GOLD MINING AND TAILINGS DAM IN OVACIK, TURKEY

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ABSTRACT

Ovacık Gold Mine is the first gold project of Turkey. It is discovered in 1989 and since then has been through long permitting process. The mine comprises open pit and underground mining and conventional CIP process. It is designed to treat 300 000 tons of ore per year to produce approximately 100 000 oz. of Au and same amount of Ag. The site and climatic conditions allow disposal of the tailings in a conventional way which is the storage of the tailings in the pond with zero volume discharge to the environment. However, waste management includes the tailings treatment in three stages chemical destruction circuit to achieve the limits set by the Ministry of Environment for storage into the impervious tailing pond. Total cyanide limit of the tailings pond is 1 mg/L. Tailings pond is sealed with composite liner system of 50 cm clay, 1.5 mm HDPE and 20 cm another clay layer. Ovacık is one of the few mines in the world to have both tailings treatment for cyanide and heavy metals for storage into the tailing pond and a geo-membrane and clay lined rock-fill tailings pond with no process water discharge to the environment.

INTRODUCTION

The Ovacık Gold Mine is owned by the Turkish Company called Eurogold Madencilik A.S., a subsidiary of Normandy Mining of Australia. The mine is located 15 km inland from the Aegean Sea and about 100 km north of Izmir, the third biggest city of Turkey. The mine is adjacent to the inter-city highway and the village of Ovacık.

Eurogold was established in 1988 to explore for gold and to undertake mine development and operation in Turkey. A regional stream sediment-sampling program was conducted in target areas in Turkey, resulting in the delineation of gold anomalies near Ovacık in 1989. Based on the drilling results, a feasibility study was undertaken and completed in 1991. The current resource estimate for the Ovacık deposit is 4.19 million tonnes at the grade of 7.6 g/t Au.

In 1996 after obtaining the required permits, an EPCM contract was signed, project financing put in place and the construction activities for CIP plant, tailings storage facilities and development of open pit and underground decline commenced. Construction of the plant, associated mines infrastructure and first stage of tailings dam were completed in December 1997. Each section of the plant including the chemical destruction circuit was successfully tested in early 1998 and small amount of dore was produced.

In 1998, the environmental permit was reworked by the court, in favour of the local environmental groups, based on the concept that no permitting should be made until all possible risk mitigating measures are physically seen in place. Eurogold adopted "Preventive concept" in mitigating the risks and taken additional precautions. In 1999, Turkish Prime Ministry instructed TUBITAK (Turkish Scientific and Technical Research Organisation) to assess risks to human health and environment. Positive report was delivered confirming that the risks had been mitigated for and reduced far below levels acceptable in the industry. The mine is currently waiting to finalise the permitting process for operating license.

Lack of information about gold mining as Ovacık being the first gold project in Turkey and misinformation about cyanide in public have led to an exhaustive permitting process and environmental standards higher than ones for comparable projects. Ovacık is one of the few mines in the world with both chemical destruction of cyanide and heavy metals to very low levels and storage of tailings in a tailings pond sealed with composite liner system of clay and HDPE geo membrane with no discharge to the environment (Yüce, A. E., et al., 1998, Yüce, A. E., Önal, G.,1998).

GEOLOGY AND MINING

Gold mineralisation at the Ovacık deposit is hosted in or immediately adjacent to the epithermal quartz veins within porphyritic andesite country rock. The regional structure setting is a series of east west trending graben and normal faults. Locally, post mineralisation faulting has caused displacement of the

Ovacık vein. Two of the veins named M and S have been shown to contain economic ore grade mineralisation. These veins are average approximately 8 m in thickness reaching a maximum of 22 m. Strike dimensions are of the order of 400 m and 280 m respectively and the veins extend at least 250 m down dip, based on the drilling to date. Gold with an average size of 5 microns within the fissures between quartz grains occurs as free grains. Sulphide minerals are almost absent (about 0.02% S).

The ore will be mined from underground and open pit in the first three and a half years and thereafter from underground. The open pit will extend to a depth of 80-85 m on two metre high benches. The open pit is subject to the physical constraints due to the proximity of the Ovacık village immediately to the south of the deposit and the presence of alluvium to the west of M vein. Access to the underground mine will be by a 4 m high and 4.5 m wide decline ramp. The ore body will be accessed by a series of cross-cuts in the hanging wall. The proposed mining method is overhand cut-and-fill stoping utilising mobile mining equipment.

ORE TREATMENT

The Ovacık Gold Mine comprises carbon-in-pulp (CIP) treatment plant of capacity 300 000 t/y. The plant is designed to treat ore of a head grade of 12.6 g/t Au and 18 g/t Ag at recovery rates of 91% Au and 73% Ag. Figure 1 shows the plant flow sheet. The plânt consist of the following unit operations:

Crushing and Screening:

The output of crushing circuit is 130 tons ore per hour of 80% minus 13 mm product suitable as rod mill feed. The 100 tonne capacity ROM ore hopper incorporating a 800 mm fixed grizzly is designed to accept feed either by direct tipping from rear dump truck or from a front end loader. A variable speed apron feeder feeds the ore from ROM bin to the crusher. Crushing in two stages utilises a 1219x1066 mm jaw crusher followed by one 1560 mm standard cone crusher. Product sizing is carried out in closed circuit with the cone crusher. Product of 100% minus 16 mm, 80% minus 13 mm reports to a fine ore bin of 1500 tons live capacity. The product screen is a double deck unit 6.1 m long x 2.44 m wide. A wet scrubber dust collection system will be provided for dust control in the crushing and screening areas.

Grinding:

A grinding circuit comprising a 315 kW 2.7 m diameter x 4.1 m long rod mill and 1300 kW 3.8 m diameter x 6.2 m long secondary ball mill has been selected. The rod mill is run open circuit and the ball mill is operated in closed circuit with the cluster of 250 mm cyclones. Product size is d_{80} of 38 microns. Hydrated lime for pH control is added to the mill feed belt feeding from a 35 ton storage silo.

Thickening:

Product from the grinding circuit reports to a high rate thickener where it is densified to 45% solids from 17.5% solids. Thickener overflow gravitates to the process water tank. Thickener underflow is pumped via a variable speed slurry pump to the leach circuit.

Leach and Adsorption:

The leach and adsorption circuit consists of two mechanically agitated leach tanks each of 690 m^3 capacity and eight mechanically agitated adsorption tanks of 210 m^3 capacity. Oxygen addition to both leach tanks and first 4 adsorption tanks has been included to increase leach rate and improve carbon loadings. Mechanically swept vertical inter-stage screens are provided in each of the adsorption tanks complete with 0.8mm aperture. Carbon is moved from last tank to first adsorption tank counter-current to the slurry flow. Adsorption circuit modelling has indicated that carbon densities of approximately 12 g/L will result in optimal loadings and recoveries.

Elution and Gold Recovery:

The carbon elution system is a split AARL circuit utilising a single column of 4 tons capacity. The elution cycle consists of the following stages:

Acid Wash: HCl acid is used to liberate calcium etc.

Hot Water Wash: Acid and liberated salts are removed.

Pre-soak: Hot caustic soda/cyanide solution dissolves gold from carbon.

Stage 1 Elution: The collected solution from the previous elution is used to the flush gold from carbon and reports to the electrolyte tank.

Stage 2 Elution: Hot water flushes gold from carbon and reports to the elution water recirculation tank.

Cool Down: Cold water cools column and reports to the elution water recirculation tank.

Total cycle time is 5.75 hours.

After completion of the stage 1 elution, electrowinning is commenced with electrolyte being circulated from the electrolyte tank to the 4 electrowinning parallel cells. Electrowinning proceeds in a recycle mode with the discharge from the electrowinning cells reporting back to the electrolyte tank until such time that the cell discharge falls below 3 ppm Au. The cell discharge is then pumped back to the first adsorption tank. Once the elution cycle is complete the barren carbon is pressure transferred to the regeneration kiln feed bin for re-activation. Re-activation takes place at 650-700 degree in the LPG fired horizontal kiln. Loaded cathodes are periodically removed from cells and plated gold and silver removed by washing with a high-pressure wash-down unit. The resulting gold/silver sludge is filtered and dried before smelting.

TAILINGS TREATMENT

Tailings slurries from CIP plant are treated in the chemical destruction circuit designed by INCO Technical Services Limited of Canada to achieve limits for total cyanide and heavy metals set by the Ministry of Environment. The limit for cyanide is 1 mg/L total.

Three stages treatment circuit is utilised. In the first stage, a solution of sodium metabisulphite, $Na_2S_2O_5$ is used to supply SO_2 and compressed air is used as a source of O_2. All weak acid dissociable cyanide which includes free cyanide and weak metal cyanide complexes such as zinc, copper, nickel cyanides are oxidised to cyanate (CNO^-). Once freed of the cyanide, the metals are precipitated as metal hydroxides. The cyanate ion is not stable and hydrolyses to carbonate and ammonium. Copper sulphate is added to catalyse the oxidation and precipitate iron cyanides. In the second stage ferric sulphate is added to precipitate arsenic and antimony. These precipitates are very stable within wide range of pH. In both stages, the strongly complex iron cyanides are removed as an insoluble metal-ferrocyanide complexes with metal ions added to the system (such as Fe^{3+} and Cu^{2+}) or available in the system (Zn^{2+}, Ni^{2+}). The precipitated complexes such as iron (II), iron (III), nickel, zinc ferrocyanides are insoluble complexes (Smith, A. and Mudder, T., 1991).

Destructed tailings are pumped to the tailing pond. Decant water from the pond is pumped back to the process plant for re-use in the process. If necessary, recycle stream of decant water can be treated in the third stage to further reduce arsenic and antimony by adding ferric sulphate to this stage. Third stage can also be used for the hypochlorite treatment of cyanide spillage collected in the process plant.

PROCESS CONTROL

The plant including the chemical destruction circuit will be operated and controlled through the PLC and operator interface program (CITECT) and a separate PLC and control room have been installed for the different units of the process providing detailed information about the performance of the mentioned units.

TAILINGS STORAGE FACILITIES

The tailings produced from the CIP plant will be deposited in the tailing pond providing a storage of 1.6 million m^3. Tailing storage facilities includes main and upstream embankments, cofferdam, run-off water pond, diversion channel, drainage and decant system.

Ovacık tailing storage facilities (TSF) are planned to be construct in two stages. The first stage consisted of construction of the main embankment and lining of abutments up to the elevation 72.00 and the upstream embankment to the final level (80.00). The second stage is the construction of main embankment and lining of abutments from elevation 72.00 to 80.00. Also, after completion of the second stage, excess waste material from the open pit will be deposited on the downstream of the main embankment increasing the stability of the main embankment. First stage of construction has been completed under the supervision of Turkish State Hydraulic Works (DSI). The second stage construction will start in the first year of production. Deposition of excess waste rock from open pit will continue until the open pit activity ceases (3.5 year after start up).

The tailings pond is covered with a composite liner system of 50 cm compacted clay, a 1.5 mm thick High-Density-Polyethylene- geo membrane, 20 cm of another compacted clay and 20 cm filter layer. Drainage pipes are placed in the filter layer to collect the tailings water into decant tower from where it is pumped to the process plant for reuse.

The mine is located in an area of seismicity where peak ground acceleration is 0.4 g. The tailings embankments were designed in accordance with the Turkish Earthquake Code and was approved by Turkish State Hydraulic Works. It is designed to withstand earthquake of 0.6 g acceleration (Report on Probabilistic Risk Assessment Ovacık Mine Tailings Dam Turkey, 1998).

ENVIRONMENTAL ASPECTS

The environmental precautions taken at Ovacık Gold Mine meet all the requirements of Turkish health and environmental regulations and international standards. The combination of chemical destruction of the cyanide and heavy metals in tailings to very low levels and deposition of the treated tailings in a sealed rock-fill tailings pond with zero discharge to the environment makes Ovacık Gold Mine over the world standards.

The environmental aspects considered at Ovacık can be summarised as below:

Waste Disposal:

The Ministry of Environment has set limits for heavy metals and cyanide in the tailings water for storage into the tailings pond (Ovacık Gold Mine, The Ministry of Environment Protocol, 1994). Due to the low heavy metal content of the ore, concentration of the most of the heavy metals in the tailings are expected to be below the Ministry limits even before the chemical treatment (INCO SO_2/Air Cyanide Destruction Process Design Criteria, 1993).

Water Management:

The design criteria and management system for Ovacık tailings pond is set for zero release of process water to the environment. This is possible, as the process plant-tailings pond system is net consumer of water.

The water management plan includes control of potential excess water that could be generated from the underground mine. Any water from the mine will be recycled to the process plant as make-up water. Any excess water will be discharged to the environment after appropriate treatment to comply with the conditions of the Turkish 'Water Pollution Control Regulation'.

Acid Rock Drainage:

According to the Acid Rock Drainage tests carried out on Ovacık ore and waste rock samples, acid production resulting in elevated concentrations of metals and sulphates in the mine water is not expected (MAPTEK, 1999).

Air Emissions:

Dust control and monitoring systems have been set up at various dust creating units of Ovacık to comply with the requirements of the Air Quality Control Regulation.

HCN gas formation is prevented in the plant by adjusting the pH of the cyanide containing solutions and slurries to minimum 10.5 by automatic lime and caustic addition system.

Blasting:

As the mine site is adjacent to Ovacık village, blasting practices such as millisecond delays that will limit peak particle velocities for ground vibration, air vibration and fly-rock to accepted standards for the properties in the village have been adopted.

Rehabilitation:

Mine site will be rehabilitated according to the protocol with the State Hydraulic Works and Forestry Department. Conceptual mine closure and rehabilitation plan has been prepared and will be reviewed annually during operation. Prior to the operation, rehabilitation bond will be provided in favour of State Hydraulic Works to secure the completion of rehabilitation and closure in accordance with the protocol.

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