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RA MINISTER OF NATURE PROTECTION

A. GRIGORYAN

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EXPERT OPINION
ON ENVIRONMENTAL IMPACT ASSESSMENT

BP 35

Initiator: **Geoteam CJSC**
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Activity: **Report on Environmental Impact Assessment of the Updated Design of the Mining Complex of Amulsar Gold-Bearing Quartzite Deposit**
RA Vayots Dzor Region, RA Syunik Region

Director of "Environmental Expertise" SNCO V. Sahakyan

Enclosed opinion: 9 pages

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Report on Environmental Impact Assessment of the Updated Design of the Mining Complex of Amulsar Gold-Bearing Quartzite Deposit submitted by Geoteam CJSC

Client:	Geoteam CJSC
Design Engineers:	“Rake” LLC, “Eco Audit” LLC
Provided materials:	Detailed Engineering Design, Assessment Report
Location:	Administrative Area of Gorayk, Saravan, Gndevaz Communities of RA Vayots Dzor and Syunik Regions

Amulsar mining complex is located within the administrative boundaries of Gorayk, Saravan, Gndevaz Communities of RA Syunik and Vayots Dzor Regions. The villages Saravan and Gndevaz are respectively 5 km south-west and 7 km west from the proposed mine, and Gorayk village is 5 km south-west. The closest urban center is the town of Jermuk, which is at least 10 km northwest from the mine and 7 km from the closest infrastructure. The community Kechut, which forms a part of Jermuk, is located 7 km north of the mine.

C_1+C_2 category reserves of the Amulsar Gold-Bearing Quartzite Deposit have been approved by two decisions of the Mineral Resources Agency of RA Ministry of Energy and Natural Resources:

For Sites Tigranes and Artavazdes these reserves amount to:

- Ore: 56,434.5 thsd. tonne (23,812 thsd. m^3)
- Gold: 52,664 kg
- Silver: 210.51 tonne

For the Site Erato:

- Ore: 32941.8 thsd. tonne (13,899.5 thsd. m^3)
- Gold: 21,069 kg
- Silver: 83,86 tonne

Value Engineering and Optimization was undertaken in 2015 to reduce the Project development costs.

Main amendments to the design are as follows:

- Barren rock volumes have increased by 14,281.276 thsd. m^3, amounting to 106,490.056 thsd. m^3;
- Maximum annual production capacity of the open pit is 10 Mt salable ore;
- Capacities, models of mining equipment have changed;
- Roads to the open pit, crusher, barren rocks storage facility, etc. relocated;
- Overland conveyor relocated;
- There will be primary and secondary crushers instead of primary, secondary and tertiary crushers;
- Use of local hotel accommodations for both construction and operations workers from outside the immediate area will be utilized in lieu of contractor-installed construction camp in the Vorotan valley;
- Fuel storage and fueling station relocated south0west of barren rock storage facility; no change to storage capacity;
- One jaw crusher will be used in lieu of gyratory crusher;
- Stockpile removed and replaced with oversized feed bin for Secondary Crushers inside crusher building;
- Increased crushing size allows circuit to operate with 3 screens. Size of the building is reduced with the elimination of tertiary crushers;
- Conveyor has been shortened, reduced to a single conveyor from two, removed one transfer tower and drive house;
- Heap Leach Facility (heap leach pad, collection ponds and diversion structures): Leach pad footprint revised slightly to permit shallower excavation of northwest diversion water channel: Three phases for leach pad increased to four phases; first phase reduced in area;
- Process pond has increased in size considering new barren solution flow volume and estimated excess water storage requirements based on new HLF water balance calculations;
- Storm ponds have increased in size;
- Truck shop and truck wash relocated to the north-west of Erato;
- Sodium cyanide consumption factor revised and cut by half;
- Gold refinery technology revised from electrowinning to zinc precipitation circuit (Merril-Crowe).

Amulsar gold-bearing quartzite deposit will be developed by two open pits.

- Sites Artavazdes and Tigranes will be developed by Open Pit №1;
- Site Erato will be developed by Open Pit №2.

Ultimately, the proposed open pits will have the following parameters:

- Open Pit №1: maximum length 1,665m; maximum width 980m; maximum depth 270m; bench height 10m; safety berm width 4m;
- Open Pit №2: maximum length 855m; maximum width 760m; maximum depth 225m; bench height 10m; safety berm width 4m.

Open Pit №2 (Erato) is proposed to be developed in two phases.

The second stage will be designed based on the results of the ongoing additional in-mine exploration.

The open pits will be operated with the following schedule:

Open Pit №1 – 1-7 years;

Open Pit №2: Phase 1 – 5-8 years; Phase 2 – 8-9 years.

According to the terms of reference, the open pits are designed to deliver 10 Mt of salable ore per annum (4,205.0 thsd. m^3).

Average barren rock productivity of the open pit is 20,000.0 thsd. m^3 (46,756.08 Kt).

Life of mine including preparation and mine closure activities is to be 19.5 years.

The open pits will be developed using two-sided continuous bench mining system, with overburden being hauled to external barren rock storage facility, and after 5th year of operation also to internal storage facilities. Parameters of the proposed development system are as follows:

- Bench height – 10m;
- Bench slope angle:
  a) Operational - $65\text{-}70^0$
  b) In the final position - $50\text{-}60^0$
  c) Open pit wall slope angle - $33\text{-}46^0 35'$
- Minimum width of the operating platform - 30-40m
- Average annual lowering during extraction –
  a) Open Pit №1 - 40m
  b) Open Pit №2 - 50m

The following works are required for development of Open Pit №1 and to reach the planned production capacity:

- Construction of production site, S = 1.0ha, V = 30400m^3.
- Construction of a road extending from the open pit level of 2970m to crusher, BRSF and truck shop – 5495m, V = 280,000m^3.
- Removal of barren rocks from the level of 2970m – V=426,150m^3;
- Removal of barren rocks from the level of 2960m - 340,000m^3, accompanying material – 20,000m^3 (47,400t);
- Removal of barren rocks from the level of 2950m – 86,600m^3;
- Barren rock storage facility – construction of unloading site – S=430m^2, V=2150m^3.
- Barren rock storage facility – construction of water diversion channel.

The open pit construction will continue for 2.0 years.

The overburden rocks are represented by alluvial and waste rocks. The alluvial rocks will be removed without primary crushing, and the overburden rocks will be hauled by the mining equipment complex (dozer, excavator, dump trucks) after primary crushing. Barren rocks will be stored in the external dump in the north of the open pit, and starting from the 4th year they will be stored in the 1st internal dump as well.

Primary crushing of the ore and barren rock will be carried out by drilling and blasting using blasthole charges.

ANFO (for dry areas) or geonit (for wet areas) will be used when blasting.

CAT-6050 excavators with 26m^3 shovel capacity will load the run of mine ore into the haul trucks, and CAT-789 haul trucks with a payload capacity of 190 tonnes (with the dump body capacity of up to 110m^3).

Total 140.65 million m^3 of barren rocks include approximately 137.88 million m^3 host overburden rocks and 2.77 million m^3 of alluvial rocks.

87.9 million m^3 of overburden rocks will be stored in an external stockpile to the north-west of the open pits and 6.1 million m^3 will be stored in the developed area upgradient the bench on the level of 2780m.

Afterwards, in parallel to extension of the Open Pit №1, the remaining overburden rocks with the total amount of 37861.65 thsd. m^3 will be stored in the developed area of the Open Pit №1 and the external dump.

The external waste dump occupies 140.69ha area with 250m height, and slope angle of 18^0. Altitude mark of the upper platform is 2710m with an area of 12.3 ha and capacity of 113,784.153 thsd. m$^{3.}$ The internal dump has a capacity of 40,936.080 thsd. m^3, area – 57ha.

Topsoil of the open pit №1 with the total volume of 138.27 thousand m^3 will be stored to the north of the open pit, in its immediate vicinity. Area occupied - 5.0 ha. Topsoil of the open pit 2 with the total volume of 130.08 thousand m^3 will be transported and stored to the north of the open pit 2. It occupies 5.06 ha.

Topsoil the external waste dumps with the total volume of 148.9 thousand m^3 will be excavated, transported and stored to the east of BRSF.

Rocks containing low-grade metals will be stored to the south-west of the BRSF, their volume makes up 9,968,373m^3.

Power supply of the open pits will be provided by fifteen 100kW diesel generators, and 24 diesel generators and compressors will be used for infrastructures and roads during construction.

To produce dore bullion ore is processed through two stages of crushing to a target crush size of 80% passing 18 mm (P_{100}=19mm). The crusher unit operations include a primary jaw crusher, and secondary cone crushing in the closed circuit with triple deck multi slope screens.

The primary crushing area is equipped with a crane for maintenance and also a dust collection system to minimize dust at all transfer points.

The overland conveyor transports the crushed ore approximately 5.3 km down slope to the crushed ore stockpile. The overland conveyor will have a regenerative drive system that will provide approximately 3 MW of power back into the electrical system.

The conveyor will have three overland and underground passages.

The crushed ore stored at the crushed ore stockpile, live capacity of 5,000 tonnes, will be reclaimed by three pan feeders underneath the stockpile which transfer the ore to the loadout bin feed conveyor. Pebble lime is added to the crushed ore as it is conveyed to the loadout bin by a screw feeder from 200 tonne capacity lime silo. Lime will be metered to ensure proper pH control for heap operation.

The loadout bin feed conveyor transfers the crushed product with lime to the 100 tonne loadout bin. A full bin will stop the pan feeders and the loadout feed conveyor. The loadout bin is sized to hold a volume of ore to fill three truck loads. Ore from the loadout bin is dumped into the heap haul truck via clam shell gates. The crushed ore will then be hauled by trucks to the heap leach pad for stacking and leaching.

The HLF is located at Site 28. The terrain is valley-shaped and undulating in some areas.

The leach pad will be constructed in four phases, and the total Phases 1-4 pad area will be approximately 1,153,900 m^2.

The leach pad will have a composite liner system consisting of a LLDPE geomembrane underlain by a 0.3-m minimum thickness compacted low-permeability soil liner, or geosynthetic clay liner (GCL) in areas.

A drain pipe network will be constructed above the pad liner and will be embedded within a 0.6-m minimum thickness liner cover drain fill layer, which will consist of free-draining, hard, and durable granular material. Solution and storm/snowmelt runoff and infiltration flows collected by the drain pipe network will gravity-drain to the process pond.

The heap leach process consists of stacking crushed ore on the leach pad in lifts and leaching each individual lift to extract the gold and silver. Barren Leach Solution (BLS) containing dilute sodium cyanide will be applied to the ore heap surface using a combination of drip emitters and sprinklers at a design application rate of 6 L/hr/m^2. The design leaching cycle of the ore heap is 60 days.

The solution will percolate through the ore to the drainage system above the pad liner, where it will be collected in a network of perforated drain pipes embedded within a 0.6-m minimum thickness granular cover drain fill layer above the liner. The solution will gravity flow to the process pond. PLS collected in the process pond will be pumped to the process plant to extract the gold and silver.

A stock-proof mesh fence with locking gates will be constructed around the perimeter of the leach pad to prevent wildlife from reaching the pad.

The ore heap on the leach pad is planned to be stacked in 8 m thick, horizontal lifts in four stages to a nominal maximum heap height of 120 m above the pad liner.

The HLF collection ponds will include the process pond, Storm Pond 1, Storm Pond 2 and Storm Pond 3. The collection ponds were sized in accordance with the Project design criteria using the results of the HLF water balance calculations. The process pond and Storm Pond 1 will be constructed during Phase 1 pad construction, Storm Pond 2 will be constructed during Phase 3 pad construction and Storm Pond 3 will be constructed during Phase 4 pad construction.

Process solution and storm/snowmelt water flows within the leach pad will gravity-drain to the pad's lowest point and through a spillway to the process pond.

The process plant consists of an Adsorption, Desorption, Recovery (ADR) plant, refining, and reagent makeup and delivery systems. The ADR plant will be located to the southeast of the HLF collection ponds, and the plant area will be lined to contain spills and any overflow from the plant will be routed to the process pond.

The plant extracts precious metals from the PLS onto activated coconut carbon. The ADR circuit adorbs metals from the PLS in carbon columns and moves the carbon from the columns into strip vessel where the metal is eluted into solution at higher tenors. This new PLS is treated

with zinc which causes gold and silver to precipitate from solution. Once the precious metals are precipitated, the solution is filtered and the cake is dried, mixed with flux and smelted to produce doré bars. The doré bars are then shipped to a refinery for further refining. The ADR circuit also regenerates the carbon through acid washing and a regeneration kiln to maintain the carbon's ability to adsorb metals in the carbon columns. Once regenerated the carbon is returned as fresh carbon to the carbon columns.

Main facilities and equipment of the heap leach and ADR flowchart are as follows: feed hopper, grizzly vibrating feeder, jaw crusher, crushed ore bin with its feeder, triple deck vibrating screen, vibrating screen oversize conveyor, secondary crushing feed bin, secondary cone crushers, overland conveyor, crushed ore stockpile, loadout bin with feeders, heap leach pad, process pond, dilute solution pond, storm water collection ponds, carbon columns (5), elution columns, barren solution surge tank, retort, furnace.

Geoteam and specializing local and international companies have undertaken appropriate surveys to assess potential impacts on air, water basin, biodiversity, lands during mining. They have also carried out surveys on potential impacts of blasting, radiation, noise.

During the production processes emissions of hazardous substances will occur when mining, haulage of ore, crushing (screening), handling of lime and loadout on the conveyor, preparing solutions and from ADR facilities.

Estimated total emissions from controlled immovable sources are 338.39 tonnes per annum, and from movable sources – 737.5 tonnes per annum.

Dust deposition survey confirmed that the majority of PM_{10} emitted from the Project (pver 95%) will be deposited within 1km from the site, with over 90% deposited within 500m of the source. Based on the distance from Project activities, PM_{10} and $PM_{2.5}$ concentrations would not exceed normal limits.

Land concentrations of cyanic, hydrohrolic acid vapours, nitrogen dioxide, carbon monoxide are within allowable limits for residential area, although the production area is outside the settlement.

In Amulsar mine area, heap leach and gold recovery facilities water is used for process and drinking-economic needs, as well as for anti-fire purposes.

The Project's overall water management strategy is to maintain, to the maximum extent where practicable, separation of non-contact water from contact water so to minimize the need to contain water. Contact water will be utilised within the HLF as much as practicable and any surplus water will be treated in a Biological Treatment System (BTS) prior to discharge to the Arpa River downstream of the planned water intake from the Arpa. The system is proposed to

comprise a series of ponds, bioreactors and wetlands that will raise pH and remove nitrate, sulphate and metals.

During the operation phase there will be three major water storage areas available to manage water in the Project area:

- The raw water pond (volume 20,450 m^3), which will receive runoff from the haul and access roads, and conveyor corridor;
- The HLF contact water pond (maximum volume approximately 1,280,000 m^3), which will receive discharge from the BRSF Toe Pond, and water from the pit sumps and truck shop storage pond; and
- Three storm ponds (maximum total volume approximately 630,000 m^3) downstream of the HLF, which will be used for active storage of process water during operations and also contain storm storage capacity.

Discharges to the environment during closure and post-closure will be from the HLF, BRSF and from reclaimed areas.

The discharge of post-closure residual waters from the BRSF will be treated to meet Category II MAC through the biological treatment system located in the vicinity of the HLF. Water will then be discharged to a series of infiltration galleries within the HLF catchment or to a tributary of the Arpa. The BRSF Toe Pond will be used to store and manage seasonal flows, controlling discharge to the biological treatment system.

During the HLF drain down phase, water will go through active treatment before discharge to the environment. The biological treatment system will be used post-closure as during operation. Discharge from the HLF system during closure will meet MAC II and/or baseline standards.

Comprehensive ecosystems and biodiversity surveys have been undertaken and potential impact on them has been assessed by specializing organizations (RA NAS Institute of Botany, RA NAS Scientific Center of Zoology and Hydrogeology, Armenian Society for the Protection of Birds, Treweek Environmental Consultants (UK)). The Project aims to achieve “no net loss” of biodiversity and to ensure that biodiversity and ecosystem functions are not systematically degraded or lost from the landscape as a result of the Project. This means that species occurring in the Project-affected area should have the same chances of long-term survival with the Project in place as without it, and have access to similar amounts of suitable habitat as in the baseline situation. A red-listed plant species *Potentilla porphyrantha* has been identified in the Project area and adjacent areas based on the results of the survey. Conservation and reproduction of this plant will be carried out in accordance with RA Government Decree 781-N as of July 31st 2014. Amulsar Mountain has a Tier 1 critical habitat for this species, which will be

affected. A formal set-aside (referred to as the “Arshak Set-aside”) was identified to avoid a viable proportion of the population. Elsewhere, individual occurrences of the plant have been marked, and access routes have been designed to avoid them.

Offset and conservation action plan and summary of potential costs have been developed as part of the Biodiversity Offset Strategy.

Based on the results of surveys undertaken by RA Nuclear Power Station and RA State Nuclear Safety Regulatory Committee of RA Government, radiation background is within normal limits. And Radman Associates’ radiological report data confirm that potential occupational radiation dosage from natural radioactive substances is within international standard limits, and the natural radiation background level of the Project area lands is lower than average background levels of the Republic of Armenian lands.

Noise and vibration impact assessment undertaken in accordance with International Finance Corporation Environmental, Health and Safety Guidelines, World Health Organization Guidelines “Noise in settlements”, and Republic of Armenia Sanitary Standards №2-III-11.3 “Noise at Workplaces, Residential, Public Buildings and Premises of Housing Development”, suggest that levels measured at adjacent residential areas are within normal limits.

Based on the calculation results, air pressure at the explosion front and vibration, as well as noise pressure levels at residential areas will not exceed IFC and RA statutory standards.

According to the submitted design, there is a 1,000m buffer zone around all the production facilities.

Estimated economic damage on the atmosphere from development of the Amulsar mining complex is 165,005,252 AMD.

Estimated economic damage to land resources is 4,985,695,500.0 AMD.

Mine Reclamation, Closure and Rehabilitation Plan and the assessment report provides land descriptions, topsoil storage, reclamation and closure monitoring costs, which amounted to 254,000,000 AMD. As all areas restored with soil will be subject to a minimum period of 5 years of active aftercare following closure, the significance of the residual effect is minor and therefore not significant.

A list of the measures for mitigations of impacts and their monitoring plan has been developed to prevent and mitigate adverse impacts on the environment during mining, heap leaching and gold extraction processes.

Requirements of the expertise

1. During construction, operation and closure of the mine and heap leach pad to be governed by statutory provisions listed in the Protocol №7/14-p as of 24.02.2014 of the RA National Academy of Sciences Expert Commission on Protection of Lake Sevan.
2. To carry out conservation and reproduction of RA red listed plant *Potentilla porphyrantha* in accordance with Agreement on Translocation of Individual Plants of New Population of the Species Listed in the Republic of Armenia Red Book" entered into between Geoteam CJSC and RA Ministry of Nature Protection on August 7th 2015.
3. Two years before the closure of the mine to submit to RA Ministry of Nature Protection the mine closure final plan for environmental impact assessment.

CONCLUSION

A positive opinion is given to the working design of Amulsar mining complex submitted by Geoteam CJSC, on condition that the Company fulfills the requirements mentioned above.

Expert A. Minasyan