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Problems of geodynamic evolution and geological structure of the Paleozoic gemeric Unit (Inner Western Carpathians) as inferred by magmatic rock study

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Abstract. Based on geochemical and petrological data from basic magmatic rocks a redefinition of lithostratigraphic division of the Paleozoic of Gemeric Unit (Inner Western Carpathians) has been made. Lithostratigraphic formations were generated in the three types of geodynamic setting: (1) back-arc basins, (2) neighbourhood of magmatic arc of convergent plate margins and (3) amagmatic passive-like plate margin. Recent tectonic structure of this area is a product of multistage deformation and nappe formations during the variscan and alpine time.

Key words: Paleozoic, metabasites, lithostratigraphy

Introduction

The Gemeric Unit is the northernmost unit of the Inner Western Carpathians. It is composed of Paleozoic and Mesozoic rock complexes. In spite of the fact that the Gemeric Unit belongs to the most intensively studied regions of the Western Carpathians, opinions on its geodynamic evolution and geological structure are controversial and insufficiently supported by exact data. Geochemical and petrologic study of magmatic, especially basic rocks, provided in the last time new data for the construction of a geodynamic model, especially due to a more precise lithostratigraphic division and determination of the geodynamic setting of Paleozoic formations of Gemericum.

Lithostratigraphy

The Paleozoic of the Gemeric Unit is built of Early and Late Paleozoic complexes. Traditionally they used to be divided into five ltihostratigraphic groups. The Early Paleozoic was represented by (1) the Gelnica Group and (2) the Gočaltovo Group, the Late Paleozoic by (3) the Dobšiná Group, (4) the Krompachy Group and (5) the Gočaltovo Group (BAJANÍK et al., 1983). However, identification of the geochemical type of metabasalts, combined with lithological data, has shown that some sequences of the Rakovec and Dobšiná Groups appear rather to be independent formations. A lithostratigraphic classification of the Paleozoic of the Gemeric Unit, incorporating these new data, is presented in Fig. 1.

The areally most extensive lithostratigraphic group is the Gelnica Group. Its Early Paleozoic age has not been yet reliably proved. It is a typical volcano-sedimentary formation, the volcanogenic material predominating over sedimentogenic. It is represented especially by acid, less by intermediary volcanoclastics, effusive acid, intermediary or basic rocks are rare. The sedimentary material is partly of deep-water (silicites, black shales) and pelagic origin (allodapic limestones), it is partly continental, chemically mature, bearing signs of multiple recycling (VOZÁROVÁ, 1993). The Gelnica Group sedimented in an environment near the base of a continental slope, and the detritic material was transported by turbidite currents (IVANIČKA et al., 1989). Acid to intermediary volcanic and volcanoclastic rocks are products of calc-alkaline volcanism. The occurrences of metabasalts in the Gelnica Group are concentrated into three discontinuous belts. Three geochemical metabasalt types have been identified in the northern belt, geochemically similar to (1) calc-alkaline basalts (CAB), back-arc basin basalts (BABB) and (3) enriched mid-ocean ridge basalts (E-MORB), or ocean island tholeiites (OIT; IVAN, 1994). The other belts contain only the last mentioned metabasalt type. Based on the preserved texture relics, the majority of metabasalts crystallised in sub-volcanic conditions. The Gelnica Group underwent multistage metamorphism. Maximum metamorphic conditions did not exceed the greenschist facies, only in the central belt of metabasalt occurrences there are indications of a higher-pressure metamorphic stage. Probably the oldest and most important metamorphic stage is the regional alkaline metasomatism caused by extensive convection of thermal water. The Gelnica Group has been sub-divided into three lithostratigraphic sequences (IVANIČKA et al., 1989). These sequences however rather reflect some properties of the tectonic structure and they are not consistent with the spatial distribution of geochemical types of basic metavolcanites.

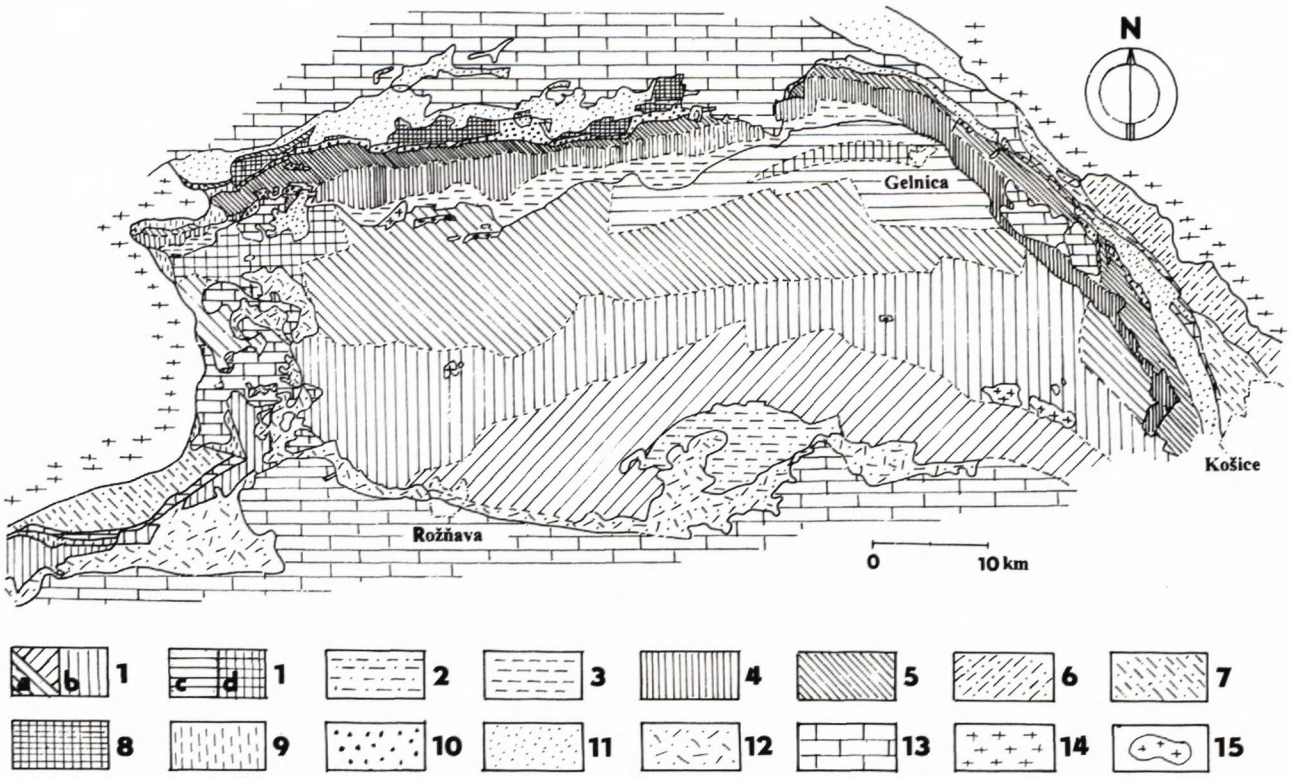

Fig. 1: Lithostratigraphic formations of the Gemeric Unit Paleozoic (BAJANÍK et al., 1983 - adopted). Explanations: 1- Gelnica Group (a-d - areas with different geochemical types of metabasalts; a - E-MORB/OIT , b- without metabasalts, c - BABB, d - CAB + E-MORB/OIT), 2 - Štós Formation, 3 - Smrečinka Formation, 4 - Rakovec Group, 5 - Klátov Group s.l. (1-5 - Early Paleozoic), 6 - Črmeľ Formation, 7 - Ochtiná Formation, 8 - Zlatník Formation, 9 - Hámor Formation, 10 - Rudňany Formation, 11 - Krompachy Group, 12 - Gočaltovo Group (6 -12 - Late Paleozoic), 13 - Mesozoic formations of the Gemeric and Meliatic Units, 14 - Veporic Unit (Central Carpathians), 15 - Gemeric granites

The Štós Formation is located south of the Gelnica Group. It used to be classified as the southern part of the Rakovec Group. It is a monotonous complex of LP/LT metamorphosed alternating pelites and psammites. The assumed Early Paleozoic age of the formation has not been reliably proved yet. Rare small metabasalt bodies are geochemically similar to CAB.

The Smrečinka Formation, having a boundary with the Gelnica Group in the north, is lithologically similar to the Štós Formation. It consists of pelitic and psammitic rock metamorphosed in the greenschist facies. A small quantity of metamorphosed basic volcanoclastics is present as well as very rare effusive metarhyolites and metabasalts. The so far only chemical analysis of a metabasalt has shown a similarity of its composition with alkaline within-plate basalts (WPB). The Smrečinka Formation was traditionally considered the lower part of the Rakovec Group (BAJANÍK et al., 1983).

The Rakovec Group is in our concept of lithostratigraphic classification represented by a complex of metamorphosed lava flows overlying the Smrečinka Formation, or directly the Gelnica Group. Besides metabasalts, pelitic metasediments are found in a smaller quantity, rarely also acid and intermediary metavolcanites. Besides the predominant lava flows there are also basic rocks of subvolcanic origin. The metabasalts are, according to their composition, similar to typical E-MORB/OIT (IVAN, 1994). They display considerable variations in composition caused by the fractionation processes. Pelitic sedimentation and the occurrence of pillow textures in some lava flows indicate subaquatic environment far from the sources of clastic material. The Rakovec Group experienced multi-stage metamorphism with evidence of a MP/LT stage and superimposed LP/LT metamorphism. There are several indications in favour of a possible HP/LT metamorphic stage. Estimated age of the Rakovec Group is probably Early Paleozoic, however, geochronological data are missing to date.

The name "Klátov Group" has been assigned to metamorphic rocks of the amphibolite facies, mostly gneisses and amphibolites, which had been formerly included into the Rakovec Group (HOVORKA et al., 1990).

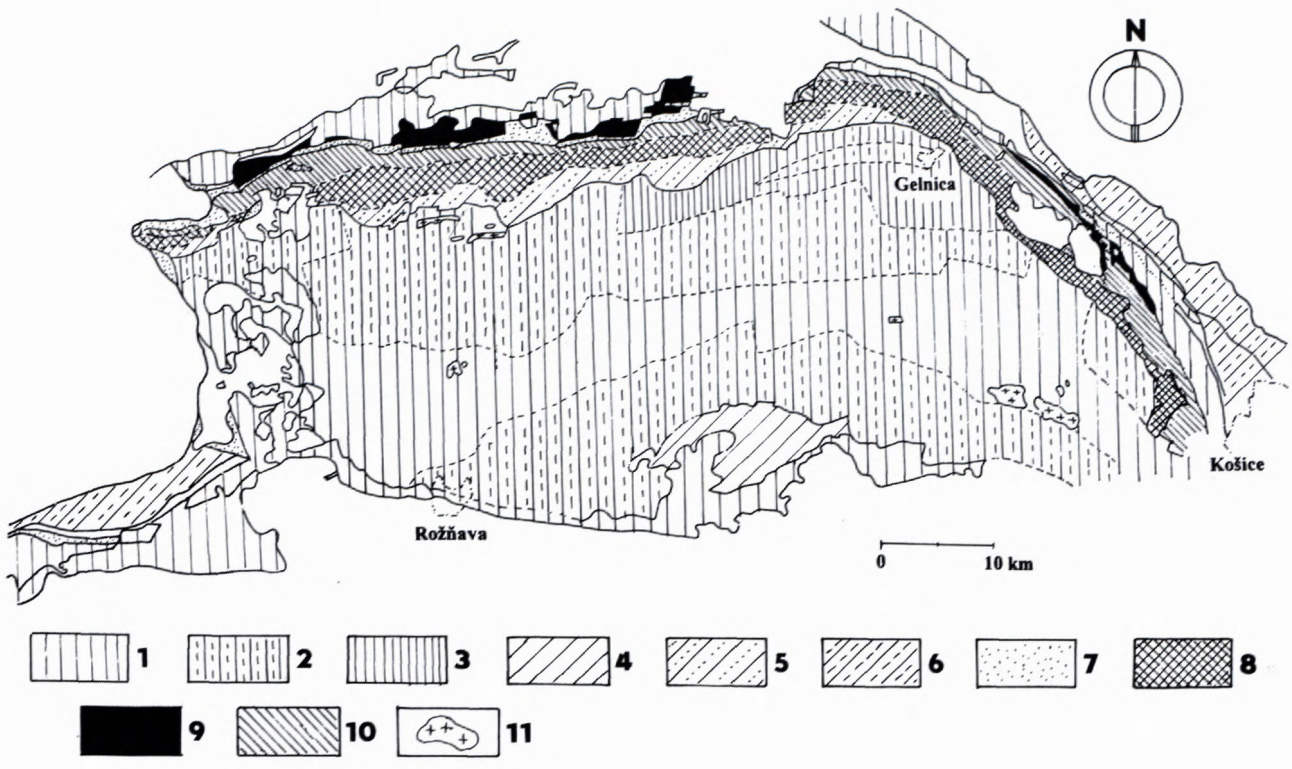

Fig. 2: Geodynamic setting of the Paleozoic formations of the Gemeric Unit.
Explanations: 1 - formations with subduction-related (calc-alkaline) volcanic rocks, 2 - the same as 1 - with volcanic rocks of immature stage of back-arc basin opening, 3 - the same as 1- with volcanic rocks of more evolved stage of back-arc basin opening (BABB), 4 - pelitic rock dominated sedimentary formations of the back-arc basin margin, 5 - the same as 4 - with volcanic rocks of initial stage of back-arc basin opening, 6 - the same as 4 with volcanic rocks of immature stage of of back-arc basin opening, 7 - amagmatic clastic formations, 8 - relic of the crust of the back-arc basin in immature stage of opening, 9 - relic of the crust of more evolved back-arc basin, 10 - reworked lower island arc (continental?) crust, 11- Gemeric granites

More recently, the Klátov Group was compared to leptyno-amphibolite complexes of the Central Western Carpathians (IVAN, 1994). The banded amphibolites, as far as the rare element distribution is concerned, resemble BABB, the enclaves of garnet amphibolites with clinopyroxene are similar to N-MORB. Metamorphic evolution of the Klátov Group was complex, multi-stage. There are indications of an oldest metamorphic stage in eclogite-, or granulite-facies conditions, followed by metamorphism in amphibolite and greenschist facies. The Klátov Group was originally known only from isolated occurrences.

According to latest preliminary data, newly found phyllonites of amphibolites and gneisses, together with a part of metasediments and metavolcanites, belong probably also to the Klátov Group, although they were previously assumed to be the top part of the Rakovec Group. The Klátov Group s.l. would thus form a continuous belt overlying the Rakovec Group. Relics of HP/LT metamorphic stage have been found also in the phyllonites.

Carboniferous complexes of the Gemeric Unit have been described by BAJANÍK et al. (1983) as the Dobšiná Group. The authors defined four stratigraphic sequences, which, according to the results of our studies, we consider to be separate formations. They are: (1) the Ochtiná Formation, (2) the Rudňany Formation, (3) the Zlatník Formation and (4) the Hámor Formation. Carboniferous age has been proved also in the Črmeľ Group. The Rudňany and Hámor Formations consist of metapsammites and metapsephites, volcanic rocks are missing. The source of sedimentary material for the Rudňany Formation was the Klátov Formation (VOZÁROVÁ & VOZÁR, 1988). Both formations were metamorphosed in greenschist facies conditions. The Ochtiná and Črmeľ Formations are built predominantly of metapsammites and metapelites, less of metabasalts and carbonates, partly substituted by metasomatic magnesite. In the Ochtiná Formation there were also found small bodies of metaultrabasites, in the Črmeľ Formation there are rare acid metavolcanoclastics. The metabasalts are geo-

chemically similar to E-MORB/OIT to BABB. Both formations were metamorphosed in greenschist facies conditions. Metabasalts are predominant in the Zlatník Formation, less frequent are metadolerites, metagabbro, from sediments metapelites and rarely also metapsammites with abundant chromium-spinelid. The metabasalt composition corresponds to typical BABB. Pelitic sedimentation is the result of a very limited contribution of clastic material into the sedimentation basin. Metamorphic conditions of the Zlatník Formation vary from prehnite-pumpellyite to amphibolite facies and they are the result of an ocean ridge type metamorphism. The age of the formation has not been supported either by geochronological or paleontological data.

The Krompachy Group occur above the Zlatník Formation and it is of Permian age. In the basalt part, conglomerates are predominant (the Knola Formation), in the middle metapsammmites alternate with acid, intermediary and rarely also basic metavolcanics and volcanoclastics (Petrova hora Formation). In the uppermost part of the Krompachy Group, metapelites with evaporites (Nová Ves Formation) are predominant. Sedimentation took place in continental conditions, at the end of the evolution also in mixed continental-marine conditions (Vozárová & Vozár, 1988). The volcanites are of calc-alkaline type. Metamorphism was connected with alkaline metasomatism and it was probably caused by the circulation of heated marine water. It varies from very low to greenschist facies, located especially around tectonic zones.

The Gočaltovo Group is located in the southern and western part of the Gemeric Unit, overlying the Gelnica Group and the Štós Formation (Fig.1). It is of Permian age. The basal part is built predominantly of metapsephites and metapsammites, acid metavolcanites and metavolcanoclastics occur sporadically. The upper part of the Gočaltovo Group contains metapelites and metapsammites, rarely also acid volcanic rocks and limestones. Sedimentation took place in continental environment, in the upper part in mixed continental-marine environment. The Gočaltovo Group was metamorphosed maximally in greenschist facies conditions.

Geodynamic setting

A scheme of the geodynamic setting of Paleozoic formations of the Gemeric Unit is shown in Fig. 2. Gelnica, Krompachy and, probably, also the Gočaltovo Groups formed in the environment of a destructive litospheric plate margin. In the case of the Gelnica Group it was probably the back-side part of a magmatic arc of a rifted island arc. The Krompachy Group formed maybe in the area of a magmatic arc and the adjoining basins, on an active continental margin. The Gočaltovo Group formed in an analogous environment, indicating the beginning of the formation of a riftogenic basin (Vozárová & Vozár, 1993) in the neighbourhood of a volcanic arc of an active continental margin. The Štós and Smrečinka Formations represent probably the clastic filling of basins which formed in the initial stages of rifting of an Early Paleozoic island arc. The Črmeľ and Ochtiná Formations formed already during a more evolved stage of rifting, on the margins of an immature basin. The Rakovec Group and the Zlatník Formation may be considered relics of the crust on the bottom of back-arc basins (Ivan et al., 1994). In the first case it is the crust of an immature basin forming on the thinned crust of an island arc (or continent). The Zlatník Formation is the relic of a more evolved back-arc basin, where magmatic activity concentrated already into the active ridge. And, finally, the amagmatic Rudňany and Hámor Formations are the products of rapid sedimentation in a delta cone, or cyclic sedimentation in a stabilised basin, in both cases in an environment which behaved as a passive micro-plate margin. The Klátov Group has been interpreted as a relic of a metamorphically reworked and migmatitised lower crust of an island arc (or continent;, Ivan, 1994). The more broadly defined Klátov Group including metavolcanites and metasediments could represent a crust thinned by extension, on which the Rakovec back-arc basin formed.

From Fig. 2 it is obvious that coincident geodynamic environment appear in Early as well as Late Paleozoic formations. In both cases, there is evidence of a subduction-related geodynamic setting and back-arc basin formation. However, the lack of geochronological data does not allow a reconstruction of these processes in time and their correlation with neighbouring areas.

Tectonic structure

Differences in lithology, geodynamic setting and metamorphic reworking of the Paleozoic formations of the Gemeric Unit Paleozoic indicate permanent interaction of the litospheric plate margins in this area in Pre-Alpine and Alpine time. They are evidence of a considerable shortening of the original space and of nappe-scale structure of the Gemeric Unit Paleozoic. The evolution of the tectonic setting was a multi-stage process. It includes Pre-Alpine, Alpine as well as Alpine stages. Among the earlier are e.g. tectonic processes connected with the exhumation of high-grade metamorphic complexes of the lower crust prior to the Upper Carboniferous, or the change of the divergent geodynamic regime in the Carboniferous to a convergent regime in the Permian. Dominant position among Alpine tectonic processes could be assigned to the reworking in an accretionary prism of an Alpine subduction zone, indicated by relics of HP/LT mineral assemblages in some Paleozic formations. In the Mesozoic rocks of the Meliatic Unit, which adjoins the Gemeric Unit in the south, the

age of the HP/LT metamorphism is Jurassic (155±2 Ma; MALUSKI et al., 1993). The last important contribution to the tectonic structure of the Gemeric Unit occurred probably in the Cretaceous (KOVÁCH et al., 1986) as a result of the closing of the Meliata-Hallstatt ocean and the subsequent collision connected with the thrusting of superficial nappes.

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