

from the Mineral Engineering laboratory, University of Mines and Technology. ChemQuest CQ 650 6x12 activated carbon was obtained from the Bogoso/Prestea Mine of Golden Star Resources and concentrate samples for the investigation were collected from the Bogoso sulphide treatment plant of Golden Star Resources Ltd, Ghana. The specific samples collected were 30 kg each of;

- Mill feed ore samples crushed to -150 mm,
- Flotation concentrate milled to -45 µm,
- Biologically (BIOX®) oxidized flotation concentrate (BIOX® CIL feed), and
- Tailings from the post BIOX® Carbon in Leach circuit (BIOX® CIL tails).

In each case, the samples were collected and composited over a two-week period, homogenised and split for the various tests. These set of samples were used for all phases of the investigations.

Standard laboratory bottle roll setup was used for all the diagnostic, kinetic, cyanide and carbon optimisation leach tests. A Metrohm 826 pH meter was used for all pH measurements. Varian spectra AA55B Atomic Absorption Spectrophotometer (AAS) was used in determining gold concentration in solution

METHODS

Partial chemical analysis of the four test samples was conducted. Gold was analysed by standard fire assay and Varian spectra AA55B Atomic Absorption Spectrophotometer (AAS) finish. Metal concentrations were determined using the Varian spectra AA55B Atomic Absorption Spectrophotometer (AAS). Sulphur and carbon related concentrations were analyzed by the LECO volumetric combustion technique using SC-144DR sulphur carbon determinator.

Diagnostic leach process allows the gold associated with oxides, carbonates, sulphides, and carbonaceous matter to be determined. Various versions of this process have been used in designing process plant flow sheets and troubleshooting low gold recovery in leach plants (Lorenzen and van Deventer, 1993; Torres and Costa, 1995). This test was conducted on the flotation concentrate, BIOX® product and BIOX® CIL tails to establish the gold deportment in the samples, and the procedure used is detailed in Figure 1.

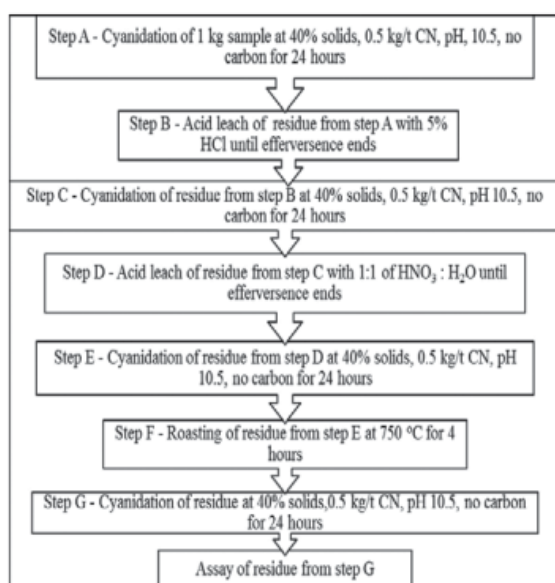


Figure 1. Diagnostic leach procedure.

The first cyanidation leach results indicate free-milling gold. To quantify the gold that was preg-robbled, but recoverable by CIL processing, a parallel sample was leached in the presence of activated carbon. The post HCl digest cyanidation leach shows gold in carbonates. The nitric acid leach releases gold associated with sulphides and gold from the roasting calcine is indicative of gold in carbonaceous matter. The tailings from the calcine leach expresses gold in quartz. At the end of each cyanide-leaching period the pulp was filtered, and the solution obtained was analysed for gold by AAS whereas the residual solids (tailings) were assayed for residual gold by fire assaying followed by AAS finish. All tests were done in duplicates.

Leach optimisation tests were conducted on the BIOX® product, and the aim was to establish the leach time, cyanide consumption and carbon concentration that lead to optimum CIL gold recovery. Samples were slurried with portable water at a pulp density of 33%. This pulp density had been established by MacIntyre, (2005) as optimum for effective miscibility due to the high viscosity of the BIOX® product. The pH was adjusted to 10.5-11.5 by the addition of lime and the slurry preconditioned for 30 minutes. For all leach tests, except carbon optimisation, 30 g/t activated carbon was added. For optimisation study of carbon concentration, 0, 10, 15, 30 and 50 g/l of fresh activated carbon were added. This was followed by the addition of 15 kg/t of NaCN and the bottles mounted on rollers. For cyanide concentration study, 1, 5, 7 and 18 kg/t of NaCN were used. Generally, leaching was allowed to progress for 40 hours in conformity with design leach residence time for Bogoso BIOX® CIL leach circuit (MacIntyre, 2005). For optimum leach residence time, samples were leached for 8, 16, 24, 36, 40, 52 hours, and tailings analysed for gold.

After completion of the leach, the loaded carbon was removed by screening, and the cyanidation slurry filtered. Tailings were washed and dried at 80°C. Cyanidation tailings, head samples and the loaded carbon were analysed for gold by fire assay and Varian spectra AA55B Atomic Absorption Spectrophotometer (AAS) finish. Filtrates were analysed for gold by AAS and residual cyanide by silver nitrate titration. The gold dissolution was calculated as shown in Equation 1, where a is gold grade in tailings (g/t) x mass of tailings (g) and b is gold grade in head sample (g/t) x mass of head sample (g)

$$\text{Gold dissolution (\%)} = \left(1 - \frac{a}{b}\right) \times 100 \quad (1)$$

The preg-robbing index of the flotation concentrate and BIOX CIL feed were evaluated. The approach is by comparing the direct cyanide leach performance without carbon with leaching with carbon. The difference in performance indicates the preg-robbing index.

RESULTS AND DISCUSSIONS

The results of the experimental programmes are presented and discussed in the ensuing sections. Results of partial chemical analysis and metallurgical optimisation and investigative tests are discussed.

PARTIAL CHEMICAL ANALYSIS

Samples of refractory gold ore products including mill feed, flotation concentrate, BIOX CIL feed (BIOX Product) and BIOX CIL tailings were analysed for major constituents and Table 1 gives results of partial chemical analysis of the four sample streams used.