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Lithological formations in the regional engineering geological rock classification

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Abstract. In the half of the previous century the regional engineering geological classification of rocks in Slovakia identified 10 lithological formations, 8 subformations and 75 lithological lithological complexes. Recent research has called for certain modifications of names, stratigraphic and spatial extent of some formations and subformations, and, mainly the number of lithological complexes defined within individual formations. The contribution deals with the issue and it gives suggestions for some modifications, mainly at the formation and subformation level. In the future, it will be inevitable to compile a revised engineering geological classification of rocks in Slovakia, in which all lithostratigraphic units depicted in recent editions of regional geological maps would be attributed to individual lithological formations.

Key words: lithological formations, Western Carpathians, regional engineering geology

Introduction

In the engineering geological rock classification we used two basic classification types. Detailed classifications are used at the rock environment characterization in the project stage in civil engineering. These classifications distinguish rock massif bodies of a high degree of physical properties homogeneity. These entities are of a rather small extent and generally, there is not possible to depict them in maps. Regional engineering geological classifications are used for purposes of larger rock environment volumes delineation, which reflects their tectonic development, rock origin and lithological character and at the same time a certain degree of homogeneity of those properties of rocks, which are significant from the engineering geological point of view.

In the second half of the previous century a four-level classification of rocks has been adopted in the countries of Central and Eastern Europe, later also in the scope of the International Association of Engineering Geology (IAEG), to meet requirements of engineering geological mapping. This classification has distinguished the following hierarchically arranged lithological units: lithological formation, lithological complex (LC), lithological type and engineering geological type (IAEG-UNESCO, 1976). The criteria applied in this classification, as well as lithological and engineering geological significance of delimited rock units presents Table 1. There are several countries (Slovakia included), which have established also another rock unit - lithological set, located between lithological complex and lithological type. It has enabled to distinguish also lithologically differing parts of lithological complexes, according to their facies development (for instance within the fluvial complex lithological set of flood-plain deposits, which is typical by irregular alternation of sandy and loamy-clayey sediments). Matula (1969) applied the classification system for the territory of the Western Carpathians. Within the first two lithological units he distinguished 10 formations, 8 subformations and 75 lithological complexes. Whereas the lithological complexes delineation has witnessed considerable changes, the lithological formations remained unchanged regarding their number and name. Based upon recent research their lithological content has been partially changed, together with their stratigraphic and space extent.

Lithological Formation Definition

The main factor, which controls petrogenetic processes and structural arrangement of rocks is the geotectonic evolution of a territory. Regarding sedimentary rocks a significant role playalso paleogeographic conditions. These factors are decisive in activation of formation's origin conditions as well as its lithological content. The advance in the knowledge about formations within the engineering geology was developed mainly by the half of the previous century. Among the foreign authors, who significantly influenced the Slovak engineering geological science, we have to mention Belousov (1954) and Popov (1957, 1961, 1965). However, the term formation was at the same time used in regional and tectonic geology. Andrusov, Maheľ and many others used it in their works. Nowadays, the term is frequently used abroad, mainly in USA and Canada. In Slovakia, the term formation has been abandoned with only exception of volcanology, by the end of the previous century. This was influenced mainly by non-equivocal opinions, how to define it, as well as by problems in translation of the term from English, while the term formation has been translated as lithological suite, series of strata, or formation.

Some older studies understood under the term formation only its stratigraphic meaning, which has been re-

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Tab. 1. Definition and content of rock units identified in the regional engineering geological classification.

Rock unit	Definition	Geological-lithological meaning	Engineering geological meaning
Lithological formation	Paragenetically associated lithological complexes, which petrogenesis and physical properties forming was conditioned by mutual geotectonic and paleogeographic evolution	Occurrence of certain lithologic rock complexes in certain spatial (superposition, mode of alternation) and proportion (prevailing complexes and their characteristic thicknesses) arrangement	Stratigraphic-lithologic model of the rock environment, which enables to determine its lithologic variability and susceptibility to geodynamic phenomena
Lithological complex	Set of rock lithological types of the same genesis, which was formed in certain part of a lithological formation, in different petrogenetic evolution conditions	Occurrence of certain petrographic types or their sets (facies complexes), in a certain spatial and proportion arrangement	Type model of lithologic conditions, which enables a preliminary assessment of foundation soil complexity and properties
Lithological type	The rock type of certain mineral composition, fabric and structure, which was formed within a lithological complex in relatively constant petrogenetic or lithofacies conditions	Occurrence of in certain way associated characteristic mineral grains and accessories, forming according to their quantitative portion petrographic rock types	Petrographically homogeneous rock body, which enables a rough determination of physical properties values interval and durability against exogenous agents
Engineering geological type	The rock type defined within a lithologic type of homogeneous physical state resulting from petrogenetic evolution and the same degree of tectonic and hypergenous alteration or water saturation	Petrographic rock types of the same degree of jointing, alteration and weathering, or consistency and relative density	Petrographically and physical-technical homogeneous bodies, which can be characterised by a set of statistically estimated physical properties

Tab. 2. Lithological formations and lithological complexes of the Western Carpathians[1]

Lithological formation	**Age**	**Lithological complexes**
Quaternary Cover Formation	Quaternary	fluvial, proluvial, glacial, glaciofluvial, deluvial, eolian, polygenetic, organic, chemogenous
Molasse Formation	Neogene	limnic and limnic-fluvial brackish shallow-neritic and littoral
Neovolcanites Formation	Neogene (Quaternary)	basalts and basaltoid andesites, their tuffs andesites, their tuffs and tuffites rhyolites and rhyodacites, their tuffs and tuffites
Flysch Formation	Late Cretaceous – Paleogene	prevailingly claystone-marlstone typical (rhythmic) flysch prevailingly sandstone basal – coarse-detritic
Sandstone-Marlstone-Limestone Formation	Late Triassic – Early Cretaceous	flyschoid marly-calcareous pelitomorphic limestone detritic-carbonate detritic Carpathian Keuper
Limestone-Dolomite Formation	Middle-Late Triassic	Lunz Member shales dolomites limestones and dolomitic limestones
Lower Terrigenous Formation	Late Permian – Early Triassic	variegated Werfen shales beach quartzites variegated shales with melaphyres variegated detritic Verrucano
Variscan Granitoids Formation	Early Carboniferous	leucocratic granitoids autometamorphosed granites and granodiorites syntectic (migmatitic) granitoids granodiorites to quartzose diorites granites to granodiorites (tonalites)
Epimetamorphosed Rocks Formation	Paleozoic	shales and phyllites, volcanic-carbonatic conglomerate, basic initial intrusives phyllitic, metadiabasic phyllitic, metaquartzite, porphyroid
High-Metamorphosed Rocks Formation	Algonkian-Early Paleozoic	gneissose, mica schistose, orthogneissose, migmatitic, amphibolitic, diaphtoritic gneissose, lit-par-lit gneissose

[1] Compiled based upon Matula – in Matula, Pašek, 1986

flected also in the Glossary of Geology (Svoboda et al., 1960), in which the formation is equal to the stratigraphic system. According to the Encyclopaedic Dictionary of Geological Science (Svoboda et al., 1983) the Russian authors understand under the term formation an „association of geological bodies (for instance beds) unified based upon paragenetic, genetic, stratigraphic or any other relation". The American terminology defines the formation as „the principal lithostratigraphic unit (prevailingly sedimentary, but also metamorphic or igneous), which can be mapped in the field and is used in the local nomenclature". From the above it is obvious, that the term formation comprises geotectonic, stratigraphic, genetic-lithological, as well as regional meanings, with their common interrelations. The geotectonic meaning is derived from the attribution of the formation to a certain stage of the Earth's crust evolution (within a given area), which, of course took place during certain period and thus, is of a certain stratigraphic range (usually several stages or divisions, eventually subdivisions). Genetical lithological meaning is related to the occurrence of rocks of certain genesis and lithological character. Regional aspect is usually expressed by the local formation name. Sometimes, geotectonical or lithological names of formations are used instead of local terms. The above meanings correspond to various formation names used in various countries. The terms geological formation, geotectonic formation and lithological formation can be also met in the geological literature. Whereas, in the Slovak regional geology the term formation is used only to define rock units within volcanic complexes, in the regional engineering geological nomenclature is in common use the term lithological formation.

The difference in formations delimitation between the geology and engineering geology is also in their spatial extent. In the regional geology the term formation has been adopted for rock complexes of local or smaller region extent, in the engineering geology it is applied for the whole Slovak territory (or Western Carpathians). It means they have been delineated based upon geotectonical, stratigraphical and lithological approach. In fact, the time-space extent of individual formations is not unique within the whole Slovakia territory. Therefore, the main criterion at their delineation has been geologic-tectonical and lithological development of the rock environment.

Lithological formations in the regional engineering geological classification of rocks in Slovakia

The lithological formations defined in the engineering geological classification of rocks in Slovakia (Matula, 1969) are derived from the geotectonic and facies-genetic approach, which reflected that time knowledge on the mobile parts of the Earth's crust evolution within the Western Carpathians space. The formations, their stratigraphic range and simplified lithological content are presented in the Table 2. In opposite to the former knowledge, which provided the base for the classification compilation, the opinion upon geotectonic evolution, character and extent of sedimentary basins (mainly the Paleozoic and older), sediments age and their further alterations have been changed. However, the formations delineated relatively reliably reflect the evolution of the rock environment in the Western Carpathians territory. A newly compiled Map of lithological formations (Fig.10) has included a new knowledge on the lithofacies evolution of the Western Carpathians territory, and, accordingly, the cartographic depiction of some lithological formations has been modified.

The Highly-Metamorphosed Rocks Formation

The formation (Fig.1) comprises strongly metamorphosed rocks. It has been subdivided into two subformations - according to the prevailing metamorphosis stage. The lowest row of the formation's cell in the Table 2 presents LCs of the catametamorphites subformation, the upper row LCs of the mesometamorphites subformation. The LCs of the middle row occur in both subformations. A typical feature of both subformations is a relative high uniaxial strength and low deformability, as well as good durability against exogenous agents action. However, some rocks of the mesometamorphites subformation show a relatively higher level of physical-mechanical anisotropy. This is valid for strongly schistose rocks, like mica schists, diaphtorised gneisses and mica schists and phyllonites, which are usually ranked among semisolid rocks group.

Fig. 1. Distribution of the Highly Metamorphosed Rocks Formation.

According to the former opinion the rocks of the formation had been formed in the Proterozoic and than they were folded and regionally metamorphosed (during Assynthian and Caledonian orogeny), but the newer opinions have brought doubts about their Proterozoic age as well as the age of their metamorphosis. According to the present knowledge the lowermost rock complexes were metamorphosed during the Early-Variscan, eventually Caledonian orogenesis phase and the metamorphosis of the upper parts was linked with granitoid magmatic activity during the Late-Variscan orogenesis (Nemčok et al., 1993). Several lithological complexes have been termed differently. The formation's rocks are the oldest and the most metamorphosed rocks in the territory of Slovakia with consequences to the engineering geological character, which has been specified by its subdivision into two subformations and several lithological complexes.

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The Epimetamorphic Rocks Formation

The formation (Fig. 2) occurs mainly in the Spišsko-gemerské rudohorie Mts. It comprises the Paleozoic, prevailingly epimetamorphosed rock complexes of schists, carbonates, tuffs and tuffites, quartzites, sandstones and conglomerates, phyllites, porphyroides, diorites and gabbros. The formation is divided into three subformations:

- subformation of Caledonian epimetamorphites (Cambrian-Silurian),
- subformation of Early-Hercynian epimetamorphites (Devonian),
- subformation of Late-Hercynian epimetamorphites (Late Carboniferous-Early Permian).

Fig. 2. Distribution of the Epimetamorphosed Rocks Formation.

The subformations correspond to three stages of geotectonical evolution of the Western Carpathians during the Paleozoic. The lithological complex of the oldest subformations have been attributed to the Gelnica Group, the Devonian subformation to the Raková and Harmónia Groups and the youngest subformation to the Ľubeník Group. Recently, mainly in the Veporicum and Hronicum, there have been numerous other groups distinguished: Revúca, Dobšiná, Črmeľ and the other groups (Bajaník, Vozárová et al., 1983), which contain the Paleozoic complexes in partially different lithological facies. Locally, the LCs of the formation have different spatial range than in previous delimitations. In spite of that, the fundamental engineering geological characteristic of the formation's rocks has remained the same. Prevailing are the low-metamorphosed rocks of the metamorphosed schists and phyllites types with a high level of physical-mechanical anisotropy. We rank them among semisolid rocks (the uniaxial compressive strength below 50 MPa), with relatively high compressibility and a low durability against exogenous agents. The other rock types with a lesser extent, mainly the magmatic and carbonate ones show relatively better engineering geological properties and they have been utilised for various purposes.

The Variscan Granitoids Formation

The formation (Fig. 3) occurs mainly in the central parts of the Core Mountains. Lithological complexes given in the Table 2 have been slightly modified, based upon the newest regional geological research; eventually their names have been changed. For instance, the so-called syntectic (migmatitic) granitoids are termed at present as the hybrid granitoids, complex of granodiorites to siliceous diorites have been subdivided into two complexes, in some mountain ranges the tonalites have been distinguished, etc. The definition and the stratigraphic range of the formation have not been changed, yet. Regarding an equal lithological and engineering geological character of rocks, into the formation have been integrated also the granitoid rock of uncertain stratigraphic range (Cretaceous?), which crop out mainly at the contact of the Veporicum and Gemericum in the Slovenské rudohorie Mts. The sound granitoid rocks of the Western Carpathians (with the exceptions of autometamorphosed and kineticly metamorphosed granitoids) show convenient engineering geological properties. However, they are frequently tectonically disrupted: fragmented into blocks, intensely jointed and mylonitized, which significantly decrease their utilisation possibilities.

Fig. 3. Distribution of the Variscan Granitoids Formation.

The Lower Terrigenous Formation

The formation (Fig. 4) is made of rocks ranging from the Late Permian to Early Triassic. According to Matula (in Matula and Pašek, 1986) it represents the opening phase of the Carpathian geosyncline evolution. However, defined lithological complexes present in the Table 2 don't represent all zones. The Veporicum and Gemericum units frequently differ in their Late Permian and Early Triassic evolution, which is reflected by several sequences. For instance, the sediments of so-called Verrucano comprise schists and carbonates (the Meliaticum Group) or sandstone-schistose beds (the Silica nappe), in the Gočaltov Group there are no quartzites and the uppermost horizon of the Early Triassic is of distinctly different facies from the Werfen Schists. A variable geotectonic and paleogeographic evolution within various parts of the territory is documented also by rauhwackes and evaporites occurrences, which at places occur at the bottom Triassic horizon (for instance in the Stratená Group), at other places at the contact of the Early/Middle Triassic (for instance the Meliata Group). This variegated spatially differentiated lithological character of the rock environment reflects complicated geotectonic and paleogeographic evolution during the sedimentary space forming, which had taken place on the Paleozoic/Mesozoic contact. The name and stratigraphic range of the forma-

tions are, in our opinion, correct. The future will put the stress upon definition of the lithological complexes in the way they would cover every lithofacies.

Fig. 4. Distribution of the Lower Terrigeneous Formation

The Limestone-Dolomite Formation

The formation (Fig. 5) represents a typical facies of the Carpathian Triassic, comprising limestones, dolomitic limestones and dolomites, locally intercalated by shales. A significant position is given to the Lunz Member (Carnian) with dark pelitic-aleuritic shales, which in the Hronicum unite and partially also in the Silicicum unit divide the Middle- and Late-Triassic dolomites (though, they are not present in the Silica nappe). A different facies has been documented in the Stratená Group, in which the shales contain also the layers of dark, at places cherty limestones. The Meliata Group contains in addition also grey and red silicites, metabasalts and their tuffs. Their superincumbent is formed of limestones (Norian), not the dolomites. In the Tatricum and Fatricum the Lunz Member is overlain by the Carpathian Keuper, which in the valid engineering geological classification belongs to another formation. The delineation of the carbonate Triassic within individual formation is substantiated by the fact, that the formation characterizes a particular epoch of a geotectonic evolution, linked with deepening of the sedimentary space and with change in paleogeographic conditions, as well as with a different lithofacies of the bottom and above formations. Thanks to its specific rock properties the relief, hydrogeological conditions and specific geodynamic phenomena distinctly manifest the formation.

Fig. 5. Distribution of the Limestone-Dolomite Formation.

The Sandstone-Marlstone-Limestone Formation

As a consequence of a gradual shallowing of the sedimentary space the sedimentation of the formation's rock complexes (Fig. 6) started in its northerly parts (Tatricum, Fatricum) in the Carnian, whereas in its southern parts in the Norian (with only exception of the Gemericum, in which carbonate facies sedimentation was continuing). While the Carpathian Keuper represents a variegated terrestrial to lagoon facies, at the beginning of the Liassic shallow-marine facies started to dominate, which is documented by the contribution of detritic material. Typical representatives are detritic and crinoidal limestones, sandstones and quartzites, locally also shales (Gresten Member). During the Later Liassic (occasionally even to the Doggerian) a similar sedimentation was continuing. In the case of the sea deepening eventually spotted marlstones and marly limestones or marly shales originated. During the Doggerian and Malmian pelitomorphic limestone complex was deposited with typical muddy, radiolarian, cherty and nodular limestones deposition. By the end of the Jurassic and at the beginning of the Cretaceous this type of sedimentation continued, forming suites of marly limestones and marlstones, with intercalations of calcareous sandstones. The Albian and Cenomanian, partly also the Turonian, are characteristic by deposition of flyschoid sandstone-marlstone sequences intercalated with limestones, with conglomerate facies at the bottom, which indicates transgression related to the Austrian orogeny phase. With these sequences the Middle Cretaceous formation evolution was closed.

Fig. 6. Distribution of the Sandstone-Marlstone-Limestone Formation.

On the Middle Cretaceous/Late Cretaceous boundary the Central Western Carpathians were folded within the Mediterranean orogeny phase and the Late Cretaceous (with only tiny occurrences) was transgressively deposited upon the Middle Cretaceous sediments. Its greater extent has been documented in the Klippen Belt, in which the flyschoid sediments containing beds of Upohlav Conglomerate overlie the Turonian sediments. Thus, the Late Cretaceous of the Western Carpathians has been ranked to the Flysch Formation.

The Flysch Formation

The Flysch Formation (Fig. 7) in the external zone of the Western Carpathians developed gradually from the

Late Cretaceous up to the Oligocene. In the internal zone it developed transgressively in the Eocene. In the Klippen Belt with the Late Cretaceous belonging to the Flysch Formation, the Paleogene invaded the sedimentary space discordantly (after the Laramide orogeny phase). Locally it began in the Paleocene, at places also in the Eocene. The above differences were closely connected with the tectonic evolution of the Western Carpathians in the period from the Mediterranean till Savian orogeny phases. The lithological content of the formation is variable due to differing facies evolution in various parts of the tectonically modified sedimentary spaces. However, it is possible to distinguish within it four types of lithological complexes (see the Table 2). The formation involves sediments of the Flysch zone and Klippen Belt, as well as the sediments of the Inner Carpathian Paleogene. In the first two zones the sediments are intensely folded with nappe structure, the sediments of the Inner Carpathian Paleogene are disturbed only by the germanotype tectonic style and only partially folded. This difference, which is manifested also by tectonic disintegration of rocks, is reflected in the engineering geological territorial zoning. In the region of the Carpathian Flysch there are distinguished subregions of the Outer Flysch Carpathians, the Klippen Belt and the Inner Flysch Carpathians.

Fig. 7. Distribution of the Flysch Formation.

The Neovolcanites Formation

The formation (Fig. 8) comprises all effusive and volcanoclastic rocks of the Cainozoic age. Their stratigraphic range within the Western Carpathians is from the Eggenburgian till Quaternary (with interruptions). The Slovak territory witnessed the most intense volcanic activity during the Badenian and Sarmatian. Besides the lithological complexes, which we present in the Table 2, we distinguish also coarse-porphyric andesites and their tuffs – these rocks show distinctly different engineering geological properties. The fundamental role in the volcanites properties played various post-genetical processes: autometamorphosis, hydrothermal alterations, propylitization, tectonic disruption and weathering. We distinguish within the rock massifs such zones in form of particular complexes; alternatively they are highlighted by proper symbols. The effusive rocks are ranked among solid rocks; the volcanoclastic and intensely propylitized rocks belong to the semisolid rocks, prevailingly. In opposite to the previous formations, which occur within the whole Carpathian Arc, the Neovolcanites Formation crops out only in the Central and Eastern Slovakia and partially also the Southern Slovakia.

Fig. 8. Distribution of the Neovolcanites Formation.

The Molasse Formation

The formation (Fig. 9) occurs in the Foredeep, in the Vienna, Danube, South Slovakia and East Slovakia basins and in majority of the intramountain depressions (Vass et al., 1998). In the area of Foredeep its deposition started in the Egerian, in the area of the South Slovakia (excluding the Cerová vrchovina Upland) in the Kiscelian, in other parts of the Western Carpathians in the Eggenburgian. Its deposition in the Carpathian Foredeep territory lasted till the Early Badenian, in the South Slovakia and along the margins of the Danube Basin till the Pannonian, in other territories as a rule till the Rumanian, at places only till the Sarmatian. During the Pliocene the deposition in some sections of the Carpathian Foredeep was renewed (Seneš in Andrusov and Samuel et al., 1983). Due to tectonic differentiated activity individual Neogene stages have different lithological facies. At places they started with sea-transgression, at other places they continue without any interruption from the below stage. The lithological complexes of the formation presented in the Table 2, which have been distinguished in the regional engineering geological classification of Slovak rocks, correspond to three subformations (s): the Miocene marine sediments s., the Miocene brackish (transitional) sediments s., and the Pliocene lacustrine-fluvial sediments s. Based upon the recent knowledge on the facies evolution of the Neogene sediments it would be convenient to abandon the names of the divisions (Miocene, Pliocene), because the lacustrine-fluvial subformation was deposited in the Badenian, Sarmatian and Pannonian (except of the Vienna Basin and the central parts of the Podunajská nížina Lowland) and the transitional (brackish) sediments occur in variable stratigraphic position (ib.). Regarding the above facts it would be suitable to rename the lowest subformation to the subformation of marine and brackish sediments and to single out the brackish sediments subformation only for the territory of the Vienna Basin and the central part of the Podunajská nížina Lowland. The lithological content of the marine and brackish involves gravelly-sandy, conglomerate-sandstone and clayey-silty (frequently marly) sediments; the subformation of the brackish sediments is made of gravelly-sandy, clayey-silty and

MAP OF LITHOLOGICAL FORMATIONS

for purposes of regional engineering geological assessment of the territory of Slovakia

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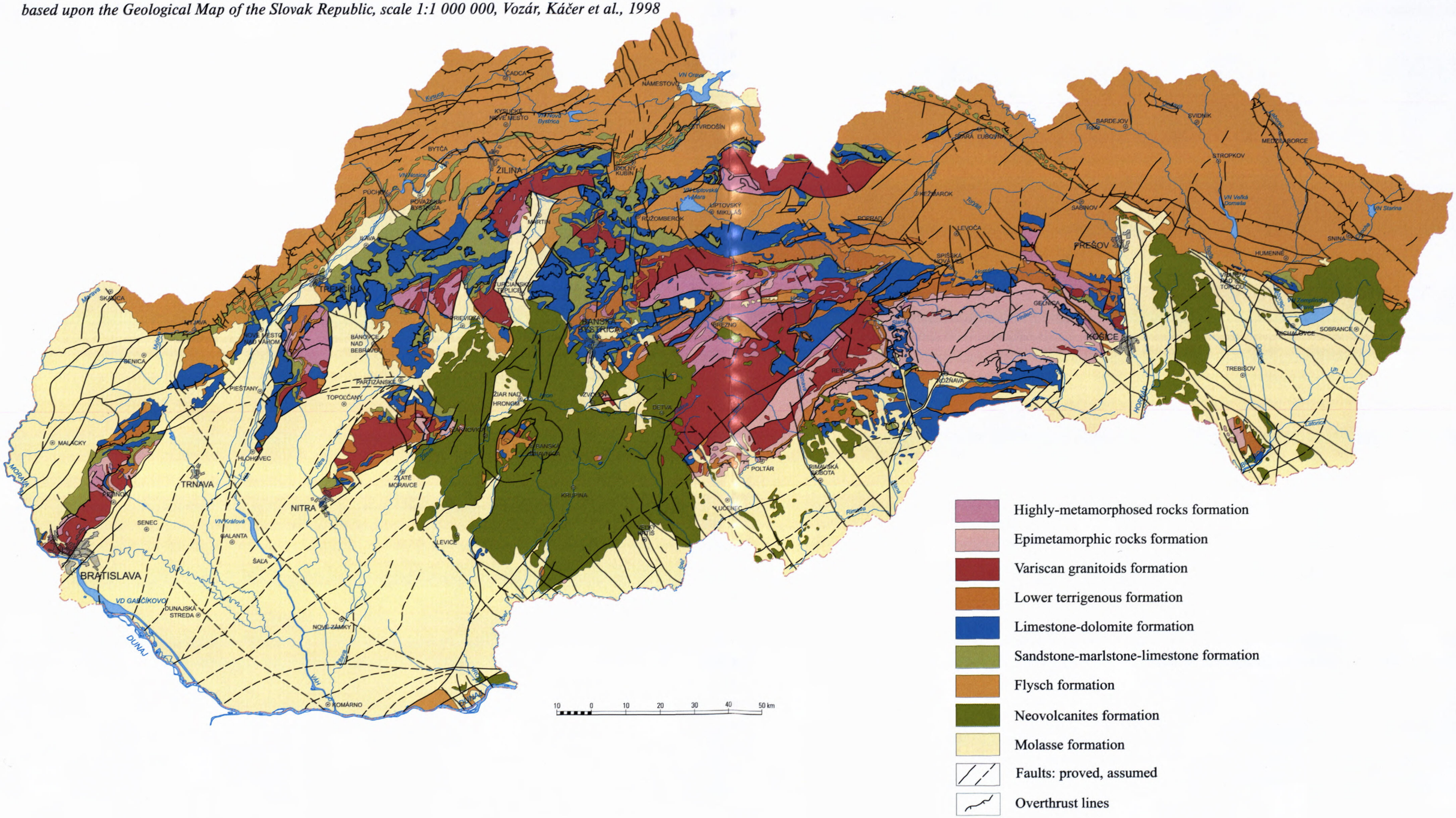
based upon the Geological Map of the Slovak Republic, scale 1:1 000 000, Vozár, Káčer et al., 1998



- Highly-metamorphosed rocks formation
- Epimetamorphic rocks formation
- Variscan granitoids formation
- Lower terrigenous formation
- Limestone-dolomite formation
- Sandstone-marlstone-limestone formation
- Flysch formation
- Neovolcanites formation
- Molasse formation
- Faults: proved, assumed
- Overthrust lines

tuffaceous clayey-silty sediments; the lacustrine-fluvial subformation is composed of gravelly-sandy and clayey-sandy sediments with sandy layers. In several depressions the Badenian sediments of the latter subformation are of volcanic-limnic facies, containing carbonate conglomerates at the base (e. g. the Budiš Formation). The younger lacustrine-fluvial sediments are characterised by a lower relative density degree, or consistency when comparing with marine and brackish sediments.

Fig. 9. Distribution of the Molasse Formation.

The Quaternary Cover Formation

The Quaternary of the Western Carpathians represents a particular evolutionary stage, which is typical for continental facies of irregular spatial distribution. The largest extent and thickness have developed in the lowlands and depressions, in opposite to high mountains. The largest thicknesses (reaching several tens of metres, even above 100 m) have been documented in the Quaternary tectonic depressions of the Záhorská, Podunajská and Východoslovenská nížina lowlands and the Liptovská kotlina Basin. The fill of these depressions consists of deluvial, proluvial, eolian, fluvial and glaciofluvial deposits. In ordinary development the largest thicknesses have been observed in glacial, deluvial, eolian, fluvial and glaciofluvial sediments (usually up to 20 to 30 m). The physical-mechanical properties of the Quaternary sediments (of the same genesis and type) vary depending upon the age, position, hydrogeologic conditions and geodynamic phenomena (slope failures, collapsibility, suffosion, volume changes, etc.). Concerning usually small extent of the formation outcrops, as well as the fact, that in some areas of its greater extent it would overlap older formations or their borders, the formation is not depicted in the Fig.10. The lithological complexes of the Quaternary Cover Formation are presented in the Map of Engineering Geological Zoning 1:500 000 published in the Landscape Atlas SR (Hrašna and Klukanová, 2002).

Conclusions

The lithological formations in the engineering geological classification of the rocks of Slovakia were distinguished based upon geotectonical and genetical-facies principles, which reflected the former knowledge from the half of the previous century. While the geotectonical approach, which reflects the main evolution stages of the Western Carpathians geological setting, can be considered as the correct one, the knowledge on the geological complexes facies, or their stratigraphic range and spatial distribution has been considerably shifted in some regions, when comparing with former interpretations. The presented Map of Lithological Formations of Slovakia (Fig.10), which was constructed based upon the Geological Map of Slovakia at 1:1 000 000 scale (Vozár and Káčer et al., 1998) has taken into account the spatial distribution of individual formations reflecting the recent knowledge. However, the scale of the map did not allow depicting some of their smaller occurrences. In the future it will be inevitable to construct more detailed maps, which would comprise all relevant stratigraphic-lithological units attributed to individual formations. The first step towards this goal might be the updating of the regional engineering geological classification of rocks at the level formation-subformation, in which these formations would comprise every lithostratigraphic units, which have been identified in the Geological Map of the Slovak Republic 1:500 000 (Biely et al.,1996).

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References

Andrusov, D., Samuel, O. et al: Stratigrafický slovník Západných Karpát. GÚDŠ, Bratislava, 1983.

Bajaník, Š., Vozárová, A. et al.: Vysvetlivky ku geologickej mape Slovenského rudohoria 1:50 000, východná časť. GÚDŠ Bratislava, 1983.

Belousov, V.,V.: Osnovnyje voprosy geotektoniki. Geol. izd. Moskva, 1954.

Biely, A. et al.: Geologická mapa Slovenskej republiky 1:500 000. MŽP SR – Geologická služba SR, 1996.

Hrašna, M. & Klukanová, A.: Inžinierskogeologická rajonizácia (mapa mierky 1:500 000). Atlas krajiny SR, sekcia 4, mapa č.13, MŽP SR, 2002.

IAEG, UNESCO: Engineering geological maps. A guide to their preparation. The UNESCO Press, Paris, 1976.

Matula, M.: Regional Engineering Geology of Czechoslovak Carpathians. Vyd. SAV, Bratislava, 1969.

Matula, M. & Pašek, J.: Regionálna inžinierska geológia ČSSR. ALFA Bratislava a SNTL Praha, 1986.

Nemčok, J. et al.: Vysvetlivky ku geologickej mape Tatier 1:50 000. GÚDŠ Bratislava, 1993.

Popov, I., V.: Teoretičeskije osnovy inženerno-geologičeskoj klassifikacii porod. Trudy Laboratorii gidrogeologičeskich problem. T. XIV, Moskva, 1957.

Popov, I., V.: Inženernaja geologija SSSR, I, II. Izd. Mosk. Univ., Moskva 1961, 1965.

Svoboda, J. F. et al.: Naučný geologický slovník. NČSAV, Praha, 1960

Vass, D. et al.: Vysvetlivky k mape Regionálne geologické členenie Západných Karpát a severných výbežkov panónskej panvy na území ČSSR 1:500 000. GÚDŠ Bratislava, 1988.

Vozár, J. & Káčer, Š. et al.: Geologická mapa Slovenskej republiky 1 : 1 000 000. MŽP SR – Geologická služba SR, 1998.