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REVIEW

PRE-UPPER CARBONIFEROUS WESTERN CARPATHIAN LITHOSTRATIGRAPHIC UNITS: SYSTEMATICS AND CORRELATION

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Abstract: A review and systematics of the Western Carpathians pre-Upper Carboniferous units is presented. The principal lithologies of individual units are characterized in the context of their metamorphic history. An attempt to correlate them with the newly proposed division is given.

Key words: Western Carpathians, pre-Upper Carboniferous units, systematics and correlation.

Introduction

The period of compilation of the 1:200,000 geological map of the territory of the state in the second half of the 1950s meant the gathering of information both about the spatial relations of the basic geological units, and about the rocks forming them. The results of this period were gathered in the synthesis of Máška & Zoubek (1960). In particular they gave a re-evaluation of the stratigraphic assignment of the pre-Upper Carboniferous metamorphic complexes of the Western Carpathians. In contrast to older ideas about the Early Paleozoic age of the pre-Upper Carboniferous metamorphic complexes (Zoubek 1936), their synthesis (l.c.) formulated the idea of the probable Precambrian age of part of the complexes of the Tatricum and Veporicum. It is necessary to state that this synthesis was not based on new findings or facts.

The preparation of the XXIII IGC in Prague (1968) required the working out of an integrated synthesis of the structure of both parts of Czechoslovakia: the Czech Massif and the Western Carpathians. Publication took the form of a collective monograph "Regional Geology of Czechoslovakia" (Svoboda, Ed. 1968) in Czech and English versions. J.Kamenický (l.c.) wrote the chapter about the pre-Upper Carboniferous complexes of the Western Carpathians. In the stratigraphic assignment of the basement, he essentially retained the conception of Máška & Zoubek (1960), but proposed new names for some units (Jarabá and Kokava Series). In the problem of the rock composition of this synthesis, he started from the findings of the period of compilation of the general geological maps (1958-1963).

From the point of view of the presentation of new data, the last two decades have an exceptional position. Dozens of papers have been published, in which the results of study of the protoliths of the metamorphic complexes, their metamorphic development, P-T-t trends of development of the basic units were presented. At the same time new geochronological data from the complexes of metamorphites and magmatite bodies of the granite series have been gathered. Publications about the mutual tectonic position of some pre-Upper Carboniferous complexes are important. Detailed geochemical studies in the complexes of metamorphites and magmatites frequently brought surprising results. The Early Paleozoic age of the complexes of prograded metamorphites of the greenschist facies (considered by Máška & Zoubek (1960) to be diaphtorites) of the central and inner zone of the Western Carpathians was confirmed by biostratigraphic and palinological data.

It is clear from this overview of the problem, that in spite of the publication of numerous papers concerning the pre-Upper Carboniferous complexes of the Western Carpathians, there is at present no integrated review of the rock composition, stratigraphy, and general geological development of this segment of the basement of the Alpides.

In cross-section, the Western Carpathians are divided into two basic zones: external and internal. The tectonic element dividing them is the Pieniny Klippen Belt (or Peripieniny Lineament). A threefold division uses a principle already published by Kober (1921). External, central and internal zones of the Western Carpathians are distinguished. In this division, the dividing elements are Alpine tectonic elements (lines, regional overthrusts). The Pieniny Klippen Belt is the boundary between the external and central Western Carpathians, and the Margecany-Lubeník Line separates the central and inner units. This threefold division is used below.

In the external zone, pre-Carboniferous complexes do not crop out on the surface. In the zone of the central Western Carpathians, pre-Upper Carboniferous complexes are included in 2 basic Alpine formed megaunites/megazones: the Tatricum and Veporicum (Fig. 1). They consist of pre-Upper Carboniferous metamorphites, Variscan magmatites of the granite series, and complexes of younger Paleozoic and Mesozoic cover. Lithostratigraphic units of various orders are defined in their con-

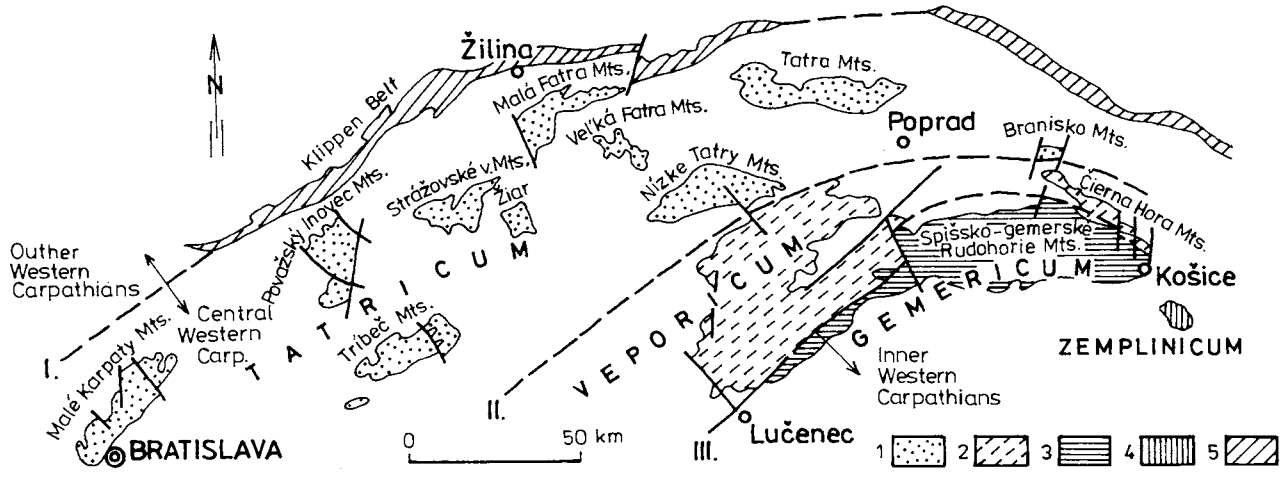

Fig.1. Simplified geological map of the Western Carpathians. **1** - Pre-Carboniferous complexes in the Tatricum. **2** - Pre-Carboniferous complexes in the Veporicum. **3** - Pre-Carboniferous complexes in the Gemericum. **4** - Pre-Carboniferous complexes in the Zemplinicum. **5** - Pieniny Klippen Belt. **I** - Peripieninian Lineament, **II** - Čertovica Fault, **III** - Margecany - Lubeník Line.

text. The most frequently used names of units and their content are given below.

The writing of this review and an attempt at correlation of the units defined up to now especially required:

a - Results of project "Geodynamic development of the Western Carpathians" which is almost finished.

b - An international conference devoted to the problems of pre-Upper Carboniferous complexes (September 1993, Stará Lesná). Some of the lectures from this conference are assigned to this number of Geologica Carpathica. From the point of view of foreign participants in the conference, but also of foreigners interested in the pre-Upper Carboniferous complexes of the Western Carpathians, this review is also an introduction to the study of the literature on the discussed complexes of the mountain range.

The Central Western Carpathians

Tatricum (Andrusov et al. 1973).

Syn.: Zone der Kerngebirge (Uhlig 1903), Tatrides (Matějka & Andrusov 1931), Tatric Unit.

The Tatricum is the lowermost and most extensive tectonic unit originated during the Alpine orogeny. It is located to the south of the Pieniny Klippen Belt. It forms the basement of individual segments, which are discontinuous on the surface, and are present in several mountain ranges. They are known as "cores" and are formed by Early Paleozoic (partly also Precambrian?) volcano-sedimentary complexes, metamorphosed under amphibolite facies conditions. They are penetrated by Upper Carboniferous magmatites of the granite clan. These complexes are partly covered by Late Paleozoic and Mesozoic complexes.

Andrusov (1968) and subsequently other authors correlate the Tatricum to the lower Eastern Alpine units ("Unterostalpin").

The Tatra Series (Máška & Zoubek 1960) - according to the Tatra Mountains.

Syn.: Jarabá Group (Kamenický 1968) - from the village of Jarabá in the Nízke Tatry Mts.

According to these authors, it is a geosynclinal sequence of pelitic and psammitic sediments with bodies of basic volcanics, which were metamorphosed under amphibolite facies conditions. It consists of paragneisses, amphibolites, orthogneisses and migmatites. The supposed age of the Tatra Series is Early Proterozoic to Early Paleozoic. The Tatra Series is known from the core mountain ranges of the central zone and from the northern Veporic region. The Precambrian age of the series is not universally accepted. Some authors consider it Early Paleozoic.

The Lower Unit (in the Tatra Mts.: Janák 1992) - according to its geological position.

The Lower Unit is composed of an aproximately 1000 m thick complex of mica schists exposed on the present surface. Alternations of pelitic and psammitic layers reflect the original flysch lithology of the metasediments, where kyanite, staurolite, fibrolitic sillimanite and almandine garnet are abundant in metapelites intercalated with quartz-rich metapsammites.

The Upper Unit (in the Tatra Mts.: Janák 1992) - due to its geological position.

The Upper Unit is formed by migmatitic paragneisses, orthogneisses, metabasites and rare calc-silicate rocks. A sheet-like granitic body which is predominantly granodiorite to tonalite in composition is intruded into it. Granitoids appear in the structurally highest levels surrounded by a zone of sillimanite bearing gneisses and migmatites, with minor bodies of amphibolites and calc-silicate rocks. The base of the Upper Unit is composed of a massive as well as banded amphibolite complex (Leptyno-Amphibolite Complex: Hovorka et al. 1992,in print; Hovorka & Méres 1993), orthogneisses and migmatites.

Both the Lower and Upper Units in the Tatra Mts. were not originally described by Janák (1992) as lithostratigraphic, but as tectonic units. Their definition is based on lithology and different intensity of metamorphic recrystallization.

Klinisko Formation (Klinisko metamorphites: Koutek 1930) - the most probably incorrect application of names of elevation points "Klin" or "Hlinisko" on the northern slopes of the Nízke Tatry Mts. in close vicinity of the mentioned formation occurrences.

The Klinisko Formation is composed of fine-grained biotite/±garnet schists (phyllites). Koutek (1930) described these rocks as pre-Triassic diaphtorites of higher-grade metamorphic rocks. New studies (Siegl 1976) are in favour of their prograde origin. Palinological data (Čorná & Kamenický 1976; Planderová 1986) suggest their Early Paleozoic age.

Table 1. Western Carpathians pre-Upper Carboniferous lithostratigraphic units: a review.

EARLY LATE (?) PROTEROZOIC (?)	CAMBRIAN ORDOVICIAN SILURIAN DEVONIAN	LOWER CARBONIFEROUS
TATRICUM		1
Tatra S (T, V)		2
Jarabá G (T, V)		3
	the Lower Unit (in the Tatra Mts.)	4
	the Upper Unit (in the Tatra Mts.)	4
	Klinisko Fm (in the Nízke Tatry Mts.)	5
	Pezinok - Pernek Series (in the Malé Karpaty Mts.)	3
	Pezinská Baba Group (in the Malé Karpaty Mts.)	6
	Pernek Fm (in the Malé Karpaty Mts.)	6
	Pezinok Fm (in the Malé Karpaty Mts.)	6
	Harmónia Fm (in the Malé Karpaty Mts.)	7
	Doľany Succession (in the Malé Karpaty Mts.)	8
	Marianka Succession (in the Malé Karpaty Mts.)	8
	Lamač Fm	9
VEPORICUM		10
Kohút S (V)		2
Kokava G (V)		3
	Hron Complex (in the Slovenské Rudohorie Mts.)	11
	Kráľova Hoľa Complex (in the Slovenské Rudohorie Mts.)	11
	Kohút Series	2
	Muráň Gneisses (in the Slovenské Rudohorie Mts.)	12
	Predná Hoľa Fm (in the Nízke Tatry Mts. - eastern part)	13
	Jánov Grúň Fm (in the Nízke Tatry Mts.)	14
	Kraklová Fm (in the Slovenské Rudohorie Mts.)	15
	Pohorelá Fm (in the Nízke Tatry Mts.)	16
	Čierny Balog G (in the Slovenské Rudohorie Mts.)	17, 18
	Ostrá Complex (in the Slovenské Rudohorie Mts.)	19
	Klenovec Complex (in the Slovenské Rudohorie Mts.)	19
	Hladomorná Dolina Complex (in the Slovenské Rudohorie Mts.)	20
	Miklušovce Complex (in the Sľubica and Čierna Hora Mts.)	21
	Lodina Complex (in the Sľubica and Čierna Hora Mts.)	21
	Bujanová Complex (in the Bujanová Massif, Sľubica Mts. and Čierna Hora Mts.)	21
ZEMPLINICUM		22
	Byšta Fm	23
GEMERICUM		1
	Gelnica G (Slovenské Rudohorie Mts. - eastern part)	24
	Rakovec G (Slovenské Rudohorie Mts. - eastern part)	25
	Klátov G (Slovenské Rudohorie Mts. - eastern part)	26
	Volovec G (Slovenské Rudohorie Mts. - eastern part)	27
	Betliar Fm (Slovenské Rudohorie Mts. - eastern part)	27
	Smolník Fm (Slovenské Rudohorie Mts. - eastern part)	27
	Hnilec Fm (Slovenské Rudohorie Mts. - eastern part)	27
	Črmeľ G (Slovenské Rudohorie Mts. - eastern part)	28
	Ochtiná Beds (Slovenské Rudohorie Mts. - eastern part)	29
PROPOSED DIVISION		30
Leptyno-Amphibolite Complex (LAC) (T, V, G (?))	Early Paleozoic Complex (EPA) (T, V, G, Z)	
	pre-Alpine Granites (PAG) (T, V, G)	

(T) - Tatricum, (V) - Veporicum, (Z) - Zemplinicum, (G) - Gemericum
G - Group, Fm - Formation, S - Series;
1 - Andrusov et al. (1973), 2 - Máška & Zoubek (1960), 3 - Kamenický (1968), 4 - Janák (1992), 5 - Koutek (1930), 6 - Grecula & Hovorka (1987), 7 - Cambel (1954), 8 - Plašienka et al. (1991), 9 - Andrusov in Andrusov & Samuel (1985), 10 - Matějka & Andrusov (1931), 11 - Klinec (1966), 12 - Hovorka et al. (1987), 13 - Bajaník et al. (1979), 14 - Miko (1981), 15 - Korikovsky & Miko (1992), 16 - Putiš (1989), 17 - Krist (1976), 18 - Krist (1977), 19 - Bezák (1982), 20 - Vrána (1974), 21 - Jacko (1985), 22 - Slávik in Fusán et al. (1971), 23 - Vozárová (1991), 24 - Matějka & Zelenka (1931), 25 - Andrusov (1958), 26 - Spišiak et al. (1985), 27 - Grecula (1982), 28 - Bajaník et al. (1983), 29 - Bouček & Přibyl (1960), 30 - Hovorka et al. (1992), (1994).

Pezinok - Pernek Series (Kamenický 1968) - named according to the communities of Pezinok and Pernek in the Malé Karpaty Mts. to the NE of Bratislava.

This series is formed by a complex of polymetamorphosed pelitic and psammitic sediments and basic volcanics of the Malé Karpaty Mts. in the tectonic (?) or stratigraphic basement of the Harmónia Formation. The range of conditions of metamorphic recrystallisation of this series is wide: it varies from greenschist to amphibolite facies conditions. Kamenický (l.c.) assigned the Pezinok - Pernek Series to the Late Proterozoic. However Cambel & Čorná (1974) consider it to be Early Paleozoic.

Pezinská Baba Group (Grecula & Hovorka 1987) - according to a topographical elevation point (754 m) in the Malé Karpaty Mts.

Three defined formations make up the Pezinská Baba Group: the Pernek Formation, the Pezinok Formation and the Harmónia Formation. The first two of these formations correspond to the Pezinok-Pernek Group in the sense of Kamenický (1968). The stratigraphic assignment of the Pezinská Baba Group is probably Early Paleozoic.

Pernek Formation (Grecula & Hovorka 1987).

The prevailing lithologies are as follows: basaltic lava flows, dolerite dykes and sporadic gabbroic bodies; extrusives are widespread. Sporadic intercalations of psammitic sediments are known. The most probable age of the Pernek Formation is Early Paleozoic. Polymetamorphic development is characteristic of the Pernek Formation.

Pezinok Formation (Grecula & Hovorka 1987).

The formation is composed of fine-grained clastic sediments, black shales and a small amount of basaltic extrusives. According to the cited authors (l.c.), the formation under consideration is in tectonic contact with the Pernek Formation. An Early Paleozoic age for the premetamorphic protolith is most probable. The formation has a polymetamorphic development.

Harmónia Formation (Cambel 1954) - according to the community of Harmónia in the Malé Karpaty Mts. NE of Bratislava.

The Harmónia Formation is a sequence of pelitic and black shales, limestones and basic volcanics. The metamorphosis corresponds to the conditions of greenschist facies. According to surviving crinoids and tentaculites, the formation belongs to the Devonian.

Very recently Plašienka et al. (1991) used the term "succession" for the Pernek Formation, Pezinok Formation and Harmónia Formation. In each of them, following Putiš (1986) proposal they distinguished 2 formations: ***A*** and ***B***. ***A*** formations are composed mostly of flysch like, predominantly pelitic-psammitic sediments (Silurian - Lower Devonian); ***B*** formations being of volcano-sedimentary type (Lower - Middle Devonian: Planderová & Pahr 1983).

Doľany Succession (Plašienka et al. 1991) - according to the community of Doľany on the SE slopes of the Malé Karpaty Mts.

It is composed of an ***A*** type succession (see above): pelitic sediments prevailing over psammites and quartzites and quarzite-graphite lithologies are also present.

Marianka Succession (Plašienka et al. 1991) - according to the community of Marianka on the NW slopes of the Malé Karpaty Mts.

In comparison to Pernek, Harmónia and Doľany Successions increased contents of sandy shales and psammites are characteristic of the Marianka Succession. In the upper parts alterations of the ***A*** formation basic pyroclastics are present. In the ***B*** formation basic tuffs and marly shales with a few centimetres thick beds of limestones are present.

Lamač Formation (Andrusov 1985, in Andrusov & Samuel) - according to the community of Lamač at the foot of the Malé Karpaty Mts. near Bratislava.

The prevailing lithologies have the character of black-shales with metabasalts and ore bodies as intercalations. The Lamač Formation represents the local development of the Pezinská Baba Group. According to Čorná (1968) the Lamač Formation is of the Upper Devonian to Lower Carboniferous in age.

Veporicum (Matějka & Andrusov 1931).

Syn.: Veporides (Zoubek 1931, 1957), Granides (Matějka & Andrusov 1931), Veporic Unit. Higher (in comparison to Tatricum) tectonic unit cropping out in the Slovenské Rudohorie Mts. and in the eastern part of the Nízke Tatry Mts. The pre-Upper Carboniferous complexes of the Sľubica Mts. and the Čierna Hora Massif could be an integral part of this unit.

In recent decades, the Veporicum has been divided into four SW to NE trending zones, on the basis of Zoubek's papers (1930, 1931, 1935, 1936, 1957). These are the Ľubietová, Kraklová, Kráľová Hoľa and Kohút Zones. The individualisation of these zones is due to the Alpine tectonic processes. Klinec (1966) found that the Kráľová Hoľa Zone (Complex) has a nappe structure overlying the Hron Complex, which he defined.

The northern Veporicum Zone or zones is overthrust on the Tatricum along the complicated Alpine Čertovica thrust plane.

The Veporicum is composed of Early Paleozoic, Late Paleozoic and Mesozoic lithostratigraphic units. It is probable that some of the Variscan complexes underwent retrogressive recrystallisation in the Variscan time span, and represent pre-Variscan blocks.

Hron Complex (Klinec 1966) - according to the River Hron.

The Hron Complex is known from the whole Veporic Unit. It includes various lithostratigraphic units. Mica schists, phyllites, amphibolites, serpentinites and gneissose granites form the rocks of the Hron Complex. The complex is a nappe representing the lowest member of the allochthonous pre-Carboniferous complexes of the central zone of the Western Carpathians. The age of the metamorphites of the Hron Complex is mostly Early Paleozoic (Klinec & Planderová 1979; Bezák & Planderová 1981).

Kráľova Hoľa Complex (Klinec 1966) - according to an elevation point in the main ridge of the Nízke Tatry Mts.

According to Klinec (l.c.), the Kráľová Hoľa Complex does not coincide with the idea of the existence of a Kráľova Hoľa Zone (Zoubek 1931). According to Klinec (l.c.), the basic rock types of the Kráľová Hoľa Complex are granitoids and migmatites. They form a tectonic unit in superposition on the Hron Complex. The Kráľová Hoľa Complex occurs in the whole north-south extent of the Veporicum, but its maximum extent is especially in its central part.

Kohút Series (Máška & Zoubek 1960) - according to the elevation of Kohút in the Slovenské Rudohorie Mts.

Syn.: Kokava Group (Kamenický 1968).

The Kohút Series is a complex of metamorphic rocks (metapelites, metapsammites, metacarbonates, black shales) which form the Kohút Zone of the Veporic Unit. This rock sequence was metamorphosed under greenschist facies conditions in the Variscan time span, and under elevated pressure of greenschist conditions in the Alpine time span.

The views on the stratigraphic assignment of the Kohút Series are controversial: Late Proterozoic (Máška & Zoubek 1960; Kamenický 1968), against Early Paleozoic (Bezák 1982).

Muráň Gneisses (Hovorka et al. 1987) - according to the village of Muráň in the Slovenské Rudohorie Mts.

Syn.: Muráň orthogneisses (Zoubek 1936).

This rock complex is formed mostly by Ab-Mi orthogneisses with transitions to Bt paragneisses. Bodies of quartz-tourmaline rocks and mostly biotitised amphibolites occur as inserts. The protoliths of the Ab-Mi orthogneisses were acidic volcanics and their volcaniclastics. The age of the complex is controversial (Late Proterozoic - Early Paleozoic).

Predná Hoľa Formation (Bajaník et al. 1979) - according to the elevation point at the eastern end of the Nízke Tatry Mts.

This is a collection of mostly pelitic metasediments and metapsammites with bodies of metakeratophyres and metaspilites and their metavolcaniclastics. Layers of carbonate phyllites are also present. The Predná Hoľa Formation underwent metamorphic recrystallisation in greenschist conditions. According to identified spores, a Devonian - Carboniferous age of the formation is probable.

Jánov Grúň Formation (Miko 1981) - according to the elevation point of Jánov Grúň (1393 m) in the Nízke Tatry Mts.

The Jánov Grúň Formation is mostly formed by products of acid volcanism and clayey sediments. Bodies of basic volcanics and syngenetic layers of quartz-tourmaline rocks are also occasionally present. The Jánov Grúň Formation underwent metamorphic recrystallisation in greenschist conditions. According to the identified sporomorphs it has an Upper Silurian to Lower Carboniferous age (Planderová & Miko 1977). The Jánov Grúň Formation is cropping out on the southern slopes of the Nízke Tatry Mts. in their Veporic, that is eastern, part.

Kraklová Formation (Korikovsky & Miko 1992) - according to the elevation point of Kraklová (984 m) in the Slovenské Rudohorie Mts.

The Kraklová Formation is formed by phyllites, metasandstones and occasional bodies of acid volcanics and volcaniclastics. Variscan metamorphosis occurred in greenschist conditions (Korikovsky & Miko, l.c.). The age of the formation is probably Early Paleozoic.

In area, the Kraklová Formation covers a substantial part of the originally defined Kraklová Zone of the Veporicum (Zoubek 1930, 1931), which, according to this author, is formed by various types of diaphtorites. Korikovsky & Miko (1992) compare the Kraklová Formation with the Jánov Grúň Formation in the Nízke Tatry Mts.

Pohorelá Formation (Pohorelá Complex: Putiš 1989) - according to the village of Pohorelá in the Hron Valley.

The Pohorelá Formation consists of phyllitic mica schists, metaquartzites and albite epidote amphibolites. It is probably of Early Paleozoic age. It crops out on the southern and northern slopes of the eastern part of the Nízke Tatry Mts. The Pohorelá Formation is part of the system of the Kráľova Hoľa Nappe.

Čierny Balog Group (Formation: Krist 1976, 1977) - according to the village of Čierny Balog in the Slovenské Rudohorie Mts.

The Čierny Balog Group consists of clayey and psammitic sediments, rich in quartz, leptite gneisses, basaltic volcanics and also sporadical migmatites. An Early Paleozoic age is supposed for this group or formation.

Ostrá Complex (Bezák 1982) - according to the Ostrá Mountain Massif near Hnúšťa in the Slovenské Rudohorie Mts. The Ostrá Complex is one of the units of the Kohút Zone of the Veporicum. The prevailing lithotypes are garnet mica schists with bodies of metalydites, black shales and amphibolites.

Age of the complex: Early Paleozoic (?; Bezák & Planderová 1981).

Metamorphosis (Variscan): greenschist, overprinted by Alpine metamorphosis in the kyanite isograde (Méres & Hovorka 1991).

Klenovec Complex (Bezák 1982) - according to the village of Klenovec in the Slovenské Rudohorie Mts.

Syn.: albite-biotite paragneisses (Bezák 1982).

The basic lithotypes are fine-grained albite-biotite paragneisses.

The Klenovec Complex laterally alternates with the Ostrá Complex; therefore an Early Paleozoic age for the Klenovec Complex is probable.

Hladomorná Dolina Formation (Vrána 1964) - according to the Hladomorná Dolina Valley in the Slovenské Rudohorie Mts.

The Hladomorná Dolina Formation includes metapelites and fine-grained metapsammites with bodies of dark quartzites and metabasites. The intensity of Variscan metamorphic recrystallisation corresponds to greenschist conditions. In its regional extent, the Hladomorná Dolina Formation is also influenced by near-contact recrystallisation in the aureole of Alpine (?) granite bodies.

Miklušovce Complex (Unit; Jacko 1985) - according to the village of Miklušovce NW of Košice.

In the Sľubica and Čierna Hora mountain ranges the Miklušovce Complex forms the northernmost zone. Various textural types of migmatites and local transitions to paragneisses prevail. The Miklušovce Complex is characterised by the presence of lenticular bodies of aplitic, frequently also hybrid granites (metres to decametres in dimensions). The age assignment of the complex is problematic. The author (l.c.) and Maheľ (1986) correlate the Miklušovce Complex with the Ľubietová Zone of the Veporicum.

Lodina Complex (Unit; Jacko 1985) - according to the village of Malá Lodina to the NW of Košice.

Syn.: complex of diaphtorised paragneisses (Jacko 1985).

The prevailing lithotypes are Gar and Gar-St mica schist affected by retrograde recrystallisation. Bodies of amphibolites are retrogressively recrystallised in greenschist conditions. Some authors correlate the Lodina Complex with the Kraklová Zone (e.g. Kraklová Formation in the sense of Korikovsky & Miko 1992). The age assignment of the Lodina Complex is problematic: Late Proterozoic to Early Paleozoic.

Bujanová Complex (Jacko 1985) - according to the Bujanová Mountain Massif (756 m) ESE of Margecany.

Syn.: Bujanová Granitised Complex (Jacko 1985).

The rocks of the Bujanová Complex are varied: paragneisses, amphibolites, various types of migmatites, Variscan granitoids. The Bujanová Complex is affected by intensive cataclastic and blastomylonitisation processes. Its stratigraphic assignment is problematic: Late Proterozoic - Early Paleozoic. According to Maheľ (1985) the Bujanová Complex forms the Bujanová Nappe.

Very recently Bezák (1994) proposed dividing the Hercynian structure of the Tatricum and Veporicum into 3 main litho-tectonic units (from top to bottom) as follows:

1 - the Upper Unit (gneisses - migmatites),

2 - the Middle Unit (mostly gneisses and mica schists with relics of low grade rocks)

3 - the Lower Unit (mostly metamorphites of the greenschist facies).

Zemplinicum (Slávik 1971, in Fusán et al. 1971)

The Zemplinicum is a tectonic unit occurring on both sides of the Slovak - Hungarian frontier to the east of Košice. It crops out over an area of only a few km^2, and its substantially greater extent is documented by boreholes. The Zemplinicum is a tectonic horst composed of pre-Mesozoic as well as Mesozoic complexes. Two main units are distinguished among the the pre-Mesozoic rock sequences, on the basis of the intensity of their metamorphic recrystallisation:

a - high-grade metamorphic rocks (gneisses, amphibolites, migmatites) forming the Byšta Formation (Vozárová 1991). Pelites, graywackes, together with tholeiitic andesite-basalts and their volcaniclastics are the protolith of Byšta Formation (l.c.). Pebbles of the above mentioned rocks occur within the Carboniferous - Permian conglomerates. The age value 960 - 980 Ma reported by Pantó et al. (1967) require confirmation. Later overprint is documented by the Ar/K age values 258 - 262 Ma for the whole rock (Pantó et al. 1967). Younger ages were reported by Lelkes-Felvári & Sassi (1981) for muscovite - 229 Ma and amphibole - 307 Ma.

b - in boreholes on Hungarian territory a sequence of low-grade metamorphites was penetrated. Their relation to the high-grade sequence is interpreted as the late-Variscan south-vergent fault (Pantó 1969). Upper Carboniferous sediments cover both these sequences.

The greenschist complex under consideration is formed by metapelites and acidic metavolcanics with local intercalation of other lithologies. Some authors consider the discussed sequence to be of retrograde (e.g. blastomylonitic) origin.

The presence of one or two pre-Upper Carboniferous complexes in the Zemplinicum is still an open problem.

Byšta Formation (Vozárová 1991) - according to the village of Byšta to the ESE of Košice. The formation under consideration is formed by gneisses, amphibolites and migmatites. Mineral associations of these lithologies originated under a high-temperature field of the amphibolite facies conditions. Processes of anatectic melting of the sequence under consideration took place locally.

The Byšta Formation forms the pre-Upper Carboniferous of the Zemplinicum on Slovak territory. Pebbles of the Byšta Formation are abundant in the Upper Carboniferous as well as in the Permian conglomerates. Based on similarity of the REE patterns of the main lithologies of the Byšta Formation to those of Precambrian sequences from several world occurrences Vozárová (1991) considers that the Byšta Formation may be of Precambrian age.

The Inner Western Carpathians

Gemericum (Andrusov et al. 1973)

Syn.: Erzführendeserie (Uhlig 1903), Gemerides.

The Gemericum is a tectonic unit of the Inner Western Carpathians shifted in the Alpine time-span onto its northern foreland - that is the Veporicum. The boundary of the shift is followed by the course of the Margecany-Lubeník Line. The rocks of the Gemericum are products of 3 developmental cycles: Early Paleozoic, Late Paleozoic and Mesozoic.

Gelnica Group (Series) named according to the town of Gelnica.

Syn.: Group de Gelnica (Matějka & Zelenka 1931, in Matějka & Andrusov 1931), porphyroid zone (Woldřich 1912), Drnava and Uhorná Series (Kuthan 1950), Cambrian-Silurian Series (Fusán et al. 1955), the greater part of the Volovec Group (Grecula 1982) namely the Hnilec Formation (Grecula 1982). Very recently the Gelnica Group has been interpreted as forming the Gelnica Terrane, which is an integral part of the Špiš Composite Terrane (Vozárová & Vozár 1992; Vozárová 1993).

The prevailing lithotypes are pelites and psammites with layers of volcaniclastics of acidic, intermediate and occasionally basic volcanics. Individual effusive bodies are rare. Black shales, carbonates and lydites are present as inserts. These lithologies were metamorphosed in Variscan times, in greenschist conditions of the LP-HT type (Sassi & Vozárová 1987, 1992). Bajaník et al. (1983) also emphasised the complex polygenetic and polycyclic development of the Gelnica Group. The late-Variscan age of the metamorphosis is shown by:

a - the supposed Cambrian-Silurian age of the protolith (Snopková & Snopko 1979);

b - from the presence of detritus of Gelnica Group rocks in the Upper Carboniferous-Permian conglomerates;

c - geochronological dating (Dallmeyer 1994).

Rakovec Group (Series) (Andrusov 1958) - named according to the settlement of Rakovec near Dobšiná.

Syn.: Grünschieferzone (Uhlig 1903), Zone der Diabasen and deren Tufe (Woldřich 1927), Phyllite-Diabase Series (Zelenka 1927), serie phyllitique (Andrusov & Matějka 1931), Grünschiefergruppe (Rozlozsnik 1935), the Rakovec Terrane (Vozárová & Vozár 1992). In Grecula's (1982) conception the Rakovec Group is a part of the Volovec Group or Rakovec Complex.

The Rakovec Group is made up of basalts and their volcaniclastics with occasional bodies of diorites and gabbros. Fine-grained sediments are present as inserts. On the basis of the prevailing lithotypes, Bajaník et al. (1983) divided the Rakovec Group into the following formations: Smrečina Formation, Sykava Formation and Štos Formation. According to the presence of rocks from the Rakovec Group in Upper Carboniferous conglomerates, a Devonian - Lower Carboniferous age is probable for the protolith of the Rakovec Group. The Rakovec Group went through a complex metamorphic development: in the first stage, metamorphic recrystallisation had a medium to high pressure character (Hovorka et al. 1988), overprinted recrystallisation occurred in the low to medium temperature area of the greenschist facies (Sassi & Vozárová 1992; Vozárová 1993) of the HT-LP type.

The lithological sequences of the Rakovec Group form a Variscan nappe (Grecula 1982). The Rakovec Group is divided into lithostratigraphic units of a lower order.

Klátov Group (Spišiak et al. 1985) - named according to the village of Vyšný and Nižný Klátov to the NW of Košice.

Syn.: Gneiss-Amphibolite Complex (Dianiška & Grecula 1979; Hovorka et al. 1979), Klátov Amphibolites (Grecula 1982).

Occurrences of the Klátov Group are known from an interrupted stripe between Dobšiná and Košice. Its basement consists of metamorphites of the greenschist facies of the Rakovec Group. The basic lithologies of the Rakovec Group are gneisses and amphibolites. Radiometric dating of them points to a Variscan age for their metamorphic recrystallisation (Cambel et al. 1980; Kantor 1980; Kantor et al. 1981). K/Ar data for the amphibole of amphibolites (391 - 258 Ma) point to a complex metamorphic development of the Klátov Group. The Klátov Group is clearly distinguished from other lithostratigraphic units (the greenschist facies) of the Gemericum by the intensity of its metamorphic recrystallisation (the amphibolite facies). The Klátov Group forms the leading sequence of the Variscan Klátov Nappe (Hovorka et al. 1984).

Volovec Group (Grecula 1982) - named according to the Volovec mountain ridge (1323 m).

According to Grecula (l.c.), the Volvovec Group represents the rock record of an Early Paleozoic riftogeneous basin.

The Volovec Group constitutes all the Early Paleozoic units defined above. The intensity of Variscan metamorphic recrystallization varies from the greenschist to amphibolite facies conditions.

The Volovec Group is devided into three superimposed lithostratigraphic units of the lower order (the Betliar, the Smolník and the Hnilec Formations). During the Variscan time span

this group was tectonically dismembered into several north-trending nappes (Grecula 1982): the Medzev, the Jedľovec, the Hummel, the Prakovce, the Mníšek, the Kojšov, the Rakovec and the Črmel Nappes.

Betliar Formation (Snopko 1957) - according to the village of Betliar near Rožňava.

The denomination was used in the past (Fusán & Máška 1956; Snopko 1957; Grecula 1970) for the sequence of black shales, lydites and limestones. The Betliar Formation constitutes the lowermost part of the Volovec Group (Gelnica Group). Its substratum is unknown. Betliar Formation is attributed (Grecula 1982) to the Silurian till Lower Devonian.

Smolník Formation (Grecula 1982) - according to the village of Smolník NNW of Rožňava.

The transition of the underlying Betliar Formation is gradual (l.c.). The prevailing lithologies are phyllites locally with psammitic intercalations. In the lowermost sections volcanics and volcaniclastics of acid as well as basic parentage are known. The age of the Smolník Formation is (with high probability) estimated to be Lower to Middle Devonian.

Hnilec Formation (Grecula 1982) - the formation is named according to the Hnilec River which cross the Hnilec Formation.

Evidently the prevailing lithologies are volcanics and volcaniclastics of uneven character (rhyolite - keratophyre - dacite - andesite - basalt). U/Pb zircon ages from metarhyolites (350 - 420 Ma, Semenko et al. 1977) assign the Hnilec Formation to the Upper Devonian - Lower Carboniferous.

Črmeľ Group (Bajaník et al. 1983) - named according to the valley near Košice.

The Črmeľ Group occurs in the northern part of the Gemericum. Its composition distinguishes it from the Gelnica and Rakovec Groups. Clayey-sandy sediments, locally with bituminous substance and layers of carbonates, prevail. The products of basic volcanism, especially in the form of volcaniclastics are also present.

The metamorphic recrystallisation of the Črmeľ Group occurred in greenschist facies conditions.

The presence of detritus of rocks of the Črmeľ Group in Upper Carboniferous conglomerates determine its upper stratigraphic limit. Its lower stratigraphic limit is unknown.

Ochtiná Beds (Bouček & Přibyl 1960) - named according to the village of Ochtiná.

Syn.: Ochtiná Formation (Vozárová 1981, in Bajaník et al. 1981).

The basal part of the Ochtiná Formation is formed by sandstones to quartz conglomerates, which continue into graphitic sediments and basalt tuffs. There are lenses of magnesites and inserts of limestones and dolomites in this stratigraphic level. On the basis of the identified association of conodonts from the lenses of dolomites underlying the bodies of magnesites (Kozur et al. 1976), the age of the Ochtiná Formation is determined as Namurian A to upper Visean, that is Lower Carboniferous.

The metamorphic recrystallisation of the Ochtiná Formation did not exceed low to medium greenschist facies conditions.

The problem of the geotectonic assignment of the Paleozoic-Mesozoic sequences of the Bükk Mts., Uppony Mts. and Sendrő Mts. in northern Hungary is controversial. According to one group of ideas, the Bükk Subunit in the framework of the Pelso Unit has a significant South Alpine - Dinaric, that is African affinity (Kovács 1982; Árkai 1991). Other authors (Mock, oral communication) assign these complexes to the Inner Western Carpathians, that is to the European geotectonic province.

The weakly metamorphosed Early Paleozoic formations known from the above mentioned mountain ranges are clearly distinguished by their lithology from the Early Paleozoic sequences of the terranes, that is from the individual formations of the Volovec Group. Gradual transitions from Devonian to Carboniferous and a substantial amount of mostly Devonian, carbonate formations (these are lacking in the Volovec Group) are very probably characteristic.

In the stratigraphic profile of the Uppony Mts., the following formations are distinguished from the oldest to the younger (Kazmér 1986):

Tapolcsány Formation - shales, lydites, sandstones with metabasalts. The Tapolcsány Formation is Silurian in age.

Strászahegy Formation - massive recrystallised limestones (Devonian ?).

Uppony Limestone Formation - massive crystalline limestones (Givetian).

Abod Limestone Formation - "cippolino" limestone formation with basic metatuffs (Givetian).

The following formations have been described in the Sendrő Mts.:

Szendrölád Limestone Formation - calcareous shale with coral bioherms (Eifelian to Frasnian).

Bükkhegy Limestone Formation - Givetian.

Abod Limestone Formation - as in the Uppony Mts.

Rakaca Formation - shallow water carbonates - sedimented simultaneously with the Abod Limestone Formation.

A new concept of the division of the pre-Upper Carboniferous Complexes

The principles applied up to now to the division of the pre-Upper Carboniferous complexes of the Western Carpathians into lithostratigraphic units (Tab. 1 on the page 263) provide only limited possibilities for the working out of a geodynamic model of the development of the pre-Alpine basement of the Western Carpathians.

Starting from the idea that the present architecture of the geological units or bodies is the product of a late-Variscan collision stage of the interaction of the megablocs of Eurasia and Gondwana, as well as the Alpine compression processes. Hovorka et al. (1992, 1993,in print) and Hovorka & Méres (1993) proposed the division of these complexes on the basis of different criteria. These are: lithology and the geochemistry of dominating sequences in the basic tectonic units, the place and manner of their origin, and metamorphic and magmatic development. On the basis of these criteria the authors (l.c.) defined the following basic lithological-tectonic units in the pre-Upper Carboniferous basement of the Western Carpathians.

Leptyno-Amphibolite Complex (LAC: Hovorka et al. 1992; 1993, in print; Hovorka & Méres 1993).

According to the definitions of the above mentioned authors (l.c.) the LAC is a newly defined rock complex for the Western Carpathians. It was formed in the lower part of the continental crust (l.c.). The main lithologies of the complex under consideration are amphibolites and light Qtz + Ab ± Gar rocks (leptynites). In vertical section they alternate many times, and towards the upper limit of the complex, they gradually pass into garnet-rich orthogneisses. The LAC includes the newly discovered bodies of Ol-Py metagabros, metaperidotites and amphibolitised eclogites. These also include bodies of other rock types, which originated by metasomatic processes, for example corundum-phlogopite rocks (Spišiak & Pitoňák 1992). In the course of its Variscan forced uplift into the upper part of the continental crust along the main Variscan Thrust Plane (variszische Hauptüberschiebungsfläche: Hovorka & Méres 1993a), the LAC was

gradually equilibrated, hydrated and in places anatectically melted. In "shallow" P-T conditions it was retrogressively recrystallised (up to greenschist conditions). Its tectonic position is shown in some mountain ranges of the central zone. The rocks of the LAC as defined above, was formerly understood as an integral part of the Tatra Series (Máška & Zoubek 1960), or Jarabá Group (Kamenický 1968).

Early Paleozoic Complex (EPA: Hovorka et al. 1992, 1993, in print).

The authors (l.c.) include in this group some lithological-tectonic units, which were metamorphosed during their pre-Alpine development, in greenschist to low-grade amphibolite facies conditions, that is in conditions of the upper to middle part of the continental crust.

On the basis of the quantitative ratio of the two basic genetic types of protolith of the metamorphites of the EPA, that is sediments and volcanics, as well as on the basis of the individual types of protolith in the framework of this group, we defined 5 basic terranes (l.c.). These are:

a - metabasalt-metagraywacke sequence (terrane);
b - metarhyolite-metapelite (terrane);
c - variegated sequence (terrane);
d - metarhyolite sequence (terrane);
e - metabasalt sequence (terrane).

These sequences or terranes were mainly formed in the marginal parts of back-arc basins. The sequences with dominant metabasites (Pernek Formation in the Malé Karpaty Mts., the Rakovec Group in the Gemericum) could represent relics of the oceanic crust of these basins (Ivan 1989; Ivan et al. 1992).

Pre-Alpine Granites (PAG).

On the basis of the initial ratios of $^{87}Sr/^{86}Sr$, Hovorka et al. (1992) and Hovorka & Méres (1993) divided the Caledonian (?) and Variscan granites of the Western Carpathians into two basic genetic groups:

a - Granites of massifs, which have a low ratio of the isotopes of Sr (0.706 - 0.707). In the view of the above mentioned authors (l.c.) they originated by the melting of LAC rocks.

b - The second genetic group is formed by granites with an $^{87}Sr/^{86}Sr$ ratio greater than 0.708. These were generated by anatectic melting of complexes mainly of EPA, or their equivalents, into which they penetrate in places through the zone of migmatites.

Conclusion

The description or division given above, enables us to define the following basic lithological-tectonic units (terranes) in the pre-Upper Carboniferous basement of the Western Carpathians:

1 - The present erosion level cross-section of the Western Carpathians includes complexes originating from the continental crust. They are:

a - Complexes (terranes) generated in the lower part of the continental crust (LAC and components).

b - Complexes which developed in the conditions of the middle part of the continental crust. These include part of the Early Paleozoic terranes (EPA). We also place the pre-Alpine granites in this category.

c - Complexes (terranes) which had a metamorphic development without the metamorphic conditions mentioned above, such as greenschist conditions (phylite and mica schist sequences and the corresponding metavolcanics: part of the EPA and all the Late Paleozoic complexes).

2 - The group of blocks or terranes of the basement also includes tectonically disintegrated terranes from back-arc basins, that is tectonically dismembered metaophiolites (Pernek Formation, Rakovec Group).

In conclusion it is necessary to emphasise that the present spatial relationships of the defined units of the pre-Upper Carboniferous basement of the Western Carpathians are tectonic.

Two basic groups of terranes can be distinguished, among the volcano-sedimentary terranes of the pre-Upper Carboniferous basement of the Western Carpathians, on the basis of lithology and also the intensity and type of metamorphic recrystallisation:

1. metabasalt and metagraywacke terranes (mentioned above as **a**);
2. other volcano-sedimentary terranes (mentioned above as **b** to **e**).

The first group of terranes, found in the Suchý, Malá Magura and Malá Fatra mountain ranges, underwent 2 pre-Alpine metamorphic events (Hovorka et al. 1989). The first event occurred in granulitic conditions, and the second, probably Variscan, event occurred in amphibolite facies conditions. It is very probable that this genetic group also includes the Byšta Formation of the Zemplinicum, with the following, unverified published ages of 960 - 980 Ma, which are still provoking experts (Pantó et al. 1967). These terranes, together with the Leptyno-Amphibolite Complex (LAC), may be taken into account as possible representatives, which need to be clearly proved, of pre-Variscan terranes in the Western Carpathians.

The terranes mentioned in the overview of the EPA as **b** to **e** underwent Variscan metamorphic recrystallisation in conditions of the high temperature area of greenschist facies to the conditions of low-grade amphibolite facies. In some of them, especially in the terranes of the southern area of the Veporicum, significant Alpine recrystallisation of the medium to high pressure type is observed (Vrána 1964; Méres & Hovorka 1991).

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