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Archean Crust as a Source of Common Lead in the Bohemian Massif

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With 6 Text-Figures and 1 Table

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Böhmische Masse
Geochronologie
Krustenentwicklung
Blei-Isotope

Contents

Archäische Kruste als Quelle gewöhnlichen Bleis in der Böhmischen Masse

Zusammenfassung

Die Isotopen-Zusammensetzung von gewöhnlichem Blei in der Böhmische Masse zeigt, daß die Kruste sich aus überprägter archäischer Kruste entwickelte. Das an thorogenen Isotopen angereicherte Blei wird durch Migmatisierung und Magmatismus erklärt und ein Homogenisierungsereignis vor 1.200 Mio Jahren vermutet.

Abstract

The isotopical composition of common lead indicates that the crust of the Bohemian Massif developed from the reworked Archean crust. The common lead enriched in thorogenic lead indicate that the strongly metamorphosed crustal material prevailed in the source.

1. Introduction

The regionally sampled isotopic data of common lead beside the model age estimations have proven useful in
1) metallogenetic analysis: HEYL et al. (1974), KUO and FOLINSBEE (1974), CHURCH et al. (1986),
2) in geological blocks definition: PATOČKA et al. (1984) and
3) in geotectonic considerations: DOE and ZARTMAN (1979), KÖPPEL (1983).

For the metallogenetic analysis the method of clustering of similar isotopic compositions called the finger print method is mostly used (GULSON, 1983) and the source of ore minerals from specified country rocks can be defined. The liaison of the defined isotopical composition to specified horizons or blocks can be evaluated in the terms of tectonostratigraphical blocks and terranes. The fact that the isotopical composition of lead may reflect the geotectonic history was successfully employed by DOE and ZARTMAN (1982) and the geotectonic reservoirs called mantle, old crust, orogen – with mixed lead and upper crust were separated by these authors. A further step in

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the evaluation of the isotopic evolution of common lead is the continuous dynamic model of AMOV (1983). This model was used in the present study of the isotopical composition of common lead in the Bohemian Massif and will be described in more detail.

2. The Dynamic Model of AMOV (1983)

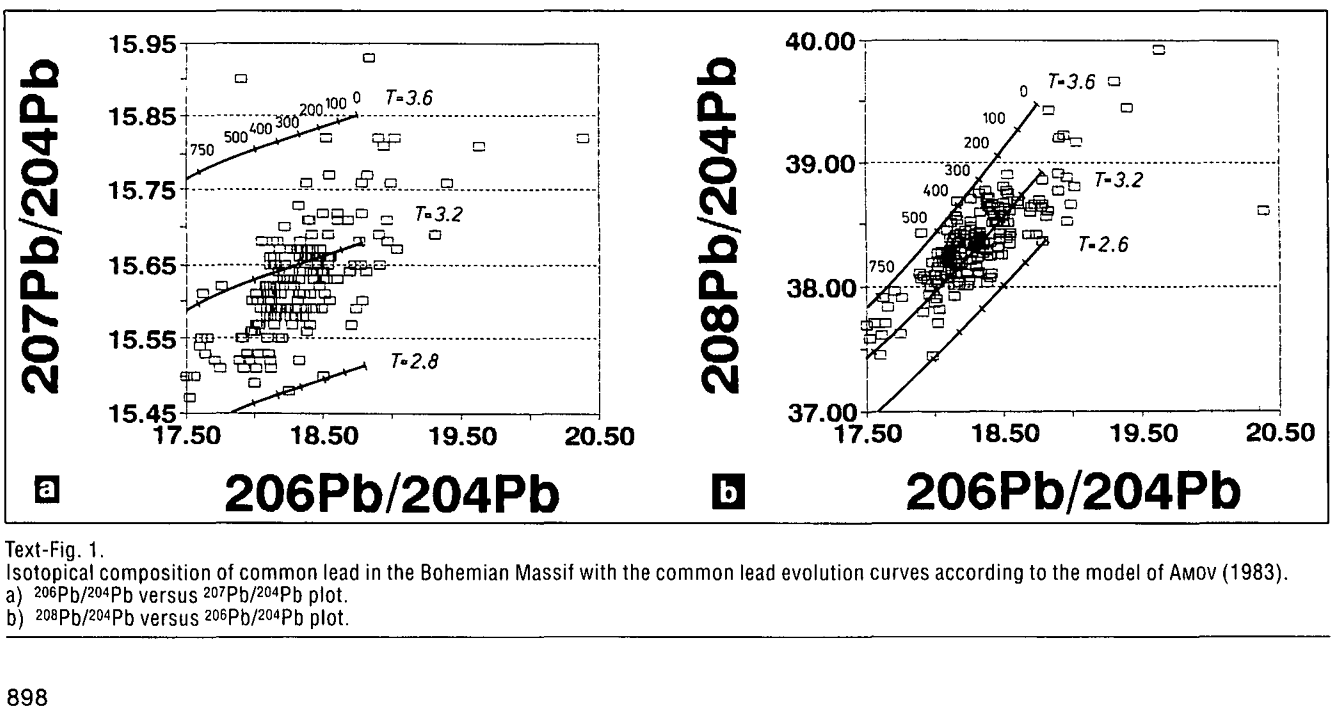
The model of AMOV (1983) is based on the assumption that as a result of chemical fractionation U, Th and Pb accumulated predominantly in the Earth's crust so that the U/Pb, Th/Pb, $\mu = {}^{238}U/{}^{204}Pb$ and $W = {}^{232}Th/{}^{204}Pb$ increased in the course of the geological time. The other assumption is that the temperature is the main factor determining the intensity of chemical fractionation and exchange of materials between the different crustal and mantle layers from which it is logical to assume that the μ and W rates of change increased in the initial stages of the Earth's differentiation and after attaining a maximum started decreasing because of the surface cooling of the Earth. The maximum was attained earlier in the upper crustal layers, whereas in the lower layers it was attained later or not at all, since the latter cooled more slowly. The transition from increasing to decreasing μ and W rates of change in a given layer of the crust can be connected with its having been formed from mantle and reworked older crustal materials. In the model the tm and T parameters are calculated and they indicate the source-type. The time tm in the model, when the μ and W rates of change attained their maximums is a model parameter, depending on the age of formation of the different layers of the crust or, in mixing processes, on the participation of materials from the older or younger crust and mantle. The tm parameter indicates thus the residence times of lead in different reservoirs such as mantle, old and younger crust during the earlier crustal evolution and it is similar to ϵ_{Nd} values. For the tectonic considerations the residence time tm brings other information than the mineral ages reported for instance by zircons which indicate mainly the last thermal reworking (fusion). The T value may be compared with the a, b and c curves of DOE & ZARTMAN (1982) characterizing tectonic environment. The T parameter can be in this way accepted as an effective (weighted mean) value that depends on the amount of materials from an older or younger crust or from the mantle. The common lead isotopic composition can be used in this way as the geochemical indicator of crustal evolution in the given region. For the Phanerozoic time the model parameter T has the following values for the three main zones i.e. $T = 3.35$ b.y. for the upper continental crust, $T = 3.1$ for the orogene and $T = 2.7$ b.y. for the mantle.

3. Data

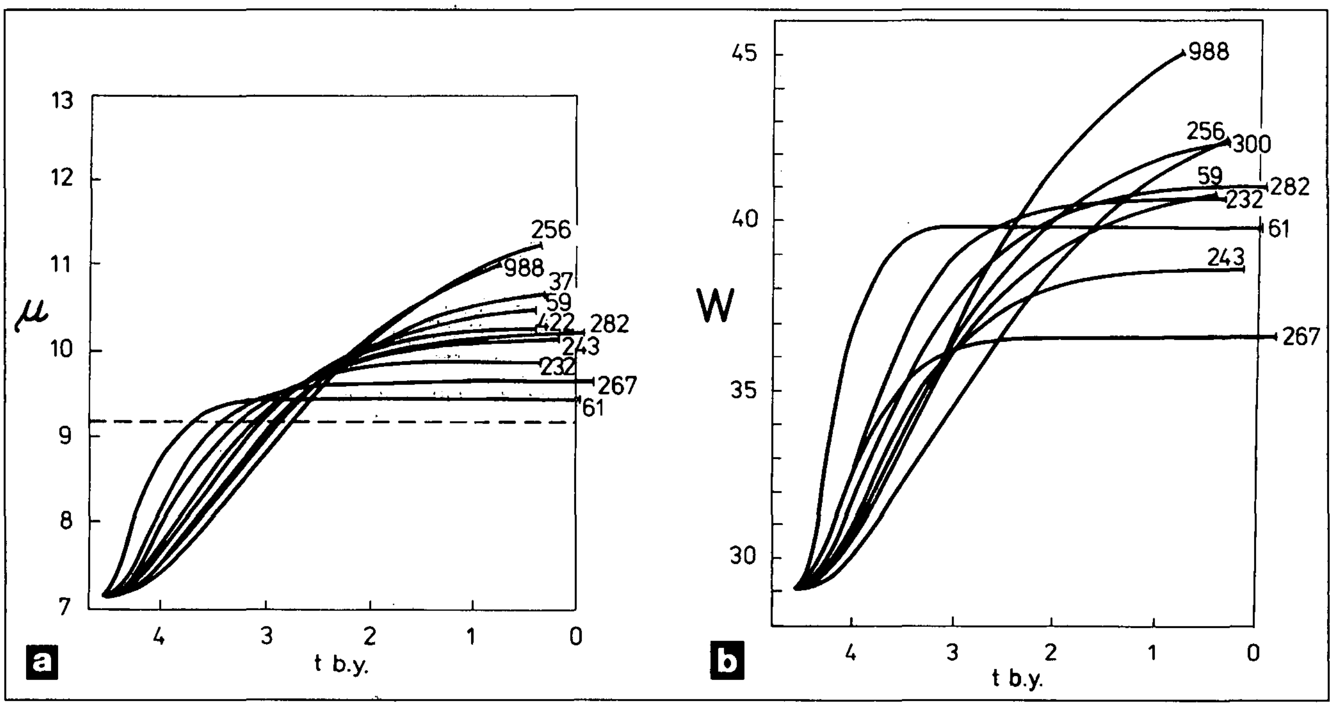
A total number of 271 published and unpublished analyses of ore lead compositions from 185 localities of galena mineralizations of the Bohemian Massif represents the basic data file processed in this study. Data on the isotope composition of ore Pb used, have been obtained in the Isotope Geology Laboratory of the Geological Survey, Prague. They are taken from published and unpublished reports of LEGIERSKI (1967, 1971, 1973), LEGIERSKI and VANĚČEK (1965), BERNARD et al. (1979) and POŠMOURNÝ and LEGIERSKI (1981). As several samples from the same deposit were measured, the mean values were calculated and resulting set of 185 localities (representing the original 271 analyses) was processed. The maximal error of the estimation of the isotopical composition can be due to older techniques as high as 0.5 %, see also RAJLICH et al. (1983). The values of LEGIERSKI before processing were recalculated to values of DOE and ZARTMAN (1979), using the galena from Bleiberg. The constants are 0.99512 for the $^{206}Pb/^{204}Pb$, 0.99052 for the $^{207}Pb/^{204}Pb$ and 0.99793 for the $^{208}Pb/^{204}Pb$ ratio.

4. Ore Lead Isotope Characteristics of the Bohemian Massif

The data are summarized in the Table 1 and Figs. 1a, 1b. An important feature of the Bohemian Massif is the similar isotope composition of Pb of the ore deposits differing substantially in mineralogy and structure, such as vein-type and strata bound base metal deposits or Pb-Zn vein deposits and greisen stock Sn deposits (containing a



Text-Fig. 1.
Isotopical composition of common lead in the Bohemian Massif with the common lead evolution curves according to the model of AMOV (1983).
a) $^{206}Pb/^{204}Pb$ versus $^{207}Pb/^{204}Pb$ plot.
b) $^{208}Pb/^{204}Pb$ versus $^{206}Pb/^{204}Pb$ plot.

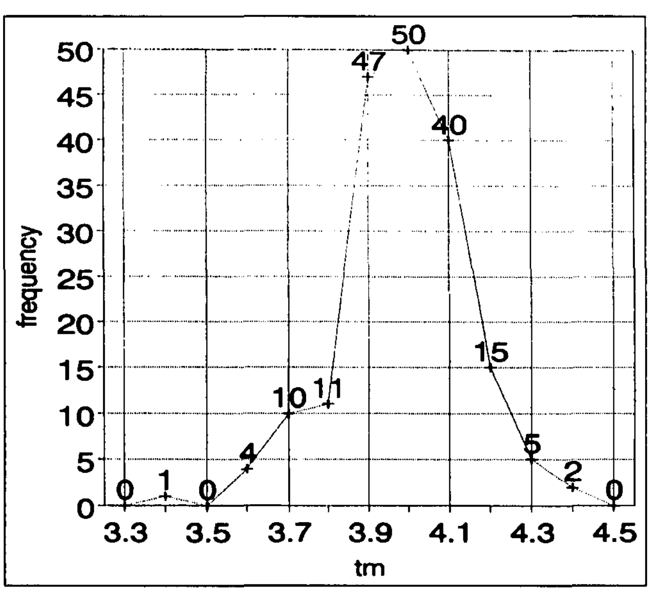


Text-Fig. 2.
a) Selected *tm* curves of the uranogenic common lead from the Bohemian Massif. The heavy dashed line indicates the value $\mu = 9.21$. The limit for Archean crust development, with greater acceleration of the μ increase is around $tm = 4.0$.
b) Selected *tm* curves of the thorogenic common lead from the Bohemian Massif.

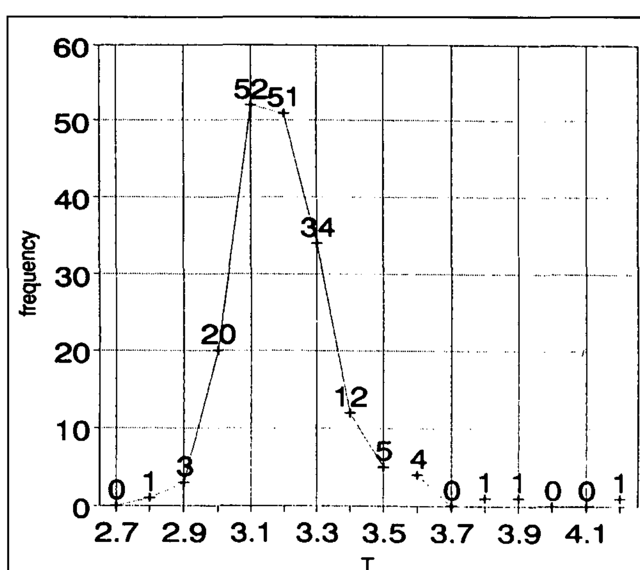
negligible amount of Pb minerals). This similarity seems to favor the idea of a common source of lead in ore deposits of various genetic types and the derivation of Pb from country rocks.

According to the frequency curve from Fig. 4 which is centered around the *T* value ≈ 3.1 with broader symmetrical parts comprising mainly upper continental crust and with the complete drop in the mantle field, the common lead of Bohemian Massif is mainly of orogene type with some participation of lower and upper crustal lead. This points to the dominant influence of a crustal source of ore lead. The data in the $^{208}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ diagram (Fig. 1b) plot closer to the orogenic curve $T = 3.2$. than the same diagram for uranogenic leads. This phenomenon noted also as older ages for the thorogenic lead by HÖHNDORF and DILL (1986) can be possibly explained as due to the derivation of lead from metamorphic rocks depleted in U as a result of high-grade metamorphism, WEDEPOHL et al., (1978), see also KÖPPEL and GRÜNENFELDER (1982), VANĚČEK et al. (1985).

Following to the *tm* value the lead shows almost continuous transition from the old (Archean) crustal source typical with high acceleration of μ in the initial stages of development (curves 61, 243, 232, 267) to the curves with incorporated younger crust (37, 59, 256, 282, 422, 988). The boundary *tm* value of this transition is $tm \approx 4.0$ and the fre-



Text-Fig. 3.
Frequency curve of the *tm* values of the common lead of the Bohemian Massif.



Text-Fig. 4.
Frequency curve of the *T* values of the common lead of the Bohemian Massif.

Table 1: Essential characteristics of the studied occurrences.

File No.	Locality	Latitude	Longitude	Order of size	Brief description	Number of data	Pb isotope ratios mean value +/- standart deviation			Model parameters (Amov 1983)		Model age (Amov 1983)
Unit I/1 - core of the Bohemian Massif							$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$	t_m (b.y.)	T (b.y.)	t (m.y.)
119	Pechtelsgrün	50 41	12 24	4	wolframite stockwork with scheelite, Pb-Zn sulphides and Co-Ni arsenides; situated in the Kirchsberg granite	1	18.09	15.62	38.45	3.96	3.16	440
108	Schönbrunn	50 25	12 11	4	fissure filling fluorite in Lower Paleozoic rocks (diabases, tuffs, shales, quartzites and limestones)	2	18.16 +/- 0.07	15.68 +/- 0.05	38.54 +/- 0.13	4.08	3.29	397
107	Erbendorf	49 50	12 03	4	vein of Ag-galena, sphalerite and chalcopyrite in Proterozoic gneisses with metabasite intercalations; some veine reach to the overlying New Red Sandstone beds	1	18.41	15.69	38.66	4.08	3.27	241
284	Freihung	49 37	11 55	4	synsedimentary Pb in Triassic beds (Keuper and Muschelkalk)	1	18.39	15.71	38.65	4.12	3.32	249
208	Wölsendorf	49 28	12 05	4	fluorite-barite veins cutting Moldanubian gneisses and granites in the N (continuation) of Bavarian Quartz Lode; rare Hg, Pb and Zn sulphides	1	18.49	15.59	38.57	3.84	3.03	194
106	Wünsteimir	49 12	12 09	4	fluorite-barite veins in Moldanubian granite	1	18.32	15.73	38.75	4.17	3.39	291
28	Lázně Kynžvart	50 0 32	12 37 40	3	vein with galena and sphalerite in amphibolites; situated near the W margin of the Mariánské Lázně metabasite body	1	18.18	15.62	38.36	3.95	3.14	382
209	Dyleň Mt.	49 58 7	12 30 12	3	U-vein mineralization	1	18.26	15.62	38.49	3.95	3.14	335

					situated near the contact of Dyleň mica schists with biotite-sillimanite Moldanubian paragneisses							
212	Vitkov	49 48 59	12 39 3	4	metasomatic ore bodies of U mineralization in Variscan biotite granites and granitic rocks	1	18.10	15.53	38.26	3.69	2.95	436
259	Zadní Chodov	49 53 30	12 39 27	4	U-minerals in tectonic fissures, developed in Moldanubian gneisses with various intercalations	2	18.30 +/- 0.11	15.58 +/- 0.12	38.40 +/- 0.18	3.84	3.04	313
260	Výškov	49 53 31	12 46 15	4	base metals veins with Ag situated in mica schists with intercalations of amphibolites and calc-silicate rocks	1	18.40	15.71	38.65	4.12	3.32	244
54	Michalovy Hory	49 53 60	12 47 2	3	-"-	1	18.33	15.64	38.40	3.97	3.16	289
258	Bor	49 42 52	12 46 31	4	small U occurrences in tectonic fissures in gneisses and amphibolites	1	18.30	15.59	38.16	3.85	3.05	310
220	Hojsova Stráž	49 12 44	13 11 54	4	Pb-Zn-Cu sulphide vein with fluorite in gneisses	1	18.26	15.67	38.71	4.06	3.25	333
223	Plánička	49 20 43	13 27 40	4	base metals vein at the contact of biotite granodiorite and the Moldanubian gneisses	1	18.11	15.66	38.28	4.06	3.25	425
23	Velhartice - Markup	49 15 19	13 23 57	4	Pb-Zn-Au-barite vein in quartzose gneisses and quartzites; situated close to the SW margin of the Central Bohemian Pluton	1	18.15	15.59	38.42	3.88	3.08	405
31	Velhartice - Borek	49 15 19	13 23 57	4	-"-	1	18.19	15.59	38.43	3.88	3.08	379
6	Nalžovské Hory	49 20 2	13 33 5	3	Pb-Zn-Ag veins situated in W apophysis of the Central Bohemian pluton (biotite granodiorite) near the	1	18.77	15.65	38.65	3.96	3.13	12

					contact with Moldanubian gneisses							
224	Lipová Lhota	49 16 56	13 33 10	4	U-Cu-fluorite veins in gneisses and mica schists in contact aureole of the Central Bohemian pluton	1	17.98	15.60	38.20	3.94	3.14	505
261	Chříč	49 58 22	13 38 46	4	antimonite-galena-sphalerite-arsenopyrite vein mineralization	1	18.14	15.58	38.01	3.85	3.05	412
63	Hůrky	50 4 35	13 33 36	4	base metals veins in the mylonitized granite of the Čistá-Jesenice pluton	1	18.28	15.62	38.32	3.93	3.12	324
214	Libušín, K. Gottwald mine	50 14 5	14 3 24	4	quartz vein with galena in basement of the coal-bed (Carboniferous)	1	18.01	15.61	38.05	3.95	3.15	486
221	Vinařice	50 10 34	14 5 31	4	quartz vein with galena in gabbro	1	18.14	15.66	37.93	4.05	3.24	406
204	Nučice	50 1 7	14 13 59	4	sedimentary Fe-ores of Ordovician age	1	18.16	15.68	38.69	4.10	3.30	395
200	Mníšek pod Brdy	49 52 0	14 15 44	4	Pb-occurrence in Proterozoic shales	1	18.68	15.71	38.42	4.03	3.28	64
201	Jílové u Prahy	49 53 44	14 29 39	4	Au-ore veins near contact of the Central Bohemian pluton (granodiorite of the Sázava type) with the Jílové zone basic and acid volcanics	4	18.03 +/- 0.17	15.57 +/- 0.11	37.82 +/- 0.22	3.83	3.05	477
217	Zbořený Kostelec	49 51 15	14 35 40	4	base metals occurrenc in hornfels of the Proterozoic age	1	17.90	15.90	38.43	4.39	3.84	569
20	Hradové Střimelice	49 54 14	14 49 5	4	base metals veins on boundary of metamorphosed Proterozoic and Paleozoic rocks; phyllites, quartzites, diorites, gabbro, latter metamorphosed locally into amphibolites	2	18.14 +/- 0.07	15.65 +/- 0.02	38.26 +/- 0.10	4.04	3.23	411
18	Stříbrná	49 53 57	14 50 56	3	-"-	1	18.02	15.60	38.27	3.92	3.12	485

	Skalice											
27	Malovidy	49 49 48	14 56 40	3	Pb-Zn-Ag lenses and disseminated ores in dolomites and dolomitic marbles	2	17.62 +/- 0.06	15.61 +/- 0.07	37.92 +/- 0.14	4.02	3.23	725
3	Kutná Hora	49 57 3	15 16 30	1	base metals veins with Ag in gneisses of Kutná Hora crystalline schists (gneisses, locally amphibolites)	2	18.09 +/- 0.19	15.59 +/- 0.12	38.21 +/- 0.28	3.89	3.09	440
222	Zdechovice	50 0 53	15 28 17	4	fissure filling U-organic minerals in the Proterozoic rocks of the Železné Hory zone	1	18.02	15.57	37.71	3.85	3.06	484
206	Chvaletice	50 2 8	15 24 59	4	minute quartz-pyrite-galena-sphalerite veins in porphyre apophysis intruding the Proterozoic sediments	2	17.75 +/- 0.09	15.51 +/- 0.11	37.63 +/- 0.24	3.65	2.95	637
210	Javorka 305, borehole, 3, 5 and 52.5 m	49 50 11	15 37 21	4	fluorit-barite with galena	1	18.54	15.77	38.61	4.20	3.44	148
910	Javorka 315, borehole	49 50 11	15 37 21	4	galena-sphalerite mineralization in marbles	1	17.76	15.62	37.92	4.02	3.23	642
16	Lukavice	49 53 27	15 50 20	4	pyrite with Pb-Zn-Cu minerals in altered quartz-porphyrites and felsites near to the N margin of Nasavrky pluton	2	18.08 +/- 0.04	15.62 +/- 0.02	38.19 +/- 0.08	3.97	3.16	445
285	Křižanovice	49 51 40	15 45 49	2	Pb-Zn-barite mineralization in acid metavolcanics	1	17.96	15.52	37.94	3.69	2.95	519
4	Příbram - Březové Hory	49 40 35	13 59 17	1	Pb,Zn,Ag veins in Cambrian sandstones and conglomerates and in the Proterozoic shales, with numerous intrusive dykes (diabase, diabase-porphyrite)	1	18.02	15.53	38.03	3.70	2.96	483
1	Bohutín	49 39 27	13 56 32	1	base metals veins in quartz diorite and Cambrian conglomerates; together with Březové Hory deposit	3	18.02 +/- 0.04	15.57 +/- 0.03	38.17 +/- 0.07	3.86	3.06	483

					480 kt Pb, 260 kt Zn, 3.5 kt Ag							
5	Vrančice	49 36 42	14 2 34	2	base metals veins in granitic rocks of the Central Bohemian pluton	3	18.04 +/- 0.13	15.59 +/- 0.10	38.09 +/- 0.22	3.90	3.10	469
17	Lešetice	49 38 50	14 1 14	4	U-veins with some Pb-sulphides mainly in the Proterozoic rocks near the contact with the W margin of the Central Bohemian pluton	3	18.10 +/- 0.06	15.61 +/- 0.05	38.23 +/- 0.11	3.94	3.13	432
10	Bytíz	49 41 1	14 4 28	4	-"-	6	18.12 +/- 0.10	15.61 +/- 0.09	38.20 +/- 0.21	3.95	3.15	419
207	Jerusalem	49 39 46	14 2 11	4	pitchblende and carbonate mineralization with rare galena	1	18.01	15.57	38.10	3.83	3.05	486
225	Kosobudy	49 34 43	14 14 19	4	quartz-barite vein with galena, pyrite and haematite cutting granitoides of Central Bohemian pluton	1	18.17	15.64	38.35	4.01	3.20	390
12	Velká	49 27 11	14 17 5	4	Pb-Zn-Ag vein in porphyric granodiorite with granite and aplite dykes	1	17.91	15.55	37.80	3.79	3.02	548
13	Košín	49 27 21	14 39 34	3	base metals mineralization in Moldanubian gneisses near contact with the Tábor syenite	1	17.92	15.51	38.09	3.64	2.93	542
11	Horky	49 24 12	14 38 43	3	Pb-Zn-Ag veins in Moldanubian biotite gneisses near Tábor syenite pluton	1	17.97	15.56	37.99	3.82	3.04	514
15	Řemíčovská Lhota	49 30 47	14 46 56	4	base metals veins with Ag in Moldanubian biotite-plagioclase gneisses, in some places with aplite dykes	1	18.13	15.68	38.36	4.08	3.29	417
7	Hlasivské Výlevy	49 30 42	14 45 36	4	-"-	1	17.95	15.53	38.05	3.70	2.96	520

19	Ratibořice	49 28 21	14 45 43	4	-"-	1	17.98	15.56	37.44	3.83	3.04	505
2	Ratibořské Hory	49 27 52	14 46 23	3	-"-	1	18.09	15.61	38.27	3.94	3.14	441
205	Chýnov - Pacova hora hill	49 25 56	14 50 3	4	galena in marbles and amphibolites	1	17.50	15.50	37.69	3.68	2.98	737
215	Křemešník hill near Pelhřimov	49 24 16	15 19 35	3	Ag-Pb-Zn ores in gneisses of contact aureole of Central Moldanubian pluton	1	18.16	15.59	38.36	3.89	3.08	340
219	Ježená	49 24 59	15 28 6	3	base metals veins with Ag in Moldanubian metamorphic rocks (biotite-sillimanite gneisses etc.)	1	18.11	15.52	38.25	3.66	2.93	427
24	Rantířov	49 24 33	15 31 1	3	-"-	1	18.15	15.59	38.21	3.87	3.07	406
29	Jezdovice	49 19 13	15 29 8	3	-"-	1	18.17	15.59	38.18	3.89	3.09	393
25	Jihlava, Na bělidle	49 24 34	15 35 44	3	-"-	2	18.13 +/- 0.08	15.61 +/- 0.07	38.27 +/- 0.17	3.89	3.09	385
30	Horní Kosov	49 24 7	15 33 31	3	-"-	1	18.22	15.65	38.34	4.02	3.22	359
9	Stříbrné Hory	49 36 7	15 41 37	3	base metals and Ag veins and disseminations in gneisses, amphibolites and serpentinites of Moldanubian unit; reserves about 3.5 kt Pb and 9.4 kt Zn	1	18.12	15.59	38.12	3.89	3.09	422
8	Mírovka	49 34 47	15 37 9	3	-"-	1	18.12	15.60	38.37	3.91	3.11	422
22	Bartoušov	49 34 52	15 38 58	3	-"-	1	18.14	15.61	38.25	3.93	3.12	407
213	Staré Ransko - U obrázku	49 39 39	15 49 41	2	Zn-deposit in mafic and ultramafic rocks of Staré Ransko intrusion	1	18.18	15.67	38.04	4.07	3.26	386
14	Nová Ves near Nové Město n.M.	49 33 49	16 4 23	4	U-veins in Moldanubian crystalline schists	1	18.11	15.58	38.20	3.84	3.05	428
218	Velké Meziříčí	49 21 21	16 0 53	4	base metals veins with Ag in Moldanubian metamorphic rocks	1	18.05	15.68	38.28	4.09	3.29	402

21	Hůry	49 0 23	14 32 27	3	-"-	1	18.14	15.62	38.40	3.96	3.15	409
26	Nedabyle	48 55 47	14 31 7	4	-"-	1	18.14	15.62	38.28	3.97	3.16	407
216	Staré Hodějovice	48 56 54	14 31 24	4	-"-	1	18.11	15.58	38.20	3.84	3.05	428
203	Okrouhlá Radouň	49 14 21	15 1 9	4	U-mineralization in migmatitized cordierite gneisses and granites of Moldanubian unit	1	18.00	15.49	37.87	3.52	2.87	491
32	Radlice	49 7 29	15 19 31	4	base metals veins in Moldanubian pluton	1	18.11	15.65	38.29	4.03	3.22	425
230	Doubice	50 53 27	14 27 48	4	disseminated galena in Jurassic dolomites and sandy limestones; along Lužice fault	1	18.45	15.64	38.51	3.97	3.15	218
229	Důlní vrch - Kryštofovo Údolí	50 46 28	14 55 41	4	base metals veins mineralization in Ještěd epizonally metamorphosed unit	1	17.66	15.55	37.84	3.86	3.08	698
288	Panenská Hůrka	50 48 27	14 56 2	3	-"-	1	18.15	15.58	38.11	3.85	3.05	405
286	Andělská Hora	50 48 7	14 57 27	3	-"-	1	17.71	15.52	37.97	3.74	3.00	665
35	Kryštofovo Údolí	50 46 26	14 55 57	3	galena-sphalerite mineralization; along contact of phyllites and crystalline marbles of Ještěd metamorphosed unit	2	18.30 +/- 0.09	15.59 +/- 0.07	38.43 +/- 0.11	3.87	3.07	313
985	Křižany near Liberec	50 44 28	14 58 2	4	barite-fluorite deposit with some Pb-Zn and Bi-Co-Ni-mineralization in phyllites of Ještěd unit	1	18.00	15.56	38.10	3.81	3.03	494
287	Příchovice	50 44 27	15 21 7	4	fissure filling U and base metals ores in biotite gneiss along the contact with Krkonoše-Jizerské hory pluton	1	18.03	15.57	38.19	3.83	3.05	479
289	Jablonec on Jizera	50 42 24	15 25 46	4	crushed quartz vein in phyllites	1	17.90	15.55	38.06	3.81	3.04	552
988	Rokytnice	50 43 55	15 27 2	3	base metals mineralization	1	17.53	15.47	37.59	3.52	2.90	765

	on Jizera				in Paleozoic quartzites and phyllites; on some places of metasomatic disseminated form							
34	Harrachov	50 46 25	15 26 4	2	barite-fluorite veins with some galena in granites of the Krkonoše-Jizerské hory pluton; reserves 19 kt Pb	5	18.43 +/- 0.04	15.63 +/- 0.04	38.58 +/- 0.07	3.94	3.13	229
36	Svatý Petr	50 43 21	15 38 25	3	quartz vein with barite and sulphides in mica schists of the Krkonoše crystalline unit, cutting base metals stratiform mineralization	2	18.40 +/- 0.14	15.57 +/- 0.07	38.25 +/- 0.09	3.79	3.00	254
105	Obří důl	50 43 31	15 43 45	3	stratiform sulphide mineralization in pyroxene-garnet hornfels near to contact with Krkonoše-Jizerské hory pluton	1	17.89	15.52	38.11	3.64	2.93	555
227	Černý Důl	50 38 8	15 42 51	3	veins in mica schists and some disseminated galena-sphalerite mineralization in calc-silicate rocks	3	17.64 +/- 0.10	15.53 +/- 0.08	37.72 +/- 0.20	3.79	3.04	707
228	Velká Úpa	50 41 26	15 46 25	4	disseminated base metals mineralization in marbles and greenschists of Krkonoše unit	2	17.56 +/- 0.08	15.50 +/- 0.07	37.72 +/- 0.14	3.67	2.97	747
116	Czarnów	50 48	15 55	4	sulphide mineralization (mainly arsenopyrite) in Krkonoše unit	1	18.52	15.82	38.77	4.26	3.56	160
115	Stara Góra	51 02	15 55	3	base metals veins near contact of Carboniferous-Permian porphyry with Precambrian phyllites	1	18.09	15.55	38.24	3.75	2.99	441
114	Stanislawów	51 06	16 00	4	barite vein mineralization with some sulphides situated in Paleozoic epimetamorphosed unit of Góry Kaczavské Mts.	1	18.12	15.51	38.14	3.58	2.89	421
113	Boguszów	50 46	16 12	4	barite vein mineralization in fault zone between	1	18.31	15.60	38.30	3.89	3.08	302

					Upper Carboniferous rhyolites and rhyodacites							
112	Strebrná Góra	50 36	16 38	3	barite veins with base metals in paragneisses of Góry Sowie Mts. unit	1	18.33	15.61	38.44	3.90	3.09	295
254	Horní Hoštice	50 25 10	16 57 38	4	base metals vein with arsenopyrite	2	18.12 +/- 0.25	15.51 +/- 0.22	38.10 +/- 0.33	3.56	2.88	420
Unit I/3 - the Orlické hory Mts. - Klodsko region												
38	Zdobnice	50 14 1	16 24 51	4	stratiform Pb-Zn mineralization in marble lenses in phyllites of the Stroňska Group	1	17.61	15.55	37.62	3.87	3.09	727
290	Nová Ves near Orlické Záhoří	50 14 24	16 31 16	4	base metals mineralization in shear zone in graphitic phyllites and spessartite dyke	1	18.19	15.61	38.30	3.94	3.13	377
232	Hynčice pod Sušinou	50 9 30	16 54 15	4	antimonite vein in amphibolites and mica schists of Orlické hory Mts. - Klodsko dome	1	18.22	15.70	38.45	3.75	2.98	376
231	Hraničná	50 18 47	17 1 9	4	Fe-skarns with Pb-Zn mineralization close to amphibolite body	1	17.60	15.54	37.45	3.83	3.07	728
234	Klepačov	49 20 32	16 40 3	4	unimportant Pb-mineralization	1	18.24	15.63	38.01	3.98	3.17	346
233	Podivice	49 22 3	17 0 41	4	galena occurrence in Culm schists and greywackes	1	18.20	15.55	38.19	4.12	3.33	356
Unit II/2 - Eastern Moravia-Silesian region												
239	Malá Morávka	50 0 54	17 19 4	4	galena occurrence in Devonian Vrbno group	1	18.17	15.55	38.01	3.74	2.98	390
39	Horní Město	49 54 32	17 12 57	2	disseminated Pb-Zn ores in keratophyres and sericite schists; reserves 9 kt Pb and 21 kt Zn	5	18.31 +/- 0.05	15.67 +/- 0.04	38.11 +/- 0.09	4.06	3.25	302

241	Nová Véska near Moravský Beroun	49 46 16	17 28 28	4	polymetalic disseminated mineralization in Culmian rocks	1	18.38	15.76	38.67	4.19	3.44	257
245	Domašov on Bystřice	49 44 37	17 26 46	4	-"-	1	18.21	15.63	38.42	3.99	3.18	365
40	Staré Oldřůvky	49 45 35	17 38 51	3	base metals veins in Lower Carboniferous shales and greywackes	2	18.33 +/- 0.05	15.67 +/- 0.04	38.31 +/- 0.10	4.05	3.24	287
242	Rudoltovice	49 44 8	17 37 53	4	-"-	1	18.32	15.63	38.31	3.97	3.16	297
291	Olověná	49 43 25	17 40 24	3	-"-	2	18.27 +/- 0.05	15.57 +/- 0.04	38.27 +/- 0.08	3.96	3.15	328
238	Hlubočky	49 37 15	17 23 59	4	-"-	1	18.26	15.58	38.21	3.84	3.04	337
244	Lipník on Bečva	49 31 37	17 35 18	4	minute veins of Pb-Zn mineralization in Culm greywackes	1	18.37	15.59	38.30	3.85	3.05	267
240	Hrabůvka	49 34 46	17 41 24	4	-"-	1	18.23	15.59	38.34	3.87	3.07	356
246	Dubová	49 48 55	17 46 27	4	base metals veins in Lower Carboniferous shales and greywackes	1	18.33	15.68	38.41	4.08	3.27	288
41	Fulnek	49 42 52	17 54 34	4	-"-	1	18.38	15.67	38.29	4.03	3.21	260
42	Jerlochovice	49 42 42	17 52 59	4	-"-	1	18.24	15.59	38.11	3.86	3.06	348
235	Mošnov NP-314, borehole, 790 m	49 41 12	18 7 52	4	galena occurrence in Carboniferous of the Upper Silesian basin		18.33	15.74	38.19			
248	Stanislavice	49 45 40	18 32 53	4	minute chalcopyrite-galena-calcite-quartz veinlets in greywacke sandstones of Culm beds	1	18.15	15.58	38.16	3.86	3.06	405
Unit II/3 - Western Moravia-Silesian region												
37	Nýznerov	50 17 20	17 4 45	4	base metals veins in Staré Město mica schists zone close to contact with tonalites	2	18.32 +/- 0.13	15.52 +/- 0.15	38.39 +/- 0.30	3.74	2.97	300

250	Branná	50 9 12	17 0 52	4	galena occurrence in marbles	1	18.36	15.61	38.34	3.91	3.09	272
251	Lipová - lázně	50 13 45	17 8 39	4	quartz vein with base metals mineralization	1	18.51	15.61	38.63	3.88	3.07	181
47	Rejvíz R-14, borehole	50 13 51	17 18 24	4	disseminated base metals mineralization in Devonian Rejvíz Group	2	18.40 +/- 0.06	15.61 +/- 0.04	38.08 +/- 0.09	3.91	3.10	246
947	Starý Rejvíz - Emil gallery	50 13 19	17 19 33	4	quartz vein near contact of the Devonian Vrbno Group with gneisses of Desná dome	1	18.41	15.59	38.11	3.03	3.03	243
45	Zlaté Hory	50 15 48	17 23 48	1	disseminated base metals mineralization (partly with Au) in quartzites and schists of Devonian Vrbno Group; reserves 174 kt Pb, 714 kt Zn, 203 kt Cu	18	18.46 +/- 0.09	15.65 +/- 0.08	38.31 +/- 0.14	3.99	3.17	206
46	Nová Ves near Rýmařov	49 59 29	17 16 38	3	base metals veins in Devonian quartzites, greenschists and phyllites	1	18.38	15.56	38.04	3.81	3.01	260
237	Dobřečov	49 55 3	17 10 54	4	disseminated base metals mineralization in Vrbno Devonian Group	1	18.32	15.61	38.12	3.91	3.10	300
44	Horní Benešov	49 58 4	17 36 18	1	disseminated Pb-Zn ores in the Devonian sedimentary and volcanic rocks; reserves 71 kt Pb, 147 kt Zn	3	18.46 +/- 0.06	15.65 +/- 0.04	38.26 +/- 0.10	3.99	3.18	206
43	Kletné	49 40 16	17 54 30	4	galena vein in the Lower Carboniferous shales and greywackes	1	18.48	15.67	38.43	4.04	3.23	193
143	Jakubčovice on Odra	49 41 47	17 46 57	3	base metals vein in Lower Carboniferous schists	1	18.54	15.66	38.34	4.00	3.18	156
253	Kouty on Desná	50 6 19	17 8 2	4	base metal mineralization in gneisses	1	18.49	15.64	38.26	3.96	3.14	193
101	Bytom	50 21	18 51	1	stratiform Pb-Zn mineralization in Triassic limestones (Mississippi Valley type)	6	18.44 +/- 0.10	15.65 +/- 0.06	38.53 +/- 0.19	3.99	3.18	218

Unit II/4 - Western Bohemia region												
257	Schneckenstein	50 25	12 26	4	barite-haematite (and rare chalcopyrite and bornite) veins in contact aureole of Karlovy Vary granite body	1	18.38	15.66	38.72	4.02	3.21	261
58	Kraslice	50 19 46	12 30 47	4	sphalerite-barite vein mineralization in the contact aureole of Karlovy Vary granite body	1	18.50	15.72	38.81	4.12	3.33	181
232	Kraslice - Bělidlo	50 19 13	12 31 30		-"-	1	18.46	15.65	38.64	3.99	3.18	206
53	Abertamy	50 22 12	12 49 7	4	Ag-U-Bi-Co-Ni stockwork in gneisses of Jáchymov ore district	6	18.42 +/- 0.07	15.67 +/- 0.06	38.61 +/- 0.10	4.04	3.23	232
61	Horka	50 10 58	12 28 58	4	quartz vein containing Pb-Zn mineralization; situated in Lower Paleozoic metamorphics	1	18.83	15.93	39.43	4.37	3.77	46
55	Oloví	50 14 42	12 33 28	3	base metals veins in gneisses W of contact with Karlovy Vary granite pluton	1	18.48	15.66	38.61	4.03	3.21	195
256	Kostelní Bříza	50 7 1	12 37 18	3	base metals veins in mica schists	1	18.25	15.48	38.05	3.39	2.79	342
255	Horní Slavkov	50 8 23	12 48 25	4	U-vein mineralization in paragneisses	1	18.42	15.66	38.51	4.02	3.20	231
51	Pernarec	49 50 29	13 6 17	4	polymetalic veins in Upper Proterozoic phyllites	1	18.50	15.64	38.51	3.97	3.15	186
57	Kšice	49 48 10	12 59 56	2	-"-	1	18.61	15.72	38.69	4.12	3.33	109
59	Přovany	49 46 48	13 7 24	4	-"-	1	18.14	15.57	38.01	3.82	3.03	408
52	Milíkov	49 44 52	12 56 18	3	base metals vein in Proterozoic shales and phyllites, sometimes in deformed metabazic rocks	3	18.40 +/- 0.07	15.57 +/- 0.07	38.35 +/- 0.16	3.76	2.98	251
49	Stříbro - Dlouhý Důl	49 44 34	13 1 30	1	-"-	1	18.50	15.50	38.67	4.08	3.28	180

60	Černovice	49 36 57	12 59 54	3	-"-	1	18.43	15.59	38.57	3.83	3.03	231
211	Oldřichov	49 47 45	12 40 23	3	U-Pb-Bi-Cu mineralization filling fault system W of Bor granite body	1	18.33	15.66	38.44	4.03	3.22	289
293	Mantov	49 38 57	13 12 35	3	Pb-Zn vein underlying small Carboniferous coal deposit	1	18.47	15.62	38.39	3.93	3.11	204
50	Chotěšov	49 39 31	13 12 19	3	-"-	2	18.53 +/- 0.09	15.66 +/- 0.08	38.51 +/- 0.19	4.01	3.19	162
56	Staňkov	49 33 8	13 4 32	3	Pb-Zn mineralization in Proterozoic shales	1	18.53	15.69	38.75	4.07	3.25	158
62	Merklín	49 33 48	13 11 53	3	quartz veins with Pb-Zn in granite near S margin of Stod pluton	1	18.39	15.66	38.72	4.02	3.21	261
Unit III/1 - Moravicum												
271	Rozsochy	49 31 14	16 12 10	4	Pb-Zn mineralization in calc-silicate rock	1	18.55	15.66	38.43	4.02	3.20	152
266	Koroužné	49 31 48	16 20 54	4	base metals mineralization in metamorphic rocks of Moravicum unit	1	18.81	15.64	38.57	3.94	3.11	- 17
273	Švařec	49 31 18	16 20 41	4	-"-	2	18.76 +/- 0.06	15.68 +/- 0.04	38.70 +/- 0.10	4.03	3.21	13
202	Rožná	49 28 41	16 14 26	4	U deposits with Pb mineralization in gneisses of Moldanubicum unit near to the contact with the Moravicum unit	14	18.35	15.64	38.27	3.99	3.17	278
262	Dolní Rožínka	49 28 48	16 12 41	4	-"-	6	18.31 +/- 0.42	15.60 +/- 0.34	38.24 +/- 0.55	3.90	3.09	306
263	Borovec	49 30 50	16 20 22	4	base metals mineralization in metamorphic rocks of the Moravicum unit	1	18.99	15.76	38.66	4.16	3.38	- 152
264	Horní Čepí	49 29 14	16 21 32	4	base metals mineralization of metasomatic type in the	1	18:74	15.59	38.42	3.81	3.00	39

					marbles of the Moravicum unit							
268	Rozseč on Kunštát	49 31 27	16 27 53	4	-"-	1	18.82	15.77	38.61	4.18	3.41	- 34
274	Štěchov	49 27 13	16 30 31	4	-"-	1	18.35	15.58	38.34	3.81	3.01	282
267	Lačnov near Lysice	49 27 5	16 30 14	4	-"-	1	19.02	15.82	38.80	4.24	3.50	- 176
269	Jasenice	49 15 31	16 9 58	4	-"-	2	18.90 +/- 0.12	15.69 +/- 0.12	38.77 +/- 0.25	4.04	3.22	- 78
64	Heroltice	49 18 42	16 24 49	3	-"-	2	18.78 +/- 0.05	15.60 +/- 0.03	38.37 +/- 0.05	3.83	3.01	10
253	Javůrek near Tišnov	49 15 19	16 21 40	4	base metals vein mineralization with barite in epimetamorphic rocks of the Svratka dome of Moravicum unit	1	18.78	15.76	38.66	4.17	3.39	- 4
272	Domašov	49 14 41	16 20 49	4	-"-	1	18.90	15.82	38.91	4.25	3.53	- 95
270	Stříbrná zmola near Javůrek	49 15 36	16 1 36	4	-"-	1	18.69	15.64	38.60	4.03	3.21	60
Unit III/2 - Krušné Hory - Labe region												
231	Potůčky	50 25 46	12 44 17	4	U-Ag-Bi-Co-Ni veins in amphibolites	2	18.94 +/- 0.07	15.81 +/- 0.03	39.22 +/- 0.10	4.24	3.50	- 116
65	Jáchymov	50 22 1	12 55 20	3	U-Ag-Bi-Co-Ni veins in mica schists	6	18.50 +/- 0.20	15.63 +/- 0.07	38.57 +/- 0.20	3.95	3.13	183
118	Zschopau	50 45	13 5	3	barite-fluorite veins containing base metals mineralization in Lower Paleozoic metamorphites	1	18.33	15.61	38.43	3.90	3.09	295
120	Brand b. Freiberg I	50 52	13 20	1	Pb-Zn (older) and Bi-Co-Ni (younger) veins; S part of the Freiberg ore field	1	18.11	15.62	38.38	3.97	3.16	426
102	Brand b. Freiberg II	50 52	13 20	1	-"-	6	18.37 +/- 0.11	15.66 +/- 0.11	38.77 +/- 0.21	4.04	3.22	265

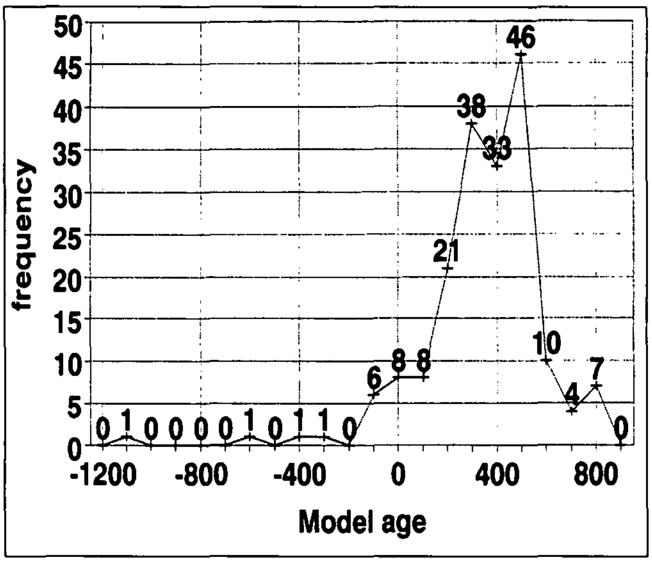
100	Freiberg	50 55	13 21	1	cluster of more than 1.000 veins; Pb-Zn-U (older - Variscan), F-Ba and Bi-Co-Ni-Ag (younger - post-Variscan) mineralizations; situated in gneissic complex intruded by Variscan granites and porphyres and by Tertiary nepheline basalt	5	18.12 +/- 0.06	15.60 +/- 0.05	38.51 +/- 0.14	3.91	3.11	419
103	Halsbrücke	50 57	13 21	3	base metals veins with barite-fluorite mineralization	5	18.53 +/- 0.16	15.65 +/- 0.13	38.90 +/- 0.20	4.00	3.18	162
117	Grosschirma	51 00	13 20	1	Pb-Zn vein mineralization; N part of Freiberg ore field	1	18.33	15.66	38.60	4.03	3.22	290
104	Scharfenburg	51 08	13 34	3	Pb-Zn veins in Meissen syenite body	2	18.15 +/- 0.05	15.65 +/- 0.03	38.57 +/- 0.10	4.03	3.22	402
278	Moldava A	50 43 16	13 39 36	4	barite-fluorite vein deposit in gneisses and granites	1	19.40	15.76	39.44	4.14	3.35	- 429
978	Moldava B	50 43 16	13 39 36	4	-"-	1	18.29	15.58	38.35	3.83	3.03	321
277	Cínovec	50 44 1	13 46 15	4	Sn-W deposit in greisen developed in vicinity of albitic granite dome	2	18.78 +/- 0.92	15.72 +/- 0.69	38.86 +/- 1.19	4.11	3.30	- 4
226	Horní Krupka	50 42 13	13 51 21	4	Sn-W mineralization in gneisses, pegmatites with some quartz veins	1	18.09	15.58	38.07	3.85	3.06	443
68	Mikulov	50 41 22	13 43 24	3	base metals veins with barite and fluorite in gneisses	1	18.01	15.51	37.90	3.61	2.91	489
66	Hrob	50 39 32	13 43 31	3	-"-	1	18.26	15.63	38.53	3.98	3.16	336
282	Jeníkov	50 38 10	13 45 27	4	fluorite, barite, galena mineralization in Teplice quartz porphyry and the Upper Cretaceous sediments	1	18.91	15.65	39.20	3.94	3.11	- 78
283	Háj near Duchcov	50 37 54	13 42 57	4	-"-	1	19.63	15.81	39.92	4.21	3.45	- 605

276	Teplice TH 3 and GU 270, borehole	50 38 45	13 50 48	4	-"-	2	19.31 +/- 0.39	15.69 +/- 0.33	39.66 +/- 0.38	4.00	3.17	- 354
280	Lahošť	50 37 15	13 46 47	4	barite-fluorite mineralization in Tertiary quartzites	1	18.70	15.57	38.64	3.76	2.96	66
67	Roztoky	50 41 15	14 10 47	3	Pb-Zn veins in Tertiary essexites	2	19.03 +/- 0.02	15.67 +/- 0.04	39.17 +/- 0.06	3.99	3.16	- 164
275	Jedomělice	50 13 59	13 58 30	4	galena in the pelosiderite concretions in Carboniferous and Permian claystones and sandstones	5	18.96 +/- 0:28	15.71 +/- 0.13	38.53 +/- 0.33	4.07	3.25	- 121
279	Hamr	50 42 13	14 50 17	4	U-mineralization in Cenoman sedimentary rocks	3	18.96 +/- 0.41	15.68 +/- 0.19	38.88 +/- 0.48	4.02	3.19	- 120
109	Bečkov	50 37 52	16 0 16	4	U-mineralization in Carboniferous sedimentary rocks and coal deposits	1	18.54	15.60	38.41	3.85	3.04	166
110	Radvanice	50 34 8	16 3 47	4	-"-	2	18.61 +/- 0.07	15.71 +/- 0.07	38.66 +/- 0.09	4.10	3.30	109
111	Rtyně	50 30 28	16 4 9	4	-"-	1	20.39	15.82	38.62	4.19	3.42	- 1192
48	Javorník - Melchior Totenkoppe	50 23 40	17 0 32	4	base metals veins with arsenopyrite	4	18.73 +/- 0.37	15.65 +/- 0.24	38.66 +/- 0.45	3.97	3.14	39
249	Zálesí	50 21 33	16 56 4	4	U-veins with As and Pb-Zn mineralization	2	18.60 +/- 0.08	15.63 +/- 0.09	38.69 +/- 0.18	3.94	3.12	120
252	Travná	50 22 28	16 56 19	4	quartz vein with galena, pyrite and chalcopyrite	1	18.52	15.63	38.39	3.93	3.11	172

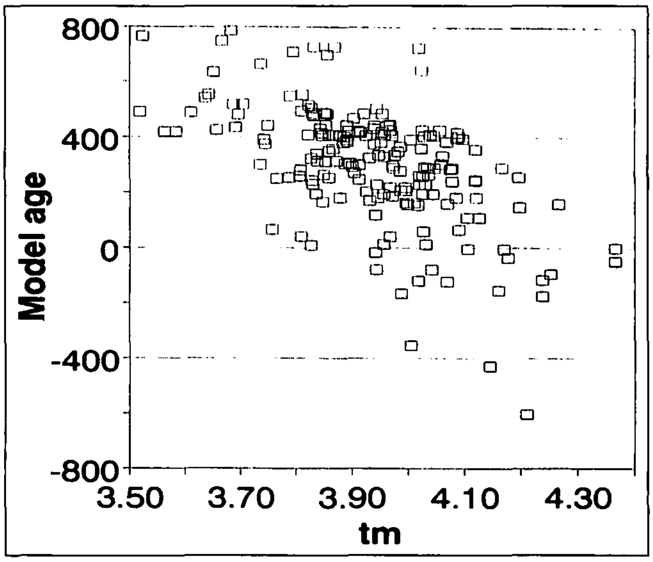
quency curve has the maxima around this value with symmetrical bell shape to both sides. From this it can be concluded that the lead developed from ancient crust. The continuous lead development is recorded also in the plot of model age against the *tm* values (Fig. 6) which shows that the J-anomalous lead (DOE 1970) developed mainly from the Archean crustal type curves.

The overall scatter of Pb isotope data from the Bohemian Massif does not conform the theoretical lead evolution curves. This provides evidence for different values of μ_0 in the source materials of ore bearing fluids as examplified by the less radiogenic isotope composition of Pb ores located in metamorphosed limestones and in some other geochemically primitive sediments (Table II). This points also to possible existence of Precambrian limestones in Bohemian Massif and to existence of less differentiated crust. All other leads are products of selective extraction from pre-existing rocks during following periods. The slope of the line fitted to the scatter is 0.1480 ±0.0117 and the strong reworking and lead redistribution of older materials before 1.200 Ma (see also PLJUSNIN and BRANDT, 1972) can be assumed in the geological history of the Bohemian Massif.

Calculated model ages (provided that they are taken only as a rough assessment of the age of lead mineralization source), indicate that the majority of Pb values for the Bohemian Massif is found



Text-Fig. 5.
Frequency curve of the model ages of the common lead of the Bohemian Massif calculated with use of the model of AMOV (1983).



Text-Fig. 6.
Model ages versus *tm* value plot. The J-anomalous lead is typical for the higher *tm* (Archean) values.

in the interval between isochrons 800 to 0 m.y, see also HÖHNDORF and DILL (1986). Considering the available geochronological dating and geotectonic history, the individual metallogenic phases which had occurred in the Bohemian Massif best fit to intervals of 800 to 600 m.y., 450 to 250 m.y. and 50 to 0 m.y.

The analysis of relation of Pb isotope composition to the development of the crust in the Bohemian Massif resulted in the separation of three metallogenetical units Table I (PATOCKA et al., 1984; VANĚČEK et al., 1985) such as

1) Core unit (Moldanubian crust) and its fragments inside other parts of the Bohemian Massif with the least radiogenic leads and with comparatively high content of ^{208}Pb isotope and with strong Variscan plutonism and older migmatitization which enabled enrichment in ^{208}Pb from the lower crust,
2) transitional unit (Proterozoic crust) with ore Pb enriched in ^{206}Pb and ^{207}Pb isotopes and probably consolidated in the pre-Variscan era and
3) area of samples with highest enrichment in radiogenic Pb isotopes and with widespread Tertiary volcanism and Mesozoic-Cenozoic sedimentation (Saxothuringian and Cretaceous basin area). This area has also low initial ^{232}Th/^{238}U values (VANĚČEK et al., 1985).

5. Conclusions

The isotopical composition of the common lead in the Bohemian Massif trace the crustal history beyond the mineral age data. The lead of Bohemian Massif is mainly of orogene type with the participation of the upper crustal lead and considering the *tm* model value of AMOV (1983), it originated by reworking of the Archean crust in the event prior to 1.2 b.y.

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