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Ore deposits in the Duboki Vagan region south and south-west of the town of Kreševo, Bosnia

Ivan JURKOVIĆ

Rudarsko-geološko-naftni fakultet Sveučilišta u Zagrebu, Pierottijeva 6, YU — 41000 Zagreb

In this paper the author gives an account of the basic characteristics of the most important ore occurrences and ore deposits south and south-west of the town of Kreševo. There are: monomineral quartz occurrences, type Busovača, quartz-siderite-hematite deposits, type Zekića brijeg, barite deposits with different amounts of quartz, siderite and Hg-tetrahedrite, type Duboki Vagan, and monomineral barite occurrences with Hg-tetrahedrite, type Međuvršje. The forms in which the ore deposits occur are described, the paragenesis of hypogenic and hypergenic minerals is established, the microphysiographic characteristics of all minerals are given, along with the sequence of mineralization and a tabular scheme of the intensity of the minerals.

A comparison of the paragenesis of the Duboki Vagan deposits with the adjacent Međuvršje region is discussed.

U ovom radu autor daje prikaz osnovnih karakteristika najvažnijih rudnih pojava i rudnih ležišta južno i jugozapadno od grada Kreševa u Bosni. To su: monomineralne kvarcne pojave tip Busovača, kvarc-siderit-hematitna ležišta tip Zekića brijeg, baritna ležišta sa različitim količinama kvarca, siderita i Hg-tetraedrita tip Duboki Vagan i monomineralne baritne pojave sa Hg-tetraedritom tip Međuvršje. Opisani su oblici pojavljivanja rudnih pojava, parageneze primarnih i sekundarnih minerala, mikrofiziografske karakteristike svih minerala, redoslijed mineralizacije te tabelarni prikaz intenziteta pojavljivanja primarne i sekundarne mineralizacije.

Posebno je izrađena usporedba parageneza rudnih pojava područja Duboki Vagan s onima u susjednom području planine Međuvršja opisane ranije po I. Jurkoviću (1987).

HISTORY

The ore deposits of the Duboki Vagan area are part of a wider ore-bearing region of Kreševo, which itself forms part of the Mid-Bosnian Ore Mountains (I. Jurković, 1956, 1957).

The Duboki Vagan area (Fig. 1) covers 6 kms² (2 × 3 kms). Its northern border runs 1 km south of the town of Kreševo, and its southern limit is 4 kms south of Kreševo. To the east the Duboki Vagan area continues on to the barite area of Mount Međuvršje described in I. Jurković's previous papers (1986 and 1987).

Fig. 1 shows the position of all the ore occurrences described and the geological map referred to earlier (I. Jurković, 1956), which has been revised on the basis of dating suggestions by R. Jovanović et

al. (1977). It is obvious from this map that the dolomite and phyllites dated earlier by F. Katzer (1926) as belonging to the Carboniferous should be ascribed to the Devonian (?) (I. Jurković, 1987, p. 315).

The earliest data on ore deposits and on mining operations in the general area of Duboki Vagan come from D. Wolf (1847). The subject was later treated by A. Conrad (1870), F. Herbich (1880), F. Vogt (1880), B. Walter (1887), F. Katzer (1907), I. Jurković (1956 and 1957), M. Jeremić (1963), V. Mikolji (1969).

ORE OCCURRENCES

In the wider ore-bearing area of Duboki Vagan, south and south-west of the town of Kreševo, ore occurrences of different paragenesis have been discovered and exploited to a greater or lesser extent in the following localities:

A. Monomineral quartz occurrences of type Busovača in the Devonian (?) schists of the Duge Njive — Zapada locality;

B. Quartz—siderite—hematite ± barite deposits Zekića brijeg along the contacts quartzporphyre—dolomite—schists;

C. Barite deposits with different amounts of quartz, siderite and Hg-tetrahedrite, type Duboki Vagan, in the dolomites of Duboki Vagan and Cvjetnjak;

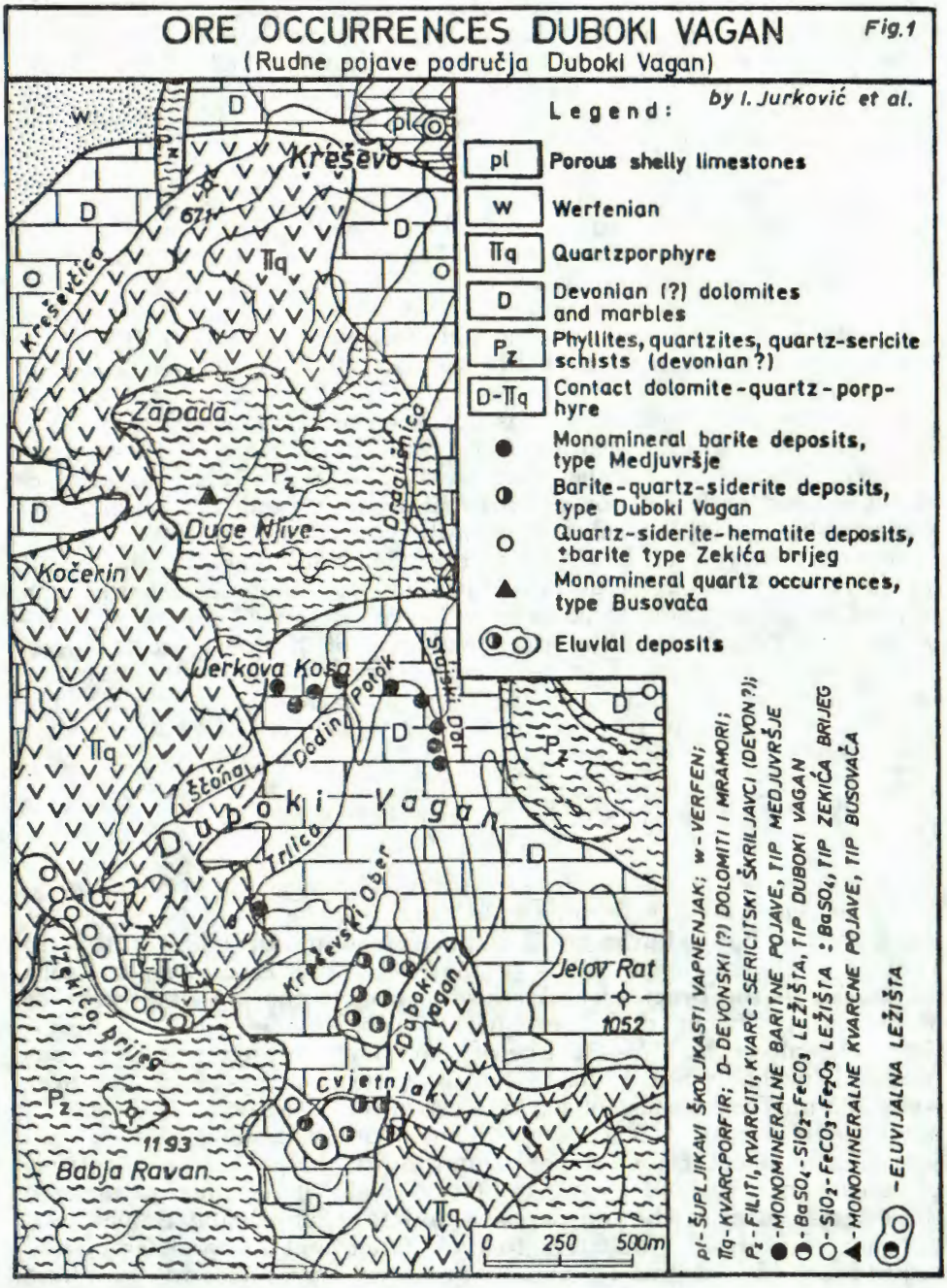
D. Monomineral barite occurrences with Hg-tetrahedrite, type Međuvršje, in the dolomites of Jerkova kosa, Dodin potok, Stajski Dol and Trlica.

A. Monomineral quartz occurrences, type Busovača

Quartz deposits are found at an absolute altitude of +940 m in the Duge Njive — Zapada location about 1.5 kms SW of the town of Kreševo, on the Rudna ridge. The area consist of Devonian (?) slates (phyllites, quartz-phyllites, quartz-sericitic slates). Towards the west there extends a quartz-porphyre massif. A number of quartz veins were discovered, running north-south and steeply inclined, which project like reefs from the softer slates on account of their greater resistance to weathering. The ore deposits are on a relatively small scale, the veins, lenticular and of irregular shape, up to 0.5 m thick, quickly disappear into the interior of the rock. They were examined by superficial excavations.

The mineral paragenesis is very simple. Among hypogenic minerals the following were identified: *quartz I, pyrite, chlorite, sericite, quartz II;* hypergenic (secondary) minerals comprised *goethite, lepidocrocite* and *psilomelane.*

Quartz I is the main mineral in all occurrences. Analyses show it as constituting 97% and even more. It is milky white in colour or else semi-transparent. It has coarse-grained crystals, individual pieces of quartz coalescing in a more or less denticular pattern. The grains are strongly cataclased, full of cracks; along the edge of the grains there


ORE OCCURRENCES DUBOKI VAGAN
Fig.1
(Rudne pojave područja Duboki Vagan)
by I. Jurković et al.
Legend:
pl Porous shelly limestones
w Werfenian
Tq Quartzporphyre
D Devonian (?) dolomites and marbles
Pz Phyllites, quartzites, quartz-sericite schists (devonian ?)
D-Tq Contact dolomite-quartz-porphyre
Monomineral barite deposits, type Medjuvršje
Barite-quartz-siderite deposits, type Duboki Vagan
Quartz-siderite-hematite deposits, ±barite type Zekića brijeg
Monomineral quartz occurrences, type Busovača
Eluvial deposits
Kreševo
Zapada
Duge Kljive
Kočerin
Jerkova Kosa
Dodin
Porok
Štóna
Duboki Vagan
Trlica
Jelov Rat
1052
Cvjetnjak
1193
Babja Ravan
0 250 500m
pl - ŠUPLJIKAVI ŠKOLJKASTI VAPNENJAK; w - VERFEN;
Tq - KVARCPORFIR; D - DEVONSKI (?) DOLOMITI I MRAMORI;
Pz - FILITI, KVARCITI, KVARC-SERICITSKI ŠKRILJAVCI (DEVON ?);
- MONOMINERALNE BARITNE POJAVE, TIP MEDJUVRŠJE
- $BaSO_4$-SiO_2-$FeCO_3$ LEŽIŠTA, TIP DUBOKI VAGAN
- SiO_2-$FeCO_3$-Fe_2O_3 LEŽIŠTA ± $BaSO_4$, TIP ZEKIĆA BRIJEG
- MONOMINERALNE KVARCNE POJAVE, TIP BUSOVAČA
- ELUVIJALNA LEŽIŠTA

may be observed the initial phase of a recrystallization into minute recrystallized grains of quartz measuring 30—50 μm. The coarse-grained quartz is optically anomalous to a marked degree, which indicates the powerful pressures to which it was subjected during the epigenetic phase. The fissures in the quartz are frequently filled with chlorite and sericite, and, in the superficial parts of the occurrences, with hypergenic minerals.

Pyrite is a subsidiary constituent of the quartz ore occurrences. It manifests itself in the form of individual crystal up to 2 mms in diameter, as nests or veinlets in quartz I. The grains are also cataclased. In the superficial areas of the ore deposits it is oxidized to a considerable degree to form goethite and lepidocrocite.

Chlorite is of a pale green colour and of weak pleochroism. It is most frequently observed next to wall-rock, but also in the diaclases of quartz I.

Sericite takes the form of microscopically fine leaves which constitute aggregates or fine films (coatings) on cracks in quartz or the wall-rock.

Quartz II is a mineral of the drusy spaces in quartz I. It is idiomorphically developed with well formed prismatic and pyramidal terminal crystallographic plates. As a rule it is optically normal.

There are very small quatities of hypergenic minerals. *Goethite* and *lepidocrocite*, products of pyrite oxidization, predominate. They are developed in colomorphic structures with typical optical features. *Psilomelane* forms dendrites in the superficial areas of the quartz occurrences.

The quartz occurrences in the Duge Njive — Zapada location are typical mineral occurrences of the same paragenetic and genetic characteristics as those in the Busovača and Travnik area (I. Jurković, 1956).

B. Quartz-siderite-hematite occurrences ± barite

A whole series of ore occurrences of this paragenetic type is to be found in the Zekića brijeg location, on the northern slopes of the mountain Babja Ravan (+1193 m) at absolute altitudes of 1050 to 1100 m, in the catchment areas of the Ščona and Trlica brooks, both tributaries of the Dragušnica. At the junction of the phyllitic rocks of Mount Babja Ravan and the quartz-porphyres, dolomites and slab limestones along the NW—SE line of that junction, there are numerous medieval (probably also in part, Roman) mine workings extending over some 500 m. They consist of major excavations, measuring individually anything from 50 to 100 m, some 15 to 20 m. wide, along with a considerable number of minor works and short shafts. Large quantities of gangue material and remnants of ores make it difficult to observe the original form of the ore deposits and to establish the actual relationship of individual minerals to each other and to work out their sequence. A high degree of silification in the dolomite and limestone indicates the metasomatic nature of the ore formation. Data recorded by D. Wolf (1847) and B. Walter (1887), also quoted by I. Jurković (1956) and V. Mikolji (1969), indicate that iron ore had been worked on Zekića brijeg or on Mount Babja Ravan. This is also

suggested by an analysis of the iron ore published by B. Walter (1887): 43.4 % Fe, 3.7 % Mn, 18.8 % Si, 0.05 % S, and 0.08 % Hg. V. Mikolji (1969, p. 116) mentions major activity in the excavation of cinnabar in the past, especially at the end of the 17th century, quoting Bajina Jela and Gunjani as one of the centres of these mining operations, which suggests that cinnabar was also being worked on Zekića brijeg.

Because of the inaccessibility of the primary ore bodies we were able to assess the ore deposits of Zekića brijeg only on the basis of material from the remains of excavated ore and gangue minerals which gives an indication of qualitative relationships but does not enable us to establish the intensity of occurrence in the case of individual minerals.

The principal minerals are *siderite* and *hematite* and *pseudomorphoses of goethite with siderite,* with *quartz* occurring in significant quantities. The occurrences in the SE part of the ore-bearing belt, nearer the Cvjetnjak location, contain a preponderance of *barite* with the siderite. In the ore mass we also observed *pyrite* and drusy *quartz II.*

Occurrences of the Zekića brijeg type will be discussed in more detail in subsequent papers on the ore deposits of the Deževice and Dusina areas west of the town of Kreševo.

C. Barite deposits with different ratios of quartz, siderite and Hg-tetrahedrite, type Duboki Vagan

The Ščona, Trlica and Duboki Vagan streams have their sources on the northern and north-eastern slopes of Mount Babja Ravan (+1193 m); on the north-western and the northern slopes of Jelovi Rat (+1052 m) rise the Stajski Dol and Vrelo streams. The Dragušnica potok which is formed from these sources flows in a northerly direction and enters the Kreševčica potok immediately south of the town of Kreševo. Halfway between Babja Ravan and Jelovi Rat there is the Ravni Vagan plateau, on the northern side of which are found the Duboki Vagan ore deposits, with the Cvjetnjak location on its southern aspect. In these two locations there are major medieval (and probably also, Roman) workings for iron ore and cinnabar.

The Duboki Vagan site lies at absolute altitudes of +900 to +1000 m., about 3 kms south of the town of Kreševo in the valley of the same name.

In a large karstified depression in the Devonian (?) dolomite measuring 100 to 220 m. across and 15 to 20 m. deep there are the remains of Roman and medieval mine workings. The bottom of the depression is filled with rubble and blocks of siliceous barite which represented gangue in earlier times. Part of this material came from mining operations, but part is the residue left by the weathering and leaching out of the ore-bearing dolomite (elluvium). These ancient miners removed the cinnabar formed by the weathering of Hg-tetrahedrite so as to get to the elemental mercury necessary for the amalgamation of gold. The barite vas rejected as gangue material. They also used limonite ore for the production of iron in the Kreševo smelting works (V. Mikolji,

1969). In most recent times the old ore dumps and eluvial deposits have been worked over and barite recovered by separating it from the considerable quantities of quartz intergrown with the barite. This clearing up of the old workings has afforded a better view of the actual form of the ore bodies. These are irregular seams running NW—SE, 1—1.5 m. thick, inclining downwards towards the NE, but there are also satellite veins of barite, the roots of which have been uncovered by more recent mine workings.

Macroscopic examination of the waste heaps and eluvial material establishes that barite is the main mineral in the ore deposits. There are significant quantities of quartz, perceptible quantities of pyrite, but significantly less Hg-tetrahedrite. Fluorite appears in the form of veinlets and nests. There are considerable quantities of »limonite«, a little cinnabar, Mn-minerals and Cu-carbonates.

The occurrences in Duboki Vagan were first mentioned by D. Wolf (1847), whose references were later published by V. Mikolji (1969). Most data are to be found in papers by F. Vogt (1880) and B. Walter (1887), whose results are also to be found in F. Katzer (1907). These include an analysis of ore from Mali Vagan: 5.26 % Cu, a trace of Hg, 0.060 % Ag, and another analysis from an unidentified site which indicates the approximate relationship of the main minerals in their paragenesis: 40.2 % $BaSO_4$, 32.6 % SiO_2, 2.4 % Hg-tetrahedrite, 0.8 % Cu, 24.8 % soluble matter. I. Jurković (1956) gave the first detailed paragenesis of ore from Duboki Vagan, and in his subsequent paper (I. Jurković, 1957) identified the genetic position of this type of ore deposit in the Mid-Bosnian Ore Moutains. M. Jeremić (1963a) only mentions that the deposit belongs to a group of barite-tetrahedrite deposits and gives an analysis of the barite: 85.10 % $BaSO_4$, 0.12 % $CaSO_4$, and 0.59 % $SrSO_4$.

The Cvjetnjak site is situated in the catchment area of the watercourses which run SSE and enter the river Lepenica. It is about 0.5 kms south of Duboki Vagan, and about 0.5—1 km. in an easterly direction from the summit of Babja Ravan (+1193 m.). A considerable number of large excavations (Die Pingen on german language) and caverns indicate earlier medieval and Roman mining for limonite and cinnabar. The workings are situated mainly in the dolomite, but also partly in the quartz-porphyres. Barite and siderite predominate in the spoil heaps, but there are also significant amounts of quartz. There is significantly less pyrite, and even less Hg-tetrahedrite. »Limonite« formed by the oxidation of siderite, pyrite and tetrahedrite dominates among the secondary minerals. Cinnabar and Cu-minerals are subsidiary constituents. The literature contains two analyses of the iron ore: 51.8 % Fe with 0.10 % Hg, and 34.16 % Fe with 0.10 % Hg.

Ore formation was in the form of stockwerks, nests and veins. The ore-bearing belt extends in a NW—SE direction. The ore occurrences are at absolute altitudes of +900 to +1000 m., and, in the extreme NW area of the belt, up to 1100 m., where the paragenesis is similar to that of Zekića brijeg. Part of the ore-bearing zone is of an eluvial character (secondary, sedimentary deposits). The first details of this site are found in B. Walter (1887), who is subsequently quoted by F. Katzer

(1907). I. Jurković (1956 and 1957) writes that the paragenesis of the Cvjetnjak deposits resembles that of Duboki Vagan, with the difference that Cvjetnjak offers significant quantities of siderite and pyrite at the expense of quartz, of which there is less. M. Jeremić (1963a) merely states that Cvjetnjak belongs to a group of barite-quartz deposits.

Microscopic examination of thin ground and polished section of ore samples from the Duboki Vagan and Cvjetnjak sites in polarized light gave the following results:

hypogenic paragenesis: barite, quarz I, siderite, pyrite, ankerite, Hg--tetrahedrite, sericite, kaolinite (?), fluorite, quartz II;

Barite is the main mineral of the ore deposits both in Duboki Vagan and in Cvjetnjak, but in Duboki Vagan quartz I is involved to a greater degree in paragenesis, whereas in Cvjetnjak there is less quartz and more siderite, with individual deposits merging into barite-siderite deposits. Barite occurs in various structural types: platy, granular, cataclased, recrystallized, breccia-like. It is white or milky white in colour, often optically anomalous.

Quartz I is microgranular or fine-grained; it occurs within the ore bodies, and in the dolomite of the wall-rock which it replaces. It forms dense masses intergrown with barite or with barite and siderite. The grains are frequently cataclased and optically anomalous.

Siderite is a subsidiary constituent in Duboki Vagan, and a primary constituent of the Cvjetnjak occurrences. It is rhombohedric in habit; at the upper levels it is completely oxidized into goethite, at lower levels the oxidization process operates on the rhombohedric faces of the cleavage, and the crystals and grains of siderite assume the characteristic brown colour (Braunspat).

Pyrite is present in the form of small compacted masses or else small individual crystals up to 2 mms in diameter. In surface areas of the deposits it is partially or totally oxidized into goethite and lepidocrocite. There is less pyrite in Duboki Vagan, but it is perceptible in Cvjetnjak.

Ankerite is observed in the dolomite of the wall-rock in the deposits. It arose through metasomatic activity.

Hg-tetrahedrite is a subsidiary ore constituent, at most a few percent of the ore mass. It is characterized by its mercury, gold and silver content. Its weathering in the oxidization zone produces basic sulfates (mainly of copper), malachite, azurite, goethite, lepidocrocite, cinnabar, and, in the cementation zone, descendent covellite and chalcocite, cinnabar, and elemental gold (electrum). Tetrahedrite appears in the form of small masses, nests and veins in barite and in wall-rock dolomite.

Sericite in the form of minute leaves of microscopic dimensions was observed in some thin ground section. We were unable to ascertain wheter a proportion of these foliate aggregates belongs more properly to *kaolinite* (?).

Fluorite is found in young veins in barite and in the wall-rock of the ore occurrences. It was identified on the Duboki Vagan site. It is transparent or violet in colour, of octahedral habit.

Quartz II is a drusy mineral; we find it in cavities of quartz I. It is developed as accreted crystals of prismatic habit with developed terminal faces or even as free(floating) crystals.

hypergenic paragenesis: goethite, lepidocrocite, »basic sulfates«, cinnabar, malachite, azurite, elemental gold, manganomelane, pyrolusite and chalcedony.

Goethite is the main mineral of the oxidization phase. It arose for the most part from siderite (Cvjetnjak), but in part also from pyrite, ankerite, tetrahedrite. It is of typical colomorphic structure.

Lepidocrocite is a product of weathering of pyrite and tetrahedrite. Whether this mineral is also of ascendent origin, as stated by I. Jurković (1956), cannot be claimed with certainty: more research into its paragenesis is required.

»*Basic sulfates*«, predominantly of copper, and *malachite* and *azurite* are products of the weathering of tetrahedrite in the oxidization zone of Duboki Vagan and Cvjetnjak. Cinnabar is also noted in this zone.

Descendent chalcocite and *covellite, cinnabar* (for the most part) and *elementary gold* (electrum) are typical minerals of the cementation zone of the ore occurrences (this zone is particularly prominent in Duboki Vagan). The microscopic properties of these minerals are the same as those of the barite deposits of Mount Međuvršje (I. Jurković, 1986 and 1987) and we do not propose to list them here.

Particularly characteristic is the occurrence of manganese minerals of the pyrolusite-manganite group as identified by H. J. Rösler (1981) in his text-book (p. 403—409). To this group the author assigns pyrolusite, manganomelane (mainly cryptomelane), manganite and hausmanite.

I. Jurković (1956) identified ascendent Mn-oxide and lepidocrocite in the upper areas of the ore body on the Duboki Vagan site. Most plentiful was *psilomelane* in the form of minute aggregates of needle-like crystals of radial-concentric, kidney-shaped and radial structure. »Psilomelane-component 3« was particularly noted, because with its marked reflective pleochroism and strongly anisotropic effects it corresponds to the properties of this mineral cited by P. Ramdohr (1955, p. 778). In drusy spaces of the psilomelane, I. Jurković *(op. cit.)* detected sub-microscopic to microscopic small-grained *pyrolusite* the surface of which is more illustrous than psilomelane, creamy yellow in colour and with stronger anisotropic effects. He also detected *polyanite* in the form of granular aggregates (in places as an incrustation on psilomelane) or as separate small crystals of prismatic habit, or even of needle-shaped habit with very sharply pointed prismatic plates (hhl) as the terminal plates on prismatic plates (110). Polyanite is of strongly reflective pleochroism; greyish-white in colour, creamy-yellow and with very strongly anisotropic effects of a pinkish-white colour. Of great lustre and very high relief.

In this paper a correction has been made, in the sense that we have included psilomelane and psilomelane-component 3 under the term *manganomelane* and pyrolusite and polyanite under the term *pyrolusite,* because we are concerned with the same type of crystallographic lattice (H. J. Rösler, 1981, p. 404). Although there are ore occurrences with ascendent pyrolusite, we are more inclined for the present to regard the above-mentioned Mn-minerals as descendent phenomena of oxidized origin from siderite, which has isomorphic manganese built into its

molecule. Whether part of this Mn paragenesis is ascendent must be the subject of further research.

Chalcedony features frequently in the oxidisation zone.

D. Monomineral barite occurrences with Hg-tetrahedrite in dolomites, Međuvršje type

In the catchment area of the Dragušnica potok (Ščona, Trlica, the Dodin potok, Stajski Dol) about 2 kms south of the town of Kreševo, as well as on the upper reaches of the Trlica brook, there is a series monomineral barite deposits with a small quantity of mercury tetrahedrite.

The Jerkova Kosa and Dodin potok sites are situated in the area between the Bajina Jela ridge and the Duge Njive ridge, between which flows the Dodin brook. Barite occurs in the Devonian (?) dolomites at absolute altitudes from +770 to +840 m. Along the wall-rock the dolomites are slightly ankeritised, and silicified at points. 4 major and several minor barite ore bodies have been located, running generally E—W, with some extending NW—SE. The ore bodies are of irregular shape, filling the tectonic fissures in the dolomites. Barite breccias are also apparent, with fragments of dolomite cemented by barite. The richer parts of the ore body have been extracted by more recent mining operations.

The main mineral is *barite;* fine-grained *quartz I, ankerite* and *Hg-tetrahedrite* are present in much lesser quantities, while *pyrite* is an accessory constituent. In the oxidisation zones, *malachite, azurite, cinnabar* and *»limonite«* are visible to the naked eye.

The Stajski Dol site is situated immediately east of the deposits in Jerkova Kosa and Dodin potok, in the lower stretch of the valley through which the Stajski Dol stream flows, at absolute altitudes of +800 to +850 m. in Devonian (?) dolomites, which are partly ankeritized and silicified. On this site research revealed a vein of barite running E—W, vertically inclined, about 0.3 m. thick as well as a number of minor irregular metasomatic barite ore bodies.

The ore occurrences were investigated by excavation and by relatively short adits.

Barite is the main mineral, beside the wall-rock there is a certain amount of *ankerite* and *quartz,* together with small quantities of *Hg-tetrahedrite* as impregnation or in nests. Among hypergenic minerals *»limonite«, malachite, azurite* and *cinnabar* may be observed with the naked eye.

The Trlica site lies at an absolute altitude of +850 to +900 m. on the upper course of the stream of the same name, about 2.5 kms SSW of the town of Kreševo. Ore formation runs along the border of dolomite and quartz-porphyry in the form of smallish barite bodies in the markedly silicified dolomite. The occurrence was examined by sapping in a NW—SE direction (I. Jurković, 1956).

Barite is the main mineral, along with some coarse-grained *quartz II. Hg-tetrahedrite* appears as impregnation, in ribbons, and interlayered.

On all four sites: Jerkova Kosa, Dodin potok, Stajski Dol and Trlica the ore occurences have the same type of common characteristics; they are on a small scale, of irregular shape, relatively seldom in the form of short veins, the orientation of the ore formation runs as a rule E—W, sometimes NE—SW. They arose through the filling of faults in Devonian (?) dolomites, metasomatic changes at the wall-rock (ankeritisation and silicification) are less strongly pronounced. The occurrences are almost entirely monomineral. Barite is clearly the dominant mineral, all others are present in minor amounts only. Microscopic analyses have established the following paragenesis: hypogenic minerals — *barite, quartz I, ankerite, pyrite, Hg-tetrahedrite;* hypergenic minerals — *»basic sulfates«, descendent chalcocite* and *covellite, cinnabar, malachite, azurite, goethite, lepidocrocite.*

The paragenesis and the microphysiographic characteristis of the minerals indicate a high degree of similarity to the occurrences on Mount Međuvršje (I. Jurković, 1987) and we have classified these occurrences also as *»Međuvršje type«.*

DISCUSSION

Comparing the ore occurrences of the wider Duboki Vagan area with those from Mount Međuvršje described earlier (I. Jurković, 1987) we arrive at the following observations:

(a) all the ore occurrences in the Duboki Vagan area and the Međuvršje area, with the exception of insignificant Busovača type monomineral quartz occurrences at Duge Njive, are located in the same stratigraphic horizon of Devonian (?) dolomites, so that they assume the characterists of so-called »strata bound« ore deposits.

(b) the most highly tempered ore deposits of the Duboki Vagan type are located either in contact with quarz-prophyre massifs (sites at Duboki Vagan, Cvjetnjak and Zekića brijeg) or else at lower absolute levels (Rudna, the lower parts of the Jelica ore occurrences) below the level of the monomineral barite deposits on Međuvršje.

(c) low tempered monomineral barite occurrences of the Međuvršje type are situated in the Međuvršje area, remote from the quartz-porphyry massif on absolute sites (Sotnica, Glumac, Vidici, Trnjač, Dubrave—Dugi Dol, Plana, Grkinja) 100—200 m. higher than the same type of monomineral barite occurrences in the Duboki Vagan region, nearer to the quartz-porphyres at the Jerkova Kosa, Dodin potok, Stajski Dol and Trlica sites.

(d) all the occurrences have mercury type tetrahedrite which contains gold and silver, while in the Zekića brijeg occurrences there is hematite of specularite type, and probably also ascendent cinnabar. The question as to the existence of very low tempered phases of manganese and iron oxides of ascendent type is still open.

All the above raises the fundamental problem as to whether we are dealing in the wider Kreševo area with Triassic metallogeny linked to a phase of intercontinental rifting (S. Janković, 1987), or Hercynian metallogeny (I. Jurković, 1957), or whether the opening of rifts

and the magmatism and metallogeny associated with this movement did not begin already in the Upper Paleozoic. Subsequent papers on the ore occurrences in the Mid-Bosnian Ore Mountains will be devoted to this issue.

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REFERENCES

Conrad, A. (1870): Bosnien mit Bezug auf seine Mineralschätze. — *Mitteil. geogr. Gesell.*, p. 219, Wien.

Herbich, F. (1880): Vergl. Erhebungen und Vorstudien über den Metallbergbau in Bosnien. — *Neues Jahrbuch für Mineralogie*, 2, p. 94, Stuttgart.

Janković, S. (1987): Genetic types and major triassic deposits of the Yugoslavia. — *Mineral Deposits of the Tethyan Eurasian Metallogenic Belt between the Alps and Pamirs* (selected samples), p. 11—33. Beograd. UNESCO — Project No 169: Geotectonic Evolution and Metallogeny of Mediterranean and SW Asia.

Jeremić, M. (1963a): Metalogenija paleozojskih ležišta barita Bosne. — *Arhiv za tehnologiju*, Godina I, Volume I, br. 1—2, Tuzla, p. 1—60.

Jeremić, M. (1963b): Hidrotermalne izmjene okolnih stijena baritnih ležišta u srednjobosanskim škriljavim planinama. — *Arhiv za tehnologiju*, Godina I, Volume I, br. 3, p. 89—98, Tuzla.

Jovanović, R. — Mojičević, M. — Tokić, S. — Rokić, Lj. (1977): Osnovna geološka karta, list Sarajevo, K 34-1, 1 : 100.000, Savezni geološki zavod, Beograd.

Jurković, I. (1956): Mineralne parageneze Srednjobosanskog Rudogorja s osobitim osvrtom na tetraedrite. — Dissertation, 306 p. Zagreb.

Jurković, I. (1957): The basic characteristics of the metallogenic region of the Mid-Bosnian Ore Mountains. — *Zbornik II Kongresa geologa Jugoslavije*, p. 504—519, Sarajevo.

Jurković, I. (1986): Quantitative Chemical and Optical Investigations of the Tetrahedrite from Barite-Bearing Deposits Vidici on the Northern Slopes of the Mountain Međuvršje South of the Town of Kreševo, Bosnia. — *Geološki Vjesnik*, *39*, 187—214, Zagreb.

Jurković, I. (1987): Barite Deposits on Mount Međuvršje South and South-Est of the Town of Kreševo, Bosnia. — *Geološki Vjesnik*, *40*, 313— 336, Zagreb.

Katzer, F. (1907): Die Fahlerz- und Quecksilbererzlagerstätten Bosniens und der Herzegovina. — Berg- und Hüttenmann. *Jahrbuch d. Montan. Hochschule zu Leoben u. Pribram*, Bd. 55, p. IV u. 121 mit Tafeln, Wien.

Katzer, F. (1925): Geologie Bosniens und der Herzegovina. Bd. I, H. 1, 480 p., Bd. I, H. 2, Sarajevo 1924/1925.

Mikolji, V. (1969): Povijest željeza i željeznog obrta u Bosni. — Izdanje Metalurškog instituta »Hasan Brkić«, Zenica.

Ramdohr, P. (1955): Die Erzmineralien und ihre Verwachsungen, 875 p., Berlin.

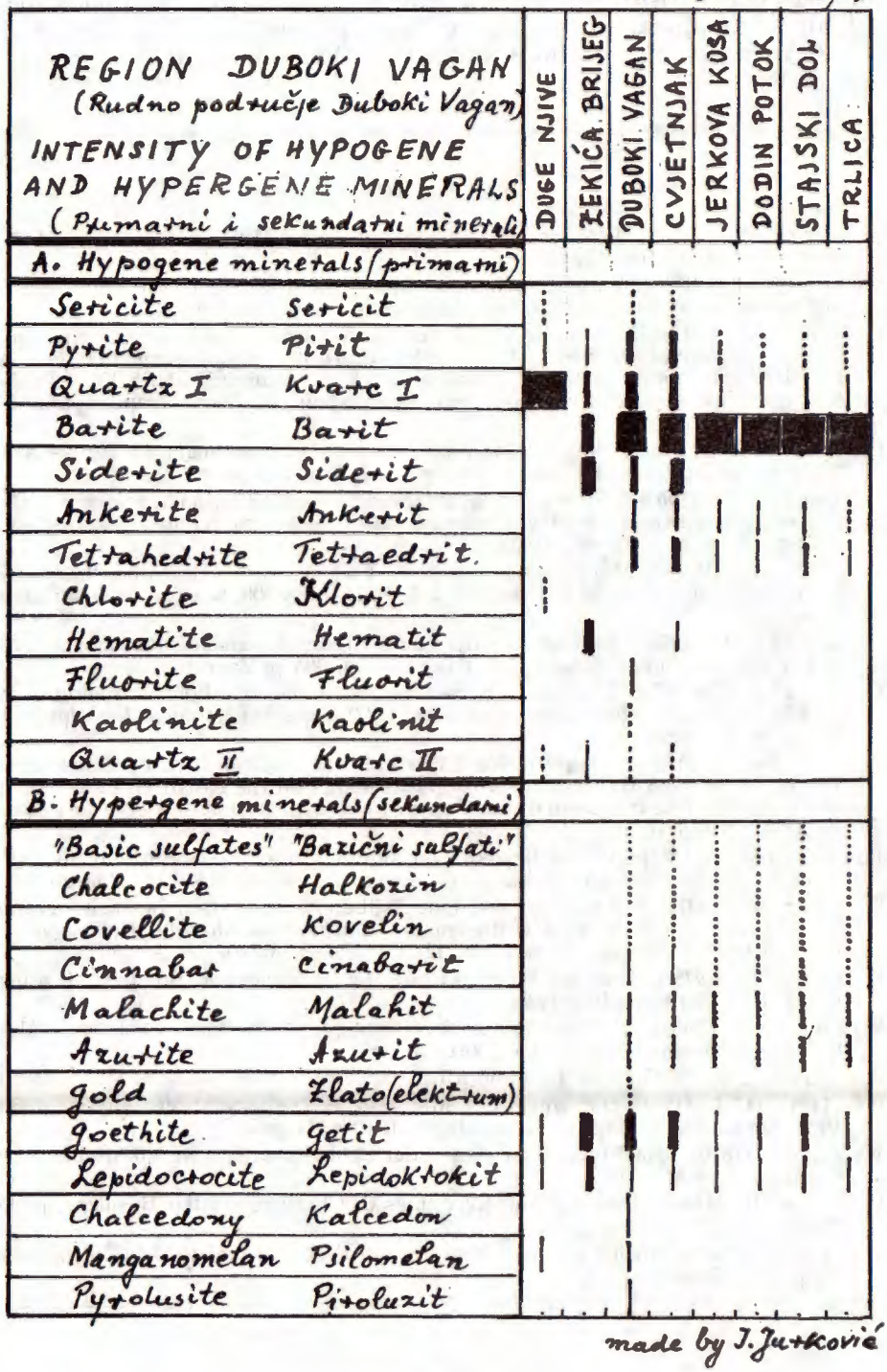
Rösler, H. J. (1981): Lehrbuch der Mineralogie, 2. überarbeitete Auflage, 833 p. VEB Deutscher Verlag für Grundstoffindustrie, Leipzig.

Vogt, F. (1880): Nachtrag I zu den zitierten Erhebungen in Vorstudien usw., Wien.

Walter, B. (1887): Beiträge zur Kenntniss der Erzlagerstätten Bosniens, p. 182, Wien.

Wolf, D. (1947): Ansichten über die Geognostisch-Montanistischen Verhältnisse Bosniens, Graz.

TABLE (TABELA) 1



made by J. Jurković

Rudne pojave u području Duboki Vagan južno i jugozapadno od grada Kreševa, Bosna

I. Jurković

Rudne pojave se javljaju zapadno ili jugozapadno od baritnih ležišta planine Međuvršje (1195 m) opisanih detaljno u prethodnom radu (I. Jurković, 1987). U širem području Dubokog Vagna postoje ostaci značajnih rimskih i srednovječnih radova na živu i željezne rude, a u najnovije doba na barit.

Utvrđena su četiri paragenetska tipa: (a) monomineralne kvarcne pojave tip Busovača; (b) kvarc-siderit-hematitne pojave Zekića brijega; (c) baritna ležišta sa značajnim količinama kvarca, siderita i Hg-tetraedrita tip Duboki Vagan te (d) monomineralne baritne pojave s malo Hg-tetraedrita tip Međuvršje. Veće ekonomsko značenje imala su rudišta tipa Duboki Vagan (slika 1).

Osnovne karakteristike pojedinih paragenetskih tipova

(a) monomineralne kvarcne pojave tipa Busovača

Nalaze se na lokaciji Duge Njive—Zapada unutar devonske (?) serije filitskih škriljavaca. Otkriveno je više kraćih kvarcnih žica koje zbog rezistentnosti na trošenje izviruju iz terena u vidu rifova. Pružanje im je S—J a pad vrlo strm, i isklinjuju brzo prema dubini. Mineralna parageneza je vrlo jednostavna: više od 97% kvarca, krupnozrnatog, naprslih ili kataklaziranih kristala, optički anomalan. Pirit je sporedan sastojak, individualiziran ili u vidu gnjezdašca i žilica. Klorit i listićavi sericit se javljaju uz salbande ili po kataklazama u kvarcu. Kvarc II je druzni mineral, često lijepo razvijenih kristala. Od hipergenih minerala ima vrlo malo getita, lepidokrokita i dendrita psilomelana.

(b) kvarc-siderit-hematitske pojave sa ili bez barita

Niz rudnih pojava tog paragenetskog tipa nalazi se na poziciji Zekića brijeg na sjevernim padinama Babje Ravni na kontaktu između filitske serije škriljavaca, kvarcporfira, dolomita te pločastih vapnenjaka. Duž linije SZ—JI duge više od 500 m nalaze se velike pinge i veći broj ranijih rudarskih okana i kraćih potkopa. Velike količine odbačene jalovine onemogućavaju uvid u oblike rudnih tijela i paragenezu. Postoje pisani podaci o rudarenju na željeznu rudu i cinabarit.

Na haldama se uočava da su glavni minerali siderit i hematit, zatim pseudomorfoze getita po sideritu, a kvarca ima u uočljivim količinama. Pirit i druzni kvarc II su sporedni sastojci. Pojave u JI smjeru, prema Cvjetnjaku sadrže pretežno barit sa sideritom.

O paragenezi Zekića brijega detaljno će se pisati u narednim radovima koji obrađuju ležišta u području Dusine i Deževice dalje zapadno od Kreševa.

(c) baritna ležišta sa promjenljivim odnosom kvarca, siderita i Hg-tetraedrita, tip Duboki Vagan

Ležišta tog paragenetskog tipa javljaju se na pozicijama Duboki Vagan i Cvjetnjak između planina Babja Ravan (1193 m) i Jelovi Rat (1052 m). Brojni, vrlo veliki stari radovi na primarna ležišta i na značajna eluvijalna ležišta u dolomitskim vrtačama dokazuju intenzivnu eksploataciju željezne rude i cinabarita. U najnovije doba razvila se eksploatacija barita sa velikih starih jalovišta kao i iz primarnih neotkopanih dijelova baritskih ležišta. Mineralizacija ima oblike žica nepravilnih oblika, manjih ili većih tijela, gnijezda, prijepaka. Karstifikacijom dolomita nastala su eluvijalna ležišta u kojima dominiraju barit, kvarc i »limonit« uvaljani u glinoviti materijal. Korijeni rudišta koji su se očuvali od erozije bili su također predmet rudarenja.

Pregledom jalovišta te dostupnih dijelova neotkopane rude i mikroskopskim ispitivanjem utvrđena je ova parageneza: barit je glavni mineral u oba rudišta, ali u Dubokom Vagnu uz njega ima značajnija količina kvarca, a u Cvjetnjaku manje kvarca, a više siderita i pirita. Živin tetraedrit u vidu uprskanja i manjih ili većih gnjezdašca i mlađih žilica sudjeluje do nekoliko procenata u

sastavu rude. Bezbojan ili ljubičast oktaedrijski fluorit karakterizira pojave u Dubokom Vagnu. Uz salbande rudnih pojava zapaža se proces ankeritizacije te pojave listićava sericita, a u kvarcu, u druznim prostorima mlađi kvarc II često lijepo kristaliziran. Getit je glavni mineral oksidacione zone, često kao pseudomorfoze po sideritu. Lepidokrokita ima manje, nastao je trošenjem pirita i tetraedrita. Živin tetraedrit u oksidacionoj zoni daje »bazične sulfate«, malahit, azurit, getit i lepidokrokit, a u cementacijskoj zoni descendentni kovelin, halkozin, cinabarit i elementarno zlato (elektrum).

Karakteristična je pojava manganskih oksida u Dubokom Vagnu u gornjim dijelovima rudnih pojava. Radi se o manganomelanu (u svom ranijem radu I. Jurković, 1956. je na temelju tada važeće sistematike, P. Ramdohr, 1955. identificirao psilomelan /kriptomelan/ i psilomelan komponentu 3) te piroluzitu (I. Jurković, *l. c.* piroluzit i polijanit). U ranijem radu autor je smatrao te manganske minerale i lepidokrokit ascendentnim pojavama u zadnjoj fazi mineralizacije. Ta tvrdnja je danas pod pitanjem iako nije isključena, te autor za sada navedene Mn minerale svrstava u grupu hipergenih minerala. Među hipergene minerale treba ubrojiti i pojavu kalcedona.

(d) monomineralne baritne pojave s malo Hg-tetraedrita, tip Međuvršje

U donjim tokovima sastavaka potoka Dragušnice, i u gornjem toku Trlice nalaze se omanje baritne pojave Jerkova Kosa, Dodin potok, Stajski Dol i Trlica. Sve se pojave nalaze u devonskim (?) dolomitima, malih su razmjera, nepravilnih oblika, ponekad kao kraće žice, pružanja I—Z, ponekad SI—JZ. Ispunjene tektonizirane zone u dolomitu, ankeritizacija i silifikacija salbandi jesu manjih razmjera ili jedva uočljivi.

Mineralne pojave su gotovo monomineralne, barit je dominantan mineral, kvarc I, Hg-tetraedrit, ankerit i pirit su akcesorni sastojci. Mikroskopskom analizom je utvrđena i grupa hipergenih minerala: »bazični sulfati« halkozin, kovelin, cinabarit, malahit, azurit, getit i lepidokrokit.

Rudna pojave po načinu pojavljivanja i paragenezama odgovaraju susjednom tipu Međuvršje (I. Jurković, 1987).

Na kraju rada autor je izvršio komparaciju mineralnih pojava rudnog područja Međuvršja sa pojavama u području Dubokog Vagna.