

METASOMATIC ALTERATION HALOES AND GENERATION OF THE ROCK SERIES THAT ASSOCIATED WITH ORE DEPOSITION PROCESSES ON THE AGHYOKHUSH GROUP DEPOSITS (CHOVDAR ORE FIELD)

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Abstract

The Aghyokhush Group of hydrothermal Au deposits illustrate recent discoveries and achievements in the mining industry of Azerbaijan. The mentioned group of deposits consists of four epithermal Au deposits – Aghyokhush 1, Aghyokhush 2, Aghyokhush 3, and Mereh deposits. Deposits are considered satellite deposits of the Chovdar Au deposit, which is one of the largest epithermal Au deposits in the country. Agyokhush group deposits are located in 4 to 7 km northeast of the Chovdar deposit. It is examined that the Chovdar ore field is situated at the junction of the morphogenetic volcano-tectonic type fault systems. The main lithologic facies that are controlled by faults, and connected with ore formation processes are basaltic to andesitic, and dacitic to rhyolitic subvolcanic to effusive (lavas, tuffs) formations that formed during the lower and upper Bajocian. Magmatism that is related to ore-forming processes of the area is also considered to be calc-alkaline and is mostly related to the formation of high-sulfidation epithermal and porphyry-type ore deposits. Mentioned lithological facies altered by the hydrothermal processes that formed alteration haloes around also within the deposits that played a significant role during the exploration periods of the deposits. Aghyokhush-1 and Aghyokhush-2, Aghyokhush-3, and Mereh deposits are considered to be high-sulfidation epithermal gold deposits, while thermobaric characteristics, depth, ore, and gangue mineral associations differ within deposits that investigated in this paper.

Keywords: *Aghyokhush group deposits, Chovdar ore area, hydrothermal alteration haloes, epithermal, porphyry-epithermal deposits*

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INTRODUCTION

Geology of the area: The regional vise Chovdar ore area is situated in the Lokh-Karabakh belt of the Lesser Caucasus metallogenic province. From the Jurassic to the approximately end of the Cretaceous

the Loh-Karabagh belt of the Lesser Caucasus belonged to a relatively continuous magmatic arc. Volcano-hydrothermal processes in the Loh-Karabakh metallogenic belt during the Jurassic to Cretaceous subduction-related magmatism resulted in Cu porphyry (Garadagh, Khar-Khar), hydrothermal Au (Chovdar, Gadabakh, Aghyokhush group, Gadir and so), skarn magnetite (Dashkasan iron ore), Alunite (Alunitdagh), volcanogenic cobalt (Dashkasan Cobalt) and so [13, 14, 15].

In common with various epithermal deposits geologic settings wise mostly occur either in island arcs or at continental margins. The geological structure of the Chovdar ore area with the Aghyokhush group and Mereh deposits formed located within a Caucasian segment of the Tethys metallogenic belt observed with the subduction and collision of Arabia and Gondwana-derived microplates with Eurasia plate, also, mentioned deposits located in the Loh-Karabakh belt of the Lesser Caucasus metallogenic province [1,7, 18]. The composition of the mentioned rocks facies on the Chovdar ore area is mostly a volcanic series of basalt, andesite, and rhyolites (Table). Samples that were analyzed were selected representatively from the rock associations. Analyzed data, examined through the TAS diagram illustrates that (on the K_2O diagram) the formations that are associated with ore mineralization strongly calc-alkaline rhyodacite to rhyolite volcanic rocks. At the same time, basalt to andesite-composed rocks correspond to low-alkaline to calc-alkaline series volcanics. The Na_2O+K_2O diagram analysis data from representative rock samples indicates a strongly sub-alkaline rock series (Figure 2) [11, 12, 19]. As a result of the given data below, also, analytical work done through different periods enables us to consider that the main rocks that played a significant role in ore-forming processes are related to calc-alkaline felsic magmatism (Table, Figure 2), which again proves potential of the region to investigate for epithermal high and low-sulfidation, and porphyry deposits [3, 8, 10]. Chovdar ore area mostly covered by Middle Jurassic (Bajocian - Bathonian) volcanogenic-sedimentary sequences comprising basalt, andesite, dacite and rhyolite lavas, lava-breccias, and tuff facies. Basalt to andesitic facies referred to as the Lower Bajocian, which made structures such as subvolcanic bodies, columns, lava flows, pillow lavas, airflow, and volcano-sedimentary tuffs on the area. Dacite to rhyolite facies are cited as the Upper Bajocian facies in geological literature. Respectively, the Upper Bajocian sequence is subdivided into the Lower and Upper phases in the region [6].

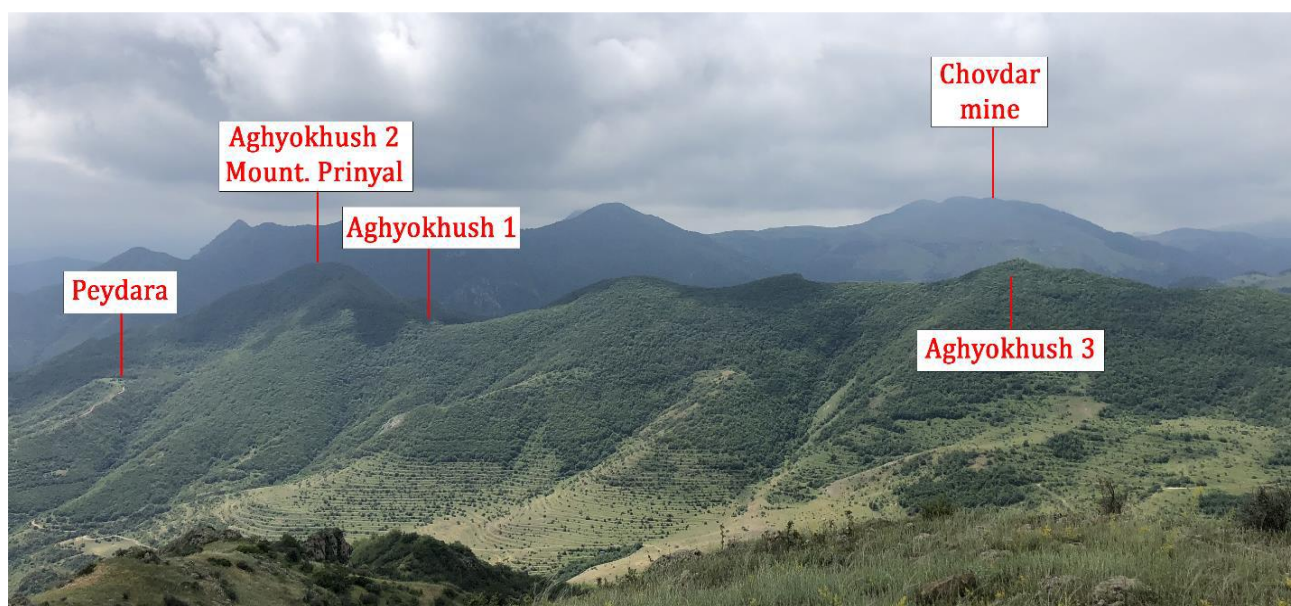


Figure 1. Plan view of the Aghyokhush group of deposits and Chovdar deposit

Chovdar and Aghyokhush group deposits are located in the lower sequence of the Upper Phase. The average thickness of the lower sequence of the Upper Bayocian Phase horizon in the ore area that

Analyses of samples do determine rock classification from Chovdar ore area

Sample	Result of analyses													International classification	
	Al ₂ O ₃	SiO ₂	Na ₂ O	MgO	Fe ₂ O ₃	CaO	TiO ₂	P ₂ O ₅	MnO	K ₂ O	Cr ₂ O ₃	Loss (PP P)	Σ	TAS LeBas, 1986	CoxVolc, 1979
CH002682	11.39	69.52	1.95	0.97	5.02	3.05	0.04	0.09	0.12	1.54	0.01	5.96	100.15	rhyolite	unclassified
CH002784	16.42	60.85	3.28	2.74	7.68	4.94	0.07	0.02	0.118	1.18	0.01	2.99	100.755	andesite	andesite
CH003860	8.25	78.94	3.37	1.67	3.83	0.67	0.19	0.03	0.06	0.13	0.01	2.75	99.895	rhyolite	unclassified
CH003864A	18.08	50.77	2.1	3.24	10.62	8.7	0.16	0.06	0.108	0.08	0.01	5.15	99.61	basaltic andesite	basalt
CH003865	13.92	69.82	3.25	1.49	4.63	0.87	0.049	0.015	0.0548	1.48	0.01	3.45	99.555	rhyolite	unclassified
CH003865OL	10.78	75.6	4.88	0.51	3.08	1.3	0.035	0.06	0.04	0.22	0.01	1.72	98.55	rhyolite	unclassified

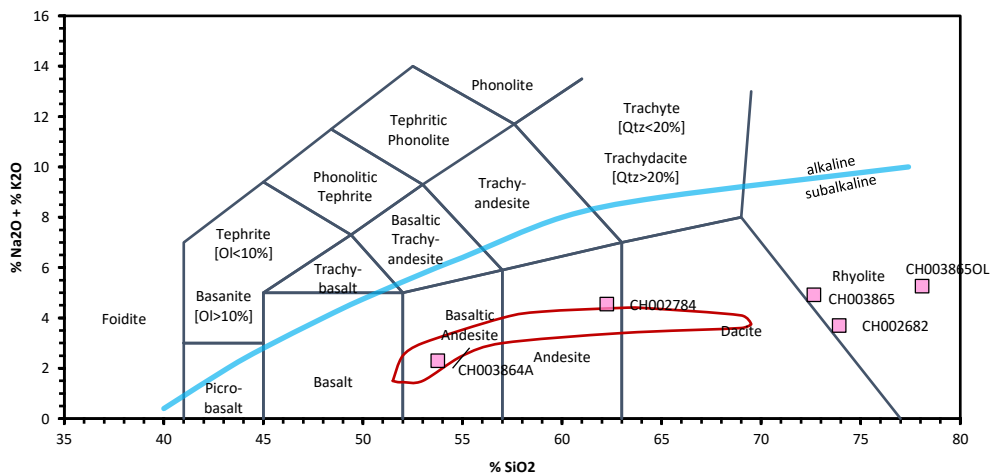
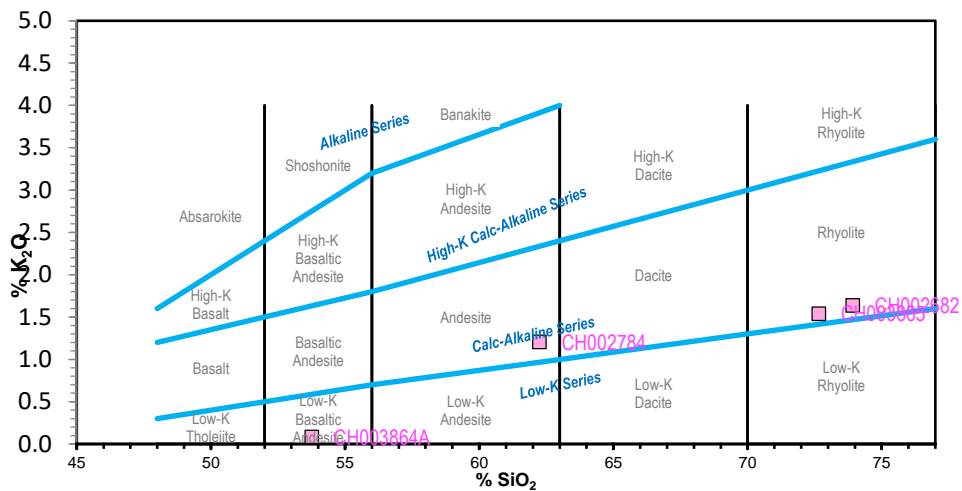


Fig. 2. Position of the analyzed rocks in the K_2O-SiO_2 & TAS classification diagram

Chovdar and Aghyokhush group deposits are located in the lower sequence of the Upper Phase. The average thickness of the lower sequence of the Upper Bayocian Phase horizon in the ore area that composed mainly consists of dacitic, rhyolite-dacitic, and rhyolitic subvolcanic bodies, lava flows, tuffs, and tuff-breccias is 800 m and. Also, the thickness of the upper Phase is around 150 m, and mostly made by coarse-grained lapilli tuff, basal-conglomerates with subordinate amounts of tuff-sandstone. Ore mineralization in the area as mentioned above, is mostly located in rhyolite to dacitic-composed rocks that hydrothermally altered. Due to the hydrothermal processes that altered the rocks, the transition between rock facies is gradual. Also, zonation between hydrothermal alteration haloes is gradual either, and hard to determine especially within sheared and crushed zones. Felsic rock formations are mainly controlled by faults that started from a cobalt mine and continue towards the the east-northern (75-85 degree) direction of Aghyokhush group deposits. Starting from this point felsic formations contain Au mineralization, and hydrothermal alterations. In some areas, rock units are cross-cut and complicated by diabase, dacite, basalt to andesite-composed dykes, and quartz-diorite subvolcanic bodies. Mentioned dyke and subvolcanic bodies are mostly barren and do not contain Au mineralization [14, 15, 16].

Characteristics of hydrothermal alteration haloes and determination of potential Au deposits in the area. In the region rocks that contain ore mineralization are called altered rhyolites and secondary quartzites. Phyllic, advanced argillitic, and argillitic alterations are observed in secondary quartzites and a significant part of the ore mineralization is observed within mentioned zones. Regionally, there are propylitic (chlorite, sericite, epidote) alterations around deposit and mineralized areas. Propylitic alteration mainly occurs in basalt, andesite, and andesite-dacitic rocks. The mentioned facies do not contain any significant Au mineralization. Starting from the south-eastern Pirinyal mountain towards the Aghyokhush-2 deposit propylitic alteration changes to argillitic, and on the top of the mountain silicic alteration occurs. Towards to the north-western direction andesite to andesite-dacitic rocks crosscut, and border the Aghyokhush-2 deposit. The thickness of the andesite-dacitic rock unit here is 150-200 m and contains propylitic alteration with the presence of chlorite, sericite, and carbonate veinlets [14, 16].

The mentioned unit borders the Aghyokhush-1 deposit from the south-eastern side. Alteration assemblages in Aghyokhush-1 deposit mainly argillitic to silicic (locally), and are mostly covered by thick vegetation. Towards the Aghyokhush-3 deposit felsic rock structure that continues 3.5-4km contains argillitic to phyllic alteration with the presence of kaolinite, sericite (rarely), propylite, halloysite, restricted silicified areas, chalcedony fragments (as hydrothermal and explosive brecciation) within the strongly altered intervals. Also, propylitic alteration occurs within intermediate rocks in the area. Unlike the Aghyokhush-1 and 2 deposits, the Aghyokhush-3 deposit is strongly controlled by faults that crosscut the felsic rock horizon. Outcrops were moderately altered and illustrate silicic to phyllic alteration with the presence of kaolinite, halloysite, and sericite, with silicification of rhyolitic rocks.

Starting from the northeastern part of the area geochemical chip sampling and mapping were conducted to determine mineralized areas, and alteration halos to project drill holes to determine mineralization within deposits. During the 2 year period geological mapping and geochemical sampling were done in the area by geologists of the Exploration Department of AzerGold CSJ. As a result, more than 2000 surface chip samples were taken and assayed (figure 3).



Figure 3. Outcrop of secondary quartzites than contain Au mineralization in Aghyokhush-1 deposit area.

As a result of conducted hard work drill holes were projected to crosscut geochemical anomalies of Au mineralization. Outcrops illustrated from argillitic to silicic alteration, and the drill holes projected to crosscut through hydrothermal alteration haloes from silicic to argillitic, where positive Au mineralization was assayed on Aghyokhush-1 and 2 deposits. Drill cores illustrated from argillitic to advanced argillic alteration on Aghyokhush-1 deposit. The grade of Au mineralization increased towards advanced argillitic. Gangue minerals that observed on Aghyokhush-1 and 2 deposits mainly within the ore body kaolinite, alunite, barite, halloysite and various textures and structures of quartz mineralization (vuggy, massive silica, chalcedony particles within hydrothermally brecciated intervals). It also ought to be mentioned that towards the center of the deposit rhyolite-dacitic volcanics (tuffs, tuff-breccias, lavas) changed to subvolcanic facies of mentioned felsic rocks. Accordingly, the intensity of advanced argillic alteration and mineralization increased. The mentioned characteristics of mineral deposition were observed both in the Aghyokhush-1 and 2 deposits. Both deposits are considered to be high-sulfidation epithermal deposits. While containing higher amounts of barite mineralization, alunite, also intensity of vuggy textured silicic alteration in Aghyokhush-2 compared to the Aghyokhush-1, Aghyokhush-2 considered to be mineralized in lower pH, high salinity environment, respectively degree of the sulfidation of was higher than Aghyokhush-1.

Alteration haloes on Aghyokhush-3 on surface outcrops illustrated silicic alteration as residual silica also chalcedony fragments, with the presence of kaolinite, halloysite, and sericite mineralization. Respectively, the deposit must be formed near the surface environment. Barite aggregates were not common, and chalcedony particles were observed within hydrothermal veinlets. Projected drill holes indicated the depth of the mineralization was 200 meters from the surface. All the mentioned deposits were almost oxidized, and sulfide mineralization was observed only in the Aghyokhush-3 within the chalcedony particles from hydrothermal or lapilli breccias. As the deposit was controlled by fault systems, the core material was strongly crushed and fractured in some intervals.

Alteration style on the Mereh deposit is characterized as silicic to phillitic altered, with the presence of residual silica (some intervals with vuggy quartz), chalcedony fragments within hydrothermal

brecciated intervals, 2M mica (rarely), kaolinite, sericite. Barit aggregates were not detected on the drill core and outcrop samples. The deposit is located on the north-western side of the Quytul-Narimanli-Aghyokhush fault system. The north-western part of the deposit is bordered by quartz-diorite subvolcanic facies. Quartz-diorite subvolcanics are mostly barren and do not represent Au mineralization. The ore body itself is weathered near to surface and contains sulfide minerals such as pyrite, and chalcopyrite (rarely). Silicification is strong within the orebody, also, logged 2M mica (rarely), kaolinite, sericite, and pyrophyllite (rarely), enables us to consider the hydrothermal alteration of Mereh deposit considered as greater depth (approximately ~500 meters), high temperature, intermediate to high-sulfidation epithermal deposit (figure 4).

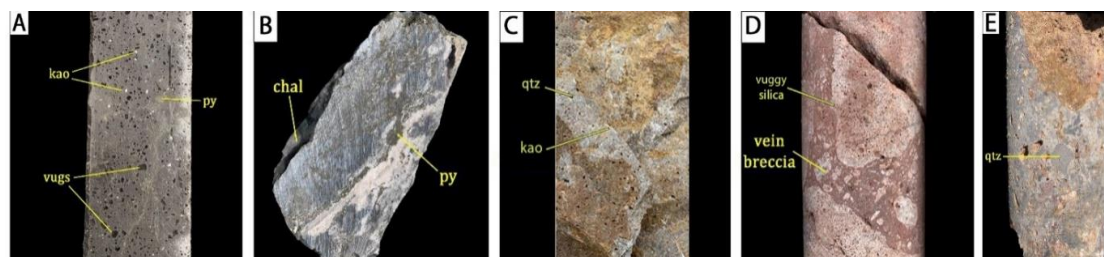


Figure 4. A. Vuggy quartz with kaolinite mineralization (ore interval, core sample) from Chovdar mine B. Chalcedony sample outcrop (ore interval, outcrop sample) from Mereh deposit C. Vuggy silica (ore zone, outcrop sample) from Aghyokhush-1 deposit. D. Hydrothermally brecciated interval with vuggy silica (ore interval, core sample) from Aghyokhush-2 deposit. E. Chalcedony breccias (ore interval, core sample) from Aghyokhush-3 deposit.

CONCLUSION

The mentioned deposits are located in the Dashkesan ore district belong to the Lok-Karabakh metallogenic belt and are tectonically situated in the subduction-related Lesser Caucasus metallogenic province. Tectonic evolution and volcanic activity result in mafic to felsic calc-alkaline magmatism within the Lokh-Kharabakh belt. The area is characterized by multi-stage volcano-plutonic activity periods that caused the formation of Chovdar, Aghyokhush, Mereh epithermal, and other porphyry-epithermal, skarn deposits. The deposits are located within composed, volcano-sedimentary, volcanic, and sub-volcanic facies. Regionally, deposits were surrounded by intrusive bodies, while despite the Mereh deposit, neither outcrops around deposits nor the core samples from Aghyokhush group deposits represented intrusive rock facies. Mafic to intermediate rock facies that surround deposits in general represent propylitic alteration characteristics, with chlorite, sericite stains, carbonate, and gypsum veinlets. Due to the metasomatic alteration transition between rock facies is gradual, followed by a change in alteration characteristics [8, 10, 17, 20]. Unaltered, hydrothermally altered felsic rock formations in the area considered to be calc-alkaline series rhyolites and rhyolite-dacites which played significant role while setting exploration targets [2, 3, 5], besides hydrothermal alteration haloes. Mentioned rocks facies in ore field generally represent argillic to silicic alteration with the presence of kaolinite, Fe oxide, and hydroxides, and silicification of rhyolite-dacitic and rhyolitic rocks, also secondary quartzites representing chalcedony and residual silicification. Change between alteration styles is also gradual [17, 20]. All the deposits are located within the mentioned rock facies and alteration haloes. Mentioned characteristics used for exploration of new mineralization prospects and mineralized locations. As a result, all mentioned factors lead to spotting new areas that contain Au mineralization such as Narimanly, Peydara, Chaikand, and so on. Outcrop sampling was done and analyzed, results indicate

positive Au content within mentioned rock facies and hydrothermally altered rocks. According to general epithermal deposit formation characteristics, high sulfidation deposits can be connected with porphyry Cu deposits in deeper roots [2, 3, 4, 9]. Following the mentioned hydrothermal alteration characteristics, fault, and shearing zones can lead to the discovery of buried porphyry deposits under the mineralization area. However, in order to answer the mentioned question, and understand formation characteristics, type, and thermobaric parameters of the mineralization of the Chovdar ore field, more detailed mineralogical, petrographic, and fluid inclusion analyses will provide more precise information.

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