GEOLOGICA CARPATHICA, 45, 3, BRATISLAVA, JUNE 1994
145 - 149

META-ULTRAMAFITE BODIES WITHIN THE PRE-CARBONIFEROUS COMPLEXES OF THE WESTERN CARPATHIANS CENTRAL ZONE: GEODYNAMIC SETTING

DUŠAN HOVORKA

Faculty of Sciences, Comenius University, Mlynská dolina G, 842 15 Bratislava, Slovak Republic

(Manuscript received March 19, 1993; accepted in revised form October 5, 1993)

Abstract: In pre-Carboniferous complexes of the central zone within the Western Carpathians two main groups of meta-ultramafite bodies occur: **1** - bodies localized in the basal part of the leptyno-amphibolite complex (LAC), and **2** - bodies of the Kohút mica schist formation. Both groups of meta-ultramafite bodies are noted for their rootless character and the evolution of reaction-metamorphic blackwalls at the margins of the individual bodies.

Key words: Western Carpathians, pre-Carboniferous complexes, meta-ultramafites.

Introduction

Fundamental data on the size, position, rock filling and geochemical picture of meta-peridotite/meta-pyroxenite bodies from the Tatric and northern Veporic Units were published in the seventies (Hovorka 1965a, b, 1967). A synthesis of the existing knowledge can be found in a monograph (Hovorka et al. 1985). A wealth of accumulated knowledge enable to suggest the following characteristics about meta-ultramafite bodies in pre-Carboniferous complexes from the area of the Western Carpathians:

a - Meta-ultramafite bodies are all rootless and in the majority of cases of lense shape. Their size are on the range of tens of metres.

b - Metamorphic recrystallization processes of hydration type were responsible for metamorphic minerals generation. These processes witnessed, in the majority of cases, to the loss of primary structural features. Despite these two facts locally preserved palimpsest features, as for instance large flaky pseudomorphic chlorite and antigorite after pyroxenes and other minerals allow, at least partially, to consider the original rocks as being pyroxenites, or peridotites, respectively.

c - All the meta-pyroxenite/meta-peridotite bodies have been subjected to metamorphic-recrystallization processes, together with the surrounding rocks. This can be documented by the evolution of marginal reaction-metamorphic blackwalls (Hovorka 1965a). Since the Alpine processes in the Triassic unit mostly displayed only folded-disjunctive character, the generation of the given blackwalls should have been associated with Variscan or earlier metamorphic processes.

d - Geochemical data (Hovorka 1977) enabled to distinguish the discussed bodies or possibly rock types from Triassic lizardite-chrysotile serpentinites of the Meliata Unit in the inner Western Carpathians (Tab. 1). The pre-Carboniferous meta-ultramafites of the Western Carpathians are to be considered as a lower continental crust-upper mantle gabbro-peridotite formation (Hovorka 1977). In contrast, the Mesozoic serpentinites of the Meliata Unit are the member of a dismembered Mesozoic ophiolite complex (Hovorka 1977).

e - The diversity of the protolith and crystallization depth, or better said, primary geodynamic setting also conditioned the diversity of the associations of ore minerals (Rojkovič & Hovorka 1979; Rojkovič 1985), in contrast with the Mesozoic bodies from the Meliata Unit. The meta-ultramafic bodies situated within leptyno-amphibolite complex, or in its derivatives respectively, are characterized by the following association of ore minerals: pyrrhotite, ilmenite, chalcopyrite and ceylonite. On the contrary, the following minerals have been found in Triassic bodies of the Meliata Unit: chromite, spinel, millerite, pentlandite and magnetite (Rojkovič 1985).

f - Hornblende peridotite body on the ridge of the Veľká Lúka (the Malá Fatra Mts.), its metamorphic development and geochemical characters speak for its assignment into category of "deuteroperidotites" (Hovorka 1967, 1977). According to this interpretation, the mineral association of this body is a contact-metamorphic product of the granite body in which deuteroperidotite occurs (originally most probably serpentinite).

I. Meta-ultramafites in leptyno-amphibolite complex

Hovorka et al. (1992) and Hovorka et al. (in press) defined the leptyno-amphibolite complex (LAC) of the Western Carpathians and stated that metaperidotite bodies are spatially associated with this complex. Consequently an entirely new interpretation was needed for the geotectonic position of meta-ultramafite bodies in the Tatric and Veporic Units. Field data (l.c.) allow to conclude that the discussed bodies occur in lower (basal) parts of the leptyno-amphibolite complex (Fig. 1) or its various derivatives. Some of these derivatives are, in our view, granite massifs of the Tatric and Veporic Units generated by anatexis of the LAC (Hovorka et al. 1992). The position of the meta-ultramafites (mostly antigorite serpentinites, but also various tectono-metamorphic derivatives of ultramafites with talc, monoclinic amphibole, Mg-chlorite, antigorite and other minerals), is mainly obvious in the occurrences near Jasenie, N of Heľpa, the bodies in the valley Hudák near Mýto pod Ďumbierom,

Table 1. Composition of meta-ultramafites from various geological units: the Western Carpathians. **1** - hornblende peridotite: Veľká Lúka; **2** - hornblende peridotite: Filipovo; **3** - Chl-Hbl serpentinite: Pohronská Polhora; **4** - Chl-Hbl serpentinite: Beňuš, (1-4 = ultramafite bodies genetically associated with LAC); **5** - antigorite serpentinite: Ostrá near Hnúšťa; **6** - antigorite serpentinite: Muránska Dlhá Lúka, (5-6 = meta-ultramafites in the Kohút crystalline complex); **7** - antigorite serpentinite: Breznička; **8** - antigorite serpentinite: Ochtiná, (7-8 = meta-ultramafites in Carboniferous); **9** - lizardite-chrysotile serpentinite: Hodkovce; **10** - lizardite-chrysotile serpentinite: Jaklovce, (9-10 = serpentinites in the Meliata Unit Triassic). Analytical data are taken from Hovorka (1977).

	1	2	3	4	5	6	7	8	9	10
SiO_2	43.07	38.72	40.08	42.46	37.52	38.93	40.47	40.98	38.15	38.95
TiO_2	0.95	0.86	0.58	0.25	tr.	tr.	0.03	0.12	0.01	0.03
H_2O_3	15.08	12.94	6.70	9.29	2.06	3.31	2.56	1.85	0.83	1.10
Fe_2O_3	4.07	4.96	12.86	4.54	0.96	0.84	8.92	2.71	5.39	8.25
FeO	7.30	7.64	4.71	5.13	6.32	6.35	-	3.81	2.58	0.41
MnO	0.17	0.31	0.32	0.10	0.16	0.12	0.15	0.54	0.11	0.14
MgO	18.98	22.74	21.05	24.42	32.24	32.99	35.92	38.17	39.58	35.51
CaO	7.16	4.12	3.40	6.35	3.32	2.72	0.42	0.50	1.37	2.20
Na_2O	0.60	0.67	0.40	0.19	0.48	0.18	0.12	0.42	0.02	0.10
K_2O	0.13	0.30	0.44	0.10	0.18	0.10	0.18	-	0.01	0.02
P_2O_5	0.04	0.05	0.18	0.11	0.26	0.01	0.09	-	0.09	0.02
H_2O^-	0.03	0.14	1.99	0.14	0.24	0.06	0.15	0.18	1.69	0.77
H_2O^+	1.98	3.02	8.10	5.87	15.82	13.62	11.72	10.54	9.46	13.02
Σ	99.56	99.57	101.65	100.14	99.58	99.23	100.84	100.03	99.92	99.83
(in ppm):										
Ni	841	831	1081	727	1274	1875	1090	1339	1391	1400
Co	120	159	248	108	122	110	85	51	127	95
Cr	2757	2988	3696	3222	3615	3050	4080	2926	3866	2765
V	132	150	94	106	73	58	63	42	34	48
Sc	19	16	13	29	10	14	10	4	5	8
Au	0.02	0.03		0.03	-	0.04	0.04	0.02	-	0.04

the body near Filipovo, Beňuš-Pôbišovo, Pohronská Polhora and other places. All these meta-ultramafic bodies occur in pre-Carboniferous complexes of the Tatric and northern Veporic Units.

The discovery of numerous occurrences of meta-ultramafite bodies in the Tatric and north Veporic Units in the basal part of LAC suggests the following possible interpretations of their genesis:

1 - The meta-ultramafic bodies represent an internal part of the LAC. They originated in the fractional crystallization of the precursor complex, i. e. the diorite-gabbro magmatic melt. This possible genesis of meta-peridotites suggests the action of fractional crystallization, whereas fractional and gravitational accumulation of mafic minerals (olivine and pyroxenes) in the basal part of a magmatic body conditioned the origin of ultramafite bodies. According to this interpretation abundance ultramafites would increase towards the basal part of LAC.

2 - Another hypothesis is that the pyroxenites/peridotites bodies represent tectonically emplaced rock fragments of the natural basement of the original LAC melt (from which, via complicated processes, in the course of the ascent within the continental crust, the present leptyno-amphibolite complex of the Western Carpathians originated (Hovorka et al. 1992, in press).

Present state of knowledge of the rock filling of meta-ultramafite bodies and their metamorphic history enable to conclude assumptions which may be applied to solve their genesis. They are as follows (Hovorka 1965a, b, 1967):

1 - Tectonic delimitation of meta-ultramafites towards surrounding LAC (or its derivatives);

2 - No facies with present plagioclases (plagioclase ultramafites) are known within meta-ultramafite bodies. Sporadically ascertained dark bands in the neighbourhood of meta-ultramafite bodies, probably formed by Ol + Px (Spišiak & Pitoňák 1990), are, in the authors' view, tectonic derivatives of meta-ultramafites displaying lense/platy shape.

3 - Geochemical picture of dark (amphibolite) LAC bands/positions and meta-ultramafite bodies is principally distinct. No transition types among them have hitherto been found.

4 - The absence of plagioclases on one side and garnets on the other one, indicates for the original ultramafites the conditions corresponding to P-T conditions of the stability of spinel (spinel peridotites).

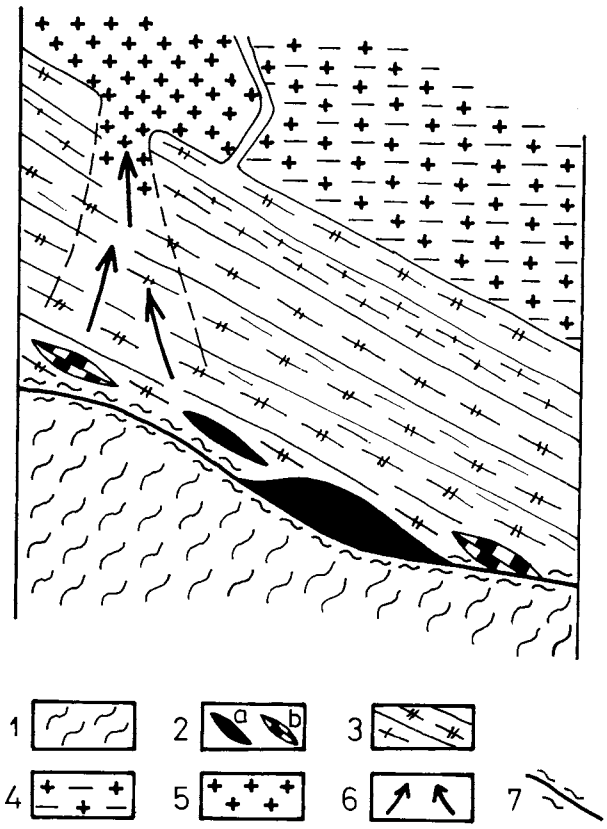

Fig. 1. Position of meta-ultramafite bodies within the leptyno-amphibolite complex (LAC). **1** - metagreywackes (gneisses); **2 a** - meta-ultramafites, **b** - amphibolitized eclogites; **3** - LAC; **4** - orthogneisses; **5** - Variscan granites; **6** - zones of anatexy; **7** - tectonic contact (blasto-mylonitization processes).

5 - Meta-ultramafite bodies of the discussed geological position contain green, Al-rich spinels (ceylonite) in the bodies at the Veľká Lúka (Rojkovič & Hovorka 1979) and in the bodies at Heľpa (new findings by Hovorka & Méres), but at the same time ascertained presence on Cr-rich spinels in the bodies near Jasenie (Stankovič & Jančula 1982; Spišiak et al. 1988). All these testify to a complicated genesis of these bodies.

The knowledge and aspects presented above lead the author of this study to favour the concept of tectonic relations of LAC (in narrow sense) and meta-ultramafite bodies, which occur in its basal part.

The presence of lense bodies of meta-pyroxenites/meta-peridotites, together with the presence of retrogressively recrystallized eclogites (Hovorka & Méres 1990; Hovorka et al. 1992) in leptyno-amphibolite complex support the concept (besides already mentioned geochemical data) of a complex generated in the lower part of the continental crust. Hydration retrogressive recrystallization of the LAC in P-T conditions of amphibolite facies proceeded in the course of pre-Alpine time span. The process took place during the decompression uplift of the LAC, in which ultramafite and eclogite bodies were incorporated. In the case of subhorizontal position of the LAC, it represents the basis of transported sequences, its direct overlier being usually different types of metamorphites generated in high P-T conditions. They usually comprise the rocks with kyanite, garnet and sillimanite, it means garnet orthogneiss, and migmatitic rocks. Different members of Early Paleozoic volcanic-sedimentary series constitute the tectonic overlier of the LAC.

Assumed genesis of the LAC allows us to derive also xenoliths of meta-ultramafites and amphibolitized eclogites from the original geotectonic position.

II. Meta-ultramafites in the Kohút mica schist series

The second distinct group of meta-ultramafite bodies is formed by the bodies of antigorite serpentinites in mica schists of the Kohút crystalline complex. Their characteristic can be found in the papers of Kantor (1956) and Hovorka (1965a, 1977). At the present time the bodies, or in some cases swarms of bodies of the given geological unit are known from the following localities: Strieborná near Cinobaňa, Uhorské I and II, Ostrá near Klenovec, Muránska Dlhá Lúka, Krokava. In the case of this group of meta-ultramafite bodies, the existing knowledge may be summed up as follows:

a - The bodies generally show only decametre dimensions, they belong to the group of rootless bodies. Surrounding rocks are always muscovitic-garnet mica schists.

b - The bodies have mutually, but also individual parts of the bodies, uniformal petrological character. Otherwise monotonous character of antigorite serpentinites of the bodies of this geological position was affected by the processes of Alpine recrystallization. This recrystallization attained in the Kohút crystalline complex the conditions of garnet-kyanite isograd. The Alpine metamorphic-recrystallization processes in meta-ultramafites testified to the origin of metamorphic new formations of monoclinic amphibole, talc, Mg-chlorite and others. Typical blackwalls (Fig. 2) originated on the rims of the bodies (Hovorka 1965a). Similar P-T trends of the Variscan and Alpine metamorphic recrystallizations do not allow to differentiate the effects of the given metamorphic events in the very meta-peridotite bodies in an exact way.

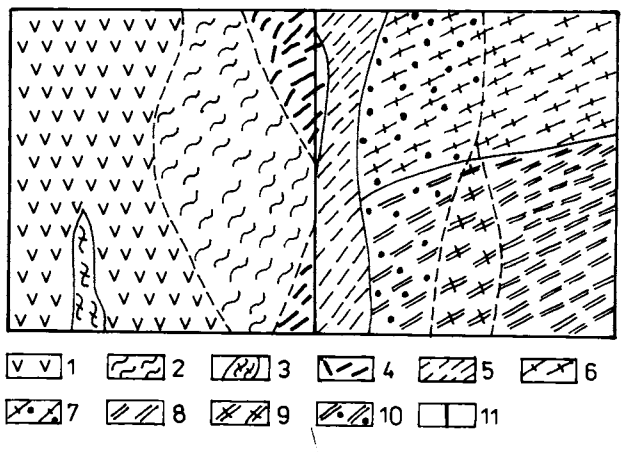

Fig. 2. Schematic representation of the blackwall rock types: **1** - antigorite serpentinites; **2** - talc schists; **3** - coarse flaky talc; **4** - actinolite schists; **5** - chlorite schists; **6** - mica schists, gneisses; **7** - as in 6 with chlorite porphyroblasts; **8** - amphibolite; **9** - biotite (phlogopite) rich zone; **10** - monomineralic hornblende rocks; **11** - original (pre-metamorphic) boundary of the ultramafic body (Hovorka 1977).

c - Geochemical picture of this group of meta-ultramafite bodies (Figs. 3, 4) may be compared with that of the Mesozoic in the inner zone of the Western Carpathians. Geochemical

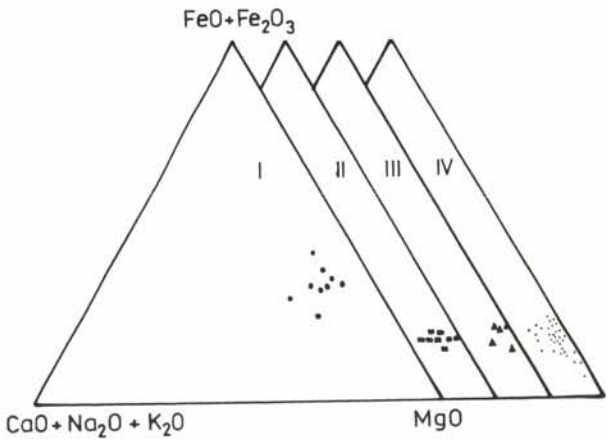

Fig. 3. Projections of ultramafic rocks of various tectonic position: **I** - meta-ultramafite bodies within the LAC; **II** - meta-ultramafite bodies within Kohút crystalline complex mica schists; **III** - meta-ultramafite bodies within the Carboniferous; **IV** - lizardite-chrysotile serpantinites within the Upper Triassic of the Meliata Unit. Analyses in Hovorka (1977).

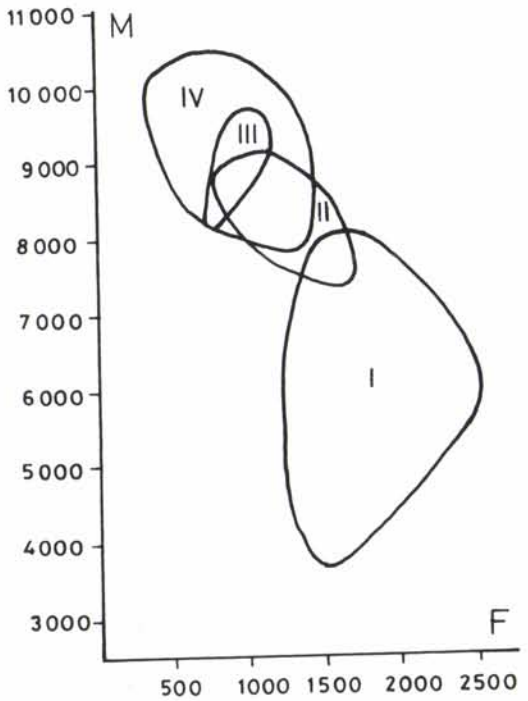

Fig. 4. Projection fields of M/F coefficients of the Western Carpathians meta-ultramafites. M = MgO; F = FeO + MnO + NiO + Fe_2O_3 (in molecular proportion). **I, II, III, IV** - see explanations to Fig. 3.

criteria (Hovorka 1977) suggest entirely hydrated and metamorphically recrystallized bodies which correspond to metamorphosed peridotites forming the basis of ophiolite complexes.

The presence of meta-peridotite bodies in the innermost unit of the centralides within the Western Carpathians, as well as the presence of petrographically and geochemically identical bodies of meta-peridotites in meta-sediments of the Upper Carboniferous of the given zone indicate the following possible geotectonic development:

1 - Meta-peridotite bodies (= the third layer of oceanic crust) were incorporated into the configuration of originally metapelite sequence of Early Paleozoic age and most probably of back-arc provenance (Méres & Hovorka 1991) from the Hallstadt-Meliata domain in the course of the Mesozoic/Tertiary development of the Western Carpathians. In the sense of the given facts, the "remixing" of Paleozoic and Mesozoic sequences took place during the enormous shortening of the space mainly due to horizontal displacements of the rock blocks.

2 - The other possible concept might be that the bodies of meta-ultramafites of identical geochemical type in the Kohút mica schist formation in meta-sediments of Carboniferous, as well as the bodies in the Upper Triassic of the Meliata Unit represent the relics/blocks of Early Paleozoic ophiolite complex. Distinct intensity of hydration/metamorphic recrystallization is, in the sense of this concept, a consequence of the position of these bodies in different rock complexes in the course of the Alpine tectono-metamorphic processes.

3 - Meta-peridotite bodies may represent olistoliths in the original sequence of geochemically mature sediments of the back-arc basin. According to this interpretation, olistoliths have experienced the Variscan and Alpine metamorphic history together with the surrounding rocks.

Discussion and conclusions

Ascertained numerous spatial association of meta-peridotite bodies in the Tatric and north Veporic Units on the LAC, and their geochemical picture, differentiate these bodies from meta-ultramafite bodies in other geological units of the Western Carpathians. Existing data indicate that the concept of the incorporation of meta-ultramafite bodies into LAC in the zone of its generation, is the most probable. They experienced common history in the following development during the ascent of the LAC + xenoliths of meta-peridotites + xenoliths of eclogites.

Meta-ultramafite bodies in the innermost unit of the central and inner zones of the Western Carpathians occur in three stratigraphic horizons/complexes: **a** - in Early Paleozoic Kohút mica schist series; **b** - in meta-sediments of the Upper Carboniferous; **c** - in the Mesozoic of the Hallstadt-Meliata terrain. All these sequences appear in the present erosion section areally very close to each other in the belt of E-W direction. Different positions in P-T fields in the course of the Alpine time span was reflected in variously intensive alterations of peridotites. Recrystallization in the conditions of greenschist facies took place in the case of the bodies in Paleozoic sequences. On the contrary, peridotite bodies in the Mesozoic were only subjected to hydration (lizardite-chrysotile serpentinites).

Meta-ultramafite bodies in mica schists of the Kohút crystalline complex (Early Paleozoic) share identical features with the Carboniferous in contact zone between the Veporic and Gemeric Units, but at the same time, also with the bodies in Triassic of the Meliata Unit within the inner Western Carpathians. Since further recurrence of identical geodynamic conditions and subsequent geotectonic processes in Early Paleozoic (mica schist formation), Carboniferous and Triassic of the Meliata Unit is not probable, the question of single-action emplacement of meta-ultramafite bodies in the given stratigraphically different sequences is probable.

Acknowledgement: This paper is a partial result of a research project No. 920203/1992, which was provided with a grant by the Ministry of Education and Science of the Slovak Republic. Author express his sincere thanks to Dr. J. Desmons for critical reading of the manuscript and for her suggestions.

References

Hovorka D., 1965a: Serpentinites of the Kohút crystalline complex and their metamorphic products. *Acta geol. geogr. Univ. Comen., Geol.*, 9, Bratislava, 91 - 140 (in Slovak).

Hovorka D., 1965b: Ultrabasische Gesteine der Westkarpaten in der Slowakei. *Geol. Zbor. Slov. Akad. Vied*, (Bratislava) 16, 1, 129 - 143.

Hovorka D., 1967: Metaultramafites of the Kraklová zone of West Carpathians. *Geol. Práce, Spr.*, 41, 107 - 151.

Hovorka D., 1977: Geochemistry of the West Carpathian Alpine-type Ultramafites. *Náuka o Zemi, Geol.*, 12, Veda, Bratislava, 1 - 148.

Hovorka D. with contributions of Ivan P., Jaroš J., Kratochvíl M., Reichwalder P., Rojkovič I., Spišiak J. & Turanová L., 1985: Ultramafic rocks of the Western Carpathians, Czechoslovakia. *Geol. Inst. D. Štúr*, Bratislava, 1 - 220.

Hovorka D. & Méres Š., 1990: Clinopyroxene-garnet metabasites of the Tribeč Mts., *Miner. slovaca*, 22, 6, 533 - 538.

Hovorka D., Méres Š. & Ivan P., 1992: Pre-Alpine Western Carpathian Mts. Basement Complexes: Geochemistry, Petrology, Geodynamic Setting. *Terra Nova*, Abstract Supl., 2, 32.

Hovorka D., Méres Š., & Ivan P., in press: Pre-Alpine Western Carpathians Complexes: Lithology and Distribution. *Mitt. Österr. geol. Gesell.*, 86.

Kantor J., 1956: Serpentinites of the southern part of the Spišsko-gemerské rudohorie Mts. *Geol. Práce, Spr.*, 6, 3 - 34 (in Slovak).

Méres Š. & Hovorka D., 1991: Geochemistry and Metamorphic Evolution of the Kohút crystalline complex mica schists (the Western Carpathians). *Acta geol. geogr. Univ. Comen., Geol.*, Bratislava, 47, 1, 15 - 66.

Rojkovič I., 1985: Ore mineralization of ultramafic bodies of the West Carpathians. *VEDA*, Bratislava, 1 - 112 (in Slovak; English summary).

Rojkovič I. & Hovorka D., 1979: Relation of ore mineralization to geochemistry of the West Carpathian ultramafic rocks. *Geol. Zbor. Geol. Carpath.*, 29, 4, 449 - 462.

Spišiak J. & Pitoňák P., 1990: The Nízke Tatry Mts. crystalline complex - new facts and interpretation (Western Carpathians, Czechoslovakia). *Geol. Zbor. Geol. Carpath.*, 41, 377 - 392.

Spišiak J., Pitoňák P. & Petro M., 1988: Metaultramafites from the area Jasenie-Kyslá, the Nízke Tatry Mts., *Miner. slovaca*, 20, 2, 143 - 148.

Stankovič J. & Jančula D., 1982: Preliminary report about the occurrence of chromspinel and Ni minerals at the locality Jasenie-Kyslá, the Nízke Tatry Mts. *Miner. slovaca*, 14, 2, 131-138.