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THE ORE BELT "OSOGOVO – BESNA KOBILA" (ORE FORMATIONS, MORPHOGENETIC TYPES OF DEPOSITS AND PHYSICO-CHEMICAL CONDITIONS OF FORMING)

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ABSTRACT. The Ag-Pb-Zn ore belt "Osogovo – Besna Kobila" is located in the NE part of the Trans-European silver belt. This part presents a polygenours, polychronos and polyformational linear metallogenic unit related to the Tertiary tectonic-magmatic processes. With the magmatites of those processes are parageneticaly connected mainly silver-lead-zinc and fluorite deposits and numerous occurrences of W-Mo, Mo, fluorite, barite, pyrite-marcasite, realgar-siderite and decorative calcit. All these deposits are united in 8 ore formations (skarn magnetite-chalcopyrite, quartz-scheelite-molybdenite, quartz-galena-sphalerite, quartz-stibnite, quartz-fluorite, pyrite-marcasite, realgar-siderite and formations of decorative calcite), which are in the form of veins, linear stokwers, metasomatic bodies of bend-like, lense-like nest-like as well as other irregular shaped bodies. The beginning of Tertiary ore-forming is related to the high temperature pneumatolithic bruins (460-370 °C) developed into pneumatolithic-hydrothermal ones (370-330° for the W-Mo bearing fluids) and typical hydrothermal (370-280° C for the main Ag-Pb-Zn mineralization) solutions of acid type (pH = 6.8) containing in g/l: KCl – 31.82, NaCl – 27.28, NH4Cl – 0.97; MgCl2 – 1.73; CaCl2 – 5.83; CaF2 – 0.78 and CaSO4 – 10.75. The total concentration of Na- and K- chlorides is up to 59.10 g/l. The fluorite mineralisations are deposited from medieval to low temperature hydrothermal solutions (210-120 °) and pyrite-marcasite and realgar-siderite mineralisations are deposited form typical low-temperature low mineralized bruins.

РУДНИЯТ ПОЯС "ОСОГОВО-БЕСНА КОБИЛА" (ФОРМАЦИОННА ПОДЯЛБА, МОРФОГЕНЕТИЧНИ ТИПОВЕ НАХОДИЩА И ФИЗИКО-ХИМИЧНИ УСЛОВИЯ НА ОБРАЗУВАНЕ)

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РЕЗЮМЕ. Сребърно-оловно-цинковият руден пояс "Осогово- Бесна кобила" заема североизточния сектор на трансевропейския сребърно-металогенен пояс. Този сектор представлява полигенна, полихронна и полиформационна линейна металогенна единица, генетично свързана с терциерните тектоно-магмени процеси. С магматитите на тези процеси са парагенетично свързани основно сребърно-оловно-цинкови и флуоритови находища, и редица проявления на W-Mo, Mo, флуорит, барит, пирит-марказит, реалгар-сидерит и декоративен тип калцит. Всички те са обединени в 8 рудни формации – скарнова магнетит-халкопиритоав, кварц-шеелит-молибденитова, кварц-галенит-сфалеритова, кварц-антимонитова, кварц-флуоритова, пирит-марказитова, реалгар-сидеритова и калцитова (декоративен тип), които идват като жили, линейни щокверки, метасоматични залежи с пластовидна, лещовидна, гнездовидна и с други неправилни форми, и като междуформационни гнездовидни залежи. Началото на терциерното рудообразуване е свързано с високотемпературни пневматолитни разтвори – 460-370°C, следвани от пневматолитно-хидротермални - 370-330° C (за волфрам-молибденовите рудопроявления), хидротермални – pH = 6,8 и с 370-280 °C (за основните сребърно-оловно-цинкови орудявания) със следния солеви състав в g/l: KCl – 31.82, NaCl – 27.28, NH_4Cl – 0.97; $MgCl_2$ – 1.73; $CaCl_2$ – 5.83; CaF_2 – 0.78 и $CaSO_4$ – 10.75. (Сума на Na-и K- хлориди - 59.10 g/l). Флуоритовите минерализации са отложени от средно- до нискотемпературни хидротермални разтвори (210 – 120 C°), а пирит-марказитовите и реалгар-сидеритовите – от типично нискотемпературни, слабо минерализирани разтвори.

Introduction

The Ag-Pb-Zn ore belt Osogovo – Besna kobila' (Mankov, 1968, 1984_2, 1988) represents the NE part of the Trans-European silver metallogenic belt (Fig.1) divided by Antonov (1968). The origin of the ore belt 'Osogovo – Besna kobila' is connected to the Alpine tectono-magmatic processes. Numerous and different types mineral deposits are localised along the Serbian-Macedonian-Bulgarian border, as well as in the part of the Northern Greece are paragenetically related to the products of these processes. The Ag-Pb-Zn and fluorite deposits have dominating role among them.

Numerous new mineralisations such as W-Mo type (Mankov and Andreeva 1974, 1975) Be type (Mankov, 1978, 1986), Sb type (Mankov, 1974; Mankov, 1984_2), Te-Bi type (Mankov, 1978; Alexandrov, Mankov, Serafimovski, 1990), pyrite-marcasite and realgar-siderite (Mankov, Andreeva, Bostandjiev, 1981, Mankov, Troneva, 1984; Mankov, 1984_2) have been established in this belt. All these studies enlarge significantly the existing knowledge for the metallogeny of the ore belt and now it is discussed as polygenous, polychronous and polyformational metallogenic unite.

Geological setting

The ore belt 'Osogovo – Besna kobila' (Fig.1) takes part from following tectono-magmatic blocks of the ancient Rhodopean massif: I – Kraischtenski block; II – Vlachinsko – Osogovski block; III – Ograjdensko – Belasischki block (Fig.2).

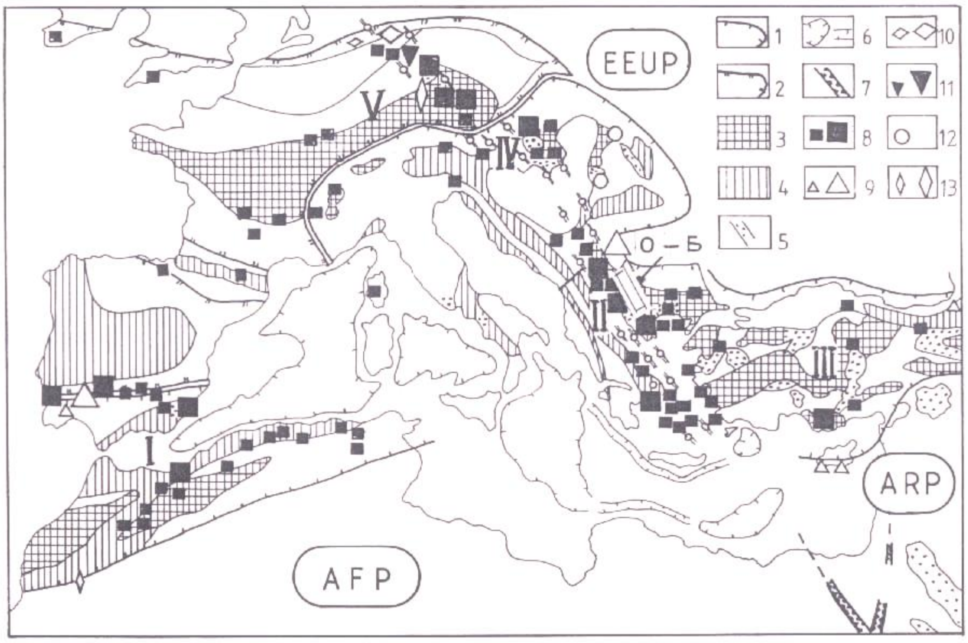

Fig. 1. Location of the Ag-Pb-Zn ore belt "Osogovo-Besna kobila" (O – B) in the Silver Trans-European the ore belt according to Antonov (1986) – western part of the Mediterranean folded belt

Siver-bearing metalogenic provinces: 1 – Alpian; 2 – Herzinian (I - Atlas-Andalusian; II – Dinaridian; III – Anatolian; IV – Alps-Carpathean; V – Central Europenean); 3 – Central massifs; 4 - geosynclinal lifting, 5 – areas involving Negene vulcanites, 6 – abyssal depressions in the Mediterranean sea, 7 – nowadays rift zones. Deposits of siver-bearing ore formations: a) small and middle size, b)large: 8-plumbum-zinc-siver, 9 – copper-pyrite, 10 – copper-pyrite-basemetal, 11 – copper containing schist; 12 – gold-silver, 13 – 5 element containing. Platforms: AFD – African, EEUP – East European, ARD – Arabian

The geological setting of these blocks involves Archaic magmatic-gneiss and metabasite-diabase formations (the Ograjdensko – Belasischki block), diabase-phyllitoide complex and high crystalline rocks (Vlachinsko-Osogovski and Kraischtenski blocks) (Bojadjiev, 1971; Mankov and Andreeva, 1974, 1975) cut by later Tertiary magmatites and Mio-Pliocene sediments overlapped on them vulcanite developed mainly in the SE part of the ore belt (the Strumitsa and Strumenischki grabens). In 1992 Alexandrov prolonged the ore belt on SE of Seres to Tasos Island – Greece and described it as ore-bearing area.

Tertiary magmatites, which cut the three of the tectono-magmatic blocks, form a chaplet-like bend. It starts from Surdulitsa (Serbia) trough the rocks of the Vlachinsko-Osogovski block of the both sides of the Bulgarian-Macedonian border and it reaches the area north of the town of Seres (Greece) in southern direction (Mankov and Andreeva, 1974, Mankov, 1984_2; Alexandrov, 1992). The implementation of the Tertiary magmatites was controlled by faults of 295° - 310° to 360° directions. They formed morphlogically different bodies – irregular ones, dykes, stocks and sills, which sizes are larger in the horst lifted parts of Osogovo (Macedonia, Greece), Besna kobila, Surdulitsa (Serbia) and Scharlia (Greece). They are acid and middle-acid magmatites, differentiated in four formations – dacite-andesitic, dellenite-porphyric, basalt-andesite-basaltic and formation of the late subalkaline volcanites. All the Tertiary magmatites from the different parts of the ore belt are differentiated in petrochemical aspect trough the normative method of R. Ivanov (1962) (Fig.3) (Mankov and Andreeva, 1975).

All the figurative points are located in the field of delenites. Delenites from Lisets and Vlachina planina are characterised by enrichment of K_2O and those from the Osogovo and Ograjden mountains are enriched with Na_2O. By its '**an**-content' the values of magmatites in the first two of the blocks are closer and differ from those in the Belasischko-Ograjden block. The better differentiation of the Tertiary magmatites is expressed on the orthogonal diagram Q:AF:CI. Grouping of the figurative points in the left part of the diagram characterises the rocks as rich in SiO_2 of maximal values of dellenites and dellenite-porphyries of the Belasischko-Ograjden block. The magmatites are characterised by higher content of mafic minerals (CI) in the field AF:CI and no significant differences are established between the other blocks. From the other hand the Tertiary magmatites of the Vlachinsko-Osogovski block is characterised by the highest total average content of iron (fm=58) ant those from the Kraischtenski block by the lowest one (fm=50). The best differentiation of the magmatites is expressed trough the parameter of the total alkalinity (AF) which is 62 for the Kraischtenski block, 58 for the Vlachinsko-Osogovski and 52 for the Belasischko-Ograjdenski block.The magmatites from the Kojuch mountain in the SE part of the ore belt 'Osogovo – Besna kobila' are located in the field of delenites with increased Na and total alkalinity and increased content of free quartz (Q). Ivanov and Zidarov (1968) refereed them to the subalkaline volcanites on this base.

Delleneite-porphyry formation and the formation of later subalkaline volcanites formed during the two magmatic stages – Oligocene-Miocene and Pliocene have the most important role for the main types of the ore mineralisations. They are overlapped on the thick consolidated Pre-Cambrian and old

Paleozoic Earth core. This core determined the formation of so called granitophilic ore formations connected to the acid magmatism (Dimitrov, Kolkovski, Mankov, 1979). They differ from the ore formations localised in the SW part of the Trans-European silver belt determined by Antonov (1986). Serafimovski (1990) describes this part as ‘ore zone Lecce-Chalcidiki’. The Earth core is relatively thin in this area and it has andesitic characteristics.

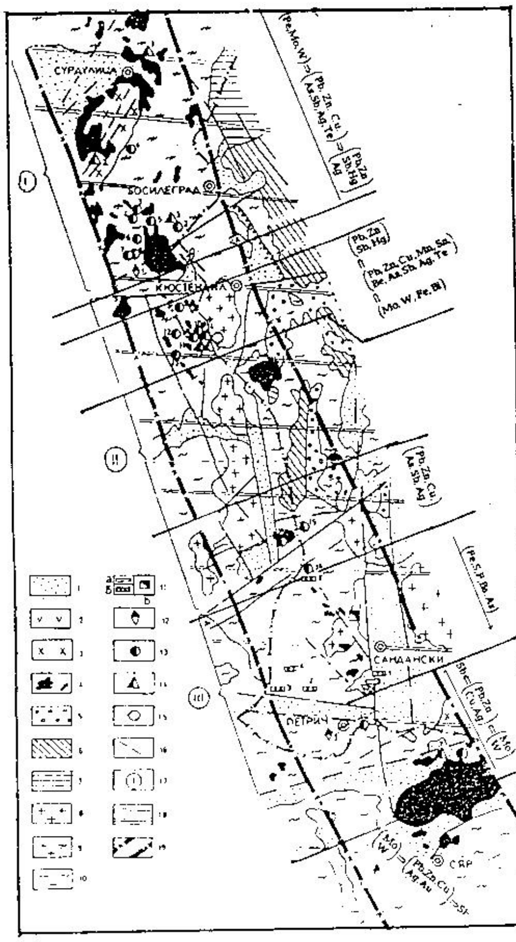

Fig. 2. Metallogenic scheme of the ore belt ‘Osogovo-Besna kobila (Mankov, 1968; Mankov and Andreeva, 1974, Mankov, 1984_2; Alexandrov, 1992)

1 – Quaternary and Neogene; 2 – Pliocene subalkaline vulcanite; 3 – Miocene granodiorite; 4 – Paleogene vulcanite; 5 – Paleogene sediment rocks; 6 – Triassic; 7 – Paleosoic; 8 – Staraplanina granite; 9 – Vlachinsko-Osogovo low-metamorphic rocks; 10 – Archean and proterosoic high-metamorphic rocks. Deposits and ore occurrences: 11^a the Kojuch decorative calcite deposit (paramorphosis of calcite and aragonite); 11^b – pyrite-marcasite ore occurrences (1. Levunovska cariera. 2. Churichene. 3. Zlatarevo. 4. Zoichan. 5. Gega.); 11^c – the Slavianka fluorite deposit; 12. stibnite deposit and ore occurrences (1. Krastov dol. 2. Ravnio rid. 3. Ivanic); 13. main Pb-Zn deposits and ore occurrences (1. Blagodat. 2. Dolno Tamlino. 3. Konev kamen. 4. Popradlovitza. 5. Bojilovo lejiste. 6. Podvirovi. 7. Plaviloto. 8. Samar. 9.Lebnitza. 10.Ruen. 11. Mali Ruen. 12. Toranitza. 13. Sasa. 14. Pehchevo. 15. Kadiitza. 16. Goremski hanove. 17. Topolnitza. 18. Scharalia) 14 – W-Mo deposits and ore occurrences (1. Matchkatitza. 2. Stari glog. 3. Leshtarska mahala. 4. Delchevski dol. 5. Svlachishteto. 6. Saska karaula. 7. Siar.); 15 – Skarn-magnetite ore occurrences (1. Golemi and Malki lisichi dupki. 2. Svlachishteto); 16 – tectonic faults and thrusts; 17 – tectonic blocks (I – Kraishtenski. II – Vlachinsko-Osogovski. III – Belasishko-Ograjdenski); 18 – Rhodopa massive; 19 – boundaries of the ore belt.

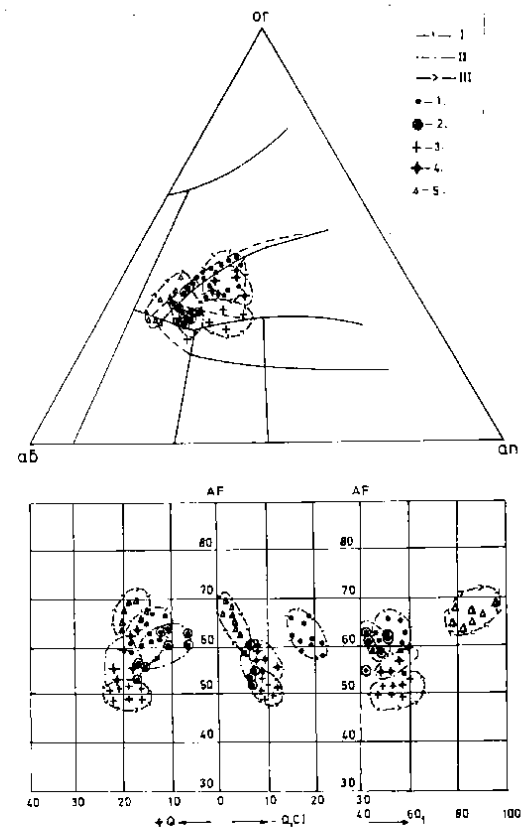

Fig. 3. or:ab:an diagram and ±Q:AF:Cl diagram of Tertiary magmatites from the Kraishtenski (I), Vlachinsko-Osogovski (II) and Belasishko-Ograjdenski (III) tectono-magmatic blocks (Mankov and Andreeva, 1974, 1975; Andreeva, 1979)

(1 – dellenite from the Lisets mountain, 2 – dellenite-porphyry from Central Osogovo, 3 – dellenite and dellenite-porphyry from the mountains of Ograjden and Malashevska, 4 – dellenite and dellenite-porphyry from Vlachina mountain, 5 – subalkaline dellenite from Kojuch, Petrich district)

The forming of the dellenite-porphyry formation in Oligocene-Miocene stage has been realised during the time of the two magmatic impulses. Fine porphyry dellenite-porphyries are related to the first impulse and the coarse-grained dellenite-porphyries are connected to the second impulse. They are largely manifested in the whole ore belt. Numerous skarn and W-Mo ore occurrences and deposits (Surdulischi block, Central Osogovo, Scharlia) are genetically and paragenetically related to the first type of rocks.Ag-Pb-Zn deposits and the ore occurrences are paragenetically related to the second type (Dragov, 1965; Mankov, 1968, 1988).

The Pliocene magmatic stage is manifested in the Central Osogovo in the form of meridianal oriented dykes from latite-andesite porphyrites along the marginal parts of the volcanic diatreme Chucarevtsi as well as magmatites from the Kojuch volcano (on the crossing of Struma and Strumescnitsa grabens) are related to this stage in the SE part of the ore belt. Numerous ore occurrences and deposits of quartz-stibnite and quartz-flourite as well as rather specific pyrite-marcasite and realgar-siderite mineralisations in the southern part of the Struma graben on Bulgarian territory are paragenetically related to this type of magmatism.

Formation sysematics of the mineralisations

Tertiary mineralisations in the ore belt 'Osogovo – Besna kobila' are typical polygenous, polychronous and polyformational mineral products and are localised is several ore fields. More important ore fields are Ruen (on Bulgarian and Macedonian territory), Karamanishko (on Serbian and Macedonian territory), Machatichko (on Serbian territory) and Seres (on Greece territory). They are divided into two ore complexes depending on the leading elements: Ag-Pb-Zn (Oligocene-Miocene) and As-Sb-F (Pliocene). They could be divided from formation point of view into 8 ore formations: scarn-magnetite-chalcopyrite (scarn Fe-oxide), quartz – scheelite-molybdenite, quartz-galena-sphalerite, quartz-stibnite, pyrite-marcasite, quartz-fluorite, realgar-siderite and formation of decorative calcite. All of these ore formations involves several mineralogical-geochemical types deposits and ore occurrences which are characterised by specific mineral compositions, trace elements, textural and structural features, morphology of ore bodies, type of the host rocks and specific role of metasomatic processes.

Scarn magnetite-chalcopyrite ore formation. It involves all the Fe-scarn occurrences in the Central Osogovo, Blagodat and Karamanitsa. The mineralisation is found as massive and veined-banded aggregates of magnetite, chalcopyrite, galenobismutite, aikinite, crupcaite, cosalite, other undiagnosed medium members of aikinite-bismuthinite series, tetradimite and native bismuth. They are overlapped on the andradite-grosular scarns and massive epidosites developed on marbles and green-schist rocks of the diabase-philitoidic complex not far from the larger bodies from the fine-porphyry dellenite-porphyries of the first impulse of the dellenite porphyry formation. They are extremely largely distributed in the SE part of the Ruen ore field (Fig.4 and Fig. 5).

Quartz-scheelite-molybdenite ore formation. The formation involves many W-Mo ore occurrences located in the SE part of the Ruen ore field in Central Osogovo (Mankov, Andreeva, 1974, Mankov, Andreeva, 1974, 1975, Alexandrov, 1992), several W and Mo ore occurrences in the Surdulischki block from the most NW flank of the ore belt (Jankovich, 19955, Simic, 1995) and some small ore occurrences in Ograjden block (Bulgaria) and in Sharlia (Greece). All these W-Mo mineralisations are related to the most lifted blocks within the frame of ore belt 'Osogovo – Besna kobila'. They are presented by a series of quartz-molybdenite, quartz-ferberite-scheelite, quartz-ferberite and quartz-pyrite veins and dissemination localised mainly in WN zones of faulting and cataclasis among fine porphyry dellenites, developed most significantly in the Central Osogovo. Mineralisations in them are most intensive in the crossing point of the zones and one large longitudinal zone of faulting which is ore-bearing and ore-controlling one (Mankov, 1988). Similar of their characteristics are mineralisations in the Surdulishki block – ore deposit Matchkatitsa. Typical trace elements are Bi, Te, Cu, Sn, Pb, Zn and specific zeolitisation – late heilandite mineralisation. Typical metasomatites quartz–K feldspathization (Mankov and Andreeva, 1973).

Quartz-galena-sphalerite ore formation. It is presented by 21 deposits and 168 ore occurrences. Significant reserves of three elements Ag-Pb-Zn are confirmed (Sasa deposit – Macedonia), Ruen deposit with its two sections – Central and Shapka; the Mali Ruen deposit - sections Central and Belite sipei. The last three deposits are situated in the Ruen ore field in Bulgaria. The deposits from this formation are typical Ag-Pb-Zn ones by their mineral composition containing as well increased contents of Cd, In, Sb, As, Bi, Te and Au. The last studies established also increased contents of Be, which forms its own mineral – helvine (Mankov, 1978, Mankov, 1986), Sn which is very typical element for the main quartz-sulphide paragenesis from (300 to 600 g/t) in the form of isomorphic mixture in chalcopyrite and pyrrothite or as kesterite (Cu_2ZnSnS_4) and one new (not well studied) Sn-Cu phase. Deposits and ore occurrences from this formation are related mainly to the large W-NW, NW longitudinal faulting zones and zones of cataclasis affecting fine- and coarse–porphyries dellenite-porphyrites as well as high- and low- crystalline rocks. The most significant ore bodies in many cases are localised in marble among quartz-graphite schist, among cataclased isotropic dellenites and green schist by metasomatic processes – it means that multicentral metasomatosis over silicified and carbonate rocks is developed. Typical metasomatites around ores are products of quartz-sericite metasomatic formation (unpublished data by Andreeva).

Quartz-stibnite ore formation. It is presented by 4 vein deposits and ore occurrences localised in the board parts of the Precolnishki graben (NW part of the Ruen ore field), Ravnio rid – S from Gueshevo and Krastov dol (Macedonia) and N and S part of the Belasitza horst on Bulgarian and Greece territory (Fig.2 and Fig.4). Therefore these are sections of the ore belt 'Osogovo – Besna kobila' which have the lowest erosion level and they occupied reasonable position on the background of the total distribution of all deposits related paragenetically to the fine-porphyry and coarse-porphyry dellenite-porphyries. Increased contents of Hg, Ag, Au, Te, Pb and Zn as well as quartz-argillite metasomatites are typical for the occurrences of this formation.

Quartz-fluorite formation is presented by 4 occurrences in the Ruen ore field found out by Dimitrov (1945), Mankov (1974), Zagorchev and Ruseva (1982) and one quartz-fluorite deposit (Slavjanka) that is situated within crystalline rocks and Miocene sediments in Ograjden block near the western board of the Struma graben (Todorov, 1984) and also by several ore occurrences in the Maleshevska mountain (Krastiltzi and Karpelevo) (Mihov et al., unpublished data). Typical trace element for this formation is As and quartz-argillite type metasomatites (Todorov, 1984). Two of ore occurrences in Ruen ore field are related to the W-NW and meridian to the N-NE fault zone in dellenites cutting the main Ag-Pb-Zn mineralisation. The other two occurrences are related to the marbelous limestone from the basement of the Eleshnitza allochthon over the Osogovo autochthon (Zagorchev, Ruseva, 1982) on the crossing point of faulting zones W-NW direction and meridian faults. This fact determines their nest-like shapes which is different from the expected layered-like, that is why the possibilities for founding out fluorite mineralisations of economic importance in the Ruen ore field are limited.

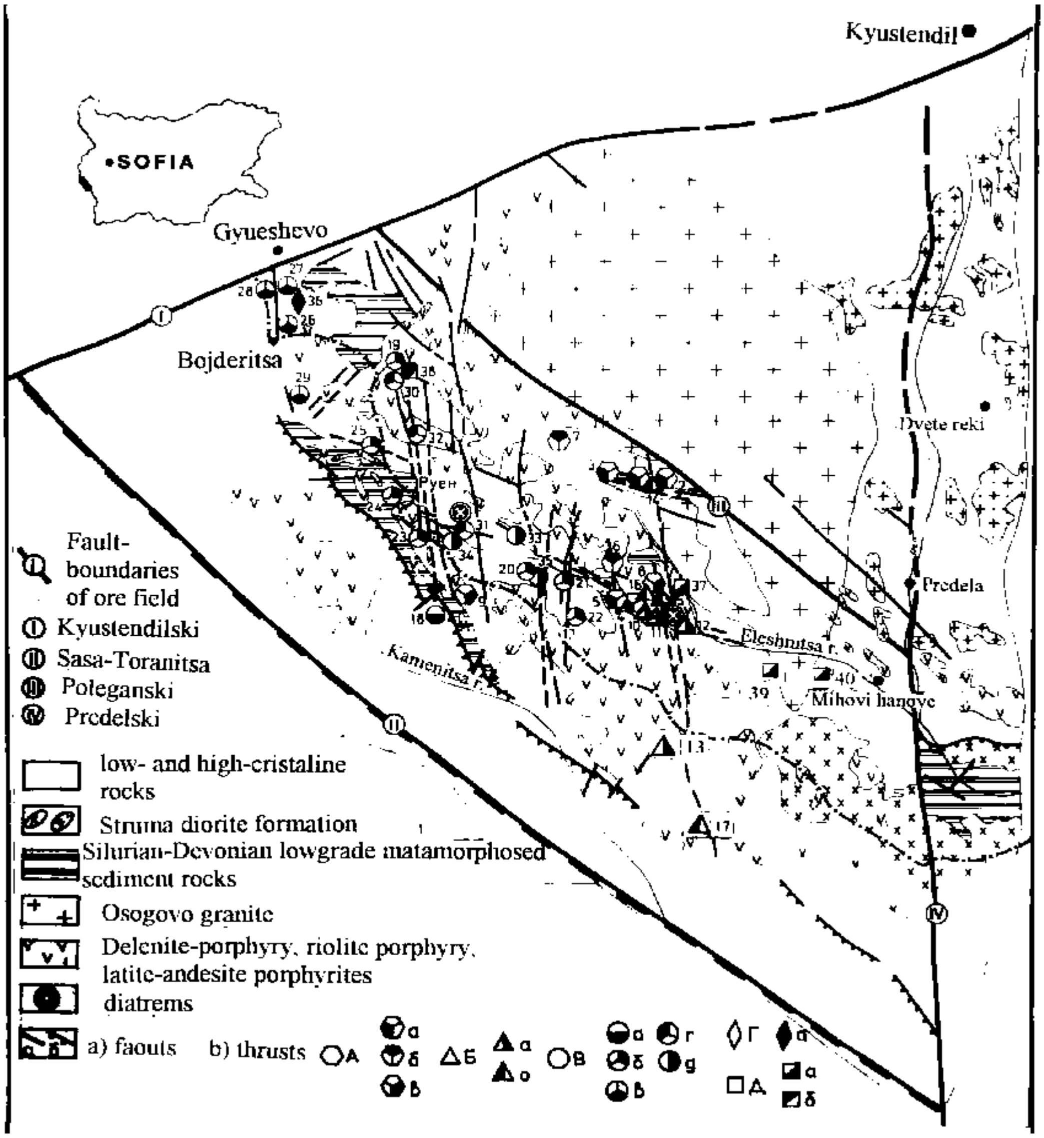

Fig. 4. Ore formations and mineral types deposits and ore occurrences in the Ruen ore field (Mankov, 1974; Mankov, 1988; Aleksandrov, 1992)
A. *Skarn magnetite-chalcopyrite:* a)andradite-magnetite epidote (1- Golemi lisischi dupki; 2 – Malki lisichi dupki, 3 – Zeleni dol, 4 – Svlachishteto, 5 – Lagera); b) pyroxene-specularite epidote (6 – Zlatanski dol, 7 – Ilan dere); c) andradite-epidote-galena (8 – Petsovska mahala, 9 – Petrova niva). B. *Quartz-scheelite-molybdenite*: a) quartz-albite-molybdenite scheelite (10 – Svlachishteto, 11 – Pchelina, 12 – Murni dol, 13 – Saska karaula); b)quartz-molybdenite (14 - Delchevski dol, 15 – Chukarevtzi, 16 – Lisin dol, 17 – Saravska mahala), C.*Quartz-galena-sphalerite:* a)diopsite-jochansenite-bustamite (18 – Sasa); b) sphalerite-galena with low distribution of gangue minerals (19 – Ruen, central part, 20 – Belite sipei, 21 – Jdrapanitza II, 22 – Prosechenik, 23 – Petrova reka, 24 – Ruen (Macedonia), 25 – Bachilski potok); c) galena-sphalerite predominated by quartz and carbonates (26 – Lebniotza I, 27 – Lebniotza II, 28 – Ravna niva, 29 – Sredno burdo); d)quartz-rodonite-basemetal with silver minerals (30 – Ruen, Shapka section, 31 – Mali Ruen, 32 – Shapka II); e) johannsenite-rodonite with galena and sphalerite (33 – Nivite, 34 – Mali Ruen – zone 4 and 5, 35 – Belite sipei – metasomatic body). D. *Quartz-stibnite:* a) quartz-stibnite (36 – Ravnio rid) *E. Quartz- fluorite:* - a) fluorite (37 - Tsurna reka, 39 – Chekanets, 40 – Zidintsi); b) barite-fluorite (38 – Ruen).

Pyrite-marcasite ore formation is established in the southern part of the ore belt in the crossing point with the Struma graben (Mankov, Andreeva, Bostanjiev, 1981). It is presented by massive layered pyrite-marcasite aggregates developed over the basal breccia-conglomerate of Neogene sediments of the Struma graben (ore occurrences Levunovska kariera) as well as by series of vein pyrite-marcasite ore occurrences – Saichan, Zlatarevo, Churichene, Kozuch, which are located along the northern edge of the Struma graben among intensively altered high-crystalline rocks of the Ograjden block. Typical elements for this formation are As, Ba and F (Mankov, 1984) and quartz-argillite type metasomatites.

Realgar-siderite ore formation is presented by layered siderite body among the Neogen sedeiments in the area of Damianitza village – southern part of Struma granben. The body is cut by series of realgar veinlets (Mankov, Andreeva, Bostanjiev, 1981). The formation of realgar is related to the active hydrothermal reprocessing of the massive pyrite-marcasite bodies from the lower part of Neogen section. As a result significant quantities of As are isomorphicaly included in pyrite lattice (Mankov, 1984; Mankov,Troneva, 1984). This way the Neogen ore formations are located in two levels – marcasite-pyrite formation occupies lower level and realgar-siderite formation is developed in the upper level (Fig.10).

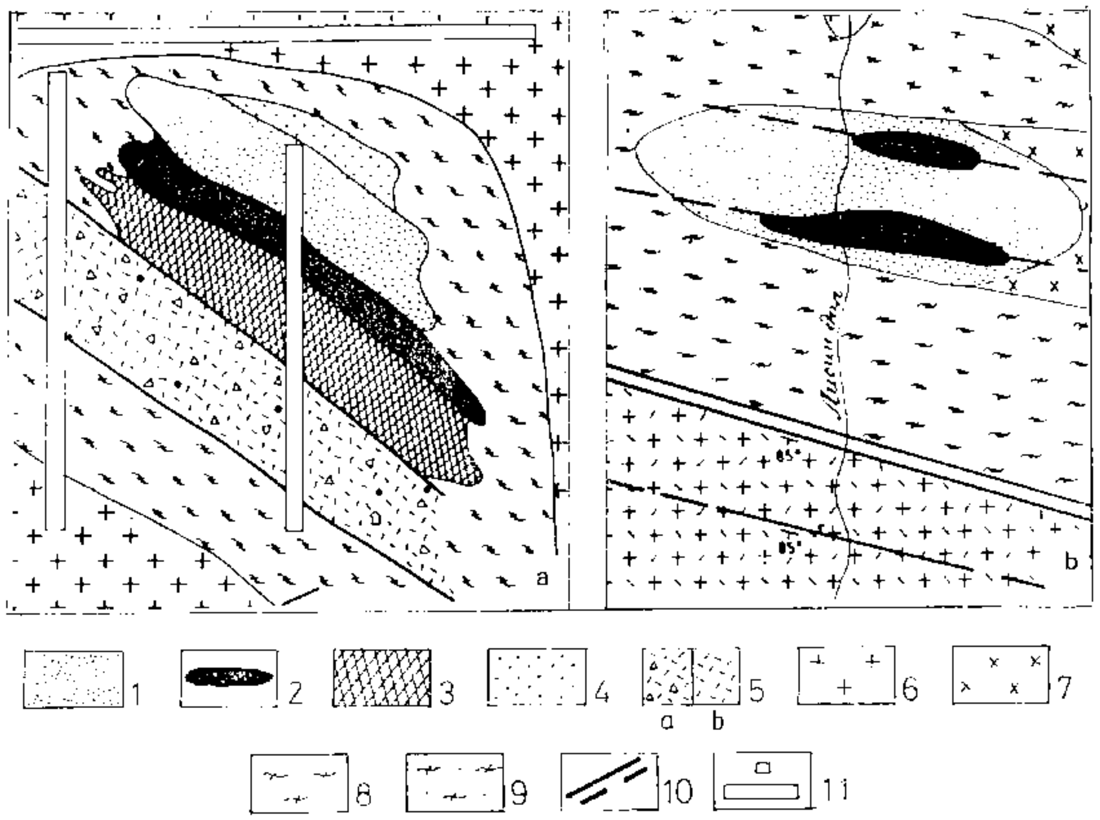

Fig. 5. Nest- and lens-like scarn-magnetite ore bodies from SE part of the Ruen ore field, Bulgaria (a – development of zonal scarns in xenolites of quartz-chlorite schist in fine-porphyry dellenites. Lagera ore occurrence; b – development of granate-epidote skarns in gabrodiorite. Lisichin dol ore occurrence. (Andreeva, 1977₁) 1 – epidosite, 2 – granate-epidote skarns with magnetite, 3 – andradite-grosular zone, 4 – zone of epidotised quartz-chlorite schist, 5 – zone of intensive faulting and cataclasis with pyritisation (a) and without pyrite (b), 6 – fine-porphyry dellenite, 7 – gabrodiorite, 8 – quartz-chlorite schist, 9 – muscovite gneiss, 10 – faults, 11 – trenches.

Formation of decorative calcite is typical for the volcanites from the hill of Kozuch. It is presented by a large but flat cone-like calcite body elongated in W-NW direction (Petrov, 1963, Milanova, 1965, unpublished data). Calcite is developed as paramorphosis of aragonite.

Morphogenetic types deposits and ore occurrences

Mineral formation from the Tertiary post-magmatic fluids in the ore belt 'Osogovo – Besna kobila' is in different zones of free infiltration drainage or in relatively closed diffusion-metasomatic system and rarely in the contractive fractures of the apical parts of larger Tertiary magmatic bodies. The different lithologic composition of the host rocks and the orientation of some of their elements (such as foliation, inclination) to the orientation of the ore-bearing solution movement gives the additional reflection on the morpho-genetical variations of ore deposits and occurrences and their ore bodies. On the other hand the physico-chemical nature of the ore-bearing solutions (T, P, C) reflects to the velocity and intensity of mineral precipitation (chemical destruction of some minerals and formation of other minerals) and implements new features in morphogenetic variations of ore deposits.

The following morphogenetic ore types could be divided distinctly on the basis of mentioned above (Mankov, 1974; Mankov, 1988; Alexandrov, 1992): 1. Veins; 2. Linear stockworks; 3. Metasomatic bodies of layer-like, lens-like and other irregular shapes; 4. In-formation nest-like bodies. Two ore more morphogenetic type ore bodies are often formed in particular deposit.

The vein type involves several Pb-Zn deposits in the Ruen ore field (Lebnitza I, Lebnitsa II, Ravna niva – Bulgaria; Sredno bardo, Ruen, Petrova reka, some of the bodies in the Sasa deposit and Bachilski potok – Macedonia), some deposits from the Karamanishko ore field (Podvirovi, Karamanitza – Serbia; Samar, Kukishte, Turska straja, Bagremi – Macedonia), Pb-Zn deposits in the Pehchevo ore field (Pehchevo, Pehchevska reka, Racovets Kadiitza in Macedonian and Bulgarian territory). This type involves also fluorite deposit Slavianca, stibnite ore occrrences Ivanic and Ravnio rid from the southern and central part of the Osogovo block, stibnite deposit Krastov dol in Macedonia which is located in the Karamanitsa ore field.

These mineralisations are located in different gneiss, gneiss-graniteq granodiorite, green schist rocks and rarely in dellenite and large, steep, longitudinal up to the NW and EW fault structures (Fig.6). They are quartz and quartz-carbonate veins that contain sulphides, dipping into W to SW (75-80°) and distinct contacts with host rocks. They are traced on the surface from 100–150 m (Ravna niva) up to 2000 m (Lebnitza I and Lebnitza II) and up to 700 m in vertical direction. In depth they have tendency to divide in a form of a hand with open fingers pointing down (Lebnitza I). Anisotropy characteristic of the host rocks determined one-way opening of ore-bearing faults during the different moments of the development of mineralisation process which is a reason for forming typical ore veins of massive, breccia-like, banded, druses, cockard and spoty structures in open fractures.

Typical vein bodies in the Podvirovi deposits (Karamanishko ore field) are located along the faults on the contact of low-crystalline rocks and coarse-porphyry dellenite (Petrovic, 1981; Simic, 1995). Typical linear stockwork from 10 to 40 m wide are established in depth among the isotropic dellenite porphyry bodies.

The second structural-morphological type deposits and occurrences – linear stockworks and stockwork-vein type deposits are related to the large zones of faulting and cataclasis, mainly with W-NW direction – 295-305° dipping in SW and W-NW (70-75°) and very rarely – to the N-NE fault zones. This type unites deposits which belong to different ore formations and mineralogical types (in Bulgaria – Ag-Pb-Zn deposits Ruen, sections Central and Shapka; Mali Ruen, sections Central and Belite sipei, Jdrapanitza II; W-Mo ore occurrences Svlachishteto, Chcarevtzi, Delchevski dol and Manastirski dol; in Macedonia – Pb-Zn deposits Ruen, Bachiloto and Plaviloto, W-Mo occurrences Saska Karaula and Sarafska mahala; in Serbia – W-Mo deposits Matchkatitza and Borovic and Pb- Zn deposit Karamanitza). Some of these deposits have economical importance. Mineralisations could be followed from 50 – 60 m up to 3000 m (Ruen, Belite sipei, Mali Ruen, Matchkalitza). The vertical interval of mineralisation is over 750 m in some of them. Ore bodies are characterised by very complicated shapes and irregular distribution of minerals manifested by metasomatic, multicentral eveloped quartz-sulphide-carbonate iimpregnation and veilets, mainly among the isotropic fine and coarse-porphyry dellenite (Fig. 7 and Fig. 8 a, b, h).

Different in their morphology and geological setting metasomatic ore bodies and mineralised zones determined as overlapped metasomatites were formed in different in their composition host rocks. The whole development of these metasomatites leads to the total reproduction of structural and textural peculiarities of the replaced dellenite-porphyries. The main part of the ore bodies in the Ruen deposit (Central part), the main ore bodies in the Mali Ruen deposit, the most of the ore bodies in the Belite sipei deposit (Bulgaria), The Ruen, Bachilski potok and Plaviloto deposits (Macedonia), the Karamanitza deposit and Mo deposits Machkatitza and Bucovic (Serbia) (Jelencovic, 1995; Simic, 1995).

Metasomatic processes have been developed in direct relation to the intensity of tectonic movements, chemical composition and structure of the host rocks, temperature and Sericitised, epidotised and rodoninitised K-feldspar and plagioclase phenocrystals of fine porphyry-dellenite and vein quartz-rodonite scarns as well as different magmatites are favourable environment for development of sulphide metamorphosis. Linear elongated zones with disseminated sulphide mineralisation (Mali Ruen, Belte sipei, Nivite, Petrova reka and Bachilski potok – the Ruen ore field in Bulgaria and Macedonia; some of the ore bodies from the Podvirovi deposit, the Karamanishko ore field, Serbia) were formed parallel and slantwise to the foliation in the green schist rocks.

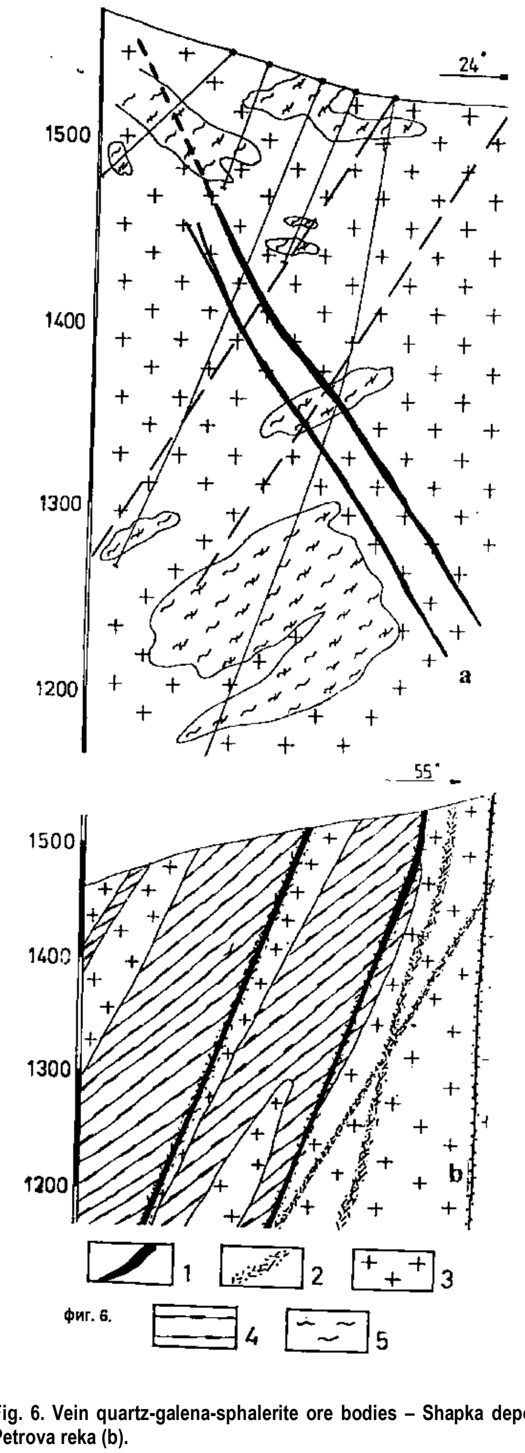

Fig. 6. Vein quartz-galena-sphalerite ore bodies – Shapka deposit (a), Petrova reka (b).
Cross sections (1 – quartz-sulphyde ore bodies; 2 – dissemination quartz-sphalerite mineralization in cataclase zones; 3 – fine porphyritic delenite; 4 – sericite-chloride schists; 5 – amphibole-biotite gneisses concentration of hydrothermal solutions (Mankov, 1974).

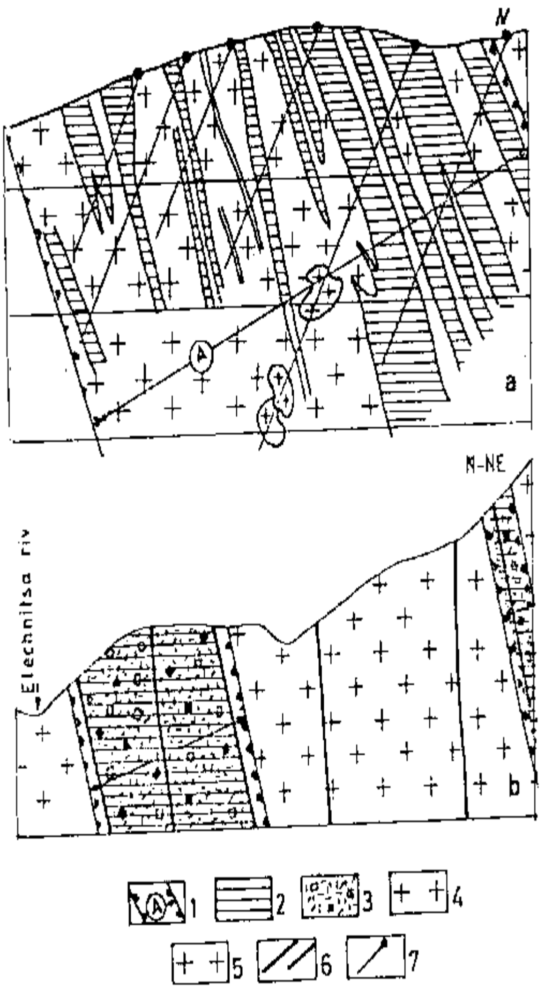

Fig. 7. Cross sections of linear stockwork quartz-molybdenite (a) ore field and quartz-scheelite- molybdenite (b) ore bodies related to zones of faulting and cataclasis (a – Borovic deposit, the Machkatitza ore field – Serbia (Simic, 1995), b – Svlachishteto ore occurrence – Chucarevski structural knot, SE part of the Ruen ore field)
1 – boundaries of zones of faulting and cataclasis, containing Mo and W-Mo mineralisations: A – Borovishka zone, B – Eleshnitza, C – Chucarevska; 2 – Mo ore bodies; 3 – quartz-scheelite-molybdenite and pyrite veinlets and disseminations; 4 – dellenite-porphyry; 5 – granodiorite-porphyrite; 6 – faults; 7 – boreholes

The shape of the ore bodies in this zones is complicated also by the ore-transporting role of the meridian fault structures and existence of contraction fissures in the apical parts of the large dellenite bodies (Dimitrov, Tsetlin, Donets, 1984). That is why the mineralisation often inclines in lower parts of the ore-containing zones and its shape is like a turned above broom (Mankov, 1978). Additional factor for the complicated morphology of the ore bodies are also several different hypsometric levels of decollement in the green schist rocks related to the thrust movements and formation of high-styled folds in part of the ore bodies in the Nivite and Belite sipei deposits according to some authors (Zagorchev, Ruseva, 1982; Vardev, 1984).

The third morpho-genetic type mineralisation is largely spread and it is most various one. Numerous scarn-magnetite-chalcopyrite occurrences (Fig.5) and parts or whole Pb-Zn deposits in the Ruen ore field, tha main part of Pb-Zn ore bodies in Blagodat (Serbia), pyrite-marcasite and realgar-siderite mineralisations from the Neogene sediments in the southern part of the Struma belong to this type.

Hydrothermal-metasomatic Pb-Zn deposits in the Bulgarian part of the Ruen ore field are massive nest-lens-like and layered bodies set up by johannsenite-rodonite and quartz-rodonite aggregates overlapped by rich sphalerite-galena mineralisation or by massive sphalerite-galena aggregates localised in small marble lenses, sericite-chlorite and epidote-chlorite schist (Belite sipei, Nivite, Ruen) (Fig.8 c).

Mineralisations of this type in the Macedonian part of the Ruen ore field, the Saska group deposits (Kozja reka and Svinja reka, Petrova reka), Toranitza I and Toranitza II and Blagodat deposits in Serbia are especially significant ones. The Pb-Zn mineralisation in the Sasa, Toranitza I and Toranitza II deposits forms a large layered lens and nest-like bodies. They are located within the marble and chalcoschists of the quartz-graphite schist and laying over and below them green schist rocks in the contact of the Tertiary magmatites (Bogoevski, 1967; Alexandrov et all, 1990; Alexandrov, 1992) (Fig.9, a, b). The sizes of the ore bodies vary within a broad range from 50-150 up to 1250 m long and from 0,50 m to 50 m thick.

Interesting case-like and slipper-like metasomatic bodies with galena-shpalerite and quartz-rododnite-sulphide composition are developed in the apical parts of the large dellenite porphyry bodies (Fig. 8 d, f, g).

The four morpho-genetic type mineralisations is presented by fluorite occurrences Checanets and Sidintzi (Zagorchev, Ruseva, 1982) and they are characterised by very small sizes. Our studies established that the filling of the open drainage structures without traces of metasomatic phenomena in the host rocks of the Triassic limestone localised under green schist rocks of the Eleshnitza thrust played the main role for their formation. The Liska deposits, that is localised within gneiss under the screen of Paleogene sediments – Kraramanitsa ore fiel, belongs to this type (Simich, oral expose).

Temperature conditions of mineral forming and chemistry of ore-bearing fluids

The different types of mineralisations in the ore belt 'Osogovo – Besna kobila' have been formed within a large temperature range. The hydrothermal brines changed their acid-alkaline features and composition within the frame of the whole mineral forming process. These peculiarities determine type of the hydrothermal metasomatic alterations and structural-texture features of ores.

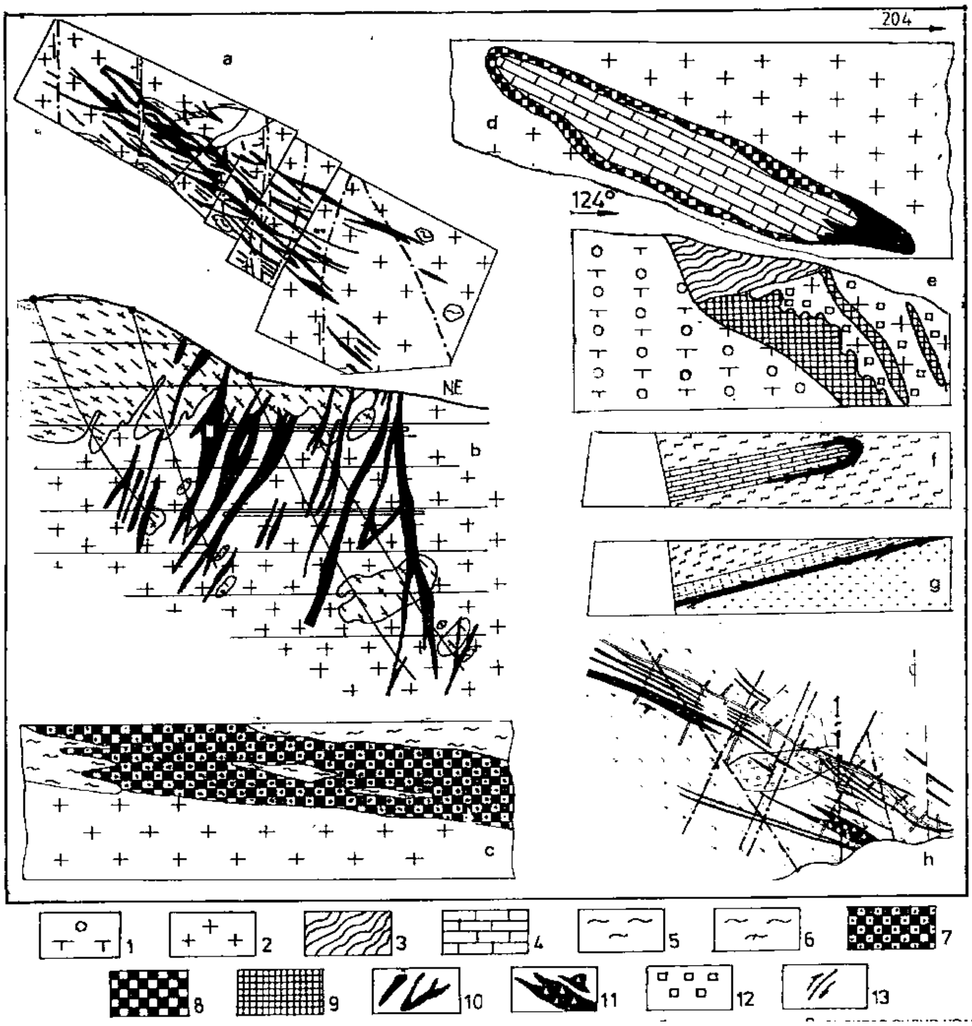

Fig. 8. Morpho-genetic types deposits and ore bodies in the Bulgarian part of Ruen ore field

a) linear stockwork set up by veinlet-disseminated type of quartz-sulphide mineralisation related to the complicated zone of faulting and cataclasis. The Ruen deposit, central part – plan of level 1480 m; b) vein ore bodies of veinlet disseminated type of distribution of quartz-sulphide mineralisation controlled by a zone of faulting and catacalsis. Cross section. The Ruen deposit, Central part; c) massive galena-sphslerite mineralization within sericite-chlorite schist on the contact fine porphyry dellenite-porphyries. Nivite deposit.; d) Case-like and crescent development of massive quartz-rodonite and quartz-sulphide mineralisation in marble xenolites in fine porphyry dellenite. Nivite deposit. e) hens-like formning of massive quartz-rodonite scarns with sulphide mineralization in SE bort of Mali Ruen volcanic vent under screen of quartz-galena schist on the border between tuff-breccia and dellenite-porphyry. f) crescent and g) layered-like ore bodies of massive quartz-rodonite and quartz-galena aggregates developed around marble lenses and layers among sericite-chlorite schist or in the contact with marble. Nivite deposit. tr. 20 and 22. h) ore bodies of complicated distribution of mineral composition containing helvine mineralisation. The Mali Ruen deposit, central part (Mankov, 1986) (1 – tuff-breccia; 2 – dellenite-porphyries; 3 – quartz-sericite-graphite schist; 4 – marbles; 5 – sericite-chlorite schist, 6 –sericite-chlorite, chlorite-epidote, quartz-sericite-graphite schist, marbleous limestones; 7 – massive galend-sphalerite mineralization; 8 - quartz-rodonite scarns; 9- quartz-rodonite scarns with galend-sphalerite mineralization; 10 – vein quartz-galena-sphalerite mineralisation; 11– vein quartz-pyrite mineralization with helvine; 12 -pyrite disseminated mineralisation; 13 – faults and directions of movements

Skarn-magnetite-chachopyrite and quartz-scheelite-molybdenite formation are formed in typical high temperature conditions (460-370°C for the first formation and 370–330 °C for the second one) as it could be concluded from the fluid inclusion studies of transperant and semi-transperant minerals. The initial stage of the mineral formation is related with fluids of high oxygenal potential, low mobility of oxygen and iron, which precipitated magnetite and hematite. Ca, Al and partly Mg, K and Na are extracted from the host rocks and they start active epidotisation and skarning (andradite-grosular type). Later development of the ore-forming process in skarn occurrences is oriented along the line high-low sulphur potential. Due to this, the sequence of mineralisations after formation of magnetite and hematite is as following: iron sulphides → copper sulphides →bismuth sulphosalts and sulphides →bismuth tellurides→native bismuth.

The precipitation of W-Mo and Mo mineralisation is in direct relation with later increasing of acidity of brines (Mankov and Andreeva, 1974, 1975, Andreeva, 1997$_2$) when it is realised the mass formation of quartz and catching Ca^{++}, liberated during the alteration of plagioclase in the form of scheelite under the impact of high temperature solutions of total concentration of CO_2 – 11,1 mol/g which is with 2,25 mol/g over the upper limit of saturation of the hydrothermal fluids with CO_2.

Deposits from quartz-galena-sphalerite formation in the Central part of Ruen ore field are formed within the temperature range 370-280°C, and these from north-western part – Lebnitsa I and Lebnitsa II – within the temperature range 310-240°C (main quartz-galena- sphalerite paragenesis) (Mankov, 1978). Typical feature of Pb-Zn deposits from the Ruen ore field is the existence of two parageneses of economical importance, the second of which is with significant higher initial temperature compared to the final temperature of the second one. Fluid inclusions in quartz from the first paragenesis homogenise at 370-280°C, at 143°C in calcite and at 120-170°C in barite. The salt concentration (g/l) and composition of fluids is determined trough analyses of the gas-liquid extraction from the inclusion as follows: KCl – 31,88; NaCl – 27,22; NH_4Cl – 0,97; $MgCl_2$ – 1,75; $CaCl_2$ – 5,83; $CaFe_2$ – 0,75; $CaSO_4$ – 10,50 and pH=6,88. Na and K chlorides predominate in this composition as it could be concluded from their total concentration of 59,10 g/l (Mankov, 1988).

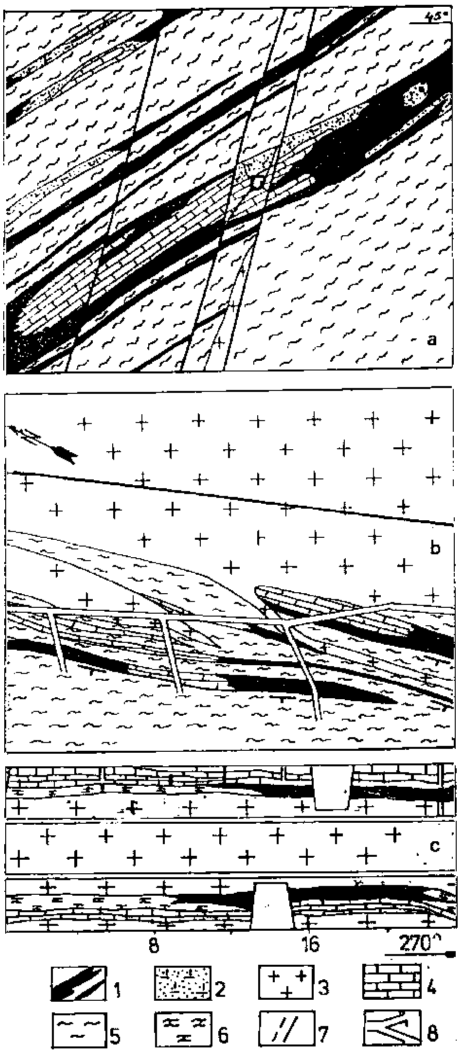

Fig. 9. Metasomatic galena-sphalerite ore bodies over marble and chalkschist involved in quartz-graphite schist and amphibole-biotite gneiss in contact with dellenite: a) cross section trough Sasa deposit, Svinia reka section (Alexandrov, 1992); b) plan on level 1775 m, Toranitza deposit (Serafimovski, Alexandrov 1995); c) nest-like quartz-rodonite-galena-sphalerite mineralisation on xenolite of marble in the apical part of dellenite stock. Ruen deposit, gal.17; 1-metasomatic ore bodies; 2-andradite-grosular skarn; 3 – dellenite; 4 – marble; 5 – sericite-chlorite schist; 6 – fault; 7 – mine works.

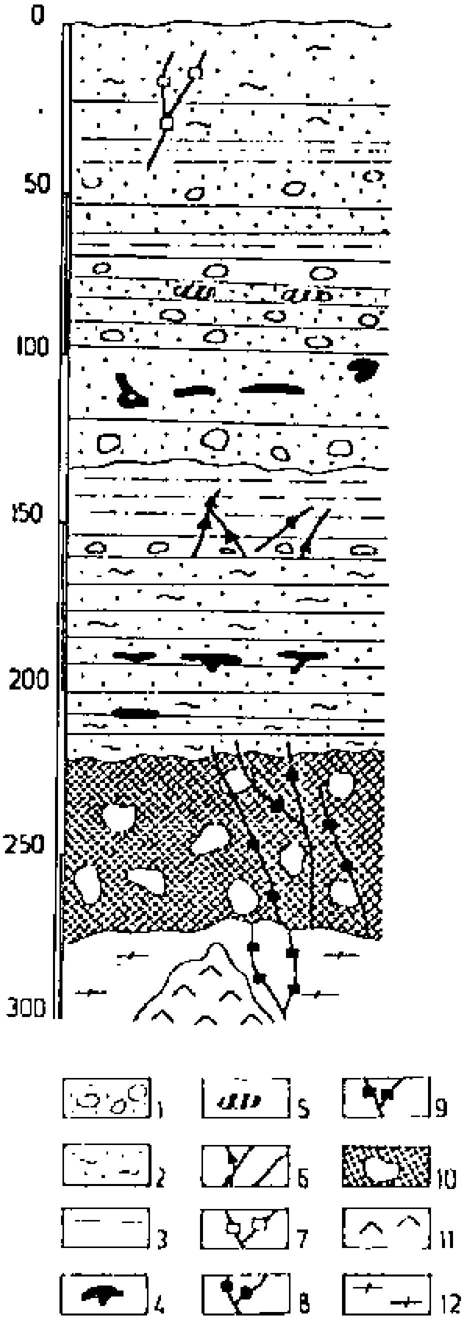

Fig. 10. Ore-lithologic section (Struma graben, Damjanitsa section) 1 – conglomerates, 2 – clay sandstones, 3 – aleurolites, 4- marcazite-pyrite lens, 5 – syderite lens, 6- realgar veins, 7 – dollomite-calcite veins, 8 – barite veins, 9 – quartz-sphalerite-galena veins, 10 – massive marcazite-pyrite body, 11 – Pliocene vulcanite, 12 – Pre-Cambrian amphibole-biotite gneisses.

Temperatures of homogenisation of gaze-liquid inclusions in quartz from the second economic quartz-carbonate-silver paragenesis is determined within 290-260°C and those in cellophane and calcite are respectively 170-140°C and 140-130°C. Formation of this paragenesis is related to implementation of hydrothermal fluids of higher temperature connected to development of the magmatic chamber or separation of fluids from its lower hypsometric levels.

Typical lower temperature hydrothermal products (270-100°C) such as stibnite, barite-fluorite, fluorite, pyrite-marcasite and realgar-siderite mineralization in the ore belt are related to the Pliocene final ore-bearing process. Fluorite mineralization are the highest temperature ones among them. The formation of the main quartz-fluorite paragenesis in the Slavianka deposit is within the range of 210-120°C as it was determined by Todorov (1984) on the basis of temperature of homogenisation in different coloured fluorite from this deposit.

As a conclusion it should be mentioned that the ore belt 'Osogovo – Besna kobila' as a part of Trans–European silver metallogenic belt has significant importance in discussion of the metallogeny in the Central Europe and the countries from the Balkan Peninsula. Unique metal concentration of Ag, Pb and Zn are located in it as well as important W-Mo, fluorite, pyrite-marcasite, stibnite and realgar-siderite occurrences are located in it. Most interesting of them are sulphides and carbonates of Mn, Ni arsenides, Cd carbonates, Be silicates, As and Sb sulphosalts of Ag, telluride of Pb, Ag and Bi, concentration of Sn, Bi sulphides and sulphosalts, As and Sb sulphosalts of copper. All these contribute for the specific features of this ore belt, which has no analogue among the other metallogenic unites in the countries from the Balkan peninsula and Central Europe.

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