SLOVAK GEOLOGICAL MAGAZINE

Protolith and geodynamic setting of the HP/LT metamorphosed basic from the northern margin of the Bôrka nappe (meliatic Unit Inner Western Carpathians)

PETER IVAN[1] & BALÁZS KRONOME[2]

[1]Comenius University, Department of Geochemistry, Mlynská dolina G, 842 15 Bratislava, Slovakia
[2]Comenius University, Department of Geology and Paleontology, Mlynská dolina G, 842 15 Bratislava, Slovakia

Abstract: According to protolith four types of metamorphosed basic rocks in Bôrka nappe have been found: (1) basalts (dolerites) with ophitic (doleritic) texture, (2) basalts with porphyric texture, (3) amphibolites and their phyllonites and (4) gneiss phyllonites. Basalts of type (1) formed originally a part of the slab of back-arc basin crust subducted Jurassic time (150-160 My). Porphyric basalts (with calc-alkaline signature) and other rock types might built up lower part of overriding plate in the contact with subduction zone. Recent tectonic position of the basic rocks of the Bôrka Nappe remain of tectonically reworked melange.

Key words: Meliatic Unit, back-arc basin, subduction, basalts

The Meliatic Unit belongs to first-order structural-tectonic units of the Inner Western Carpathians. It is thought to have been formed by the closing of the Triassic-Jurassic Meliata-Hallstatt ocean (KOZUR & MOCK, 1987; KOZUR, 1991). The Meliatic Unit is divided (according to the above mentioned authors) into three subunits: (1) Meliata Unit s.s, (2) Shale Unit of northern Bükk Mts. and probably also (3) Bôrka Nappe. All these subunits contain basic rocks. High pressure - low temperature (HP/LT) metamorphosed basic rocks from the northern margin of the Bôrka Nappe were the subject of this study .

The Bôrka Nappe rests on the subautochthon formed of the Gemeric Unit. According to REICHWALDER (1973) and LEŠKO & VARGA (1980), the Bôrka Nappe is represented by strongly imbricated slices and nappe outliers. Metamorphosed basic rocks form mainly isolated bodies varying in size, in phyllitic or carbonate host rocks.

Four important occurrences of basic rocks - (1) Vyšná Slaná - Radzim, (2) Bôrka, (3) Hačava and (4) Rudník (Fig. 1) - are located at the northern margin of the Bôrka Nappe. Based on a petrographic study, their protolith has been recognized as follows: (1) basalt (or dolerite) mostly with ophitic texture, (2) basalt (basaltic andesite) with porphyric texture, (3) amphibolites and their phyllonites and (4) gneiss phyllonites (IVAN & KRONOME, 1996). All the above rocks have been metamorphosed in HP/LT metamorphic conditions except the porphyric basalt, which displays LP/LT conditions only.

Metabasalts with relic ophitic structure occur at Vyšná Slaná - Radzim (southern slope), Hačava and Bôrka - Čremošná Valley. At the first site they were originally formed in a lava flow, with coarse-grained basalt in the central parts and fine-grained or vitrophyric partly brecciated basalts in external parts of the flow. HP/LT metamorphosed basic rocks from Hačava were originally medium- to coarse-grained basalts with ophitic texture. Basaltic protolith of the basic rocks from the Bôrka-Čremošná Valley is indicated by poorly preserved relics of ophitic texture only. These basalts were accompanied by smectite/ chlorite-rich sediments and stratiform Fe-mineralization.

Metabasalts with relic ophitic texture are composed of Na-amphibole, epidote/clinozoisite, chlorite, albite, titanite, rarely Na-pyroxene or garnet and white mica. Relics of pumpellyite and actinolite suggest progressive metamorphic evolution of these rocks. Magmatic clinopyroxenes are preserved in some coarse-grained rock types. Their composition (using the discrimination by LETERRIER et al., 1982) points to anorogenic, tholeiitic character of the parental basalt.

Metabasalt (basaltic andesite) with relic porphyric texture occurs at Vyšná Slaná - Radzim (SW slope). The original mineral composition consisting of plagioclase and pyroxene phenocrysts in trachytic matrix was replaced by a typical greenschist assemblage: chlorite + epidote + zoisite + carbonate + titanite. However, pre-existing HP/LT metamorphic stage cannot be fully excluded.

High-grade metamorphic rocks (amphibolites and gneisses) overprinted by HP/LT metamorphism were described from Rudník (approx. 15 km W of Košice) by FARYAD (1988). The amphibolites contain brown amphibole rimmed by Na-amphibole. Prevailing rock types are here HP/LT metamorphosed amphibolite and gneiss phyllonites. Bluish-grey amphibolite phyllonites are composed mainly of fine-grained inhomogeneous aggregate of albite, zoizite, epidote, Na-amphibole and titanite. An

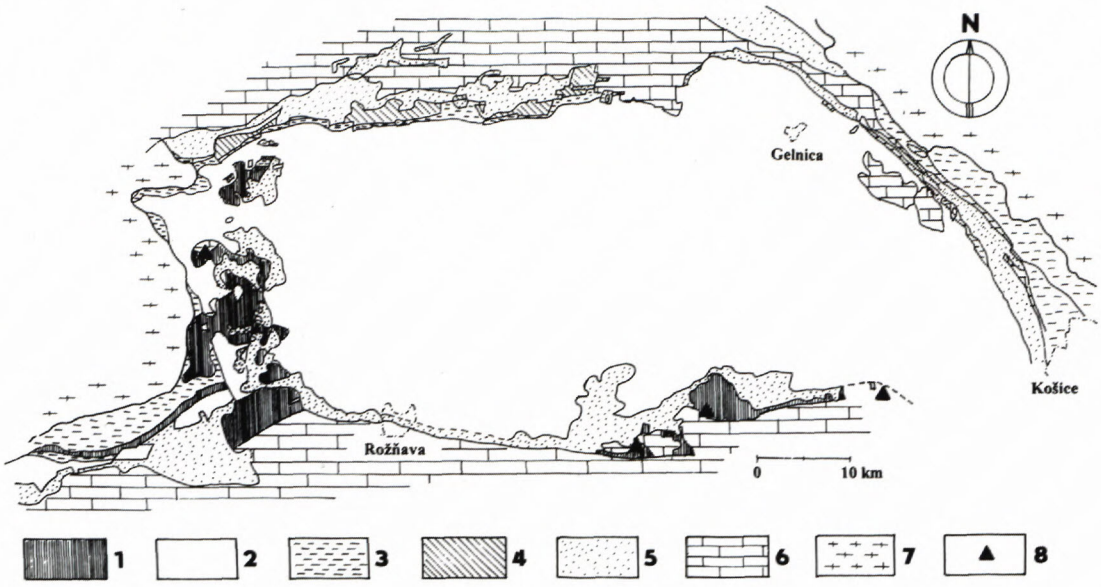

Fig. 1: The position of the Bôrka Nappe in the geological structure of the Inner Western Carpathians (BAJANÍK et al., 1983 - adopted).
1- Bôrka Nappe, 2 - Early Paleozoic formations, 3 - clastic Carboniferous formations, 4 - Zlatník Formation (Carboniferous?) - ancient back-arc basin crust, 5 - Permian volcano-sedimentary formations (2-5 - Paleozoic of Gemeric Unit),6 - Mesozoic formations of the Gemeric and Meliatic Units, 7- Veporic Unit of the Central Western Carpathians, 8 - studied localities

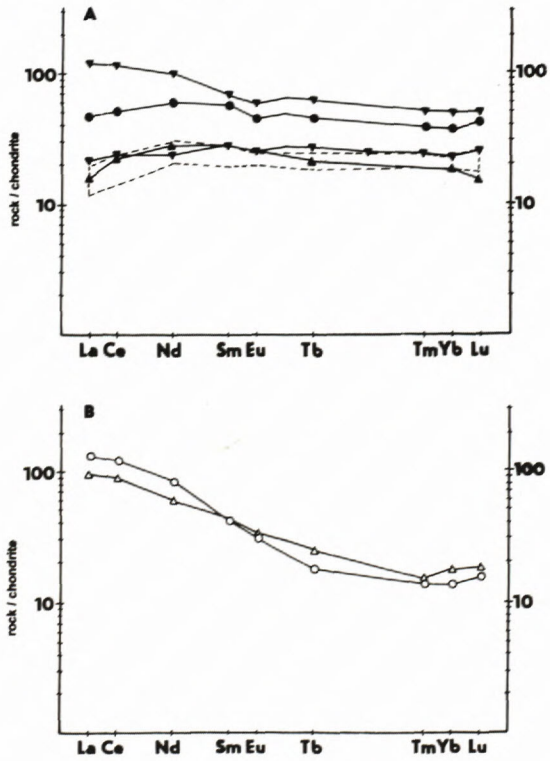

Fig. 2: Normalised REE patterns of metamorphosed basic rocks of the northern margin of the Bôrka Nappe.
A- rocks with flat REE pattern. Dashed field - REE patterns of four samples LP/LT metamorphosed basalts from Jaklovce (Meliata Unit s.s.) for comparison. B- rocks with differentiated LREE/HREE enrichment.
Explanation of symbols - see Fig. 3. Normalisation by EVENSEN et al. (1978).

other occurrence of blueschist with amphibolite protolith is Bôrka - Čilakovský kopec Hill. Mineral assemblages of these rocks are similar to common epidote blueschists, but in adition they usually contain Ca-amphibole (rimmed by Na-amphibole), quartz and white mica. Phantoms of a garnet have been also found. Rutile concentrically rimmed by ilmenite and titanite indicates possible origin of the amphibolite protolith by retrogression of an eclogite.

The protolith of epidote blueschists which have been found in Šugov Valley remains unknown as no relics of pre-metamorphic texture have been preserved.

The interpretation of geodynamic setting of the studied rocks is based on a trace element distribution study. Based on REE patterns (Fig. 2A,B), the basic rocks of the Bôrka Nappe can be divided into three groups: (1) metabasites with flat REE patterns, low total REE content similar to typical N-MORB, (2) metabasites with flat REE patterns and total REE content higher than in the previous group (close to more evolved types of N-MORB) and (3) metabasites with steep slope patterns due to a differentiated LREE/HREE enrichment. The first group is represented by metabasalts with relic ophitic texture and amphibolite phyllonite from Rudník, the second group includes metabasalt from Čremošná Valley and basic rocks from Šugov Valley with unknown protolith. To the third group belong amphibolites with HP/LT metamorphic overprint from Čilakovský kopec Hill and LP/LT metamorphosed porphyric basalt from Radzim Hill. More detailed geochemical classification of these rocks has been performed using discrimination diagrams

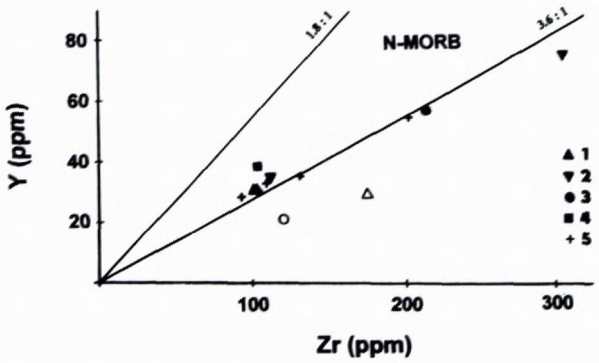

Fig. 3: Zr vs. Y diagram (LE ROEX et al., 1983) for the metamorphosed basic rocks of the northern margin of the Bôrka Nappe. LP/LT metamorphosed basalts of Meliata Unit s.s. from Jaklovce are plotted for comparison. Explanation of symbols: 1- Vyšná Slaná - Radzim, 2- Hačava, 3 - Bôrka, 4 - Rudník, 5 - Jaklovce. Empty symbols - samples with differentiated LREE/HREE enrichment.

Fig. 4: Zr/4-2Nb-Y discrimination diagram (MESCHEDE, 1986) metamorphosed basic rocks of the northern margin of the Bôrka Nappe. Explanation of symbols: see Fig. 3; AI - alkali within-plate basalts (WPB), AII- alkali and tholeiitic within-plate basalts, B - enriched mid-ocean ridge basalts (E-MORB), C - normal mid-ocean ridge basalts (N-MORB) and volcanic arc basalts (VAB), D - VAB and within-plate tholeiites (WPT).

based mainly on HFSE distribution. Zr vs. Y and Zr/4-2Nb-Ta diagrams (Fig. 3 and Fig. 4) classify the rocks with flat REE patterns as N-MORB, although in the first diagram they are plotted on the boundary of N-MORB field. The rocks with steep-slope REE patterns fall into the VAB/ WPT field (Fig. 4). In the Hf/3-Th-Ta diagram (WOOD, 1980; Fig. 5) they are classified as calc-alkaline volcanics and the rocks with a flat REE pattern fall mainly into the island arc tholeiite field. Although discrimination diagrams seemingly provide conflicting information in the

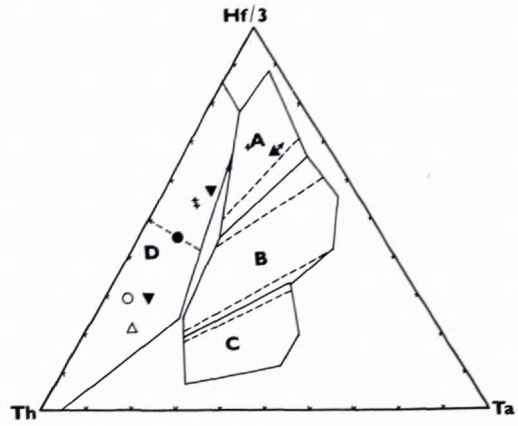

Fig. 5: H/3-Th-Ta discrimination diagram (WOOD, 1980) metamorphosed basic rocks of the northern margin of the Bôrka Nappe. Explanation of symbols: see Fig. 3; A - N-MORB, B- E-MORB, C - alkali WPB, D - destructive plate margin basalts (= VAB).

case of rocks with flat REE patterns, this type of trace element distribution is typical for back-arc basin basalts (BABB, i.g. FLOYD et al., 1991). Summing up the results - at the studied occurrences of the Bôrka Nappe, two geochemical types of basic metavolcanics - BABB and CAB - can be distinguished.

P,T-conditions of HP/LT metamorphism were estimated as 9-12 kbar/380-460°C or 8-11 kbar/380-420°C; (FARYAD, 1995). The relatedness of such type of metamorphism to the subduction processes is generally accepted. The age of metamorphism is about 150-160 Ma (MALUSKI et al., 1993). HP/LT metamorphosed basalts with BABB signature were probably a part of a subducted slab of the Meliata-Hallstatt ocean. They are geochemically very similar to the basalts formed in recent back-arc basins. Amphibolites, gneisses, their phyllonites and amphibolitized eclogites(?) which experienced HP/LT metamorphism built primarily the hanging wall of the subduction zone, i.e. they were the lower part of the overriding continental slab. Differences in the protolith and metamorphic history of the basic rocks of the Bôrka Nappe indicate that the recent position of these rocks is in the form of blocks in a mélange. The mélange was intensively reworked especially during the pre-Gosau nappe formation, because the Gosau conglomerate in the Dobšinská Ľadová Cave contains pebbles from Bôrka Nappe rocks (HOVORKA et al., 1990).

References

BAJANÍK, Š., HANZEL, V., IVANIČKA, J., MELLO, J., PRISTAŠ, J., REICHWALDER, P., SNOPKO, L., VOZÁR, J., VOZÁROVÁ, A., 1983:Geol. map. of Slovenské rudohorie Mts. - East. part, 1:50 000. GÚDŠ, Bratislava

FARYAD, S. W., 1988: Glaucophanized amphibolites and gneisses near Rudník (Slovenské rudohorie Mts.). Geol. Zbor. Geologica carpath., 39, p.747-763

FARYAD, S.W., 1995: Phase petrology and p,T conditions of mafic blueschists from the Meliata Unit, West Carpathians, Slovakia. J. metamorph. Geol., 13, p. 701-714

FLOYD, P.A., KELLING, G., GOKCEN S.L. & GOKCEN N., 1991: Geochemistry and tectonic environment of basaltic rocks from the Misis ophiolitic mélange, south Turkey. Chem. Geol., 89, p. 263-280

HOVORKA, D., IVAN, P., MOCK R., ROZLOŽNÍK, L. & SPIŠIAK, J., 1990: Sediments of Gossau type near Dobšiná Ice Cave: Ideas for their non-traditional interpretation. (In Slovak). Mineralia slov., 22, p. 519-525

IVAN, P. & KRONOME, B., 1996: Protolith and geodynamic setting of the HP/LT metamorphosed basic rocks at selected localities of the Meliatic Unit (Inner Western Carpathians). (In Slovak). Mineralia slov., 28, p. 26-37

KOZUR, H., 1991: The geological evolution at the Western end of Cimmerian ocean in the Western Carpathians and Eastern Alps. Zbl. Geol. Paläont. Teil I, 1, p. 99-121

KOZUR, H. & MOCK R., 1987: Deckenstrukturen im sudlichen Randbereich der Westkarpaten (Vorläufige Mitteilung). Geol.-paläont. Mitt., 14, p. 131-155

LEROEX A. P., DICK H. J. B., ERLANK A. J., REID A. M., FREY F. A., & HART S.R., 1983: Geochemistry, mineralogy and petrogenesis of lavas erupted along the southwest Indian Ridge between the Bouvet triple junction and 11 degrees east. J. Petrology, 24, p. 267-318

LEŠKO B. & VARGA I. 1980: Alpine elements in the West Carpathian structure and their significance. Mineralia slov., 12, p. 97-130

MALUSKI, H., RAJLICH P. & MATTE P., 1993: Ar-39/Ar-40 dating of the inner Carpathians Variscan basement and Alpine mylonitic overprinting. Tectonophysics, 223, p. 313-338

MESCHEDE, M., 1986: A method of dicriminating between different types of mid-ocean ridge basalts and continental tholeiites with the Nb-Zr-Y diagram. Chem. Geol., 56, p. 207-218

REICHWALDER P., 1973: Geology of the Late Paleozoic of the southwestern part of the Spišsko-gemerské rudohorie Mts. (In Slovak). Západné Karpaty, 18, p. 99-139

WOOD, D. A., 1980: The application of a Th-Hf-Ta diagram to problems of tectonomagmatic classification and to establishing the nature of crustal contamination of basaltic lavas of the Brittish Tertiary volcanic province. Earth planet. Sci. Lett., 50, p. 11-30