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Early Paleozoic of the Gemeric Unit (Inner Western Carpathians): Geodynamic Setting as Inferred from Metabasalt Geochemistry Data

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8 Text-Figures, 1 Table

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Altpaläozoikum des Gemerikums (Innere Westkarpaten): Geodynamische Rekonstruktion aus geochemischen Daten von Metabasalten

Zusammenfassung

Die altpaläozoische Schichtfolge im Gemerikum läßt sich in drei Gruppen untergliedern: 1) die Gelnica-, 2) die Rakovec- und 3) die Klátov-Gruppe.

Die Gelnica-Gruppe setzt sich im wesentlichen aus kalkalkalischen Vulkanoklastika und untergeordneten sandigen und tonigen Sedimenten, die in Grünschieferfazies metamorphosiert sind, zusammen. Geringmächtige Metabasaltkörper konzentrieren sich in drei – im allgemeinen west–ost-streichenden – Gürteln. Die Metabasalte im nördlichen Gürtel sind geochemisch N-MORB/BABB, CAB und E-MORB/OIT vergleichbar. Der mittlere und südliche Gürtel enthält lediglich E-MORB/OIT-Typen. Die Gelnica-Gruppe wurde im randlichen Teil eines back-arc-basin, das einem magmatischen Bogen benachbart war, gebildet.

Die nördliche Rakovec-Gruppe – zumindest unter mittleren Druckbedingungen metamorph geworden – ist im wesentlichen aus Metabasalten mit einer einheitlichen E-MORB/OIT-Signatur zusammengesetzt. Sie könnte ebenfalls von Krustenresten aus dem randlichen Teil eines back-arc-basins aufgebaut worden sein.

Die nördliche, altpaläozoische Gruppe, die Klátov-Gruppe, besteht aus einem migmatischen Leptynit-Amphibolit-Komplex. Sie enthält Einschlüsse amphibolitisierter Eklogite, ursprünglich Metabasalte mit N-MORB-Charakteristik. Die Klátov-Gruppe stellt vermutlich eine kräftig wiederaufgearbeitete Unterkruste eines Inselbogens dar mit Relikten einer alten, subduzierten, ozeanischen Kruste.

Die altpaläozoischen Gesteine des Gemerikums stellen insgesamt den Rest eines zerbrochenen Inselbogens dar, der durch variszische und alpidische Ereignisse zu einem Deckensystem verkürzt wurde.

Abstract

The Early Paleozoic of the Gemeric unit can be divided into three groups: 1) the Gelnica Group, 2) the Rakovec Group and 3) the Klátov Group.

The Gelnica Group is composed mainly of calc-alkaline volcanoclastics, subordinate psammitic and pelitic sediments, metamorphosed in greenschist facies. Small metabasalt bodies occur in three generally W–E trending belts. Metabasalts in the northern belt are geochemically similar to the N-MORB/BABB, CAB and E-MORB/OIT types, the central and southern belts contain the E-MORB/OIT type only. The Gelnica Group was formed in the marginal part of a back-arc basin adjacent to a magmatic arc.

The northern Rakovec Group, metamorphosed at least under medium-pressure conditions, is composed of metabasalts with a uniform E-MORB/OIT signature. They may be considered as remnants of the crust of a marginal part of a back-arc basin.

The northernmost Early Paleozoic group – the Klátov Group – is formed by a migmatized leptynite-amphibolite complex. There are enclaves of amphibolitized eclogites – originally metabasalts – with N-MORB signature. The Klátov Group presumably represents strongly reworked lower crust of an island arc with relics of subducted ancient oceanic crust.

The Early Paleozoic of the Gemeric unit as a whole may be considered as a remnant of a rifted island arc strongly shortened into a nappe system by Variscan and Alpine events.

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1. Introduction

The Gemeric unit is the northernmost unit of the Inner Western Carpathians. It is composed of a Paleozoic basement and a Mesozoic envelope. The Paleozoic basement belongs to the most metallogenetically significant areas of Central Europe and it has been intensely studied over several decades. Concurrent with these investigations a controversy developed over the geological structure of the Gemeric unit and its evolution.

Geochemical studies especially of incompatible trace elements in magmatic rocks, provide a significant tool for a better verification of the lithostratigraphic division and geodynamic setting of the rock complexes.

This paper intends to summarize recent data on the geological structure and geodynamic setting of the Early Paleozoic part of the basement of the Gemeric unit, as inferred from the geochemical study of metabasalts.

2. Geology

The Paleozoic basement of the Gemeric unit is composed of Early and also Late Paleozoic lithostratigraphic groups.

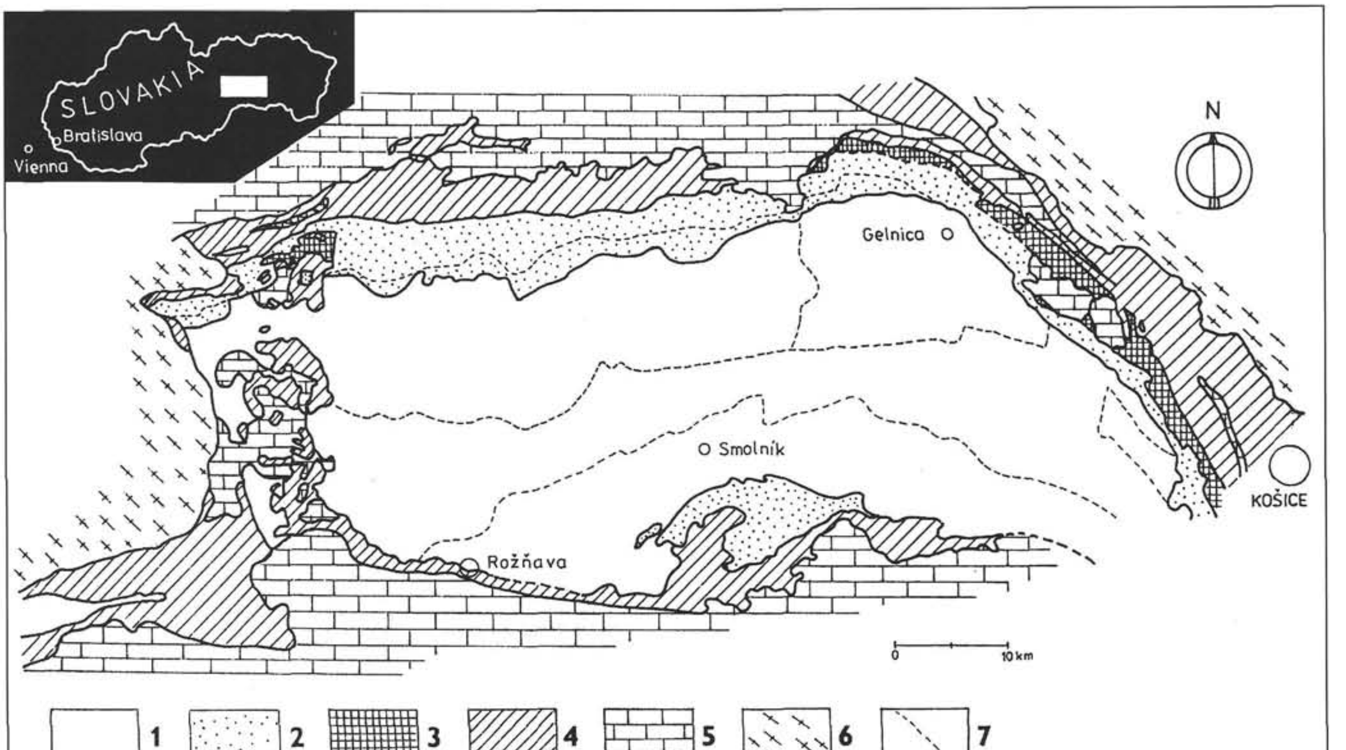
The former groups are located in the central part of the Gemeric unit, the latter in its external parts (Text-Fig. 1). The Early Paleozoic of the Gemeric unit is divided into three lithostratigraphic groups (BAJANÍK et al., 1983; HOVORKA et al., 1990; Text-Fig. 1):

1) the Gelnica,
2) the Rakovec and
3) the Klátov Group.

The largest of all, the Gelnica Group, a Silurian-Devonian volcanosedimentary complex (palynological data, IVANIČKA et al., 1989) is comprised of acid volcaniclastics and psammitic sediments with a predominance of volcanogenic material. Acid, intermediate and basic volcanics appear in subordinate amounts (FARYAD & GRECULA, 1984). They form mainly small subvolcanic bodies. Metabasalt bodies are usually conformably oriented lenses reaching few hundred meters in length. They are concentrated into three discontinuous belts in the northern, central and southern parts of the Gelnica Group. Sediments such a black shales, lydites and limestones are mostly concentrated into isolated horizons. The Gelnica Group was metamorphosed in greenschist facies (FARYAD, 1991), often associated with regional alkaline metasomatism and it was locally intruded by pre-Alpine granitoids.

Basic volcanism predominates the Rakovec Group. The exact age of this group is unknown but believed to be probably Early Paleozoic because its rocks were found as pebbles in the Upper Carboniferous conglomerates (BAJANÍK et al., 1983).

This group can be divided into two sequences. In the lower sequence pelitic and subordinate psammitic metasediments predominate over basic metavolcanics. The upper sequence is volcanogenic, with subordinate presence of pelitic metasediments. Among the metavolcanics, basalts are originally dominant, basaltic andesites are more rare, and acid volcanics occur only sporadically. They form numerous lava flows with usually aphanitic rims and phyric central parts within the flow. Local pillow textures point to subaquatic conditions (BAJANÍK, 1975). The thickness of the flows attains several meters. The Rakovec Group underwent polyphase metamorphism. The oldest event took place in medium-pressure conditions – relics of Na-Ca amphiboles have been found. Variations in the amphibole com-



Text-Fig. 1.
Location and geology of the Early Paleozoic basement lithostratigraphic groups of the Gemeric unit (BAJANÍK et al., 1983; adopted).
1 = Gelnica Group (Silurian = Devonian), 2 = Rakovec Group (Early Paleozoic?), 3 = Klátov Group (Early Paleozoic), 4 = Late Paleozoic groups of the Gemeric unit, 5 = Mesozoic groups of the Gemeric unit, 6 = central Western Carpathians groups, 7 = boundaries of lithostratigraphic sequences in the Gelnica and Rakovec Groups.

position suggest high-pressure blueschist facies as the preceding metamorphic condition. During the further evolution this event (or events) was overprinted by greenschist facies metamorphism (HOVORKA et al., 1988). It cannot be ruled out that the original metamorphic conditions attained the blueschist facies in the Rakovec Grpup (HOVORKA et al., 1988).

The Klátov Group is the northernmost lithostratigraphic group of the Early Paleozoic part of the Gemeric unit basement. It is mainly composed of amphibolites and gneisses. Metamorphosed ultrabasics (mainly antigoritic serpentinites), metacarbonates (skarns) as well as aplites and pegmatites (HOVORKA et al., 1984, 1990) are subordinate. The age of this group is Early Paleozoic. Its material forms components in the Upper Carboniferous conglomerates of the Dobsina Group.

The Klátov Group has recently been regarded as a leptynite-amphibolite complex of presumably lower-crustal magmatic origin, which underwent migmatization of varying intensity and multiphase metamorphic alteration (IVAN et al., 1992). In the best-preserved parts it is formed of fine-grained amphibolites alternating with mm to even 20 cm thick leptynite bands. Garnet amphibolites (amphibolitized eclogites) and ultrabasics (serpentinites) constitute the enclaves in this complex with a few meters in size. Migmatitization caused the alteration of leptynites and amphibolites into various types of gneisses. The final metamorphic stages proceed in greenschist facies.

3. Petrography

The basic metavolcanics of the Early Paleozoic groups in the basement of the Gemeric unit are petrographically variable owing to primary (magmatic) as well as secondary differences related to different type or the intensities of metamorphism.

The petrography of the metabasalts of the Gelnica Group will be described according to their geochemical assignment. As shown below, the metabasalts can be divided in three geochemical types similar to N-MORB, E-MORB/OIT and CAB (normal mid-ocean ridge basalt, enriched mid-ocean ridge basalt or oceanic island tholeiit and calc-alkaline basalt). Metabasalts of N-MORB type observed only in the northern belt preserve their original doleritic character. Rare clinopyroxene represents the only magmatic mineral phase. The majority of these rocks contains only the metamorphic association actinolite + chlorite + zoisite + albite + carbonate.

The petrography of E-MORB metabasalts of E-MORB/OIT-type varies significantly with their occurrence.

In the northern belt only original aphanitic to fine-grained metavolcanics were found with relic ophitic texture and the association epidote + chlorite + albite + carbonate.

Metavolcanics of the southern belt have coarse-grained character and a ophitic texture. They resemble N-MORB type metabasalts of the northern belt and also comprise an identical metamorphic mineral association.

A different development can be seen in E-MORB/OIT type metabasalts in the central belt where the metamorphism displays at least two phases. The mineral association actinolite + epidote + chlorite + albite overprints an older association containing magnesio-hornblende.

Metabasalts similar to CAB have neither retained relics of the original magmatic textures nor primary minerals. They comprise the association actinolite + chlorite + zoisite + albite + carbonate. They were found only in the northern belt.

Metabasalts of the Rakovec Group display, at some localities, well preserved primary features. Porphyric and aphyric types were documented by BAJANÍK (1976). Clinopyroxene and/or plagioclase phenocrysts are in the phyric lavas up to 2 cm. The composition of clinopyroxene corresponds accordingly to the discrimination criteria by LETERRIER et al. (1982) to tholeiitic anorogenic basalts (HOVORKA et al., 1988). In the aphyric types relic trachytic or ophitic textures can be observed. Medium-pressure metamorphism caused the substitution of the magmatic minerals by the association Na-Ca amphibole + albite + garnet + stilpnomelane + chlorite + carbonate. This earlier paragenesis was transformed into younger greenschist facies minerals such as actinolite + epidote + chlorite + albite, or even into chlorite + albite + carbonate (HOVORKA et al., 1988). Due to the intensity of the metamorphism most of the metavolcanics of the Rakovec Group lost their original magmatic features and were altered into prasinites and greenstones.

Two types of metamorphosed basic rocks occur in the Klátov Group: banded amphibolites and massive garnet-bearing or speckled amphibolites respectively. The first type is represented by fine-grained oriented amphibolites composed mostly of amphibole and plagioclase. They alternate locally with bands of leptynite. Rarely preserved relics of clinopyroxene and uralitized orthopyroxene indicate their origin from gabbronorites. The garnet-bearing and speckled amphibolites are more scarce. They are composed of amphibole, plagioclase, garnet, clinozoisite, quartz, clinopyroxene and sulphides. Relics of clinopyroxene-albite symplectites, kelyphitic rims around garnets as well as rarely preserved garnet with high content of pyrope (HOVORKA & SPIŠIAK, 1981) indicate amphibolitized eclogites. Two types of amphiboles – the older brown magnesio-hornblende and younger actinolite – provide some evidence for a multistage retrograde alteration.

4. Geochemistry

It is generally accepted that the chemical composition of basalts, especially the distribution of incompatible trace elements sensitively reflects the conditions of the basaltic magma generation. These conditions display a specific character for the individual geodynamic settings, therefore the study of the chemical composition of basalts is a useful tool for the geodynamic reconstruction.

All the studied rocks were affected by secondary processes including low-grade metamorphism (in the Klátov Group high-grade metamorphism) leading to the change in concentrations of some major as well as some trace elements. Therefore only those elements were used for the interpretation of the geodynamic setting, which are generally considered only slightly mobile or even immobile during the metamorphism, as for instance the HFSE (high field-strength elements) such as Ti, Zr, Y, Nb, Hf, Ta (SAUNDERS et al., 1980), REE (HAJASH, 1984; BARTLEY, 1986; SHATSKY et al., 1990), but also some transition metals (V, Cr, Sc) (PEARCE et al., 1981; SHERVAIS, 1982).

Metabasalts of the Gelnica Group (Tab. 1) were tested by discrimination diagrams based on the incompatible elements and proved to be close to the three geochemical types:

1) N-MORB/BABB,
2) E-MORB/OIT and
3) CAB.

Table 1.
Representative trace-element analyses for the Early Paleozoic metabasalts and amphibolites from the Gemeric Unit.
1 – 3 = metabasalts of E-MORB/OIT-type from the Gelnica Group (1 = southern, 2 = central, 3 = northern belt); 4 = metabasalt of CAB-type from the Gelnica Group; 5 = metabasalt of BABB-type from the Gelnica Group; 6 = metabasalt of E-MORB/OIT-type from the Rakovec Group; 7 = banded amphibolite from the Klátov Group; 8 = garnet amphibolite from the Klátov Group.
All trace elements except Zr, Y and V were determined by INAA in laboratories MEGA Inc., Stráž p. Ralskem, Czech Republic. Zr, Y and V were analyzed by XRF in the same laboratories.
*/** = standard deviation of activity measuring 20–30/30–40 percent.

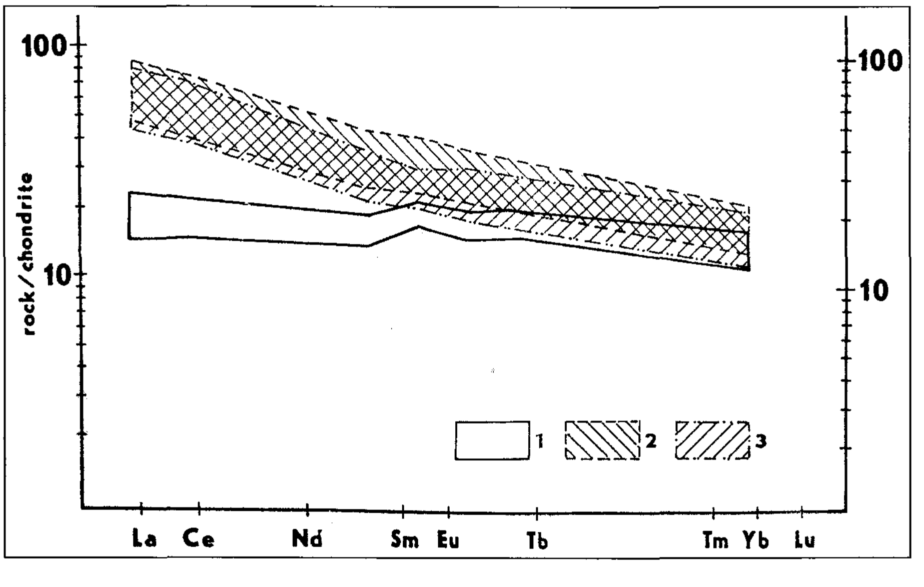
	1	2	3	4	5	6	7	8
	FMZ-10	BSV-38	FD-206	BSL-281	BSL-287	FR-400	FR-395	FD-253
Cr	445	8.7 *	235	420	300	34.0	72.0	118
Co	41.0	54.0	46.0	41.0	39.5	47.0	52.0	46.5
Sc	26.9	84.5	36.5	38.5	30.0	32.0	39.0	42.5
V	453	1498	651	568	482	1215	1226	930
La	12.1	17.8	12.7	13.0	5.8	16,6	13.2	7.4
Ce	28.6	42.0	28.1	29.7	15.2	47.5	40.0	18.4
Nd	16.8	21.1	19.8	18.4	11.9	29.2	24.9	13.1 *
Sm	2.90	6.7	4.2 *	4.2	2.80	6.9	7.4	4.9
Eu	1.10	1.95	1.70	1.20	1.05	2.10	2.10	1.55
Tb	0.45	1.15	0.88	0.67	0.59*	1.05	1.30	0.98*
Yb	1.30*	3.8	3.4	2.70	2.05	2.65	3.8	4.6
Lu	0.18*	0.65	0.63	0.47*	0.43*	0.41	0.58	0.77
Hf	2.20	5.2	4.0	3.2	2.15	5.0	5.3	3.4
Ta	0.86	1.10	0.69	0.31*	0.26**	1.25	1.25	0.18**
Th	2.10	1.65	1.95	2.10	0.70	1.75	0.43*	0.35**
Zr	247	227	197	206	49	277	224	149
Y	15	37	30	27	18	24	37	54

All three types were only identified in the northern belt. The central and southern belt contained E-MORB/OIT type.

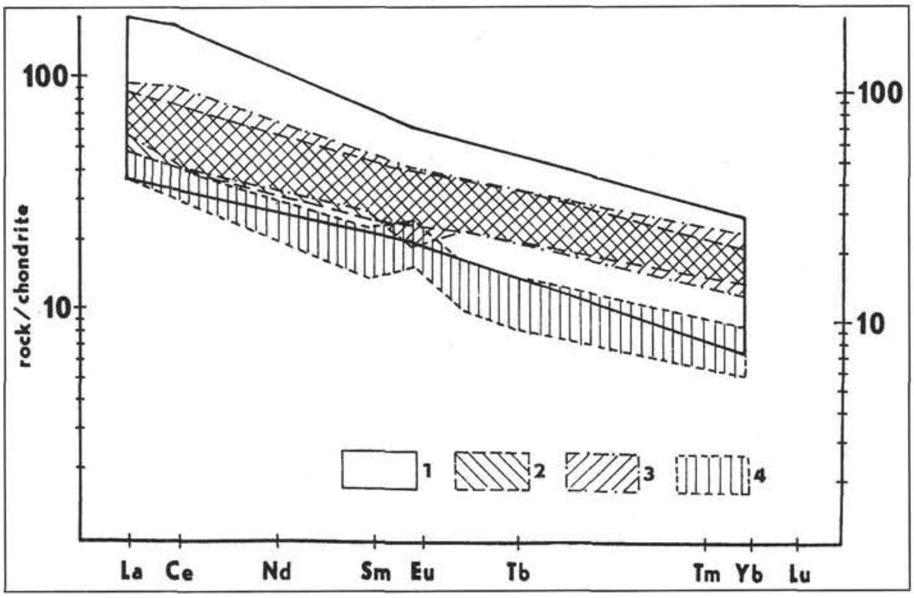
Metabasalts of N-MORB type display a characteristic flat or slightly LREE enrichment pattern in chondrite normalised REE diagrams (La_N/Yb_N: 0.85–1.91) and a low total content of REE (Text-Fig. 2). Contents of other immobile incompatible elements are also similar to N-MORB type of basalts.

In discrimination diagrams such a TiO_2 vs Zr, Cr vs Y (PEARCE et al., 1981), Zr vs Y (LE ROEX et al., 1983; Fig. 6) they plot in the field of the ocean ridge basalts. In the Hf/3 – Th – Ta diagram (WOOD, 1980; Fig. 4) these metabasalts project into two fields – the N-MORB field and the primitive calc-alkaline basalt field. Such compositional trends are typical for BABBs (back-arc basin basalts; FALLOON et al., 1992). Identical results were revealed using the 3xTb – 2xTa – Th diagram (CABANIS, 1986, in CABANIS & THIEBLEMONT, l988; Fig. 5) in which some of the points fall immediately in the BABB's field.

The E-MORB/OIT type metabasalts of the Gelnica Group exhibit a general enrichment in LREE with La_N/Yb_N varying from 3,25 to 6,71 (Text-Fig. 3) and elevated HFSE contents. In the diagrams Hf/3 – Th – Ta (WOOD, 1980; Fig. 4), or Th/Yb vs Ta/Yb (PEARCE et al. 1981) respectively, they project into the field of E-MORBs. In the diagram 3xTb – 2xTa – Th (CABANIS, 1986, in CABANIS and THIEBLEMONT, 1988; Fig. 5), the points plot only partly in the E-MORB field, the majority is concentrated in the field CT (continental tholeiites). The E-MORB/OIT type metabasalts vary in some geochemical parameters between the belts. In the northern belt they show no Eu-anomalies, but REE



Text-Fig. 2.
REE patterns of three different geochemical types of metabasalts from the northern belt of metabasalt occurrences in the Gelnica Group.
1 = N-MORB/BABB (9 analyses), 2 = E-MORB/OIT (4 analyses), 3 = CAB (7 analyses).
Data by BAJANÍK (1981), IVAN (in print) and unpublished data.



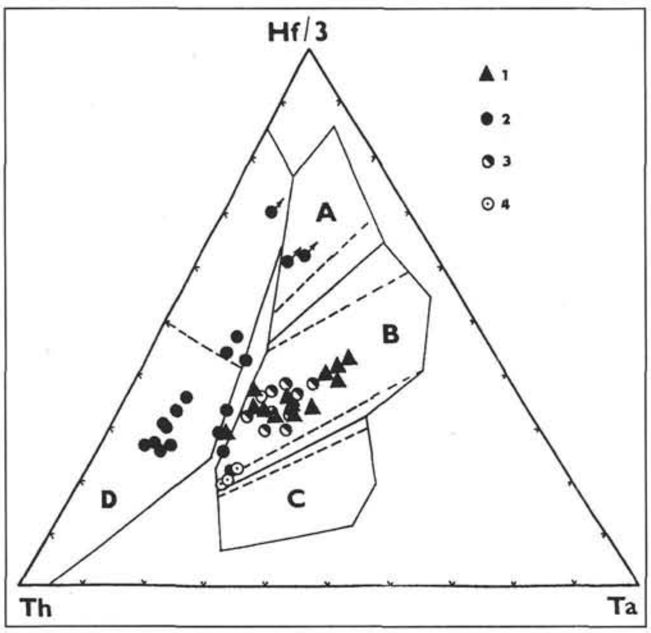
Text-Fig. 3.
REE patterns of E-MORB/OIT-type metabasalts of the Rakovec and Gelnica Groups.
1 = Rakovec Group (18 analyses), 2 = Gelnica Group – northern belt (4 analyses), 3 = Gelnica Group – central belt (8 analyses, 4 = Gelnica Group – southern belt (10 analyses).
Data by BAJANÍK (1981), HOVORKA et al. (1988) and IVAN (in print).

patterns in the central belt display sometimes negative and in the southern belt positive Eu anomalies (Text-Fig. 3). The reason of the Eu anomalies is the fractionation of plagioclase. Some small differences in the composition of basalts from different belts are also obvious from the diagrams Hf/3 – Th – Ta (Text-Fig. 4) and 3xTb – 2xTa – Th (Text-Fig. 5).

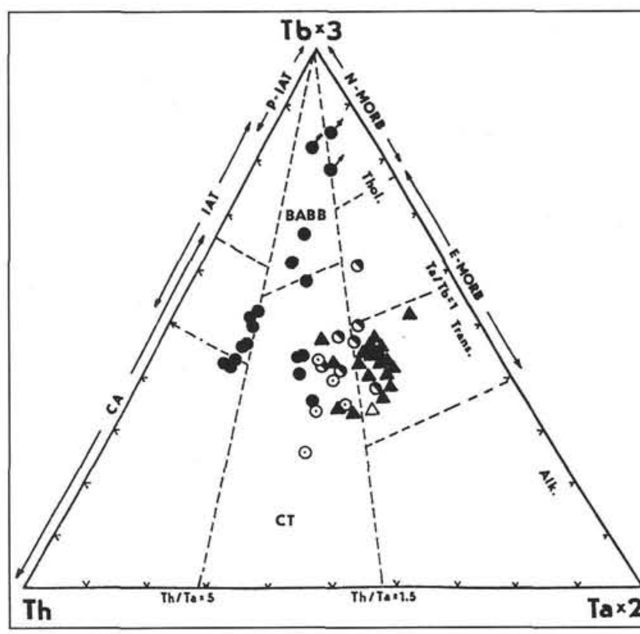
Metabasalts from the Gelnica Group, geochemically close to CAB, constitute a homogeneous group, differing from other types by their characteristic low content of Ta (Figs. 4, 5). Their REE pattern (Text-Fig. 2) indicates their enrichment in LREE (La_N/Yb_N: 3,21–4, 2). Contents of other incompatible elements also correspond to these characteristics of CAB.

In the Rakovec Group (Tab. 1) only metabasalts geochemically similar to E-MORB/OIT type were ascertained (HOVORKA et al., 1988; IVAN, 1989; IVAN, in print). The REE pattern displays an enrichment in LREE (La_N/Yb_N: 4,45–7,61; Text-Fig. 3). Higher concentrations of HFSE definitely attribute them to E-MORB type in discrimination diagrams Th/Yb vs Ta/Yb and/or Hf/3 – Th – Ta (Text-Fig. 4). In the latter diagram the metabasalts of the Rakovec Group display a typical "subduction mantle enrichment trend" (WEVER & STOREY, 1992). In comparison with analog rocks of the Gelnica Group displaying an affinity to the continental tholeiite composition, their characteristics are similar to E-MORB. Their higher variability of total REE contents (Text-Fig. 3), attributed to the presence of more evolved rock types such as basaltic andesites and to the fractionation of clinopyroxene is also remarkable (IVAN, in print). Occurrences of small bodies of clinopyroxene-rich rocks also suggest fractionation. The considerable varying Cr content (6–1640 ppm) is also resulting from the clinopyroxene (and maybe chromspinelide) fractionation.

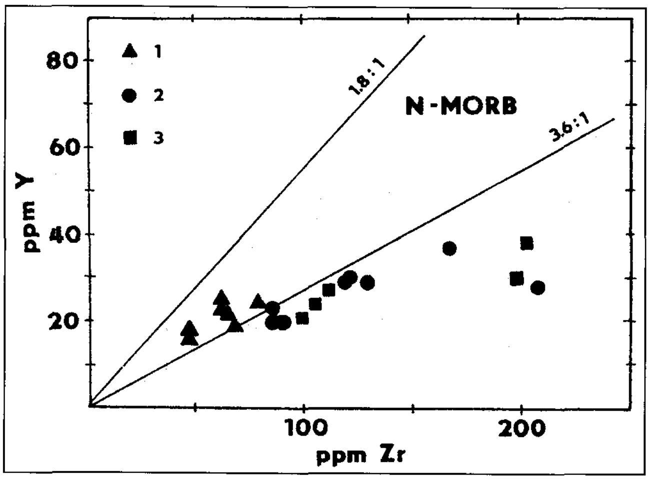
Two petrographically distinct types of metabasites within the Klátov Group also have distinct geochemical characteristics (Tab. 1). The banded amphibolites, together with-



Text-Fig. 4.
Diagram Hf/3 – Th – Ta (WOOD, 1980) for metabasalts of the Gelnica and Rakovec Groups.
1 = Rakovec Group, 2 = Gelnica Group = northern belt, 3 = Gelnica Group = central belt, 4 = Gelnica Group = southern belt; A = N-MORB, B = E-MORB, C = within-plate alkali basalts, D = destructive plate margin basalts, dashed lines = overlapping of tectonomagmatic fields.
Data: see Text-Figs. 2 and 3.



Text-Fig. 5.
Diagram 3xTb – 2xTa – Th (CABANIS, 1986, in CABANIS & THIEBLEMONT, 1988) for metabasalts of the Rakovec and Gelnica Groups.
Symbols: see Text-Fig. 4.



Text-Fig. 6.
Diagram Zr vs. Y (LE ROEX et al., 1983) for metabasalts from the northern belt of occurrences in the Gelnica Group.
1 = N-MORB/BABB-type, 2 = CAB-type, 3 = E-MORB/OIT-type.
Data see Text-Fig. 2.

leptynites, represent presumably metamorphosed layered intrusive magmatic bodies. This conclusion follows from REE patterns of the selected rock types (Text-Fig. 7). REE patterns of these rocks are highly variable. Fine-grained amphibolites from localities absent in leptynites exhibit a basalt-like REE pattern with a distinct enrichment in LREE.

According to trace element distributions they resemble transitional MORB (T-MORB) or BABB.

The banded amphibolites intercalated with leptynites display REE pattern similar to cumulate gabbros or to their more differentiated fractions with the negative Eu anomaly (IVAN, in prep.). Leptynites have low REE contents and as a rule positive Eu-anomaly (Text-Fig. 7). They probably represent a fractionation product, originally rich in plagioclase.

The second type of metabasites, garnet amphibolites (amphibolitized eclogites) show a flat REE pattern with a depletion of LREE and a small negative Eu-anomaly (Text-Fig. 7).

The geochemical character of these rocks is similar to N-MORB, although the original REE patterns, where some were probably affected by limited REE fractionation during the eclogite stage metamorphism (c.f. BERNARD-GRIFFITS et al., 1991).

5. Geodynamic Setting: Discussion

As mentioned at the beginning, concepts of the geological development of the Early Paleozoic of the Gemeric unit are somewhat controversial in respect to the geodynamic setting as well as the tectonics.

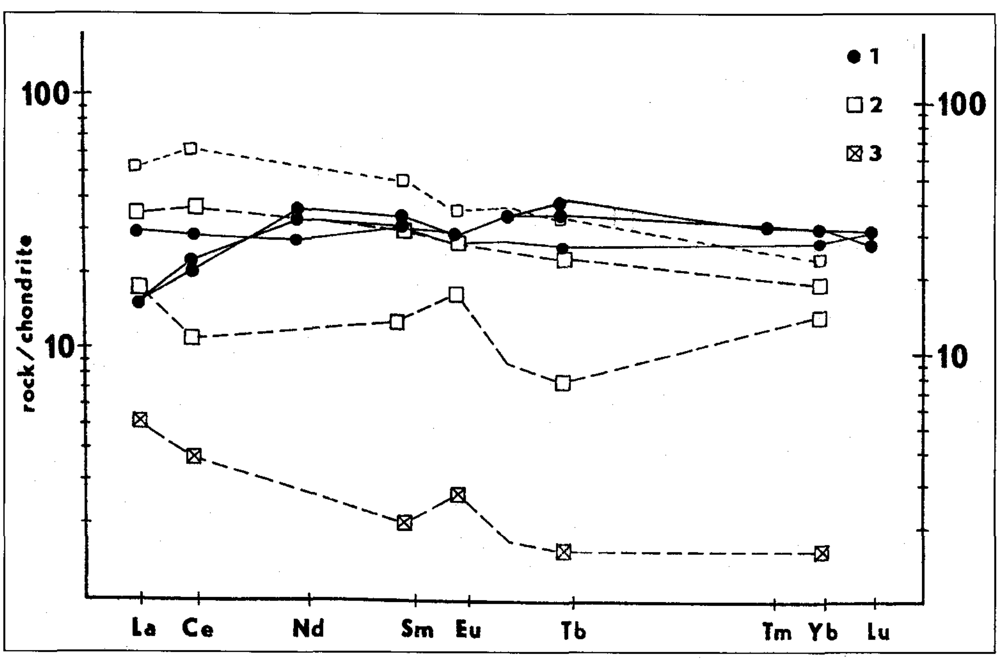
BAJANÍK (1981) and BAJANÍK et al. (1983) supposed the Gelnica and Rakovec Groups to be in normal stratigraphic position and assumed they originated in an island arc environment. On the contrary, GRECULA (1982, 1987) regards the Early Paleozoic of the Gemeric Unit as "the filling" of a continental rift with previously evolved oceanic crust in the center (the Rakovec Group), that was shortly after closed again. According to this author, the Variscan events are responsible for the formation of a system of nappes in the Early Paleozoic basement of the Gemeric unit.

Constraints following from the geochemistry of the Early Paleozoic metabasalts significantly modify the present concepts and confirm the following important findings (Text-Fig. 8):

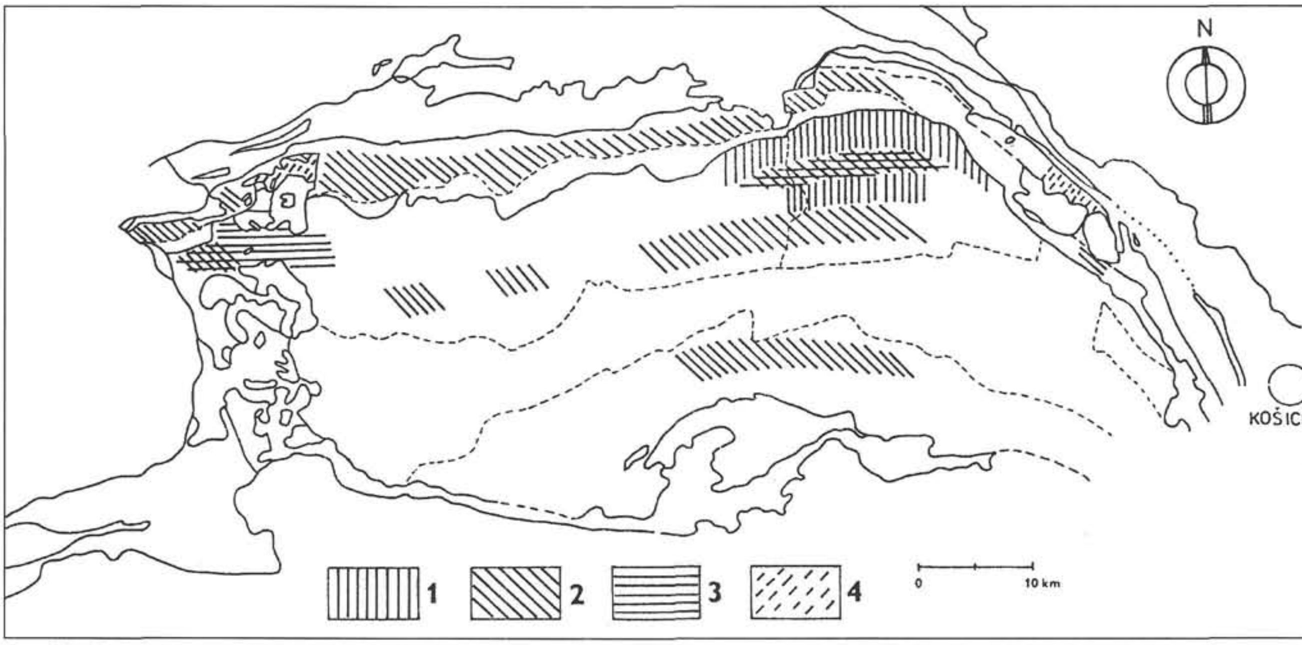
1) the division of the Early Paleozoic into three lithostratigraphic groups and
2) the tectonic relationships existing not only between the groups but also within the Gelnica Group itself.

In the Gelnica Group three geochemical types of metabasalts have been found: N-MORB/BABB, E-MORB/OIT and CAB. The combination of CAB with the E-MORB/OIT, or N-MORB types , respectively, is relatively frequent in Variscan terrains both in Western Europe and the Appalachian Mts. (LEAT & THORPE, 1986; SMEDLEY, 1988; WERNER et al., 1987; SWINDEN et al. (1990); FYFFE & SWINDEN, 1991). Modern analogs of these terrains are back-arc basins. Metabasalts close to E-MORB/OIT are believed to be associated with incipient back-arc rifting. In the course of basin evolution the basalts with transitional characteristics to N-MORB and/or arc basalts are produced. They are usually denoted as BABBs. In the mature stages of the back-arc basin evolution characterized by rapid spreading N-MORBs dominate (HAWKINS & MELCHIOR, 1985; VOLPE et al., 1988; IKEDA & YUASA, 1989; REAGAN & GILL, 1989; HOCHSTAEDTER et al., 1990; PRICE et al., 1990; FALLOON et al., 1992).

A possible environment of the formation of the Gelnica Group would be the margin of a back-arc



Text-Fig. 7.
REE patterns of amphibolites and leptynite of the Klátov Group.
1 = garnet amphibolite (amphibolitized eclogite), 2 = banded amphibolite, 3 = leptynite.
Unpublished data.



Text-Fig. 8.
Spatial distribution of geochemical types of basic metavolcanics and magmatites in the Early Paleozoic of the Gemeric unit.
1 = N-MORB/BABB-type, 2 = E-MORB/OIT-type, 3 = CAB-type, 4 = transition type between N- and E-MORB.

basin adjacent to a magmatic arc. This is inferred from the metabasalt geochemistry as from flysch-like character of the sedimentation (IVANIČKA et al., 1989). This suggests an accumulation of sediments and volcanic rocks at the base of a continental slope of an island arc. According to GRECULA (1987) Variscan events caused an intensive shortening of the original realm of the Gelnica Group and lead to a system of nappes being preserved up to now. This idea seems to be compatible with the spatial distribution of geochemical types of basic metavolcanics in the Gelnica Group (Text-Fig. 8), although there are some discrepancies in the nappe boundaries assumed by the previously mentioned author. As follows from Text-Fig. 8 the distribution of geochemical types cannot be entirely identitified with the lithostratigraphic sequences defined by IVANICKA et al. (1989) too.

Shortening of the original space is probably responsible for small trace element variations and differences in the Eu anomaly found in E-MORB/OIT-type metabasalts. The presence of Eu anomalies suggest the fractionation of magma in secondary chambers within the crust. Such fractionation was proved in the central and southern belt. The central belt contains fractions with partly removed plagioclase, while the metabasalts in the southern belt are represented by fractions enriched in plagioclase. Metapicrite was also found here – with olivine as the most important cumulate mineral (IVAN, 1991; IVAN, in print). Different modes of the fractionation of the E-MORB/OIT magmas indicate differences in time and character of the magma emplacement. The trace element distribution somewhat similar to that of continental tholeiites and small variations mainly of thorium and tantal between belts (Text-Figs. 4, 5) probably reflected inhomogeneities in the mantle sources and/or a lesser probability of contamination by the upper continental crust.

The presence of CAB-type metavolcanics in the Gelnica Group may be explained by the proximity to a magmatic arc in the course of its deposition. Modern analogs of metabasalts close to N-MORBs or BABBs were both erupted on the spreading ridges of back-arc basins (PRICE et al., 1990; FALLOON et al., 1992). In the case of the Gelnica Group, same basalt types, are perhaps related to the incipient stage of the oceanic crust formed during the opening of a back-arc basin.

The Rakovec Group contains only metabasalts with characteristics similar to E-MORB/OIT (HOVORKA et al., 1988; IVAN, in print). The geochemical accordance with the spatially most widespread geochemical type of the Gelnica Group indicates a possible genetic association between both lithostratigraphic groups. The existing differences in metamorphism (at least medium-pressure in the Rakovec Group in contrast to greenschist facies in the Gelnica Group) and in the geochemistry of metabasalts (typical E-MORB/OIT compared with the types closer to CT in the Gelnica Group; Text-Fig. 5), confirm the tectonic disruption of the original terrain and the partly different geodynamic setting of both groups. The Rakovec Group may be regarded as the remnant of the crust of a marginal part of a back arc basin. Such interpretation is supported by the existence of a mantle enrichment trend in the metabasalts of this group.

The composition of the Klátov Group metabasic rocks and its metamorphic character differs so much from the Rakovec Group that its tectonic position should be assumed as an independent nappe (HOVORKA et al., 1984). Petrographically it is not principally different from the leptynite-amphibolite complexes of the Tatric and Veporic Units of the Western Carpathians (IVAN et al., 1992; HOVORKA et al., 1992).

The leptynite-amphibolite complex of the Klátov Group is distinguished from the classical occurrences in Western European Variscides (Massif Central – SANTALLIER et al., 1988) by a more intensive retrograde metamorphism. The distribution of REE in leptynites and amphibolite bands (Text-Fig. 7) testifies to their cumulate origin and may be formed by oscillatory crystallization (cf. WANG & MERINO, 1993). The composition of the leptynites and amphibolites regarding their immobile incompatible elements is in good accordance with those from granulites and basic granulites of cumulate origin from the lower-crust xenoliths of basalts (LOOCK et al., 1992). Some of them are considered to be complexes from the lower crust of island arcs (LUCASSEN & FRANZ, 1990). Garnet amphibolites, the product of the amphibolitization of eclogites together with metaperidotites, constitute the enclaves of variable genesis in the leptynite-amphibolite complex.

The geochemical character similar to N-MORB is also known in the case of eclogites in analog complexes (BERNARD-GRIFFITHS et al., 1985; STOSCH & LUGMAIR, 1990) and is considered to be evidence for the origin from subducted oceanic crust. The leptynite-amphibolite complex of the Klátov Group might be on the basis of above mentioned facts regarded as the lower crust of an island arc. By a later migmatitization it was for the most part transformed into a complex of gneisses and amphibolites and it was affected by retrograde metamorphism. The alterations proceeded probably still in the Variscan period, because the Upper Carboniferous conglomerates of the Dobšina Group already contain gneisses and amphibolites petrographically identical with the rocks of the Klátov Group.

The Early Paleozoic of the Gemeric unit should be considered as a part of rifted island arc intensively shortened during Variscan and Alpine tectonic events. The geodynamic setting of a similar type is known from several localities of Western European Variscides (Northern Moravia – PATOCKA, 1987; Vogtland – WERNER et al., 1987). In the Eastern Alps there are similar series as Stubach Complex and Habach Formation in the Tauern Window (VAVRA & FRISCH, 1989). The development of a geodynamic model of the Early Paleozoic evolution within the Gemeric unit is impossible due to the lack of geochronological data.

4. Conclusions

The following conclusions may be drawn for the geodynamic position from the study of the REE and HFSE distribution in basic magmatic rocks of Early Paleozoic of the Gemeric unit in the Western Carpathians:

- The Early Paleozoic of the Gemeric unit is composed of three lithostratigraphic groups generated in different tectonic settings .
- The Gelnica Group was formed at the margin of a back arc basin adjacent to a magmatic arc .
- The Rakovec Group may be considered to be the remnant of the crust of a marginal part of a back arc basin .
- The Klátov Group is an intensively metamorphosed layered intrusive complex similar to lower crust complexes of island arcs with enclaves of probably ancient subducted oceanic crust .
- The Early Paleozoic complexes of the Gemeric Unit represent a part of a rifted island arc strongly shortened and transformed to a system of nappes by Variscan and Alpine events.

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