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MAIN CHARACTERISTICS OF THE METALLOGENY OF THE NÍZKE TATRY MTS.

(1 Fig.)

Abstract: Mineral deposits of the Nízke Tatry Mts. were formed in the Caledonian, Variscan and Alpine metallogenic epochs. The most abundant of them are hydrothermal deposits of the siderite formation with zonal pattern of mineral assemblages. From the centre to the periphery the assemblages are: quartz-pyrite, quartz-scheelite, quartz-siderite, base metal and antimonite. The author notes spatial relationship of the siderite formation to neotectotic deep-seated fault zones. The orebodies in crystalline, less frequently in Mesozoic, rocks postdate metamorphic processes and have been developed in Alpine fold structures as well as younger faults in the Tatricum and Veporicum.
On the basis of these results the author assigns mineral deposits of the siderite formation to the Alpine metallogenic epoch and as a source of their mineralization he regards granitoids indicated at depth with a complex of surrounding rocks from where the mineralizing constituents were carried by hydrothermal solutions (meteoric and juvenile) into higher horizons.

Резюме: Месторождения Низких Татер возникли в каледонской, варисцийской и альпийской эпохе металогенезиса. Наиболее частыми являются месторождения сидеритовой формации с зональным распределением минеральных ассоциаций. Из центра к периферии находятся следующие ассоциации: кварц-пиритовая, кварц-шелитовая, кварц-сидеритовая, полиметалическая и антимонитовая. Указывается на пространственную связь сидеритовой формации с неотектоническими глубинными зонами разломов. Рудные тела в породах кристаллиникума, менее в мезозойских породах, возникли после метаморфических процессов и они развиты на альпийских складчатых структурах и более молодых разломах в татрикуме и вепорикуме. На основе этих результатов автор отнес месторождения сидеритовой формации к альпийской металогенетической эпохе и источником минерализации считает гранитоиды определены в глубине вместе с комплексом окружающих пород, откуда была гидротермалными расплавами (метеорическими и ювенильными) перенесена в высшие горизонты.

In the past, the Nízke Tatry Mts. was an important source of mineral raw materials, predominantly ores. Orebodies on or close to the surface were mined out, in other ones mining ended for various, most frequently economic, reasons. At present, mining continues in the only site — Dúbrava antimony deposit. As regards the amount of metal extracted, it belongs among the largest antimony deposits in Europe.

From the viewpoint of metallogeny, small ore occurrences are also significant. Iron, tungsten, copper, lead-zinc, antimony, gold-silver, pyrite, manga-

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nese, arsenic and uranium orebodies concentrate predominantly in the crystalline massif (less frequently in Mesozoic rocks). Industrial minerals present in the area comprise barite, building stones, precious and decorative stones as well as sandy gravels. Because the area concerned lies in a national park and its protective zone, mining of industrial minerals is only sporadic.

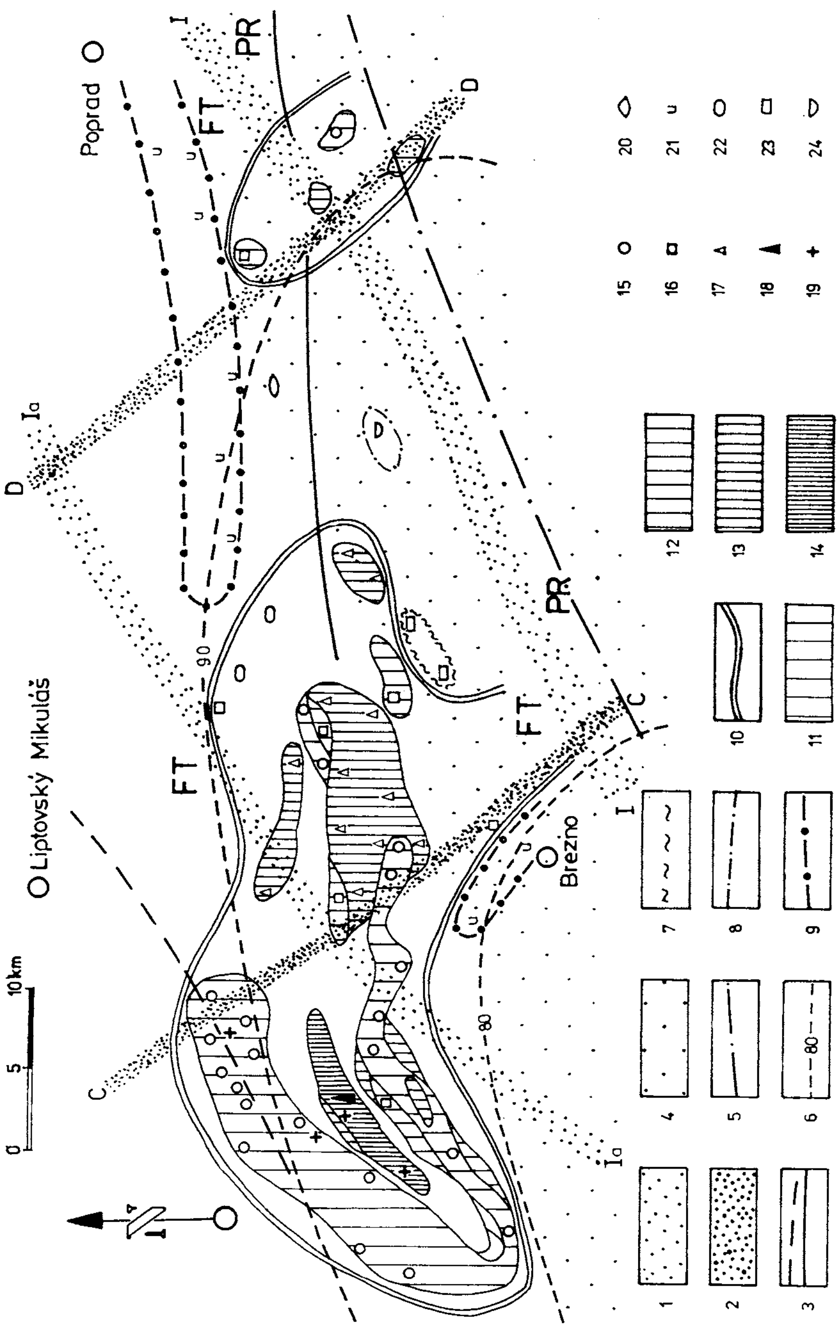
A substantial part of orebodies and occurrences is situated in the western part of the Nízke Tatry Mts. Study of their distribution allows us to determine areas clearly dominated by a certain ore type (Fig. 1). In the territory bordered by Chopok Mt., Mýto pod Ďumbierom village, elevation point Oravcová (1544 m) and Nižná Boca village there occur iron ores. Towards the west, roughly between the spring of Vajskovký potok brook and Ráztocká hoľa Mt. (1565 m) is a fairly narrow belt of tungsten ores. Both these areas constitute a "core" of the overall mineralization. Along both sides it is fringed by antimony mineralization. In the south, antimony deposits extend from Vážna brook (north of Hiadeľ) as far as Mlynná dolina valley (north of Mýto pod Ďumbierom) and in the north they occur in a wide zone from Prašivá Mt. (1652 m) to Podlužanka valley (north of Dúbrava). Base metal and copper ores occur predominantly in the southern antimonite zone and along its border with the tungsten and iron ore zones. Barite bodies are present in the drainage area of Malužiná brook, uranium ores in that of the Čierny Váh River, stratiform pyrite and iron ores are known in the upper ends of valleys north of Polomka and north of Heľpa. Results obtained so far suggest that most orebodies were formed in the Alpine metallogenic epoch, less frequently in the Variscan and Caledonian epochs.

Metallogenic division

Metallogenic division of our territory has been presented by Ilavský — Sattran (1980) in their metallogenic map of Czechoslovakia. Slovakia is assigned to this Carpathian metallogenic province, the Nízke Tatry area belongs into the West Carpathian region and into the Fatro-Tatric and Veporic metallogenic zones.

The Nízke Tatry area comprises two structural metallogenic zones. The western portion belongs to the Tatricum and covers only part of the Nízke

Fig. 1. Distribution of ore formations and assemblages in the Nízke Tatry Mts.
Explanations: 1 — lineaments of 1st order (hidden); 2 — deep-seated fault zones of 2nd order hidden); 3 — deep-seated fault zones of 3rd order (hidden, apparent); 4 — astenolith; 5 — axis of astenolith; 6 — thickness of lithosphere (1—6 from Šefara, 1987); 7 — magnetite formation; 8 — pyrite formation; 9 — uranium formation; 10 — siderite formation; 11 — antimonite assemblage; 12 — base-metal assemblage; 13 — siderite assemblage, 14 — scheelite assemblage;
15—24 — deposits and most important prospects: 15 — Sb ores, 16 — Pb, Zn, Cu ores, 17 — Fe ores, 18 — W ores, 19 — Au ores, 20 — Mn ores, 21 — U ores, 22 — barite, 23 — magnetite ores, 24 — pyrite ores.
Neotectonic blocks: FT — Fatra-Tatry block, PR — Pilíš-rudohorie block.
Deep-seated fault zones: I — southern deep-seated fault zone of Vepor lineament, Ia — northern deep-seated fault zone of Vepor lineament, C — Kysuca-Tisovec deep-seated fault zone, D — Silica-Čierny Váh deep-seated fault zone.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Tatry ore district determined by Ilavský—Sattran (1980), whereas the eastern tract comprises part of the North Veporic and minor part of the Central Veporic ore district and belongs to the Veporicum. Their border roughly corresponds with the Čertovica line.

The geological structure is complicated and geologic-tectonic units are in allochthonous position. In the course of their development each of them had its own mineral (deposit) content. There is no unequivocal evidence for the presence of the Caledonian metallogenic stage, but the intensively folded and metamorphosed Heľpa pyrite-pyrrhotite deposit may be assigned to this stage because of its similarity to some mineral deposits of the Spišsko-gemerské rudohorie Mts. (Smolník, Bystrý Potok). The Variscan metallogenic stage took place in association with the emplacement of Variscan granites (molybdenite in pegmatites — Malé Železné), but most important are Permian stratiform copper and copper-uranium ores. The assignation of hydrothermal deposits to either Variscan or Alpine metallogenic stage is controversial. Some data indicate that the deposits are Variscan, but there is also evidence of their Alpine age.

The Alpine disturbances led to further considerable nearing and overlapping of geologic-tectonic units. Mineral deposits of the above-mentioned stages were thus placed into the same space, forming two or more storeys (representing original ore districts) overlying each other. The pre-existing mineral deposits were deformed and altered, to different degree, by the associated tectonic and metamorphic processes. The subsequent geotectonic development resulted in faulting and block structure of the territory, thus forming a favourable setting for new mineral accumulations. Into the Alpine metallogenic stage we place mainly hydrothermal vein and stockwork deposits of the siderite formation developed in the crystalline as well as Mesozoic rocks, replacement base-metal ores, stratiform manganese ores and the youngest fluorite-realgar mineralization near Šumiac.

These facts indicate that the complicated spatial distribution of the mineralization directly depends on the complex geological structure and is further enhanced by processes that transported some mineralizations from the lower units into the upper ones, and/or vice versa, or brought new mineral content related to igneous activity.

As a result, mineralization is now present in all geologic-tectonic units, making it difficult to assign individual mineral deposits to the Caledonian, Variscan or Alpine metallogenic stage.

Relationship between mineralization and geological structure

The Nízke Tatry Mts. are at present slowly uplifted at a rate of 0.5 mm/year (Vanko, 1984, in: Šefara, compiled 1987). The western and southern parts of the mountain range are intersected by boundaries interpreted by remote sensing (Pospíšil—Schenková—Schenk, 1985), to which earthquakes are bound.

From our viewpoint, the Hron boundary in the Hron River valley is important. Janku et al. (1984) and Klinec et al. (1985) regard it as a transcurrent fault with considerable strike-slip displacement, which was of prime importance for the formation of the gravitational nappe in the Nízke Tatry Mts.

Under the Nízke Tatry Mts., the MOHO discontinuity relief sinks from a depth of some 34 km in the east to approximately 36 km in the west (Šefara, 1987). The thickness of the lithosphere, according to a model of seismic data (Babuška et al., 1985), is about 80—100 km. This elevation of the lithosphere registered at two deep-seated faults (Beránek et al., 1979) is associated with the most important deep discontinuity — Vepor lineament of lithospheric importance (Šefara, 1987), which was determined after the re-evaluation of the Vepor deep-seated fault in the sense of Fusán et al. (1981).

The Nízke Tatry Mts. area is intersected by the following deep-seated fault zones of the 2nd order (Šefara, 1987): Kysuca-Tisovec (C), i.e. Mytro-Tisovec break of Plančár et al. (1977) and Silica-Čierny Váh (D). NW-SE, NE-SW and E-W trending faults of the 3rd order indicated mainly by the results of gravimetry, magnetometry and remote sensing, as well as faults of lower orders are also present.

A significant item is the interpreted areal and depth extent of granitoids. In the Brezno-Poprad-Ružomberok area they are suggested by a NE-SW trending distinct negative gravity anomaly (Šefara — Velich in: Šefara, compiled 1987), which has not yet been verified by drilling. The upper boundary of the anomaly source (granitoid) is placed by the above authors to a depth of 2.5—3 km, its thickness amounting up to 4—6 km.

The Alpine granitoids have not yet been unequivocally proved on the surface. K/Ar dating by Kantor (1959) of pegmatites from the vicinity of Trangoška, described by Kubíny (1960) as a manifestation of a late-orogenic Cretaceous intrusive stage of the "Hrončok"-type, indicates their Variscan age.

Younger granites intersected by drilling at Rochovce in an area of gravity anomaly suggest that their existence also in the Nízke Tatry Mts. is possible. Obernauer (in Šefara et al., 1987) assumes, on the basis of two-dimensional specific-density models, that an extensive granite body might exist at depth.

The relation of epigenetic deposits (representing the largest and most widely distributed group) to deep structure, neotectonics and neotectonic blocks (Fig. 1) is conspicuous. An important element is an astenolith, whose axis is interpreted to be of ENE direction running from Čierny Balog via Kráľova hoľa Mt. to Vernár. Mineralization occurs north of the axis, roughly between the 80—95 km isolines marking the interpreted thickness of the lithosphere.

In the western part of the Nízke Tatry Mts., the intersection of the northern deep-seated fault zone of the Vepor lineament (Ia) with the Kysuca-Tisovec one (C) is situated amidst the area of the siderite formation. Mineral deposits of the individual assemblages are located at faults of much lower orders, predominantly NNW-SSE and NE-SW trending, with the deep-seated fault zones representing routes for hydrothermal solutions from the depth to the upper parts.

The situation is similar in the eastern part of the Nízke Tatry Mts., where the siderite formation, though much less extensive, is developed around the intersection of the southern deep-seated fault zone of the Vepor lineament (I) with that of Silica-Čierny Váh (D).

Rozložník (in: Fusán et al., 1987) describes the siderite formation as regionally distributed in the West Carpathians. In his opinion the siderite formation is younger than the Gemeric Granites (Rozložník, 1976) and is bound to the lower structure (shear zone) with a different tectonic style favourable for epigenetic mineralization.

The composition and distribution of mineral deposits of the Nízke Tatry Mts. are, in many respects, similar to those of the Spišsko-gemerské rudohorie Mts. First of all it is their tectonic style substantially affected by the Alpine tectonic processes and similarity of mineral assemblages, of which only the magnesite one is absent in the Nízke Tatry Mts. Cassiterite has been identified only in heavy mineral concentrates from territories with quartz-scheelite assemblage.

These signs make it possible for us to assign the epigenetic mineralization of the Nízke Tatry Mts. to the siderite formation. The formation has been characterized by Slavkay (in Slavkay et al., 1988) as epigenetic, with vein and stockwork-disseminated orebodies discordant as well as concordant with schistosity, postdating metamorphic processes as well as Alpine structures with distinct spatial zonality. Their vertical zonal pattern is less known, as the deposits were explored and mined only at small depths. In contrast, the lateral zonality of the mineral assemblages is well documented, but their source and linkage to it have not been proved, yet.

Mineral assemblages and questions of their genesis

The most abundant in the territory concerned are hydrothermal depostits assigned to the siderite formation. Within this formation we distinguish the following mineral assemblages (Slavkay, in Slavkay et al., 1988):

1. Quartz-pyrite assemblage is only represented by one stock-work-disseminated and two vein deposits of small magnitude. Along with the following assemblages, they are involved also in other mineral deposits.

2. Quartz-scheelite assemblage occurs in the inner zone and constitutes a core of the mineralized area. It is associated with fissure systems parallel as well as perpendicular to S_1 planes and located in stromatitic and ophtalmitic migmatites, amphibolites and less metamorphosed rocks of the Lower Paleozoic. It occurs as a narrow (several hundreds of metres) zone in an antiform structure (Pulec — Klinec, 1985) from the upper end of the Vajsková valley as far as Sopotnička valley.

3. Quartz-siderite assemblage. Its substantial part is located east of the foregoing assemblage, from the upper tracts of Bystrianka and Demänovka brooks to the Nižná Boca area. It extends, however, as far as Zadná hoľa Mt. (1660 m) in the east and the Hiadeľ area in the west. The assemblage is developed in granitoids and migmatites, but penetrates also in the Mesozoic rocks (Sokolová dolina valley) forming discordant veins. One third of the deposits contains barite, which corresponds to the siderite-barite assemblage of the Spišsko-gemerské rudohorie.

4. Base-metal assemblage forms no marked areal concentrations. The individual deposits fringe the quartz-scheelite and quartz-siderite assemblages, occur also in the western part where they concentrate in a narrow zone, also in the antimonite assemblage. It forms hydrothermal, clearly epigenetic veins, but also stockwork-disseminated and replacement orebodies located mainly in migmatites, weakly metamorphosed crystalline schists, Mesozoic sandstones and limestones. The assemblage is confined to the southern part of the mineralized territory.

5. Antimonite assemblage constitutes the most abundant deposits and occurrences in the territory concerned. From the Hiadeľ deposit they are developed in two branches. The northern one, some 5 km wide, comes to its end in Polúdžanka valley. The orebodies intersecting 4 small migmatite layers occur in granites and form veins and stockworks. The southern branch, about 2 km in width, extends as far as Mlynná valley. It forms veins discordant, less frequently concordant, with schistosity. A saddle vein has also been found (Lomnistá). The assemblage occurs also in the form of stockwork-disseminated bodies. The orebodies are located in migmatites and less metamorphosed crystalline schists.

The above assemblages are ranked according to the time succession of their formation, which corresponds also to mineralogical researches carried out so far. At the time when Hak (1962) established a theoretic succession scheme of the Nízke Tatry Mts., no scheelite occurrences were known. Nevertheless, his scheme of a united metallogenic dvelopment is confirmed by newer researches. He distinguished four assemblages: 1 — quartz-sulphide, 2 — carbonate with barite, 3 — base-metal, 4 — antimonite with gold.

Beňka (in Pulec et al., 1984) determined four mineralization stages within the independent quartz-scheelite-gold-bearing formation. These are 1 — quartz-pyrite, 2 — carbonate, 3 — quartz-sulphidic, 4 — mobilization stage. Within the quartz-sulphidic stage, the quartz-scheelite substage is the oldest, followed by base-metal and antimonite ones. He regards the 1st to 3rd stages as Variscan, whereas the mobilization stage comprising mineralization of the foregoing stages is Alpine.

Of course, the submitted time relations among the individual assemblages and stages cannot be regarded as ultimate. Many problems still have to be solved to explain unequivocally the genesis and conditions of distribution of the individual mineral assemblages and thus also the formation of the mineral deposits (as given above).

Zonal distribution of assemblages of ore bodies and occurrences is evident. Dispersion aureoles of elements and minerals (primary as well as secondary) show distinct zonation indicated by lithogeochemical, soil-geochemical, placer and stream-sediment anomalies. The distribution of individual minerals within the deposits is also zonal.

The epigenetic hydrothermal depostits occur in three main zones:

a) inner, higher-temperature (W, Fe $\pm$ Au)

b) intermediate, medium-temperature (Pb, Cu, Zn $\pm$ Ag)

c) outer, low-temperature (Sb $\pm$ Au).

Selected minerals, despite their presence also in the adjacent zones, have also zonal arrangement. The fact that gold and barite do not occur in common deposits is an important finding. The Dúbrava deposit is the only exception.

The same applies also to antimonite and barite, with the exception of the Dúbrava, Riavka and Lom deposits. Siderite is often accompanied by ankerite. In the centre of the quartz-siderite assemblage, however, there occurs only siderite and in the periphery exclusively ankerite. In many places, galena and sphalerite are separated from each other. The former tends to occur in the outer zone, the latter in the inner one. In the norther part, tetrahedrite and chalcopyrite are usually present together, whereas in the south they are separated from each other, with chalcopyrite being closer to the periphery. Scheelite only occurs in a narrow belt in the centre of the inner zone.

This knowledge may be useful in spatial modelling and combined with other criteria and factors it may result in determination of areas with possible ore occurrences. Regularities in mineral and deposit distribution in horizontal direction make it possible to infer their depth.

We face the question whether the mineralization process is related to the Ďumbier granitoid pluton (Pulec, 1987) or to a hypothetical source in depth. Rozložník (in Fusán et al., 1987) admits that lighter rocks of the crystalline mountain ranges in part of the Inner West Carpathians, in the Spišsko-gemerské rudohorie Mts., might be underlain by a deeply underthrusted unit which underwent basification. He explains the siderite formation as a product of the early-Alpine remobilization of this unit due to increased heat flow.

On the other hand, a distinct NE-SW trending gravity anomaly described by Šefara and Velich (in Šefara et al.. 1987) in the Brezno—Poprad—Ružomberok area indicates possible occurrence of granitoids with their ceiling at a depth of 2.5—3 km.

Our genetic conclusions necessarily have to be based on deposits of larger territory. Here we encounter some contradicting views. Numerous authors regard the deposits as Variscan. It was already Hynie (1921—1922) who studied mineralization in the vicinity of Staré Hory and Špania Dolina, and so did Cambel (1961). Ilavský and Čillík (1956) were critical of the age of the mineralization — they regard the antimony as well as base-metal and siderite deposits as Variscan, but place them into a later stage of the Variscan metallogenic epoch. Similarly, Koutek (1947) considers the mineralization as pre-tectonic, whereas Zoubek (1937) admits possible existence of Variscan as well as Alpine mineralizations. Numerous authors, e.g. Pouba—Vejnár (1955) and Kubíny (1956), regard the main mineralization stage as Alpine. Others assume that the whole siderite formation is Alpine in age, formed as late as after the end of the main phases of the Alpine folding (Lower—Upper Cretaceous). This view was described in detail by Máška (1956) who assumes that the West Carpathian metallogeny had several stages. Varček (1959) and others are of a similar opinion. Kravjanský (1959, 1962) distinguished six types of mineralization in the Nízke Tatry Mts., of which the first two (siderite-quartz-pyrite-arsenopyrite) he regards as Lower Paleozoic and the others (quartz-antimonite, copper-base metal with carbonates, quartz-galena with barite and barite-base metal) as Mesozoic. On the basis of a detailed study of mineral assemblages and geochemical relationships on the ore veins of the Nízke Tatry Mts., Hak—Losert (1962) assumed that the mineralizations in the Mesozoic and crystalline of the Nízke Tatry Mts. were roughly simultaneous and were formed from isogenetic solutions of similar character related to some of the Alpine orogenic stages.

Those who favour Variscan age of the mineralization explain the presence of ore occurrences in Mesozoic rocks by means of regeneration in the sense of Schneiderhöhn (1952) thus eliminating one of the principal obstacles. At the deposits in the Nízke Tatry Mts., however, no typical signs of regeneration (reverse succession, change in chemistry etc.) have been found. The question of the presence of antimony veins in areas with higher-temperature mineralizations was investigated by Varček (1962). He assumes that in the Spišsko-gemerské rudohorie Mts., where such deposits occur in the centre of the mountains, they might have been created by younger metallogenic processes. The Husárka and Lomnistá antimonite deposits were later studied in detail by Slavkay (1970, 1971). On the basis of their structural position and linkage to Alpine structures, he regards the antimony deposits as epigenetic and assigns them to the Alpine metallogenic epoch.

On the basis of research works, predominantly study of structures of scheelite-gold mineralization, Molák and Pecho (1983) consider it as epigenetic, Alpine, formed by a single mineralization process. Investigations of undulatory extinction of quartz indicate, according to Repčok (1984), that the mineralization is of Variscan as well as Alpine ages. He assumes a polystage mineralization process in the course of which scheelite was formed in the Silurian, middle age of the Upper Carboniferous (maximum), Lower Permian, Lias and Lower Cretaceous. According to spatial distribution of the mineral deposits, Slavkay (1985) noted their zonal pattern relative to the Alpine tectonic structure with scheelite mineralization and towards the periphery base-metal and antimonite ones.

Pulec (1987) states that the mineralization is related to a major very deep scar which served, along with fault systems, as a route for thermal front and associated mineralization in the course of metamorphic processes as well as Alpine stage. The structure occurs amidst the most intensively altered rocks, which the latter author explains by the uplift of the axial central zone at the end of the Mesozoic and in the Tertiary. On the basis of recent K/Ar datings of biotite from salbands of a quartz-scheelite veinlet carried out by Kantor, Molák regards this mineralization as Variscan (Pulec — Molák, 1988 in Slavkay et al., 1988).

After the overall evaluation of results obtained so far, mainly:

— spatial relationship of the siderite formation to neotectonic deep-seated fault zones,

— zonal distribution of deposits of the individual mineral assemblages within the siderite formation,

— presence of mineral deposits in Alpine fold structures and younger faults in the Tatricum and Veporicum,

— location of mineralizations in crystalline as well as Mesozoic rocks,

— younger age of the orebodies relative to metamorphic processes.

I assign the deposits of the siderite formation to the Alpine metallogenic epoch, in which they developed. The source may have been granitoids indicated at depth with a complex of surrounding rocks from where hydrothermal solutions (meteoric and juvenile) carried mineral content into the space of the present-day deposits.

Metallogenic development of the Nízke Tatry Mts. is very complex. Metamorphic, tectonic and other phenomena resulted in a very complicated geological structure of the territory, which makes it difficult to decipher metallogenic processes. Individual mineral deposits have been assigned to the Caledonian, Variscan and Alpine metallogenic stages. The most significant of them is the siderite formation which may provide new mineral resources for the national economy.

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REFERENCES

BABUŠKA, V. — PLOMEROVÁ, J. — PETR, V. — PĚČOVA, J. — PRAUS, O., 1985: Mocnost litosféry ve střední Evrope odvozená ze seismologických a magnetotelurických pozorování. 8. celostátni konference geofyziků. Zborník, sekce S-6, pp. 26—32.

BERÁNEK, B. — LEŠKO, B. — MAYEROVÁ, M., 1979: Interpretation of seismic measurements along the trans-carpathian profile K III. VEDA, Bratislava, pp. 201—205.

CAMBEL, B., 1961: Zum Problem der Metalogeneze in der West Karpathen. Geol. Práce, Zoš. (Bratislava), 60 pp.

FILO, M. — MEDO, S., 1977: Výsledky interpretácie magnetických anomálií Slovenska. In: Geofyzikálne interpretačné metódy, Zborník referátov, VEDA, Bratislava, pp. 122—130.

FILO, M. — KUBEŠ, P., 1986: Geologická interpretácia magnetických anomálií Západných Karpát. In: Blížkovský, M. et al., 1986: Geofyzikálny model litosféry.

FUSÁN, O., 1985: Náčrt hlbinnej stavby Západných Karpát. Miner. slov. (Bratislava), pp. 195—204.

FUSÁN, O. — BIELY, A. — IBRMAJER, J. — PLANČÁR, J. — ROZLOŽNÍK, L., 1987: Podložie terciéru vnútorných Západných Karpát. GÚDŠ, Bratislava, 123 pp.

HAK, J., 1962: Příspěvek k metalogenezi centrální části Nízkych Tater. Geol. Práce, Zoš. (Bratislava), 62, pp. 165—169.

HYNIE, O., 1921—22: O Příslušnosti a stáří rudní formace v okoli Starých Hor a Špané Doliny na Slovensku. Zborník klubu přírodovědců v Praze.

ILAVSKÝ, J. — ČILÍK, I., 1959: Náčrt metalogenézy Západných Karpát (aplikáciou zo Spišsko-gemerského rudohoria). Geol. Práce, Zoš. (Bratislava), pp. 109—113.

ILAVSKÝ, J. et al., 1979: Metallogenese de l'Europe alpine centrale et du sud-est. 414 pp.

ILAVSKÝ, J. — SATTRAN, V., 1980: Vysvětlivky k metalogenetické mapě Československa 1 : 500 000. ÚÚG Praha, 48 pp.

JANKU, J. — POSPÍŠIL, L. — VASS, D., 1984: Príspevok diaľkového prieskumu Zeme k poznaniu stavby Západných Karpát. Miner. slov. (Bratislava), 16, 2.

KANTOR, J., 1959: Príspevok ku geochronológii nízkotatranských granitoidov. Geol. Práce, Zoš. (Bratislava), 55, pp. 159—169.

KLINEC, A. — POSPÍŠIL, L. — PULEC, M. — FERANEC, J. — STANKOVIANSKÝ, M., 1985: Identifikácia gravitačného príkrovu v Nízkych Tatrách pomocou kozmických snímok. Miner. slov. (Bratislava), 17, 6.

KOUTEK, J., 1947: Predběžné výsledky studia rudních ložisek revíru Staré Hory Špania Dolina. Věst. Ústř. geol. úst. (Praha), XXII.

KRAVJANSKÝ, I., 1959: Príspevok ku metalogenéze západnej časti Nízkych Tatier. Acta geol. geogr. Univ. Comen., Geol. (Bratislava), 2, pp. 32—43.

KRAVJANSKÝ, I., 1962: K problematike zrudnenia v Nízkych Tatrách a priľahlých pohoriach. Geol. Práce, Zoš. (Bratislava), 62, pp. 28—36.

KUBÍNY, D., 1956: Správa o výskume ústrednej časti ďumbierskeho masívu. Geol. Práce, Spr. (Bratislava), 9.

KUBÍNY, D., 1960: Príspevok ku geológii okolia Trangošky. Geol. Práce, Zpr. (Bratislava), 17, pp. 97—104.

MÁŠKA, M., 1956: Správa o studiu předneogénní metalogeneze Západních Karpat, zvláště Spišsko-gemerského rudohoří. Geol. Práce, Zoš. (Bratislava), 46.

MOLÁK, B. — PECHO, J., 1983: Geologicko-ložisková charakteristika scheelitovo--zlatonosného zrudnenia v oblasti Jasenia. In: Zborník „Scheelitovo-zlatonosné zrudnenie v Nízkych Tatrách". GÚDŠ, Bratislava, pp. 61—70.
PLANČÁR, J. — FILO, M. — ŠEFARA, J. — SNOPKO, L. — KLINEC, A., 1977: Geofyzikálna a geologická interpretácia tiažových a magnetických anomálií v Slovenskom rudohorí. Západ. Karpaty, Sér. Geol. (Bratislava), 2, pp. 7—144.
POSPÍŠIL, L. — SCHENKOVÁ, Z. — SCHENK, V., 1985: Fotolineace a jejich vztah k ohniskům zemětresení. Čas. Mineral. Geol. (Praha).
POUBA, Z. — VEJNAR, Z., 1956: Polymetalické rudní žíly u Jasenie v Nízkych Tatrách. Sborník ÚGÚ, XXVII, Praha.
PULEC, M., 1987: Distribúcia zlata na južných svahoch v západnej časti Nízkych Tatier a jeho vzťah k primárnym výskytom. In: Zborník „Zlato v Západných Karpatoch..." GÚDŠ, Bratislava, pp. 71—74.
PULEC, M., 1987: Prospekcia a genetická charakteristika scheelitových zrudnení vo vzťahu k metalogenéze v ďumbierskej časti Nízkych Tatier. Manuscript, arch. GÚDŠ, Bratislava, 197 pp.
PULEC, M. — KLINEC, A. — BEŇKA, J. — SUCHÝ, Š. — MOLÁK, B. — PLANDEROVÁ, E. — GUBAČ, J. — CHMELÍK, J. — DOVINA, V. — RAPANT, S. — VYBÍRAL, V. — REPČOK, J., 1984: Geologicko-ložiskový výskum scheelitovo--zlatonosného zrudnenia v oblasti Lomnistá až Vajskovská dolina (Nízke Tatry), III. etapa. Manuscript, arch. GÚDŠ, Bratislava.
PULEC, M. — KLINEC, A., 1985: Scheelite-gold bearing mineralization at the southern slopes in the western part of the Nízke Tatry Mts. Geol. Zbor. Geol. carpath. (Bratislava), 36, 5, pp. 589—596.
PULEC, M. — MOLÁK, B., 1988: Štruktúrne a geochronologické postavenie scheelitového zrudnenia v Nízkych Tatrách. In: M. Slavkay et al., 1988. Manuscript, arch. GÚDŠ, Bratiislava.
REPČOK, I., 1984: Využitie undulózneho zhášania kremeňa a scheelitu pre ich relatívne časové zaradenie. Manuscript, arch. GÚDŠ, Bratislava.
ROZLOŽNÍK, L., 1976: Vzťah zrudnenia k tektonike Spišsko-gemerského rudohoria. In: Zborník „Geológia, metalogenéza a prognózy surovín Spišsko-gemerského rudohoria". Košice, pp. 63—79.
SLÁVIK, J. et al., 1967: Nerastné suroviny Slovenska. ÚGÚ, Praha, Bratislava, 510 pp.
SLAVKAY, M., 1971: Vzťah niektorých nízkotatranských ložísk ku geologickým štruktúram. Miner. slov. (Bratislava), 3, 9, pp. 5—22.
SLAVKAY, M., 1985: Postavenie scheelitových a antimonitových rúd v Nízkych Tatrách. Miner. slov. (Bratislava), 17, 4, pp. 339—340.
SLAVKAY, M. — BURIAN, J. — TÖZSER, J. VARČEK, C., 1984: New aspects in the metallogeny of the West Carpathians (Czechoslovakia). Geol. Zbor. Geol. carpath. (Bratislava), 36, 4, pp. 421—432.
SLAVKAY, M. — GUBAČ, J. — PULEC, M. — BIELY, A. — BADÁR, J. — ČILÍK, I. — ĎUĎA, R., 1988: Regionálna mapa ložísk a prognóz nerastných surovín Nízke Tatry (1 : 50 000). GÚDŠ, Bratislava, 349 pp.
SCHNEIDERHÖHN, H., 1952: Genetische Lagerstättengliederung auf geotektonischer Grundlageneues. Jb. f. Min., M4, 3—3.
ŠEFARA, J. edit., 1987: Štruktúrno-tektonická mapa vnútorných Západných Karpát pre účely prognózovania ložísk, geofyzikálne interpretácie. Text k súboru máp. SGÚ Bratislava, Geofyzika Brno, Uránový prieskum Liberec. Bratislava, 267 pp.
VARČEK, C., 1959: Zum Problem der regenerierten Lagerstätten im Sinne H. Schneiderhöhns in den Westkarpaten. Zeitsch. f. angen. geologie, Hf 7.
VARČEK, C., 1962: Vývoj hydrotermálnej mineralizácie Spišsko-gemerského rudohoria v čase a priestore. Geol. Práce, Zoš. (Bratislava), 80.
ZOUBEK, V., 1937: Dva nálezy rud v mezozoiku ďumbierske zóny. Věst. SGÚ ČSR, (Praha), 13, pp. 38—45.

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