Republic of Armenia

Global Gold Mining LLC

REPORT

"Technical and economic grounds (TEG) of assessment of commercial significance of Central Area of Tukhmanuk gold deposit with development of conditions for reserves calculation as of 01.01.2009"

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YEREVAN 2009

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REVIEW

H. Mkrtchian, V. Harutyunian and others. “TEG of commercial significance of Central Area of Tukhmanuk Gold Deposit with Development of Conditions for Reserves Calculation as of 01.01.2009”.

Report—134 pages of body text, 19 pages of text attachments, 20 pages of graphic attachments, seven titles are used in the list of used sources.

The work is implemented by Global Gold Mining LLC, registered office: 1/1 Zarobian St.

Materials of geological-exploration and exploitation-exploration works implemented at Central Area of Tukhmanuk gold deposit are summarized, and geological-economic assessment (TEG) is implemented.

The work includes figures of mining works and ore processing, as well as capital and exploitation costs, project of condition figures for reserves calculation.

Basic provisions of the assessment are as follows:

Gold and silver extraction at Tukhmanuk deposit is implemented from an open pit. The pit’s length makes 1200m by strike; its width makes 400m and depth—160m.

Overburden will be stored south-west of the pit at a distance of 2.0km. According to the estimation, there are 18.8mln t of ore within the pit with average grade of 2.08 gr/t. General angles of pit slope are determined with consideration of safety factors and they make from 55 – 56^0; they were used for the determination of the pit contour with economic gold grade.

Three years are required for the construction of the pit, processing plant, ground infrastructure and capital stripping works. The ore mining starts from the third year of the works schedule. The estimated capacity of mining and processing will averagely make 1.5mln t of ore per year. In total, during the operation of the mining and processing enterprise, 27.mln m^3 of rock (around 55.0mln t) will be mined from the 1st stage pit, out of which 18.8mln t of ore will be processed.

The economic indexes of the project (economic criterion for the cutoff grade estimation) are provided in relevant chapters of TEG.

The project of conditions includes the following factors:

1. Calculation of reserves of balance ores shall be implemented within the designed contours of the pit;
2. The cutoff grade of conditional gold for contouring the balance reserves makes– 0.6 gr/t, in case of minimum natural gold grade of 0.4gr/t, and silver—10gr/t.
3. The economic cut-off grade of conditional gold in calculated blocks (benches) of balance reserves as a control parameter makes 0.8 gr/t;
4. The reduction coefficient of natural silver grades to gold grades makes 0.008. The natural gold grades above 0.4gr/t and natural silver grades above 10gr/t shall be considered during the conditional gold grade's determination.
5. The ores with conditional gold grades below the cut-off grade and up to its grade of 0.4gr/t in flotation tails shall be considered among off-balance reserves within the designed contour of the pit. Ores outside the pit shall be considered to be off-balance ones, irrespective of their gold grade.
6. The lowest level of reserves calculation is established at 2150m;
7. The minimum thickness of ore intervals and maximum thickness of "waste" or off-grade ores included in the calculation are not limited.

Key words: deposit, exploration, ore, gold, development, recovery, capital and exploitation costs, profitability, conditions.

Prepared by H. Mkrtchian

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Introduction

This work is implemented as per approved plan for 2009 provided by GGM.

The report aims to summarize the results of geological and exploration works and exploitation, including the results of geological and exploration works implemented before 2003, which are included in the report with reserves calculation as of 01.10.2003, as well as data of the deposit's supplementary exploration from 2005-2007. An analysis of the results of the deposit's exploration and exploitation exploration is implemented, which is provided in chapter 5.

Currently, Tukhmanuk deposit reserves are recorded in the State Balance of Minerals of the Republic of Armenia at the following quantities:
Ore reserves—($C_1 + C_2$)–1.16mln t;
Gold—7687kg;
Silver—43.6t.

Tukhmanuk mining and processing enterprise is an operating mining enterprise, which has a plant with annual processing capacity of 100thous. t of ore.

Basic features of the ore bodies' morphology and their spatial position are clarified due to the results of supplementary exploration and exploitation. The deposit is described in this work as a hydro-thermally changed thick zone, within borders of which veins (#1, 2, 15 and others) are placed. The sharp increase in the scope of mining works and ore processing, reasoning of mining through open method instead of the previously approved underground method required a radical review of Tukhmanuk deposit's development strategy, the basic provisions of which are provided in this work. The obtained information as a whole is enough for the geological and economic estimation of the deposit and preliminary calculation of reserves. The ore reserves considered in the work considerably exceed the ROA GKZ reserves—by more than 14 times, and secure the enterprise's operation for more than 12 years with the annual ore processing volume of 1.5mln t.

The ore reserves are aligned with JORC model and UN framework classification by their level of geological study.

The economic calculations are done in US dollars and the dynamics of increase in its price decreases the risk of a non-confirmation of economic indexes and our calculations of parameters of condition.

The forecast resources of the deposit are estimated to make 12-15t of gold.

1. General Information

Central Area of Tukhmanuk gold deposit is located within borders of the ore field of the same name. It is mostly located on the south-western slope of Tsaghkunyats mountain ridge and administratively it is in Aragatsotn region of the Republic of Armenia.

It is located 3.0-3.5km east of Melikgyugh village and 15.0km of Aparan town. It is connected with Yerevan by a 72km highway.

The region is characterized by a split, high-mountain relief with deep gorges and ravines. The absolute height marks vary from 2100-2800m. The relative height of watershed above gorges' bottom makes 1000–1200m on an average.

The highest absolute levels of the aforementioned mountain ridge are: Ukhtasar—2549.5, Tukhmanuk—2762.0m and Damlik—2781m. Kasakh River is the main river artery of the region with its numerous tributaries, which are feed by water from melted snow, spring water and precipitation.

The region has a humid climate; the quantity of annual average precipitation makes 800mm, the annual average temperature makes $+14^{0}C$ in summer and $-17^{0}C$ in winter.

Its flora is sub-alpine and alpine (2000-2200 and 2200-2300m above sea level, respectively.)

From 1983-1986, exploration ad exploration-estimation works were carried out at the territory of the ore field, which occupies around $35.0km^2$. As a result of them, perspective areas were revealed: Tukhmanuk (Central), Mirak, Melikgyugh, etc.

Between 1983-1986, the works were continued, and forecast gold and silver resources were determined at Central Area for the revealed ore bodies—1, 7, 8, 11, 12, 13, 15, at the following quantities: gold—8365kg, silver 21.5t. Due to a range of technical and economic reasons, the works at Central Area were terminated, which hampered provision of geological and economic estimation of the revealed areas.

In 2001, Mego-Gold LLC continued implementation of the geological and exploration works, first of all, at Central Area of Tukhmanuk deposit. Here, the stages of preliminary and detail exploration of the area under exploration were essentially combined.

Central Area of Tukhmanuk deposit occupies a territory of 4.0km^2 within height marks from 2100-2760m.

Supplementary geological and surveying works were implemented at this area, previously drifted alpine workings were restored and partially re-sampled, new exploration drill holes were drilled, a pilot open pit was established and developed at ore veins #1 and 15.

In 2005, Global Gold Mining LLC obtained the right to exploitation of the deposit. From 2007-2008, the pilot processing plant was reconstructed with the annual capacity of 100thous. t. 59thous. t of ore and 22.3kg of gold have been extracted at the deposit since the start of works.

2. Geological Description of Region and Deposit

The region is characterized by complexity of the geological structure, wide development of the grid of tectonic faults of various types, intrusive bodies of various morphology and facial belonging and complicated folding. Many peculiarities of the geological structure of the territory remain unknown and require thorough supplementary studies.

Metamorphic shales of post-Paleozoic age and volcanogenic-sedimentary formations of lower Bajocian age participate in the geological structure.

These rocks are ruptured by granodiorites, quartz diorites. Formations of Quaternary age, which are represented by alluvial-dealluvial sediments, are widely developed at the area.

The stratigraphic section of the region is represented by a stratum of ancient Pre-Cambrian metamorphic shales, sedimentary formations of Jurassic and Chalk age, pyroclastic formations of Lower Plyocene and modern friable formations.

Intrusive rocks crop out in the basin of Kasakh, Getuk rivers, as well as on Tsaghkunyats mountain chain. These rocks are of different ages and differ by variety of petrographic composition.

The following intrusive formations are present from ancient to young ones:
ultramafic, plagiogranite, granite-gneiss, gabbro and tonalite.

The following complexes of small intrusions of tertiary age are outlined in the region:

1. Sub-volcanic complex of micro-gabbro—diabases;
2. Dyke complex of spessartites; peculiar rocks of deep-green–brown color; they crop out east of Tukhmanuk peak and Mirak intrusion;
3. Sub-volcanic complex of quartz porphyries. Spatially and by age it is the most close one to the basic gold-polymetallic ore formation. It intersects Lusagyugh and Tukhmanuk suites and is split by dykes of granodiorite-porphyries. It crops out in Tukhmanuk, Mirak and Lusagyugh areas. It has a circum-latitudinal direction.

Tectonically, the deposit is attributed to Zangezur-Hankavan folded zone, which is characterized by distribution of volcanogenic-sedimentary formations of Pre-Paleozoic–Lower Paleozoic, Upper Chalk and Tertiary Age.

Within this folded zone, Tukhmanuk ore field basically occupies the western part of Tsaghkunyats mountain chain, including:

Tukhmanuk syncline—it is formed by volcanogenic-sedimentary rocks and pyroclastic formations. It is observed in north-eastern direction.

This structure is intersected by tectonic faults, which are ore controlling and they lead to ore structures for formation of gold-polymetallic mineralization.

Melikgyugh anticline. It also has north-eastern strike, the width of which reaches 2km and more. The anticline's core is comprised of metamorphosed andesite porphyries of Post-Paleozoic age, which are ruptured by plagiogranites of Chalk age. Melikgyugh anticline and Tukhmanuk syncline neighbor with Hankavan-Melikgyugh fracture of deep-seated location.

Lusagyugh anticline—it is observed in north-eastern direction, it is comprised of porphyries, tuffites, metamorphic shales of Paleozoic age, which are ruptured by intrusive rocks of granodiorite composition.

This structure and Tukhmanuk syncline neighbor with Mirak fracture of deep-seated location.

In this region, fault tectonics is expressed rather intensively and it makes the basic tectonic frame of the area. The following systems of fault structures are outlined:

1. Longitudinal faults of north-western strike (270 - 325^0)

   Hankavan-Melikgyugh fracture, which is one of branches of Marmarik-Sarakain deep-seated fracture. It trends from Hankavan village to Tukhmanuk pass. In north-east, it is observed north of Melikgyugh village and is covered by modern friable sediments.

   A formation of hydro-thermally altered rocks' belt is observed along the fracture.

   By feature, it is a fault system and with plane dip it shifted to north—north-east at an angle of 65^0.

Mirak fracture trends from Saralanj village and reaches Mirak village with azimuth of 320^0, it dips to north-east at 55^0.

2. ***Meridional fault of northern strike***– it intersects plicated and discontinuous faults of the region. It is accompanied by zones of brecciation and foliation.

2.1 Useful Minerals

The region's deposits and manifestations basically are located at lines of regional fractures (in disjunctive faults of north-eastern strike, which feather these fractures.) The hugest fractures are: Marmarik-Sarikan and Hankavan-Melikgyugh (the latter is the branching of Marmarik-Sarikan fracture), along which almost all known deposits and manifestations of the region are located.

Meghradzor gold deposit and Tsaghkunyats gold-polymetallic ore manifestation are associated with the aforementioned structures. The ore manifestations are associated with the belt of Baydak regional discontinuous structure (Shoraghbyur—copper, Debalin—copper-hematite, Kosh–Deressin—copper, Baydak—copper), etc.

During the previous geological exploration of the licensed territory of GGM, 9 gold manifestations were revealed at it and studied to different levels, territorially and, to some extent, economically they trend to Tukhmanuk deposit (Pic. 2.)

They are as follows: Mirak, Melikgyugh, Vanassar, Tsitskar, Grebnevaya, Drury Gallagher (Ojakhidzor), Ozyornaya, South-Eastern vein zone. These manifestations will be explored by the company's plan of works from 2009-2013, due to which their brief description is provided.

2.1.1 Mirak Manifestation

It is located 2.5km south-east of Mirak village, on the left bank of Kasakh River. It occupies two areas, which are associated with a common hydro-thermally altered zone: Mirak and Tukhmanuk.

It is located 2.5–3km south-east of Melikgyugh village. The ore manifestation is intersected by a junction of deep-seated fractures of different directions. Volcanites of Jurassic Age, which in their turn are ruptured by bodies of Chalk Age, participate in the area's structure. A hydro-thermally altered zone with 1m thickness is observed within granite intrusions, it has a north-eastern direction, it is comprised of quartz veins and stringers with sulphide mineralization.

Ore bodies #1 and # 6 with gold mineralization are known here. Exploration trenches, clearings and bore pits were drifted at these bodies. The ore bodies have north-eastern strike and south-eastern dip at an angle of 60 – 65^0. The enclosing hydro-thermally altered rocks reach thickness up to 1-4m.

The ore consists of pyrite, rarer—chalcopyrite, sphalerite and arsenopyrite. An adit was worked at the level of 2172m for the exploration of lower levels, and it intersected the vein at 40 and 60m. According to data of the adit's sampling, the gold grade is low and is below 1.4gr/t, silver—6.8gr/t.

Vein #6 is revealed 350m south-east of vein #1, it is located in volcanites of Mirak suite.

Earlier, 12 drill holes were drilled at the area with dip of 50 – 60^0, their purpose was to intersect the vein to define its actual thickness.

Exploration trenches were drifted with depth of 2-3m, bore pits—up to 5m.

The expected reserves at Mirak area are as follows by C_2 + P_1 categories: ore—350thous. t with average gold grade of 3gr/t, silver—6gr/t; gold reserves—1050kg, silver—2100kg.

2.1.2. Melikgyugh manifestation

The area is located north-east of Melikgyugh village, at a distance of 700–800m, at a level of 2150m. Pre-Cambrian shales participate in the geological structure of the area, among them there are graphitized variations and pyritized quartzites, Paleozoic plagiogranites and leucocratic granites, as well as horny porphyries of Eocene.

A zone of hydro-thermal alteration and brecciation passes in the latter; it has a south-eastern circum-latitudinal strike with north-eastern dip at an angle of $70\text{-}80^0$. The zone's thickness varies from 150 to 300m.

The hydro-thermal alteration is expressed by epidotization, silicification and pyritization. Two sub-zones are clearly outlined in the zone:

Sub-zone # 1. Its thickness varies from 0.8 to 1.5m, it is traced by the strike for up to 450m in three sections on surface; samples showed the following gold grades in it: 5.5, 2.5 and 6.8gr/t, respectively, in other surface workings, which have stripped porous silicificated rocks of this zone, gold grades from 0.2 to 0.6gr/t were established as well.

Sub-zone #2. It is traced for 400m with thickness of 1 – 1.3m. Samples showed gold grades from 0.2 to 2.8gr/t, which served as a basis for placing adit #1 with depth of 60m.

The adit has stripped horny epidotized and, partially, chloritized porphyries with copper presence.

At the interval of 26-38m of the adit, the gold grade made 1.6 and 2.6gr/t in hydro-thermally rocks, which indicates the gold ore structure's distribution at depth. However, the clear contacts of the sub-zones are blurred at the adit's level and they are not observed. The second sub-zone is in drifts 1 and 2, for which the gold grade made from 0.5 to 1.5gr/t.

We would like to note that the adit's level passed through oxide varieties, as a result of which the prospects of Melikgyugh sulphide ores remained unclear.

2.1.3. Vanasar manifestation (Emin-Yurt)

It is located in the upper course of Ojakhidzor, 4-5km north-west of Hankavan village.

Paleozoic plagiogranites and quartz diorites, which rupture the first ones that points to their relative young age (the upper age limit of quartz diorites is accepted to be Pre-Turonian), participate in the geological structure of the area. They were subjected to weathering in the near-surface part and turned into gruss in some places.

Andesite covers, liparites and obsidians are widely developed in the inter-stream parts of the area.

Vein-rocks are represented in a wide diapason.

Dykes of diorite-porphyries, porphyries, hornblende gabbros, lamprophyres, plagiogranite-porphyries, porphyric aplites and pegmatites are established at the area.

Six ore zones are established within borders of Vanasar manifestation, ore zone #2 is the most interesting one among them, it is traced along the strike by bore-pits and trenches up to 550m with average thickness of 4–5m.

Trenches were drifted at this zone by sections; they are placed at a distance of 150-200m from each other.

In the first section, according to data of 4-meter trench samples, the gold grade makes 1.8, 2.0, 4.2 and 0.9gr/t, respectively, it makes 2.2gr/t on an average for the section. In the second section, the gold grade by four samples makes 3.6, 3.4, 0.2 and 0.1gr/t, while the average grade for the section makes 1.8gr/t. One sample was taken in the third section with gold grade of 1.4gr/t. Since the surface sections for zone #2 showed high gold grades, an adit was drifted along the zone's strike to the depth of 136m. The hydro-thermally altered zone is associated with a tectonic fracture with clay gouge with elements of occurrence: dip azimuth—130–140^0 with dip angle of 80-85^0.

Adit #5 has stripped a quartz-ore vein in hanging wall of the zone, and it is controlled by the mentioned zone. The entire structure is represented by a zone of crushing and brecciation among quartz diorites, where the hydro-thermal alteration is expressed by silicification, pyritization (limonitization) and, partially, by kaolinization. The quartz-ore vein is stripped by an adit in this zone, it is represented by clear contacts and, in general, it has regular bedding with the zone.

Crosscuts were drifted at intervals of 20m from the shaft of adit #5, which came to unaltered quartz diorites after stripping of the full thickness of the zone. According to the crosscuts' data, the thickness of the quartz-ore vein is from 0.2 to 2.0m.

The gold grade in the zone is lower at the adit's level than in surface workings—from 0.1 to 1.1gr/t, and it showed 8.5gr/t only in one sample. Almost the same grades are established in the quartz-ore vein, where, according to data of 30 trench samples, the gold grade varies from 0.1 to 1.2gr/t and it showed 14.1gr/t only in sample #1683.

Since adit #5 is in the zone of weathered rocks, through which underground waters circulate intensively, gold is possibly removed both in the zone and in the quartz vein.

Zone #1 is traced by trenches and bore-pits for a distance of 560m. It is represented by hydro-thermally altered, silicificated, ocherous, quartz diorites.

A quartz vein passes along the zone, it is interrupted at some intervals, making lens aggregations of chalcedony-like quartz with pyrite. The vein's thickness varies from 1.2 to 1.5m. Fire assays show gold contamination of up to 1.8gr/t.

Ore body #5 is intensively pyritized. Its thickness varies from 0.5 to 1m. It is traced on surface by bore-pits and trenches in north-eastern direction for 200-250m. The gold grade in surface workings reaches 9.8gr/t.

Ore body #6 is traced by the strike for 120-130m, its thickness makes 0.3-0.6m. The gold grade in the ore body varies from 0.2 to 57.2gr/t (sample #88 from trench 1034.) This body's thickness in the mentioned intersection makes 0.25m, and such high grade is the peak one out of all results.

2.1.4. Drury Gallagher (Talma) Manifestation

The area is located in north-eastern part of Tukhmanuk ore field.

The geological structure and the feature of the area's mineralization distribution were studied in 2006 during the process of 1:1000 scale mapping.

Exploration works were not implemented previously.

In 2007, 1:2000 scale prospecting works were carried at the area's south-western part, at a territory of 10ha; 28 trenches and 36 bore-pits were drifted with volume of 880m^3 and 92m, respectively; 158 trench samples were taken. The average gold grade did not exceed 1gr/t.

Medium-grained whitish plagiogranites and amphibolite's micas of Upper Proterozoic age are present in the geological structure of the area. Block-xenoliths of amphibolite's micas have north-eastern strike.

Lime material, which is formed in amphibolites during the intrusion of plagiogranites, accompanied the formation of skarns, in which sulphide minerals are observed.

The area is located at Hankavan-Melikgyugh tectonic fracture, as a result of which the rocks are rather fractured and brecciated at the area. Along the fracture's strike, the rocks were subjected to hydro-thermal alteration, plagiogranites have transformed into sericitic quartzites.

11 hydro-thermally altered zones were revealed and described as a result of the prospecting works, which basically trend in north-eastern (20-650) direction. Their width is up to 5m, they are traced up to 160–170m.

The mineralization is of stringer-impregnated type. The stringers are represented by quartz-hematite-limonite, quartz-sulphide mineralization. In some places, stringers up to 7-8cm are met. Veins are not revealed.

The mineralization is feebly marked; ore minerals are represented by pyrite, galenite, limonite and hematite.

From 2009–2013, estimation works are planned to be implemented at the area and, in case of their positive results, reserves and resources of C2 and P1 categories will be revealed and calculated.

2.1.5 Voskedzor manifestation

It is located 2-2.5km west of Hankavan village, in the middle stream of Namazolyan River. The area is comprised of quartz diorites, which are basically crushed and transferred into gruss. However, hydro-thermally altered variations differ among them; they make a thick zone extended in the meridional direction. Within the area, quartz diorites are ruptured by dykes of hornblende diorite-porphyries, quartz-porphyrites, quartz-porphyries, lamprophyries and hornblende gabbros. The dykes have north-eastern strike—30-400m, with dip angles of $70\text{-}90^0$. Along the mentioned dykes, a belt of hydro-thermally altered quartz-diorites is developed and quartz veins with low thickness are embedded. The thickness of the hydro-thermally altered zone is increasing from south-west to north-east, starting from several meters up to 100-120m. This zone's strike is controlled by a fault of the same strike, which, possibly, is the feathering structure of Marmarik fracture.

The hydro-thermal alteration of rocks is expressed by silicification, pyritization, carbonate formation, kaolinization and sericitization of feldspars, chloritization; the rock is rather ocherous as a result of pyrite oxidation.

Microscopically, the mineralization is represented by pyrite, hematite and limonite.

Small tectonic faults are widely developed at the area.

The quartz veins of Voskedzor manifestation are characterized by sporadically high gold grades, by showing an inverse ratio with veins' thickness. For example, vein #1 is traced in the ravine of the left constituent of Namazolyan river, with thickness of 0.3-0.5m, in north-eastern direction at a distance of 25-30m. Fire assays of four samples taken at an interval of 10m showed gold grades of 0.6, 53, 21 and 34.2gr/t. This vein wedges out by the strike. Chalcedony-like quartz veins are intensively pyritized. In the upper streams of Namazolyan river, quartz vein #2 is revealed with thickness of 0.3-0.5m. It is traced by the strike for 60 – 70m. The gold grade in it varies from "traces" to 10.7gr/t, and high grades are associated with the thinnest part of the quartz vein.

The zone of hydro-thermally altered quartz diorites is the most interesting one, it is developed along the dyke of hornblende gabbro. In south-western part of that zone, where its thickness does not exceed 15-16m, silicificated and ocherous hydro-thermally altered rocks are stripped by a trench placed along the channel of Namazolyan river. Samples from this trench showed gold grades of 6.0, 1.5, 1.9 and 12.9gr/t.

The mentioned zone is traced by the strike for 600-700m in north-eastern direction, but gold is established only in quartz bodies penetrating into this zone.

The area's exploration is implemented through bore-pits and trenches with depth of up to 8m.

In 2007, 8 drill holes with total length of 756.7m were drilled at Voskedzor area. Trenches with volume of 154.2m^3 and bore pits—113.5m, were drifted. The results of assays showed gold presence of up to 1.41gr/t in drill holes.

2.1.6 Tsits Kar manifestation

It is located in the south-western part of Hankavan ore field, 0.8-0.9km south-east of Lusagyugh marble deposit.

Hydro-thermally altered rocks of granitoid composition are present in the geological structure of the area: granosyenites, adamellites, granodiorites.

In west, basalt-andesite-basalts of Upper Jurassic-Lower Chalk age, serpentinites and granodiorite-porphyries of Upper Proterozoic age are distributed.

In south, granosyenites are ruptured by dykes and stocks of granodiorite-porphyry composition.

Most part of surface is represented by hydro-thermal metasomatites.

The hydro-thermal alterations are represented by quartz-sericites. According to data of prospecting works, gold has uneven distribution.

Trenches and bore-pits were drifted at the area with volume of $1200m^3$ and 76m, respectively, 355 samples were taken, 1:2000 scale geological map was prepared at a territory of 16ha.

The gold grade is from 0.65gr/t to 21.5gr/t. The works planned for 2009–2013 will provide with the opportunity to reveal and estimate reserves by C2 category at the amount of 150–200thous. t of ore and resources by P1 category—200-250thous. t. The average gold grade is expected to be from 3.0–3.5gr/t.

Hydro-thermally altered zones and ore manifestations were revealed at **Grebnevaya, South-Eastern** and **Ozyornaya** areas during 1:50000 and 1:25000 scale mapping. Data about qualitative and quantitative grades of metals is very limited, thus, a necessity has arisen to explore these areas in detail, which will provide with the opportunity to obtain a preliminary geological-economic estimation.

2.1.7 Grebnevaya manifestation

The area is the connecting link between Tukhmanuk and Mirak ore fields. Tukhmanuk volcanogenic-sedimentary stratum is ruptured at the area by dyke-like bodies of granodiorite-porphyries.

The gold and silver manifestations and limited data about their grades, to our opinion, do not give a complete picture about the level of their reserves. From 2009-2013, prospecting works will be carried out at the area.

2.1.8 Ozyornaya manifestation

The area is located north of Lusagyugh village. Positive results for gold were obtained during the heavy concentrate survey of basins of Lusajour and Saralanj rivers. Fragments of hydro-thermal rocks are observed everywhere in the existing here landslides; a grid of splits of eastern direction, where rocks are rather fractured and brecciated, is developed at the area. In some places, this area is filled up by secondary quartzite and ore minerals. Prospecting works are planned to be implemented at the area from 2009-2013.

2.1.9. South-Eastern vein zone

It is located at the south-eastern flank of the manifestation, 1.0km south of vein zone #5. More than 10 veins and zones are stripped in clearing #9, at an interval of 0-140m, they are represented by quartz-carbonate veins with impregnation of pyrite and galenite. Four veins are characterized by gold grade from 2.6 to 12.6gr/t, with total thickness of 9.5м.

In north-eastern direction, the zone outcrops in the gorge of Marmarik river's tributary, where two quartz veins are sampled. The gold grade makes 13.0gr/t and silver—15.0gr/t in the vein with thickness of 0.3m.

According to data of decoding of aerophotos, the south-eastern vein zone trends in north-eastern direction towards geo-chemical anomalies of the basin of Talma river, and in south-western direction it outcrops in Demidzor ravine, where quartz veins with total thickness of around 10m and dip angle of 40^0 outcrop in the zone of hydro-thermally altered rocks with thickness of 100m. Carbonic acid and mineral water of small discharge come out from the zone's joint near the river's edge. The veins are observed at surface continuously for 70m and disappear under overburden. The vein filling is comprised of macrocrystalline quartz with interstices of regular crystallographic contours, apparently, at the place of weathered ankerite. Some veins give bulges with thickness of 30cm, they narrow and extend into lines.

The mentioned vein zone is identical to zone #1 of Tukhmanuk area by its morphological features, thickness and elements of strike, but it differs only by a slightly flat dip to south-east. Parallel to the vein zone, 50m southward, the ridge is intersected by a dyke of granodiorite-porphyry.

The total traced length of the south-eastern zone makes more than 4km.

2.2 Brief description of geological structure of Central Area

The deposit is associated with the junction of intersection of Hankavan, Bjni-Gekharot and Lusagyugh fractures. The deposit's area is comprised of basically hydro-thermally altered volcanogenic formations of Middle Jurassic Age, which are ruptured by granodiorites of Chalk. The first ones are represented by andesites, andesite-dacites and their pyrocrystalls. The complex of effusive and intrusive rocks is ruptured by young (Post-Neocomian rocks, possibly, tertiary ones) sub-volcanic and dyke formations: quartz porphyrites, diorite-porphyrites and gabbro-diabases. The territory's area is almost covered by modern eluvial-proluvial and alluvial formations with thicknesses of 2-10m and more in some places. The mineralized zones, rocks are subjected to tectonic deformations and they are strongly hydro-thermally altered. The hydro-thermally altered zones are basically related to fissuring of north-eastern direction, there are meridional and north-western zones. They, irrespective of lithologic borders, appear in volcanites and intrusions, they transfer from rocks of Jurassic age into Pre-Cambrian rocks, etc. The zones' width is different starting from several meters up to 100m and more. Their length reaches several kilometers in some manifestations, making 200-300m on an average.

The tectonic faults within the area of estimation are of shearing type of submeridional and north-western strike, they dip to east—north-east at angles of $65\text{-}85^0$.

The largest fault of this type trends by the contact of volcanogenic stratum with an intrusive complex.

Numerous bond-failure cracks are observed in lateral, circum-latitudinal and north-eastern directions, as a rule, they dip to southern bearings at angles of $65\text{-}85^0$.

Such structures are established both within volcanogenic rocks and among intrusive formations. Large displacements during their transfer from one stratum to another are not fixed. A part of fractured structures is filled by products of hydro-thermal ore emplacement—quartz-sulphide material, which bears the gold-silver mineralization. They represent the vein ore bodies typical for Tukhmanuk deposit, which are enclosed in mineralized silicificated rocks of impregnated-stringer type. The basic mass of economic reserves of the deposit is related to the latter.

Around 20 ore veins and zones (pic. 3) with relatively high grade of gold and silver are revealed at Central Area of Tukhmanuk deposit

These sub-parallel bodies are grouped within zones of hydro-thermally altered rocks.

The gold-bearing quartz-sulphide veins are traced by the strike with interruptions for hundreds of meters, sometimes—above 1.0km.

Their morphology and elements of their occurrence are basically determined by the relevant parameters of above-mentioned ore localizing fractured structures: circum-latitudinal, south-western strike and sharp dip to south-east. The thickness of quartz-sulphide ores varies within 0.5-1.5m, in bulges—up to 2.5m.

The ore bodies' borders /contacts/ are basically distinct and tectonic. An intensively impregnated sulphide mineralization, which bears the gold mineralization, is observed only in some places, as a rule, in veins' hanging wall. At such parts, ore body's borders are determined conditionally, according to the established cutoff gold grade. The economic mineralization is represented by a mineral association of pyrite-galenite-sphalerite-native gold. The association of vein minerals is represented by quartz-ankerite-adularia.

Quartz-sulphide stringers contain ore minerals: pyrite, arsenopyrite, sphalerite, chalcopyrite, galenite, galenite, fahlite, markasite, ore minerals—native gold, tellurides of gold, silver, bismuth, etc.

During the exploration (2003), veins #1 and 15 obtained commercial estimation; their brief description is provided below:

Vein #1

The ore body has a "plate-like" contour; it occurs in quartz-sericitic metasomatite and hydro-thermally altered intrusive rocks.

It has a north-eastern—south-western strike, dip angle—65-75^0 into southern bearings. The ore body's length by strike is more than 1000m on surface. It is traced to the depth of up to 300m. The vein's thickness varies from 0.4 to 3.4m, 1.1m on an average.

At this state of exploration, displacements and other complication of morphology of the vein are not established. It should be noted that, however, at the western flank of the area, it apparently joins vein #2 and gets closer to vein #15 (see the plan.)

Microscopically the vein is observed as a quartz-carbonate-feldspar mass containing nests, impregnations and stringers of sulphides.

At surface, the ore minerals, as a rule, are oxide and are represented by hydroxides of iron.

The gold grade varies in the vein from traces to 23.4gr/t, while silver—10.0–240.5gr/t.

Vein #15

It is the biggest one among the revealed and studied ore bodies. It is located south of vein #1 and is characterized by similar conditions of occurrence.

At surface, the ore body is traced for more than 1100m, at depth—from 300–350m.

The average thickness of the vein makes 1.4m. It dips to south-east at angles of 65 – 80^0.

In some places, a symmetric-band structure of the ore body is observed: "quartz cores" are noted in its central parts, and intensive sulphide mineralization and carbonates—in selvages. Interstices from 10-20cm are fixed in quartz "cores", their walls are covered by macrocrystalline, combed quartz.

In addition to veins #1 and 15, which are explored in detail, manifestations and separate veins, vein zones, which are within the zone of Central Area's influence, are established at the ore field. Their brief description is provided below.

Vein zone #5

It is located at the south-eastern flank of the manifestation, 500-600m south-east of vein zone #15. The zone's thickness varies from 50 to 200m and more.

4 (5/1, 5/2, 5/3, 5/4) quartz-carbonate-sulphide vein zones of north-eastern strike are outlined in the zone. Traces of ancient mining are revealed at the south-western edge of the zone; the total length of vein zone #5 makes 5km (up to Mirak manifestation.) The inter-vein space is comprised of hydro-thermally altered rocks, which are feebly ocherous and silicificated.

Vein zone # 5/1 passes by the south-eastern contact of the zone in north-eastern direction. At surface, the zone is stripped by alpine workings (trenches, clearings) at 16 sections. The traced length makes 1280m. In central part, the vein zone is covered by a stream of acid lavas (obsidians, perlites, liparites.)

The vein zone is represented by a quartz-carbonate mass and quartz vein in north-east. The vein zone has south-western dip at angles of $60 – 90^0$. The gold grade varies from 2.2 to 14.4gr/t, making 7.0gr/t on an average, while silver—from 2.9 to 18.3 gr/t.

At depth of 53– 55.5m, at the north-eastern flank, the vein zone is stripped by drill hole #15, where horizontal thickness makes 1.0m, the gold grade makes 7.5gr/t and silver—7.2gr/t.

Vein zone #5/2 is located 5–50m north-east of vein zone # 5/1 and it is the poorly explored one in vein zone #5, since it is covered by a thick stream of acid lavas in the central part.

At surface, vein zone #5/2 is stripped by three clearings, where the vein thickness makes 0.6, 1.0 and 0.7m. The total traced length of the vein zone makes 1100 м. It has a north-eastern strike with south-western dip at angles of $65 – 80^0$.

The vein zone is represented by a quartz-carbonate mass with impregnation of pyrite and galenite.

The gold grade makes 8.8, 7.2 and 8.7gr/t, while silver—8.8, 9.7 and 10.5gr/t, respectively.

At the north-eastern flank, at interval from 52.4–55.3m, the vein zone is stripped by drill hole #16, where it is represented by a quartz-chalcedony mass with impregnation of pyrite, galenite and, rarer, by chalcopyrite.

The average gold grade makes 3.4gr/t, silver—1.3gr/t, and horizontal thickness makes 1.2m.

Vein zone # 5/3 passes 10-30m north-east of vein zone #5/2, it is explored on surface by 11 workings for around 1170m.

The vein zone is comprised of quartz, carbonate, chalcedonic quartz, ocherized and kaolinized mass with impregnated mineralization of pyrite, galenite and, rarer, chalcopyrite. The vein zone has south-eastern dip at angles of 60 – 80^0. The gold grade varies from 1.6 to 11.7gr/t (average—5.7 gr/t), silver—from 5.9 to 19.2gr/t (average—10.5gr/t), while its thickness is from 0.4 to 4.0m (average—2.0m.)

At a depth of 47–49.4m (at the north-eastern flank) the vein zone is intersected by drill hole #17, where its horizontal thickness makes 1.0m and the gold grade makes 5.5gr/t, silver—8.6gr/t.

Vein zone #5/4 has an arched form and passes by the north-eastern contact of vein zone #5/3. At surface, it is traced by the strike for around 1400m by trenches and clearings. According to their data, it is represented by a quartz-carbonate or quartz-chalcedony vein with thickness from 0.6 to 4.0m (average—1.8m), the gold grades are from 1.0 to 17.4gr/t, silver—from 2.2 to 20.2gr/t. The vein has south-eastern dip at angles of 70 – 85^0.

The provided data for vein zone #5 is subject to verification by drill holes of inclined drilling.

At the north-eastern flank, the vein zone is intersected by drill hole #18 at interval of 52–54.4m, where the gold grade makes 7.4gr/t, silver—14.2gr/t. It is represented by a quartz-chalcedony mass with impregnated mineralization of pyrite, galenite and chalcopyrite.

Vein zone #17 is located 20–50m north-west of vein zone #11, in the lying-contact of the common zone of hydro-thermally altered rocks. It is represented by a quartz vein with thickness of 0.2–0.5m with nested and impregnated mineralization of pyrite, chalcopyrite and polymetals with high grades of gold and silver (from 2 to 28gr/t; 12.55gr/t on an average), by which it differs from other veins of the area.

Ancient workings—trenches are revealed along the entire length of the vein zone (around 1100m), their total length makes around 400m.

The vein has south-eastern dip at angles of $70\text{-}85^0$.

The south-eastern zone is located at the deposit's flank of the same name, 1.0km south of vein zone #5. More than 10 veins and zones are stripped in clearing # 9 at interval from 0–140m, they are represented by quartz-carbonate veins with impregnation of pyrite and galenite. Four of them are characterized by gold grades from 2.6 to 12.6gr/t, with total thickness of 9.5m.

In north-eastern direction, the zone outcrops in the gorge of tributary of Marmarik river, where two quartz veins are sampled. In the vein with thickness of 3m the grade of gold makes 8.1gr/t and silver—10.2gr/t, while in the vein with thickness of 0.3m the gold grade makes 13.0gr/t, silver—15.0gr/t.

According to data of decoding of aerophotos, the south-eastern vein zone trends in north-eastern direction towards geo-chemical anomalies of the basin of Talma river, and in south-western direction it outcrops in Demidzor ravine, where quartz veins with total thickness of around 10m and occurring with azimuth of 140^0, $<40^0$ outcrop in the zone of hydro-thermally altered rocks with thickness of 100m. Carbonic acid and mineral water of small discharge come out from the zone's joint near the river's edge. The veins are observed on surface continuously for 70m and disappear under overburden. The vein filling is comprised of macrocrystalline quartz with interstices of regular crystallographic contours, apparently, at the place of weathered ankerite. Some veins give bulges with thickness of 30cm, they narrow and extend into lines.

The mentioned vein zone is identical to the zone of Tukhmanuk area by its morphological features, thickness and elements of strike, but it differs only by a slightly flat dip to south-east.

The total traced length of the south-eastern zone makes more than 4km.

The other gold-bearing mineralized zones and veins of the area were explored only by singular workings at the stage of prospecting works, and they were not estimated during summarizing of the collected material. The mineralized zone's parameters have the following values on an average: gold grade—4.9gr/t, silver—6.3gr/t, thickness—6.4m.

Vein zone #2 is located north-west of vein zone #1. It is stripped and explored at the central part by clearings and exploitation benches. Besides, it is explored in the shaft of adit #2, at the level of 2380m, and in the shaft of adit #5, at the level of 2307m, it is stripped by drill hole #9 at depth of 68.5–70m, where the gold grade makes 15.6gr/t, silver—159.0gr/t.

The explored length of the vein on surface makes 1100m by strike.

The vein zone is represented by hydro-thermally strongly altered, ocherous rocks with quartz-sulphide stringers, and, according to data of drill holes #2 and 5, the vein is represented at depth by hydro-thermally intensively altered rocks intersected by a system of quartz-sulphide stringers. The zone's contacts with enclosing rocks are clear and tectonic, with black clay gouge.

According to the results of analyses of samples from surface and at depth, the zone is characterized by a low gold grade—from traces to 2.4gr/t, while the grade of silver is from 5.0 to 22.6gr/t. It differs from the other veins by the phenomenon that here the silver grade is much higher than the gold grade.

Vein zone #7 is located 340m south-east of vein zone #1. It occurs in quartz porphyries. It is explored on surface by four trenches; it trends for around 600m by strike with thickness of 1.6m.

It is a zone of rather broken kaolinized rocks intersected by numerous thin quartz-sulphide stringers. The thickness of these stringers is from 5-7m, the average gold grade makes 4.0gr/t and silver—2.5 – 32.0gr/t.

Vein zone #8 is located 25m south-east of zone #7. It is explored on surface by four trenches for the distance of 160m. The zone is represented by broken, kaolinized, chloritized rocks intersected by quartz-sulphide stringers with thickness of 2 – 8cm. The gold grade is from 0.4 to 5.2gr/t and silver—4.0–22.6gr/t.

Vein zone # 11 is located 250m north-west of vein zone #1. It is traced by the strike for around 700m by six trenches. The zone is represented by hydro-thermally altered, mineralized, silicificated mass. The average gold grade makes 3.5gr/t and silver—7.6–10.0gr/t, while the thickness makes 0.7m.

Vein zone # 12 is traced on surface by alpine workings (8 sections) for 1150m. It is represented by hydro-thermally intensively altered, pyritized, kaolinized, fractured rocks with stringers of quartz-sulphide minerals. The contacts with enclosing rocks are distinct and tectonic. The dip's azimuth makes 135^0, angle—60–65^0. The zone's thickness varies from 0.5 to 1.7m with average gold grade of 3.5gr/t, silver—20gr/t. The thickness of circum-vein altered rocks varies from 0.5–2.0m. The alteration is expressed by silicification, chloritization, epidotization and pyritization.

Vein zone # 13 is explored on surface along the strike by eight surface workings for 1300m. It is a zone of broken, schistose, beresitized rocks intersected by small quartz-sulphide stringers. Pyrite, chalcopyrite and, rarer, galenite participate in the ores' composition. The results of silver grades reach 300gr/t, while the average gold grade makes 3.5 г/т.

The zone has north-eastern strike with south-eastern dip at azimuth of 350^0 and angles—55–60^0, the thickness varies from 0.4-1.2, making 1.0m on an average. The zone's contacts are distinct and tectonic with black clay gouge.

3. Material Composition and Technological Features of Ores

The mineralogical study (2008) of the ore was implemented on two samples. The sulphide sample is marked MT-1 and the oxide one—MT-2. Below are the description of the ore samples and mineral composition.

MT-1 Sample is described below—it is of light grey color, very brecciated with poor stringer-impregnation mineralization.

Sericitic quartzite is the ore-containing rock. The rock is crossed by quartz stringers, which contain ore minerals. The original-magmatic minerals have not been preserved. The rock is rather cataclased. The quartz-ore stringers cement small fractions of sericitic quartzites.

The grade of sulphides in the sample is around 5-6%, hydroxides of iron make 2%.

Pyrite prevails, while arsenopyrite, blende and galenite are present in a subordinate quantity, chalcopyrite and weathered ores are observed as single grains. Hydroxides of iron are noted in small numbers.

Below is the description of minerals.

Pyrite prevails, it is observed as xenomorphic aggregates, pnenocrysts of idiomorphic crystals and fractures of shattered grains of up to 7mm (pic. 1.) Pyrite is rather cataclased, structures of crushing and crossing of aggregates of pyrite by mass of stringers of blende, galenite and chalcopyrite are observed. Pyrite closely associates with arsenopyrite, making joints with it. Streaky micro-textures of quartz-pyrite-blende-arsenopyrite composition are noted, where pyrite and arsenopyrite are present as separate crystals or shattered fractures cemented by blende or quartz. Sizes vary from 2-3mm to 0.005m and smaller.

Arsenopyrite is observed as xenomorphic aggregates in joints with pyrite with size of up to 2-3mm and separate rhombs with size of up to 0.1mm and smaller (pic. 2.)

Blende makes large, up to 2-3mm, xenomorphic separations in interstices of crystals of quartz, it closely associates with galenite, chalcopyrite and weathered ore. It penetrates by fractures into pyrite and pyrite-arsenopyrite aggregates. It often contains "emulsion" impregnation of chalcopyrite (pic. 3.)

Galenite is represented both by crystal aggregates with size of up to 2-3mm and thin stringers and impregnations in pyrite and blende. It often substitutes shattered grains of pyrite, it is observed in close association with blende, chalcopyrite and weathered ores (pic. 4.)

Chalcopyrite is observed as small, rare xenomorphic separations with size of up to 0.05mm in close association with blende, weathered ore and galenite. Smallest powder-like and thread-like bodies of chalcopyrite with sizes up to the resolution of microscope make "emulsion" impregnation in blende.

Weathered ore is represented by *tennantite*, makes small rare xenomorphic separations, as well as thin stringers, it closely associates with galenite, chalcopyrite and blende.

Sample MT-2 is represented by rather brecciated, friable, completely oxidized ore. The rock is intersected by stringers of quartz and oxide ore minerals. Limonites are various: blooms, cavity fillings, entire accumulations, scattered separations in rock and friable ochre are observed. Prevailing in the ore are coloring, ingrained hydroxides of iron associated with face of fissures and walls of voids in rock.

The ore-containing rock is rather ferruginized by quartz-sericitic metasomatite. In some places, relicts of primary rock with typical cryptocrystalline-xenomorphic structure and quartz-feldspar composition of basic mass are preserved, which is substituted by secondary quartz, chlorite, sericite and carbonate. The grade of sulphides in the sample makes less than 0.5%, hydroxides of iron make 12-13%.

The studied technological samples correspond by the gold grade to the ores received at the processing plant. An efficient analysis of forms of gold placement and distribution of precious metals by classes of size was implemented with ore samples (tables 3.1 and 3.2).

Table 3.1

Results of fire assay of ores of samples under study

Batch/weight	Grade, gr/t							
	MT-1		**MT-2**		**MT-3**		**MT-4**	
	Au	Ag	Au	Ag	Au	Ag	Au	Ag

Batch/weight 1	1.13	18.07	2.53	8.07	12.68	59.72	4.67	10.93
Batch/weight 2	1.18	19.32	2.51	11.89	11.82	61.38	5.38	11.02
Batch/weight 3	1.03	13.37	2.75	9.65				
Average:	**1.11**	**16.92**	**2.60**	**9.87**	**12.25**	**60.55**	**5.03**	**10.98**

Table 3.2

Chemical Composition of ores of technological samples

Sample	Grade, %								
	Cu	*Fe*	*S*	*Pb*	*Zn*	*As*	*Sb*	*Bi*	*Se*
MT-1	0.024	3.250	2.576	0.27	0.29	0.19	0.0005	0.0025	Is not revealed
MT -2	0.016	8.330	0.267	0.056	0.055	0.52	0.0004	Is not revealed	Is not revealed
MT -3	0.032	4.26	4.60	1.56	0.45	0.049	0.003	0.009	Is not revealed
MT -4	0.013	7.68	0.36	0.15	0.053	0.70	0.002	Is not revealed	Is not revealed

Table 3.3

Quantitative feature of minerals in ore samples, %.

Sample	*Pyrite*	*Blende*	*Arsenopyrite*	*Galenite*	*Chalcopyrite*	*Hydroxides of iron*
MT -1	4.0-4.5	0.4-0.5	0.4	0.3	sing. grains	2.0
MT -2	0.3-0.5	sing. grains	sing. grains	sing. grains	sing. grains	12-13

Table 3.4

Silicate composition of technological samples

Sample	Grade, %							
	SiO_2	Al_2O_3	*CaO*	*MgO*	TiO_2	P_2O_5	Fe_2O_3	$nnn+H_2O$
MT-1	65.90	15.10	1.45	0.60	0.45	0.35	4.65	4.46
MT -2	58.10	15.76	1.23	0.95	1.00	0.85	11.91	6.52

Table 3.5

Phase composition of forms of placement of copper, iron and sulfur

Sample	Grade, %											
	Cu				*Fe*				*S*			
	total	*sulphide*	*oxide*	*% oxid.*	*total*	*Sulphid.*	*oxide+ pyrrhotine*	*% oxid.*	*total*	*sulphid.*	*sulphat.*	*% oxid.*
MT-1	**0.0241**	0.024	0.0001	0.41	**3.25**	2.22	1.03	31.69	**2.576**	2.52	0.056	2.17
MT -2	**0.016**	0.014	0.002	12.50	**8.33**	0.25	8.08	97.00	**0.267**	0.17	0.097	36.33

Table 3.6

Results of efficient analysis of forms of gold placement in ores of sample

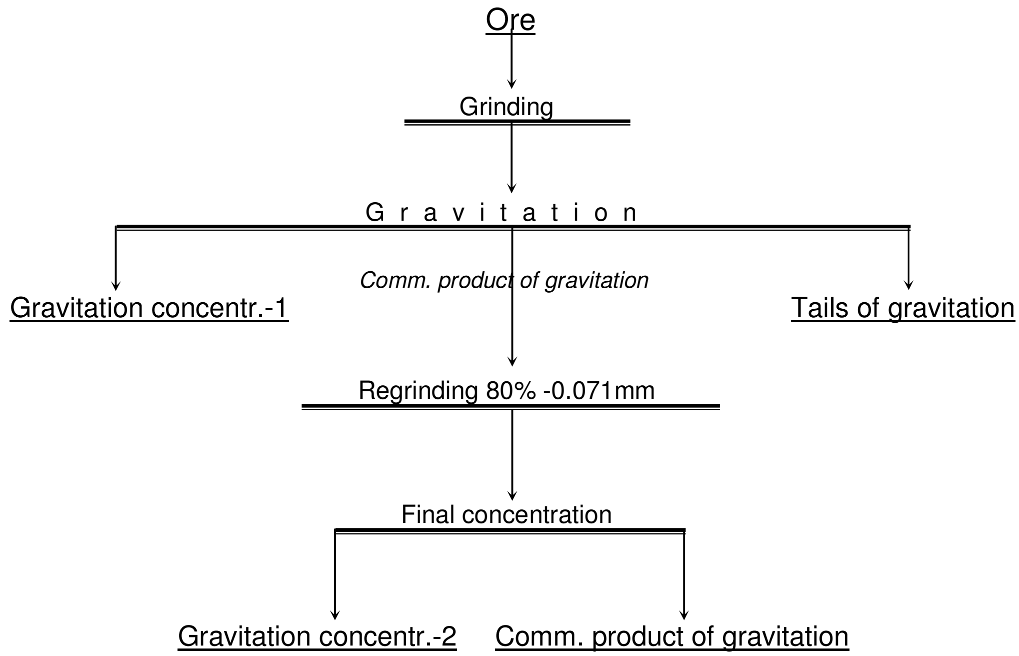
Sample	Forms of gold placement	Grade of Au, gr/t	Distribution of Au, %
MT-1	*"free"*	0.09	8.38
	in joints	0.42	37.72
	Total easy-to-cyanidation:	**0.51**	**46.11**
	"rusty"	0.01	0.90
	With sulphides	0.47	42.22
	With rock	0.12	10.78
	In initial sample:	1.11	100.0
MT-2	*"free"*	0.27	10.27
	in joints	1.99	76.64
	Total easy-to-cyanidation:	**2.26**	**86.91**
	"rusty"	0.10	3.85
	With sulphides	0.11	4.22
	With rock	0.13	5.02
	In initial sample:	2.60	100.0

Gravitation enrichment of the ores under study is implemented with different grinding fineness—80% -0.5mm and 80% -0.071mm, on shaking table SKO-0.5.

Table 3.6

Results of ores enrichment in case of different grinding fineness

Sample	Ore grinding fineness	Product of enrichment	Outcome, %	Grade, gr/t		Recovery, %	
				Au	Ag	Au	Ag
MT-1	80% -0.5mm	Gravitation concentrate	3.32	17.50	293.50	45.47	49.02
		Tails of gravitation	96.68	0.72	10.47	54.53	50.98
		Ore	100.0	1.28	19.86	100.0	100.0
	80% -0.071mm	Gravitation concentrate	2.78	24.60	329.02	58.48	49.40
		Tails of gravitation	97.22	0.50	9.65	41.52	50.60
		Ore	100.0	1.17	18.54	100.0	100.0
MT-2	80% -0.5mm	Gravitation concentrate	0.59	34.41	49.34	8.75	3.00
		Tails of gravitation	99.41	2.13	9.47	91.25	97.00
		Ore	100.0	2.32	9.71	100.0	100.0
	80% -0.071mm	Gravitation concentrate	0.74	39.75	57.75	9.99	4.05
		Tails of gravitation	99.26	2.67	10.20	90.01	95.95
		Ore	100.0	2.94	10.55	100.0	100.0



Pic.3.1. Scheme of implementation of experiments on ores' gravitation

During the enrichment of sulphide and oxide ores, which have high grades of precious metals, the gold and silver grades in gravitation concentrates and the gold recovery increase sharply.

Studies on flotation of ores were implemented to determine the optimal regime parameters of flotation enrichment.

Table 3.7

Conditions of experiments for determination of collector's optimal consumption

Process of enrichment	Time, min	Consumption, gr/t		
		Na2S (sample MT-2)	Pine oil	Xanthate
Grinding 65% -0.071mm		100		140/160/180
Flotation	20		80	
Total:		**100**	**80**	**140/160/180**

Table 3.8

Conditions of flotation experiment for determination of optimal grinding fineness of samples

Process of enrichment	Time, min	Consumption, gr/t		
		Na2S (sample MT-2)	Xanthate	Pine oil (samples MT-1/MT-2)
Grinding		100	120	
Flotation	20			60/80
Total:		**100**	**120**	**60/80**

Table *3.9*

Results of tails flotation of gravitation enrichment of low grade ores

Sample	Product of enrichment	Outcome, %	Grade, gr/t		Recovery, %	
			Au	*Ag*	*Au*	*Ag*
MT-1	Concentrate	1.35	30.00	500.06	52.97	45.36
	Commercial product-1	15.75	1.05	16.02	21.63	16.95
	Commercial product-2	2.80	1.50	34.15	5.49	6.42
	Total into prelim. concentrate:	**19.90**	**3.08**	**51.41**	**80.09**	**68.73**
	Tails of flotation	80.10	0.19	5.81	19.91	31.27
	Initial sample—tails of gravitation	100.0	0.76	14.88	100.0	100.0
MT-2	Concentrate	0.15	110.00	228.77	6.72	3.36
	Commercial product-1	13.85	3.84	11.36	21.67	15.41
	Commercial product-2	1.85	6.78	27.22	5.11	4.93
	Total into prelim. concentrate:	**15.85**	**5.19**	**15.27**	**33.50**	**23.70**
	Tails of flotation	84.15	1.94	9.26	66.50	76.30
	Initial sample—tails of gravitation	100.0	2.45	10.21	100.0	100.0
	Concentrate	1.30	40.00	198.25	34.15	25.03
	Commercial product-1	14.33	1.20	11.32	11.29	15.75

Mixture	Commercial product-2	3.93	2.10	26.84	5.42	10.24
	Total into prelim. concentrate:	**19.56**	**3.96**	**26.86**	**50.87**	**51.02**
	Tails of flotation	80.44	0.93	6.27	49.13	48.98
	Initial sample—tails of gravitation	100.0	1.52	10.30	100.0	100.0

The gold and silver grades in final concentrates of flotation made: for sulphide ores—54.8gr/t and 1146.3gr/t, respectively; for oxide ores—76.4gr/t and 330.0gr/t; for mixture's ores—60.5gr/t and 988.05gr/t.

Based on the studies' results, the following regime for flotation of mixture of low and high gold grade sulphide and oxide ores was developed and implemented:

- Ore grinding fineness–65% -0.071mm;
- Basic flotation duration–30min;
- Control flotation duration–30min;
- Preliminary concentrate's aeration duration–30min;
- Duration of concentrate's first refining–10min;
- Duration of the second refining–6min;
- Reagent regime,gr/t:

  - into grinding:

  sulfur natrium – 100

  butyl xanthogenate of natrium – 120

  - for the basic flotation:

  butyl xanthogenate of natrium – 0/20

  pine oil – 60/100

  - for the control flotation:

  butyl xanthogenate of natrium – 80

  pine oil – 40

  - for the aeration:

  lime – 1250/1500

  - for the first refining:

  lime – 250/0

The technological scheme of the operating plant includes crushing in a jaw crusher, two-stage grinding in ball mills—in an open cycle at the first stage of grinding with unloading in a sump, which is common with the mill of the second stage, and in a closed cycle at the second stage with hydrocyclone, sands of which are the feeding of the mill of the second stage grinding, while the hydrocyclone's discharge is the feeding of the gravitation unit (pic. 11.) The gravitation enrichment unit consists from the operation of the primary gravitation, which is implemented on two concentration tables SKO-22, from control operation of the gravitation tails of the primary gravitation on concentration table SKO-15, final concentration of commercial products of the primary gravitation on table SKO-15 and from final concentration of the primary gravitation concentrate on table SKO-7.5 with the return of the industrial product of final concentration into the hydrocyclone's sump.

Tails of gravitation enrichment are pumped into the intermediary thickener and after the thickening up to 35-40% of solid they go to the conditioner, the feeding unit of flotation enrichment, which consists from the operations of basic and control flotation. The control flotation's concentrate goes to the head of the basic flotation, while the basic flotation's concentrate goes for the aeration in a lime environment in two cells of flotator NF-2.8. The preliminary concentrate of flotation is sent for the first refining after the aeration, while the industrial product—into the basic operation's head. The industrial product of the second refining is returned to the head of the first refining, and the concentrate is sent to the concentrate's thickener, the thickened product of which goes to the drum vacuum-filter, the cake of which is the marketable flotation concentrate.

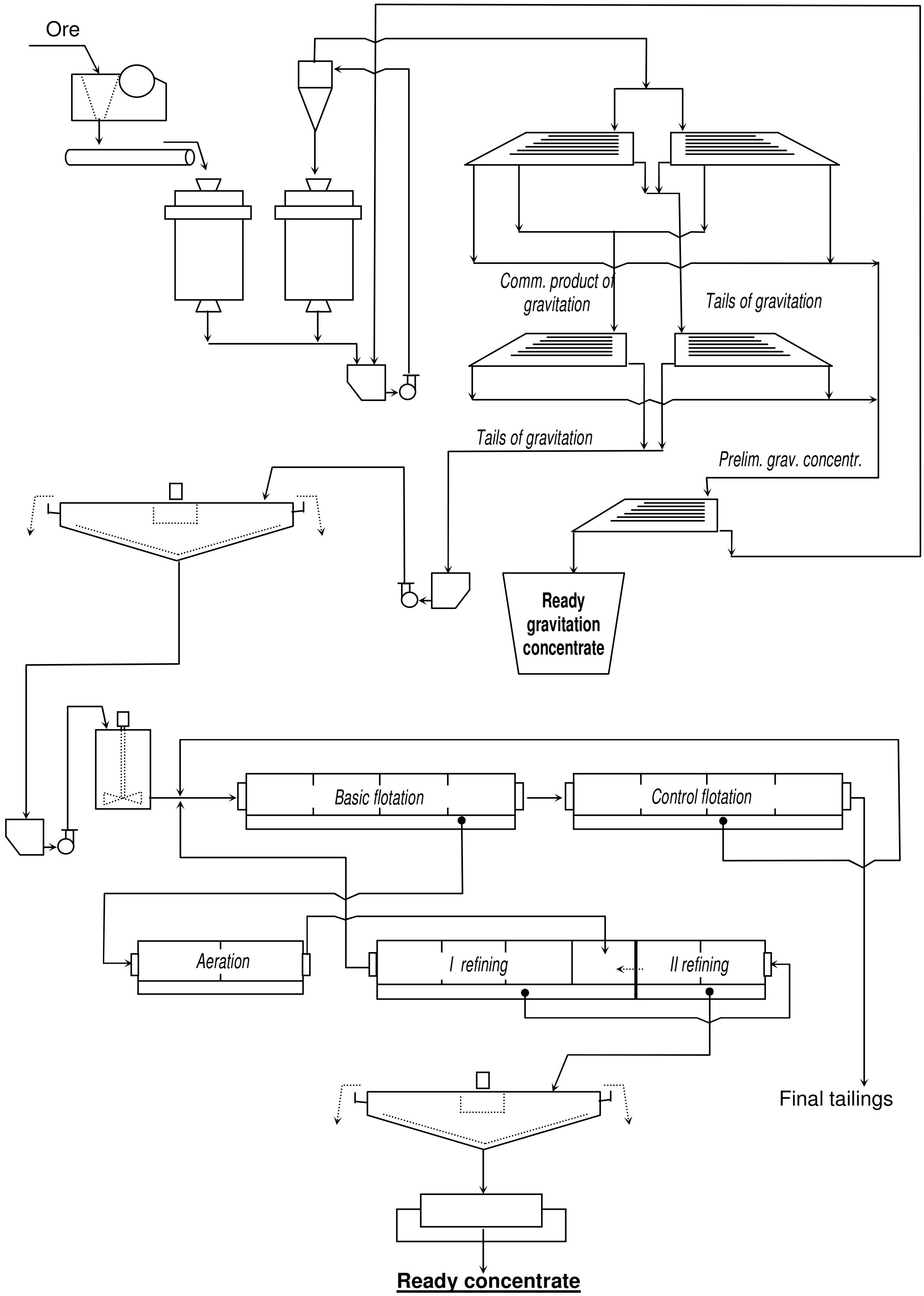


Рис.3.4. Operating scheme of the circuit of devices of the processing plant.

To secure the gravitation and flotation concentrates' quality, such scheme of gravitation is recommended, which includes preliminary gravitation on two concentration tables SKO-22 and one table SKO-15, the tails of which are united with industrial products and sent for flotation after thickening, and the concentrate—for refining on table SKO-7.5 with return of the industrial product of refining into the hydrocyclone's sump of the grinding unit.

The following conclusions have been made based on the mineralogical and technological laboratory analyses of Mirak-Tukhmanuk deposit's ores, which are characterized by different levels of oxidation:

- Sulphide and oxide gold-containing ores are received at the plant.
- The grade of "free" gold in poor ores is low, and the gold recovery into gravitation concentrates is secured due to recovery of gold-containing sulphides into concentrates.
- The gravitation enrichment of poor ores secures gold recovery of 10-25%.
- The gravitation enrichment of rich ores secures gold recovery of 48-82%.
- The flotation recovery of both rich and poor sulphide ores provides with the opportunity to recover up to 80% of gold.
- The flotation recovery of both rich and poor oxide ores provides with the opportunity to recover up to 55% of gold.
- From 68 to 79% of gold is recovered by the flotation of mixture of oxide and sulphide ores at a ratio of 1:1.
- The enrichment by the combined scheme secures total gold recovery of 91-98% in case of sulphide ores' processing, 40-79%—in case of oxide ores and 63-85%—in case of processing of the ores' mixture.
- Taking into consideration the high gold recovery from sulphide ores and the low recovery from oxide ores, it is recommended to implement the ores' recovery in mixture at a ratio of 2:1 of sulphide and oxide ores.

4. HYDRO-GEOLOGICAL AND ENGINEERING-GEOLOGICAL CHARACTERISTICS OF DEPOSIT

4.1. Hydro-geological characteristics

The deposit is located in the upper stream of Getuk river, above base level. The rocks comprising the deposit are dense, fractured and, basically, permeable. Quartz diorites, which occupy the basic part of the deposit's area, are the most widely distributed ones. Leucocratic granites and dyke rocks are less distributed. Rocks with significant permeability are widely distributed at inter-stream parts.

Rocks are broken by numerous splits, a part of which crop out and make ways for penetration of ground water to lower levels.

One of basic factors of ground water accumulation in splits is the infiltration of precipitation making 600mm in a year. The infiltration's level significantly depends on the relief's form and rock's composition. The deposit's region has a positive topographic form, it is covered by modern sediments and flora. The latter significantly hampers the processes of erosion and creates favorable conditions for the infiltration of precipitation. Besides, the significantly split relief creates conditions for quick water collection of precipitation into the rivet net, specifically during the spring snowmelt and pluvial period. A part of precipitation goes to surface flow, while the other part is infiltrated by splits into deep levels making ground and interstitial water, which outcrops in the form of short-term springs.

The alpine workings drifted at the deposit have stripped interstitial water with discharge fluctuation from drip to 2.5l/sec.

It was found out due to observations that basically water inflow decreases in them up to complete disappearance on 8^{th}-10^{th} day.

Ground water in alpine workings has almost similar physical features: they are clear, transparent, colorless with temperature fluctuation from 8 – 10^{0}C.

It is found out based on drilling data that the penetration of surface water into deep levels of the deposit takes place through the zone of altered, fissured and fractured rocks.

It shall be noted that incomparably bigger part of the deposit is comprised of andesites, andesite-dacites, which in their mass are permeable and contribute to the penetration of ground water into deeper levels.

This is proved by observations of preservation of circulating fluid of drill holes and persistence of its piezometric surface in the process of drilling.

Materials of hydro-geological study of the deposit indicate the following:

- Ground and underground water reaches the maximum discharge during the period of snowmelt. Since the start of summer, it gradually decreases to the minimum with insignificant increase in October-November;

- Due to comparison of water regime of northern and southern slopes of the gorge, it was found out that water has relatively permanent regime;

The inflow of interstitial water into the open pit area, which is located above the line/edge of Getuk river, is expected to be moderate. In case of lowering of the open pit's bottom below the level of Getuk river, water drainage will be implemented by pumping facilities.

Springs' water at the deposit's territory can be used for economic needs and drinking. Two groups are outlined among them, which have permanent discharge of around 4.5 – 5.0l/s with average temperature of 7-8^{0}C. The first one is located 1–1.5km south-east of the deposit, it satisfies the population's demands. The second group is located 3–3.5km west of the deposit and is used only during summer season.

Hydro-geological monitoring was implemented at the deposit's region, as a result of which it was found out that springs are fed by infiltration water with unsteady seasonal discharge.

Springs with relatively steady discharge with temperature of 7–8^{0}C are also revealed at the deposit's region due to hydro-geological observations. From the qualitative point of view, the springs are feebly hydro-carbonaceous, sweet and potable. Studies on chemistry of water of the deposit were implemented. Molybdenum, copper, bromine, iodine, lithium, strontium and gold grades were determined.

By their composition, waters of the deposit belong to the hydro-carbonaceous—calcium type and, partially, to hydro-carbonaceous—sodium type. During the detail subdivision of water, four types of water are outlined (by Kurlov's formula), taking into consideration the anions and cations grade above 10%.

Water of hydro-carbonaceous—calcium composition is considered among the first type, it has a rather wide distribution at the deposit; water of hydro-carbonaceous—calcium—sodium composition is considered among the second type, it is less distributed; water of hydro-carbonaceous—sodium—calcium composition is considered among the third type, it is even rarer; and water of hydro-carbonaceous—calcium—magnesium composition is placed among the fourth type, which is observed basically in a skarn belt.

4.2. Engineering-Geological Characteristics

Geological formations at the deposit's territory are divided into two complexes:

1. Complex of surface friable-fragmental formations;
2. Complex of rocks of chain warp.

Soils of the complex of friable-fragmental formations are represented at the deposit's territory by three genetic types—artificial soils, alluvial-proluvial, eluvial-dealluvial sediments.

- The artificial soils have rather local distribution in the form of separate piles near adits' entrance and they constitute a coarse material, which consists of fragments and blocks of bedrock.
- The alluvial-proluvial sediments are developed in flood-lands of Getuk river.

  They are represented by boulder-pebbly, pebble-gravelly formations with sand, sabulous-loamy fillers up to 35-45%. The thickness of these sediments in flood-lands of Getuk river reaches 2–8m.

These are water-bearing sediments and the level of underflow water is within 0.6–0.7m.

- The eluvial-dealluvial formations are basically developed on gorges' slopes. They are represented by loamy soil, sabulous and loamy rocks with inclusions of crushed rocks and gruss up to 30%.
    - The physical-mechanical features of these formations are provided below by averaged figures.

Table 4.1

##	Name of figure, notation and dimension	Values of figures		
		loamy soil	sandy loam	clay
1	2	3	4	5
1	Density of mineral part d_0 kg/dm^3	2.62	2.58	2.70
2	Density d kg/dm^3	1.50	1.50	1.65
3	Hygroscopic moisture W %	2.05	1.33	2.51
4	Plasticity index	11.8	4.40	21.0
5	Filtration factor F_f m/day	0.058	0.88	0.010

The rocks of chain warp are stripped by alpine workings and drill holes. They are represented by quartz diorites, leucocratic granites and, partially, by skarns and skarn rocks, dyke formations. These rocks are altered to different level, they are fissured.

The factor of fissure void is within 0.20–0.98% with fissuring module of 0.007–0.010.

The basic ore-containing quartz diorites are characterized by the following figures.

Table 4.2

##	Name of figure, notation and dimension	Range of variation	
		Maximum	Minimum
1	2	3	4
1	Density of mineral part, kg/dm^3	2.95	2.75
2	Density, kg/dm^3	2.89	2.65
3	Porosity, %	5.89	1.08
4	Water absorption,%	0.61	0.04
5	Softening factor	0.45	0.97
6	Ultimate strength, kg/cm^2 a) dry sample	2315	650
	б) water-saturated sample	1766	613

4.3. Exogenous geological processes

Geodynamic processes, which are related to the effect of surface water (mudflow, ground erosion, sheet erosion), as well as processes conditioned by the effect of gravity when a movement takes place together with loss of contact with a slope (collapses, slide-rocks) are developed at the deposit's territory.

Mudflows can be the most dangerous ones out of the aforementioned geodynamic processes in flood-lands of Getuk river. The most important factor, which determines the formation of mudflows, is the accumulation of friable-fragmental material within the catchment basin or its part, which is available for washout and erosion by surface water.

The steep slope of these rivers' catchment basin and precipitation's storm rainfall nature also contribute to mudflows' occurrence.

The possibility of mudflows shall be taken into consideration during the deposit's designing and mining.

5. Analysis of materials on deposit's exploration

5.1. Extent of deposit's exploration

Central area of Tukhmanuk deposit occupies around 10–12% of the ore field's territory, which is located on northern and north-eastern slopes of Tukhmanuk mountain. Earlier, estimation works were implemented at the area, which included geochemical, geophysical surveys, as a result of which a series of quartz-sulphide veins was revealed.

Almost all these bodies are stripped by surface alpine workings (trenches, bore-pits and clearings) and they are partially traced by the strike.

Veins #1 and 15, by which the calculation of reserves was implemented, are explored on surface and at depth—by alpine workings of adit type and drill holes of core drilling, they were stripped also by a pilot open pit.

Vein #1 is traced on surface by 18 surface workings for a distance of 1040m, within height marks of 2480-2330m. The density of intersections in eastern part of the ore body makes 20-40m, while in western part—60-100m.

The ore body is stripped at depth by adits #2 (2380m) and #5 (2310m), 13 drill holes–up to the absolute level of 2190m, as well as by the pilot open pit at the level of 2295m.

The distance between the drill holes is from 30-110m.

The ore body is continuously traced by underground workings and at the pit for a distance of 100m.

Vein #15 is traced on surface by 19 workings for a distance of 1100m, within height marks of 2520-2330m, the density of intersections at surface varies from 10 to 80m.

The ore body is stripped at depth by adit #5 (2310m), 16 drill holes—up to the level of 2200m, as well as by the pilot open pit—at the level of 2295m.

The distance between the drill holes is from 30 to 110m.

The ore body is continuously traced by underground workings for a distance of 400m.

Core samples were taken from the drill holes. In case of drilling diameter of 110mm and more, half core, which was split along its long axis, was sampled; while in case of smaller drilling diameters, the entire core was sampled.

After relevant treatment, the samples were subjected to fire and, partially, AAS assays for gold and silver.

Group samples were prepared from duplicate ordinary samples, and the grades of associated useful components were determined in them [group samples]: lead, zinc, and copper, as well as of harmful components—arsenic and stibium.

Above 200 samples were sampled and assayed for vein #1 and its selvages, 71 of them took part in the calculation; above 350 samples—for vein #15 (147 samples took part in the reserves calculation.)

The work [2] provides grounds of conditions accepted for the reserves calculation.

Gold is the basic useful component among the deposit's ores. The recoverable value of silver makes 2.0 – 3.0 %. The economic significance of other useful components is problematic.

The basic limits of the quality of ores included in the contour of balance reserves are as follows: the minimum average gold grade in the estimated block (commercial minimum), the cutoff gold grade in samples during contouring by thickness of an ore body without clear geological borders, as well as the minimum average gold grade in extreme sections during contouring of an ore body by strike.

According to 2003 TEG, the minimum average gold grade is determined to make 1.5gr/t Au in a sample; the minimum average gold grade in extreme sections is accepted to be 2.5gr/t.

The minimum average gold grade in the estimated block is determined by direct technical-economic calculations and makes 4.7gr/t, while in simultaneously stripped blocks neighboring with the balance reserves—4.0gr/t.

The final depth, which was limited to the level of 2150m, of the balance reserves' calculation was another parameter of the conditions.

This parameter was determined based on a scheme, which provided with the opportunity to implement adit stripping of explored and preliminarily estimated reserves of the deposit.

The reserves' calculation is implemented by the method of geological blocks contoured at longitudinal vertical projections of ore bodies.

The estimated blocks are outlined in compliance with the extent of their exploration (grid density of observations) with consideration of placement of adit levels and geological elements under observation—contacts of ore enclosing strata and tectonic faults.

The reserves referred to C_1 category are limited to almost boundaries of the internal contour. The grid density of exploration workings makes 20.0–60.0m here.

Extrapolation to the depth of 70.0–100.0m is accepted during contouring of reserves referred to C_2 category.

The economic estimation of resources of vein #1 (2003) is characterized by the following figures:

Table 5.1

		C_1	C_2	$C_1 + C_2$
1	Ore, thous. t	83.7	416.1	499.8
2	Gold, kg	457.0	2252.5	2709.5
3	Silver, t	2.3	10.6	12.9

The ratio of C_1 and C_2 categories is as follows, %:

Table 5.2

		C_1	C_2
1	Ore	16.7	83.3
2	Gold	16.8	83.2
3	Silver	17.8	82.2

GKZ reserves are determined for the vein by C_1 + C_2 categories at the following quantities:

Table 5.3

		C_1	C_2	$C_1 + C_2$
1	Ore, thous. t	263.7	495.3	759.0
2	Gold, kg	2185.1	3112.7	5597.8
3	Silver, t	16.6	15.2	31.8

The reserves’ ratio by categories is as follows, %:

Table 5.4

		C_1	C_2
1	Ore	34.7	65.3
2	Gold	41.2	58.8
3	Silver	52.2	47.8

The ratio of confirmed reserves for the two veins by categories is as follows:

Table 5.5.

Vein	Reserve category	Ratio of explored reserves,%	
		For ore	For gold
Vein # 1	C_1	16.74	16.89
	C_2	83.26	83.11
Vein # 15	C_1	34.79	41.24
	C_2	65.21	58.76
Average	C_1	27.63	32.99
	C_2	72.37	67.01

It becomes evident from the table that C2 category reserves exceed C1 category reserves by 2.6 times by ore and 2 times by gold.

Earlier, under the planned economy's conditions, state investments for economic development of deposits were allotted in case of achievement of a certain ratio of categories reserves. Specifically, for deposits of III group of complexity of geological structure, to which Tukhmanuk gold deposit is referred, a ratio of 80% to 20% of C_1:C_2 reserves was required for the allotment of state capital investments for mining enterprise's construction. Nowadays, such requirements do not function for market economy, since the issue of investments is decided by an investor himself/herself. At the same time, it should be noted that the experience of a great number of exploited deposits indicates that such regulation of reserves' ratio secures normal implementation of mining works and it may serve as a guideline for the estimation of extent of investments' risk.

The provided figures of reserves indicate that the deposit was not supplementary explored and it is characterized by low self-descriptiveness of the initial data, primarily, this refers to the quality of drilling works.

Central Area of Tukhmanuk deposit occupies a territory of around 4km^2 and is located at height marks of 2100-2760m. After the deposit's transfer to GGM, supplementary exploration of the deposit was implemented through 92 drill holes of core drilling with total metreage of 13342m, including 70 drill holes drilled within the contours of comparison. The quality of drilling of the last period, which was determined by the outcome and integrity of core, is high, it reaches 95% and more on an average, the grid density of drill holes is around 30*30m. Core samples were sampled from each meter of drilling deeper; they were sawed by diamond disk along the long axis. Half of it was marked and stored as a duplicate; the other half was subjected to treatment up to the analytical weight/sub-sample. The samples were subjected to fire assay for determination of gold and silver grades.

Drill holes were drilled in hanging wall of the hydro-thermal zone into north-western bearings (310 - 350^0), basically, with dip angles of 55 - 65^0. The drill holes are measured, the core material and documentation are completely preserved. According to data of down-hole surveys, the projected route of drill holes is almost (up to1-2^0) preserved.

258 samples were assayed at the laboratory of Mining Metallurgical Institute by a combined method: successively by fire and AAS assays of the same sample for 31 dill holes, 704 samples were assayed by Analytic laboratory of the Ministry of Environment, which, under the ROA Government's decision, is recognized to be a control one. The comparison of laboratories' data showed satisfactory precision of analyses without systematic inaccuracy. Besides, the analyses' quality was controlled by SOS (Canadian standards) with deviations not exceeding the admissible one.

5.2. Comparison of exploration data with results of exploitation exploration

The comparison of exploration data with exploitation exploration was implemented to reveal the reasons of established discrepancies and updating the method of exploration and reserves calculation. The re-estimation of reserves of ore veins #1 and 15 by results of supplementary works was implemented with consideration of all workings used in the reserves calculation (2003), of calculation parameters and other figures without their change. Besides, it is noted for future that C_2 reserves shall be contoured more discreetly (factually, C_2 makes more than 72% of ore and 67% of gold), since they are taken into account in the project on mining of the deposit, determination of annual production capacity of the mine, salable production, volume of investments and cash flow. Taking into consideration these conditions, the contouring of balance reserves with the application of interpolation and extrapolation methods shall be implemented reasonably. The exploitation exploration was implemented from 2005–2007 basically through drilling of 92 drill holes by a grid of around 30*30m with total metreage of 13342m, including drill holes within the borders of comparison—65, and together with drill holes drilled earlier—99. The comparison is implemented only within contours of C_1.

Data of drill holes drilled before 2003 is accepted without corrections.

The reserves' calculation for veins #1 and 15 is provided in table 5.6.

Due to analyses of results of exploration and supplementary exploration, the reasons of revealed discrepancies in reserves are established, which are conditioned by the following:

- Insufficient extent of exploration of the deposit and, as a consequence, wrong interpretation of ore bodies' forms, figures of mineralization quality;
- Technical inaccuracy of initial data;

Interpolation (analogy) error, which in itself is inevitable during all stages of deposit's exploration. The error figure can be minimized through increase of the density of exploration works up to the quantities securing the required accuracy for contouring and estimation of reserves. The drill holes' grid, which is accepted at the deposit—30*30m, is a standard for comparison with the exploration data.

The analysis of the grid density of drill holes showed that, for the purposes of a certain estimation of reserves in suspension circuit in case of a steep dip of ore bodies, the accepted extrapolation depth shall be equal to the height of no more than 2 levels of exploration to avoid negative consequences of a wrong decision.

Ore body	Name of estimated block and reserves category	Area /S/m^2	Thickness /m/m	Average grade /C/ gr/t		Volume /V/m^3	Volume weight /D/m^3	Ore reserves /Q/ thous. t	Metal reserves /P/	
				Au	Ag				Au, kg	Ag, t
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Vein #1	1-C_1	29356	1.1	3.87	17.59	32291.6	2.85	92.0	356.0	1.6
	2-C_2	51208	1.2	2.90	8.10	61449.6		175.1	507.8	1.4
	3-C_2	39640	1.0	5.16	24.98	39640.0		113.0	582.9	2.8
	4-C_2	31248	1.3	5.52	25.22	40622.4		115.8	639.1	2.9
	Total C_1			3.87	17.59			92.0	356.0	1.6
	Total C_2			4.28	17.58			403.9	1729.8	7.1
	Total C_1+ C_2			4.21	17.58			495.9	2085.8	8.7
Vein # 15										
	1 - C_1	31088	1.4	4.50	27.82	43523.2	2.85	124.0	558.2	3.4
	2 - C_1	24164	1.1	5.76	59.29	26580.4		75.8	436.3	4.5
	3 - C_1	13288	1.1	4.72	11.34	14616.8		41.7	196.6	0.4
	Total C_1			4.93	34.37			241.5	1191.1	8.3
	4 - C_2	28392	1.6	2.65	6.57	45427.2		129.5	343.1	0.9
	5 - C_2	14284	1.3	4.21	13.25	18569.2		52.9	222.8	0.7
	6 - C_2	44848	1.0	5.17	20.81	44848.0		127.8	660.8	2.7
	7 - C_2	24224	1.0	4.81	19.15	24224.0		69.0	332.1	1.3
	Total C_2			4.11	14.77			379.2	1558.8	5.6
	Total C_1+ C_2			4.43	22.39			620.7	2749.9	13.9
Veins #1 and 15										
	Total C_1			4.64	29.68			333.5	1547.1	9.9
	Total C_2			4.20	16.22			783.1	3288.6	12.7
	Total C_1+ C_2			4.33	20.24			1116.6	4835.7	22.6

Table 5.7.

Statistical analysis of gold grades of samples from veins within borders of comparison

Class of grade, gr/t	Mean value, gr/t	Number of samples		Product		Frequency /probability/,%	
		of given class	Increasing	By class	Increasing	By class	Increasing
1	2	3	4	5	6	7	8
up to 1	0.6	30	30	18	18	2.4	2.4
1-4	2.5	78	108	195	213	25.7	28.1
4-8	6.0	41	149	246	459	32.4	60.5
8-12	10.0	19	168	190	649	25.0	85.5
12-16	14	4	172	56	705	7.4	92.9
16-20	18	3	175	54	759	7.1	100

The average statistical gold grade within contours of comparison makes 4.34gr/t.

The modal value of gold is 2.5gr/t (is contained in 44.6% of samples from the total aggregate.) The average gold grade in reserves of vein mass has coincided with its statistical value.

We would like to note that the analysis and estimation of reserves by the method of statistical modeling is widely applied in advanced mining countries.

The comparison of exploration data (2003) and exploitation exploration comes to the following:

1. The results of comparison indicated gold grade's divergence within the same contours of comparison, the basic reason of comparison for C_1 category reserves is the insufficient grid density of

exploration workings (intersections.) Inaccuracies of technical type were revealed and corrected.

2. The established deviations are characterized by the following values:
ore reserves—11.9 %, including C_1 category—5.2%;
gold reserves—39.6%, including C_1 category—41.4%

The reserves of veins #1 and # 15 of Central area of Tukhmanuk deposit are estimated as follows:

C_1 category:
- ore reserves - 0.33mln t
- gold reserves - 1547.1kg
- silver reserves - 9.9t

C_2 category:
- ore reserves - 0.78mln t
- gold reserves - 3288.6kg
- silver reserves - 12.7t

Total ore reserves in $C_1 + C_2$ categories:
- ore reserves - 1.11mln t
- gold reserves - 4835.7kg
- silver reserves - 22.6t

The discrepancies revealed during the elaboration of this TEG have no fundamental importance and we consider the provided figures to be a conditional definition of the optimal grid density of exploration drill holes.

5.3. Statistical analysis of initial information

Statistical analysis is implemented to reveal the following parameters of mineralization massif:

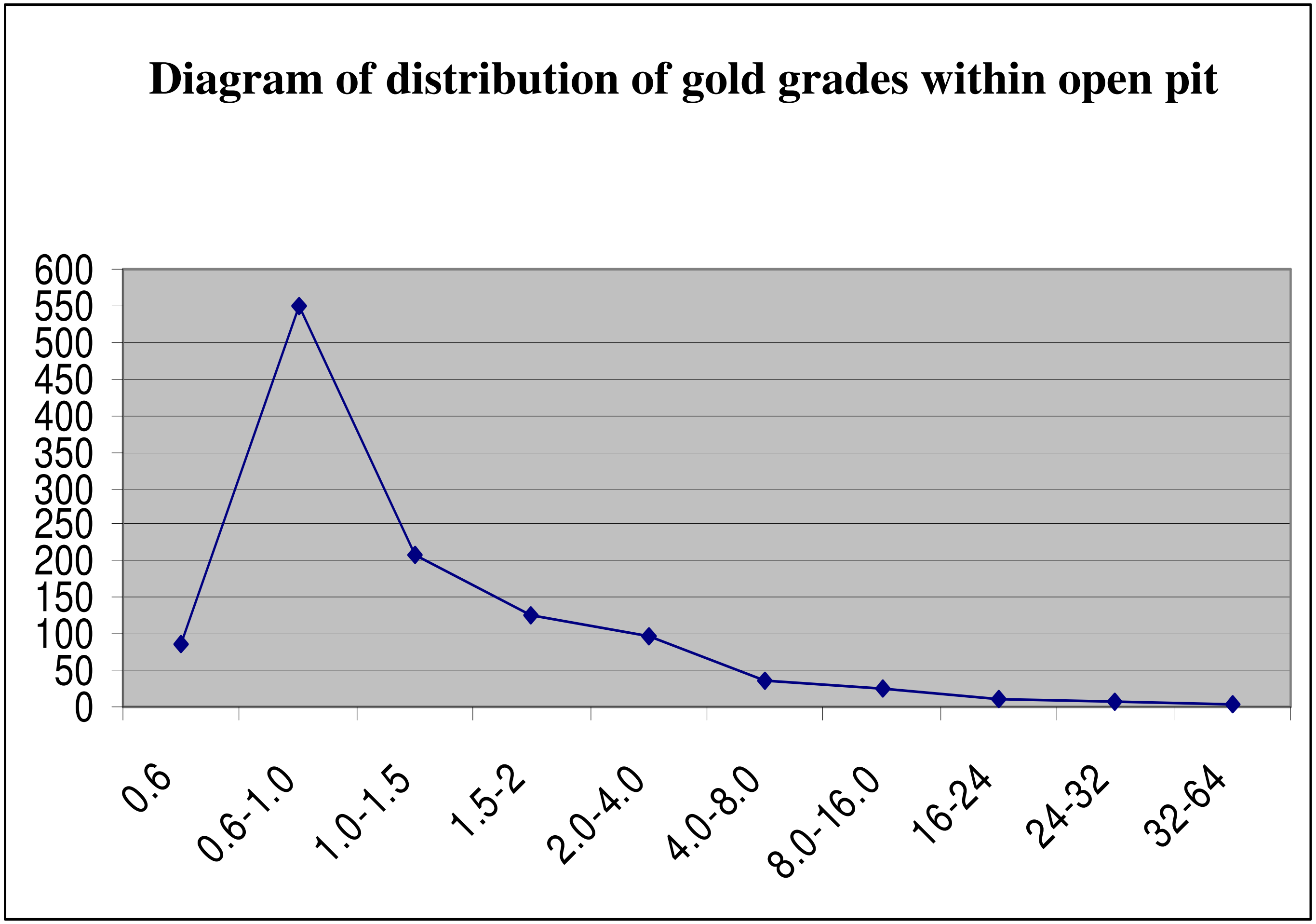
- Determination of the feature and rule of distribution of gold mineralization in deposit's ores;
- Revelation of the field of occurrence of hurricane grades with confidentiality not less than 0.90;
- Correlability of data of statistical analysis with the results of the preliminary calculation of reserves.

The model of gold grade distribution in the studied aggregate was constructed by 2293 samples from workings and drill holes. The results of samples are brought to 10 classes by gold grades and provided in table 5.8, as well as linear reserve's graphical construction is implemented. As one can see on the picture, the gold grades' distribution in ores of the deposit is characterized by a sharp asymmetry, which is typical for gold deposits, and logarithmically normal type. The statistical distribution's check-up is implemented on a probability paper at logarithmical scale. The picture provides a diagram of cumulative gold distribution within the constructed open pit, where the upper limit of normal gold grade (norm) in a sample makes 24gr/t with confidentiality of 0.90.

Gold grade distribution in linear reserves

Table 5.8

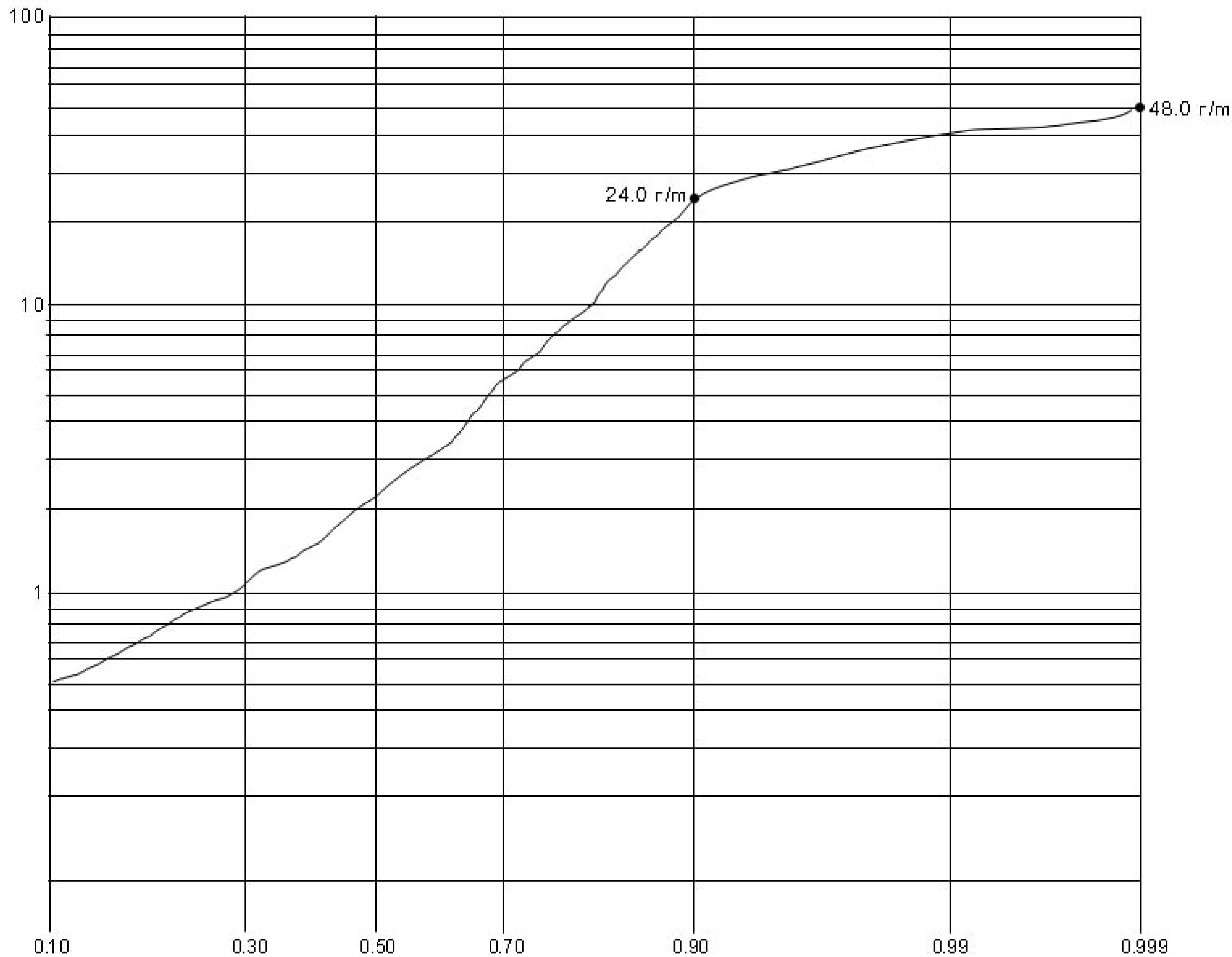
##	Class of grade, gr/t	Mean value, gr/t	Number of samples		Product		Frequency (possibility)	
			Of the given class	increasing	By class	increasing	By class	increasing
1	2	3	4	5	6	7	8	9
1	Up to 0.6	0.3	85	85	25.5	25.5	0.012	0.012
2	0.6-1.0	0.75	550	635	440	465.5	0.20	0.212
3	1.0-1.5	1.25	207	842	258.75	724.25	0.125	0.337
4	1.5-2	1.75	127	969	222.25	946.5	0.107	0.445
5	2-4	3	97	1066	291	1227	0.14	0.586
6	4-8	6	36	1102	216	1453	0.105	0.69
7	8-16	12	26	1128	312	1765	0.126	0.82
8	16-24	20	10	1138	200	1965	0.068	0.90
9	24-32	28	6	1144	168	2133	0.070	0.95
10	32-64	40	4	1148	160	2293	0.046	1.0



Gold grade in sample, gr/t

Pic.5.1

Cumulative density distribution of gold in linear reserves within contour of open pit



Gold grade, gr/t

Cumulative possibility, fractions

Pic. 5.2

The table shows that the feebly mineralized rocks with gold grade of up to 0.6gr/t make 7.4% of the ore mass within the open pit and they are referred to inter-ore dilution, and the rest—92.6% is commercial ore. It can be also noted that around 20% of the ore mass is represented by cutoff grade and 11% is characterized by the average gold grade in the studied aggregate. The rest—62% of the linear reserve has a grade, which is above the deposit's average grade, we refer 11.6% of them with average gold grade of 32.8gr/t to hurricane values. Our approach for revelation and leveling of **hurricane** gold grades with respect to Tukhmanuk deposit is the following:

In general, those metal grades, thicknesses and other calculation parameters, which significantly increase the average figures of mining, are referred to **hurricane** values. Numerous publications are devoted to the issue of revelation and neutralization of hurricane values, and they recommend different approaches for the establishment of normative values of the parameter under study. This proves that there is not any universal method in practice for calculation of hurricane values, and it cannot be. Meanwhile, the existing suggestions for the method of their determinations are brought to two groups: directive-empiric group and group of usage of methods of mathematical statistics. Irrespective of the method of separation of hurricane samples, the adopted decisions are aimed at decreasing the risk of non-confirmation of the average grade in the calculated aggregate. With respect to this we would like to note that the non-confirmation of useful component's average grade has greater negative consequence for the operation of a mining enterprise than the non-confirmation of the reserves' quantity that brings only to the reduction of the term of its existence. Based on statistical analysis of gold distribution by classified data, we accepted the upper level of normal grade to make 24gr/t with confidentiality of 0.90. Those values of some samples, which exceed this level, are substituted by 24gr/t.

According to table 5.8, the average gold grade in linear reserves without restriction of hurricane values makes 2.0gr/t, while after their exclusion and substitution by 24gr/t the average gold grade decreases to 1.86gr/t or by 10%. The norm of hurricane silver grade, which is above 112gr/t, is determined by the same method.

5.4. Ways and methods for calculation of preliminary reserves

Here, we mean the deposit's Central Area, within borders of which (of the constructed open pit) the preliminary calculation of reserves of quartz-sulphide, stringer-impregnated mineralization is implemented with usage of the recommended parameters of conditions. The entire exploration information and data of exploration as of 01.012009 is used in the estimation of reserves.

During the exploitation period of exploration from 2005-2007, surface workings were drifted and 92 drill holes were drilled at the area on 30-50x30-50m grid with total metreage of 13342m, the core recovery made 92-97%. From 2006-2008, the ore extraction was implemented on geologically documented levels of 2280-2380m.

The calculation of ore, gold and silver reserves was implemented through the method of parallel horizontal sections with consideration of morphological peculiarities and conditions of mineralization zone's occurrence, as well as of the adopted method of its exploration through mining-drilling system of workings and of the adopted open system of mining.

14 exploration vertical sections, which are constructed basically by drill holes, are located transverse to ore zone's strike. As it was already noted, the distances between exploration drill holes make 30-50m at exploration sections, drill holes' depth is from 150–200m. Adit #5 and a part of surface workings are presented on the plan "fragmentally" due to their mining; major part of drill holes is included in the contour of mining.

According to international models of JORC, UN Framework Classification, Russian Federation (2008), Tukhmanuk deposit's reserves under estimation are referred to the following categories by the level of their geological study: measured (B category), indicated (C_1 category) and interred (C_2). B category is estimated by the following conditions:

- Peculiarities of tectonic structure, dimensions and conditions of the ore deposit, its internal structure, variability of useful mineral's features, which is characterized by the ratio of variation of gold grade in ore within 72-110%, are established;
- Native varieties of the mineralization and deposit, which are contoured by alpine workings and drill holes with high quality of the core material recovery—95% and more, are determined;
- Contours of the ore zone are determined by the results of sampling of drill holes drilled on 30–40x30–40m grid, as well as alpine workings and data of ore benches under exploitation.

The following reserves are referred to C_1 category:

- Reserves by requirements of B category, which are stripped and contoured by a relatively wide-spaced grid of workings—40-50x40-50m;

C_2 category reserves are determined based on results of sampling of singular drill holes with consideration of geological constructions, which are confirmed by the exploitation's data.

The database of drill holes, alpine workings and exploitation benches served as initial information for the preliminary calculation of reserves.

The length of samples makes 1m in all workings and drill holes done from 2005-2007, while it makes 1-2.0m for the drill holes drilled earlier.

The contouring of the ore zone with outlining of balance and off-balance reserves is implemented on horizontal sections under calculation. The average grades of horizons under calculation, except for the drill holes drilled before 2003, are determined by the method of arithmetic mean, while the average grades for drill holes drilled before 2003 are determined by weighing of relevant intervals for length. The volume of polygonal blocks under calculation was determined by well-known formulas of geometry, the ore reserves were determined with consideration of volume weight of 2.6t/m^3.

The samples, which were taken during the period of exploitation exploration and deposit's mining, are of good quality. Core samples are kept in properly equipped core storage; they are documented and photographed (in wet and dry condition.)

The assays of samples of the exploitation period are implemented in modern atomic-absorption and fire assay laboratories of Tukhmanuk Mining and Processing Enterprise. Quality control assays were implemented in sufficient volume—at *Analitic* control laboratory of the ROA Ministry of Environment (where 704 ordinary assays were done in 2007), laboratory of Mining Metallurgy Institute CJSC, 258 assays were done in Canada. The internal control of the laboratory is implemented with usage of standard samples. The deviations of ordinary assays were within norms/standards of relevant classes of gold grades.

5.5. Results of reserves calculation

The reserves are calculated by the traditional method of polygonal estimation at horizontal sections with interval of 20m down-dip. The reserves' borders are determined for each horizontal section through joining of intervals of balance mineralization in a polygonal block. The upper limit of reserves is determined with usage of surface workings and data of exploitation benches; the bottom limit is established through joining of drill holes' points.

The borders of reserves of intermediate levels were constructed also with usage of data of adit workings.

The zones of mineralization are interpolated for a distance of 25-30m from the end (sideline) drill hole or for a half distance between an ore drill hole and off-balance "waste" rock.

The reserves of benches (blocks) under calculation are determined by data of surface and underground workings, drill holes, exploitation sampling of mined benches and by trench samples.

The reserves of C_2 (interred) category within the open pit's contour are outlined out of borders of C_1 category. The nature of reserves is provided on plans of benches under calculation.

Central Area of Tukhmanuk gold deposit

Below are the summarized figures of calculation of reserves for 1st and 2nd stage open pits

1st stage open pit

##	Name	Unit of measurement	Value
1	2	3	4
Balance reserves within the open pit contour			
1	Ore reserves in sub-surface	mln t	18.8
2	Gold reserves in sub-surface	kg/ounces	39100/121630
3	Silver reserves in sub-surface	t/thous. ounces	300.8/9356
Average metal grades in balance reserves			
1	Gold in sub-surface	gr/t	2.08
2	Silver in sub-surface	gr/t	16
Off-balance ores within the open pit contour			
1	Reserves in sub-surface	mln t	18.4

2	Gold reserves in sub-surface	t	8.5
3	Silver reserves in sub-surface	t	43.6
Average metal grades in off-balance reserves			
1	Gold in sub-surface	gr/t	0.46
2	Silver in sub-surface	gr/t	2.37

2nd stage open pit

##	Name	Unit of measurement	Value
1	2	3	4
Balance reserves within the open pit contour			
1	Ore reserves in sub-surface	mln t	21.5
2	Gold reserves in sub-surface	kg/ounce	44075/1417060
3	Silver reserves in sub-surface	t/thous. ounces	264.4/8224
Average metal grades in balance reserves			
1	Gold in sub-surface	gr/t	2.05
2	Silver in sub-surface	gr/t	12.3
Total within borders of the big open pit (of first and second stages)			
1	Ore reserves in sub-surface	mln t	40.3
2	Gold reserves in sub-surface	kg/ounce	83390/2674170
3	Silver reserves in sub-surface	t/thous. ounces	565.2/1758.0
Metal grades			
1	Gold grade	gr/t	2.07
2	Silver grade	gr/t	14

Reserves within borders of the 2nd stage open pit will be mined after 2020, if a decision on increase of the annual production capacity of the ore processing plant is not adopted.

A summary table of preliminary calculation of Tukhmanuk gold deposit reserves

(1st stage open pit contour)

N	Bench	Reserves of balance ore by categories, thous. t			Average grade by categories gr/t						Metal reserves by categories, t					
					B		C_1		C_2		B		C_1		C_2	
		B	C_1	C_2	Au	Ag	Au	Ag	Au	Ag	Au	Ag	Au	Ag	Au	Ag
1	2150	50.8	42.6	29.5	3.13	25.20	1.92	10.68	1.21	10.15	1.16	1.28	0.08	0.45	0.04	0.30
2	2170	104.3	115,5	80.2	3.06	20.87	1.66	12.59	1.28	9.80	0.32	2.18	0.19	1.45	0.10	0.78
3	2190	268.0	235.2	163.2	3.10	22.34	1.60	14.28	1.13	8.48	0.83	6.00	0.38	3.36	0.18	1.38
4	2210	572.8	324.8	300.6	2.89	28.10	1.79	13.65	1.07	7.60	1.66	16.10	0.58	4.43	0.32	2.28
5	2230	796.3	504.3	622.3	2.92	23.75	1.86	15.20	1.18	6.94	2.32	18.91	0.94	7.67	0.73	4.32
6	2250	1203.8	619.8	688.3	3.08	21.68	1.72	11.34	1.22	7.81	3.71	26.10	1.07	7.03	0.84	5.38
7	2270	1877.8	778.9	865.0	3.36	26.19	1.62	13.10	1.04	9.70	6.31	49.18	1.26	10.20	0.90	8.39
8	2290	943.4	945.0	874.6	2.91	20.76	1.83	14.71	1.02	9.35	2.74	19.56	1.73	13.90	0.89	8.18
9	2310	226.8	593.7	549.5	2.89	20.74	1.58	15.65	1.45	11.40	0.66	4.70	0.94	9.29	0.80	6.26
10	2330	-	497.9	460.8	-	-	1.73	11.08	1.51	7.20	-	-	0.86	5.52	0.70	3.32
11	2350	-	423.2	391.7	-	-	1.39	10.98	1.23	6.85	-	-	0.59	4.65	0.48	2.68
12	2370	-	350.0	323.9	-	-	2.09	16.40	0.70	8.43	-	-	0.73	5.74	0.23	2.73
13	2390	-	451.0	278.3	-	-	2.13	16.48	0.60	8.35	-	-	0.96	7.43	0.17	2.32
14	Above 2390		600.0	600.0			3.08	22.8	3.08	22.8			1.84	13.7	1.84	13.7
	Total	6043	6482	6228	3.10	23.83	1.87	14.6	1.31	9.9	18.71	144.01	12.15	94.82	8.22	62.02

Ore reserves within the 1st stage open pit contour by B+ C_1+ C_2—18.8mln t

Gold– 39.1t

Silver – 300.8t

Average grade, gr/t

Gold – 2.01

Silver – 16.02

A summary table of preliminary calculation of Tukhmanuk gold deposit reserves
(2^{nd} stage open pit contour)

N	Bench	Reserves of balance ore by categories, thous. t		Average grade by categories gr/t				Metal reserves by categories, kg			
				C_1		C_2		C_1		C_2	
		C_1	C_2	Au	Ag	Au	Ag	Au, kg	Ag, kg	Au, kg	Ag, kg
1	**2290**	483.7	322.5	2.05	12.3	2.05	12.3	991.6	5949.5	661.1	3966.8
2	2310	640.7	427.1	2.05	12.3	2.05	12.3	1313.4	7880.6	875.6	5253.3
3	2330	771.2	514.0	2.05	12.3	2.05	12.3	1581.0	9485.8	1053.7	6322.2
4	2350	891.7	594.5	2.05	12.3	2.05	12.3	1828.0	10967.9	1218.7	7312.4
5	2370	1014.4	676.3	2.05	12.3	2.05	12.3	2079.5	12477.1	1386.4	8318.5
6	2390	1110.7	740.4	2.05	12.3	2.05	12.3	2277.0	13661.6	1517.8	9106.9
7	2410	1116.5	744.3	2.05	12.3	2.05	12.3	2288.8	13733.0	1525.8	9154.9
8	2430	1021.6	681.1	2.05	12.3	2.05	12.3	2094.3	12565.7	1396.3	8377.5
9	2450	927.1	618.0	2.05	12.3	2.05	12.3	1900.6	11403.3	1266.9	7601.4
10	2470	901.7	601.2	2.05	12.3	2.05	12.3	1848.5	11090.9	1232.5	7394.8
11	2490	860.5	573.7	2.05	12.3	2.05	12.3	1764.0	10584.2	1176.1	7056.5
12	2510	833.4	555.6	2.05	12.3	2.05	12.3	1708.5	10250.8	1139.0	6833.9
13	2530	781.5	521.0	2.05	12.3	2.05	12.3	1602.1	9612.4	1068.0	6408.3
14	2550	391.3	260.9	2.05	12.3	2.05	12.3	802.2	4813.0	534.8	3209.1
15	2570	259.4	172.9	2.05	12.3	2.05	12.3	531.8	3190.6	354.4	2126.7
16	2590	150.1	100.0	2.05	12.3	2.05	12.3	307.7	1846.2	205.0	1230.0
17	2610	129.4	86.3	2.05	12.3	2.05	12.3	265.3	1591.6	176.9	1061.5
	Total	12284.9	8189.8					25184.3	151104.2	16789.0	100734.7