NEW DEVELOPMENTS IN THE BOLEO COPPER-COBALT-ZINC-MANGANESE PROJECT

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1.0 INTRODUCTION

The Boleo Copper-Cobalt-Zinc-Manganese Project of Baja Mining Corp. is situated adjacent to Santa Rosalia on the Baja Peninsula of Mexico (Figure 1). Formal mining of the Boleo Property ("Boleo") was initially undertaken by a French company, the Compagnie du Boleo, (the "Compagnie") in 1865.

Figure 1. Geographical Location of the Boleo Copper-Cobalt-Zinc-Manganese Project.

Baja Mining Corp. assumed ownership of the Boleo project in April 2004. Baja Mining Corp. has commissioned a Definitive Feasibility Study (DFS) led by Bateman Engineering Pty. Limited (Australia). This DFS is expected to be completed in the 3rd quarter of 2006.

An initial "proof of principle" pilot plant was executed at SGS Lakefield Research in Canada in November of 2004. The major focus of the proof of principle pilot plant was to confirm that the clayey Boleo ores could be thickened and washed in a conventional CCD train using high rate thickeners and that the CSIRO "DSX" solvent extraction system could be used to recover a cobalt and zinc product.

Since the initial proof of principle pilot plant, further work has been undertaken to optimize the DSX solvent extraction composition and to add a manganese recovery process to the overall flowsheet. The purpose of this paper is to review the metallurgical flowsheet for Boleo and to comment on the potential to recover a manganese co-product at Boleo.

The complete metallurgical flowsheet will be the subject of a further pilot plant test in June of 2006. This pilot plant will treat up to 8 tonnes of ore through a fully integrated, custom built pilot plant under construction at SGS Lakefield in Canada. The ore sample has been obtained during the very successful test mining trial that is just being completed. The results of this pilot plant will be used to confirm engineering and design parameters for the DFS feasibility study and produce final products of Cu, Co, Zn and Mn for market evaluation.

2.0 MINERALIZATION AND RESOURCES OF BOLEO

The copper-cobalt-zinc mineralization at Boleo occurs within widespread, stratiform clay-rich horizons or beds known as "Mantos". At Boleo up to 7 Mantos have been identified. These occur as relatively flat to generally shallow dipping, stratabound and uniform beds. These include, with increasing depth, Manto 0, 1, 2, 3AA, 3A, 3, 4. Historically, the major producing Manto was number 3.

The Mantos tend to be clay rich (montmorillonite). Underlying lithologies vary from predominantly ortho-conglomerates in the heart of the Boleo basin to coarse sandstones. The contact between the Mantos and the footwall is sharp. Overlying lithologies vary from fine to medium grade sandstones.

Hellman and Schofield have completed a resource estimate for Boleo upon which to base the development of a mine plan. Hellman and Schofield have also built a 3D block model for the deposit.

The resource estimate has been summarized in Table 1 below using the Copper Equivalent method. The copper equivalent is defined as;

Cu equiv = Cu% + Co% x (12/0.95) + Zn% x (0.45/0.95)

Table 1: Hellman and Schofield Resource Estimate (March 2005)

Cu EQUIV CUT-OFF GRADE		**0.5%**	**1.0%**	**1.5%**	**2.0%**
Measured	Tonnes (10^6)	51.7	45.7	35.3	24.7
	CuEq %	2.09	2.26	2.56	2.91
	Cu %	0.76	0.83	0.99	1.18
	Co %	0.089	0.096	0.107	0.119
	Zn %	0.45	0.46	0.47	0.47
Indicated	Tonnes (10^6)	172.1	114.1	65.4	36.1
	CuEq %	1.49	1.86	2.33	2.82
	Cu %	0.57	0.78	1.09	1.46
	Co %	0.050	0.061	0.072	0.081
	Zn %	0.58	0.66	0.68	0.68
Total	Tonnes (10^6)	223.8	159.8	100.7	60.8
	CuEq%	1.63	1.97	2.41	2.86
	Cu %	0.62	0.79	1.06	1.35
	Co %	0.059	0.071	0.084	0.097
	Zn%	0.55	0.60	0.61	0.61
Inferred	Tonnes (10^6)	310.3	188.13	112.34	65.6
	CuEq%	1.47	1.95	2.43	2.94
	Cu %	0.57	0.83	1.14	1.51
	Co %	0.045	0.057	0.067	0.074
	Zn%	0.69	0.85	0.95	1.03
Grand Total	Tonnes (10^6)	534.1	347.9	213.0	126.4
	CuEq%	1.53	1.96	2.42	2.90
	Cu %	0.59	0.81	1.10	1.43
	Co %	0.051	0.063	0.075	0.085
	Zn%	0.63	0.73	0.79	0.82

As is apparent from the formula, a copper price of $0.95/lb, a cobalt price of $12/lb and a zinc price of $0.45/lb have been used as the basis of the copper equivalent calculation. The base pricing for copper and zinc is very conservative (by today's standards) and does not yet include an economic benefit for a manganese co-product recovery.

The resource models developed by Hellman and Schofield have allowed mine planning to move forward. A major effort by Baja Mining has confirmed that underground shortwall mining can be used to selectively mine the Mantos. The mining plan shows 2.6 Mtpa of ore (dry basis) being mined and processed over a 20 year life. The mining plan is targeted to produce 50,000 tpa copper. Cobalt production is up to close to 2000 tpa and zinc production peaks at up to 9,000 tpa (as zinc in a zinc sulfate salt product). The full potential of manganese production has not yet been confirmed but is expected to vary up to 75,000 tonnes per year of Mn to product. This production would be realized using a using a value of 3.4% Mn in feed, 94% extraction to solution and 90% recovery to a Mn carbonate product.

3.0 METALLURGICAL TREATMENT OF BOLEO ORE

The metallurgical treatment of the Boleo ore has been largely described in a paper presented at ALTA 2005. After a quick review of the major elements of the process, the focus of this paper will be on production of a manganese carbonate by-product.

Milling and Leaching Circuit

The Boleo ores are clayey and generally fine grained and easily broken. The milling circuit design takes material from the ROM pad into a static grizzly with the oversize to a primary crusher. The combined product is then scrubbed in copper solvent extraction raffinate. The scrubber product is screened with the oversize to a secondary crusher. The combined product goes to the ball mill sump before sizing. The oversize material product is directed to the ball mill. Milling is in raffinate.

The milled product is heated to a target temperature of 80 °C for atmospheric leaching. Leaching proceeds in two steps; acid, oxidation leaching with manganese dioxide oxidation for leaching of Cu, Zn and Mn sulfides and; acid reduction leaching with addition of sulfur dioxide gas to reduce residual manganese dioxides.

Oxidation leaching (acid leaching with manganese dioxide in the ore)

$$Cu_2S + 2MnO_2 + 4H_2SO_4 = 2CuSO_4 + 2MnSO_4 + S + 4H_2O$$
$$ZnS + MnO_2 + 2H_2SO_4 = ZnSO_4 + MnSO_4 + S + 2H_2O$$
$$CoS + MnO_2 + 2H_2SO_4 = CoSO_4 + MnSO_4 + S + 2H_2O$$

Reduction leaching (addition of sulfur dioxide to the ore slurry)

$$MnO_2 + SO_2 = MnSO_4$$

The slurry from oxidation and reduction leaching is then partially neutralized using local limestone that is available on the Boleo mine lease. The purity of the limestone is about 60-65% and it is highly reactive for acid neutralization. A small amount of air is added during partial neutralization to ensure that there is no residual cuprous ion (which may form if reductive leaching goes to too low a redox value) remaining in solution. Cuprous ion is not extracted by solvent extraction with conventional oxime extractants.

Solid-Liquid Separation and CCD Washing

The first "proof-of-principle" pilot plant confirmed that the Boleo leach pulp could be thickened and washed using high rate thickening. High rate thickening involves the dilution of the incoming slurry (by recycle of overflow from the same thickener) so as to create a dilute slurry (2-3% solids) for flocculation and settling into the thickener bed. This approach was verified by testing performed by Pocock Industrial and by Outokumpu in lab and pilot scale testing at SGS – Lakefield. The wash solution to be used at Boleo consists of a combination of barren solution (after cobalt, zinc and manganese removal) and fresh brine solution.

Copper Solvent Extraction and Electrowinning

The recovery of copper from complex – chloride containing solutions is feasible using modern selective copper solvent extractants combined with a "wash stage" during SX recovery of copper to prevent transfer of chloride from leaching through to electrowinning. This approach has been widely reported at plants in Chile with saline PLS solutions and has been adopted for Boleo as well. High levels of copper extraction are expected due to the low free acid level in solution (after partial neutralization) and the use of a strong oxime formulation.

Copper Extraction

$$CuSO_4 + 2HR(org) = CuR_2(org) + H_2SO_4$$

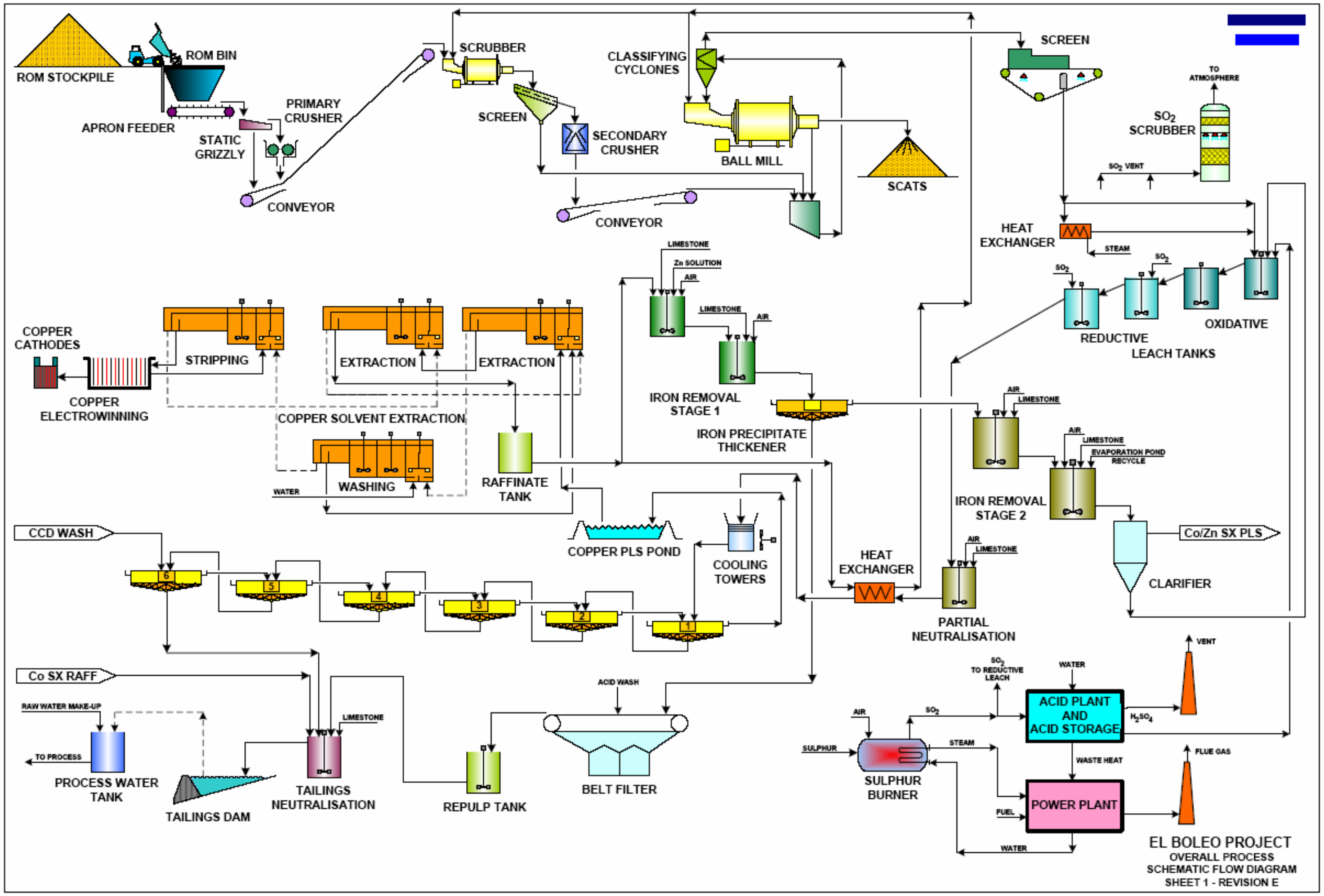

Figure 2: Flowsheet for Boleo Process – Part 1: Feed Preparation, Leach, CCD, Copper SX/EW, Iron Removal, Acid/Power Plant

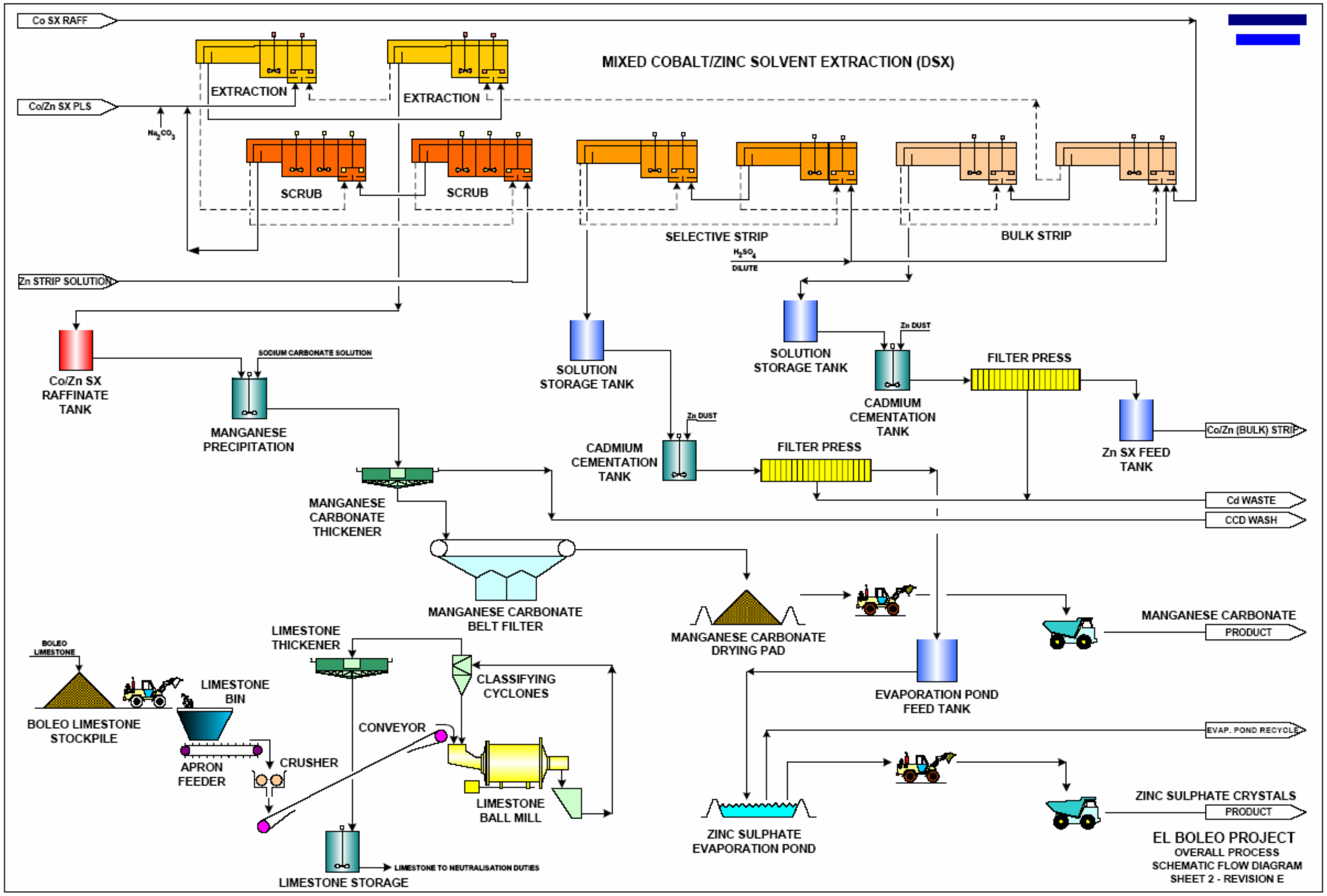

Figure 3: Flowsheet for Boleo Process – Part 2: Cobalt and Zinc SX Using DSX, Zinc Sulfate Evaporation, Manganese Carbonate Precipitation and Limestone Milling

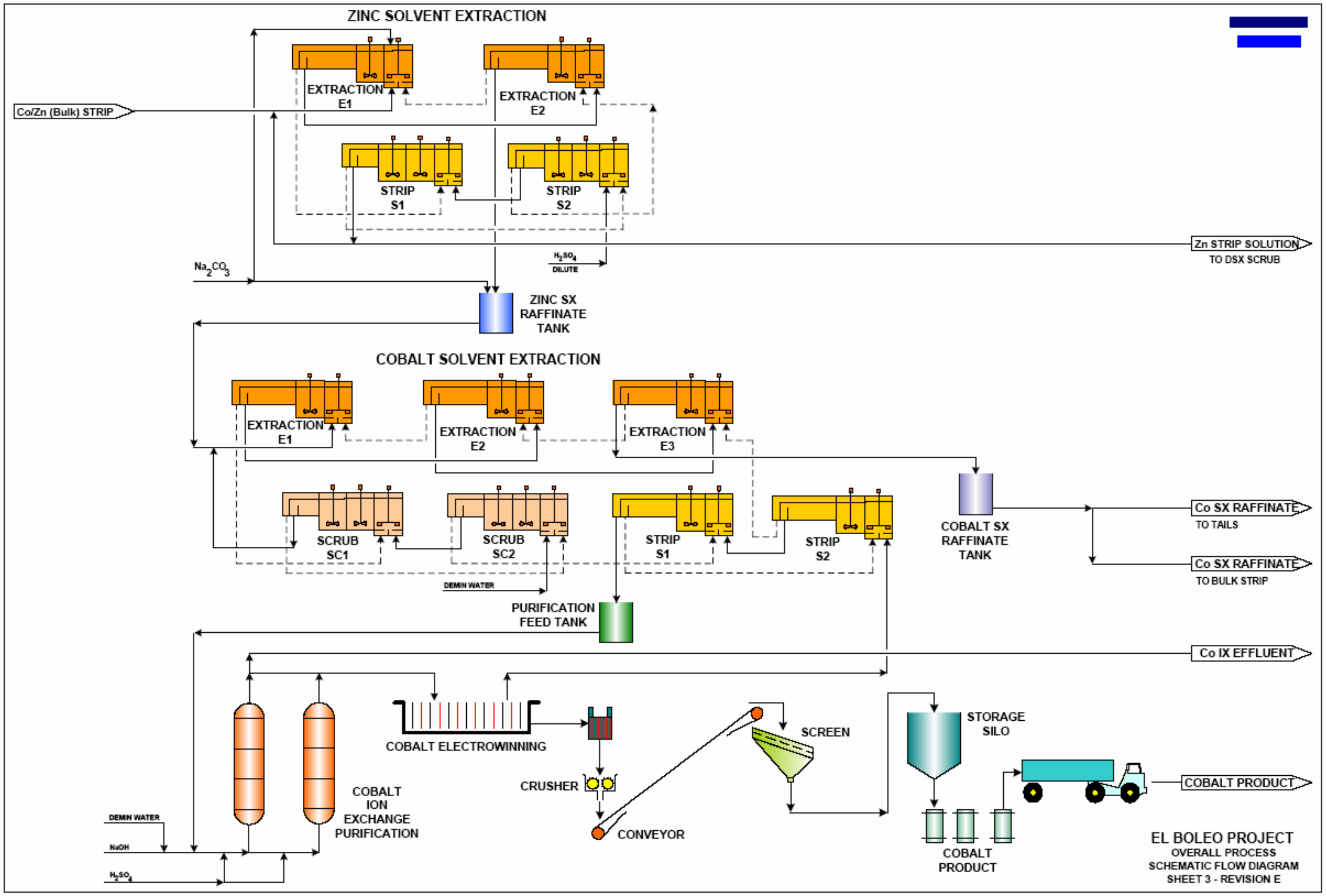

Figure 4: Flowsheet for Boleo Process – Part 3: Zinc and Cobalt Solvent Extraction and Cobalt Electrowinning.

Copper Stripping

$$CuR_2(org) + H_2SO_4 = CuSO_4 + 2HR(org)$$

Copper Electrowinning

$$CuSO_4 + H_2O = Cu + O_2(gas) + H_2SO_4$$

Copper is electrowon conventionally using permaneant cathode blank technology. LME Grade A cathode quality was produced in the proof-of-principle pilot plant and is also expected to be produced in the commercial plant.

The copper solvent extraction raffinate contains free acid (from copper solvent extraction) and so it is advantageous to return a portion of the raffinate to the milling and leaching circuit, to reduce overall use of fresh acid. This will also allow the Co, Zn and Mn concentrations to build up, reducing the physical size of the downstream operating plant. The balance of the raffinate is directed to the Co, Zn, Mn recovery circuit.

Iron Removal

The removal of iron from the raffinate advancing to Co, Zn, Mn recovery is accomplished with pH adjustment and aeration. The bulk of the iron in solution will be present as ferrous. Ferrous is oxidized and precipitated as ferric hydroxide precipitates. Aluminum will co-precipitate with iron in this step.

Two stages of iron removal are allowed in the plant design. The first stage is used to precipitate more than 95% of the iron with the second stage precipitation reducing iron to less than 10 ppm residual. The second stage precipitate is returned to oxidative leaching to ensure that any co-precipitated “pay-metals” are recovered. The first stage cake is filtered, washed and then re-pulped and sent to tailings.

The iron removal solution is then advanced to cobalt and zinc solvent extraction.

Cobalt and Zinc Solvent Extraction

The use of the CSIRO “Direct Solvent Extraction (DSX)” system was reported at ALTA 2005 for the recovery of Co/Zn from Boleo solutions. CSIRO has developed a range of synergistic extractants, tailored to specific metal separations. In the case of Boleo, the major challenge is the extraction of cobalt and zinc without extraction of manganese. The particular synergistic system selected for Boleo is the Versatic 10 – LIX 63 mixture. Cobalt is loaded in preference to zinc which in turn is loaded in preference to manganese with this system.

The cobalt and zinc circuit is designed for bulk extraction and selective stripping of zinc and cobalt. Some of the zinc strip solution is also employed as a manganese scrub solution makeup. Zinc and cobalt loading must be done with pH control. The most convenient alkali for this duty is sodium carbonate. Selective stripping of zinc (first) and cobalt (second) is performed using sulfuric acid and pH control.

Cobalt and Zinc Solvent Extraction (with small amount of Mn co-extraction)

$$CoSO_4 + 2HR(org) + Na_2CO_3 = CoR_2(org) + Na_2SO_4 + CO_2(g) + H_2O$$
$$ZnSO_4 + 2HR(org) + Na_2CO_3 = ZnR_2(org) + Na_2SO_4 + CO_2(g) + H_2O$$
$$MnSO_4 + 2HR(org) + Na_2CO_3 = MnR_2(org) + Na_2SO_4 + CO_2(g) + H_2O$$

Manganese Scrubbing

$$MnR_2(org) + ZnSO_4 = ZnR_2(org) + MnSO_4$$

Zinc Stripping

$$ZnR_2(org) + H_2SO_4 = ZnSO_4 + 2HR(org)$$

Cobalt Stripping

$$CoR_2(org) + H_2SO_4 = CoSO_4 + 2HR(org)$$

The fully stripped organic is then recycled back to loading. The DSX raffinate advances to manganese recovery.

Cadmium Control

Cadmium is a minor impurity in the Boleo ore and must be removed from both the zinc and cobalt strip solutions prior to zinc sulfate crystallization and cobalt solvent extraction and electrowinning. The method chosen for cadmium control is zinc dust cementation. Zinc dust is widely used for cadmium control in conventional roast-leach-electrowin (RLE) plants for zinc recovery from concentrates.

In this application, it is important to cement only cadmium and not cobalt. This can be accomplished using lower temperature (<50 C) and not "activating" the cementation. Activation with Cu/As or Cu/Sb is the method used in the removal of cobalt by cementation in conventional RLE plants.

Cadmium Cementation

$$CdSO_4 + Zn = Cd + ZnSO_4$$

Zinc Sulfate Crystallization

The recovery of zinc as a metal product by electrolysis is technically challenging and probably not cost-effective at a low production rate (notwithstanding the current prices of zinc metal). Hence, the zinc product selected for the Boleo process is zinc sulfate crystals. Zinc sulfate crystals are used in a variety of agricultural formulations (fertilizers and feeds). At Boleo, the very arid, warm environment will be harnessed to evaporate zinc strip solutions from the DSX circuit to produce zinc sulfate crystals. These crystals will be harvested and delivered to an "off-take" party for marketing and sale.

Zinc Sulfate Crystallization

$$ZnSO_4 \text{ (aqueous)} + xH_2O = ZnSO_4.xH_2O \text{ (crystals)}$$

The final degree of hydration of the zinc sulfate crystals is still the subject of study and design. It is preferred to produce a low degree of hydration (mono-hydrate) so as to reduce final shipping weight of product.

Cobalt Metal Electrowinning

The cobalt strip solution from DSX will contain some zinc and other minor impurities. This solution will be treated sequentially by zinc solvent extraction and stripping and then cobalt solvent extraction, stripping and electrowinning. The zinc and cobalt solvent extraction circuits will both use Cyanex 272 extractant.

There is provision in the cobalt electrolysis circuit for ion exchange polishing of minor elements prior to sulfate electrolysis. The cobalt cathode deposit is harvested, crushed and marketed.

Zinc Extraction

$$ZnSO_4 + 2HR(org) + Na_2CO_3 = ZnR_2(org) + Na_2SO_4 + CO_2(g) + H_2O$$

Zinc Stripping

$$ZnR_2(org) + H_2SO_4 = ZnSO_4 + 2HR(org)$$

Cobalt Extraction

$$CoSO_4 + 2HR(org) + Na_2CO_3 = CoR_2(org) + Na_2SO_4 + CO_2(g) + H_2O$$

Cobalt Stripping

$$CoR_2(org) + H_2SO_4 = CoSO_4 + 2HR(org)$$

Cobalt Electrowinning

$$CoSO_4 + H_2O = Co + O_2(gas) + H_2SO_4$$

Manganese Carbonate Recovery

The raffinate from the DSX circuit has been subjected to iron/aluminum removal and the use of DSX to recover cobalt and zinc. The DSX is also effective at removing other heavy metals from solution. The remaining cations in solution are largely manganese, magnesium, calcium and sodium. The manganese rich nature of the Boleo ore provides a perfect opportunity for recovery of a manganese by-product from this solution. The potential for manganese product recovery from Boleo will be discussed below.

4.0 MANGANESE RECOVERY FROM DSX RAFFINATE SOLUTIONS

The DSX solvent extraction system separates Co/Zn away from Mn. The results of the 2004 pilot plant tests on the DSX solvent extraction are shown in Table 2 below. The raffinate in the case of the 2004 test contained 21.8 g/L Mn, 6.66 g/L Mg, 0.592 g/L Ca and minor Zn and Co. The copper and iron levels in this solution were below detection limit.

Table 2: DSX Circuit Results for 2004 Proof-of-Principle Pilot Plant

Stream	**Analysis (mg/L)**						
	Cu	**Co**	**Zn**	**Mn**	**Fe**	**Ca**	**Mg**
PLS	30	128	592	23,100	<3	623	7,050
Raffinate	<3	15	31	21,800	<1	592	6,660
Scrub Liquor	<2	16	668	9,990	<1	57	505
Zn Strip Liquor	<2	184	12,500	2,050	<1	4	11
Co Strip Liquor	715	2,660	5,600	48	4	2	0
Loaded Organic	152	571	2,380	609	3	<2	<2
Scrubbed Organic	159	589	2,710	338	3	<2	<2
Zn Stripped Organic	148	527	1,170	50	3	<2	<2
Co Stripped Organic	64	142	116	2	3	<2	<2

There are a number of alternatives to precipitate a Mn product from the DSX raffinate. These include hydroxide and carbonate precipitation. There are a variety of considerations in selecting a preferred route for Mn precipitation including (1) selectivity of the precipitant, (2) cost of the precipitant and (3) physical handling of the final product (thickening, filtration, washing, granulometry). The cost of precipitant (Na_2CO_3 versus NaOH) gives preference to Na_2CO_3 as its prices, currently about $170 USD/t compares favourably with the current price of NaOH, typically over 400/t (though highly cyclical).

With respect to selectivity, the key elements to reject are Ca and Mg. The relative selectivity can be expressed using the reactions below (thermodynamic calculations by HSC Program, Version 5.1). A high value of Log K (equilibrium constant) indicates a favourable separation. For the hydroxides, the precipitation of $Mn(OH)_2$ is very favourable with respect to calcium but only modestly favoured versus magnesium. This is not ideal as the calcium is already low in solution (Table 2) due to low solubility of gypsum in solution while the magnesium level in raffinate is fairly high at 6.66 g/L versus 21.8 g/L for Mn. The preferred selectivity would be for Mn over Mg, not Mn over Ca.

For the carbonates, the selectivity for Mn over Ca is modest and the selectivity for Mn over Mg is very high (Log K = 5.33). This is ideal for the major element composition of the raffinate (Table 2). The carbonate system was therefore chosen for experimental study and inclusion in the Boleo flowsheet.

Hydroxide Selectivity Reactions

$Ca(OH)_2 + Mn^{2+} = Mn(OH)_2 + Ca^{2+}$, Log K = 7.42

$Mg(OH)_2 + Mn^{2+} = Mn(OH)_2 + Mg^{2+}$, Log K = 1.43

Carbonate Selectivity Reactions

$CaCO_3 + Mn^{2+} = MnCO_3 + Ca^{2+}$, Log K = 2.34

$MgCO_3 + Mn^{2+} = MnCO_3 + Mg^{2+}$, Log K = 5.33

To complete the discussion on precipitation thermodynamics, it is important to also consider minor (heavy elements). The reaction below shows that zinc will be preferentially precipitated with respect to manganese. Similar selectivities are expected for minor elements such as Co, Ni, etc. These elements will therefore contaminate the final product in proportion to their starting concentration and the extent of manganese precipitation.

Zinc Carbonate Selectivity Reaction

$ZnCO_3 + Mn^{2+} = MnCO_3 + Zn^{2+}$, Log K = 0.77

4.1 CONTINUOUS MANGANESE CARBONATE PRECIPITATION EXPERIMENTS

The manganese carbonate precipitation experiments were performed at SGS Lakefield Research using a custom-built mini-pilot rig. The design of the rig is shown in Figure 5. DSX raffinate was injected into a bottom feed line with recycle precipitate from the product thickener. Nitrogen was sparged to keep an inert atmosphere (and prevent formation of higher order oxidation species of manganese). 150 g/L sodium carbonate solution was added to reactor 1. The redox potential was monitored in reactor 1 and the pH monitored in reactor 2. The addition of sodium carbonate was fixed in proportion to the volumetric flow of DSX raffinate solution to target an extent of manganese precipitation. The manganese carbonate product was thickened and recycled to "seed" the precipitation to improve selectivity and settling behaviour of the precipitate.

The precipitation temperature was controlled at 28-30 °C. The residence time for each stage of the precipitation was 15 minutes for a total of 30 minutes. The volume of the thickener was 5X the volume of each stage for an average 75 minute residence time. The thickener underflow solids easily settled to approximately 40% solids. A 500% recycle was used to seed the precipitation (i.e. 5 kg of precipitated $MnCO_3$ recycled per 1 kg of fresh $MnCO_3$ to be precipitated).

The results for three precipitation tests are summarized in Table 3 and 4 below. The final precipitate composition rises to 48% Mn. The theoretical composition of $MnCO_3$ is 48% Mn. This close agreement is a testament to the selectivity of the precipitation and the purity of the final product. The zinc analysis of the product decreases by dilution of the precipitated zinc by the greater mass of $MnCO_3$ precipitate. Cobalt and nickel precipitate to a great extent, producing very low residual metal contents in solution and modest contamination of the product. The precipitation of magnesium is very slight (most of the drop in magnesium concentration in final solution is in fact due to dilution of the incoming DSX raffinate). Up to 2 % of the Mg is precipitated at 90% Mn precipitation.

The manganese carbonate product analysis for minor elements (Table 4) shows remarkably low levels for most impurities. Copper and cadmium are very low due to extraction of these species by the DSX extraction system. Lead and mercury contamination are negligible. The calcium level ranges from 4400 to 6500 ppm or 0.44 to 0.65%. The alkali and other metals are at low values. Interestingly, the chloride level is washed to < 200 ppm when precipitating from a seawater solution. In contrast, the sulfate level is between 1.8 and 2.7%, probably due to some inclusion of sulfate in the carbonate precipitate structure (possibly a basic manganese sulfate compound).

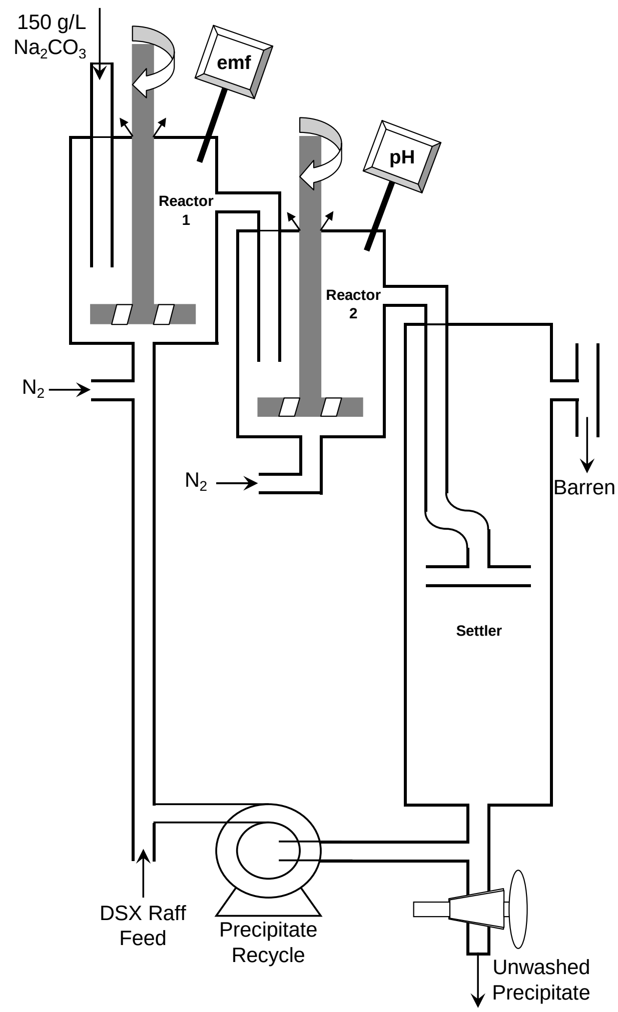

Figure 5. Manganese carbonate precipitation setup.

Table 3. Manganese Precipitation Results for 60, 75 and 90% Precipitation of Manganese from DSX Raffinate. Major Element Behaviour,

Stream	**Assays (mg/L, %[1], g/t)**					**Distribution (%)**				
	Mn	**Zn**	**Co**	**Ni**	**Mg**	**Mn**	**Zn**	**Co**	**Ni**	**Mg**
DSX Raffinate	23000	6.8	13	30	7400	100	100	100	100	100
60% Mn Precipitation										
Solution	7600	0.7	5.6	17	6200	39	9	45	76	99
Solids	46.3[1]	260	268	210	1350	61	91	55	24	1
75% Mn Precipitation										
Solution	3620	0.7	3.1	13	5710	25	11	34	61	98
Solids	48[1]	180	240	310	2700	75	89	66	39	1
90% Mn Precipitation										
Solution	1670	1	1.8	9.5	5400	9	15	17	38	97
Solids	48[1]	150	246	430	3730	91	85	83	62	2

The particle size of the final precipitate was reasonably coarse with d_{50} values of around 40 µm and d_{90} values up to 100 µm. The precipitate was easily settled, filtered and washed. The moisture level in the filter cake was low at 14-22%, indicating very little hydration, if any, of the carbonate crystal. This moisture is present as free moisture in the cake.

Table 4. Analysis of Manganese Carbonate Product from the Precipitation Experiments with Minor Element Analysis.

Element		Precipitate Assays		
	% Mn Pptn.	60	75	90
Mn	%	46.3	48	48
Zn	g/t	260	180	150
Co	g/t	268	240	246
Ni	g/t	210	310	430
Cu	g/t	8.4	6.5	6.0
Cd	g/t	6	3	5.8
Pb	g/t	<2	<2	0.6
Fe	g/t	37	29	10
Mg	g/t	1350	2700	3730
Ca	g/t	4400	6500	6050
Na	g/t	6500	8000	8500
K	g/t	120	100	93
Li	g/t	71	86	84
Al	g/t	860	600	460
Si	g/t	290	280	83
Cl	g/t	199	154	113
Hg	g/t	<0.3	<0.3	<0.3
SO_4	%	2.5	1.8	2.7
d_{50}	µm	33	48	47
d_{90}	µm	63	102	90
Specific Surface Area	m^2/g	0.40	0.26	0.26
Moisture in Wet Cake	wt %	14.4	17.5	22.4

4.2 MANGANESE CARBONATE MARKETING

The marketing of manganese carbonate production from Boleo is under discussion with potential off-take parties and customers. The high quality precipitate with low impurity content make the Boleo material ideal for the manganese chemical market or for manufacture into products such as manganese metal or electrolytic manganese dioxide.

5.0 SUMMARY AND CONCLUSIONS

The Boleo project of Baja Mining Corp continues to move forward to the conclusion of a definitive feasibility study (DFS). The process selected for Boleo involves oxidative and reductive leaching of the milled ore, conventional counter current decantation (CCD) washing of the leached ore in high rate thickeners, copper solvent extraction and electrowinning, cobalt and zinc solvent extraction and recovery as zinc sulfate crystals and cobalt metal and finally manganese carbonate production as a by-product.

The initial Boleo ore treatment rate has been set at 7,500 tpd or 2.6 Mtpa of ore with a copper production target of 50,000 tpa. Cobalt production of up to 2,000 tpa and zinc production of up to 9,000 tpa of Zn contained in zinc sulfate are expected. The full potential of manganese production has not yet been confirmed but is expected to vary up to 75,000 tonnes per year of Mn to product.

The technical development of the Boleo flow-sheet will be the subject of a further definitive, integrated pilot plant at SGS Lakefield Research in June of 2006 prior to completion of the DFS.

The goal will be to test and demonstrate the chemistry and processing of the Boleo ore over an extended period and to produce final products for evaluation and commercial sampling. Further improvement and optimization of CCD performance, iron removal, DSX extraction and selective stripping and impurity management in production of final zinc sulfate and cobalt metal products is expected. A sample of Boleo limestone ore has been sourced and will be used for neutralization duty through the pilot plant (commercial limestone was used in the first pilot plant).

The inclusion of a manganese recovery step in the Boleo flowsheet, made possible by the unique chemistry of the ore and the metal extraction process, has led to the potential of a major supply of manganese as manganese carbonate from Boleo. The manganese carbonate product is high quality, easily filtered and handled and is of a nature as to be able to penetrate various markets. Manganese carbonate production is expected to add significantly to the revenue and profitability of the Boleo mining enterprise.