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PETER IVAN*

OCEANIC CRUST IN THE WESTERN CARPATHIANS OROGEN? DISCUSSION

(10 Figs.)

Abstract: Petrographic data indicate that dismembered ophiolites (basalts, gabbros, ultrabasic rocks and also radiolarites) found 1) in the Klátov Group (Paleozoic of the Gemericum) as blocks of various size and 2) in conglomerate material from the village of Dobšinská Ľadová Jaskyňa could be regarded as relics of oceanic crust in the Western Carpathians. Preliminary study of the distribution of REE and elements immobile during metamorphism (Th, Hf, Ta, Zr, Y) in metamorphosed basalts of the above-mentioned occurrences has so far proved their appurtenance to typical ophiolites (MORB-type basalts) only in the first case. MORB-type basalts, without other igneous rocks of ophiolite suite, occur in the Meliata unit (possibly the uppermost part of the original ophiolite complex) and on the north-eastern margin of the Gelnica Group (Paleozoic of the Gemericum, possibly manifestations of incipient rifting of an island arc).

Резюме: На основе петрографических данных можно к реликтом древней океанской коры в Западных Карпатах относить разобщенные офиолиты (базальты, габбро, гипербазиты, иногда радиолариты), которые находятся: 1. в Клатовской группе (палеозой гемерикума) как блоки различных размеров; 2. в гальке меловых конгломератов близ Добшинска Ладова Яскиня (мел типа «Госау»). Результаты предварительного изучения распределения в метабазальтах редкоземельных элементов и элементов мало мобильных в процессах метаморфизма (Th, Hf, Ta, Zr, Y) показало возможную принадлежность к типичным офиолитам (базальты типа БСОХ), только у пород клатовской группы. Только базальты типа БСОХ, при отсутствии остальных магматических пород офиолитового комплекса, были обнаружены в мелятской единице (мезозой, кажется самая верхняя часть офиолитового комплекса) и на СВ окраине гелницкой группы (палеозой гемерикума; может быть инициальное проявление рифтинга островной дуги).

Introduction

Ophiolites - basic and ultrabasic bodies of characteristic magmatic stratigraphy and usually with bathyal sediments in their uppermost part are generally regarded as relics of oceanic crust. If developed completely, they form allochthonous units and their individual rock types, in the form of either blocks or variously sized fragments, are part of tectonic melanges (Coleman, 1977; Moores, 1982).

Recent petrographic investigations have proved that:
— not all ophiolite-type rock associations can be considered as former oceanic

* RNDr. P. Ivan, CSc., Department of Geochemistry, Faculty of Natural Sciences, Comenius University, Mlynská dolina G. 842 15 Bratislava.
The paper takes into account only the Czechoslovak part of the Western Carpathians orogen.

crust. There are known examples when associations similar to ophiolites originate in relation to the formation of calc-alkaline volcanics in a typical magmatic arc (Burns, 1985; Beard, 1986 and others).
— classical interpretation of ophiolites as segments of oceanic crust or marginal sea crust and upper mantle obducted on continental crust of a continental margin or island arc is only a partly valid and much simplified picture of the reality. It seems that oceanic crust of more extensive oceans is not preserved in orogenic belts (Coleman, 1983). Overwhelming majority of ophiolite sequences in orogens are allochthonous fragments of oceanic crust of young oceans or marginal seas. The fact that volcanics of at least part of the basalt layer of some ophiolites resemble volcanic rocks of primitive island arcs inspired speculations on their possible formation in the setting of an island arc element (Leitch, 1984) or on special mechanism of separation and implanatation of ophiolites by means of the subduction of a spreading ridge (Mitchell, 1985).

What was regarded as ophiolites in the Western Carpathians?

Typical ophiolite complexes with manifestations of magmatic stratification are not developed in the Western Carpathians, or have not been discovered, yet. That is why a more significant role of oceanic crust by the formation of the Western Carpathian orogen was not supposed. Space shortening due to intracrustal subduction within continental crust was regarded as the decisive mechanism (e. g. Jaroš, 1980). Only recently there appeared speculations on possible subduction of larger areas of oceanic crust. Nevertheless, these are still only tectonic hypotheses (Kozur—Moçk, 1987). Because of joint occurrences of basic and ultrabasic rocks and other lithological characteristics, the Paleozoic of the Rakovec Group (Dianiška—Grecula, 1979; Grecula, 1982 and others) and Mesozoic Meliata unit (incomplete ophiolites — Hovorka, 1979) in the Gemeric unit of the Inner Western Carpathians were designated as ophiolites.

As ophiolite was also considered the source of basic material in Cretaceous conglomerates of the Klippen and Manín Belts (Šímová, 1985 and others). This view was also supported by the discovery of abundant chrome-spinelide detritus in some limestone pebbles of these conglomerates (Mišík et al., 1980).

Are ophiolites (and therefore also oceanic crust) in the Western Carpathians?

A typical ophiolite complex has to comply with the following criteria:
— rock types of the complex have to be compatible with rocks of ophiolite type profile;
— basalts must have geochemical characteristics of ocean ridge basalts (MORB) or back-arc basin basalts (BABB), the latter being virtually equal to the former.

The application of both these criteria in the Western Carpathians is difficult because the original character of rocks may be altered by metamorphism. Also in the case of metamorphosed rocks, however, reliable results may be provided by geochemical discrimination methods which focus on elements little mobile

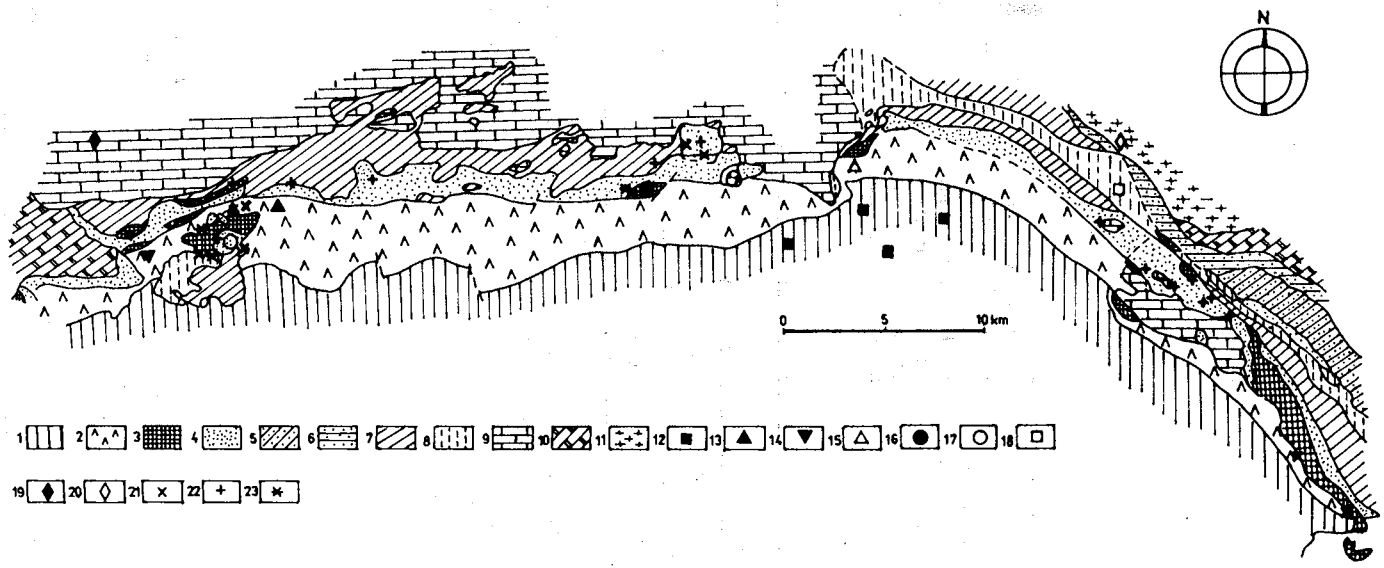

Fig. 1. Simplified geological-tectonic sketch-map of the northern part of the Inner Western Carpathians. From H o v o r k a—I v a n (1985) — modified.

Explanations: 1 — Gelnica Group; 2 — Rakovec Group; 3 — Klátov Group (1—3 Early Paleozoic); 4 — Dobšiná Group (Upper Carboniferous); 5 — Črmeľ Group (Carboniferous): 6 — Carboniferous of the envelope unit of the Čierna hora Mts. zone; 7 — Krompachy Group (Permian); 8 — metamorphosed Mesozoic (Meliata unit); 9 — Mesozoic of the Stratenská hornatina Mts.; 10, 11 — units of the Central West Carpathians: 12—20 — locations of analysed metabasalts: 12 — Slovinky (Gelnica Group), 13 — Rakovec; 14 — Dobšiná; 15 — Slovinky (Rakovec Group); 16 — Rudňany, 17 — Dobšiná (Dobšiná Group): 18 — Jaklovce; 19 — Dobšinská Ľadová Jaskyňa: 20 — Kľuknava; 21 — serpentinites (mostly hydrothermally altered to listvenites) in the Klátov Group; 22 — serpentinites tectonically implanted into the Dobšiná Group (mostly hydrothermally altered to listvenites); 23 — metagabbro.

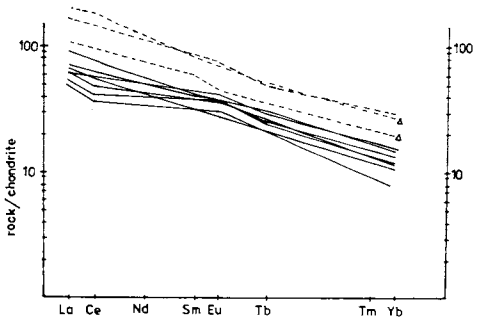

Fig. 2. Normalized REE contents in metamorphosed basalts (solid line) and basaltoid andesites (dashed line) of the Rakovec Group from the communities of Rakovec and Dobšiná (marked by triangle). Analytic data: Hovorka et al. (1988) and Bajaník (1981).
Explanations: see Fig. 3.

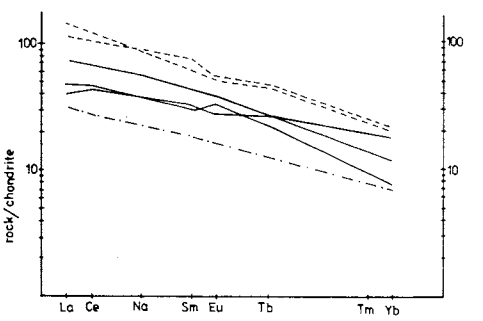

Fig. 3. Normalized REE contents in metamorphosed basic rocks of the Rakovec Group from the town of Slovinky. Ivan — unpublished.
Explanations: metamorphosed basalts-solid line, basalts rich in clinopyroxene phenocrysts-dotted and dashed, basaltoid andesites — dashed.

during metamorphism — Th, Ta, Hf, Zr, Y, rare earth elements (REE) and others.

Our research has so far concentrated mainly on Paleozoic metabasalts of the Gemeric unit (Fig. 1). The review of the results obtained, given in this paper, is illustrated by chondrite normalized REE patterns and by discrimination diagrams Hf/3-Ta-Th (Wood et al., 1979) and Zr/Y (Leroex et al., 1983) which seem to be most suitable for the determination of the geodynamic setting of the formation of the metabasalts. Nevertheless, mostly analogical results were provided also by other discrimination diagrams based on elements which are immobile during metamorphism, such as Ta/Yb—Th/Yb (Pearce et al., 1981), Ti—V (Shervais, 1982), or TiO_2—Zr (Pearce et al., 1981) diagrams. More detailed data on petrology and geochemistry of studied metabasalts, including analytic data, are or will be published in separate works (Hovorka et al., 1988; Ivan, in prep.).

Our study has so far yielded the following results:

1. The Rakovec Group cannot be regarded as ophiolite complex. Except for basalts (although with pillow structures), it contains no other rock type typical of ophiolite sequences. Moreover, the group comprises also basaltoid andesites, rhyolites and dacites (Bajaník, 1969) polymetamorphosed in green-schist facies. The metabasalts are geochemically similar to the so called E-MORB (enriched mid-ocean ridge basalts) or ocean island tholeiites (OIT) (Figs. 2, 3, 4). These may occur in several geodynamic settings (c. f. Nye—Reid, 1986; Smedley, 1986 and others) and on the basis of other data we suppose that the metabasalts of the Rakovec Group were formed in the setting of destructive margins of lithospheric plates (active continental margin, island arc; Hovorka et al., 1988).

2. From the geochemical viewpoint, MORB-type basalts are remarkably equal to metabasalts (metadolerites) of the north-eastern margin of the Gelni-

ca Group (wider vicinity of the village of Slovinky, Figs. 4, 5). Because of their conformable position in a complex of acid volcanics, volcanoclastics and psephitic-psammitic sediments as well as absence of the other members of ophiolite sequence these metabasalts cannot be assigned to ophiolites. They indicate, however, the beginning of the ocean crust formation in fore- or back-arc rifting (I v a n, in prep.).

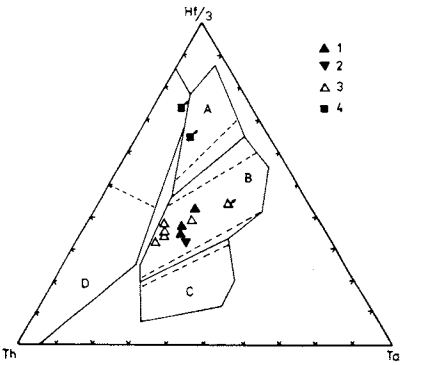

Fig. 4. Metamorphosed basalts and basaltoid andesites of the Rakovec Group and metamorphosed basalts of the Gelnica Group in discrimination diagram Th-Hf/3-Ta (W o o d et al., 1979). Analytic data: H o v o r k a et al. (1988) and I v a n — unpublished.
Explanations: 1 — Rakovec; 2 — Dobšiná; 3 — Slovinky (1—3 Rakovec Group); 4 — Slovinky (Gelnica Group); A — field of mid-ocean ridge basalts (N-MORB); B — field of enriched mid-ocean ridge basalts (E-MORB) and/or ocean island tholeiites (OIT); C — field of intraplate alkali basalts (WPA); D — field of basalts of destructive margins of lithospheric plates.

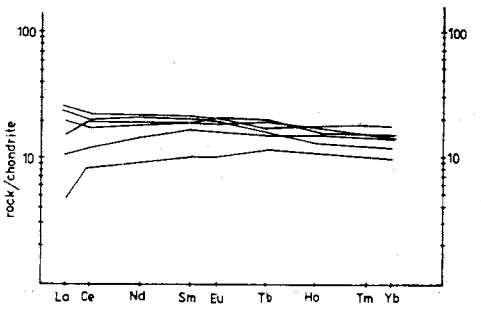

Fig. 5. Normalized REE contents in metabasalts of the Gelnica Group in the vicinity of Slovinky. Analytic data: B a j a n í k (1981), I v a n (in prep.).

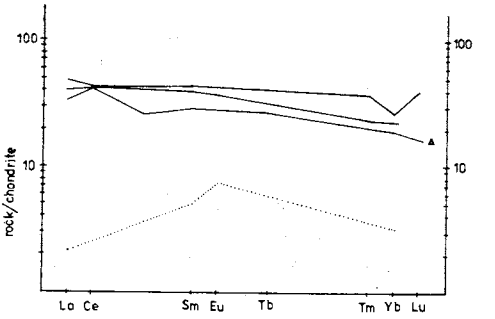

Fig. 6. Normalized REE contents in metamorphosed basalt, dolerite and gabbro of the Klátov Group (locality Rudňany) and metabasalt of the Dobšiná Group (locality Dobšiná, marked by triangle). I v a n — unpublished data.
Explanations: gabbro — dotted.

3. As the strongest candidate for the assignation to ophiolite sequences we regard the Klátov Group (H o v o r k a—I v a n, 1985; former gneiss-amphibolite complex of the Rakovec Group) or a part of it. Besides prevailing gneisses and amphibolites (originally probably psammites and effusive-type basalts and volcanoclastics) subordinate carbonates and meta-hyaloclastites, the Klátov Group also contains blocks and fragments of serpentinized ultrabasic rocks, gabbros and dolerites.

The ultrabasic rocks are serpentinized and subsequently also hydrothermally altered, whereas the basic rocks underwent metamorphism which suggests the setting of spreading axes (variable metamorphic degree from low facies to high amphibolite one). From geochemical viewpoint, the metabasalts (metadolerites) are similar to the MORB type, whereas the metagabbros resemble typical ophiolite gabbros (Figs. 6, 7).

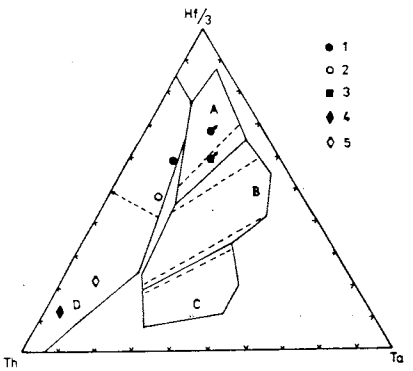

Fig. 7. Metabasalts (and/or metadolerites) of the Klátov, Dobšiná and Meliata Groups and also metabasalts as pebbles in conglomerates from Dobšinská Ľadová Jaskyňa (Cretaceous) and Kľuknava (Paleogene) in discrimination diagram Th-Hf/3-Ta (Wood et al., 1979). Analytic data: Ivan — unpublished. *Explanations:* 1 — Klátov Group; 2 — Dobšiná Group; 3 — Meliata unit; 4 — Dobšinská Ľadová Jaskyňa; 5 — Kľuknava; fields A, B, C, D see Fig. 4.

The metamorphosed ultrabasic rocks, gabbros, dolerites and some basalts of the Klátov Group could therefore be regarded as relics of an ancient Paleozoic oceanic crust.

4. Metabasalt from the vicinity of Dobšiná, assigned by Rozložník (1963) to the Dobšiná Group (Carboniferous), also resembles the type MORB (flat course of the normalized REE pattern), but contents of other immobile elements suggest island arc tholeiites (IAT, Figs. 6, 7). Serpentinites (mostly altered to listvenites) present in the Dobšiná Group are only tectonic slices from the underlying Klátov Group (Hovorka—Ivan, 1985).

5. Metabasalts of the Meliata unit (including its Jaklovce part) indicate clear affinity to the type MORB (Figs. 7, 8), which could confirm the assignation of the Meliata unit to incomplete ophiolites. It is noteworthy, however, that the Meliata unit may represent only the uppermost part of an ophiolite sequence (dolerites and gabbros are absent, present ultrabasic rocks may be regarded only as bodies in secondary, tectonic position where they were implanted because of their considerable plasticity due to serpentinization). Present state of knowledge does not allow any closer interpretation of the geodynamic regime in which the Meliata unit formed. We may only state that it represented a divergent contact of lithospheric plates.

6. A remarkable, virtually complete rock association of ophliolite profile (radiolarites, basalts, dolerites, various types of gabbros and ultrabasic rocks) along with limestones, psammitic sediments as well as rhyolites is contained in Cretaceous ("Gosau") conglomerates from the village of Dobšinská Ľadová Jaskyňa. Interestingly, a so far single result clearly assigns the basalts of this association to calc-alkaline types (i. e. it suggests destructive margin of lithospheric plates — Figs. 7, 9). An analogical result was yielded from dolerite of a similar rock

association from basal conglomerates of the Kľuknava Paleogene (Figs. 7, 9). In both cases, however, we have to take into account the possibly complicated geological history of the source area of the conglomerate material and therefore a detailed study will be necessary to confirm or rule out the supposition that at least part of the clastic material came from former oceanic crust. It seems that a destructive margin of lithospheric plates is responsible for the origin of the basalt and gabbro association (without ultrabasic rocks) which occurs, along with andesites and rhyolites, in Cretaceous conglomerates of the Manín and Klippen Belts (Fig. 10).

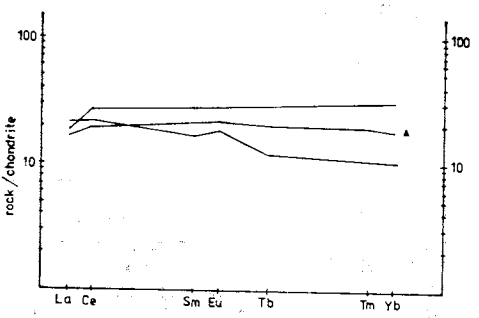

Fig. 8. Normalized REE contents in metabasalts of the Meliata unit from Jaklovce and Čoltovo (marked by triangle). Analytic data: Hovorka — Spišiak (1988).

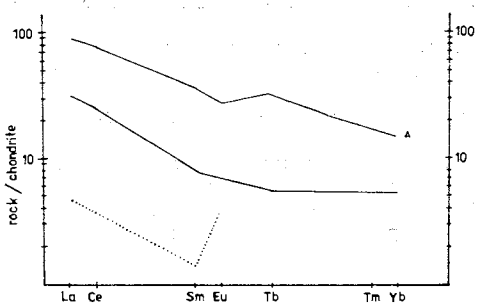

Fig. 9. Normalized REE contents in metabasalts and gabbro from conglomerates from Dobšinská Ľadová Jaskyňa (Cretaceous) and in metabasalt from conglomerates near Kľuknava (Paleogene, marked by triangle). Analytic data: Ivan — unpublished.

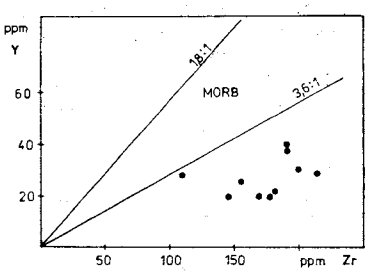

Fig. 10. Metabasalts from conglomerates of the Klippen and Manín Belts in discrimination diagram Y/Zr (Leroex et al., 1983). Analytic data: Šímová (1985).

Conclusions

In the Western Carpathians we actually know two occurrences of complete, although dismembered, sequences similar to ophiolites.

1. Dismembered metamorphosed Paleozoic ophiolites in the Klátov Group of the Gemericum.

2. Complete rock association of the ophiolite profile in Cretaceous conglomerates near the village of Dobšinská Ľadová Jaskyňa.

On the basis of data obtained so far, only the first occurrence can be considered as a relict of former oceanic crust. As regards the conglomerates, a reliable assignation of some part of their material to the former oceanic crust will require further studies.

The Meliata Group or its part represented by bathyal sediments associated with metabasalts most probably developed on the oceanic-type crust.

The former oceanic crust does not build up the volcano-sedimentary complex of the Rakovec Group (Paleozoic of the Gemericum), nor was it involved in the structure of the source area of the Cretaceous conglomerate material of the Klippen and Manín Belts.

Translated by Ľ. Böhmer.

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