Rudarsko-geološko-naftni zbornik	Vol. 9	str. 11–16	Zagreb, 1997.

UDC 553.689:553.497/99:(497.15)

Izvorni znanstveni članak

The project »Magmatism, metamorphism and mineral deposits of Dinarides«, No 195004, financed by Ministry of Science and Technology of the Republic of Croatia

TETRAHEDRITE FROM THE DUBRAVE – DUGI DOL BARITE DEPOSITS, KREŠEVO, BOSNIA AND HERZEGOVINA

Ivan JURKOVIĆ[1] and Slobodan MIKO[2]

[1] *Faculty of Mining, Geology and Petroleum Engineering, Univ. of Zagreb, Pierottijeva 6, HR-10000 Zagreb, Croatia*
[2] *Institute of Geology, Sachsova 2, HR-10000 Zagreb, Croatia*

Key-words: Mercurian-antimonian tetrahedrite, Chemical and isotopic compositions, Dubrave barite deposit, Kreševo, Bosnia.

The chemical composition of the tetrahedrite from the barite deposit Dubrave – Dugi Dol, south of the town Kreševo, Bosnia, hosted by Devonian Dolomite is as follows: $(Cu_{10.65}Ag_{0.073}Hg_{0.03})_{10.75}$ $(Fe_{0.81}Zn_{0.94})_{1.75}$ $(Sb_{3.57}As_{0.34}Bi_{0.004})_{3.91}S_{13.00}$. Cation proportions are: $Me^{2+}:Me^{3+}:S$ = 3.20:1.00:3.33. The $\delta^{34}S$ = –10.91‰. The calculated formula is in good correspondence with the compositions of other analyzed tetrahedrites from the whole Middle Bosnian Schist Mountains. These results as those of the fluid inclusion studies of gangue minerals suggests the generation of tetrahedrites from highly homogenized, hot (190–310 °C), high saline (24.2–26.3 wt% NaCl equiv.) mineralizing solutions generated by mixing of ascending deep seated upper mantle (Hg, F, Cu-bearing) and metamorphogenic lower crust (Zn, Fe, Ag, Au-bearing) fluids with descending highly evolved Upper Permian saline formation waters. The obtained data exclude the applicability of the fractional crystallization generation model.

Ključne riječi: živin-antimonski tetraedrit, kemijski i izotopski sastav, baritsko ležište Dubrave, Kreševo, Bosna.

Kemijski sastav tetraedrita iz baritnog ležišta Dubrave – Dugi Dol, Kreševo, Bosna je slijedeći: $(Cu_{10.65}Ag_{0.073}Hg_{0.03})_{10.75}$ $(Fe_{0.81}Zn_{0.94})_{1.75}$ $(Sb_{3.57}As_{0.34}Bi_{0.004})_{3.91}S_{13.00}$. Odnos kationa je: $Me^{2+}:Me^{3+}:S$ = 3.20:1.00:3.33. The $\delta^{34}S$ = –10.91‰. Formula tetraedrita se vrlo dobro uklapa u opći raspon sastava analiziranih tetraedrita iz cijelog područja Srednjobosanskih škriljavih planina. Navedeni rezultati kao i rezultati studije fluidnih inkluzija minerala jalovine upućuju na postanak tetraedrita iz vrlo homogeniziranih, vrućih (190–310 °C), jako slanih (24.2–26.3 wt% NaCl equ.) mineralizirajućih otopina generiranih miješanjem uzlaznih, duboko smještenih u gornjem omotaču (nosilaca Hg, F, Cu) i metamorfogenih iz donjeg dijela kore (nosilaca Zn, Fe, Ag, Au) sa silaznim, jako slanim formacijskim vodama gornjopermskog evaporitnog horizonta. Dobiveni analitički rezultati isključuju primjenu modela frakcione kristalizacije za genezu tetraedrita.

Introduction

Barite deposits Dubrave and Dugi Dol are situated about 1 km south-east of the summit of Međuvršje (+1195 m) and 3 km south-east of the town of Kreševo in the Mid-Bosnian Schist Mountains (**fig. 1**).

The mineralization occurs in dolomites, and assigned with some reservation as Devonian by Jovanović et al., (1977/78) based on analogy with the identical fossiliferous rocks in the Prozor area (Živanović, 1972). Ore occurrences are in the form of irregular nests, lense-shaped veins, networks of veins and veinlets, locally they occur as ore-breccias in tectonically dislocated dolomites (**Fig. 2a, 2b**). The ore occurrences have an east west extension. There are also significant allochtonous, residual barite deposits on a karstified relief of dolomite (**fig. 2c**).

The Dubrave deposit is situated at an elevation from +970 m to +1000 m, in a belt 30 m to 50 m wide. The Dugi Dol deposit occurs at elevations from +880 m to +930 m.

The deposit paragenesis is described in detail by Jurković (1987). ***Barite*** is the main and preponderant ore mineral. Its platy habit is relatively frequent, and granular structure (polygonal, allotriomorphic, hypidiomorphic, recrystallized, locally breccia-like) is most frequent (**Plate I, phot. 1 and 3**) ***Tetrahedrite*** is the most abundant sulphide, but it participates only with <1 wt% to 5 wt%. ***Pyrite*** (**Plate I, phot. 4**), ***chalcopyrite I and II***, two unidentified ***copper sulphosalts, colloform pyrite*** and ***ascedent goethite*** are present only as accessories in these deposits.

Tetrahedrite forms nests, veinlets, incrustations, small rounded masses, dispersed idiomorphic grains replacing barite along the margins of grains or along fine cracks and fissures (**Plate I phot. 1 and 2**). It is, in places, very strongly cataclased.

Subordinate gangue minerals ***quartz I and II*** occur as small nests, small irregular masses, or system consisting of more or less dense arrays of veinlets. Transparent ***fluorite***, violet in colour or colourless, noticeably corroded (Barić, 1952), scarce leafs of ***sericite*** and ***rutile*** crystals are accessories. Ferrodolomitization, and simultaneous recrystallization of dolomite is stronger in the more silicified parts of the deposit.

Recently, Radanović-Gužvica (1995) investigated two barite crystals from the deposit Dubrave. The habit of these crystals corresponds to the rectangular-platy type according to Braun (1932). They are thick-platy or columnar crystals, elongated paralllely with one of the crystallographic axis [100] with forms: (001), (010), (210), (011), (101), (213). Chemical analyses made by the ICP-AES method (Jobin-Yvon 50 Polyscan instrument) gave: crystal K_1 2.93 wt% $SrSO_4$, crystal K_2 0.38 wt% $SrSO_4$.

Analytical methods and results

I Strontium contents in barites

The two barite samples were investigated: 215/1 (thick platy aggregates) and 215/2 (recrystallized masses) by dr. D. Šiftar who utilized his own spectrographic method (Šiftar, 1974), and was controlled with a method by Gordon et al., (1959).

The obtained values of 7.32 wt% $SrSO_4$ for sample 215/1, and of 5.1 wt% $SrSO_4$ for sample 215/2 are relatively high and characteristic for barites from the Kreševo area (Šiftar, 1988).

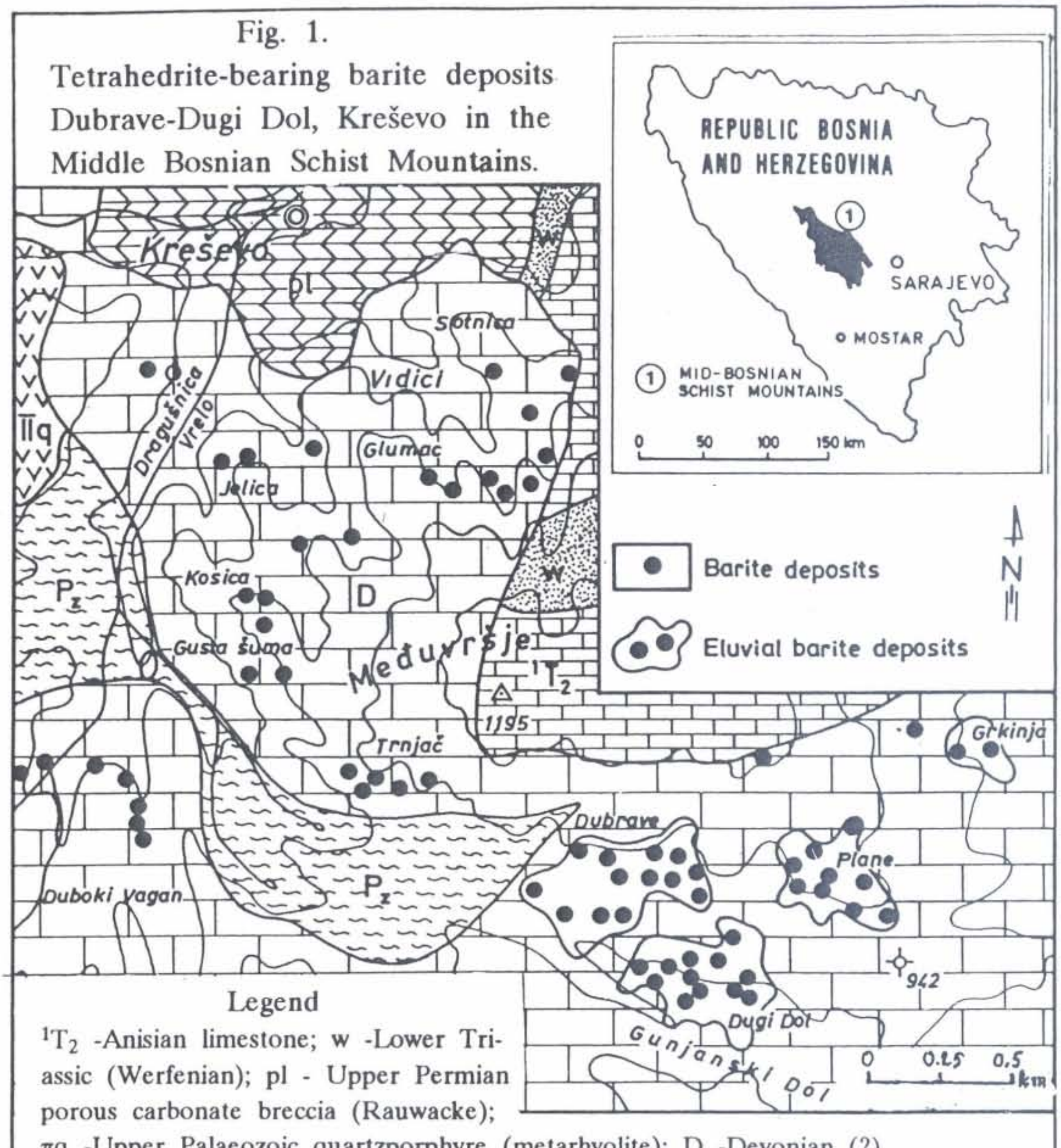


Fig. 1.
Tetrahedrite-bearing barite deposits Dubrave-Dugi Dol, Kreševo in the Middle Bosnian Schist Mountains.

Legend
$^1T_2$ -Anisian limestone; w -Lower Triassic (Werfenian); pl - Upper Permian porous carbonate breccia (Rauwacke); πq -Upper Palaeozoic quartzporphyre (metarhyolite); D -Devonian (?) dolomite; Pz - Pre-Devonian phyllite, quartzite, quartz-sericite schist
Geological map made by I. Jurković et al. 1951, Jurković, 1956,1987.

II Sulphate sulphur isotopic composition of barite

The barite sample 215/2 prepared and measured in the Institute Jože Štefan (Ljubljana) gave: $\delta^{34}S$ = +11.35‰.

III Sulphide sulphur isotopic composition of tetrahedrite

The tetrahedrite sample T_1 was analysed in the Institute Jože Štefan (Ljubljana). The $\delta^{34}S$ of this tetrahedrite sample is –10.91‰.

IV Chemical analyses of tetrahedrites

For the chemical analyses we collected small (1 to 3 mm in diameter) individual dispersed tetrahedrite crystals found within the dolomite fragments inside the barite bodies. The grains were more or less rounded or with the terminal planes. All collected material was carefully purified under the binocular microscope. The tetrahedrite crystals and grains prepared for analyses were fresh, not weathered.

Sample preparation for AAS and ICP-AES analysis

Powdered tetrahedrite samples weighing 0.1 g were digested with a mixture consisting of 2 ml Br_2 and 15 ml conc. HCl on a water bath at 65 °C. The resulting solutions were diluted to 100 ml with 10% HCl.

The solutions were analyzed by flame atomic absorption spectrophotometry for the following elements: Ag, Au, Sb, As, Bi, Pb, Cd, Mn, Fe, Ni and Cr. Mercury was analyzed by cold wapor AAS after Hg reduction with $SnCl_2 \times H_2O$ (10% wt. solution) and H_4ClNO (hydroxylammonium chloride 20% wt. solution). All analysis were performed on a Pye Unicam SP9 AAS instrument. Copper was analyzed by a Jobin Yvon 50P simultaneous ICP-AES spectrometer with RSD of 2%. Accuracy was controlled with USGS geochemical standards GXR-1

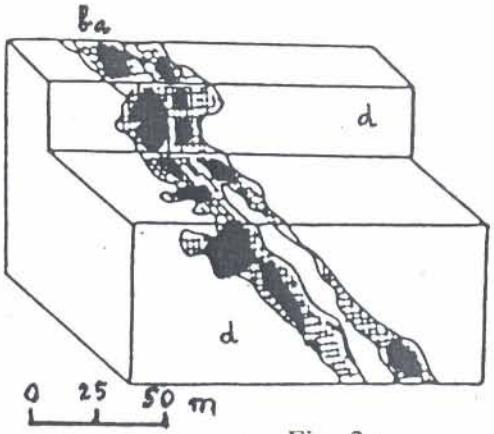


Fig. 2a

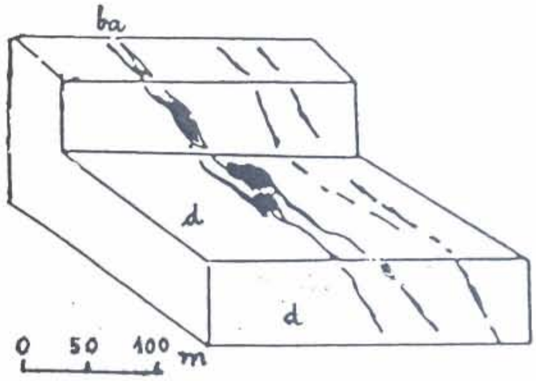


Fig. 2b

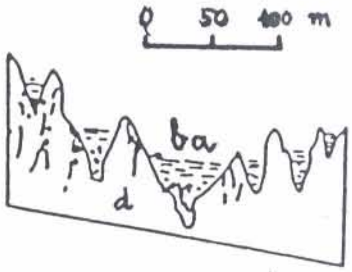


Fig. 2c

Fig. 2. Dubrave-Dugi Dol, Kreševo. Forms of barite deposits

2a - large irregular barite bodies (ba) in dolomite (d); 2b - discontinuous system of barite (ba) veins, lenses, and larger ore bodies in dolomite (d); 2c - residual barite (ba) deposits on karstified dolomite (d)
designed by M. Ramović (1979)

Table 1. Chemical composition and cation proportions of the tetrahedrite sample 215, Dubrave – Dugi Dol barite deposit

			Cation proportions	
Elements		Wt%	Elements	Me^2+Me^3+S
Me^2+	Fe Cu Zn Hg Ag	2.67 40.09 3.65 0.383 0.466	0.047809 0.630882 0.055836 0.001909 0.004320	0.740756
Me^3+	Sb As Bi	25.73 1.49 0.045	0.211335 0.019887 0.000215	0.231437
S	S	24.70	0.770334	0.770334
	Total	99.224	1.742527	1.742527
	Me^{2+}: Me^{3+}: S = 3.20 : 1.00 : 3.33			

X_{Ag} = 0.68 X_{Sb} = 91.4 X_{Fe} = 46.1

Table 2. Four partial chemical analyses of tetrahedrites from Dubrave – Dugi Dol deposit (samples T_1–T_4) as compared with the complete chemical analysis of the sample 215 (analyst S. Miko).

Components	Tet-1	Tet-2	Tet-3	Tet-4	215
Fe	2.68	2.60	2.71	2.60	2.67
Cu	41.25	37.59	38.45	41.45	40.09
Zn	3.98	3.86	3.65	3.89	3.65
Hg		0.32	0.29	0.31	0.383
Ag	0.26	0.27	0.26	0.20	0.466
Sb	23.81			24.24	25.73
As	2.69				1.49
Bi	0.067			0.063	0.045
S	22.14			24.54	24.70

Utilizing ICP-AES analysis the authors obtained the following additional very similar values for copper: 41.62; 40.54; 41.17 and 39.78 wt%.

Table 3. Trace elements (in ppm) in tetrahedrite from the Dubrave – Dugi Dol barite deposit

Element	Tet-1	Tet-2	Tet-3	Tet-4	215
Co	8.5			8.7	
Ni				6.7	40.0
Au	9.3			7.2	
Cd	154.0	179.0	134.0	157.0	130.0
Mn	16.6		19.6	18.9	90.0
Pb	94.0	88.0		90.0	110.0
Cr	18.5			22.0	
Mo⁺	< 40	< 40	< 40	< 40	
Sc⁺	< 30	< 30	< 30	< 30	

⁺ The values for molybdenum and selenium are below detection limit in the tetrahedrite

and GXR-4. Sulphur was analysed by »wet« chemical method.

The calculated formula on the basis of the performed analysis **(Table 1)** is as follows:
$(Me^{2+})_{12.50}(Me^{3+})_{3.91}S_{13.00}$ **or**
$(Cu_{10.65}Ag_{0.073}Hg_{0.03})_{10.75}(Fe_{0.81}Zn_{0.94})_{1.75}$
$(Sb_{3.57}As_{0.34}Bi_{0.004})_{3.91}S_{13.00}$.
The tetrahedrite from the barite deposit Dubrave – Dugi Dol (Kreševo) belongs to the group of typical **antimonian tetrahedrites** with small partition of silver and mercury.

Authors performed four additional partial chemical analyses (AAS-technique) of tetrahedrites from the same deposit **(Table 2)** with an intention to define the composition span of the main tetrahedrite components (in wt%). The values for iron, zinc, mercury, silver and bismuth show relatively narrow ranges, whereas the values for copper, antimony, arsenic and sulphur display a wide range.

V Trace elements

The following trace elements have been analyzed by AAS: copper, nickel, gold, cadmium, manganese, lead, chromium, molybdenum and selenium **(Table 3)**.

Discussion

In **Table 4** are presented the formulae of six tetrahedrite samples from the Middle Bosnian Schist Mountains (MBSM) ore deposits calculated on the basis of performed chemical analyses. Five of them (1–5) are already published, the sixth is the result of analysis presented in this paper. Ten additional complete chemical analyses of MBSM tetrahedrites are printed recently (Jurković et al., 1997)).

The obtained most characteristic results are as follows:

(1) Tetrahedrites from the *Gornji Vakuf area:* (a) those in the Mačkara siderite-barite vein hosted by pre-Devonian metamorphic rocks, and (b) those in the Sabiljine Pećine, big irregular barite bodies, hosted by Devonian carbonate rocks, are distinguished by high contents of mercury (5 wt% in average, but locally up to 16 wt% Hg). This area is particularly suitable (permeable) for inflow of mercury-bearing fluids deriving from deep parts of the degassed upper mantle along the first-order Voljevac fault which stretches NNW-SSE as do all ore veins in the same area.

The tetrahedrites from the Gornji Vakuf area are typical **mercurian-antimonian tetrahedrites or schwatzites.** The zinc content of these tetrahedrites is very low.

(2) Tetrahedrites from the *Kreševo area* barite deposits, hosted by Devonian dolomites, which are distant to the major first-order Busovača fault on the eastern margin of the MBSM, are confined to second-order faults which were evidently less permeable for ascending fluids. This is reflected in the lowering of the mercury content, which averages 2.7 wt% Hg. The content of zinc is elevated and that of iron lowered. These tetrahedrites also belong to the group of **mercurian-tetrahedrites** with relatively lower mercury content.

(3)Tetrahedrites from the *Fojnica area* (the Trošnik deposit) hosted by carbonate rocks intercalated in the highest horizon of pre-Devonian metamorphic rock complex, represent typical **ferroan, antimonian tetrahedrites** with only traces of mercury, and low arsenic content.

Table 4. Formulae of tetrahedrites from the Middle Bosnian Schist Mountains (MBSM) ore deposits

No	Locality	Formulae, cation proportions, analysts
1	Mačkara Gornji Vakuf	$(Cu_{11.65}Ag_{0.03}Hg_{0.73})_{12.41}(Fe_{0.97}Zn_{0.21})_{1.18}(Sb_{4.34})_{4.34}S_{13.00}$ $Me^{2+} : Me^{3+} : S = 3.13 : 1.00 : 2.90$ Analyst: Patera in F. Poech (1900)
2	Mačkara Gornji Vakuf	$(Cu_{8.83}Hg_{0.48})_{9.31}(Fe_{1.02})_{1.02}(Sb_{3.48}As_{0.32})_{3.80}S_{13.00}$ $Me^{2+} : Me^{3+} : S = 2.72 : 1.00 : 3.42$ Analyst: V. Vesely (1921)
3	Mačkara Gornji Vakuf	$(Cu_{9.79}Ag_{0.02}Hg_{0.63})_{10.41}(Fe_{1.14}Zn\ tr)_{1.14}(Sb_{2.76}As_{1.04}Bi_{0.03})_{3.83}S_{13.00}$ $Me^{2+} : Me^{3+} : S = 3.03 : 1.00 : 3.32$ Analyst: I. Jurković (1960)
4	Vidici Kreševo	$(Cu_{10.90}Ag_{0.03}Hg_{0.16})_{11.09}(Fe_{1.28}Zn_{0.31})_{1.60}(Sb_{3.52}As_{0.63}Bi\ tr)_{4.15}S_{13.00}$ $Me^{2+} : Me^{3+} : S = 3.06 : 1.00 : 3.14$ Analyst: I. Jurković (1986)
5	Trošnik Fojnica	$(Cu_{10.13}Ag_{0.03}Hg_{0.02})_{10.18}(Fe_{1.86}Zn_{0.49})_{2.35}(Sb_{3.62}As_{0.25}Bi_{0.02})_{3.89}S_{13.00}$ $Me^{2+} : Me^{3+} : S = 3.22 : 1.00 : 3.34$ Analyst: I. Jurković (1959)
6	Dubrave Kreševo	$(Cu_{10.65}Ag_{0.073}Hg_{0.03})_{10.75}(Fe_{0.81}Zn_{0.9})_{1.74}(Sb_{3.57}As_{0.34}Bi_{0.004})_{3.91}S_{13.00}$ $Me^{2+} : Me^{3+} : S = 3.20 : 1.00 : 3.33$ Analyst: S. Miko, this paper

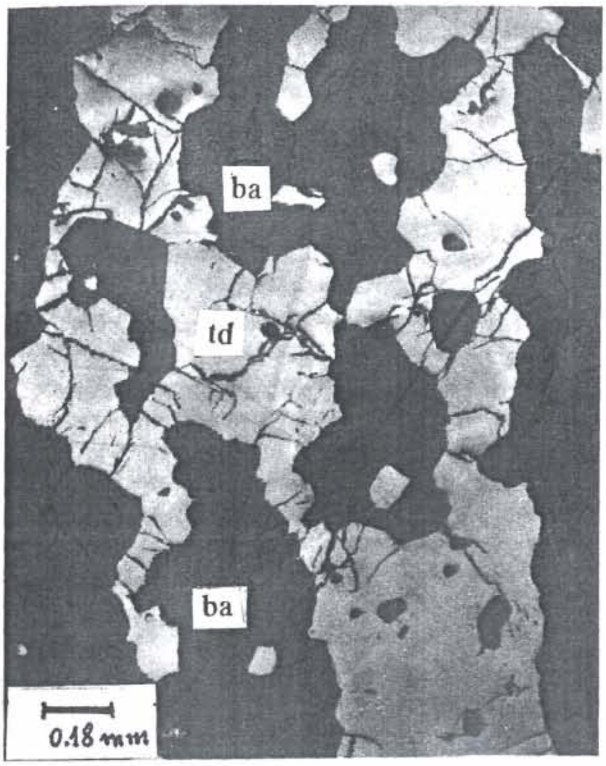
Plate I

Phot. 1. Dubrave – Dugi Dol, Kreševo. Polished section, parallel nicols. Tetrahedrite (td, light gray) replaces coarse grained barite (ba, dark gray).

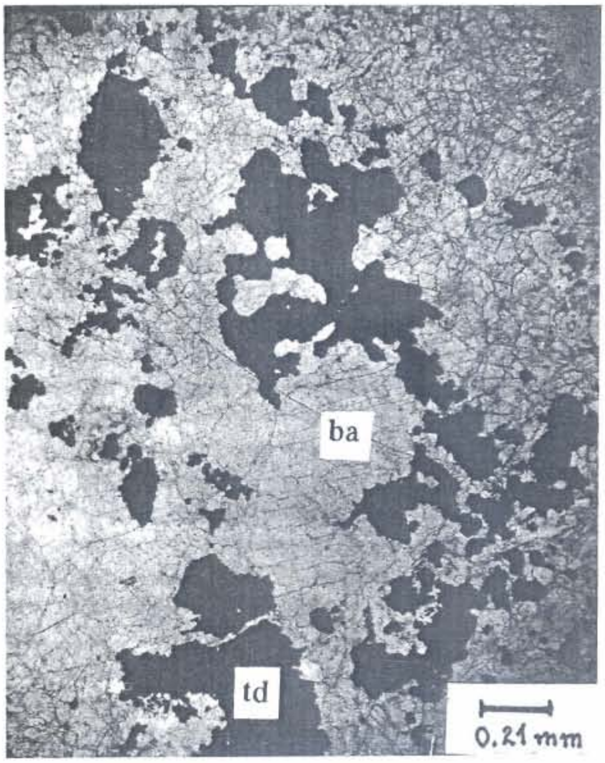
Phot. 2. Dubrave – Dugi Dol, Kreševo. Thin section, parallel nicols. Tetrahedrite (td, black) replaces barite (ba, light gray). Inside tetrahedrite sieved relics of replaced barite. Barite crystals are stronlgy cataclased.

Phot. 3. Dubrave – Dugi dol, Kreševo. Thin section, crossed nicols. Allotriomorphic texture of barite (ba).

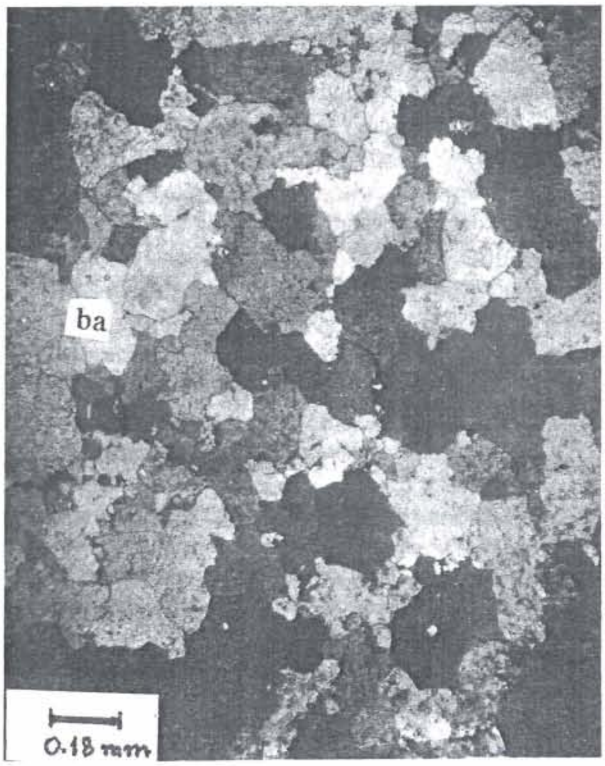
Phot. 4. Dubrave – Dugi Dol, Kreševo. Polished section, parallel nicols. Pyrite grains (py, light gray) zonary replaced by tetrahedrite (td, dark gray). Barite (ba, almost black) is the main gangue mineral.



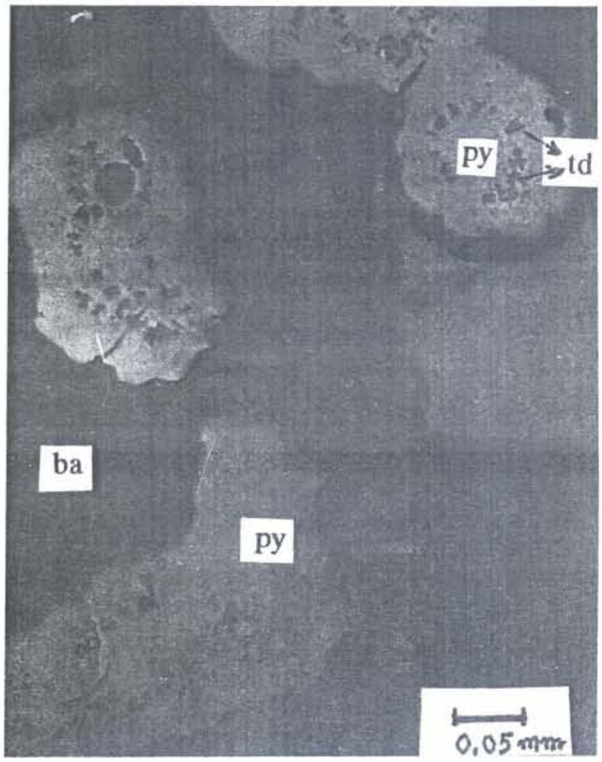
phot. 1



phot. 2



phot. 3



phot. 4

(4) All tetrahedrites from the MBSM are gold-bearing and contain (in ppm): 50; 30; 21.8; 27.3; 62; 154.5; 8.3; 13.4; 11.6 (Jurković et al., 1997) – an average 42.1 = 42.1 g/t. Mercury-bearing tetrahedrites from Brixlegg, Austria (Lukas, 1971; Gstrein, 1983) and those from the Rudnany deposit, Slovakia (Cambel-Jurkovski et al., 1985) are not gold-bearing.

(5) Tetrahedrites from the MBSM deposits contain (from 14 analyzed tetrahedrite samples) only 0.20 wt% Ag varying from 0.083 to 0.62 wt%. Since the range is relatively narrow, the model of fractional crystallization proposed for the argentinian tetrahedrites from the Orcopampa deposit (Peru) by Hackbarth & Petersen (1984) and Petersen et al., (1990), can not be applied for the MBSM tetrahedrite deposits.

(6) The fluid inclusion study (Palinkaš & Jurković, 1994) of (a) quartz, fluorite, and barite crystals from the Kreševo tetrahedrite-bearing barite deposits; (b) of barite crystals from the Mačkara tetrahedrite-bearing siderite-barite deposits, and (c) of quartz crystals from the Busovača monomineral quartz deposits, implies a simultaneous and uniform generation of tetrahedrite bearing, ore deposits from the uniformly extended mineralizing fluids through the whole Middle Bosnian Schist Mountains (MBSM). These fluids were highly homogenized, hot (190°–310 °C), and saline (24.2 to wt% NaCl equiv.).

They were formed by mixing of the ascending hydrothermal deep seated magmatic and/or metamorphogenic fluids with descending highly evolved Upper Permian formation (evaporite) waters.

This homogeneity of fluids is also supported by the fact that all 18 analyzed tetrahedrites showed pronounced negative $\delta^{34}S$ values (ranging from –5.5‰ to –15.4‰, on the average –10.48‰) suggesting the uniform generative process.

Received: 1997–02–19
Accepted: 1997–07–10

REFERENCES

Barić, Lj. (1952): Optički fluorit u okolini Kreševa u Bosni. *Geol. vjesnik II–IV,* 83–86, Zagreb.

Braun, F. (1932): Morphologische, genetische und paragenetische Trachststudien an Baryt. *N. Jahrb. Min., Geol., Palaeont., Abh., 65, Beilage Band, Abt. A.,* 173–222.

Cambel, B. & Jurkovsky, J. et al. (1985): The Rudnany ore field – geochemical-metallogenetic characteristics (in Slovakian). *Slovenska akademia vied,* 363 pp., Bratislava.

Gordon, L., Salutsky, M. L., and Willard, H. H. (1959): Precipitation from homogenous solution *Wiley, VIII+187 p.,* New York.

Gstrein, P. (1983): Ueber mögliche Umlagerungen von Fahlerzen im devonischen Schwazer Dolomit wie auch in der angrenzenden Schwazer Trias. *Oester. Akad. d. Wiss. 6,* 65–74. In »Ore Mobilization in the Alps and in SE-Europe, Leoben–Wien.

Hackbarth, C. J. & Petersen, U. (1984): A Fractional Crystallization Model for the Deposition of Argentinian Tetrahedrite *Econ. Geology 79,* 448–460.

Jovanović, R., Mojičević, M., Tokić, S. and Rokić, Lj. (1977/78): Osnovna geološka karta, list Sarajevo, 1:100.000. *Savezni geol. zavod,* Beograd.

Jurković, I. (1956): Mineralne parageneze u Srednjobosanskom Rudogorju s osobitim osvrtom na tetraedrite. *Dissertation,* 306 pp. Univ. of Zagreb, Zagreb.

Jurković, I. (1959): Tetraedrit iz rudišta Trošnik kraj Fojnice u Srednjobosanskom Rudogorju (Tetrahedrite from the ore deposit of Trošnik near Fojnica in the Mid-Bosnian Ore Mountains). *Geološki glasnik 4,* 221–246, Sarajevo.

Jurković, I. (1960): Quecksilberfahlerz vom Mačkaragang bei Gornji Vakuf in Bosnien (Jugoslawien). *N. Jb. Miner., Abh. 94,* 539–558, Festband Ramdohr, Stuttgart.

Jurković, I. (1986): Quantitative Chemical and Optical Investigations of the Tetrahedrite from Barite-bearing Deposit Vidici on the Northern Slopes of the Mountain Meduvršje South of the Town of Kreševo, Bosnia. *Geol. vjesnik 39,* 187–214, Zagreb.

Jurković, I. (1987): Barite deposits on Mount Meduvršje south and south-east of the town of Kreševo, Bosnia. *Geol. vjesnik, 40,* 313–336, Zagreb.

Jurković, I. (1991): Gold- and silver-bearing Hg-tetrahedrite deposits in Central Bosnia, Yugoslavia. EUG VI Biennal Meeting, Strasbourg, France. *TERRA, Abstract 3, No 1,* 411.

Jurković, I., Miko, S., Jakšić, M., Pęzdič, J., Palinkaš, L. A., Slovenec, D., and Šiftar, D. (1997): Geochemical Characteristics of mercurian tetrahedrites from the Middle Bosnian Schist Mountains. *4th Biennal SGA Meeting, August 11–13, 1997,* Turku, Finland. Printed in: Mineral Deposits, Research and Exploration, p. 829–833, Papunen (ed.), 1997, Balkema, Rotterdam.

Katzer, F. (1907): Die Fahlerz- und Quecksilberzlagerstätten Bosniens und der Herecgovina, pp. 121. Sonderabdruck aus dem *Berg- und Hüttenmännischen Jahrbuch der k.k. montanistischen Hochschulen zu Leoben und Příbram, LV Band, 2 Heft.* Vienne.

Lukas, W. (1971): Tektonisch-genetische Untersuchung der Fahlerz-Lagerstätte am Falkenstein bei Schwaz (Tirol). *N. Jb. Geol. Paläont. Mh.,* 47–63.

Ozerova, N. A. (1977): O degazacii rtuti iz glubin Zemli. Geohemija processov migracii rudnih elementov. *Nauka,* 15–35, Moskva.

Palinkaš, L. A. & Jurković, I. (1994): Lanthanide geochemistry and fluid inclusion peculiarities of the fluorite from the barite deposits south of Kreševo, Bosnia, *Geologica croatica 47/2,* 103–116, Zagreb.

Petersen, U. E., Petersen, U. and Hackbarth, Cl. (1990): Ore zoning and Tetrahedrite Compositional Variation at Orcopampa, Peru. *Econ. Geology, 85,* 1491–1503.

Poech, F. (1900): L'industrie minérale de Bosnie-Herzégovine. Vienne.

Radanović-Gužvica, B. (1995): Morfološke i kemijske značajke barita odabranih iz zbirke Hrv. prirodosl. muzeja u Zagrebu. *Magistarski rad,* pp. 155, Sveučilište u Zagrebu.

Šiftar, D. (1974): Određivanje stroncija u baritu spektrokemijskom metodom. *Zbornik radova RGN fakulteta,* 45–49, Zagreb.

Šiftar, D. (1988): Chemical characteristic of barites from some deposits in Bosnia. *Rud.-met.-zbornik 35 (1–4),* 75–89, Ljubljana (in Croatian).

Vesely, V. (1921): Tetraedrit iz Maškare u Bosni. Glasnik Hrv. Prir. društva, I. pol. 99, Zagreb.

Vogt, F. (1880): Nachtrag I zu den F. Herbisch's Erhebungen und Vorstudien über den Metallbergbau in Bosnien, Wien 1880, S. 12. *Neues Jahrbuch f. Mineralogie u.s.w. 1880,* Wien.

Živanović, M. (1972): Geological structure and tectonic framework of the Vranica Mountain in Central Bosnia (in Serbian). *Dissertation,* Univ. of Beograd.