

CASE STUDY

**CLEAN MINING ACHIEVES
91% GOLD RECOVERY
AND ELIMINATES TOXIC
PRE-TREATMENTS IN
CARBONACEOUS ORES**



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Gold extraction using cyanide ineffective for carbonaceous Brazilian ore due to preg-robbing

Client advised pilot plant conditions were kerosene and aeration pre-treatments followed by RIL and **cyanide extraction achieving 83% recovery (>1% TOC)**

Clean Mining's reagent achieves **87% gold recovery** for carbonaceous ore (>2% TOC) at laboratory scale with no pre-treatments, reducing CAPEX and OPEX

Clean Mining's **reagent blend shown to be effective without ore pre-treatment or conditioning**

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OVERVIEW

The Problem

Cyanide has long been the go-to chemical for gold extraction in the industry, however there have been growing concerns about its use due to its negative health and environmental impacts. Several countries and jurisdictions have already banned the use of cyanide for gold extraction, and it is inevitable that more will follow. Even where its use is not banned, costly and time-consuming regulatory requirements around cyanide use can hinder the operation of existing gold processing facilities as well as the start-up of new projects.

Clean Mining (CM) was approached by a client in Brazil who were seeking a clean gold extraction technology that eliminates the need for toxic reagents, pre-treatments and would work on a carbonaceous ore. The client's ore had 2.2% organic carbon present, therefore gold extraction was significantly hindered by preg-robbing effects and needed multiple pre-treatments.



Gold mines often need to process carbonaceous ores that can hinder gold extraction if not adequately pre-treated. Carbonaceous ores contain carbon-based material that can adsorb dissolved gold when extracted using cyanide (an effect known as preg-robbing). As such, the carbonaceous constituents in these ores must generally either be passivated or destroyed by some form of pre-treatment(s) to enable gold extraction by cyanide leaching.



The Solution

Clean Mining has developed a non-toxic reagent blend which eliminates the need for cyanide use in gold extraction for most ore types.

Due to the client's ore being carbonaceous, CM's reagent was a potentially strong solution due to cyanides inherently negative relationship with preg-robbing ore. CM's reagent negates the preg-robbing effect due to the ionic nature of the gold-thiosulfate complex formed which is not readily adsorbed by carbonaceous materials.

FEED ORE

Clean Mining was provided two ore types to test: dactic ore and carbonaceous ore. The composition of key analytes are shown below in Table 1. Each ore type was tested separately alongside a 50/50 blend.

Table 1: Key Analytes in Brazilian Ores Tested

KEY ANALYTES	DACITIC ORE	CARBONACEOUS ORE
Gold (Au)	1.33 ppm	1.33 ppm
Organic Carbon	0.03%	2.16%
Silica (SiO ₂)	71%	59%
Copper (Cu)	80 ppm	139 ppm
Silver (Ag)	0.2 ppm	1 ppm
Arsenic (As)	855 ppm	286 ppm
Sulfides (S ₂)	0.64%	0.74%
Lead (Pb)	9 ppm	19 ppm

LABORATORY TESTING - CARBONACEOUS SAMPLE

Testing of this ore was critical due to the ineffectiveness of traditional cyanidation due to preg-robbing. Clean Mining's reagent was tested on the sample using 40% solids, a 48-hour leach, and 500g charges. Two additional tests were completed with the following ore pre-treatments:

1. Kerosene pre-treatment (6 hours) of the ore to passivate the preg-robbing material.
2. Pre-aeration of the ore (2 hours) to oxidise the carbonaceous material before resin in leach (RIL).



Resin in leach (RIL) is when a gold adsorption resin is added to the leaching vessel so that gold leaching and adsorption can occur simultaneously.



The results of the carbonaceous ore testing are shown in Figure 1.

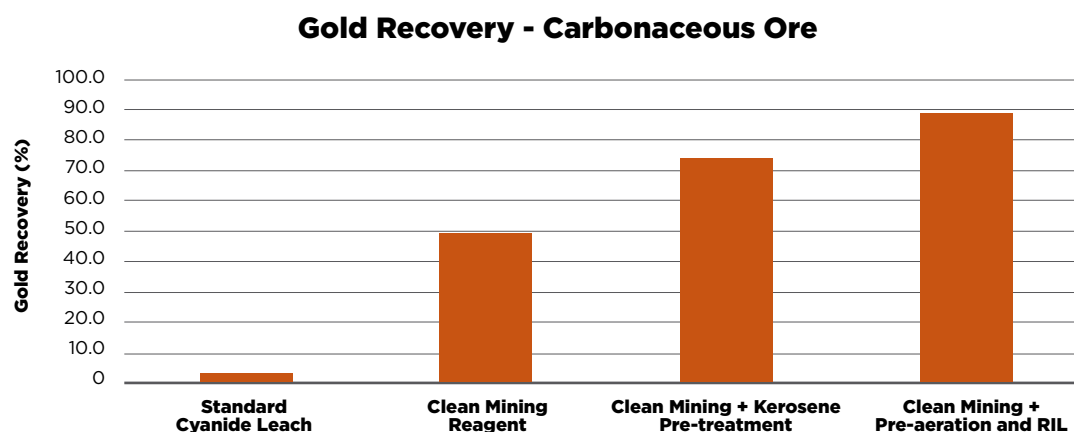


Figure 1: Gold Recovery Tests for Carbonaceous Ore

It was evident from the testing that gold extraction via traditional cyanidation was ineffective without pre-treatments due to preg-robbing effects (only achieving 3% gold recovery), while CM's reagent was able to achieve nearly 50% gold recovery. CM's reagent was also shown to be effective with both kerosene and aeration pre-treatments, along with a RIL system.

Gold leaching using CM's reagent only required 24-hours due to fast leaching kinetics (as per Figure 2).

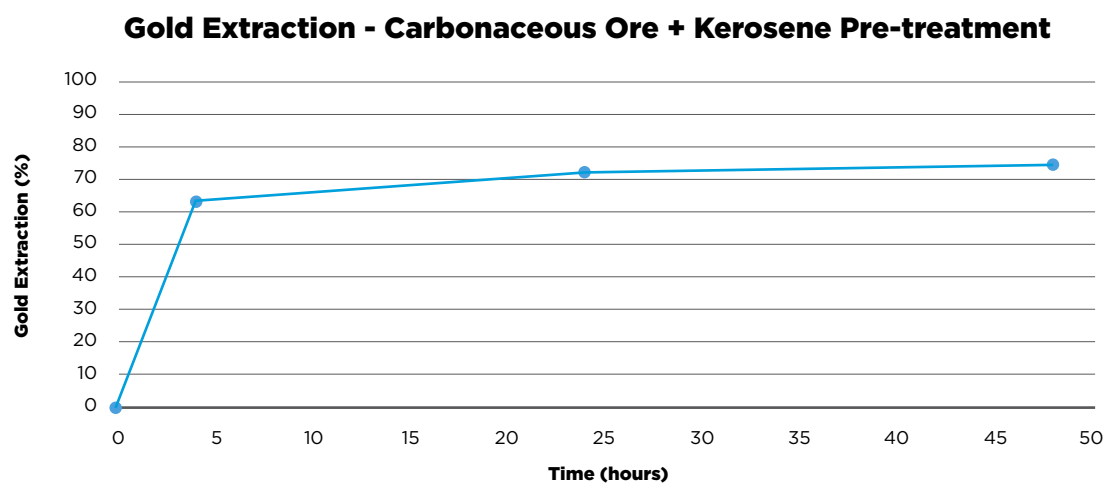
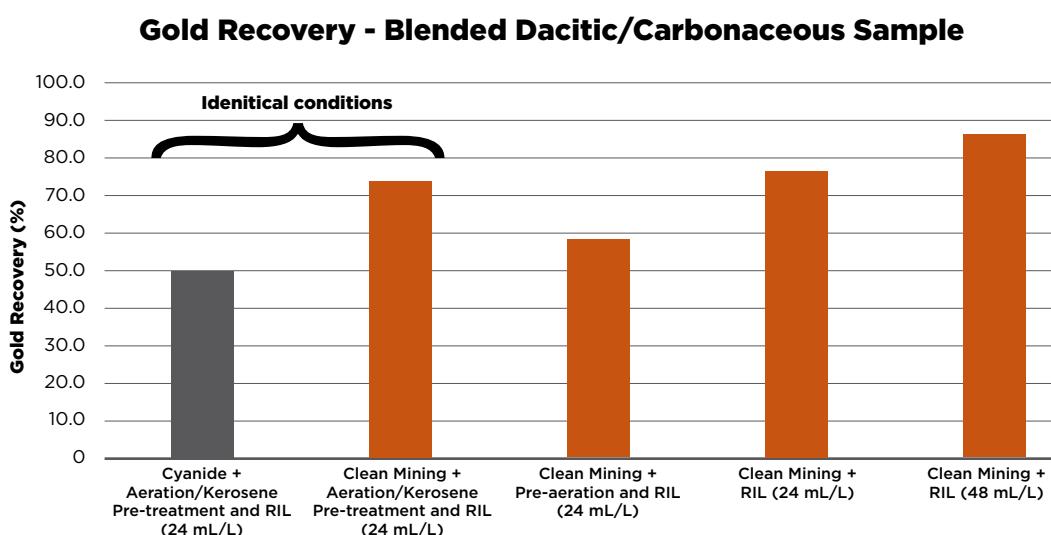


Figure 2: Gold Extraction Curve for Carbonaceous Ore with Kerosene Pre-treatment

LABORATORY TESTING - DACITIC-CARBONACEOUS BLENDED SAMPLE

A blended sample of dacitic and carbonaceous ore (50/50) was tested using the clients pilot plant condition: ore was pre-treated with kerosene and aeration for 6 hours and then a RIL combine with cyanide. Based on these conditions, the average recovery was 83%.

Figure 3: Gold Recovery Test Results for the Blended Dacitic-Carbonaceous Ore Sample



As shown by Figure 3, Clean Mining's reagent was far superior to cyanidation even with the same pre-treatments and RIL conditions (73% vs. 49% respectively). More interestingly, CM's reagent showed a stronger performance when no pre-treatments were applied, achieving 76% and 86% gold recoveries for 24 mL/L and 48 mL/L RIL tests.

Removing pre-treatments significantly reduces cost associated with both CAPEX and OPEX as fewer reagents are required, less tanks for pre-treatment conditioning and the reduction in equipment and maintenance.

CONCLUSION

The key conclusions from the laboratory testing of Clean Mining's reagent are:

- 1 Clean Mining has shown that even with pre-treatments, preg-robbing effects of the Brazilian ore significantly reduce overall gold recovery when using traditional cyanidation methods.
- 2 Clean Mining's reagent can drastically improve gold extraction rates on carbonaceous ores without pre-treatments.
- 3 The introduction of resin to the circuit (RIL) substantially enhances gold recovery when using Clean Mining's reagent on the carbonaceous ore, achieving **87% gold recovery** at laboratory scale. Conversely, using RIL did not improve gold recovery using cyanidation (hence did not negate the preg-robbing effects).
- 4 Clean Mining has demonstrated the ability to significantly reduce project CAPEX and OPEX by removing the need for pre-treatments and achieving **86% gold recovery**, compared to the current client advised pilot recovery of 83%.

FURTHER OPTIMISATION

Further optimisation work on Clean Mining's reagent blend was completed on the Dacitic/Carbonaceous 50:50 blend. This testwork involved no pre-treatments and achieved 91% total gold recovery with RIL, which is significantly more than the client advised recovery of 83% using kerosene and pre-aeration with RIL.

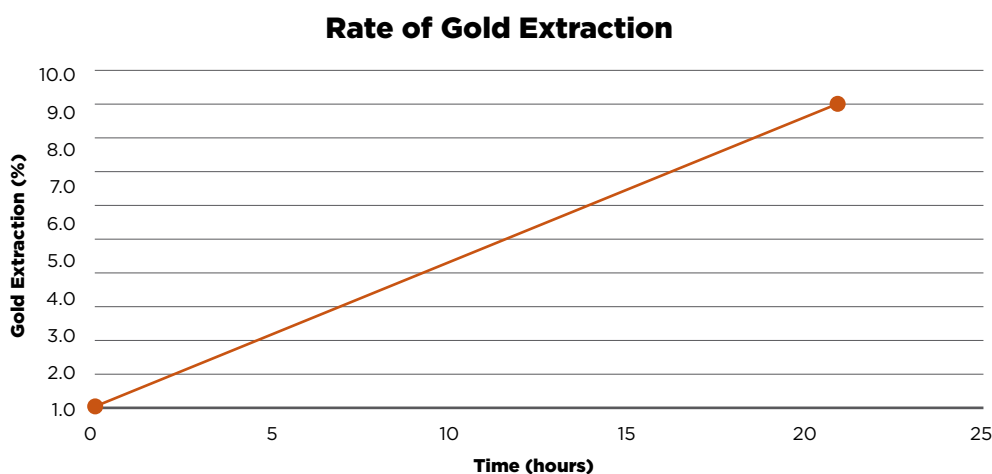


Figure 4: Optimised Reagent Conditions RIL Gold Recovery



For more information:

Email: info@cleanmining.co

Call: +65 6816 6676

Visit: www.cleanmining.co

