REDUCTION OF GOLD INVENTORY IN CYANIDE HEAP LEACHING

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ABSTRACT

This paper will combine three SME annual meeting presentations on reducing gold inventory in cyanide heap leaching. Information on Part I – Side slope leaching (SME 2003), Part II – Determining the dry zones using geophysical resistivity (SME 2004), and Part III - Presents a new technology "Hydro-Jex", to introduce the required lixiviants to the un-leach or under-leach zones in heaps (SME 2005). This paper will describe how Newmont Mining Corporation continues to improve the economics of the heap leaching process for precious metals recovery.

INTRODUCTION

Many heap leach operations are very large, covering many hectares of containment and contain millions of metric tons of low grade ore. Operators estimate recovery from column tests on ore samples and barring reagent issues, produce metal values somewhat lower than the column leach tests with a resultant inventory in the heaps. Generally, after the ore material is placed, the only operational technique to improve recovery evolves around solution percolation and permeability. The key to reducing metal values in the heap leach inventory is to promote the contact of the leaching lixiviant to the valuable mineral and rinsing the dissolved metal from the ore material to a recovery system. Various common leach practices and new technologies will be presented to maximize heap leach recovery.

INVENTORY

The inventory of recoverable metal values in a heap leach operation is tracked by accounting for the recoverable values placed minus the metal values recovered and sold. Newmont Mining Corporation's ore control department tracks each leach polygon kriged, mined and placed on the heap leach pads, **Figure 1**.

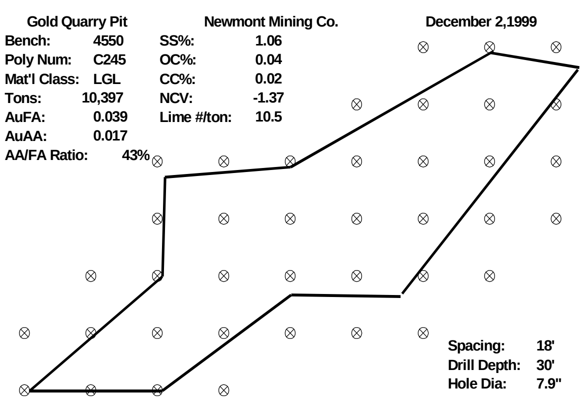

FIGURE 1 Ore Control Kriged Polygon.

The gold grade, AUFA is determined on a pulverized ore sample from each blast hole by fire assay and the cyanide soluble gold grade, AUAA or AuCN, also uses a sample split subjected to a basic NaCN shake test with a following liquid analysis by atomic absorption spectroscopy. Results are reported in troy ounces of precious metal per short ton. Newmont Mining Corporation tracks ore placement each month on the heap leach pad by tons, grade, and potential CN soluble troy ounces.

Determining the quantity of recoverable metal values placed as inventory evolves from the data on AUAA, the size distribution of the ore placed, plus assumptions on permeability and leaching kinetics observed in monthly column leach tests, **Figure 2**. Where F_{ext} is the percent extraction of the AUAA or AuCN data tracked from each blast hole assay, polygon and represents the ore placed each month via column leach tests.

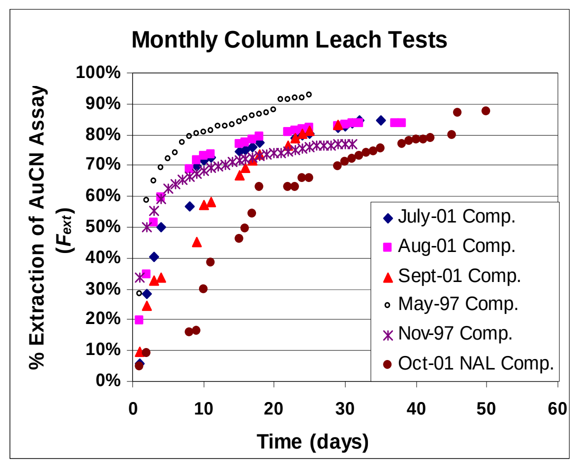

FIGURE 2 Monthly Column Leach Tests

The physical properties of the material, such as size, porosity, amount of clay and chemical composition impacts the permeability and the leach solution flow pattern. The stacking method for ore placement on the heap leach pad also determines the permeability of the pad and affects recovery. Truck dumping ore on a heap leach pad promotes compaction and effects leaching permeability and metal value inventory, **Figure 3**.

Metal value inventory can be further classified as 1) active inventory – ore placed and under leach, 2) passive inventory – ore not under leach, 3) in pond inventory – leached metal values ready for recovery, and 4) ore without leaching – ore prior to leaching.

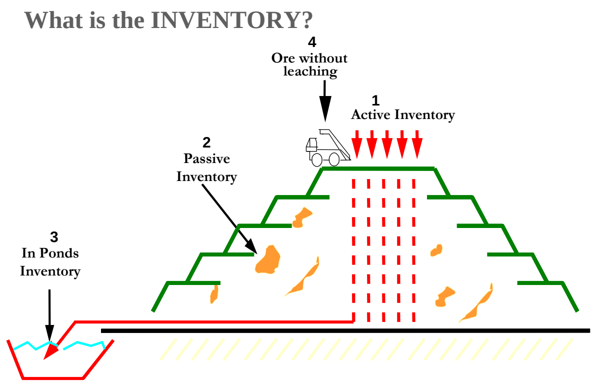

FIGURE 3 Inventories in Heap Leaching

Accounting and tracking each of these types of inventory are important in determining the metal value recovery in a heap leach operation. The primary subject of this work will focus on the passive inventory. After two years of leaching and rinsing the Newmont Mining Corporation's Property Pad on the Carlin Trend there is still an estimated 39,000 recoverable ounces in inventory, **Figure 4**. This un-leached inventory is attributed to under-leached side slopes and compacted zones in the interior of the heap.

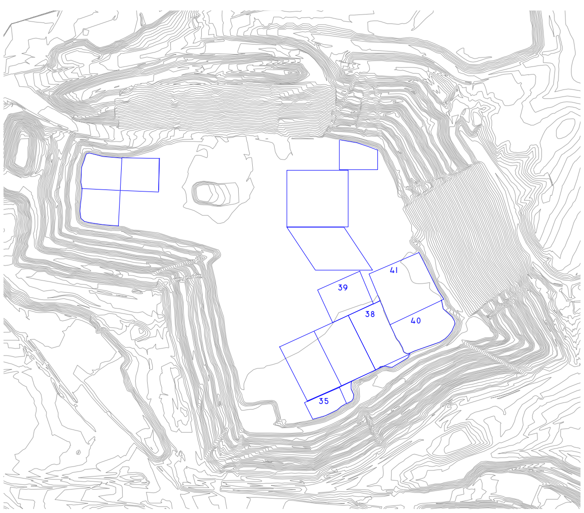

FIGURE 4 Carlin Trend Property Pad

THE PASSIVE INVENTORY

The side slopes of the Property Pad represent over forty percent of the 100 million metric tons of ore placed. During active leaching and rapid placement of ore, the side slope metal value inventory was inadequately leached. As the ore placement rate decreased, attention was directed to this side slope inventory.

While the side slope ore volume do represent a significant portion of the passive inventory, additional zones of un-leached and under-leached volumes of ore are found in the interior of the heap. These dry and semi-dry zones also represent a portion of the potential recoverable gold inventory and are located using geophysical resistivity surveys, **Figure 5-6**. The field resistivity data was imported into Vulcan software for shapes and volumes.[1]

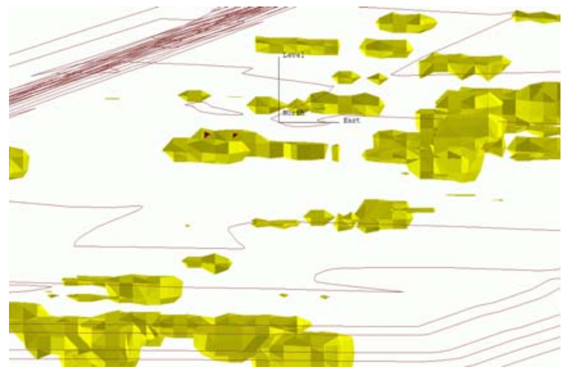

FIGURE 5 High Resistive (Dry) Zones in a Heap Leach Pad by Geophysical Resistivity Survey.

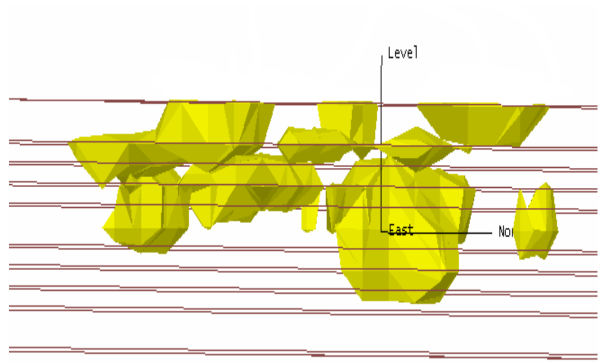

FIGURE 6 Side View of High Resistive (Dry) Zones in a Heap Leach Pad by Geophysical Resistivity Survey.

INVENTORY REDUCTION

The primary means to reduce passive inventory is to introduce lixiviants to the location of the metal values, allow time for leaching and then rinse the dissolved metal values to report to the in pond inventory. The challenge is the lixiviant introduction and rinsing. Various methods for facilitating inventory reduction will be examined such as, adequate ripping of the pad surface, solution management, side slope leaching and a potential new technology, "Hydro-Jex".

RIPPING TRUCK DUMPED LEACH PADS

Adequate ripping or re-ripping of the surface of heap leach pads breaks up the surface compaction layers caused by truck traffic. By minimizing the compaction on the surface, solution percolation is more uniform, reducing solution channeling, and allows ores to leach more completely, reducing the inventory in the heap leach pads. Field studies found that truck-induced compaction is limited to the upper 2.4 m (8 ft).[2] The surface of the pads also includes the side slopes, **Figure 7**.

FIGURE 7 Heap Leach Pad Side Slope Contouring.

SOLUTION MANAGEMENT

Large column leaching and rinsing studies provided data on solution application rates that impacted the residual inventory, **Figure 8**. The higher the solution application rates in the columns, the more efficient the rinsing of the dissolved metal values, but the lower the pregnant grade. Experience show that the application rate should not exceed the percolation rate, or the solution will flow horizontal and channel downward.[3]

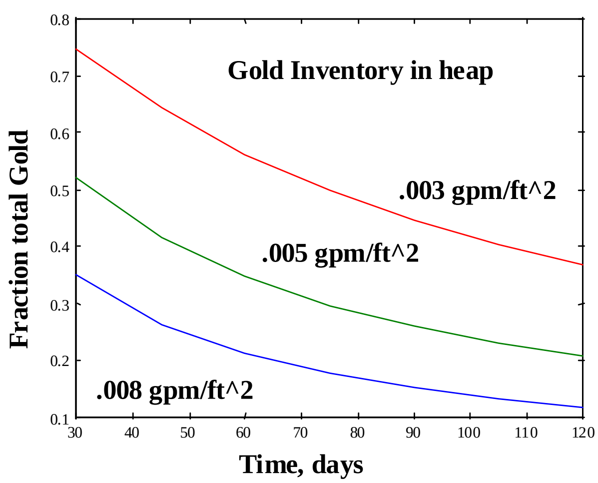

FIGURE 8 Gold Inventory Reduction by Rinsing Application Rates.

The optimal solution management operation occurs by initially wetting the freshly ripped ore at the percolation rate until such time as the new ore is uniformly wetted. This is followed by application rates near 0.06 L/m^2/hr (0.003 gpm/ft^2) for the leaching cycle. Then rinsing the dissolved metal values with the maximum percolation rate determined during the first wetting phase to reduce the recoverable metal values.

SIDE SLOPE LEACHING

Newmont Mining Corporation in preparation for closure and to allow uniform solution application, re-sloped the sides of the heap at 2.5:1 for the side slope leaching program, **Figure 7**. In conjunction with the emitter supplier, the design utilized three different flow rate emitters for side slopes that provided more leach solution on the top and less on the bottom. This would allow the wave of pregnant solution to arrive at the liner at about the same time, thus reducing dilution. This application also addressed the installation challenges on the steep slopes, **Figure 9**.

FIGURE 9 Side Slope Emitter Placements.

The design emitter and tube run incorporates emitters: 7.6 L/hr (2 gal/hr) for the top 1/3, 3.8 L/hr (1 gal/hr) for the center 1/3 and 1.9 L/hr (0.5 gal/hr) for the bottom 1/3 of the single factory fabricated line. Emitter and tube run lines are ordered for the length of the side slopes from the supplier. Operators can grab several lines and walk downhill placing the lines, as they go to the bottom of the cell where a vehicle provides a ride to the top and the cycle repeats. Valves are added to the bottom for periodic line flushing.

HYDRO-JEX

In an effort to meet the challenge of introducing all the lixiviants to the dissolution site and then rinsing the dissolved metal values, a new technology is being developed, and a provisional patent on the technology has been filed. The technology is called Hydro-Jex for water chemistry-lixiviant solution injection and metal extraction.[1] This new technology has been designed to sample the heap leach pads and quantify the inventory, then facilitate reagent addition to targeted zones of un-leached or under-leached ore material. The technology also includes a design for periodic rinsing of the dissolved metal values for recovery. Thus, with the Hydro-Jex technology a heap leach operator can add a gamut of reagents concentrations to a pre-selective zone or depth to facilitate leaching, change the chemistry or pH in the zone, re-channel solution migration paths, or rinse the dissolved metal values. Enhancing the rinsing process could reduce pumping and closure time and costs. This process is currently undergoing field development and is approximated in **Figure 10**.

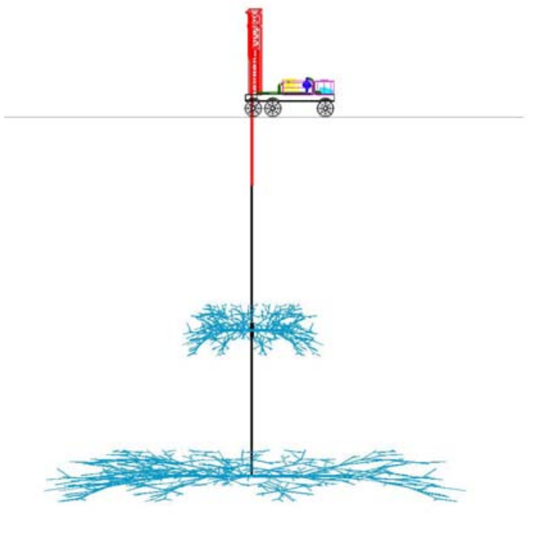

FIGURE 10 Hydro-Jex Illustration.

CONCLUSIONS

Metal values located as inventory in large heap leach operations represents a significant economic resource and a challenge to recover. Extensive capital expenditures have been spent to place this resource on the heap; such as containment construction, mining, hauling, and reagents addition. In addition, operational expenses, including pumping costs, will be utilized to attempt to rinse as much of the inventory resources from the heap prior to closure. In an effort to optimize these expenditures, heap leach operators need to optimize the leaching process by introducing the dissolving lixiviant reagents to the location of the metal values and then rinsing the dissolved metals for recovery. Identifying the location of the inventory, with use of resistivity surveys can aid in solution application cycles. Adequate ripping of the heap leach surface prior to solution application will promote uniform wetting and dissolution of metal values. Side slopes metal inventory can be leached in conjunction with closure contouring. Development of the Hydro-Jex technology could add an important tool for heap leach operations to improve metal recovery and reduce rinsing time and expense during the closure process.

ACKNOWLEDGEMENTS

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REFERENCES

1. Seal, T., (2004), Enhanced Gold Extraction in Cyanide Heap Leaching Using Hydro-Jex Technology, Ph.D. Dissertation, U of Idaho, May, pp 90-99.
2. Uhrie, J. L. and Koons, G. J., (2001), "Evaluation of deeply ripping truck-dumped copper leach stockpiles", *Mining Engineering*, December, pp 54-56.
3. Bartlett, R. W., (1992), Solution Mining, Gordon and Beach Pub, pp 145.