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MINERALOGY PARTICULARITIES OF GOLD-BEARING SULPHIDIC POLYMETALLIC ORES

The Shaumian sulphidic collective polymetallic concentrate analysis is carried out by X-ray and microscopic methods, in order to estimate by its example the mineralogical structure and interrelation of minerals for this type of gold bearing copper – zinc – lead complex ores, from the point of view valuable metals recoverability. It is shown that the gold and silver are allocated mainly in sulphide grains which must be decomposed to recover the noble metals. And the some minerals are combined so closely with each other (especially, sphalerite with chalcopyrite and chalcopyrite with galena) that it is quite impossible to separate them in ordinary industrial milling and flotation conditions.

Keywords: mineralogy, sulphide, polymetallic concentrate, chalcopyrite, sphalerite, galena, pyrite, quartz.

The scope of this study is to determine the mineral composition of gold- and silver-bearing ore occurrences in Shaumyan (town Kapan, Armenia) deposit in relation with Um Samuki deposit (Eastern Desert, Egypt) to assess potential behavior of corresponding concentrates in the metallurgical treatment cycle. Both of them are sulphide polymetallic (complex) deposits. Its mineralogical compositions and metallogenic associations are similar.

Shaumyan ore is a copper – zinc - lead sulphide deposit in the southern area of Armenia [1]. It is a polymetallic (complex) ore. Gold – sulphide formation mineral bodies cause the middle drifes. They are represented mainly by quartz – sulphide reefs embeded with mineral belts. The average contents of gold is 2.5 *g/t*, silver 50 *g/t*, copper 0.6 *%*.

Um Samuki is a gold bearing volcanogenic massive zinc – copper - lead sulphide deposit in an area of very rugged topography amidst the belt of island arc volcanic rocks [2]. It is the largest in the Egyptian volcanic hosted reserves and the best in ore grade.

Two distinct spatial and mineralogical associations of gold mineralization are identified:

a) Au – Ag – Zn association where gold grades are very low (generally in the range of 0.3…0.4 *g/t*) and silver is anomalous, averaging 109.25 *g/t*. This association occurs typically in the upper levels of the deposit where low-temperature sulphides are abundant. This association deposits in the initial stage of the massive sulphide body development where gold was transported as thio-complex $Au(H_2S)$ with significant amounts of lead, zinc and silver, usually in the range of 150…250 ^{0}C.

b) Au – Cu association typically occurs in the footwall rock alteration zone (the keel zone) and the lowest parts of the massive sulphide body. Gold grades reach up to 5.54 *g/t* but average is 1 *g/t*. Silver is very low, usually in the range of 4…10 *g/t*. Lead usually, but not always, accompanies gold in this association. This association deposited in the later stages where gold and copper were transported as chloride complexes, in relatively high-temperature fluids ($>$300 ^{0}C) with low pH ($<$ 4.5), low H_2S concentration, high salinity (greater than that of seawater) and moderate to high oxygen fugacity. Deposition took place due to decreasing pH conditions.

The X-ray diffraction analysis, used to identify the main minerals of Shaumyan collective polymetallic concentrate from a commercial batch, is performed on a DRON-2.0 diffractometer

(Russia) with Cu-K_α radiation at the Rentgenometric laboratory of SEUA. The diffractogram interpretation was made with American X-ray ASTM Card File [3].

The concentrate size distribution is evaluated using the conventional screening test with a ro-tap and a set of screens from 45 to 160 *microns* particle size and the density is measured using the classical pycnometer method.

Inspection with a light microscope is used to identify and examine gold and silver as well as sulphide mineral particles and their characteristics. For this study the powder samples are mounted in cylindric glass lames with an epoxy resin and carefully polished. Morphological characteristics studied included particle shape (rounded, elongated, irregular, folded, etc.), particle size range, presence and simple percentage of minerals and free metals other than gold, crystalline characteristics (optically flat surfaces, twinned or multiple crystals, and straight edges not created by fracture), surface irregularities (scratching, amalgamation, oxides, traces of gangue materials, fractures, holes, clusters), and general color (rough determination of gold purity and possible surface oxidation).

As it is properly seen from the photomicrograph in Fig. 1 and diffractogram in the Fig. 2, the ore minerals of Shaumyan orebody are represented mainly by sphalerite (ZnS), chalcopyrite ($CuFeS_2$), galena (PbS), pyrite (FeS_2) and minor tennantite ($(Cu,Fe,Ag)As_4S_{13}$). Secondary minerals include iron hydroxides (FeOOH, $FeOOH.nH_2O$), single grains of gold and silver tellurides (Ag_2Te, $(Au,Ag)_2Te$), native gold and silver. For the case of Um Samuki orebody has nearly the same minerals: sphalerite, chalcopyrite, pyrite, marcasite and galena [4].

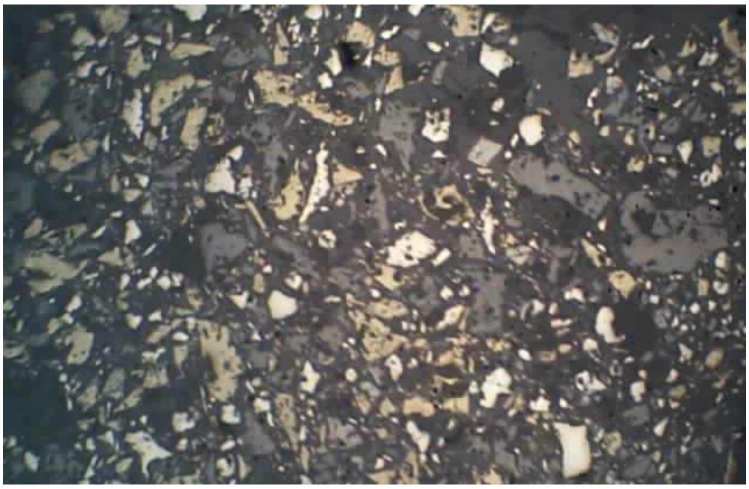

Fig. 1. Photomicrograph (x100) of Shaumian polymetallic concentrate showing complex mineralization mainly by various sulphides, tellurides, iron hydroxides and quartz

On the whole 90…95 % sulphides, about 1 % iron hydroxides, and 5 % gangue minerals (mainly quartz) are present in this concentrate.

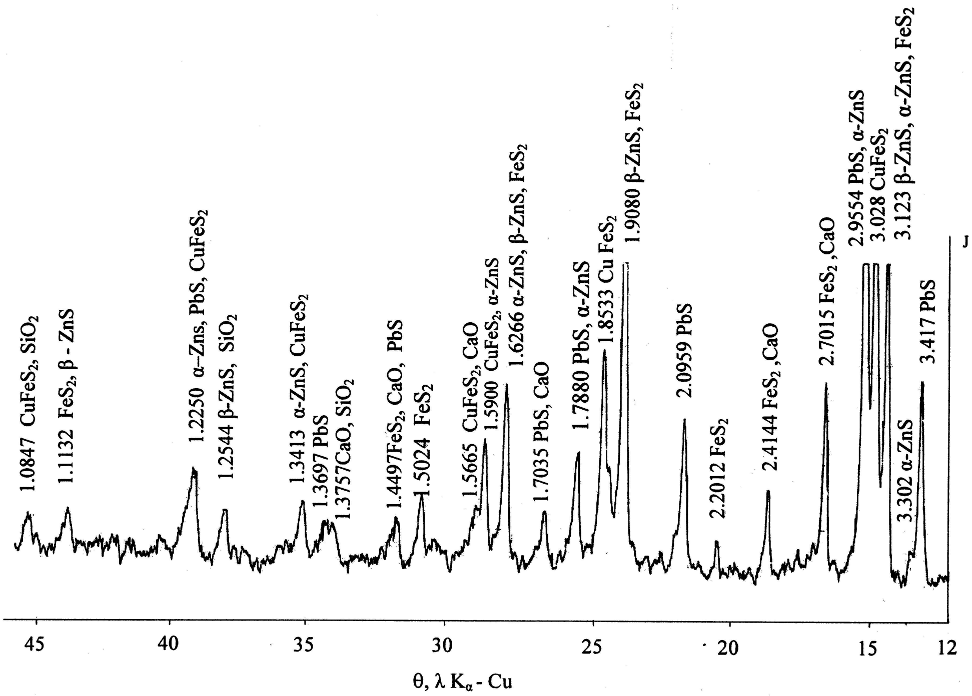

Fig. 2. Diffractogram scanned with the Shaumian polymetallic collective concentrate

Sphalerite (ZnS) values range 30 to 35 % of the tested concentrate. On the photomicrograph the sphalerite is presented as the free grains as well as in combinations with other sulphide minerals. In some sphalerite grains the chalcopyrite is emulsively by enclosed (random position) and rarely enclosed with gold and silver telluride as well as colloidal particles of native gold and silver.

Chalcopyrite ($CuFeS_2$) values range within 20…25 % of the concentrate. Mainly it occurs in free grain form with dimensions from some *microns* to 0.05 *mm*. Includings of pyrite small grains are observed in the grains of 0.08 *mm.*Sertain associations of chalcopyrite with tennantite and sphalerite are noted. Somtimes the spheroidal small including of gold and silver tellurides in 0.01 *mm* sizes are observed in the chalcopyrite grains.

Galena (PbS) values range about 10 % of concentrate. It is present mainly in free grain forms and very rarely combined with chalcopyrite grains.

The pyrite (FeS_2) is present in large amounts. Its values range from 20 to 25 % of concentrate. Pyrite is observed mainly as free grains. Sometimes combinations with chalcopyrite and quartz take place. Sometimes the includings of sphalerite and chalcopyrite are enclosed in pyrite grains. The big pyrite grains are cuted by mass of thin veins of chalcopyrite, chalcopyrite-tennantite and chalcopyrite-sphalerite-tennantite.

Native gold is observed as the spheroidal free grains with a particle size of 0.01 *mm* in sphalerite and chalcopyrite (fig. 3).

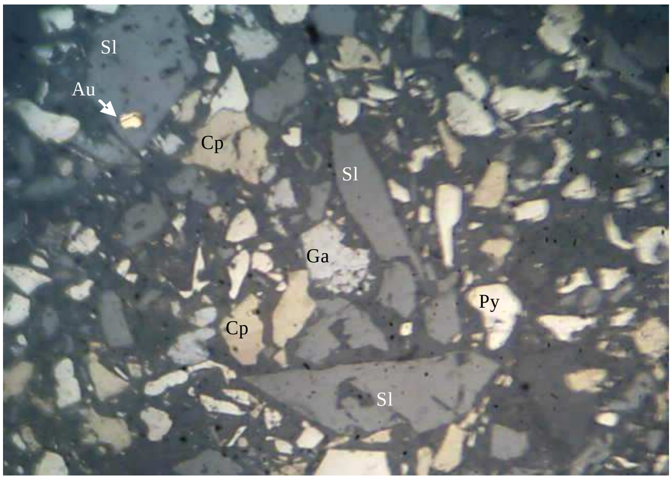

Fig. 3. Photomicrograph (x250) of main mineralization of Shaumian polymetallic concentrate: sphalerite (Sl) in which native gold grain (Au) is observed, chalcopyrite (Cp), galena (Ga) and pyrite (Py)

Native silver occurs more often than gold and is observed in grains of sphalerite, chalcopyrite and galena. Its dimensions are up to 5…7 *microns* (Fig.4).

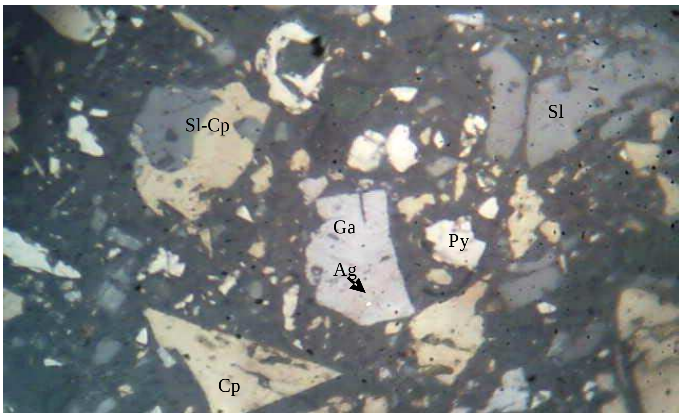

Fig. 4. Photomicrograph (x400) of Shaumian polymetallic concentrate showing sphalerite (Sl) occurenced at the boundary of chalcopyrite (Cp), free grains of sphalerite (Sl), chalcopyrite (Cp) and pyrite (Py) and native silver (Ag) occurenced in galena (Ga) grain

The tennantite mineral that is argentiferrous tennantite – $(Cu,Fe,Ag)As_4S_{13}$ is noted mainly in combinations with chalcopyrite, sometimes with sphalerite and pyrite.

The tellurids are present mainly by smaller enclosures of hessite (Ag_2Te) and pedzite ($(Au,Ag)_2Te$) into grains of sphalerite, chalcopyrite and galena (particle size of 0.02 *mm*), sometimes in cramped associations with native gold.

Iron hydroxides (FeOOH, FeOOH.nH2O) compose less than 1 *%* of concentrate. They are in the sulphide minerals in a form of thin veins, and very rarely it can be found full oxidized grains as "relict-islands" of sulphides.

Gangue (that is the worthless minerals) values range about 5 *%* of concentrate. They are present with the quartz, carbonats and rocks containing dilute enclosuries of pyrite, sphalerite and chalcopyrite.

As a result, gold and silver in sulphidic polymetallic complex ores are allocated mainly in sulphide grains which must be decoposed to recover the noble metals. Some minerals are combined so closely with each other (especially, sphalerite with chalcopyrite and chalcopyrite with galena) that it is quite impossible to separate them in ordinary industrial milling and flotation conditions.

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ՈՍԿԵՏԱՐ ՍՈՒԼՖԻԴԱ-ԲԱԶՄԱՄԵՏԱՂԱՅԻՆ ՀԱՆՔԱՆՅՈՒԹԵՐԻ ՄԻՆԵՐԱԼՈԳԻԱՅԻ ԱՌԱՆՁՆԱՀԱՏԿՈՒԹՅՈՒՆՆԵՐԸ

Ռենտգենաֆազային և մանրադիտակային վերլուծության մեթոդներով հետազոտվել է Շահումյանի միասնական սուլֆիդա-բազմամետաղային խտանյութը՝ դրա օրինակով գնահատելու համար այդ համալիր տեսակի ոսկետար պղինձ – ցինկ – կապարային հանքանյութերի միներալոգիական կազմը և միներալների փոխհարաբերությունը՝ արժեքավոր մետաղների կորզվելիության առումով: Ցույց է տրված, որ ոսկին և արծաթը բաշխված են հիմնականում սուլֆիդային հատիկներում և որ դրանք պետք է քայքայվեն, որպեսզի կորզվեն ազնիվ մետաղները: Որոշ միներալներ այն աստիճանի են սերտաճած մեկը մյուսին (հատկապես, սֆալերիտը խալկոպիրիտի հետ և խալկոպիրիտը՝ գալենիտի), որ անհնար է դրանց տարանջատել հանքանյութի սովորական արտադրական մանրացման և ֆլոտացման պայմաններում:

Առանցքային բառեր. միներալոգիա, սուլֆիդ, բազմամետաղային խտանյութ, խալկոպիրիտ, սֆալերիտ, գալենիտ, պիրիտ, քվարց:

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ОСОБЕННОСТИ МИНЕРАЛОГИИ ЗОЛОТОСОДЕРЖАЩИХ СУЛЬФИДНО-ПОЛИМЕТАЛЛИЧЕСКИХ РУДОМАТЕРИАЛОВ

Методами рентгенофазового и микроскопического анализов исследован Шаумянский коллективный полиметаллический концентрат для оценки на его примере минерального состава и взаимоотношениях минералов в такого рода комплексных золотосодержащих медь-цинк-свинцовых рудоматериалах с точки зрения извлекаемости ценных металлов. Показано, что золото и серебро распределены в основном в сульфидных зернах, которые должны быть разложены для извлечения благородных металлов. Некоторые минералы объединены настолько тесно (особенно сфалерит с хальконпиритом, халькопирит с галенитом), что вовсе невозможно разделить их в обычных условиях производственного измельчения и флотации.

Ключевые слова: минералогия, сульфид, полиметаллический концентрат, халькопирит, сфалерит, галенит, пирит, кварц.