GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA, 31, 4, BRATISLAVA DECEMBER 1980, PP. 421—439

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CLASSIFICATION OF THE MINERALIZED STRUCTURES IN THE SPIŠSKO-GEMERSKÉ RUDOHORIE MOUNTAINS

(Figs. 1—7)

Abstract: In the work a classification of mineralized structures in the complicated polycyclic metallogenetic region of the Spišsko-gemerské rudohorie Mts. is presented. It was set out:

1. from relation of mineralized structures to the inner structure of surrounding rocks,
2. from the morphogenetic character of the proper ore bodies and tectogenesis of mineralized structures,
3. from relation of the ore bodies to the petrographic character of surrounding rocks.

The classification shows that the mineralized structures of the Spišsko-gemerské rudohorie Mts. are characterized by uncommon diversity of forms, equivalent to the complicated and multiphase pre-ore tectonic development of the region with complicated inherited anisotropy. When also a considerable part of the ore bodies is of the character of „cleavage-microjoint structures" according to V. N. Krejter (1956) or is connected with „schistosity" zones according to V. J. Smirnov (1965), there is not a common case of mineralized schistose mountains. Mineralization does not seek for only „favourable rocks" and mainly interfoliation spaces made accessible to ore mineralization by folding, but especially for dislocations, conformable and uncoformable with the course of one or another foliation. They are dislocations, which, similarly as in the case of the interfoliation bodies, were made accessible to mineralization by particular transversal folding. In most cases the mineralized structures of the Spišsko-gemerské rudohorie Mts. represent combined structures, i. e. foliation-folded, faulted-folded etc.

Резюме: В работе представлена классификация минерализованных структур в сложной полициклической металлогенетической области Спишско-гемерского рудогория. При классификации мы исходили из:

1. отношения минерализованных структур к внутренней стройке окружающих пород;
2. морфогенетического характера собственных рудных тел и тектогенеза минерализованных структур;
3. отношения рудных тел к петрографическому характеру окружающих пород.

Классификация показывает, что минерализованные структуры Спишско-гемерского рудогория отличаются черезвычайной разновидностью форм, соответственной сложному многофазовому дорудному тектоническому развитию территории, получившей в наследство сложную анизотропию. И в том случае, когда у значительной части рудных тел характер „кливажевых — микротрещиноватых структур" по В. М. Крейтеру (1956) или он связан с зонами „сланцеватости" по В. И. Смирнову (1955), речь здесь идет о обыкновенном случае минерализованных сланцевых гор. Минерализация не разыскивает только „подходящих пород" и, особенно, расслаиваний, сделанных доступными для рудной минерализации складкообразованием, но, главным образом, дислокации, согласные и несогласные с течением одного или другого расслоения. Речь идет о дислокациях, которые аналогичным образом, как это бывает у тел расслоений, были сделаны доступными для минерализации особым поперечным складкообразовением. В большинстве случаев минерализо-

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ванные структуры Спишско-гемерского рудогория представляют собой комбинированные, т. е. расслоенно-складчатые, сбросово-складчатые структуры.

Academician Michal M a h e ľ in the frame of his many-years scientific-research work devoted to knowledge of geology of the West Carpathians did not omit such an important field of geology as metallogenesis. He devoted tens of works to our most important ore region the Spišsko-gemerské rudohorie Mts., contributing to knowledge of its stratigraphy and tectonics. These works helped very much to clear up geologcal position of mineral raw material deposits and total metallogenetic development. Delimitation of two particular tectonic styles in the Spišsko-gemerské rudohorie Mts. (M. M a h e ľ, 1957) has given an answer to the question why mainly Paleozoic elements are the bearer of the Alpjine siderite formation and why ore mineralization is practically missing in the Mesozoic and also stimulated to a more detailed study of the character of these styles from the standpoint of favourableness for ore mineralization (L. R o z l o ž n í k, 1963). Academician M a h e ľ stimulated investigations focused on the role of faults in formation of the West Carpathians. The tectonic conference in the year 1967 in Tatranská Lomnica organized under his management opened an important stage of the study of mineralized structures in the Spišsko-gemerské rudohorie Mts., where he himself (M. M a h e ľ, 1966, 1969) laid the foundation for classification of faults.

The attempt of classification of mineralized structures in the Spišsko-gemerské rudohorie Mts., mentioned next, so is connected with stimulations from the works of Academician M. M a h e ľ.

Principles of classification

The Spišsko-gemerské rudohorie Mts. is a polycyclic metallogenetic region, in which Hercynian as well as several Alpine metallogenetic stages were evident, among them also the Mesoalpine (in the sense of M. M a h e ľ, 1974), according to all facts Upper Cretaceous, giving rise to endogenic, hydrothermal ore mineralization with cassiterite-wolframite, magnesite, siderite-barite, quartz-sulphide and quartz-antimonite associations. We use to designate these Mesoalpine associations under the common name „siderite formation". The presented classification is prevailingly dealing with the structures of this formation dominating in the Spišsko-gemerské rudohorie Mts. The ore mineralization is predominantly located in the complicated deformed Paleozoic complex with deep tectonic style, formed, by Early Paleozoic groups: the Gelnica and Rakovec group as well as by the Carboniferous and Permian. The complex is of the character of structures of schistose mountains. The siderite formation forms bodies of high morphogenetic variability. Diversity of the mineralized structures is adequate to complexity of tectonic development of the Spišsko-gemerské rudohorie Mts.

The below mentioned classification of mineralized structures concerns structural-metallogenetic units of lowest order, i.e. individual ore bodies.

In typization of the mineralized structures is taken into account:

F i r s t, relation of the mineralized structure to the inner structure of surrounding rocks. Clearing up to this relation permits to consider many important sides of the position of ore bodies, especially as to timing of ore mineralization in connection with tectonic development and also helps to reveal favourable structural factors of ore location.

Second, the morphological character and tectogenesis of mineralized structure are concerned. Knowledge of morphogenesis of mineralized structu-

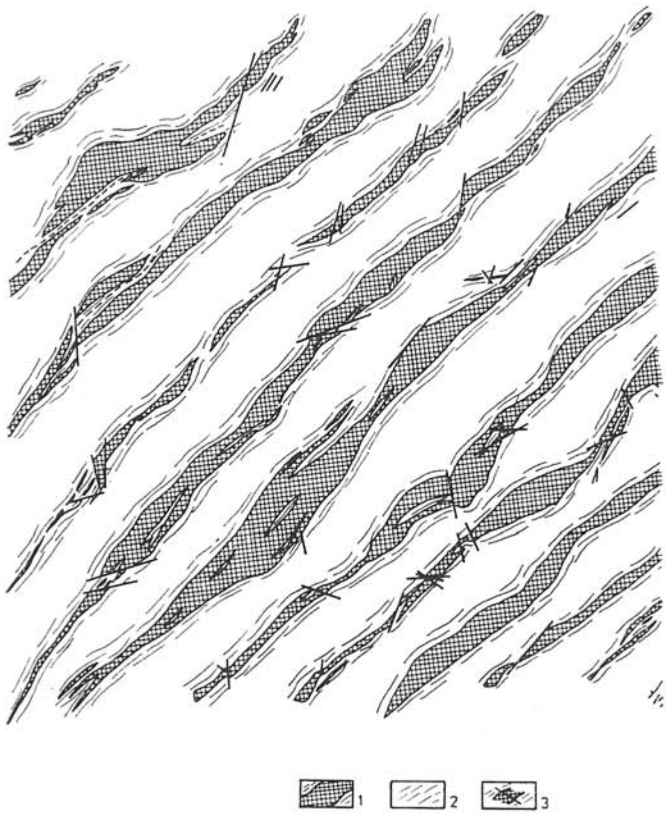

Fig. 1. Example of intercleavage siderite veins. Sadlovská vein, Rožňava. Profiles XII—XXI, Fig. 2. *Explanations:* 1 — Ore vein, 2 — porphyroid, 3 — faults. Compiled by: V. Čekalová—L. Rozložník.

res helps to distinguish those structures, which in the frame of the variegated palette of various types of rock complex deformations of the Spišško-gemerské rudohorie Mts. are most often the bearers of ore mineralization.

Third, the analysis of morphological development of ore bodies and of frequency of their occurrence in dependence on the petrographic character of surrounding rocks — thus an analysis of the influence of the surrounding environment is concerned.

The up to present results of metallogenetic investigations in the Spišško-gemerské rudohorie Mts. show that the deposits in this region belong to most diverse genetic types, originated in various periods. Knowledge of genesis and age of the deposit origin is the first-rate precondition of possibility of structural-metallogenetic classification of deposits. In the Spišsko-gemerské rudohorie Mts. some deposits have so far not quite unambiguously cleared up genesis. It concerns mainly deposits of Fe and Cu—Mo—U ores in the Permo-Triassic. As to the position of age, often closer delimitation is missing. For example, according to existing data the origin of siderite formation deposits may be ranged to the period Upper Cretaceous-Paleocene, however, for more detailed determination of age sufficient reliable data are missing, equally as to their relation of age to Gemeride granite. There is a dispute also about the content and succession of individual supply periods of the siderite formation. Moreover, the Spišsko-gemerské rudohorie Mts. are a region with a variegated palette of diverse structures formed from complicated several-orogenic development with numerous partial stages. So the mineralization processes of the siderite formation, which are the main subject of this work, meet already a very complicated anisotropic structure.

Setting out from above mentioned we try to divide the deposits of the Spišsko-gemerské rudohorie Mts. according to the following criterii:

A. According to relation of ore bodies to the inner structure of surrounding rocks characterized by regionally spread types of foliation and lineation defined already before by L. Rozložník (1963, 1965).

The position of ore bodies compared with foliation can be:

1. conformable with s_1 (but unconformable with s_2),
2. conformable with s_1 as well as s_2,
3. conformable with s_2 (but incorformable with s_1),
4. unconformable with s_1 as well as s_2.

Regarding to lineation the position of ore bodies can be:

— conformable with the course of longitudinal lineal elements (L_1 and L_2 = B),
— diagonal with regard to course of longitudinal lineation,
— symmetrological regarding to transversal lineation (L_1 and L_2 = B),
— position without symmetrological relation to transversal lineation.

B. According to the morphogenetic character the following ore bodies may be distanguished:

a) Syngenetic:
1. Intraformation ore bodies

b) Epigenetic, bound to:
1. Horizons of „favourable" rocks
2. Tectonic disjunctives:
   — upthrusts
   — strike-slip faults
   — normal faults
   — clefts
3. Tectonic joint zones and fields
4. Contraction joints in intrusive rocks

c) According to relation to the petrographic charakter of the environment the ore bodies:

1. intersect rock bodies of various composition,
2. occur at the boundaries of lithologically-mechanically distinctly different complexes,
3. occur in carbonates,
4. in psephites (or metapsephites),
5. in psammites (or metapsammites),
6. in pelites (or phyllites),
7. in quartzites (or quartz phyllites),
8. in porphyroids (or quartz porphyries, mylonitized gneisses, amphibolites etc.)

A. Structural types with regard to relation of ore bodies to the structure of surrounding rocks

Ore bodies conformable with s_1 surfaces (stratiform bodies).

With regard to planes of bedding or bedding schistosity conformable — interbedded ore deposits in the Spišsko-gemerské rudohorie Mts. may be divided into three genetically different groups:

The first group includes sedimentary or sedimentary exhalation — sedimentary — exhalation — metamorphosed syngenetic deposits: for instance, the occurrences of magnetite bound to basites of the Gelnica group (Trochanka type), manganese ores (Čučma type), pyrite deposits (Smolník type), or in the Rakovec group occurrences of Lahn — Dill type haematite (Štumfeberg and others), deposits of haematite ores in the Permotriassic (Licince, Šankovce, Lúčka — Bôrka, Folkmár a.o.) or of so called copper sandstones, also in the Permotriassic (Novoveská Huta). Except for many unclear points of their genesis, structural relation to surrounding rocks is in all cases unambiguously conformable to stratification.

The second group includes epigenetic deposits of hydro-metasomatic origin bound to „favourable rocks" — mostly carbonate rocks, of the Gelnica group (Nižná Slaná type), Rakovec group (Georgi — Dobšiná type), Carboniferous (Zuzana type Mlynky at siderite deposits and Miková type — Jelšava at magnetite deposits). Also at this group, if we do not take into regard postmetallogenetic tectonics, conformability of the position of ore bodies compared with the primary structure of surrounding rocks is without doubt. In this case there are, however, also different opinions of the genesis.

The third group includes hydrothermal ore veins of the siderite formation, apparently of epigenetic origin.

The interbedded — bedded veins are not a result of mere opening of bedding joints. Opening proper was preceded by interjacent crushing connected with dislocation movement. It is not a rare case that for formation of interbed dislocation the boundary of bedding of two lithologically-mechanically distinctly different environments was used, e.g. of phyllites and quartzites of the Gelnica group.

The areal extension of interbedded veins shows that foundation of their structure was only exceptional, in places where the s_1 — surfaces were of suitable orientation to the principal strain axes during north-southern and east-western compression, where s_1 — surfaces represented against the compressing strain the surfaces of best passability, along which gliding movements could have taken place. So it is in general at the classical locality of interbedded veins in the area of Jedlovec described by P. G r e c u l a (1963) and elsewhere. In all cases s_1 surfaces are inclined to the south. An exception from this rule are some Co—Ni veins in Dobšiná and similar veins at Zlatník, following s_1-surfaces inclined to north.

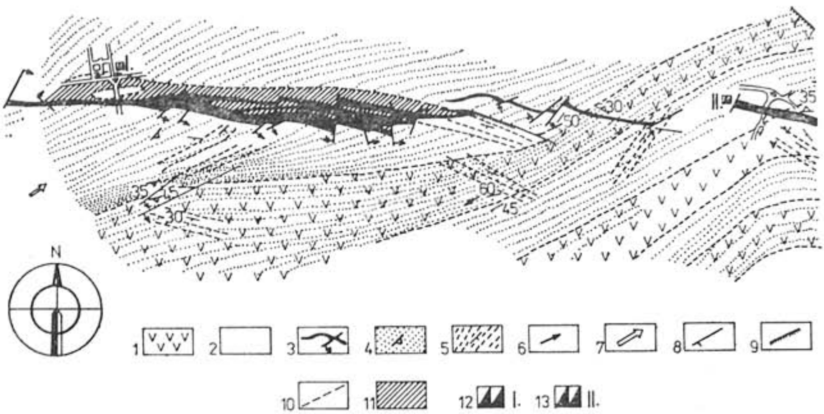

Fig. 2. Example of ore vein crossing s_1 as well as s_2 surfaces. Droždiak vein-Rudňany. Compiled by: S. Konečný (1974).

Explanations: 1 — diabases, diabase tuffs and tuffites, 2 — graphitic phyllites (Upper Carboniferous), 3 — vein structure, 4 — bedded schistosity, 5 — transversal schistosity, 6 — lineation, 7 — β-axes, 8 — faults, 9 — faults with tectonic clay, 10 — boundaries between rocks, 11 — hydrothermally altered rocks, 12 — 5 RP shaft, 13 — Jozef shaft.

Interbed veins form two subgroups: conformable with s_1, but uncorformable with s_2 and so conformable with s_1 as well as s_2 surfaces.

Ore bodies conformable with the course of s_2-surface and unconformable with s_1-surfaces (Rožňava type).

They are the so called intercleavage veins (M. M á š k a, 1956), distinguished as „intrafoliation“ veins, which equally as at interbed veins do not represent simple interfoliation opened and filled up spaces, formed only with detachment — opening of foliation planes but mostly dislocations, using the inherited anisotropy of rock complexes. A classical example of intercleavage veins are the Rožňava veins, following in strike and dip the s_2-surfaces of porphyroids with complicated bending. Even the system of Rožňava veins as a whole, according to J. S l a v k o v s k ý (1979), imitates the fan style of transversal schistosity of porphyroids.

The intercleavage veins so belong among mostly spread structural types of ore veins of the Spišsko-gemerské rudohorie Mts. They are especially abundant in the Gelnica group. In direction to younger formations, with fading out transversal schistosity, also the number of these intercleavage veins is rarer.

Ore bodies intersecting bedding schistosity as well as transversal schistosity (Rudňany type)

This abundant group, also rich in forms, includes ore bodies located in disjunctives, transgressively penetrating structural anisotropy — s_1 and s_2-surfaces of rock complexes. Thus they are dykes.

An illustrative representative of this group are the Rudňany veins, penetrating across bedding and transversal schistosity even of three formations: the Rakovec group, Carboniferous and Permian.

In morphology and tectogenesis this type is very diverse. Besides bodies bound to upthrusts (e.g. the Gelnica vein) or to particular clefts (e.g. the Rudňany veins), also the majority of bodies located in tectonic joint zones (e.g. Zlatá Idka veins) belong to it.

Although we encounter the mentioned type in many areas in the whole Spišsko-gemerské rudohorie Mts. region, nevertheless it is possible to delimit two areas of its most important occurrence: the northern part of the Spišsko-gemerské rudohorie Mts. in the areas between Bindt and Gelnica and in the middle part veins of the so called antimonite strip from Čučman to Zlatá Idka.

Position of ore bodies to lineation of surrounding rocks

Symmetrological linking of individual ore bodies with the course of longitudinal structural directions of the Spišsko-gemerské rudohorie Mts. (=B axes nearly of E—W/direction) is very close. All bodies conformable with primary foliation of rock complexes display also geometric conformability with the course of L_1 lineation and fold axes of higher order (B-axes), as their pre-metallic structures were deformed parrellely with s_1 surfaces.

As to intercleavage ore veins, these display close relation to L_2 lineation of s_2-surfaces, which is usually stressed by s_1/s_2 intersection lines. In the majority of cases, in the Spišsko-gemerské rudohorie region L_2 is identical with L_1 in strike and so also with the course of rock strips; consequently the known prenomenon is given that the ore veins of this region usually follow the principal longitudinal structural directions. Even several authors, (P. Reichwalder, 1971 and P. Grecula, 1959) call attention that also many dykes penetrating s_1 as well as s_2 surfaces are of equal strike as the course of rock strips with longitudinal structural directions. Some dykes, however, in the area of Rudňany, Slovinky — Gelnica, ale according to V. Konečný (1971) diagonal to longitudinal structural directions.

Relation of ore bodies to transversal structural directions, roughly of north-southern course, i.e. to lineation L'_1 and L'_2 ($\doteq$—B') is given by symmetrology of their mutual spatial distribution, which is nearly perpendicular to each other. The regularity appears: where transversal bending of convex or concave character of longitudinal structures occurs, there is also more intense development of mineralization. Many veins are of arch-, crescent-or s-shape in horizontal section (e.g. veins of Rožňava, Mlynky, Lucia Baňa a.o.).

Closing with classification of ore bodies according to their relation to the structure of surrounding rocks it is necessary to remark that „pure types", interbed, intercleavage veins or dykes are rather an exception than a rule.

In many dykes it can be observed that while the principal vein is really a dyke, its offset veins are of interfoliation position or vice versa: the main body is of interfoliation character but its offsets are dyke bodies, intersecting foliation systems. Such cases were described from Dobšiná (L. Rozložník, 1963), Rudňany (S. Konečný, 1969) a.o.

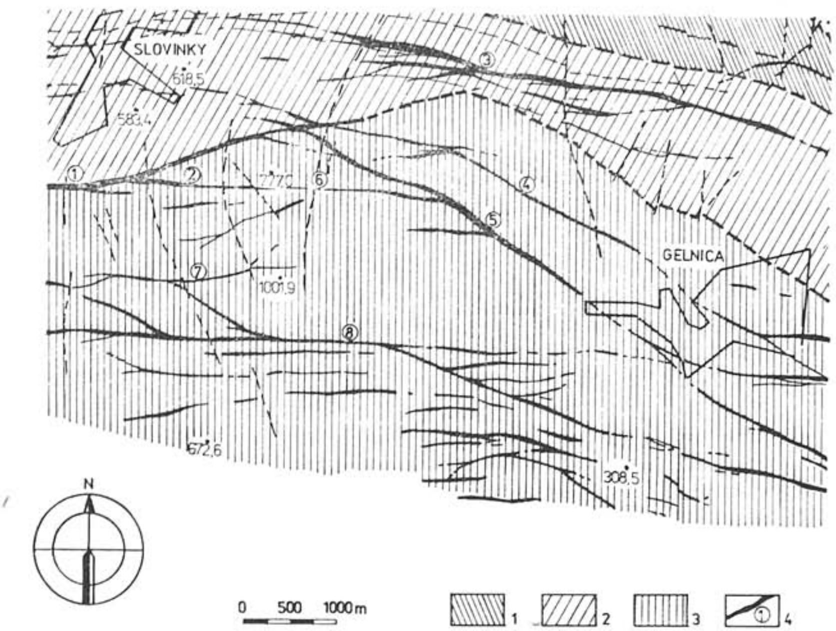

Fig. 3. Example of foundation of mineralized structures in highly anisotropic environment. Geological-deposit map of a part of the Slovinky—Gelnica ore district. Compiled by: J. Hudáček, 1970.

Explanations: 1 — Carboniferous. 2 — Rakovec group. 3 — Gelnica group. 4 — vein structures (1 — Slovinky thick stockwork, 2 — N vein, 3 — Klippberg—Žakarovce stockwork, 4 — Cross vein, 5 — Gelnica vein, 6 — Gelnica overlying vein, 7 — Black vein, Golden vein).

As most important conclusions resulting from the classification of mineralized structures in relation to the structure of surrounding rocks may be mentioned:

First: ore bodies of the siderite formation of the Spišsko-gemerské rudohorie Mts. show various relations to structoural elements of surrounding rocks: they are partly interbedded, partly interfoliation, partly dykes, intersecting foliation systems. Nevertheless, as to quality, they display closest relation (proved also statistically in more than 45 % of ore veins) to transversal schistosity planes (— s_2 planes), fully confirming the thesis expressed by L. Rozložník (1959) about closest symmetrological relation of ore mineralization to transversal schistosity.

Second: The great portion (40 % of all ore veins) ore dykes with typical siderite mineralization unambiguously testifies to ore mineralization, which must have taken place after the origin of s_1 as well as s_2 surfaces, again fully confirming the theses expressed by M. Máška (1957) and L. Rozložník (1959) that ore mineralization is polymetamorphic and originated after rise of s_2 surfaces.

Third, distinct, direct or symmetrological relation of ore bodies to linear elements unambiguously confirms and underlines the importance of folding, as ore-location factor in the Spišsko-gemerské rudohorie Mts.

B. Structural types with regard to morphogenetic properties of ore bodies

a) Syngenetic ore bodies

Stratiform ore bodies, formerly distinguished as the first group of bodies conformable with the course of s_1-surfaces-interbed bodies, have a bedded streaky form, mostly tending to already primary lenticular development. According to J. Ilavský (1974, 1978), who studied the mentioned deposits universally, morphological modelling of these deposits was mainly conditioned by stratigraphic-volcanogenic and paleogeographical conditions or intrastratification unrest (paleocurrent phenomena, e.g. at the Smolník deposit, intrastratification breccias at the deposit Šankovce a.o.). The inner structure, structural and textural particularities of these deposits display marks of primary conditions of their origin: banded — planar parallel structure, grading of grain size a.o. Their present-day shape and position were, however, largely completed by tectonic deformations and metamorphism, taking place after their origin. On the whole, from this position also the view of E. Drnzík (1971) on occurrences of „copper sandstones" and haematite deposits of the Permotriassic in the northern part of the Spišsko-gemerské rudohorie Mts. sets out.

b) Epigenetic ore bodies

1. Ore bodies bound to horizons of „favourable rocks".

This group includes bodies of magnesite-dolomite or talc and/or siderite-ankerite. We consider them as bodies originated in hydro-metasomatic way.

At metasomatic deposits of the Spišsko-gemerské rudohorie Mts., magnesite-dolomite as well as siderite-ankerite deposits the following common features may be observed on the whole:

- the ore bodies may be designated as stratiform on the whole, as they are mostly conformable with the course of original bedding,
- they display irregular lenticular development, often stressed by post-metallogenic deformations (the lenticles have usually a core of siderite and dolomite or ankerite fringe — cover),
- the presence of superposed vein forms with filling at magnesite deposits: mainly magnesite, dolomite and quartz with sulphides, at siderite deposits: siderite, ankerite and quartz with various sulphides,
- metasomatic bodies of magnesite-dolomite as well as siderite-ankerite are not bound to carbonates only of some formations but are also found in the Gelnica and Rakovec groups, Carboniferous and in Hungary siderite-ankerite deposits also in the Triassic.

There are two essentially antagonistic opinions of morphogenesis of stratiform magnetite or siderite bodies: of B. Zorkovský (1955), J. Ilavský (1978) about their syngenetic origin and the opinion of others about their epigenetic origin (M. Kužvart, 1954; V. Hanuš, 1959; L. Rozložník, 1965; A. Abonyi, 1971 a.o.).

In our opinion, the arguments about the syngenetic origin of stratiform magnesite and siderite deposits are not convincing, do not disprove the opinions of their epigenetic position and hydrothermal origin. As defined by V. Hanuš (1959) and L. Rozložník (1965), as the main factor taking part in formation of metasomatic deposits may be considered the presence of carbonate bodies, made accessible for polyascendent hydrothearmal solutions by tectonic elements.

2. Ore bodies bound to tectonic disjunctives (faults).

The prevailing majority of ore bodies in the Spišsko-gemerské rudohorie Mts. is bound to disjunctives of tectonic origin. They are so called vein forms of the siderite formation. According to relation to surrounding rocks, from the above mentioned classification of ore bodies results that there are prevailingly disjunctives, utilizing the inherited anisotropy of rock complexes of the Spišsko-gemerské rudohorie Mts. — complicatedly bent s_1 and mainly s_2 surfaces. This is the case mainly in complexes of the Gemeride Early Paleozoic where dykes are rather rare than common. Shaping of older anisotropy by ore-bearing disjunctives is one of the particularities of the Spišsko-gemerské rudohorie Mts. also resulting in uncommon shapes of vein bodies: frequent s-forms in strike as well as dip.

The morphogenetic classification of mineralized disjunctives in the Spišsko-gemerské rudohorie Mts. is mainly rendered difficult by:

— polygenetic development of the majority of mineralized dislocations,
— the unequal age of their foundation,
— heterogeneity of environment, which significantly influences their morphogenetic properties and in some complexes also
— lacking stratigraphic criterii for judging the tectogenetic character of mineralized dislocation.

When in spite of the mentioned facts we strive for a morphogenetic classification of mineralized structures of tectonic origin in the Spišsko-gemerské rudohorie Mts., then as comprehensible, it is possible to realize provided that we shall take into regard their main morphogenetic features only.

Upthrusts

The prevailing majority of ore veins in the Spišsko-gemerské rudohorie Mts. is derived from upthrusts and so as to quality these appear as the most important structural-metallogenetic element of the siderite formation.

According to up to present knowledge an ore vein, obviously founded on an upthrust with great amplitude of displacement, is the Filip vein of Mlynky, located on the upthrust plane of the Carboniferous over the Permian. Of similar position are also some vein bodies running parallely with it, following the big overthrust of the Rakovec group on the Carboniferous and many other veins in closer and wider neighbourhood of Dobšiná (L. Rozložník, 1959). As concincing may be considered ranging of many (not all) ore veins to upthrusts in the Roztok, Bindt and Gretl ore field by J. Pecho (1969). A structural upthrust position is also ascribed to the Slovinky stockwork and many veins occuring in the swarm between Gelnica and Košice (Košické Hámre, Košická Belá), indicating that very probably an upthrust position of most veins should be considered also in this section.

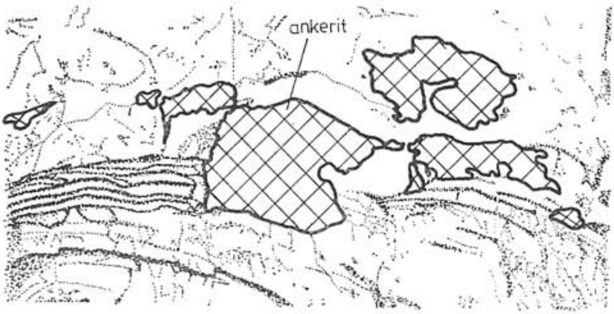

Fig. 4. Contrasting structure of bodies of metasomatic ankerite in fine-laminated limestones of the Gelnica group. Ochtiná aragonite cave—Marble room.

Whereas stratigraphic-lithological variety of three to four formations in the mentioned northern strip of the Spišsko-gemerské rudohorie Mts. provides reliable criterii for judging tectogenetic competence of the individual ore veins, so in the area formed by the Gelnica group are less such criterii and only on well examined veins substantiated conclusions on their morphogenesis may be accepted. To such ones may be ranged the area of Jedlovec, considered by P. Grecula (1969) as a system of fold thrusts. P. Reichwalder (1970) characterizes the area of Jedlovec as a zone of pressure faults, bound symmetrologically and obviously also genetically to a fan of s_2 surfaces. Nevertheless, on the flanks of the fan these pressure faults assume the role of distinct upthrusts (e.g. the south-vergent western flank of the Lucia Baňa system).

Strike — slip faults

The structural plans of partial sections of some ore districts indicate that their foundation is of polygenetic character, with strike — slip movements taking up an important place in their development. Strike-slip-gliding movements played an important part during pre-metallic tectonic preparation in connection with the so called transversal folding. The plans of some vein systems, e.g. at the Terezia veins of Dobšiná (L. Rozložník, 1965) or at linked offsets of the Gelnica Zlatá žila (Golden vein) Zelená — Green and Čierna žila — Black vein, also veins of Boží dar equally as at the stockwork of Čierna Hora, testify to older compression movements in N—S direction, which induced positive vertical displacements (upthrusts), replaced by compression nearly in E—W direction with horizontal gliding movements, mostly reduced to older planes of weakend cohesion, at the same time, however, partly induced also the origin of new, formerly not existing discontinuities in the shape of pinnate shear joints of tension joints.

In general, it may be concluded that movements of strike-slip character were mostly reduced along old planes of weakening and resulted in foundation of smaller discontinuities of joint character only.

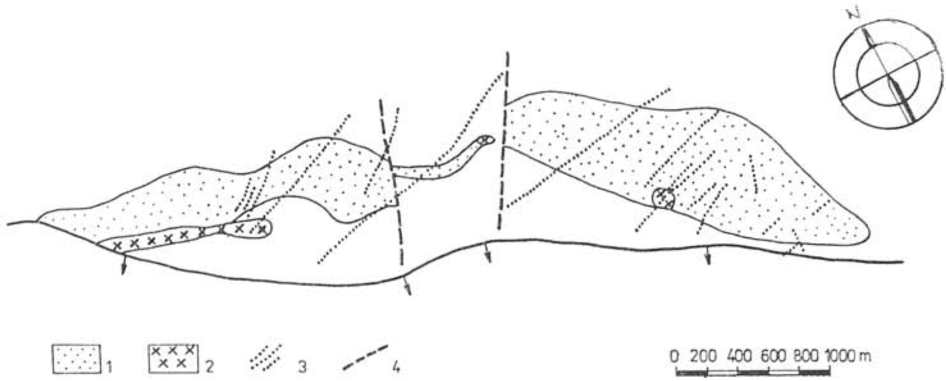

Fig. 5. Example of foundation of ladder ore veins. Zlatá Idka. *Explanations:* 1 — hornfelses, 2 — Gemeride granite, 3 — ore veins, 4 — faults.

Normal faults

In the area of Bindt at profiles constructed by K. Ondrejkovič (1970) some ore veins are of normal fault position, also when the author is inclined to atribute this position to post-metallogenetic tectonics. J. Hudáček (1971) unambiguously writes about normal fault structure in the area of the Zahura stockwork zone in case of the Irena vein.

The possibility of location of the mentioned and other veins (mainly of veins belonging to swarms of ankerite-quartz-sulphide type, occurring in the Permian, mainly on normal faults, is necessary to admit also in the case if we put foundation of mineralized dislocations unambiguously into connection with compression only. It results from the studies of O. Wagnebreth (1969) that with the compressive regime, besides upthrusts, also normal faults can (even have to) originate. Besides this uparching of the central part of the Spišsko-gemerské rudohorie Mts. (see in the next) it must have induced, besides other, also normal faults at the flanks.

Clefts

Under the concept „cleft" we shall understand fissures of higher order. We encounter this morphogenetic type mainly in the area of Rudňany.

Between Závadka nad Poráč S. Konečný (1968, 1974) delimits „the Rudňany ore district" with particular tectonic development and morphogenesis of ore veins, which can be characterized briefly from the mentioned aspect as follows:

- there are thick veins steeply dipping, along which no greater movements took place in the pre-metallic stage,
- the veins are symmetrologically and spatially bound to a transversal elevation of cupola type with the north-southern axis,
- on the whole the veins are dykes, crossing s_1 as well as s_2 surfaces, equally also linear elements,
- veins passing into the peripheral part of elevation are splitting and fade out.

S. Konečný puts the tectogenesis of these vein structures of particular type into connection with the stage of transversal folding. Similar to the Rudňany veins are morphogenetically the veins at Bindt. The description and morphogenic interpretation of the Rudňany veins from the side of S. Konečný (1968) is so far as convincing that in our opinion it is fully substantiated to accept the Rudňany type of ore veins as particular structural metallogenetic morphogenuetic type in the Spišsko-gemerské rudohorie Mts. which has its place also in the morphogenetic classification. We designated it as the cleft fissure type. The origin of the structures of cleft type in Rudňany is probably connected with the conclusions of development and structure of the Spišsko-gemerské rudohorie Mts., when the frontal part of the North-Gemeride zone was intensely wedging in between the Veporide and Branisko—Čierna hora block. It is the period when the strongest transversal compression in E—W direction took place.

3. Ore bodies bound to joint systems of tectonic origin.

One of the contribution of the latest studies with structural metallogenetic aiming is revealing of the importance of joints as ore-locating structures in the Spišsko-gemerské rudohorie Mts. To them we range such mineralized structural elements of disjunctive character, which have a short reach in strike and depth. They represent genetically a very variegated group. Some of them represent joint zones bound to normal fault line or flexures bends. Elsewhere such zones or joint fields are obviously connected with big faults of strike-slip character, in the frame of which some joints are of slip, others of tension type. As it is evident from the profiles of the Zlatník deposit, compiled by J. Hudáček (1970), among the joint zones bound to normal fault, flexure-normal fault lines, according to all facts, belongs the swarm of small vein bodies filled up with ankerite-quartz-sulphide mineralization in the area of Zlatník. According to the interpretation of J. Hudáček they are younger veins than the main siderite-barite ($\pm$ sulphidic) body of Zlatník. This structural deposit type of the Spišsko-gemerské rudohorie Mts. has not been investigated nearer so far. We consider, however, as probable that the swarms of ankerite-quartz-sulphide small veins, known mainly in the Permian in the northern part of the Spišsko-gemerské rudohorie Mts. (e.g. Gápel near Dobšiná north of Mlynky, Novoveská Huta, Zahura a.o.) are of similar type.

With a particular type of joint structures we meet in the area of Dobšiná (at known Co-Ni veins) and veins of Zlatá Idka type near of Zlatá Idka and at the locality Diana near Košice. Their common feature is preferential location of ore-bearing structures in bodies of rigid rocks amidst plastic rocks. In case of the Dobšiná cobalt-nickel-bearing veins there si a gneiss-amphibolite complex (L. R o z l o ž n í k, 1959), in Zlatá Idka Gemeride granite and its contact aureole (L. R o z l o ž n í k, 1971) and at the Diana deposit a slice of Jurassic and Triassic dolomites and limestones of the Čierna hora mantle

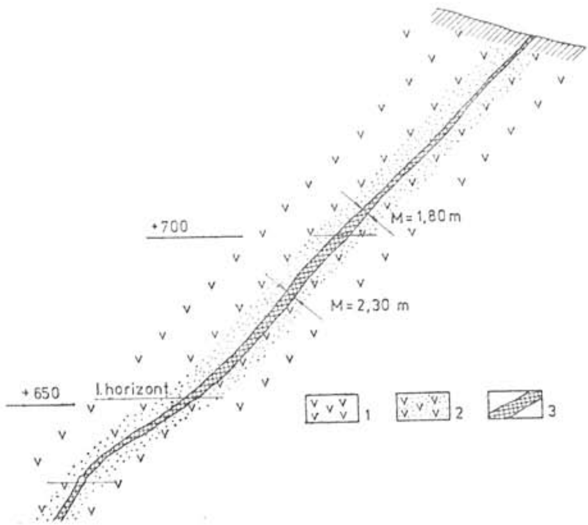

Fig. 6. Example of regular development of ore vein. Cross section through the Gustáv vein - Nálepkovo. Compiled by: J. Pecho, 1958.
Explanations: 1 — diabases, 2 — hydrothermally altered rocks, 3 — siderite vein.

amidst the Črmeľ group. Whereas the Dobšiná Co-Ni veins are essentially bound to upthrusts (L. R o z l o ž n í k, 1959), at argentiferous-antimonite veins of Zlatá Idka there are most probably shear and tension joint systems in the form of ladder veins (L. R o z l o ž n í k — J. S l a v k o v s k ý, 1978).

4. Contraction joints in intrusive bodies.

The mineralized structures bound to the so called granite tectonics or joint systems bound to prototectonics of intrusives of the solid stage were discovered only recently in connection with manifestations of Sn-W mineralization in greisenized Gemeride granites (J. B a r a n — L. D r n z í k o v á — K. M a n d á k o v á, 1970). E. D r n z í k (1974) tried also to work out a geometric classification of joint systems occurring in the Hnilec granite from the aspect of greisenization.

The presented classification of mineralized structures according to morphogenetic properties cannot be considered as exhausted for the reasons mentioned. On the other hand, we think that it helps to reveal the regularities of ore mineralization distribution.

C. Classification of ore bodies according to relation to the petrographic character of surrounding rocks

Older as well as recent works dealing with development of ore bodies in the Spišsko-gemerské rudohorie Mts. are stressing the importance of the influence of surrounding rocks, the importance of the so called lithological factors of location. In the Spišsko-gemerské rudohorie Mts. an importance can be ascribed to the influence of surrounding rocks on formation of ore bodies from two view-points:

— from the view-point of environment conditioning their preferential location,
— from the view-point of favourable (unfavourable) influence on their morphology (thickness, stability, regularity etc.)

The degree of importance of the lithological factor in the eyes of individual authors is not equal. In our opinion (L. Rozložník, 1962) the lithological factor in the Spišsko-gemerské rudohorie Mts. is of local importance.

The significance of the rock environment as factor of preferential location in the frame of the Spišsko-gemerské rudohorie Mts. is restricted to some members only: carbonate bodies of the Paleozoic and to the Gemeride granites, or to the boundary of two rock complexes of various mechanical properties.

Whereas in the case of Paleozoic carbonate rocks a preferential location is concerned, mainly owing to their chemical disposition, at deposits of Zlatá Idka type and Co—Ni ore veins near Dobšiná there is a favourable mechanical disposition given by the rigide environment suitable for formation of splintery structures. At Sn—W deposits located in greisenized Gemeride granites preferential location is obviously given by combination of the structural and magmatic factor.

In the role of the factor of preferential location in the Spišsko-gemerské rudohorie Mts. also the boundary of mechanically contrasting rock environments appears, the boundaries of competent and incompetent rocks. The favourableness of the rock boundary for the location of ore bodies is stressed with justification by many authors dealing with the problems of spatial distribution of deposits in the Spišsko-gemerské rudohorie Mts. Most often are the boundaries: phyllite or schist and porphyroid, or other eruptive rock, phyllite-quartzite, phyllite (schist)-psammite or psephite. Mostly, however, here is not a stratigraphic but tectonic boundary or tectonically highly reworked stratigraphic boundary.

It is possible to mention a series of examples for foundation of ore veins at the boundary of competent and incompetent rock complexes: the veins between Rákoš and Hrádok, some Sb veins near Čučma nad Poproč (L. Rozložník — J. Slavkovský, 1978), vein system of Lucia — Fortuna — Rufus (O. Rozložník — P. Reichwalder, 1971), Jedľovec veins (P. Grecula, 1970), many veins near Dobšiná (L. Rozložník, 1965), some veins at Bindt, some veins of Slovinky and Gelnica veins (J. Hudáček and S. Konečný, 1971) a.o. The importance of the lithological factor in formation of ore bodies in the Spišsko-gemerské rudohorie Mts. was pointed out first by J. Ilavský (1956).

M. Maheľ (1966) defined 4 categories of rock environment from the view-point of their „favourableness" in this hierarchy:
1. boundary of competent and incompetent sequences, 2. compact rocks (quartzites, limestones, diabases, quartz porphyries and conglomerates), 3. phyllites and tuffogenic pyroclastics and 4. graphitic phyllites and lydites.

The correctness of the mentioned classification has been fully confirmed by up to present studies.

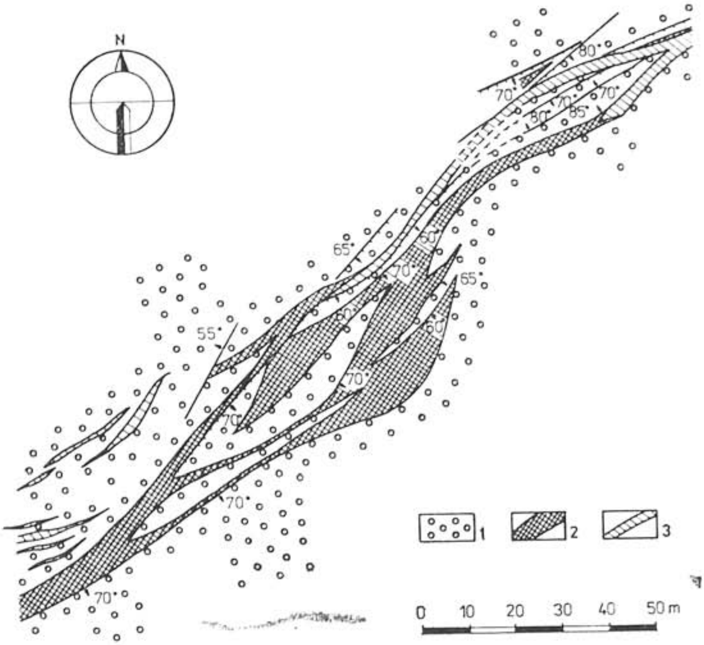

Fig. 7. Example of distribution of veins in inhomogeneous environment. Map of the IIIrd level of the vein-Gretla. Compiled by: J. Bartalský, 1953.

A part of ore bodies crosses rocks of various petrographic character. Among such belongs e.g. the Droždiak vein of Rudňany, which is stated (J. Rozložník, 1965) to wedge out toward depth with its transition into soft beds of the Rakovec group. J. Pecho (1968) also mentions that stability and total favourable development of the large veins in the northern part of the Spišsko-gemerské rudohorie Mts., e.g. of the Hrubá vein at Bindt and Roztok vein depends on surrounding rocks. They are mostly developed in compact rocks in diabases and conglomerates, whilst with transition into schists they split and fade out.

Several authors (J. Pecho, 1968; P. Grecula, 1970) state that the veins amidst highly foliated rocks (schists, phyllites, porphyroids) are tending to lenticular development. A classical example of swelling we encounter at the Rožňava veins. As the results of studies by J. Slavkovský (1978) show, the origin of lenticular swelling at the Rožňava veins is connected with transversal folding of distinct foliation of porphyroids. The results of study of spatial orientation of ore lenticle axes also confirm the complicated several--acts course of transversal folding.

The highly inhomogenous environment in pelitic rocks induces overveined development with many short, rapidly thinning out thin veins.

The opinions of the position of conglomerates in the frame of favourableness of environment disagree: e.g. J. Slavkovský (1971) observes equal development of the Rožňava veins at their transition from porphyroids into conglomerates of Rožňava-Železník type whereas in the northern part of the Spišsko-gemerské rudohorie Mts. Permian conglomerates are considered as negative factor in the sense that important Rudňany veins fade out in them (S. Konečný, 1969).

The structural analysis of individual bodies and ore districts, carried out by many authors, confirmed the thesis proved by L. Rozložník (1965) that „favourableness" of the lithological environment is a local morphogenetic factor only. The first-rate factor remains „tectonic preparing". P. Grecula (1970) complements very plastically this thesis on the situation of Jedľovec. P. Grecula states that at Jedľovec the lithologically favourable field continues also in the eastern part, on the other hand structures favourable for ore mineralization are missing here and the author concludes that the rock environment itself is not a guarantee of favourableness of ore mineralization development.

Conclusions

In the foregoing text we established three fundamental criterii for structural classification of ore bodies, as follows:

1. the relation to the structure of surrounding rocks
2. morphogenetic characters of mineralized structure and
3. petrographic character of surrounding rocks.

As comprehensible, they are not isolated criterii but criterii characterizing the position of deposits with its mutual interrelations.

The classification shows that the Spišsko-gemerské rudohorie Mts. as one unit is of the character of structural-metallogenetic unit, in which prevailingly the majority of ore bodies are marked by a position of bodies in „cleavage--microjoint structures", according to V. M. Krejter (1956), or in zones of „schistosity" — according to V. I. Smirnov (1965).

Nevertheless, there is not a common case of mineralized schistose mountains. The mineralization does not chose only „favourable rocks" and mainly interfoliation spaces made accessible for ore mineralization by folding but especially dislocations, conformable and unconformable with the course of one or another foliation. They are dislocations, which analogous to interfoliation bodies, were made accessible for ore mineralization by particular transversal folding. The mineralized structures are characterized by uncommon diversity of forms, appropriate to the complicated multi-phase pre-metallic tectonic development of the territory and its result: complicated pre-metalic structure with complicated inherited anisotropy. It results from the above mentioned that in case of mineralized structures of the Spišsko-gemerské rudohorie Mts. one cannot speak about „pure" well-defined forms of structures but about structures combined. The fact that the folding was the mediator of location of ore mineralization in a highly anisotropic environment with many diverse structures, testifies that combined structures must be present there: foliation-folding, faulted-folding etc., already not speaking about the influence of lithological environment.

Translated by J. Pevný

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Manuscript received April 28, 1980