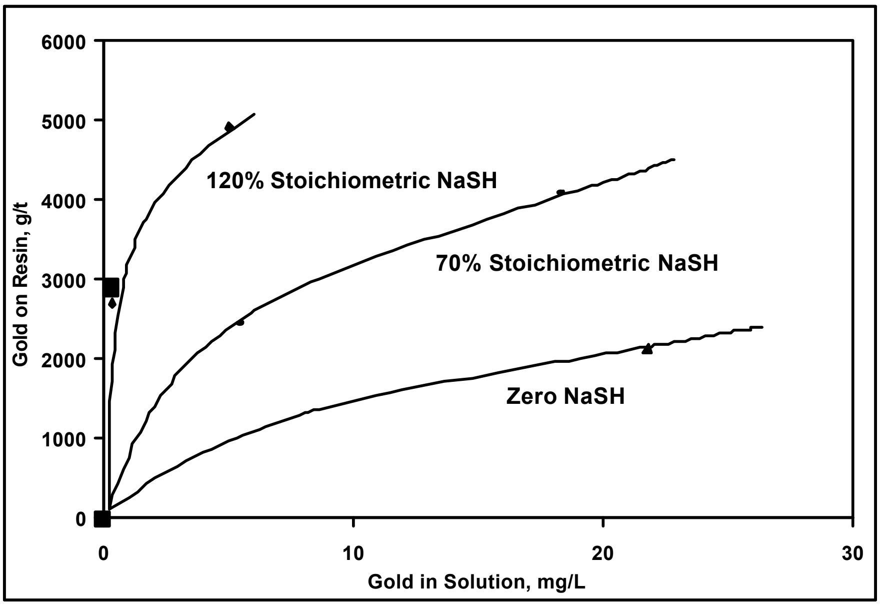

Figure 2 – The Equilibrium Loading of Gold Thiosulphate on a Strong-Base Resin Before and After Regeneration with Sodium Hydrogen Sulphide, (the equilibrium point denoted ■ refers to fresh resin).

after treatment, indicating complete reaction of the sulphide with the polythionate species in the resin matrix.

After regeneration, the three resin samples were contacted with a synthetic gold thiosulphate solution to determine the effect of regeneration on the capacity of the resins for the gold thiosulphate complex. The results are shown in Figure 2, and indicate that sulphide is very effective at restoring the capacity of the strong-base resin.

e) Recovery of gold from polythionate eluates

Cementation with iron or copper powder has been investigated as methods of recovering gold from polythionate eluates. Both these reductants were effective for the treatment of gold thiocyanate eluates, but have proven to be less effective for the treatment of polythionate eluates

The results of a 4-cycle test, in which the same batch of trithionate eluate was used to elute four successive batches of loaded resin, are shown in Table VIII. The eluate was treated with iron or copper powder to cement out the gold after each elution cycle.

The results show that cementation with iron powder was reasonably efficient in the first cycle, although a large excess of iron was needed (~60 g Fe per gram of gold). However, the efficiency dropped from 94% in the first cycle to 56% in the second cycle, and the eluate had to be retreated with successive, high concentrations of iron and copper powder to reduce the gold in solution to <10 mg/L. In the two subsequent cycles (3 and 4) copper powder was used, and although it proved to be more effective than iron powder, a significant amount of the excess copper powder was leached into the trithionate eluate, and its presence seemed to have a serious effect on gold elution efficiency.

Work is continuing in this area, and alternatives that are being tested include electrolysis, precipitation with sulphide and reduction with borohydride.

f) Stability of polythionate eluates.

A solution of trithionate (~150 g/L) was made up, and then split three ways. The sub-samples were kept in sealed bottles for 3 weeks and maintained at pH values of 6, 8 and 10 respectively. Samples were taken periodically and analysed for thiosalt speciation to determine the rate of break down of trithionate (Note: this is the species of particular interest, since tetrathionate breaks down relatively more rapidly, to form trithionate).

The results indicated that the half-life for trithionate break down (at all 3 pH values) was about 1 week. This is a fairly high rate of break down, which means that the most economical way of incorporating polythionate elution into an overall, integrated process may be to:

- synthesize polythionate on site by treatment of concentrated thiosulphate solution with SO_2 gas (equation 19)
- use the polythionate solution as the eluant for gold elution (equation 14)
- recover the gold by precipitation with sulphide, at the same time reducing the polythionate back to thiosulphate (Table 1, equations 8 and 9).
- use the barren eluate as a copper eluant and then as thiosulphate make-up in the leach circuit.

Conceptual flowsheets for this scheme are shown in Figures 3 and 4.

CYCLE NUMBER	GOLD ON RESIN			CEMENTATION		GOLD IN ELUATE			COPPER IN BARREN ELUATE
	LOADED g/t	ELUTED g/t	EFFICIENCY %	METAL POWDER	CONC g/L	PREG mg/L	BARREN mg/L	EFFICIENCY %	
1	2911	7	99.8	Fe	7.5	119	7	94	<1
2a	2758	11	99.7	Fe	7.5	121	53	56	2
2b				Fe	7.5	53	11	91	<1
2c				Cu	10	11	1	99	3200
3	2505	181	88.3	Cu	15	112	7	93	4800
4	2591	307	83.4	Cu	15	82	10	88	7580

Table VIII. Elution of Gold Thiosulphate with a 200 g/L Solution of Trithionate Followed by Cementation of the Eluted Gold and Recycle of the Barren Eluate

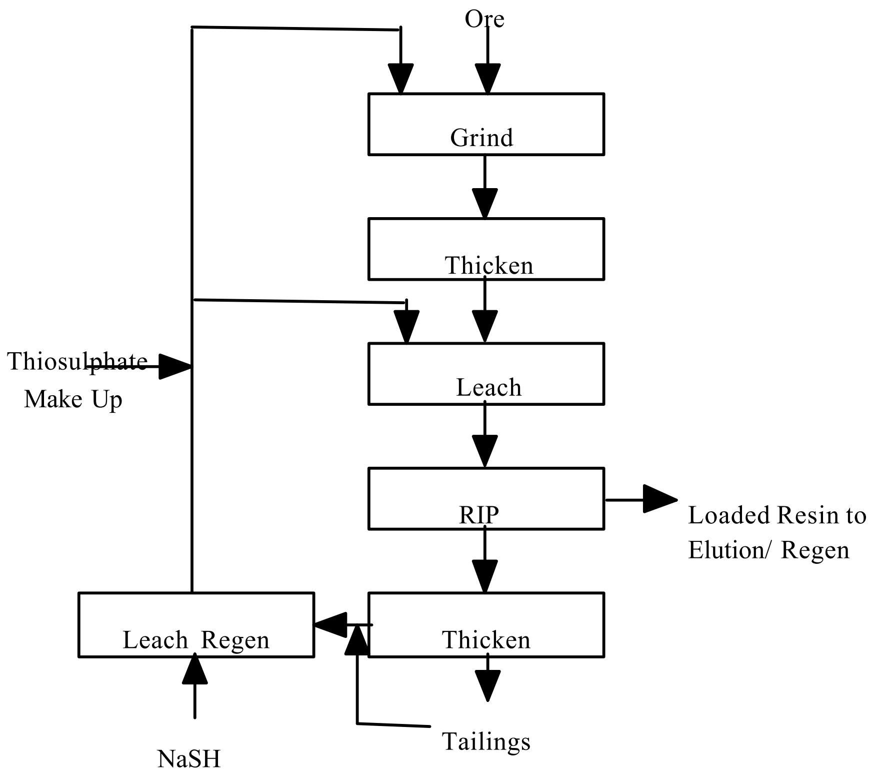

Figure 3. Overall Flowsheet

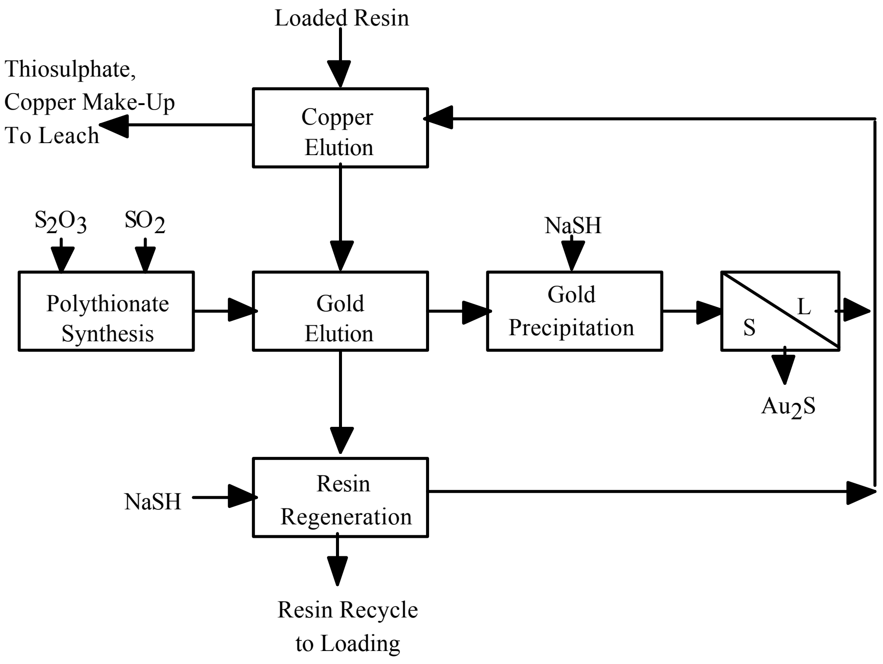

Figure 4. Resin Elution/Regeneration Flowsheet

CONCLUSIONS

The double refractory ores of Barrick's Goldstrike operation have been found to be amenable to a process involving sulphide oxidation (by autoclaving), thiosulphate leaching and resin in pulp. The mild thiosulphate leaching conditions required for these ore types are compatible with efficient and economical gold recovery by adsorption on anion exchange resins. The economics of this process have been shown to be similar to the conventional cyanidation/ CIL process that is used to treat the non preg-robbing ores at Goldstrike (unpublished SNC-Lavalin feasibility study).

These same conditions have been found to be suitable for ores from a few other mining companies as well, but are not universally applicable. In many cases, far more aggressive thiosulphate leaching conditions are needed to achieve gold recoveries that are comparable to the cyanidation process. These more aggressive leaching conditions are not compatible with resin in pulp because of competitive adsorption from the high concentrations of polythionates that are produced during leaching.

The gold elution process that was first developed for the Goldstrike flowsheet (involving thiocyanate displacement of gold thiosulphate by anion exchange) was fast and very efficient, even under ambient conditions. However, there were economic and environmental issues with this method of gold elution, and considerable effort has been invested in developing an alternative process.

A new gold elution/resin regeneration process has been developed, which involves the use of polythionate (tetra and trithionate anions) to displace the gold thiosulphate from the resin, by anion exchange. This process is also very efficient, achieving complete gold elution (>99%) in only a few hours, under ambient conditions. After elution, the resin is readily regenerated and restored to the activity and loading capacity of fresh resin. The entire resin cycle (loading, copper elution, gold elution, and regeneration) is carried out with solutions that are in a near-neutral pH range, and resin losses due to osmotic shock are expected to be minimal.

All the compounds that are used in leaching and the new elution/regeneration processes are thiosalts, and no foreign ions are introduced at any stage. Chemistry has been developed and demonstrated at a bench scale for an overall scheme in which polythionates for gold elution are produced by oxidation of thiosulphate with sulphur dioxide, and the products from gold elution (eluate plus eluted resin) are then treated with sulphide ions to (a) recover the gold as a precipitate and (b) reduce the polythionates back to thiosulphate for leach liquor makeup. The consumables in this process are sulphur dioxide and sulphide ions.

This elution process and the associated sulphur chemistry have not yet been demonstrated in a continuous pilot plant over a number of loading/elution cycles.

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