OCAMPO, MEXICO
PROCESS DESIGN RESPONSES TO
HIGH RAINFALL AND EXTREME TOPOGRAPHY

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ABSTRACT

The $140 million Ocampo Project of Gammon Lake Resources (Chihuahua, Mexico) has been in operation since late 2006. Facilities include both open pit and underground mines, a 12,000 tonne/day heap leach, and a 1,500 tonne/day agitated cyanide leach plant. Extreme topography coupled with high rainfall required some interesting design and operational tradeoffs. This paper discusses the design and startup issues of process solution and tailings management, and the unique spiral stacking method used to construct the heap.

INTRODUCTION

Ocampo, Mexico, is a traditional historic mining camp located at an elevation of 1900 meters in the Sierra Madre Mountains, about five hours' drive west of the city of Chihuahua. Near the mine, the terrain becomes very precipitous - for example, the Basaseachic waterfall (20 km from Ocampo) has a single drop of 990 vertical feet. In January and February 2007, there were four significant snowfalls at Ocampo.

Kappes, Cassiday first became involved with the project in 1997, and our role eventually evolved to that of EPCM Contractor (Engineering, Procurement and Construction Management Contractor) in 2005 for Gammon Lake Resources of Halifax, Nova Scotia. A previous paper: "OCAMPO, MEXICO - HEAP LEACH AND MILL CONSTRUCTION IN A VERY CHALLENGING SETTING" presented at the February 2007 SME conference in Denver, discusses some of the construction challenges.

Figure 1 presents a map showing the general location of Ocampo, and identifies other nearby recent mineral developments in the Sierra Madre. At least five other significant deposits are in development or have recently been placed into production. Ocampo, like many of the others, consists of quartz veins and stockworks containing minor sulfides, in a volcanic or intrusive host rock. Silver leaches slower than gold, and requires finer crushing, higher cyanide levels, and longer leach times. Figure 2 highlights the difficult access - in order to move in the larger mining and processing equipment, a public road tunnel had to be enlarged, and all equipment had to move through the town of Ocampo, requiring relocation of some structures. Minor snowfalls result in closure of the public roads for up to four days each year.

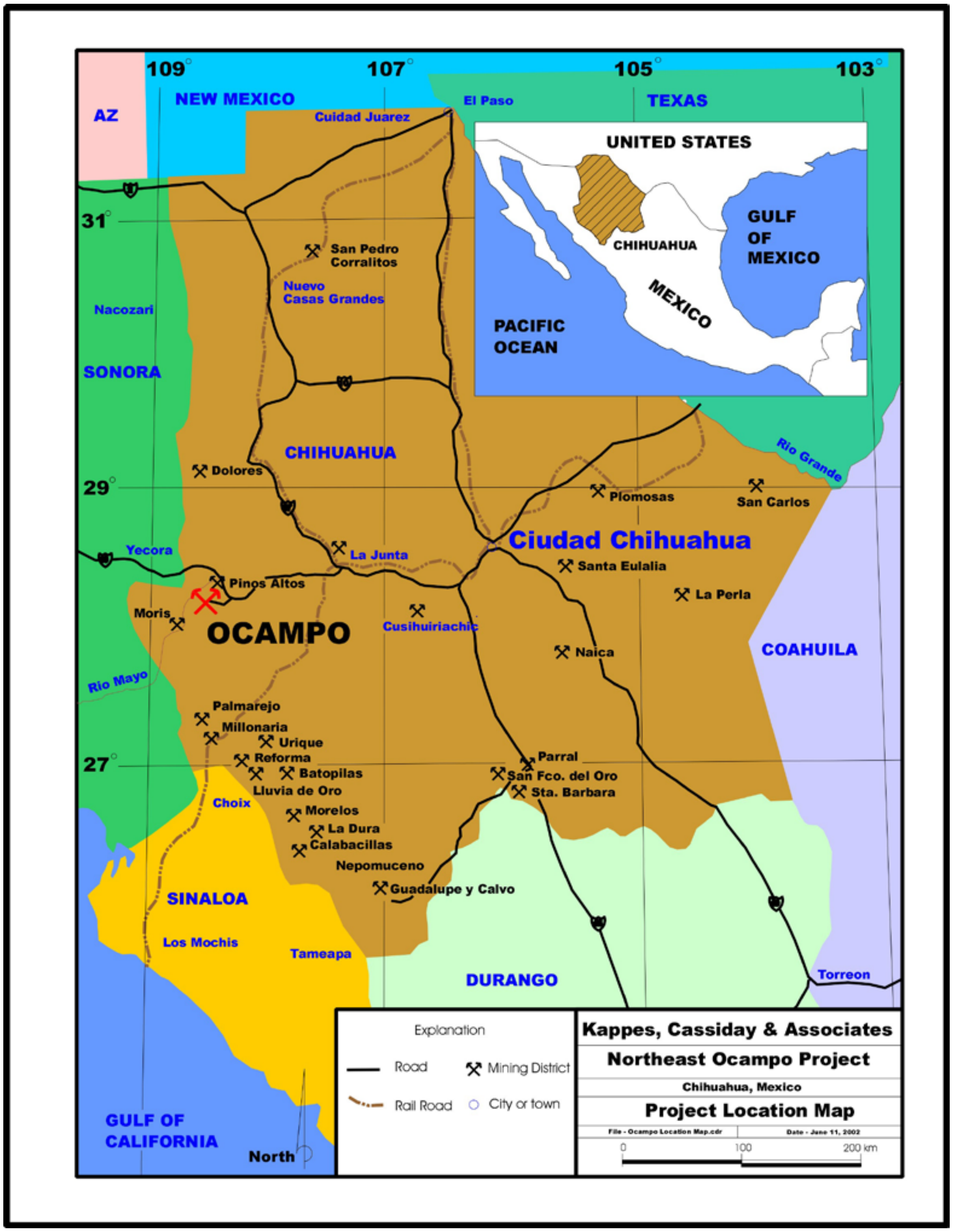

FIGURE 1. OCAMPO IS LOCATED IN THE SIERRA MADRE MOUNTAINS, STATE OF CHIHUAHUA, MEXICO

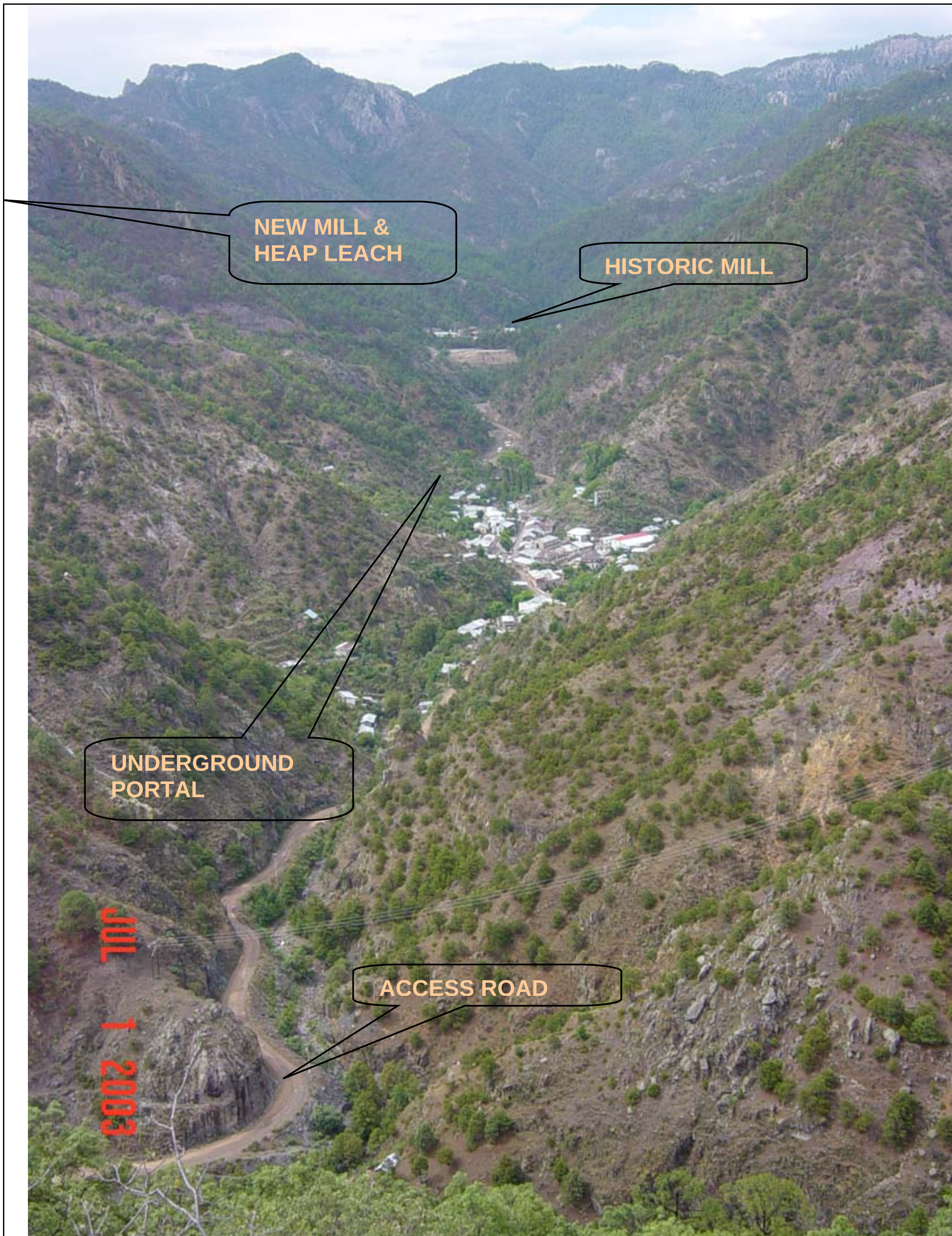

FIGURE 2. PUEBLO OF OCAMPO
(PHOTO IS TAKEN FROM ACCESS ROAD)

PROCESS DESIGN CHALLENGES

There are several aspects of the Ocampo process design which are somewhat unusual, among them:

- Water Management
- Tailings Management & cyanide destruction
- Advance spiral stacking of the heap

WATER MANAGEMENT

Water Management was one of the most difficult aspects of the Ocampo design. The Ocampo area typically receives rainfall of 300 mm in July and August, with common excursions to 500 mm. It can be totally rain free from October to June. Annual rainfall is about one meter. The very steep terrain provides almost no opportunity for water or process solution storage. To accommodate these issues, the mill and the heap leach, located about 2 km from each other, are connected by a pipe carrying mill overflow solution to the heap leach process pond:

- All water entering the process systems is used in the mill, as wash water in the Countercurrent Decantation Thickeners.

- There is no mill tailings pond (tailings are dry stacked).

- Excess water (process solution) is discharged (via a barren tank overflow pipe) to the heap.

- If the heap does not need water, then less water is used in the mill, and CCD removal and recycle of cyanide becomes less efficient.

- Because of terrain limitations, there is only one pond at the heap leach. This pond has an operating volume of 15,000 cu m and an excess solution (storm-water) capacity of 50,000 cu m. The pond functions as a pregnant solution pond, with barren solution pumped from a tank to the heap.

- Fresh water is stored in a 1,000,000 cu m reservoir. Water equal to all process and site requirements is pumped into this reservoir from wells.

The costs and operating parameters for this system of limiting input water to the mill are shown in Table 1.

TABLE 1. WATER USE AND ITS EFFECT ON OPERATING COST

	Water Use (new water addition to CCD thickeners) cu m per day	NaCN to destruct plant Kg per tonne of ore (NaCN remaining in slurry after CCD washing)	Reagent cost in destruct plant, plus replacement NaCN cost, US$ per tonne of ore
Rainy Season (3 months)	0	3.03	9.09
Dry Season	153	0.04	0.12
12-month Average for a wet Year	115	0.79	2.37
Figures are for a worst-case wet season. In most years, cost will be about 50% of those shown in the table.			

Table entries are described below.

Water Use. Since the operation operates under zero discharge rules, the amount of fresh water that can be used is a total of a) water discharged with tailings; and b) the amount of water that is consumed in the heap leach.

Water Discharged with Tailings. The pre-production lab testwork indicated it would be possible to achieve 14% moisture content in the tailings discharged from the recessed plate pressure filters. In practice, it is more common to see 18 to 20% moisture. The tailings are discharged via a conveyor to a dry-stack tailings area, and can be spread with a bulldozer up to a moisture content of about 22%. So, this higher-than-design moisture content does not seem to be a problem. It does, however, require close control of the cyanide destruct circuit to ensure that a low level of cyanide is maintained. The site typically achieves 10 ppm WAD NaCN in the contained solution in the tailings.

The high moisture content in the tailings, and a related issue - longer cake formation time on the filters (7.5 minutes instead of 3.5) - are largely due to overgrinding in the ballmill. The ballmill routinely achieves its target of 60% minus 200 mesh (75 microns), but in fact nearly all the minus 200 mesh material is minus 325 mesh (44 microns). It appears that this problem can be corrected by close control of the ball charge in the mill, but it has been difficult for the operators to achieve this. Also, the mills were designed with one discharge cyclone, whereas the system would be more flexible if there was a bank of smaller cyclones.

Water Consumed in the Heap Leach. The heap leach uses wobbler sprinklers in the rainy season (to maximize evaporation), and drip irrigation during extreme dry seasons (to conserve water). For much of the year, dual piping systems are maintained on the heap to optimize water management. Nominal heap production rate is 12,400 tonnes/day of dry ore, which normally contains about 3% moisture in the dry season (380 cu m of water per day) and 6% in the wet season (1200 cu m of water per day). Ore under active leaching contains about 12% un-drainable moisture, and 3.5% drainable moisture. So, the 12,400 tonnes of ore placed onto the heap each day, absorb 1890 cu m of solution per day in the dry season, and 1070 cu m per day in the wet season. In addition to this, evaporation is estimated to be 3% of solution pumped through wobbler sprinklers in the rainy season, and 8% in the dry season. Sprinkler rate is 500 cu m per hour, so evaporated water is 360 cu m/day in the rainy season, and up to 960 cu m per day in the dry season. Drip irrigation is used on the heap to conserve water in dry periods.

Rainfall which collects on the heap leach and pond areas (120,000 sq m) enters the water system. The “worst case” design is 500 mm per month. This is equal to 2000 cu m per day during a design 3-month rainy season, and zero for the remaining part of the year.

Total Water Consumption. Adding up all the above numbers, we can calculate water consumed, which is also maximum water use in the table 2.

TABLE 2. TOTAL PROCESS SYSTEM WATER LOSS OR (GAIN), CU M PER DAY

	Rainy Season	Dry Season	Average Year
Water in mill tails (15% net of 3% incoming moisture)	260	260	260
Consumption by Heap Ore	1070	1890	1680
Evaporation	360	960	1530
Rainfall	(2000)	0	500
Total Water	(310)	3110	3970

The net maximum rainy season gain of 310 cu m per day (27,900 cu m over three months) can be easily stored in the process pond, which has a stormwater capacity of 50,000 cu m. But, as a good safety measure, no new water is used in the mill during the rainy season. In a typical year, a relatively low July rainfall will allow the operators to begin using wash water in the mill, starting in August.

CCD THICKENER OPERATION IN THE MILL

Ore processed in the mill contains 4 grams gold per tonne and 240 grams silver per tonne. Leaching takes place in agitated leach tanks at 45% solids, 5,000 ppm NaCN (high cyanide levels are required for silver recovery). After leaching, the solution is separated from the ore, and is processed in a Merrill Crowe zinc precipitation circuit. Solution separation takes place in a series of five CCD (Countercurrent Decantion) wash thickeners, in which the slurry, moving from thickener 1 to thickener 5, is progressively diluted with wash water or recycled barren solution, moving from thickener 5 to thickener 1. The thickeners have two somewhat independent functions: a) to recover the maximum amount of gold and silver; and b) to recover as much cyanide as possible, in order to minimize the amount of cyanide which must be destroyed in the cyanide destruct circuit.

The Merrill Crowe circuit is designed to process twice the amount of solution which flows through the leach tanks (one tonne of pregnant solution diluted with one tonne of wash water).

Because of the requirement for no new (fresh) water addition in a very wet rainy season, the CCD thickeners operate within the limits of no added fresh water during the rainy season, and a 2:1 wash ratio (2440 cu m/day of wash water) during the dry season. Even though no new water can be added during the rainy season, some cyanide-free water - 500 cu m per day (0.4 to 1 wash ratio) - is always available as the amount recycled after cyanide destruction and tailings filtration. The CCD thickener discharge to the cyanide destruct plant therefore ranges from 3,300 ppm NaCN during the rainy season, to 35 ppm NaCN during the dry season. These numbers have been used to calculate the costs in table 1. In an average or below average rainy season, the level of solution in the heap leach pond, and the production rate of new ore to the heap leach, will be monitored daily. If these parameters are OK, then beginning in early August, about half the dry season wash water volume can be used as wash water in the mill.

TAILINGS FILTRATION AND TAILINGS MANAGEMENT

Mill tailings are deposited into a dry tailings pond. A lined, wet tailings pond was considered, but the cost to line this pond and manage the excess solution would exceed the cost of the tailings filters. Also, since the only areas available are steep-walled canyons, the construction of a geotechnically-stable tailings dam to contain water-saturated tailings, may not be economically feasible.

Tailings, exiting the CCD 5 wash thickener at 52% solids, as sent to an Inco process cyanide destruct circuit, where WAD NaCN is reduced to less than 10 ppm in the contained solution. The tailings are then filtered to less than 20% moisture on two Lasta recessed plate filters (manufactured by Industrial Process Machinery Inc), then discharged onto a reversible conveyor which parallels the filter building.

FIGURE 3. TAILINGS FILTER BUILDING AND TAILINGS CONVEYOR

With the full system in operation, the reversible conveyor on the front edge of the filter building, discharges onto a 450 meter long tailings transport conveyor, installed on a 26% (45 degree) downslope. At the conveyor discharge, the tailings are spread and compacted with a bulldozer. When the tailings discharge conveyor is being serviced, or during periodic re-positioning of this conveyor, the reversible conveyor discharges onto the upper slope of the tailings storage area, and is moved directly by bulldozer. This install-lation can be seen in Figure 3. There have been no problems with the steep conveyor angle, but other mill issues have resulted in a larger-than-planned discharge of tailings to the upper slope area. Unrelated earthworks have resulted in a general re-contouring of the tailings storage area which will require some re-design of the area, but the design concept and system appears to be valid.

Cyanide Destruction. The tailings storage area is unlined, so the cyanide level in discharged tailings is maintained below 10 ppm WAD NaCN. As discussed earlier, much of the cyanide is recovered in the CCD wash thickeners. Residual cyanide is destroyed in an Inco-process plant using copper sulfate and sulfur dioxide (or sodium metabisulfite). A sulfur burning facility was installed at Ocampo, but it has proved difficult to import the prilled sulfur used in the plant, and within Mexico this material is not available. While the import issues are being resolved, the more expensive alternative - sodium metabisulfite - is being used. Startup and operation of the cyanide destruct plant, and achieving the design level of cyanide destruction, were relatively easy.

UNUSUAL TECHNOLOGIES AT THE HEAP

Ore from the open pits is crushed, then sent across a steep valley to the heap leach site via two downhill overland conveyors, each 800 meters long on a downhill 18% slope. The final conveyor discharges onto a 24-hr capacity stockpile. It is then reclaimed by the heap conveyor stacking system, consisting of a 200 meter long reclaim conveyor, up to 19 sectional conveyors, and a radial stacker. The ore does not normally need agglomeration. But to ensure good heap performance, cement and process solution are added in the conveyor system. Capacity of these systems is over 17,000 tonnes per day.

The heap leach site is shown in Figures 4 through 6. As with everything else at Ocampo, the site was heroically cut out of steep terrain. Leach pad sideslopes are up to 40 degrees, and the site is very small for the tonnage involved. Fresh ore must be stacked above partially leached ore within 45 days of initial leaching, even though the leach cycle exceeds 120 days. To work within these difficult parameters, the stacking system is designed for top-stacking (forward stacking) of the heap - the stacker runs on top of the new ore being stacked. The heap is build as a continuous spiral ramp. The leading edge of the ramp is maintained at a height of ten meters above the material below it.

FIGURE 4. SIDESLOPE LINER CONSISTS OF A GEOTEXTILE LAYER, A LAYER OF GCL (CLAY ENCLOSED IN GEOTEXTILE), AND A TOP 60 MIL HDPE COVER.

FIGURE 5. IN THIS EARLY PHOTO, THE PATTERN OF SPIRAL STACKING IS JUST BEING ESTABLISHED

FIGURE 6. THE STACKING SYSTEM IS NOW ON AN UPPER LEVEL. IT ADVANCED WHILE STACKING UP A SPIRAL RAMP, AND IS SHOWN ADVANCING ON A LEVEL SURFACE, 10 METERS ABOVE AN EARLIER BENCH. LEACH PIPES ARE REMOVED AS THE HEAP ADVANCES OVER THE OLDER MATERIAL.

The stacking system was built by TNT Technologies with considerable design input by KCA, and is working well. An Excel-based heap production model is maintained, and this shows that heap performance is very close to the prediction from feasibility-study lab column tests. As in the mill, silver recovery is dependent on cyanide level. KCA felt that cyanide level in the heap could be maintained at 300 ppm NaCN given the long leach times available, but early heap performance showed that a level of 1000 ppm was necessary to achieve the model results. Fortunately, cyanide consumption in the heap was lower than predicted by the column tests, so the higher cyanide level can be maintained without excessive use of cyanide.

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