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ORE MINERALIZATION ON THE CONTACT OF AN ALPINE-TYPE ULTRAMAFIC BODY (DANKOVÁ, SPIŠSKO-GEMERSKÉ RUDOHORIE MTS., WEST CARPATHIANS)

(Tabs. 1—3, Figs. 1—19)

Abstract: On the contact of an alpine-type ultramafic body with Triassic sediments at Danková, Spišsko-gemerské rudohorie (West Carpathians) an interesting association originated of „rodingitized sediments", of vesuvian — garnet — pyroxene composition with ore minerals. Authors connect the genessis of this association with serpentinization processes in the ultrabasic body.

Резюме: На контакте альпийскотипного ультраосновного тела с нижне триассовыми отложениями на Данковой (Западные Карпаты) образовалась интересная ассоциация „родингитизованных отложений" везувиан — гранит — пироксенового состава с рудными минералами. Авторы связывают возникновение этой ассоциации с процессами серпентинизации в ультраосновном теле.

Geological position of the ultramafic body

The ultramafite bodies along with basic volcanite bodies form in the West Carpathian Gemerides 2 belts (D. Hovorka, 1979). The southern belt, carrying beside these rock types also bodies of glaucophane schists is localized in the Meliata Group. To the northern group belong also the ultrabasic body at Danková. At the contact with the Lower Triassic sediments an interesting association of „contact" rocks and ore minerals had generated.

The locality investigated is situated on the southern slope of the ridge between the elevation points Strmá drť (1190 m) and Cuzenisko (1059 m), approximately 6 km NW of Dobšiná. The denomination Danková derives from a previous settlement in the valley of the brook Dobšiná.

The occurence of the investigated association belongs geographically to the Stratená highland, representing by its geology a part of the northern Mesozoic zone bordering the Paleozoic Gemeride anticlinorium. A synthetizing study dealing with the geology and stratigraphy of Stratená highland derives from M. Maheľ (1957).

The lense-shaped ultramafic body at Danková follows conformly the boundary of the schistose-marly complex of Campilian age and the overlying carbonate Middle Triassic complex (Fig. 1). Its strike length reaches 1200 m, its thickness being variable owing to tectonic destruction (false thickness max. 50 m). It plunges under an 30° angle beneath the overlying limestone complex, as it is corroborated also by the course of the izogams of profile magnetometry (J. Fedor 1968). By Alpine tectonic processes marked destruction set in, namely in the region of its lenticular wedging. Pronounced

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schistosity is noticeable with formation of serpentinite tectonites (serpentine schists). On the east the body terminates likely at the tectonic deformation along which the „squeezing" or uplift of the underlying Werfenian complex took place.

The ultramafic body at Danková belongs to the group of typical allochthonous ultramafic bodies of the ophiolite complexes. Its present position is the result of Laramic and probably even younger Alpine tectonic processes. According to D. Hovorka and J. Zlocha (1974) it is a prototype of the group of „isolated", subhorizontally oriented lenticular gemeride Mesozoic bodies. In its immediate environment, especially in marly limestones and marly shales (Campilian) J. Kamenický (1951, 1957) and M. Maheľ (1957) described contact-thermic effects of the ultrabasic body also in white Anisian limestones.

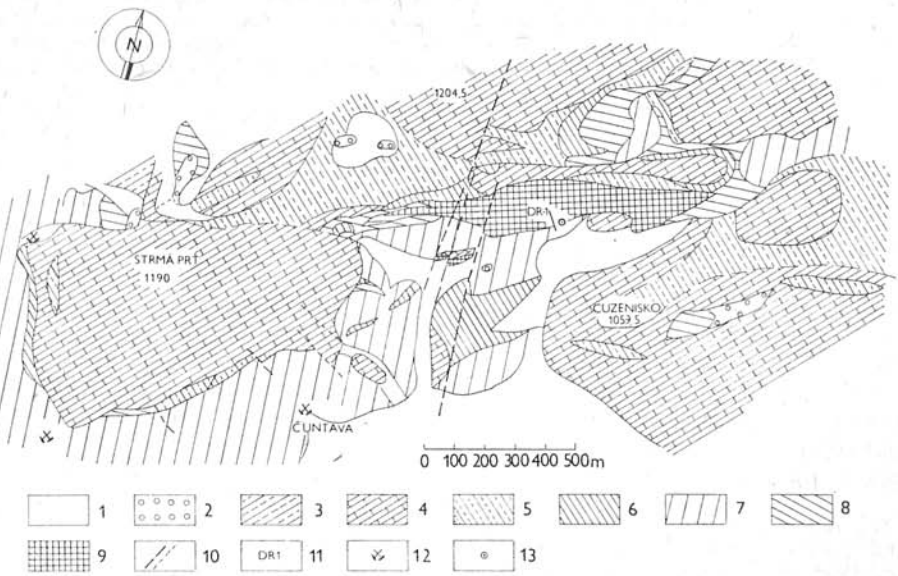

Fig. 1. Geological map of the area Danková — Čuntava; according to M. Maheľ (1957, revised by J. Fedor 1968). 1 — Quaternary; 2 — Upper Cretaceous — Paleogene; 3 — Ladinian (light dolomite); 4 — Ladinian (light limestone); 5 — Anisian (dark limestone); 6 — Anisian (dark dolomite); 7 — Campilian (marly-limestone sequence); 8 — Zeiss (schistose-sandstone sequence); 9 — serpentinite; 10 — tectonic fault; 11 — prospection pit; 12 — abandoned mines; 13 — exposure of the contact of serpentinite with the Werfenian complex.

Character of the ultramafic body

J. Kamenický (1951, 1957) established that the ultramafic body at Danková shows the character of a serpentinite composed of strongly predominating serpentine minerals, relics of rhombic and monoclinic pyroxenes, chlorite and accessories: magnetite, ilmenite, hematite, chromite and garnet.

We would like to complete this characteristic by new findings. Serpentinization grade of the body is in average high (more than 90 %; nevertheless, within the body appear beds of irregular shape and size in which 20 — 40 % clinopyroxenes are preserved. Chrysotile veinlets of up to 2 mm, scarcely even up to 10 mm thickness are characteristic of this body.

Spinel group minerals are characteristic primary accessories of serpentinite. L. Drnzíková (in J. Fedor 1968) has identified chromite up to chromspinelides. In sense of I. N. Irvine's classification (1965) it is spinel to picrochromite, or according to M. Panayotova-Zhelyaskova (1971) magnospinel to magnochromite (I. Rojkovič — D. Hovorka — J. Krištín, 1978) is concerned. In addition to spinel the authors described from this body pentlandite, magnetite and pyrite.

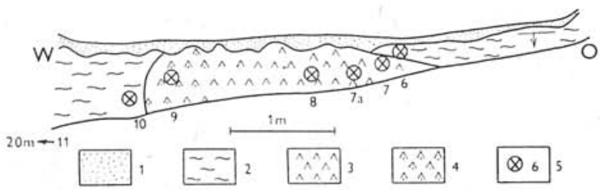

Fig. 2. Contact of serpentinite in the road cut at Danková; 1 — serpentinite; 2 — „rodingitized" sediment; 3 — more intensive sulphidic mineralization; 4 — sites of sampling.

Typical accessories are also minute turquois-green garnets. On the basis of their analogous appearance and similar optic character (microscopically observed anizotropy, zonality of crystals) like the garnets from Dobšiná (E. Fediuková et al. 1976), we regard them for a product of metamorphosis of the ultrabasic body. These garnets with prevailingly andradite molecule and variable, but low Cr_2O_3 content.

Geochamical characteristics of the investigated ultrabasic body corresponds to the geochemical characteristic of the other serpentinite bodies in the Triassic of Spišsko-gemerské rudohorie Mts. (D. Hovorka 1978). We give the average contents of some elements in trace concentrations (in ppm) from the serpentinite body at Danková (n = 8): Mn — 1160, Ni — 1254, Co — 113, Cr — 3545, V — 83, Ti — 369, Sc — 24, Cu — 7.

Character of the contact rocks

According to J. Kamenický (1957, p. 19—24) the original lherzolite induced contact-thermic, less amount also contact-metasomatic alterations. They acted in the sediments of the Werfenian. He classified among the rocks of the contact aureole equal grained corundum-sillimanite hornfelses with a graphitic pigment (?) and quartz, as well as albite-sillimanite hornfelses with quartz (40 %) accessory calcite, actinolite and magnetite. Within the first type he described also hornfelses with „miaroles" filled with diopside augite, sillimanite, chlorite, calcite, chrysotile, magnetite, scarcely also corundum.

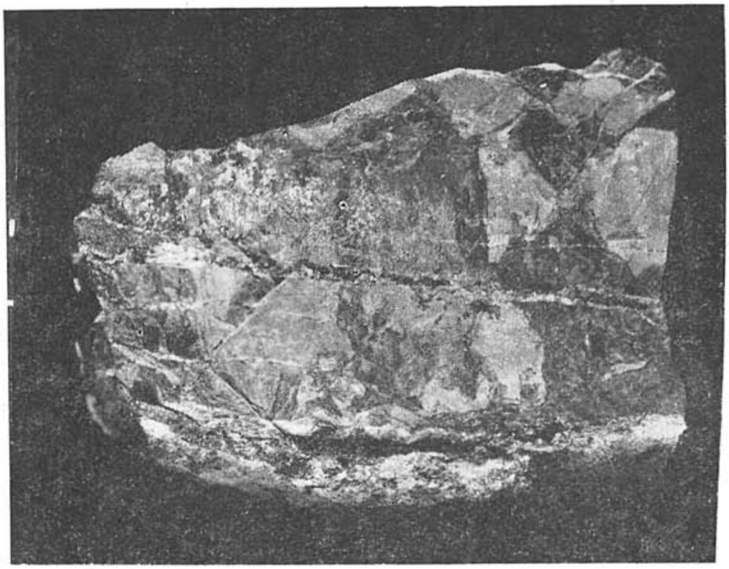

Fig. 3. Calcite veins with silicate (hornblendes, pyroxenes, chlorite) and ore minerals in an unequally pigmented rodingitized sedíment Danková diminished to 1/2.

On the forest road at the southern border of the serpentinite body (Fig. 2) we have studied its direct contact with the Lower Triassic sediments. The contact may be traced in approximately 3 m length. Serpentinite in the contact-near zone is intensively tectonically crushed. The rock from the exocontact shows the character of a massive, stringy, macroscopically afanitic, in places spotted rock (Fig. 3). The grey-coloured rock type predominates, with commoly present dark-grey fields of elongated or even isometric shape. Their size is rather variable. The intimate contact plane of 1—2 cm thickness is dark-grey up to greyish-black. The transitions towards the country rock are gradual (Fig. 4).

Yellowish-brown to red-brown mass with lacking pronouced cleavage of definite morphologic features predominates by volume in the rock. It has high refraction, low up to zero birefringence. It is marked by irregular confinement. In places it is of aggregate polarizing character and uncoherent colour tint. On the basis of these for definite identification few suitable features, vesuvian is concerned.

In the dominating mass of this nature appear aggregates of minute pyroxene columns, garnet, chambers filled with flaky chlorite, often with indicated radial structure and locally spotted iron or manganese hydrate infiltrations (Fig. 5). Sporadic rutile columns are present. Close to the contact an important amount of ore minerals occurs in the rock, in the form of impregnations and inseminations. We identified magnetite, chalcopyrite, sphalerite, galenite, pyrrhotite and hematite. Their amount in the rock decreases with the distance from the contact.

For the above mentioned rock type „miaroles" are characteristic and epigenetic veinlets, partly described by J. Kamenický (l. c.). According to

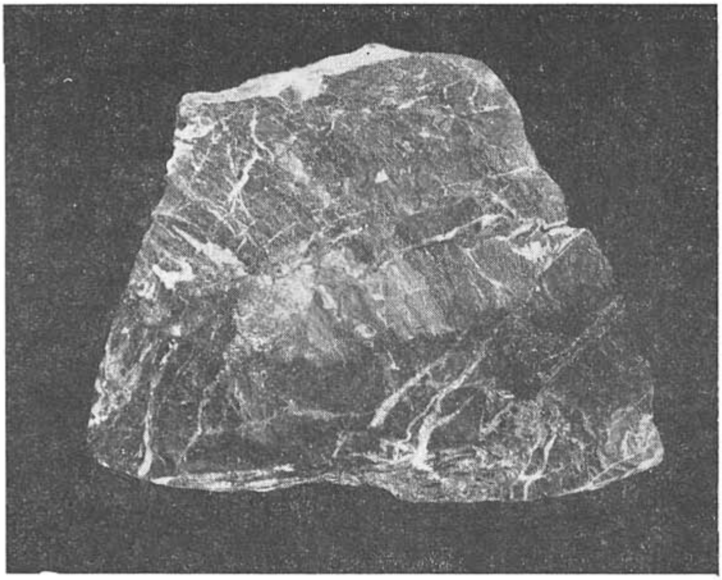

Fig. 4. Direct contact of serpentinite (bottom of the figure) with the rodingitized Low Triassic sediment. Penetrations of lyightgreen serpentinite veins into rodingite. Danková, diminished to 3/4.

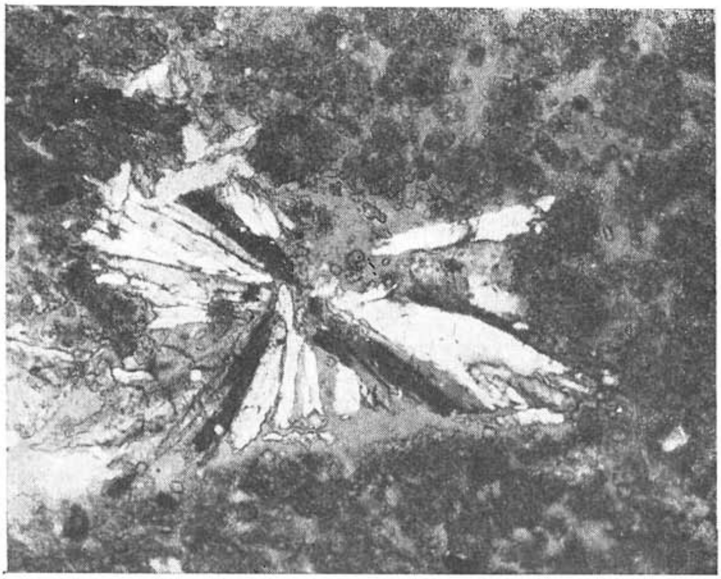

Fig. 5. Spherulitic structure of a pyroxene aggregate in miarolitic formation in a rodingitized sediment made up prevalently of vesuvian. Danková, thin section, X pol., enlarged 90 x.

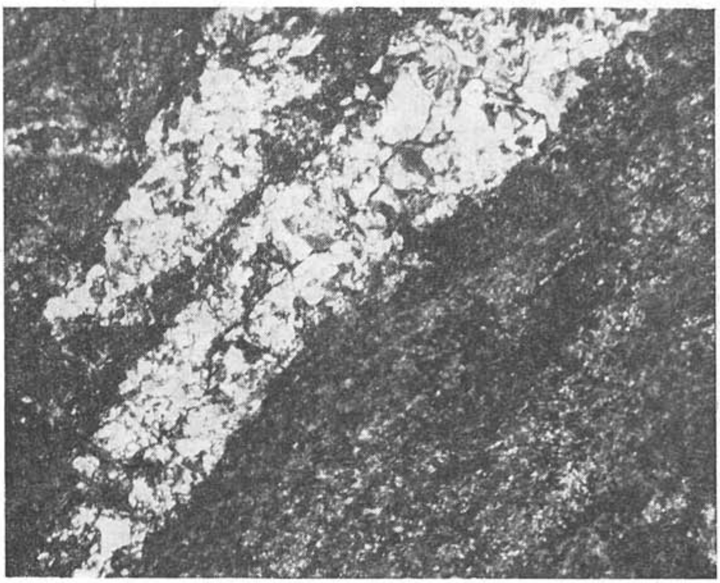

Fig. 6. In an aggregate polarizing rodingite mass elongated „miarolitic" formations built by calcite, chlorite pyroxene. Danková, thin section, X pol., enlarged 45. x.

the material we had investigated in the composition of the „miaroles" participate: monoclinic pyroxene, Ca-Fe garnet, chlorite, calcite (Fig. 6), sporadically an aggregately polarizing serpentine aggregate. The presence of ore minerals, especially of sulphides is obligatory.

Longcolumnar habitus and indicated radial structure is characteristic for monoclinic pyroxene. In case of zonal structure of the miarolitic formations pyroxene builds always the marginal zone (Fig. 7).

Ca-Fe garnet is marked by an optic anomaly (it is optically anizotropic, in places with sector, eventually on thin or polished sections observable zonal structure) (Fig. 8). It is colourless, up to yellowish or light green. Zonal structure was proved by study on the electron microprobe and microhardness. The chemical composition of garnet so far established only quantitatively, corresponds to Ca-Fe-Al garnet with low Mn content (Fig. 9a, b). Microhardness examined (VHN_{100}) in the individual zones varied from 8760 MPa up to 10300 MPa.

Chlorite (prevailingly pennine) builds various structural forms (spherulitic, divergent, flake intergrowths after 0001 etc.) (Fig. 6). Calcite fills the miarole core in form of a medium-grained crystalline aggregate, rarely also as minute idiomorphic rhombohedral crystals.

The investigated epigenetic veintlets in the vicinity of the contact differ by their mineral filling. We distinguish: — pyroxene — garnet — chlorite — calcite veins with subordinately present quartz, light green actinolite amphibole with numerous ore minerals; in places the veinlets gain up to anchimonomineralic character (Fig. 10); — talc veinlets; — monomineralic veinlets filled with a spherulitic aggregate of longcolumnar monoclinic pyro-

Fig. 7. Zonal structure of a miarolitic formation. The border made up of pyroxenes (lightgrey) and chlorite flakes, the central part by galenite (white). Danková, polished section, enlarged 48 x.

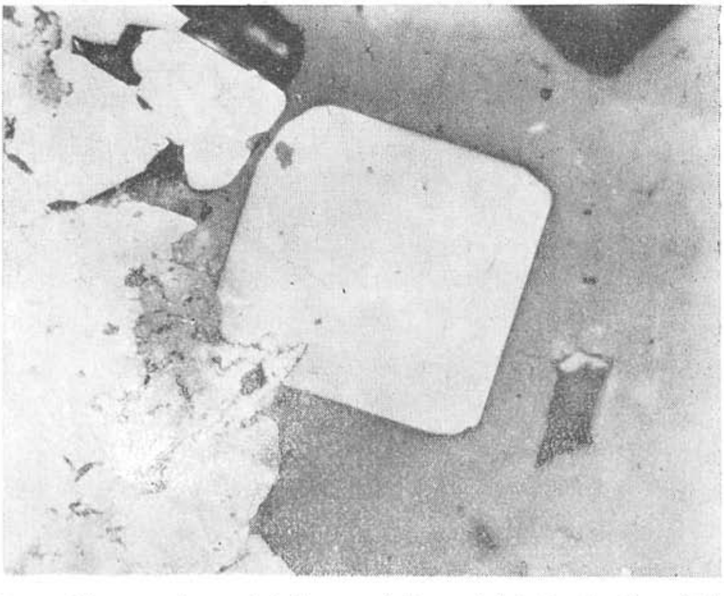

Fig. 8. Idiomorphic garnet crystal in a calcite veinlet. Danková, polished section, enlarged 185 x.

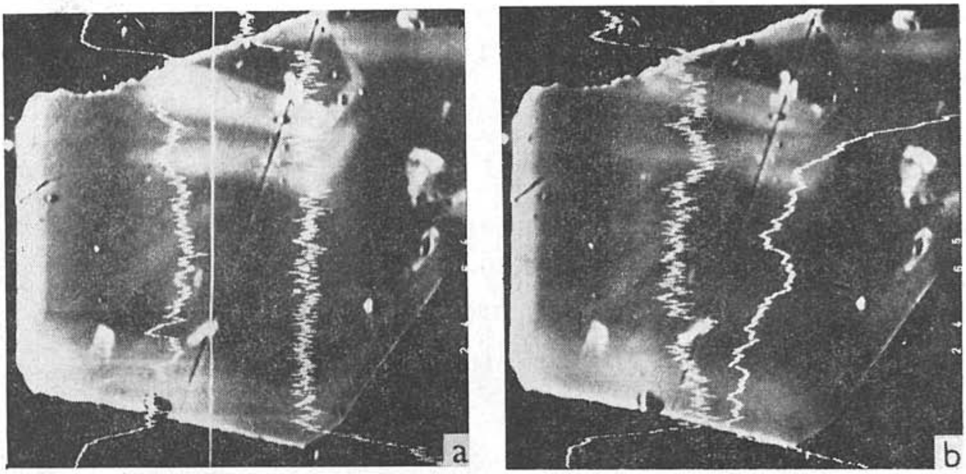

Fig. 9. Zonal idiomorphic garnet crystal from a veinlet in rodingite. Composition with line profiles: a — on the left Al, at right Ca; b — on the left Fe, at right Mn.

xene, and — veinlets of aggregate polarizing serpentine most often along with chlorite, garnet and magnetite.

Numerous ore minerals appear in the contact rocks in the form of impregnations, miarole filling, as well as filling of epigenetic veinlets. Sporadically they were found also in veins in the serpentitnite on the immediate contact, and in fragments of schistose quartzy rocks in the eluvium and deluvium not far from the contact. We identified the following minerals: magnetite, hemattie, rutile, pyrrhotite, pyrite, marcasite, sphalerite, galenite, chalcopyrite, tetrahedrite, limonite (geothite), Mn-dendrites and cerrusite.

Magnetite appears in accesory amount in serpetinite, in the contact zone and in the epigenetic veinlets (Fig. 11). It forms in the ultramafic rock irregular grain aggregates, sporadically idiomorphic, sometimes corroded octahedral crystals, though at the close contact mostly various loopy formations by filling up the minute joints. The individual grain size in the aggregate varies from 0,1 to 0,01 mm. Its origin is closely allied to serpentinization processes. Magnetite builds in the contact rock separate idiomorphic, sporadically also tabular crystals up to 0,1 mm in size. It is likely that it had generated by hematite musketovization closely after its formation in course of contact-metasomatic processes. By microhardness determination a lower VHN_{100} value has been established for magnetite of the first type — 4920 MPa, compared with musketovite — 5350 MPA.

Hematite was found in the contact rock in form of small (up to 0,1 mm) tabular crystals of typical optic features and typical hardness anizotropy (VHN_{min} — 7650 MPa, VHN_{max} — 10000 MPa). Concentration of hematite flakes in the vicinity of sphalerite is of interest (Fig. 12).

Rutile makes up in the contact rock irregular up to isometrically confined grainlets, as well as shortcolumnar crystals. It must likely belong to the primary clastic minerals of the sedimentary rocks.

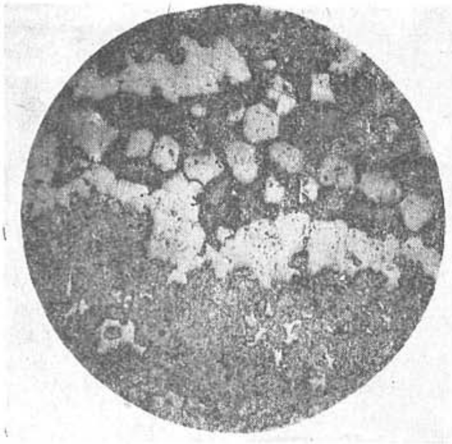

Fig. 10. Epigenetic veinlet in a rodingitized sediment. At the rim crusty garnets, in the centre calcite with solitaire garnets. Danková, polished section, enlarged 48 x.

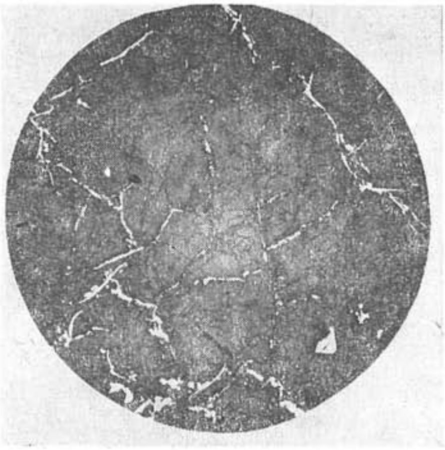

Fig. 11. Magnetite filling of hairlike veinlets in serpentinite. In the right upper quadrant a single galenite grain. Danková, polished section, enlarged 43 x.

P y r r h o t i t e occurs in the contact rock and in quartzy schists. Along with other sulphides it forms abundant inclusions, aggregates, rerely even veinlets. It is often within the sulfide associations the oldest and dominating mineral (Fig. 13). We detected microscopically allotriomorphic granular

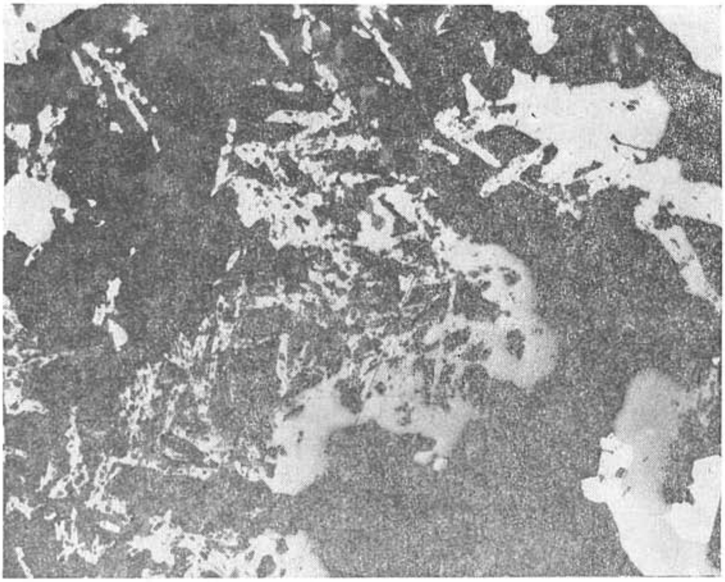

Fig. 12. Hematite flakes with galenite (white) and sphalerite (lightgrey) in a rodingitized sediments with garnets (darkgrey). Danková, polished section, enlarged 180 x.

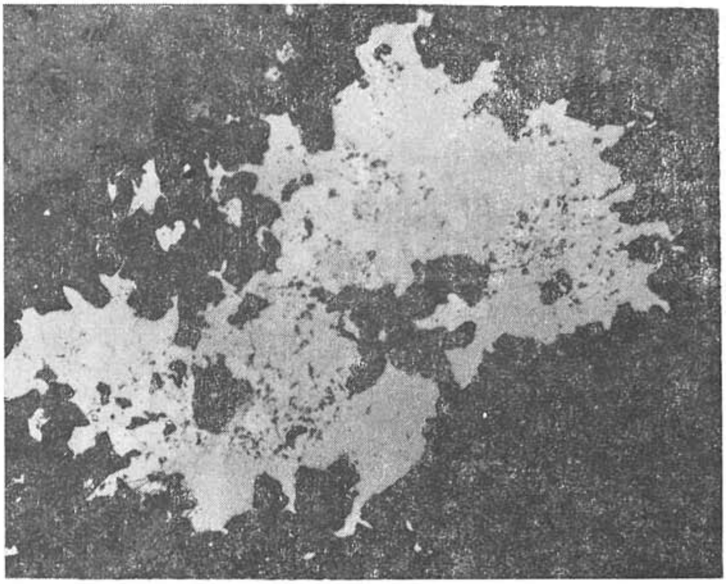

Fig. 13. Miarolitic formation with concentric structure in the rodingitized sediment; the border made up of pyroxene (darkgrey), the central part by pyrrhotite (lightgrey) with ýounger chalkopyrite and galenite grains (white). Danková, polished section, enlarged 95 x.

aggregates, grain shape in the aggregate being polygonal. In some grains good cleavage after (0001) may be found. Hardness varies in the range of 2320 — 2830 MPa. On polished sections appears secondary replacement of pyrrhotite by pyrite or a pyrite — marcasite aggregate.

P y r i t e appears rarely. Beside its origination with marcasite by pyrrhotite replacement, it has been established microscopically in form of sporadic

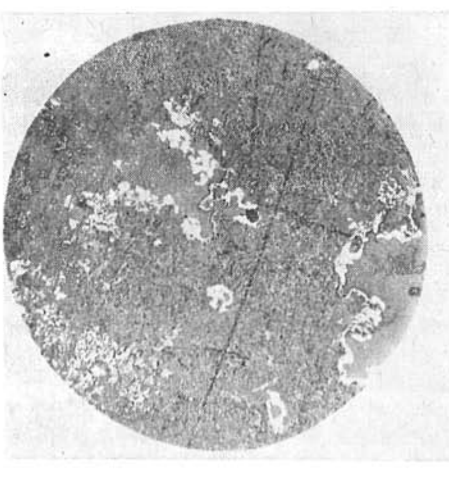

Fig. 14. Sphalerite and galenite rims in a sedimentary fineclastic Low Triassic rock. Danková, polished section, enlarged 25 x.

Table 1

Semiquantitative spectral analyses of sphalerite

	> 1 %	1—0.01 %	0.01 — 0.001 %	< 0.001 %
Sphalerite in rock	Zn, Fe	Cu, Ca, Si	Cd, Mn, In, Mg, Al	Na, V, Ni, Co, Cr
Sphalerite I.	Zn, Fe	Cu, Ca	Cd, Mn, Mg, Si, Al	In, Na, V, Cr
Sphalerite II.	Zn	Fe, Cu, Cd	Mn, Mg, Na, K Ca, Si	Ni, Co, In Ti, V

minute crystals of hexahedric habitus often in skeletal development. They are cataclazed and replaced by silicates, galenite, sphalerite and limonite. The hardness of the individual types (VHN_{100}) corresponds to hardness data for pyrites of different genesis. While lower hardness (9700 MPa) is characteristic for pyrite after pyrrhotite, hardness of idiomorphic crystals varies between 10980 — 1236 MPa, corresponding to the hardness of sedimentary origin pyrites (M. Háber 1965).

Sphalerite occurs in several positions. The first type builds inclusions in the quartzy rock, and even in the contact rock it appears in form of pore filling, or it builds crust-like overgrowths on the individual rock grains. Here it appears particularly along with pyrrhotite and galenite (Fig. 14). Sphalerite of this type has increased mean hardness (VHN_{50}) — 2040 MPa, at which basis we suggest higher Fe content in its structure (C. Varček et al. 1968). This fact was corroborated also by means of electron microprobe (5 % Fe) and spectral analysis (Tab. 1).

Sphalerite of the second type is represented by 2—3 sphalerite generations in epigenetic veinlets and in the filling of miarolitic formations. It appears along with pyrrhotite, galenite, chalcopyrite, garnets, pyroxenes, chlorite and calcite (Fig. 15). It forms a fine-grained allotriomorphic grains aggregate and well confined crystals of fairly noticeable cleavage. Rarely it builds even „colomorphic" crust at the rim of the vein. Under the microscope grain zonality appears often which generated by growth of younger generations on already existing sphalerite crystals. In addition these younger sphalerite generations fill up along with other sulphides cataclastic cracks in the earlier mineralization, or they replace i.e. older calcite along the cleavage and twinning-lamellae under the formation of sphalerite with „tabular" habitus. The oldest sphalerite generation is macroscopically of light brown colour; the internal reflexes are noticeable only in immersion, microhardness (VHN_{50}) value varies in the range of 1680 — 1820 MPa, lattice constant $a_o = 5{,}417 \pm 0{,}003 \times 10_{-10}$m. It reminds by its characteristics sphalerite of the first type. Sphalerite II is macroscopically darker yellow-brown coloured. In reflected light has relatively strong internal reflexes of yellow to orange tints. Hardness value varies in the scope of 1470 — 1610 MPa. Size of the lattice constant $a_o = 5{,}402 \pm 0{,}004 \times 10_{-10}$ m. Both sphalerites differ by some element contents in trace concentrations, particularly by izomorphic Fe con-

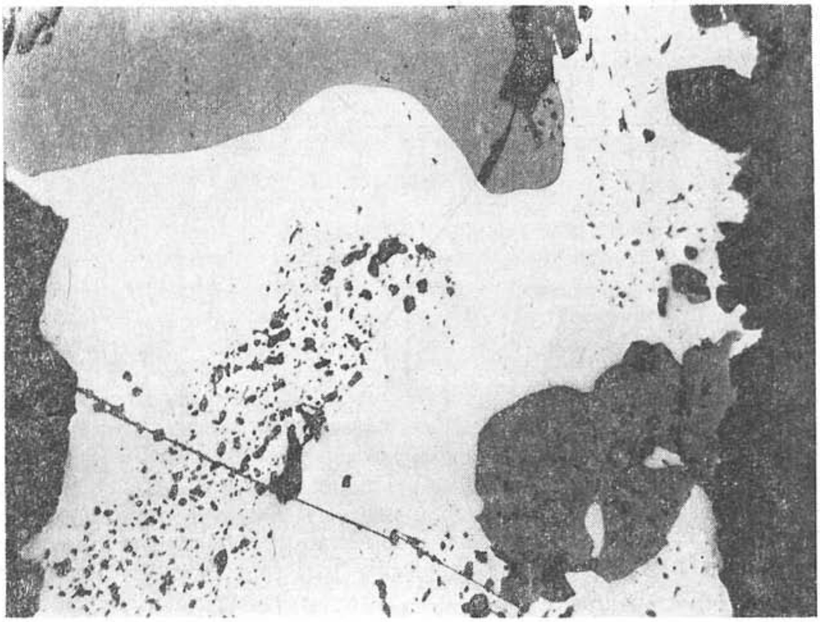

Fig. 15. Calcite vein with galenite (white) and sphalerite (lightgrey) in a rodingitized sediment. In galenite abundant inclusions of the primary rock. Danková, polished section, enlarged 95 x.

tent (Tab. 1). By the microprobe for sphalerite I 4 % Fe and sphalerite II 1 % Fe was established.

Temperature of sphalerite formation was examined by the decrepitation thermovacuum impulse method (J. Kantor — K. Eliáš (1974). The sphalerite investigated is poor in gaseous-fluid inclusions, which however, are of relatively larger sizes. From the analysis results it follows, that sphalerite

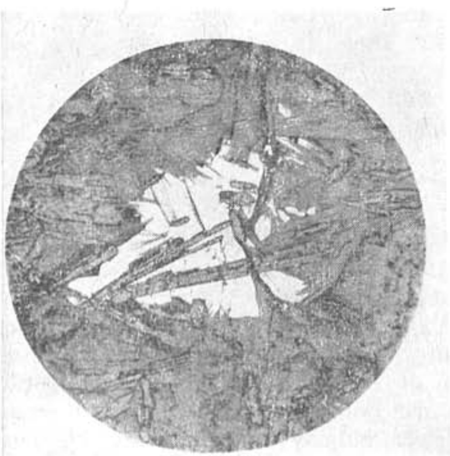

Fig. 16. Galenite grain in a rodingitized sediment penetrated by chlorite flakes. Danková, polished section, enlarged 22 x.

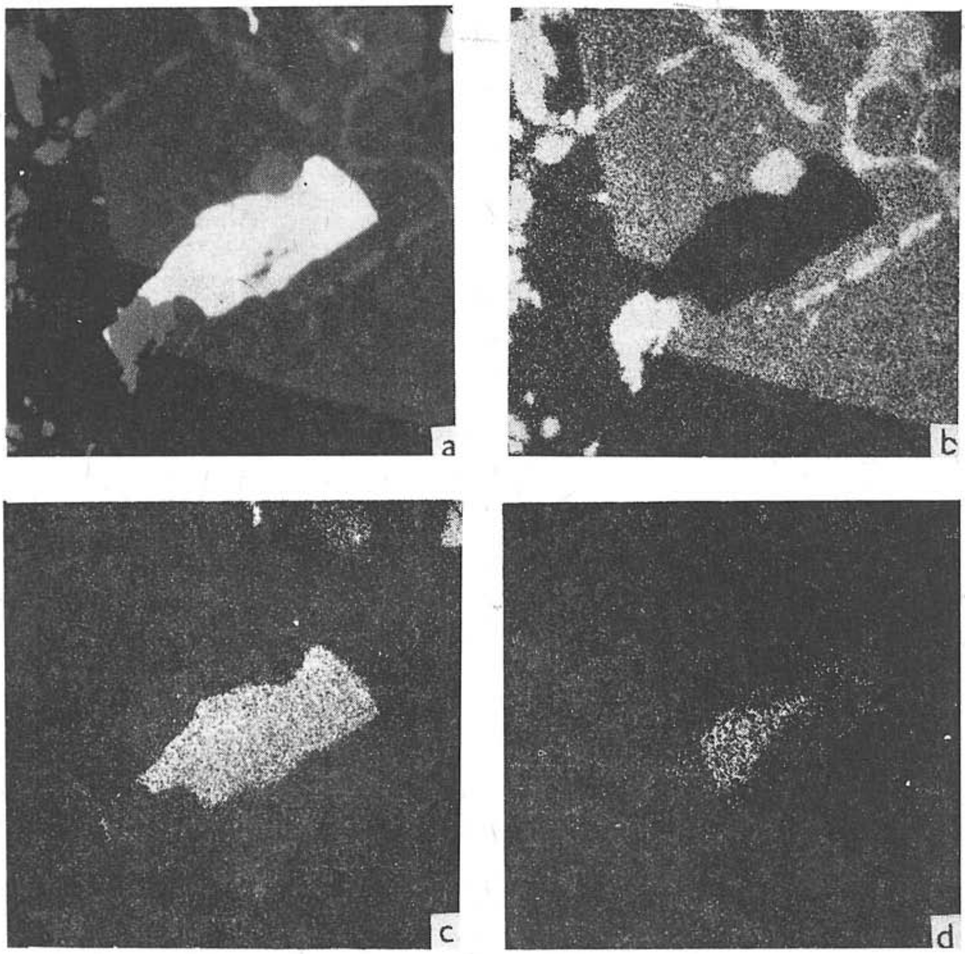

Fig. 17. Idiomorphic garnet crystal in a rodingitized sediment with magnetite veins replaced by cerrusite. Fe, Pb and S distribution in minerals: a) composition, enlarged 300 x; b) distribution FeK, enlarged 300 x; c) distribution PbK, enlarged 300 x; d) distribution SK, enlarged 300 x. Danková, polished section.

generated at temperatures about 160 °C, galenite appears also in two types. It builds inclusions in rock pores, or it cements the individual grains in the contact rock. It occurs also in miarolitic formations and epigenetic veins. These types however, cannot be differentiated neither by macroscopic nor microscopic observation. It builds accumulations of a crystalline aggregate. The established hardness (VHN_{10}) ranges from 630 — 735 MPa. Lattice constant a_0 is $5{,}983 \pm 0{,}003 \times 10^{-10}$ m. Its temperature of formation corresponds to mass decrepitation at a temperature of 150 °C. The age relations of galenite to the other sulphides especially to sphalerite differ in these two differentiated types. In impregnations galenite generated after pyrrhotite and chalcopyrite, but prior to sphalerite. In veinlets and miaroles in turn, galenite is the younger mineral. Younger garnets enclose galenite grains and often its replacement and penetration by chlorite may be notices particularly in the contact rock (Fig. 16). Replacement of galenite by cerussite from the rim and along the cleavage is often noticeable (Fig. 17a, b, c, d).

Chalcopyrite is very scarce mineral on the studied locality. It appears in the rock in sulphide aggregates, or forms separate grains in the altered sediment. It generated after pyrrhotite, but prior to sphalerite and galenite. Microhardness (VHN_{50}) varies form 1880 up to 2090 MPa.

Tetrahedrite was found only sporadically with garnets in a carbonate veinlet. It is of typical grey colour with brownish tint and shows medium reflectivity. Established microhardness (VHN_{50}) is 3380 MPa.

Garnets are present in two and eventually in three generations. Solitaire (single) garnets in the contact altered rock (Fig. 18) build the oldest generation. The younger generation is represented by „crustal" garnets on crack and vein margins. The youngest generation build idiomorphic garnets in the midst of calcite veinlets in the transformed rock and in the serpentinite (Fig. 10, 19).

The succession of creation for the individual mineral associations in the „contact" zone may be at last generally characterized.

In the altered sediments and quartzy shale fragments of the Werfenian appear sulphide minerals, the genetic assignment of which is clear. Pyrite crystals may be considered as synsedimentary. On the basis of age relation studies the youngest age of sphalerite can be documented.

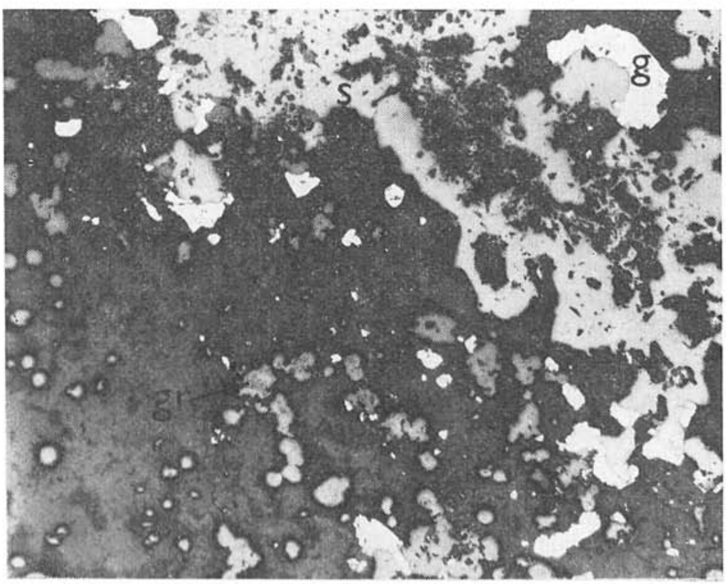

Fig. 18. Galenite (lightgrey), sphalerite (white) and flaky hematite insemination in rodingitized sediment with solitaire garnets. Danková, polished section, enlarged 95 x.

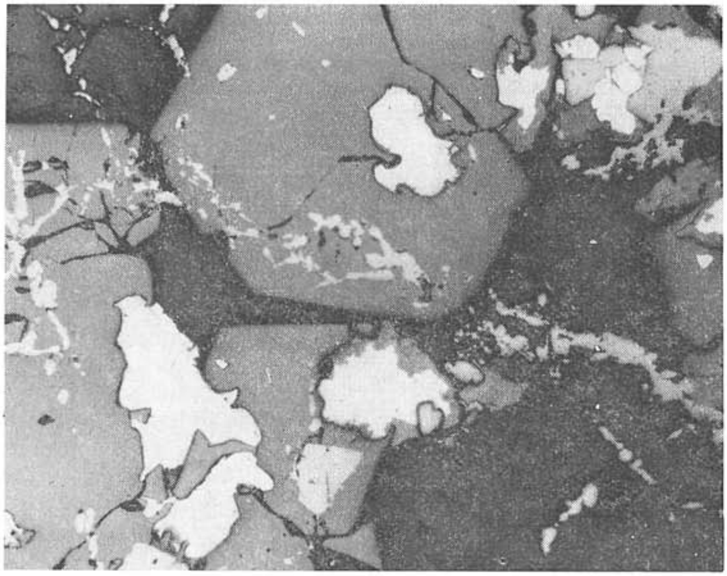

Fig. 19. Idiomorphic garnets in serpentinite with enclosed older magnetite veinlets, but replaced by younger galenite (white), which is from the periphery replaced by cerrusite (grey). Danková, polished section, enlarged 95 x. Photo: figs. 3—8, 10—16, 18—19 — L. Osvald; figs. 9, 17 — Dr. J. Krištín.

In epigenetic veins and miarolitic forms monoclinic pyroxene and crusty garnets did generate as first. In younger stripes pyrrhotite originated primarily. With increasing partial pressure of sulphur it was replaced by a pyrite-marcasite aggregate. Chalcopyrite is a younger, though very scare mineral. Subsequently to chalcopyrite an older sphalerite generation, as well as a less amount of galenite originated. Later on calcite with garnets and a small amount of quartz was formed. Subsequently sphalerite of the second generation and the substantial portion of galenite generated in younger transversal veinlets. In the closure of the mineralization process again carbonate with amphibole and chlorite formed.

Geochemical characteristics of the contact zone

We evaluated in total 20 rock samples from the immediate vicinity of the contact line (3 samples of serpentinite, 5 limestones and dolomites, 5 samples of clayey and clayey-marly quartzose schists and 7 samples of a contact altered rock). The samples were analyzed (O. Karelová, analyst) by means of procedures published in the papers of J. Medveď — J. Jarkovský (1969) and J. Medveď et al. (1974). The results of analyses are quoted in table 2. We involved in the evaluation quantitatively established Ag, B, Ba, Be, Co, Cr, Cu, Ge, Mn, Mo, Ni, Pb, Sc, Sn, Sr, Ti, V and Zr contents. Very low Zn contents of the contact rock, determined only in some samples of the contact rock by semiquantitative spectral analysis we interpretated as the

Table 2

Quantitative analyses of rocks from the contact zone
(in ppm)

No of sample	Ba	Co	Cr	Cu	Mn	Ni	Pb	Sr	Ti	V	Ag
V-1-D	3	3	2	1	23	1	8	112	5	3	—
V-2-D	3	3	8	3	35	3	83	70	14	3	1
V-3-D	3	3	6	1	27	2	41	182	3	3	1
V-4-D	19	3	4	5	1450	23	7	102	43	5	1
V-5-D	3	3	4	2	58	2	26	151	44	26	1
V-6-D	4	112	2497	5	828	1898	11	5	3661	56	—
V-7-D	6	23	248	6	3000	109	3	12	2000	100	—
V-7a-D	5	17	93	4	4400	81	9	10	3020	63	4
V-8-D	68	7	109	7	1780	52	7	209	3520	732	3
V-9-D	6	17	499	7	3000	83	469	45	3520	114	—
V-10-D	3	93	2225	6	1377	1688	134	4	269	39	—
V-11-D	4	129	2457	5	1385	2083	28	5	83	44	—
V-12-D	54	3	25	14	1150	14	5	1000	1010	10	5
V-13-D	245	29	182	234	720	170	45	251	2950	174	1
V-14-D	3	3	3	1	27	3	36	117	17	14	1
V-15-D	3	3	4	1	10	1	3	102	3	6	1
V-16-D	3	3	3	1	23	1	9	112	6	5	1
V-17-D	4	29	112	8	3000	177	3	14	1280	77	—
V-18-D	3	3	6	7	400	3	2	630	269	8	1
V-19-D	3	3	10	5	174	2	6	31	46	3	1
$\bar{x}_{I.}$	4	111	2393	5	1200	1890	58	5	28	46	?
$\bar{x}_{II.}$	4	3	5	3	223	4	22	161	45	8	1
$\bar{x}_{III.}$	64	18	181	40	2650	98	77	233	2528	96	2

result of low sensitivity of spectral determination of Zn contents on one hand, and by the considerable mobility of this element and its concentration during geochemical processes within the epigenetic veinlets and miaroles in form of several sphalerite generations on the other one.

Trace element contents in the individual rock sets correspond in general to the average contents of these elements cited for similar rock in literature (K. K. Turekian — K. A. Wedepohl 1961, A. P. Vinogradov 1962 etc.).

For the ultrabasic rock set (I) primary high Cr content ($\bar{x} = 2393$ ppm) is typical, Ni ($\bar{x} = 1890$ ppm), Co ($\bar{x} = 111$ ppm), increased Mn content ($\bar{x} = 1200$ ppm), low Ti ($\bar{x} = 28$ ppm), Ba ($\bar{x} = 4$ ppm) and Sr content ($\bar{x} = 5$ ppm) is lower than values quoted in literature (10—20 ppm). Pb content ($\bar{x} = 20$ ppm) exceeds considerably the values cited in literature (0,1 — 1 ppm). This fact may be explained by the presence of unseparable galenite and cerussite inclusions in the somple from the immediate contact.

B	Ge	Sc	Sn	Mo	Zr		Rock characteristic
30	3	10	—	3	—	10	dolomitic limestone
30	4	10	—	3	—	10	limestone, dolomit. lim.
30	3	10	—	3	—	11	limestone
30	3	10	—	3	—	10	limestone
30	3	10	9	3	—	10	dolomitic limestone
—	—	—	—	—	—	—	serpentinite
—	—	—	17	—	—	—	rodingitized sediment
74	17	31	—	6	10	135	rodingitized sediment
30	3	11	—	4	—	79	rodingitized sediment
—	—	—	14	—	—	—	rodingitized sediment with galenite inseminations
—	—	—	5	—	—	—	rodingitized sediment
—	—	—	5	—	—	—	serpentinite
86	3	10	—	3	—	36	rodingitized sediment
30	3	20	—	4	—	59	rodingitized sediment
30	3	10	—	3	—	10	silicified clayey schists
30	3	10	—	3	—	10	clayey-marly schists
30	3	10	—	3	—	11	clayey-marly schists
—	—	—	4	—	—	—	rodingitized sediment
30	3	10	—	3	—	12	quartzy schist
35	3	10	—	3	—	10	silicified clayey schist
?	?	—	6	?	—	?	ultrabasic rocks (n = 3)
23	3	11	—	2	—	8	adjacent Low and Middle Triassic rocks (n = 10)
30	3	10	12	3	—	77	rodingitized sedimentss (n = 7)

For the adjacent, Low and Middle Triassic rock set without their closer distinction (II) comparatively low Ba ($\bar{x}$ = 4 ppm), Cu ($\bar{x}$ = 3 ppm), Mn ($\bar{x}$ = 223 ppm), Ni ($\bar{x}$ = 4 ppm), Ti ($\bar{x}$ = 45 ppm) and V ($\bar{x}$ = 8 ppm) concentrations are characteristic compared with the other sets and the data from literature. In comparison to published data slight increase in Pb content ($\bar{x}$ = 22 ppm) may be stated. Sr content ($\bar{x}$ = 161 ppm) can be considered as typical. Increased Hg contents were established in this set (especially in limestones). For the set of samples from the contact altered rock (III) high Mn ($\bar{x}$ = 2650 ppm), Ti ($\bar{x}$ = 2528 ppm), V ($\bar{x}$ = 96 ppm), increased Cu ($\bar{x}$ = 40 ppm), Pb ($\bar{x}$ = 77 ppm) and Ba ($\bar{x}$ = 64 ppm), Cr ($\bar{x}$ = 181 ppm), Ni ($\bar{x}$ = 98 ppm) and Co ($\bar{x}$ = 18 ppm) content is characteristic. The presence of Ag, B, Be, Ga, Sn and Zr content is characteristic. In this sample set increased natrium and kalium contents and throughout low mercury and zink contents had been established.

Table 3

Semiquantitative spectral analyses of rock of the contact zone

No of sample	Ag	Al	As	Fe	Ga	Hg	K	Na	Sb	Sn	W	Zn
V-1-D	4	3—2	0	2—3	5	2	0	4	0	5	0	0
V-2-D	3	3—2	0	2	4	0	0	4—3	0	4—3	0	5
V-3-D	3—4	3	0	2—3	0	0	0	4	0	4	0	0
V-4-D	3—4	2—3	5	1	0	4—3	4—3	4	0	0	0	0
V-5-D	4—3	3—2	0	2—3	0	0	0	4—3	0	5	0	0
V-6-D	3—2	1	5—4	1	0	0	0	4	4—3	4	0	0
V-7-D	3—2	1	4	1	4	0	0	3	0	4	5	3
V-7a-D	3—2	1	5	1	3—4	5	0	3—2	0	4—3	4—5	4
V-8-D	3	1	0	1	4—3	4—5	2	1	0	4	4—5	4
V-9-D	3	1	4—5	1	4	0	0	3	4	4	5	3—2
V-10-D	3	1	4—5	1	0	0	0	3—4	3	4	0	3—2
V-11-D	3	1	4—5	1	0	0	0	4	3	4	0	5
V-12-D	3—2	1	5	1—2	4	4	2—3	2—1	0	4	0	0
V-13-D	3	1	0	1	4—3	4	2	1	0	4—3	5—4	4
V-14-D	4	3—2	0	3—2	0	0	0	4—3	0	0	0	5
V-15-D	4—3	3	0	3	5	0	0	4—3	0	4—5	0	0
V-16-D	3—4	3—2	0	3	0	0	0	4	0	0	0	0
V-18-D	3	1	4—5	1	4	5	0	4	0	4	0	5
V-17-D	4	1	0	1	4	0	4	2	0	4	0	0
V-19-D	3—4	3—2	4—5	1—2	4	0	0	4	0	4	0	5

1 — 1 %, 2 — 1—0.1 %, 3 — 0.1—0.001 %, 4 — 0.001 %, 5 — tr.
1) type of analyzed sample see tab. 2

Discussion

1. Although the contact-thermic effect of the Alpine-type (ophiolite) ultramafic massifs on the adjacent rock complexes are well-known (massif Tinaquilo in Venezuela — D. B. MacKenzie 1960; massif Lizard in Scotland — D. H. Green 1964; massif Brezovica in Serbia — S. Karamata 1968 a. o.), this problem in alliance with new conceptions of the origin of ophiolite series is still not definitely interpreted.

The discussed rocks from the exocontact of the ultrabasic body near Danková were interpreted by J. Kamenický (1957) in consistence with the up to date level of world-wide knowledge as contact-thermic and contact--metasomatic metamorphosed Werfenian sediments.

On the basis of several years systematic material sampling from „contact" of West Carpathian ultramafic bodies by one of the authors (D. H.) and after conducted preliminary (for the present microscopic) study we designate the discussed rocks „rodingitized sediments". In world literature rocks which had originated particularly from basic rock veins and in places also from sedimentary rocks occurring directly in ultramafic rocks of the periodite type, resp. on their exocontacts are designated as rodingites.

The process of rodingitization consists in low-temperated, namely Ca-metasomatism of these rock types. Metasomatism was acting synchronously with serpentinization, when the generating serpentine minerals were not able to bind Ca released from ultramafic bodies. Calcium migrated during this process into the environment of the ultramafic bodies under the formation of the rodingite mineral association: rhombic pyroxenes, vesuvian, Ca-garnet, minerals of the epidote group, pumpellyite, chlorite etc.

Despite the fact that the association pyroxene — garnet — vesuvian seems to be high-temperated, particularly the presence of garnet and pyroxenes in lenticular formations and on epigenetic veinlets document the low-temperature origin of this mineral association.

In the case of consistence with the majority of the authors we should limit the upper boundary of serpentinization processes by 400—450 °C, also the process of creation of the mineral association of „rodingitized" sediments should be delimitated by temperature relation under this critical temperature.

Such occurrences of apparently high-temperated minerals in an environment of relatively lower thermality do not contradict the theoretical knowledge and are known in our literature (F. F e d i u k 1962).

2. We came to the conclusion that Ca, Al and migration of some other elements during serpentinization processes in the ultramafic body operated most likely in the aqueous phase. The genesis of chlorite, talc, serpentine minerals, calcite and sulphides in rodingitized sediments is the proof of it. Owing to increased thermality and aggressivity of hydrothermal solutions it is probable that during migration they became enriched in some elements of the adjacent rock minerals. In favourable conditions of rodingitized sediments their average content in the vicinity of the contact did rise, resp. they were expelled in the form of minerals of impregnations, filling the miarolitic formations and in epigenetic veins.

It could be corroborated that migration of Ni, Co and Cr from the serpentinite area and Ba, Sr, Zn, Pb, Cu and probably even Ti and Mn from the adjacent Triassic sedimentary rocks set it. From the results of analyses Mn decreases in rocks at the immediate vicinity of the contact (mainly in sediments) and its remarkable concentration in the altered zone is striking.

The study of age relations of the rock-forming and ore minerals demonstrated, that their origin is as a whole related to hydrothermal processes (see for example pyroxene and garnet before, and chlorite and calcite formation in veinlets after pyrrhotite, chalcopyrite, sphalerite and galenite creation. In this way established temperatures of some ore mineral genesis (sphalerite, galenite) provide to a certain measure data on the temperature of some corrollary associated silicate mineral formation.

3. Pb—Zn—Cu mineralization is an mineralization atypical for the region of Spišsko-gemerské rudohorie Mts. According to our conceptions it was the presence of clayey and clayey-marly rocks with increased background content of ore elements on one, and hydrothermal solutions circulating in the contact-near zone of the ultramafic body during its serpentinization on the other hand, induced redeposition of ore and non-metallic elements the adjacent rocks, whereby their migration in the scope of the hydrothermal-metasomatically altered zone set in. Considering the overprinting of hydrothermal mineralization allied for example to metallogenetic hydrothermal processes, during which typical siderite-sulphide mineralization in the region of the Spišsko-gemerské rudohorie Mts. took place, appearing also in the region of Čuntava and Danková (J. I l a v s k ý, 1956, G. H a l a h y j o v á - A n d r u s o v á, 1959 etc.), the question of essential significance would still remain

unanswered, why the investigated mineral association was formed only in the contact zone and not also in the adjacent carbonate, quartzy and ultramafic rocks sequences, representing in general a suitable environment for the operation of metasomatic processes at appropriate tectonic predisposition even ore gangues.

4. It is likely, that with more precise research of the contact zones and other ultramafic bodies in the region of Spišsko-gemerské rudohorie Mts. of similar geological position as the body near Danková i.e. presence of Lower Triassic clayey, marly and carbonate rocks in the immediate vicinity of ultramafite strongly serpentinized bodies, analougous Pb—Zn—Cu mineralization occurrences may be expected. The first findings of higher Pb and Zn contents in some contact rocks from the exocontact of the bodies of Dobšiná and Jaklovce are the evidence of it (J. Z l o c h a, oral communication).

Translated by L. Mináriková

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