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ENDOGENOUS GEOCHEMICAL HALOS OF GOLD AND SILVER IN THE GADABAY GROUP OF DEPOSITS

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Abstract

Modern concepts of chemical element migration processes within ore zones, based on factor analysis models, can be successfully used to identify promising areas hidden at depth. For a more detailed study of the deposit, prospecting and evaluation mineralogical and geochemical criteria have been developed. Geochemical anomalies with a complex mineralogical and geochemical composition have been identified within the studied area. The conducted studies have recommended several promising areas in the central part, on the northern and southwestern flanks of the deposit, for exploration of veinlet-disseminated mineralization.

Keywords: *mineralization, host rocks, clarke, horizons, gold, silver, flanks, adit, stage, productive, halo.*

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INTRODUCTION

Structurally, the Gadabay ore district, according to numerous researchers, comprises ores from three formations:

gold-sulfide-quartz (Gosha deposit and several occurrences – Itkyran, Perzamanli, Khatynjan, Pelekli, Kalaboyun, and Garibli); 2) copper-polymetallic mineralization sites (Chobansygnakh, Chatakh, Kilisalin, Aginbulag, Boyuk-Gishlagh, Dzhurdag, and Almalytala); 3) copper pyrite (the Goydere, Kejvan, Shikheybat, Bala Shamlyg groups, and the Safarly manifestation), genetically linked by a common magmatic chamber. The Gosha deposit and the Safarly ore manifestation are characterized by the highest gold concentrations [1].

The geological position of ore clusters and fields in the study area is determined by their relationship with hidden deep basement faults, including the ore-controlling Ahmedabad-Gosha fault, which strikes sublatitudinal (along the axis of the anticline of the same name), and the submeridional Shikheybat and Eldag faults [4, 5].

The ore district is divided by numerous faults trending northwest (300-320°), submeridional (350-10°), and sublatitudinal (80-90°). These faults are represented by zones of shear fractures, shear fractures, and hydrothermal alterations of the host rocks.

The Gosha ore field is located on the northwestern flank of the Ahmedabad-Gosha anticline, which trends sublatitudinal. The Gosha ore field is composed of volcanogenic-sedimentary rocks, predominantly andesitic, of the Bathonian Dashkesan Formation (upper sequence), greenstone effusives of the Upper Bajocian Gizilja volcanogenic rhyolite-dacitic sequence (quartz plagioporphyry sequence), and the Zeyemchay volcanogenic basalt-andesite sequence (lower sequence). These sequences are intruded by intrusive formations, which in turn are penetrated by numerous quartz-diorite-porphyrite and diabase dikes.

Thus, the following factors are important for the localization of gold mineralization:

1) confinement to tectonic blocks of varying elevations, but predominantly occupying elevated positions; 2) localization of gold deposits and manifestations at the intersections of deep structures; 3 - spatial connection with the granitoid massif [3,5].

Based on the analytical data obtained, we identified endogenous geochemical halos of gold and silver along three horizons (sites 2, 4, and 6), the configurations of which depend on the tectonic features of the deposit and the morphology of the ore bodies [2]. The geochemical halos of gold and silver were compiled based on the results of chemical and spectral analyses of samples collected across the strike of the ore deposit.

The gold and silver halos at the horizon of adit № 6 (1584 m) have an elongated morphology, bordering the ore deposit and adjacent host rocks in a sub latitudinal direction. Most of the study area is characterized by low metal grades – from clarke to 0.1 g/t-1.0 g/t. Halos with relatively high gold and silver grades (1.0-3.0 g/t and 1.0-5.0 g/t) outline the latter, repeating their outlines. Isometric endogenous halos with high gold concentrations (5-24 g/t) at the horizon of adit №6 also spatially coincide with those of silver (10.0-25.0 g/t), which are morebroad field in comparison. They were identified in the central parts of the ore deposit along zones of ore-controlling and ore-hosting faults of sub latitudinal and NE strike. The latter are outlined by halos of low Au (3.0-5.0 g/t) and Ag (5.0-10.0 g/t) grades, elongated sub meridionally to the west and east.

The identified linear endogenous halos of gold and silver at the horizon of adit № 4 (1555.7) are confined to an ore-controlling, northeast-trending fault.

The halos, as at the horizon of adit № 6, are characterized by insignificant gold and silver contents. More significant gold (1.0-3.0 g/t) and silver (1.0-5.0 g/t) contents are confined to the western and eastern flanks with sublatitudinal and submeridional orientation of the ore deposit, respectively. Against this background, halos of isometric forms with gold contents (3.0-5.0 g/t) and silver contents (5.0-10.0 g/t) stand out. On the northeastern and eastern flanks of the ore deposit, the latter are bordered by gold halos (5.0-24.0 g/t), where anomalous points with contents (25-77 g/t) are identified. Here, in the central parts of the silver halos (10.0-25.0 g/t), areas with a grade of 25.0-45.0 g/t and anomalous areas (46-222 g/t) were identified. At the horizon of adit № 2 (1542.7 m), two endogenous halos, sublatitudinal and submeridional, intersect. Within the ore deposit and host rocks, with grades ranging from traces to 0.1 g/t (primary Au and Ag halos), are separate, isolated areas with varying orientations. Some of these linear halos (0.1-1.1 g/t) contain fields with grades of 1.0-3.0-5.0-24.0 g/t gold and 1.0-5.0-10.0-25.0-45.0 g/t silver, respectively. Here, gold and silver halos partially overlap, but areas with elevated metal grades are isolated. Equant gold halos (3.0-5.0 g/t) outline halos with grades (5.0-24.0 g/t), with areas with anomalous concentrations (over 24 g/t) identified in the northern and southern parts. Spotted silver halos with high concentrations (10.0-25.0-45.0 g/t) are observed on the northern and southern flanks of the deposit, extending submeridionally for 200 m with anomalous manifestations (over 45 g/t).

Thus, the identified endogenous geochemical halos indicate a complex and unique morphology of the ore deposit, with a number of localized areas of maximum gold (45-77 g/t) and silver (222 g/t) concentrations in the central parts, as well as on the northern and southwestern flanks of the deposit. The predicted increase in metal concentrations with depth can be used in the future as a predictive and prospecting criterion for identifying promising areas with potentially commercial concentrations of gold and silver [3].

Gold-silver ratios in ores. It is known that quantitative ratios between gold and silver in ores can serve as an indicator of mineral formation processes and the migration capacity of silver and gold. In practice, the K = Au:Ag ratio is used in some cases to identify hypogene zoning elements, and in others, to evaluate ore bodies at depth. Within a deposit, the magnitude of this ratio varies and changes unevenly with depth.

We studied and identified patterns in gold-to-silver ratios from the surface to a depth of 360.4 m. Approximately 2,000 gold and silver assays from ore zones and host rocks in various adit horizons were processed. Table 1 shows data from three horizons.

At the Gosha deposit, a consistent increase in average gold and silver grades with depth is observed.

At adit horizon № 6 (1,584 m):

a) the ore deposit contains 1.2 g/t Au (KK = 279.0) and 2.9 g/t Ag (KK = 41.4).

b) the host rocks contain 0.14 g/t Au (KK = 32.6) and 1.2 g/t Ag (KK = 17.1).

Adit № 4 (1555.7 m):

a) ore deposit - Au 1.5 g/t (CC=348.8) and Ag 3.54 g/t (CC=50.6).

b) host rocks - Au 0.18 g/t (CC=41.8) and Ag 1.13 g/t (CC=16.1).

Adit № 2 (1549 m):

a) ore deposit - Au 3.8 g/t (CC=883.7), Ag 16.0 g/t (CC=228.6).

b) host rocks - Au 0.12 g/t (CC=27.9) and Ag 1.6 g/t (CC=22.9).

Thus, the studies of three horizons (Table 1) of the ore deposit showed that the gold content increases sharply, varying in single samples from 0.005 g / t to 77 g / t, on average, amounting to 2.2 g / t (0.00022%) at KK = 511.7 (100 times higher than CL). Silver reaches 222.6 g / t in individual samples, on average, it is 7.5 g / t at KK = 107.1, which is 10 times higher than CL. Accordingly, the value (K) Au:Ag in the ore deposits at different horizons varies within the range of 1: 3-1: 2. In the host rocks, the gold content reaches a maximum of 9 g / t, on average 0.15 g / t at KK-34.9, which is several times higher than CL. The silver content is 37 g / t, on average 1.3 g / t at KK-18.7. The Au:Ag ratio ranges from 1:11 to 1:10

Table 1

Distribution of Au, Ag contents and their ratios in host rocks and ore deposits (by adit horizons).

Horizons of adits	Enclosing rocks and ores	Number analyses	Elements		K=Au :Ag
			Au	Ag	
adit № 6	Enclosing	91	0,005 - 4,0 0,14 (32,6)	0,0 - 26,0 1,2 (17,1)	1:12
	Ore deposit	156	0,005 - 4,3 1,2 (279,0)	0,0 - 72,0 2,9 (4 1,4)	1:2
adit № 4	Enclosing	543	0,005 - 9,0 0,18 (41,8)	0,005-37,0 1,13 (16,1)	1:6
	Ore deposit	632	0,005-77,0 1,5 (348,8)	0,005-222,6 3,54 (50,6)	1:2
adit № 2	Enclosing	213	0,0 - 1,6 0,12 (27,9)	0,0-13,2 1,6 (22,9)	1:12

	Ore deposit	193	0,0 - 46,4 3,8 (883,7)	0,0-86,0 16,0 (228,6)	1:3

Note: the numerator shows variations in the element contents; the denominator shows the average content; in brackets are the clarke values of the concentrations.

Consequently, the nature of gold-silver ratio variations based on geochemical sampling results at three horizons (adits № 2, 4, and 6) is as follows:

At adit № 6, a uniform distribution of ratios (1:5-1:3) is observed, with isolated halos of minimum values (1:12) sporadically identified, manifested in the western and eastern parts of the halos (1:11-1:10). These halos, in turn, are outlined by wide halos (1:5-1:3) of ratios, spatially creating a patchy morphology with varying orientations.

At adit № 4, halos of minimum Au:Ag ratios are uniformly distributed both across the entire ore deposit and along the periphery of the host rocks, with a general northeastern orientation. The halos (1:10) in the northern part of the ore deposit outline two thick halos with elevated gold-silver ratios (1:5 and 1:2). The central parts of these halos contain microfields with high (1:1) values, traced in a sublatitudinal direction for distances of 310 m (western halos) and 295 m (eastern halos), respectively.

At the horizon of adit № 2, a halo of linearly elongated morphology can be traced for approximately 100 m with a submeridional orientation. Here, a uniformly distributed halo of gold-silver ratios (1:10) outlines the entire area of the ore deposit, where it locally borders areas with minimal (1:12) and high (1:5 and 1:2) values. Of greatest interest are the halos identified in the central and southern parts of the ore deposit, with high gold-silver ratios (1:2-1:1), oriented sublatitudinally, and interconnected with the primary gold and silver halos [4].

CONCLUSION

1. At the studied horizons of adits № 2, 4, and 6, an uneven distribution and unequal change with depth in the gold-silver ratio (K) in the ore deposit and host rocks is generally revealed.

2. The ores of the Gosha gold-sulfide deposit have three productive mineral associations (quartz-pyrite, quartz-gold-telluride, and quartz-gold-goethite-hydrogoethite).

3. Characterized by a fairly consistent gold-to-silver ratio of 1:3-1:2, occurring in the central, northeastern, and southern flanks of the ore deposit. It has been noted that the (K) value increases with increasing gold grade in the samples. This is explained, on the one hand, by the increasing fineness of gold in the ores, and on the other hand, by the relative decrease in the amount of silver minerals associated with gold.

4. In altered host rocks adjacent to the ore zones, containing disseminated pyrite and chalcopyrite, the gold and silver content decreases sharply. The gold-to-silver ratio (K) falls below unity (1:11-1:10).

5. During ore formation, silver was concentrated in the ore bodies to a lesser extent than gold and was dispersed to a greater extent in the host rocks. It should also be noted that the Au:Ag ratio increases as one approaches the surface (in the oxidation zone of primary ores), which is apparently due to the secondary enrichment of ores with gold, which is the most productive for gold at depths no greater than 90-100 m [5].

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