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A new synthesis of the geological structure of Slovakia – the general geological map at 1:200 000 scale

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Systematic geological mapping of the Slovak Republic territory over the last forty years, when many regional geological maps at 1:50 000 scale were issued, culminated in 2008 and 2009 in a new synthesis of the geological structure of the Western Carpathians on the Slovak territory in the form of a general geological map at 1:200 000 scale. An integral part of this activity was the solving of interregional correlation problems, a settled of tectonic classification of the Western Carpathians as well as a specification of the lithostratigraphical content of the tectonic units. The results of this synthesis are described in this contribution – a brief review of the principal geological units of the Western Carpathians that are depicted in the tectonic interpretation and in the geological sections. The Western Carpathians are geologically divided into the Outer (Flysch Belt) and Inner (Inner Carpathian Block). These two zones are products of the youngest, mainly Neogene Neo-Alpine tectonic activity. Separating the two zones is a tectonic structure – the Klippen Belt – which contains elements from both. The Inner Carpathian Block possesses a Palaeoalpine tectonic pattern composed of crustal tectonic units and superficial nappes. The crustal units are composed of the crystalline basement and its Upper Paleozoic and Mesozoic cover. The basement consists of fragments of Hercynian tectonic units from the Paleozoic phase of crustal evolution. The superficial nappes comprise mostly upper Paleozoic and Mesozoic sequences. Cenozoic deposits and volcanic rocks are deposited on the Palaeoalpine nappe structure.

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Key words: Slovakia, Western Carpathians, geological structure, general 1:200 000 geological map.

INTRODUCTION

Long-term investigation of the Slovak part of the Western Carpathians resulted in the creation of several syntheses (e.g., Uhlig, 1907; Matějka and Andrusov, 1931; Biely *et al*., 1968; Andrusov *et al*., 1973). One of these was the first edition of the 1:200 000 general maps in the 1960's. Subsequently, the systematic geological mapping the Slovak Republic at 1:25 000 scale began. The mapping was organized by individual regions, reflecting than the different topographic elements of Slovakia (an alternation of mountain ranges and depressions and/or lowlands). On the basis of these maps, regional maps at 1:50 000 scale were compiled and published, together with explanatory books for public use. At the present day nearly all of the Slovakian territory is covered by regional geological maps at 1:50 000 scale. From 1972, when the first 1:50 000 regional map was issued, to the present, 47 regional maps out of a total of 51 have seen issued. Thus much data has accumulated in the past forty years, but these have brought geological problems too.

The 1:50 000 maps were a base for the creation of the new general 1:200 000 map. The main task of this general map was a correlation of the regional maps and their incorporation into a consistent synthesis of the structure of the Western Carpathians. The synthesis also incorporates later studies on Carpathian geology (e.g., Kováč, 2000; Plašienka, 2003; Bielik *et al*., 2004; Froitzheim *et al*., 2008) and geophysical works (e.g., Vozár *et al*., 1999; Guterch *et al*., 2003). The new general geological map of Slovakia at 1:200 000 scale came out in the 2008 in individual sheets and as a whole (Bezák *et al*., 2008) and in 2009 the explanatory text (Bezák *et al*., 2009) was published. The map sheets are complemented by geological sections, sketches of the tectonic units and – summary of – the authors' contributions. The compilation of the 1:200 000 maps and text explanations involved teams of geologists dominantly from the State Geological Institute of Dionýz Štúr, but also from the Slovak Academy of Sciences, the Faculty of Natural Sciences, the Bratislava Faculty of Mining and the Technical University at Košice.

In comparison with the old edition of the general map, the new one contains much that is new, for example the division of the principal tectonic units, especially the Palaeoalpine superficial nappes. In the crystalline basement fragments of Hercynian tectonic units have been identified, while the interpretetion of the Klippen Belt has also changed. The Neogene sedimentary basins and volcanics in the relation to tectonic setting have been classified. The map is principally of the solid geology, but important Quaternary sediments are shown (e.g., in basins where they attain considerable thickness, while major alluvial and glacio-fluvial deposits are illustrated). The aim of this work is to given a current geological synthesis of the Western Carpathians in Slovakia as expressed in the new general geological map.

OVERVIEW OF THE GEOLOGICAL STRUCTURE OF SLOVAKIA

The Slovak Republic is located in the Western Carpathian mountain range. The tectonic structure of this region is complex as a result of its long-term tectonic evolution. Tectonic elements originated during two main orogenic stages, of the Hercynian and Alpine.

A modern view of the geological structure and tectonic division of the Western Carpathians is shown on the new general map. This interpretation has been based on current understanding of the region's tectonic evolution and conforms to the Tectonic Map of the Slovak Republic at 1:500 000 scale (Bezák *et al*., 2004). The Western Carpathians are divided into Outer and Inner zones, a result of the youngest Neoalpine (mostly Miocene) tectonic activity between the European platform and the Inner Carpathian Block. The Outer Carpathians are represented by the Flysch Belt. An element that separates Outer and Inner blocks is the Neoalpine structure of the Klippen Belt which contains units from both units.

The Inner Carpathian Block comprises a Palaeoalpine (Late Cretaceous) nappe system and post-nappe Cenozoic volcanic and sedimentary rocks. The Palaeoalpine tectonic units comprise crustal units as well as a system of superficial nappes. The crustal tectonic units of Tatricum, Veporicum, Gemericum and Zemplinicum are built up of crystalline basement with incorporated fragments of Hercynian tectonic units, as well as cover formations of Upper Paleozoic and Mesozoic age. The Palaeoalpine superficial nappe units comprise the nappe systems of Fatricum, Hronicum, Meliaticum, Turnaicum and Silicicum. These units are built up mainly of Mesozoic and Upper Paleozoic sequences.

The distribution of tectonic units is shown in Figure 1. The main elements of the geological structure of the Western Carpathians are portrayed on selected cross-sections (Fig. 2). The location of the cross-sections was chosen to shown the position of the principal tectonic units. The first cross-section runs from the Klippen Belt through the Inner Carpathian Paleogene into the core region (the Vysoké Tatry Mts.) and continues through the Paleogene of the Poprad Basin into other core mountains (the Nízke Tatry Mts.). The second cross-section is essentially a prolongation of the first one and depicts nappes and cover units of the Nízke Tatry Mts. Its continuation towards the south reflects the Gemericum unit over which nappes of the Meliaticum, Turnaicum and Silicicum are overthrust. The third cross-section begins in the Flysch Belt, crosses the Klippen Belt and terminates in the core mountains (Malá and Veľká Fatra Mts.). The fourth cross-section is continuation of previous one and goes through the Nízke Tatry Mts. and the contact of the Tatricum and the Veporicum units (Čertovica tectonic zone) into crystalline complexes of the Veporicum unit overlain by Neogene volcanic complexes of the Poľana stratovolcano.

THE MAIN GEOLOGICAL UNITS OF THE WESTERN CARPATHIANS

NEOALPINE TECTONIC UNITS OF THE OUTER CARPATHIANS (FLYSCH BELT)

The Flysch Belt forms a characteristic arc around the outer perimeter of the Carpathians. It reaches the territories of Moravia, Slovakia, Poland, Ukraine and Roumania where it passes into the Flysch Belt of the Eastern Carpathians. It is represented by a system of rootless nappes, i.e. sedimentary sequences detached from the basement, imbricated and thrust onto various elements of the North European Platform. The age of the sedimentary sequences is from the Albian to the Oligocene. The system of nappes and slices is divided according to the lithofacies content into an outer (Krosno) and an inner (Magura) group of nappes. In Slovakia the greater part of the Flysch Belt is formed by the Magura nappes. Of the outer (Krosno) group of nappes in the western part of the country, only a Silesian Nappe has a small outcrop, and in the northeastern borderland, the Dukla Nappe occurs.

Nappes of the Krosno group rest relatively flat on a substrate formed by the European Platform ramp. The Silesian and the Dukla units plunge beneath the Magura Nappe system to the south. The Smilno inlier in the Magura Nappe seems to belong to the group of the Fore-Magura units. A special structural element is the Miková–Snina Zone (slices zone between Magura and Dukla units), which comprise lithostratigraphic elements from both units.

The Magura Nappe group consists of (from north to south) the Rača, Bystrica, Oravská Magura and Krynica partial nappes. As a whole, they were thrust northwards by some 40 km (Roth, 1963). In the western sector, the partial nappes are obliquely terminated at the contact with the Klippen Belt; in some sectors (e.g., the boundary in Orava) they were even backthrust over, or sliced and incorporated into the Klippen Belt. The folding of the Magura Basin (and the entire flysch basin) and conversion into north-verging nappes took place largely from the Late Oligocene to the Badenian (Oszczypko, 1998).

The Biele Karpaty group of nappes, formerly included within the Magura nappes, was later defined as an individual tectonic unit of higher order because of evident lithofacies differences (Potfaj, 1993).

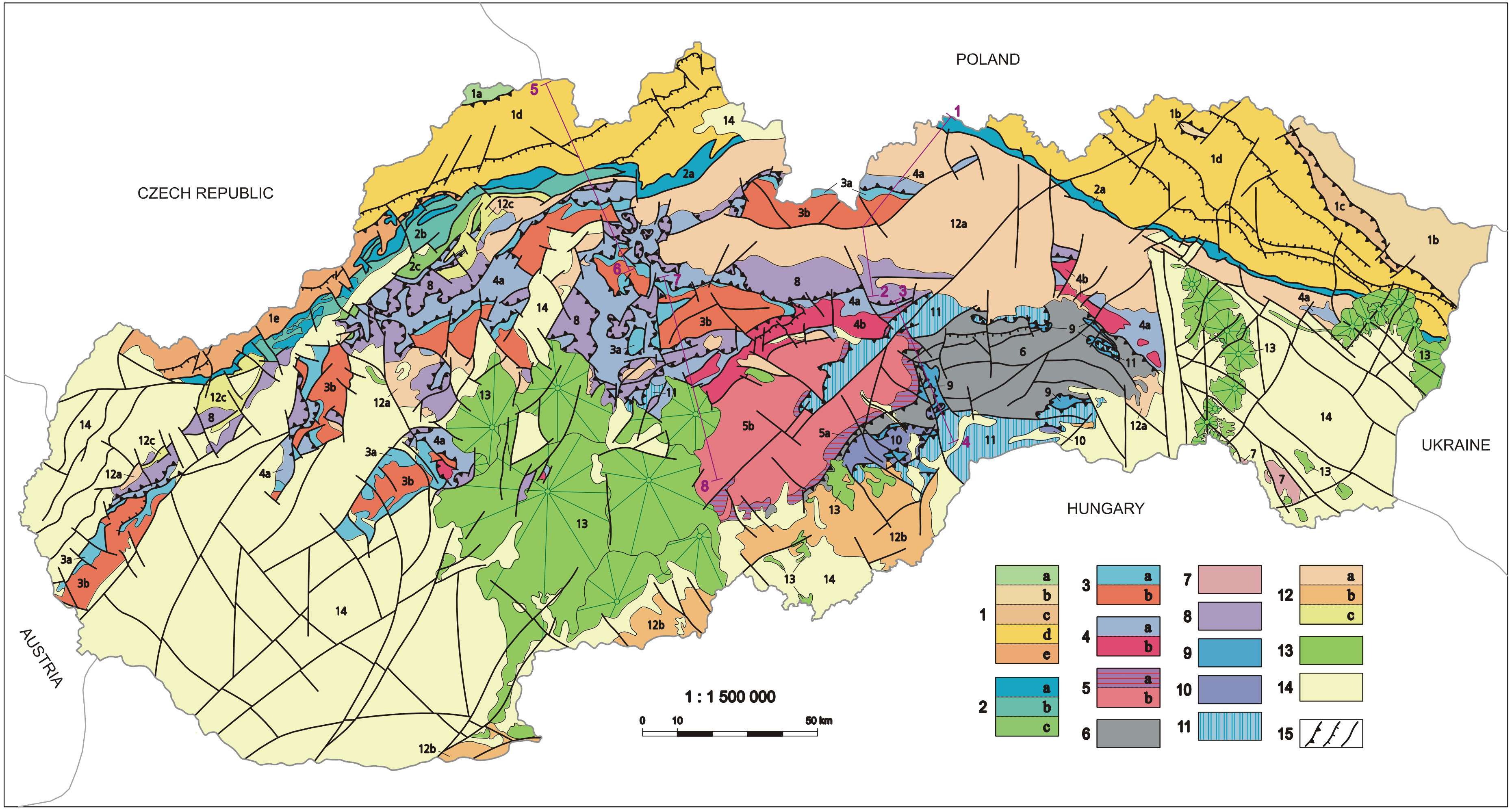

Fig 1. Tectonic units of the Western Carpathians (according to General geological map of the Slovak Republic 1:200 000, Bezák *et al*., 2008)

Neoalpine tectonic units of the Outer Carpthians: **1** – Flysch Belt: a – Silesian Nappe, b – Dukla Unit and Smilno tectonic inlier, c – Miková–Snina Zone, d – Magura group of nappes, e – group of Biele Karpaty nappes; **2** – Klippen Belt *s.l.*: a – Klippen Belt *s.s.* undivided, b – Klape tectonic unit, c – Manín and Haligovce tectonic units; **Palaeoalpine tectonic units of the Inner Western Carpathians**: **3** – Tatricum: a – mostly Mesozoic and Late Paleozoic formations, b – crystalline complexes; **4** – Fatricum and northern Veporicum: a – Mesozoic and Late Paleozoic formations, b – crystalline complexes; **5** – southern Veporicum: a – Mesozoic and Late Paleozoic formations, b – crystalline complexes; **6** – Gemericum; **7** – Zemplinicum; **8** – Hronicum; **9** – Meliaticum; **10** – Turnaicum; **11** – Silicicum; **formation superimposed over the nappe structure**: **12** – sedimentary basins with Paleogene and Late Cretaceous fill: a – Inner Carpathian Paleogene basin, b – Buda Basin, c – Late Cretaceous and Paleogene deposits; **13** – Neogene and Quaternary volcanics; **14** – Neogene and Quaternary deposits; **tectonic boundaries**: **15**: a – main Alpine thrusts, b – other overthrust lines, c – unspecified faults; 1–8 purple lines – cross-sections

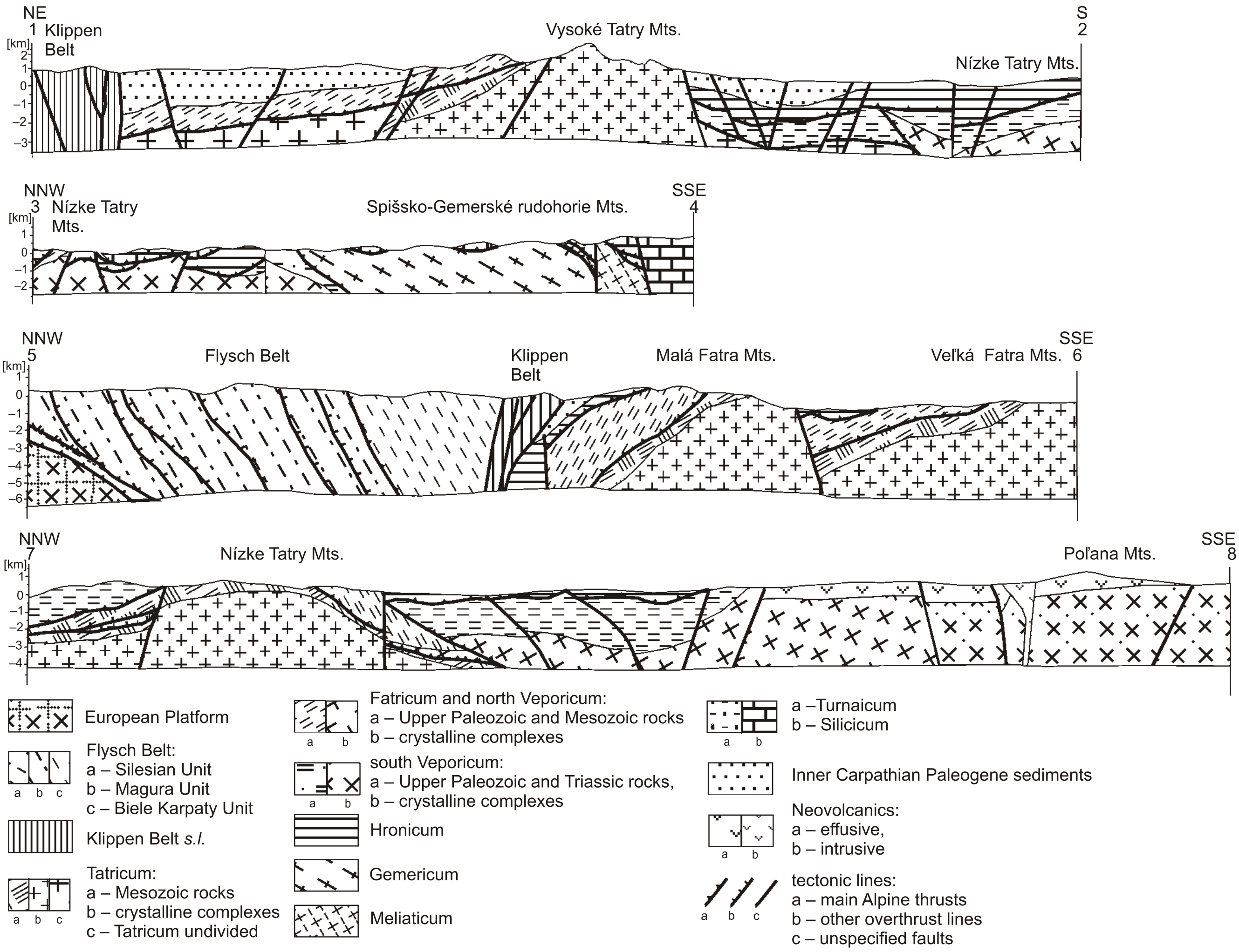

Fig. 2. Cross-sections (marked on Figure 1) through the Western Carpathians (according to Bezák *et al*., 2008)

KLIPPEN BELT *s.l.*

The Klippen Belt is an internally complicated narrow, more or less steep tectonic zone, trending from Podbranč through Považie to the Orava region, where it descends beneath the Neogene strata of the Orava Basin. It emerges in Poland and in the Pieniny area it reaches Slovakia once more. To the SE it extends beneath the volcanic complexes of Vihorlat and near Beňatina village it passes into Ukraine.

The Klippen Belt all along its length parallels the presumed deep contact between the European Platform and the Inner Carpathian Block, indicated by the zone of divergence the Pieniny lineament. The term Klippen Belt *s.l.* was introduced on the new tectonic map of Slovakia (Bezák *et al*., 2004) for the Neogene structure which originated due to the strike-slip movement at on the contact between the Outer and Inner Carpathians (see also Birkenmajer, 1985). Its origin was polyphase: the last important movements occurred approximately between the Badenian and the Sarmatian. The vertical structure of the belt has a mostly fan-like shape.

Into the structure of the Klippen Belt *s.l.* there were dragged, besides Klippen Belt units *s.s.* (as Kysuca, Pieniny, Czorstyn and other units) also units originally deposited adjacent to the Klippen Belt *s.s.* These belong mainly to the Klape, Manín and Haligovce tectonic units, and represent original Palaeoalpine units from the foreland of Tatricum, or remnants of Mesoalpine (mostly early Paleogene) units.

In the Klippen Belt *s.s.* the Jurassic and Lower Cretaceous carbonate units of various klippen sequences form morphological and structural klippes measuring some metre to several kilometres. The Cretaceous flysch and marly units sedimented above or between the older klippen formations. Later they were squeezed into or pulled out from normal stratigraphic successions and strongly tectonised due to their low competency. In this way they form the matrix between individual klippes – the so-called klippen envelope.

PALAEOALPINE TECTONIC UNITS OF THE INNER WESTERN CARPATHIANS

CRUSTAL TECTONIC UNITS

The **Tatricum** outcrops in the core mountains (Neogene horsts with a crystalline core and mostly Mesozoic cover) and comprise a crystalline core and a Late Paleozoic and Mesozoic cover (of Early Triassic to early Turonian age).

Taking into account the different development of their Jurassic and Lower Cretaceous successions the Tatric Mesozoic units are divided into units containing either deep-water deposits (Šiprúň Unit) or shallow-water deposits (Červená Magura sequence and some of the Vysoké Tatry and Tribeč sequences). The Triassic development in both units is of shallow water character. The Upper Paleozoic formations also have corresponding development and are represented mainly by upper Permian clastic deposits (mainly in the Tribeč, Považský Inovec and Malé Karpaty Mts.). The upper Carboniferous strata are present only in the Považský Inovec Mts.

The crystalline basement contains relicts of Hercynian tectonic units. The Tatric crystalline basement has specific features in some core mountains, but generally it is made up of medium- to high-grade metamorphic rocks (mostly paragneisses, orthogneisses, migmatites, amphibolites) and Hercynian granitoids. In contrast, low-grade metamorphosed complexes occur in some mountain ranges (Tribeč, Malé Karpaty and Považský Inovec Mts.). The boundaries of these complexes of different metamorphic grade are tectonic and mostly Hercynian, an assumption that was confirmed by structural-tectonic investigations in some mountains, such as the Západné Tatry (e.g., Fritz *et al*., 1992).

The Tatricum is the deepest exposed tectonic unit of the Inner Carpathians, an autochthon relative to all overlying units. The extent to which the Tatricum itself is allochthonous can be inferred only from broader relationships (Plašienka *et al*., 1997) and seismic profiles (Vozár *et al*., 1999). This issue was studied in more detail by Mahel' (1981) who defined the Vahicum as a hypothetical equivalent to the Alpine southern Penninicum at the front of the Inner Carpathians.

The **Veporicum** represents the crustal tectonic unit of the Inner Western Carpathians, being formed during the Palaeoalpine collision. It overthrusts the Tatricum along the Čertovica thrust zone, and descends beneath Gemericum along the Lubeník and Margecany tectonic zones. The Veporic unit is composed of crystalline basement and Upper Paleozoic and Mesozoic cover formations. The relicts of various Hercynian tectonic units in recent Veporicum had a common Paleozoic development (Bezák *et al*., 1997).

The Veporic cover formations are divided into the northern Veporic and southern Veporic units (e.g., Andrusov *et al*., 1973). The northern Veporic cover sequences are represented by Upper Paleozoic clastic sediments, mainly of Permian age as well as by a Mesozoic sequence ranging from Lower Triassic to Lower Cretaceous. In lithofacies it is early identical to the Mesozoic lithology of the Fatricum with characteristic deposits of the Carpathian Keuper (Veľký bok sequences). The Upper Paleozoic lithology of the southern Veporic zones is represented by the upper Carboniferous to Permian strata of the Revúca Group (Vozárová and Vozár, 1988). The Mesozoic succession is built of Triassic strata without the presence of Carpathian Keuper in the Foederata sequence. The strong metamorphic overprint is a characteristic feature of these sequences.

The NE-trending fault systems divide the Veporicum Unit into parallel tectonic belts (Zoubek, 1957). The internal structure of the crystalline basement is complicated as it involves several lithotectonic units. There are units of granitoids with highly-metamorphosed rocks, as well as units of weakly-metamorphosed Early Paleozoic rocks. 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 tectonism. A number of local units were defined in the Veporic and Tatric crystallines, yet their tectonic-metamorphic history and analysis of deep structure allow the distinction of four major Hercynian lithotectonic units (Bezák *et al*., 1997).

The **Gemericum** is a Palaeoalpine tectonic unit overthrust on the Veporicum. It comprises fragments of Hercynian tectonic units (Ochtiná, Klátov, Rakovec, Gelnica and Štós units) and Carboniferous, Permian and Triassic cover formations.

Mesozoic sequences are rarely present in Gemericum. The cover formations are represented by: the Kobeliarovo group (Early to Middle Triassic), the Gočaltovo group (Permian–Early Triassic), the Krompachy group (Permian–?Early Triassic) and the Dobšiná group (late Carboniferous).

The lower Carboniferous (Mississippian) Ochtiná tectonic unit outcrops in the northern part of Gemericum. It is built of a flysch sequence of coarse- to fine-grained deposits associated with metabasalts and their metavolcanoclastics. The biostratigraphically confirmed age of this sequence is Tournaisian–Visean. Upwards this rock sequence gradually passes into shallow-water pelitic-carbonatic facies with organodetritic carbonates replaced by magnesites. The basalts show similarities to E-MORB basalts with moderate affinities to island-arc basalts (Ivan *et al*., 1992). This also suggests interpretation of these lower Carboniferous basins as remnant basins floored by oceanic crust of back-arc type.

The Klátov tectonic unit is located in the northern part of Gemericum. It is built up of rocks of a gneiss-amphibolite complex of high-grade metamorphism, being defined as a separate tectonic unit (Spišiak *et al*., 1985).

The Rakovec tectonic unit outcrops in the northern part of Gemericum. It is built up of thick piles of basic metavolcanics (Bajaník *et al*., 1981). Only small amounts of pelitic metasediments are associated with the metavolcanics. Most of the metasediments and metavolcanics contain mineral assemblages corresponding to P–T conditions of low-pressure greenschist facies, while relics of high-pressure metamorphisme are present also (Faryad, 1997). The Rakovec unit represents a strongly compressionally destroyed relict of an island arc initiated on oceanic crust of back-arc basin type (Ivan *et al*., 1992).

The Gelnica tectonic unit outcrops in the southern zone of Gemericum. Thick Lower Paleozoic volcanogenic flysch sequences are genetically related to the development of a magmatic arc on an active continental margin (Vozárová, 1993). Despite this, it is not an immediate part of the magmatic arc because higher temperature facies of low pressure metamorphism are not present. Typological analysis of zircons from metasandstones of the Gelnica Group confirmed crustal and crustal-mantle magmatic sources, which supports the relation of synsedimentary volcanism to subduction. The supposed age of the sedimentary sequences of the Gelnica unit is upper Cambrian to Lower Devonian. A different genetic interpretation of the Gelnica tectonic unit favours a model of rifting on continental crust caused by the convectional heat flow (Grecula, 1982).

The Štós tectonic unit is located in the southern part of Gemericum. We infer a tectonic contact between the Štós and

Gelnica units. Because both units overlap with Permian continental deposits of the Gočaltovo Group, this tectonic contact is interpreted to be a relict of Hercynian tectonics.

The **Zemplinicum** comprises high-grade metamorphosed crystalline complex and its Carboniferous–Permian and Mesozoic cover. Predominating rocks in the crystalline complex are paragneisses, amphibolites and migmatites; their mineral associations indicate P–T conditions of higher-grade amphibolite facies (e.g., Vozárová, 1991). The Upper Paleozoic deposits of the Zemplinicum have their peculiarities in comparison with nother units of the Western Carpathians. The post-orogenic Hercynian sequence starts with Stephanian continental deposits having several limno-fluvial coal cyclothems.

The Zemplinicum tectonic unit became a part of Inner Western Carpathian block only during the youngest Neogene phases of tectonic development. Its former competence is not known. It may be a part of the southernmore units with a Cadomian basement.

PALAEOALPINE SUPERFICIAL NAPPES

The **Fatricum** represents a system of near-surface nappes overlying the Tatricum. It consists of Permian and Mesozoic sequences, locally with relics of crystalline basement. The designation Fatricum to this tectonic unit was given by Andrusov *et al*. (1973). In the Fatricum, we have distinguished formations at Jurassic and Lower Cretaceous deep-water deposits, being represented by the Zliechov sequence, as well as formations of Jurassic and Lower Cretaceous shallow-water strata (Vysoká, Belá, Il'anová sequences), outcropping in several partial nappes. In both areas defined Lower Triassic sedimentation is represented by clastics of the Lúžna Formation.

The **Hronicum** represents a complicated tectonic unit – the system of nappes in the outlier of the Tatricum, Fatricum and Veporicum. It is characterized by Carboniferous and Permian sedimentary-volcanic sequences and Triassic deposits, mostly carbonates, and only locally preserved Jurassic formations. The designation Hronicum was introduced by Andrusov *et al.* (1973) during redefinition of the large tectonic units of the Inner Western Carpathians. The Triassic is characterized by two facies – a monotonous dolomite (Čierny Váh sequence) and a stratigraphically differentiated (Biely Váh sequence), which is part of two partial nappes. However, the assumed relationship of the facies to the partial nappes generally is not valid (e.g., Mahel', 1986) and therefore we understand the Hronicum as a system of piled up partial nappes and slices.

A different palaeogeographic interpretation of the Hronicum in the Middle and partially also in Upper Triassic was suggested by Havrila (e.g., Bezák *et al*., 2004). According to this, sedimentary sequences of the Hronicum are interpreted as representing carbonatic platforms and intraplatform basins, subsequently incorporated into partial nappes of Hronicum.

The **Meliaticum** consists of Triassic-Jurassic metamorphosed sedimentary and volcanic rocks formed on oceanic crust. It includes rocks derived from the Meliatic oceanic trough of Triassic-Jurassic Tethys between the shelf of Europe and Apulia. The trough originated between the Pelsonian and the Carnian and ceased being active during collision in the Late Jurassic (Oxfordian). At the time of its strongest expansion it reached, according to various assumptions, of width of 800–1000 km and a depth probably several thousand metres. Its location is still a matter of discussion.

The tectonic inlier of the Meliaticum is either unknown or the Meliaticum is overthrust onto the Gemericum or even onto the Veporicum. An outlier of the Meliaticum is represented by the Turnaicum or Silicicum. The characteristic feature of the Meliaticum is the presence of deep-water deposits (pelagic, usually radiolarian limestones, radiolarites, siliceous pelites and turbidites, mainly of Jurassic age). Sedimentation during active rifting was accompanied by submarine volcanic activity (basic and ultrabasic rocks of an ophiolitic suite). In the pre-collisional phase turbidites were typically deposited and there originated also extensive olistostromes with blocks of thickness up to several hundreds metres (Mello *et al*., 1996). Their characteristic sign is an Alpine medium- to high-pressure metamorphism (e.g., Mazzoli *et al*., 1992).

The **Turnaicum** is an Upper Paleozoic-Jurassic metamorphosed tectonic unit deposited on a continental crust. This unit includes a system of nappes, of lithostratigraphic content corresponding to an original position between the sedimentary zones of the Meliaticum and the Silicicum. In the Mid and Later Triassic, continental slope facies prevailed. Jurassic rocks are to those in the Meliaticum. In the basal part, continental Permian and middle Carboniferous flysch sequences are preserved (Vozárová and Vozár, 1992). The characteristic feature of the Turnaicum is the metamorphic overprint of formations (mostly in anchizonal to greenschists facies conditions).

The **Silicicum** represents an upper Permian-Jurassic unmetamorphosed tectonic unit deposited on continental crust. The Silica Nappe was defined by Kozur and Mock (1973) after confirming the Triassic age of the Meliata succession.

The Silicicum is a horizontal or subhorizontal nappe body consisting of sedimentary (and scarce volcanic) rocks of age ranging from uppermost Permian to Upper Jurassic. This extended body was segmented during or after overthrusting into several partial structures and blocks. The strongly disturbed parts have been removed by erosion and denudation, so the Silicicum as an uppermost known tectonic unit of the Inner Western Carpathians is preserved only in isolated tectonic structures, e.g. in the Slovak Karst, Slovak Paradise, Galmus, Muráň plain and in the surroundings of Banská Bystrica town. The Jurassic successions, but to a large extent also the Upper Triassic ones, are preserved only locally. Of largest extent are Middle and Upper Triassic strata.

SEDIMENTARY FORMATIONS SUPERIMPOSED ON THE NAPPE STRUCTURES

UPPER CRETACEOUS AND PALEOGENE STRATA

The Upper Cretaceous (Senonian) strata belong to the Gosau Group. They were deposited after the main phase of displacement of the Inner Carpathian nappes and overlaid them transgressively. Superficially they outcrop mainly in the Brezovské Karpaty Mts. and in the Myjavská pahorkatina upland. In the innermost zones of the Western Carpathians, the Senonian deposits are known only in a few occurrences, being included into the Gosau Group in the Upper Hron Valley near

Šumiac and near the Dobšiná Ice Cave. Small outcrops of Upper Cretaceous strata are known also from the area of the Slovak Karst Mts.

The Inner Carpathian Paleogene strata (mostly Eocene to Oligocene, locally Miocene), which discordantly overlap the Pre-Tertiary Inner Western Carpathian units, are represented by flysch deposits of the Podtatranska Group and the Myjava–Hričov Group and are retained within the Inner Carpathian morphostructures (Turiec, Liptov, Upper Nitra, Zvolen, Bánovce basins and Horehronské podolie), as well as north of the zone of core mountains (mainly in the Žilina, Rajec, Poprad and Hornád basins, the Oravská vrchovina Mts., the Skorušinské vrchy Mts., the Levočské vrchy Mts. and the Spišská Magura Mts.), locally are exposed in the erosional windows from below the Central Neovolcanites (Štiavnica Hills).

The strata of the Buda Basin (Paleogene–Egerian) encroach onto the territory of Slovakia from the south to the area of Štúrovo, and also from the fill of the Ipeľ, Lučenec and Rimava Basins in the Cerová Highlands and the Turňa Basin.

NEOGENE AND QUATERNARY VOLCANICS

In the Neogene period the Carpathians represented an island arc, with a microcontinent of the Inner Western Carpathians, which migrated to the NNE to E. As a result of oceanic or suboceanic crustal subduction of the flysch basins this microcontinent gradually collided with the passive margin of the European Platform. Arc retreat in the above direction was compensated by back-arc extension, which included diapiric upwelling of the asthenosphere and a lateral escape of the lithosphere from the collision zone of the Alps (Csontos *et al*., 1992; Lexa and Konečný, 1998).

The magmatic material originating from partial melting of metasomatically affected mantle (after the previous subduction of the crust of the Magura–Pieniny Flysch Basin), with succeeding diapiric upwelling in conditions of back-arc extension provided the sources for andesite volcanism in Central Slovakia (Lexa and Konečný, *op. cit*.). The andesite volcanism in Central Slovakia lasted from the lower Badenian until the Pannonian and resulted in the emergence of the Central Slovakian Neovolcanic Field covering an area of approximately 5000 km^2. The andesite volcanism was preceded by acid rhyodacite-rhyolite volcanism. Its sources were magma masses generated by crustal material melting due to diapiric upwelling of the asthenosphere. The centres of this volcanic activity, situated within the Pannonian Basin in Northern Hungary, produced large volumes of pyroclastic ash-pumice material which was deposited in Southern and Eastern Slovakia in marine deposits of the Eggenburgian, Karpathian and lower Badenian age.

The basalt-andesite to andesite volcanism of island arc type was active in the late Badenian to mid Sarmatian in East Slovakian basin and is characteristic of intensive volcanic activity tied to fault systems at the margins of a basin. This volcanic activity resulted in the origin of the volcanic mountains of the Slanské vrchy and Vihorlat Mts. having a distinct linear arrangement of andesite stratovolcanoes.

The alkaline basalt volcanism, active during the Pannonian, Pliocene and Pleistocene, represents the final stage of volcanic activity in Slovakia.

NEOGENE AND QUATERNARY STRATA

Neogene strata were deposited in tectonic basins. Decisive tectonic factors for the emergence of the Western Carpathians Neogene basins were:

– Subduction in the Outer Carpathians, which culminated in the collision of the North European and Carpathian-Pannonian lithospheric plates and faded gradually during the Neogene from W to E.
– The upwelling of the asthenosphere in the Pannonian region (Pannonian asthenolith).
– Alpine collision of the Apulian promontory of the Afro-Arabian lithospheric plate with the Bohemian Massif, or with the North European lithospheric plate.

According to these genetic factors the Neogene basins can be divided into post-collision depressions and the collision or pre-collision basins and depressions (Vass in Bezák *et al*., 2004). In Slovakia these are the Vienna, Danube and Eastern Slovakian basins and the Miocene Southern Slovakia Basin. Besides these Neogene deposits fill intermontane basins.

The Quaternary fill in the general map is displayed only in the lowlands, where it constitutes greater accumulations around the larger rivers; some other important deposits are also shown (aeolian, fluvio-glacial).

CONCLUSIONS

The new general geological map of the Slovak Republic at 1:200 000 scale encompasses a synthesis of up-to-date knowledge of the geological setting of Slovakia, arrived at since the first edition geological maps at 1:200 000 scale in the 1960's.

The new geological 1:200 000 map is a synthesis of work by almost two generations of Slovakian geologists. There is a necessity of continued research and geological mapping, especially in such an extremely geologically and morphologically complex area as the Western Carpathians. A number of continuing problems among different regional maps brought difficulties in the compilation of the 1:200 000 geological maps.

Each map is only a subjective model, needing continued refinement by ongoing geological mapping.

The general 1:200 000 maps are significant because they enable a view of the geological setting over the entire territory. For this purpose, the 1:50 000 scale is too large, not enabling correlations and showing too much detail. On the other hand a map of smaller scale, for instance 1:500 000, has limitations in what it can depict.

Maps at 1:200 000 scale have been compiled in many European countries. They are convenient for scientific syntheses and for applied geology information. These maps may be used to correlate geological structures with those of neighbouring countries and for wider international geological correlations, particularly in the Alpine-Carpathian mountain system.

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