JÁN KANTOR, MARTIN RYBÁR*

ISOTOPES OF ORE-LEAD FROM SEVERAL DEPOSITS OF WEST CARPATHIAN CRYSTALLINE[1]

(Textfigs 1—2)

A b s t r a c t : Numerous deposits and occurences mainly of coloured metals appear in the West Carpathian Crystalline. There is still little geological evidence regarding the age of the mineralisation. Lead isotope abundances of minerals of this region indicate similarity to typical Variscian mineralization of Western Europe (Cornwall-Devon, Germany, etc.). Mathematical treatment according the Holmes-Houtermans model indicate for the lead usually also Variscian model age. The model ages of Pb-minerals are coincident or lower than absolute ages of granitoids and crystalline schists determined by Potassium-Argon method in West Carpathian Crystalline. Oldest model ages were obtained for lead from pyrite deposits occuring in the Cambro-Silurian Series of the Spišsko-gemerské rudohorie Mts. Listed also are anomalous leads of B- and J-types.

As a part of young Alpine-Himalayan orogenic system the West Carpathians bear a very complicated geologic structure with corresponding complicated problems of metallogenesis.

Although the studies of West Carpathian ore deposits in recent years were carried out by modern methods a series of basic problems remained unsolved so far. The fact is obvious if all the kind of mineralization belonging to different orogenic epochs were taken into consideration with possible migrations and secondary hydrothermal transportation of products of previous metallogenic periods during the later magmatic, intrusive and metamorphic processes.

The above facts are reflected fully in the opinions on the West Carpathian metallogenesis. There is a diversity of all possible explanations on the problem unitarian regarding all the hydrothermal deposits as a product of one orogeny Variscian by some, Cretaceous by other, Paleogene or even Neogene. Besides there are opinions proposing polygenic or regenerated origin for the West Carpathian ore deposits.

The same is the question of feeding source and relation between the individual ore-formations lacking an apropriate explanation so far.

In order to obtain further data helping to explain various matallogenic problems we started with isotopic studies in the first stage of lead from ore deposits.

It may be pointed out however that up till now only a very limited number of isotopic analyses of galenas from the whole Carpatho-Balkanian system has been carried out.

In Alps the situation in this particular problem is more favourable due to the systematic studies of Pb isotopes by Houtermans and his associates.

* Dr. Ján K a n t o r, Martin R y b á r, Dionýz Štúr Institute of Geology, Bratislava, Mlynská dolina 1.

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The submitted paper deals in the first place with isotopes of several deposits located in the deeper metamorphosed crystalline masses of West Carpathians.

Part of analyses have been carried out at the Dionýz Štúr Institute of Geology in Bratislava while for the other one we are deeply gratefull to J. E. Starik corresponding member and president of the Commision for Absolute Age Determination of USSR Academy of Sciences.

For the work in Bratislava a Nier type masspectrometer of Soviet made MI-1305 has been applied. We used solid-source technique. After each sample the system was controlled for backround. New lead-iodide samples were inserted only if there was no measurable memory effect from previous measurements.

The lead isotope 204 was measured on lead iodide ions; for the rest of isotopes the lead and lead iodide — ions were used.

It is supposed that the analyses are correct to about 0,5 % in their measurements of lead 206,207 and 208 and to about 1—2 % for the isotope 204.

Some of the samples of Pb — minerals provided prof. B. Cambel and Doc. C. Varček. The chemical treatment of material was by M. Šulcová, the separation of minerals by M. Strešňáková and F. Pažitný from D. Štúr Inst. of Geology whilst to Ing. K. Dillnberger we are indebted for bis assistance in the masspectrometric determinations.

To all these we are gratefull for their part in realization of our investigation.

Ore Deposits of West Carpathian Crystalline

In West Carpathian Crystalline comprised are the pre-Carboniferous mostly katametamorphosed formations within the s. c. „Core Mountains" (Malé Karpaty, Tribeč, Inovec, Suchý, Malá Magura, Fatra, Ľubochniansky masív, Nízke a Vysoké Tatry) and mostly mesometamorphosed in Veporidy (s. c. Tatroveporidy unit). Independent is the position of Spišsko-gemeské rudohorie Mts built by epimetamorphosed complexes thrusted as a nappe over Veporidy unit (Textfig. 1).

Concerning the stratigraphy of the members of the Tatroveporidy crystalline their age so far has been proved definitively as pre-Carboniferous. The share of pre-Paleozoic sediments isn't satisfactorily cleared up.

The same applies to the age of metamorphosis of Tatroveporidy cristalline. In the recently published „Tectonic Development of Czechoslovakia" the authors suggest the pre-Cambrian age for both the metamorphic processes and the intrusions of posttectonic granitoids constituting the majority of West Carpathian Crystalline.

By the geochronological methods however for the majority of posttectonic granitoids (Kantor 1959) as well as by the detailed geological investigations for Malé Karpaty granitoids (Cambel 1959) the age determined indicate Variscian orogeny.

The same age in general has been determined for the crystalline schists of Core Mountains by Potassium-Argon method (Kantor 1959—1961). Although the possibility of older orogenies taking part cannot be excluded the dominant role in plutonism and metamorphosis of mantle series of Tatridy belong to Variscian orogeny. No relicts of old, pre-Cambrian metamorphic processes by Pottassium-Argon method could have been till now determined.

For the Kohút-Zone of the Tatroveporide unit a wide spread Alpine meta-

Textfig. 1.

1 — Crystalline schists (meso- katametamorphic)
2 — Granitoids
} Crystalline of the Tatraveporidy-unit

3 — Pre-Carboniferous epimeta-metamorphous rocks — Spišsko-gemerské rudohorie Mts.

4 — Andesites, rhyolites, dacites, pyroclastics
5 — Basalts
} Late Tertiary effusives of the Inner Belt

6 — Carboniferous and younger sediments

7 — Localities of isotopically analysed samples

morphosis of prevailing Upper Cretaceous age has been determined by geochronological methods (Kantor 1960). Alpine metamorphosis led to the recrystallization of older crystalline formations and progressive metamorphosis of certain younger comprising Mesozoic Föderata series.

Malé Karpaty

The only deposits of economic interest here are the pyrite and antimony ores. Pb-Zn, Au-Ag and other prospecting failed or resulted only in very limited mining.

Pezinok — Baba (6, 7)*

One of the three Pb-Zn localities in Malé Karpaty, situated between Pezinok and Pernek some 3 kms from the latter.

Detailed geological and metallogenic investigations were compiled by B. Cam-

* Numbers indicate localities on textfigures 1 and 2 as well as on tables 1 and 2.

b e l (1959). The Baba environments comprise complexes of metamorphic rocks, biotite-garnet and staurolithe paragneisses intruded and cut by minor apophyses of acidic granites and pegmatites. Intensity of metamorphosis decreases gradually westwards; the rocks are replaced by biotite schists and phyllites with local intercalations of metamorphosed basic effusives and pyroclastics wich according to C a m b e l (l. c.) belong to Caledonian tectomagmatic cycle.

In the transitional zone between gneisses and schists a system of thin iregular fissures developed carrying Pb-Zn mineralization.

B. C a m b e l determined 3 periods of mineralization: 1. Quartz, pyrite and arsenopyrite, 2. quartz, pyrite, sphalerite, galena, andorite, freislebenite, chalkopyrite, 3. quartz, carbonates, barite.

Two veins are known in the locality: Upper-striking NE-SW and Lower-striking N-S. In spite of similarity in mineralization the Upper vein differs by the presence of barite missing in the Lower one at the expense of carbonates.

According to C a m b e l (l. c.) the hydrothermal mineralization of Malé Karpaty is closely related both in space and genesis to the granitoids and pegmatites Other authors on the contrary believed (Č i l l í k, S o b o l o v i č - Ž á k o v s k ý 1959) at least a part of it or (Z o u b e k 1937, M á š k a 1957) the whole of it belong to the Alpine orogeny.

P e z i n o k — R ý h o v á a d i t (18)

In the vicinity of Pezinok and Pernek large pyrite-pyrrhotite bodies occur. The sulphides were previously believed to be of hydrothermal origin. Recent mining works and drilling prospecting all indicate close genetic relations between the deposits and submarine volcanic activity.

The deposits are believed to be derived from Caledonian exhalative-sedimentary mineralization and metamorphosed by Variscian granitic intrusions at several places (C a m b e l 1959, P o l á k 1956).

The country-rock of these several tens of metres thick sulphide lenses is usually formed by actinolite and graphite schists.

Pyrite-pyrrhotite lenses are cut by stibnite fissure veins and impregnations at several places.

M a l á M a g u r a — S u c h ý

Malá Magura and Suchý crystalline have been recently investigated by A. K l i n e c (1958) and M. I v a n o v (1957).

As to the above authors the super-crustal series are composed of biotite paragneisses in the west and late orogenic migmatites in the east of the mountains. Amphibolites occur only as subordinated thin, lenticular intercalations.

The Variscian age of metamorphosis for both the biotite paragneiss of Poruba and migmatite paragneiss of Čavoj by Potassium-Argon method was determined by K a n t o r (1960).

Granitoids are represented by hornblende-biotite, diorite, leucocratic granites and granodiorites, autometamorphic biotite and biotite-muscovite granites and granodiorites, aplitic and pegmatite granites. The relations among the above types of granitoids are complicated and not yet satisfactorily explained.

In the Suchý and Malá Magura crystalline core hydrothermal deposits of Pb-Zn and Au-ores appear, previously intensely exploited.

Pb-Zn fissure veins strike NE-SW carrying quartz with some barite and carbonates. Ore minerals are represented by galena and sphalerite with subordinate pyrite and arsenopyrite.

Under the Temešská skala (5) near Čavoj fissure veins occur in biotite gneisses.

From the vicinity of Chvojnica (2) we have analyzed galena occuring in a fissure vein at the contact of crystalline schist xenolith with granites.

Nízke Tatry

Numerous ore occurences appear in Nízke Tatry region where mainly Sb-Au veins are of practical significance. Majority of those more important deposits are concentrated in the western part of the mountains.

Nothern slopes are composed almost exclusively of granitoids, with prevailing biotite-quartz diorite to granodiorite (Ďumbier type) and autometamorphic biotite to biotite-muscovite granite (Prašivá type).

Leucocratic quartz diorite facies together with the s. c. „contact metasomatic" varieties at the boundary of Ďumbier and Prašivá granitoids have inferior representation.

Southern slopes comprise almost exclusively supercrustal formations, migmatites and migmatite orthogneisses prevailing. Paragneisses with lower migmatization are restrincted to limited areas.

As to the age of granitoids the opinions are diverse. For the main types Kantor (1959, 1961) determined by Potassium-Argon method the Variscian age. The age of crystalline schists metamorphosis has been determined identical.

Jasenie — Soviansko (1)

The deposit is localized some 6 kms north of Jasenie village in metamorphosed paragneisses surrounded by migmatites.

Epigenetic, polymetallic mineralization occurs in steep NE-SW striking fissures. Main mineral is galena with inferior amounts of sphalerite, tetraedrite, bournonite, semseyite, chalkopyrite, pyrite (Pouba, Vejnar 1955).

Gangue is represented by quartz and barite with subordinated ankerite, calcite, rare albite and epidote.

According to Pouba and Vejnar (l. c.) mineralization is developed in several stages. After the first quartz, pyrite stage followed ankeritic then polymetallic and finally barite-calcite stage.

Dolná Lehota — Ždiar (10)

Fissure vein with siderite, quartz, barite and bournonite, tetrahedrite mineralization appears in migmatitic orthogneisses. In the central somewhat higher localized part of the vein barite prevails decreasing with the depth.

Dolná Lehota — Dve vody (3)

Stibnite mineralization is related to a WNW-ESE striking system of iregular fissure veins.

Most frequent among the ore minerals is stibnite. Further occuring are arsenopyrite, pyrite, galena, boulangerite, bournonite, sphalerite, native gold.

Quartz is the main gangue mineral with local carbonates.

For the isotope investigations galena from a younger veinlet cutting and dislocating the Nová Vyšná adit stibnite vein has been used.

Malé Železnô (8)

The deposit occurs in the NW portion of Nízke Tatry Mts near to the contact of Prašivá granites with Klinisko crystalline schists.

In the near vicinity of deposit diorites, lamprophyres and aplitic granites appear. Michalenko (1959) states molybdenite from pegmatites. A Variscian age has been determined for the pegmatite by A/K-method (Kantor 1961).

The pegmatites are cut by younger quartz-stibnite veinlets with pyrite, galena and sphalerite. J. Hak (1957) listed further zinkenite, bournonite, boulangerite and barite gangue.

Dolná Lehota — Lom (9)

Deposit occurs also in migmatite rocks of Nízke Tatry southern slopes. It is represented by a quartz-stibnite vein striking N-S previously intensely exploited.

The mineralogy has been studied by Hak (1957) who listed stibnite, pyrite, native gold, sphalerite, galena, chalkopyrite, zinkenite, dolomite, calcite, ankerite.

Trangoška (4)

The deposit has been studied in detail by V. Zoubek (1937) and demonstrated as an example of Alpine mineralization in West Carpathian Crystalline.

Recently the paragenetic studies were carried out by J. Turan (1961) and J. Hak (1962).

The environments comprise mainly various types of migmatites in these parts intruded by numerous muscovite pegmatites. After Zoubek (l. c.) and geochronological investigations of Kantor (1959) these pegmatites are in genetic relationship with the „Králička“anatectic granites and cannot be therefore regarded as Cretaceous and related to the mineralization as suggested by Kubíny (1962).

Opposite to other Pb-mineralization of Nízke Tatry region described above the Trangoška ore veins and impregnations penetrate the Lower Triassic quartzites folded and clammed into crystalline in the form of a narrow syncline.

The first mineralizing period yielded quartz, siderite, ankerite, barite with some pyrite and albite. In the second period prevail sulphides with sphalerite, galena, tetrahedrite, chalkopyrite, bournonite and pyrite.

Velence — Hungary

Very thorough and based upon modern methods is the regional monography of B. Jantsky (1957).

A Cambro-Silurian-Lower Carboniferous complex of predominantly sedimentary rocks regionally epimetamorphosed was intruded by granitoid pluton of Velence Mts., followed by numerous dykes of granite-porphyries, aplites and pegmatites.

According to Jantsky (l. c.) field observations the granite intrusion is supposed to be of upper Carboniferous age. The suggestion is based upon the presence of pebbles of silicified aplites, turmaline aplites and turmalinised contact rocks in Upper Permian conglomerates.

Jantsky (l. c.) suggested the genetic relations of granites and hydrothermal fissure veins in Velence Mts.

Mineralization comprises quartz-molybdenite veins (Retezi), quartz, fluorite (Szüzvár, Pákozd, Körakás), stibnite (Nadáp) and barite veins.

Szüzvár (11)

Quartz fluorite veins are characterized by fluorite in upper and quartz mineralization in the lower levels. Sulphides — sphalerite, galena, tetrahedrite, chalcopyrite and pyrite occur locally as fragments and iregular impregnations.

The age of Velence granites determined by Rb/Sr method indicated 217 ± 40 million years. (Földváry — Vogl).

Ovčinnikov, Panova, Šangaraev (1961) reported 360×10^6 years for biotite of porphyric variety A^{40}/K^{40} and 280×10^6 years for feldspar. Absolute age for the coarse grained variety of berezitized granite by the same authors is given as 175 million years.

Spišsko-gemerské rudohorie Mts

Beside the numerous hydrothermal (Fe, Cu, Pb-Zn, Sb, Hg, etc.,) deposits in pre-Carboniferous formations of Spišsko-gemerské rudohorie there occur also several pyrite and pyrite-polymetallic deposits.

One of the well known deposit is Smolník (Schmöllnitz) and similar deposits are known also northwards near Mníšek n/Hnilcom and westwards in the vicinity of Švedlár and Veľká Poloma. The deposits are composed of lenses reaching several tens of meters thickness within the rocks of Cambrosilurian series. Mineralization bears usually character of impregnations in chlorite and chlorite-sericite phyllites. Locally occur compact and very fine grained pyrite and more frequent Pb-Zn-Cu minerals.

The metamorphosis and recrystallisation of the mineralisation are usually expressive. The pyrite lenses are intersected by younger siderite-chalkopyrite fissure veins. Kantor and more recently J. Ilavský (1962) have studied this mineralisation. According to isotope investigations carried out in Leningrade laboratories of Academician I. E. Starik the leads from Smolník and Alžbeta adit near Švedlár show old model ages indicating a syngenetic origin of the mineralization (Kantor 1962), supported recently also by B. Cambel (1959) and J. Ilavský (1962).

New isotopic analyses have been recently carried out on lead from Mníšek nad Hnilcom — Jalovičí vrch (12) galena impregnations of pyrite bodies.

Neogene lead-zinc Deposits

The age of certain subvolcanic Au, Ag, Cu-Pb-Zn, Hg deposits in Carpathians has been since long reliably determined as Neogene. Included in this group are: Banská Štiavnica (Schemnitz) (15) and Hodruša (Hodritsch) (14).

In the vicinity of Tisovec (13) a contact metasomatic deposit occurs at the contact of diorite and mesozoic limestones which is believed to be of Miocene or Cretaceous age.

Gyöngyösoroszi (17) in Hungarian Mátra Mts. is a deposit with geological and mineralogical features very similar to that of Banská Štiavnica (Vidacs 1961).

Valea Mori (16) near Brad in Roumania belongs also to the above type of deposit.

Isotope abundances

The interpretation of the isotopic composition of lead minerals for their dating is practically based on similar principles as absolute age determination of radioactive minerals: The isotope ratios represent in this case the result of different, often very variable and complex geochemical influences.

The age formula for the mathematical treatment depends therefore always on certain simplifications or models. Only if these assumptions were satisfied the model yields an age comparable with the geologic setting and the history of the sample.

The Holmes-Houtermans model has been provisionally chosen to interpret the measured isotope ratios of lead in galenas. The Russel-Cumming-Farquhar and the Russell-Stanton-Farquhar model show less satisfactory agreement when applied to geologically well dated galenas of Miocene age from the Carpathians. The Holmes — Houtermans model is based on the following values: t_0 — 4510 m. y.; a_0 — 9,50; b_0 — 10,35; λ_{238} — $0,1537 \times 10^{-9}.y^{-1}$; λ_{235} — $0,9722 \times \times 10^{-9}.y^{-1}$; U^{238}/U^{235} — 137,8 (Russell, Farquhar l. c.).

New measurements of isotope ratios are presented on Table 1. Analyses No. 1, 4, 5, 15 were kindly carried out in the Leningrade laboratory of I. E. Starik.

Published isotope abundances for predominantly Tertiary lead mineralisations are for comparision shown on Table 2. (Bern: No 22, 23, 25, 28, 29; Columbia: 21, 24, 27; Leningrad: 30, 31; Moscow: 20, 19; Toronto: 26; Bratislava: 17, 18, new).

The plots for the isotopic ratios of galenas from the West Carpathians are arranged in three distinct groups. Near the zero isochron are situated galenas genetically related to the andesiterhyolite volcanisme of Miocene age. The mean value being Pb^{204} — 1,00; Pb^{206} — 18,84; Pb^{207} — 15,73; Pb^{208} — 39,09. Similar values were obtained for young Tertiary mineralizations of the Alpine-Himalayan system outside the West Carpathians (table 2).

Around the 250 m. y. isochron are arranged the plots for lead from ore deposits of the West Carpathian Crystalline. Mean values for samples 1—4, 8—10 are: lead 204 — 1,00; 206 — 18,24; 207 — 15,57; 208 — 38,31.

Comparable isotope abundances show galenas from Cornwall and Devon in England investigated by S. Moorbath (1962) as well as those from Germany studied by Geiss, Ehrenberg, Murtz (in Russell, Farquhar, l. c.).

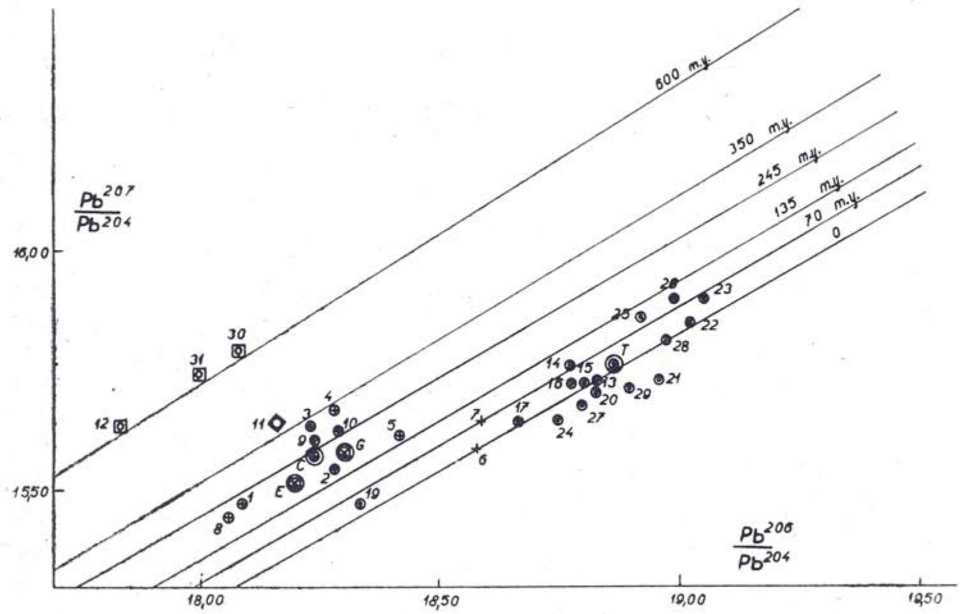
Table 1

№		204	206	207	208
1.	Jasenie —	1,375	24,86	21,27	52,49
	Soviansko	1,000	18,09	15,47	38,17
		5,531	100,00	85,56	211,14
2.	Chvojnica	1,372	25,08	21,33	52,22
		1,000	18,28	15,54	38,06
		5,471	100,00	85,04	208,25
3.	Dolná Lehota —	1,365	24,88	21,34	52,42
	Dve Vody	1,000	18,23	15,63	38,40
		5,486	100,00	85,77	210,68
4.	Trangoška	1,360	24,86	21,33	52,42
		1,000	18,28	15,67	38,54
		5,471	100,00	85,80	210,86
5.	Čavoj	1,359	25,03	21,21	52,40
		1,000	18,42	15,61	38,55
		5,429	100,00	84,74	209,35
6.	Pezinok — Baba	1,357	25,21	21,15	52,29
	Horná	1,000	18,58	15,58	38,53
		5,383	100,00	83,90	207,42
7.	Pezinok — Baba	1,354	25,16	21,18	52,30
	Dolná	1,000	18,59	15,64	38,63
		5,402	100,00	84,17	207,84
8.	Magurka — Malé	1,381	24,94	21,33	52,48
	Železnô	1,000	18,07	15,44	38,03
		5,533	100,00	85,51	210,41
9.	Horná Lehota —	1,364	24,88	21,28	52,48
	Lom	1,000	18,24	15,60	38,48
		5,483	100,00	85,52	210,95
10.	Dolná Lehota —	1,367	25,00	21,36	52,28
	Ždiar	1,000	18,29	15,62	38,24
		5,468	100,00	85,44	209,12
11.	Szüzvár Velence	1,362	24,73	21,30	52,60
	Hungary	1,000	18,16	15,64	38,62
		5,507	100,00	86,13	212,67
12.	Mníšek	1,385	24,69	21,64	52,28
	nad Hnilcom	1,000	17,83	15,63	37,75
	Stirkenberg	5,610	100,00	87,65	211,75
13.	Tisovec	1,336	25,15	21,00	52,40
		1,000	18,82	15,72	39,22
		5,312	100,00	83,50	208,35
14.	Hodruša	1,336	25,08	21,06	52,52
		1,000	18,77	15,76	39,31
		5,327	100,00	83,97	209,40
15.	B. Štiavnica	1,340	25,21	21,07	52,38
		1,000	18,81	15,72	39,08
		5,315	100,00	83,58	207,77
16.	Valea Mori	1,342	25,20	21,10	52,35
	Roumania	1,000	18,78	15,72	39,00
		5,325	100,00	83,70	207,70

Table 2

№		204	206	207	208
17.	Gyöngyösoroszi Mátra Hungary	1,354 1,000 5,359	25,26 18,66 100,00	21.18 15,64 83,84	52,20 38,56 206,64
18.	Pezinok Rýhová štôlňa	1,202 1,000 3,623	33,18 27,60 100,00	19,43 16,16 58,56	46,19 38,43 139,21
19.	Mukanovo Zakarpatie USSR	1,344 1,000 5,457	24,63 18,33 100,00	20,79 15,47 84,40	53,24 39,62 216,15
20.	B. Štiavnica	1,350 1,000 5,311	25,42 18,83 100,00	21,19 15,70 83,38	52,04 38,56 204,72
21.	B. Štiavnica	1,334 1,000 5,275	25,29 18,96 100,00	20,98 15,73 82,96	52,39 39,27 207,16
22.	Baia Sprie Roumania	1,329 1,000 5,255	25,29 19,03 100,00	21,06 15,85 83,27	52,32 39,37 206,88
23.	Herja Roumania	1,326 1,000 5,250	25,25 19,05 100,00	21,07 15,90 83,45	52,35 39,49 207,33
24.	Trepča Yougoslavia	1,341 1,000 5,333	25,15 18,75 100,00	20,98 15,64 83,42	52,53 39,17 208,87
25.	Yougoslavia Trepča	1,331 1,000 5,285	25,18 18,92 100,00	21,11 15,86 83,85	52,37 39,35 208,00
26.	Laurium Greece	1,333 1,000 5,265	25,32 18,99 100,00	21,19 15,90 83,69	52,16 39,13 206,00
27.	Laurium Greece	1,343 1,000 5,319	25,25 18,80 100,00	21,05 15,67 83,36	52,36 38,99 207,37
28.	Val d'Antrona Italy	1,335 1,000 5,270	25,33 18,98 100,00	21,10 15,81 83,30	52,23 39,13 206,20
29.	Val d'Anzasca Italy	1,341 1,000 5,290	25,36 18,90 100,00	21,07 15,71 83,10	52,23 38,94 206,00
30.	Smolník	1,366 1,000 5,546	24,63 18,08 100,00	21,56 15,78 87,54	52,44 38,39 212,91
31.	Švedlár	1,365 1,000 5,556	24,57 18,00 100,00	21,50 15,74 87,51	52,59 38,58 214,04

x. — periods with main supply Au, Ag.



Textfig. 2. Holmes-Houtermans isochron diagram. Mean values: T — Tertiary, C — Crystalline (West-Carpathian), E — England (Cornwall-Devon), Variscian, G — Germany, Variscian.

The age of the Cornwall-Devon samples has been well established by geological and geochronological methods as late Variscian. Age of the granite 271 m. y. by A/K-method, 277 m. y. by Rb/Sr and 288 by U/Pb method. The plot for galenas related to this granite is on the Holmes — Houtermans diagram (Fig. 2) indicated by E, german samples by G, samples from the West Carpathian Crystalline by C, and late Tertiary mineralizations by T (mean values are given).

Taking into consideration the average values for lead of the West Carpathian Crystalline (18,24; 15,57; 38,31) and those genetically related to Miocene igneous activity, the following model ages can be calculated:

Model	Crystalline m. y.	Tertiary m. y.	Difference m. y.
Russell — Farquhar — Cumming (t_6, t_8)	350	— 10	360
Russell — Stanton — Farquhar ($t_{6.7}$, $t_{8.4}$)	215	— 155	370
Holmes — Houtermans	250	0	250

Model ages based on the lead 206 to lead 207 ratio are less sensitive to errors in the abundance determination of the isotop 204 and hence more accurate. The age difference between the lead of these two mineralizations is according to the

Rusell—Stanton—Farquhar model ($t_{6\ 7}$) 290 m. y. whilst the Holmes—Houtermans model gives a value of 250 m. y.

Post orogenetic granitoids of the West Carpathians „Core Mountains" were dated by the argon-potassium method to 290—320 m. y. (Kantor 1959). Analogous values were obtained for the metamorphosis of the crystalline schists. Masspectrometric analyses of lead referred to in this paper were carried out on samples from true veins cutting both granitoids as well as crystalline schists.

According to these investigations it seems reasonable to assign a primary Variscian age to the leads of the above mentioned mineralizations in the Crystalline.

An exception is represented by the Trangoška deposit, where Werfenian beds are mineralised. If a Cretaceous age for this deposit is postulated (Zoubek 1937) then the isotopic constitution is anomalous of the B-type. Galenas from the Triassic of Austria (Bleiberg) and Poland (Siewierz, Baliń, Bytom) are known to be caracterised by analogous isotope ratios. An alternative interpretation would be that the lead of both mineralisations was derived not only from an identical deepseated source but also deposited in a shorter than Variscian-Cretaceous time interval. We intend to deal with the problem of B-anomalous leads of the West Carpathians in a separate paper.

A Variscian model age is suggested by the isotopic composition of lead from Szüzvár in the Velence Mts., Hungary. Jantsky (l. c.) reached a conclusion about late Carboniferous age of these deposits on geological reasons.

Our investigations do not support the concept of a unitaristic Tertiary metalogenesis for the West Carpathians as postulated for example by W. E. Petraschek (1953).

T. Galkiewicz (1961) makes a comparision of the well known Silesian zinc-lead ores of Poland occuring in Triassic and Devonian carbonates with the Miocene mineralization of Banská Štiavnica. Similarities in the isotope ratios of both types indicating a late Tertiary mineralization are emphasized. Isotopic investigations of ore leads in the West Carpathians could not bring evidence in favour of this concept. On the contrary isotope ratios of undoubtedly Miocene galenas are quite different from those occuring in the Triassic.

Most ancient model ages were stated for lead from pyrite bodies in the Cambro-Silurian Series of the Spišsko-gemerské rudohorie Mts. The lead isotope as well as sulphur isotope ratios S^{32}/S^{34} — 22,91 (analysis kindly carried out in the laboratory of Prof. O. W. Oelsner, Freiberg) indicate a syngenetic origin of Caledonian age for these pyrite and pyrite-polymetallic mineralizations. Besides an undoubtedly hydrothermal activity and later remobilisation of these older leads was stated (Kantor 1962).

The trace lead from pyrite of the Pezinok deposit (18) revealed a quite different picture. It is J-type anomalous indicating relations to an environment with high concentrations of uranium and a possibility to use isotopic investigations in prospecting for uranium and thorium ores.

The J-type anomaly is here perhaps the result of mixing of the primary syngenetic lead of the pyrites with mainly radiogenic (uranium) lead mobilised during the variscian intrusive activity from highly radioactive bituminous schists.

Further investigations are needed in the Malé Karpaty Mts. to find an unambiguous explanation for this J-anomaly as well as for the lead isotope ratios of the Baba samples (J-anomaly or younger mineralisation?).

We are of the opinion that an detailed isotopic investigation of the ore deposits, of the lead in feldspars of magmatic rocks, in sedimentary rocks, combined with other geochronologic methods would contribute to a better understanding of the complex metallogenetic processes that took place in the West Carpathians.

Translated by J. Kováčik.

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