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1112/2

COMPANY: Flinders Mines Limited
ATTENTION: Mick Anstey
FROM: Graeme Campbell
SUBJECT: Flinders Pilbara Iron-Ore Project (FPIOP): Geochemical
Characterisation of Process-Tailings-Solids Sample and
Management Implications

NO. PAGES (including this page): 60 DATE: 15th November 2011

Mick,

The testwork results obtained in this study are presented in Tables 1-4.

Details of the tailings-solids sample submitted for testing are presented in Attachment I.

Details of the testwork methods are presented in Attachment II, and classification criteria in terms of Acid-Formation Potential (AFP) are summarised in Attachment III. Copies of the laboratory reports are presented in Attachment IV.

1.0 TESTWORK OUTCOMES

The tailings-solids sample contained "negligible-sulphides" and "minute/trace-carbonates" (viz. Sulphide-S value of 0.01 %, and CO₃-C value of 0.07 %), and is classified as Non-Acid Forming (NAF) [Table 1].

Although the tailings-solids sample was variously enriched in As, Sb, Se, and Ag (Table 2), the degree of enrichment was not marked.

The sample was dominated by hematite with sub-ordinate kaolinite, goethite, and quartz (Table 3).

The stability of the sorbed forms of minor-elements in the tailings-solids sample is shown by the very-low concentrations in the leachates generated over six (6) weekly-weathering-cycles (Table 4). The occurrence of "ultra-fines" (e.g. Fe/Al-sesquioxides of "near-nano" dimensions [viz. colloidal]) that passed through the 0.45- μ m-membrane during vacuum-filtration means that the recorded minor-element concentrations are variously biased "on-the-high-side", due to contributions from particulates. The recorded minor-element concentrations were typically close to, or below, the respective detection-limits within the range 0.1-10 μ g/L.

2.0 CONCLUSIONS

Based on the testwork results obtain in this study, it is concluded that the process-tailings to be produced during the FPIOP should be geochemically benign. In essence, due to the strongly-weathered and -leached status of the ores *in situ*, the process-tailings have "nothing-to-give", hydrogeochemically, as they are subjected to slow 'residual-weathering' under the episodic, pulsed rainfall-regime of the Pilbara.

3.0 CLOSURE

I trust the above is useful to you.

Regards,

Dr GD Campbell
Director

encl. Tables 1-4.
Attachments I to IV.

TABLES

Table 1: Acid-Base-Analysis and Net-Acid-Generation Results

GCA-SAMPLE NO.	TOTAL-S (%)	SO ₄ -S (%)	SULPHIDE-S (%)	TOTAL-C (%)	CO ₃ -C (%)	Bulk-ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
						kg H ₂ SO ₄ /tonne				
GCA9766	0.01 (0.02)	0.01 (0.01)	0.01	0.17 (0.16)	0.07 (0.07)	5 (4)	nc	<0.5 (<0.5)	5.5 (5.6)	NAF

Notes:

ANC = Acid-Neutralisation-Capacity; NAPP = Net-Acid-Producing-Potential; AFP = Acid-Formation-Potential; NAG = Net-Acid Generation; nc = not calculated; NAF = Non-Acid-Forming. All results expressed on a dry-weight basis, except for NAG-pH.

Values in parentheses represent duplicates.

Table 2: Multi-Element-Analysis Results

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)	AV.-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL- ABUNDANCE INDEX (GAI)
	GCA9766		GCA9766
Al	3.3%	8.2%	0
Fe	48.8%	4.1%	3
Na	0.017%	2.3%	0
K	0.11%	2.1%	0
Mg	0.08%	2.3%	0
Ca	0.2%	4.1%	0
Ag	2.9	0.07	5
Cu	14	50	0
Zn	23	75	0
Cd	0.06	0.11	0
Pb	19	14	0
Cr	110	100	0
Ni	10	80	0
Co	2.7	20	0
Mn	170	950	0
Hg	0.01	0.05	0
Sn	3.8	2.2	0
Sr	6.9	370	0
Ba	21	500	0
Th	6.7	12	0
U	1.4	2.4	0
Tl	0.06	0.6	0
V	58	160	0
As	16	1.5	3
Bi	0.24	0.048	2
Sb	1.9	0.2	3
Se	1.0	0.05	4
Mo	2.2	1.5	0
B	<50	10	0
P	440	1,000	0
F	210	950	0

Note: Average-crustal abundance of elements based on Bowen (1979), and the Geochemical-Abundance Index (GAI) is based on Förstner *et al.* (1993). Refer Attachment II.

Table 3: Mineralogical Results

GCA9766				
hematite kaolinite quartz goethite carbonate biotite leucoxene		dominant minor accessory trace		
eCEC [cmol (p+)/kg]	% -Proportion of eCEC			
	Na	K	Mg	Ca
3.6	14	5	40	41

Notes:

eCEC = effective-Cation-Exchange-Capacity.

dominant = greater than 50 %; minor = 10-20 %; accessory = 2-10 %; and, trace = less than 2 %

Table 4: Column-Leachate-Analysis Results

ELEMENT/ PARAMETER	PRE- RINSING- CYCLE	WEEKLY-WEATHERING-CYCLES (GCA9766)					
		1	2	3	4	5	6
<i>Major-Parameters</i>							
pH	7.4	6.9	7.0	7.0	7.0	7.1	6.9
EC [μ S/cm]	390	69	43	37	33	31	26
<i>Major-Ions (mg/L)</i>							
Cl	73	5	<2	<2	<2	<2	<2
HCO ₃	32	-	-	-	-	-	-
SO ₄	34	6	3	2	1	1	1
Na	55	15	9.4	8.2	7.7	6.7	5.2
K	3.6	1.3	1.1	0.9	0.8	0.7	0.7
Mg	7.3	1.8	1.9	1.5	1.2	0.67	0.65
Ca	9.3	2.5	2.6	2.0	1.6	1.1	0.99
Fe	0.38	1.6	1.4	1.2	0.82	0.39	0.34
Al	0.44	2.7	2.6	2.2	1.7	0.73	0.71
Si	16	21	18	18	18	18	16
Leachate Wt (kg)	0.65	0.69	0.73	0.71	0.76	0.76	0.70

Notes: EC = Electrical-Conductivity. A hyphen for HCO₃ indicates that acidimetric-titration to determine HCO₃ could not be undertaken, since the filtered-(0.45mm-membrane)-leachates were turbid, due to "ultra-fines" of sesquioxides/silicates (likely of near-colloidal dimensions).

ELEMENT/ PARAMETER	PRE- RINSING- CYCLE	WEEKLY-WEATHERING-CYCLES (GCA9766)					
		1	2	3	4	5	6
<i>Minor-Ions (μg/L)</i>							
Cu	<10	30	20	10	20	20	10
Ni	<10	<10	<10	<10	<10	<10	<10
Zn	<10	40	40	40	20	<10	10
Co	0.2	0.6	0.5	0.4	0.3	0.2	0.2
Cd	0.03	0.24	0.09	0.06	0.06	0.03	0.02
Pb	1.5	6.6	6.6	5.2	4.2	4.0	4.2
Cr	<10	<10	<10	<10	<10	<10	<10
Hg	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1
As	1.8	0.6	0.4	0.2	0.3	<0.1	0.5
Sb	0.10	0.21	0.18	0.20	0.23	0.25	0.22
Bi	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005
Se	6.2	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
B	20	220	140	140	120	130	140
Mo	0.74	3.6	3.3	2.9	2.9	3.4	3.8
P	<100	<100	<100	<100	<100	<100	<100
Ag	0.09	0.18	0.22	0.16	0.19	0.19	0.23
Ba	75	19	21	18	14	18	13
Sr	61	20	19	15	12	7.4	7.8
Tl	<0.01	0.02	0.01	<0.01	<0.01	0.01	<0.01
V	<10	<10	<10	<10	<10	<10	<10
Sn	<0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1
U	0.044	0.20	0.19	0.17	0.13	0.076	0.081
Th	0.012	0.040	0.034	0.030	0.023	0.007	<0.005
Mn	20	20	20	10	10	<10	<10

ATTACHMENT I

SAMPLE DETAILS



WorleyParsons®

resources & energy



FLINDERS MINES LIMITED

EcoNomics™

Pilbara Iron Ore Project

Tailings Sample Testwork

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30-Aug-11

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**FLINDERS MINES LIMITED
PILBARA IRON ORE PROJECT
TAILINGS SAMPLE TESTWORK**

SYNOPSIS

This note provides a summary of the tailings sample assay used for the mineralogy analysis performed by Graeme Campbell.

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PROJECT 201012-00322 - PILBARA IRON ORE PROJECT

REV	DESCRIPTION	ORIG	REVIEW	WORLEY- PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Study	J Patel	M Esvelt	N/A	30-Aug-11	N/A	



**FLINDERS MINES LIMITED
PILBARA IRON ORE PROJECT
TAILINGS SAMPLE TESTWORK**

SUMMARY

WorleyParsons Services Pty Ltd (WorleyParsons) developed a testwork programme, directed sample compilation and managed the testwork to prepare samples for sinter testwork. The programme exclusively focussed on the detrital iron deposit (DID 2, DID 3 and DID 4 composites) and Brockman iron deposit (BIDg and BIDh composites) ores of the Delta deposit from the Blacksmith tenements.

Both DID and BID composites were crushed to -6.3 mm, with the DID 2 and DID 3 composites subjected to a 0.3 mm wet screening step. In addition to this beneficiation step, the sample were grade controlled and blended to ensure that the >58% Fe, <6% SiO₂ and <3.5% for DID and <3.0% for BID Al₂O₃ target grades were met prior to sinter testwork.

The mineralogy report noted that for the reject samples from DID 2 and DID 3, that ~50% of the total mineral mass of the goethite, hematite and magnetite was liberated. However, the remaining iron oxides were locked in silicates (7-18%), iron oxide interface (8-28%) and iron oxide interface with silicates (11-32%). The main host of Al was the kaolinite-Fe oxide interface.

The grade of the tailings sample (from DID 2 and DID 3) is as tabled below:

Fe	SiO ₂	Al ₂ O ₃	TiO ₂	Mn	CaO	P XRF	S XRF
%	%	%	%	%	%	%	%
52.5	13.3	6.7	0.564	0.020	0.075	0.050	0.024

MgO	K ₂ O	Na ₂ O	Cl	LOI 371	LOI 371-650	LOI 650-1000	LOI 1000
%	%	%	ppm	%	%	%	%
0.123	0.044	0.037	106.8	2.2	1.4	0.2	3.9

The silica range was between 11 and 21.6 in the composites and the alumina range was between 5.85 and 10.03%

ATTACHMENT II

TESTWORK METHODS

ATTACHMENT II

TESTWORK METHODS

The testwork methods outlined below are proven approaches to 'static-testing' and 'kinetic-testing' within the Australian, and international mining-industries (e.g. Price 2009; Stewart *et al.* 2006; AMIRA 2002; Morin and Hutt 1997).¹ The MEND-document prepared by Price (2009), and *c.* 10-20 years in the making by an experienced practitioner, is an invaluable source of information on testing methods on mine-waste geochemistry. There is also the Global-Acid-Rock-Drainage-Guide (GARD Guide) which is an INAP initiative (go to: www.gardguide.com). However, in terms of comprehensiveness, structure, and clarity, the document by Price (2009) is recommended.

Part of the acid-base-account (ABA) testing, and all of the multi-element analyses, and clay-surface-chemical determinations, are carried out by Genalysis Laboratory Services Pty Ltd [GLS] (Maddington). Specialised ABA-testing, and kinetic-testing, is undertaken by GCA (Bridgetown). Characterisation of rock- and clay-mineralogy is carried out by Roger Townend & Associates (Malaga).

Samples are crushed to 2mm (nominal) in a jaw/rolls-crusher, and pulverised to 75µm (nominal), for specific tests, as required. These sample-splits are referred to herein as "crushings" and "pulp", respectively.

It should be noted that the testwork methods described below are routinely employed in work programmes undertaken by GCA. However, the testwork methods described are generic, and specific tests may not necessarily be undertaken in a given study.

1.0 ACID-BASE-CHEMISTRY AND SALINITY TESTWORK

Acid-base chemistry and salinity are assessed by determining:

- pH and Electrical-Conductivity (EC) on sample slurries;
- Total-Sulphur (Total-S), and Sulphate-Sulphur (SO₄-S);
- Acid-Neutralisation-Capacity (ANC), and CO₃-C;
- Net-Acid-Producing-Potential (NAPP); and,
- Net-Acid-Generation (NAG).

Relevant details of the testwork methods employed are discussed below. Further details are presented in the laboratory reports.

¹ 'Static'-testing' corresponds to "whole-rock" analyses and tests.

1.1 pH-(1:2) and EC-(1:2) Tests

Measurements of pH and EC are performed on slurries prepared using deionised-water, and a solid:water ratio of *c.* 1:2 (w/w). The slurries are allowed to age for *c.* 24 hours, prior to measuring pH and EC.² These tests are performed on the crushings.

pH-(1:2) and EC-(1:2) values provide a measure of the inherent acidity/alkalinity and salinity.³

1.2 Total-S and SO₄-S

Total-S is determined by Leco combustion (@ 1300 °C) with detection of evolved SO_{2(g)} by infra-red spectroscopy. SO₄-S is determined by the Na₂CO₃-Extraction Method (Berigari and Al-Any 1994; Lenahan and Murray-Smith 1986).⁴ The difference between Total-S and SO₄-S indicates the Sulphide-S (strictly Non-Sulphate-S) value. The Total-S and SO₄-S tests are performed on pulps.

1.3 Acid-Consuming Properties

1.3.1 ANC

ANC is determined by a procedure based on that of Sobek *et al.* (1978) which is the "standard" ANC-testing method (AMIRA 2002; Morin and Hutt 1997).

Samples (as crushings) are reacted with dilute HCl for *c.* 2 hours at 80-90 °C, followed by back-titration with NaOH to a pH=7 end-point to determine the amount of acid consumed.⁵ The simmering step for *c.* 2 hours differs from the Sobek *et al.* procedure wherein test-mixtures are heated to near boiling until reaction is deemed to be complete, followed by boiling for one minute. In terms of the dissolution of carbonate- and primary-silicate-minerals, this variation to the Sobek *et al.* method is inconsequential.

The Sobek *et al.* (1978) procedure subjects samples to both strongly-acidic conditions (e.g. pH of 1-2), and a near-boiling temperature. Provided excess acid is added, the dissolution of carbonate-minerals is near-quantitative, and traces of primary-silicates

² The slurries are stirred at the beginning of the testwork, and once again immediately prior to measuring pH and EC.

³ The pH-(1:2) values approximate the "Abrasion-pH" values for identifying minerals in the field (e.g. Stevens and Carron 1948).

⁴ The Na₂CO₃-reagent extracts SO₄ which occurs as soluble sulphates, and calcium sulphates (e.g. gypsum and anhydrite). It also extracts SO₄ sorbed to the surfaces of sesquioxides, clays and primary-silicates. However, SO₄ present as barytes (BaSO₄) is not extracted, and SO₄ associated with jarositic-type and alunitic-type compounds is incompletely extracted.

⁵ A few drops of 30 % (w/w) H₂O₂ are added to the test mixtures as the pH=7 end-point is approached, so that Fe(II) forms released by the acid-attack of ferroan-carbonates (and -silicates) are oxidised to Fe(III) forms (which then hydrolyse to "Fe(OH)₃"). This step ensures that the resulting ANC values are not unduly biased "on-the-high-side", due to the release of Fe(II) during the acid-digestion step (AMIRA 2002), provided that the ferroan-carbonate content is not excessive (e.g. siderite-C values less than 1.5 % [Stewart *et al.* 2006]).

also dissolve. However, at circum-neutral-pH (viz. pH 6-8) relevant to mine-waste and environmental management, the dissolution of primary-silicates is kinetically limiting (e.g. see review-monograph by White and Brantley [1995]).

In the absence of inhibiting alteration-rims, dissolution rates of mafic/felsic-silicates generally equate to H₂SO₄-consumption rates 'of-the-order' 10⁻¹¹-10⁻¹² moles/m²/s. Accordingly, for particle-sizes within the sub-mm range, circum-neutral-dissolution rates of primary-silicates correspond to Sulphide-Oxidation Rates (SORs) 'of-the-order' 1-10 mg SO₄/kg/week (= c. 0.1-1.0 kg H₂SO₄/tonne/year).⁶ In practice, circum-neutral buffering through the surface-hydrolysis/dissolution of primary-silicates is therefore restricted to both particle-gradings akin to "rock-flour" (viz. sub-mm), and slow rates of sulphide-oxidation (e.g. as exhibited by "trace-sulphides" which are not atypically reactive).⁷

Despite aggressive-digestion conditions, the ANC values determined by the Sobek *et al.* (1978) method allow an informed "screening" of acid-consuming properties, especially when due regard is given to groundmass-mineralogy (Morin and Hutt 1997). Jambor *et al.* (2005, 2002, 2000) list 'Sobek-ANC' values for different types of primary-silicates which assists interpretation of ANC-testwork results.

That the ANC value is not an intrinsic property of a sample of geologic media, but rather the outcome of the particular ANC-testwork method employed, is shown by Morin and Hutt (2009).

1.3.2 CO₃-C

CO₃-C is the difference between the Total-C and Total-Organic-C (TOC). Total-C is measured by Leco combustion (@ 1300 °C) with detection of evolved CO_{2(g)} by infra-red spectroscopy. TOC is determined by Leco combustion on a sub-sample which had been treated with strong HCl to decompose carbonate-minerals. Pulps are used for these determinations.

1.3.3 pH-Buffering Properties

pH-Buffering properties are determined via a Metrohm[®] 736 Titrino auto-titrator, and 0.05 M-H₂SO₄. Auto-titrations comprise regular addition of H₂SO₄ to decrease the pH values of the test-suspensions (prepared using pulps) to 3.0 typically over the course of

⁶ SORs of this magnitude (at circum-neutral-pH) would typically only be recorded for the oxidation of "trace-sulphides" (e.g. Sulphide-S contents less than c. 0.5 %) which are not hyper-reactive, and so excludes *inter alia* framboidal-pyrite, and marcasite.

⁷ Primary-particle-sizes within the "rock-flour" range is a given for process-tailings-solids. In the case of mine-wastes, despite its usually small weight-based abundance, this size-fraction is invariably the main seat of geochemical-weathering reactions within waste-dumps, and thereby the main "source-term" for solute generation (e.g. Price and Kwong 1997). Such "rock-flour" occurs in two forms: that obtained via dry-sieving, and that associated with the surfaces of clasts of wide-ranging sizes, and which can only be obtained via wet-sieving.

c. 1 day.⁸ Despite taking up to 1 day to complete, the H₂SO₄-addition rates employed in the auto-titrations are 'orders-of-magnitude' faster than the sulphide-oxidation rates typically observed under "ambient-weathering" conditions.

1.4 NAPP Calculations

NAPP values are calculated from Total-S, SO₄-S and ANC values, assuming that all of the Sulphide-S occurs in the form of pyrite, and/or pyrrhotite. NAPP values facilitate assessment of Acid-Formation Potential (AFP).

The complete-oxidation of pyrite (and/or marcasite) may be described by:



The complete-oxidation of pyrrhotite may be described by:



Since pyrrhotite is non-stoichiometric, expressing it as "FeS" is approximate (Janzen *et al.* 2000). Elemental-S may also be produced during pyrrhotite weathering (Nicholson and Scharer 1994), especially at low-pH. However, Elemental-S is ultimately oxidised to H₂SO₄.

It may be shown that, if the Sulphide-S (in %S) occurs as pyrite/pyrrhotite, then the amount of acid (in kg H₂SO₄/tonne) produced through complete-oxidation is given by **30.6 x %S**. That is, the same conversion-factor of 30.6 applies for both pyrite-, and pyrrhotite-oxidation.

Note: The above treatment of oxidation-reaction stoichiometry is restricted to oxidation by 'atmospheric-O₂' which is the dominant oxidant at circum-neutral-pH. A different oxidation-stoichiometry applies under acidic conditions (e.g. pH less than 3-4) where soluble-Fe(III) forms prevail, and then function as the chief oxidant (e.g. Rimstidt and Newcomb 1993).

Mechanistic aspects of pyrite- and pyrrhotite-oxidation were reviewed by Rimstidt and Vaughan (2003), and Belzile *et al.* (2004), respectively.

1.5 NAG Tests

The NAG Test is a direct measure of the potential for acid-production through sulphide-oxidation, and also provides an indication of the reactivity of the sulphide-minerals, and the availability of alkalinity-forms (AMIRA 2002; Miller *et al.* 1997, 1994). Since this test is performed on pulps, sulphide-grains are fully liberated, and available for reaction.

⁸ In titrating to a pH=3.0 end-point, any Fe(II) released through acid attack of ferroan-carbonates and -silicates is not quantitatively oxidised to Fe(III), and subsequently hydrolysed/precipitated to "Fe(OH)₃". The equivalent of c. 0.5 kg H₂SO₄/tonne is generally required to decrease the pH of the "solution-only" to pH=3.0. No correction is made for this "electrolyte-consumption" of H₂SO₄.

The sample is reacted with H₂O₂ to oxidise sulphide-minerals, and allow the produced acid to react with the acid-neutralising components (chiefly carbonate-minerals). The results from NAG testwork supplement the NAPP-based assessment of AFP (Stewart *et al.* 2006; Shaw 2005; Morin and Hutt 1997).

The NAG-testing methodology used by GCA is the 'Static-NAG Test' in its "single-addition" mode, with NaOH-titration to a pH=7 end-point (AMIRA 2002; Miller *et al.* 1994, 1997). The Start-pH of the 15 % (v/v) H₂O₂ solution (prepared from A.R.-grade H₂O₂) is adjusted to pH=4.5 using 0.1 M-NaOH. The boiling treatment to decompose residual, unreacted-H₂O₂ following overnight reaction is carried out in two stages (viz. boiling for *c.* 2 hours initially, cooling and addition of 1 mL of 0.02 M-CuSO₄, followed by boiling for a further *c.* 2 hours). The addition of Cu(II) catalyses the decomposition of unreacted-H₂O₂, and thereby prevents "positive-blank" values (McElnea and Ahern 2004; O'Shay *et al.* 1990).⁹

Prior to the boiling steps, the pH values of the test-suspensions are measured. Such pH values reflect buffering under ambient conditions without accelerated dissolution of groundmass-minerals through boiling. In the interpretation of NAG-testwork results, it is important to note the pH values prior to the boiling steps, especially for lithotypes characterised by "trace-sulphides" (e.g. Sulphide-S within the sub-% range), and ANC values less than *c.* 10-20 kg H₂SO₄/tonne (e.g. a groundmass devoid of carbonate-minerals). The rates of "peroxide-oxidation" are orders-of-magnitude faster than those of "ambient-oxidation" (viz. SORs recorded in kinetic-testing employing Weathering-Columns). If circum-neutral-pH is to prevail during NAG testwork, then the rate of acid-consumption must be proportionately faster than that for "ambient-oxidation", and is essentially restricted to buffering by reactive-carbonate-minerals (e.g. calcites, dolomites, and ankerites). This aspect must be borne in mind when interpreting NAG-testwork results, especially for samples that contain "trace-sulphides" in a carbonate-deficient groundmass.

2.0 MULTI-ELEMENT ANALYSES

The total content of a wide range of major- and minor-elements are determined through the use of various digestion and analytical techniques. The respective detection-limits are appropriate for environmental investigations.

Element enrichments are identified using the *Geochemical Abundance Index (GAI)*.¹⁰ The GAI quantifies an assay result for a particular element in terms of the average-

⁹ Where samples contain sufficient Cu(II), then Cu(II) forms will be released to solution during reaction with H₂O₂, especially at low-pH.

¹⁰ The GAI was developed by Förstner *et al* (1993), and is defined as:

$$GAI = \log_2 [C_n / (1.5 \times B_n)]$$

where:

C_n = measured content of n-th element in the sample.

B_n = "background" content of the n-th element in the sample.

crustal-abundance of that element.¹¹ The latter corresponds to the typical composition of soils, regoliths and bedrocks derived from unmineralised terrain.

The GAI (based on a log-2 scale) is expressed in 7 integer increments (viz. 0 to 6). A GAI of 0 indicates that the content of the element is less than, or similar to, the average-crustal-abundance; a GAI of 3 corresponds to a 12-fold enrichment above the average-crustal-abundance; and so forth, up to a GAI of 6 which corresponds to a 96-fold, or greater, enrichment above average-crustal-abundances.

3.0 MINERALOGY AND CLAY-SURFACE CHEMISTRY

The semi-quantitative mineralogy, and clay-surface chemistry (generally restricted to waste-regoliths, oxide-ores, and/or soils), are determined using methods routinely used in geology, and soil science.

Indicative abundances of mineral fall into one of the following broad classes, viz.

- | | | |
|---|-----------|-------------------|
| • | dominant | greater than 50 % |
| • | major | 20-50 % |
| • | minor | 10-20 % |
| • | accessory | 2-10 % |
| • | trace | less than 2 % |

Randomly- and preferentially-oriented specimens are prepared, and variously treated with sodium-hexametaphosphate (dispersant), ethylene-glycol, and heating, to quantify non-expansive, and expansive (e.g. smectites), varieties of clay-minerals.

The Effective-Cation-Exchange Capacity (eCEC), and suite of Exchangeable-Cations, are determined by different methods for samples (as crushings) of non-calcareous and calcareous materials (Rengasamy and Churchman 1999). In both cases, soluble-salts are initially removed via pre-washing using a "mixed-organic-solvent" (viz. ethylene-glycol and ethanol). Method 15A2 in Rayment and Higginson (1992) is then employed for non-calcareous samples to determine eCEC, and Exchangeable-Sodium Percentage (ESP). In the case of calcareous samples, a method based on that described by Pierce and Morris (2004) is used, and prevents the dissolution of carbonate-minerals (e.g. calcites and dolomites).¹² After the initial pre-washing step above, extraction is carried out with 1 M-NH₄Cl buffered at pH=8.5 in an ethanolic-aqueous solution. Without such precautions to suppress dissolution of carbonate-minerals, the eCEC is biased "on-the-high-side", and ESP biased "on-the-low-side". Depending on the abundance and nature of the carbonate-minerals, the magnitude of this bias can be marked.

¹¹ The average-crustal-abundances of the elements for the GAI calculations are based on the values listed in Bowen (1979).

¹² The procedure described by Pierce and Morris (2004) is closely related to that originally developed by Tucker (1974).

4.0 SOLUBILITY OF MAJOR/MINOR-ELEMENTS

4.1 Water-Extraction Testwork

Water-Extraction Testwork on the crushings is performed via the bottle-roll technique, and using deionised-water. The test-slurries have a solid:solution ratio of *c.* 1:2 (w/w), and are bottle-rolled for *c.* 1 day before being left to "still-stand" for *c.* 1 day to allow suspended mineral-fines to settle. The resulting supernatants are decanted, vacuum-filtered (0.45µm-membrane), and preserved, as appropriate, for specific analyses. Where required, centrifuging at *c.* 4,000 G for 30 minutes is undertaken to expedite solid-solution separation for vacuum-filtration. The Water-Extraction Testwork is performed in the GCA-Testing Laboratory.

4.2 Na₂EDTA-Extraction Testwork

Na₂EDTA-Extraction Testwork (at pH=6) is carried out on the crushings, based on the method described by Clayton and Tiller (1979). The test-slurries have a solid:solution ratio of *c.* 1:2 (w/w), and are bottle-rolled for *c.* 7 days. This testwork provides a measure of the "metal-pool" potentially available for uptake by biota (e.g. absorption by plant roots).

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KINETIC-TESTING METHODOLOGY EMPLOYED IN THE GCA-TESTING LABORATORY

1.0 GENERAL

The kinetic-testing methodology employed in the GCA-Testing Laboratory is based on "standard" procedures developed by practitioners, academics, and regulators both within Australia, and the northern-hemisphere (chiefly Canada and USA). Such "standard" procedures vary in detail, but essentially entail inundating a rigid, porous sample-bed in a column (or "cell") to elute solutes produced from weathering, followed by dewatering to promote weathering (e.g. sulphide-oxidation) prior to the next flushing-step. The drying-phase often produces a final moisture status that is at, or close to, residual-moistures/suctions.

The GCA-kinetic-testing methodology also reflects research by Dr. Graeme Campbell since the early-1990s, as governed by the diverse demands of projects in terms of both lithotype traits (viz. geochemistry, mineralogy, and physicals), and biophysical setting of the project-site (especially climate).

Where geochemically logical, modifications to the basic procedure (performed for routine kinetic-testing) are made to meet study objectives, and assist management-decision making (c.f. "blind-adherence" to some "standard" protocol which may provide information on reaction dynamics and solubility behaviour that is inconclusive, at best, or worse still, misleading).

2.0 WEATHERING-COLUMNS

- The (short) weathering-columns allow assessment of reaction dynamics under aeration and moisture regimes which are near-optimal for sulphide-oxidation.

The sample-bed-lengths in the columns are typically within the range **5-7 cm**.

- The weathering-columns, and the geometry of the gantry housing the columns and flood-lamps (see Plate 1a), are based on those described in AMIRA (2002).¹

The main departures from AMIRA (2002) are:

- the power, and operation, of the flood-lamps in order to constrain the maximum/minimum-temperatures of the sample-beds during the drying-phase; and,
- the use of weekly-weathering-cycles (i.e. weekly-flushing), and a greater rate of deionised-water addition during flushing.

¹ Six (6) flood-lamps are employed per ten (10) weathering-columns to ensure that the "end-column-pairs" receive the same daily heat-loads as the other "internal-column-pairs" (c.f. the use of 4 flood-lamps per 10 columns, as per AMIRA [2002], where the "end-column-pairs" receive reduced daily heat-loads).

Salient details of the above are discussed below.

2.1 Sample-Bed-Temperature Control

- The gantry housing the weathering-columns is located in a modern, high-ceiling (*c.* 10 m), workshop-type area fitted with roof-venting-whirlygigs, but without air-conditioning.² Accordingly, ambient-temperatures vary both diurnally, and seasonally, under the (inland) Mediterranean climate of Bridgetown.
- In order to constrain variations in the sample-bed-temperatures, 80W-flood-lamps are employed, and turned-on intermittently during the night-time (via automatic-timers) as follows (see Plate 1b):
 - June to September
9 hrs: 17.00-19.00, 22.00-24.00, 2.00-5.00, and, 7.00-9.00
 - October to May
6 hrs: 22.00-24.00, 2.00-5.00, and, 8.00-9.00
- The above differs from that described in AMIRA (2002) where 150W-flood-lamps are turned-on continuously during the daytime for *c.* 8-10 hrs. Although it is implied in AMIRA (2002) that this setup maintains a surface-temperature of *c.* 30-35 °C, this is not the case under the conditions of our laboratory.

GCA-research (unpublished) using columns instrumented with thermistors and soil-moisture sensors, and automatically logged hourly (see Plate 2), has shown that, during the latter stages of drying when residual-moisture contents are attained, the methodology described in AMIRA (2002) results in summer-peak-temperatures (for *c.* 1-2 hrs in mid-afternoon) up to *c.* 70-80 °C in the top *c.* 10 mm on the side of the sample-beds closest to the centre of the flood-lamps (i.e. near-lamp-side).³ However, with the 80W-flood-lamps operated intermittently during the night-time, the near-lamp-side temperature in the top *c.* 10 mm ranges up to *c.* 40 °C only on extreme-summer-days. Since the peak-temperature is in the top *c.* 10 mm on the near-lamp-side, the remainder of the sample-bed has temperatures ranging up to no greater than 30-40 °C.

² To routinely operate multiple (e.g. 20-30+) heat-lamps simultaneously to dewater multiple columns, and then to attempt to "air-condition" the working area via refrigerated-air-conditioning, would be, these days, environmentally irresponsible.

³ The temperature extremes are realised as residual-moistures are approached, due to the limited contribution of water to the heat-capacity of the sample-bed/water/air mixture overall. In the 4-weekly-weathering-cycles of the AMIRA (2002) procedure, the sample-beds are only "partially-wetted" in 3 of the 4 weeks (c.f. saturated when flushing), so that residual-moistures occur for quite a number of days during each cycle. The above extreme-summer-peak-temperatures would then prevail for quite a number of days during weathering-cycles that span the summer period.

Likewise, during winter, the operation of the 80W-flood-lamps during the night-time ensures that the basal-section of the sample-beds on the far-lamp-side have winter-peak-temperatures typically above 10-15 °C during the coldest nights with ambient-temperature-minima near 5 °C.⁴ During the winter-months, the flood-lamps are operated 9 hrs per day (c.f. 6 hrs per day for the rest of year) to ensure that sulphide-oxidation is not limited by restricted evaporative-drying (i.e. relative-saturation of pore-spaces remaining above 80-85 % for too long).⁵

- Summarising, operation of weathering-columns in the GCA-Testing Laboratory, as described, has been [proved to constrain maximum-sample-bed-temperatures to within 30-40 °C during the latter stages of the drying-phase when residual-moisture are attained, even on extreme-summer days.](#)

In terms of assessing the temperature dependence of sulphide-oxidation rates (SORs), the winter- and summer-peak-SORs broadly correspond to mean-sample-bed-temperatures of 20 °C, and 30 °C, respectively. Therefore, where SORs have more-or-less stabilised during kinetic-testing (as often observed during circum-neutral-weathering), the difference between the peak-seasonal-SORs, together with the mean-peak-seasonal-temperature difference of 10 °C, allows estimation of the activation-energy (E_a) for sulphide-oxidation specific to the tested-lithotype.⁶ Such lithotype-specific estimates of E_a then serve as useful input to geochemical modelling of sulphide-oxidation rates at field-scale (and so supplement literature-derived E_a values obtained for "pristine" (i.e. sulphide-grain-surfaces purposely "pre-cleaned"), monomineralic specimens of specific sulphide-minerals [e.g. pyrite]).

2.2 Weekly-Weathering-Cycles

- The columns are weighed each day to track the rate, and extent, of dewatering.⁷

Where the attainment of residual-moisture contents is not desired (e.g. for mine-sites in well-watered settings), an addition of 0.10-0.20 kg of deionised-water is added to "wet" (but not "flush") the sample-beds part way through the drying-phase of each weathering-cycle. The amount and timing of such "remoistening" is sample- and project-specific.

⁴ In terms of the peak-temperatures attained with the AMIRA (2002) procedure during the winter-months, the instrumented-columns showed that the top c. 10 mm on the near-lamp-side of the sample-beds reached c. 45-50 °C as residual-moistures were approached.

⁵ Pan-evaporation (E_{pan}) rates are routinely determined, and range from 3-5 mm/day over the winter-peak, to 6-8 mm/day over the summer-peak.

⁶ In practice, it generally means that the kinetic-testing programme would need to run for at least 1-2 years in order to capture the seasonal-extremes of "stable-SORs" for E_a estimation.

⁷ Due to the "sub-decimetre" thickness of the sample-beds, and the seepage-face-lower-boundary condition, the actual-evaporation rates (E_{actual}) are typically close to the corresponding E_{pan} rates until residual-moisture/suctions are approached.

-
- The flood-lamps are operated intermittently commencing on Monday, Tuesday, Wednesday, and Thursday evenings/nights (i.e. flood-lamps operated over four nights during each weathering-cycle). The flushing-step is undertaken late-morning on Fridays, and corresponds to a "**flooding-with-ponding**" mode of deionised-water addition. Where required, the top 5-10 mm of the sample-bed-surface is worked-over with a spatula to fill-in/seal-over, any desiccation-cracks developed during the drying-phase, and thereby prevent inefficient leaching from "breakthrough", and "by-pass", during the flushing-step.
 - The AMIRA (2002) procedure involves the wetting of the sample-beds at the end of Week-1, Week-2, and Week-3, and then flushing at the end of Week-4 to produce leachates for analysis (i.e. 4-weekly-flushing regime with weekly-wetting between). The rate of deionised-water addition (viz. 0.10 kg deionised-water per kg solids) in the wetting-step is typically shy of "field-capacity" (enhanced by the seepage-face-lower-boundary condition), so there is generally no drainage.

Weekly-weathering-cycles (i.e. flushing with leachate collection on a weekly basis) are employed in the GCA procedure.

- Typically, there is **1.50 kg** (dry-solids-equivalent) of sample in each weathering-column.⁸ 1.00 kg of deionised-water is generally added to each column during the flushing-step, corresponding to 0.66 kg of deionised-water per kg of solids (i.e. 1.00 kg of deionised-water used to flush 1.50 kg of solids). This rate of water addition exceeds the 0.40 kg per kg solids advocated in AMIRA (2002) which occurs every 4-weeks (c.f. 2.7 kg of deionised-water per kg solids over 4-weeks herein). Where the Leachate-EC value indicate that flushing of solutes from the columns is limited, then a second 1.00-kg-lot of deionised-water is added, and a "communal-leachate" then generated.⁹

The weekly-flushing regime, and rate of deionised-water addition, employed by GCA is similar to that typically employed in "humidity-cell" testing in Canada, and the USA (Price 2009; Morin and Hutt 1997; ASTM 2007).

In broad terms, the addition of 1.00 kg of deionised-water to each column corresponds to a storm-depth of *c.* 45 mm. This provides a useful, approximate basis for cross-correlating lab-weathering and field-weathering dynamics under the episodic, pulsed rainfall-regime of the Australian interior.

- The residence-time of water during the flushing-step is generally ranges up to *c.* 12 hrs, as governed by sample texture.

⁸ With 1.50 kg of solids in each column there is sufficient free-board, and so expedites flushing with deionised-water.

⁹ EC = Electrical-Conductivity.

-
- The leachates are collected in beakers beneath the columns, and left to "age" under ambient conditions until the Monday when the next weathering-cycle commences.

All leachates are weighed (for mass-balance calculations), prior to Leachate-pH and Leachate-EC values being determined, followed by vacuum-filtering (0.45- μ m-membrane), and preservation, as appropriate, for the determination of specific analytes.

- Prior to commencing the weathering-cycles, the GCA-columns are subjected to a thorough pre-rinsing treatment using deionised-water to elute pre-existing solutes. Pre-rinsing is continued using 1.00-kg lots of deionised-water until the EC value of the "last-incremental-leachate" (e.g. last 100 mL) is less than *c.* 300-500 μ S/cm. This pre-rinsing step facilitates interpretation of the kinetic-testing results overall.

3.0 REFERENCES

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Plate 1a: Typical Weathering-Column Assembly

Layout and configuration-geometry as per AMIRA (2002).

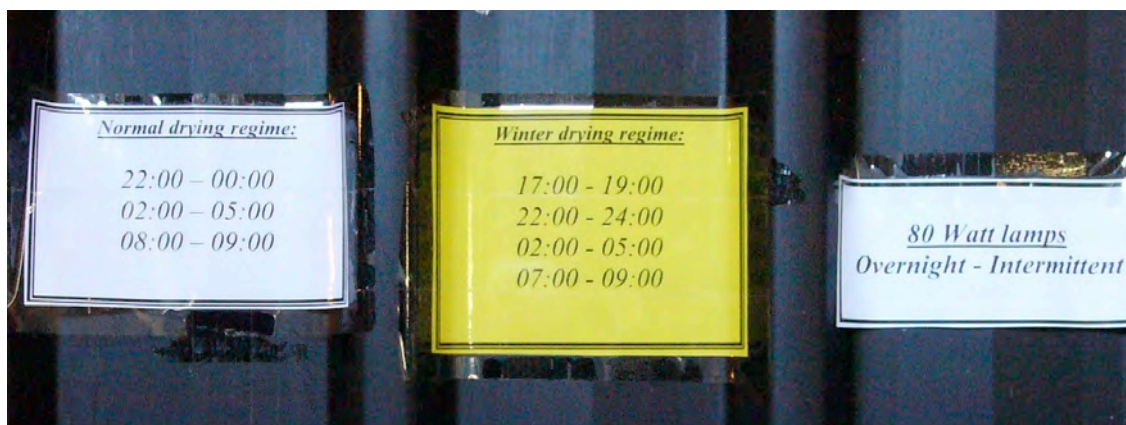


Plate 1b: Seasonal and Diurnal Schedule for Operation of 80W-Flood-Lamps.

Required variation to AMIRA (2002) in order to constrain maximum-temperatures of sample-beds to within 30-40 °C.



Plate 2: GCA-Research Project: Instrumented-Weathering-Column with -4.75mm Fraction of Trace-Sulphide/Calcareous-Basalt-waste-bedrock Sample.

Circum-neutral Weathering.

Volumetric-Water Content (VWC) of upper-half and lower-half of sample-beds logged hourly using calibrated MP406-sensors.

Temperature of top *c.* 10 mm, and bottom *c.* 10 mm, on both the near-lamp-side, and far-lamp-side (as seen in front of columns in photograph), logged hourly using thermistors.

Daily-pan-evaporation rates determined via daily weighing of perspex-container to the left of columns.

ATTACHMENT III

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

ATTACHMENT III

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

Notes: The geochemically-based parameters, and AFP-classification criteria, indicated below apply equally to samples of mine-wastes (e.g. waste-regoliths and waste-bedrocks), low-grade-ores, and process-tailings-solids. The generic descriptor "test-sample" is employed below.

1.0 CALCULATED PARAMETERS

Maximum-Potential-Acidity (MPA) values (in kg H₂SO₄/tonne) of test-samples are typically calculated by multiplying the Sulphide-S values (in %) by 30.6. The multiplication-factor of 30.6 reflects both the reaction stoichiometry for the complete-oxidation of pyrite, by O₂ to "Fe(OH)₃" and H₂SO₄, and the different weight-based units of %, and kg H₂SO₄/tonne.

Net-Acid-Producing-Potential (NAPP) values (in kg H₂SO₄/tonne) are calculated from the corresponding MPA and Acid-Neutralisation-Capacity (ANC) values (i.e. NAPP = MPA - ANC).

2.0 CLASSIFICATION CRITERIA

In terms of AFP, test-samples may be classified into one of the following categories, viz.

- Non-Acid Forming (NAF)
- Potentially-Acid Forming (PAF)

There are **no** unifying, "standard" criteria for classifying the AFP of test-samples (e.g. Price 2009; AMIRA 2002), and reflects the diversity of sulphide- and gangue-mineral assemblages within (un)mineralised-lithotypes of varying weathering- and alteration-status. Rather, criteria for classifying AFP may need to be tailored to deposit-specific geochemistry, mineralogy, and site-specific climate.

The AFP-classification criteria often employed at mining-operations worldwide are:

- **NAF:** Sulphide-S < 0.3 %. For Sulphide-S ≥ 0.3 %, both a negative NAPP value, and an ANC/MPA ratio ≥ 2.0
- **PAF:** For Sulphide-S ≥ 0.3 %, any positive-NAPP value; negative-NAPP value with an ANC/MPA ratio < 2.0

In assessing AFP, lithotypes from hard-rock mines with Sulphide-S values less than 0.3 % are unlikely to acidify (e.g. pH less than 4-5) through sulphide-oxidation. This position holds especially where the groundmass hosting the "trace-sulphides" is not simply quartz, soil-clays, and/or sesquioxides (Price *et al.* 1997), and where the sulphide-minerals are not hyper-reactive varieties (e.g. framboidal-pyrite). A "cut-off" of 0.3 % for Sulphide-S also accords with the findings of kinetic-testing, since the late-1980s, by Dr. Graeme Campbell for test-samples of diverse mineralogy in terms of sulphide-weathering dynamics, and solubility behaviour.

The risk posed by PAF-lithotypes during the active-mine-life is governed primarily by the duration of the lag-phase (i.e. the period during which sulphide-oxidation occurs, but acidification does not develop, due to circum-neutral buffering by gangue-phases [chiefly reactive-carbonate-minerals]).¹ Although the duration of the lag-phase for mine-wastes at field-scale cannot be accurately predicted *a priori*, estimates may still be needed to identify threshold exposure-times for the safe handling of PAF-lithotypes. Lag-phase duration may be estimated via kinetic-testing (viz. Weathering-Columns), and consideration of the moisture/aeration/thermal-regimes of exposed (i.e. uncovered) mine-wastes under the site's climatic conditions. In the absence of results from kinetic-testing, experience permits "first-pass" estimates of sulphide-oxidation rates and lag-phase duration to be made from the results of static-testing, and thereby classify PAF-lithotypes into **PAF-[Short-Lag]** and **PAF-[Long-Lag]** sub-categories. Such "first-pass" estimations are necessarily provisional, and subject to revision, in the light of the outcomes of kinetic-testing, and field observations.

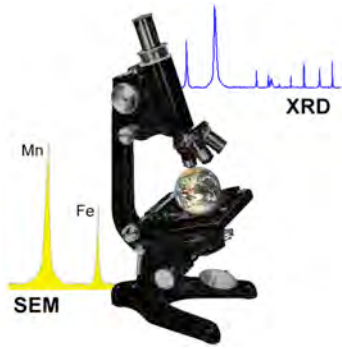
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¹ SO₄ is still produced by sulphide-oxidation during the lag-phase, and appreciable amounts of soluble-forms of certain minor-elements (e.g. Ni and As) may be released at circum-neutral-pH during lag-phase weathering. However, in the latter case, the mine-wastes would need to be sufficiently enriched in Total-Ni and Total-As to begin with.

ATTACHMENT IV

LABORATORY REPORTS



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GRAEME CAMPBELL AND ASSOC.

2-11-2011

PO BOX 247,

BRIDGETOWN

WA

OUR REFERENCE 22987

YOUR REFERENCE: 1112/2 (FLINDERS PIOP)

XRD/PLM ANALYSIS OF ONE ROCK PULP.

D TOWNEND

Correspondence to Box 3129, Malaga D.C. WA 6945

ACN 069 920 476 ABN 92 076 109 663

RESULTS XRD/PLM ANALYSES

MINERAL	GCA9766
HEMATITE	DOMINANT
GOETHITE	ACCESSORY
QUARTZ	MINOR
KAOLINITE	MINOR
LEUCOXENE	TRACE
BIOTITE	TRACE
CARBONATE	TRACE

**Dr G Campbell**

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PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/1107964
No. of SAMPLES	1
CLIENT O/N	GCA 1112/2
PROJECT	Pilbara Iron-Ore
STATE	Tailings Samples
DATE RECEIVED	8/06/2011
DATE COMPLETED	24/06/2011

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
()	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

The sample was received as tailings solid. The sample was dried at 80C crushed to a nominal -2mm. A split was taken and fine pulverised to a nominal -75um

Results of analysis on:

Element		S	S-SO4	C	TOC+C	C-CO3
Method		/CSA	S72/GR	/CSA	C71/CSA	/CALC
Detection		0.01	0.01	0.01	0.01	0.01
Units		%	%	%	%	%
Sample Name						
Control Blank		X	X	0.02	X	
GCA9766		0.02	0.01	0.24	0.17	0.07
GCA9766	check	0.01	0.01	0.23	0.16	0.07
OREAS 93		0.71		0.12		
MA-1b		1.22		2.48		
TOC-1					1.41	
S_SO4_A			0.56			
S_SO4_B			1.28			

Notes

- Total-S and Total-C were determined on the pulps
- Total-C and Total-S was determined using an induction furnace according to Genalysis method number MPL_W043. The samples are ignited in oxygen ~1700C and the CO2 and SO2 measured by infrared detectors
- S-SO4 was determined on the pulps by precipitation of BaSO4 according to Genalysis method number ENV_W039, after digestion with Na2CO3
- TOC+C (acid insoluble carbon compounds and elemental carbon) by a C&S analyser after removal of carbonates and soluble organic carbon using hot hydrochloric acid according to Genalysis method number MPL_W046.

Results of analysis on:

sample		Fizz	volume	HCl	NaOH	Colour	pH	ANC	ANC
name		Rate	ml	M	M	Change	Drop	soln pH	(kgH ₂ SO ₄ /t)
GCA9766		0	8	0.558	0.188	N		1.4	5
GCA9766	check	0	8	0.558	0.188	N		1.5	4

Notes:

1. ANC was determined on 2g of the crushings -. Acid concentrations are as stated.
2. Colour change: Y indicates the appearance of a green colouration as the pH=7 endpoint was approached. N indicates no colour change. Two drops of 30 % hydrogen peroxide are added to each sample as the endpoint is approached to oxidise any ferrous iron.
3. pH drop : Result reported when the pH drops to a value below 4 on addition of peroxide
4. This "Bulk-ANC" static-testing procedure is based on AMIRA (2002), according to Genalysis method number ENV_W035

NATA ENDORSED DOCUMENT**Company Accreditation Number 3244**

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NATA Signatory: Ann Evers

Ann Evers

Date: 24/06/2011



This document is issued in accordance with NATA accreditation requirements.

Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g)	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H ₂ SO ₄ /tonne)
				pH	EC (µS/cm)		
GCA9766	3.0	No apparent reaction	5.2	5.5	29	0.20	<0.5
GCA9766-1	3.0	No apparent reaction	5.2	5.6	28	0.30	<0.5
BLANK1	3.0	Reaction peaked overnight	5.8	7.1	62	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997), and AMIRA (2002) for the 'Static-NAG-Test' in its "Single-Additon-Mode". The pH of the 15 % (v/v) H₂O₂ solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Following an overnight-reaction period, the test-mixtures were boiled for *c.* 2 hours. Then, after allowing the test-mixtures to cool, *c.* 1.0 mL of 0.016 M-CuSO₄ solution was added, and the test-mixtures again boiled for *c.* 2 hours. The addition of Cu(II) catalyses the decomposition of any residual, unreacted-H₂O₂ in the test-mixtures (McElnea and Ahern 2004; O'Shay *et al.* 1990). K-Feldspar was employed for the Blank.

Dr GD Campbell
12th September 2011

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE : 143.0/1108180
No. of SAMPLES : 1
No. of ELEMENTS : 33
CLIENT O/N : GCA1112/2 (Job 1 of 1)
SAMPLE SUBMISSION No. :
PROJECT : Pilbara Iron-Ore Project
STATE : Ex-Pulp
DATE RECEIVED : 14/06/2011
DATE COMPLETED : 27/06/2011
DATE PRINTED : 27/06/2011
PRIMARY LABORATORY : Genalysis Main Laboratory

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
() = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method
OV = Value over-range for Package

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TOWNSVILLE LABORATORY

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Tel: +61 7 4774 3655 Fax: +61 7 4774 4692

SAMPLE DETAILS

DISCLAIMER

Genalysis Laboratory Services Pty Ltd wishes to make the following disclaimer pertaining to the accompanying analytical results.

Genalysis Laboratory Services Pty Ltd disclaims any liability, legal or otherwise, for any inferences implied from this report relating to either the origin of, or the sampling technique employed in the collection of, the submitted samples.

SIGNIFICANT FIGURES

It is common practice to report data derived from analytical instrumentation to a maximum of two or three significant figures. Some data reported herein may show more figures than this. The reporting of more than two or three figures in no way implies that the third, fourth and subsequent figures may be real or significant.

Genalysis Laboratory Services Pty Ltd accepts no responsibility whatsoever for any interpretation by any party of any data where more than two or three significant figures have been reported.

SAMPLE STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

Bulk Residues and Pulps will be stored for 60 DAYS without charge. After this time all Bulk Residues and Pulps will be stored at a rate of \$3.30 per cubic metre per day until your written advice regarding collection or disposal is received. Expenses related to the return or disposal of samples will be charged to you at cost. Current disposal cost is charged at \$100.00 per cubic metre.

SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

NOTES

*** NATA ENDORSED DOCUMENT ****

Company Accreditation Number 3244

The contents of this report have been prepared in accordance with the terms of NATA accreditation and as such should only be reproduced in full.

The analysis results reported herein have been obtained using the following methods and conditions:

The samples as listed were received as being 'Tailing-Solids' which had been dried and pulverised in a zirconia bowl as per Genalysis job number 143_0_1107964.

The results have been determined according to Genalysis methods codes :

Digestions : MPL_W001 (4A/), MPL_W005 (SE1/), ENV_W012 (FC7/SIE), MPL_W011 (FP1/), MPL_W008 (HG1/).

Analytical Finishes: ICP_W004 (/OE), ICP_W005 (/MS), and AAS_W004 (/CV).

The results included the assay of blanks and international reference standards STSD-2, AMIS0076 and AMIS0085 and Genalysis in-house standards HgSTD-4 and OREAS 97.01

The results are expressed as parts per million or percent by mass in the dried and prepared material.

NATA Signatory: A Evers
Chief Chemist

Date: 27/06/2011

This document is issued in accordance with NATA's accreditation requirements.

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	%	%	ppm	ppm	ppm	ppm
DETECTION LIMIT	1	50	0.01	0.01	0.05	0.01	1	0.1	20	1
DIGEST	4A/	FC7/	FP1/	HG1/	FP1/	FP1/	4A/	4A/	4A/	4A/
ANALYTICAL FINISH	OE	SIE	OE	CV	OE	OE	OE	MS	OE	OE
SAMPLE NUMBERS										
0001 GCA9766	14	163	48.62	0.01	0.08	0.08	165	2.2	167	9
CHECKS										
0001 GCA9766	13	208	48.74	0.01	0.11	0.08	170	2.2	170	10
STANDARDS										
0001 AMIS0076			3.50		0.36	0.30				
0002 AMIS0085	430						498	3.9	1.27%	66
0003 HgSTD-4				0.38						
0004 OREAS 97.01										
0005 STSD-2		1004								
BLANKS										
0001 Control Blank	2	X	0.02	X	X	X	1	X	X	1
0002 Control Blank			0.02		X	X				
0003 Control Blank				X						
0004 Acid Blank	X						X	X	X	X
0005 Acid Blank			X		X	X				
0006 Acid Blank				X						

ANALYSIS

ELEMENTS	U	V	Zn
UNITS	ppm	ppm	ppm
DETECTION LIMIT	0.01	1	1
DIGEST	4A/	4A/	4A/
ANALYTICAL FINISH	MS	OE	OE

SAMPLE NUMBERS

0001 GCA9766	1.36	58	23
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CHECKS

0001 GCA9766	1.35	57	22
--------------	------	----	----

STANDARDS

0001 AMIS0076			
0002 AMIS0085	273.25	30	94
0003 HgSTD-4			
0004 OREAS 97.01			
0005 STSD-2			

BLANKS

0001 Control Blank	X	X	2
0002 Control Blank			
0003 Control Blank			
0004 Acid Blank	X	X	X
0005 Acid Blank			
0006 Acid Blank			

METHOD CODE DESCRIPTION

- 4A/MS** Genalysis Main Laboratory
Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Tubes. Analysed by Inductively Coupled Plasma Mass Spectrometry.
- 4A/OE** Genalysis Main Laboratory
Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Tubes. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.
- FC7/SIE** Genalysis Main Laboratory
Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.
- FP1/OE** Genalysis Main Laboratory
Sodium peroxide fusion (Nickel crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled PI
- HG1/CV** Genalysis Main Laboratory
Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.
- SE1/MS** Genalysis Main Laboratory
Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled PI

ANALYTICAL REPORT

Dr G. CAMPBELL
CAMPBELL, GRAEME and ASSOCIATES
PO Box 247
BRIDGETOWN, W.A. 6255
AUSTRALIA

JOB INFORMATION

JOB CODE : 143.0/1108182
No. of SAMPLES : 1
No. of ELEMENTS : 14
CLIENT O/N : GCA1112/2 (Job 1 of 1)
SAMPLE SUBMISSION No. :
PROJECT : Pilbara Iron-Ore Project
STATE : Ex-Pulp
DATE RECEIVED : 14/06/2011
DATE COMPLETED : 06/07/2011
DATE PRINTED : 21/07/2011
PRIMARY LABORATORY : Genalysis Main Laboratory

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
() = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method
OV = Value over-range for Package

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SAMPLE STORAGE OF SOLUTIONS

Samples received as liquids, waters or solutions will be held for 60 DAYS free of charge then disposed of, unless written advice for return or collection is received.

ANALYSIS

ELEMENTS	Al2O3	CaO	Cr2O3	Fe2O3	K2O	LOI	MgO	MnO	Na2O	P2O5
UNITS	%	%	%	%	%	%	%	%	%	%
DETECTION LIMIT	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.002
DIGEST	FB1/	FB1/	FB1/	FB1/	FB1/		FB1/	FB1/	FB1/	FB1/
ANALYTICAL FINISH	XRF50	XRF50	XRF50	XRF50	XRF50	/TGA	XRF50	XRF50	XRF50	XRF50
SAMPLE NUMBERS										
0001 GCA9766	6.76	0.07	X	75.07	0.04	3.85	0.11	0.02	0.03	0.112
CHECKS										
0001 GCA9766	6.80	0.06	X	74.98	0.04	3.86	0.12	0.02	0.03	0.111
STANDARDS										
0001 SY-4	20.66	7.93	X	6.20	1.66		0.52	0.11	7.24	0.125
BLANKS										
0001 Control Blank	X	X	X	X	X	0.07	X	X	X	X

ANALYSIS

ELEMENTS	SO3	SiO2	TiO2	Total
UNITS	%	%	%	%
DETECTION LIMIT	0.002	0.01	0.01	0.01
DIGEST	FB1/	FB1/	FB1/	FB1/
ANALYTICAL FINISH	XRF50	XRF50	XRF50	XRF50

SAMPLE NUMBERS

0001 GCA9766	0.059	13.34	0.56	100.02
--------------	-------	-------	------	--------

CHECKS

0001 GCA9766	0.057	13.21	0.56	99.85
--------------	-------	-------	------	-------

STANDARDS

0001 SY-4	0.044	49.93	0.29	
-----------	-------	-------	------	--

BLANKS

0001 Control Blank	X	99.51	X	
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METHOD CODE DESCRIPTION

/TGA

Genalysis Main Laboratory

No digestion or other pre-treatment undertaken. Analysed by Thermal Gravimetric Analyser

FB1/XRF50

Genalysis Main Laboratory

Fused Disk preparation for XRF analysis Analysed by XRF Spectrometry. Clay Minerals Package

**Dr G Campbell**

CAMPBELL, GRAEME and ASSOCIATES PTY LTD
 PO Box 247
 BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143.0/1108181
No. of SAMPLES	1
CLIENT O/N	GCA 1112/2
PROJECT	Pilbara Iron-Ore Project
STATE	Tailings Solid
DATE RECEIVED	8/06/2011
DATE COMPLETED	7/07/2011

LEGEND

X	= Less than Detection Limit
N/R	= Sample Not Received
*	= Result Checked
()	= Result still to come
I/S	= Insufficient Sample for Analysis
E6	= Result X 1,000,000
UA	= Unable to Assay
>	= Value beyond Limit of Method

The sample was received as a dry tailings solid and was indicated to be non calcareous i.e C-CO₃<0.1%

The digest NH₄Cl₇ was used as follows for these non calcareous samples:

2g of each of the samples were weighed into a centrifuge tube and pre- washed with 2x 25ml 10 % (v/v) deionised ethylene glycol in 90 % (v/v) ethanol which has been previously deionised by passing through Amberlite resin

After the centrifuge stage there may be finely dispersed material in suspension. If this is the case a few drops of PVA may be necessary. The PVA aqueous solution is 0.05 % (w/v) polyvinyl alcohol. Addition made.

Extraction step for Exchangeable cations

After decanting following completion of the 2nd pre-wash, the residue in centrifuge tube is subjected to 2 x 30-minute extractions via end-over-end tumbling at approx. 10 rpm. Each extraction uses 20 ml of 1 M-NH₄Cl buffered at pH 7.0 using ammonia solution 28 % (w/w). At the completion of each extraction, the suspensions are centrifuged and the supernatants decanted and collected into a communal extract. The final communal extract is brought to 50 ml with 4 M-HCl.

Sample analysed for Ca,Mg,K and Na by OES

Reference:

Based on procedure 15B2

Australian laboratory handbook of soil and water chemical methods / G.E. Rayment and F.R. Higginson 1992
 Inkata Press

Results of analysis on:

Element		Ca	K	Mg	Na	eCEC	Ca	K	Mg	Na
Method		NH4Cl7/OE	NH4Cl7/OE	NH4Cl7/OE	NH4Cl7/OE		exch	exch	exch	exch
										ESP
Units		cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg		%	%	%	%
GCA9766		1.40	0.11	1.29	0.46	3.26	42.9	3.4	39.6	14.1
GCA9766	check	1.49	0.16	1.43	0.48	3.56	41.8	4.5	40.1	13.5
ASPAC-33		42.31	1.54	35.18	1.84	80.86	52.3	1.9	43.5	2.3

Ann Evers

7/07/2011

KINETIC-TESTING WORKSHEET (WEATHERING-COLUMNS)

Job No: 1112/2

Client: Flinders-PIOP

	GCA9766
Column-Packing	
Wt Column-Only (kg)	0.32
Wt Column + Sample (kg)	1.82
Wt Sample (kg)	1.50

	GCA9766	GCA9766	GCA9766
Weathering-Cycles			
Cycle No.	1	2	3
DAY-1 (i.e. Start-of-Day-1) [Monday]			
Lamps-On: Date	20/6/11	27/6/11	4/7/11
Lamps-On: Time	17:00	17:00	17:00
DAY-2 [Tuesday]			
Time	09:00	09:00	09:00
Wt Column (kg)	2.03	2.10	2.13
Gravimetric-Water-Content (% w/w)	14.0	18.7	20.7
DAY-3 [Wednesday]			
Time	09:00	09:00	09:00
Wt Drying-Column (kg)	1.98	2.04	2.06
Gravimetric-Water-Content (% w/w)	10.7	14.7	16.0
DAY-4 [Thursday]			
Time	09:00	09:00	09:00
Wt Drying-Column (kg)	1.93	1.98	2.00
Gravimetric-Water-Content (% w/w)	7.3	10.7	12.0
DAY-5 [Friday]			
Time	09:00	09:00	09:00
Wt Drying-Column (kg)	1.89	1.94	1.93
Gravimetric-Water-Content (% w/w)	4.7	8.0	7.3
Wt Deionised-Water Added (kg)	1.00	1.00	1.00
(Lamps remain off)			
DAY-7 (i.e. End-of-Day-7)			
Wt Drained-Column(kg)	2.17	2.19	2.19
Gravimetric-Water-Content (% w/w)	23.3	24.7	24.7
Wt Leachate + Beaker (kg)	0.95	0.99	0.97
Wt Beaker (kg)	0.26	0.26	0.26
Wt Leachate (kg)	0.69	0.73	0.71
Leachate-pH	6.9	6.5	6.8
Leachate-EC (μ S/cm)	86	63	38

	GCA9766	GCA9766	GCA9766
Weathering-Cycles			
Cycle No.	4	5	6
<u>DAY-1 (i.e. Start-of-Day-1) [Monday]</u>			
Lamps-On: Date	11/7/11	18/7/11	25/7/11
Lamps-On: Time	17:00	17:00	17:00
<u>DAY-2 [Tuesday]</u>			
Time	09:00	09:00	09:00
Wt Column (kg)	2.14	2.12	2.12
Gravimetric-Water-Content (% , w/w)	21.3	20.0	20.0
<u>DAY-3 [Wednesday]</u>			
Time	09:00	09:00	09:00
Wt Drying-Column (kg)	2.08	2.07	2.05
Gravimetric-Water-Content (% , w/w)	17.3	16.7	15.3
<u>DAY-4 [Thursday]</u>			
Time	09:00	09:00	09:00
Wt Drying-Column (kg)	2.02	2.01	1.98
Gravimetric-Water-Content (% , w/w)	13.3	12.7	10.7
<u>DAY-5 [Friday]</u>			
Time	09:00	09:00	09:00
Wt Drying-Column (kg)	1.96	1.96	1.91
Gravimetric-Water-Content (% , w/w)	9.3	9.3	6.0
Wt Deionised-Water Added (kg)	1.00	1.00	1.00
(Lamps remain off)			
<u>DAY-7 (i.e. End-of-Day-7)</u>			
Wt Drained-Column(kg)	2.17	2.18	2.18
Gravimetric-Water-Content (% , w/w)	23.3	24.0	24.0
Wt Leachate + Beaker (kg)	1.02	1.02	0.96
Wt Beaker (kg)	0.26	0.26	0.26
Wt Leachate (kg)	0.76	0.76	0.70
Leachate-pH	6.7	6.4	6.4
Leachate-EC (μ S/cm)	42	19	23

**Dr G Campbell**

CAMPBELL, GRAEME and ASSOCIATES PTY LTD
PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/1107963
No. of SAMPLES	1
CLIENT O/N	GCA 1112/2
PROJECT	Flinders PIOP
STATE	Column leachates
DATE RECEIVED	8/06/2011
DATE COMPLETED	30/06/2011

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
() = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

A turbid column leachate was received. The sample was centrifuged and filtered a split was then taken and dosed with HNO₃

The pH, EC and Cl of the "raw" sample was measured Genalysis method codes ENV-W001, ENV-W002, ENV_W013 and the alkalinity measured using APHA method code 2320B

APHA code refers to "Standard methods for the examination of water and wastewater", 21st Edition 2005

The HNO₃ dosed filtered solution was analysed for the requested element suite (including S) by ICPMS and /or ICPOES: Genalysis method codes (ICP_W003, ICP_W004)

The charge balance was calculated and found to be within +/- 10%

Results of analysis on:

Element		Cl	EC	HCO ₃	pH
Method		/COL	/MTR	/VOL	/MTR
Detection		2	10	1	0.1
Units		mg/l	uS/cm	mgHCO ₃ /l	NONE
Sample Name					
Control Blank					
GCA9766-0 Raw		73	386	32	7.4
GCA9766-0 Raw	check	73	386	33	7.4

Element	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co
Method	/MS	/OE	/MS	/OE	/MS	/MS	/OE	/MS	/MS
Detection	0.01	0.01	0.1	0.01	0.05	0.005	0.01	0.02	0.1
Units	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l
Sample Name									
Control Blank	0.01	0.02	X	X	X	X	X	X	X
GCA9766-0 HNO ₃	0.09	0.44	1.8	0.2	74.48	X	9.23	0.03	0.2
Alcoa-High3-MS	20.29		110		22.13	18.40		21.25	1057
Alcoa10-OES		1.82		1.13			47.77		

Element	Cr	Cu	Fe-Sol	Hg	K	Mg	Mn	Mo	Na
Method	/OE	/OE	/OE	/MS	/OE	/OE	/OE	/MS	/OE
Detection	0.01	0.01	0.01	0.1	0.1	0.01	0.01	0.05	0.1
Units	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l
Sample Name									
Control Blank	X	X	X	X	X	X	X	X	X
GCA9766-0 HNO3	X	X	0.38	X	3.6	7.22	0.02	0.74	54.9
Alcoa-High3-MS				20.8				22.04	
Alcoa10-OES	0.47	0.24	1.91		3.6	55.09	0.47		228.7

Element	Ni	P	Pb	S	Sb	Se	Si	Sn	Sr
Method	/OE	/OE	/MS	/OE	/MS	/MS	/OE	/MS	/MS
Detection	0.01	0.1	0.5	0.1	0.01	0.5	0.05	0.1	0.02
Units	mg/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l
Sample Name									
Control Blank	X	X	X	0.2	X	X	X	X	X
GCA9766-0 HNO3	X	X	1.5	11.1	0.1	6.2	15.38	X	60.2
Alcoa-High3-MS			21.4		23	114		22.6	1071.2
Alcoa10-OES	0.51	0.9		19.5			23.95		

Element	Th	Tl	U	V	Zn
Method	/MS	/MS	/MS	/OE	/OE
Detection	0.005	0.01	0.005	0.01	0.01
Units	ug/l	ug/l	ug/l	mg/l	mg/l
Sample Name					
Control Blank	X	X	X	X	X
GCA9766-0 HNO3	0.012	X	0.044	X	X
Alcoa-High3-MS	19.11	19.8	18.79		
Alcoa10-OES				0.47	0.47

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NATA Signatory: Ann Evers

Ann Evers

Date: 30/06//2011



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Dr G Campbell
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 PO Box 247
 BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	143/1111212
No. of SAMPLES	8
CLIENT O/N	GCA 1112/2
PROJECT	Flinders PIOP
STATE	Column leachates
DATE RECEIVED	27/07/2011
DATE COMPLETED	16/08/2011

LEGEND

- X = Less than Detection Limit
- N/R = Sample Not Received
- * = Result Checked
- () = Result still to come
- I/S = Insufficient Sample for Analysis
- E6 = Result X 1,000,000
- UA = Unable to Assay
- > = Value beyond Limit of Method

A series of column leachates were received as turbid column leachates, these samples were centrifuged and filtered (0.45um) a split was then taken and dosed with HNO3
 The pH, EC and Cl of the "raw" samples was measured Genalysis method codes ENV-W001, ENV-W002
 Due to the brown colour of the filtered raw samples the alkalinity was not measured

The HNO3 dosed filtered solution was analysed for the requested element suite (including S) by ICPMS and /or ICPOES: Genalysis method codes (ICP_W003, ICP_W004)

Results of analysis on:

Element		Cl	EC	pH
Method		/COL	/MTR	/MTR
Detection		2	10	0.1
Units		mg/l	uS/cm	NONE
Sample Name				
Control Blank		X		
GCA9766-1 raw		5	70	6.9
GCA9766-1 raw	check	5	69	6.9
GCA9766-2 raw		X	43	7
GCA9766-3 raw		X	37	7
GCA9766-4 raw		X	33	7

Element	Ag	Al	As	B	Ba	Bi	Ca	Cd
Method	/MS	/OE	/MS	/OE	/MS	/MS	/OE	/MS
Detection	0.01	0.01	0.1	0.01	0.05	0.005	0.01	0.02
Units	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l
Sample Name								
Control Blank	0.02	X	X	0.03	X	X	X	X
GCA9766-1 HNO3	0.18	2.64	0.6	0.22	18.5	X	2.45	0.24
GCA9766-2 HNO3	0.22	2.56	0.4	0.14	20.02	X	2.52	0.09
GCA9766-3 HNO3	0.16	2.14	0.2	0.14	17.08	X	1.95	0.06
GCA9766-4 HNO3	0.19	1.64	0.3	0.12	13.55	X	1.53	0.06
Alcoa17-MS	5.2		28.1		5.94	4.736		5.5
Alcoa11-OES		1.97		1			51.78	

Element	Co	Cr	Cu	Fe-Sol	Hg	K	Mg	Mn
Method	/MS	/OE	/OE	/OE	/MS	/OE	/OE	/OE
Detection	0.1	0.01	0.01	0.01	0.1	0.1	0.01	0.01
Units	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
Sample Name								
Control Blank	0.1	X	X	X	X	X	X	X
GCA9766-1 HNO3	0.6	X	0.03	1.54	X	1.3	1.78	0.02
GCA9766-2 HNO3	0.5	X	0.02	1.38	X	1.1	1.85	0.02
GCA9766-3 HNO3	0.4	X	0.01	1.13	X	0.9	1.47	0.01
GCA9766-4 HNO3	0.3	X	0.02	0.82	X	0.8	1.14	0.01
Alcoa17-MS	566.8				5.7			
Alcoa11-OES		0.53	0.54	2.07		3.9	49.89	0.53

Element	Mo	Na	Ni	P	Pb	S	Sb	Se
Method	/MS	/OE	/OE	/OE	/MS	/OE	/MS	/MS
Detection	0.05	0.1	0.01	0.1	0.5	0.1	0.01	0.5
Units	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	ug/l	ug/l
Sample Name								
Control Blank	X	X	X	X	X	X	X	X
GCA9766-1 HNO3	3.57	14.1	X	X	6.6	1.9	0.21	0.5
GCA9766-2 HNO3	3.3	9.4	X	X	6.6	0.7	0.18	X
GCA9766-3 HNO3	2.89	8.2	X	X	5.2	0.4	0.2	X
GCA9766-4 HNO3	2.84	7.7	X	X	4.2	0.2	0.23	X
Alcoa17-MS	5.54				5.5		5.55	27.1
Alcoa11-OES		253.9	0.51	1		18.8		

Element	Si	Sn	Sr	Th	Tl	U	V	Zn
Method	/OE	/MS	/MS	/MS	/MS	/MS	/OE	/OE
Detection	0.05	0.1	0.02	0.005	0.01	0.005	0.01	0.01
Units	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l	mg/l
Sample Name								
Control Blank	X	X	X	0.011	X	X	X	X
GCA9766-1 HNO3	20.72	0.1	19.42	0.04	0.02	0.197	X	0.04
GCA9766-2 HNO3	17.53	0.1	18.98	0.034	0.01	0.188	X	0.04
GCA9766-3 HNO3	17.71	0.1	14.66	0.03	X	0.167	X	0.04
GCA9766-4 HNO3	17.67	X	11.89	0.023	X	0.129	X	0.02
Alcoa17-MS		5.6	547.81	4.935	4.72	5.048		
Alcoa11-OES	16.6						0.54	0.55

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Ann Evers

Date: 16/08//2011



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**Dr G Campbell**

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JOB INFORMATION

JOB CODE	143/1111962
No. of SAMPLES	4
CLIENT O/N	GCA 1112
PROJECT	Flinders PIOP
STATE	Column leachates
DATE RECEIVED	10/08/2011
DATE COMPLETED	31/08/2011

LEGEND

X = Less than Detection Limit
N/R = Sample Not Received
* = Result Checked
() = Result still to come
I/S = Insufficient Sample for Analysis
E6 = Result X 1,000,000
UA = Unable to Assay
> = Value beyond Limit of Method

A series of column leachates were received, some were slurries. These samples were centrifuged and filtered (0.45um) a split was then taken and dosed with HNO₃

The pH, EC and Cl of each "raw" sample was measured using Genalysis method codes: ENV-W001, ENV-W002, and ENV_W013

The alkalinity was not measured due to the brown colour of the solutions

The HNO₃ dosed filtered solution was analysed for the requested element suite (including S) by ICPMS and /or ICPOES: Genalysis method codes (ICP_W003, ICP_W004). The charge balance was not calculated

Results of analysis on:

Element		Cl	EC	pH
Method		/COL	/MTR	/MTR
Detection		2	10	0.1
Units		mg/l	uS/cm	NONE
Sample Name				
Control Blank		X		
GCA9766-5 Raw		X	32	7
GCA9766-5 Raw	check	X	31	7.1
GCA9766-6 Raw		X	26	6.9
N191		96		

Element	Ag	Al	As	B	Ba	Bi	Ca	Cd
Method	/MS	/OE	/MS	/OE	/MS	/MS	/OE	/MS
Detection	0.01	0.01	0.1	0.01	0.05	0.005	0.01	0.02
Units	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l
Sample Name								
Control Blank	0.01	0.02	X	0.02	X	X	X	X
GCA9766-5 HNO ₃	0.19	0.73	X	0.13	17.43	0.006	1.02	0.03
GCA9766-6 HNO ₃	0.23	0.71	0.5	0.14	12.37	X	0.99	0.02
Alcoa17-MS	5.08		26.7		6.08	4.671		5.52
Alcoa11-OES		2.01		0.99			51.09	

Element	Co	Cr	Cu	Fe-Sol	Hg	K	Mg	Mn
Method	/MS	/OE	/OE	/OE	/MS	/OE	/OE	/OE
Detection	0.1	0.01	0.01	0.01	0.1	0.1	0.01	0.01
Units	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
Sample Name								
Control Blank	X	X	0.02	X	X	X	X	X
GCA9766-5 HNO3	0.2	X	0.02	0.39	0.2	0.7	0.67	X
GCA9766-6 HNO3	0.2	X	0.01	0.34	X	0.7	0.65	X
Alcoa17-MS	572.2				5.6			
Alcoa11-OES		0.52	0.53	2.06		3.8	49.77	0.51

Element	Mo	Na	Ni	P	Pb	S	Sb	Se
Method	/MS	/OE	/OE	/OE	/MS	/OE	/MS	/MS
Detection	0.05	0.1	0.01	0.1	0.5	0.1	0.01	0.5
Units	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	ug/l	ug/l
Sample Name								
Control Blank	X	X	X	X	X	X	X	X
GCA9766-5 HNO3	3.37	6.7	X	X	4	0.3	0.25	X
GCA9766-6 HNO3	3.79	5.2	X	X	4.2	0.3	0.22	X
Alcoa17-MS	5.58				5.5		5.76	28.3
Alcoa11-OES		245.3	0.49	0.9		16.4		

Element	Si	Sn	Sr	Th	Tl	U	V	Zn
Method	/OE	/MS	/MS	/MS	/MS	/MS	/OE	/OE
Detection	0.05	0.1	0.02	0.005	0.01	0.005	0.01	0.01
Units	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l	mg/l
Sample Name								
Control Blank	X	X	X	X	X	X	X	X
GCA9766-5 HNO3	17.28	X	7.34	0.007	0.01	0.076	X	X
GCA9766-6 HNO3	15.86	X	7.75	X	X	0.081	X	0.01
Alcoa17-MS		5.6	549.86	5.218	4.92	5.144		
Alcoa11-OES	18.04						0.51	0.52

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NATA Signatory: Ann Evers

Ann Evers

Date: 31/08//2011



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