FEATURES OF GEOLOGICAL STRUCTURE AND GOLD-BEARING OF THE GOSHA DEPOSIT (THE LESSER CAUCASUS, AZERBAIJAN SECTOR)

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In the paper there have been considered the geological structure and the terms of the formation of Gosha gold-bearing deposit. There has been emphasized the importance of fractured, fault, ring and linear structures in the formation of the structural habit of the deposit. Analysis of peculiarities of forms and structure of the ore bodies in the deposit enabled to identify morphological types among them which are given below: zones of hydrothermal-modified rocks; quartz-sulphide veins and veinlets; stockwork formations. There have been also considered the results of statistical analysis of the distribution peculiarities of gold and concomitant ore elements in ores and in the enclosing rocks in the deposit. On the basis of results of the claster analysis there has been performed grouping of the ore component and there have been made a conclusions about their sources.

General information of the deposit. It was discovered in 1966 and is a typical volcanogenic deposit with a progressive ore-formation. It is linked with a contrast andesite-basalt (lower Bajocian-Zegamchai suite)-rhyolite (upper Bajocian-Gyzyldjin suite) formation. The deposit is a constituent part of the Gosha ore magmatic system (OMS) (1, 2, 5), including the Itkyrylan, Boyuk-Kishlak, Safarly, Perizamanly, Okzyuzlin and other manifestations. It is located in the far north-west part of the Shamkir uplift. Complex mosaic-block structure of the Gosha OMS with a system of faults of different types, is closely linked with a deep structure of the earth crust. It is proved by the results of geophysical investigations (seismic sounding, gravimetric and magnitometric survey).For the Akhmedabad-Gosha volcanic-tectonic complex which exists in the recent plan as an anticline of a near-latitudinal strike of the same name, wide range spread of the alternating lavo-, tuff – and eruptive breccia is typical. They are accompanied by the crushing and fluidization of the enclosing rocks and flows of ignimbrites. Their magmas possessed the same property as the rocks of acid ore-bearing subvolcanic intrusions, andesite – dacites, rhyolites with numerous extrusions – their root facies (8). In the central part of the structure there occur small stocks of quartz diorites with a pear-shaped widening and branching in the upper parts. There also occur dykes of mainly neutral acid composition. The dykes are of a submeridional and north-east strike. Of the same strike are fractures, quartz-ore veins and zones of hydrothermal-modified rocks. It looks as if they set against the quartz-diorite intrusive and then go on towards the SW along the Gosha-

Itkyrylan faults as far as more than 3 km till the Itkyrylan gold-bearing deposit (2, 3, 5).

The Gosha deposit itself is related to a conjugation of two fault dislocations of different directions of a different age, extension and orientation which is expressed in the surface by a zone of increased dislocation, including middle Jurassic subvolcanic, late Jurassic intrusive bodies and dyke formations. Most of them are linear magma-controlling faults of the pre-Jurassic location and they are of the north-west (general Caucasian) strike. They are traced along the axial line of the Akhmedabag-Gosha anticline having asymmetric structure – the north slope is steep (up to 45^0) as compared with the south one, having dip angle of about 20^0. Younger fault dislocations linked with the formation of the volcanic-tectonic complex are of significantly less extension and depth of location. Manifestation of extending tensions determined location of two systems of dislocations – near – latitudinal, transverse and near-meridional of a thrust type, breaking the area of the deposit into several geological-structural blocks with the amplitude of dislocation of 80-100 m. Less intensive fledge dislocations in many cases are ore-enclosing ones. The first system of dislocations which is of the west-north-west strike ($270-285^0$) with dip of the plane southwards under steep angles ($70-80^0$) till the vertical one and coinciding in time with the opening of old fractures and with the formation of new ones, is expressed by intensive fracturing and crushing of rocks with the further hydrothermal change till the formation of secondary quartzites. Rather high thickness (about 100 m and more) and intensive hydrothermal processing of rocks as well as existence of faults of dyke bodies of small intrusions with a steep dip angle and zones of tectonic breccia of cataclasites etc., demonstrate large depth of the fault zone which is traced along the arch of the Akhmedabad-Gosha paleovolcanic complex. And tectonic movements repeated many times. For this reason the faults have several planes of the ruling. They are accompanied from the suspended and the lying blocks by series of echelon local fractures, by zones of the crushing of 2-2,5 cm thick with a tectonic clay and friction plane. The total amplitude of displacements along a group of close dislocators of the fractures is 8-10 m. Gold-bearing zones, in particular, № 1, 2, 3, 5 etc., are related to these zones.

The pre-ore age of these fault structures is proved by the relation to some of them not only of the zones of veinlet-impregnated ore mineralization, but of the subvolcanic bodies as well.

The second system of faults: near-meridional, transverse as related to general Caucasian and NW faults. They are of submeridional ($355-10^0$) to the NE ($40-50^0$) extension with steep dip angles ($70-85^0$) westwards and eastwards. Submeridional faults are more wide spread in the deposit (mainly, thrusts). In some intervals having curved, they acquire north-east strike. To these systems of faults, to be more exact, to their suspended blocks "filled" with hydrothermal-modified rocks (till the secondary quartzites 0,2-2,0 m thick), the richest zones of gold-sulphide mineralization are related (zones № 4, 10, 11, 12, 13 etc). Besides the rectilinear, relatively wide range movements, during the further stages there were formed radial, arch and ring faults. Along these faults there occur compensation subsidence of some blocks. They, due to symmetric (negative and positive) magnetic anomalies, zones, systems of small echelon shaped fractures, geomorphological ledges, linear and arch areals of changes of the rocks etc., are very well seen in the cosmic images. Moreover, the subsidence to a greater extent took place in the central part of the deposit, where the arch faults are characterized by a steeper dip.

Mineralization of the gold-pyritaceous type is concentrated in dilation veins of a different orientation and in the zones of hydrothermal development of lava-pyroclastic thickness of andesites of the lower and rhyodacitic porphyries in the upper Bajocian in the form of metasomatic bodies. The quartz veins by their morphology are usually of a different range. Together with relatively large ordinary veins, there occur short, not strike and dip cured veins. They have complex up dip branching with a transition into zones of thin veinlets and brecciation. Ore bodies are zones of most intensive modified hydrothermally modified rocks, impregnated with gold-bearing sulphides of productive mineral associations – pyrite, chalcopyrite etc., which are characterized by the veinlet character of the formation.

Metasomatic changes of the enclosing rocks. Intensive pre-ore propyllitization, silification and kaolinization are the peculiar features of the deposit. The propyllitic fields are characterized by a zonal structure. This reflects the increase of temperature and acidity of solutions towards the centre of the deposit. Among the field of propyllites, locally along the zones of the fracturing and fault dislocations the secondary quartzites are located, finishing processes of the pre-ore metamorphism. They mainly formed in the acid rocks. For the reason of heavy hydrothermal processing, the initial composition of the rocks can be hardly recognized due to relicts of the initial structures and impregnations of quartz. It is quite possible that the secondary quartzitic metasomatites were formed mainly in the acid rocks and rarely in tufts. Main minerals of the secondary quartzites – alunite, diaspore, dykite, sericite and kaoline form different paragenesises. Besides the above mentioned main minerals, there often occur pyrophyllite, zynyite and barite. The most important thing for the identification of the zoning in metasomatites is the presence of sericite. The secondary quartzites in the form of a line 100-150 m wide, spread along the fault zones. Judging by the outcropping of the rocks, they have stratal, raincoat like form. They steeply (70-85^0) subside westwards and eastwards. This structural plan of the secondary quartzitic metasomatites is validated by the data of the drilling and hypsometric position of facial boundaries. Irrespect of mineral types of the secondary quartzites, they form in the hydrothermal – ore system the upper above – ore zone being indicators of the mineralization at depth. This requires their re-estimation in respect of the determination of the ore bodies underneath. Formation of secondary quartzites was accompanied by the entry of chlorine, precious and nonferrous metals. Moreover, the amount of the ore components was increased by 1-2 orders in propyllites and by 1-2 orders – in the secondary quartzites. The main way of the deposition of the matter at the ore stage – is the filling of the fractured cavities and pores. Metasomatosis prevails at the pre-ore stage; it manifests itself significantly in the beginning of the ore stage and accompanies the deposition of the ore matter as a side phenomenon in the near-vein space.

Structure of the ore bodies and zones of mineralization. The deposit is stripped by five horizons. It is formed by a system of quartz-sulphide veins and veinlets of a small extension (quartz-sulphide morphological type), by a series of close steeply diping mineralized and vein zones, (morphological type of mineralized and vein zones) and by the stockwork zones (morphological type – zones of the stockwork veins). Ore bodies of a vein type are localized in the central part of the deposit. Their dip is steep, nearly vertical. They are ore bodies №№ 4, 10, 11 12, 13. They have rather distinct geological boundaries and insignificant near-ore change of the enclosing rocks, demonstrating the prevalence of the process of the filling during the ore deposition. A typical feature of the mineralized and vein the zones is that the gold is distributed rather uneven and from there exist distinct ore columns. They are ore bodies №№ 5, 5-west and 3 in the south flank and №№ 1 and 2 in the north flank of the field. The ore zones are represented by the silicified, kaolinized (with the formation of the quartz-kaoline association) and pyritized hydrothermal modified rocks, penetrated by the quartz veinlets. One can identify the zones of intensive peritization with small lenses, veinlets, pockets and with impregnation of pyrite, chalcopyrite, sphalerite and magnetite. The vein filling is composed mainly of quarts – often of adulyar and rarely of carbonates. The rest of the minerals, including the ore minerals in amount of 30 species, are admixtures. For this reason, composition of the vein mass in the Gosha deposit should be considered as quartz. The quartz – kaoline mass with the above mentioned ore minerals and quartz fillings form ore zones having distinct boundaries with the enclosing rocks, though the latter are mineralized and with gold. Just for this reason, the contour of the vein-like and lens-like gold – ore bodies determined by the testing, very often goes beyond the ore-bearing zones. The veins are characterized by a steep dip (60-90^0) and presence of numerous apohyses. Thickness of the veins varies 0,2-0,3 up to 1-2,5 m with the extension of 20-30 up to 300-400 m. Some veins stretch as far as the Itkyrylan field and are traced far beyond it. Taking into account the spatial relation of these ore bodies to a united structure of a near-latitudinal strike, one can judge about prospects of determination of commercial concentrations of gold in the secondary quartzites in the Itkyrylan field to the west of Arangeran mountain. The most favourable structures for the determination of gold-ore mineralization are the near-vent secondary quartzites of the separated volcanic structures.

Along their dip the ore bodies are located echelon-like. The main structure enclosing the stockwork gold-ore mineralization are the wedge-like nodes of conjugation of the fault dislocations of different trends. These nodes were stripped in horizons of gallery № 4 by crosscut № 2 and gallery № 7 by crosscut 2-a.

The mineralized zones and ore bodies are characterized by significant extension – 700-800 m and more with thickness from several meters up to 15-20 m, and in some zone it is 30-50 m and more. Amount of gold varies in a wide range (from "traces" to 60-90 g/tn) not only in ore-bearing zones, but in the enclosed quartz – pyritaceous (with a subordinate chalcopyrite) ore bodies of a lens-vein form. In some intervals (and sections) they are characterized by a high amount of gold. In relatively enriched intervals of the ore zones there prevail samples with amount of Au 2,0-12,0 g/tn.

The average amount of gold in the preliminary investigated ore bodies is 5,47 g/tn with the average thickness 3,1 m. Amount of Au in the modified rocks in the ore-bearing vein zones is from "traces" to the first hundreds of g/tn, including significant gold-ore intervals – from 3-4 to 100-130 g/tn, average amount in the deposit – 19 g/tn. It is interesting, that according to the data of the survey, in the horizon of gallery № 2 (200-210 m lower than the outcrop of vein bodies) in ores of the vein zone № 4, the amount of Au is 9,7 g/tn. This demonstrates the gold potential not only in the zone of oxidation of the deposit, but in its primary ores as well. Amount of Cu in the ore zones from the first hundreds to 3,5% (there prevail samples with amount of Cu up to 0,3-0,4%), Zn and Pb – up to 0,1-0,2%, Co – 0,01-0,02%. Areas, corresponding to the conjugation of the ore-enclosing structures of different orientation, are the most typical of the formation of the ore columns with the same mineralization, enclosing veins. The ore columns occur in bunches of the veins related to the areas of the crossing, conjugation and branching of the fractures. The most favourable for the formation of the ore columns are the bendings of the ore-enclosing structures, nodes of the crossing of the pre-ore faults and zones of the fracturing of gold-quartz veins, apophises, bunches and pinches, areas of combination of mineral associations of different ages etc. This takes place in zones №№ 1, 2, 4, 5, 9. The length of the ore zones along strike – 100-450 m with thickness 0,8-8,1 m. The traced not complete extension along dip is 30-60 m to 210 m and more (3, 5, 6).

Peculiarities of distribution of gold and the concomitant components in the deposit. Zones of metasomatites in the Gosha gold-ore deposit differ not only by the spatial position, mineral composition and by the intensity of change, but by the amount and character of behaviour of gold and concomitant ore elements – Ag, Cu, Pb, Zn, Mo, Co, As, Hg, Bi, Mn, Ti (7, 9).

Gold, being a leading ore component of the deposit is characterized by extremely uneven dissemination. Its amount varies $(4,5 – 390,0) \cdot 10^{-2}$ g/tn and is $16,51 \cdot 10^{-2}$ g/tn on the average. The amount of silver just like gold varies in a wide range – $(4,0\text{-}568,0)\cdot10^{-2}$ g/tn and is $128,2\cdot10^{-2}$ g/tn on the average. Amount of copper is $7,23\cdot10^{-3}$ g/tn elements is hardly the klark one.

The rocks composing the interstitial zone of the gold-ore bodies are characterized by higher amounts of the ore elements, especially of gold, silver, copper, cobalt and mercury (Table 1). Amount of gold varies $(2,7\text{-}700,0)\cdot10^{-2}$ g/tn and is $98,0\cdot10^{-2}$ g/tn on average. Amount of silver is $(4,5\text{-}800,0)\cdot10^{-2}$ g/th and it varies in a wider range than gold. Amount of copper is higher than the klark one. At R 5% level of significance (r=0,310) there has been determined significant relation between pairs of elements (Table 2): Au-Ag, Pb-Zn, Au-Cu, Cu-Pb, Co-Bi, Au-As, Mn-Co, Mn-Co, Co-As, Zn-Co, As-Bi, Co-Bi. The rocks in the inner zone are characterized by higher amounts of main (Au and Ag) and concomitant components (Table 3). Microscopic investigations revealed thin-disperse nature of this zone. They exist in pyrite, chalcopyrite and arconopyrite.

Table 1

Statistic parameters of distribution of the ore elements in sulphidized zones of hydrothermal-modified rocks (n=45%)

Elements	Amount	$\overline{X}$	S2	V
Au ($x10^{-2}$ q/t)	2.00-1500.0	150.5	435.9	1.45
Ag ($x10^{-2}$ q/t)	5.00-2800.0	645.0	1745.4	1.32
Cu ($x10^{-3}$ %)	0.5-51.70	9.2	85.6	1.54
As ($x10^{-3}$ %)	0.55-7.00	1.3	0.3	0.65
Hg ($x10^{-6}$ %)	1.00-85.0	4.8	0.45	0.50
Zn ($x10^{-2}$ %)	0.4-150	35.4	151.6	2.5
Pb ($x10^{-3}$ %)	0.5-4.30	0.85	0.1	0.42
Mo ($x10^{-4}$ %)	0.3-15.6	5.4	8.7	0.1
Co ($x10^{-3}$ %)	2.0-450.0	150.5	251.6	0.9
Mn ($x10^{-3}$ %)	1.0-30.0	4.6	8.4	0.95
Ti ($x10^{-3}$ %)	1.00-6.5	2.8	0.6	0.4
Bi ($x10^{-3}$%)	15.0-35.00	26.6	10.4	0.3

Table 2

Correlation matrix of distribution of the ore elements in sulphidized zones of hydrothermal-modified rocks (n=45; >>0,300, reliability 95%)

	Ag	Cu	Pb	Zn	Co	Mo	As	Hg	Bi	Mn	Ti
Au	0.654	0.421	0.105	0.085	0.023	0.016	0.540	0.125	0.098	0.123	0.145
Ag		0.245	0.216	0.125	-0.420	-0.120	0.240	-0.143	0.175	-0.145	-0.216
Cu			0.310	0.140	0.120	0.213	0.310	-0.117	0.066	0.054	0.105
Pb				0.545	0.195	0.061	0.055	0.017	0.098	0.095	0.024
Zn					0.245	0.078	0.129	0.021	0.078	0.215	0.044
Co						0.088	0.256	0.044	0.044	0.127	0.019
Mo							0.038	0.016	0.099	0.111	0.015
As								0.218	0.411	0.012	0.150
Hg									0.315	0.022	0.133
Bi										0.113	0.083
Mn											0.428

Correlation analysis (Table 4) (at R 5% level of significance r+0,300) has determined a relation between the pairs of elements: Au-Ag, Pb-Zn, Au-As, Au-Cu, Bi-As, Bi-Hg, Mn-Ti, Cu-Pb, Cu-As. Negative significant relation has been determined between Ag-Co. By the claster analysis of R type there has been conducted clastering of elements by groups in every studied zone. The results of the grouping of elements in weakly hydrothermal modified rocks demonstrate that at R 5% level of significance (r=0,38), three groups of elements have been identified: 1) Au-Ag-As-Cu-Bi-Hg; 2) Zn-Pb; 3) Mn-Ti.

Table 4

Statistic parameters of distribution
of elements in the intensively hydrothermal modified rocks (n=42)

Elements	**Amount**	$\overline{X}$	**S2**	**V**
Au ($x \cdot 10^{-2}$ g/t)	2.70-700.0	98.0	75.4	0.9
Ag ($x \cdot 10^{-2}$ q/t)	4.50-800.0	142.4	3254.3	0.99
Cu ($x \cdot 10^{-3}$ %)	1.00-970.0	33.2	3.9	2.8
As ($x \cdot 10^{-3}$ %)	0.40-120.5	2.9	2.7	1.1
Hg ($x \cdot 10^{-6}$ %)	1.00-5.20	1.9	0.5	0.43
Zn ($x \cdot 10^{-2}$ %)	0.70-930.0	12.4	21.7	2.33
Pb ($x \cdot 10^{-3}$ %)	1.40-	9.3	15.1	1.50
Mo ($x \cdot 10^{-4}$ %)	0.40-5.20	2.0	1.9	0.85
Co ($x \cdot 10^{-3}$ %)	2.00-1500.0	56.7	1820.5	1.36
Mn ($x \cdot 10^{-3}$ %)	0.80-5.40	1.4	42.0	0.89
Ti ($x \cdot 10^{-3}$ %)	0.30-955	3.1	8.5	0.88
Bi ($x \cdot 10^{-3}$ %)	0.40-24.00	15.85	32.5	0.45

In rocks composing the interstitial zone of ore-metasomatic column, at R 5% level of significance (r+0,380) two groups of elements have been identified: 1) Au-Ag-Cu-Bi; 2) Pb-Zn. Somewhat below this level one can identify an independent group Mn-Ti. In the central zone represented by sulphidized hydrothermal-modified rocks, at R (5%) level of significance (r=300,0), four discrete groups of elements have been identified: 1) Au-Ag; 2) Cu-As-Bi; 3) Pb-Zn; 4) Mn-Ti.

Table 5

Correlation matrix of distribution of the ore elements in the intensively hydrothermal-modified rocks (n=42, r>0,38, reliability 95%)

	Ag	**Cu**	**Pb**	**Zn**	**Co**	**Mo**	**As**	**Hg**	**Bi**	**Mn**	**Ti**
Au	0.566	0.429	0.134	0.128	0.129	0.019	0.346	0.009	0.099	0.008	0.103
Ag		0.126	0.135	0.131	0.049	0.124	0.129	0.017	0.143	0.019	0.058
Cu			0.416	0.135	0.128	0.217	0.317	0.051	0.416	0.121	0.014
Pb				0.535	0.136	0.091	0.120	0.025	0.100	0.066	0.095
Zn					0.312	0.044	0.211	0.074	0.200	0.216	0.145
Co						0.166	0.318	0.016	0.310	0.314	0.128
Mo							0.097	0.009	0.036	0.009	0.026
AS								0.218	0.311	0.121	0.024
Hg									0.222	0.144	0.015
Bi										0.027	0.009
Mn											0.315

Analysis of the position of elements in groups enables to divide them into three groups according to their genetic features: 10 Au-Ag-Cu-As-Bi-Pb-Zn; 2) Co-Mo-Hg; 3) Mn-Ti. The first group includes elements of a hydrothermal origin. The main argument in favour of this conclusion is, first, regular increase of their amount in the direction from the enclosing rocks towards the mineralized zone. The second group includes elements having no proper places in clasters and their composition does not indicate zone of their location. By their genetic features they have been considered as polygenic, i.e. they can be mobilized out of the enclosing rocks. Elements from the third group Ti-Mn are characterized by nearly stable amount in all the three zones and they always have close positive relation between each other. They are petrogenic and they are borrowed from the enclosing tuffaceous rocks.

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QOŞA YATAĞININ GEOLOJI QURULUŞU VƏ QIZILLIĞI (KIÇIK QAFQAZ, AZƏRBAYCAN HISSƏSI)

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Məqalədə Qoşa qızıl yatağının geoloji quruluşuna və əmələ gəlmə şəraitinə baxılır. Yatağın struktur xüsusiyyətlərinin formalaşmasında qırılma, çat, həlqəvi və xətti strukturların əhəmiyyətli rolu müəyyən edilmişdir. Filiz kütlələrinin quruluşu və formasının xüsusiyyətlərinin təhlili, onlar arasında aşağıdakı morfoloji tipləri ayırmağa imkan verir: hidrotermal dəyişilmiş süxur zonaları, kvars - sulfid damar və damarcıqları və ştokverklər. Ətraf süxurlarda və filizlərdə qızılın və onu müşayiət edən filiz elementlərinin təyin olunma xüsusiyyətlərinin təhlilinin statistik nəticələri verilmişdir. Klaster analizi nəticələrindən istifadə etməklə, filiz komponentlərinin qruplaşdırılması aparılmış və onların mənbələri haqqında nəticələr göstərilmişdir.