

R. Groenewoud Email communication: 14 January 2008

The last 2 tests at AST were done on 90g wet sample each plus about 10g for initial solid analysis. About 100g per test would suffice. More would be comfortable if additional initial solid analysis were required for confirmation later on.

Test #86 was carried out on 50g dried sample in 500ml acid containing 25g 98% H₂SO₄ at upto 27°C. The 2nd AST test used 90g wet sample (55.62g dry) in 300ml (330 total) to which 21.5g 98% H₂SO₄ was added in 4 stages. The temperature was kept close to 90°C. The final acidity in the AST test was approx. 22g/L, whereas test #86 would have been approx. 18g/L. The latter was lower, because of the larger volume and the higher zinc dissolution.

A closer look at the graph of test #86 indicates a zero order rate reaction, which is typical of bioleaching. A similar graph is shown in the article '**Bioleaching of Zinc Sulphide (ZnS) Ore using *Thiobacillus ferrooxidans***' (1st article when googling, **bioleaching zinc**). The bacterium used in this was *Thiobacillus ferrooxidans*, which operates in an aerobic environment. Test #86 would have been anaerobic, therefore different bacteria would have been at work.

If this hunch is correct, it is important to identify the bacterium. So I suggest Neil does another test and all samples are analysed by AST, including for bacterial analysis. If this is correct we may have a breakthrough. However, where did the bugs come from? Were they already in the ore or did they come with the water used in test #86?

In the meantime I suggest, if the samples are available, that AST analyses a sample of test #86 leach liquor, and a residue sample.

R. Groenewoud Email communication: 5 March 2008

I've attached the calculation results for the 3 tests.

My preliminary conclusions are as follows,

Test#1,

This test was carried out at a final pH 2.3, which was an acidity of 1.35g/L (the intention had been to keep the acidity between 5 and 10g/L), and approximately 85C.

This test indicates that it is possible to recover acid at approximately 120kg/tonne ore, with a zinc extraction of 8%.

If it is possible to recover the zinc extracted in the acid recovery stage in a separate Ion Exchange column, then a higher acid recovery could be possible.

(Note: Only acid that is regenerated in IE, and that, which makes up the acidity of the solution can be recovered. All other acid, which produces metal sulphates can not be recovered. It is therefore important to physically remove any dolomite or limestone to lower the magnesium and calcium in the feed (This is what Neil did in test#95 by removing the >2mm particles.) By far the biggest consumer of acid is aluminium which is present in feldspar and clay.)

Test#2,

This test was carried out at approximately 20g/L and 90C over a 5hour period. Acid usage was 385kg/tonne ore.

The zinc extraction was rapid for the 1st 30minutes, but then slowed rapidly coming to an almost stand still after 5hours, at which the extraction was only 23.5%.(calculations suggest that the maximum zinc extraction would have been 24.2% after 7hours.)

The only explanation I can give is that at 90C, which is close to the sulphur melting point, the particles become coated with sulphur, which is produced according to the following reaction $\text{ZnS} + \text{Fe}_2(\text{SO}_4)_3 = \text{ZnSO}_4 + \text{FeSO}_4 + \text{S}$. Pyrite FeS_2 reacts rapidly with more than 50% Fe extraction in the 1st 30minutes. This produces FeSO_4 , which oxidises to $\text{Fe}_2(\text{SO}_4)_3$. It may be reasonable to assume that at a lower temperature this slow down of the zinc extraction may not happen. I therefore suggest we repeat this test at 60C.

Test#3

This test consisted of a full analysis of the solutions and solids from test#95 carried out by Dr. Neil Allen. This test#95 was carried out in 2stages, the 1st stage at pH2, then a decant wash, and then a 2nd stage 19days later at mostly ambient temperature with a short period, 2or 3hours at 34C, over a 9day period at a final acidity of 14g/L(calculated). The AST analysis were done about another month later. The concentrations of the metals in the 9day and final solution samples were similar except in the case of iron. The iron analysis of the final solution is suspect, because it results in a metal balance of several hundred %.

The results indicate that the extractions of Al, Fe, and Mg were similar to those in test#2. The extraction of Zn was approx 60% based on both the solution and solids analysis. This is a considerable improvement on the extraction of Zn in test#2. Acid Usage was 429kg/tonne ore.

Test 1

Head Assays of Pit Samples

Pit No.	Zn %	Pb %	Fe %	Mg %	Al %	Ca %	Na %	total S %	sulphide %	calc.SO4 %	calc.CO3 %	SiO2 %	Mn ppm	Cu ppm	Cd ppm	As ppm
115	2.84	0.06	0.79	0.10	1.16		0.10	2.63	1.77	2.58	0.10	32.80	20	40	10	<50
170	2.53	0.10	4.01	1.24	0.77		0.09	4.94	3.72	3.66	7.55	35.00	300	20	20	<50
181	17.50	1.45	2.10	0.03	2.27		0.03	11.50	10.30	3.60	0.15	9.16	10	50	330	250
264	2.69	0.09	4.33	0.57	0.87		0.06	6.89	4.04	8.55	7.50	3.02	140	20	20	<50
368	4.98	1.63	1.10	0.11	1.21		0.68	3.74	2.93	2.43	4.50	22.90	<10	290	130	100
Average %	6.11	0.67	2.47	0.41	1.26		0.19	5.94	4.55	4.16	3.96	20.6	94	84	102	70

AST calculated **7.34** **1.29** **1.80** **0.96** **2.42** **1.89** **5.86** **5.20** **112** **60** **89** **64**

Calculated S is based on ZnS, FeS2, and PbS.

Calculated CO3 is based on CaCO3 and MgCO3.

Experimental Results.

Analyte	1470	1910	2250	2080	2260	Solids	initial	final	initial calc	solids final calc	dissolved	solution
minutes	30	60	120	180	240	As	64	66 mg/kg	3.52	3.14	0.38	mg
Al	789	737	428	773	714 mg/L	Cd	89	96 mg/kg	4.89	4.57	0.32	mg
Ca	1470	1910	2250	2080	2260 mg/L	Co	29	10 mg/kg	1.59	0.48	1.12	mg
Cu	<1	<1	<1	<1	<1 mg/L	Cr	53	51 mg/kg	2.91	2.43	0.49	mg
Fe	1320	1740	1700	1810	1810 mg/L	Cu	60	81 mg/kg	3.30	3.86	-0.56	mg
Mg	1460	1620	1600	1810	1830 mg/L	Mn	112	23 mg/kg	6.16	1.10	5.06	mg
Mn	18.7	24.8	23.8	25.2	25.7 mg/L	Ni	70	30 mg/kg	3.85	1.43	2.42	mg
Pb	33	37.4	37.3	31.3	36 mg/L	Pb	12900	7330 mg/kg	0.71	0.35	0.36	0.011 g
S	9650	11600	13500	13200	13000 mg/L	Zn	73400	69000 mg/kg	4.04	3.29	0.75	0.334 g
Zn	992	1140	1060	1130	1130 mg/L	Mg	9580	1640 mg/kg	0.53	0.08	0.45	0.542 g
						Fe	18017	11137 mg/kg	0.99	0.53	0.46	0.536 g
						Al	24192	19970 mg/kg	1.33	0.95	0.38	0.211 g
						Ca	18879	18772 mg/kg	1.04	0.89	0.14	0.669 g

Max Ca solubility is 620mg/L

Calculations

	initial	final	wet weight	moisture	dry weight
liquor	300	235 ml	g	%	g
moisture	35	29 ml	ore	90	38.9
4hr sample	5 ml	5 ml	final solids	76.8	38
	335	269 ml	change g		47.62
other samples	20 ml	20 ml	change %		7.37
					13.4

Evaporation 46 ml
Over 4hours 11.5 ml/hour

Assumptions:

1. Mg is MgCO3.
2. Ca is CaCO3
3. Zn, Pb and Fe are sulphides, Fe is FeS2.
4. Al is as Al2O3

Pit No.	ZnS,PbS, FeS2
115	2.63 2.30
170	4.94 5.85
181	11.5 11.19
264	6.89 6.29
368	3.74 3.95
average	5.94 5.92

Zn extraction calculations

without adjustments 8.1 %
with sampling and dilution corrections 8.3 %

Acid requirement for maximum extraction

Zn	110.0 kg/tonne	Extraction ' adjusted for
Fe	31.6 kg/tonne	% metal balance
Pb	6.1 kg/tonne	Al 15.9 18.6
Al	87.9 kg/tonne	Fe 54.1 53.7
Mg	38.6 kg/tonne	Mg 102.8 98.6
Ca	46.3 kg/tonne	Mn 123.5 98.5
		Zn 8.3 9.3

Ca and Pb can only be estimated, because their sulphates have low solubilities

Acid Recovery

based on 7g acid addition 118.6 kg/tonne

Note: Acid can only be recovered from Zn in solution by IE or SX, and from acidity in solution. Acid used to produce of the other metal sulphates can not be recovered

Correction for evaporation

evap.factor	0.98283	0.9654	0.92998	0.893964	0.857305
minutes	30	60	120	180	240
Al	775	712	398	691	612 mg/L
Ca	1445	1844	2092	1859	1938 mg/L
Cu					mg/L
Fe	1297	1680	1581	1618	1552 mg/L
Mg	1435	1564	1488	1618	1569 mg/L
Mn	18	24	22	23	22 mg/L
Pb	32	36	35	28	31 mg/L
S	9484	11199	12555	11800	11145 mg/L
Zn	975	1101	986	1010	969 mg/L

Correction for evaporation + dilution

(Assuming Mn is maximum after 1hour and remains constant at 22.7mg/L)

minutes	30	60	120	180	240
Al	775	675	408	696	631
Ca	1445	1748	2146	1874	1996
Cu	0	0	0	0	0
Fe	1297	1593	1621	1630	1599
Mg	1435	1483	1526	1630	1616
Mn	18.4	22.7	22.7	22.7	22.7
Pb	32.4	34.2	35.6	28.2	31.8
S	9484	10618	12876	11890	11482
Zn	975	1043	1011	1018	998

Acid Balance

	After 2hours and 6g acid		After 4hours and 7g acid	
	grams	H2SO4 g	grams	H2SO4 g
Al	0.137	0.75	0.211	1.15
Ca	0.62	1.53	0.62	1.53
Cu	0.000		0.000	
Fe	0.543	0.95	0.536	0.94
Mg	0.511	2.07	0.542	2.19
Mn	0.008	0.014	0.008	0.014
Pb	0.43	0.201	0.43	0.201
S	4.314		3.847	
Zn	0.339	0.51	0.334	0.50
	total g	6.01	total g	6.52
			pH2.3	0.45
			total g	6.97
SO4 in solution g	4.70		SO4 in solution g	5.64

Assumes Ca & Pb had reacted 60% after 2hours and 60% after 4hours.

Final pH2.3 is 1.35g/L H2SO4

Metal balances %

Analysis as received		Analysis corrected for evaporation and dilution.		Average concentrations for 1st four samples	
Al	85.4 %	Al	86.0 %	Al	682 mg/L
Ca	142.0 %	Ca	144.9 %	Ca	1928 mg/L
Cu		Cu		Cu	0 mg/L
Fe	100.7 %	Fe	102.9 %	Fe	1643 mg/L
Mg	104.3 %	Mg	108.7 %	Mg	1623 mg/L
Mn	125.4 %	Mn	130.5 %	Mn	23 mg/L
Pb	50.5 %	Pb	50.6 %	Pb	35 mg/L
S		S		S	11988 mg/L
Zn	88.6 %	Zn	89.0 %	Zn	1081 mg/L

The large discrepancy in the elements that have a large proportion in the residue is due to insufficient mixing of the residue before sampling.

Max Ca solubility is 620mg/L, Ca metal balances are then 101.6% and 102.2%

Test 2 AST Results

Analyte							Solids		
minutes	30	60	120	180	240	300		initial	
Al	2.65	3.13	2.88	2.67	3.23	2.94 g/L	As		64
Ca	1.52	1.69	1.53	1.24	1.95	1.26 g/L	Cd		89
Cu	<5	<5	<5	<5	<5	<5 mg/L	Co		29
Fe	1.72	1.88	1.74	1.62	1.90	1.70 g/L	Cr		53
Mg	1.34	1.43	1.33	1.26	1.50	1.34 mg/L	Cu		60
Mn	18.3	19.5	18.5	16.9	20.2	17.8 mg/L	Mn		112
Pb	35.7	38.2	34.5	31.1	40.3	34.8 mg/L	Ni		70
S						g/L	Pb		12900
Zn	1.48	1.94	2.15	2.26	2.91	2.73 g/L	Zn	67200	73400
							Mg		9580
							Fe		18017
							Al		24192
							Ca		18879
	wet weight	moisture	dry weight						
	g	%	g						
ore	90.09	38	55.9						
final solids	76.8	38	47.62						

If it is assumed that the Mg concentration is at a maximum within the 1st hour and remains constant during the remainder of the test, then fluctuations in volume and errors in dilution prior to analysis should be evened out.

volume	0.334	0.325	0.315	0.355	0.325	0.325	0.325
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Dilution factors

minutes	30	60	120	180	240	300	
sampling	1.000	1.015	1.031	1.047	1.064	1.081	
volume change	0.973	0.943	1.063	0.973	0.973	0.973	
combined	0.973	0.957	1.096	1.019	1.035	1.052	average
Al	2.58	3.00	3.16	2.72	3.34	3.09	3.06
Mg	1.30	1.37	1.46	1.28	1.55	1.41	1.41
Mn	17.8	18.7	20.3	17.2	20.9	18.7	19.16

Extraction

	liquor %	solids %
Al	76.7	
Ca		
Cu		
Fe	59.6	
Mg	88.3	
Mn	100.3	
Pb		
Zn	23.48	21.95

Acid Usage

acid added	21.5 g
	384.9 kg/tonne ore

	Analyte								at 30min	1hour	2hour	3hours	4hours	5hours	
	minutes	30	60	120	180	240	300	acid g	15	19.5	19.5	21.5	21.5	21.5	
volume litre	0.334	0.325	0.315	0.355	0.325	0.325	0.325	liquor litre	0.334	0.334	0.334	0.334	0.334	0.334	
	dilution	0.973	0.957	1.096	1.018	1.034	1.050		SO4 g	SO4 g	SO4 g	SO4 g	SO4 g	SO4 g	
	Al	2.58	3.10	3.06	3.00	3.05	3.10 g/L	Al	13.77	16.54	16.36	16.01	16.27	16.58	
	Ca	1.48	1.67	1.63	1.39	1.84	1.33 g/L	Ca	3.55	4.02	3.91	3.34	4.42	3.19	
	Cu	<5	<5	<5	<5	<5	<5 mg/L	Cu							
	Fe	1.67	1.86	1.85	1.82	1.79	1.79 g/L	Fe	2.88	3.20	3.18	3.13	3.08	3.09	
	Mg	1.30	1.41	1.41	1.41	1.41	1.41 g/L	Mg	5.15	5.59	5.59	5.59	5.59	5.59	
	Mn	17.81	19.29	19.67	18.97	19.05	18.79 mg/L	Mn	0.03	0.03	0.03	0.03	0.03	0.03	
	Pb	34.74	37.78	36.69	34.91	38.00	36.73 mg/L	Pb	0.02	0.02	0.02	0.02	0.02	0.02	
	Zn	1.440	1.919	2.286	2.537	2.744	2.882 g/L	Zn	2.12	2.82	3.36	3.73	4.03	4.23	
	pH dilution/10	1.96	1.70	1.76	1.65	1.71	1.70	total SO4 g/L	27.52	32.21	32.45	31.85	33.44	32.73	
	H2SO4 g/L	11.7	21.7	19.1	24.2	21.5	21.44	H2SO4 g/L	19.6	28.5	28.1	34.0	33.5	33.0	
	adjusted for sampling and dilution							Ca	7.74	7.74	7.74	7.74	7.74	7.74	
		11.4	20.8	20.9	24.7	22.3	22.6	Pb	1.02	1.02	1.02	1.02	1.02	1.02	
								H2SO4 g/L calculated	10.8	19.7	19.3	25.2	24.7	24.2	124.0
								H2SO4 g/L from pH	11.4	20.8	20.9	24.7	22.3	22.9	122.9

Zinc Extraction Rate

minutes	0	30	60	120	180	240	300
Zn g/L	0	1.44	1.92	2.29	2.54	2.74	2.88
maximum extraction occurs after 7hours at 2.976g/L, which is							24.2 %

0.1N NaOH Titration

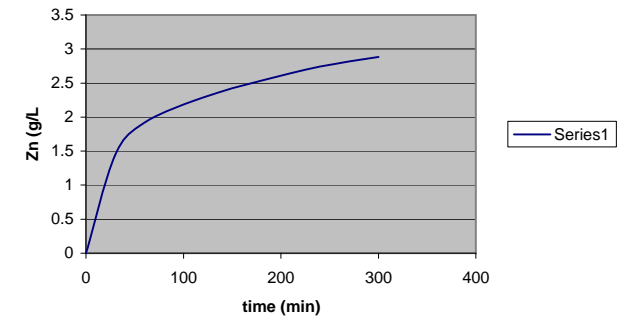
						0.1N NaOH required			
pH	0.1N NaOH	ml	SO4 g/L	H2SO4	SO4	H2SO4	pH	Al?	
0.81	0.00	5.00	52.12	21.44	31.12	0.00	0.81	0.00	
1.00	2.15	7.15	36.45	14.35	22.39	0.94	1.00	1.21	
1.50	11.06	16.06	16.23	4.87	11.46	5.91	1.50	5.15	
2.00	18.77	23.77	10.96	1.72	9.28	13.55	2.00	5.22	
2.50	23.58	28.58	9.12	0.576	8.55	18.52	2.50	5.06	
3.00	25.25	30.25	8.61	0.188	8.43	20.72	3.00	4.53	
3.50	26.90	31.90	8.17	0.059	8.11	21.49	3.50	5.41	
4.00	29.55	34.55	7.54	0.018	7.53	21.75	4.00	7.80	
4.50	38.60	43.60	5.98	0.0050	5.97	21.83	4.50	16.77	
5.00	41.48	46.48	5.61	0.0016	5.61	21.86	5.00	19.62	

2.94 g/L Al	16.3 ml 0.1N NaOH	adjusted for dilution and sampling
21.8 g/L H2SO4	22.2 ml 0.1N NaOH	
total	38.6 ml 0.1N NaOH	

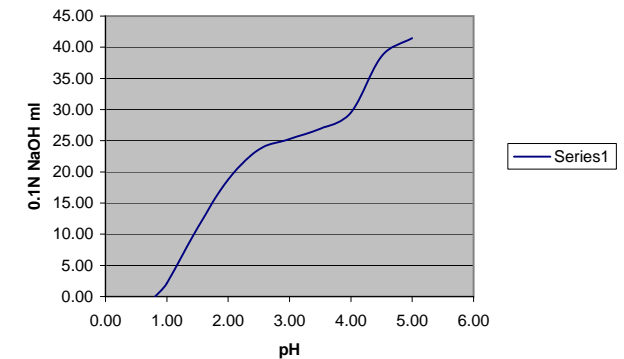
	g/L	activity coefficient	activity moles/L
pH	5.00	1	0.0000
total SO4	5.61	0.440	0.0257
2nd proton dissociation constant K 0.0120			
1st H	0.000	100.00 %	
2nd H	-0.00001	-36.29 %	
total H	0.00001	0.00001	
H2SO4	0.00154		
SO4	5.608		

	g/L	activity coefficient	activity moles/L
H2SO4	2.15	1	0.0219
added SO4	3.1	0.500	0.0162
	5.216		
2nd proton dissociation constant K 0.0120			
1st H	0.022	100.00 %	
2nd H	-0.0019	-8.70 %	
total H	0.02001		
pH	1.699		

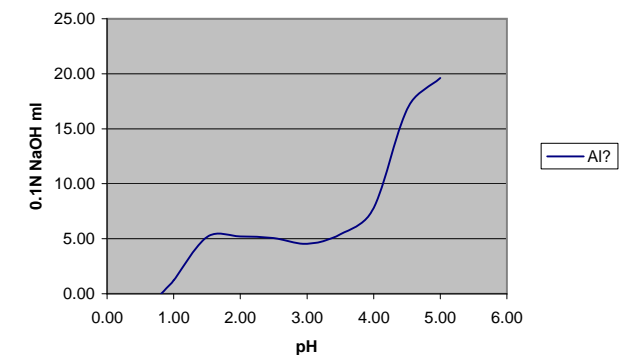
Zn reaction rate



0.1N NaOH titration of 5ml extract



0.1N NaOH excess



ANALYTICAL SERVICES TASMANIA

Report No: 34335 Issue No: 1

Report Date: 10-Jan-2008 17:10

Method	Analyte	Units / Sampled On :	Lab No.:		Sample Id.:		Excessat 30mins		Excessat 60mins		Excessat 120mins		Excessat 180mins		Excessat 240mins		Excessat 300mins	
			120941	120942	120943	120944	120945	120946	120941	120942	120943	120944	120945	120946	120941	120942	120943	120944
1311-Water	Al Total	µg/L	26500000	31300000	28800000	26700000	32300000	28400000	26500000	31300000	28800000	26700000	32300000	28400000	26500000	31300000	28800000	26700000
	Ca Total	mg/L	1520	1690	1630	1240	1950	1260	1520	1690	1630	1240	1950	1260	1520	1690	1630	1240
	Cd Total	µg/L	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500	<500
	Co Total	µg/L	3300	3220	3000	3160	3520	3010	3300	3220	3000	3160	3520	3010	3300	3220	3000	3160
	Cr Total	µg/L	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000
	Cu Total	µg/L	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000	<50000
	Pb Total	µg/L	17200000	18800000	17400000	16200000	19000000	17000000	17200000	18800000	17400000	16200000	19000000	17000000	17200000	18800000	17400000	16200000
	K Total	mg/L	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250
	Mn Total	mg/L	1340	1430	1320	1260	1500	1340	1340	1430	1320	1260	1500	1340	1340	1430	1320	1260
	Mo Total	µg/L	18300	16900	18600	16900	20200	17800	18300	16900	18600	16900	20200	17800	18300	16900	18600	16900
	Na Total	mg/L	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250	<250
	Ni Total	µg/L	8210	8390	8460	7500	8260	8020	8210	8390	8460	7500	8260	8020	8210	8390	8460	7500
	Pb Total	µg/L	35700	38200	34600	31100	40300	34800	35700	38200	34600	31100	40300	34800	35700	38200	34600	31100
	Zn Total	µg/L	14800000	16400000	21500000	22600000	28100000	27300000	14800000	16400000	21500000	22600000	28100000	27300000	14800000	16400000	21500000	22600000

Test 95

1. Stage 1 solution after attempt to place silicon into solution at pH 2. This is the solution decanted at the completion of stage 1.
2. Stage 1 wash solution. After the initial decanting the slurry was brought back to 4 litres volume and again lowered to pH 2 with H2SO4 (4.5 g acid needed). This is the decanted solution after stirring and allowing to settle overnight.
3. Stage 2 slurry. This is the complete slurry from the zinc digestion stage, - 19 days after adding the acid. Solution Zn assay on 21st Jan, after heating from 11C to 34C over 2.5 hours, was 0.46% Zn.
4. Stage 2 solution sample after 9 days digestion at ambient temperature. This represents the highest recovery of Zn to solution, and is the small solution sample in the test tube. It assayed at 0.54% Zn on 12th Jan.

Test 96 slurry

This slurry was prepared on 3rd December.
 500 g wet combined sample ground in 500 ml water in small rod mill, then screened at 2 mm and originally made up to 4 litres of slurry. The volume has since been reduced by evaporation.
 No acid was added. The sample was intended for a repeat of the "failed" Hobart higher temperature digestion, but this was not carried out.
 Also, taped to the container, are the larger (>2mm) particles.

Test 95 Analysis

ID		stage 1 decant	decant wash	9days	slurry		slurry slds %	feed slds %	balance %		dry solids g	moisture g	"washed" dry solids g	%
SO4	pH	2.2	2.2		1.4	1.34								
	g/L	8.04	2.98	48.1	34.9	S	5.15	4.38			10.62	2.07	8.56	4.15
H2SO4	g/L	1.26	0.78		7.95							6.20		
Al	g/L	1.15	0.309	0.465	0.446	Al	0.415	2.3	93.8		0.86	0.12	0.74	0.357
Cu	mg/L	0.231	0.154	0.052	0.039	Cu	0.063	0.0124			0.13	0.00	0.13	0.063
Fe	g/L	0.68	0.230	0.392	1.63	Fe	1.36	1.99	116.8		2.81	0.11	2.70	1.31
Pb	mg/L	7.44	4.5	2.39	3.15	Pb	0.925	0.696			1.91	0.00	1.91	0.925
Zn	g/L	0.759	0.227	3.08	3.02	Zn	3.25	7.5	86.8		6.70	0.81	5.89	2.86
Ca	g/L	0.398	0.50	0.509	0.491	Ca	0.64	1.78	103.9		1.32	0.13	1.19	0.576
Mg	g/L	0.621	0.157	0.073	0.063	Mg	0.036	1.09	76.4		0.074	0.017	0.057	0.028

Analysis impossibly high.

Low Mg metal balance due to removal of >2mm particles.

Feed analysis shown includes >2mm particles.

Feed Solids

340 g

Slurry solids

wet g	dry g	moisture
475	206	269
678	294	383

56.6 %

56.6

Slurry Solids calculated from

AST	201
Pb balance	251
Test2	272

Zn recovery

solution	56.3 %
solids	69.5 %

SO4 dissolution

	stage 1 decant SO4	decant wash SO4	decant wash % into slurry 2.76	9days SO4	slurry SO4	SO4 increase in 2nd stage
Al	6.14	1.65	0.17	2.48	2.38	2.31 g/L
Cu						
Fe	1.17	0.40	0.03	0.67	0.67	0.64 g/L
Pb						
Zn	1.11	0.33	0.03	4.52	4.43	4.49 g/L
Ca	0.96	1.20	0.48	1.22	1.18	0.74 g/L
Mg	2.45	0.62	0.07	0.29	0.25	0.22 g/L
total	11.83	4.19	0.78	9.19	8.91	8.41 g/L
H2SO4	12.07	4.28	0.80	9.38	9.10	8.58 g/L

Acid required for Ca and Pb.

	g
PbSO4	1.12
CaSO4	14.83
total	15.95
1st stage Ca & Pb	4.61
wash Ca & Pb	4.92
2nd stage Ca & Pb	6.42

Used 9day analysis

Acid calculation

acid	added	removed	remained		
1st stage	52.0	47.2	4.83588	1.26 g/L	added 53.1g 98% acid,
decant			4.83588	1.26 g/L	
		4.03		removed	3.20 litres
wash	12.6	9.6	2.99	0.78 g/L	made up to 4L slurry
		2.5		removed	3.20 litres
2nd stage	88.7	34.0	54.65	14.24 g/L	added 90g 98% acid, and made up to 4L slurry

If SO₄ in 9day sample is 48.1g/L,
and 1/10 dilution sample has pH1.6,
then acidity is 25.1g/L.
This is 11.2g/L more than that calculated,
which is an additional 44g 98% acid.
This means that if both the SO₄ analysis and
the pH are correct then the acid addition to
the 2nd stage must have been an extra 44g 98%acid.

SO₄ calculation

SO ₄	added	removed	remained		
1st stage	50.0	0.85	49.1		added 53.1g 98% acid.
decant			49.1	12.80 g/L	
		40.9		removed	3.20 litres
wash	12.3	0.85	19.6	5.12 g/L	addition for pH adjustment etc.
		16.4		removed	3.20 litres
2nd stage	87.9	2.61	88.6	23.1 g/L	added 90g 98% acid, and made up to 4L slurry

Al, Fe, Zn, Ca and Mg calculations

	added	removed	remained	total	
1st stage and decant					
Al	4.41			4.41	1.150 g/L
Fe	2.61			2.61	0.680 g/L
Zn	2.91			2.91	0.759 g/L
Ca	1.53			1.53	0.398 g/L
Mg	2.38			2.38	0.621 g/L
wash	g	g			
Al	0.45	3.68	0.73	1.19	0.309 g/L
Fe	0.45	2.18	0.43	0.88	0.230 g/L
Zn	0.39	2.43	0.48	0.87	0.227 g/L
Ca	1.66	1.27	0.25	1.91	0.498 g/L
Mg	0.21	1.99	0.40	0.60	0.157 g/L
"9days"	g	g	g		
Al	1.49	0.99	0.20	1.69	0.465 g/L
Fe	1.28	0.74	0.15	1.43	0.392 g/L
Zn	11.06	0.73	0.14	11.21	3.080 g/L
Ca	1.53	1.59	0.32	1.85	0.509 g/L
Mg	0.17	0.50	0.10	0.27	0.073 g/L

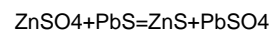
Extraction

	extraction %			for 100%	
	1st stage	wash	2nd stage	total %	balance
Al	56.4	5.8	19.1	81.3	86.7
Fe	38.6	6.6	18.9	64.1	54.9
Zn	11.4	1.5	43.4	56.3	64.9
Ca	25.2	27.4	25.3	78.0	75.0
Mg	64.3	5.6	4.5	74.3	97.3

Acid Usage

	acid usage g			
	1st stage	wash	2nd stage	total %
Al	24.05	2.46	8.14	22.60
Fe	4.58	0.79	2.24	4.96
Zn	4.37	0.58	16.57	14.04
Ca	3.74	4.06	3.76	7.54
Mg	9.60	0.83	0.67	7.24
additional for CaSO ₄ &PbSO ₄	0.86	0.86	2.66	2.86
total	47.20	9.59	34.05	
acidity	4.84	2.99	54.7	40.75
used	52.04	12.6	88.7	100.00

Acid added 153.3 g
removed in decants 5.4 g
nett 147.9 g
435.1 kg/tonne ore



lithopone-paint pigment

																			Total Carbon	Non-carbonate Carbon %	Calc CO ₂ %	Elemental Carbon %	Calc Organic Carbon %	Dry Solid SG	Bulk Density	Moisture Content	Ca %
Pit No.	Zn %	Pb %	Ag g/t	Cu ppm	As ppm	Fe %	Ba ppm	Au g/t	Mn ppm	Cd ppm	Na ppm	Mg ppm	Al %	SiO ₂ %	S total %	S total Repeat%	Sulphide S %	Calc SO ₄	%						Wetcake	%	
115	2.84	0.058	2	40	<50	0.79	40	<0.1	20	10	1010	1040	1.16	32.8	2.63	2.38	1.77	2.58	16.7	16.6	0.1	2.32	14.3	2.23	1.29		
170	2.53	0.103	2	20	<50	4.01	30	<0.1	300	20	890	12400	0.77	35	4.94	4.6	3.72	3.66	7.79	6.28	7.55	1.89	4.39	2.62	1.56		
181	17.5	1.45	3	50	250	2.1	<10	<0.1	10	330	250	320	2.27	9.16	11.5	10.7	10.3	3.6	16.8	16.5	0.15	1.55	15	2.31	1.55	42.9	
264	2.69	0.088	3	20	<50	4.33	<10	<0.1	140	20	590	5710	0.87	3.02	6.89	6.37	4.04	8.55	27.8	26.3	7.5	16.3	10	1.8	1.32		
368	4.98	1.63	12	290	100	1.1	10	<0.1	<10	130	6800	1110	1.21	22.9	3.74	3.63	2.93	2.43	21.5	20.6	4.5	10.6	10	2.1	1.51		

Zinc Leach Test # 2 Procedure

The aim of the test work is to determine the rate of dissolution of Zn in 5 -10g/L H₂SO₄ at about 90C, and to determine the acid requirement.

Procedure:

To 120g of sample in a 1L conical flask with stirrer, add 400ml of distilled water, and heat to 80C. Add 8g 98% H₂SO₄ to the slurry. (initial acidity approx.18g/L)

After 30minutes, 1, 2, and 3 hours take a 5ml sample, dilute to 50ml, filter, and analyse for Zn, Fe, and H₂SO₄.

Aim to maintain acidity at about 5 to10g/L, by adding 1g H₂SO₄ to the slurry for every 2g/L the acidity is less than 10g/L H₂SO₄. Record acid additions. Aim to maintain the temperature at about 90C. Record temperature before taking each sample.

After 4 hours filter the pulp, and wash and dry the solids. Keep the liquor and wash separate and record the volumes. Record the wet and dry weights of the solids. Analyse liquor for Zn and H₂SO₄. Analyse the wash liquor, and the solids for Zn. Keep the final liquor and solid samples.

Note: To ensure that only H₂SO₄ is determined in the titration an end point at pH3 is required for the diluted solutions, to prevent precipitation of ferric hydroxide and silica.

Analysis required,

Ore sample: Zn, Fe, Al, Mg, Cu, Ca, Pb, S.

Final leach solution: Zn, Fe, Al, Mg, Cu, Si.

Final solids: Zn, Pb.

Test 2 AST Results

Analyte							Solids		
minutes	30	60	120	180	240	300		initial	
Al	2.65	3.13	2.88	2.67	3.23	2.94 g/L	As		64
Ca	1.52	1.69	1.53	1.24	1.95	1.26 g/L	Cd		89
Cu	<5	<5	<5	<5	<5	<5 mg/L	Co		29
Fe	1.72	1.88	1.74	1.62	1.9	1.7 g/L	Cr		53
Mg	1.34	1.43	1.33	1.26	1.5	1.34 mg/L	Cu		60
Mn	18.3	19.5	18.5	16.9	20.2	17.8 mg/L	Mn		112
Pb	35.7	38.2	34.5	31.1	40.3	34.8 mg/L	Ni		70
S						g/L	Pb		12900
Zn	1.48	1.94	2.15	2.26	2.91	2.73 g/L	Zn		73400 67200
							Mg		9580
							Fe		18017
							Al		24192
							Ca		18879
	wet weight	moisture	dry weight						
	g	%	g						
ore	90.09		38	55.8558					
final solids	76.8		38	47.616					

If it is assumed that the Mg concentration is at a maximum within the 1st hour and remains constant during the remainder of the test, then fluctuations in volume and errors in dilution prior to analysis should be evened out.

volume	0.334	0.325	0.315	0.355	0.325	0.325	0.325	
Dilution factors								
minutes	30	60	120	180	240	300		
sampling	1.000	1.015	1.031	1.047	1.064	1.081		
volume change	0.973	0.943	1.063	0.973	0.973	0.973		
combined	0.973	0.957	1.096	1.019	1.035	1.052	average	
Al	2.58	3.00	3.16	2.72	3.34	3.09	3.06	
Mg	1.30	1.37	1.46	1.28	1.55	1.41	1.41	
Mn	17.81	18.67	20.27	17.22	20.91	18.72	19.16	

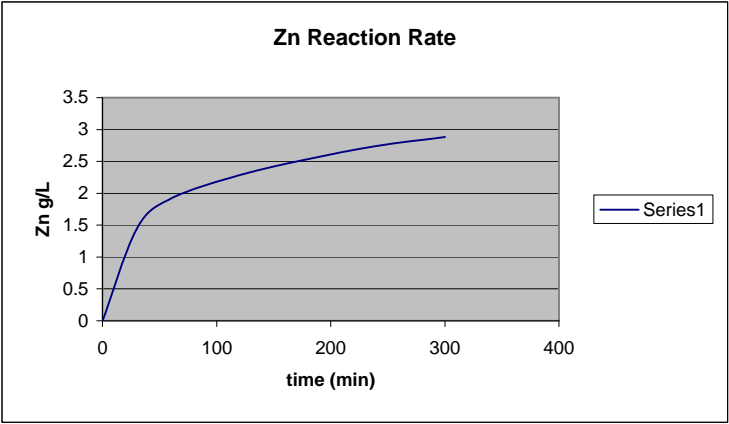
Extraction		
	liquor %	solids %
Al	76.7	
Ca		
Cu		
Fe	59.6	
Mg	88.3	
Mn	100.3	
Pb		
Zn	23.5	22.0
Acid Usage		
acid added	21.5 g	
	385 kg/tonne ore	

								at 30min	1hour	2hour	3hours	4hours	5hours	
Analyte	minutes	30	60	120	180	240	300	acid g	15	19.5	19.5	21.5	21.5	21.5
volume litre	0.334	0.325	0.315	0.355	0.325	0.325	0.325	liquor litre	0.334	0.334	0.334	0.334	0.334	0.334
dilution		0.973	0.957	1.096	1.018	1.034	1.050	SO4 g	SO4 g	SO4 g	SO4 g	SO4 g	SO4 g	SO4 g
Al		2.58	3.10	3.06	3.00	3.05	3.10 g/L	Al	13.77	16.54	16.36	16.01	16.27	16.58
Ca		1.48	1.67	1.63	1.39	1.84	1.33 g/L	Ca	3.55	4.02	3.91	3.34	4.42	3.19
Cu		<5	<5	<5	<5	<5	mg/L	Cu						
Fe		1.67	1.86	1.85	1.82	1.79	1.79 g/L	Fe	2.88	3.20	3.18	3.13	3.08	3.09
Mg		1.30	1.41	1.41	1.41	1.41	1.41 g/L	Mg	5.15	5.59	5.59	5.59	5.59	5.59
Mn		17.81	19.29	19.67	18.97	19.05	18.79 mg/L	Mn	0.03	0.03	0.03	0.03	0.03	0.03

Pb	34.74	37.78	36.69	34.91	38.00	36.73 mg/L	Pb	0.02	0.02	0.02	0.02	0.02	0.02
Zn	1.44	1.92	2.29	2.54	2.74	2.88 g/L	Zn	2.12	2.82	3.36	3.73	4.03	4.23
pH dilution,	1.96	1.70	1.76	1.65	1.71	1.70	total SO4 g/L	27.52	32.21	32.45	31.85	33.44	32.73
H2SO4 g/L	11.7	21.7	19.1	24.2	21.5	21.44	H2SO4 g/L	19.6	28.5	28.1	34.0	33.5	33.0
adjusted for sampling and dilution							Ca	7.74	7.74	7.74	7.74	7.74	7.74
	11.4	20.8	20.9	24.7	22.3	22.6	Pb	1.02	1.02	1.02	1.02	1.02	1.02
							H2SO4 g/L calculated	10.8	19.7	19.3	25.2	24.7	24.2
							H2SO4 g/L from pH	11.4	20.8	20.9	24.7	22.3	22.9

Zinc Extraction Rate

minutes	0	30	60	120	180	240	300
Zn g/L	0	1.44	1.92	2.29	2.54	2.74	2.88
maximum extraction occurs after 7hours at 2.976g/L, which is							24.2 %



Test 95 Analysis

ID		stage 1 decant	decant wash	9days	slurry		slurry slds %	feed slds %	balance %		dry solids g	moisture g	"washed" dry solids g	%
	pH	2.2	2.2		1.4	1.34								
SO4	g/L	8.04	2.98	48.1	34.9	S	5.15	4.38		S	10.62	2.07	8.56	4.15
H2SO4	g/L	1.26	0.78		7.95					SO4		6.20		
Al	g/L	1.15	0.309	0.465	0.446	Al	0.415	2.3	93.8	Al	0.86	0.12	0.74	0.357
Cu	mg/L	0.231	0.154	0.052	0.039	Cu	0.063	0.0124		Cu	0.13	0.00	0.13	0.063
Fe	g/L	0.68	0.230	0.392	1.63	Fe	1.36	1.99	116.8	Fe	2.81	0.11	2.70	1.31
Pb	mg/L	7.44	4.5	2.39	3.15	Pb	0.925	0.696		Pb	1.91	0.00	1.91	0.925
Zn	g/L	0.759	0.227	3.08	3.02	Zn	3.25	7.5	86.8	Zn	6.70	0.81	5.89	2.86
Ca	g/L	0.398	0.50	0.509	0.491	Ca	0.64	1.78	103.9	Ca	1.32	0.13	1.19	0.576
Mg	g/L	0.621	0.157	0.073	0.063	Mg	0.036	1.09	76.4	Mg	0.074	0.017	0.057	0.028

Analysis impossibly high.

Low Mg metal balance due to removal of >2mm particles.

Feed analysis shown includes >2mm particles.

Feed Solids

340 g

Slurry solids

wet g	dry g	moisture	
475	206	269	56.6 %
678	294	383	56.6

Slurry Solids calculated from

AST	201
Pb balance	251
Test2	272

Zn recovery

solution	56.3 %
solids	69.5 %

SO4 dissolution

	stage 1 decant SO4	decant wash SO4	decant wash % into slurry 2.76	9days SO4	slurry SO4	SO4 increase in 2nd stage
Al	6.14	1.65	0.17	2.48	2.38	2.31 g/L
Cu						
Fe	1.17	0.40	0.03	0.67	0.67	0.64 g/L
Pb						
Zn	1.11	0.33	0.03	4.52	4.43	4.49 g/L
Ca	0.96	1.20	0.48	1.22	1.18	0.74 g/L
Mg	2.45	0.62	0.07	0.29	0.25	0.22 g/L
total	11.83	4.19	0.78	9.19	8.91	8.41 g/L
H2SO4	12.07	4.28	0.80	9.38	9.10	8.58 g/L

Used 9day analysis

Acid required for Ca and Pb.

	g
PbSO4	1.12
CaSO4	14.83
total	15.95
1st stage	
Ca & Pb	4.61
wash	
Ca & Pb	4.92
2nd stage	
Ca & Pb	6.42

Acid calculation

acid	added	removed	remained		
1st stage	52.0	47.2	4.83588	1.26 g/L	added 53.1g 98% acid,
decant			4.83588	1.26 g/L	
		4.03		removed	3.20 litres
wash	12.6	9.6	2.99	0.78 g/L	made up to 4L slurry
		2.5		removed	3.20 litres
2nd stage	88.7	34.0	54.65	14.24 g/L	added 90g 98% acid, and made up to 4L slurry

If SO4 in 9day sample is 48.1g/L,
and 1/10 dilution sample has pH1.6,
then acidity is 25.1g/L.
This is 11.2g/L more than that calculated,
which is an additional 44g 98% acid.
This means that if both the SO4 analysis and
the pH are correct then the acid addition to
the 2nd stage must have been an extra 44g 98%acid.

SO4 calculation

SO4	added	removed	remained		
1st stage	50.0	0.85	49.1		added 53.1g 98% acid.
decant			49.1	12.80 g/L	
		40.9		removed	3.20 litres
wash	12.3	0.85	19.6	5.12 g/L	addition for pH adjustment etc.
		16.4		removed	3.20 litres
2nd stage	87.9	2.61	88.6	23.1 g/L	added 90g 98% acid, and made up to 4L slurry

Al, Fe, Zn, Ca and Mg calculations

	added	removed	remained	total	
1st stage and decant					
Al	4.41			4.41	1.150 g/L
Fe	2.61			2.61	0.680 g/L
Zn	2.91			2.91	0.759 g/L
Ca	1.53			1.53	0.398 g/L
Mg	2.38			2.38	0.621 g/L
wash	g	g			
Al	0.45	3.68	0.73	1.19	0.309 g/L
Fe	0.45	2.18	0.43	0.88	0.230 g/L
Zn	0.39	2.43	0.48	0.87	0.227 g/L
Ca	1.66	1.27	0.25	1.91	0.498 g/L
Mg	0.21	1.99	0.40	0.60	0.157 g/L
"9days"	g	g	g		
Al	1.49	0.99	0.20	1.69	0.465 g/L
Fe	1.28	0.74	0.15	1.43	0.392 g/L
Zn	11.06	0.73	0.14	11.21	3.080 g/L
Ca	1.53	1.59	0.32	1.85	0.509 g/L
Mg	0.17	0.50	0.10	0.27	0.073 g/L

Extraction

	extraction %			for 100%	
	1st stage	wash	2nd stage	total %	balance
Al	56.4	5.8	19.1	81.3	86.7
Fe	38.6	6.6	18.9	64.1	54.9
Zn	11.4	1.5	43.4	56.3	64.9
Ca	25.2	27.4	25.3	78.0	75.0
Mg	64.3	5.6	4.5	74.3	97.3

Acid Usage

	acid usage g			total %
	1st stage	wash	2nd stage	
Al	24.05	2.46	8.14	22.60
Fe	4.58	0.79	2.24	4.96
Zn	4.37	0.58	16.57	14.04
Ca	3.74	4.06	3.76	7.54
Mg	9.60	0.83	0.67	7.24
additional for CaSO4&PbSO4	0.86	0.86	2.66	2.86
total	47.20	9.59	34.05	
acidity	4.84	2.99	54.7	40.75
used	52.04	12.6	88.7	100.00

Acid added 153.3 g
removed in decants 5.4 g
nett 147.9 g
435.1 kg/tonne ore