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Are there tectonic units derived from the Meliata-Hallstatt trough incorporated into the tectonic structure of the Tisovec Karst ? (Muráň karstic plateau, Slovakia)

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Abstract: The Tisovec karst and Kučelach massif area are composed of several tectonic units displaying different degree of metamorphism, character of deformation, age and lithological composition. By means of geological mapping, structural and stratigraphical research, several tectonic units were distinguished. The lowermost one is the crystalline basement and the Permo-Triassic Federata Cover Unit (metasediments) of the southern Vepor Unit. The Vepor Unit is overthrust by (from the bottom to the top) epimetamorphosed Carboniferous sediments of the Gemer Unit and slices of the Meliata Unit(?) and Torna Unit(?) composed of anchimetamorphosed sediments. These include newly described nappe units within this area. The Muráň nappe of the Silica Unit forms the Tisovec karst, which is the uppermost nappe unit. Undeformed postnappe the Paleogene sediments and remnants of the originally volumnous the Neogene volcano-plutonic complex, which cover older structures at the mapped area and are the youngest tectonic units.

Key words: lithology, stratigraphy, nappe tectonics, Silica, Torna and Meliata Units, Western Carpathians, Muráň karstic plateau

Introduction

The Tisovec karst is situated in the central part of the Veporské rudohorie Mts. The Tisovec karst belongs to the subunit of the Muránska planina plateau (Mazúr & Lukniš, 1986). The studied area is cca 70 km^2 large.

Main goal of this paper is to present a study that contributes to the knowledge concerning geology, stratigraphy and tectonics of the Tisovec karst and the Kučelach tectonic outlier northwest of Tisovec town.

This study was focussed on a revision of the geological map of the Tisovec karst area at scale of 1:10,000, with an emphasis on stratigraphy and structural geology. The geological map (Fig. 1) was drawn on the basis of new field work and a review and reinterpretation of archived and published materials (Bystrický, 1959; Bacsó & Valko, 1969; Klinec, 1976; Bezák et al., 1996). This work is an attempt to assemble a comprehesive geological summary of the area, because no throughout study territory has yet been published about this area.

Standard field research methods were used with the geological mapping. These methods include geological observations, structural measurements, documentation of outcrops and sample collecting. Field work was concluded by lithological and stratigraphical analyses.

Regional tectonic structural features were interpreted in this synthesis results gained by geological mapping and laboratory analysis, and applied to regional tectonic situations.

Tectonic unit

Geological structures in the area of Tisovec karst have a sandwich-like character, composed of several superposed tectonic units (Fig. 1, 4), formed compressively during Variscan and Alpine orogenesis. These tectonic units are summarized from the lowest to the highest units.

The southern Vepor Unit

This unit was formed by the Variscan and the Alpine orogene. The Alpine orogeny overprinted on the Variscan Vepor Unit the Alpine orogenic character.

The Vepor Unit is one of the main tectonic units of the Western Carpathians. It comprises a Paleozoic crystalline basement and a Late Paleozoic-Mesozoic metasedimentary cover sequence. The structures although elements of the older Variscan structure were preserved, too.

The Permian-Triassic formations of the Federata Sequence were widely deposited on the Prealpine crystalline basement (Rozlozsnik, 1935; Schönnenberg, 1946; Vozár in Bajaník et al., 1983).

The crystalline basement is represented by granitoids of the Vepor pluton (the Kráľová hoľa complex-sensu Klinec; 1966,1976). The porphyric varieties of the granitoid rocks occur in the northern and northwestern part of this area. The paragneisses, migmatites and granites of the Hybrid complex are located mainly southeast of the Muráň fault zone (Bezák, 1988; Bezák & Hraško, 1992; Lexa & Bezák,

1996). Porphyric granitoids of the Vepor type built mainly higher structural levels of crystalline basement, and they form smaller dikes in the Hybrid complex (Bezák et al., 1999).

The Vepor Unit and the Federata Sequence are epithermally metamorphosed and deformed in a ductile regime.

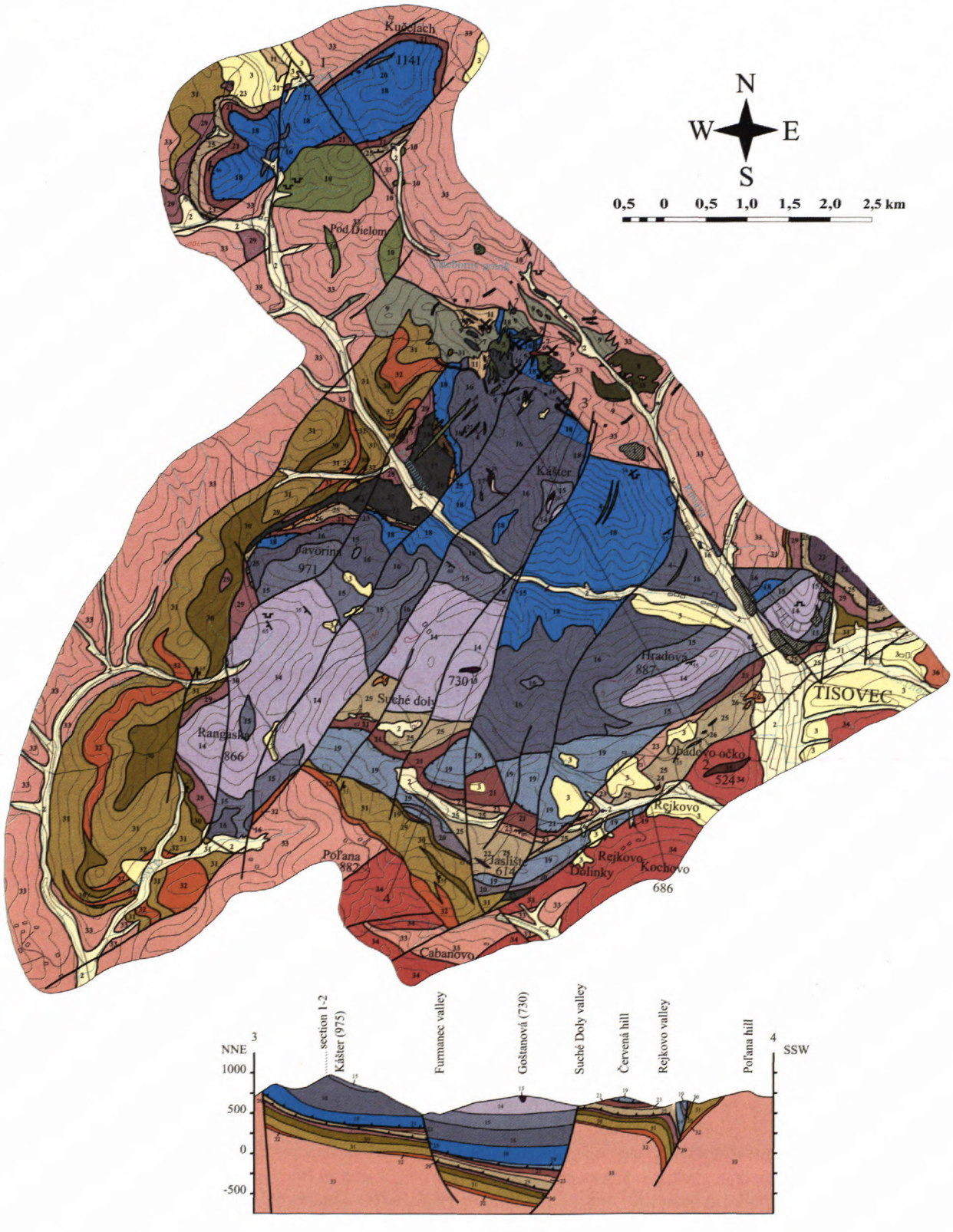


Fig. 1 Geological map of the Tisovec karst and Kučelach massif with geological cross-section and explanations (after Vojtko, 1999).

EXPLANATIONS TO GEOLOGICAL MAP AND PROFILES

(1:25 000)

QUARTERNARY

Holocene - Pleistocene

1 antropogenous deposits; waste dumps and transferred piles

2 fluvial sediments; river and brook alluvium, gravels, sands, loames

3 deluvial sediments; loamy-gravelous

TERTIARY

VEPOR VOLCANO-PLUTONIC COMPLEX

Neogene - Miocene

4 veins of andesites; basalt andesites

5 subvolcanic andesites; amphibole-pyroxene andesites

6 scarns

7 diorites; pyroxene diorites to dioritic porphyrites

8 diorites; biotite-pyroxene diorites

9 subvolcanic andesites; pyroxene andesites

10 subvolcanic andesites; garnet-pyroxene (biotite) andesites

SUBTATRAS GROUP

Paleogene - Eocene

11 Huty Formation?; dark claystones, locally sandstones (Priabonian)

12 Huty Formation?; layers of sandstones and conglomerates (Priabonian?)

MESOZOIC

SILICA UNIT - MURÁŇ NAPPE

JURASSIC - TRIASSIC

Goštanová Limestones; dark crinoidal limestones (Rhaetian-Liassic)

14 Dachstein Limestones; light to dark coarse-bedded (Norian - Rhaetian?)

15 Tisovec Limestones; light reef limestones, locally brecciated (Julian-Tuvalian)

16 Wetterstein Dolomites; light-grey, locally dark dolomites (Cordevolian)

17 light-pink crystalline limestones and dolomites (Cordevolian?)

18 Wetterstein Limestones; light-grey, grey with dolomitic lenses (Ladinian)

19 Steinalm Limestones; light massive locally thick-bedded (Pelsonian-Illyrian)

20 Gutenstein Beds; dark-grey limestones and dolomites (Aegenian-Bithynian)

TORNA UNIT

Triassic

21 Reifling, Nádaška, Schreyeralm Limestones and Gutenstein Beds (Pelsonian-Sinemurian)

22 Gutenstein Beds; dark-grey carbonates (Aegenian-Bithynian)

23 Szin Beds; sandstones, shales, marlstones and limestones (Scythian)

24 rhyolitic pyrhoclastics (Scythian)

25 Bódvaszilas Beds; sandstones and shales (Scythian)

26 tectonic breccias and rauhwackes

LATE PALEOZOIC

GEMER UNIT - DOBŠINÁ GROUP

Late Carboniferous

27 Hámor Formation?; shales, sandstones and conglomerates

28 Ochtiná Formations; grey shales and marlstones, dark limestones and conglomerates

PALEOZOIC - MESOZOIC

VEPOR UNIT - FEDERATA SEQUENCE

Permian - Triassic

29 Tuhár Succession?; rauhwackes, dolomites and limestones (Triassic)

30 clayed and sandy shales (Scythian)

31 Lúžna Formation; quartzites and quartzitic sandstones (Scythian)

32 Rimava Formation; arkosed sandstones and conglomerates (Permian)

VEPOR CRYSTALLINE BASEMENT

Paleozoic

33 granitoides; mainly porphyric granitoides (Carboniferous)

34 deformed hybrid granitoides and migmatites (Early Paleozoic?)

35 biotite gneisses (Early Paleozoic)

36 Muráň Orthogneisses (Early Paleozoic?)

SYMBOLS

lithological boundaries

faults; observed, inferred, covered

thrust fault

35 bedding (dip of direction)

25 schistosity (dip of direction)

springs

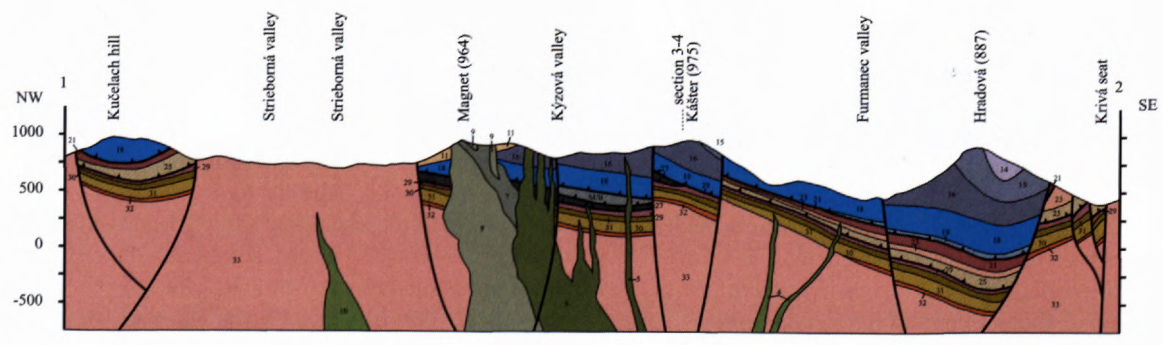
mines out of operation

quaries; in operation, abandoned

TV-10 boreholes

1 2 lines of geological sections

area of the contact metamorphose



The Hybrid complex

Rocks of the Hybrid complex are distributed at the surface in a local area southeast of the Muráň fault zone (Fig. 1). These rocks are probably the oldest elements of the Vepor Unit. The Hybrid complex is made up of remnants of the high-metamorphic gneiss-migmatite mantle, which are incorporated into granitoids of this complex. There are two types of the hybrid granitoids. The first one is distinctively foliated, displaying laminated and augen fabric. The second one is formed of homogeneous granitoids, which developed only weak foliation. Their composition ranges from granodiorite to tonalite (Bezák & Hraško, 1992).

The Kráľová hoľa complex

The basement of all tectonic units is formed by the Kráľová hoľa complex, distributed between the Muráň fault zone and the Zbojská saddle northwestern part of the area.

Overlying the Kráľová hoľa complex is the Federata Sequence, which is situated on granitoid rocks of the complex (Klinec, 1966;1976). It is viewed as the Kráľová hoľa nappe (sensu Putiš, 1989). The Kráľová hoľa complex mainly consists of granitoids of the Vepor pluton. There are middle-coarse grained biotite granodiorites, porphyric granodiorites to granites (Vepor type s.s.), and locally small bodies of coarse-grained diorite (as clasts in debris in the Štrompľovská dolina and Rimavská dolina valleys) and xenolithes of paragneisses (Vojtko, 1999). The pegmatite veins were found locally in this complex. These granitoids are deformed, metamorphosed and to different degrees mylonitised to phyllonitised at the contact with overlying cover sequence (Vrána, 1966; Lexa & Bezák, 1996).

The Federata Cover Sequence (the Permian-Middle Triassic)

The Federata Sequence forms an autochtonous or paraautochtonous sedimentary cover of the Prealpine Southern Vepor basement. Its probable age ranges from the Permian to the Middle-Upper Triassic. This sequence, together with its basement, is epimetamorphosed and intensively deformed in a ductile regime. The Federata Sequence is situated beneath the Gemer Unit.

The Federata Sequence consists of four formations and forms an irregular rim at the western and southern edge of the Tisovec karst and part of the eastern periphery of the mapped area. It occurs also west of the Kučelach outlier of the Silica nappe, where carbonate members are better preserved.

The Rimava Formation (Permian)

The Rimava Formation consists of arkosic quartzitic sandstones and conglomerates. It had strongly a low-grade penetration metamorphic foliation and mineral lineations. The post-deformational thickness of the formation randes from several metres to one hundred metres. The rocks lithologically correspond to the Rimava Formation s.s. of the Revúca Group of southern part of the Vepor Unit.

The Lúžna Formation (Lower Scythian)

The Lúžna Formation consists of a pale grey-green to white imbricated and cleavaged fine-grained quartzitic sandstones, which are deformed and metamorphosed and they have penetration foliations and lineations. Its maximal thickness is 100-200 metres and its composition corresponds to the Lúžna Formation s.s. (Bezák, et al., 1999).

Between the Permian arkoses and the Scythian quartzites are gradual lithological changes. The quartzites and the quartzitic sandstones represent a normal lithological sedimentary succession. The Lúžna Formation pass to the Werfen Formation gradually.

The Werfen Formation (Upper Scythian)

The Werfen Formation consists of dark grinish-grey (originally) clayed, silty and sandy shales with thin intercalations of light-colored quartzitic sandstones in lower part, which indicate gradual development from underlying quartzites in the marine origine.

The Gemer Unit – the Dobšiná Group

The Dobšiná Group is in the tectonic contact both with its underlying (the Federata Sequence) and the overlying Turňa Unit(?), locally the Muráň nappe in Magnet hill domain.

The sequence of sediments belonging to the Ochtiná Formation of the Dobšiná Group is newly described tectonic unit in the structure of this area (Soták & Plašienka, in press).

This sedimentary succesion was formerly described as the Ipoltica Group of the Choč nappe (Vozárová & Vozár, 1988). It forms a tectonic slice between the detrital probably the Upper Carboniferous sediments and the rhauwackized tectonic breccia along the base. The sediments of this formation consist of fine-grained, grey, phyllitic and commonly marly shales with the layers of quartzitic conglomerates. The grey and brown carbonates create both thick beds of the massive or bioclastic limestones and thin imbricated detritic sandy and bioclastic, mainly crinoidal limestones. The limestones are locally ankeritized. The crinoidal internodes are very abundant in the crinoidal limestones. Their thickness is about 20 mm. Locally there are solitary corals with the size about 45 mm. Black carbonates and sandy crinoidal limestones are in the Ochtiná Formation too. The Carboniferous age of the limestones was determined by their microfauna from the Furmanec valley. The microfauna populations (*Stacheoides* and forams *Archaediscus karreri* and *Nanicella sp.*) indicate the Visean age of the limestones (Soták & Plašienka, in press; Bezák et al., 1999).

The sequence of detrital dark sediments is provisionally correlated with the Hámor Formation (the Gemer Unit). The Hámor Formation contrary to the Ochtiná Formation has not carbonate members and clastical mica in phyllites, sandstones and conglomerates (Bezák et al., 1999). The Hámor Formation is comparatible with the Nižná Boca Formation of the Ipoltica Group of the Choč nappe

(Vozárová & Vozár, 1988), but it is tightly spatially and deformationally connected with the Ochtiná Formation of the Gemeric Unit. Rocks observed in the mapped area are lithologically similar to the Hámor Formation (Soták & Plašienka, in press; Bezák et al., 1999). New data mainly from boreholes that are located at the eastern slope of Magnet hill points out also to other solution of this problems, as mentioned below.

The Meliata Unit(?)

Among the borehole drilled in Magnet hill domain, realised while prospecting for of scarn and polymetalic Pb-Zn (Cu) ores, is a very interesting borehole TV-10 (Bacsó & Valko, 1969). This borehole TV-10 cut the Carnian Wetterstein Dolomite, the Ladinian Wetterstein Limestone and the Steinalm Limestone (the Pelsonian-Illyrian) and at the depth span 411-520 m was spotted interesting succesion of rocks including evaporites. This borehole was situated outside of the area affected by the contact metamorphosis, which was considerable because size of grains in recrystallised limestones is often more then 15 mm. Evaporites do not occur in the other boreholes probably due to the effects of contact metamorphosis.

Borehole TV-10 was projected to resolve the lithostratigraphy of this area. Complete lithological profile of the borehole TV-10 is listed below (Bacsó & Valko, 1969):

411,0-430,0 m	black phyllites
430,0-434,1 m	white to grey fine-grained gypsum
434,1-435,5 m	gypsum with layers of graphitic phyllites
435,5-445,5 m	graphitic phyllites
445,5-446,0 m	white-grey fine-grained gypsum
446,0-485,0 m	graphitic phyllites locally with quartzitic veinlets
485,0-487,5 m	quarzite-graphitic phyllites
487,5-489,5 m	chlotite-quartzitic phyllites
489,5-494,0 m	white-grey, light green fine-grained to massive gypsum
494,0-494,5 m	breccia of gypsum and graphitic phyllites
494,5-501,0 m	graphitic phyllites
501,0-507,0 m	chlorite-quartzitic phyllites
507,0-520,0 m	green quartzite-chloritic phyllites disseminated by the pyrite

This succession Bacsó (1973) interpreted as "the Gemer Carboniferous sediments". This idea contradicts the well-known lithology in the area of "the Carboniferous strip" in the Gemer Unit between Dobšiná town and the Podrečany village. Bacsó & Valko (1969) did not excluded this succession represents the Meliata Unit. This for this area surprising succession of rocks has not been noticed for 30 years.

A detailed study of rocks of the borehole TV-10 is necessary for tectonic interpretation of this succession, and other boreholes in Magnet hill domain also could be important for solution of this problem. On the base of above mentioned lithology we do not rule out, that at least part of these rocks represents the Meliata Unit. The duplexes of the Meliata rocks (?) in this area are in a similar position as the evaporite melanges of the Meliata Unit, which were described at many places of southern Slovakia and northern Hungary (Bystrický & Fusán, 1961 in Mello et al., 1997; Bystrický & Oravcová, 1962 in Mello et al., 1997; Réti, 1985; Kozur & Réti, 1986; Horváth, 1997).

The Turňa Unit(?)

The most recent study about the Muráň nappe let to extensive changes of the stratigraphy of its, mainly through the study of cherty limestones (before regarded as the Gutenstein limestone). Havrila (1997) described Conodonta, Holothuria and problematic rests of organisms of the Cordevolian age. On the basis of these data Havrila (l.c.) separated from the Muráň nappe of the Silica Unit "the lower Muráň nappe of the Silica Unit" (consisting of the entire lower part of the succession beneath the Steinalm Limestone). The Steinalm Limestone and higher succession is regarded as the Muráň nappe s.s. The lower Muráň nappe overlies of the Dobšiná Group or the Federata Sequence and is covered by the Muráň nappe s.s. We provisionally include it with the Turňa Unit (sensu Less et al., 1981). This succession was separated from the Muráň nappe s.l. on account of the stratigraphic clasification of dark often cherty and having nodular limestones lying beneath of the Steinalm Limestone belonging to the southern Vepor Unit. The Turňa Unit(?) has features of a duplex structure. It locally taper out, mainly in Magnet hill domain. If we admit that rocks included into to the Hámor Formation (maybe part from them) at the surface can belong to the Meliata Unit then their position is analogous to that in the Slovak Karst area. We include this succession into the Turňa Unit (equivalent of the Slovenská skala nappe) provisionally on the basis of a very similar lithology, stratigraphy, anchimetamorphosis absence of Wetterstein facies and commonly the absence of the light Steinalm or Honce Limestones under the base of dark largely cherty limestones. On the other hand there are rhyolite pyroclastics of the Scythian age in the mapped area, while they are missing in the Silica and the Turňa Units in the area of the Slovak Karst.

The occurences of volcanic rocks are not well substantialed in the saddles north of Kerek and Dlhý hills, in the Turňa Depression and on the southern slope of Horný vrch hill (Melo, 1979). These rocks are included in the Turňa Unit (Mello et al., 1997).

Rocks of rhyolite composition were found in the Muránska planina plateau area at several places (near Telgart village – at Gregová hill where there occurs the largest body of the Scythian rhyolites in the Central Western Carpathians; in the Rácovo valley; on the northern slope of Veľká Stožka hill, Klinec, 1976; and locally debris in the Kačkava stream), in the Tisovec karst area (the Rejkovská dolina valley-in terraces and locality in situ). The rock occurences of the Scythian rhyolite are in the Drienok nappe and also at the base of the Neogene volcanic rocks and the Paleogene rocks of the Štiavnica Stratovolcano (Vozár, 1969; Vozár, 1973). This distribution point to the likeli-

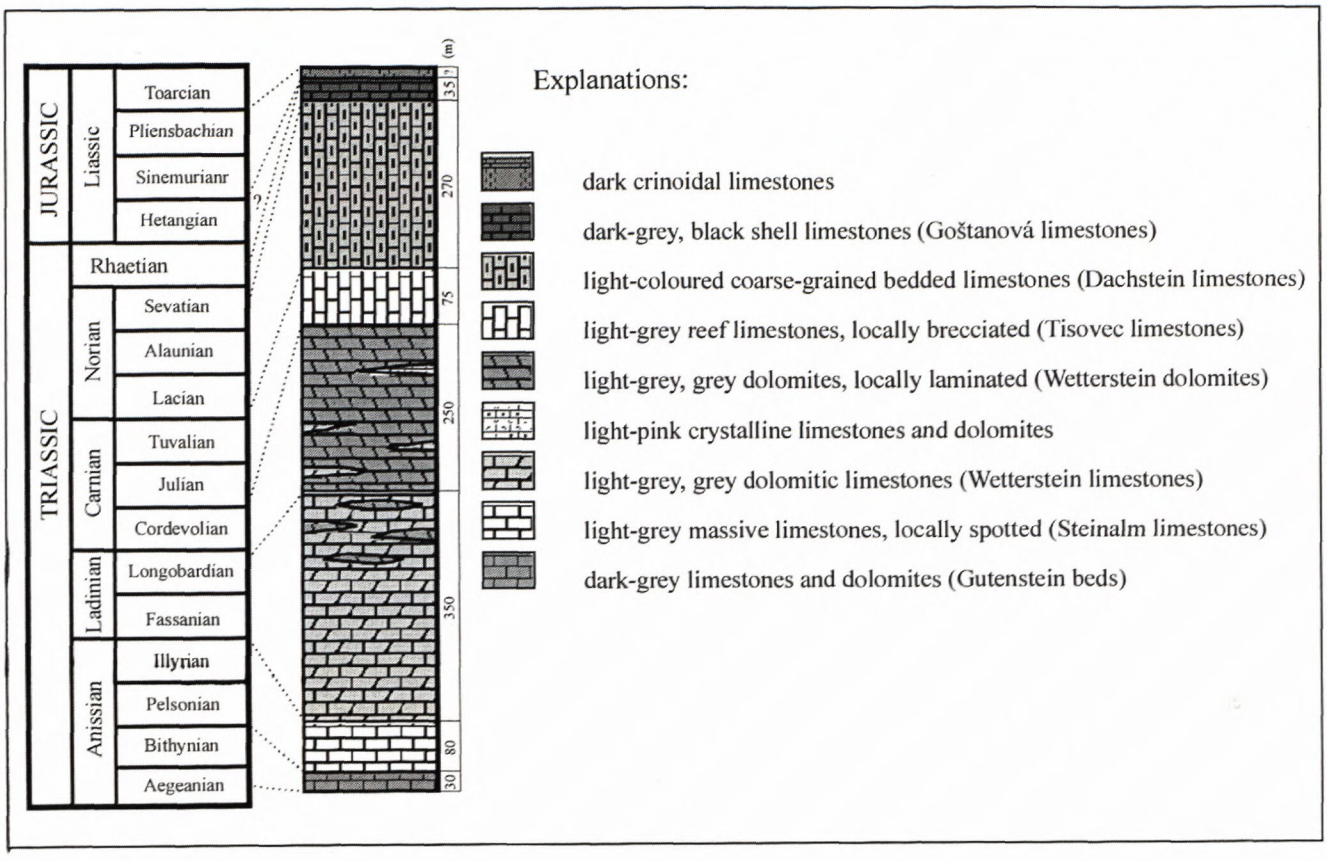


Fig. 2 Lithostratigraphic column of the Silica Unit (the Muráň nappe) in the Tisovec karst and the Kučelach massif area (Vojtko, original figure).

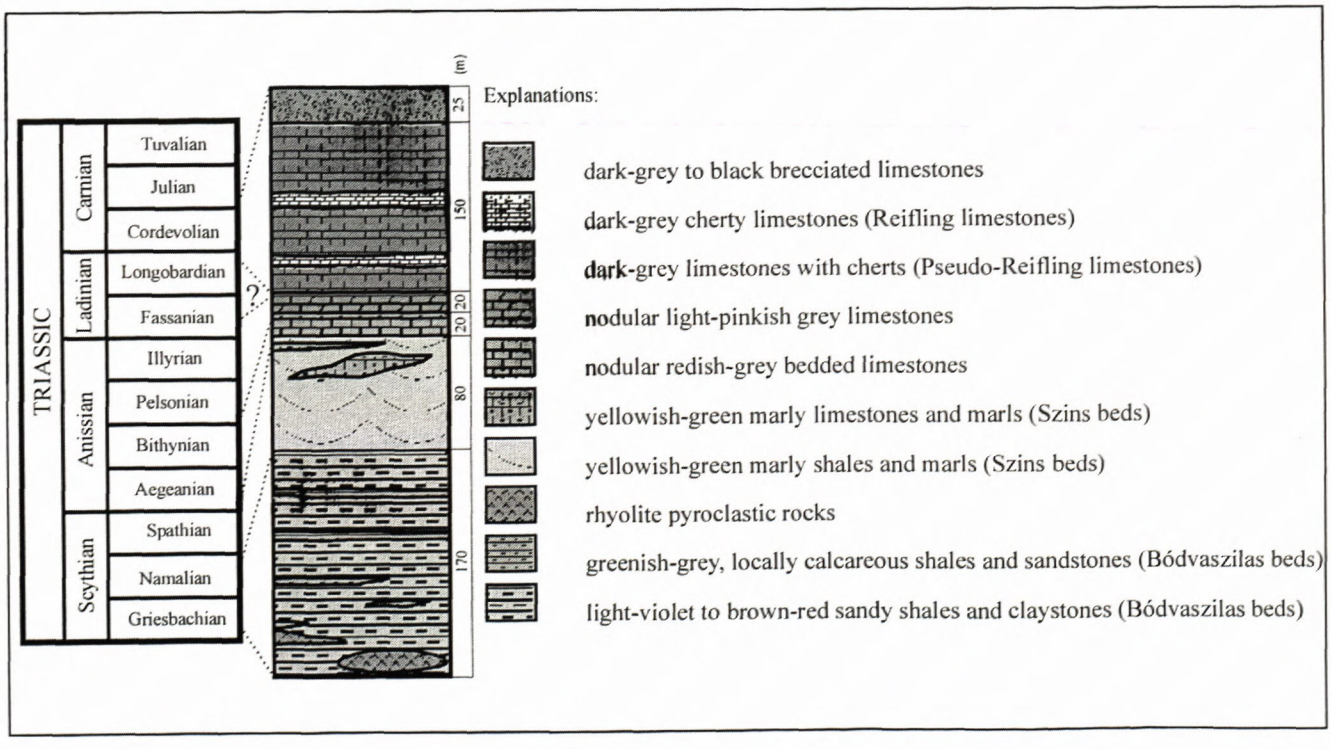


Fig. 3 Lithostratigraphic column of the Torna Unit (?) in the Tisovec karst and the Kučelach massif area (after Vojtko, 1999).

hood that these units in the base of the Muráň nappe, the Drienok nappe and the unit under the base of the Štiavnica Stratovolcano have at least lithological, if not also tectonic similarities. In the Drienok nappe bedded members of the Scythian age, with rhyolite, lying under the Wetterstein Limestone have the same position as in the Tisovec Karst and in the Muránska planina plateau and they could belong to the Turňa Unit too.

In the Turňa Unit in the Slovak Karst there occurs acid volcanic rocks of the Permian age. The rhyolites are even directly in the base of the Bódvaszilas beds and upon the sediments of the Dobšiná Group(?) (maybe the Meliata Unit) in the Rácovo valley.

Bódvaszilas beds (Griensbachian-Namalian)

The Bódvaszilas beds are the lowermost member of the Turňa Unit(?) with an irregular occurence in the mapped area. They occur mainly south of the Hradová fault, where they underlie an outcrop band about 250 m wide, that run from Tisovec town and the Krivá saddle domain to the Rejkovská dolina, Jaslište and Suché Doly valley. Small occurences of this formation are also found on the northwestern slope of Javorina hill, on the southern slope of Magnet hill and Kučelach and Čeremošná hills. They are formed of variegated sandstones and shales, of violet, green and grey colours (Fig. 3).

Szin beds (Namalian-Spathian)

The Szin beds also occur south of the Hradová fault on the southern slope of Hradová hill and the Jaslište area. In the Kučelach outlier they occur only at the western slope of Remetisko hill and the Koryto valley. A local occurence of the Szin beds was also observed on the northwestern slope of Javorina hill.

These rocks are the best exposed on the northern slope of Jaslište hill, where occur marly limestones to lumachela limestones. They are formed by the grey to yellowish-green marly shales and grey to greenish-grey bedded marly limestones with conchoidal fractures (maybe caused by the anchimetamorphosis).

Carbonate complex (Anisian-Carnian?)

This assemblage made us of dark to black limestones, which occurs mainly in the Kučelach outlier and in the Tisovec karst around Červená hill. Small occurences are also founded on the northern slope of Javorina hill.

This complex is formed by the Gutenstein Limestone and Dolomite, Nádaska Limestones and Reifling Limestones (Uppermost Ladinian-Cordevolian) with foraminifera *Turriglominna mesotrasica* ZANINETTI determined by Soták. Reifling Limestones have the character of a basinal facies with cherts.

The Silica Unit – Muráň nappe

The Silica Unit is represented by the Muráň nappe in the study area. It is probably gravitional nappe. Its stratigraphical range of sedimentary rocks is from the Anisian to the Liassic (Fig.2). They are non-metamorphic rocks with a thickness of at much as 800 metres. The Silica Unit forms the uppermost Mesoalpine unit in the Tisovec karst. In the basement of this unit is the Turňa Unit(?) except at the Magnet hill domain. Under the Muráň nappe are the Federata Sequence, the Dobšiná Group of the Gemer Unit or the Meliata Unit in the area of the Magnet hill (cut by borehole TV-10).

Gutenstein Formation (Aegeanian-Bithynian)

Occurences of the Gutenstein Formation are rare, and limited to the south and southeast side of the Hradová fault. The sediments of this formation are preserved only as lenticular bodies.

The Gutenstein Formation is chert free dark thick-bedded limestones with characteristic veins of the white calcite. Dark limestones replaced by dolomite with the characteristic fracturing of the dolomite.

Both their distribution and inclusion into the Muráň nappe are problematic. In the Muráň nappe are included only the Gutenstein Limestone and Dolomite, which are incorporated to the lenticular bodies in the Jaslište domain and to the Muráň fault zone, but we do not rule on that they could belong to the Turňa Unit(?).

Part of dark limestone could belong to the Muráň nappe. It is above the Reifling Limestone with cherts (the Turňa Unit(?)) and below the Steinalm Limestone on the southern slope of Červená hill. Precision of stratigraphy is necessary for outcrop identification and the inclusion of the Gutenstein Formation to the corresponding tectonic unit.

Steinalm Limestone (Pelsonian-Illyrian)

They occur only at the southern part of the study area at Červená and Podhrad hills and they also form tectonic lenticular bodies on the northern slope of Kochovo hill and in the Jaslište domain.

They are light-coloured massive, commonly spotted crinoidal limestones or light-coloured thick-bedded to massive limestones with a finely brecciated fabric. The Steinalm Limestone contain dasycladaceans of the genus *Physsoporella*. The foraminiferas *Meandrospira dinnarica* were described from Červená hill (Salaj et al., 1983).

Wetterstein Limestone (Fassanian-Cordevolian)

The largest occurence of this formation is at the Kášter hill domain and northern slope of Grúniky hill. They occur also in the central part of the Kučelach-Remetisko syncline. Smaller occurences are on the northern slope of Kereška hill and on the southern slopes of Magnet and Pacherka hills. The Wetterstein Limestone are locally dolomitised or changed to dolomites in the Tisovec Karst. Dolomites form irregular bodies, mainly lenses or layers in this limestones. The Wetterstein Limestone are enriched upward by dolomite component. The Wetterstein Limestone gradually change to the Wetter-

stein Dolomite of the Carnian age. The Wetterstein Limestone are light-grey or grey, massive, and locally thick bedded. They often contain Dasycladaceae. The *Teutloporella herculea* (STOPP.) commonly occurs in the Wetterstein Limestone and big gastropods were found locally.

The upper part of the Wetterstein Limestone is formed by Wetterstein dolomite. This dolomite create an important layer for geological mapping as a distinctive marker because they separate a lower carbonate platform from an upper carbonate platform. This geological layer is well developed in this territory. The thickness of the Wetterstein dolomite is 75 to 375 m; about 250 m is an average thickness.

They occur almost in all of the karst, and mainly on the northern slopes of Grúniky, Hradová, Javorina, Kereške hills and on the central part of Pacherka hill.

Dolomites are light grey to grey, locally white and dark. They have a grained or massive fabric, bedding is visible mainly as the alternating dark and light thin beds. In their lower part occur lenses of light limestones and locally are pink crystalline bedded limestones. This crystalline limestones are describe Bezák et al. (1996), probably also by Bystrický (1959). Limestone lenses are syngenetic and their bedding is congruent with bedding of the neighbouring dolomites. Therefore, we do not expect that these lenses are neptunean dikes of the Jurassic limestones as proposed by Bezák et al., 1996.

Tisovec Limestone (Julian-Tuvalian)

The Tisovec Limestone (sensu Soták 1990) occur mainly on the northern slope of Hradová hill where it forms huge cliffs, as well as at the area of Kášter hill. The Tisovec Limestone do not form a distinctive morphological contrast in the domain of Javorina hill. Their geological age is the Juvalian to Tuvalian. These limestones were not confirmed on the type locality by Krystyn et al. (1990), but Soták (1990) confirmed their occurence. In this paper we use this term for limestones directly overlying the Wetterstein dolomites and the base of the bedded Dachstein limestones. These limestones are light-coloured, locally grey, grained, and bioclastic. Their the most important feature is a brecciaed fabric, which is expressive mainly in the lower part of this layer and second one is the filling of caverns by the aragonite druses between clasts. These druses are recrystallised to calcite. This phenomenon is confirmed by the habitus, which is also still aragonite and locally calcite. These characteristic features were main reasons, to separate them from the bedded Dachstein Limestone.

Dachstein Limestone (Norian-Lower Rhaetian?)

Above the light-coloured the Tisovec Limestone occur light grey to grey limestones, which are distinctively bedded. They occur in all the profile from base to the top in the domain of the Teplica and Suché doly valley, Goštanová hill. Other incomplete occurences are in the Tepličné, Rangaska, Hradová, Čremošná and Kášter hills. They provide records of cyclical sedimentation with features of emersion which were described by Borza (1977).

The Dachstein Limestone are microscopically sparitic and towards the top increases in micrite and only part of limestones are micritic with fenestral structures filled by coarse pellucid sparite on the border between the Sevathian and the Rhaetian(?). Among the fossils were found Amodiscidal Foraminiferas of the species *Agathammina inconstans, Earlandia sp., Opthalmidium triadicum* KRISTAN; and questionable Involutinidal Foraminiferas with manifestations of hard sparitisation and the form of the Nodosarial Foraminiferas. The crinoidal internodes, Ostracoda and oval paramorphosis of the organisms represent a lagoonal facies. The fossils and the Upper Sevathian and the Lower Rhaetian(?) age of this limestones were determined by Soták.

Goštanová Limestone (Rhaetian)

The Goštanová Limestone was mapped by Biely in the Muráň nappe and was named by Michalík (in Bystrický et al., 1973). They were correlated by Kochanová with the limestones of the Bleskový prameň domain on account of their bivalves.

The fauna of the brachiopods (l.c.) is different from the fauna of the Bleskový prameň limestones but similar to the brachiopods of the Hybe Formation (*Rhaetina pyriformis, Zeilleria norica, Zeilleria elliptica, Euxinella subrimosa, Austririnchia cornigeria, Sinucosta emmrichi, Zugmaerella koessenensis*). The Goštanová Limestone are medium grained, grey to pale grey, crinoidal biosparite with brachiopods and bivalves (Michalík; 1977, 1980). They form the lenticular sedimentary bodies and the neptunean dikes, too, in the uppermost part of the Dachstein Limestone succession (Michalík, 1977).

„Crinoidal" limestones (Pliensbachian-Sinemurian)

This formation is represented only by dark crinoidal limestones, which occur very locally in the Tisovec Karst. Goštanová hill is their only occurence, where the limestones form a morphologically conspicuous shallow E-W trending depresion in the marking an erosional remnant or Neptunean dike (Fig. 1). They are above the Dachstein Limestone and are the youngest member of the Muráň nappe in the Tisovec Karst. These limestones are wackestone microscopically, which contain ostracods of the family Ogmoconcha; Amodiscidal Foraminifera – small forms of the Frondicularia, species *Amodiscus incertus* d'ORBIGNY and *Amodiscus multivolutus* REITLINGER; Nodosarial Foraminifera – species *Nodosaria nitidana* BRAND, *Agathamina austroalpina* KRISTAN-TOLLMANN et TOLLMANN; fragments of bivalvia first and foremost the family Periostraca. They contain also crinoidal internodes, sea urchin spines and thecas of punctate brachiopods. These fossils have been described by Soták who interpreted their age as the Pliensbachian-Sinemúrian. Sediments of the Hetangian age have not been found. I think that they do not occur in this territory.

The Subtatras Group

The Subtatras Group was well-known only in the erossional remnants in the Zbojská saddle, the Kučelach massive. The new locality of this group form the sedimentary cover at Magnet hill which is cut into two parts by pyroxenic andesite and pyroxenic diorite.

The northern part is formed by dark Globigerine marly claystones, fine-grained sandy claystones to fine-grainded sandstones. These rocks are contact metamorphosed by Neogene magmatic intrusions and they are converted to shales with cherts and locally by porcelanites (Fig. 1).

Quartzitic conglomerates are distributed in the southern part of the area. These conglomerates create lenses in claystones reported by Bacsó (1964), but he considered all formations from northern part of the area as the Carboniferous sediments of the Gemer Unit (Bacsó; 1964, 1973; Bacsó & Valko, 1969). Underlying these conglomerates are the Wetterstein Limestone and Dolomite of the Muráň nappe, which is contact metamorphosed in the Magnet hill domain. These carbonates are metamorphosed to marbles, as shown in the TV-4 and TV-9 boreholes (Bacsó & Valko, 1969). The Paleogene sediments are at most about 60 m thick and they dip WSW 5°-10° and in the southern part to 20°. Globigerine claystones represent the basinal facies.

The Neogene volcano-plutonic complex

The subvolcanic levels expected in the Tisovec stratovolcano were eroded due to the uplift in the Veporské vrchy Mts. and in this domain were not preserved characteristic morphological features in contrast to the Eastern Slovakian and Central Slovakian volcano-plutonic complexes. Erosion created unique conditions for study of volcanic and geological relations of the deposits and the deeper levels of the volcano-plutonic complex at the surface. Volcano-plutonic complex of the Veporské vrchy Mts. is divided to several lithostratigraphical formations (Burian et al., 1985; Vojtko, 1999).

The Železnícke predhorie Formation is located north of the Rimava basin. This formation build up of the Pokoradz and Blh platforms NNE from Rimavská Sobota town. The peripheral part of the Vepor volcano-plutonic complex is formed by the Železnícke predhorie formation. This formation comprises by explosive products, extrusive sheets, tuffs, tuffites, agglomerates and lahars. These rocks include pyroxene andesites and hornblend-pyroxene andesites, which are autometamorphosed (Marková & Vaňová in Burian et al., 1985).

Both types of andesites are related to well-known types in the Tisovec intrusive complex and they are probably products of this intrusive complex. The age of the amphibole-pyroxene andesites was determined by the fission track method as the 16.4 ± 0.6 MA from the epiclastical conglomerates (Višňové village) and from the pyrhoclastic flow of the pyroxene andesites as the 16.2 ± 0.8 MA (the Lower Badenian) near Chvalová village (Repčok, 1981). We expect that subvolcano intrusive rocks Tisovec town have the same age (Vojtko, 1999). The age of the basal formation near Vyšná Pokoradz village was determined by means of macroflora as the Sarmathian (Němejc in Fusán et al., 1962).

The centre of the Vepor volcano-plutonic complex was probably in Tisovec town area according to the volcano paleoflow tracks. These paleoflow tracks are directed from NNW to SSE (Konečný & Lexa in Vass et al., 1982).

The Hájna hora Formation consists of relict of the volcano-sedimentary bedding south of the Brezno depression. Its thickness is 150 m (Konečný & Lexa in Ivanička, 1986). This formation represents a paleovalley fill of NW-SE-trending. NW of the proposed volcanic centre (Magnet hill) fine-grained sediments and sandy sediments predominate. Amphibole, pyroxene, amphibole-pyroxene andesites and andesites with accessory garnet are present in this formation as fragments of volcanic rocks (Konečný & Lexa in Ivanička et al., 1986).

The Pacherka Formation is characterised by penetration of subvolcanic dikes in the southeast zone of the Tisovec intrusive complex. The composition of volcanic rocks is basaltic andesite to basalt. This is the last volcanic activity.

The Magnet hill Formation consists of amphibole-pyroxene andesites, which are very well developed in Tisovec town area. Generally, bodies of amphibole-pyroxene andesites occupy area about 4000 m long and 1500 m width, elongated NW-SE.

The typical phenomenon of andesite intrusions with amphibole-pyroxene composition is that they cut diorite bodies. This phenomenon makes posible to determine their relative succession and age. The Tisovec intrusive complex makes the central zone of the Vepor volcano-plutonic complex, which is situated in the wider domain of Magnet hill in the studied area. The Tisovec intrusive complex is built up of nine diorite bodies with irregular shape, which extent is 2,500 x 500 m. Their occurence begins near top of Magnet hill and ends on the southwestern slope of Huta hill. The biggest and easternmost diorite body is in the middle of the body of porphyric granodiorites. These are relatively strong contact metamorphosed to a distance of 300 m, and rarely even more. This body has the composition of a biotite-pyroxene diorite (Bacsó & Valko, 1969; Bacsó, 1973).

Other diorite bodies are situated in Magnet hill domain and their surrouding is built up of a pyroxene andesites, the Wetterstein Limestone and dolomites of the Muráň nappe and also locally by the Paleogene dark globigerina marly shales.

Hyperstene-diopside diorites dominate especially in the easternmost body and occur as apophysal protrusions, which consist of pyroxene diorite porphyry. The southern part of the largest body consists of pyroxene-quartzitic diorite (Bascó, 1964). The four easternmost diorite bodies at Magnet hill are developed directly in the Tisovec fault zone. Most of the diorite bodies pass to porphyric varieties at their margins.

The Vepor formation in Magnet hill domain is characterised by the penetration of pyroxene andesites, which are relatively older than diorite bodies. The are most abundant

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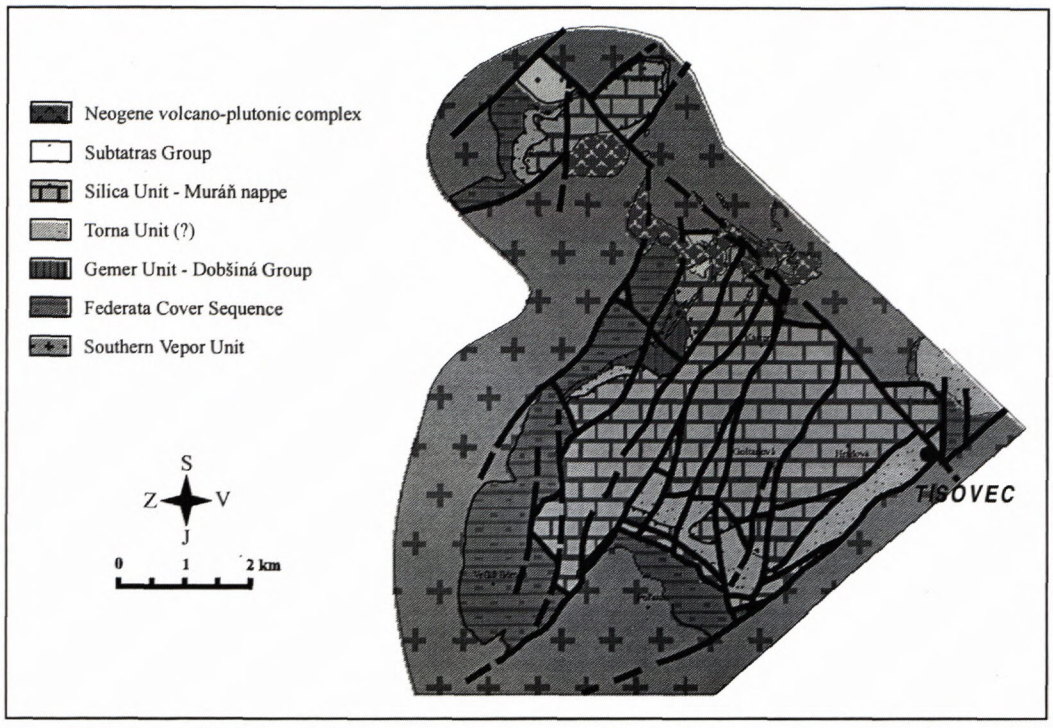

Fig. 4 Schematic tectonic sketch of the Tisovec karst and the Kučelach massif (Vojtko, original figure).

at the western and eastern parts of Magnet hill and southern part of Huta hill.

The Strieborný potok formation occurs northwest of Magnet hill in the study area and consists of garnet-pyroxene±biotite andesites. By analogy with others volcanic Mts. of central Slovakia, they are considered to be the oldest ones. (Konečný, 1998; Šimon, 1997).

Tectonics

The studied area is built up by these superposed tectonic units, which are listed from the bottom to the top:

Paleo-Meso alpine epizonally metamorphosed nappe units (Fig.4):

a) the southern Vepor Unit with the Federata Sequence
b) the Gemer Unit (the Dobšiná Group)
c) the Meliata Unit s.l.(?)

Mesoalpine anchizonally metamorphosed and non-metamorphosed nappe units:

a) the Turňa Unit(?)
b) the Silica Unit (the Muráň nappe)

Post-nappe formations:

a) the Subtatras Group
b) the Neogene volcano-plutonic complex (the Tisovec stratovolcano).

The Paleoalpine epizonally metamorphosed nappe units have features of low-grade metamorphosed recrystallization and ductile deformation, which were overprinted by structures of younger deformation stages (Plašienka, 1981,1993).

The Mesoalpine anchimetamorphosed to non-metamorphosed nappe units are without features of epizonal metamorphosis. Post-nappe formations are deformed only in the brittle regimes. Older deformation stages connected with metamorphosis were not in the focus our interest and so we will not deal with them here.

The pregosau displacement of the Muráň nappe represents the oldest tectonic event in our interest. Both the Turňa(?) and the Silica Units are superficial nappes. Their displacement had only minimal influence on the para-autochtonous Veporic basement (Bezák et al., 1999).

Deformations close to the décolement products of brittle cataclasis, crushing and brecciation of carbonates of the Federata Sequence and the rocks of the Turňa nappe(?). Rauwackised carbonate tectonic breccias held many features of the hydrotectonic phenomena and complicate fluidal regimes approximately in the environment of pore fluids overpressure. These phenomena a enabled smooth displacement of superficial nappes (Plašienka & Soták, 1996; Milovský, 1996; Milovský et al.,1998; Milovský, 2000).

Cataclasis and rauwackization appear mainly along the base of the Turňa Unit(?). On the contact between the Turňa(?) and Silica Units only cataclastic fracturing is developed. The maximum thickness of this zone is 5 m. This phenomenon partly confirms that the Silica nappe was probably carried passively upon the Turňa Unit(?) (Vojtko, 1999), that means the Turňa Unit could be in para-autochtonous position in relation to the Silica Unit.

The tectonics in the area of the Tisovec Karst and Kučelach massif is very complicated, with a evolution of important fault structures. The character of the tectonic structure of the studied area was influenced by the two regional faults (the Muráň and Tisovec faults), which cross on the eastern part of the Tisovec karst.

During the Late Cretaceous time at higher structural levels dextral movement occured along the NW-SE ori-

ented faults (Plašienka, 1993). N-S compression lasted during the Late Cretaceous and the Paleogene ages. The structures due to cooling and uplift became „colder" and deformation was localised to sinistral SW-NE (the Muráň fault; Marko, 1993a) and dextral SE-NW (the Mýto--Tisovec fault zone; Marko, 1993b) brittle fault zones.

Within the Muráň fault zone operated sinistral transpression. In the Muráň nappe were formed fan like synforms of WSW-ENE strike (Marko, 1993a). The south wings of this synforms are considerably compressed and they have complicated fold-duplexes structure like the south wings of the Tesná skala synform sensu (Bystrický, 1959) the Hradová and Červená synforms in the Tisovec Karst and in Šarkanica hill domain (Marko, 1993a; Plašienka, 1993; Bezák et al., 1999; Vojtko, 1999). The eastern edges of these synforms were truncated by the Muráň fault during the Paleogene (the Pre-Oligocene) period (Marko, 1993a).

The youngest are extensional normal faults, which renew the mainly SW-NE originally transpressional faults. The normal NNE-SSW faults are for geomorphological and the Quarternary development of the Tisovec Karst the most important. They cut the whole karst area and create structure of the irregular grabens with maximum subsidence in the Suché Doly valley and Goštanová hill domain. NNE-SSW faults were supply ways for the Neogene volcanic rocks of Magnet, Pacherka and Kášter hills (Bacsó, 1964, 1973; Bezák et al., 1996; Vojtko, 1999). NNE-SSW normal faults mediate movement of ground waters from the ponores in the Suché Doly domain to the exsurgences in the Furmanecká dolina valley, too. Probably the Badenian-Sarmathian age of volcanic rocks and normal character of the NNE-SSW faults correspond with NNE-SSW orientation of principal compressional stress ascertained for this period in the western part (Marko et al., 1995) and central part of Western Carpathians (Kováč & Hók, 1993).

Conclusions

The geological mapping of the Tisovec Karst confirmed that geological structure and its evolution is more complicated than it was expected in the past.

The southern Vepor Unit forms the basement of the subautochtonous Federata Cover Sequence in the Tisovec Karst area. Metamorphosed formations (the Ochtiná and Hámor Formations) of the Dobšiná Group (the Gemer Unit) are overthrusted. New described tectonic units in this area are the Meliata(?) and Turňa(?) Units. As Turňa Unit(?) we regard members under the Steinalm Limestone of the Muráň nappe (the Silica Unit) with stratigraphical range from the Scythian (the Upper Permian?) to the Cordevolian. The Muráň nappe has a stratigraphical range only from the Anissian to the Pliensbachian, which is stratigraphically confirmed an erossion remnant on Goštanová hill.

Five eruptive phases were earmarked in Magnet hill domain. These phases are distinguished on the basis both their mineralogical-petrological composition and their spatial distribution. In the Magnet hill domain occur the Paleogene sediments. These sediments were regarded formerly as the Carboniferous rocks of the Gemer Unit or the Choč nappe (the Ipoltica Group). The Quarternary sediments do not create more important accumulations and their thickness do not reach more than 3.5 metres.

Several fault structures, which have not been mapped before were identified by the structural research of the Tisovec Karst. The dominant fault structures trend NNE-SSW normal faults, which break the whole territory to asymetric grabens with maximum subsidence in block the Suché Doly valley and Goštanová hill domain.

References

Bacsó Z., 1964: The Post-Triassic scarn deposits near Tisovec town. Geol. Práce, Zprávy, 31, GÚDŠ, Bratislava, 13-45 (in Slovak).

Bacsó Z., 1973: Origin of the Post-Triassic scarn deposit near Tisovec. Rigorózna práca. Sp. N. Ves-Košice, Manuscript, Geofond, Bratislava, 108p (in Slovak).

Bacsó Z. & Valko P., 1969: Final report and calculation of resouces, the 1st part: Horehronie valley from locality Tisovec-Hnúšťa-investigation, raw material Fe, state 1.XI. 1968. GP Sp. N. Ves – GS Rožňava, Manuscript, Geofond, Bratislava, 200p (in Slovak).

Bajaník Š., Hanzel V., Ivanička J., Mello J., Pristaš J., Reichalder P., Snopko L., Vozár J. & Vozárová A., 1983: Explanation to geological map of the Slovenské rudohorie Mts. (Eastern part; 1:50 000). GÚDŠ, Bratislava, 223p (in Slovak).

Bezák V., 1988: Tectonic development of the south-western part of Veporicum, West Carpathians. Miner. Slov., 20, 131-142 (in Slovak).

Bezák V. & Hraško Ľ., 1992: Basic geological classification of a granitoids in the western part of the Slovenské rudohorie Mts. Geol. Práce, Správy, 95, 25-31 (in Slovak).

Bezák V., Hraško Ľ., Kováčik M., Lexa O., Plašienka D., Pristaš J., & Siman P., 1996: Geological map and explanation (1: 25 000). Map 36-244, 36-442, GÚDŠ, Bratislava (in Slovak).

Bezák V., Dublan L., Hraško Ľ., Konečný V., Kováčik M., Madarás J., Plašienka D. & Pristaš J., 1999: Geological map of the Sovenské rudohorie Mts. and explanations (1:50 000). Vyd. D. Štúra, GS SR, Bratislava (in Slovak).

Borza K., 1977: Cyclic sedimentation of Dachstein limestones of the Muránska planina plateau. GÚDŠ, Bratislava, Geol. práce, Správy 67, 23-52 (in Slovak).

Burian J., Slavkay M., Štohl J. & Tőzsér J., 1985: Metalogenesis of the neovulkanites of Slovakia. Monography, ALFA (Bratislava), 269p (in Slovak).

Bystrický J., 1959: Contribution to stratigraphy of the Muráň Mesozoic. Geol. Práce, Zošit, 56, 1- 53 (in Slovak).

Bystrický J., et al., 1973: Triassic of the W. Carpathians. Guide to excursion D. X-th Congr. of CBGA, Bratislava, 137p.

Fusán O., Bystrický J., Čechovič V., Franko O., Hanáček., J., Ilavský J., Kullman E., Kuthan M., Lukniš M. & Regásek F., 1962: Explanation to geological map, ČSSR 1: 200 000, Map Rimavská Sobota. Manuscript, Geofond, Bratislava, 123p (in Slovak).

Havrila M., 1997: Relationship between Hronicum and Silicicum. Manuscript GSSR, Bratislava, 31p (in Slovak).

Horváth P., 1997: High-pressure metamorphism and P-T path of the metabasic rocks in the borehole Komjáti-11, Bódva valley area, NE Hungary. Acta Mineralogica-petrographica, Szeged, XXXVIII, 151-163.

Ivanička J., Pulec M., Halouzka R., Konečný V., Lexa J., Planderová E., Dovina V., Motlidba I., Šucha P., Kováčik M. & Vážna Ľ., 1986: Explanation to geological map 1: 25 000, map Pohronská Polhora – 1 /36-241/. Manuscript-archives GÚDŠ, Bratislava, 84p (in Slovak).

Klinec A., 1966: About problems of structure and genesis of the Vepor crystalline basement. Sbor. Geol. Vied, rad ZK, 6, 7-28 (in Slovak).

Klinec A., 1976: Geological map of the Slovenské rudohorie Mts. and Nízke Tatry Mts. GÚDŠ, Bratislava.

Konečný V., 1998: Geological map of the Štiavnické vrchy hills and Pohronský Inovec Mts. and explanation (Štiavnica stratovolcano). 1st part (1:50 000). GSSR, Vyd. D. Štúra, Bratislava, 248p (in Slovak).

Kováč P. and Hók J., 1993: The Central Slovak Fault System – field evidence of a strike slip. Geol. Carpath., 44, 155-159.

Kozur H. & Réti Z., 1986: The first paleontological evidence of Triassic ophiolites in Hungary. N. Jb. Geol. Paläont. Mh., Stuttgart, 284-292.

Krystyn L., Lein R., Mello J., Riedel P. & Piller W., 1990: "Tisovec Limestone" – an example of the problems of lithostratigraphic correlation between the Northern Calcareous Alps and the Central West Carpathians. In Minaříková D. and Lobitzer H. (eds): Thirty years of geological cooperation betwen Austria and Czechoslovakia. Fed. Geol. Surv., Vienna, Geol. Surv., Prague, 125-136.

Less G. et at., 1981: Explication to the 25 000 geological map of the Aggtelek-Rudabánya Mountains, Hidvégardó sheet. MAFI, Budapest, 84p.

Lexa O. & Bezák V., 1996: Porphyric granitoids in the western part of the Slovenské rudohorie Mts.: Emplacement and deformation in shear zones. Slovak Geol. Mag., 3-4, Bratislava, 189-197.

Marko F., 1993a: Kinematics of Muráň fault betwen Hrabušice and Tuhár village. In Rakús M. and Vozár J. (eds): Geodynamický model a hlbinná stavba Západných Karpát. Konf. Symp. Sem., GÚDŠ, Bratislava, 253-261.

Marko F., 1993b: Structural and geological analysis of the Mýto-Tisovec fault between Brezno and Tisovec towns. Manuscript Dept. of geol. a paleont. Comenius Univ., Fac. of Sciences, Bratislava, 8p (in Slovak).

Marko F., Plašienka D. and Fodor L., 1995: Meso-Cenozoic tectonic stress fields within the Alpine-Carpathian transition zone: a review. Geol. Carpath., 46, 19-27.

Mazúr E. & Lukniš M., 1986: Geomorfological dividement of SSR a ČSSR (map). Slovak Cartography, Bratislava (in Slovak).

Mello J., 1979: Belong the higher Subtatric nappes and the Silica nappe to the Gemeric unit? Miner. slov., 11, 3, Bratislava 279-281 (in Slovak).

Mello J., Elečko M., Pristaš J., Reichwalder P., Snopko L., Vass D., Vozárová A., Gaál Ľ., Hanzel V., Hók J., Kováč P., Slavkay M. & Steiner A., 1997: Geological map of the Slovenský kras karst and explanation (1:50 000). GSSR, Bratislava, 255p (in Slovak).

Michalík., 1977: Paleogeographycal investigation of the Fatra beds (Kössen formation) on the northern part Fatricum in the Western Carpathians. Geol. Zbor., Geol. carpath., 28, Bratislava, 71-94 (in German).

Michalík J., 1980: Paleoenvironmental and paleoecological analysis of the West Carpathians part of the Northern Tethyan nearshore region in the latest Triassic time. Riv., Ital., Paleont., 85, 3-4, 1047-1064.

Milovský R., 1996: Distribution of deformation and structural relationship on profile between Veporic crystaline basement and the base Muráň nappe. Diploma work, Manuscript-archives Comenius Univ., Fac. of Sciences, Bratislava, 92p (in Slovak).

Milovský, R., Plašienka, D. and Soták, J., 1998: Rauhwackes – a key to understanding the superficial thrusting emchanisms: case study from the Muráň nappe. Geol. Carpath., 50, spec. issue, 157–158.

Milovský R., 2000: Overthrusting mechanisms of superficial nappes of the Central Western Carpathians: fluid pressure role at the nappe sole. PhD theses, Manuscript-archive, Slovak academy of Sciences, Bratislava, 110p (in Slovak).

Plašienka D., 1981: Tectonic position some of metamorphosed Mesozoic series of Veporicum. PhD Thesis, Manuscript GlÚ SAV, Bratislava, 153p (in Slovak).

Plašienka D., 1993: Structural pattern and partitioning of deformation in the Veporic Foederata cover unit (Central Western Carpathians). In Rakús a Vozár (eds): Geodynamický model a hlbinná stavba Západných Karpát. Knf. Symp. Sem., GÚDŠ, Bratislava, 269-277.

Plašienka D. & Soták J., 1996: Rauhwackized carbonate tectonic breccias in the West Carpathian nappe edifice: introductory remarks and preliminary results. Slovak Geol. Mag., 3-4, 287-291.

Putiš M., 1989: Structural-metamorphic development of the crystalline complex of the eastern part of the Low Tatras. Miner. Slov., 21, 217-224 (in Slovak).

Repčok I., 1981: Dating of some Central Slovakian neovolcanic rocks by fission track method. Západné Karpaty, Sér. miner. petrogr., geochém., metalog., 8, 59-104 (in Slovak).

Réti Z., 1985: Triassic ophiolite fragments in an evaporitic melange, Northern Hungary. Ofioliti (Bologna), 10 (2/3), 411-422.

Rozlozsnik P., 1935: Geological relationships of the Dobšiná surrouding. Geol. Hung., Ser. Geol., 5, 118p (in German).

Salaj J., Borza K & Samuel O., 1983: Triassic foraminiferas of the West Carpathians. Monografia, GÚDŠ (Bratislava), 213p.

Schönenberg R., 1946: Geological investigation on north-western margin of the Spišsko-gemerské rudohorie Mts. (Western Carpathians). Z. Dtsch. Geol. Gesell., 98, 70-120 (in German).

Soták J., 1990: Stratigraphy and litology of limestone complex of the Tisovec deposit. GP Spiš.N.Ves, 15p (in Slovak).

Soták J. & Plašienka D., Stratigraphic and tectonic position of Carboniferous sediments in the Furmanec Valley (Muráň Plateau, Central Western Carpathians). Slovak Geol. Mag., in press.

Šimon L., 1997: Geological map of the Vtáčnik Mts. and Hornonitrianska kotlina valley and explanation (1:50 000). GSSR, Vyd. D. Štúra, Bratislava, 281p (in Slovak).

Vass D. et al., 1982: Explanation to geological map 1: 25 000, map 36 442. Manuscript-archives GÚDŠ, Bratislava (in Slovak).

Vojtko R., 1999: Geology and tectonics of the Tisovský kras karst and its surrouding. Diploma work, Manuscript-archives Comenius Univ., Fac. of Sciences, Bratislava, 77p (in Slovak).

Vozár J., 1969: Volcanoclastic material in the Mesozoic in the Basement of the Neovolcanites South of Banská Štiavnica. Geol. práce, Správy, 48, 47-52 (in Slovak).

Vozár J., 1973: Petrographical-Lithological characterization of the Choč Unit and Gemeride Mesozoic in the Basement of the Neovolcanites North of Levice. Rad Západné Karpaty, 18, 183-213 (in Slovak).

Vozárová A. & Vozár J., 1988: Late Paleozoic in West Carpathians. GÚDŠ, Bratislava, 314p.

Vrána S., 1966: Apline metamorphose of the granitoids and Federata Group in central part of Veporicum. Sbor. Geol. Vied, rad ZK, 6, 29-84 (in German).