



eXtreme Processing – maximum benefit for minimum effort

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Synopsis

The advent of continuous gravity technology affords the opportunity to capture not only the free liberated gold, but also the gold carrying species into a small, high-grade concentrate. This concentrate can then be treated under more intensive conditions in a small, dedicated plant for maximum recovery. The benefits are obviously lower capital plant installation costs and lower operating costs since only a fraction of the ore is treated. Knelson Gravity Solutions has coined the term eXtreme Processing to describe a processing system comprising of continuous gravity concentration via Knelson CVD followed by a regrind upon the concentrates and intensive cyanidation upon the resulting slurry. A further refinement, under investigation at this time, is the direct electrowinning of gold as solid cathode from the pregnant liquor.



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1. Introduction

In gold ores where the mineralization is such that the gold is deposited as free elemental gold at typical grind sizes, the gold is amenable to gravity capture and this method is widely practiced. It is reasonably common to find a secondary department to the sulphide minerals present, such that a very high proportion of the total gold may be captured if both the elemental gold and the sulphide associated gold are targeted. In such systems, the vast majority of the target value can be contained into a relatively small mass of proportionately high grade. For example, Knelson gravity tests conducted upon a Witwatersrand ore resulted in a recovery of 84.39% of the value into 3.2% of the feed mass. 48.37% of this recovery was as GRG, or free gold, with the remaining 36.02% reporting as high value sulphide mineral assaying 132 g/t Au (ref 4).

The benefit accrues not only from a much smaller plant, but also from the potential for a more intense treatment regime upon the concentrated species. The increased efficiency of the subsequent processing may even offset any recovery deficit that may occur in the primary gravity capture.

The Extreme Processing concept is therefore an amalgamation of continuous gravity technology with enhanced process chemistry to result in more favourable capital and operational economics. The concept is not only restricted to ores, but can also be applied to process tailings where sub-economic grades can be rendered treatable.

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2. Process Description

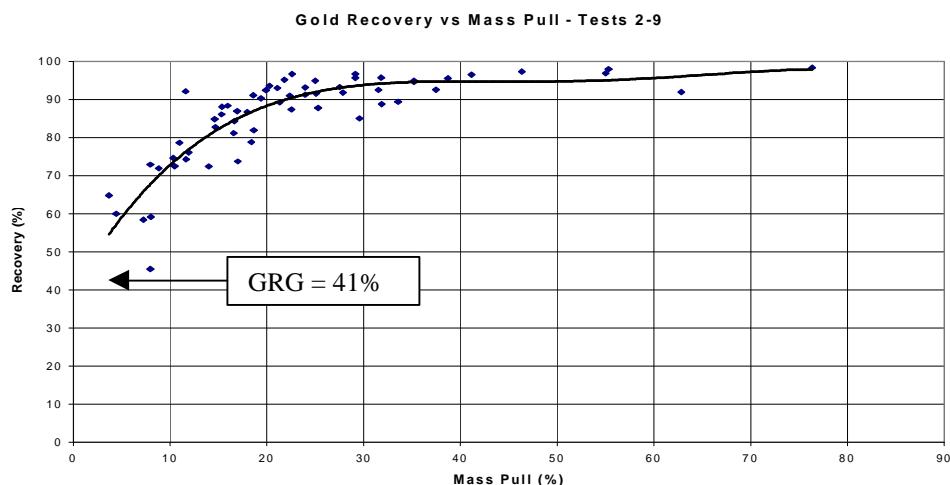
2.1 Production of gravity concentrate

Knelson batch concentrators are synonymous with the recovery of free gold, or gravity recoverable gold (GRG) as it has come to be known. With the advent of Knelson's continuous concentrator, the CVD, the same proven centrifugal technology is applied to the recovery of a larger mass of heavy mineral. On a gold ore, this is usually the sulphide mineral component. Due to the design configuration, the CVD is able to simultaneously capture the free gold as well as the sulphide bound component. In a batch Knelson application the free gold, or GRG, is captured into an extremely small mass, typically about 0.03% of the feed. In reality, since the elemental gold is the target in batch concentration, the actual relevant mass is the gold itself, which is almost insignificant in terms of the feed.

When the capture is expanded to include the sulphide carrier, the target mass obviously becomes the mass of the sulphides present, which is typically less than 5%, but may be up to 20%. Fortunately, the CVD can be adjusted for mass pull and can therefore be tailored to suit virtually any application. Changes in the ore and circumstances can also be accommodated with little more than keystroke changes.

This ability is demonstrated in the results, shown in Figure 1 of a pilot trial using a Knelson CVD6 in the milling circuit of the Sadiola Hill Mine, Mali (ref 6). Each of the plot points on the recovery vs mass curve represents the result of a separate run at varying machine settings, demonstrating not only the ability of the CVD to capture the vast majority of the ore value, but also the ability to vary the mass pull for optimum recovery and grade.

Figure 1: Recovery Sadiola Hill Mine; Knelson CVD6 trial



Note: each data point represents a separate run at varying parameter conditions

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The idea of separating out the gold carrying sulphides for a more intensive treatment is nothing new. The classical flotation – cyanidation plants were a common method of treatment prior to the popular adoption of CIP in the eighties.

Gravity is an inexpensive process in terms of both capital and operating costs, the only consumables being power and water, and even these usages are very modest. The machine size is also extremely small relative to the task performed, resulting in far less floor space and building requirement. Whereas a typical flotation plant, for example, has a residence time of twenty minutes or more and consumes up to three reagents, the Knelson CVD has a residence time of less than half a second and requires no reagent addition!

There are other advantages which may also give gravity a significant edge over classical processes. For example, in flotation the ore requires to be ground to a nominal particle size of 150 microns or less, even though the target mineral may have been liberated at a much coarser size. Because the denser sulphides remain in the grinding circuit for longer than the lighter ore, they become over-ground, rendering them more difficult to recover in flotation. The extra grinding energy employed may therefore be inappropriate and possibly destructive. The Knelson CVD, conversely, is applicable upon feeds at up to 2mm and the coarser the size that the target mineral is liberated at within this range, the better.

It is also possible to target semi-liberated or even totally occluded mineral particles as classified in the hypothetical mineral classes of Figure 2.

Figure 2: Target mineral classes

Class		Gravity	Cyanide	Float
1		y	y	y
2		y	y	?
3		y	n	n
4		y	n	n
5		y	?	?
6		n	?	?

By exploiting favourable size distributions and particle shape factors it is also sometimes possible to eject a fine, problematic gangue mineral using the counter fluidisation water flow of the CVD. For example, at Bogoso Mine a CVD is producing a sulphide concentrate for cyanidation whilst simultaneously elutriating preg-robbing

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graphite from the concentrate. Whilst this sort of result may also be achieved in flotation, it would typically involve gangue depression or even a differential flotation step, i.e. more reagents or residence time or both.

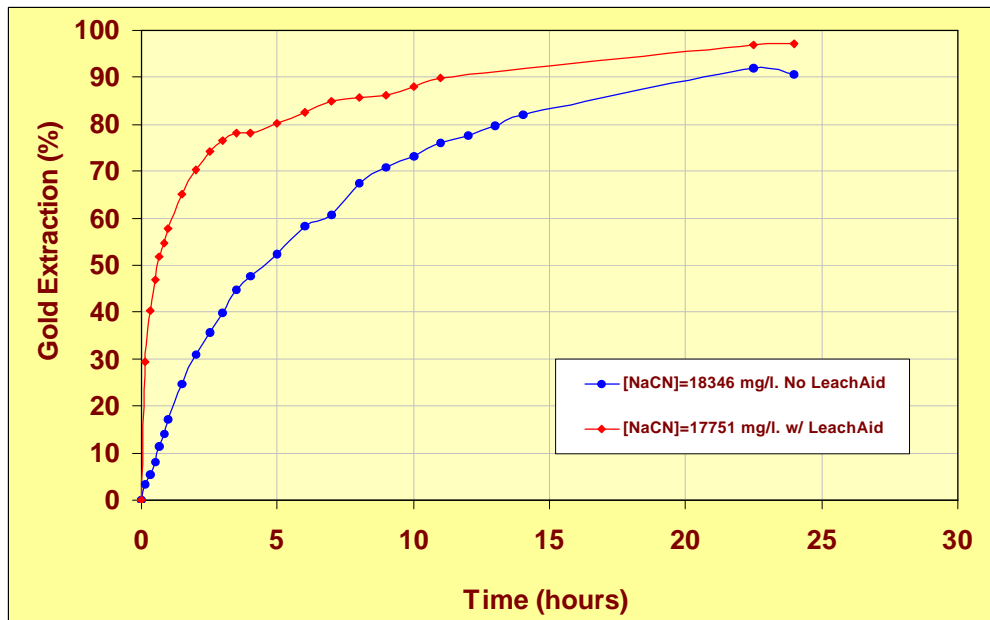
2.2 Sub-processing of concentrates

2.2.1 Chemistry

A smaller volume, higher grade concentrate allows for more intensive treatment regimes to be applied. Several methods of treatment of the concentrates are available and depending upon the degree of refractoriness of the concentrate these may range from simple cyanidation, through intensive cyanidation to pre-oxidative measures such as roasting or biox prior to cyanidation. Indeed, new techniques using alternative lixiviants like thiosulphate or bromine compounds could be employed upon the higher grade concentrates.

In the context of Extreme Processing, Knelson Gravity Solutions has restricted the definition and scope of its approach to intensive cyanidation after a regrind. The chemistry may nevertheless be enhanced by addition of Leachaid® if the concentrate is of sufficiently high grade (ref3).

Figure 3: Enhancement of gold dissolution kinetics with Leachaid® addition



Even where relatively modest conditions are employed, significant increases in recovery are possible. Table 1 outlines the results of a laboratory trial upon a sample of transition ore from the Sadiola Hill Mine comparing whole-ore cyanidation against cyanidation of gravity concentrates and tails (ref 2).

**Table 1: Whole-ore cyanidation vs separate cyanidation of gravity concentrate and tails**

Ref	Procedure	Conditions	Recovery
1	Whole ore	82% -75mic, 40% solids, 1.2kg/t NaCN, pH 11	78.8%
2	Cyanidation of gravity tails	82% - 75 mic, 40% solids, 1.2kg/t NaCN, pH 11	70.2%
3	Cyanidation + grind on concentrates	20% solids, 12 kg/t NaCN, pH11	85.3%
4	Total via separate gravity/regrind/cyanidation		84.0%
	BENEFIT		5.2%

A further major benefit to accrue from the treatment of higher grade concentrates is of course higher grade pregnant liquors. The possibility exists to employ direct electrowinning to recover the gold and KGS has performed successful laboratory trials utilising the EMT EMEW electro cell technology. The benefit of this technology is that the gold is won as a solid cathode, thereby eliminating the sludge collection, acid dissolution and smelting steps. The gold depletion curve from this trial is shown in Figure 4. The unique design of the EMEW cell, as modified by Knelson, allows for the presence of some solids with no detrimental effect upon electrowinning performance or cathode quality. It is therefore not necessary to obtain perfectly clear pregnant solutions, which allows for relaxation in the design of the Extreme Processing plant.

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Figure 4 : Electrowinning performance: EMEW pilot trial

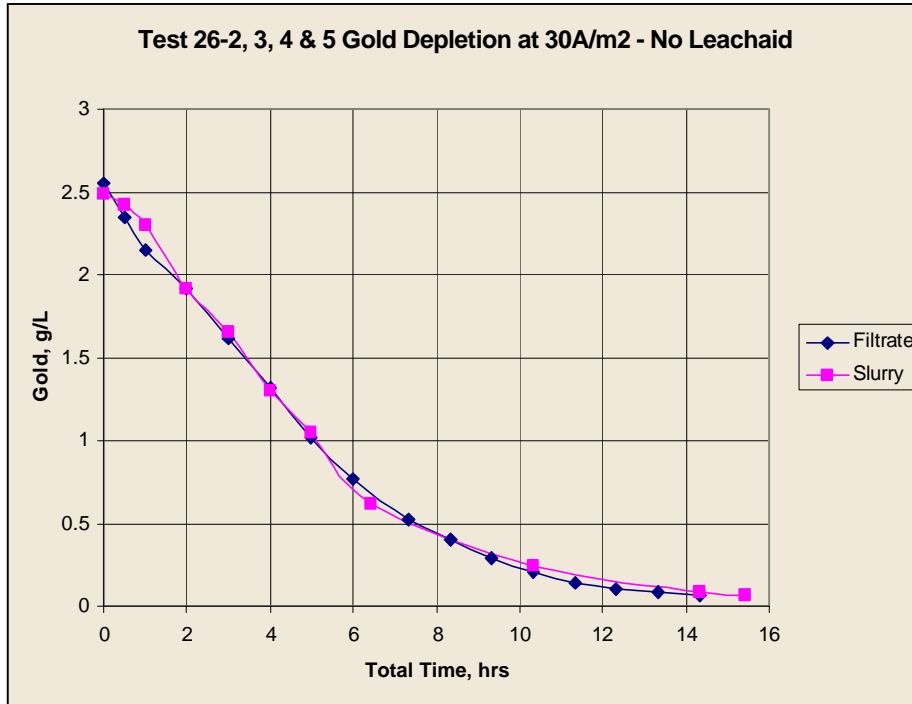
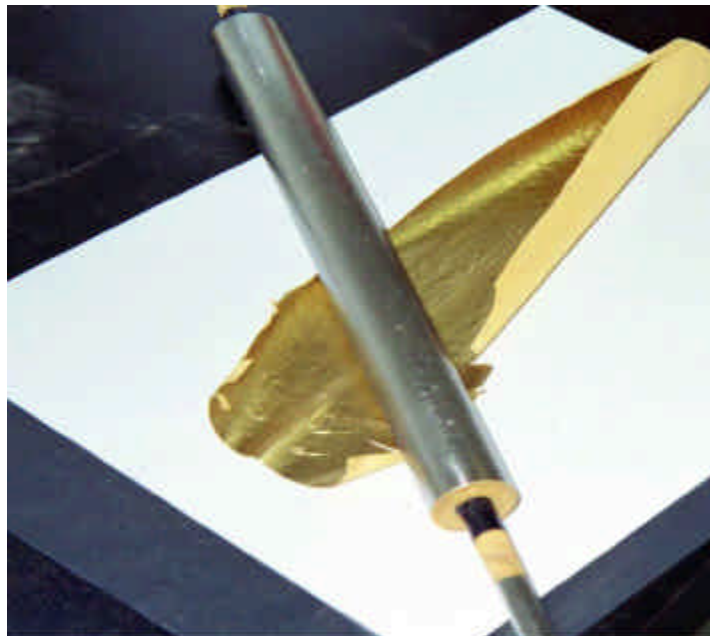


Figure 5: Deposition of solid gold cathode ex EMEW trial

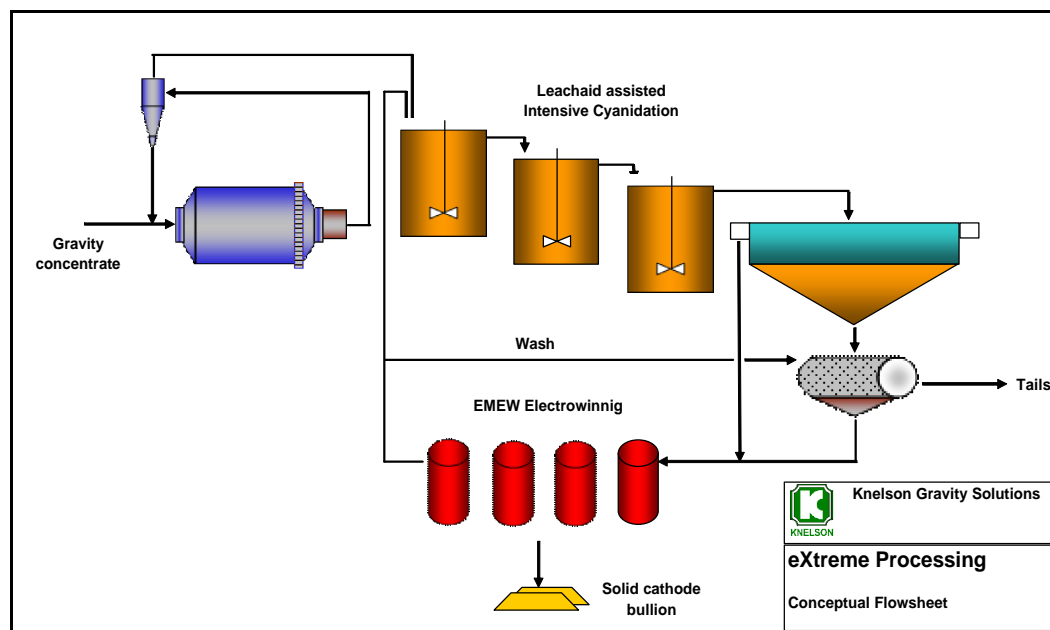


2.2.2 Plant configuration

Due to the diverse nature of the concentrates encountered a flexible approach is called for, with the overriding principle nevertheless being simplicity and minimalism.

A conventional ball mill and conventional leach tanks are employed, resulting in a high degree of confidence in the solution. Being applied to the concentrate alone, the scale of these unit components is obviously far smaller than would have been necessary if the whole-ore were treated. There is the possibility of reducing the residence time and therefore reactor volumes even further by enhancing the leach kinetics with Leachaid®. This is the same oxidative accelerant that is used in the Consep Acacia reactor, and again this is a well established and accepted reagent.

Figure 6: Typical plant flowsheet; Bogoso CVD32-2 trial





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3. Applicability

The applicability of Extreme Processing depends firstly upon the amenability of the gold-carrying species to gravity concentration and secondly upon the response of the gravity concentrate to subsequent dissolution treatment.

By performing test work to simulate whole-ore treatment and comparing the results with those from an Extreme Processing simulation, the benefits become apparent. Even if the results are similar, the Extreme Processing route may nevertheless be justified upon the basis of minimalism alone, but more often than not a significant advantage in recovery is apparent.



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4. Testing and evaluation

The Knelson Research and Testing Centre has developed a test to specifically evaluate candidate ores. Like the GRG test it determines the free gold recovery potential, but in addition it also determines the gold deported to the gravity-amenable carrier. Once amenability has been established, a quantity of concentrate is generated and this is subjected to intensive cyanidation and accelerated intensive cyanidation tests.

If amenability testing proves positive, KGS is able to undertake a pilot trial using the Knelson CVD6 itself, with comprehensive pilot cyanidation tests upon the concentrate.

Should this trial prove positive the KGS design department is able to perform a first-order conceptual design and costing for an appropriate module to treat the ore.



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