GEOLOGY AND ORE COMPOSITION STUDIES OF DULAAN KHAR UUL POLY METAL DEPOSIT

Tamir, B[1]*., Dorjgotov, D[1]., Lkhagvatseren, B.[2]

[1] *School of Arts and Sciences, National University of Mongolia, Ulaanbaatar P.O.Box 46-337 Mongolia*
[2]*Yushengming LLC*

ABSTRACT

Dulaan khar uul deposit is situated in the NW of the Deluun-Sagsay metallogenic zone, identified within Devonian rift-like structure of Western Mongolia. As for geologic settings, it consists of Devonian Baast uul, Otog formation bimodal volcanic, sedimentary, tufogenic rock units and spatially and genetically interrelated subvolcanic units. The poly metal mineralization develops lenses, layers and vein-like bodies within NE-SW-directed quartz-sericite metasomatite zones extending 700m in length and 300m in width. As a result of geological survey there are identified totally five ore bodies and three of which (id no. I, II-1 and II) are exposed at the surface while the ore bodies no. III and IV are concealed. The ore body no. I continues 600m in extension and dips into the west with an angle of 48-72°. As well, along the dip it extends up to 210m and ranges from 1.33m to 12.2m in width; the oxidation zone is approx.50m in thickness. The ore body no. II contains most of the ore resources and marginally converges into the depth of 50-100m. It also shapes like lenses with dipping angle of 36-87° to the west and occurs in 600m in length extension along strike and extends 350m along dip; the thickness ranges between 0.5m and 18.0m. The ore body no. II-1 exists between the ore bodies no. I and II and is 350m in extension along strike direction and up to 300m along dipping. This vein-like body extends with dipping angle of 51-73°; the thickness ranges from 0.5m to 19.3m. The ore body no. III is concealed in the depth interval of 150-200m below the surface, extends 600m along strike with the thickness of 10.94m. It dips toward the NW with dipping angles of 45-70° as split veins and plates. The ore body no. IV is in 350m in strike length extension and 80m along dipping. The thickness is between 1.15m and 18.3m. The mineral composition of the deposit ore is characterized by mainly sphalerite and galena with pyrite, slight amount of chalcopyrite, occasionally tennantite, marcasite, ilmenite, cerussite, smithsonite, hematite, malachite, arsenopyrite, siderite, gold etc. Two types of sphalerite are identified: (Zn, Fe)S, marmanite with iron and (ZnS) native zin sulfide cleiophane.

As for ore chemical composition, the deposit refers to poly metal type or Zn-Pb with Au-Ag. Technological concentration result reveals Cd, Ag and Au in Zn, Pb and Cu concentrates, respectively.

Keywords: Dulaan Khar Uul deposit, formation, structure, mineralization, poly metal

***Corresponding author**. Tel.: +976-990 52065

E-mail address: *tamir1201@num.edu.mn*

1.Introduction

Dulaan khar uul deposit is located in the area of Nogoonnuur soum of Bayan-Ulgiy province. Geographically, it is at the elevation of 1500-2100m a.s.l at the back side of the Mongol Altay Mountain Range. The deposit was explored by geological mapping in 1980-1990 (N.A.Shubin et.al) and prospecting and recon survey in 1991-1992 (Filonenko et.al). Exploration for the deposit was conducted by Yushengming LLC (geologists Lhagvatseren, Lhagvadorj et al) in 2006-2009 and excavated total of 32 boreholes (10632.5line m) and 1500m inclined shaft at the ore body no. II. As a result, the ore was analyzed technologically and evaluated.

2. Geology

Dulaan khar uul deposit occurs in Dulaan khar uul volcanic-tectonic structure north of Deluun-Sagsay metallogenic zone (Dorjgotov, 2002). The setting is very complicated: mostly composed of Baast uul formation igneous, sedimentary units, subordinate Otog formation igneous, sedimentary units and Uuregnuur complex diorite dikes (Fig.1).

Lower Devonian Otog formation (D_1Ot). The formation units are associated with

Fhoto. 1. Amygdule andesite *(D_1Ot_2)*

Fhoto. 2. Silicified bedding *(D_1Ot_2)*

Lower-Middle Devonian Baast uul formation (D_{1-2} bs). Baast uul formation is well identified in the central part of the deposit mostly consisting of tuff sandstone, rhyolite interbedded with psammite tuff, and rhyolite tuff. The lower section of the formation is made up of rhyolite, rhyolite tuff, and tuff breccia underlain by tuff gravellite of 7-10m in thickness while the upper section is composed of rhyolite tuff lava and clastic lava. Baast uul formation is identified to be 310m in thickness. Devonian subvolcanic complex to form Dulaan khar uul volcanic-tectonic structure which consists of three members. The middle member units are found throughout the deposit area.

Middle member *(D_1Ot_2)*distributes over a limited area in the NW part of the deposit where Ordovician succession is overlain by basal conglomerate. Lithology of the formation is characterized by conglomerate, sandstone, silicified tuff siltstone, tuff sandstone acidic tuff, dacite, and amygdule andesite.

the center of the deposit there is observed a couple of NE-oriented parallel occurring faults. No data about the extension along strike is available; however, it is revealed that the faults cut across the target deposit and the width reaches to 300m while dipping into the NW with the angle of 65-75^0. The faults are controlled by rock fraction and vein-like bodies.

3.Ore body extension and ore composition

The Zn-Pb metal mineralization of Dulaan khar uul deposit area is characterized by NE-directed fault zone cutting through Baast uul formation rhyolite, rhyolite tuff lava, tuff breccia, and tuff series. The survey results identify five different ore bodies which are considered to be commercially important.

3.1Ore body I is exposed at the surface**,** extends for 600m along strike, dips to the west at the depth with dipping angle of 48-72^0. In addition, it extends 210m along the dip and ranges from 1.33m to 12.2m in thickness.

Oxidation zone of the ore is approximately 50m in thickness. As for mineral composition, it is dominant of Pb oxide at the surface and galena and sphalerite at the depth. The ore minerals occur as inclusions, coatings, and veinlets. Reserve estimated ore is identified to have the average grades of Pb-2.0% and Zn – 3.19%.

3.2 Ore body II is characterized by Baast uul formation andesite and rhyolite lava

breccia, rhyolite and rhyolite porphyry, outcrops exposed at the surface; contains the most amounts of the industrially important reserves. Marginally it converges into the depth of 50-100m below the surface and exists as lenses-like body with the dipping angle of 36-87° to the NW. Also, the body extends 600m along strike and 350m along dipping. The thickness ranges from 0.5m to 18.0m. The oxidation zone is approx. 50-80m in thickness. The ore composition is mainly made up of sphalerite and galena. The ore minerals are arranged as spot, nest, vein, coating, inclusion, small concentrates and veinlets.

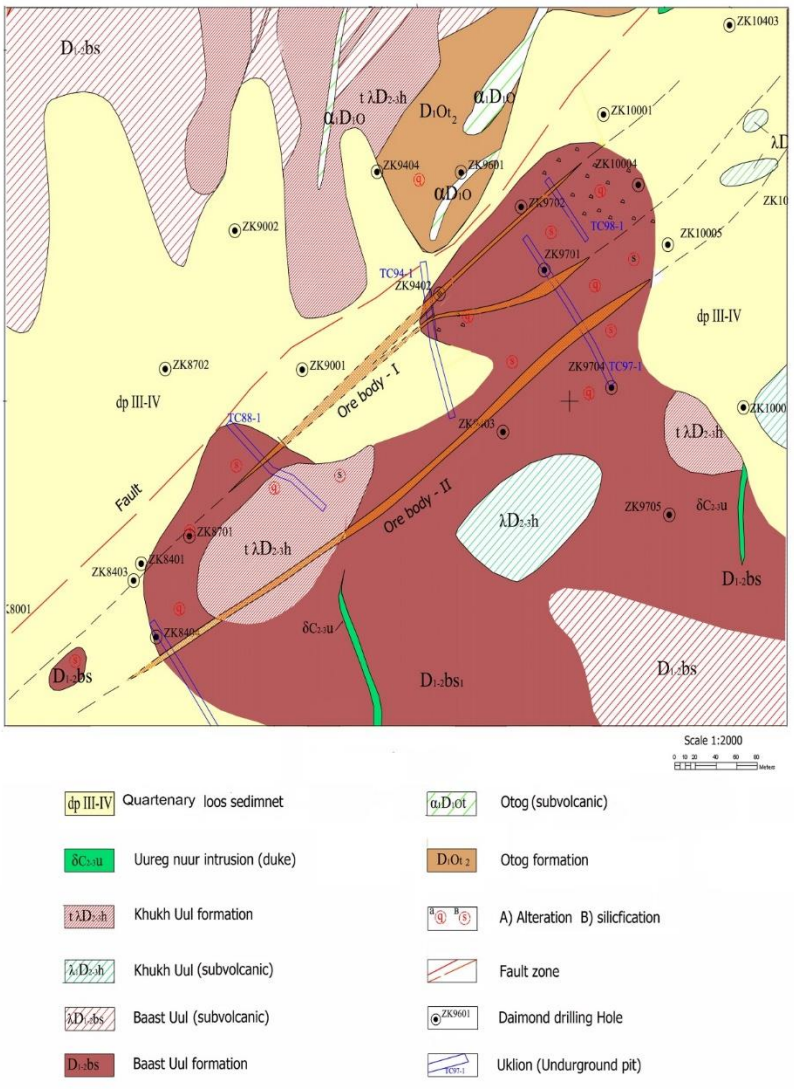

Fig. 1. Geological map of the Dulaan Khar Uul deposit

Photo. 3. Rhyolite tuff lava *(D_{1-2} bs)*

Photo. 4. Rhyolite tuff breccia *(D_{1-2} bs)*

Photo. 5. Core taken from borehole no.9002 of ore body no. III galena –sphalerite veinlets and nest-like mineralization）

Photo. 6.Sphalerite nest-like mineralization

Photo. 7. Rhyolite with sphalerite veinlets in rhyolite tuff breccia

Ore body II-1 is hosted in quartz-sericite metasomatic alteration zone of rhyolite breccia between the ore bodies no. I and II at the center of Baast uul extrusive body. It extends 350m along strike and 300m along dipping, exists as vein-like body with the thickness of 0.5-19.3m and dips with dipping angle of 51-73^0. The ore is oxidized at the depth of 50m. The grades of Pb and Zn are 0.02-5.24% and 1.49-20.23%, respectively throughout the body.

Photo. 8. Rhyolite tuff lava with sphalerite

Photo.9. Rhyolite with malachite coatings at cracks veinlets and inclusions

3.3 Ore body III is concealed at the depth of 150-200m in quartz-sericite metasomatite zone of baast uul formation rhyolite lava breccia. It extends 600m along strike, 10.94m in thickness, as well as occurs as splitting veins and plates dipping to the NW with angle of 45-70^0. The average grade of Pb and Zn throughout the ore body is estimated to be 0.02-13.05%, and 1.36-25.80%, respectively.

Ore body IV is found in quartz-sericite alteration zone within rhyolite lava breccia near baast uul rhyolite extrusive body contact; it extends 350m along its strike and 80m along dipping; the thickness ranges from 1.15m to 18.3m; exists as concealed splitting veins with dipping angle of 45-65^0. The ore grades are estimated to be 0-1.66% (Pb) and 1.31-7.35% (Zn).

3.4 Mineral composition. The ore of the target deposit is composed of mostly sphalerite, galena subordinately accompanied pyrite, chalcopyrite, tennantite, marcasite, cerussite, smithsonite, hematite, malachite, arsenopyrite, greenockite, siderite, and gold etc., It occurs as veinlets and inclusions in its texture. The sphalerite comprises approx.85-90% of the entire sulfide in the deposit and is found as spot concentrates of 0.3-2.5m in size. Also, it can exist as veinlets usually of 1-4mm, rarely up to 4cm in size. Sphalerite hosts para-generated inclusions of galena, pyrite, chalcopyrite, tennantite, gold and cerussite. Technological analysis identified two types of sphalerite: Fe-bearing sphalerite or marmanite (Zn,Fe)S and native Zn sulfide or cleiophanne (ZnS).

The galena is one of the most important constituents and makes up 3-5% of total sulfide. It occurs as parageneration of 0.02-1mm, rarely up to 7mm in size. The ore has no individual mineral of Ag; instead, a mixture of Ag in galena has been identified. There are revealed three types of galena in the ore. The first type is dust-like scattered inclusions. The second type of galena occurs as vertical plates up to 0.6mm in size whereas the third type is found as idiomorphic cubes in quartz-carbonate veins.

As observed in the ore mineralization study results, K-feldspar, muscovite, mica were developed at pre-mineralization stage while quartz-sericite-mica were grown at the stage of metasomatism. The next stage of quartz-mixed metal development stage is believed to allow quartz-I, mica, calcite, sphalerite, galena, subordinate asenopyrite and siderite growing. Finally, quartz –II, carbonate and pyrite were developed at the post mineralization stage. Hypergenic stage favored to develop oxidation minerals such as cerussite, anglesite, goethite and hydrogoethit

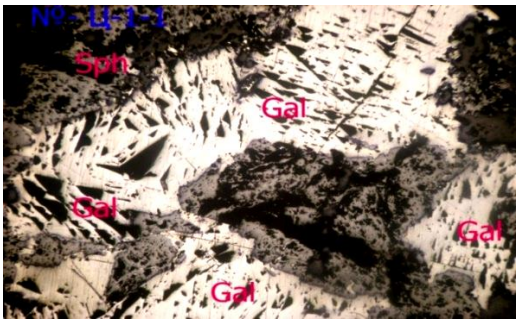

Fig. 2. Polished block Borehole ID 1-1. Irregular, long extended grains of galena (white) within Sph- sphalerite (whitish grey); Gal- black triangle is clearly visible within galena Magnification 5x.

Fig. 3. Polished block Borehole ID -1-2 small emulsion-like grains of chalcopyrite (greenish pale) in sphalerite (whitish grey) magnification 200x.

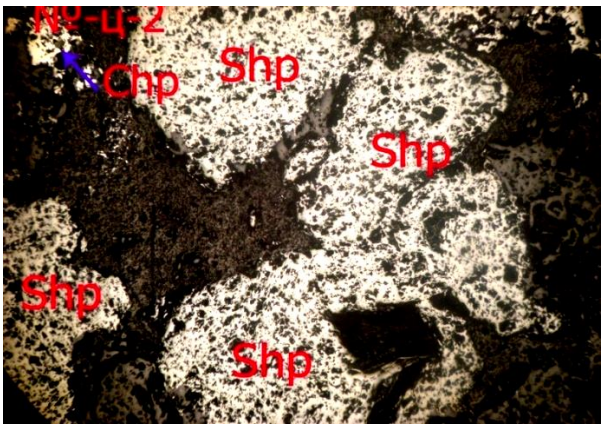

Fig. 4. Polished block Borehole ID -2 Irregular, long-extended grains of Sph-sphalerite (whitish grey)magnification 50x.

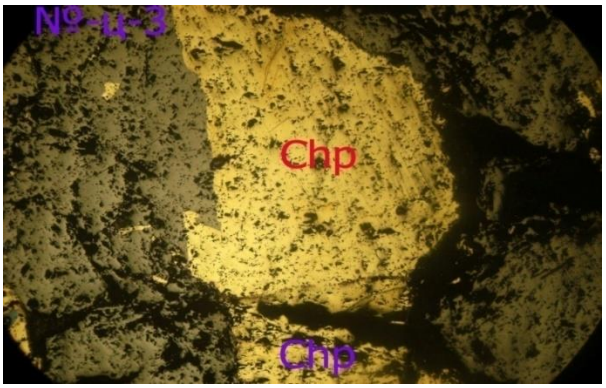

Fig. 5. Polished block Borehole ID -3 Irregular coarse grains of Chp-chalcopyrite (greenish pale)magnification 50x.

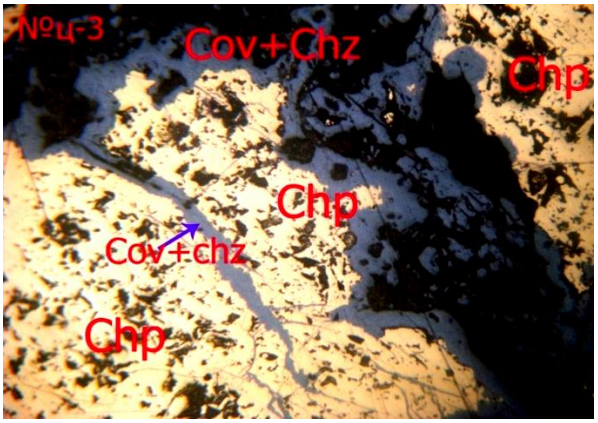

Fig. 6. Polished block Borehole -3. Irregular grains and veins of Chz-chalcocite, Cov-covellite (bluish) cutting through Chp- chalcopyrite.magnification 50x.

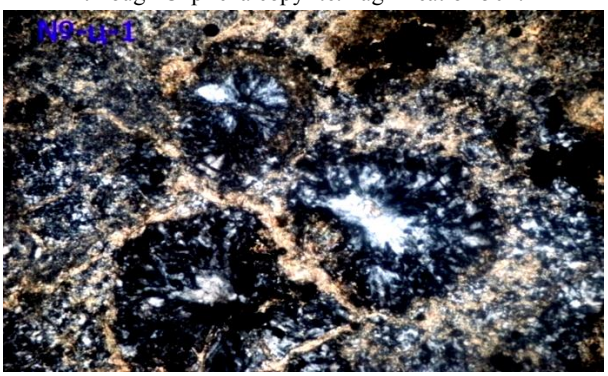

Fig. 7. Polished block Borehole ID-1 Quartz-sericite metasomatite magnification 100x.

4. Chemical composition of the deposit ore

Chemically the ore refers to poly metal or Zn-Pb type. Recent survey results show that the average grades of the economical constituents are estimated to be 4.5% (Zn) and 1.5% (Pb). Previously conducted ore composition studies (Dorjgotov, Tseden et al, 1 992) indicated the grades of Pb, Zn, Cu, Au and Ba to be 1%, 1-10%, 0.5-1%, 0.2-3 g/t and 0.

2%, respectively. The most distributed ore is q uartz-sericite metasomatite ore in which the to tal grade of the most important constituents (8 elements) reaches to 11% and the grade of roc k forming oxides exceeds 89%. Chemical anal ysis of technological samples shows very little poisonous impurity which would not affect ore concentration. As the result of technological st udies and chemical analysis the grades of elem ents range as follows: Cd-0.001-0.09% in Zn concentrate, Ag-49.32 g/t in Pb concentrate and Cu-7.91 % in Cu concentrates.

Cu-bearing mineral hosts Au as mixture and the grade of Au in the primary ore concentrate is 3.67g/t. The minerals of Au, Ag and Cu resulted from ore concentration can be extracted; thus, it is recommended to do more detailed research.

Table 1. XRF results of primary ore samples (content of oxides), %

oxides	content	oxides	content	oxides	content
SiO_2	57.87	TiO_2	0.260	K_2O	1.69
Fe_2O_3	12.00	CaO	0.29	Na_2O	<0.01
Al_2O_3	11.25	MgO	4.55	MnO	0.730
FeO	-	P_2O_5	0.04	F	<0.05

Table 2. Chemistry of primary ore

Sample ID	**grades, %**						grades, g/t	
	∑Fe	**∑ S**	**Cd**	**Zn**	**Cu**	**Pb**	**Au**	**Ag**
FL-0612	8.4	3.52	0.009	3.67	0.55	0.36	3.86	5.90

5. Conclusions and Discussion

Dulaan khar uul deposit is poly metal or Au and Ag-bearing Zn-Pb deposit located in Dulaan khar uul ore district (having the same name as the deposit) NW of Deluun-Sagsay metallogenic zone. The ore mineralization is identified as five different ore bodies occurring within NE-directed fault zone of quartz-sericite metasomatite alteration zone. The mixed metal elements within metasomatite zone exist as veins, lenses, and layers. The ore is very complex in composition and consists of Zn, Pb, Ag, Cu, Au and cadmium. There is also known NE-oriented fault zone cutting through Early and Middle Devonian baast uul, otog formation rhyolite, rhyolite tuff lava, tuff breccia, and tuff series. The mineral composition of the ore is characterized by sphalerite, galena, accompanied pyrite, chalcopyrite, tennantite, marcasite, ilmenite, cerussite, smithsonite, hematite, malachite, arsenopyrite, greenockite, siderite, and gold. As shown in the chemical composition of the ore, it is possible to extract Zn, cadmium, Cu from sphalerite ore concentration, Ag from Pb ore as well as Au from Cu-bearing ore.

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