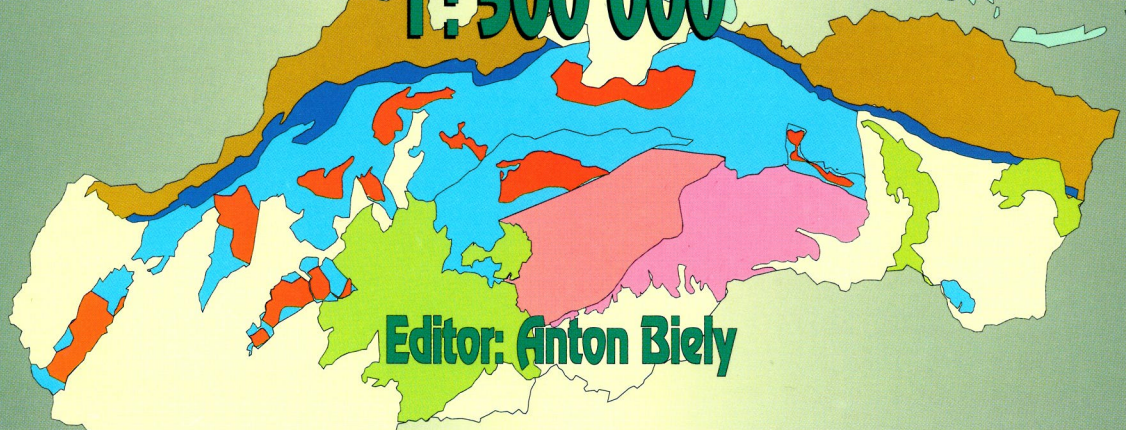
MINISTRY OF ENVIRONMENT OF SLOVAK REPUBLIC
GEOLOGICAL SURVEY OF SLOVAK REPUBLIC

Explanation to geological map of Slovakia

1 : 500 000



Editor: Anton Biely

Anton Biely, Vladimír Bezák, Michal Elečko, Pavel Gross, Michal Kaličiak, Vlastimil Konečný, Jaroslav Lexa, Ján Mello, †Ján Nemčok, Michal Potfaj, Miloš Rakús, Dionýz Vass, Jozef Vozár, Anna Vozárová

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Vysvetlivky
k regionálnym
geologickým
mapám
Slovenska

Explanation
to regional
geological
maps
of Slovakia

CONTENTS

ABSTRACT

The new geological map of the Slovak Republic at scale 1:500 000 is an uncovered one, i.e. it ignores Quaternary deposits. About 80 % of the illustrated territory has been derived from base geological maps at scale 1 : 25 000 and regional geological maps at scale 1 : 50 000 compiled between 1963 and 1992. Therefore it presents current knowledge of the basic structural division and geological structure of the Slovak territory. The geological map is strictly lithostratigraphic as its legend does not give assignation to tectonic units. These are schematically shown on a separate scheme at a smaller scale.

The introductory part of the Explanations deals with the latest review of the West Carpathians' structural division, geological structure and history in the extent needed for correct understanding of explanatory texts in individual items of the legend.

The Explanations to the geological map define and clear up: (1) content of individual items in the legend to the geological map, (2) geographic distribution and variability of groups, formations and complexes, (3) occurrences in tectonic and regional-geologic units, also by means of overall tables, (4) relationship to publications defining lithostratigraphic units through references (however, the Explanations do not contain information given in stratigraphic dictionary).

The bulk of the Explanations' text is devoted to systematic description of individual items of the legend commenting on their geographic distribution and variability, occurrences in tectonic and regional-geologic units, distribution of lithostratigraphic units, detailed lithologic-petrographic characteristics and chronostratigraphic assignation. Like the legend, the text is also divided into chapters: Neogene, Neogene volcanics, Inner Carpathian Upper Cretaceous and Paleogene, Outer Carpathian Cretaceous and Paleogene, Inner Carpathian Mesozoic, Inner Carpathian Late Paleozoic, Gemeric Early Paleozoic, Veporic and Tatric Early Paleozoic and Proterozoic ?, and abyssal igneous rocks.

Each of the above chapters contains an easy-to-review table showing the occurrences of the legend's individual items in tectonic and/or regional-geologic units including lithostratigraphic units (groups, formations, complexes, members).

SUMMARY OF THE GEOLOGICAL STRUCTURE OF SLOVAKIA

The territory of the Slovak Republic is occupied by the Alpine mountain belt of the West Carpathians. Their western geographical boundary is placed in the Danube Valley, but a more evident geological boundary with the Eastern Alps is a depression west of the Hundsheim Mts., the so-called Carnuntian Gate. Alpine units extend into Slovakia below the Vienna Basin Neogene fill, but are not exposed at the surface. In the east, the boundary with the East Carpathians is arbitrarily placed in the Uh Valley. The West Carpathian northern boundary corresponds to the erosional, mostly morphologically pronounced edge of Alpine nappes, resting on the foreland. The southern boundary is less clear, because the inner edge of the West Carpathians is occupied by vast lowlands penetrating deep into the mountain system. The northern margin of the Great Hungarian Lowland south of the Bükk and Matra Mts. is morphologically conspicuous and therefore these two mountains are assigned to the Carpathians.

The West Carpathian zonal structure was recognized as early as in the 19t^{h} century (Štúr, 1860, Uhlig, 1903). It was confirmed by subsequent investigations which also revealed that the Mesozoic and Tertiary formations, in arcuate belts, resulted from a complicated tectonic transformation of qualitatively and temporally different basins into fold-nappe systems that sometimes incorporated not only their sedimentary fillings, but in places, also their original substratum.

THE CARPATHIAN FORELAND consists of Variscan and pre-Variscan elements of the Bohemian Massif and the Cracow Plateau, outside of Slovakia.

A system of Neogene and Paleogene (less common foredeeps on the Foreland fringes the outer edge of the folded Carpathians and makes up the Carpathian Foredeep. Its Early Miocene sediments crop out only in a narrow belt, which is, at places, separated from the Foreland by faults or flexures. Along with the underlying Foreland elements, these sediments plunge deep below the Outer Carpathian nappes. An analysis of geophysical fields suggests that they stretch at least as far as the axis of a central gravity low (line Hodonín - Námestovo - Krosno - Borislav), or as far as the so-called "Peripieninic lineament", which is roughly identical with the axis and is perceived as a deep fault between the North European Platform (underthrust beneath the Magura Flysch) and the Tertiary Carpathian-Pannonian block (or Inner Carpathians, in part). Other conceptions (Uhlig, 1907; Leško - Varga, 1980; and others) suggest that the North European Platform and Foredeep sediments extend far to the south below the Inner Carpathians. The Carpathian Foredeep is not exposed in Slovak territory.

The West Carpathians are divided into an Outer belt and an Inner belt. The Outer belt is made up of Neoalpine nappes whereas the Inner belt has Paleoalpine, pre-Paleogene structure. The two are separated by a Klippen Belt.

THE OUTER CARPATHIANS make up the external zone of the West Carpathians. Their characteristic features comprise flysch-dominated Mesozoic and Paleogene formations, virtually missing pre-Mesozoic formations and a negligible distribution of post-nappe cover. Elements of this zone in Moravia, and also below the Vienna Basin Neogene sediments in western Slovakia, are associated with the Rhine-Danube Alpine flysch. They stretch further east in an immense continuous arc through Poland and eastern Slovakia as far as the East Carpathians.

THE FLYSCH BELT Consists of nappes, ranged into three groups (Nowak, 1927; Roth *in* Buday *et al*, 1967):

1. Marginal group. It consists of the Pouzdřany unit, of limited extent, in the Ždánický les Mts. of Moravia (Czech Republic). Its essentially nonflysch Late Eocene to Karpatian sediments display clear lithofacial affinity to the Tertiary filling of the Foredeep onto which they were thrust, thereby being analogous to the folded Alpine molasse (Andrusov, 1968). They are absent in Slovak territory, lying entirely to the west of it.

2. Middle, or Krosno-Menilite Group. It is composed of Jurassic-Cretaceous and Paleogene lithostratigraphic units of various paleogeographic character. Ždánice-Subsilesian and Silesian units in the western sector of the Outer Carpathians (Roth in Buday et al. 1967) scarcely extend into Slovakia. In the Ždánický les and Pavlovské vrchy Mts., the Ždánice unit is thrust as a fold-scale system over the Pouzdřany unit, or onto the Foredeep Neogene fill. Its Oxfordian to Karpatian sediments (with a most notable hiatus in the Lower Cretaceous) largely are of nonflysch character and, according to Andrusov (1968), they represent an element of the inner (folded) molasse and an extension of the Waschberg zone from Austria. The Stebnik-Borislav nappe has an analogous position in the eastern sector of the West Carpathian Flysch Belt, but lies mainly in the East Carpathians (l.c.).

In the Moravsko-slezské Beskydy Mts., the Subsilesian unit forms a nearly horizontal strongly folded nappe. It contains flysch, as well as nonflysch sequences (Turonian to Eocene) and it rests on structures of the marginal group, or directly on the Karpatian, its front sections also lies on the Early Badenian of the Moravian Foredeep.

The Silesian unit is a higher tectonic unit of the Krosno-Menilite Group in the Moravsko-slezské Beskydy. Its sequences, ranging in age from the Malm to Oligocene, are mostly of flysch character, with a variegated volcanic assemblage of teschenites in the Early Cretaceous. It is divided into two facies nappes - Tešín and Godula.

The Silesian and Subsilesian units stretch further to the eastern sector of the flysch Carpathians where they join the Dukla unit in the south and the Skole unit (part

of the Krosno-Menilite Group) in the north. Widespread in the northeastern corner of Slovakia, the former is the only unit of this nappe group to have appreciable extent in Slovakia. Composed of Cretaceous and Paleogene largely flysch formations, it forms folds and imbricated thrust sheets distributed between the Silesian and Magura units. This system pinches out westward in Polish territory. Further west, slices of the Fore-Magura unit stretch as far as the Moravsko-slezské Beskydy Mts. The Dukla unit plunges beneath the Magura to the south. Some concepts assume that it also includes the sequences of the so called Inlier unit or "Ropa-Pisarzova" (Kozikowski, 1958) (or Grybow unit - G. Ksiazkiewicz, 1972) exposed in inliers beneath the Magura nappe. The Silesian unit plunges under the Dukla unit but in eastern Slovakia the latter is underlain by sequences (revealed by drilling) of the Obidowa-Slopnice unit (Korába - Ďurkovič, 1980) defined in the Polish territory (Jawor - Sikora, 1979).

3. Inner - Magura nappe Group. It is divided formally by the Tatry meridian into the western and eastern sectors. The Magura unit forms a continuous arc along the entire West Carpathians. Its continuation to the elements of the Rhine-Danube flysch is obscured by post-nappe Neogene sediments of the Vienna Basin.

The Magura Nappe group consists primarily of Paleogene flysch sequences. Cretaceous sediments rarely crop out. Jurassic klippen in the front of this group in Moravia (so called Outer Klippen Belt) are mostly olistoliths of the Silesian Cordillera sediments, rather than deposits of the Magura trough s.s.

The Magura nappe group comprises (from north to south) the Rača, Bystrica, Krynica and Biele Karpaty partial nappes. As a whole, they were thrust northward on the middle Flysch Belt group. In the western sector, the partial nappes are obliquely terminated at the Pieniny Klippen Belt boundary, in some sectors (e.g. boundary in Orava) they were backthrust over, or folded and sliced into the Klippen Belt.

The incorporation of the Magura Basin (and the entire flysch basin) into north vergent nappes took place largely from the Late Oligocene age to Badenian stage inclusive (Savian-Styrian folding phases).

The current bivergent form of the Magura nappe system thrust onto the foreland and hinterland (at least in western sector) resulted from Moldovan (Sarmatian) movements (Roth, 1980).

The Outer West Carpathians are represented by a system of rootless nappes, i.e. sedimentary sequences detached from the basement and thrust onto various elements of the North European Platform. The original basement of these sequences is unknown. There are different views about its character (thinned continental, quasioceanic or oceanic crust) and on the mode of its partial or complete subduction.

The Pieniny Klippen Belt is the most complicated zone in the West Carpathians. It emerges from beneath the Vienna Basin Neogene fill near Podbranč and extends as a narrow belt, arched to the north, between the Outer and Inner Carpathians as far as Romania. Its characteristic signs include the above-mentioned position, the presence only of varied Jurassic, Cretaceous and of Paleogene deposits and the typical klippen tectonic style. In this style Jurassic - Lower Cretaceous limestone lenses form Pieniny-type klippen (Andrusov - Scheibner, 1968) penetrating through Cretaceous and Paleogene marly and flysch formations.

Although complicated, locally in disarray or even chaotic, the Klippen Belt's structure systematically comprises two contrasting Jurassic-Cretaceous sequences and a multitude of transient sequences (Andrusov 1968). The Czorsztyn sequence is characterized by Jurassic crinoidal and nodular limestones, an Early Cretaceous hiatus and a variegated marlstone facies (couches rouges) of Albian to Maastrichtian age. The Kysuca (Pieniny) sequence is characterized by Dogger marlstones and radiolarites, cherty and pelagic Late Jurassic and Early Cretaceous limestones. Since the Cenomanian (Albian ?) it was dominated by the couches rouges facies and flysch complexes, frequently with conglomerates. M. Maheľ (1986) designates the Czorsztyn and Kysuca sequences as the Oravicum.

In the Váh Valley and Orava, the Klippen Belt structure also includes the Klape sequence composed mostly of Cretaceous flysch formations. Locally they contain abundant exotic clast conglomerate. The Senonian part also has couches rouges layers (Marschalko, 1986). Some authors (Rakús, 1975) assume that the variegated marlstones were dragged tectonically into the flysch sequences. It is disputable whether Jurassic shallow-water limestones are an indigenous part of the sequence or are olistoliths (at Klape, after which the sequence was formerly named).

In the Váh Valley, the Klippen Belt comprises also the Manín sequence, which is characterized mainly by shallow-water limestones of Lower Jurassic (Hierlatz Limestones) or Lower Cretaceous age (Urgonian Limestones) and by Cenomanian and Senonian flysch. The Inner Carpathian origin of the pre-Senonian part of the sequence is agreed upon, but controversies persist over whether it is the front of the Tatricum (Andrusov, 1968) or of the Krížna nappe (Maheľ, 1986). The Haligovce sequence in the Pieniny stretch of the Klippen Belt is equivalent to the Manín sequence.

The destruction of basins in which all the above sequences were laid down was an extreme one, and the conceptions of their distribution involve assumptions and speculations. Palinspastic reconstruction reveals that the outermost section of the sedimentary basin was a Czorsztyn elevation, and zones situated farther to the south from the external basin edge comprised a bathyal Pieniny-Kysuca trough. At least since the Albian, the Klape Basin, which is linked to the difficult issue of the existence of an "ultrapieniny cordillera" (Andrusov, 1968), points out that in the Cretaceous, the cordillera supplied exotic detritus, inclusive of Jurassic and Early Cretaceous acid, mafic and ultramafic igneous rocks and glaucophanites).

The character of the Czorsztyn sequence suggests that it was deposited in a basin underlain by continental crust. Some authors (Birkenmajer, 1977, 1986) assume that the Pieniny-Kysuce trough may have rested on a crust of oceanic character, but a similar sequence (Veporic Zliechov sequence) originated on a thinned, but undoubtedly continental crust.

The Klippen Belt was therefore formed by the transformation of a complicated sedimentary basin into a Laramian north vergent system of near-surface nappes at the Inner Carpathian front. Following the deposition of the Jarmuta and Proč Members, the system was disturbed by post-Paleogene foldings. At that time the Klippen Belt was formed into its present-day shape. Its original substratum was subducted or adjacent systems were thrust onto it. The Klippen Belt's modern boundaries are tectonic. They have the character of near vertical faults also with horizontal (sinistral) movements (Birkenmajer, 1985). It seems that the Klippen Belt could hardly be shaped to its modern form without major horizontal displacements as was noted by Rutten as early as 1965 (*in* Andrusov, 1967). The original Czorsztyn and Kysuca sequences and Laramian nappes created from them were destroyed to such an extent that attempts to distinguish individual nappes here are meaningless. Only in the Klape and Manín nappes are some individual features preserved, although the character of their original Laramian contacts is controversial.

THE INNER CARPATHIANS. In the last decade, the essentially synonymous terms "Central" and "Inner" Carpathians became the basis of regional division (cf. Mišík et al., 1985). In the light of current knowledge about the distribution of Meliaticum, the Rožňava Line has no relationship to the Central/Inner Carpathian boundary. According to another proposal, these two regional units are separated by the Lubeník line. The line is clearly visible at the contact of exposed parts of the Veporicum and Gemericum, but it is impossible to identify the boundary in the area between Dobšiná and Krompachy, where the contact is masked by thick masses of the Besník nappe or Galmus zone, not yet removed by erosion. Although the southern vergence of the Silica nappe is not certain, we state that the Inner Carpathians are made up of pre-Gosau fold-nappe system that originated from basins deformed during Kimmerian through to Mediterranean phases, regardless of the character of the basins and of the post-nappe disturbances.

The Inner Carpathians, defined in this way, are vertically divided into a nappe system and an overlying post-nappe Late Cretaceous to Neogene sedimentary and volcanic formations.

The pre-Gosau nappe system comprises crystalline masses and Late Paleozoic formations, which are grouped into Alpine tectonic units defined by Matějka and Andrusov as early as 1931. Each such unit consists of a basement and characteristic Mesozoic sequences, regardless of whether the latter rests on its original basement or was detached and displaced as a nappe onto a different basement elsewhere. Now, after numerous refinements, the Inner Carpathian major tectonic units are divided as follows:

The Tatricum is exposed in the core mountains. It consists of a crystalline core and its indigenous Late Paleozoic (Permian) and Mesozoic envelope (Early Triassic to Early Turonian). The Tatric crystalline basement has specific features in some core mountains, but generally it is made up of medium- to high-grade metamorphic rocks (mica-schist gneisses, gneisses) and granitoids. Some evidence indicates the presence of higher-pressure relics. In contrast, low-grade metamorphosed complexes occur in some mountain ranges (Tríbeč, Malé Karpaty and Považský Inovec Mts.). The boundaries of these complexes of different metamorphic grade are tectonic and probably mostly Hercynian, an assumption that was confirmed by structural-tectonic investigations in some mountains, such as the Západné Tatry (Fritz et al. 1992, Janák, 1992). The character and evolution of crystalline rocks of Tatricum and Northern Veporicum is similar - the Tatric terrane was defined (acc. Vozárová - Vozár, 1996). The sedimentary envelope, notably its Early Jurassic formations, display marked contrasts in their rock composition: sandy and crinoidal limestones versus marlstones with cherty limestones (cf. Maheľ 1986). In some mountains, the Tatricum is deformed into complicated slices, recumbent folds and partial nappes (Malé Karpaty, Tatry, Nízke Tatry), which underwent Alpine metamorphism (Tríbeč, Malé Karpaty).

The Tatricum is the deepest exposed tectonic unit of the Inner Carpathians, an autochthon relative to all overlying units. To which extent the Tatricum itself is in allochthonous position can be inferred only from broader relationships and seismic profiles. Interpretations ranging from Uhlig (1907) to Bezák et al. (1993) differ in details and are not dealt with here. If the Tatricum is in an allochthonous position, then it is due to Tertiary tectonics. It is worth mentioning that the Tatricum - equivalent to the Lower Austroalpinicum in the Eastern Alps can be underlain by the Penninicum. Andrusov (1960) said that if the Penninicum were present in the Carpathians, its exposures would occur at the contact of the Inner Carpathians with the Klippen Belt. This issue was studied in more detail by Maheľ (1981) who defined the Vahicum as a hypothetical equivalent to the Alpine-southern Penninicum at the front of the Inner Carpathians. Surface occurrences of this unit may include the Cretaceous formations described by Plašienka et al. (1994) amidst the Inovec crystalline massif.

The Veporicum - the definition of this basic tectonic unit has changed several times since 1931. In accordance with proposals by Andusov (1960) and Maheľ (1986), the Veporicum comprises: (1) crystalline masifs of Čierťaž, Veporské and Stolické vrchy Mts. in Slovenské rudohorie, Kráľovohoľské Tatry, Čierna hora and Branisko Mts., and overlying Late Paleozoic and Mesozoic formations, which form the indigenous

sedimentary envelope of the crystalline massifs and (2) a nappe system composed of Mesozoic complexes overlying the Tatricum, which Andrusov (l.c.) designated as the Lower Subtatricum or Krížna nappe, Andrusov - Bystrický and Fusán (1973) as the Fatricum, and Maheľ (1986) in a hierarchy of the basic tectonic unit - the Krížna nappe.

1. The Veporicum is composed of a crystalline core and its envelope which were thrust onto the Tatricum along the Čertovica line. The Veporicum plunges under the Gemericum along the Lubeník-Margecany line (Zoubek, 1957).

The internal structure of the crystalline basement is complicated as it involves several lithotectonic units (complexes). There are units of granitoid and highly-metamorphosed rocks, as well as those of weakly-metamorphosed Early Paleozoic, Late Paleozoic and Mesozoic sequences, which are lithologically different in the northern Veporicum and in the southern Veporicum (see Andrusov et al., 1973, Vozárová - Vozár, 1988). The superposition of the crystalline complexes essentially dates back as early as the Hercynian tectonic processes although, especially in the Veporicum, it was considerably rejuvenated or destroyed by Alpine disturbances. A number of local units were defined in the Veporic and Tatric crystallines, yet their tectonic-metamorphic history and analysis of deep structure allow a distinction of three major Hercynian lithotectonic units (Bezák, 1994): The Upper Hercynian lithotectonic unit, composed largely of the highest-grade units and granitoids, is present in the Veporicum only as relics. The middle (medium- and high-grade metamorphic rocks and granitoids) and lower units (low-grade metamorphic rocks present chiefly in the Kohút zone) account for the most of the Veporic crystalline rocks. Relics of weakly metamorphosed complexes in an upper position may suggest the existence of another tectonic unit. The Early Paleozoic complexes in the Gemericum make up a separate domain. Hercynian tectonic-metamorphic evolution was a long and complex one, and its reconstruction is made even more complicated by Alpine reworking.

The Veporic crystalline is divided by nearly vertical faults into the Ľubietová, Krakľová, Kráľova hoľa and Kohút zones (Zoubek, 1957 and others). In this respect, the character of their Late Paleozoic but mainly Mesozoic envelopes is noteworthy. The first two zones, in the so called northern Veporicum, the Late Paleozoic and Mesozoic envelope constitute the Veľký Bok sequence (Permian - Neocomian). Although different in details, the Veľký Bok is essentially similar to the Krížna nappe Mesozoic inasmuch as it was deposited in the innermost sector of the basin that was to become the Krížna nappe (Fatricum, according to Andrusov et al., 1973) and was not detached from its original basement. The sequence falls into the Triassic facies area, characterized by the lithostratigraphic unit of the Carpathian Keuper.

In the Kráľova hoľa and Kohút zones, in the so called southern Veporicum, only remnants of the envelope unit were preserved. The envelope is represented by the Stephanian to Permian of the Revúca Group (Vozárová - Vozár, 1982, 1988) and the Mesozoic of the Federata (Rozlozsnik, 1935) or Struženík (Maheľ et al., 1967) and/or Tuhár (in Fusán et al., 1963) or Ružín (Maheľ et al., 1967) sequence. With the presence of the Stephanian and Permian on the one hand, and missing Keuper formation on the other hand, the envelope of the Southern Veporicum is essentially different from the envelope of the Northern Veporicum, although many members, mainly in the Mesozoic, are similar in both parts of the Veporicum s.l.

The fact that these Veporic sequences lie side by side raises the question of how they and their crystalline basements got so close to one another. Signs of strike-slip movements along the Pohorelá line, noted by Hók and Hraško (1990), indicate one possible solution. If the division of the Inner Carpathians into Alpine tectonic units is based on the character of their Mesozoic, it is questionable whether the northern and southern Veporicum are parts of a single tectonic unit. The entire Veporic tract in question was Alpine-metamorphosed.

2. The Veporicum, made up of a group of near-surface nappes (Fatricum according to Andrusov et al., 1973) overthrusting the Tatricum in all core mountains, has a uniform Triassic (with a characteristic Carpathian Keuper facies), but has a differentiated Jurassic and partly also Early Cretaceous aspect. In some core mountains the Tatricum immediately underlies a partial nappe characterized by Jurassic crinoidal and cherty limestones - the Vysoká nappe. The Vysoká, and somewhere also directly the Tatricum, are overlain by a nappe, that has a moderately complicated internal structure and has Jurassic spotted limestones, radiolarian limestones and radiolarites. This overlying nappe has been designated the Krížna nappe (a different terminology was introduced by Maheľ, 1986). The origin of this section of the Veporicum (or Fatricum, according to Andrusov et al., 1973) is undoubtedly ultratatric. Its original basement (probably a thinned continental crust, or "heavy crust", according to Maheľ 1986) was almost completely subducted and its remnants are confined to the Staré Hory inlier. As the Veľký Bok sequence (whose facies resembles the Krížna nappe) rests on the crystalline massif of the northern Veporicum, the Ľubietová and Krakľová zones of the northern Veporicum may possibly be a basement nappe, attesting to the character of the original basement of the southern tract of the Krížna nappe.

The Zemplinicum. The Zemplinicum (sensu Slávik, 1971 in Fusán et al., 1971) is composed of the high-grade metamorphosed crystalline complex and its Carboniferous - Permian and Mesozoic envelope. Predominating rocks in the crystalline complex are paragneisses, amphibolites and migmatites; their mineral associations indicate P-T conditions of higher-grade amphibolite facies (Vozárová, 1991, Faryad, 1995). The post-orogenic Variscan sequence starts with Stephanian continental sediments having several limno-fluvial coal cyclothems and it

continues with the coarse grained Permian continental "red-beds". Mesozoic sequences are mainly represented by Lower Triassic quartzites and shales and Middle Triassic epiplatform carbonate sequences (Bouček - Přybil, 1959, Grecula - Együd, 1982, Vozárová - Vozár, 1988). According to the results of the study of crystalline rocks and Late Paleozoic - Mesozoic sequences, we can correlate Zemplinicum with the Veporicum.

The Hronicum is a nappe system (or middle Subtatricum, according to Andrusov 1968) characterized by uniform Permo-Carboniferous sedimentary-volcanic sequences, differentiated Oberostalpine-type Triassic and only locally preserved Jurassic - Early Cretaceous formations.

The Triassic here is characterized by two facies, a monotonous, dolomite (Ćierny Váh sequence or facial area) and a vertically differentiated (Biely Váh sequence or facies area). Believing that the former is bound to a lower partial nappe and the latter to an upper partial nappe, Andrusov et al. (1973) designated them as the Šturec and Choč nappes. However, the assumed relationship of the facies to the partial nappes generally is not valid (e.g. Maheľ 1986) and therefore we understand the Hronicum as a system of piled up partial nappes and slices (or basic polyfacial Choč nappe, according to Maheľ 1986), whose geometric relationships from one mountain range to another are often controversial due to various disturbances.

The allochthonous position of Hronic rootless nappes relative to the basement clearly indicates their ultraveporic origin, presumably from an area between the Veporicum and Gemericum (Biely - Fusán, 1967, Andrusov, 1960) but this has also been challenged now. The original basement was completely destroyed, but the presence of a carbonatic-platform-type Triassic confirms that the crust was a continental one, possibly thinned in the Jurassic.

The lithological character of Late Paleozoic sediments and volcanics (Nižná Boca and Malužiná Formations) points to their origin in a basin of riftogenic character founded on continental crust (Vozárová - Vozár, 1988, 1996). This opinion is also supported by finds of tectonic fragments of mylonitized granitoids in the basal part of the lower partial Hronicum nappe (Andrusov, 1936, Vozárová and Vozár, 1979).

The Gemericum. The classical definitions (Andrusov, 1968) in this tectonic unit include the Paleozoic sequences of the Volovské vrchy Mts. and the Mesozoic sequences of Oberostalpin facies development, with units such as Slovak Karst, Stratenská hornatina Mts., Muráňska planina). These terms became untenable after the age of the Meliata Group was established (Kozur - Mock, 1973a, b) and after allochthoneity of the Silicicum was proved. These new interpretations and also the detailed lithofacies studies of the Late Paleozoic sequences (Varga, 1971, Vozárová 1973, Reichwalder, 1973) led to division of the Late Paleozoic envelope of the Gemericum. This envelope was believed to be a single unit recently, but is now seen as divisible into the Northern and Southern Gemericum units (Bajaník et al. 1984, Vozárová - Vozár, 1988). Separation of metamorphosed clastic - carbonate units, with their metabasalt tuffs, metabasalts and glaucophanites (the Dúbrava Beds in the sense of Fusán, 1959) from Carboniferous units helped to demonstrate their allochthoneity. Furthermore, their assignment to the Meliaticum unit (in Bajaník et al. 1983, 1984) brough further arguments for this division into the Northern and Southern Gemericum.

The Northern and Southern Gemericum units consist mainly of Paleozoic formations, i.e. of metamorphosed pre-Carboniferous complexes and Late Paleozoic syn- and post-orogenic formations, from the Mesozoic part of the envelope in both linking of the Lower Triassic and Permian is evident only (with exception of some areas in the Stratenská hornatina and Galmus Mts.), the position of the Triassic and Permian gives the impression of stratigraphic linking (Maheľ and Vozár, 1971).

Conflicting interpretations were given the stratigraphic position of the pre-Carboniferous formations and this situation led to controversy about their internal structure. In one view it forms an asymmetric, strongly Alpine reworked meganticline, underlain by granitoid (see the map Bajaník et al., 1984). In an alternative view (Grecula, 1982) the inner structure of the Gemericum comprises a system of Late Variscan nappes, in which granites are also included. This alternative, however, is not in agreement with the results of the deep seismic profile G-1 (Vozár et al., 1993, 1996), which confirms an Alpine type of north-vergent nappe structures and younger - Cretaceous? age of the granitoids. Both interpretations however, share in common the concept that the Early Paleozoic development of the Northern and Southern Gemericum took place in one geotectonic domain, whether already with continuous lateral or vertical connection.

The Northern Gemericum is a tectonic unit of volcanic-sedimentary formations reflecting subduction and collision processes of the Variscan orogen. In the Northern Gemericum the Bretonic, Sudetic, Asturian movement phases and metamorphic events of Lower and Middle Carboniferous ages are recognized. This is indicated by relics of fills of the Lower Carboniferous deposits containing olistholiths of serpentinized ultrabasic rocks (Ochtiná Formation, Črmeľ Group) as well as of a peripheral shallow-marine Westphalian basin (the remaining formations of the Dobšiná Group), These sediments were deformed by Variscan structures. The post-orogenic transpressional regime was linked with the development of the continental Permian sequences. Some Upper Permian - Lower Triassic lagoonal-sabkha formations were connected with the beginning of the Alpine cycle.

The Southern Gemericum is composed largely of Early Paleozoic volcanogenic flysch (Gelnica Group, Snopko - Ivanička, 1979, Ivanička et al., 1989), This flysch was folded and to low-grade metamorphosed during the Late Variscan. The formation of this flysch is

connected with the active margin of a continent (Bajaník - Reichwalder 1979, Vozárová, 1993). The South Gemeric Early Paleozoic overlies an angular disconformity and is covered by a Permian continental rift-related sequence (Gočaltovo Group) prograding during the Upper Permian - Lower Triassic to a lagoonal or shallow-marine regime. This sequence is genetically connected with the beginning of the Alpine development cycle.

During the pre-Gosau period these Northern and Southern Gemericum Units amalgamated to form a paleoalpine terrane that was widely overthrust on the Veporicum.

The Meliaticum. Although the Meliatic "series" was defined as a lithostratigraphic unit more than 40 years ago, the views on its position and stratigraphy still differ. The Meliata "series" pro parte was originally regarded as Early Triassic (Čekalová 1954), mainly owing to its position below the Slovak Karst Middle Triassic formations. Evidence of its Late Triassic age put forward by Kozur - Mock (1973b) and others radically changed the views on the tectonic position of the Slovak Karst Austroalpine Triassic (= Silica nappe) and the palinspastic reconstruction of the inner sector of the Carpathian area.

The views on the Meliaticum lithostratigraphy also changed considerably. Kozur - Mock (1973b) considered a classical section near a mill at Meliata as a continuous Middle to Late Triassic sequence. The Jurassic age was discovered at this section later (Kozur - Mock, 1985). The Meliata Formation is now defined as a Jurassic sequence of black shales, as much as several hundred metres thick, intercalated with dark and greenish-red radiolarites, sandstones and marlstones (Mock et al. 1992, Mello et al., 1992). Olistostromes in this shaly sequence include clasts and blocks, mostly of Triassic rocks (the original Middle-Upper Triassic Meliata series), as much as several thousands of m^3 in size. Part of the formation is assigned into the Jurassic (Bathonian - Callovian), and the spotted marlstones and shales with sandstones are Liassic. In places, the Meliata Formation is tectonically fractured into "mélange" (Jaklovce).

The Meliaticum is now perceived to be a tectonic unit which originated in an oceanic or paraoceanic domain that was closed in the Late Jurassic - ? Early Cretaceous. It is exposed in numerous inliers surrounded by the Silica nappe, fringing the southern edge of the Gemeric Paleozoic and in some slices in the so called Nižná Slaná depression between Jelšava and Dobšiná. The components making up this unit are still uncertain. They presumably consist of two units, one of them, the Meliata Group sensu stricto (Držkovce, Honce, Meliata, Jaklovce) is a relic of sediments and volcanics probably deposited in a basin underlain by oceanic crust. The other, immediately overthrusting the Gemeric Paleozoic, may be genetically associated with the Gemericum as its envelope. However, this quasi-Gemeric section of the "Meliaticum" also includes glaucophanites and therefore some authors believe that its position above the Paleozoic is allochthonous (the Bôrka nappe, Leško - Varga, 1980).

The Bôrka nappe was recently redefined (Mello et al., 1992, 1996). Now it also includes occurrences of Late Paleozoic - Mesozoic metamorphosed rocks (Hačava type) along the northern edge of the Slovak Karst between Jasov and Štítnik and in the Nižná Slaná depression. Their characteristic signature is an Alpine medium- to high-pressure metamorphism (Mazzoli et al., 1992). Their lithology is variable and includes abundant metamorphosed mafic rocks (largely glaucophanites) displaying affinity to the Meliaticum.

The Turnaicum. This unit of Middle and Late Triassic age, comprises a nappe group whose lithology reflects its original site of deposition between the Silicic and Meliatic zones, such as slope and basinal ones (Mello et al., 1996). The initial-carbonate-platform facies here were not restored. Another characteristic sign of these formations is their anchizonal to greenschist facies metamorphism. In the basal part of the Turnaicum the continental Permian (Brusník Fm.) and Middle Carboniferous flysch (Turiec Fm.) are preserved (Vozárová, 1992) Turnaic nappes are widespread in the Slovak Karst, mostly above the Meliaticum and below the Silicicum (Vozárová - Vozár, 1992).

The Silicicum. The Tornaicum tectonic units are overlain by outliers dominated by the Oberostalpine-type of Triassic rocks, such as the Strážov and Nedzov nappes in the core mountains (called the Upper Subtatricum by Andrusov, 1968) as well as the Murán nappe, Galmus zone (equals the Besník nappe of Maheľ, 1986) and the Slovak Karst (equals the Gemericum of Andrusov, 1968). They were assigned to the Gemericum because of their facies similarities (Biely et al. 1968 and others). However, the revelation that the Austroalpine Triassic of the Slovak Karst constitutes the Silica nappe rather, than a single tectonic unit with the Gemeric Paleozoic (Kozur - Mock, 1973a) cast strong doubts on the original connection with the Gemeric Paleozoic, and so Mello (1979b) designated them as the Silicicum. The allochthonous position of all Silicic outliers and their outward vergence is evident (except in some areas in the Stratenské vrchy and Galmus Mts. where the Triassic overlies the Permian suggesting normal stratigraphic sequence). Nevertheless, the original vergence of the Silica nappe is controversial; it is either southward (Kozur - Mock, 1973a and Andrusov, 1975) or northward (Maheľ, 1986, and Hók, et al., 1995).

INNER CARPATHIAN POST-NAPPE FORMATIONS

Very little is known about the evolution of the Inner Carpathian area in the Senonian because these sediments occur in only a few small areas of the Miglinc Valley, and the Dobšinská Ľadová Jaskyňa, Šumiac, Čierna lúka and Brezovské Karpaty Mts. They invariably rest transgressively and unconformably on their substratum. In the former four localities, the Senonian is made up of marine limestones and marlstones intercalated with sandstones and are mostly of Santonian-Campanian age. These deposits are less than 100 m thick. The Late Cre-

taceous in the Dobšinská Ľadová jaskyňa area also includes red conglomerates intercalated with claystones of uncertain marine origin and age.

Thicker Cretaceous sediments of the Brezová Group (formerly series) are as much as 1500 m thick and are widely distributed in the Brezovské Karpaty Mts. These rocks are equivalent to the Eastern Alp's Gossau Cretaceous (Samuel et al., 1980). The sediments comprise Campanian flysch formations with a layer of red marlstones, as well as conglomerates and Orbitoids limestones.

The occurrences of Senonian sediments are few and small leading to assume that the Inner Carpathian area at that time was mostly dry land. Nevertheless, the small but widely distributed occurrences, relics of a marine basin, suggest that a considerable part of the contemporaneous "Inner Carpathians" may have been inundated. Finally, we emphasize that all these occurrences rest unconformably on Triassic calcareous formations which are assigned to the Silicicum or the higher "Subtatric" nappes. The position of the Senonian deposits indicates a pre-Gossau structural development (inversion) of the Mesozoic basins and the development of the Inner Carpathian nappe system (Andrusov - Bystrický, 1959).

During the Paleocene the Inner Carpathian area was probably dominated by dry land. Paleocene formations were preserved in tectonically bordered belts along the inner edge of the Klippen Belt and in an extensive area in the Brezovské Karpaty Mts., where they rest on the Brezová Group. They make up the Myjava Group (Samuel et al., 1980), which is composed of a suite of marlstones, flysch with blocks of algal-coral limestones and conglomerate layers. More than 1000 m thick, they are of Paleocene - Eocene age.

Similar sediments in the Váh Valley are referred to as the "Hričov-Žilina Paleogene facies". The facies distribution of this Paleogene indicates that virtually all peripheral part of the original basin were displaced elsewhere and the actual contact with the Klippen Belt is tectonic.

In the Paleocene and Early Eocene the Inner Carpathian pre-Gossau nappe system underwent disturbances which have not yet been adequately investigated. The Inner Carpathian Paleogene is made up of the Subtatric Group (Gross et al., 1984). It has basal conglomerates, claystones and flysch deposits whose total thickness exceeds 1000 m. The group's age is diachronnous, ranging from Cuissian stage to Oligocene epoch (and to Egerian stage in the Handlová Basin). It is widespread mainly in the Upper Nitra, Turiec, Subtatric and Hornád Basins, as well as in the Skorušinské vrchy, Spišská Magura, Levočské vrchy and Šarišská vrchovina Mts. Recent distribution of the Subtatric Group suggests that, except in the Slovenské rudohorie area, the territory of the Inner Carpathian nappes was a realm of deposition in the Eocene and Oligocene.

Sediments of the Buda-facies (or Hungarian Paleogene) stretch out to the Slovak territory only to a limited extent.

The Paleogene sediments generally dip gently; are warped into shallow meganticlines and megasynclines. They obviously seal the Inner Carpathian nappe system. Only in a narrow zone along the Klippen Belt are the Paleogene sediments deformed into shingled thrust faults and folds. This deformation was caused by the tectonic processes, which shaped the Klippen Belt into its modern form, and cut off a considerable part of the Inner Carpathian basin.

BASINS AND DEPRESSIONS

Topographic basins and the core mountains are the most characteristic features of the Western Carpathian region. Mostly the topographic basins coincide with structural basins.

According to the classical geosynclinal model, structural basins can be divided into foredeep, intramontane and backdeep basins (Vass in press). In the lithospheric-convergence model, the foredeep corresponds to deep plate foreland basins, intramontane basins to fore-arc or inter-arc basins and backdeep basins to back-arc basins. The assumption that the Buda Basin or Hungarian Paleogene basins are flexural retroarc basins lacks reliable evidence.

The Carpathian Foredeep lies in Bohemia and southern Poland and does not extend to the Slovak territory. Intramontane or fore-arc basins include the Vienna Basin and all small inner basins, as well as the Eastern Slovakia Basin which, during one evolutionary stage, was in the position of an inter-arc basin. The Danube Basin is a variable type of feature, having some signs of both inter-arc and back-arc basins. The southern Slovakian basins fall into the back-arc category.

The West Carpathian basins are filled with sediments and partly with coeval volcanics. The sediments are largely "siliciclastic", and locally contain coal or evaporites. The sparse carbonates are primarily organogenic. Detritus originated from the rising Carpathian mountains. Sediments in major basins are as much as several thousands of metres thick. The deposition took place mostly in a marine environment which gradually changed into marine-brackish, lacustrine and fluvial environments. Minor basins were dominated by lacustrine-fluvial deposition. The sedimentary and/or volcano-sedimentary basinal fill deposits rest unconformably on older West Carpathian units. The fill is much less tectonically disturbed than is the basement (Buday et al., 1965, 1967).

Faults are the principal structural elements in the basins. They confine most basins, some are syngenetic and others that cut the fill are epigenetic. Normal faults prevail. In addition to vertical movements, many faults, notably those in intramontane basins, also had considerable strike-slip movement. Some faults active during the deposition had major vertical movements. Manifestations of compressional tectonics (reverse faults, folds, inverse uplifts) are limited. Earlier fill near the margins of major intramontane basins is warped to form a monoclinal structure dipping toward the basin centres.

The formation of the West Carpathian basins was governed by geodynamic processes that controlled the Carpathian arc evolution at the end of the Paleogene and during the Neogene. These processes were propelled mainly by the ongoing or culminating convergence of Eurasia and Africa, which resulted in:

a) subduction along the Carpathian front, accompanied by the formation of an accretionary prism and by volcanism,

b) asthenosphere activation due to subduction and subsequent asthenosphere uplift (formation of a mantle diapir), which caused crustal extension, tectonic subsidence and subsequent collapse and thermal subsidence in the back-arc area, such as in the Carpathian hinterland,

c) tectonic transfer of crustal fragments from the Alps and Dinarides to the West Carpathian and Pannonian areas.

The lithospheric-plate convergence that gave rise to subduction in the Outer Carpathians was oblique slip. The oblique convergence caused a component of shear stress along the edge of the overthrust plate. Under these circumstances, pull-apart basins opened at intervals along the inner side of the Klippen Belt. This is exemplified by the Transcarpathian Basin, particularly its western sector, i.e. the East Slovakian Basin (Vass et al., 1988). The Vienna Basin opened in a similar way, notably in the Styrian and post-Styrian, i.e. younger evolutionary stages. However, the Vienna Basin is a special kind of pull-apart basin because, unlike the other basins of this type, it is not underlain by a thinned crust, contains neither thermal anomaly nor volcanic centres, and the faults with lateral displacements that opened the basin are shallow and are not of subcrustal extent as in a thin-skinned pull-apart basin (Royden, 1985).

The Buda Basin (also called the Hungarian Paleogene basins) extends into southern Slovakia and was created on the background of tectonic escape of crustal segments from the Alpine-Dinaric area. Hungarian geologists group the escaped segments into the Pelsó megaunit (Dank and Fülöp, 1990). Basins formed during the escape process were also opened through the pull-apart mechanism, decisive role being played by faults and fault zones having major strike-slip components of movements. The tectonic escape of the Pelsó megaunit ended in the Egerian. The last basinal structure genetically related to the escape was the residual short-lived Fiľakovo-Pétervására Basin of Early Eggenburgian age (about 2 Ma; Vass, 1995). When the stress related to the tectonic escape of crustal segments relaxed, it caused significant horizontal rotation of the escaped as well as adjacent crustal segments (Márton, 1993, Márton, et al., 1996). At the same time, the first manifestations of rifting due to the rising asthenosphere and subsequent lithosphere extension took place in the back-arc area. Extensional and transtensional basins opened in the Pannonian area. In the Pelsó megaunit area, the process was complicated by successive vertical movements and a final rotational movement of blocks, which set them into their present-day position. Further rifting continued mainly in the Pannonian area. At the end of the Miocene, due to cooling of the Pannonian asthenolith, the syn-rifting or tectonic-subsidence regime gave way to post-rift thermal subsidence when the thickest sedimentary complexes (several thousands of metres) of the Pannonian Basin were laid down. In Slovakia, thick sediments of post-rift deposition fill the Danube Basin.

Several inner basins lie between those fringing the inner edge of the Klippen Belt and those of the Buda Basin or superimposed basins. Some of these inner basins closest to the Inner Carpathian northern edge, have two stages of fill (Buday et al., 1967). The earlier stage is linked to pull-apart depressions formed during oblique convergence of the Outer Carpathians. The younger stage of fill, as well as all other basins, such as those situated amid and along the margins of the Central Slovakia neovolcanics, were formed under direct influence of lithospheric extension caused by the rising asthenosphere. This basin-and-range structural type is controlled by normal and strike-slip faults (Nemčok and Lexa, 1990, Hók et al., 1995).

According to Roth (1963) the Orava or Nowy Targ Basin originated as a result of flexure warping caused by the reverse overthrust of the Magura unit onto the Klippen Belt and Inner Carpathians; it is therefore a retroarc-type basin. The steepness of the basin burial curves, however, indicates the presence of a pull-apart mechanism.

NEOGENE VOLCANICS

Neogene volcanics, present chiefly in central, southern and eastern Slovakia, are part of a vast volcanic complex of the Carpathian arc and Pannonian Basin. Their origin is related to subduction and to backarc extension processes during the Neogene evolution of the Carpathian arc, which during that time gradually collided with the European Platform edge (Lexa et al., 1993). The volcanics are divided as follows based on their spatial distribution, temporal evolution, petrographic and geochemical composition, and relationship to principal geodynamic phenomena.

1. Acid areal-type calc-alkali volcanics mostly of rhyodacite to rhyolite composition associated with backarc-extension processes. Their activity started in the Early Miocene in northern Hungary, in Slovakia they are represented only by distal-facies tuffs in the Eggenburgian formations in the southern and eastern Slovakia basins. During the Middle Miocene acid volcanism extended into central and eastern Slovakia where it alternated with andesite volcanism. In central Slovakia, acid volcanism occurred during the Early Sarmatian of the Poľana stratovolcano and during the Late Sarmatian to Early Pannonian in the wider areas of the Vtáčnik, Kremnické vrchy and the Štiavnica stratovolcano. In eastern Slovakia, a rhyodacite-tuff horizon is interbedded in Early Badenian sediments, and is associated with rhyodacite to rhyolite extrusive bodies, Late Badenian to

Early Sarmatian tuffs and Late Sarmatian rhyolites occur in the Milič and Zemplín areas.

2. Intermediate areal-type calc-alkali volcanics of andesite to dacite composition associated with backarc-extension processes. In central Slovakia their activity began during the Early Badenian with outpourings of hypersthene-amphibole- garnet andesites. Nearly coeval submarine volcanism of amphibole-pyroxene andesites of the Vinica Formation was activated along the Šahy-Lysec volcano-tectonic zone in the Krupinská planina area. During the Early Badenian, and contemporaneously with the first manifestations of extension tectonics, major stratovolcanoes of pyroxene to amphibole-pyroxene andesites were formed in the southern tract of this area. Deposits from this volcano were dropped in a near-shore marine environment. They include mainly pyroclastic material of the volcanoes Čelovce and Lysec in the Krupinská planina, the Javorie and Poľana stratovolcanos, and the stratovolcano in the Kremnické vrchy Mts. Further history of the above stratovolcanoes in the Early Badenian (Javorie) and in the Late Badenian was dominated by erosion and creation of volcano-tectonic depressions that were filled with more mafic rocks or differentiated rocks. At the subvolcanic level, the evolution of these magmatic centers involved the emplacement of intrusive diorite bodies and of a large intrusive complex of granodiorites and diorites, granodiorite and quartz-diorite porphyries of the Štiavnica stratovolcano. Renewed volcanism of pyroxene, amphibole-pyroxene and biotite-amphibole-pyroxene andesites during the Sarmatian gave rise to the upper structural level of the Javorie volcano (Javorie Formation) and Štiavnica stratovolcano (formations of the 4th evolutionary stage) as well as to a multitude of separate volcanoes in the Vtáčnik (Vtáčnik Formation), Kremnické vrchy (Remata, Flochová, Sielnica and Turová Formations) and Poľana (Abčina and Veľká Detva Formations). The youngest manifestations of areal andesite volcanism in central Slovakia are Lower Pannonian basaltic andesites in the Kremnické vrchy area (Vlčí vrch Formation and Šibeničný vrch Complex).

Erosional remnants of andesite volcanoes in the Rudohorie Mts. and Rimava Basin are equivalent to central Slovakia Badenian volcanics. Areal-type intermediate volcanism in eastern Slovakia is limited only to the Milič and Zemplín areas and starts as late as the Upper Badenian. The oldest volcanics are known only as pebbles in younger volcanics and sediments. The discontinuous Sírnik-Brehov-Plešany Complex of pyroxene and amphibole-pyroxene andesites was formed in the latest Badenian to Early Sarmatian, and another discontinuous comples of basaltic-andesite lava flows originated in the earliest Pannonian.

3. Intermediate arc-type calc-alkali volcanics, largely basaltic andesites and pyroxene andesites and exceptionally, dacites closely associated with subduction in the foreland of the Carpathian arc. Their close relationship with subduction is reflected by their linear distribution parallel with the arc in defined segments stretching as far south as northern Romania. The earliest manifestations of volcanism of this kind are known in the Late Badenian, but they started in earnest as late as the Early Sarmatian in the Slanské vrchy Mts. and in the Transcarpathian Basin (stratovolcanoes Šebastovka, Šťavica, Zlatá Baňa, Vechec, Rankovské skaly, Makovica, Strechov, Bogota, Hradisko, Bradlo, Milič, buried volcanoes Malčice and Beša-Čičarovce). Another defined segment consists of diorite porphyries, amphibole-pyroxene andesites, and exceptional andesites with garnet of Middle Sarmatian age in a line running from Kapušany Castle to Vinné. This segment may be equivalent to intrusive andesite bodies in the Pieniny area, Váh Valley and near Uherský Brod which have identical petrographic composition but some of them are demonstratedly of Middle Sarmatian age. The third and youngest segment is made up of andesite volcanics of Middle Sarmatian to Early Pannonian age in the Vihorlatské vrchy (stratovolcanoes Kyjov, Sokolský potok, Vihorlat, Morské Oko, Diel and Popriečny).

4. Mafic alkaline volcanics, largely nepheline basanites to alkaline olivine basalts are associated with a period of overall thermal subsidence of the Pannonian Basin and isostatic readjustment in extensional regime. Present only in central and southern Slovakia, mafic alkaline volcanics date from the Late Pannonian to Pontian, and from the Pliocene to Pleistocene. The first period of volcanism occurs in the Štiavnické vrchy Mts. and the western Lučenec Basin. The second, comprises occurrences in the Cerová vrchovina Mts. with the youngest volcano of this kind - Pútikov vŕšok near Nová Baňa.

NEOGENE

1 freshwater limestones - travertines / *Pliocene - Quaternary*

Travertine piles were formed in places of mineral and/or thermal springs. They are situated on faults or fault intersections. Some travertine piles are of Quaternary age.

2 gray and variegated clays, silts, sands, gravels, lignite, freshwater limestones and tuffite horizons (Brodské, Gbely, Kolárovo, Volkovce and Čečehov Formations) / *Dacian - Romanian*

These deposits are widespread in all major basins in the West Carpathians. Two of these formations occur in the Vienna Basin. The Brodské Formation, Romanian (Bartek, 1989), consists of 50 - 60-m of gravels, sands interlayered with variegated and spotted clays and allochthonous coal. It was laid down in an alluvial environment. The Gbely Formation, Dacian is composed of variegated clays with calcareous concretions, sand and quartzose gravel layers. Its thickness amounts to 100 - 150 m. The formation was deposited in a lacustrine-fluvial environment.

The Danube Basin also contains two formations. The Kolárovo Formation, Romanian (Dlabač, 1960) consists of 100 - 200-m of sands and fine gravel. It was laid down in a fluvial environment. The Volkovce Formation, Dacian (Vass in Keith et al., 1989, Harčár and Priechodská et al. 1988), has peripheral sands, gravels and clays and the basin center facies of variegated calcareous clays, local freshwater limestones and lignite beds. The formation is 1000 m thick. It was deposited in a fluvial delta and lacustrine prodelta.

The Pliocene Čečehov Formation in the Eastern Slovakia Basin (Vass and Čverčko 1985) is made up of 100 - 200-m of variegated clays with andesite gravels, sands and tuffites. The formation was laid down in fluvial and lacustrine environments.

In the Turiec Basin, the Blážovce Formation of Pliocene age is composed of gravelly sands, dark-gray clays with lignite, sand and tuffite layers (Gašparik,1995).

Detrital sediments of the "ancient" Hron River in the Upper Hron Valley are also regarded as Pliocene.

3 clays with lignite, sands, gravels (Orava, Trenčín and Ilava Basins) / *Late Miocene - Pliocene*

Sediments exposed on the surface in the Orava Basin cannot be dated precisely and therefore are referred to as "Pliocene - Late Miocene". They include grey to blue-gray clays alternating with sandy layers and carbonaceous clays, with lignite beds and with rare bentonite and acid-tuffite layers. The basin fill is topped with sandy gravels and sandy-clayey sediments. The approximately 400-m-thick formation is Sarmatian to Pliocene. It was formed in a lacustrine-fluvial environment. The Trenčín and Ilava Basins are topped with Pliocene gravels about 100 m thick interlayered with sand and variegated clays. These are fluvial deposits.

4 variegated kaolinite clays, sands, gravels, rare lignite seams (Poltár, Senné and Lelovce Formations) / *Pontian*

In the Rožňava, Moldava and Southern Slovakia Basins, the Pontian stage is made up of the Poltár Formation (Andrusov and Zorkovský 1950, Vass- Elečko et al., 1989, 1992). It consists of gravels, sands, variegated kaolinic clays, and rarely also interlayered with lignite. The formation's maximum is as much as 100 m thick. It was laid down in a fluvial environment. In the Trebišov partial basin, the Senné Formation (Vass and Čverčko, 1985) was considered to be of Pontian age[1]. Its basal member are the Pozdišovce Gravels with variegated clays. It was deposited in a fluvial environment (Mišík, 1954, Vass and Elečko, 1977, Vass and Čverčko, 1985). Most of the formation is composed of grey and variegated clays and includes the Iňačovce Member (Vass - Čverčko, 1985) composed of gray clays with lignite beds together as much as 600 m thick. The variegated clays are lacustrine; the gray clays with lignite environment are swamp deposits. In the Upper Nitra Basin, the Pontian is represented by the Lelovce Formation (Slávik, 1959, Konečný et al., 1983) - 200 m of gravels, sands and variegated clays. It was deposited in a fluvial environment.

5 gray, mostly calcareous clays, silts, sands, gravels, lignite seams, freshwater limestone horizons (Čáry, Beladice, Záhorie and Ivánka Formations / *Pannonian - Pontian*

In the Vienna and Danube Basins, the Pontian and Pannonian beds can only be distinguished locally. In the Vienna Basin, the Čáry Formation (Bartek, 1989)[1] - sands, gray calcareous clays and lignite beds (Dubňany Member, Brzobohatý et al. *in* Samuel and Gašpariková, 1983) are of Pontian age. It was laid down in a lacustrine-fluvial or paludal environment. Its maximum thickness attains 600-700 m. The Čáry Formation is underlain by the Záhorie Formation (Late Pannonian) composed of clays to claystones interlayered with sands (Bartek, 1989). The Early Pannonian consists of deltaic sands (Jiříček, 1985) that grade into clays (prodelta or basinal facies). The Kyjov Member: lignites and dark clays (Brzobohatý, l.c.) constitute the base of the Pannonian and has a maximum thickness of about 600 m. The sedimentary environment was lacustrine-caspi-brackish and swampy.

In the Danube Basin, the Pontian consists of the Beladice Formation (Vass *in* Keith et al. 1989, Harčár and Priechodská et al., 1988), made up of several hundreds of metres of calcareous clays to silts, carbonaceous-clay layers and lignite beds. The formation was deposited in a lacustrine-fluvial environment with swamps. The Pannonian is represented by the Ivánka Formation (Vass, l.c., Harčár and Priechodská, et al. l.c.). It consists of deltaic sediments as much as 2000 m thick, largely of sands in the western sector of the Gabčíkovo partial basin, in Blatné and Rišňovce depressions, but of pelites in the eastern section of the basin.

6 gray and variegated clays, sands, gravels /conglomerates, lignite seams, freshwater limestones, rhyolite and andesite tuffs (Sečovce and Martin Formations, Sekule Mb.) / *Pannonian*

In the East Slovakian Basin, the Pannonian beds are made up of gray calcareous clays with layers of carbonaceous clays and lignite, tuffites and tuffs (Albinov Tuffs, Janáček, 1959) of the Sečovce Formation (Vass and Čverčko, 1985). The Hažín Tuffites and Hnojné Member with lignite beds are several hundreds of metres thick (Vass and Čverčko, l.c.) and occur around the Vihorlat Mts. They were laid down in lacustrine and paludal environments..

The Turiec Basin contains about 1000 - 1200 m thick of gray calcareous clays interlayered with freshwater limestones, tuffaceous clays, carbonaceous clays and thin lignite beds of Pannonian, Sarmatian and possibly also Pontian ages (Martin Formation, Buday, 1962, Gašparik, 1995). They were deposited in lacustrine and paludal environments.

7 gray calcareous clays, sands/sandstones, siltstones, acid tuffs, bentonite, rare lignite seams (Tokaj and Kochanovce Formations) / *Sarmatian*

In the western sectors of the Eastern Slovakia Basin, the Middle and Late Sarmatian was a time of deposition of light gray clays with tuffites, bentonites, lignite beds and carbonaceous clays, all of the Kochanovce Formation (Vass and Čverčko, 1985). The Sarmatian in the Roňava Valley is known as the Tokaj Formation, comprising andesite and rhyolite volcanoclastics (Vass and Elečko in Baňacký, et al. 1989). The sedimentation took place in a lacustrine environment.

8 gray calcareous, clays/claystones, siltstones, sands/sandstones, conglomerates, acid tuffs, bentonite, organogenic limestones (Stretava, Ptrukša, Vráble and Holíč Formations) / *Sarmatian*

The Holíč Formation (Elečko in Baňacký et al., 1996) in the Vienna Basin is assigned here to the Sarmatian. It consists of as much as 1000 m of coarse-detrital sediments on the edges of the basin and of gray calcareous clays, sands to sandstones in its center. The sediments were laid down partly in a deltaic and partly in a basinal environment of a brackish sea. On the NW slopes of the Malé Karpaty Mts. (Karlova Ves - Dúbravka) occur clastic sediments alternating with lumachelle and oolitic limestones with nubecularia and bryozoan-serpule limestones referred to as the Karlova Ves Member (Koutek, 1936, Mišík et al., 1974, Nagy et al. 1993).

An equivalent in the Danube Basin is the 1500 m thick Vráble Formation. (Vass in Keith et al., 1989, Harčár and Priechodská et al., 1988) composed of conglomerates, organodetrital limestones, sandstones, acid tuffites, clays, locally carbonaceous clays and lignite beds gray calcareous clays. The lignitebearing beds are a basal and marginal facies and the gray clays basinal facies of a brackish sea. The formation attains its maximum thickness in the Rišňovce depression.

In the Eastern Slovakian Basin, the Early and Middle Sarmatian is represented by the 1600 m thick Stretava Formation (Vass - Čverčko 1985). About 1 600 m of gray, calcareous clays deposited in a brackish sea and the Košice Gravels (delta) and tuff layers (Myšľa, Olšany and Rankovce Tuffs) (Janočko 1993, Seneš, 1955, Švagrovský, 1959, 1964, Vass and Čverčko, 1985, Kaličiak, et al. 1991) occur at the western edge of the basin.

The marine-brackish Ptrukša Formation (Vass and Čverčko, 1985) is nowhere exposed at the surface.

9 gray claystones/siltstones, sandstones, conglomerates, coal seams, acid tuffs, andesite epiclastic rocks (Klčovo, Svinná, Lehota, Koš, Nováky, Handlová and Budiš Formations) / *Late Badenian - Sarmatian*

In the Eastern Slovakia Basin, the Late Badenian and earliest Sarmatian are made up of the Klčovo Formation (Čverčko et al., 1968, Vass and Čverčko, 1985) - sands, silts, clays, the Varhaňovce Gravels (Švagrovský, 1950, Janočko, 1990) and the Kráľovce Rhyodacite Tuff (Vass and Čverčko, 1985). This deltaic formation is as much as 1700 m thick.

The Late Badenian to Early Sarmatian in the Bánovce Basin comprises the Svinná Formation, made up of gray claystones and siltstones with an admixture of volcano-clastic material, and freshwater limestones (Vass in Keith, 1989, Keith et al., 1994). The formation gradually passes into andesite volcanoclastics of the Ruskov Formation (Vass, l.c., Keith, l.c., Kováč et al., 1993) of Early Sarmatian to Pannonian age. Both formations are marked by the same symbol on the map.

The Late Badenian in the Upper Nitra Basin comprises the coal-bearing Handlová and Nováky Formations (Čechovič 1959, Konečný et al. 1983) made up of dark clays, tuffites, carbonaceous clays and coal beds (paludal environment). These are overlain by the Koš

Correlation of Neogene lithostratigraphic units – part 1

	Vienna Basin (Slovak part)	Danube Basin (Slovak part)	Eastern Slovakia Basin	Southern Slovakia Basin	Upper Nitra Basin
Dacian - Romanian (Pliocene)	2 Brodské Fm Gbely Fm	2 Kolárovo Fm Volkovce Fm	2 Čečehov Fm		
Pontian	5 Čáry Fm	5 Beladice Fm	4 Senné Fm (Poltár Fm)	4 Poltár Fm	4 Lelovce Fm
Pannonian	5 Záhorie Fm	5 Ivánka Fm	6 Sečovce Fm		
Sarmatian	8 Holíč Fm	8 Vráble Fm	7 Tokaj Fm Kochanovce Fm 8 Stretava Fm		
Late Badenian	10 Studienka Fm	9 Ruskovce Fm Svinná Fm 10 Pozba Fm Madunice Fm	9 Klčovo Fm 10 Lastomír Fm		9 Lehota, Koš Handlová, Nováky Formations
Middle Badenian	11 Jakubov Fm	11 Špačince Fm Trakovice Fm	11 Vranov, Zbudza Fms Mirkovce Fm (upper part)		
Early Badenian	12 Lanžhot Fm	12 Bajtava Fm	12 Nižný Hrabovec Fm Mirkovce Fm (lower part)		
Karpatian	13 Závod Fm Lakšár Fm	13 Planinka Fm Bánovce Fm (upper part)	13 Kladzany Fm Soľná Baňa Fm Teriakovce Fm	13 Modrý Kameň Fm	
Ottnangian		14 Bánovce Fm (lower p.) 15 gray claystones siltstones sandston. conglo-merates		14 Salgótarján Fm	
Eggenburgian	17 Lužice Fm Chropov, Winterberg, Brezová, Dobrá Voda conglomerates	17 Čauša Fm	17 Čelovce Fm Prešov Fm	16 Bukovinka Fm 17 Fiľakovo Fm	17 Čauša Fm
Egerian		19 Lučenec Fm		19 Lučenec Fm 20 Bretka Mbr Budikovany Mbr	

Correlation of Neogene lithostratigraphic units – part 2

Turiec Basin	Trenčín, Ilava Basins	Rožňava Basin	Turňa Basin	Orava Basin	Upper Hron Valley
2 Blážovce Fm	3 clays with lignite, sands, gravels			3 clays with lignite, sands, gravels	2 "Paleo-Hron" sediments
		4 Poltár Fm	4 Poltár Fm		
6 Martin Fm				?	
9 Budiš Fm					
17 Rakšany Fm	17 Čauša Fm		18 Drieňovec conglomerates		18 Vajsková conglomerates

Formation composed of gray calcareous clays and silts, layers of small-pebble gravels, tuffites, diatomite and locally also coal beds. Its thickness is as much as 300 m. Next overlying is the Lehota Formation of fluvial gravels with abundant calcareous and small content of volcanic pebbles, sands and variegated clays.

The Budiš Formation (Gašparik, 1995) in the Turiec Basin is Badenian - Early Sarmatian in age. It consists of gravels, conglomerates (Abramová Member), sands and andesite volcanoclastics. These largely fluvial sediments are as much as 400 m thick.

10 gray calcareous claystones, siltstones, sandstones, conglomerates, thin coal seams, silicic tuffs (Studienka, Pozba, Madunice, Lastomír Formations) / *Late Badenian*

In the Vienna Basin, the Late Badenian consists of the 400 - 600-m-thick Studienka Formation (Špička, 1966, Vass, 1989). It consists of gray calcareous friable claystones and siltstones, and on the edge of the basin of sands, thin coal seams and carboniferous clays. The Sandberg Member contains sands, conglomerates, breccias, gray calcareous clays, organogenic and organodetrital limestones (Baráth et al., 1994) that were deposited on the foothills of the Malé Karpaty Mts.

In the Danube Basin, the Late Badenian constitutes two formations. The western part of the basin is underlain by the marine Madunice Formation (Vass in Keith et al., 1989, Keith et al., 1994) dominated by gray calcareous friable claystones and siltstones interlayered with sandstones; near the western edge of the basin freshwater sediments with carbonaceous clays and thin lignite beds occur. In the eastern part of the basin, the Late Badenian is represented by the Pozba Formation dominated by sandy calcareous friable claystones, sands to sandstones with tuffite layers (Vass in Keith, 1989, Keith, et al., 1994, Harčár and Priechodská et al., 1988). The basal and transgressive member of the formation consists of conglomerates and sandstones, locally organogenic limestones.

In the Eastern Slovakia Basin, the Lastomír Formation is a prodeltaic or basinal equivalent to the Late Badenian Klčovo delta (Vass and Čverčko, 1985). The formation is as much as 2000-m-thick and consists of gray friable calcareous claystones and siltstones interlayered with rhyolitic tuff. In the Zatín area the Lastomír Formation also contains the Zatín Andesite (Vass and Čverčko, l.c.) as much as 1400 m thick.

11 gray calcareous siltstones, claystones, sandstones, sands, conglomerates, evaporites, algal limestones (Jakubov, Špačince, Vranov and Zbudza Formations) / *Middle Badenian*

In the Vienna Basin, the Middle Badenian is represented by the Jakubov Formation (Špička 1966, Vass 1989) composed of gray calcareous claystones and siltstones with sparse acid-tuff and tuffite layers. The deltaic Gajary Member has sands and gravels (Vass, l.c), whereas the coarse clastic Devínska Nová Ves and Hrušky Members (Špička, 1966, Vass et al., 1988, 1990) have conglomerates and breccias widespread on the edges of the basin.

In the Danube Basin, the Middle Badenian is partly constituted by the marine Trakovice Formation several hundreds of metres thick. Basal conglomerates are overlain by gray calcareous sandy claystones and siltstones interlayered with sandstones and acid tuffs (Jiříček in Papp et al., 1978, Vass in Keith et al., 1989, Keith et al., 1994). Another Middle Badenian formation is the Špačince Formation (Vass in Keith, 1989, Keith et al., 1994). Basal sediments include conglomerates, sandstones and algal biohermal limestones; the basinal facies consists of gray calcareous claystones or siltstones. Around Madunice the formation is topped by sands as much as 400 m thick. These are probably of deltaic origin.

In the Eastern Slovakia Basin, the Middle Badenian constitutes the Vranov and Zbudza formations: (1) The marine Vranov Formation is 500 - 600 m thick and has gray calcareous claystones or siltstones alternating with sandstones and (2) lagoonal, the Zbudza Formation composed of gray clays and evaporites, rock salt, gypsum and anhydrite. Both formations have been defined by Vass and Čverčko (1985).

12 gray calcareous siltstones, claystones, sandstones, conglomerates, algal limestones, rhyolite and andesite tuffs (Lanžhot, Bajtava and Nižný Hrabovec Formations, Príbelce Member) / *Early Badenian*

The Early Badenian in the Vienna Basin is represented by the Lanžhot Formation, the basal and marginal Zohor Member (Špička, 1966, Vass, 1989). The basinal facies are made up of about 2300 m thick gray calcareous clays or claystones and siltstones ("tégl").The basal and marginal Zohor Member is composed of gravels to conglomerates and sands.

In the Danube Basin, and especially the Early Badenian Želiezovce depression of this basin, is represented by the marine Bajtava Formation, the transgressive conglomerates and sandstones at the base.. In the eastern part of the depression marginal volcanoclastic detritus derived from the Börsöny stratovolcano ocurs in the transgressive clastics. Towards the basin center these grade into algal limestones and Amphistegina sandstones (Seneš, 1975, Vass in Keith et al., 1989, Keith et al., 1994). Generally, in the basin centre the deposits are gray calcareous siltstones and claystones. The whole formation is about 500 m thick.

The Early Badenian in the Eastern Slovakia is represented by 500 - 600 m of marine gray calcareous siltstones and claystones interlayered with sandstones, and the zeolitized Hrabovec Tuff of the Nižný Hrabovec Formation (Buday in Matějka et al., 1964, Vass and Čverčko, 1985).

Early to Middle Badenian marine sediments in the Prešov Depression are dominated by gray calcareous claystones to siltstones and basal sands making up a single Mirkovce Formation (Zlinská and Karoli, 1988).

Cross-bedded mud of Príbelce Member on S slopes of Krupinská planina belongs to Vinica Formation.

13 gray and variegated siltstones, claystones, sandstones, conglomerates, gravels, evaporites (Závod, Lakšár, Teriakovce, Soľná Baňa, Kladzany and Modrý Kameň Formations) / *Karpatian*

In the Vienna Basin, the Karpatian sediments are divided into an underlying Lakšárska Nová Ves and an overlying Závod Formations both of which were laid down in a marine environment and the Jablonica Conglomerates that is a basin-margin deposit lateral facies of the marine formations. The 600-900 m thick Lakšárska Nová Ves Formation consists of gray calcareous silts to siltstones with sandy layers, rhyolite tuffs and bentonites (Špička and Zapletalová, 1963, Vass, 1989), sandstones alternating with siltstones, referred to as "flyschoid facies". Locally recognized is a Prietrž Member of Elečko and Vass *in* Baňacký et al., (1996). Higher levels of the Karpatian in the basin, the Závod Formation (Špička and Zapletalová, 1963, Vass, 1989) consists of as much as 1 000 m of gray calcareous siltstones and claystones (schlier) that contains sparse marine fauna. The Láb Member of freshwater siltstones and claystones interlayered with sandstones is correlative with the Závod Formation (Buday 1955, Vass, 1989).

In the Brezová depression, the Karpatian is made up of the upper levels of the Planina Formation including gray siltstones, sandstones and claystones, and along the basin margin, of conglomerates and breccias (Kováč et al., 1992). The sediments were deposited in a marine environment.

In the northern part of the Danube Basin, particularly in the Bánovce Basin, the Karpatian constitutes the upper part of the Bánovce Formation. It consists of 250 m of gray calcareous siltstones and claystones, shales (schlier) interlayered with acid tuffs and diatomite (Seneš, 1971, Vass in Keith et al., 1989, Keith et al., 1994), all deposited in a marine environment.

In the Eastern Slovakia Basin, the Karpatian sediments, in rising sequence, are divided into the Teriakovce, Soľná Baňa and Kladzany Formations (Leško, 1955, Budaj *in* Matějka et al., 1964, Vass and Čverčko, 1985). The 250 - 400 m thick Teriakovce Formation is made up of conglomerates that grade into gray siltstones and claystones with sandstone layers. The 250 - 400 m thick Soľná Baňa Formation has gray clays with rock salt, gypsum and anhydrite and is of lagoonal origin. The 1000 m thick Kladzany Formation is made up of red and gray claystones, siltstones and sandstones and was deposited in a shallow sea.

In the southern Slovakian basins, the Karpatian is constituted by the Modrý Kameň Formation, comprising 3 members having a total thickness of more than 300 m (Čechovič 1952, Vass et al. 1983). At the base is the Medokýš Member having fine-grained sands to silts with Rzehakia sp. In the middle is the Krtíš Member having sands containing a marine fauna. At the top is the Sečianky Member of gray calcareous siltstones and claystones (schlier) also containing a marine fauna.

14 gray claystones, sands, coal seams, carbonaceous clays (Salgótarián and Bánovce Formations) / *Ottnangian*

The Ottnangian is widespread in the northern parts of the Danube Basin, notably in the Bánovce Basin. It accounts for the lower part of the 300-m-thick Bánovce Formation: gray calcareous claystones to siltstones alternating with sandstones. In the Dobrá Voda depression, the Ottnangian is made up of the lower part of the Planina Formation: conglomerates and pebbly mudstone, prevailing dark siltstones and claystones. Both formations were laid down in a marine environment whose communication with the open sea was limited.

In the southern Slovakia basins there is the Salgótarián Formation (Noszky 1930, Vass et al. 1983), about 250 m thick and made up of the lower Pôtor Member (sands with coal beds) and the upper Plachtince Member of monotonous gray claystones (Čechovič 1952, Vass et al. 1983). The formation was deposited in a paludal and lacustrine environment with a few sea ingressions.

15 gray claystones, siltstones, sandstones, conglomerates / *Eggenburgian - Ottnangian*

Gray calcareous claystones and sandy-calcareous claystones in the Vaďovce depression, Myjavská pahorkatina Hills, Brezovské and Čachtické Karpaty Mts. are correlated with the lower part of the Lužice and Čauša Formations. They are largely of Eggenburgian age but possibly also extend into the Ottnangian (Salaj et al. 1987). In the Vienna Basin, the base of the Ottnangian is represented by the Štefanov and Hodonín Sandstones (Buday 1955, Vass 1989). The thickness of the Ottnangian part of the formation is estimated at 100 - 700m.

16 Variegated clays, sands, gravels, rhyodacite tuffs (Bukovinka Formation) / *Eggenburgian*

The Bukovinka Formation is widespread in southern Slovakia and consists of gravels, sands and variegated clays of fluvial and lacustrine origin that contains rhyodacite tuffs. The formation is as much as 200 m thick (Vass et al. 1983, Vass and Elečko et al. 1992).

17 siltstones, claystones, sandstones, tuffites, variegated and coal clays, coal, conglomerates, organodetritic limestones (Lužice, Čauša, Fiľakovo, Prešov and Čelovce Formations) / *Eggenburgian*

In the Vienna Basin, the Eggenburgian accounts for the lower part of the Lužice Formation (Buday and Cicha 1956). Its base consists of coarse clastics: Chropov Conglomerates (Buday 1955) with pebbles from the Outer Flysch; Brezová and Dobrá Voda Conglomerates with carbonate pebbles (Buday et al. 1962, Vass 1989) and Veterník (Winterberg) Conglomerates with variegated pebbles (Buday and Cicha 1956). The main basinal facies consists of gray calcareous siltstones. These marine sediments are as much as 350 m thick.

In the Upper Nitra Basin is the Čauša Formation (Čechovič et al. 1959, Gašparik in Steininger et al. 1985) whose basal Veľká Čauša Member includes gray sandy clays and gravels, gray calcareous sandy clays and sands intercalated with coal and containing brackish fauna and sands and small-pebbled gravels with rich marine fauna (Čechovič et al. 1959, Hók et al. 1995). Elsewhere, the basal member is the Kľačno Conglomerate laid down in a littoral marine environment. Their equivalents occur in the Bánovce Basin, too. Most of the formation consists of gray calcareous clays, sandy clays and silts as friable as shales (schlier) which are interlayered with rhyodacite tuffite. The formation is 400 - 500 m thick. Similar sediments are also present in the northern Danube, Trenčín and Ilava Basins. In the Turiec Basin, the Eggenburgian is constituted by the Rakša Formation - conglomerates with abundant marine fauna, organogenic limestones and sands (Gašparik 1995). The formation probably once also included a basinal facies which was eroded away.

In the Eastern Slovakia Basin, the Eggenburgian comprises the underlying Prešov and overlying Čelovce Formations. The marine Prešov Formation, about 1000 m thick consists of gray calcareous siltstones and fine-grained calcareous sandstones. These are marine deposits. The Čelovce Formation is as much as 400 m thick and consists of sandstones, conglomerates, gray, variegated and dark clays intercalated with coal. These are prograding delta deposits. (Čechovič 1950, Švagrovský 1952, Leško 1957, Vass and Čverčko 1985).

The Cerová vrchovina Mts. in southern Slovakia are partly underlain by the marine sandy Fiľakovo Formation (Seneš in Andrusov 1965, Vass and Elečko 1982) 250 - 300 m thick. It consists of sands (Tachty Sands), cross-bedded sandstones (Jalová Member), sandstones with abundant marine fauna (Lipovany Sandstones) and fine-grained sandstones and siltstones of schlier appearance - the Čakanovce Member (Vass and Elečko et al. 1992).

18 conglomerate (Drieňovec and Vajsková Conglomerates) / *Early Miocene*

The Early Miocene (Egerian - Eggenburgian), occurring only in the Turňa depression, comprises the Drieňovec Conglomerates. These are more than 300 m thick and are noted for their basal bauxites (Matějka 1958, Vass et al. 1994). These are alluvial fan deposits. The Drieňovec Conglomerate can probably be correlated with the Vajsková Conglomerate and Breccia in the Upper Hron Valley which are as much as 250 m thick (Biely and Samuel 1982).

19 gray calcareous siltstones (Lučenec Formation) / *Egerian*

The marine Lučenec Formation occurs in southern Slovakian basins (Seneš in Andrusov 1965, Vass and Elečko 1982, Vass and Elečko et al 1992). The formation is more than 1000 m thick. Its base is made up of the Panica Member sandstones and conglomerates. The upper and main part of it is the Szécsény Schlier having gray calcareous siltstones and friable sandstones. The formation's regressive member are deltaic sediments. One delta prograded into the Ipeľ Basin giving rise to the Opatová Member made up of gray calcareous siltstones, sandstones, gravels, variegated clays and thin coal beds with associated dark clays (Vass et al. 1983, Šútovská and Holcová et al. 1993), and the other, designated as Kováčov Sands, prograded into the Štúrovo area where it deposited sands, clays to claystones with rich shallow-marine and brackish fauna (Seneš 1958, Báldi 1969).

20 organodetritic limestones, conglomerates, marlstones (Bretka and Budikovany Members) / *Egerian*

These sediments are present in the southern Slovakia's basins either as a basal member of the Lučenec Formation - Budikovany Member or as a marginal equivalent to the upper part of Lučenec Formation basinal sediments - Bretka Member (Seneš in Steininger et al. 1975, Vass and Elečko 1982, Vass et al. 1986, Vass and Elečko 1989, 1992).

21 alkali basalts and basanites (Cerová Basalt Formation) / *Pliocene - Pleistocene*

In central Slovakia these rocks occur in only one cinder cone, (21P) Pútikov vŕšok hill near Nová Baňa and the associated lava flows (21A) resting on a Quaternary terrace of the Hron River, thereby indicating their very young Pleistocene age (Šimon et al. 1996). However, in southern Slovakia these rocks are widespread in the Cerová vrchovina Mts., where they are designated as the Cerová Basalt Formation (Vass and Elečko et al. 1992) of Pliocene to Pleistocene age (radiometric ages 5.4 - 1.1 m.y. - Konečný et al. 1995). Volcanic forms here include lava flows 10-50 m thick with breccias (21A), necks composed of explosive-lava material (21E), narrow dykes (21F), maars filled with phreatic pyroclastics and/or agglomerates, agglutinates and exceptionally also sediments (21H), diatremes filled with palagonitized phreatic tuffs with a variable proportion of nonvolcanic material or cinder in the upper part (21I), and cinder cones composed of varied agglomerates and agglutinates with volcanic bombs (21P).

22 alkali basalts and basanites (Podrečany Basalt Formation) / *Late Pannonian - Pontian*

In central Slovakia they form nepheline basanite lava necks (22E) near Banská Štiavnica and lava flows (22A) in the vicinity of Ostrá Lúka south of Zvolen and near Devičie south of Krupina. Radiometric ages of 8.0 - 6.6 m.y. suggest an Upper Pannonian to Pontian age (Konečný et al. 1995). In the western and northern tracts of the Lučenec Basin of southern Slovakia they constitute the Podrečany Basalt Formation (Vass - Elečko et al. 1992), which is Pontian in age (radiometric ages 7.2 - 6.4 m.y. - Konečný et al. 1995). The Podrečany Basalt Formation comprises lava flows in the northwestern Lučenec Basin (22A) and maars near Jelšovec and Pinciná (22H) filled with phreatic pyroclastics, as well as clayey, diatomic and alginite sediments of maar lakes.

23 basaltic andesites (Šibeničný vrch Complex, Vlčí vrch Formation) / *Late Sarmatian? - Pannonian*

The rocks are known at two sites in central Slovakia and one in eastern Slovakia. Basaltic andesites dominate over minor calc-alkali basalts and pyroxene andesites:

Remnants of a small stratovolcano occur in the northern Kremnické vrchy Mts. of central Slovakia (Vlčí vrch Formation - Konečný et al. 1983). They consists of a central intrusive body of diorite porphyry (40L), a stratovolcanic cone composed of agglutinates, agglomerates and thin brecciated lava flows of porphyritic basaltic andesites (23 O) and, near the cone, a complex of thick mildly brecciated basaltic andesites lava flows (23A); and rare pyroxene andesites with accessory hornblende; the Vlčí vrch Formation is presumably Pannonian in age but a Late Sarmatian age cannot be ruled out.

The Šibeničný vrch Complex (Konečný et al. 1983) in the southern part of Kremnické vrchy and exceptionally also in the northern part of the Štiavnické vrchy and in southern Vtáčnik Mts. includes laccoliths of aphanitic basalts and basaltic andesites amidst rhyolite tuffs (23K), lava flows of basaltic andesites and pyroxene andesites (23A) and phreatic pyroclastics (23C).

In eastern Slovakia, the category includes basaltic andesite lava flows (23A) near Zemplín (Baňacký et al. 1989) accompanied with hyaloclastite-type breccias.

24 rhyolites and rhyodacites (Jastrabá and Strelníky Formations, Byšta-Viničky Rhyolites, Rankovce Rhyolite Tuffs) / *Sarmatian - Pannonian*

This unit includes hornblende-biotite rhyodacites, biotite rhyodacites, rhyodacites with accessory garnet (Strelníky Formation), plagioclase rhyolites, plagioclase-sanidine rhyolites, sanidine rhyolites and perlites (glassy rhyolites). In central Slovakia it includes rhyodacite and rhyolite volcanics of the Jastrabá Formation of Late Sarmatian to Early Pannonian age (Konečný et al. 1983). These rocks are widespread in the Štiavnické vrchy, Pohronský Inovec, Vtáčnik, and Kremnické vrchy mountain ranges and Žiar Basin and are bound to N-S to NE-SW-trending fault systems. Also included are rhyodacite volcanics of the Strelníky Formation of Early Sarmatian age (Dublan 1993) which are spread around the Poľana stratovolcano and adjoining tract of the Zvolen Basin, associated with a small caldera in the Poľana stratovolcano central zone. In eastern Slovakia there are the Late Sarmatian Byšta-Viničky Rhyolites (Baňacký et al. 1989) in the Milič and Zemplín areas, Early Sarmatian Rankovce Rhyolite Tuffs (Kaličiak et al. 1991) on the western foothills of the Slanské vrchy and a lone Middle Sarmatian rhyodacite body near Podhoroď.

The rhyodacite and rhyolite volcanics include: dykes (24F); extrusive bodies and short and thick lava flows accompanied by thick extrusive breccias (24C) made up of felsitic to spherolithic rhyodacites or rhyolites passing into a glassy facies near the margins of bodies and in breccias; bodies of unreworked to redeposited tuffs and pumice tuffs (24C) with a variable proportion of deposits of pyroclastic/pumice flows and epiclastic volcanic breccias, conglomerates and sandstones whose material is dominated by glassy rhyodacites or rhyolites.

25 rhyolites and rhyodacites (Merník Rhyodacites, Lesné Rhyolites, Cejkov Rhyodacites, Kráľovce and Hrabovec Rhyolite Tuffs) / *Late Badenian*

;Distributed only in eastern Slovakia, this category includes a thin sheet of distal facies fine-grained redeposited rhyodacite tuffs (Hrabovec Tuffs - 25c) laid down in a marine environment in the upper part of the Early Badenian Nižný Hrabovec Formation, some (25c) present at the base of the Klčov Formation (Kráľovce Rhyolite Tuffs - Kaličiak et al. 1991), a group of intrusive to extrusive rhyodacite bodies with accessory garnet amidst Paleogene sediments NW of Vranov (Merník Rhyodacites - 25C), a group of extrusive domes of rhyolites with garnet in the Michalovce area (Lesné Rhyolites - 25C), Cejkov Rhyodacites (Baňacký et al. 1989) including extrusive bodies of felsitic rhyodacites bearing signs of hydrothermal silicification situated on marginal faults fringing the Zemplín horst (25C) and redeposited rhyodacite tuffs, pumice tuffs and slump bodies (25c) laid down in a marine environment.

26 Limnoquartzites / *Late Sarmatian - Early Pannonian*

Lacustrine quartzites are light, red-brown or dark opal-like silicites deposited in a limnic or lacustrine environment. On the map, they occur only amid rhyolite tuffs of the Late Sarmatian to Early Pannonian Jastrabá Formation north of Žiar nad Hronom. They form podiform bodies as much as 20 m thick that are interbedded with bentonitized rhyolite tuffs. Their origin is likely to have been connected with silica introduction from hydrothermal systems. (The map does not show sparse small lacustrine quartzite occurrences in the Late Badenian of the Zemplín area and in the Pannonian to Pontian of the Žiar Basin).

27 pyroxene and hornblende-pyroxene andesites (younger stratovolcanoes of central and eastern Slovakia) / Sarmatian - Early Pannonian

Includes mainly pyroxene and hornblende-pyroxene andesites and some basaltic andesites, leucocratic andesites and biotite-hornblende-pyroxene andesites. In central Slovakia, the lava flows and volcanoclastics make up the upper structural level (above Badenian formations) of the Javorie stratovolcano (Javorie Formation), Poľana (Abčina and Veľká Detva Formations) and Štiavnica stratovolcanoes (formations of the 4th stage - Konečný et al. 1983) and separate stratovolcanoes of the Vtáčnik, Remata, Flochová, Sielnica and Turová Formations in the Vtáčnik and Kremnické vrchy Mts. (Konečný et al. l.c.). The central Slovakia formations are mostly Early to Middle Sarmatian in age, only some lithostratigraphic units (Breznica Complex, Drastvica Formation, Priesil Effusive Complex, Inovec Formation, Jabloňový vrch Complex, Sielnica, Turová and Veľká Detva Formations) may in part be of Late Sarmatian age. In eastern Slovakia, the category comprises andesite stratovolcanoes of the Slanské vrchy, Veľký Milič and Vihorlatské vrchy Mts. (Kaličiak et al. 1986, 1991, 1993, 1995). Those in the Slanské vrchy and Veľký Milič are Early to Late Sarmatian in age; only the northern stratovolcanoes seem to have been active until the Early Pannonian. The Vihorlatské vrchy stratovolcanoes are of Middle Sarmatian to Early Pannonian age. The category also comprises bodies of pyroxene-hornblende andesites in the Lysá Stráž - Oblík Formation.

Lithofacial analysis and paleovolcanic reconstruction have allowed us to distinguish on the geological map: massive-andesite dykes (27F); sills of chloritized and altered andesite porphyries (41); extrusive domes to short thick lava flows composed of andesite bearing signs of autometamorphic alterations and passing into extrusive breccias near the edges of the bodies (27C); andesite lava flows and effusive complexes mostly forming stratovolcanic mantles and less frequently filling radiating paleovalleys on stratovolcanic slopes (27A) - individual lava flows are commonly 10 - 25 m thick, exceptionally as much as 100 m, brecciated at their bases and tops - the effusive complexes also may embody sparse layers of pyroclastic and epiclastic breccias; effusive cones composed of radially outward dipping thin brecciated lava flows interlayered with rare agglomerates and tuffs (27M); stratovolcanic cones composed of radially outward dipping thin brecciated lava flows alternating with pyroclastic breccias, agglomerates and tuffs (27 O); pyroclastic breccias and agglomerates in volcanic cones (Vihorlatské vrchy and Vtáčnik stratovolcanoes), as well as deposits of pyroclastic flows (Javorie and Kremnické vrchy stratovolcanoes) (27a); ignimbrites and welded pumice tuffs of biotite-hornblende-pyroxene andesite (Drastvica Formation) laid down in paleovalleys on the western and southern slopes of the Štiavnica stratovolcano (27a); largely redeposited tuffs and pumice tuffs of biotite-hornblende-pyroxene andesite including pumice-flow deposits (27c) (Biely Kameň and Ladzany Formations) locally interlayered with epiclastic volcanic sandstones and fine-grained breccias; bodies of epiclastic volcanic breccias at the foot of volcanic cones and their immediate vicinity (27d); epiclastic bodies in the distal zone in fluvial and marine environments composed of mixed breccias and conglomerates (27e), conglomerates and sandstones (27f), sandstones (27g), siltstones and sandstones (27h), small- to coarse-blocky hyaloclastite breccias formed at the contact of lava flows with water (27j) which were locally redeposited.

28 pyroxene and hornblende-pyroxene andesites (Sírnik - Brehov - Plešany Andesites) / *Early Sarmatian*

Early Sarmatian pyroxene and hornblende-pyroxene andesites occur only in the Zemplín area. They are fault-lined relics of an effusive complex filling volcanotectonic depressions (28B). Individual lava flows are of

medium to large thickness and are associated with hyaloclastite breccias indicating a shallow-marine environment of deposition. Near Brehov and Somotor, hornblende-pyroxene andesites form extrusive domes (28C) passing into blocky extrusive breccias at edges.

29 basaltic and pyroxene andesites (Turček Formation, Kľakovská dolina Formation, Ošvárska Formation) / *Late Badenian*

In central Slovakia, this category includes the as much as 500-m-thick Turčok and Kľakovská dolina Formations (Konečný et al. 1983) which constitute the lower part of the fill of the Kremnica graben and Žiar Basin. The rocks are mostly pyroxene andesites with less common basaltic and leucocratic andesites. They are largely an effusive suite of moderately to strongly brecciated lava flows (29B) locally grading into hyaloclastite breccias, interlayered with unreworked and redeposited partly phreatic pyroclastics including pyroclastic-flow deposits. The area south of Nová Lehota is dominated by epiclastic volcanic breccias and redeposited pyroclastics (29d) with layers of redeposited tuffs, pumice tuffs and epiclastic volcanic sandstones.

In Slanské vrchy the Ošvárska Formation (Kaličiak et al. 1991) is the relic of a pyroxene-andesite stratovolcano. It comprises a central neck surrounded by abundant lava flows (29A) and layers of autochthonous pyroclastic breccias and agglomerates. Its Late Badenian age was obtained from radiometric data and its position relative to products of the Zlatá Baňa and Makovica volcanoes.

30 pyroxene and hornblende-pyroxene andesites (older stratovolcanoes of Central Slovakia) / *Badenian*

These rocks occur in the Central Slovakia Neogene Volcanic field where effusive and explosive activity in the late Early Badenian, Middle Badenian and possibly also in part of the Late Badenian gave rise to the pyroclastic volcanoes Čelovce and Lysec in the Krupinská planina Plateau, laid down an effusive sequence in the Javorie volcano-tectonic depression (Blýskavica Formation) and created the lower structural level of the Poľana stratovolcano (Šutovka Formation), Štiavnica stratovolcano (1st stage, Sebechleby Formation, Žibritov Effusive Complex) and volcanics of the Kremnické vrchy (Zlatá studňa Formation). Volcanics of the Pokoradz Formation in northern Rimava Basin and remnants volcanics of the Slovenské rudohorie also fall into this group.

Pyroclastic pyroxene-andesite volcanoes Čelovce and Lysec (Vass et al. 1979) have central zones composed of relict pyroclastic cones (30N) which, in turn, consist of pyroclastic-flow breccias prevailing over autochthonous pyroclastic breccias and agglomerates. The centre of the former volcano includes dykes (30F) and necks (30E) and that of the latter contains protrusions and tholoids of pyroxene-hornblende andesite porphyry (30D). Deposits of pyroclastic flows (30a) and mostly thick epiclastic volcanic breccias (30d) accumulated at the foot of the volcanic cones.

The Blýskavica Formation (Konečný et al. 1983) filling the Javorie volcano-tectonic depression is an effusive assemblage of basaltic and pyroxene andesites (30B) associated with hyaloclastite breccias that indicate a subaqueous environment of deposition. On the stratovolcano slopes the Blýskavica Formation constitutes bodies of hyaloclastite breccias (30j) which grade into a variety of epiclastic volcanic breccias (30d).

The Šutovka Formation (Dublan 1993) in the centre of the Poľana stratovolcano consists of chloritized lava flows of hornblende-pyroxene andesites (30A) and epiclastic volcanic breccias (30d) intruded by sills of hornblende-pyroxene andesite porphyries (30J, 42) and pyroxene-andesite dykes (30F).

The lower structure of the Štiavnica stratovolcano in the Hodruša-Štiavnica horst, Pukanec, Nová Baňa, Župkov, Prochoť and Beluja areas consists of propylized andesite porphyries sills, along with relics of volcanic structure (42). The stratovolcano's slopes outside the caldera are dominated mostly by coarse, variously brecciated, lava flows of pyroxene, hornblende-pyroxene and rarely also biotite-hornblende-pyroxene andesites (30A) associated with pyroclastic-flow breccias of hornblende-pyroxene andesites (30a) and bodies largely of coarse epiclastic volcanic breccias (30d).

The Zlatá studňa Formation in the Kremnické vrchy (Konečný et al. 1993) is made up of propylized pyroxene-andesite lava flows (30A) and andesite-porphyry sills (42). Its proximal zone is constituted by a typical stratovolcanic assemblage of mildly brecciated pyroxene andesite lava flows (30A) alternating mainly with coarse epiclastic volcanic breccias (30d).

The distal zones of all stratovolcanoes consist of epiclastic volcanic breccias and conglomerates (30e), epiclastic volcanic conglomerates and sandstones (30f), and epiclastic volcanic sandstones (30g) deposited chiefly in a fluvial, but to the south in marine environment.

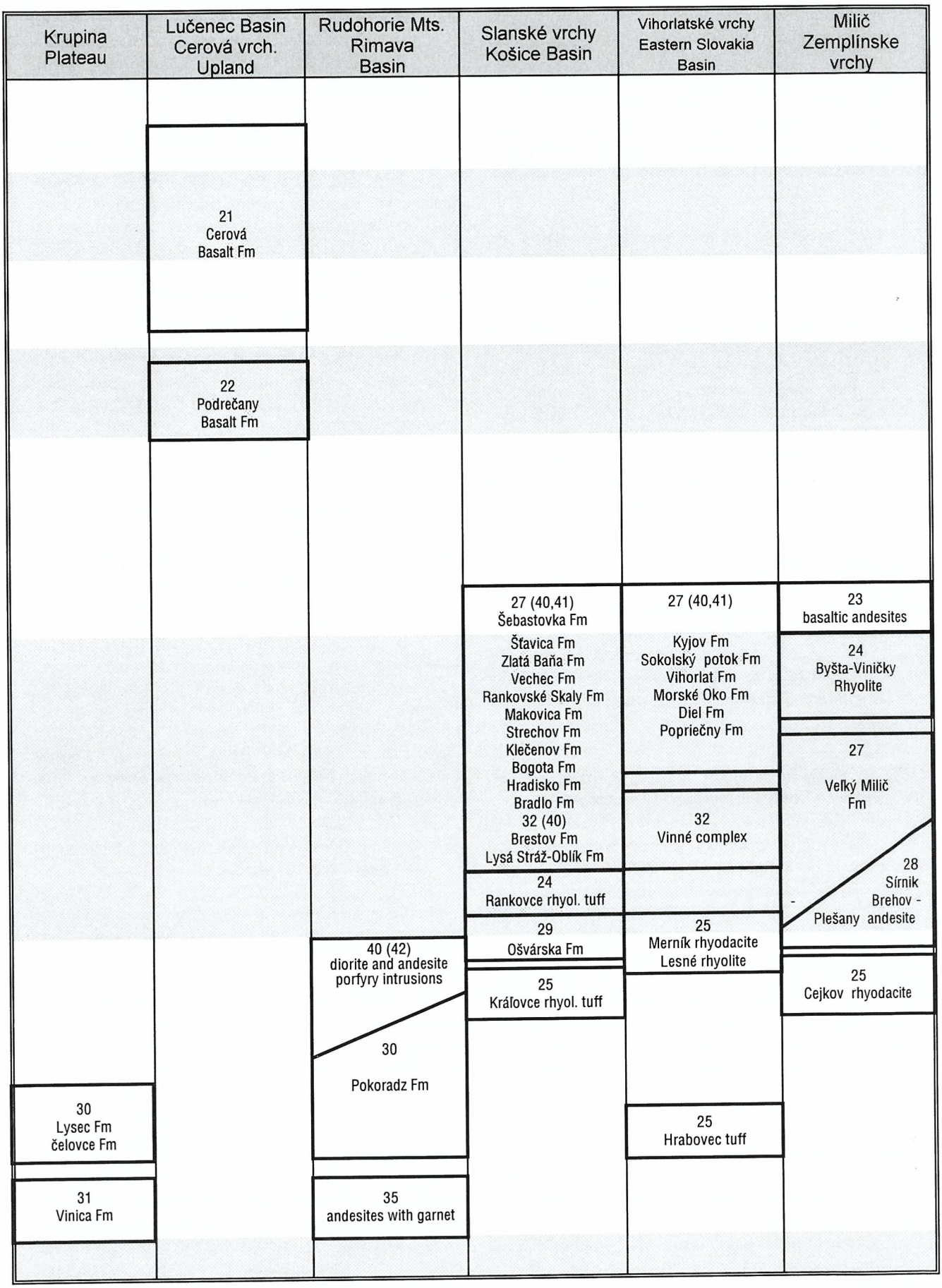
Volcanic relics in the Slovenské rudohorie comprise Klenovský Vepor lava flow (30A) and a variety of mostly coarse epiclastic volcanic breccias (30d) with sparse conglomerates at the base (Hájna hora Complex south of Brezno). Volcanics in the northern tract of the Rimava Basin include pyroclastic-flow breccias (30a), epiclastic volcanic breccias (30d), massive beds of thick to blocky epiclastic volcanic conglomerates interlayered with sandstones (30f) and epiclastic volcanic sandstones (30g) laid down in a near-shore marine environment.

31 pyroxene and hornblende-pyroxene andesites (Stará huta Complex, Vinica Formation) / *Early Badenian*

It includes rocks of the lower structural level of the Javorie stratovolcano (Stará huta Complex - Konečný et al. 1983), Vinica Formation (Vass et al. 1979) in the

Correlation of Neogene volcanic lithostratigraphic units - part 1

	Štiavnica stratovolcano	Vtáčnik	Kremnické vrchy	Poľana	Javorie
Pleistocene	21 alkali basalts and basanites				
Romanian					
Dacian					
Pontian	22 alkali basalts and basanites				
Pannonian	23 Šibeničný vrch c.	23 Šibeničný vrch c.	23 Šibeničný vrch c. Vlčí vrch Fm		
Sarmatian	24, 26 Jastrabá Fm	24 Jastrabá Fm	24, 26 Jastrabá Fm		
	27 Jablonový vrch c. Inovec Fm Priesil effusive c. Drastvica Fm Breznica c. Sitno effusive c. Humenica c. Baďan Fm Biely Kameň Fm Ladzany Fm	27 Vtáčnik Fm	27 Turová Fm Sielnica Fm Remata Fm Flochová Fm	40 Šafranička intr. complex / 27 Veľká Detva Fm Abčina Fm / 24 Strelníky Fm	27 Javorie Fm
Badenian	33 Studenec Fm Červená studňa Formation / 39 Banisko i ntr. complex	33 Stráň effusive c. Plešina Fm	33 Krahule Fm Kremnický štít Fm	34 Rohy Fm	40 Kalinka intr. complex / 34 Rohy Fm
		29 Kľakovská dolina Fm	29 Turček Fm		
	38 Zlatno i.c. / 36, 37 Hodr.-Štiav. intr.c. / 30 I. etapa / Tanád c. (42) / Žibritov c. / Sebechleby Fm / 35 Neresnica Fm	30 Kamenec Fm	30 (42) Zlatá studňa Fm / 35 Kordíky Fm andesites with garnet	30 (42) Šútovka Fm	30 Blýskavica Fm / 31 Stará Huta complex
Karpatian					


Krupina Plateau
Lučenec Basin Cerová vrch. Upland
Rudohorie Mts. Rimava Basin
Slanské vrchy Košice Basin
Vihorlatské vrchy Eastern Slovakia Basin
Milič Zemplínske vrchy
21 Cerová Basalt Fm
22 Podrečany Basalt Fm
27 (40,41) Šebastovka Fm
Šťavica Fm
Zlatá Baňa Fm
Vechec Fm
Rankovské Skaly Fm
Makovica Fm
Strechov Fm
Klečenov Fm
Bogota Fm
Hradisko Fm
Bradlo Fm
32 (40) Brestov Fm
Lysá Stráž-Oblík Fm
24 Rankovce rhyol. tuff
29 Ošvárska Fm
25 Kráľovce rhyol. tuff
40 (42) diorite and andesite porfyry intrusions
30 Pokoradz Fm
35 andesites with garnet
30 Lysec Fm čelovce Fm
31 Vinica Fm
27 (40,41)
Kyjov Fm
Sokolský potok Fm
Vihorlat Fm
Morské Oko Fm
Diel Fm
Popriečny Fm
32 Vinné complex
25 Merník rhyodacite Lesné rhyolite
25 Hrabovec tuff
23 basaltic andesites
24 Byšta-Viničky Rhyolite
27 Veľký Milič Fm
28 Sírnik - Brehov - Plešany andesite
25 Cejkov rhyodacite

Krupinská planina Plateau and Burda volcanics near Štúrovo extending to Slovakia from Hungary. The Vinica Formation and Burda volcanics are a more mafic equivalent to hornblende-pyroxene and hypersthene-hornblende andesites with garnet - symbol 35.

Unlike the other central Slovakia stratovolcanoes, the lower structural level of the Javorie stratovolcano is confined only to the Early Badenian. The Stará huta Complex, as much as 700 m thick, is largely covered with younger rocks and crops out only in the eastern Javorie, where it consists of variably brecciated lava flows of basaltic and pyroxene andesites (in the lower part) and of hornblende-pyroxene andesites in the upper part (31A). In the lower part the lava flows are also associated with hyaloclastite breccias. The lava flows alternate with layers of thick epiclastic breccias (31d) and rare pyroclastic-flow breccias which, away from the volcanic centre, grade into bodies of epiclastic volcanic breccias and conglomerates (31e).

The Vinica Formation and Burda volcanics evolved in a shallow marine environment which considerably affected their lithology. Submarine extrusive domes (35G) are extensively brecciated, often even in places where they penetrate through the subjacent rocks. Large bodies of coarse epiclastic breccias (35d) formed around the submarine extrusive domes from which they moved further away as submarine breccia flows and slumps. Under marine conditions the epiclastic material was reworked into vast bodies of volcanic breccias and conglomerates (35e), conglomerates and sandstones (35f) and, in the distal zone mostly coarse-grained sandstones (35f) with some siltstones and fine-grained sandstones (35h).

32 pyroxene-hornblende andesites (Brestov and Stráž - Oblík Formations) / *Sarmatian*

Differentiated rocks of this catergory are restricted to the Middle Sarmatian of eastern Slovakia. Hypersthene-hornblende and hornblende-hypersthene andesites constitute the Brestovo Formation in the Zlatá Baňa stratovolcano, pyroxene-hornblende andesites commonly with accessory garnet dominate the Lysá Stráž–Oblík Formation (Kaličiak et al. 1991), hornblende-pyroxene to pyroxene-hornblende andesites make up the Viničky Complex in the southwestern Vihorlatské vrchy (Kaličiak et al. 1986). The Brestovo Formation consists of mildly brecciated mostly thick lava flows (32A), extrusive domes grading into short and thick lava flows (32C) accompanied by extrusive breccias, and a complex of predominantly thick epiclastic volcanic breccias (32d). The Lysá Stráž-Oblík Formation is made up of extrusive domes to semi-intrusive bodies (32C) amidst Paleogene sediments. The Viničky Complex embodies extrusive domes that typically are brecciated on the margins (32C) and nearby bodies of thick epiclastic volcanic breccias (32d).

33 hornblende-pyroxene, pyroxene-hornblende and biotite-hornblende andesites (Studenec, Krahule, Plešina and Kremnický štít Formations, Stráň Complex) / *Late Badenian*

Confined to the Central Slovakia Neovolcanics, these rocks fill Upper Badenian volcanotectonic depressions, such as the Štiavnica caldera and the Kremnica graben. The former is filled with a formation of epiclastic volcanic sandstones intercalated with claystones, lignite and biotite-hornblende andesites clastics derived from explosive activity (Červená studňa Formation) at the base of the Štiavnica caldera, and with 300-500-m-thick hypersthene-biotite-hornblende, biotite-hornblende and hornblende-biotite andesites of the Studenec Formation filling the caldera and locally extending onto the stratovolcanic slopes to fill radiating paleovalleys (Konečný et al. 1983). These andesites form huge extrusive domes passing into thick lava flows and extrusive breccias (33C). Pumice-flow deposits, redeposited tuffs and finer epiclastics are all scarce.

In the Vtáčnik area, this category includes: extrusive bodies of hypersthene-hornblende andesites (33C) and bodies of thick epiclastic volcanic breccias (33d) of the Plešina Formation, and lava flows of hornblende-pyroxene to biotite-pyroxene-hornblende andesites (33A) of the Stráň Effusive Complex (Konečný et al. 1983).

The Kremnické vrchy area is underlain by an assemblage of variably brecciated thick lava flows of hornblende-pyroxene, pyroxene-hornblende and biotite-pyroxene-hornblende andesites of the Kremnický štít Formation (33A) and by extrusive domes of biotite-hornblende andesite of the Krahule Formation, whose edges pass into thick lava flows and extrusive breccias (33C) and that locally are also accompanied by thick bodies of epiclastic breccias (33d).

34 pyroxene-hornblende andesites (Rohy Formation) / *Middle - Late ?Badenian*

Differentiated pyroxene-hornblende, and rarely also hornblende-pyroxene and biotite-hornblende-pyroxene andesites, exceptionally even dacites of higher Late Badenian (to lower Late Badenian ?) age are confined to central Slovakia where they occur in the Javorie volcanotectonic depression and the Vígľaš depression extending down the southern slopes of the Poľana stratovolcano (Rohy Formation - Konečný et al. 1983). The Rohy Formation is dominated by extrusive domes,which in rare cases grade into short and thick lava flows (34C) whose inner parts consist of massive autometamorphosed andesites and whose edges pass into coarse blocky extrusive breccias. Dykes and intrusve rocks of irregular shapes (34F) have been identified in exceptional cases. Disintegrating extrusive bodies gave rise to adjacent bodies of chiefly coarse epiclastic volcanic breccias (34d) rarely interlayered with pyroclastic-flow breccias and pumice tuffs. Vol-

canoclastics were redeposited by intermittent streams as bodies of epiclastic volcanic conglomerates and sandstones (34f) along the edges of the formation.

35 garnet-bearing hornblende-pyroxene and hypersthene-hornblende andesites (Neresnica Formation, Kordíky Formation) / *Early - Middle Badenian*

These rocks occur in scattered intrusive-extrusive bodies along regional fault systems and in related volcanoclastics present at the base of volcanics in of the Kremnické vrchy (a suite of andesites with garnet and Kordíky Formation), the Vtáčnik and Štiavnica stratovolcanos, the Neresnica Formation south of Zvolen (Konečný et al. 1983) and relics of several bodies and volcanoclastics in the Slovenské rudohorie southeast of Brezno. These rocks are hornblende-hypersthene and hypersthene-hornblende andesites, sometimes with biotite and accessory garnet.

The most widespread volcanic forms are extrusive domes that grade into thick lava flows (35C); most are accompanied by extrusive breccias on the dome-flow margins. Largely coarse epiclastic breccias (35d) pile up around the extrusive domes, while further away are epiclastic volcanic breccias and conglomerates (35e) and epiclastic volcanic sandstones (35g), variably interlayered with reworked tuffs.

The Vinica Formation and Burda volcanics are lateral equivalents to the above-mentioned rocks and assemblages. However, these are dominated by pyroxene to hornblende-pyroxene andesites and therefore are assigned to category 31.

36 granodiorites (Hodruša-Štiavnica Intrusive Complex) / Badenian

These rocks are confined to a subvolcanic intrusive complex in the central zone of the Štiavnica stratovolcano in an elevated block of the Hodruša-Štiavniva horst. Granodiorites here, along with diorites (37), are designated as the Hodruša-Štiavnica Intrusive Complex (Konečný et al. 1983). The granodiorites constitute a huge bell-shaped intrusive body intruded into the pre-volcanic substratum. Its flat top corresponds to nearly-horizontal discontinuities between the crystalline rocks, the Veľký Bok sequence and the base of the Choč nappe. Its upper parts in places enclose blocks of crystalline rocks. It forms short apophyses at the contact with the Mesozoic rocks. Petrographically, it is a coarse-grained biotite-hornblende granodiorite whose texture varies from slightly poikilitic inside the body through equigrained to porphyritic on the edges of the body. In apophyses it has a character of granodiorite or granite porphyries, exceptionally with endoskarns. Thin aplite dykes and dark spherical enclosures of diorite composition are extremely rare. All the body is variably propylitized.

37 diorites (Hodruša-Štiavnica Intrusive Complex) / *Badenian*

They are confined only to a subvolcanic intrusive suite in the central zone of the Štiavnica stratovolcano in the Hodruša-Štiavnica horst. Together, older diorites and younger granodiorites (36) are designated as the Hodruša-Štiavnica Intrusive Complex (Konečný et al. 1983). The diorites occur as a large body on the northern edge of the intrusive complex and as minor relics capping the granodiorite. The former occurs amid rocks of the crystalline unit and Early Triassic quartzose shales of the Choč nappe. The rocks are medium-grained and near the margins are mildly porphyritic hornblende-pyroxene and biotite-hornblende-pyroxene diorites that were generally propylitized. Locally, at contacts with crystalline rocks, the diorite caused recrystallization, granitization and anatexis.

Diorites are also known at depth in the central zone of the Badenian stratovolcano of the Zlatá studňa Formation in the Kremnica area and in the Javorie stratovolcano central zone (Kalinka Intrusive Complex).

38 granodiorite porphyry (Tatiar and Zlatno Intrusive Complexes) / *Badenian*

These rocks constitute dyke swarms and minor stocks (at subvolcanic level) of the Zlatno Intrusive Complex (Konečný et al. 1993) in the Hodruša-Štiavnica horst and of Tatiar Intrusive Complex west of Pukanec (Brlay et al. 1985), both parts of the Štiavnica stratovolcano The dyke swarms and stocks were emplaced into the 1st-stage andesites and pre-volcanic substratum through a combination of active injection and stoping. Dike to dike contacts and zoning of individual dykes and other bodies suggest a multistage intrusion from a differentiated magma source The rocks are mainly coarse-grained biotite-hornblende granodiorite porphyries, but biotite-hornblende quartz-diorite porphyries are also abundant. Thin dykes of pyroxene-hornblende diorite porphyries are scarce. Diorite porphyries constitute margins of dykes and bodies of more acid rocks. Most rocks were intensively propylitized, or silicified, sericitized and pyritized in connection with porphyry Cu mineralization.

39 quartz-diorite porphyry (Banisko Intrusive Complex) / *Badenian*

These rocks make up a group of dykes and sills in the central zone of the Štiavnica stratovolcano and are designated as the Banisko Intrusive Complex (Konečný et al. 1983, 1993. The intrusive bodies consist of a group of sills emplaced in the pre-volcanic substratum, along the contacts of granodiorite with subjacent rocks and a swarm of dykes mostly striking NNE and dipping away from the volcanic centre. The sills are a few meters to 200 m thick. The dykes are a few meters to 100 m thick. The sill and dyke complex was emplaced through

a ring-dyke mechanism (central block subsidence). The rocks are mainly medium- to coarse-grained biotite-hornblende quartz-diorite porphyries and less commonly are fine- to medium-grained pyroxene-hornblende diorite porphyries. The rocks generally are propylitized.

40 diorite porphyry (Kalinka and Šafranička Intrusive Complexes, central volcanic zones of eastern Slovakia stratovolcanoes) / *Badenian - Sarmatian*

These rocks are found in central zones of the Javorie (Kalinka Intrusive Complex) and the Poľana stratovolcanoes (Šafranička Intrusive Complex), in an eroded volcanic centre NW of Tisovec in the Slovenské rudohorie, in central zones of the Sarmatian stratovolcanoes in eastern Slovakia and in the Lysá Stráž - Oblík Formation. Diorite porphyries form dykes, intrusions and small stocks, some of which become large diorite bodies at depth (Javorie, Poľana, Morské Oko). The rocks are medium-grained, pyroxene, hornblende-pyroxene and pyroxene-hornblende diorite porphyries, and locally also include quartz-diorite porphyries. Most of them are chloritized or propylitized or are hydrothermally altered.

41 andesite porphyry (central volcanic zones of eastern Slovakia stratovolcanoes) / *Sarmatian*

The porphyries occur in central zones of Sarmatian andesite stratovolcanoes of eastern Slovakia. They make sills and laccoliths that are emplaced in the lower part of the volcanic complex, or along the boundary of the volcanic complex with the pre-volcanic substratum or complexes of sills with relics of the original volcanic structure. The thickness of this intruded part of the volcanic complex is as much as 500 m. Intrusive breccias are also present. The rocks are mostly pyroxene or hornblende-pyroxene, less commonly pyroxene-hornblende andesite porphyries, and they generally are autometamorphically altered and chloritized.

42 andesite porphyry (Tanád, Beluj, Župkov and Prochot Intrusive Complexes, Dudáš Complex) /*Badenian*

These rocks are located in the central zone of the Štiavnica stratovolcano (Tanád Intrusive Copmplex) on the slopes of the Štiavnica stratovolcano where they occur in parasitic intrusive centres (Pukanec and Nová Baňa areas, Beluj, Župkov and Prochot Intrusive Complexes) and in the central zone of the Poľana stratovolcano (Dudáš Complex). They constitute sills and laccoliths in the lower part of the volcanic pile or at the boundary of the volcanic pile with the pre-volcanic substratum. This intrusive assemblage has a thickness of 1000 m. Intrusive breccias and exceptional tuffisite breccias are also present. The rocks are chiefly pyroxene and hornblende-pyroxene, less commonnly pyroxene-hornblende andesite porphyries, and these are mostly autometamorphosed and chloritized.

LATE CRETACEOUS AND PALEOGENE OF THE INNER CARPATHIANS

43 sandstones, claystones, marls (Buda facies - Číž Formation) / *Oligocene*

Underlying the Lučenec Formation, the Číž Formation near Štúrovo in the South Slovakia Basin (Vass - Elečko 1982) is about 300 m thick and is divided into the basal fluvial member, a medial coal-bearing swamp, or lagoonal member and an upper marine member. The basal Skálnik Member consists of gravels, sands, variegated clays.The medial Hostišovce Member has dark clays with coal beds. The upper Blh Member contains chiefly littoral sands-sandstones and some calcareous claystones and siltstones.

44 claystones, sandstones, conglomerates, coal, marly limestones (Šomodi Formation) / *Priabonian - Oligocene*

The Šomodi Formation (Vass et al. 1994) lies in the Turňa depression. Its characteristic rock type are laminated algal limestones (alginites) and dark limestones with coal beds (sediments deposited in marine lagoons). These are overlain by conglomerates, sandstones, variegated clays and coal beds (fluvial and paludal sediments), slide sediments (pebbly mudstone) and beige lacustrine limestones. The formation is several hundreds of metres thick.

45 sandstones, subordinate shales (Biely Potok Formation) / *Priabonian - Egerian*

The Biely Potok Formation typically consists of sandstone beds as much as several metres thick with sporadic interbedded claystones. Polymict conglomerates (submarine slides) and intercalations of fine-conglomerate flysch occur locally. The sandstones contain claystone, siltstone and pelocarbonate intraclasts as well as armoured mudstone-balls. Gulls and amalgamated beds are widespread. The formation contains sparse microfauna assemblages indicating a stenohaline marine environment (Gross et al. 1984). The formation is as much as 500 m thick in the Skorušinské vrchy and as much as 900 m in the Levočské vrchy Mts.

The formation was dated as the Earliest Priabonian in Orava and near Varín, Oligocene in the Levočské vrchy and Šarišská vrchovina Mts. and Egerian in the Handlová Basin.

46 sandstones, calcareous claystones - flysch (Huty and Zuberec Formations), a) - mainly conglomerates (Šambron Member) / *Lutetian - Oligocene*

This unit comprises Inner Carpathian Paleogene sediments between the basal Borové Formation and the uppermost Biely Potok Formation. It consists of the Huty and Zuberec Formations and Šambron Member (thick conglomerate layers in the Huty Formation) (Gross et al. 1984).

The Huty Formation is made up mainly of variably-calcareous claystones in units tens-of-metres-thick that alternate with thin beds of fine conglomerates, sandstones and siltstones. Also found but sparse are pelocarbonate lenses and Menilite-type silicified claystones with fish scales and bone fragments. Layers of Globigerina marlstones are also sparse. Mn oxide-carbonate laminae and thin beds, which may locally reach economic importance (Kišovce - Švábovce) are widely scattered. The thickness of the formation varies from several tens of metres to 800 m.

The Šambron Member is part of the Huty Formation. This member is exposed in the so called "Hromoš-Šambron anticlinal zone" along the Klippen Belt. It consits of thick bodies of polymict conglomerates with thinner layers of fine-rhythmical flysch or claystones. In places Paleogene-sandstone intraclasts are 2 m across. Chmelík (1959) formerly regarded them as a basal member, an assumption later invalidated by Marschalko (1966) and Gross et al. (1996).

The Zuberec Formation has a flysch character. It consists of thick beds of sandstones, and a few of fine conglomerates and claystones. Subfacies of typical flysch, claystone-dominated flysch and sandstone-dominated flysch have been distinguished here. The clastic material of the sediments is quarz-carbonate. The Zuberec Formation is from several hundreds of metres to 1200 m thick.

The Huty Formation, Šambron Member and Zuberec Formation are Late Lutetian to Priabonian in age. In the Hornád, Handlová and Bánovce Basins and in the Šarišská vrchovina Mts., the formations are generally younger, extending as late as the Kiscelian (Early Oligocene). In contrast, the Huty Formation in the Malé Karpaty is of Middle Eocene age. The common thickness of the formations locally exceeds 2000 m.

47 conglomerates, sandstones, limestones, breccias (Borové Formation, "Súľov Conglomerates") / *Lutetian - Priabonian*

The Borové Formation (Gross et al. 1984) is a transgressive marine sequence resting on the Paleozoic and Mesozoic substratum of the Inner Carpathians. The base of the formation contains fragments and pebbles from the immediate substratum. Breccias, conglomerates, sandstones, sandy limestones, organoclastic and organogenic limestones alternate and substitute each other both vertically and laterally. The formation was deposited in a warm littoral to neritic environment. Bioherm and reef bodies were formed in places (e.g. Hrubý Grúň). Bioherm-limestone clasts are found in this formation in the Malé Karpaty. The thickness of the formation ranges widely from several tens of cm to 200 m (south of Šuňava).

The Borové Formation is diachronous, with the oldest age in the Malé Karpaty where large foraminifers indicate its Ilerdian - Cuisian age. Lutetian age has been proved in the north-west (Skorušinské vrchy), Bartonian in the Bánovce Basin, and Priabonian in the Handlová Basin. Towards the north-east (near the village of Lučivná), deposition persisted almost till the Eocene/ Oligocene boundary.

Pre-transgessive sediments of various origin (deluvial, proluvial, fluvial, deltaic) have locally been preserved in the substratum of the Borové Formation. They include also small bauxite bodies (Mojtín, Markušovce) or carbonaceous claystones, coal (Šuňava) and paleokarst fragments.

The unit also comprises the Súľov Conglomerate Formation which is widespread in the central Váh Valley, Rajec Basin and Humenské pohorie. It consists of carbonatic conglomerates to sandstones. Its material composition is monotonous inasmuch Triassic dolomite clasts of various degree of rounding account for over 90 %. The formation is as much as 1200 m thick and rests transgressively on the Mesozoic substratum, which belongs to various tectonic units (Manín and Kostelec units, Krížna and Choč nappes) (Kysela et al. 1982, Marschalko - Samuel 1993).

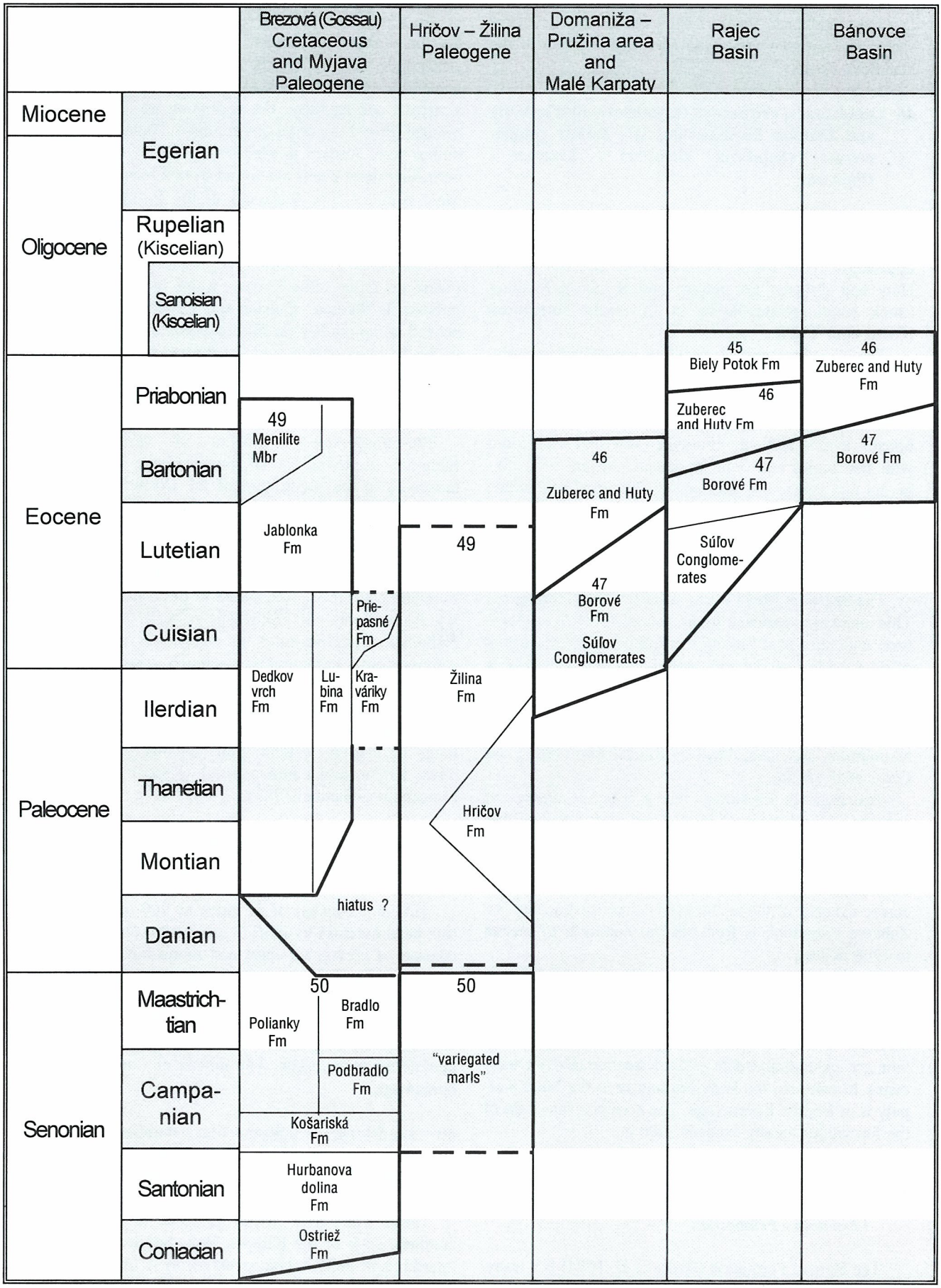
48 limestones, claystones, marlstones, coal seams (Buda facies) / *Eocene*

This unit consists of as much as 900-m of non-marine beds overlain by marine sediments. The lower part consists of variegated clays and sandstones of freshwater, paludal and shallow-water near-shore origin A medial part is the Obid Member made up of carbonaceous clays and coal beds (up to 8 m thick). The upper part of the formation consists of interbedded sandy clays and marlstones with fossils. The unit is of Lutetian - Priabonian age.

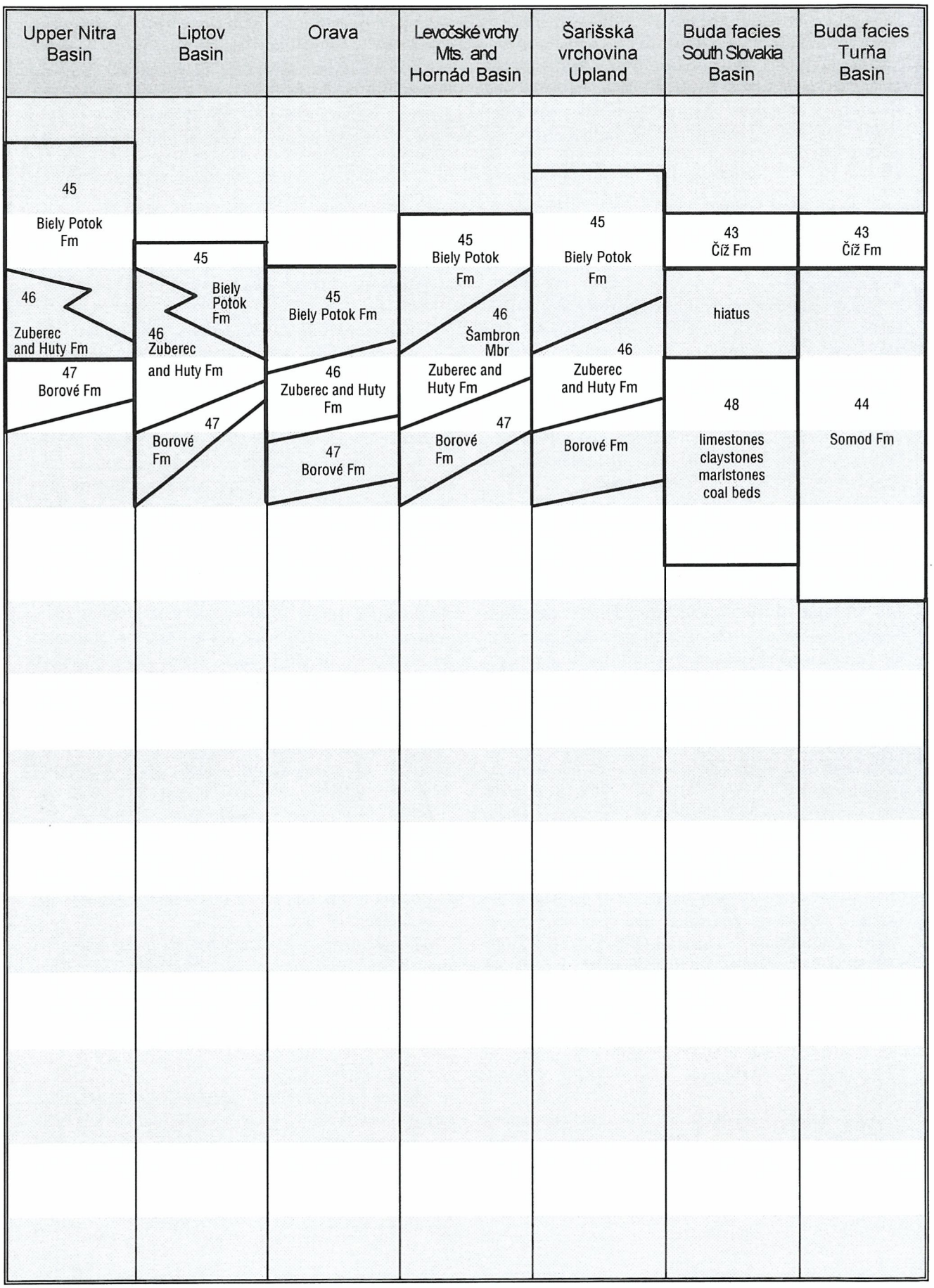
49 sandstones, conglomerates, marlstones, flysch with reef limestone blocks (Myjava, Hričov – Žilina facies) / *Paleocene - Eocene*

These Paleogene rocks underlie a zone along southern edge of the Klippen Belt. Subdivision of this "periklippen belt" is controversial, as is its relationship to surrounding formations and tectonic units. The belt

Correlation of Inner Carpathian Late Cretaceous and Paleogene lithostrat. units - part 1



Correlation of Inner Carpathian Late Cretaceous and Paleogene lithostrat. units - part 2



was set aside as a separate unit of the Inner Carpathian Paleogene and designated as the "Myjava facies" by Andrusov (1965). It is defined as Paleocene - Middle Eocene marly and flysch facies intercalated with conglomerates and several levels of olistoliths of the reef Kambühel Limestones. Local (and mostly incomplete) sequences ("facies") were defined in various areas, such as the Myjava Group with Bradlo, Stará Turá and Surovín "facies" (Salaj et al. 1987) in the Myjava area, "Hričov - Žilina Paleogene" in the Váh Valley (Samuel et al., 1972), Haligovce "facies" in Pieniny and Beňatina "facies" in eastern Slovakia. Each of these areas has some specific signs, but essentially four lithofacies can be distinguished:

1) Organodetrital, reef, algal-coral limestones intercalated with marls, which constitute members in the Myjava area in the "Surovín facies" of Dedkov vrch Formation. In the Hričov Formation, they are known only as olistoliths. The lithofacies also includes dark organodetrital limestones and sandstones of the so called "Jablonové Formation" found south-west of Hričovské Podhradie (Salaj et al. 1978, Kysela et al. 1982). The facies ranges in age from Early Paleocene to Early Eocene.

2) Marlstone-claystone beds with red, gray and greenish, more or less sandy and calcareous claystones interlayered with siltstones and fine-grained sandstones. They comprise the upper part of the Polianka Formation, lower part of the Dedkov vrch Formation (Samuel et al. 1980, Salaj et al. 1987), part of the Hričov and Žilina Formations (Samuel 1972) as well as some localities in the Hanušovce and Beňatina parts of the Klippen Belt. Their biostratigraphic age is Paleocene (Montian - Thanetian) west of Žilina (Bystrická et al. 1983), as at Beňatina, even of Early to Middle Eocene age (Leško - Samuel 1968, Bystrická 1981). The Cretaceous to Paleogene sequence in the Hradisko section was formerly regarded as continuous (Salaj et al. 1978), but a hiatus was later proved to be at the base of Paleocene (Danian) (Hansen et al. 1990).

3) flysch beds with calcareous sandstones to organodetrital limestones and calcareous sandy claystones. They comprise: the Lubina Formation of the Stará Turá sequence, Kravárik Formation and "Surovín facies" Priepasné Formation (Salaj et al. 1987) and the Žilina Formation (Samuel 1972). Organodetrital breccias are widespread, polymict conglomerates occur in the Kravárik Formation near Myjava (Samuel et al. 1982). They are of Late Paleocene (Ilerdian) to Early Eocene age. The flysch complex hosts olistoliths of bioherm reef limestones rich in Paleocene fossils (Samuel et al. 1972).

4) calcareous conglomerates to medium-grained sandstones with well-rounded clasts, known as Súľov conglomerates. They are present in the Váh Valley between Hlboké and Žilina, near Nededza, in Pieniny (Aksamitka) and near Beňatina. This assignment is based strictly on lithofacies and this term is not identical with the homonymous unit resting transgressively on the Inner Carpathian units (leg. 47).

Individual sequences are widespread and occur scattered along the southern edge of the Klippen Belt (Haligovka) (Uhlig 1891). The sequences vary in thickness. The thickest one, the Lubina Formation, is as much as 1000 m in the Myjava area.

On the map, the unit also comprises the Jablonka Formation and about 400 m thick the Menilite Member of Middle Eocene - Early Priabonian age, exposed in the Myjava brick plant (Samuel 1975).

50 marls, carbonate sandstones, limestones, conglomerates (Brezová/Gossau facies) / *Senonian*

This "post-orogenic" sedimentary sequence is characterized by transgressive basal members of the Ostrież Formation (Valchov Conglomerates) on the Hronic - "Silicic" nappes. The conglomerates and breccias are made up of local calcareous material and locally are intercalated with red claystones. They grade upward into the calcareous Baranec Sandstones (as much as 150 m thick) and the sandy Štverník Marls (50 - 100 m thick). Overlying them is the 350-600-m-thick Hurbanova dolina Formation composed of flysch with conglomerate lenses in the upper part. It is, in turn, overlain by variegated marls of the Košariská Formation (as much as 50 m thick). Above the Košariská Formation is the Podbradlianska Formation as much as 600-m-thick, in which calcareous sandstones become more abundant and the marls less so. The sequence is topped by the Bradlo Formation. At its base are "Orbitoid Limestones"; its middle part consists of "Mosnáček Marls"; and its top part is "Podlipovec Flysch". The entire sequence is Coniacian to Maastrichtian in age (Samuel et al. 1980, Salaj et al. 1987). The Polianka Formation, composed of gray-greenish marls interbedded with gray-blue fine-grained sandstones at the bottom of Campanian - Danian age, crops out parallel to it.

This group also includes Senonian occurrences near Šumiac (Andrusov - Bystrický 1959), Dobšiná Ice Cave (munieria freshwater limestones regarded as Early Cretaceous by Bystrický 1978); variegated conglomerates and claystones (Kettner 1951), gray marlstones (Samuel 1977) and foraminifera limestones in the Miglinec Valley (Mello - Salaj 1982).

This unit also includes Campanian to Maastrichtian varicoloured (yellow, green, locally red) marls with conglomerate intercalations at Hradisko, assigned to the Manín (?) unit (Kysela et al. 1982, Salaj et al. 1978).

51 calcareous sandstones, siltstones and marly claystones, locally laminated limestones (Cergowa Member, Krosno Formation) / *Priabonian - Oligocene*

In the Dukla unit, it comprises a thin-bedded claystone-dominated flysch formation referred to as the Cergowa Member (Korába - Ďurkovič 1978). Fine-grained graywacke sandstones to graywackes with carbonate fragments have bedding that averages about 4 cm in thickness, and, rarely, as much as 1 m. Beds are mosty ripple-laminated. The claystones are calcareous, gray-brown, yellow to ocher-brown, and are intercalated with dark-brown Menilite-type calcareous claystones. The beds are about 15 cm thick. In the Medzilaborce syncline the formation contains laminated Tylawa Limestones, a correlation horizon. The maximum thickness of the formation does not exceed 1000 m.

The Krosno Formation in the Silesian unit consists of thick beds of fine- to medium-grained sandstones alternating with sandy calcareous gray claystones. The percentages of pelites and psammites are variable. Pelocarbonate beds occur in places. The formation's maximum thickness is 1000 m (Menčík et al. 1983).

Foraminifers attest to a Priabonian - Early Oligocene age of the Cergowa Member and the Krosno Formation.

On the map the Krosno Formation of the Silesian unit also comprises fragmentary occurrences of the Menilite Formation in the Magura nappe foreland.

52 calcareous claystones, siltstones, sandstones, slumps (Malcov and Racibor Formations) / *Priabonian - Oligocene*

The Malcov Formation is a flysch composed of prevailing calcareous claystones alternating with fine-grained thin-bedded quartz-carbonate sandstones and siltstones intercalated with graywacke sandstones and interlayered with landslide masses. The sandstones are rich in carbonate fragments. The lower bedding planes of the sandstone beds contain abundant bioglyphs. The formation (about 600 m thick) is Latest Eocene - Early Oligocene in age. In eastern Slovakia, its lower part is intercalated with brown "Menilite-type" calcareous claystones. The 5-10 cm thick beds of tuffaceous-montmorillonite clays are found south of Richvald. Above these claystones is a lithotamnium marker horizon (Leško - Samuel 1968).

The Racibor Formation is exposed on the southeastern slopes of the Kubínska Hoľa and Oravská Magura Mts. and locally also between Babín and Vavrečka. It is a flysch composed of calcareous, locally silty claystones alternating with graywacke and fine- to coarse-grained sandstones. The sandstone/claystone ratio is variable, but the latter usually prevail. Beds of gray marlstones weathering beige occur in many places. The 600-1000 m thick formation is Middle Eocene to Early Oligocene in age. The Račová Member (Potfaj et al. 1991) is a pelitic part of the Racibor Formation.

53 brown claystones, sandstones, cherts (Menilite Formation) / *Priabonian - Oligocene*

The lower part of the formation consists of brown and black calcareous claystones with sporadic sandstone intercalations and pelocarbonate lenses and beds. The middle part is characterized by brown to black silicified claystones prevailing over thick-bedded black cherts. The upper part of the Menilite Formation is composed of brown, black and dark-gray calcareous claystones which weather white to light-blue (Korába - Ďurkovič 1978).

The Menilite Formation occurs mainly in the Dukla and Silesian units where it is as much as 300 m thick. Because of its limited areal extent in the Silesian unit, the Menilite Formation in the Silesian unit is labled on the map together with the Krosno Formation. Menilite-type beds are present in the lower part of the Magura unit of the Malcov Formation and in the Inner Carpathian Paleogene. The formation is Late Eocene - Oligocene in age.

54 sandstones, microconglomerates, subordinate mudstones (Strihovce Member) / *Lutetian - Early Priabonian*

The formation is composed of sandstones prevailing over claystones. Fine-grained conglomerates are widespread either at the base of beds or as separate layers. Petrographically, the sandstones are largely medium-grained graywacke sandstones, thick-bedded with abundant claystone fragments that in places are as much as 1 m across. Slump folds several metres in amplitude at Drenica and in a railway cut near Demjata suggest that the sediments were laid down on a steep slope and slumped before consolidation. The Middle Eocene - earliest Priabonian formation is several hundreds of metres thick. The formation is present in the Krynica unit in eastern Slovakia (Mišík et al. 1991).

55 variegated manganiferous claystones ("Globigerina Marls") / *Lutetian - Priabonian*

The unit consists of crimson-red, bluish and gray-green claystone beds with thin intercalations of graywacke sandstones. To the north the structures are richer in sand and manganese nodules than to the south. Small foraminifers attest to its Middle Eocene age (Leško - Samuel 1968). They grade into green Globigerina marls with abundant Priabonian foraminifers. The lower part of the unit is as much as 25 m thick, and the Globigerina marker does not exceed 2 m. The unit occurs in the Klippen Belt and on the southern slopes of the Magura unit.

56 marly shales, sandstones (Vsetín Member) / *Lutetian - Priabonian*

The Vsetín Member is dominated by largely calcareous, green and brown-gray claystones with conchoidal jointing, 30 - 300 cm thick. Sandstone beds about 70 cm thick occur but rarely (Pesl 1968). Northern slices of the Rača unit in Kysuce comprise also sequences whose facies are similar to the Bysrica Member (compare Beleš - Potfaj 1996). These 1300-m-thick beds are Middle to Late Eocene in age. In eastern Slovakia, the Vsetín Member is part of the Zlín Formation.

57 graywacke arkosic sandstones, mudstones (Kýčera Member, Babia hora and Makovica Sandstones) / *Middle Eocene - Priabonian*

This unit is an assemblage of thick-bedded, mostly medium-grained sandstones prevailing over Bystrica-type siltstones to claystones. The lowermost parts of the Kýčera Member in the Pilsko and Minčol mountains are intercalated with thin-bedded flysch. The uppermost parts contain layers of thick-bedded claystone-dominated flysch. In the northern zone of the Bystrica unit, the Kýčera Member, composed almost entirely of massive sandstones, rests on the Bystrica Member. The unit totals about 1500 m in thickness. The Kýčera Member is probably Late Eocene in age, but may possibly start as early as the end of the Middle Eocene (Pivko et al. 1991). Its equivalent in the Orava area is the Babia hora Sandstones (Pesl 1968). The Kýčera Member occurs in the Rača unit of the Magura nappe.

In eastern Slovakia, the Middle Eocene sandstone suite is referred to as the Makovica Sandstones. It crops out in isolated, erosional, about 700 m thick remnants overlying the Beloveža Formation. The graywacke sandstones are dominated by quartz. The Makovica Sandstones are widespread in the Rača and Bystrica units of eastern Slovakia.

This unit also includes the so called "Tvarožec Sandstones" (Nemčok 1980). Their geological position and the Middle Eocene age indicated by the Nummulite assemblage (Nemčok et al. 1990, p. 60), allow us to assign them to this group of sandstones.

58 mudstones, glauconitic sandstones, marlstones (Bystrica Member, Vychylovka Formation) / *Lutetian - Priabonian*

Flysch composed of thick- to thin-bedded graywacke sandstones alternating with thick (up to 9 m) conchoidally jointed "Bystrica-type" dark-gray claystones ("Schiefer von Lacko"). Furthermore, the formation contains quartz-bearing arkosic sandstones with glauconite. Beds of gray marlstones that typically weather beige, are present. In general, claystones prevail, but groups of sandstones beds are locally as much as 20 m thick. As much as 1200 m thick formation is Bartonian to Priabonian in age. The Bystrica Member represents the main part of the Bystrica subunit.

The Vychylovka Formation is a transition between the Beloveža and Zlín Formations (Potfaj 1989). It consists of two facies types: thin-bedded Beloveža-type flysch (prevailing in the lower part) and thick-bedded flysch of the Bystrica Member, whose percentage increases upwards. The formation occurs mainly in the southernmost slice of the Bystrica tectonic unit, where it is about 250 m thick. It is of Middle Eocene age. On the map, the Vychylovka Formation and Bystrica Member make up a single symbol.

59 shales, glauconitic sandstones: thick-bedded flysch (Zlín Formation undifferentiated) / *Lutetian - Priabonian*

This unit is a thick-bedded flysch formation about 1000 m thick with variable percentages of pelitic and psammitic constituents. This polyfacies formation is subdivided into the Kýčera, Vsetín and Bystrica Members (Pesl 1968) whose mutual relationship is either a stratigraphic or a lateral facies transition. The formation age is Middle Eocene - latest Eocene (in the Zlín area even as late as the Early Oligocene). The formation is exposed in the Rača and Bystrica tectonic units of the Magura nappe. The formation has not been subdivided in eastern Slovakia.

60 greenish-gray, at places red claystones, glauconitic sandstones, pelitic Fe-carbonates ("Hieroglyph Member", Submenilite Formation) / *Eocene*

The Variegated Member in the Rača tectonic unit is overlain by the "Hieroglyph Member" dominated by thin- to medium-bedded flysch in which fine-grained sandstones prevail over claystones. Thick-bedded hard sandstones with glauconite, interlayered with conglomerates ("Pasierbiec Sandstones") are less abundant. The formation is of Middle Eocene age, its base being late Early Eocene. Pesl (1968) correlates them with the so called "Lower Zlín" (or Újezd) Member.

The Submenilite Formation in the Silesian tectonic unit has a variable facies composition. The claystones are dark-gray and green to greenish-brown, commonly intercalated with siltstones and pelocarbonates. Sandstone beds are more abundant towards the top of the formation where it has a typical flysch character. Conglomerate beds and red claystone intercalations occur in places. The thickness of the formation is estimated at 800 m, but in most of the territory it was tectonically reduced. The formation is Paleocene - Late Eocene in age.

The Submenilite Formation (Member) in the Dukla unit consists of green, gray and red, mostly non-calcareous claystones interbedded with thin-bedded sandstones and siltstones. Blue-gray fine- to coarse-grained sandstones are calcareous, some beds have an increased

contents of glauconite.The maximum thickness of the formation does not exceed 1000 m (Koráb - Ďurkovič 1978).

61 sandstones, subordinate shales: coarse flysch (Čergov and Magura Sandstones) / *Eocene*

Unit 61 is an assemblage of coarse- to medium-grained graywacke sandstones forming beds up to 3.5 m thick. They are interlayered with gray, sandy, variably calcareous claystones as much as 30 cm thick. Locally, the sandstones contain small-pebble conglomerates. The sandstone/claystone ratio is high, always above 1/1. The Early - Middle Eocene Magura Sandstones in Orava are about 1000 m thick on the crest of the Oravská Magura Mts. and at least 300 - 600 m in northern tectonic slices (Potfaj 1983).

The Beloveža Member (Stráník 1965, Nemčok et al. 1990) grades into sandstone flysch of the Čergov Sandstones in the Krynica unit of eastern Slovakia. The sandstones are gray, blue-gray, fine- to coarse-grained, and with muscovite. The beds are interlayered with 5 - 30-cm-thick gray, green-gray and dark-gray sandy claystones, in places with intercalations of carbonized plant remains. The claystones only contain assemblages of agglutinated microfauna and therefore the age of the Čergov Formation has been derived from its stratigraphic position.

62 sandstones, shales: thin-bedded flysch, red claystones (Beloveža Formation, "Variegated beds" Member) / *Paleocene - Early Eocene*

This group includes very-thin- to thin-bedded flysch with variable percentage of red claystones. Its occurrences in various tectonic units differ from one another in details. It constitutes the Variegated beds in the Biele Karpaty unit, and the Beloveža Formation and "Variegated" beds in the Magura unit.

The Variegated beds in the Biele Karpaty unit consist of red, green-gray and blue-gray claystones to clays with variable percentage of silt, and mostly with disseminated muscovite. Thin beds of fine-grained sandstones, either quartzose, or with glauconite, are very rare. The Variegated beds occur at several levels in the Paleocene and Eocene. The lower ones are intercalated with green slightly-calcareous claystones, and the upper with brown-gray calcareous claystones. Reduced by tectonism, their thickness varies from several meters to tens of metres. Its Paleocene age has been determined in western Slovakia, whereas Early Eocene was determined in neighboring countries.

In the Magura nappe, the unit 62 consists of two major lithofacies:

1) varicoloured (red, green, gray) claystones prevailing over thin-bedded fine-grained sandstones and siltstones and

2) thin- to very-thin-bedded flysch in which fine-grained sandstones to siltstones prevail over gray and green claystones. Black-brown hard claystones with curved leaf-like to conchoidal jointing occur in places. The claystones only rarely prevail over sandstones. The lower bedding planes of the sandstones contain abundant current marks and bioglyphs (characteristic Paleodyction).

The identification of these two lithofacies resulted in the division of the Beloveža Formation into the Lower Beloveža Member with red claystones and the Upper Beloveža Member without them. About 600 m thick, the Lower Beloveža Member is Late Paleocene - earliest Eocene in age.

These are equivalent to the "Variegated" beds of the Rača tectonic unit in Orava. The member consists mainly of variegated (red and green) claystones prevailing over sandstones of various kinds. Tectonically reduced, the sequence is about 150 m thick. The sandstone/claystone ratio is variable, locally with fine-conglomerate layers, thick-bedded flysch zones and massive sandstones layers (Pivko et al. 1991).

The Upper Beloveža Member is as much as 600-700 m thick and its top is Early Eocene in age.

63 coarse-grained sandstones, subordinate claystones (Chabová Member) / *Paleocene - Early Eocene*

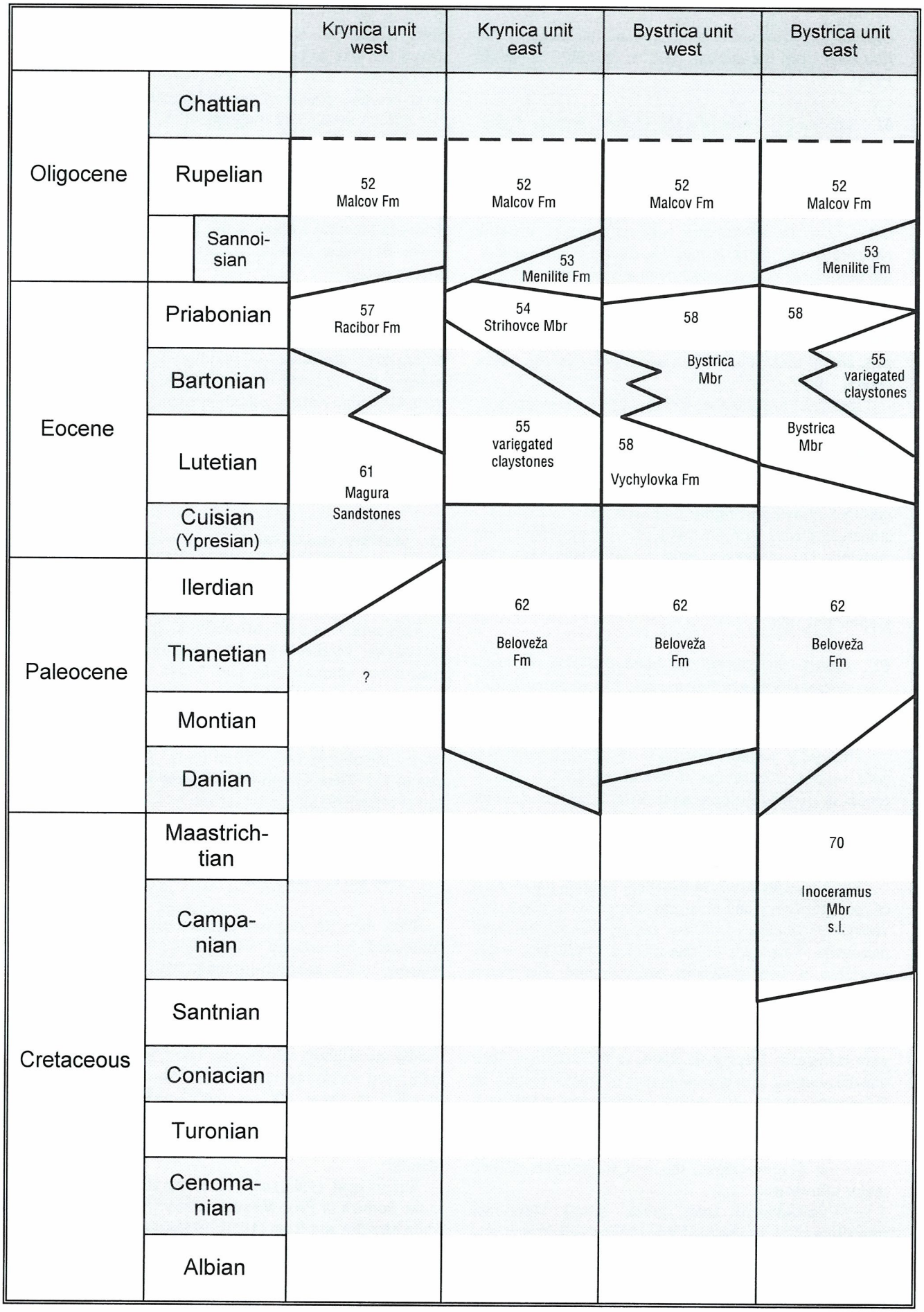
This unit is a suite of medium- to coarse-grained graywacke sandstones with carbonate clasts and muscovite. Intercalations and lenses of fine conglomerates are present, too. Green-gray, slightly calcareous, highly sandy claystones are rare. The Chabová Member is Late Paleocene to Early Eocene in age. The eroded member is now 150 m thick. The formation is part of the Vlára Group of the Biele Karpaty tectonic unit (Potfaj 1993).

64 sandstones, sandy claystones: flysch (Rajkovec Member) / *Paleocene*

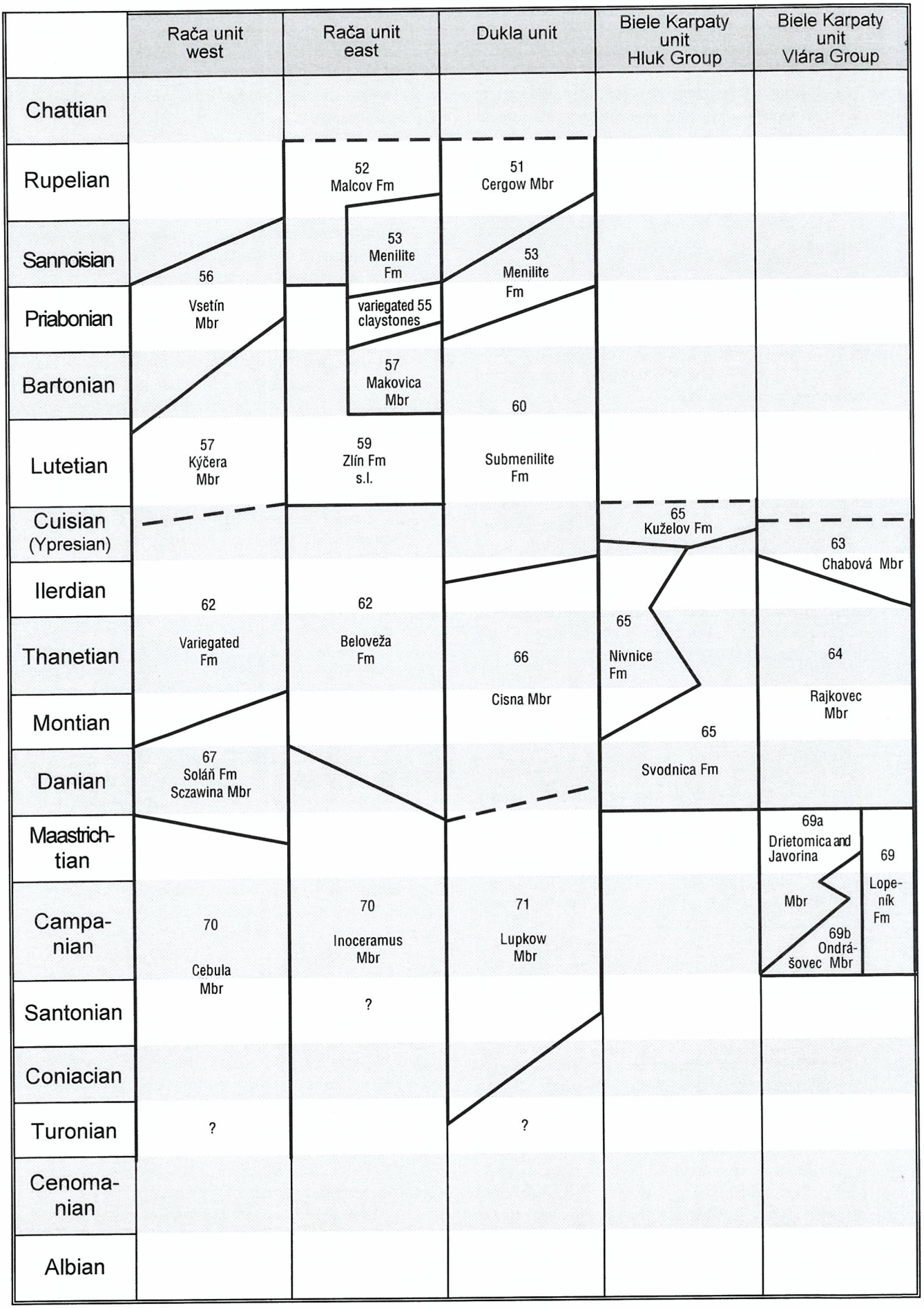
This thin- to medium-bedded flysch is strongly dominated by arkosic sandstones. These are fine-grained, rarely medium-grained, with muscovite and carbonate clasts (as much as 10 %), in beds 2 - 40 cm, and rarely 2 m thick. The claystones are gray, green-gray and dark-brown-gray, and in the lower part locally are slightly calcareous. The layers are 1 - 5 cm thick, and rarely as much as 30 cm. The Rajkovec Member is about 500 m thick. Calcareous nannoplanktons provide a Paleocene - Early Eocene age. Their lithofacies resembles that of the older Javorina Member.

Stráník et al. (1986) considered the Rajkovec Member as the Jarmuta or Proč Member of the "Kopanice" facies, while Matějka and Roth (1950, 1956) referred to it as the Vlára facies and did not differentiate it from our Javorina Member. Pesl (1968) used it as a basis for defining the "Vlára zone".

Correlation of Outer Carpathian Cretaceous and Paleogene lithostratigraphic units - part 1



Correlation of Outer Carpathian Cretaceous and Paleogene lithostratigraphic units - part 2



65 sandstones, sandy claystones: flysch (Svodnice and Nivnica Formations) / *Paleocene - Eocene*

The Svodnice Formation is typically composed of 0.5-2.5 m thick gray and brown-gray calcareous claystones, silty at the base, of conchoidally jointed rock macroscopically similar to claystones of the Bystrica (Zlín) Member. Furthermore, the formation consists of greenish-gray and dark-gray claystones and slightly sandy gray claystones as much as several cm thick. Graywacke sandstones to calcareous graywackes are fine- to coarse-grained, and contain muscovite. They make up beds 5-30-cm thick, but commonly as much as 1.5 m thick. In the upper part of the formation are 2 - 4 beds of gray clay-rich limestones as much as 70 cm thick that weather white. The sandstone-claystone ratio varies from 1:3 to 4:1. The 700-m-thick formation is of Paleocene - Early Eocene age.

The thin-bedded flysch of the Nivnica Formation consists of fine-grained calcareous sandstones forming beds up to 40 cm thick. These alternate with light brown-gray, greenish and beige claystones. The uppermost parts of depositional rhythms commonly contain thin (1 -5 cm) beds of dark-gray and greenish claystones. Thick (as much as 2.5 m) graded beds of sandstones occur in places. The Late Paleocene Nivnica Formation is about 600 m thick (Stráník et al. 1989b). West of Myjava, the formation cannot be distinguished from the Svodnice formation. Both formations are confined to the Biele Karpaty tectonic unit.

66 sandstones, subordinate shales, conglomerates: coarse sandy flysch (Cisna Member) / *Senonian-Paleocene*

This unit consists of thick-bedded sandstone flysch, composed mainly of medium- to coarse-grained sandstones and to small-pebbled conglomerates and minor fine-grained sandstones. The conglomerate pebbles are as much as 1 cm across, are poorly rounded to angular, and are composed chiefly of quartz and metamorphosed rocks. Sparse claystones are bluish-gray, to dark greenish and commonly are sandy. The unit is Maastrichtian? - Paleocene and is 40 to 400 m thick. The formation is present in the Dukla tectonic unit (Koráb - Ďurkovič 1978).

67 graywacke/arkose muskovitic sandstones, microconglomerates (Szczawina Member, Soláň Formation) / *Maastrichtian - Paleocene*

This unit is made up of a sequence of thick-bedded massive muscovite sandstones with thin claystone intercalations. The sandstones are classified as quartzose sandstones, arkosic sandstones and graywackes. In the Rača unit of the Magura nappe, it is singled out from the Soláň Formation under the name of the Szczawina Member (Pivko et al. 1991). This unit contains sparse sequences of variegated beds several tens of cm to tens of m thick with thin beds of "green flysch" dispersed in the sandstone assemblage and is at its margins 900 m thick. The Szczawina Member is of Maastrichtian to (?) Paleocene age.

68 sandstones, subordinate shales (Istebná Member) / *Senonian - Paleocene (Danian)*

This unit is a thick-bedded formation of sandstones and conglomerates with dark-gray claystones. The sandstones are fine- to coarse-grained, thick-bedded (as much as several meters). They contain as much as 10 % feldspars and 35 % micas. The medium-pebbled conglomerates are polymict; the quartz, crystalline-rock and limestone pebbles are well rounded. The 1000 - 1200 m thick Istebná Member is Campanian - Danian in age. It occurs in the Silesian tectonic unit (Menčík et al. 1983).

69 sandstones, claystones, fine conglomerates: flysch (Lopeník Formation) a) sandy flysch (Javorina Member), b) red shales (Ondrášovec Member) / *Campanian - Maastrichtian*

This unit is made up of the Lopeník Formation which is dominated by a thin-bedded sandstone flysch called the Javorina Member (Potfaj 1993). Thicker sandstone beds in the upper part of the formation make up the Drietomica Member. The lower part of the formation typically consists of red and gray marls interbedded with sandstones, or red claystones which are a characteristic sign of the Ondrášovec Member. About 900 m thick, the Lopeník Formation is Campanian - Maastrichtian in age. The formation extends along the southeastern edge of the Biele Karpaty tectonic unit between Zubák in the north and Stará Myjava in the south.

a) The Ondrášovec Member is a flysch, composed of fine-grained sandstones and greenish-gray calcareous and noncalcareous claystones alternating with red claystone beds, with scattered beds of coarse-grained graywacke sandstones 0.5 - 4 m thick. The Ondrášovec Member is 120 - 340 m thick.

b) The Javorina Member is a thin-bedded, mostly sandstone flysch, in the Javorina and Lopeník areas. It has banks of coarse-grained sandstones and microconglomerates. Fine-grained calcareous sandstones containing muscovite are the prevailing rock type. The claystones are gray and green, largely with silt admixture. Beds of gray silty limestones occur in places. The Javorina Member is 500 - 700 m thick.

c) The Drietomica Member differs from the Javorina Member in its predominance of thick-bedded (0.5 - 1.5 m), fine- to coarse-grained quartz-carbonate sandstones with thin claystone intercalations. Maastrichtian in age, the Drietomica Member has a maximum thickness of 200 m.

70 dark gray and green shales, sandstones ("Inoceramian" Member, Cebula Member) / *Turonian ? - Senonian*

Unit 70 comprises a medium gray to dark gray, largely claystone sequence that is intercalated with sandstones and siltstones. In eastern Slovakia it is known as the Inoceramus Member of the Rača tectonic unit. On the southern edge of the Smilno tectonic block are blue-gray and dark-gray claystones interlayered with sandstones as much as 25 cm thick. On the lower bedding planes of sandstones are abundant bioglyphs and current marks. The formation is part of the Dukla sequence.

The Cebula Member of the Soláň Formation in Orava (Pivko et al. 1991) consists of variegated claystones alternating with medium-rhythmical flysch of marlstones, siltstones and sandstones. The variegated claystones prevail over the marlstone beds. Some sandstones occur at the top of the sequence. The Campanian - Early Maastrichtian Cebula Member is about 150 m thick in Slovakia.

71 dark-gray and green shales, fine sandstones (Lupkov Formation) / *Cenomanian? - Senonian - Paleocene*

The Lupkov Formation is dominated by dark-gray to black, fairly hard scaly-friable claystones interbedded with fine-grained quartzose-calcareous-muscovite sandstones and siltstones (Koráb - Ďurkovič 1978). The upper part of the formation also contains sandstone beds up to 60 cm in thickness. Soft dark-blue calcareous claystones and gray silty Fuccoid marlstones occur in places.

MESOZOIC AND PALEOGENE OF THE KLIPPEN BELT

72 sandstones, shales and conglomerates (Jarmuta and Proč Members) *Maastrichtian - Eocene*

The lithology of this group is highly variable. Basal parts consist of varicoloured sedimentary breccias. These are overlain by calcareous sandstones (Jarmuta Sandstones) alternating with calcareous claystones (flysch). This part of sequence is interlayered with conglomerates and olistostromes. These sediments are Maastrichtian to Paleocene in age (Birkenmajer - Dudziak 1991).

A Paleogene part of the formation in eastern Slovakia was designated as the Proč Member (Leško 1960, Leško - Samuel 1968). Due to tectonic reduction, the thickness of the sequence varies, but does not exceed 1 000 m.

73 variegated marlstones ("couches rouges") / *Late Albian - Early Maastrichtian*

This fairly thick formation (50 - 170 m) consists of gray, green, but mostly red (couches rouges) marlstones to clayey limestones (pelagic foraminifera limestones). In places the marlstones have intercalated calcareous sandstones (calciturbidites), several cm to tens of cm thick and rarely also thicker layers of sandstones with conglomerates. In the Klippen Belt, this rock sequence has several local names, such as Púchov Marls (Štúr 1860), Gbely Member (Liebus - Schubert 1903), and Jaworki Formation (Birkenmajer 1977).

The "couches rouges" have a wide stratigraphic range: Upper Albian - Cenomanian to Lower Maastrichtian (Czorsztyn sequence). They are most abundant in the Senonian (Coniacian - Campanian).

Their composition is similar to that of the Kaumberg ("= Gbely") Member of Albian - Turonian age (Stráník et al. 1995). 30 - 70-m-thick, dark-gray, greenish-gray, bluish-green and red, partly calcareous claystones rarely intercalated with dark claystones and fine-grained-muscovite-bearing quartzose-calcareous sandstones that fringe the Čakanov klippe. They are shown along with Jurassic sequences. Their assignment to either the Biele Karpaty tectonic unit or to the Klippen Belt is still uncertain.

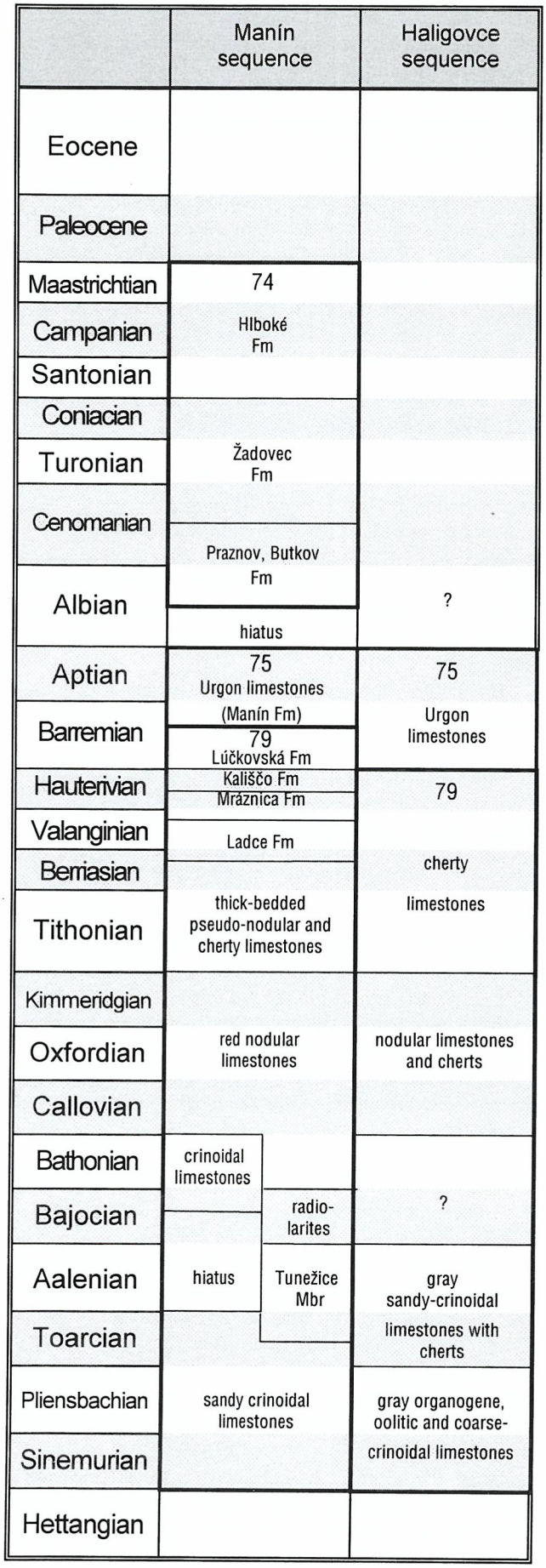
74 shales, marlstones, sandstones and conglomerates: flysch ("spherosiderite", "Upohlav" and Pupov Mbs., Orlové Sandstones) / *Aptian - Senonian*

The Klape unit consists of extremely thick (as much as 3500 m) flysch sequences each of which, in turn, is composed of several megacycles. In their lower parts, the flysch sediments are dominated by pelites, locally with concretions and thin beds of pelosiderites ("Spherosiderite" Member). Olistostrome layers, exotic simmictite-type conglomerates or thick sandstone layers (Orlové Sandstones) occur at scattered sites. The uppermost parts consist of flysch sediments with exotic clast intraformational conglomerates, formerly called the Upohlav Conglomerates (Began et al. 1965).

A thin-bedded flysch sequence of Coniacian - Santonian age that is designated as the Pupov Member (Andrusov - Samuel 1973) occurs between Varín and Zázrivá.

Correlation of the Klippen belt Jurassic to Paleogene lithostratigraphic units - part 1

		Czorsztyn sequence	Kysuca sequence	Drietoma sequence	Klape sequence
Paleogene	Eocene	72 Proč and Jarmuta Mbr			
	Paleocene				
Late Cretaceous	Maastrichtian	73 variegated marlstones (couches rouges)	73 Gbely Mbr	?	74 Klape Flysch
	Campanian		Snežnica Mbr		
	Santonian				
	Coniacian				
	Turonian		Kysuca Mbr	74 flysch, spotted marls, glaucinitic limestones	Orlová sandstone
	Cenomanian		Lalinok Mbr		
Early Cretaceous	Albian		78 Tissalo Mbr		Klape flysch
	Aptian		Koňhora Mbr	75 organodetrit.	clayey limestones
	Barremian	hiatus	Pieniny Limestone Fm	79 pelagic limestones	?
	Hauterivian				
	Valanginian				
	Berriasian				
Late Jurassic (Malm)	Tithonian	Dursztyn limest. / 77 / Rogožnik br.			79
	Kimmeridgian	Czorsztyn Fm	red nodular limestones	red nodular limestones	
	Oxfordian	Vršatec limestones	Czajakowa Fm	red and green cherts	pink micritic limestones
Middle Jurassic (Dogger)	Callovian	Czorsztyn Fm			
	Bathonian				
	Bajocian	Smolegowa Fm	Szlachtowa Fm "Posidonia Mbr"	?	crinoidal limestones with cherts
	Aalenian	Szlachtowa Fm			
Early Jurassic (Lias)	Toarcian	Allgäu Fm	Adneth limest. / Allgäu Fm	Allgäu Fm	
	Pliensbachian		Kozinec Mbr		
	Sinemurian		Zázrivá Mbr		
	Hettangian		"Gresten" Fm	Kopienec Fm	sandy-crinoidal limestones



75 organodetritic limestones (Urgonian facies) / *Barremian - Aptian*

This unit is characterized by thick-bedded to mostly massive organodetrital limestones (rudistes, orbitolinas, corals, calcareous algae). The lower boundary is uncertain, but the upper one is always sharp, topped by hardground, and overlain by Late Albian sediments. The Urgonian Limestones facies may pass laterally into cherty limestones. Its total thickness is as much as 120 m.

The Urgonian facies (Podhorie Formation) is widespread in the Manín nappe, but minor occurrences are also found in the Nižná (Scheibner 1967) and Haligovce sequences. It occurs fairly commonly as blocks in the Klape unit olistostromes.

76 bedded clayey limestones and cherty limestones (Pieniny Formation) / *Tithonian - Barremian*

Unit 76 includes bedded, massive sublithographic beige limestones ("biancone"-type) with Calpionellids that grade upward into bedded, white or gray pelagic cherty limestones (with Calpionellid, Nannoconus and/or Radiolarians). Higher parts of the sequence have intercalated marlstones. Their thickness in the Kysuca sequence exceeds 200 m at Pieniny, but elsewhere is about 100 m (Birkenmajer 1977).

77 spotted limestones, crinoidal and nodular limestones (Czorsztyn sequence) / *Sinemurian - Tithonian*

This category comprises beds of the Czorsztyn sequence, as well as of the transitional facies. The oldest Jurassic member is dark-gray fine-sandy limestone and marlstone of Sinemurian age (Dolný Mlyn, Beňatina). It is overlain by the Allgäu Member (Lotharingian - Toarcian), which in turn is overlain by the "flysch Aalenian" or Posidonia, "Opalina", and "Murchisonia" Members (=Krempachy, Szlachtowa and Opalienec Formations). Still higher are sandy-crinoidal limestones of Bajocian age (Smolegowa and Krupianka Formations). Its most conspicuous rock type are red nodular limestones (Czorsztyn Limestones) ranging in age from Bathonian to Kimmeridgian and locally even to Tithonian. Reef limestones (or Vršatec Limestones, Mišík 1979) or brecciated Rogoznik Limestones are less widespread.

78 calcareous sandstones, spotted limestones, radiolarites and nodular limestones (Kysuca sequence) / Hettangian - Kimmeridgian

This unit includes deep-water (trough) facies of the Klippen Belt Jurassic (mainly the Kysuca sequence, Andrusov 1971). It is equivalent to the Branisko-Pieniny sequence in Poland. The oldest Jurassic member is calcareous to arkosic sandstones (Arietites sandstones) overlain by alternating sandy-crinoidal

limestones and shales (Zázrivá Member, Haško - Planderová 1977) of Sinemurian age. Above are gray spotted limestones and marlstones - Allgäu Formation (Lotharingian - Toarcian) which in places, grade laterally into variegated limestones of the Kozinec Member (Haško - Polák 1979). The uppermost Lias of the Orava sequence (Haško 1979) consists of red nodular limestones "ammonitico rosso" (Toarcian) overlain by green and red radiolarites of Callovian - Oxfordian age. The lower Dogger sediments in the Kysuca succession itself are characterized by marlstones (Krempachy Formation) overlain by red and green radiolarites (Czajakowa Formation in Poland). The latest Jurassic is composed of red nodular and Calpionella limestones (Pieniny Formation).

79 sandy crinoidal, cherty and nodular limestoes (Drietoma, Haligovce and Manín sequences) / *Sinemurian - Kimmeridgian*

The lowest Jurassic member in these sequences are sandy crinoidal cherty limestones. Sandy shales with calcareous sandstones (Drietoma) occur sparcely. Green claystone layers (Toarcian, Rakús 1977) appear in the uppermost parts of the Manín sequences. Spotted limestones (Allgäu Member) interlayered with crinoidal limestones occur in the Drietoma sequence. The Middle and Late Jurassic consist of radiolarian and nodular Czorsztyn-type limestones.

80 variegated shales and sandstones (Carpathian Keuper) / *Norian*

This unit comprises red, yellowish, gray to greenish sandy shales interlayered with brownish and gray sandstones and quartzites. Gypsum is present in places (Záblatie). In the Klippen Belt, the Carpathian Keuper facies is found in the vicinity of Myjava, Drietoma and Chotúč. The entire unit is less than 100 m thick.

81 dolomites and limestones (Mariková, Púchov, Haligovce) *Middle - Late Triassic*

Two occurrences of Triassic carbonates are known in the Klippen Belt. One of them, composed of gray granular dolomites, is near Horná Mariková (Váh Valley - Andrusov 1959). The other, located at Haligovka (Pieniny - Uhlig 1891, Matějka 1961), consists of gray thick-bedded limestones with rare black chert nodules. Above are layers of dolomitic limestones grading into dolomites.

By analogy, the carbonates are considered as Middle - Late Triassic. Their thickness is approximately 160 m.

MESOZOIC OF THE INNER CARPATHIANS

82 sandstones, marlstones, shales: flysch (Poruba Formation) / *Albian - Lower Turonian, in the Považský Inovec Mts. also Senonian*

Unit 82 is a flysch sequence as much as 400 m thick that is divided by Jablonský *in* Samuel et al. (1988) into lower order: the Homôlka Marlstones, Čavoj Member (claystones with sandstone laminae), Senkov Flysch and Ludrová Member (conglomerates). This unit contains some organodetrital limestone beds. The Poruba Formation is known in most core mountains of the Tatricum and Veporicum. Its stratigraphic range is Albian - Middle Turonian. It is equivalent to the Zabiják Marls of Albian - Early Turonian age (Lefeld 1985). For cartographic reasons, Senonian flyschs of the Belice sequence are also included in this group (Plašienka et al. 1994).

83 organodetritic, locally cherty limestones (Urgonian facies) / *Barremian - Aptian*

This unit is dominated by gray, massive or thick-bedded, in places brecciated limestones. They are rich in rudistes, colonial corals, gastropods, calcareous algae, and other fossils. Urgonian-type limestones have several local names. In the Vysoké Tatry sequence, they are referred to as the Wysoka Turna Formation. In addition, the Urgonian-type limestones occur in threshold facies of the Krížna nappe (Belá sequence in Strážovské vrchy, Murán Limestone in Belanské Tatry and Brekov Limestone in Humenské vrchy). Dark-gray fine-grained organodetrital cherty limestones (e.g. Osobitá Limestones) are basinal equivalents to this formation. Their thickness is 50 - 100 m.

84 bedded clayey limestones, marlstones and breccias / *Tithonian - Aptian*

This more than 100 m thick formation consists of light-gray and beige, thick-bedded, more or less clayey, pelagic limestones. In places the limestones contain layers of breccias, allodapic limestones (Nozdrovica Breccia) and organodetrital limestones. Local varieties are variously named: Jasenica (partly), Osnica, Mraznica and Koscielec Formations. In a few places the Nedzov nappe is intercalated with the organodetrital and algal beds of the Barmstein Limestones (Mišík - Sýkora 1982). The uppermost parts of the formation consist primarily of marlstones, locally interlayered with breccias (partly Vlkolínec Breccia). The formation is found in the Veporicum and Hronicum.

85 bedded cherty, partially clayey limestones (Lučivná Formation) / *Berriasian - Early Aptian*

This unit is a sequence of slightly clayey evenly-bedded black cherty limestones. Upwards they become more marly and are intercalated with calcareous claystones. The formation is a characteristic lithostratigraphic member of the Tatric sequences and it also occurs in some Veporic facies (along with Early Jurassic threshold facies). It is as much as 140 m thick.

86 sandy and spotted limestones, radiolarites, nodular limestones ("basin facies") / *(Rhetian?) Hettangian - Kimmeridgian*

Unit 86 consists of a group of claystone and limestone facies typiied by the "fleckenmergel", or spotted marls. A member low in this group is the Kopienec Formation of Hettangian to Early Sinemurian age which consists of claystones interlayered with organodetrital and sandy limestones. Because the boundary with the underlying Kössen Member cannot be defined, on the map the Kössen Member is incorporated into this group. The Trlenec Formation (Bujnovský et al. 1979) is a lateral equivalent of the Kopienec Formation in the Šipruň sequence. It is overlain by a 150-m-thick formation of spotted marls - "fleckenmergel" auct.. (or Allgäu Formation, or Janowki Formation) which may laterally pass into the Adnet Formation. Also included is the Dogger which consists of "quartzose fleckenmergel" and green-red radiolarian limestones and radiolarites of Callovian - Oxfordian age. The Late Jurassic part is composed of bedded red nodular saccocoma limestones of the Jasenica Formation. This whole group of beds is referred to as the Zliechov sequence in the Veporicum and as the Šiprúň sequence in the Tatricum. Maheľ (1961) assigned them into the West Carpathian series.

87 sandy and crinoidal limestones, cherty and nodular limestones at the upper part ("cordirella facies") / *(Rhetian?) Hettangian - Kimmeridgian*

For cartographic reasons, this unit (like the previous one) also includes Rhetian rocks. However, the Jurassic cycle starts here after a long hiatus between the Rhetian and Hettangian. The most characteristic member of this group is made up of sandy crinoidal limestones. The content of clastics is variable, ranging from calcareous sandstones (Červená Magura) to Hierlatz-type crinoidal limestones or Adnet-type nodular limestones. Condensed Fe/Mn layers occur commonly (Toarcian - Bajocian). The Dogger sequence consists of variegated facies - crinoidal, cherty and radiolarian limestones, olistostromes and radiolarites. The Late Jurassic is made up of pelagic or nodular limestones (type "ammonitico rosso").

88 shales, sandstones (Korenec Formation), breccia limestones (Borinka Limestones) and breccias (Somár B.) / *Lias - Dogger*

A flyschoid sequence of shales with calcareous graded-bedded sandstones and with podiform bodies of gray massive limestones and breccias (Korenec Formation, Plašienka 1987) make up unit 88. Its uppermost parts are characterized by black shales with thin intercalations of detrital limestones (Mariánka Formation). The Korenec Formation grades laterally into the Prepadlé Formation. The main rock types are gray, massive or thick-bedded, mostly structureless limestones. Also included are organodetrital limestones with exotic clasts of Triassic carbonates (Borinka Limestones). Some of these limestones are identical with masses of unstratified polymict Somár Breccias.

89 shales, radiolarites, sandstones: olistostrome (Meliata Formation) / *Lias - Callovian*

Unit 89 is a sequence of dark-gray to black, locally greenish-gray shales, several tens to hundreds of metres thick with thin beds of black, gray to green and red radiolarites. Thin intercalations of fine- to medium-grained graded-bedded sandstones and gray-green bioturbated marlstones are also present. This shaly sequence contains olistostromes, whose clasts and blocks of pre-existing, mostly Triassic rocks, vary in size from several cm^3 to several thousands of m^3. The Triassic rocks include crystalline limestones, siliceous limestones, sandy limestones, radiolarites, volcanics (intermediate, dolerite-type basic rocks and serpentinites) (Mello - Gaál 1984, Mock et al. 1992).

On the basis of radiolarians, the Meliata Formation is assigned into the Jurassic (Bathonian - Callovian) (Kozur - Mock 1985, Ondrejíčková 1990, Ožvoldová in Mock et al. 1992). Spotted marlstones and shales with sandstones are considered as Liassic.

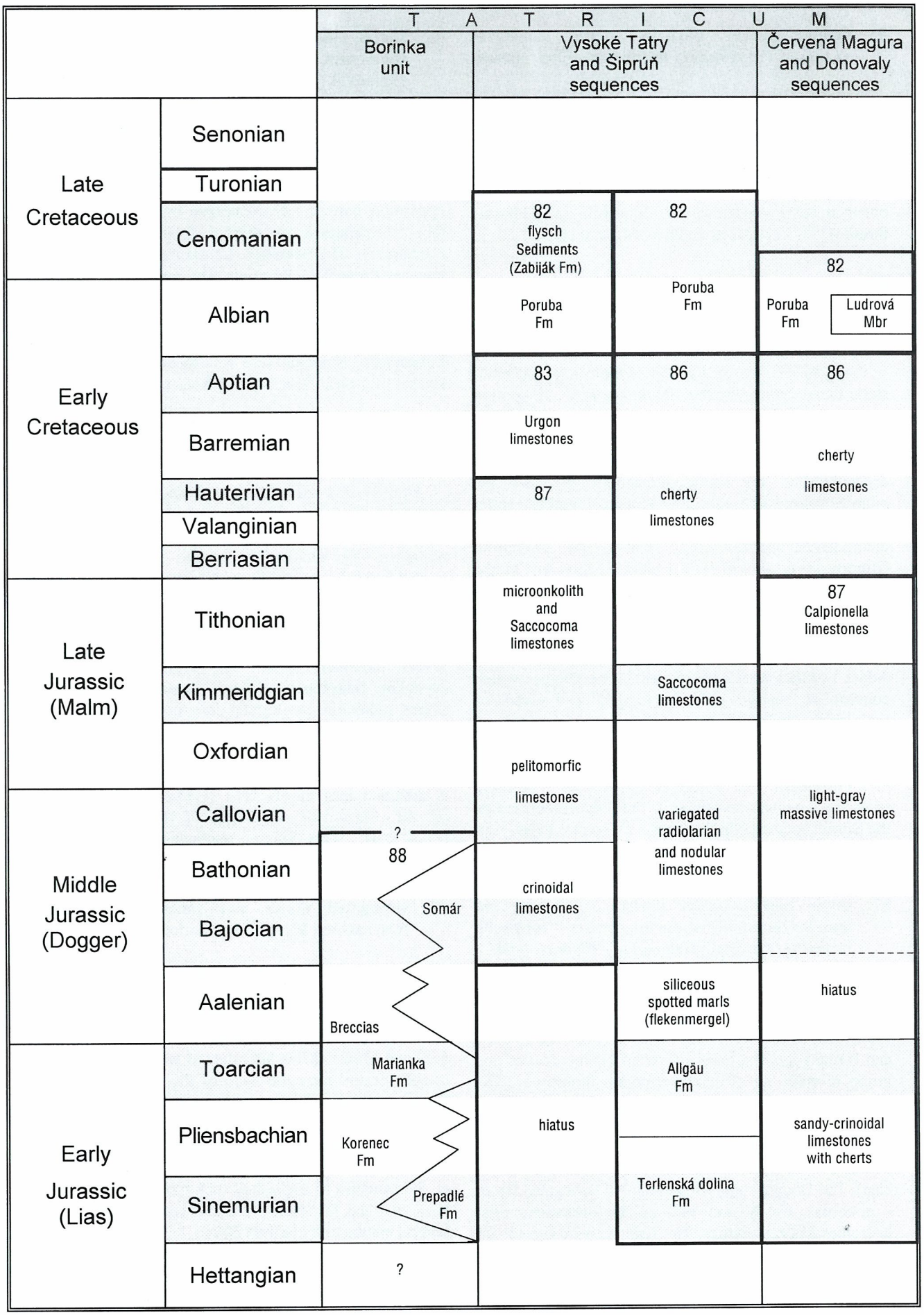
90 variegated shales, sandstones and dolomites (Carpathian Keuper Formation) / *Norian*

This unit is typical of the Late Triassic (Norian) rocks in the Tatric and Veporic tectonic units. It is a conspicuous and easy-to-distinguish continental and lagoonal formation of variegated (red, violet, green, gray and black) shales interlayered with sandstones that usually occurs near the base of the formation. In the Tatric unit some fine conglomerates also occur. Elsewhere yellowish dolomites and locally also gypsum is present. The dolomites in some parts of the unit are as much as several tens of metres thick.

Percentages of individual rock types are highly variable, and the thickness of the formation ranges from several metres to more than 200 m.

The Carpathian Keuper Formation is widespread in all core mountains. In the Tatricum, it is usually very

Correlation of Inner Carpathian Jurassic to Cretaceous lithostratigraphic units - part 1



Correlation of Inner Carpathian Jurassic to Cretaceous lithostratigraphic units - part 2

	V E P O R I C U M			H R O N I C U M	
	Vysoká and Belá sequences	Zliechov sequence (Krížna nappe s.s.)	Veľký Bok Group	Rohatá skala	Nedzov nappe
Senonian					
Turonian					
Cenoman.					
Albian	82 Poruba Fm	82 Poruba Fm	82 Poruba Fm		
Aptian	87 Hlboč Fm	84 Mráznica Fm / Strážov Mbr	84 Mráznica Fm		
Barremian					
Hauterivian					
Valanginian				87 marlstones and bedded sandy limestones	
Berriasian	Padlá voda Fm	86 Osnica Fm	86 Osnica Fm	Calpionella limestones	87 Calpionella limestones with cherts / Barmstein limestones
Tithonian					
Kimmeridg.	Tegernsee Fm	Jasenica Fm	Jasenica Fm	red nodular limestones	red nodular limestones
Oxfordian		radiolarites	radiolarites		radiolarian limestones
Callovian	Ruhpolding Fm			pelagic and radiolarian limestones	pelagic and radiolarian limestones
Bathonian		siliceous spotted marls (leckenmergel)	green schistose limestones		
Bajocian	condensed Fe/Mn horizon	zrnité limestones		condensed Fe/Mn horizon	condensed Fe/Mn horizon
Aalenian					
Toarcian	Algäu Fm	Adneth Fm	Adneth Fm		
Pliensb.	crinoidal lime-stones / brecciated crinoidal lime-stones	Algäu Fm	Drienkyňa brecciated limestones	Hierlatz Fm and cherty limestones	Hierlatz Fm and cherty limestones / phosphatic horizon
Sinemur.					
Hettangian	Kopienec Fm	Kopienec Fm	hiatus	hiatus	hiatus

Correlation of Inner Carpathian Jurassic to Cretaceous lithostratigraphic units - part 3

				MELIATICUM	TURNAICUM	SILICICUM
		Muráň and Stratená nappes	Bôrka nappe	Meliaticum	Turnaicum	Silicicum
Late Cretaceous	Senonian					
	Turonian					
	Cenoman.					
Early Cretaceous	Albian					
	Aptian					
	Barremian					
	Hauterivian					
	Valanginian					
	Berriasian					
Late Jurassic (Malm)	Tithonian					
	Kimmeridg.	87 Saccocomalimestones				
	Oxfordian	?				
Middle Jurassic (Dogger)	Callovian		97	89	99	87
	Bathonian	dark radiolarites		dark hales with radiolarite, sandstone and olisthostrome intercalations	radiolarites	radiolarites and breccias
	Bajocian					Allgäu Fm and olisthostromes
	Aalenian	dark schistose and cherty limestones	Hačava Fm			
Early Jurassic (Lias)	Toarcian					Adneth limestones
	Pliensb.	variegated crinoidal limestones (Allgäu Fm)		spotted limestones with calc. sandstone intercalations	? dark shales	Hierlatz limest.
	Sinemur.					Hierlatz limestones
	Hettangian	hiát	?			hiatus / clayey limst. with calc. ss. intercal.

thin and therefore is incorporated into the unit 100 rather than being labled separately on the map.

91 variegated limestones, locally shales (Hallstatt, Aflenz, Zlambach and Pötschen Limestones) / *Norian - Rhetian*

These Late Triassic lithostratigraphic units occur mainly in the Slovak Karst and to a lesser extent also in the Stratenská hornatina Upland and Rock Dudlavá skala (Upper Hron Valley, Bystrický 1964 and Bystrický et al. 1982). These are a group of basinal formations of fairly varied composition. In the Slovak Karst they include chiefly the Hallstatt Limestones of Norian age, which is mostly red, more or less nodular, and locally cherty. These are overlain by gray thick-bedded clayey limestones and shales predominantly of Rhetian age, known as the Zlambach Member. They are present in the Silica nappe. Their equivalent in the Turňa nappe arè the Pötschen Limestones - gray thick-bedded and bedded cherty limestones. In the Stratenská hornatina, this group includes gray thick-bedded cherty limestones - the Aflenz Limestones and in a few places the Dešná Limestones of Norian age. They are regarded as the near-reef facies - lateral equivalent to the Hallstatt Limestones.

92 pale, mainly organodetritic limestones (Tisovec, Furmanec, Dachstein Limestones) and dolomites / *Carnian - Rhaetian*

This unit is a limestone-dominated sequence as much as 800 m thick that is widespread mainly in the Silicicum. It consists primarily of light-gray to white, massive or bedded organodetrital limestones subdivided into several lithostratigraphic units. At the bottom are chiefly the Tisovec Limestones rich, in diploporas and foraminifers. Above them are largely massive reef Furmanec Limestones (Andrusovová - Kolárová 1960) and their lateral equivalent - the bedded Dachstein Limestones, locally having variegated shale intercalations.

On the Muránska planina Plateau, the unit is capped at a few places by organodetrital limestones called the Goštanová and Skalka Limestones (Michalík 1977).

The limestone unit also includes some thick dolomites, mainly in the Stratenská hornatina and Muránska planina. In these two uplands the dolomites and limestones contain thin lenses of black shales correlative with the Reingraben Shales.

These formations have only been preserved locally in the core mountains. Of these remnants only the Dachstein Limestones in the Hronicum are fairly abundant. On the map they are shown only in the Nízke Tatry and Malé Karpaty Mts.

93 dolomites (Hauptdolomit), locally limestones (Opponitz L.) and shales / *Carnian - Norian*

Unit 93 makes up the Hauptdolomit which is a distinctive and most widespread Late Triassic lithofacies in all parts of the Hronicum. Overlying and underlying beds, as well as some beds of the Hauptdolomit vary with regard to the tectonic unit and/or facies area.

In the Čierny Váh facies area, it rests locally on the Lunz Member, elsewhere on the Ramsau or Wetterstein Dolomites from which it cannot be reliably distinguished and therefore they all are marked by the single number (93).

In the Biely Váh and Bebrava facies areas, it rests on the Lunz Member, and mainly in the latter area it is interlayered with the yellowish clayey micritic Opponitz Limestones as much as 20 m thick. In the Brezovské Karpaty, it contains in addition to the Opponitz Limestones also irregular layers of light-coloured massive limestones as much as 80 m thick (Salaj et al. 1987). These are locally intercalated with variegated shales several cm thick (Čachtické Karpaty, Strážovská hornatina), but mostly they consist of thick masses of gray massive or reef dolomites, and of abundant bedded (lagoonal) dolomites as much as 500 - 600 m thick. They are widespread mainly in the Nízke Tatry, Strážovská hornatina, and also occur in the Malé, Brezovské and Čachtické Karpaty.

The Hauptdolomit is locally overlain by the Dachstein (Norian) Limestones or by the Kössen Member included in unit 93 or, in places given as unit 92.

94 dark-gray shales and sandstones (Lunz Member) / *Carnian*

The Lunz Member consists of a sequence of beds of black or greenish sandy, micaceous shales variably alternating with beds of dark-gray to greenish sandstones. It contains sporadic thin coal beds and abundant "plant remains".

This Middle Carnian Formation is present to a limited extent in the Krížna nappe (number 100 on the map), but appears mainly in the Hronicum, particularly in the Biely Váh facies area. In the vicinity of Liptovský Hrádok and in eastern Chočské vrchy, the formation attains a thickness of 300 m. The Lunz Member is also widely distributed in the Upper Hron Valley, around Liptovská Osada, in the Strážovské vrchy and to a smaller extent in the Malé Karpaty.

The Lunz Member was deposited in the Middle Triassic intraplatform Hronic depression during the so called Reibel event. It is overlain by the Hauptdolomit in all Hronic facies areas.

95 dark-gray limestones (Gutenstein L.) and dolomites (Wetterstein D., Hauptdolomite) / *Middle - Late Triassic*

These rocks comprise three Middle and Late Triassic monotonous lithostratigraphic units of the Hronicum known as the Čierny Váh sequence (Maheľ 1962) or facies area. They are found in the Nízke Tatry, Bansko-Bystrická vrchovina, Žiar, Tríbeč, Strážovská hornatina, Veľká and Malá Fatra and Inovec.

Correlation of Inner Carpathian Triassic lithostratigraphic units - part 1

		KLIPPEN BELT	TATRICUM	VEPORICUM	
				Veľký Bok Group Krížna nappe	Föderata sequence
Rhetian		79 Kössen Mbr	87 Tomanová Mbr	87 Kössen Mbr	
Norian	Sevatian	80 Carpathian Keuper	90 Carpathian Keuper	90 Carpathian Keuper	
	Alaunian				
	Lacian				
Carnian	Tuvalian		100	100 Main dolomites	
	Julian			Lunz Mbr	96 Föderata sequence s.l.
	Cordevolian	81 Ramsau dolomites	Ramsau dolomites	Ramsau dolomites	
Ladinian	Longobardian				
	Fasanian				
Anisian	Illyrian				
	Pelsonian				
	Bithynian	Gutenstein Mbr	Gutenstein Mbr	Gutenstein Mbr	
	Aegean				
Scythian	Spathian		103 Werfen Fm	103 Werfen Fm	103 Werfen Fm
	Namalian				
	Griesbachian		Lúžna Fm	Lúžna Fm	Lúžna Fm

Correlation of Inner Carpathian Triassic lithostratigraphic units - part 2

H R O N I C U M			Bôrka nappe	TURNAICUM	S I L I C I C U M	
Biely Váh sequence		Čierny Váh sequence			Vernár, Muráň, Stratená nappes	Silica nappe
92 Kössen Mbr			97		92 Goštanová and Skalka limestones	91 Zlambach Mbr
Dachstein limestones		95		99	Dach-stein (Furma-nec)	91 Hallstatt, Aflenz, Dešťany limestones
		Main dolomites		Pötschen limestones		Hallstatt limestones
93 Main dolomites			Hačava Fm		limestones	
				dark crystalline limestones	Tisovec limestones	92 Tisovec limestones
94 Lunz Mbr		Lunz Mbr			Rein-graben Mbr	
101 Ttrachyceras Mbr		Wetterstein dolomites		Dvorníky Mbr	102 Wetterstein limestones	102 Wetterstein limestones
Wetterstein limestones						
Reifling limestones s.l.			Dúbrava Fm	Žarnov and Reifling limestones		Nádaska, Schreyeralm, Reifling limestones
		Ramsau dolomites			Schreyeralm limestones	
				Steinalm limestones	Steinalm limestones	Steinalm limestones
Ramsau dolomites						
Gutenstein Mbr		Gutenstein Mbr	Gutenstein Mbr rauwackes ?	Gutenstein Mbr	Gutenstein Mbr	Gutenstein Mbr
105 Šuňava Mbr	104 Šuňava Mbr	105 Sin Mbr	Jelšava Mbr	105 Sin Mbr	105 Sin Mbr	105 Sin Mbr
Bodva-silas Mbr	Benkovský potok Fm	Bodvasilas Mbr		Bodvasilas Mbr	Bodvasilas Mbr	Bodvasilas Mbr

At the base are the dark Anisian Gutenstein Limestones usually only 50 - 100 m in thickness. In places (e.g. in Čierny Váh Valley), the base of this limestone is a layer of breccias and rauhwackes. The limestones are overlain by dolomite more than 100-m thick. The lower part of the dolomite is composed largely of dark-gray bedded rocks of Anisian age. These are overlain by light-gray to white, locally massive dolomites. The dolomites are primarily Ladinian and Early Carnian in age, corresponding to the Ramsau or Wetterstein Dolomites.

These dolomites are overlain by the Lunz Member, gray sandstones and shales of Carnian age. They are thin (only as much as 20 m). Above them, but sometimes directly above the Wetterstein Dolomites, are dolomites of Late Carnian and Norian age - the Hauptdolomit. Where the Lunz Member is absent, these two dolomites cannot be distinguished from one another and therefore are marked by a single number on the map.

The Čierny Váh facies is a lateral equivalent to the Biely Váh facies and therefore the Reifling Limestones can locally occur also in this described sequence (but only in some substages). The light-coloured Wetterstein Limestone is also found in some places, notably in the Veľká Fatra, Tríbeč and Strážovská hornatina.

96 dolomites, recrystallized and cherty limestones, shales (Föderata sequence) /*Middle - Late Triassic*

Designated as the Struženík sequence, these metamorphosed rocks make up a Mesozoic sedimentary envelope around the Southern Veporic crystalline unit. Palynomorphs and conodonts indicate its Middle and Late Triassic age (Straka 1981).

Although the rocks in the respective occurrences differ from one another (Dobšiná semi-inlier, southern and eastern slopes of the Kráľova hoľa, Muránska planina, Tuhár), the Middle and Late Triassic sequence can be generalized as follows: dolomites (rauhwackes), dark and light-coloured crystalline limestones, clayey and siliceous cherty limestones, clayey sandy and calcareous shales with lenses of dark cherty limestones, capped by dolomites equivalent to the Hauptdolomit. The thickness of the Föderata sequence is 200 - 450 m.

97 dolomites, recrystallized limestones with glaucophanites, phyllites and metasiltstones (Dúbrava and Hačava Formations) / *Middle - Late Triassic - ?Jurassic*

This unit includes almost all of the sequence of the Bôrka nappe which are dominated by light-coloured crystalline limestones and paleobasalts that are altered to glaucophanites (Dúbrava Formation). The limestones have an admixture of volcanic material. The base of the carbonate beds locally contains dolomites and dark crystalline limestones equivalent to the Gutenstein Formation. Sericite and chlorite phyllites and metasiltstones (redefined as the Hačava Formation) sometimes attain considerable thickness (200 - 400 m). They are presumably equivalent to the Jurassic Meliata Formation, as is suggested by blocks of different rocks (largely light-coloured crystalline limestones) which may be olistoliths.

98 metamorphosed sandy and marly limestones, marbles / Triassic

This is a narrow belt of rocks stretching between the Gemeric Paleozoic and the Turňa nappe in the western sector of the Slovak Karst. Although still assigned to the Triassic of the Meliaticum (Bajaník et al. 1984), it has in fact the position of the Bôrka nappe as in the Nižná Slaná depression and in the eastern section of the Slovak Karst.

Aside from metamorphosed sandy and clayey limestones (Jelšava Member), the group also includes light-coloured crystalline Honce Limestones, as well as dark and green-gray shales of either Early Triassic or Jurassic age (south of Rákoš). The belt also hosts hematite shales and hematites at Bradlo. The complex is 20 - 100 m thick and south of Jelšava, even 250 m.

99 dark limestones, recrystalized and cherty limestones, dark schistose limestones / *Middle - Late Triassic*

This unit includes the entire Middle and Late Triassic sequence of the Turňa nappe. It is composed of the Gutenstein Dolomites and Limestones, light-coloured crystalline Honce Limestones, Reifling Limestones, Carnian shales, dark crystalline limestones and Norian Pötschen Limestones (Mello et al. 1992). The Hallstatt facies occurs at Stráňa near Jelšavská Teplica (Gaál - Mello 1983b). The above formations indicate that the Middle and Late Triassic sequence of the Turňa nappe consists of slope and basinal facies, except for an Anisian carbonate platform. All formations underwent weak regional metamorphism. The biggest and best known occurrences are in the Turňa Basin in the mountain group Tri peniažky - Slovenská skala and in the vicinity of Honce and Štítnik. In the past they were assigned into the Triassic Rudabánya facies.

100 dark limestones (Gutenstein L.) and dolomites (Ramsau D.) / *Anisian - Carnian*

This unitIt is a fairly monotonous carbonate sequence. Its lower part is composed of dark-gray to black limestones with more or less abundant dolomite intercalations that generally is referred to as the Gutenstein Member or Limestone. These rocks are mostly Early to Middle Triassic in age, but sometimes the limestone layers extend into the Late Anisian or Ladinian (Nízke Tatry). Above them are chiefly bedded gray dolomites,

rarely of reef origin. These Middle Anisian to Cordevolian sediments were laid down in a vast shallow sea. As much as 500 m thick, they occur in the Tatricum and Veporicum.

The Ramsau Dolomites in the Veporic units are overlain by the Lunz Member which is as much as 20 m thick and is distributed over only a small area. The Lunz Member underlies gray dolomites which, owing to their position and implied Carnian age, are regarded as correlative to the Hauptdolomit. They are of limited extent and often difficult to distinguish from the Ramsau Dolomites, and therefore are also included in unit 100. The unit also includes beds of the Carpathian Keuper in the Tatricum and locally also in the Veporicum. This unit thus frequently contains formations ranging from rocks of the Anisian to the Norian.

101 dark limestones (Gutenstein L.), dolomites and cherty limestones (Reifling L.) / *Anisian – Carnian*

These lithostratigraphic units make up the Middle Triassic of the Hronic Biely Váh sequence (Maheľ 1962) and are found in nearly all core mountains. At the bottom of the sequence are gray to black bedded limestones that are intercalated with dolomites and in places by breccias (Gutenstein Member) totalling 300 m in thickness. Above them are bedded dolomites. In places the upper part of the dolomite is cherty. They correlate with the Pelsonian pro parte (as much as 200 m thick).

A typical member of this succession are the Reifling Limestones - gray and light-gray cherty limestones, in places intercalated with marlstones. They are up to 100 m thick and range from the Late Pelsonian to Cordevolian in age.

The uppermost member consists of bedded dark-gray to black limestones intercalated with claystones or marlstones and in places also with cherts - the Trachyceras Member or Korytnica Limestones. They are Early Carnian in age and their thickness usually does not exceed 50 m. This succession of lithostratigraphic units comprises also minor outcrops of the Wetterstein Limestones (e.g. in Ružomberok area) representing a lateral facies of some Reifling Limestones. This sequence of beds represents a basinal facies of the Hronicum.

102 limestones (Gutenstein, Steinalm, Wetterstein, locally Schreyeralm, Reifling L.) and dolomites / *Anisian - Carnian*

These lithostratigraphic units make up vast carbonate massifs primarily in the Slovak Karst, Stratenská hornatina, Galmus and Muránska planina, as well as in the core mountains (Malé, Brezovské and Čachtické Karpaty, Strážovská hornatina, Veľká Fatra). At the base are the dark-gray to black Gutenstein Limestones and Dolomites overlain by light-coloured to white organodetrital limestones, in places reef limestones. Their Anisian part is referred to as the Steinalm Limestones, and the Ladin and Early Carnian part as the Wetterstein Limestones. These limestones (typical carbonate-platform facies) grade laterally into the gray bedded Reifling Limestones or red Schreyeralm and Nadaška Limestones (facies typical of intraplatform depressions). However, their thickness is so small that they are not identified independently. They crop out at the Gombasek serpentines (on the road to Silická Brezová). In the Malé Karpaty, the Wetterstein Limestones range only from the Late Ladinian to Early Carnian. Total thickness of the above limestones may attain as much as 1000 m.

103 quartzites, sandstones and shales (Lúžna and Werfen Formations) / *Scythian*

These lithostratigraphic units are widespread in the Tatricum and Veporicum. The lower Lúžna Formation (Fejdiová 1980) rests transgressively on the substratum and is composed of fine- and medium-grained light-gray (locally red) quartzites, quartzose and arkosic sandstones, commonly cross-bedded, elsewhere with thin beds of small-pebbled conglomerates. The formation is 50-150 m thick. These beds gradually grade up into a formation of red and greenish shales intercalated with fine-grained thin-bedded sandstones and locally also rauhwackes; which reflect the past presence of gypsum, as was found through drilling. The drillhole gypsum was inaccurately referred to as the Werfenian Member. Where interlayered with sparse bedded limestones they resemble the "Szin Member" (south of Salatín in Nízke Tatry).

104 quartzites, sandstones, calcareous shales and limestones (Benkov and Šuňava Members) / *Scythian*

These two formations constitute the Early Triassic in the Hronicum of the core mountains. The composition and thickness of the Benkov Member are identical to those of the Lúžna Formation described in unit 103. Up section, the quartzite and sandstone beds become increasingly interlayered with red and greenish shales which gradually prevail. The upper Šuňava Member consits of varicoloured clayey and calcareous shales alternating mostly with micaceous bedded sandstones and, locally with organodetrital and lumachelle limestones. This member is as much as 100 m thick. It may be correlative with the Szin Member in the Slovak Karst, formerly designated as the Campilian Member.

105 sandstones, shales, calcareous shales and limestones (Bodvaszilas and Szin Members) a) rhyolites / *Scythian*

The terms Bodvaszilas and Szin Members apply to Early Triassic sediments so far designated as the Seisian and Campilian Members. They are widespread

at the base of nearly all Triassic carbonate sequences of the Silicicum and Turnaicum. The lower, Bodvaszilas Member is composed of fine-grained red, greenish and gray sandstones and intercalate locally sandy shales. They are Early Scythian - Griesbachian in age and, unlike the above-described quartzites and sandstones (Units 103 and 104), are undoubtedly of marine origin.

The upper - Szin Member consists of locally calcareous shales alternating with fine-grained sandstones but mainly with bedded limestones. The Szin Member is correlative with the Šuňava Member described in unit 104. They are of Late Scythian and possibly also of Early Anisian age. They reach their maximum thickness of 400-800 m in the Slovak Karst. The member hosts rhyolites and volcanoclastics near Poniky and Telgárt (105a).

An identical Early Triassic unit occurs at the base of the Hronicum in the Lopej Basin. It passes laterally into the Early Triassic formations mentioned in unit 104.

LATE PALEOZOIC OF THE INNER CARPATHIANS

106 shales, sandstones, rhyolite volcanics, subordinate dolomitic limestones and phosphatic sandstones (Štítnik Formation) / *Late Permian - Triassic?*

This unit is a sequence of cyclically alternating sandstones, siltstones and schists, in whose upper part are irregular beds of carbonate schists, dolomitic limestones and carbonate sandstones (about 30 m thick, 1-1.5 km long). The sandstones are associated with small podiform bodies of phosphorites and phosphatic sandstones (thickness 0.2-0.4 m, strike length 2-5 m) with U mineralization (Tréger 1973). The sequence also comprises thin bodies of rhyolite volcanoclastics. Designated as the Štítnik Formation (Bajaník, Vozárová and Reichwalder 1981), it is part of the southern Gemeric envelope sequence.

The number and thickness of sandstone beds in the Štítnik Formation decrease upwards and so do the grain-size and maturity of sediments. The sandstones correspond to lithic and arkosic graywackes containing 75-85 % of quartz grains. The sedimentary environment was initially alluvial-lacustrine, and later was near-shore marine and lagoonal.

Its direct stratigraphic substratum is the Rožňava Formation. Their boundary is lithological. The formation's upper boundary is always tectonic and is accompanied by outliers of Meliaticum s.s., Turnaicum or Bôrka nappe.

Flora and fauna (Šuf 1963) found at the top of the Štítnik Formation testifies to its Late Permian age Němejc in Šuf 1963). With regard to microflora assemblages, Planderová (1980) has extended stratigraphic range of the uppermost part of the Štítnik Formation into the Early Triassic. Tectonically reduced, the Štítnik Formation is now only 400-600 m thick.

107 conglomerates, sandstones, shales, rhyolite/dacite volcanics (Rimava, Brusno, Predajná, Korytné, Skýcov Formations) / *Permian undifferentiated*

This unit is made up of varicoloured mostly coarse-clastic sediments deposited in continental basins. Tectonically reduced fill remnants of these basins have been preserved only in the Tatricum and Veporicum. Two lithostratigraphic types of sequences have been distinguished:

1. coarse-grained sedimentary sequences without conspicuous vertical division dominated by conglomerates and coarse-grained sandstones composed of granitoid detritus. Structurally and mineralogically very immature, they are deposits of alluvial fans. The slightly subalkaline to alkaline products of rhyolite-dacite synsedimentary volcanism include largely volcanoclastic beds with sporadic small lava flows as much as 5 m thick.

2. varicoloured sequences of clastic sediments with clear vertical lithological division. They typically display small alluvial sedimentary cycles of conglomerate-sandstone riverbed (channel-lag) sediments alternating with finer-grained floodplain facies and/or wedges of the ephemeral-lake and playas facies. Their detritus is dominated by granitoids with minor crystalline schists and material from synsedimentary volcanic centres. The synsedimentary rhyolite/dacite volcanism generally has a calc-alkaline trend but in places grading into an alkaline or subalklaine one. Volcanoclastic deposits and minor lava flows occur. The volcanogene Harnobis horizon in the Brusno Formation also contains ignimbrite. These volcanic rocks are as much as 150 m thick and 5 km along strike, thereby making the largest Permian pile in the Tatricum and Veporicum.

The first group includes occurrences in the Malé Karpaty (Devín Formation), Malá Fatra (Stráňany Formation), Vysoké Tatry (Meďodoly Formation), Ďumbier part of the Nízke Tatry (Vážna Formation), Branisko (Korytné Formation), Starohorské vrchy (Špania Dolina Formation), Revúcka vrchovina and eastern section of the Veporské vrchy (Rimava Formation). The second group comprises sequences in the following mountains: Čierťaž, Kráľova hoľa part of the Nízke Tatry, Sľubica and Čierna hora (Brusno and Predajná Formations), Tríbeč (Skýcov and Slopňa Formations) and in the Považský Inovec (Kálnica_Group). The sequences are mostly 300 - 900 m, and locally even 1500 m thick. Both types of sequences rest on their crystalline basement with angular unconformity. They cannot be precisely dated because of the absence of organic remains, but their geological position and lithologic composition suggest a Permian age. Poorly preserved microflora found in the Starohorské vrchy (Planderová 1974, Planderová - Čillík 1990) and Čierťaž (Planderová - Vozárová 1982) may range in age from the Early Saxonian to Early Thuringian or possibly ?Late Autunian - Saxonian.

The metamorphic grade of the sediments here generally does not exceed P-T conditions for the beginning of the greenschist facies, i.e. 250 - 300 °C at low to medium pressure. Rimava Formation sediments in the southern Veporicum are the only exception for regional metamorphism here took place under medium- to high-pressure greenschist facies conditions, and a subsequent stage (related to the intrusion of Alpine granitoids) gave rise to a high-temperature mineral assemblage (Vozárová 1990).

108 conglomerates, sandstones, variegated shales, volcanics (Malužiná, Knola, Petrova hora, Novoveská Huta, Cejkov and Černochov Formations), a - andesite-basalt volcanics / *Permian*

Characteristic signs of this unit include: a) presence entirely of terrigeneous sediments and rare evaporites and carbonates; b) mostly immature sediments; c) source of clastic material in the immediate substratum; d) clear sedimentary cycles including regional-scale megacycles, e) synsedimentary polystage volcanism and f) continental sedimentary environments with the alluvial-fans, braided- and meandering-river, intracontinental-lake and playa facies. These formations have been preserved in the Hronic, northern Gemeric and Zemplinic tectonic units.

Permian sedimentary sequences of the Zemplinicum (Cejkov and Černochov Formations) evolved from subjacent Late Carboniferous sediments. Associated volcanics have rhyolite composition. Stephanian D - Autunian microflora assemblages were identified by Planderová (Planderová et al. 1981) in horizons corresponding to the lower part of the Cejkov Formation. Microflora found in the upper part of the Cejkov Formation suggests a Late Permian age (l.c.). Clasts in these sediments came from high-grade metamorphic rocks, synsedimentary volcanics and rarely from low-grade metamorphic rocks.

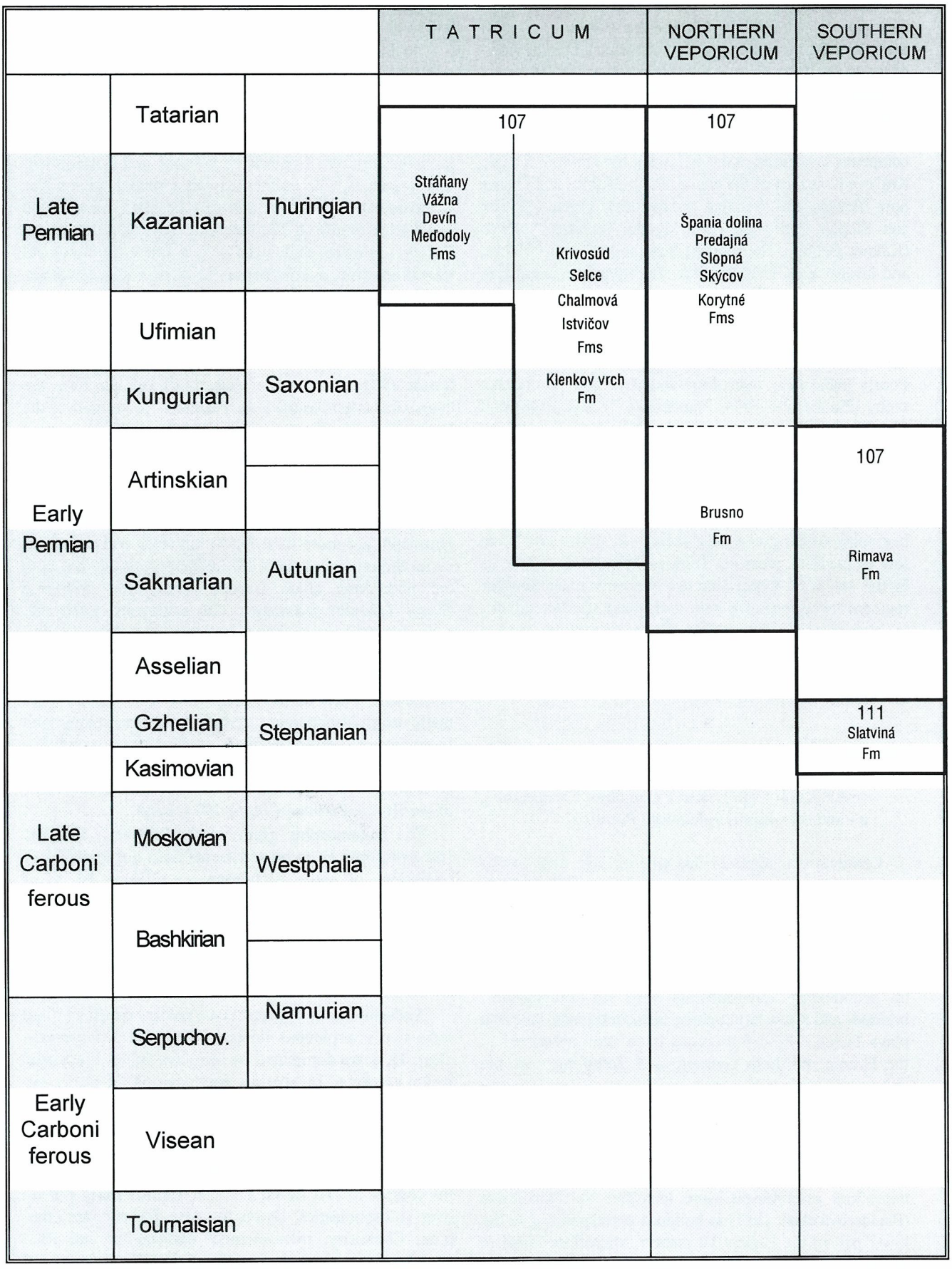
In the northern Gemericum (Knola, Petrova Hora and Novoveská Huta Formations), coarse-clastic deposits of the Knola Formation rest unconformably on various sections of Carboniferous and pre-Carboniferous units. Detritus composition suggests that its sources included northern Gemeric formations and synsedimentary volcanics. The volcanism was bimodal, giving rise to rhyodacites, andesites and rare basalts (calc-alkaline to alkaline trend). A characteristic sign of the northern Gemeric Permian sequences is their gradual lithological transition from a continental to a near-shore marine, sabkha-lagoonal sedimentary environment in the Late Permian - Early Triassic. Evaporites of the Novoveská Huta Formation are prograded to shallow-marine detrital-carbonate deposits with Claraia clarai (Maheľ - Vozár 1971). An isotope analysis of sulphur from the evaporites attests to the Late Permian - lower part of the Early Triassic (Kantor et al. 1982). A Pb/U isotope analysis of uraniferous volcanogenic horizons of the Petrova Hora Formation indicates ages 263 - 274 m.y. (Novotný - Rojkovič 1981).

The Permian sequences (Malužiná Formation) of the Hronicum are more than 2 200 mn thick and constitute either the immediate base of the nappe or pass into both the underlying (Late Carboniferous) and overlying (Early Triassic) sediments. The sediments' Early and Late Permian age is shown by their macroflora (Sitár - Vozár 1973) and microflora assemblages (Planderová 1973, 1979) and by their boundary with the Late Carboniferous. Their detritus originated in an eroded magmatic arc (feldspars and granitoid fragments, along with fragments of synsedimentary volcanics; Vozárová - Vozár 1988, 1993). Polystage andesite-basalt continental-tholeiite-type volcanism is one of characteristic signs of the Hronic Permian (Vozár 1977, 1984).

The metamorphic grade of the Northern Gemeric and Zemplinic Permian sediments does not exceed P-T conditions of upper anchizone, i.e. 200 - 250 °C or 210 - 270 °C (Šucha - Eberl 1992, Milička et al. 1991). The Hronic Permian complexes underwent only subsidence metamorhism at temperatures up to 150 - 200 °C (Vrána - Vozár 1969, Šucha 1989, Plašienka et al. 1989).

Andesite-basalt volcanics and volcanoclastics (108a) form two conspicuous horizons (1st and 3rd megacycles). They are dominated by thin lava flows, brecciated where contacted by shallow water basins, in places pahoehoe-structured. Multiple 0.5-2-m-thick lava flows positioned above one another (sheeted lavas) total 350-450 m in thickness. Thin brecciation zones and contamination of earlier products by younger ones occur at the contact of two flows. Effusive forms clearly prevail over volcanoclastics. Dykes are rare, but sills are common. Chemistry, microelement distribution and REE abundances suggest a continental-tholeiite-type of rift magmatism.

Correlation of Inner Carpathian Late Paleozoic lithostratigraphic units - part 1



Correlation of Inner Carpathian Late Paleozoic lithostratigraphic units - part 2

		ZEMPLINICUM	HRONICUM	NORTHERN GEMERICUM	SOUTHERN GEMERICUM	TURNAICUM
Tatarian		108	108	108	106	110
Kazanian	Thuringian	Černochov Fm		Nová Ves Fm	Štítnik Fm	Brusník Fm
Ufimian			Malužiná Fm	Petrova Hora Fm		
Kungurian	Saxonian				109	
Artinskian		Cejkov Fm				
Sakmarian	Autunian			Knola Fm	Rožňava Fm	
Asselian						
Gzhelian	Stephanian	111	111 Nižná Boca Fm			
Kasimovian		Kašov Tŕňa, Luhyňa Čerhov Fms				
Moskovian	Westphalia			112 Hámor Zlatník Rudňany Fms		
Bashkirian						113 Turiec Fm
Serpuchov.	Namurian			114		
Visean				Ochtiná Fm Črmeľ Group		
Tournaisian						

109 conglomerates, sandstones, rare rhyolite volcanics (Rožňava Formation) / *Early Permian*

The base of this volcanosedimentary formation consists of oligomict conglomerates which grade upwards locally to cross-bedded sandstone layers with a small proportion of fine-grained sediments. Aside from prevailing quartz, the pebbles contain also low-grade metamorphic rocks of the Gelnica Group and Štós Formation (Vozárová 1973). The basal conglomerate horizon is overlain by the first volcanogenic horizon. It is thin but regionally widespread. It is composed of rhyolite tuffs with rare bodies of felsitic, increasingly alkaline rhyolites and dacites. The upper part of the formation contains the second conglomerate horizon with fragments of synsedimentary volcanics. It is associated with the second volcanic stage composed of rhyodacite and volcanoclastic bodies.

The formation constitutes the basal part of the southern Gemeric envelope sequence. Its characteristic signs are the presence of mature clastic material and a grainsize decreasing upwards. The formation rests with angular disconformity on the Early Paleozoic substratum of the Southern Gemericum.

Microflora finds show its Early Permian age (Planderová 1980). The sediments were deposited in a continental alluvial-fan environment. They were metamorphosed under P-T conditions corresponding to the beginning of the greenschist facies. The complex is 200 - 400 m thick (Bajaník - Vozárová - Reichwalder 1981).

110 conglomerates, sandstones, shales of the "redbeds" type (Brusník Formation) / *Permian*

A sequence of coarse-clastic, largely violet or gray-violet sediments of cyclical structure whose grainsize decreases upwards. It is made up of three major sedimentary cycles roughly 100 m or more in thickness. The lower parts of the cycles are dominated by conglomerates. In the upper parts the sandstones alternate with siltstones and shales. Beds of redeposited rhyolite volcanoclastics and of small carbonate lenses (as much as 2 m) occur sporadically in the uppermost part. The sedimentary environment is characterized as continental alluvial fans and intracontinental lakes. The Brusník Formation crops out in an anticlinal structure near Brusník and is assigned to the Turnaicum (Vozárová - Vozár 1992). The biostratigraphic age of this 350-450-m-thick formation has not yet been determined.

111 conglomerates, sandstones, shales, acid volcanics, rare coal (Slatvina, Čerhov, Luhyňa, Tŕňa, Kašov, Nižná Boca Formations) / *Late Carboniferous*

Unit 111 is made up mostly of gray to dark-gray clastic sediments as are known in the Southern Veporicum (Revúcka vrchovina, Veporské vrchy), Zemplinicum (Zemplínske vrchy) and Hronic nappes.

The sequences in the southern Veporicum (Slatviná Formation, 500-800 m thick) constitute a regressive formation (transition from a deltaic, shallow-water sedimentary environment to a continental, fluvial one). It is characterized by gray sandstones multiply alternating with dark shales grouped into two major regional regression cycles. Horizons of graphite schists with abundant plant detritus and remains of insects reflect deposition under anoxic conditions. Microflora of these horizons is of Stephanian C-D age (Planderová - Vozárová 1978). The sequence contains layers of redeposited dacite-andesite, rarely also of basalt and of volcanoclastics.

The metamorphic development is a polystage one. Firstly regional-metamorphic mineral assemblages reaching P-T conditions of the beginning of the greenschist facies. During the second stage the first-formed minerals were replaced by a high-temperature assemblage locally reaching the Bt and Bt+Crd zone (Vozárová 1990).

Late Carboniferous sedimentary sequences in the Zemplinicum (Čerhov, Luhyňa, Tŕňa, Kašov Formations) were laid down in a continental sedimentary environment. Initial, mostly conglomerate alluvial deposits gave way to fluvial-lacustrine facies containing limnofluvial cyclothemes with thin coal beds. The Carboniferous cycle is topped by a sequence of sandstone-dominated fluvial deposits. General characteristics of the sedimentary sequence include its cyclical pattern, rhyolite-dacite synsedimentary volcanism and angular discordance at the contact with the underlying high-grade metamorphic rocks of the Zemplinic basement. The volcanism dominated by tuffs and ignimbrites displays a calc-alkaline trend (Grecula - Együd 1982). The Carboniferous formations in the Zemplinicum total about 1500 m in thickness. Their metamorphic grade corresponds to anchizone, i.e. 210-270 °C (Milička et al. 1991). Macro- and microflora shows their Stephanian A-B-C age (Šusta 1931, Němejc 1946, Němejc-Obrhel 1958, Planderová et al. 1981).

The tectonically reduced remnants of clastic sequence at the base of Hronic nappes (Nižná Boca Formation, up to 400 m thick) coarsen upward. Their contact with overlying Permian sediments is transitional. This regressive sequence (Vozárová 1981) consists of multiple cycles composed of sandstones (and/or conglomerates) and shales. Synsedimentary dacite-andesite volcanism gave rise to abundant redeposited volcanoclastic material and to several tuff layers. Preserved sills of diorite composition between 1 m and several tens of metres thick (Vozár 1973) are regarded as subvolcanic forms of the Permian volcanism, which have contact aureoles 3 to 30 cm thick. Regional metamorphic grade is low, corresponding to temperatures around 150, up to 200 °C (Vrána - Vozár 1969, Plašienka et al. 1989, Šucha 1989). Macroflora shows that these rocks are Stephanian B-C (Sitár - Vozár 1973), while microflora assemblages indicate a Westphalian C-D to Stephanian A-B-C-D (Ilavská 1964, Planderová 1979) age. Sedimentary structures suggest a lacustrine, deltaic-

lacustrine and fluvial-dominated environment in the uppermost part of the unit.

112 conglomerates, sandstones, siltstones, shales, basic volcanics, rare organodetritic carbonates (Rudňany, Zlatník, Hámor Formations) / *Middle - Late Carboniferous*

The base of unit 112 consists of coarse-detrital to bouldery conglomerates (Rudňany Formation, 8 - 200 m thick). The whole sequence of mostly clastic formations rests unconformably on various lithological members of northern Gemeric pre-Westphalian formations (Vozárová, 1973) The sedimentary environment is interpreted as delta-fan facies.. Overlying lenses of organodetritic limestones, partly metasomatically replaced by siderite, yielded Westphalian B-C marker trilobite fossils (Rakusz 1932, Bouček - Přibyl 1960). Flora finds testify to Westphalian A-B (Němejc 1946) and conodonts to Westphalian A (Kozur - Mock 1977). This horizon is overlain by sandstones and schists with basalt tuffs and minor basalts (Zlatník Formation, 400 m thick). The volcanics' chemistry corresponds to Th-magmatic trend with an affinity to E-MORB or BABB types (Ivan et al. 1992). The Westphalian sequence is topped with a regressive paralic formation (Hámor Formation, 50-370 m thick). The regressive cycles composed of schists, sandstones and conglomerates contain thin seams of anthracite. Microflora indicates its Westphalian D - Stephanian A age (Ilavská 1961).

The regional metamorphic grade does not exceed P-T conditions of the greenschist facies (about 300 °C), except in occurrences rooted in the Lubeník-Margecany line where it is a little higher.

113 phyllites, metasiltstones, sandstones, rare conglomerates, acid volcanics and carbonate olistoliths - flysch (Turiec Formation) / *Middle Carboniferous*

Exposed in the Brusník anticline, this flysch olistostrome formation (Vozárová 1992) has been correlated with the Dinaric - South Alpine facies and is assigned to the Turnaicum (Vozárová - Vozár 1992). It is in tectonic contacts with Jurassic olistostrome formations of the Meliaticum and is unconformably overlain by the Permian Brusník Formation. Its characteristic features are fine-grained turbidite sediments with wedges of paraconglomerates, redeposited rhyolite volcanoclastics and a carbonate olistostrome. Mixed conodont fauna in the carbonate olistoliths is of Emsian-Tournaisian and Namurian B-C - Westphalian A age (Ebner et al. 1990). Microflora assemblages in the fine-grained flysch sediments and in the olistostrome groundmass indicate the Namurian A-B - Westphalian A age (Planderová in Vozár et al. 1989).

The metamorphic grade attains conditions of the low-pressure greenschist facies (T = 350-370 °C, pressure around 2 kbar, Mazzoli - Vozárová 1989). The formation is more than 600 m thick.

114 metamorphosed sandstones and conglomerates, phyllites, mafic volcanics, in the upper part dolomites and magnesites, a - metabasalts, metagabbrodiorites (Ochtiná Formation and Črmeľ Group) / *Early Carboniferous*

Common signs of these volcanosedimentary formations include flysch facies in their lower parts and fairly intensive basic volcanism. In contrast, lithological differences comprise more abundant coarse-grained paraconglomerate turbidites in the Ochtiná Formation and rare volcanoclastic rhyolite turbidites in the Črmeľ Group. Both sequences become shallower-water upwards, as is indicated by a dolomite and magnesite horizon with minor limestones. The magnesite horizon of the Ochtiná_Formation yielded abundant fauna of Namurian age (Bouček - Přibyl 1960). Conodont finds indicate a more precise age of the Late Visean - Serpuchovian (Kozur - Mock - Mostler 1976). Microflora assemblages in the lower part of the Ochtiná Formation show a Tournaisian - Visean age (Bajaník - Planderová 1985). The Črmeľ Group is also Tournaisian - Visean in age (Bajaník - Snopková - Vozárová 1986). The metamorphic grade of both sequences corresponds to the low-temperature low-pressure greenschist facies (Sassi - Vozárová 1987).

Major metabasalt and metagabbro-diorite layers (114/a) are marked on the map. Their chemistry corresponds to igneous rocks of Th-magmatic E-MORB trend enriched in L-REE. Variscan regional metamorphism gave rise to the mineral assemblage: Act+Chl+Ab with preserved relics of magmatic amphiboles.

The Ochtiná Formation is more than 1000 m and the Črmeľ Group over 1500 m thick.

115 metamorphosed spilite-keratophyre volcanics, phyllites, rare carbonates (Sykavka Formation), a - metabasalts / *Middle - Late Devonian ?*

The Sykavka Formation (Bajaník et al. 1981) is a predominant constituent of the Rakovec Group which is a characteristic Variscan unit of the Northern Gemericum. Its most abundant lithologic types include metabasalts, metabasalt tuffs, tuffites and phyllites. Fine-grained metasandstones occur sporadically. The effusive mafic rocks are interlayered with hematite phyllites and quartzose sandstones and with a coeval magnetite-hematite mineralization. In a few places the phyllites and metabasalt tuffites are associated with thin carbonate beds or silicite laminae. The thickness is estimated at 1000 - 1500 m.

On the basis of their chemistry and rare-earths distribution, Bajaník (1976) defined the mafic volcanics as island-arc tholeiites. Subsequent studies (Hovorka et al. 1988; Ivan et al. 1992, 1993) confirmed that the basalts have a clear E-MORB trend. Regional metamorphism of these rocks had a polystage history, HP/LT in the first stage (Hovorka et al. 1988) and HT/LP in the second one (Sassi - Vozárová 1992). Temperatures did not exceed the greenschist-facies values in either of these two stages.

The Sykavka Formation has not yet been biostratigraphically dated. Its pre-Vestphalian age is indicated by its fragments found in Westphalian conglomerates of the Rudňany Formation (Vozárová 1973).

In places the metabasalts (115a) preserved their original volcanic structures, such as pillow lavas, agglomerates, disintegrated lavas, fluidal structures. They are associated with dykes. Relict textures comprise intersertal, ophitic and porphyritic. Relics of magmatic pyroxenes are very rare. The metamorphic mineral assemblage consists of Act+Cht+Ab with epidote, quartz and calcite. Relics of Na-Ca amphiboles suggest the first high-pressure stage of regional metamorphism.

116 metasandstones, phyllites (Smrečinka Formation), a - spilite-keratophyre volcanics / *Middle - Late Devonian?*

The Smrečinka Formation in the Northern Gemericum makes up the basal part of the Rakovec Group. It is dominated by metasandstones, quartzose and sericitic phyllites with wedges of metabasalts, related tuffs and tuffites towards the top. Rhyolite bodies 2-3 m in thickness and 10-20 m in strike length occur in places. The composition of the sandstones, particularly by the plagioclase grains and fragments of chloritized volcanics, reflects their source area. The most conspicuous sedimentary sign is predominant planparallel lamination. The formation's thickness is estimated at 150-600 m. The formation is tectonically reduced at the contact with the Southern Gemericum.

The age of the Smrečinka Formation results from superposition inasmuch as biostratigraphic evidence is missing.

117 metasandstones, phyllites, rare metabasalts (Štós Formation) / *Late? Devonian - Early? Carboniferous*

The Štós Formation, as part of the Southern Gemericum, tectonically overlies the Gelnica Group. It is dominated by fine-grained horizontally-laminated metasandstones and gray, green-gray, chlorite-sericite and sericite phyllites. The structure of these metasediments is well preserved. Small metabasalt sills occur rarely. Metasandstone detrital modes suggest mixed sources of clastic material, mainly volcano-magmatic (assumed magmatic arc) and continental, characterized by chemically mature detritus (Vozárová 1993). The regional metamorphic grade of the Štós Formation corresponds to the low-pressure greenschist facies (Mazzoli - Vozárová 1989). Pebbles of these rocks in the Rožňava Conglomerates indicate the metamorphism is Variscan in age. The formation's thickness is estimated at 500-800 m. Biostratigraphic evidence on its age is lacking. In the past it was considered to be an equivalent to the Smrečiny Formation in the basal part of the Rakovec Group (Bajaník et al. 1981).

118 amphibolites, gneisses, metaultramafic rocks, gabbrodiorites, marbles (Klátov Group) / *Devonian?*

The Klátov Group is a lithostratigraphic unit in the Northern Gemericum. Its typical feature is the presence of rocks metamorphosed under P-T conditions of the higher-temperature amphibolite facies. Its contact with the epi-metamorphosed Rakovec Group is tectonic. These rocks were formerly assigned to a single unit with low-grade rocks of the Rakovec Group, but Spišiak et al. (1985) defined them as a separate rock suite.

The Klátov Group as part of the Northern Gemericum is dominated by amphibolites with minor gneisses, serpentinized spinel peridotites (altered to antigorite serpentinites and their hydrothermal-metasomatic derivatives) and very rare Ca-silicate rocks. With regard to mineral assemblages and textural characteristics, Hovorka et al. (1992) speculate about possible occurrences of enclaves of amphibolitized eclogites. The following mineral assemblages were identified: (1) in paragneisses: Bt+Alm+Pl (20-30)+Ms+Qtz+Hbl; (2) in amphibolites: Hbl+Pl (30-35)+Grt; (3) in Ca-silicate rocks: Grt+Cpx; (4) in amphibolitized eclogites: Rtl+Grt+Cpx+Hbl (Bajaník - Hovorka 1981; Hovorka - Spišiak 1981; Hovorka et al. 1992). Geothermobarometric estimates indicate temperatures 550-630°C at medium pressure (Spišiak - Hovorka 1984, Faryad 1990). Pebbles from this already metamor

Correlation of the Gemericum Early Paleozoic lithostratigraphic units

		NORTHERN GEMERICUM		SOUTHERN GEMERICUM	
		Klátov Group	Rakovec Group	Gelnica Group	
Carboniferous	Early				
	Late	118	115 Sykavka Fm		117 Štós Fm
Devonian	Middle	Klátov Group	116 Smrečinka Fm		
	Early			119 Drnava Fm	
Silurian	Late			120 Bystrý Potok Fm	
	Early			121	
Ordovician	Late			Vlachovo Fm	
	Middle				
	Early				
Cambrium	Late				
	Middle				

phosed complex found in Vestphalian conglomerates show its pre-Upper Carboniferous age (Vozárová 1973). Geochronological data do not rule out also pre-Variscan age of the group (Cambel et al. 1990). Its metamorphic history was polystage, the retrograde stage reaching P-T conditions of the low-pressure greenschists facies.

119 metasandstones, phyllites, carbonates, lydites, rare conglomerates, basic volcanics (Drnava Formation), a - acid volcanics / *Early Devonian*

The Drnava Formation is the youngest and dominant lithostratigraphic unit of the Gelnica Group. Because of its lithology and preserved sedimentary structures (mainly turbidite sequences, slumping bodies), it is a volcanogenic-sedimentary flysch formation. It lies near the southern edge of the Gelnica Group - east of the Smolník fault system, and near the northern edge, where it contacts tectonically the Rakovec Group. Cycles in the lower parts are dominated by coarse-clastic sediments - deposits of upper tracts of submarine troughs and gravitational slides. Upwards they gradually grade into proximal and basinal facies. The latter are represented by black schist and lydite horizons. The areal distribution of the flysch facies was compiled by Snopko and Ivanička (in Bajaník et al. 1984). Bodies of allodapic carbonates occur rarely. The Drnava Formation includes also olistoliths of metabasalts and associated horizons with redeposited volcanoclastic material. Their chemical composition is similar to CAB, E- and N-MORB basalts (Ivan et al. 1992). The total thickness of the Drnava Formation is estimated at 2000 - 2500 m.

The formation is Lower Devonian in age. Most palinomorphs are Gedinian-Siegenian, some are Emsian (Čorná - Kamenický 1976, Snopková in Ivanička et al. 1989).

Largely rhyolite and dacite volcanoclastics redeposited along with nonvolcanic detritus (119a) are concentrated along two conspicuous zones in the northern and southern sectors of the Drnava Formation. Very rare metarhyolite and metakeratophyre bodies are found in the Pača and Uhorná areas.

120 metasandstones, phyllites, carbonates, lydites, conglomerates, basic volcanics (Bystrý potok Formation), a - acid volcanics / *Late Silurian*

Unit 120 is 1100 - 2500 m thick and is the middle lithostratigraphic unit of the Gelnica Group. The formation is of Late Silurian/Early Devonian age (Čorná 1972, Snopková - Snopko 1979, Ivanička et al. 1986). The sediments bear all the signs of deposition in a deep flysch basin, such as preserved features characteristic of gravitational-flow sedimentation including turbidity currents, grain-flows and debris-flow slide bodies. A vertical section reveals a proximal flysch facies alternating with distal ones (Snopko 1967, Snopko - Ivanička 1978, l.c. in Bajaník et al. 1984). Although the Gelnica Group rocks were subjected to regional metamorphism under P-T conditions of the low-pressure greenschist facies (Sassi - Vozárová 1987), they retained most of their sedimentary signs. The distal flysch facies contain horizons of lydites and allodapic limestones. Eastern occurrences of the *Bystrý potok Formation* host thin layers of metabasalt tuffs, tuffites and sparse associated metabasalts. Their geochemistry corresponds to E-MORB/OIT metabasalts (Ivan et al. 1993).

Acid volcanics (120a) comprise redeposited volcanoclastics of rhyolite-dacite, rarely andesite composition. Their structures suggest transport by gravitational currents. They are mixed with nonvolcanic detritus to a various degree. Small bodies of their effusive equivalents, possibly olistoliths, are also present. Some of these fragments have retained their ignimbrite structures. Their chemistry corresponds to a calc-alkaline magma related to the evolution of a magmatic arc on an active continental margin.

121 metasandstones, phyllites, carbonates, lydites, rare conglomerates, basic metavolcanics (Vlachovo Formation) / *Early-Middle Silurian*, a - ditto / *Late Cambrian - Ordovician*, b - silicic volcanics / *Late Cambrian - Middle Silurian*

Unit 121 is the oldest stratigraphically dated unit of the Gelnica Group. Microflora assemblages attest to its Late Cambrium - Early-Middle Silurian age (Snopková - Snopko 1979). The Vlachovo Formation's thickness is estimated at more than 2500 m. It has a flysch character (Snopko - Ivanička 1978, Ivanička et al. 1989). Distribution of respective lithofacies, composition of sandstone detritus, as well as regional metamorphic grade, are the same as in the other Gelnica Group formations. In addition to the regional metamorphism, rock assemblages of all three formations of the Gelnica Group were subjected to contact-thermic metamorphism in the vicinity of apical tops of Gemeric granitoids. Metabasalts and metavolcanoclastics are rare in the Vlachovo Formation. Carbonates were alterated to ankerites, siderites (Nižná Slaná ore field) magnesites and dolomites. In the western and central Gemericum, the Vlachovo Formation has tectonic contacts with the Rakovec Group.

The parts of the Vlachovo Formation with identified Upper Cambrian - Ordovicain microflora (121a) are specially marked on the map.

Metarhyolite volcanoclastics (121b) form massive bodies widespread over large areas. Sedimentary structures indicate redeposition under conditions of flysch sedimentation. Both petrographically and geochemically, this volcanism corresponds to continental magmatic-arc-type calc-alkaline trend.

122 phyllites, schists, metasandstones, metavolcanics, locally metacarbonates / *Early Paleozoic*

This group includes metasediments and metavolcanics in the Tatric and Veporic crystalline units in which Early Paleozoic palinomorphs were found and whose metamorphic grade does not exceed the greenschist conditions (mostly chlorite, up to biotite and to garnet zones). Their small occurrences are scattered across various mountain ranges in which they are referred to by local names, such as Harmónia series, Klinisko phyllites, Janov Grúň complex, Predná hoľa complex, Sinec complex and others. They largely form tectonically confined schuppen amidst higher metamorposed complexes. Some rest on granitoids bodies and some were subjected to contact metamorphism.

In the Malé Karpaty, the Early Paleozoic low-grade metamorphosed rocks making up the Harmónia series and part of the Pezinok-Pernek crystalline unit were metamorphosed under conditions of the greenschist facies. The Harmónia series (Cambel 1954) consists mainly of metamorphosed shales and bituminous shales with layers of metamorphosed carbonates and mafic volcanics. It was contact-metamorphosed by the Modra Granitoid. The low-metamorphosed part of the Pezinok-Pernek crystalline unit is composed of metapsammites and metapelites commonly with carbonaceous matter (black schists) and abundant metamorphosed mafic volcanics. The contact with the higher-grade metamorphosed part (paragneisses, migmatites), subjected to periplutonic metamorphism by an intrusion of the Bratislava Granitoid, was probably tectonic as early as the pre-Alpine period (disturbed metamorphic zoning). The original character of the contact, however, is masked by younger tectonic processes.

On the northern slopes of the Ďumbierske Nízke Tatry are relics of low-grade metamorphosed Klinisko biotite phyllites adjacent to leucocratic granitoids. Nevertheless, no contact metamorphism has been noted. On the southern slopes, relics of similar rocks form narrow belts folded into high-metamorphosed rocks. The metasediments are locally enriched in subgraphitic admixture (Molák et al. 1986).

Further low-grade metamorphosed Early Paleozoic complexes are found in the Veporic (Kráľova hoľa) sector of the Nízke Tatry. They form shingled thrust slices folded into higher-grade metamorphosed rocks. The Predná hoľa complex (Bajaník et al. 1979) consists of metapelites, metapsammites, metamorphosed largely by intermediate and mafic effusives and volcanoclastics, and locally also metamorphosed carbonates. The Janov Grúň complex (Miko 1981) is made up mainly of metasediments (phyllites, metasandstones) and acid metavolcanics. Mafic and intermediate volcanics are less widespread. The metapelites mostly consist of quartz, albite, muscovite, chlorite and locally also biotite. Mineral assemblages and geothermometers suggest that the metamorphic temperature amounted to 350-430 °C.

Similar rock types were also noted in the Veporicum's Krakľová zone in the Slovenské rudohorie, where they are referred to as the Krakľová Formation (Korikovskiy - Miko 1992) and in southern sector of the Ľubietová zone. Their distribution has not yet been determined in detail and therefore their mapped extent is provisional.

In the Veporicum's Kohút zone, these rocks are included in the Sinec complex (Bezák 1982). They are dominated by schists with variable proportion of chlorite, muscovite and quartz along with metacarbonate layers altered mostly to magnesite, and mafic volcanics. The Lovinobaňa complex, whose rare remnants occur in the southwestern Kohút zone, has a lithology dominated by graywacke metapsammites, presumably with an admixture of intermediate volcanic material.

123 mica schists to gneisses, locally phyllites / *Early Paleozoic*

This group involves metamorphic rocks of the uppermost part of the greenschist facies to lower part of the amphibolite facies (mainly garnet zone) which yielded Early Paleozoic palinomorphs. They are confined mostly to the southern Slovenské rudohorie (Veporicum's Kohút zone), some inliers amidst the Neogene, and the Tríbeč.

Three complexes of this type have been described in the Kohút zone: Ostrá, Klenovec and Hladomorná dolina. Their metamorphic grades are similar, but lithologies are different (Bezák 1989). The Ostrá complex was dominated by claystones, in places interlayered with mafic volcanics and sediments enriched in organic matter. Iron- and aluminium-rich sediments, possibly redeposited laterites, are found as well (Kováčik 1990). In contrast, the Klenovec complex is dominated by graywacke sediments possibly with admixture of intermediate volcanoclastic material and rare orthogneisses.

The Hladomorná dolina complex has a protolith similar to that of the Klenovec complex, but it is interlayered chiefly with mafic volcanics. A part of the Hladomorná dolina complex was redefined as Stephanian (acc. microflora Planderová - Vozárová 1978), Slatviná Formation (Vozárová - Vozár 1982).

The above-described rocks were metamorphosed mainly to mica schists, mica-schist gneisses, albite gneisses and minor amounts of biotite phyllites, all interlayered with amphibolites, orthogneisses, graphite schists and metaquartzites. The mica schists in the Kohút zone and in the Razdiel part of Tríbeč are mostly chlorite-muscovite and garnet mica-schists, rarely with staurolite, kyanite and chloritoid. Mineral assemblages (quartz + plagioclase + chlorite ± muscovite ± biotite ± almandine ± staurolite ± kyanite ± chloritoid) as well as

calculations using graphite and garnet-biotite thermometers indicate that their Hercynian metamorphism took place at temperatures 450-530 °C and medium pressures. Subsequent metamorphic processes (Neohercynian, Paleoalpine) were associated with lower temperatures and had diaphthoric effects.

124 gneisses, mica schists and products of their diaphthoresis

They are most widespread in the northern Veporicum (Krakľová zone) but occur also amidst the Ľubietová zone, in the Čierna Hora (Lodiná complex, Jacko 1985), northern sector of the Považský Inovec and underlie granitoids and migmatites in the Západné Tatry. The group comprises crystalline schists (gneisses, mica-schist gneisses, mica schists locally intercalated with more quartzitic varieties and metamorphosed mafic rocks) subjected largely to amphibolite-facies metamorphism. Its typical features are various intensive manifestations of diaphthoresis by younger tectonometamorphic processes. They concentrated mainly in shear zones and gave rise to a wide spectrum of diaphthorized rocks ranging from diaphthorized gneisses to diaphthoric mica schists to phyllonites.

Their protolith consisted most probably of flyschoid rocks (graywackes and claystones) of unclear age (Early Paleozoic - Proterozoic?). Petrologic investigations (e.g. Putiš 1987, 1989) indicate that the prograde metamorphism took place at 540-640 °C and 5-7 kbar, but lower metamorphosed sequences and remnants of higher-metamorphosed complexes (e.g. Beňuš Paragneisses in the Hron Valley) occur here and there. Inverse zoning was noted in the Západné Tatry (Janák et al. 1988). Metamorphic conditions reflect the basic prograde mineral assemblage: quartz + plagioclase + muscovite + biotite + almandine + staurolite. In places pelites contain index minerals andalusite, kyanite, silimanite, rarely all of them together (Považský Inovec). The Hercynian retrograde assemblage typically contains chlorite, muscovite, albite, biotite, garnet and chloritoid while the superposed Alpine metamorphism is characterized only by muscovite, chlorite and albite. Radiometric data attest to three essential stages in the metamorphic history: main Hercynian metamorphism (380-350 m.y.), Late Hercynian uplift and cooling, and Alpine structural-metamorphic reworking (94 + 18 m.y., Burchart et al. 1987).

125 biotite and two-mica plagioclase paragneisses, migmatitic paragneisses

These are the most typical metamorphosed rocks in the core mountains. Only their areally extensive occurrences are marked on the map (Malá Fatra, Strážovské vrchy, Malé Karpaty). However, in variable amounts they are found in all higher-grade metamorphosed complexes of crystalline units in the Tatricum, Veporicum and Zemplinicum. They commonly form enclaves in granitoids and migmatites (Ďumbierske Nízke Tatry, Západné Tatry, southern Veporicum, southern block of the Považský Inovec and elsewhere).

Before subjected to metamorphism, the rocks were mostly graywacke sediments with minor quartzites, mafic and calc-silica rocks. They are assigned to the Proterozoic - Early Paleozoic inasmuch as their exact age is not known.. The main metamorphosed equivalent are medium- to fine-grained biotite or two-mica plagioclase paragneisses. The main mineral assemblage quartz + plagioclase + biotite is accompanied with muscovite, garnet (almandine fairly rich in pyrope component), K-feldspar, sillimanite, staurolite, cordierite, andalusite and kyanite, whose collective presence depends on the protolith composition and metamorphic grade. Rare skarnoid rocks (southern Veporicum) are considered to be metamorphosed sedimentary Fe-ores. The gneisses are locally enriched in graphite.

The metamorphic history under the temperature-pressure conditions of the amphibolite facies had special features in each segment of the crystalline unit. Manifestations of higher-grade metamorphism preceding the amphibolite-facies one occur e.g. in the Malá Fatra (Hovorka - Méres 1989) and Zemplinicum (Vozárová 1991). Authors who studied the petrology of these complexes (Spišiak - Pitoňák 1990, Dyda 1990, Janák et al. 1988, Méres - Hovorka 1989 and others) generally agree that at least two metamorphic stages can be distinguished. The first one took place under higher pressures, whereas the second, during emplacement of granitoid intrusions, saw decreasing pressure and rising temperatures sometimes beyond the point of partial melting (migmatized paragneisses).

126 banded gneisses, augengneisses and migmatites

Fairly monotonous complexes essentially made up of rocks composed of light quartz-feldspar and dark biotite bands are found in several mountain ranges but on the southern slopes of the Ďumbierske Nízke Tatry they are the most widespread rock type of the crystalline unit. A couple of structural types have been distinguished with regard to the shape and thickness of the bands, the principal ones being banded- and eye-structured. The eyes largely consist of ductile-deformed K-feldspars or plagioclases commonly more than 1 cm in size. These two types gradually pass into one another. The rock composition is locally made less monotonous by fine-grained orthogneisses, granitoid varieties, as well as by gneiss and amphibole enclaves.

The two main types are referred to as orthogneisses or migmatites (stromatites, ophthalmites). Their genesis and protolith are unknown but there are some indications of their granitoid origin. What do we know is that they were tectono-metamorphosed in the early states of the Hercynian orogeny under the conditions of the upper amphibolite facies. Parts of the rock complex underwent partial melting, which gave rise to a wide variety of migmatitized rocks.

127 amphibolites, locally amphibole gneisses

The group comprises amphibolites in all tectonic units regardless of their age. They occur in metamorphosed rocks or as enclaves amid granitoids nearly in all mountain ranges. They mostly form small bodies (several metres to tens of metres large) conformable with schistosity. Bodies of large areal extent, such as those in the northern Veporicum, are rare.

Genetically, they are largely metamorphosed mafic volcanics. Their petrographic varieties are controlled by the primary type of the volcanic rock (effusives, volcanoclastics). The most widespread variety is dark-green fine- to medium-grained amphibolite s.s. essentially composed of amphibole+plagioclase. Other kinds include also biotite and garnet. The metamorphic grade varies from the upper part of the greenschist facies to the upper part of the amphibolite facies, and some authors even speculate about the presence of high-pressure products.

Banded amphibolites known primarily in the Nízke and Západné Tatry Mts. (Spišiak - Pitoňák 1992, Hovorka - Méres 1993, Janák et al. 1993) are a special type. They consist of thin amphibolite and leucocratic bands, and occurrences of metamorphosed ultramafic rocks have been described, too (Spišiak et al. 1988).

The amphibolites are associated with amphibole or biotite-amphibole gneisses which, aside from amphibole and increased amounts of plagioclase, contain also essential quartz.

128 orthogneisses (silicic metavolcanics?)

These rocks are present chiefly in the so called Muráň Orthogneiss Complex. They occur in the Kohút zone close to the Muráň fault and, according to some authors, also near Pohronská Polhora below an overlying granitoid-gneiss complex.

The principal rocks of this complex are light-coloured fine-grained orthogneisses composed of quartz and feldspars (mainly albite and microcline) with a small admixture of micas (muscovite, biotite) and very rare garnet. They are interbedded in places with mafic metavolcanics and mica schists. According to Hovorka et al. (1987), their protolith consists of acid volcanics, mainly effusives, whose metamorphic grade did not exceed almandine isograd, i.e. lower part of the amphibolite facies. Orthogneiss bodies amid Klenovec Complex gneisses have a similar character.

ABYSSAL IGNEOUS ROCKS

129 leucocratic granitic rocks / *Hercynian*

A common sign of granitoids of this group is their light colour due to a low content of mafic minerals. Their grainsize is variable, but fine-grained varieties prevail. They are mostly confining-structured, even-grained, and less commonly are porphyritic. Major minerals include plagioclases (albite, acid oligoclase), quartz, K-feldspars, with rare micas.

The granitoids vary in genesis and age from one West Carpathian sector to another. Present largely as small bodies or dykes in all granitoid massifs, they resulted from differentiation of other types of granitoids or from partial melting.

Major bodies are found in the Tatry (the highest sectors of the Západné Tatry and northern edge of the mountain range), Nízke Tatry (types Kotliská, Králička, Železnô), Strážovská hornatina, Žiar, Veľká Fatra (type Ľubochňa) and in Tríbeč (northeastern tract).

These rocks also comprise aplite and pegmatite dykes in all kinds of granitoids. The main mineral assemblage is quartz + plagioclase + K-feldspar + muscovite + biotite. Pegmatites with rare-element-bearing accessory minerals occur as well (Uher 1993).

130 two-mica and biotite granites to granodiorites / *Hercynian*

This unit is widespread mainly in the Malé Karpaty (type Bratislava, Cambel - Vilinovič 1987), Považský Inovec, Malá Fatra (primarily in the Kriváň sector) and Veľká Fatra (type Lipová, Kohút 1992). Minor amounts of similar rocks have been noted in other mountains, too.

They are medium- to coarse-grained and locally porphyritic. The basic mineral assemblage includes quartz, plagioclase (oligoclase), K-feldspar (orthoclase and microcline), biotite, muscovite. The biotite/muscovite ratio is variable. Accessory minerals typically comprise monazite and ilmenite (Broska - Gregor 1992). Several radiometric measurements indicate that these granitoids are 360-340 m.y. old.

131 porphyritic granodiorites to granites /*Hecynian*

Granodiorites are more abundant than granites in this unit. These rocks are genetically associated with two-mica granitoids and with tonalites. Typically, these rock types are porphyritic textured, but they also include nonporphyric or cryptoporphyric types. The K-feldspar phenocryst sizes reach several cm. Geochemical character and accessory assemblages are controlled by the genetic type of the porphyritic granitoids.

The porphyritic granitoids are widespread in the Tatry, Nízke Tatry, Žiar and in the Veporicum and they occur in many other places as well. At those sites where the rock types are of the common sort no special names are applied. Thus, in the Západné Tatry separate bodies of distinctly different compositional phases are mapped, but in the Vysoké Tatry where compositional phases are

subtle only on basic rock type is mapped. A Goryczkowa-type of granitoid with pink-red K-feldspar phenocrysts, is found along Alpine structures in the Červené vrchy and Giewont areas. A Prašivá type of granitoid occurs in the Ďumbier sector of the Nízke Tatry and is probably genetically linked to the Ďumbier type. The locally distributed Latiborská-hoľa type is presumably of metasomatic origin (Lukáčik 1981).

A porphyric type of granitoid is widespread in the eastern sector of the Kráľova hoľa zone in the Slovenské rudohorie and in the Nízke Tatry, as well as along its western edge and below Neogene volcanic formations of the Javorie Mts. In the central Veporicum the Sihla-type tonalite is common. The Hrončok-type granitoids of the northern Veporicum are enriched in alkalies. Granite porphyries in the Ľubietová zone have a special position.

Further occurrences of the porphyritic types are in the Kohút zone of the Veporicum Unit.

The most conspicuous sign of porphyritic granitoids in the Veporicum is their tectonometamorphic reworking under P-T conditions reaching the biotite zone which resulted in their deformation and change in mineral and chemical compositions (Vrána 1966). These rocks can be referred to as metagranitoids or orthogneisses.

132 biotite tonalites to granodiorites, locally porphyritic / *Hercynian*

Granitoids of this kind are widespread in all outcrops of the crystalline unit in the Tatricum and Veporicum. In different mountain ranges they have different local names (the best known include the Sihla, Ďumbier, Vysoké Tatry, Smrekovica and Modra types). Attempts have recently been made to define the united characteristics of all these granitoids and group them under the name Sihla-type tonalite sensu lato (Broska - Petrík 1993).

Petrographically, they are biotite tonalite to granodiorite, mostly medium-grained, locally porphyritic (plagioclase phenocrysts). Major minerals comprise plagioclase (An20-35), quartz, biotite, ± K-feldspar ± muscovite. Amphibole is rarely present. The accessorry assemblage typically includes titanite, allanite and magnetite. The presence of mafic microdiorite enclaves is typical.

The Sihla-type granitoids are considered as representatives of I-types (Petrík et al. 1993) in a later stage of Hercynian granitoid magmatism (several U/Pb data indicate they are 310-290 m.y. old). They resemble earlier tonalites in a hybrid suite and therefore are difficult to distinguish in the field. Strongly mylonitized granitoids on the southern slopes of the Kráľova hoľa sector of the Nízke Tatry (type Sparistá) differ from the main type.

133 hybrid granodiorites or tonalites that locally grade into migmatites / *Hercynian*

This group of granitoid rocks is extremely heterogeneous because of its close links to the metamorphic mantle. Its typical composition is granodiorite or tonalite and its typical features include gradual passages into migmatites or abundant gneiss enclaves. The granitoids themselves are largely directional-, schlier- to irregular-banded-structured owing to biotite schliers. The inhomogeneity may result from alternating layers of different kinds of granitoids (biotite, leucocratic, porphyritic) and gneisses. The plagioclase composition is that of oligoclase-andesine, the K-feldspar content is variable, and that mineral may be absent. The hybrid granitoids are plastically deformed at temperatures close to anatexis (some rocks are partially melted). Reliable geochronological data are lacking because of later metamorphic reworking. Nevertheless, their geological position suggests that they rank among the oldest in the West Carpathians (even a pre-Hercynian age is possible for some of them).

They are abundant in the Západné Tatry, on the southern edge of the Ďumbier Massif granitoids (nebulite zone) but mainly in the southern Veporic crystalline unit, with occurrences of banded migmatites.

134 diorites to gabbros / *Hercynian*

Mostly they are biotite-amphibole quartz diorites. Their major minerals include amphibole, biotite and plagioclase (andesine). The gabbroid rocks are less abundant. Aside from amphibole and plagioclase, the rocks also contain pyroxene. They are mostly evenly structured, medium-grained, but locally are coarse-grained. In places the rocks grade into pegmatitoid varieties.

These rocks form rare small bodies (tens of metres in size) in granitoid massifs or metamorphic rocks. They are most commonly found in the southwestern Slovenské rudohorie, also in the Malé Karpaty, and very rarely in the Tatry, Nízke Tatry and other mountains (Strážovské vrchy, Malá Fatra, Čierna Hora).

135 ultramafic rocks, mostly serpentinites / age uncertain

Bodies of ultramafic rocks occur rarely in the Tatric and Veporic crystalline units. The bodies are so small (metres to tens of metres) that most of them cannot be depicted at the map scale. They are surrounded by metamorphic rocks (gneisses, mica schists) or granitoid bodies. Their age is unknown.

Hovorka (1985) distinguished two basic rock types, amphibole peridotites (occur on the crest of Mt. Veľká Lúka in the Malá Fatra and near Filipovo in the Veporicum's Krakľová zone) and metamorphosed ultramafic rocks (occur near Pohronská Polhora and Kohút zone of the Veporicum, e.g. near Muráňska Dlhá Lúka, Uhorské, Málinec, Strieborná and elsewhere). The basic type of these serpentinized ultramafic rocks is antigorite serpentinite, composed of antigorite, talc, tremolite, chlorite, carbonates and ore minerals in various amounts.

Aside from the Tatric and Veporic crystalline units, the serpentinites are also found in the Gemericum's Ochtiná Formation and Klátov Group. In the Ochtiná Formation they form a few separate bodies near Breznička (about 1.5 km long and 300 m wide) and small occurrences near Ratková and Sirk. The rock is an antigorite serpentinite, locally strongly steatitized with long-fibre chrysotile in hydrothermally altered zones (Hovorka 1985). The principal rock-forming minerals include antigorite, Mg-chlorite, talc and tremolite. The metamorphic history of the serpentinite bodies was a polystage one, associated with regional metamorphic processes under greenschist-facies PT conditions and later hydrothermal processes.

Thin, tectonically reduced, podiform serpentinite bodies (up to several tens of metres thick and 200-300 m long) occur at the contact of the Klátov Group gneiss-amphibolite complex with Rakovec Group low-grade metamorphic rocks (most important bodies are in the Vyšný Klátov - Bukovec area). Petrographically, they also correspond to antigorite serpentinites which are locally subjected to hydrothermal metasomatic alterations of various grades.

136 biotite to two-mica granites / age uncertain

This category consists of granitoids of uncertain age found in the Gemeric complexes. Apical parts of the granitoid bodies with obvious contact aureoles occur mainly amidst rock sequences of the Gelnica Group (north of Betliar, near Podsúľová, Delava, valley Surovec, Čertova hoľa, Poproč, Zlatá Idka, valley Hummel, near Železník and Turčok), as well as Rakovec Group (Hnilec and Súľová areas).

The rocks are dominated by massive biotite and two-mica granites of calc-alkaline magmatic trend. They were subject to moderately strong tectonic mylonitization only in the valley Surovec and Turčok area. Their contact thermal metamorphism is associated with hydrothermal metasomatic processes (albitization, tourmalinization, greisenization). The granites postdate the Early Paleozoic sequences in which they are emplaced. A wide range of radiometric data (290-70 m.y. by K/Ar and Rb/Sr methods, Cambel et al. 1990) attests to a complex magmatogenic history and therefore further petrographic and geochronologic studies will be needed to determine their age.

137 leucocratic granites to granodiorites / age range uncertain

In this group we include granitoid bodies of the southern margin of the Kohút zone of the Veporicum, formerly also designated as the Rimavica type. They commonly are leucocratic rocks, and probalbly include several genetic and age types. In some places they form a continuous zone such as the small massifs in Lower Paleozoic metamorphic rocks, and in others they occur in Late Paleozoic sequences contact metamorphism zones (area of Klenovec, Kokava n. Rimavicou–Krná, Cinobaňa – Uhorské, Sinec massif). Their age ranges from Mesohercynian to Neohercynian and to Alpine ones (Kantor 1960 in Vozárová a Vozár 1979), the latter represented by the Rochovce type (Klinec et al. 1980).

Petrographical and geochemical inhomogenity of the granitoids of this group is characteristic. The individual subtypes are commonly restricted to specific massifs which are separated from one another by young faults. These subtypes include: 1) leucocratic to subleucocratic biotitic to two-mica granites (less commonly also granodiorites) in the Dubovo massif (area of České Brezovo - Zlatno - Lehota n. Rimavicou); 2) leucocratic granites - forming massifs and stocks in gneisses of the Klenovec complex, marked by geochemically differentiated character and an abundance of metasomatic grossular-almandine garnets, and the presence of dark tourmaline; 3) tonalites to granodiorites (less commonly granites) in the zone Krokava - Ľubeník - Hladomorná dolina valley, grading into marginal facies (granodiorite or less commonly granite) of the Kohút and Stolica massif in the east. In this type intense metasomatic processes took place to form albite, clinozoisite, fengite, almandite-grossular spessartite; 4) Veins of aplites and stocks of muscovite granites that intersect the previous types of granites, the Lower Paleozoic and Late Paleozoic sequences, are the youngest granitoids exposed on the surface; 5) Rochovce type of granitoid bodies not cropping out but only encountered in boreholes in southern part of the Kohút massif. These occur as intrusive bodies showing contact metamorphic halos against the Gemericum and Veporicum tectonic units (Vozárová, 1990). The Alpine age of these granitoids is shown by the dating of zircons (81-82 m. y., Hraško et al., 1993, 1995). Two groups of Rochovce granitoid bodies were distinguished - coarse-grained porphyritic granites with phenocrysts of pink potassium feldspars and leucogranite porphyries, aplites and alkalic-feldspar granites (Határ et al., 1989).

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