Conclusions

The disseminated copper mineralization is related to the Permian postvolcanic hydrothermal activity of basaltic volcanism. The association of minerals reflects composition of wall-rocks, as confirmed by the presence of Ni-Co minerals (siegenite, gersdorffite and carollite).

The vein copper mineralization is associated with faults formed during the Alpine overthrust of the Hronicum Unit. These structures allowed the circulation of the hydrothermal fluids. More data are needed to explain the origin of these fluids. Metallic elements might be mobilized from disseminated preconcentrations, and subsequently transported and deposited into the structurally favourable milieu.

Low temperature chalcopyrite, digenite, covellite, idaite, malachite, azurite, iron hydroxides, jarosite and gypsum represent supergene association of minerals.

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Hydrothermal Carbonate and Sulphide Mineralization in the Late Paleozoic Phyllites (Bacúch, Nízke Tatry Mts.)

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ABSTRACT: Two significant occurrences of Fe-carbonate mineralization in the vicinity of Bacúch village, are hosted by metamorphosed volcanosedimentary rocks of the Jánov grúň complex in the Veporic Unit of Nízke Tatry Mts. The occurrences are paragenetically close to other Fe-carbonate deposits in the region. At the locality Jánov grúň Hill occurs carbonate and quartz-sulphide stages. At the locality Sokolova dolina Valley is older carbonate stage cut by younger quartz-sulphide stage. Quartz-sulphide mineralization consists of two generations of pyrite, sphalerite, and chalcopyrite Galena occurred with PbBi, CuPbBi *and Ag PbBi sulphosalts, bismuthinite and native bismuth. Fluids were formed from solutions of H_2O – NaCl – KCl type. Homogenisation temperature varies from 170 °C to 250 °C for older ankerite and from 100 °C to 200 °C for quartz. Salinity was from 17 to 26 wt.% equiv. NaCl for ankerite and from 9 to 24 wt.% equiv. NaCl for quartz.*

KEY WORDS: carbonates, Bi (Cu, Pb, Ag) sulphosalts, fluid inclusions, the Nízke Tatry Mts.

Introduction

Fe, Cu, and Ag ores were mined near Bacúch village in the past times. The oldest record about mining is from 1274 (Bergfest 1955). 320 kg of copper ore with 4% Cu and 80 ppm Ag (Bergfest 1955) were mined at the locality Bacúch–Hutky (Sokolova dolina Valley) in the years 1811–1814. Siderite sometimes magnetite was probably mined before. Sokolova dolina Valley is the most significant locality, where siderite and Cu, Ag sulphides were mined. Fe and Cu ore was mined in the Jánov Grúň mine gallery. Mineralogy at these two localities was studied by Petro (1973, 1976). We acquired new data about minerals, mineral assemblages and conditions of origin of the hydrothermal mineralization, obtained by detailed mineralogical research.

Geological setting

Studied localities are hosted by crystalline rocks of Veporic Unit of Nízke Tatry Mts. Early and Late Paleozoic metamorphosed rocks are dominant in the studied area (Fig. 1). Both localities are hosted by phyllites of Jánov grúň complex, which consist of metamorphosed volcanic and sedimentary rocks (Miko and Korikovskij 1993). Permian–Triassic age (216 ± 5 Ma, 255 ± 2 Ma a 278 ± 11 Ma) of Jánov Grúň complex was determined by U/Pb method (Kotov et al. 1996). Triassic–Jurassic quartzites, limestones and dolomites of Mesozoic cover were infolded into the veporic basement by younger tectonic movements.

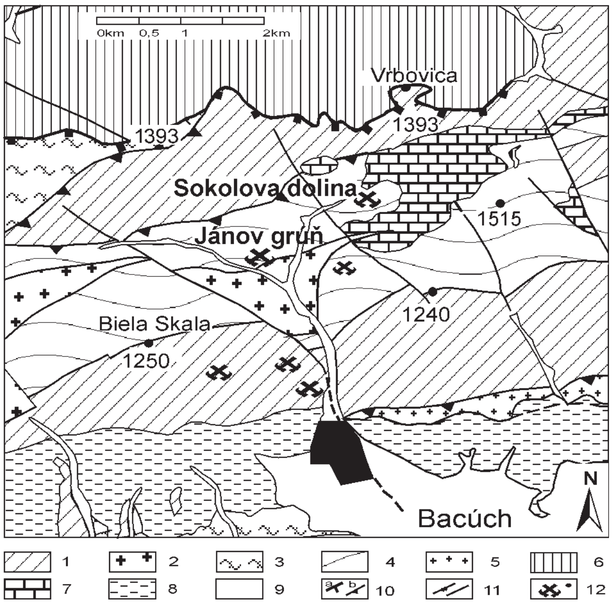

Fig. 1. Geological map of Bacúch area (modified after Biely et al. 1992).
Abbreviations: 1 Hron complex – micaschists, pegmatites, amphibolites, 2 Kráľova hoľa complex – granodiorites, 3 Ľubietová complex – paragneisses, 4,5 Jánov grúň complex 4 - phyllites, metadacites, metarhyodacites, 5 – granitoides, 6 Tatric unit – granitoides, gneisses, quartzites, limestones, 7 – Velký Bok unit – quartzites, limestones, dolomites, 8 – Quaternary, 9 – alluvium, 10 – nappes lines; a – alpinian, b – variscian?, 11 – a upthrusts, b faults, 12 - mines, cotes.

Vein hydrothermal mineralization is situated at two localities: at Sokolova dolina Valley with E-W striking veins up to 1 m thick and at the Jánov grúň Hill with NEE-SWW striking up to 1 m thick. Mineralization is hosted by phyllites, exceptionally reached carbonates rocks of Mesozoic cover at the Sokolova dolina Valley Petro (1973).

Methods

Minerals were identified by wave-dispersion (WDS) analysis at JEOL SUPERPROBE 733 on the Geological Survey of Slovak Republic (GS SR) and JEOL JXA 840 A on the Faculty of Natural Sciences (Prif UK) under following conditions: 20 nA, 20 kV, ∅ of ray 5 μm and standards: FeAsS (Fe, As), HgS (Hg), Ag (Ag), PbS (Pb), Cu (Cu), Bi (Bi), Zn (Zn), Sb (Sb), Au (Au). All presented X-ray microanalysis satisfy the valence balance rule (± 1). Fluid inclusions were studied at the LINKAM THMSG 600 (Prif UK). Chemical characteristics of fluids were calculated by programme Flincor Brown (1989).

Results

Mineralization was studied at two localities in the Bacúch area. The mining gallery was measured at the Jánov grúň–Hill. This adit is tunnelled in phyllites of the Jánov grún complex. Quartz – – ankerite vein with prevailing chalcopyrite is located there.

Samples were collected from dumps of three broken adits at the Sokolova dolina Valley. Siderite and chalcopyrite prevail there. Various association of Bi (Cu, Pb, Ag) sulphosalts are also present.
Presence of individual minerals and their supposed succesion of crystalization is offered in Tab. 1,2.

Minerals	Stage of mineralization		
	Carbo -nate	Quartz – carbonate - sulphide	Hyper -genic
Quartz	—	▬---- ▬▬▬	
Siderite		—	
Baryte		—	
Pyrite		— —	
Marcasite		—	
Sphalerite		— —	
Chalcopyrite		—	
Galena		—	
Bi sulphosalts		—	
Chalcocite			–
Covellite			—
Malachite			—
Goethite			—
Fe-hydroxides			—

Tab. 1. Succesion scheme of the hydrothermal mineralization at the Sokolova dolina Valley.

Mineral	Stage of mineralization		
	Carbo -nate	Qartz – Ankerite - sulphide	Hyper -genic
Quartz	—?		
Dolomite	—		
Ankerite			
Calcite		—	
Pyrite		—	
Arsenopyrite		—	
Chalcopyrite			
Chalcocite			—
Covellite			—
Goethite			—
Fe-hydroxides			—
Malachite			—

Tab. 2. Succesion scheme of the hydrothermal mineralization at Jánov grúň Hill.

Minerals

Native bismuth forms small microscopic grains maximal size 1 mm only at Sokolova dolina Valley. It occurs in association with galena, chalcopyrite, in complicated intergrowths with Bi minerals (Fig. 2D) or as small grains in galena.

Sphalerite forms two generations at the Sokolova dolina Valley. Sphalerite I forms small anhedral grains accompanied by exsolutions of chalcopyrite and contains 6,5 wt.% of Fe (Tab. 3). Sphalerite II contains inclusions of chalcopyrite, pyrite and galena and contains up to 2 wt.% of Fe (Tab. 3).

Chalcopyrite is the most common ore mineral. It forms grains and thin veinlets filling fissures in carbonates and quartz. Two generations of chalcopyrite occurred at Sokolova dolina Valley. Chalcopyrite I is accompanied by pyrite, Bi sulphosalts and galena. Chalcopyrite II forms veinlets with sphalerite. Chalcopyrite contains very small amounts of minor elements (Tab. 4).

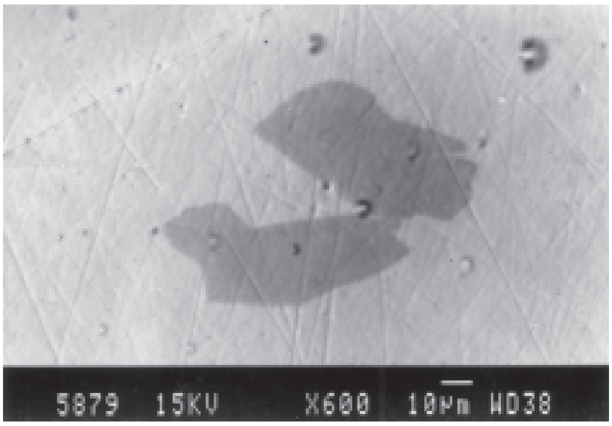

Fig. 2a. Inclusions of aikinite (darkgrey) in galena (white).

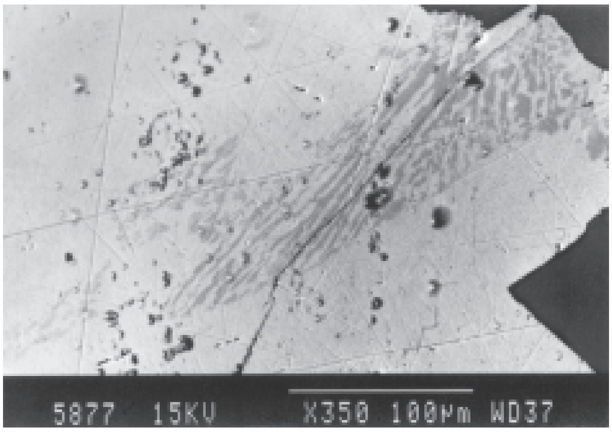

Fig. 2b. Myrmekitic intergrowth of CuPbBi sulphosalts (darkgrey) with galena (white).

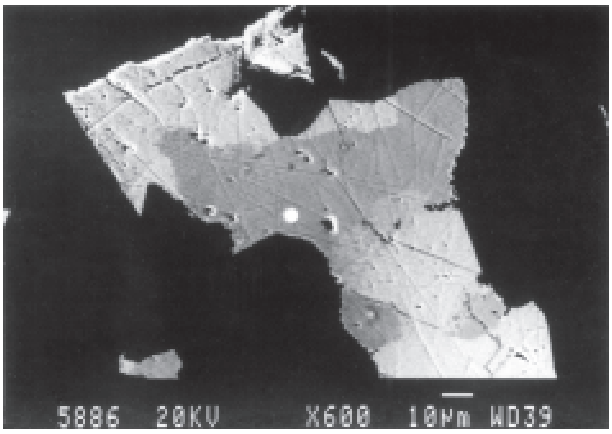

Fig. 2c. CuPbBi sulphosalts (darkgrey) with AgPbBi sulphosalts (light grey) on the border between galena and CuPbBi sulphosalts in galena (white) Black is chalcopyrite.

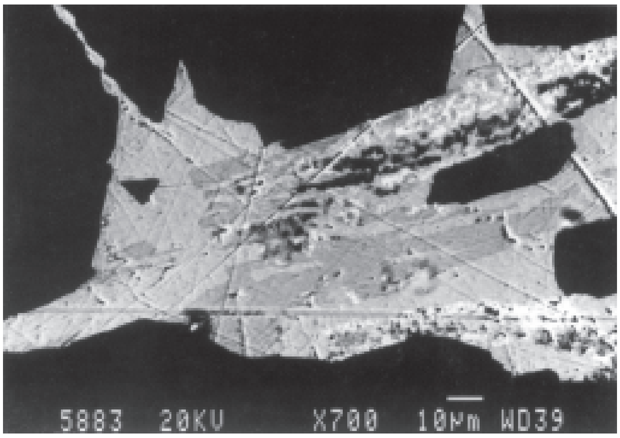

Fig. 2d. Grains of cosalite (dark grey) with native Bi (white) in galena (light grey). Black is chalcopyrite.

	Zn	Cu	S	Cd	Mn	Fe	Total	Zn	Cu	S	Cd	Mn	Fe
	weight %							atomic %					
sphI(2)	61.62	0.68	33.36	0.03	0.08	5.12	101.28	45.03	0.52	49.67	0.01	0.06	4.70
sphII(3)	65.79	0.12	32.69	0.05	0.07	1.66	100.46	48.92	0.09	49.46	0.02	0.07	1.44

Tab. 3. The X-ray microanalysis of sphalerite (sph) from Sokolova dolina Valley.

	Jánov grúň - hill		Sokolova dolina - valley	
Sample	Bac 103	Bac 109	Bac 72	Bac 62
		weight %		
Zn	0.01	0.02	0.73	0.01
Cu	35.63	34.76	35.12	33.64
S	34.65	35.16	33.86	35.43
Bi	0.00	0.19	0.02	0.03
Ag	0.06	0.04	0.14	0.01
Sn	0.00	0.01	0.00	0.03
Sb	0.02	0.06	0.00	n.a.
Fe	29.61	28.95	30.10	30.63
Total	99.98	99.19	99.97	99.78
		atomic %		
Zn	0.01	0.01	0.52	0.01
Cu	25.81	25.28	25.59	24.25
S	49.75	50.67	48.88	50.61
Bi	0.00	0.04	0.00	0.01
Ag	0.03	0.02	0.06	0.00
Sn	0.00	0.00	0.00	0.01
Sb	0.01	0.02	0.00	n.a.
Fe	24.40	23.96	24.95	25.12

Tab. 4. The X – ray microanalysis of chalcopyrite from the Bacúch area.

Sample	Bac 64	Bac68b	Bac 65d	Bac 72
mineral	bm	bm	ga	ga
		weight %		
S	18.48	17.79	14.17	13.37
Ag	0.00	0.09	0.84	0.72
Sb	0.09	0.04	0.17	0.00
Bi	78.29	78.61	0.28	1.04
Pb	1.26	3.53	84.33	83.80
Cu	0.14	0.40	0.10	0.43
Fe	0.73	0.06	0.00	0.60
Total	99.00	100.52	99.88	99.96
		atomic %		
S	59.22	58.01	51.53	49.03
Ag	0.00	0.09	0.90	0.79
Sb	0.08	0.04	0.16	0.00
Bi	38.5	39.32	0.15	0.58
Pb	0.63	1.78	47.28	47.54
Cu	0.23	0.65	0.18	0.79
Fe	1.35	0.11	0.00	1.27

Explanations: bm – bismuthinite, ga – galena

Tab. 5. The X-ray microanalysis of bismuthinite and galena from Sokolova dolina Valley.

	Jánov grúň Hill			Sokolova dolina Valley	
mineral	asp(4)	py	py	py	py
		weight %			
Au	n.a.	0.00	0.07	0.04	0.01
Sb	0.48	0.00	0.08	n.a.	n.a.
S	22.76	52.68	54.45	53.42	53.24
Fe	34.13	46.92	46.43	47.31	47.46
Co	0.05	0.65	0.10	0.03	0,08
Ni	0.05	0.02	0.00	0.10	0.00
Cu	0.03	0.04	0.06	0.06	0.17
As	43.60	0.00	0.22	0.09	0.00
Total	101.12	100.32	101.41	101.05	100.96
		atomic %			
Au	n.a.	0.00	0.01	0.01	0.00
Sb	0.20	0.00	0.03	n.a.	n.a.
S	37.16	65.84	66.96	66.17	66.04
Fe	32.01	33.67	32.78	33.65	33.80
Co	0.05	0.44	0.07	0.02	0.05
Ni	0.05	0.02	0.00	0.07	0.00
Cu	0.03	0.03	0.04	0.03	0.11
As	30.42	0.00	0.12	0.05	0.00

explanations: asp – arsenopyrite, py – pyrite

Tab. 6. The X-ray microanalysis of pyrite and arsenopyrite from the Bacúch area.

Galena is common at Sokolova dolina Valley, but only in small amounts. It most commonly occurs with Bi minerals, sphalerite and chalcopyrite in quartz, sometimes in siderite. It replaces chalcopyrite and is replaced by Bi minerals. Contents of Ag up to 1 wt.% and Bi sometimes to 7 wt.% probably correspond with intergrowths with Bi minerals (Tab.5).

Bismuthinite forms irregular grains up to 1 mm in size and intergrows with Bi sulphosalts, native bismuth and galena, confirmed by X-ray microanalysis. (Tab. 5).

Pyrite is common, the oldest sulphide mineral at both studied localities. It forms aggregates of homogenous euhedral crystals and their aggregates arranged in bands or disseminated in quartz or carbonates. It formed two generations at the Sokolova dolina Valley. Pyrite I forms small crystals and is associated with chalcopyrite I and sphalerite I, Bi minerals and galena. Pyrite II veins cuts other sulphide minerals. Higher content of Co was observed in the pyrite from Jánov grúň Hill (Tab. 6).

Marcasite occurs associated with pyrite and chalcopyrite in quartz.

Arsenopyrite occurs rarely as aggregates around the pyrite grains with chalcopyrite in quartz. It was confirmed by X-ray microanalysis (tab. 6).

Sulphosalts are common in siderite veins at Sokolova dolina Valley and they were identified by X-ray microanalysis (Tab. 7). Sulphosalts are represented by minerals of lillianite homologous series, PbBi sulphosalts and isotype series of aikinite (Makovický 1977, 1989; Makovický and Karup–Møller 1977 a, b; Springer 1971).

Sulphosalts of *aikinite isotype series* (CuPbBi) belonging to the meneghinite homologous series are wide-spread in siderite veins of this area. They are accompanied by galena, chalcopyrite, bismuthinite, native bismuth and other Bi sulphosalts.

Sample	Bac64	Bac73a	Bac73a	Bac73a	Bac65d	Bac65d	Bac70	Bac73a
mineral	aik	fri	ham	lin	gus	sch	cos	cos
				weight %				
Bi	37.41	44.47	49.25	52.97	50.28	39.14	39.92	39.85
Pb	34.92	30.78	26.29	23.54	22.91	38.00	39.81	41.79
Cu	10.21	8.46	6.92	5.67	0.35	0.30	1.20	1.21
Fe	0.21	0.00	0.01	0.03	0.06	0.05	0.23	0.01
S	16.29	17.3	16.86	17.45	17.51	16.41	16.43	16.75
Ag	0.12	n.a.	n.a.	n.a.	8.34	7.13	1.85	1.26
Sb	0.18	0.18	0.03	0.10	0.05	0.06	0.16	0.15
Total	99.34	101.19	99.36	99.77	99.51	101.09	99.60	101.01
				atomic %				
Bi	17.50	20.55	23.62	25.29	24.51	19.62	20.39	20.14
Pb	16.48	14.35	12.71	11.34	11.26	19.21	20.51	21.30
Cu	15.71	12.86	10.92	8.91	0.57	0.49	2.02	2.00
Fe	0.36	0.00	0.02	0.06	0.11	0.10	0.44	0.02
S	49.69	52.10	52.17	54.32	55.64	53.61	54.68	55.18
Ag	0.11	n.a.	n.a.	n.a.	7.88	6.92	1.83	1.23
Sb	0.15	0.14	0.02	0.09	0.04	0.05	0.14	0.13

explanations: aik – aikinite, fri – friedrichite, ham – hammarite, lin – lindströmite, gus – gustavite, sch – schirmerite, cos – cosalite.

Tab. 7. The X – ray microanalysis of sulphosalts from Sokolova dolina Valley.

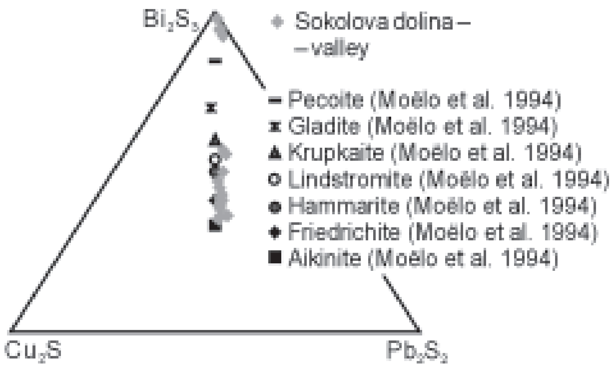

Fig. 3. Triangular diagram of the sulphosalts of aikinite isoseries from Sokolova dolina Valley.

They form inclusions in galena up to 1 mm (Fig. 2A) and myrmekitic intergrowths with galena (Fig. 2B). X-ray microanalysis correspond to *aikinite, friedrichite, lindströmite* and *hammarite* (Fig. 3).

Sulphosalts of *lillianite homologous series* formed inclusions in cosalite sometimes in CuPbBi sulphosalts (Fig. 2C). According to X-ray microanalysis, they correspond to *gustavite* and *schirmerite* (Fig. 4).

Pb-Bi sulphosalts – *Cosalite* (?) is associated with galena, chalcopyrite, Bi sulphosalts and native bismuth (Fig. 2D). X–ray microanalysis correspond to theoretical cosalite with higher content of Ag and Cu (Fig. 5).

Quartz is common mineral. It is most frequently white rarely grey. It forms veins about 2 cm thick in carbonates.

Carbonates are very abundant in the carbonate-quartz-sulphide veins. Siderite occur in Sokolova dolina Valley and dol-

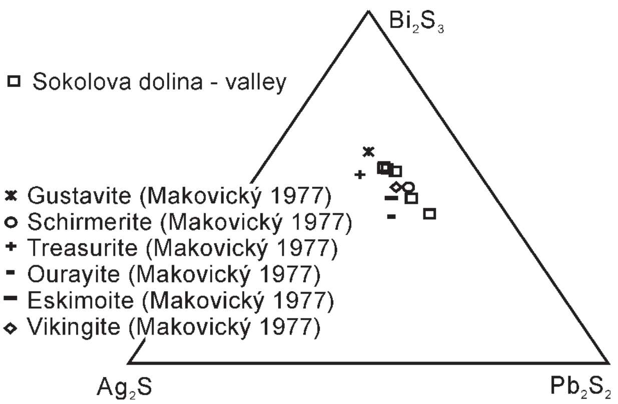

Fig. 4. Triangular diagram of the sulphosalts of lillianite homologous series from Sokolova dolina Valley.

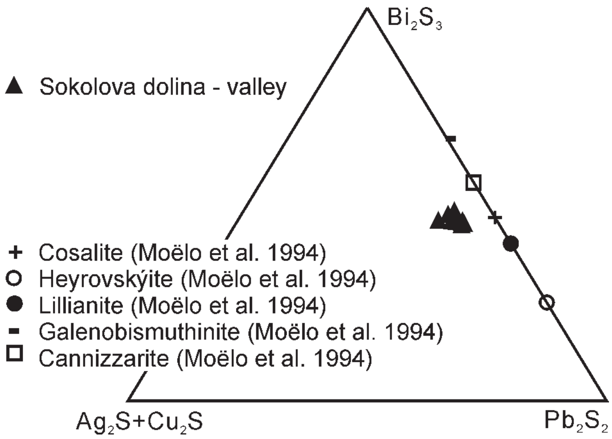

Fig. 5. Triangular diagram of cosalite from Sokolova dolina Valley.

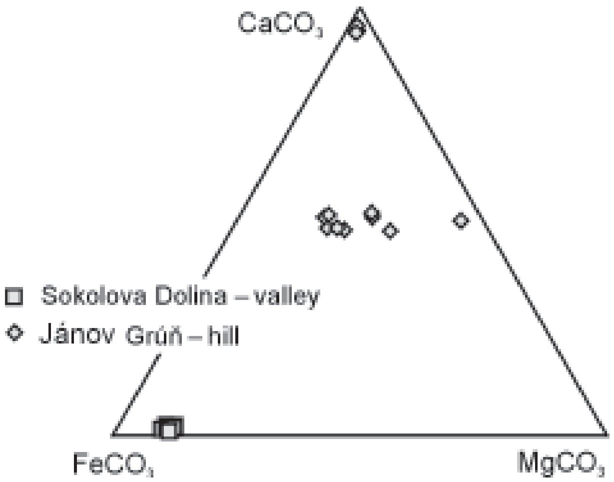

Fig. 6. Triangular diagram of carbonates from the Bacúch area.

omite, Fe rich dolomite, ankerite and calcite were identified at the Jánov grúň Hill.

Siderite is the main mineral at Sokolova dolina Valley. It forms two generations. Coarse-grained siderit forms aggregates several cm large. They are cemented by quartz and fine-grained siderite II. Both generations have similar chemical composition with low content of Mg (Fig. 6, Tab. 8).

Calcite forms small veinlets with white colour cutting older minerals. It is the youngest mineral at the Jánov grúň Hill (Fig. 6, Tab. 8).

Dolomite is the oldest carbonate at the Jánov grúň Hill. It forms aggregates cemented by younger mineralization.

Ankerite is most common mineral in the adit at the Jánov grúň Hill. It forms coarse-grained zonal aggregates of ankerite, darker zone correspond to Fe rich dolomite. It was identified by X-ray microanalysis (Fig. 6, Tab. 8), and X-ray diffraction analysis (2.9–100; 2.19–12; 1.81–14; 1.79–13).

	Sokolova dolina Valley			Jánov grúň Hill		
mineral	sid	sid	dol	ank l	ank d	cal
			weight %			
Ca	0.62	0.68	19.56	18.67	18.17	37.70
Mg	1.62	1.18	12.71	5.87	8.83	0.38
Fe	39.21	39.36	2.07	14.03	9.16	1.67
Mn	4.87	5.14	0.70	2.30	1.62	1.04
Sr	0.08	0.00	0.02	0.05	0.00	0.00
Total	60.38	60.20	52.04	56.91	53.95	56.87
			% oxides			
CaO	0.86	0.96	27.36	26.12	25.43	52.74
MgO	2.69	1.96	21.08	9.73	14.65	0.63
FeO	50.45	50.64	2.67	18.05	11.79	2.15
MnO	6.29	6.64	0.90	2.97	2.09	1.34
SrO	0.09	0.00	0.03	0.06	0.00	0.00
CO_2	38.46	38.03	46.70	44.05	44.47	44.23
Total	98.84	98.23	98.74	100.98	98.43	101.09

Explanations: sid – siderite, dol – dolomite, ank l – ankerite light phase, ank d – ankerite dark phase, cal – calcite.

Tab. 8. The X-ray microanalysis of carbonates from the Bacúch area.

Barite – fine-grained white aggregates, are rare at the Sokolova dolina Valley. It owergrows siderite grains or forms banded structure with siderite II.

Chalcocite and *covellite* are common products of weathering of chalcopyrite. They replaced chalcopyrite and sphalerite I with exsolutions of chalcopyrite after fissures and borders of grains.

Fe-bearing hydroxides are very abundant and they are associated with Fe-bearing carbonates, pyrite and chalcopyrite

Malachite is a common secondary mineral. It forms mainly coatings on the rocks and ore. It was identified by X-ray diffraction analysis.

Mineral assemblages

Hydrothermal vein mineralization was formed in two stages in the studied area (Tab. 1,2). Siderite prevails in older, carbonate stage at the Sokolova dolina Valley, where it is the dominating mineral. This stage is less present in the Jánov grúň adit and is represented by dolomite.

Quartz is the dominating mineral in the younger, second stage at the Sokolova dolina Valley. Siderite and barite are rare. Chalcopyrite is the prevailing ore mineral, sometimes pyrite and galena often with Bi (Cu, Pb, Ag) sulphosalts and sphalerite are also present. Succession is shown at the Tab. X. Fragments of carbonates and altered rocks are cemented by younger quartz--carbonates aggregates and form brecciated texture. Sometimes banded textures formed by siderite, quartz less barite and massive pyrite-chalcopyrite ores occur in the Sokolova dolina Valley.

Simple mineralization with prevailing ankerite and chalcopyrite as prevailing ore mineral is presented at the Jánov grúň Hill.

Fluid inclusions

We measured inclusions in ankerite from Jánov grúň Hill and inclusions in quartz from Jánov grúň Hill and from Sokolova dolina Valley.

Two-phase inclusions were observed in studied minerals. They consist of vapour and aqueous solution of NaCl with small amount of KCl (Tab. 9).

Inclusions in ankerite consist of vapour and aqueous solution of NaCl with small amount of KCl. They are concentrated on growth surface and their size is less than 7 µm. Melting

Fluid inclusions	Ankerite (24) (Jánov grúň gallery)	Quartz (28) (Jánov grúň gallery)	Quartz (13) (Sokolova dol. Valley)
Th (°C)	173 to 246	98 to 201	138 to 200
Tm (°C)	-13 to -27	-5 to -23	-7 to -13
Te (°C)	not measured	-18 to -32	-22 to -25
ρ (g.cm$_3$)	0.97 - 1.08	0.98 - 1.09	0.98 - 1.04
Ř (µm)	3 - 7	3 - 11	4 - 11
V (vol. %)	10	10	10
salinity (wt. % of NaCl equiv.)	17 - 26	9 - 24	11 - 16

Tab. 9. Fluid inclusions data from the Bacúch area.

temperature of ice (Tmi) varies from −13 °C to −26 °C. Homogenization temperature (Th) varies from 173 °C to 246 °C with maximum data from 210 °C to 225 °C. Calculated salinity varies from 17 to 26 wt.% NaCl equiv.

Inclusions in quartz consist of vapour and aqueous solution of NaCl with small amount of KCl . Eutectic temperature (Te) varies from −18 °C to −32 °C. Their size is up to 12 mm. Tmi varies from −5 °C to −23 °C. Inclusions were homogenized on liquid in temperature from 98 °C to 201 °C. Salinity varies from 9 to 24 wt.% NaCl equiv.

We can observe decreasing salinity with the gradual decreasing temperature (T) (Fig. 7).

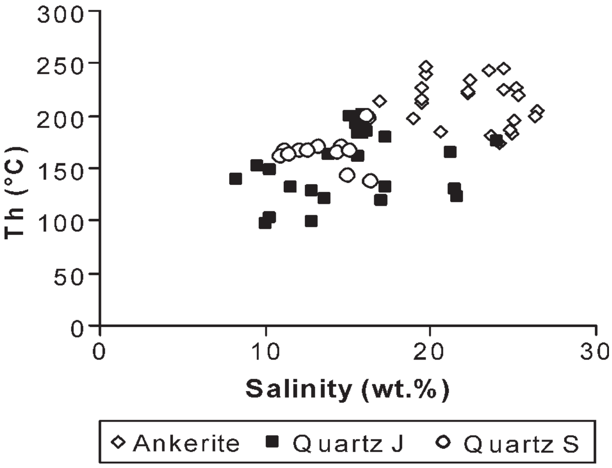

Fig.7. Relations of the homogenization temperature on salinity. Quartz J – quartz from Jánov grúň Hill. Quartz S – quartz from Sokolova dolina Valley.

We tried to estimate approximative pressure and depth of origin of mineralization: Jánov grúň Hill (ankerite): pressure (p) is less than 1.3 kbar and depth less than 4.73 km at T 250 °C, (quartz): pressure is 1.9 kbar and depth 7.23 km at T 200 °C with density of average crust 2750 kg/m^3. Sokolova dolina Valley (quartz): pressure is less than 1.1 kbar, depth is less than 4.23 km at T 200 °C with density (r) of average crust 2750 kg/m^3.

Conclusions

We have identified sulphosalts Bi (Cu, Ag, Pb), native bismuth, arsenopyrite, marcasite, calcite and dolomite nearby Bacúch village for the first time. Dominated gangue minerals are carbonates: ankerite, Fe rich dolomite, dolomite, siderite and calcite and quartz. Carbonates of ankerite-dolomite series and calcite occurred at the Jánov grúň Hill and siderite occurred only at Sokolova dolina Valley.

We supposed that carbonate mineralization in the Bacúch area and in the Veporic and Tatric Units is similar with some differences. From Veporic Unit, carbonates correspond to mesitine (feromagnesite) and ankerite (Hvo•ďara 1971), and Mg-Fe ankerite and calcite (Iró 1996) were described. Presence of siderite with low content of Mg was still not confirmed in Veporic Unit. Siderite is a typical mineral in the eastern part of Ďumbierske Tatry (Tatric Unit) whereas ankerite-dolomite and calcite are rare (Ozdín and Chovan 1999). Chalcopyrite is the main sulphide in the Bacúch, with common pyrite. Tetraedrite was not identified at the localities nearby Bacúch; it is the main sulphide mineral of siderite deposits in Tatric Unit and Gemeric Unit. Bi sulphosalts are characteristic for siderite veins. Sulphosalts of aikinite isotype series are most common. Cosalite and Bi- sulphosalts with Ag are rare. Members of aikinite isotype series and pavonite are known from Tatric Unit (Majzlan and Ozdín 1995) and from Gemeric Unit (Antal 1991; Ďuďa 1996; Kupčík et al. 1969 and others.).

Similar Th (from 80 °C to 240 °C) of fluid inclusions were obtained from Gemeric Unit. Composition of solution is different. System $CaCl_2$-NaCl-H_2O was described in Gemeric Unit (Hurai et al. 1998) and system NaCl-KCl-H_2O in Bacúch. Hydrothermal mineralization could have formed at the following conditions: Jánov grúň Hill – ankerite p 1.3 kbar and T 250 °C and quartz p 1.9 kbar and T 200 °C; Sokolova dolina Valley – – quartz p 1.1 kbar and T 200 °C calculated from fluid inclusions data. Jánov Grúň complex was originated at following p, T conditions p 3–4 kbar and T 350–370 °C by regional metamorphism.

Structural setting of carbonate veins in Bacúch (generally direction E-W dipping to the S) is similar as in other tectonic units of Western Carpathians (Slavkay and Petro 1993; Ozdín and Chovan 1999; Kodĕra et al. 1986, 1990; Grecula et al. 1995). We supposed the existence of one ore zone of carbonate mineralization (from Vyšná Boca to Bacúch), which continues from Tatric to Veporic Unit. Younger age of mineralization than Alpine overfault of Veporic Unit through Tatric Unit were supposed by Slavkay a Petro (1993), Chovan et al., (1999) and others. Carbonate veins cut rocks of the complex Jánov grúň dated by U/Pb method as Permian–Lower Triassic. Hydrothermal mineralization reached Jurassic carbonates in Bacúch (Petro 1973). Siderite mineralization cuts Triassic rocks (Ozdín and Chovan 1999; Hak and Losert 1962) at the other places in Tatric Unit. Variscian age of the oldest siderite veins is supposed by age models from galena and younger generations of siderite (Kantor and Rybár 1964; Černyšev et. al. 1984) could be the products of Alpine remobilisation.

Siderite mineralization could have originated by Variscian magmatic processes (Ilavský 1986) or Variscian metamorphic processes with eventual Alpine remobilisation (Grecula et al 1995). The occurrence of crosscutting of siderite veins to the Permoskythian sandstones and conglomerates are also mentioned in Eastern Alps (Nordlich grauwacken zone). It is expected that siderite mineralization was formed in an initial stage of the Alpine tectono-metamorphic event and can be correlated with extensional phases in the Permoskythian (Prochaska 1998).

We expect that carbonate mineralization in the vicinity of Bacúch village was formed in the Alpine tectono-metamorphic event. This opinion is supported by observed mineral assemblages, structural setting and continuation of the carbonate ore zone from Veporic to Tatric Unit through Alpine overfault and the occurrence of carbonate veins in the Permian–Lower Triassic complex of Jánov Grúň.

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Early Paleozoic Manganese Ores in the Gemericum Superunit Western Carpathians, Slovakia

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ABSTRACT: Stratiform manganese ores are bound to the metamorphosed Early Paleozoic black shale of the Gemericum Superunit. Sedimentary – diagenetic manganese accumulation is overlapped by the association of the metamorphic minerals due to the Hercynian metamorphism. Rhodonite, rhodochrosite, anthophyllite, chlorite, quartz, Mn-rich calcite, magnetite, pyroxmangite, pyrophanite, spessartite and tephroite represent metamorphosed manganese carbonate-silicate rock (queluzite). Pyrite, chalcopyrite, cobaltite, pyrrhotite, galena, pentlandite, sphalerite, ullmannite, calcite and quartz represent the younger hydrothermal phase of mineralization. Pyrolusite, todorokite, cryptomelane and iron hydroxides were formed in the oxidation zone.

KEY WORDS: manganese ore, mineral associations, metamorphism, Slovakia.