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NEW ASPECTS IN THE METALLOGENY OF THE WEST CARPATHIANS

Abstract: The development of metallogeny is briefly characterized for the polycyclic area of the West Carpathians. Pre-Variscan, Variscan and Alpine metallogenetic epochs are outlined respectively and a gradual increase of intensity and diversity of their products from the oldest to the youngest epoch is stated. Analogies and pecularities of the West Carpathian metallogeny in comparison with the neighbour segments of the Alpine orogenic belt are underlined. Several new positive results of ore prospection are evaluated in detail with emphasis on nontraditional ore types for the West Carpathians (tungsten, tin, porphyry-copper and base — metal ores).

Резюме: В статье кратко характеризовано развитие металлогении в полициклическом районе Западных Карпат. В указанном порядке изложены доварисцийская, варисцийская и альпийская металлогенетические эпохи и установлено постепенное повышение интенсивности и разнообразия их продуктов с самой раней до самой поздей эпохи. Уделяется внимание аналогиям и особенностям металлогении Западных Карпат в сравнении с соседними сегментами альпийского орогенетического пояса. Подробно оценено несколько новых положительных результатов рудной разведки с ударением на нетрадиционные рудные типы Западных Карпат (вольфрамовые, оловянные, медно порфировые и другие руды).

Introduction

The West Carpathians participate on the northern branch of the Alpine-Mediterranean orogenic belt representing, namely with their internal zones, an area where metallogenetic processes developed very intensively. This is testimonied by the famous history of mining in the Carpathians.

The metallogenetic development of the West Carpathians well remainds, till to Cenozoic time, the one of the neighbour Eastern Alps. To the contrary, by its intense metallogenesis in Neogene time, related to important centres of subsequent volcanic activity along the border zone between the folded Carpathian arc and the Pannonian basin, the West Carpathian area bears similarities to the pattern found in the Eastern Carpathians (Varček 1963; 1973).

The first synthetic outlines of West Carpathian metallogenetic development (Ilavský—Čilík, 1959; Varček, 1963) were based on the model of cyclic metallogenetic development in geosynclinal zones by H. Stille, H. Schneiderhöhn, Yu. A. Bilibin, further developed by V. I. Smirnov, J. Auboin and others. Certain later modifications were motivated by reflections of new knowledge on stratigraphical or tectonic position of some structural units or by data on genesis and age of some known or newly found

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mineralization types. However the basic subdivision into metallogenic epochs and stages remains, basically, valid up to present (Varček, 1963, 1973; Rozložník, 1979; Rozložník—Slavkay, 1980). Considerable differences, resulting from uncertainty in some problems and subjective explanation of some data are reflected by papers of Ilavský (1968 and others) what has been borrowed into collective, broader metallogenic studies even (Ilavský et al., 1979; Egel et al., 1978; Lazarenko et al., 1973; Ilavský—Sattran, 1980, and others). From further outlines of metallogeny in the Alpine-Carpathian-Balkan zone, papers by W. E. Petrascheck should be emphasized, well representing the state of art in the area.

Recently, ideas of new global tectonics invaded even the metallogeny of the Mediterranean belt, the West Carpathians including which may contribute to better understanding of several broader relations and rules of geotectonic and metallogenetic development.

The reality is however that no generally acceptable picture of the West Carpathians, nor of the entire Mediterranean belt, has been proposed up to now based on the principles of new global tectonics. The situation is not clear enough either with regard to relations during the Neo-Alpine era and, easy to understand, much more less to the development during the older epochs when also the considerable portion of the metallogenetic content originated in the West Carpathians. Probably, Petrascheck (1977) has a lot of true pointing out that with regard to uncertainties in the plate-tectonic model of the Alps and the diversity of views on the age of majority of ore deposits in the area, the correlation of plate-tectonics and metallogeny represents an attempt to solve a sole equation with two unknowns. Hens we concentrete on more detailed information from remarkable types of ore deposits subject to recent prospection in the West Carpathians.

Metallogenetic epochs in the West Carpathians

1 The Pre-Variscan metallogenetic epoch

Metamorphosed geosynklinal complex of Proterozoic to Lower Paleozoic age are known from all parts in the northern branch of the Alpine-Mediterranean belt from the Pyrenees through the Alps, Carpathians, Balkan to the Caucasus (Tvalchrelidze, 1980). From the metallogenetic point of view, mainly zones with abundant submarine volcanites, namely basites, are important where stratiform volcano-sedimentary ore deposits also developed. From this type of deposits, those of the sulphidic formation are the most significantly developed in the West Carpathians. Single sulphidic deposits are related to Lower Paleozoic crystalline schists in the Little Carpathians between Pezinok and Pernek, to zones of graphite schists and metabasites (amphibolite and amphibolite-bearing metatuff). Ores are represented by layers and lenses of poor pyrite ores (the sulphur content is 10 to 30 %) alternated partly to pyrrhotite in the contact ranges of Variscan granitoid massifs. Other sulphides are but accessory (chalcopyrite, sphalerite) and the ore is not exploited. A peculiar antimonite mineralization occurs in the same zones assumed recently to represent, by some of authors (Maucher—Höll, 1968; Ilavský, 1968; 1980), even syngenetic ore concentrations. However, views on epigenetic nature of mineralization related to the Variscan granitoids are still persisting.

In rocks of the Gelnica group of the Spiš-Gemer Ore Mts., ore occurrences of the sulphidic ore formation are concentrated in a volcanogenous member of Silurian age: the Smolník deposit furnished much copper and pyrite from the medieval times but has no more great perspectives. However, recent prospection is concentrated over further similar occurrences in the Mníšek nad Hnilcom — Prakovce area. Ores contain here more base metalls (copper, lead and zinc) what is related to a broader differentiation span of volcanites toward more acidic types. Similar volcanogenous formations with sulphidic deposits are known also from the Eastern Carpathians in the Maramuresh zone in Soviet and Roumanian territories, as well as in the Eastalpine Greywacke zone and Upper Eastalpine units. Analogies are underlined even by lesser occurrences of metamorphosed stratiform manganese and iron ores in all three segments mentioned in the Alpine-Carpathian belt. Continuation of this zone may, in no case, be searched from Roumania accross the Gemeric unit into the Central European Variscids (Jeseníky and Harz Mts., Lahn-Dill area) as attempted by Kräutner (1970).

Stratiform or "strata-bound" deposits of the tungsten-antimony-mercury ore formation outlined by A. Maucher occur in analogous volcano-sedimentary sequences of the Alpine-Mediterranean belt (Pyrenees, Eastern Alps, Caucasus). In the West Carpathians, indications of a similar scheelite mineralization are subject to investigation already 20 years. The problem is treated in further part of the paper.

2. The Variscan metallogenetic epoch

In the course of the geosynclinal stage represented mainly by the Rakovec Group of the Gemeric unit, in spite of huge basic volcanism present, no volcano-sedimentary deposits are known, except for insignificant siliceous oxidic iron ores of Lahn-Dill type. The granitoid plutonism of the orogenic stage is well represented in the "core mountains" of the Tatroveporic unit in crystalline block units reworked into the recent Alpine structure. Only small remnants of the original mantle of plutonic bodies are preserved where unimportant hydrothermal ores of gold, lead-zinc and antimony are present. Probably, part of such mineralizations, namely in the Low Tatra Mts., is of Alpine age.

In the postorogenic Permian complexes, lesser accumulations of stratiform type uranium ores (+ copper and molybdenium) originated preferredly in areas with more abundant acidic volcanism (Novoveská Huta in the Gemeric unit, Kálnica in the Považsky Inovec Mts.). The low metallogenetic productivity of the Variscan epoch and the single mineralization types are similar to the situations in neighbour segments of the Alpine belt (Eastern Alps and Eastern Carpathians) making the belt clearly distinct from the Central European Variscids.

3. The Alpine metallogenetic epoch

No important ore deposits originated in the course of development of the

Alpine geosynclinal zone (Triassic to Lower Cretaceous) and this statement is valid for the entire northern Alpide branch contrasting with the southern, Dinaric, one.

During the orogenetic stage and being related to the main Middle Cretaceous tectogenesis, a domatic uplift of the entire Central West Carpathians has been induced by ascent of sialic palingenic magma. Topmost apophyses of this magmatic suite are known on the recent surface or discovered by numerous drillings in small depths namely in the central part of the Gemeric anticlinorium and in the southern Veporic zone. The ascent of a broad front of mixed metamorphogenous to magmatic hydrothermal solutions was also related to this upwelling and created the most wide-spread mineralization in the West Carpathians. Its products are large and numerous deposits of metasomatic magnesite, a set of siderite veins and several metasomatic bodies of it associating with local accumulations of barite and products of a relatively later quartz-sulphidic mineralization stage (sulphides of iron, copper, nickel, cobalt, bismuth, lead, zinc and mercury). From the more important deposits, the following should be mentioned: Nižná Slaná, Rudňany, Rožňava, Slovinky, Dobšiná, Železník, Gelnica among others in the Gemeric unit and numerous smaller deposits in the Veporic and Tatric units.

The youngest mineralization stage resulted in several vein deposits of the antimony ore formation (± gold, tungsten, lead, zinc and silver) in Čučma, Poproč, Zlatá Idka, Betliar, Spišská baňa and Helcmanovce.

Some apophyses of the Gemeric granite are mineralized by tin-bearing greisens followed by subsequent weak uranium mineralization in veins located in the enclosing rocks around granite. Remarkable indices of kassiterite, wolframite, scheelite, molybdenite and gold have been stated by panning and mineralogical prospection even in the Veporic and Tatric units. The age of all these mineralizations represents a several years disputed problem. In fact, whe majority of ore deposits is situated in pre-Triassic rock sequences that led some authors (Ilavský) to the deduction that the deposits have Variscan ages, or, the metasomatic accumulations represent syngenetic ores (of subsequently Silurian, Devonian, Carboniferous, Permian or Triassic age according to the enclosing rock unit). However, it has been generally proved that these deposits are organically related to the Alpine structures and, in places, the mineralization extends even into the Mesozoic sequences and that mineralization processes are closely related to metamorphogenous migration processes of Alpine age.

Smaller deposits and occurrences of sedimentary manganese ores originated in postorogenic sequences of Paleogene age in several Central Carpathian basins (Kišovce—Švábovce, Michalová and others).

A strong subsequent volcanism appeared during the Neogene in the marginal zone of the folded Carpathian chain towards the Pannonian basin. The generation and ascent of several andesite and rhyolite phases was related to continuous upthrusting of the Carpathians over the North European Platform (or, to the subduction of the platform beneath the Carpathians) and to the generation of the internal Pannonian basin with attenuated crust due to a rising mantle diapir (Stegena et al., 1975; Lexa — Konečný, 1974 and others). The distribution of main centres of this neovolcanism in Slovakian territory is closely related to intersections of pronounced young radial fault belts in the West Carpathian basement. Along such faults, neovolcanites deeply penetrate into the central and, subordinately, even into the external West Carpathian zones. A very intense Neoalpine metallogenetic subepoch is related to this volcanic activity producing important deposits of precious and base metals as well as of copper ores together with smaller deposits of mercury, antimony ores and magnetite skarns with base-metals together with further types of mineralizations.

Some recent results of ore prospection

A. Tungsten ores

In the past, only occurrences of accessory tungsten minerals have been known in the West Carpathians. A more remarkable scheelite mineralization in veins or disseminated ores has been discovered by Kantor — Eliáš (1962) and Kantor (1965) near Jasenie village in the Low Tatra Mts. Further scheelite occurrences have been found by panning prospection also in other West Carpathian mountain ranges (Hvožďara, 1967; 1971 a. o.). Significantly anomalous scheelite content has been stated in panning samples along the southern slopes of the Low Tatra Mts. and, consequently, rich scheelite mineralization was found in fragments of vein quartz, rock debris and even in natural outcrops (Pulec, 1976—1978; Pulec et al., 1977). A zone 2 km long and about 400 to 1,000 m broad has been then outlined which appears as the prognostic area for scheelite-gold ore. The zone runs parellely to the southern margin of a Variscan granitoid massif in 500 to 1,000 m distance from the contact approaching in some places till the granite body. From lithological point of view, migmatite with amphibolite layers, amphibole and biotite paragneiss are present there and slices of metasediments and metavolcanites in green-schist facies are wedging in the former. Palynological data from the green-schist point to Upper Paleozoic age (Planderová, 1983).

Up to recently, drilling and prospection mining work discovered an about 3 km long part of the prospective zone at Jasenie — Kyslá locality. Three main ore-bearing structures are outlined running in the rough direction of single rock belts. Ore bodies could be subdivided morphologically into three types: 1— scheelite and gold-bearing quartz veins cutting mostly discordantly the preferred foliation of mother rock; 2 — lense-like and irregular bodies of disseminated to stockwork ore; 3 — irregular bodies with weak disseminated mineralization (Molák — Pecho, 1983).

The ore-bearing structures are more-or-less strongly milonitized and hydrothermally altered zones where single ore-bodies are discontinuous or arranged en echelon. The length of single bodies attains several tens of metres the thickness is 3—4 m in average and the mean tungsten content is 0.25—0.40 % (exceeding, in smaller parts, 3 to 4 times the average) whereas the gold content fluctuates in the 1—4 g/t range but, in some veins and stockworks, even several g/t. Generally, a negative correlation exists between the gold and tungsten contents. The hitherto proved vertical range of mineralization is about 500—600 m.

Scheelite is the main ore (containing but traces of molybdenium) associating, almost everywhere, with quartz and frequently with natural gold. Wolframite occurs in quartz veins only in places and in small chambers. Little amounts of sulphides (arsenopyrite, pyrite, chalcopyrite, accessory tetradymite and tellurobismuthite) are also known (Beňka — Suchý, 1983). Either veinlets of further mineral parageneses are known in the area of scheelite mineralization (e. g. siderite, ankerite with quartz, chalcopyrite, tetraedrite, further pyrite, arsenopyrite, galenite, sphalerite, antimonite berthierite and others) representing peculiar and wide-spread ore formations in the Low Tatra Mts.

According to the mode of occurrence and ore structures, this is a clearly epigenetic hydrothermal mineralization. Well stratified ores known e. g. from the Mittersill deposit in Austria have not been found here. Nevertheless, the tungsten mineralization is related to a belt with pronouncedly variegated lithology where amphibole-bearing rocks do occur and this is a general feature of tungsten mineralization even in further West Carpathian mountain ranges similarly as in the other parts of the Alpine-Mediterranean belt. These signs led several authors to the view that we deal even here with a syngenetic volcano-sedimentary ore mineralization reworked by subsequent metamorphic and hydrothermal processes. Others relate the mineralization with the neighbour Variscan granitoid pluton. However, the relation of the scheelite mineralization to Alpine structures appears clearly as proved even by mineralized Upper Paleozoic sequence wedging in as narrow slices together with Triassic rocks amidst the enclosing crystalline during the main Alpine orogenesis. The whole ore-bearing zone occurs in a structural antiform. Similar relations have been found by Slavkay (1971) also around near antimonite deposits distributed however along synform structures arranged according to the B — axes of folds. Belts of scheelite and antimonite ore bodies run almost in parallel direction in about 1 km mutual distance. Quartz-carbonate-barite veinlets carrying lead-zinc-silver ores occur in between and point to thermal zonality from the scheelite to antimony zone, but the decrease of thermality appears not only in direction from granite but even towards the body.

On the northern slopes of the Low Tatra Mts., the most important West Carpathian antimonite deposits are located right inside the granitoid plutonite body (Magurka and Dúbrava deposits). Hitherto, Alpine granitoids have safely not been proved in the area, nevertheless may be expected in the depth namely beneath the mineralized tungsten-gold ore zone. Such granites could be discovered only after the completion of further prospection work on the base of detailed mineralogy, geochemistry and isotopic studies.

B. Tin ores

Former views did not concile with tin mineralization in the Carpathians nor in the Alps. Although a weak greisenization of small granite bodies in the Gemeric unit (Hnilec and Betliar localities) has been known some 35—45 years ago and indices of kassiterite, topas and fluorite do occur there, only the modern geochemical prospection and continuous exploration proved that this leucocratic granite is prospective for tin (+ tungsten and molybdenium) ores (Baran et al., 1970; 1974).

The Hnilec ore district is built by the Gelnica and Rakovec Groups of Lower

Paleozoic age. The first unit consists of mainly silicic sericite-chlorite phyllite, porphyroids, graphite schists with phtanite layers and of a lesser amount of diabase volcanite. Similar quartz-sericite and chlorite phyllite creates the Rakovec Group with quartzite and abundant diabase volcanite. Near to the tectonic contact of both units, there are several small granite bodies imposing contact metamorphism onto the enclosing rocks with spotted slate and garnet, sillimanite, corundum and hornblende-bearing hornfels.

The granite is pronouncedly acidic and the tin content is as high as 30 to 70—200 p. p. m. in the rock, together with high concentrations of B, Rb, F, Li and higher radioactivity at low Th/U ratios. Two granite types have been discerned during the prospection, the first type of which creates small bodies elongated in E-W direction harmonically with the enclosing rocks and clearly foliated coincidently with the Alpine cleavage of surrounding rock units. The second granite type builds a relatively larger body of NE-SW elongated shape and the granite is equigranular and shows pronounced facial zonality passing from marginal fine-grained aplitic granite through medium grained muscovite and two-mica granite into biotite granite. Some salient small aplite dykes and apophyses penetrate the surrounding rocks. The data mentioned led Kusák (1976) to the conclusion that the first granite type is relatively older and generated before the development of Alpine cleveage whereas the second type intruded after this foliation. Older geochronological datings also substantiated an Upper Cretaceous age for the second (unfoliated) granite type. However, according to a more recent dating (Kovách et al., 1979; 1981), Grecula (1982) holds an opinion on the oldest age of tin-bearing granites in the Spiš-Gemer Ore Mts. (Middle Carboniferous to Upper Permian).

The tin mineralization in the Súľová granite body (2nd type) is bound to greisenized zones near to granite contacts and in small distances inside the body as well as to apophyses and veins in the exocontact zone. From the centre of the body towards the margins, the several-stage autometamorphism produced a central mineralized zone followed by zone of albitization with mineralized ore-bearing greisen layers (30—100 m), a zone of ore-bearing quartz-mica greisen (about 30 m) and a marginal quartz zone (up to 1 m). The average tin content in greisen bodies is low (up to 0.125 %) whereas in three explored vein bodies the tin content is as much as 1.2—2.6 %. Two mineralization stages have been distinguished: the first quartz-kassiterite stage with topas, tourmaline and arsenopyrite and the second quartz-sulphidic stage with pyrite, pyrrhotite, chalcopyrite, sphalerite, stannite and others. Local assemblages are that of topas-ferberite, quartz-molybdenite and tourmaline-apatite-chlorite with rich kassiterite content in veins and mantle rocks, however the thicknesses attain only 10—15 cm. Fluorite and hydrothermal quartz veins are the youngest products of mineralization.

The hitherto realized prospection work allowed to formulate criteria serving as base for further prospection of tin ores in other localities in the area of Hnilec granite as well as over other known and outcropping or buried apophyses of Gemeric granite. Indices of tin mineralization have been discovered by panning and geochemical reconnaissance and prospection even in the Veporic and Tatric units what opens new possibilities for prospection of tin (tungsten and molybdenium) ores in the West Carpathians.

C. Mineralization in the metallogenetic zone of Neogene volcanites

The volcano-tectonic development of Neogene volcanites (Badenian—Pannonian) in several stages took place in the central part of the West Carpathians. From genetic and structural points of view, the evolution of metallogenetic processes connected with the production of economic accumulations of polymetallic and precious metal-mineralization is there related to volcanic-intrusive formations being situated in the central zones of polygene stratovolcanos. In the Banská Štiavnica volcanic complex (Štohl, 1979) three metallogenetic stages are distinguishable connected with the first, third, and fifth stage of volcanism with post-volcanic hydrothermal processes or a contact-metasomatic activity of intrusive formation, respectively.

In the termination phase of the first stage of volcanism, subsidence of the central zone (Upper Badenian) takes there place resulting in a diorite — quartz diorite — granodiorite — aplite subvolcanic to hypabyssal intrusive complex formation connected with stockwork — impregnation mineralization of skarn and porphyry type. Up to the termination of the third stage of volcanism (Lower Sarmatian), quartz — diorite porphyry sills, dykes and veins are formed being connected from genetic and structural points of view with hydrothermal vein, hydrothermal metasomatic and stockwork — impregnation polymetalic ± Ag and Au mineralization as well (second metallogenetic stage). The latest precious metal mineralization of vein type is associated to rhyolite masses of the fifth volcanic stage (Upper Sarmatian — beginning of Pannonian) outlining the complex zoning of the subject central zone.

Intrusive complex mineralization in the Štiavnické vrchy Mts.

Fe-skarn mineralization. The origin of magnetite skarns with later Pb, Zn, Cu mineralization is recently (Štohl, 1976) believed to be connected with the activity of diorite magmatism. In the area of invasion of the diorite apophyse through variegated Upper Triassic formations, origination of Ca-Mg skarn facies with smaller magnetite bodies, haematite and muscovite took there place.

Polymetallic stockwork — impregnation mineralization of predominantly pyrite filling with low chalcopyrite content has been in Banská Štiavnica noticed at the contact of quartz diorite and of thin Triassic sediment mantle affected by contact metamorphysm. In Hodruša, two smaller ore bodies composed of Pb, Zn, Cu sulphines, quartz and calcite are proved in granodiorite their roof being formed by an unmineralized quartz-diorite porphyry dyke.

Porphyry copper, skarn ± Pb, Zn, Au, Ag mineralization. In the Zlatno Valley there is a small granodiorite porphyry intrusion of WNW-ESE strike (900×400 m) penetrating upwards the crystalline rocks (migmatites, granites), Middle Triassic (marly limestones, dolomites, evaporites), Permo—Carboniferous of the Choč Unit (greywacke and arcose sandstones, shales) and the products of the first stage of volcanism (amphibole—pyroxene andesite complex). In the intrusion mantle, skarnization into Ca-Mg skarn facies and endoskarnization of the intrusion margins with copper ore accumulation took place. The subject mineralization has four stages, as follows: skarn (pyroxenes, garnet-andradite, grossularite, forsterite, scapolite, vesuvianite, actinolite, tremolite), oxide (magnetite, haematite, muschketowite), sulphide (pyrrhotite, pyrite, chalcopyrite, bornite, chalcocite ± galena and sphalerite) and polymetallic-quartz-carbonate (galena, sphalerite, chalcopyrite ± Ag, Au, quartz, calcite and gypsum). The average grade in this zone is 0.35 % Cu, 0.6 % Pb + Zn, 4—6 g/t Ag and up to 0.1 g/t of Au.

The metallogenetic specialization of the subject intrusion is proved by lithogeochemical survey of borehole profiles and at the surface as well. In andesites the primary and secondary geochemical fields show 40 to 60 ppm Cu while in the porphyry body it does up to 700 ppm of Cu.

In the Javorie Mts. four mineralised zones are recognized in the diorite to monzodiorite intrusive body. Štohl (1979) distinguishes earlier hydrothermal processes connected with postmagmatic mechanism of the intrusion and some later ones related to solphatara activity.

Copper mineralization of stockwork type in the deeper-seated zones has been noticed in the Pukanec region being situated at the contacts of granodiorite porphyry to granodiorite intrusion with the underlying rocks. Polymetallic mineralization of stockwork — impregnation type in the higher — situated parts of the subject structure is present being localised in the middle of granodiorite and quartz-diorite porphyry intrusions.

The East Slovakian volcanism in Lower Miocene (Eggenburgian—Upper Badenian) time, was of acid and explosive nature exclusively its centres having been situated at the crossing of marginal zones of NE-SW strike with deep-seated faults of the Rába — Rožňava, Zemplin — Záhreb and the Darnó lines. The Intermediate volcanism development lasted there since Upper Badenian up to Middle Pannonian epoch and resulted in composite volcano-plutonic complex origination, from among which the Slánske vrchy Mts., the Vihorlatské vrchy Mts. and the buried Zemplin Volcanic Mountains should be first of all mentioned.

Four volcanic complexes are distinguishable in the Slánske vrchy Mts. (Slávik—Tözser, 1973; Tözser—Rudinec, 1975 and Kaličiak, 1977 with the Zlatá Baňa, Makovica, Strechov and Bogota central zones. Volcanic activity in five stages took there place. Areal propylitization, argillitization and in some places silicification taking place in the central volcanic zones is connected with the terminal phases of the first stage of intermediate volcanism, while the terminal phase of intrusive processes during the third stage is responsible for an important polymetallic formation of stockwork — impregnation, stockwork and breccia type as well as for an antimony formation (Zlatá Baňa) origination.

Opal formation in the transition and external zone of volcanic complexes is associated to the fourth stage of intermediate volcanism and postvolcanic processes of the fifth stage are considered to be in connection with the Hg, Sb, As ore formation of economic importance, the precious opal (the well-known Libanka and Šimonka deposits) as well as with the marcasite formation origination).

In the Vihorlatské vrchy Mts. four volcanoplutonic complexes (Morské oko, Porubský potok, Sokolský potok and Kyjov) with five central zones were recognized (Bacso, 1979; 1981) lying in the area of Zemplin — Záhreb discontinuity zone and having been developed in four stages (Upper Badenian—Lower Pannonian).

Within the termination phase of second stage of magmatism with fumarole and solphatara activity, secondary quartzites and crater breccias have been formed. The corundum-topas-andalusite metasomatite origination with the manifestations of poor Cu, Mo, Pb, Zn mineralization of stockwork — impregnation type is associated to hydrothermal activity by the end of the third stage. The cinnabar mineralization at the periphery is considered to be the result of post-volcanic activity following the fourth stage of volcanism.

From the above mentioned it follows that the central zones of the intermediate magmatism volcanoplutonic complexes are subjects to first-rate interest as the most prognostic ones, especially those where a wide intermediate magma differentiation trend is observable and where subvolcanic and intrusive facies are also present. The classification and delimitation of prognostic areas of porphyry copper ores in Eastern Slovakian neovolcanites was derived from the above mentioned fundamental date (S l a v k a y, 1982).

In such a way, the new results obtained by geological survey carried out prove the metallogenetic zone of Neogene volcanites to be promissing from raw material prospection point of view.

Translated I. Varga

REFERENCES

BACSO, Z., 1979: Neovulkanické formácie Vihorlatu a ich vzťah k tektonike a epigenetickej mineralizácii: Miner. slov. (Bratislava), 11, 1, pp. 21—53.

BACSO, Z., 1981: Perspektívy vyhľadávania nerastných surovín vo vulkanických štruktúrach Vihorlatu, Popriečneho a Zemplínskych vrchov. In: IV. Slov. geologická konferencia (Bratislava), pp. 217—219.

BARAN, J. — DRNZÍKOVÁ, L. — MANDÁKOVÁ, K., 1970: Sn-W zrudnenie viazané na hnilecké granity. Miner. slov. (Spišská Nová Ves), 2, 6, pp. 159—165.

BARAN, J. — DRNZÍKOVÁ, L. — DRNZÍK, E. — MANDÁKOVÁ, K., 1974: Tin and tungsten mineralization in the West Carpathians. Symposium MAWAM, (Prague), Vol. I.

BEŇKA, J. — SUCHÝ, J., 1983: Mineralogická charakteristika volframového zrudnenia v Kyslej pri Jasení. In: Scheelitovo-zlatonosné zrudnenie v Nízkych Tatrách. Geol. Úst. D. Štúra (Bratislava), pp. 71—84.

ČERNYŠEV, I. — CAMBEL, B. — KODĚRA, M., 1984: Lead isotopes in galenas of the West Carpathians. Geol. Zbor. Geol. Carpath. (Bratislava), 35, 3, pp. 307—328.

EGEĽ, L.,, et al., 1978: Rudnyje formaciji Karpato-Balkanskoj oblasti. Nedra, Moskva, 239 pp.

GRECULA, P., 1982: Gemericum — segment of the Paleotethyan riftogenous basin. Miner. slov. (Bratislava), p. 263.

HÖLL, R. — MAUCHER, A., 1976: The strata-bound ore deposits in the Eastern Alps. In: Handbook of strata-bound and stratiform ore deposits (Edit. K. H. Wolf), 5, pp. 1—36.

HVOŽĎARA, P., 1967: Zlato-scheelitová mineralizácia v strednej časti Veporíd. Geol. Práce, Spr. (Bratislava), 41, pp. 167—172.

HVOŽĎARA, P., 1971: Indície vysokotermálnych, Au-W-mineralizácií v tatroveporidách. Miner. slov. (Spišská Nová Ves), 3, 11, pp. 255—260.

ILAVSKÝ, J., 1968: Zur Metallogenetischen Karte der Westkarpaten 1:1 000 000. Geol. Práce, Spr. (Bratislava), 44—45, pp. 51—72.

ILAVSKÝ, J. — ČILLÍK, I., 1959: Náčrt metalogenézy Západných Karpát. Geol. Práce (Bratislava), 55, pp. 109—113.

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

ILAVSKÝ, J. — SATTRAN, V., 1980: Explanations to metallogenic map of Czechoslovakia 1:500 000. Geol. Úst. D. Štúra, Bratislava, 144 pp.
KALIČIAK, M., 1977: Metalogenetické pomery zlatobanského vulkanického aparátu v severnej časti Slanských vrchov. Kandidátska dizertačná práca, Geofond, Bratislava, 114 pp.
KANTOR, J. — ELIÁŠ, K., 1962: O niektorých nových výskytoch scheelitu na západokarpatských ložiskách (Hodruša, Banská Štiavnica, Jasenie, Smolnícka Píla, Tinesgrund). Manuskript, archív GÚDŠ, Bratislava.
KANTOR, J., 1965: Tungsten in the West Carpathian, metallogenetic province. Geol. Práce, Spr. (Bratislava), 36, pp. 199—217.
KOVÁCH, A. — SVINGOR, E. — GRECULA, P., 1979: Nové údaje o gemeridných granitoch. Miner. slov. (Bratislava), 11, 2, pp. 71—77.
KOVÁCH, A. — SVINGOR, E. — GRECULA, P., 1981: Isotopic age relationships of the granitoid rocks in the Spiš—Gemer metalliferous Mont., Eastern Slovakia. Mater. XII. Cong. CBGA (Abstract), Bucurest, pp. 8—13.
KRÄUTNER, H. G., 1970: Die hercynische Geosynklinalerzbildung in den rumänischen Karpaten und ihre Beziehung zu der hercynischen Metallogenese Mitteleuropas. Mineralium Depos. (Berlin), 5, 4, pp. 323—344.
LAZARENKO, E. K. — LAZARENKO, E. A. — MALYGINA, O. A., 1973: Metallogenija Karpat. Materialy Komissiji mineralogiji i geochimiji. Kijev, 2, pp. 5—98.
LEXA, J. — KONEČNÝ, V., 1974: The Carpathian volcanic arc: a discusion. Acta geol. Acad. Sci. hung. (Budapest), 18, pp. 279—293.
MAUCHER, A. — HÖLL, R., 1968: Die Bedeutung geochemischstratigraphischer Bezugshorizonte für die Altersstellung der Antimonitlagerstätte von Schlaining im Burgenland, Österreich. Mineralium Depos. (Berlin), 3, pp. 272—285.
MOLÁK, B. — PECHO, J., 1983: Geologicko-ložisková charakteristika scheelitovo-zlatonosného zrudnenia v oblasti Jasenia. In: Scheelitovo-zlatonosné zrudnenie v Nízkych Tatrách. Geol. Úst. D. Štúra (Bratislava), pp. 61—70.
PETRASCHECK, W. E., 1963: Die alpin-mediterrane Metallogenese. Geol. Rdsch. (Stuttgart), 53, pp. 376—389.
PETRASCHECK, W. E., 1977: Alpine metallogenesis and plate tectonics-still a problematic correlation. Problems of Ore Deposits. IV IAGOD Symp., Varna 1974, Sofia, pp. 504—508.
PLANDEROVÁ, E., 1983: Biostratigrafia slabometamorfovaných sedimentov v oblasti Jasenia. In: Scheelitovo-zlatonosné zrudnenie v Nízkych Tatrách, Geol. Úst. D. Štúra (Bratislava), pp. 55—56.
PULEC, M., 1976: Šlichovanie na liste Mýto pod Ďumbierom. Manuskript, archív GÚDŠ (Bratislava).
PULEC, M. et al., 1977: Perspektívne scheelitové zrudnenie v západnej časti Nízkych Tatier. Manuskript, GÚDŠ Bratislava.
PULEC, M., 1978: Perspektívne volfrámové zrudnenie v Nízkych Tatrách. Geol. Průzk. (Praha), 20, 6, pp. 175—177.
ROZLOŽNÍK, L., 1979: Alpine metallogenesis in the West Carpathians and global tectonics. Czechoslovak geology and global tectonics. VEDA, vydav. SAV, Bratislava, pp. 235—244.
ROZLOŽNÍK, L. — SLAVKAY, M., 1980: On the problems of metallogenesis of the West Carpathians. Vážnejšie problémy geologického vývoja a stavby ČSSR. ČS — VTS/GÚDŠ, Bratislava, I. A, pp. 125—146.
SLÁVIK, J. — TÖZSER, J., 1973: Geological structure of the Prešovské pohorie Mts. and its relation the boundary of the West and East Carpathians. Geol. Zbor. Geol. Carpath. (Bratislava), 24, pp. 23—52.
SLAVKAY, M., 1971: Some antimony deposits in the Low Tatras Mts. Related to geological structures. Miner. slov. (Spišská Nová Ves), III/9, pp. 5—22.
SLAVKAY, M., 1971: Ložiská polymetalických rúd pri Ponikách. Miner. slov. (Bratislava), 3, 11, pp. 181—214.
SLAVKAY, M., 1982: Prognostic areas of porphyry copper ores in volcanites of Neogene age in Eastern Slovakia. Miner. slov. (Bratislava), 14, 3, pp. 195—207.
STEGENA, L. — GÉCZY, B. — HORVÁTH, F., 1975: Late Cenozoic evolution on the Pannonian Basin. Tectonophysics (Amsterdam), 26, pp. 71—90.

ŠTOHL, J., 1976: Zrudnenie stredoslovenských neovulkanitov spojené s centrálnokarpatským lineamentom. Záp. Karpaty, Sér. Mineral. Petrogr. Geochém. Lož. (Bratislava), 2, pp. 7—40.
ŠTOHL, J., 1979: Metalogenetická mapa stredoslovenských neovulkanitov v mierke 1:1 000 000. Manuskript, GÚDŠ, Bratislava.
TÖZSER, J. — RUDINEC, R., 1975: Geologická stavba a nerastné suroviny neogénu východného Slovenska a jeho podložia. Miner. slov. (Bratislava), 7, pp. 81—104.
VARČEK, C., 1963: Die Beziehungen der lagerstättenbildenden Prozesse in den Westkarpaten zu ihrer geologischen Entwicklung. Acta geol. geogr. Univ. Comen., Geol. (Bratislava), 8, pp. 7—37.
VARČEK, C., 1967: Überblick der Metallogenese der Westkarpaten. Geol. Zborn. Geol. Carpath. (Bratislava), 13, 1, pp. 3—9.
VARČEK, C., 1973: A brief survey of the metallogeny of the West Carpathians. In: Deposits of mineral raw materials of the West Carpathians. X Congr. CBGA, Bratislava, pp. 5—13.
ТВАЛЧРЕЛИДЗЕ, Г. А., 1980: Металлогеническое районирование Центрального Средиземноморья пояса. Наука, Москва, pp. 88—98.

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