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Pb-ISOTOPE STUDY IN Sb-MINERALISATION FROM WESTERN CARPATHIAN (SLOVAKIA)

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Abstract: The article present the comparison of the Pb-isotope study of antimony-ores from important Sb-mineralisation of Western Carpathian: from Tatric unit (Pezinok, Kuchyňa, Pernek, Dúbrava, Magurka, Lom, Trangoška, Jasenie, Kriváň deposits and occurrences), Gemeric unit (Helcmanovce, Grexa and Poproč deposits) and from Eastern Slovakian neovolcanites (Zlatá Baňa). The study is compared with results of previous investigations of affiliated galena mineralisation. The lead is of a crustal origine. The lead from Taric and that from Gemeric unit (and Eastern Slovakian Neovolcanites) seems to be derived from different reservoirs.

Keywords: stibnite, gudmundite, galena, Pb-isotopes, model ages, orogenic lead, crustal lead

1. INTRODUCTION

Antimony ores are widespread in the Western Carpathian and in the past they have been subject to economically important exploitation. According to Chovan et al. (1994) the most important Sb-mineralisation in Western Carpathian is located in four structural and metallogenic zones: 1. Tatric unit, 2. Veporic unit, 3. Gemeric unit and 4. in neovolcanic complexes (Fig. 1). The Sb-hydro-thermal mineralisation of the Western Carpathian is genetically related to the Variscan and Alpine orogenic cycles.

Our study is focused to the investtigation of the Pb origin in hydrothermal fluids and to the problems of polycyclic ore formation during orogenic cycles with respect to the model ages. The calculation of model age and the geochemical environment parameters are mostly restricted to the^{206}Pb/^{207}Pb ratio and the μ value. In this paper, the ^{206}Pb/^{208}Pb data and the W value are additionally in discussion.

Previous Pb isotope studies (Kantor & Rybár, 1964; Černyšev et al., 1984) in Western Carpathian have shown that there are various isotope ratios in galena from hydrothermal mineralisation. They suppose a Variscan age of the majority of Sb-mineralisation. Contamination with radiogenic lead give J-anomalous ages. The ages from the Gemeric unit (Černyšev et al., 1984) are explained as a conseqence of the mobilisation of the lead from the rocks of Gelnica group into the crosscuting veins. Very slight contamination with younger lead indicates Early Paleozoic age of the mineralisation; witch may be close to that of the Cambro-Silurian volcanogenic massive sulphide ores.

There are several different models of lead isotope evolution (e. g. plumbotectonics Doe & Zartman, 1979 model; Stacey & Kramers, 1975 model etc.). The most important disadvantage of the Stacey & Kramers (1975) model is that the unknown parameters in the equation of this two-stage model are μ_1, t_1, μ_2 and t_2 and only two of them (μ, t) can be determined from the two equations of the uranogenic lead and only one from the equation of the thorogenic lead. In some models (e. g. Amov, 1983 a, b) attempts have been made to relate the lead isotope evolution to the geodynamic development of the crust and the mantle and the interaction between them.

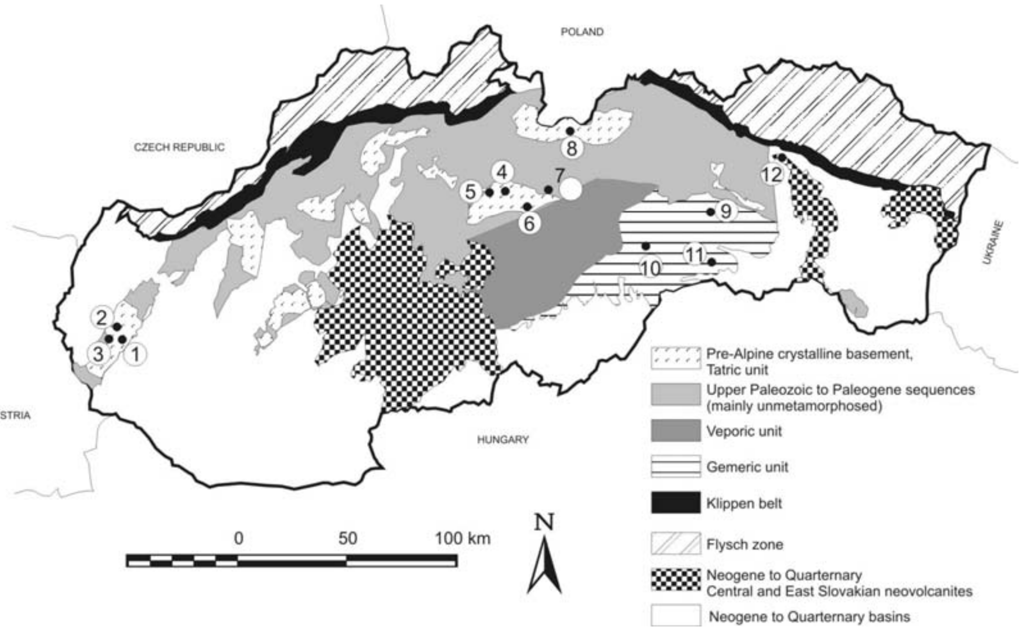

Figure 1. Schematic map of Western Carpathians with the position of the studied deposits and occurrences. Explantations to Fig. 1-5: A - Malé Karpaty Mts. 1-Pezinok, 2-Kuchyňa, 3-Pernek-Pod Krížnicou; B-Nízke Tatry Mts. 4-Dúbrava, 5-Malužiná, 6-Magurka, 7-Mlynná Dolina Valley; C-Tatry Mts. 8-Kriváň; D-Spiš-Gemer Mts. (Gemeric unit) 9-Helcmanovce, 10-Grexa, 11-Poproč, E-Eastern Slovakian Neovolcanites 12-Zlatá Baňa

1.1. Geological setting and metallogeny of units

1.1.1. Tatric unit

The Tatric basement has in general well preserved Variscan structures without a significant Alpine overprint. The basement is mainly composed of crystalline rocks: medium- to high-grade metamorphis Early Paleozoic volcano-sedimentary complexes – paragneisses, mica-schists, orthogneisses and amphibolites, and phyllites in the Malé Karpaty – and several suites of Variscan granitoides intruding mostly the high-grade gneiss-migmatitic complexes. The crystalline basement units are incorporated into several thick Variscan nappe structures (Plašienka et al., 1997).

The origin of high temperature scheelite and molybdenite mineralisation and mesothermal quartz-pyrite, arsenopyrite-gold mineralisation are related to both, Variscan metamorphism and granitoid intrusions (320-360 Ma). The epithermal stibnite mineralisation is regionally most abundant and of economic importance. Younger carbonate (with quartz and sulphides) and barite minerali-sation were formed and/or remobilised during the Alpine orogeny (Slavkay et al., 1994). Data about the mineralisation age are not available.

The Sb mineralisation form both vein-type (e.g. Dúbrava, Magurka, Čučma, Poproč) and strata-bound (e.g. Pezinok, Kuchyňa) mineralisation. The Sb-mineralisation is represented predominantly by stibnite, but gudmundite, berthierite and native antimony are too relatively common in some deposits. The age of the Sb-containing hydrothermal mineralisation in Variscan basement is not satisfactory explained. Most of the authors accept the possibility of a Variscan age of the high temperature assemblages (scheelite, molybdenite, arsenopyrite, gold, pyrite), and most likely also substantial part of the stibnite. They assume connection with Variscan magmatic and/or metamorphic processes. The Alpine rejuvenisation however, had an important role (Hurai et al., 2002a). The age of the Sb-Neovolcanic mineralisation is considered to be of Badenian/ Sarmatian.

The geological structure of the Malé Karpaty Mts. is characterised by several superposed Alpine nappes. The deeper units consist of a pre-Alpine basement and Mesozoic cover rocks, the higher nappes are composed exclusively of Mesozoic sediments (Plašienka et al., 1991). The crystalline complex developed from Ordovician? - Devonian volcano-sedimentary formations are composed of pelitic-psammitic flyschoid formation and the volcano-sedimentary formations, noc-sisting of basalts and their tuffs, black schists, carbonates, and sometimes also gabbros and gabbro-diorites.

The whole complex subjected to a low-grade regional metamorphism in Devonian (380 ± 20 Ma, Rb-Sr data) and later to contact metamorphism around intrusions of Late Variscan granitoids (348 ± 4 Ma, or 320±3 Ma, Rb-Sr and U-Pb data, respectively; Cambel et al., 1990).

In Malé Karpaty Mts. were described several Sb-deposits (Pezinok and Pernek) and numerous occurrences (Kuchyňa, Trojárová etc.) of Sb mineralisation (quartz, carbonates, stibnite, gudmundite, berthierite, arsenopyrite, pyrite, pyrrhotite). Sb mineralisation is accompanied by other space- and time-related mineralisation, e. g. Pb-Zn mineralisation in the Pod Babou area and carbonate with Cu (±Ni-Co, Pb, Sb, Ag) sulphide mineralisation in Častá (Chovan et al., 1992). It has been assumed that metals were mobilised by peterating fluids not only from black schists, but also from the synsedimentary sulphidic mineralisation and sedimentary-volcanic rocks.

Nízke Tatry Mts. crystalline complex is composed of Variscan granitoides and medium to high-metamorphosed rocks (migmatites and various gneisses and amphibolites). The crystalline complex was overthrusted by Mesozoic napps. Most of the vein deposits are situated in regionally mylonised Variscan shear zones (about 330 Ma according to ^{40}Ar/ ^{39}Ar muscovite dating), both in the granitoides and the metamorphic rocks, but they were reactivated during the Alpine (80 – 100 Ma) orogeny (Dallmeyer et al., 1996). Alpine tectonic-metamorphic events caused weak retrograde metamorph-ism (Petrík et al., 1994).

Formation of hydrothermal Sb-minerali-sation was predated by hydrothermal alteration of host rocks. Gradual decrease of homogenisation temperatures and salinity of fluid inclusions indicates influx of meteoric water into fluids responsible for the formation of stibnite, tetrahedrite and barite. Generally, the δ^{34}S values for the sulphide minerals suggest significant influence of mantle-derived sulphur with signs of gradual fluid mix-ing and contamination by recycled crustal sulphur, which played an important role during crystallisation of later sulphides, including stibnite. The vein mineralisation consists of: quartz, carbonates (barite), scheelite, native gold, pyrite, arsenopyrite, molybdenite, stibnite, Ag-tetrahedrite, bournonite, chalcopyrite, sphalerite, zinckenite, and Pb-Sb and Pb-Sb-Bi sulphosalts and other ore minerals as hematite, magnetite etc. (Chovan et al., 1996).

1.1.2. Gemeric unit

The Gemeric unit consists mostly of Early Paleozoic low-grade metamorphic complexes. These volcano-sedimentary groups form the south-vergent basement nappes which are crosscut by numerous Permian granites (290 ± 40 Ma to 145 ± 6 Ma, Rb/Sr data – Cambel and Kráľ, 1989; Ar/Ar data – Vozárová et al., 2000; Permian ages by U/Th – total lead determination on monasites – Finger & Broska, 1999), although part of them (granite body at Rochovce) can be of Cretaceous age (Hraško et al., 1995; Poller et al., 2001).

Overlying Late Paleozoic (Carboniferous, Permian) and Mesozoic lithological sequences are preserved in the periphery of the unit (Grecula, 1982).

The Gemeric basement complexes as a part of the Variscan chain represent a characteristic fold and thrust belt formed during the Late Variscan accretion of the Gondwana-related fragments to the southern margin of the northern Variscan plate. Alpine reactivation of the Gemeric basement units occurred at lower temperatures and medium pressures (Faryad, 1997) due the shortening of passive continental margin of the Meliata Ocean following the southward subduction of oceanic crust. Structural analysis of Cretaceous collision was published by Lexa et al. (2003). The Alpine thrust and later transpressional and extensional tectonics (like in the South-Veporic domain) played the decisive role also in metal vein forming processes.

The Paleozoic evolution of the Gemeric unit occurred in a riftogenous sedimentary area where single rifting stages determined the characteristic features. The high thermal flux in the rifting area of the Early Paleozoic basin, namely in its part, where oceanic or thin continental core created the bottom, caused not only stronger magmatic and metamorphic activity but also ore deposition (Grecula et al., 1995).

Significant source of metals (Sb, Pb, Zn, Cu, As, Ag, Ni) were rocks from which circulating solutions in later metallogenetic processes mobilised and transported the elements. Hydrothermal and exhalative sedimentary ores have by Lower Devonian metamorphism been reworked during the Variscan time (Grecula et al., 1995).

Within the hydrothermal veins the following mineralisation is distinguished: magnesite, siderite, quartz-sulphide and quartz-stibnite phases (Varček in Grecula ed., 1995). Antimony in the Gemeric unit is bound especially to the Au-quartz-stibnite and polysulphide mineralisation but also in the siderite veins in tetrahedrite.

Progressively increasing fluid pressures and temperatures during crystallisation of veins and drusy siderite in the Gemeric unit could be attributed to a compressional regime and crustal thickening triggered by Jurassic subduction or to a continental collision during Middle Cretaceous times (Hurai et al., 2002b). The quartz-stibnite phase is considered to be younger (Varček in Cambel & Jarkovský, 1985; Grecula, 1995). According to microprobe U – Pb–Th dating of monazite, the stibnite-bearing veins formed during early Cretaceous thrusting of the Gemeric basement over the adjacent Veporic unit. The low thermal gradients and the CO_2-CH_4-N_2 composition indicate metamorphogenic origin of fluids. (Urban et al., 2006). To this group of Sb-deposits belong also Betliar – Čučma and Poproč.

1.1.3. Eastern Slovakian neovolcanites

The volcanic complexes in Central and East Slovakia are situated at the inner side of the Western Carpathian arc. These regions represent a part of the Cenozoic volcano-plutonic suite (Carpathian segment) that exhibits affinity to a subduction zone and to the existence of mantle diapirism. Calderas and grabens were developed in the regions of polygene stratovolcanoes and/or horsts as a result of a deep-seated intrusive activity (12.05 Ma K/Ar for pyroxene-amphibolite-diorite porphyry; Ďurica et al., 1978). The Middle Miocene - Pliocene stratovolcanic complex Zlatá Baňa (10.0 – 11.95 ± 1 Ma K/Ar, Ďurica et al. 1978) show transitional character between active continental margin and island arc type magmatic rocks (Kaličiak, 1977).

The occurrences of the Sb-mineralisation are related to the rim of the central colapse zone of the strato-volcano. In altered andesite complex is possible distinguish: a) quartz veins and b) stockworks with disseminated ores. The mineral paragenesis is as follows: quartz, stibnite, jamesonite, boulangerite, berthierite, arsenopyrite, pyrite and marcasite (Burian et al., 1985).

2. SAMPLING AND ANALYTICAL CONDITIONS

The electron microprobe analyses of stibnite, gudmundite and galena samples enabled select monomineral samples without mineral inclusions for Pb-isotope study. Pb content was determined by AAS analysis in flame air/C_2H_2 using spectrophotometer PU-9000 Pye Unicam/ Philips.

The chemical preparation of the samples was made in the laboratory of The State Geological Institute of Dionýz Štúr in Bratislava. The isotopic composition of lead was measured in static multicollector mode (Faraday collectors, 50 ratios, filament temperature 1200 – 1250 °C) on VG Sector 54E thermal ionisation mass spectrometer installed at the Institute of Geological Sciences, Polish Academy of Science, Warsaw. During the period of analyses, 11 analysis of SRM-981 standard yielded the fol-lowing ratios $^{206}Pb/^{204}Pb = 16.941 \pm 0.015$, $^{207}Pb/^{204}Pb = 15.499 \pm 0.020$, $^{208}Pb/^{204}Pb = 36.721 \pm 0.063$. All measured ratios in Table 1 were corrected by a fractionation factor of 800 ppm on the basis of the SRM-981 analyses. The corrected measurements yield 2σ-error of ±0.004% for $^{206}Pb/^{204}Pb$, ± 0.008% for $^{207}Pb/^{204}Pb$ and ± 0.1% for $^{208}Pb/^{204}Pb$.

Additionally to the Pb/Pb ratios, the environmental factors (μ_2), W_2 and the model ages of uranogenic and thorogenic lead, t(U) and t(Th) and TGa are used for representation. Pb growth curves, and the isochrons were calculated using the mathematical modelling of the continuous lead isotope evolution according to Amov (1983a, b). The 2σ -error are ±0. 8 (μ_2), ± 0.7 (W_2), refered to ± 20 Ma t_2(U) and ± 40 Ma t_2(Th).

3. RESULTS

Table 1 lists the Pb isotope data of the sample set from studied Western Carpathian Sb-mineralisation. The $^{206}Pb/^{204}Pb$ ratio in samples from Tatric unit vary from 18.292 to 18.747, those from Gemeric unit fluctuate in range from 18.560 to 18.737 and in the single sample from Eastern Slovak neovolcanites is 18.878. The samples from the Gemeric unit and from Eastern Slovak neovolcanites seem to be more radiogenic. The first impression when plotting the results on the Amov (1983a,b) Pb-Pb diagrams (Fig 2) is that within the Tatric unit is possible recognise two partly overlaped populations: the first one characterise Malé Karpaty Mts. ($^{206}Pb/^{204}Pb$ = 18.378 – 18.747) and the second one ores from Nízke Tatry Mts. ($^{206}Pb/^{204}Pb$ = 18.292 – 18.511). The single sample from Tatry Mts. is close to the data from Malé Karpaty Mts.

The $^{207}Pb/^{204}Pb$ ratio vary in the Tatric unit from 15.593 to 15.705, in Gemeric unit from 15.648 to 15.696 and the $^{206}Pb/^{204}Pb$ ratio in stibnite from Zlatá Baňa deposit (Eastern Slovak neovolcanites) is 15.680 (Table 1, Fig. 2).

The composition of $^{208}Pb/^{204}Pb$ isotopes enable distinguish two basic clusters both on Amov (1983a,b) Pb-Pb diagram (Fig. 3): the first one for the samples from the Tatric unit ($^{208}Pb/^{204}Pb$ = 38.133 – 38.700) and the second one for samples from Gemeric unit ($^{208}Pb/^{204}$ Pb = 38.956 – 39.111) and from Eastern Slovak neovolcanites ($^{208}Pb/^{204}Pb$ = 39.044).

The lead isotope composition of all investigated stibnite, gudmundite and galena samples from Western Carpathian show that the μ_2 values ($^{238}U/^{204}Pb$) are between the evolution curves of orogenic and upper crustal lead (Fig. 2, 3).

Table 1 Pb isotope data in stibnite and galena, Western Carpatian (Slovakia)

Locality	Locality No.	Mineral	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	TGa	t(U) Ma	t(Th) Ma
Tatric unit								
Malé Karpaty Mts.								
Pezinok	1	stibnite	18.638	15.702	38.542	3.278	91	255
Pezinok	1	stibnite	18.553	15.677	38.442	3.230	148	274
Pezinok	1	stibnite	18.471	15.661	38.352	3.203	201	301
Pezinok	1	stibnite	18.626	15.698	38.532	3.270	99	254
Pezinok	1	gudmundite	18.480	15.646	38.468	3.166	196	218
Pezinok	1	stibnite	18.557	15.637	38.319	3.134	149	273
Pezinok	1	gudmundite	18.747	15.702	38.533	3.265	20	251
Kuchyňa	2	stibnite	18.379	15.705	38.535	3.318	257	284
Pernek	3	stibnite	18.520	15.620	38.133	3.098	173	344
Nízke Tatry Mts.								
Dúbrava	4	stibnite	18.511	15.666	38.523	3.209	175	219
Dúbrava	4	stibnite	18.442	15.688	38.700	3.270	218	169
Dúbrava	4	stibnite	18.336	15.593	38.181	3.059	289	293
Dúbrava	4	stibnite	18.414	15.608	38.303	3.084	240	248
Dúbrava	4	stibnite	18.443	15.625	38.317	3.121	221	265
Dúbrava	4	stibnite	18.502	15.625	38.404	3.113	184	215
Magurka	5	stibnite	18.462	15.664	38.630	3.090	316	224
Magurka	5	stibnite	18.382	15.664	38.630	3.211	207	166
Mlynná Dolina	6	galena	18.292	15.603	38.357	3.222	57	173
Malužiná	7	galena	18.410	15.687	38.603	3.267	238	217
Tatry Mts.								
Kriváň	8	stibnite	18.594	15.677	38.638	3.228	121	171
Gemeric unit								
Spiš-Gemer Mts.								
Helcmanovce	9	stibnite	18.737	15.696	39.111	3.253	27	-52
Grexa	10	stibnite	18.589	15.656	39.012	3.176	127	-51
Poproč	11	stibnite	18.560	15.648	38.956	3.160	146	-36
Eastern Slovakian Neovolcanites								
Slánske vrchy Mts.								
Zlatá Baňa	12	stibnite	18.878	15.680	39.044	3.199	-63	-54

Samples from Malé Karpaty Mts. are closer to the upper crustal lead curve and the samples from Nízke Tatry Mts. contain inconsiderable greater portion of orogenic lead. Some samples yield μ_2 values higher than the average crust value (9.74). Samples from Kuchyňa (μ_2 = 10.15) and Magurka and deposits are close to the upper crustal lead (μ_2> 10). Their heterogenity within some single deposits (e. g. Pezinok, Dúbrava) indicate the importance of the fluid mixing during the origination of the vein formation and suggest that the lead was leached from the granitic and metasedimentary host rocks.

The comparison to the Amov (1983 a,b) $^{207}Pb/^{204}Pb$ vs. $^{206}Pb/^{204}Pb$ (Fig. 2) and $^{207}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$ (Fig. 3) plots the results are quite different for model ages of thorogenic lead (Fig. 4), since the crustal lead prevail in the investigated samples. If we exclude the extreme values, the model ages of Sb-mineralisation from Malé Karpaty Mts. Range from 91 – 201 t(U)Ma and 251 – 301 t(Th)Ma, in Nízke Tatry Mts and Tatry Mts. From 121 – 189 t(U)Ma and 169-265 t(Th)Ma. The model ages of Sb mineralisation from Spiš-Gemer Mts. are 127 t(U)Ma and -51 t(Th)Ma and from Zlatá Baňa deposit -63 t(U)Ma and -54 t(Th)Ma (Table 1).

Pb-Pb model ages do not substiute geochronological data. The different model ages can not be related to different chronological events but also to a same event during which lead has been derived from different reservoirs or from mixing in different proportions of several reservoirs.

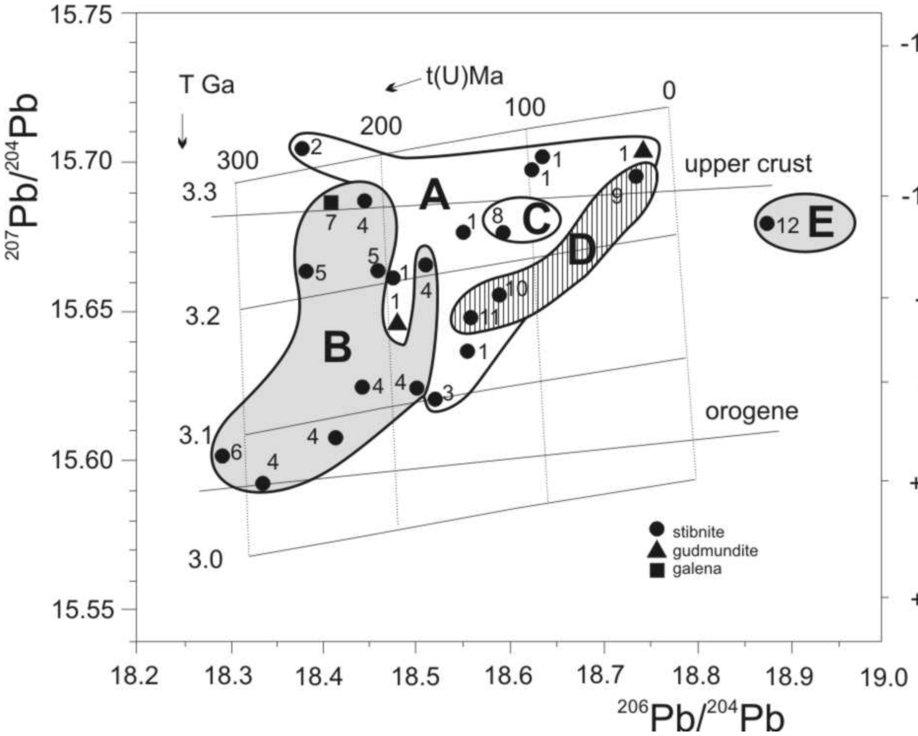

Figure 2. Evolution diagram of $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$ - isotopic composition in Sb-minerals and galena (according to Amov, 1993) from Western Carpathian.

Deposits and occurrences (explantation to figs. 2 - 4) A – Malé Karpaty Mts. 1-Pezinok, 2-Kuchyňa, 3-Pernek-Pod Krížnicou; B - Nízke Tatry Mts. 4-Dúbrava, 5-Magurka, 6-Mlynná Dolina Valley, 7-Malužiná C - Tatry Mts. 8-Kriváň; D - Spiš-Gemer Mts. (Gemeric unit) 9-Helcmanovce, 10-Grexa, 11-Poproč; E - Eastern Slovakian Neovolcanites 12-Zlatá Baňa

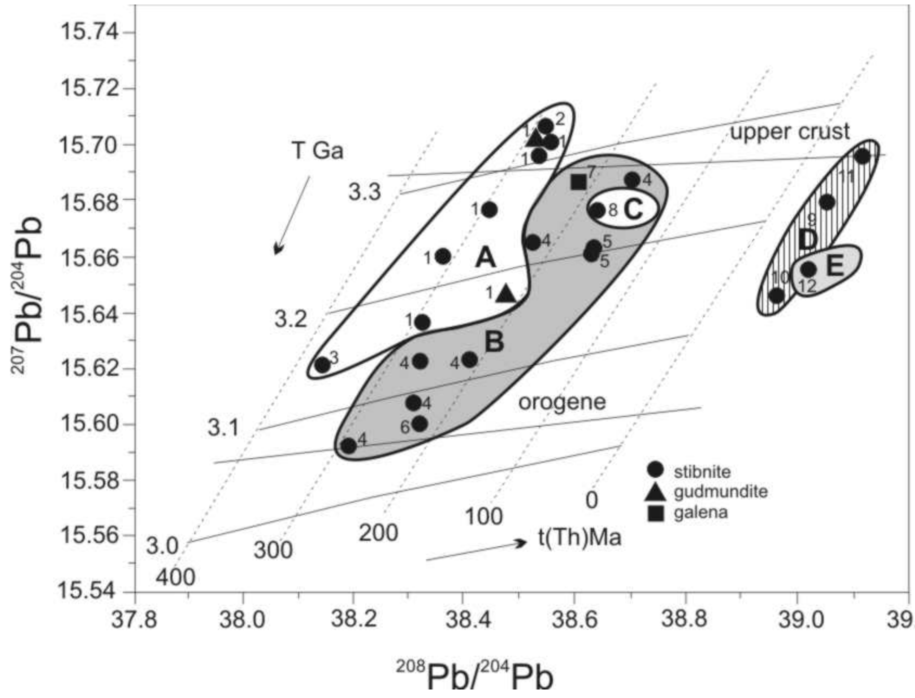

Figure 3. Evolution diagram of $^{208}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$ - isotopic composition in Sb-minerals and galena (according to Amov, 1993) from Western Carpathian.

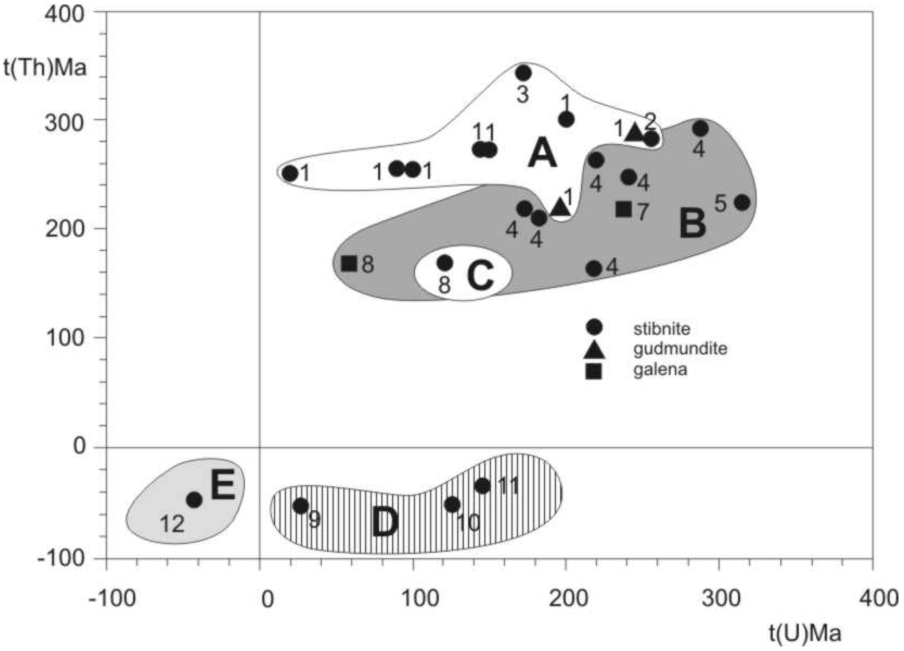

Figure 4. Comparison of uranogenic t(U)Ma and thorogenic t(Th)Ma model ages

Without real radiometric dating (e.g. U/Pb, Sm/Nd, Os/Re etc.) is the exploitation of the Pb-Pb model ages questionable.

The data in table 1 and at figue 4 show t(Th)Ma > t(U)Ma for the mineralisation in Malé Karpaty Mts., which could be explained with an earlier fluid enrichment of U^{6+} in the sources rocks. For mineralisation with lower $^{207}Pb/^{204}Pb$ in the Nízke Tatry Mts. t(U)Ma ~ t(Th)Ma ~ tTh Malé Karpaty Mts. and they are close to the age of intrusions. Most probably this is the real age of mineralisation, related to the intrusions and post-intrusion events during the Carboniferous – Permian. The lower t(Th)Ma for mineralisation with higher $^{207}Pb/^{204}Pb$ in Nízke Tatry Mts, as well as in Gemeric unit, could be explained with a higher content of Th in the granites from these regions.

On the other hand, unlike the Sb-mineralisation from Gemeric unit (and Eastern Slovakian Neovolcanites), some model ages in stibnite from Tatric unit, e. g. from Pezinok – 301 t(Th)Ma, Pernek – 344 t(Th)Ma, Dúbrava – 293 t(Th)Ma and Magurka – 316 t(U)Ma indicate originally Varican age of mineralisation.

4. DISCUSSION

The lead in the stibnites from the Tatric and Gemeric units seems to be derived from different reservoirs. The samples from Gemeric unit and from the Zlatá Baňa neovolcanic deposit have highest $^{208}Pb/^{204}Pb$ values while the samples from Grexa and Helcmanovce show lover $^{207}Pb/^{204}Pb$ ratios. This shows different mixture of crustal and mantle materials and a later enrichment in μ ($^{238}U/^{204}Pb$) and W ($^{232}Th/^{204}Pb$), i. e. during younger events, e. g. metamorphosis, mobilisation of metals, recrystallisation etc. Similar data (ore mineralisation in Baia Mare district was formed by successive mineralising events) were published also from the Romanian Carpathian Mountains by Marcoux et al. (2002). Some leads yield μ_2 values higher than the average crust value (Fig. 2, 3). Samples from Kuchyňa and Magurka deposits are close to the upper crustal lead (μ_2> 10). For sample with lower $^{207}Pb/^{204}Pb$ ratios (15.593 – 15.637) i. e. near to the orogenic growth curve (Table 1, Fig. 3), the model ages of thorogenic lead (Table 1, Fig. 4) are higher and more reliable and vice versa: at higher $^{207}Pb/^{204}Pb$ ratios (15.646 – 15.705) near to the growth curve of upper crust.

Pb-Pb model ages are for the reason of great Pb-mobility in ores not considered. Usually, for orogenic lead source the calculated model ages t(U)Ma and t(Th)Ma (Table 1, Fig. 4) are close to the real age, but they differ for other type of sources (upper crust, lower crust and mantle; Amov, 1983a, b).

The model ages of thorogenic lead are implicated with the U/Th ratio of the geochemical environment and the different geochemical behavior of both elements. Because of the less migration ability of Th than U under fluids (Rollinson, 1998), the model ages of thorogenic lead are less influenced by younger events than of uranogenic lead.

In a previous study, the comparison of lead isotope data of galena from the Eastern Alps and the

Western Carpathians illustrated the characteristics of lead isotope data in these metallogentic provinces (Andraš et al., 2000). The model ages of uranogenic lead of galena of deposits affilated with magmatogenic rocks, e.g., hydrothermal deposits in granitic environment or volcanogenic massive sulphides (VMS) deposits, are generally conformable with the geochronological system and tend to real model ages (N-type). Leads displaying anomalous negative model ages of uranogenic lead (J-type) are typical in the Eastern Alps due to the more intensive Alpidic metamorphism. In heritance of the pre-Alpidic basement effects anomalous old ages (B-type) (Schroll et al., 1999).

Mostly, in the crustal sources isotopic anomalies occur in uranogenic lead. These anomalies can be explained with the change in the valent state of uranium from U^{4+} at reductive conditions in the mantle to U^{6+} at oxidative conditions in the crust, whereas the valent state of thorium is only Th^{4+}. The U^{6+} chemical compounds are soluble in water and therefore the U^{6+} migrates easily than Th^{4+} (Rollinson, 1998). The anomalous model ages of uranogenic and thorogenic lead reflect different geochemical conditions in the sources of the rocks and ores and a better interpretation of these anomalies provides useful information for the genesis of rocks and ores.

The distribution of lead isotopes in galena, published by Kantor and Rybár (1964) and Černyšev et al. (1984) show identical patterns of metamorphic proces-ses and these data are closed to these for orogenic lead in the Doe and Zartman (1979) model. For a consideration of Pb-Pb model ages calculated according to Stacey and Kramers (1975) connection between Sb-mineralisation in crystalline complexes of Tatric unit and Variscan magmatism was assumed as far back up as Černyšev et al. (1984). On the other hand Černyšev et al. recognised the possibility of lead remobilisation from the orriginally Variscan mineralisation during the neoid metallogenesis.

5. CONCLUSIONS

The original source of the lead from the Sb-deposits of the Western Carpathians is not homogenous. The orogenic lead ($\mu_1 = >9.74 - 10.15$) was predominantly derived from crustal and upper crustal granitic and meta-sedimentary wall rocks or from related material. The composition of Pb isotopes enable distinguish two basic Sb-deposit groups: the first one for the samples from the Tatric unit (Pezinok, Pernek, Kuchyňa, Dúbrava, Magurka, Mlyná Dolina Valley, Kriváň) and the second one for samples from Gemeric unit and from Eastern Slovak neovolcanites (Grexa, Helcmanovce, Poproč, Zlatá Baňa).

The model ages of the Sb-mineralisation are influenced by younger events. The age of Sb-mineralisation from Tatric unit seems to be Variscan and is close to the age of intrusions. These ores were later remobilised during neoid metallogenesis or other younger events. The lower t(Th)Ma for mineralisation from Gemeric unit, could be explained with a higher content of Th in the granites or the model ages reflect the real younger age of this mineralisation.

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