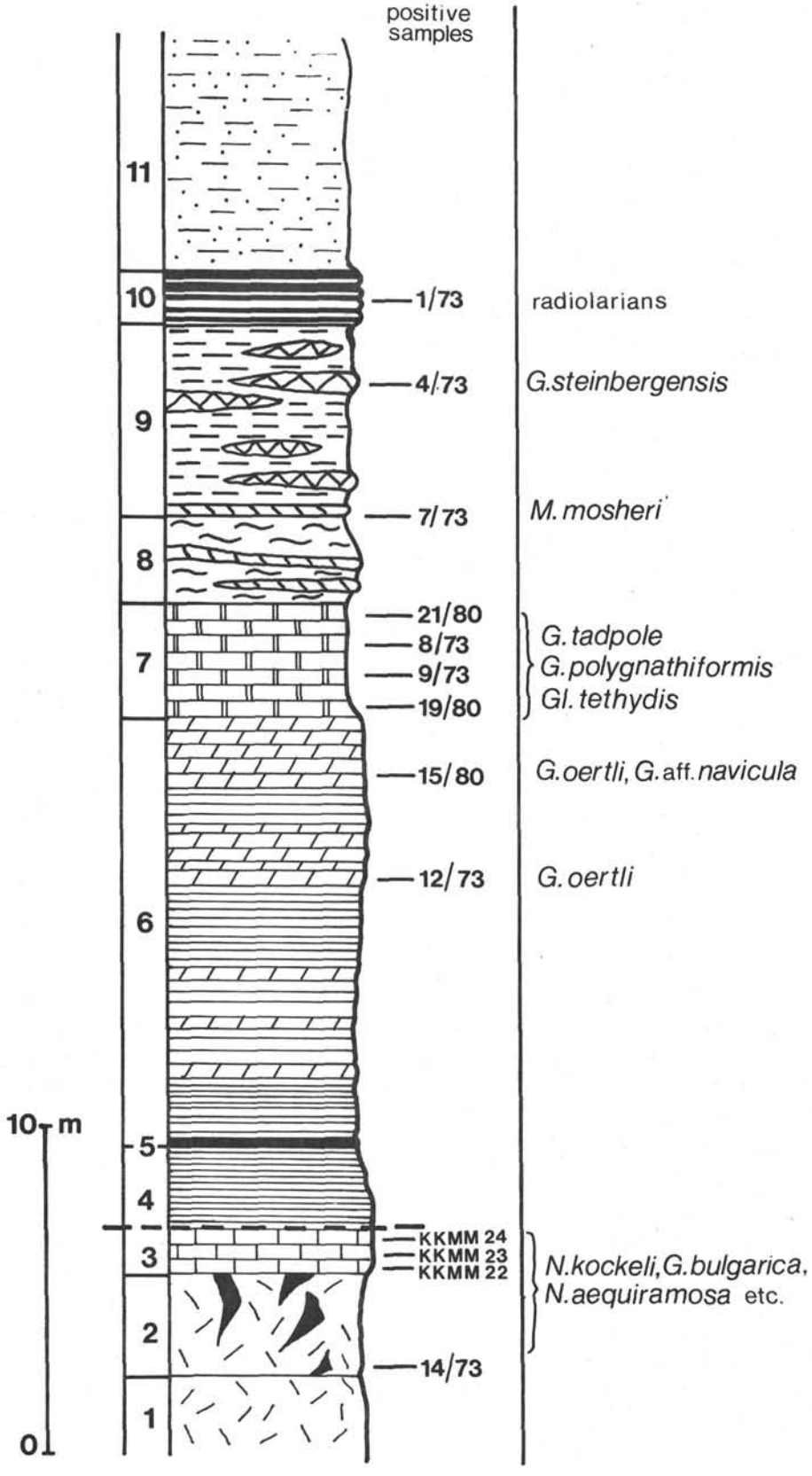

Fig. 5: Lithological section of the Meliata Group at Meliata.

to several 100 m. Yet, we do not know their substratum. Microfacial signs have completely been destroyed. According to their position we assume a Lower Anisian age. In the premetamorphic stage they might have been limestones of the Steinalm type. In the upper part of these crystalline limestones spots and thin intercalations of red shales and nests (probably fissure fillings) of red-brown limestones appear. One of it produced a rich Pelsonian conodont fauna (sample No. 14/73 by H. KOZUR & R. MOCK 1973 a, b): *Chirodella dinoides* (TATGE), *Enantiognathus petraeviridis* (HUCKR.), *E. ziegleri* (DIEBEL), *Gladigondolella tethydis* (HUCKR.), *Gl. malayensis* NOGAMI, *Gondolella acuta* KOZUR, *G. bulgarica* (BUDUROV & STEFANOV), *Gondolella excelsa* (MOSHER), *G. prava* KOZUR, *Hibbardella lautissima* (HUCKR.), *H. magnidentata* (TATGE), *Metaprioniodus multihamatus* (HUCKR.), *M. spengleri* (HUCKR.), *M. suevicus* (TATGE), *Neohindeodella sequiramosa* KOZUR & MOSTLER, *N. dropla* (SPASSOV & GANEV), *N. triassica* (MÜLLER), *Neoplectospathodus muelleri* KOZUR & MOSTLER, *Neospathodus germanicus* KOZUR, *N. kockeli* (TATGE), *Ozarkodina tortilis diebeli* KOZUR & MOSTLER, *Cypridodella muelleri* (TATGE), *C. venusta* (HUCKR.) and *Veghella delicatula* (BUDUROV).

This association is typically Dinarian. Higher up the crystalline limestone becomes more and more red in colour and passes into bedded limestones. This part ends in several beds of red micritic limestone. Remarkably this facies does not show any optical indications of metamorphism. These limestones (samples KKMM 22, 23, 24) are very rich in Pelsonian conodonts. The association is practically the same as in sample No. 14/73. Dominating species are *Neospathodus kockeli, Gondolella bulgarica, Neohindeodella aequiramosa* and *Gladigondolella malayensis.*

The Pelsonian limestone is limited by a fault; this causes a reduction – tectonical hiatus – in the profile. At present, we do not know exactly which lithological and stratigraphical members are lacking.

Above the fault there follows an about 20 m thick sequence of red „radiolarites". It is the most remarkable part at this locality. The results of lithological and microfacial analyses point to an abyssal environment. Such facies in the Triassic are, with the exception of the Bükk Mountains (Hungary), unknown in other units of the West Carpathians and, generally, in the whole tethydal Europe too.

In their lower part mostly reddish „Kieselschiefer" (quartzitic stratified rocks) with thin intercalations of red clayey shales occur and horizons of thin-bedded true radiolarites. Higher up these rocks pass into bedded red „radiolarites" (10 to 20 cm thick), that actually are silicified red limestones. In the microscope one can see their original microfacies – filamentous micrites with globochaetes and radiolarians. From two large samples (Nos. 12/73 and 15/80), dissolved in hydrofluoric acid, conodonts were gained: *Gondolella oertli* KOVÁCS & KOZUR, *G.* n. sp. aff. *navicula* HUCKR., *Cypridodella venusta* (HUCKR.), fragments of blade-like conodonts and spicules of sponges. I assign them to the Cordevolian.

The red siliceous rocks gradually pass into grey, bedded, cherty, sometimes nodular limestones, the thickness of which is about 3 m. In 3 samples (Nos. 19/80, 9/73 and 8/73) a relatively rich fauna was found pointing to a Carnian age (Cordevolian to Lower Julian): *Gondolella tadpole* HAYASHI, *G. polygnathiformis* BUDUROV & STEFANOV, *G.* cf. *navicula* HUCKR., *Gladigondolella tethydis* (HUCKR.), *C. muelleri* (TATGE), *Ozarkodina saginata* HUCKR., *O. tortilis* TATGE.

It follows an alternation of light creamy marly limestones and marly shales (2 m). This sequence starts to have the character of flyschoidal sedimentation. Marked slumping structures and olistholites do, however, not occur here. Higher up are more and more shales and limestones only forming thin intercalations (20 to 30 cm thick). From one of such a limestone bed sample No. 7/73 was taken. This light fine-grained limestone is poor in conodonts. In 1973 we obtained some specimens of *Metapolygnathus* which we supposed as a new species *„Metapolygnathus misiki"*, ascribing to it mainly with regard to the safely Carnian age of the underlying positive samples, Carnian – Upper Cordevolian or Lower Tuvalian age (H. KOZUR & R. MOCK 1973 a). Already then we had stated that this new species was similar to the Norian species *M. bidentatus* and *M. posterus,* but especially to *M. mosheri.*

We understood this similarity to be a phenomenon of homeomorphy. Later on, I gained (from 20 kg of rocks) about 50 specimens of *„Metapolygnathus misiki"*. From this material follows that the vast majority of specimens by no means can be distinguished from *Metapolygnathus mosheri* (KOZUR & MOSTLER). The range of this species known at present is Sevatian (*bidentatus*-Zone). For this reason sample No. 7/73 should be considered to be most likely Sevatian. However, there remains the problem as to the presence of some fragments of blade-like conodonts of the *Gladigondolella tethydis* multielement, for example, *Cypridodella venusta* (HUCKR.). A mixed fauna is unlikely.

Higher in the profile there follow marly and clayey shales (appr. 7 m) of dark grey colour by their appearance imposing as Culm roofing slates. In the shales 5 thin lenses of blue-grey (allodapic?) lime-

stones are intercalated. From one of it a specimen of *Gondolella hallstattensis* (MOSHER) is derived (sample No. 4/73). This species is typical for the Sevatian. The other limestone lenticles yielded no fossils at all not even from a large amount of rocks.

Above it, there is a 140 cm thick sequence of dark grey to black „lydites". The microscope clearly shows them to be true radiolarites. By dissolving in highly diluted HF (sample No. 1/73) a rich fauna of radiolarians was found (A. MODROVÁ 1980) which, as a result of a preliminary study, points to a Rhaetian or Lower Liassic age.

Hence, it may be concluded that the whole sequence of overlying dark shales, sandy shales and sandstones belongs to the Jurassic (probably Liassic). Of these flyschoidal sediments more than 50 m are exposed.

The above mentioned series are transgressively overlain by Neogene sedimentary rocks.

STOP 9. Gombasek (fig. 6)

Middle Triassic basin facies containing conodonts.

In the cut of the road leading from Gombasek to the village of Silica there are good exposures in the Middle Triassic sequences of the Silica nappe; of these we will concentrate on the basin facies, the Reifling Limestone and the Schreyeralm Limestone. So far no macrofossils have been found here.

Study of the section (fig. 6) starts in the light Steinalm Limestones of the Anisian. They are organodetritic (biosparitic, less biomicritic) limestones with Dasycladaceae *(Physoporella, Macroporella),* Foraminifera and other fossils, mostly in fragments. The Steinalm Limestone are underlain by dark Gutenstein Dolomites.

Above the light limestones there is a sequence of bedded, markedly nodular limestones, appr. 50 m in thickness. At the base, they are dark grey Reifling Limestones, higher up they represent red Schreyeralm Limestones.

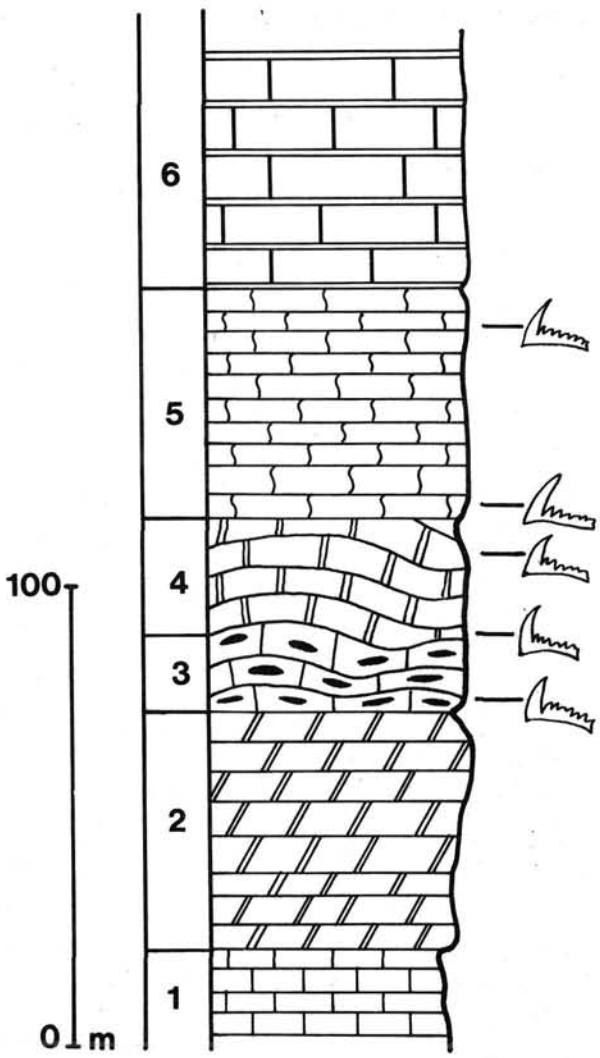

Fig. 6: Simplified lithological section of the Middle Triassic near the village of Gombasek.
1: Gutenstein Dolomite; 2: Steinalm Lst. with layers of white dolomites; 3: Dark nodular limestones with cherts; 4: Pink and red Schreyeralm Lst.; 5: Dark grey limestones (Reifling Bankkalk); 6: Wetterstein Lst.

Occasionally the dark grey limestones contain black cherts. Among single beds of limestones there are thin intercalations of grey-green shales. They are fine grained limestones – micrites and pelmicrites – with filaments and locally crinoids. Lithologically these rocks correspond to the facies of the Reiflinger Knollenkalk of the Eastern Alps. They contain a great number of well-preserved conodonts (R. MOCK 1971): *Gondolella excelsa* (MOSHER), *G. cornuta* (BUDUROV & STEFANOV), *G. constricta* (MOSHER), *Enantiognathus petraeviridis* (HUCKR.), *Cypridodella venusta* (HUCKR.) and various other blade-like conodonts. According to present knowledge this association in the Austroalpine province corresponds to the Illyrian-Fassanian boundary.

Higher up there follow pink and red limestones with red cherts, both lithologically and microfacially different but otherwise wholly similar to the dark underlying limestones. They represent the Schreyeralm Limestone in which at other localities of the Slovak Karst ammonites occur.

These limestones are also rich in conodonts

which point to Fassanian (*Aplococeras avisianus* Zone): *Gladigondolella tethydis* (HUCKR) and the blade-like forms of this multielement, *Gondolella excelsa* (MOSHER), *G. constricta* (MOSHER) and some stratigraphically less important compound conodonts.

With a sharp transition the red Schreyeralm Limestone is followed by dark grey, conspicuously bedded limestones, corresponding in facies to the Reiflinger Bankkalk of the Eastern Alps. At other places these limestones contain a great amount of dark cherts. Their thickness is about 50 m. Towards the overlier they gradually pass into Wetterstein Limestone. Microfacially they are mostly micrites with filaments of juvenile bivalves. The assemblage of conodonts is essentially the same as in the underlying Schreyeralm Limestone (R. MOCK 1971). The following species are dominating: *Gladigondolella tethydis* (HUCKR.), *Gondolella excelsa* (MOSHER) and *Enantiognathus petraeviridis* (HUCKR.). As in the foregoing limestones we also regard this fauna to be of Fassanian age.

Among other microfossils the ecologically interesting ostracode species *Ceratobairdia gombasekensis* KOZUR has been found here.

It follows Ladinian-Carnian Wetterstein Limestone which is of great thickness; it participates to a great extent in the structure of the limestone plateaus of the Slovak Karst.

With the aid of conodonts it was possible to demonstrate that the Middle Triassic basin facies of the Silica nappe is a diachronous unit both regarding its base and top. At places it starts as early as in the Illyrian (*Paraceratites trinodosus* Zone), e. g., at the localities Zakázané and Kečovo, and range up to the Langobardian (*Protrachyceras archelaus* Zone), e. g., at the locality Skalica near Gemerská Hôrka.

STOP 10. Strážne Hill near Zádielske Dvorniky (fig. 7)

Tectonic window of the Meliata Group, Carnian and Norian metamorphosed limestones with conodonts.

The Strážne Hill above the village Zádielske Dvorniky is situated in the Turnianska kotlina Basin in the eastern part of the Slovak Karst. It is a demonstrative place which clearly shows the nappe superposition of the Silica nappe lying here upon the Upper Triassic of the slightly metamorphosed Meliata Group (J. MELLO & R. MOCK, in J. MELLO 1975).

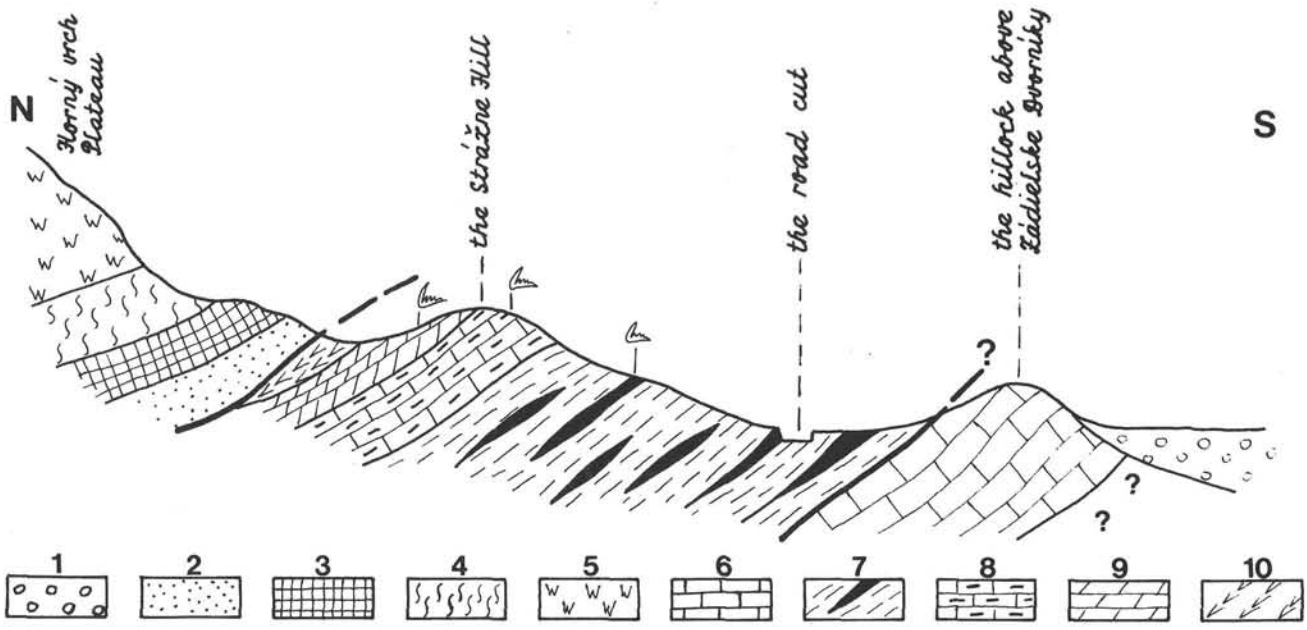

Fig. 7: Geological section between Zádielske Dvorniky and the Strážne Hill.
1: Neogene; 2: Lower Triassic; 3: Gutenstein Lst. and Dolomites; 4: Steinalm Lst.; 5: Wetterstein Lst.. 2–5: Silica nappe; 6: Light massive crystalline limestones (Lower Anisian ?); 7: Dark shales with intercalations of limestones, tuffs and glaucophanites (Ladinian ? – Julian); 8: Dark bedded cherty limestones (Tuvalian); 9 Light cherty limestones (Norian); 10: Shales and schistose limestones (Rhaetian ?); 6–10: Meliata Group.

The Meliata Group forms some morphologically striking hillocks. In the past the rocks outcropping here were considered to be Carboniferous due to their metamorphosis as well as their position below the paleontologically proved non-metamorphosed Triassic of the Horný vrch Plateau.

Here, the succession of the Meliata Group is as follows (fig. 7): The bottommost outcropping member are light massive crystalline limestones similar to those seen at the locality Meliata. We regard them to be of Lower to Middle Anisian age. They form the well-visible hillock south of our locality right above the village Zádielske Dvorniky. In the light limestones there is a layer of partly ankeritized grey dolomite.

Higher members can only be studiedin the detritus. Between the two morphologically characteristic hillocks there is an extremely variegated series of rocks which is dominated by shales of different colour and of different composition, i. e., clayey, marly, tuffitic shales, in which intercalations of tuffs, tuffites, glaucophanites and various crystalline limestones occur. From a sample of light cherty limestone with volcanic admixture (taken from the debris) from the vineyard below the Strážny Hill I obtained the conodonts *Gondolella polygnathiformis* BUDUROV & STEFANOV and *Gladigondolella tethydis* (HUCKR.). Presumably, this variegated series of rocks represents Ladinian to Julian. The top part of our hillock consists of crystalline limestones. At the base, they are well-exposed grey bedded limestones with black cherts; they pass into inconspicuously bedded light to white limestones with light cherts.

From the grey bedded cherty limestones in the highest part of the hill I obtained a relatively rich conodont fauna of the Tuvalian comprising the species *Gondolella noah* HAYASHI and *G. praeangusta* KOZUR, MIRAUTA & MOCK. They are black conodonts and conspicuously pressure-deformed. According to few poorly preserved specimens of *Metapolygnathus abneptis spatulatus* (HAYASHI) I concluded a Norian age for the overlying white limestones.

Higher up follow dark sandy and marly shales and schistose limestones visible only in fragments in the vineyards; according to their position they might be of Rhaetian or even Liassic age.

To sum up, the Meliata Group as exposed here is a development different from that of the type locality near the village Meliata. The succession practically changes from one exposure to another. The geotectonic development trend is, however, always the same. This facial variability can be explained by the great synsedimentary mobility of the sedimentation area. In fact, one can not exclude the possibility that the Meliata Group represents several tectonic units; evidence of this is, however, still lacking.

To the north we can see the panorama of the limestone plateau Horný vrch with the karst canyon of the Zádielska dolina which cuts into the Wetterstein Limestone (Ladinian to Cordevolian) of the Silica nappe. Its lower members are the Steinalm Limestone, the Gutenstein Limestone and the Lower Triassic „Campilian Beds" and the „Seisian Beds". In the upper part of the Zádielska dolina valley the Meliata Group outcrops again in a small window.

References

ANDRUSOV, D. (1975): Apercu bref du bati des Carpathes Occidentales. – Proceed. of the Xth Cong. CBGA, Gen. proc., Geol. Ústav D. Štúra, 95–108, Bratislava.

BORZA, K., BEGAN, A. & KOCHANOVÁ, M. (1965): Poznámky k tzv. jure pri Budikovanoch. – Zpr. geol. Výsk. **1964**, 2, 62–63, Bratislava.

BUDUROV, K. & PEVNÝ, J. (1970): Über die Anwesenheit von Trias-Conodonten in den Westkarpathen. – Geol. práce, Správy **51**, 165–171, Bratislava.

BYSTRICKÝ, J. (1964): Slovenský kras. Stratigrafia a Dasycladaceae mezozoika Slovenského krasu. – Ústredny úst. geol., 204 p., Bratislava.

BYSTRYCKÝ, J. et al. (1973): Triassic of the West Carpathians Mts. Guide to excursion D, Xth Cong. CBGA. – Geol. ústav. D. Štúra, 1–137, Bratislava.

ČEKALOVÁ, V. (1954): Geologické pomery západnej časti Juhoslovenského krasu. – Geol. práce, Správy, **1**, 48–49, Bratislava.

GAÁL, L. (1980): Stratigrafia, faciálne vzt'ahy a mikroproblematiká triasových vápencov západnej časti Spošsko-gemerského rudohoria. – Manuscript, Archives of Department of Geology and Paleontology, Komenský University, Bratislava.

KALISKÁ, G. (1980): Príspevok k poznaniu triasu južných častí Západných Karpát. – Manuscript, Archives of Department of geology and paleontology, Komenský University, Bratislava.

KOZUR, H. (1972 a): Vorläufige Mitteilung zur Parallelisierung der germanischen und tethyalen Trias sowie einige Bemerkungen zur Stufen- und Unterstufengliederung der Trias. – Mitt. Ges. Geol. Bergbaustud., 21, 361–412, Innbruck.
– (1972 b): Die Conodontengattung *Metapolygnathus* HAYASHI 1968 und ihr stratigraphischer Wert. – Geol. Paläont. Mitt. Innsbruck, 2, 11, 1–37, Innsbruck.
– (1973): Faunenprovinzen in der Trias und ihre Bedeutung für die Klärung der Paläogeographie. – Geol. Paläont. Mitt. Innsbruck, 3, 8, 1–41, Innsbruck.
– (1979): Einige Probleme der geologischen Entwicklung im südlichen Teil der Inneren Westkarpaten. – Geol. Paläont. Mitt. Innsbruck, 9, 4, 155–170, Innsbruck.
– & MOCK, R. (1972): Neue Conodonten aus der Trias der Slowakei und ihr stratigraphischer Wert. – Geol. Paläont. Mitt. Innsbruck, 2, 4, 1–20, Innsbruck.
– & MOCK, R. (1973 a): Die Bedeutung der Trias-Conodonten für die Stratigraphie und Tektonik der Trias in den Westkarpaten. – Geol. Paläont. Mitt. Innsbruck, 3, 2, 1–14, Innsbruck.
– & MOCK, R. (1973 b): Zum Alter und zur tektonischen Stellung der Meliata-Serie des Slowakischen Karstes. – Geol. Zborn. – Geologica Carpathica 24, 2, 365–374, Bratislava.
– & MOCK, R. (1973 c): Das Alter der Hauptspaltengenerationen in den Hallstätter Kalken des Salzkammergutes (Österreich) und der Slowakei. – Geol. Paläont. Mitt. Innsbruck, 3, 10, 1–32, Innsbruck.
– & MOCK, R. (1974 a): Zwei neue Conodonten-Arten aus der Trias des Slowakischen Karstes. – Časopis mineralog. geol., 19, 2, 135–139, Praha.
– & MOCK, R. (1974 b): Holothurien-Sklerite aus der Trias der Slowakei und ihre stratigraphische Bedeutung. – Geol. Zborn. – Geologica Carpathica 25, 1, 113–143, Bratislava.
– & MOCK, R. (1974 c): *Misikella posthernsteini* n. sp., die jüngste Conodontenart der tethyalen Trias. – Časopis mineralog. geol., 19, 3, 245–250, Praha.
– , MOCK, R. & MOSTLER, H. (1976): Stratigraphische Neueinstufung der Karbonatgesteine der „unteren Schichtfolge" von Ochtiná (Slowakei) in das oberste Visé und Serpukhovian (Namur A). – Geol. Paläont. Mitt. Innsbruck, 6, 1, 1–29, Innsbruck.
– & MOSTLER, H. (1972): Die Bedeutung der Conodonten für stratigraphische und paläogeographische Untersuchungen in der Trias. – Mitt. Ges. Geol. Bergbaustud. 21, 777–810, Innsbruck.
MELLO, J. (1975): Mladšie paleozoikum a mezozoikum gemerika a pril'ahlej časti Čiernej hory. – Mineralia slovaca 7, 4, 29–63, Spišská Nová Ves.
– & MOCK, R. (1977): Nove poznatky o triase cs. casti Rudabanskeho poharia. – Geol. prace, Správy 68, 7–20, Bratislava.
MIŠÍK, M. & BORZA, K. (1976): Obere Trias be Silická Brezová (Westkarpaten). – Acta geol. et geograph. Univ. Comeniane, 30, 5–49, Bratislava.
– , MOCK, R. & SÝKORA, M. (1977): Die Trias der Klippenzone der Westkarpaten. - Geol. Zborn. – Geol. Carpathica 28, 1, 27–69, Bratislava.
MOCK, R. (1971): Conodonten aus der Trias der Slowakei und ihre Verwendung in der Stratigraphie. – Geol. Zborn. – Geol. Carpathica 22, 2, 241–260, Bratislava.
– (1973): Über einen Fund von Zlambach-Schichten (Nor) im Slowakischen Karst. – Geol. práce, Správy 60, 221–224, Bratislava.
– (1978): Nové poznatky o južných častiach Západných Karpát. In: VOZÁR, J. (edit.): Paleogeografický vývoj Západných Karpát. – Geol. ústav. D. Štúra, 321–341, Bratislava.
– (1979): *Gondolella carpathica* n. sp., eine wichtige tuvalische Conodontenart. – Geol. Paläont. Mitt. Innsbruck, 9, 4, 171–174, Innsbruck.
MODROVÁ, A. (1980): Mikrofosílie z nerozpustných zvyškov mezozoických a terciérnych hornín. – Archives of Department of geology and paleontology, Komenský University, Bratislava.
MOSTLER, H. (1972): Holothuriensklerite der alpinen Trias und ihre stratigraphische Bedeutung. – Mitt. Ges. Geol. Bergbaustud. 21, 729–744, Innsbruck.