APPENDIX 2.16.9

GEOCHEMICAL CHARACTERISATION OF FLOTATION TAILINGS

PERSEUS MINING LIMITED

CENTRAL ASHANTI GOLD PROJECT

GEOCHEMICAL CHARACTERISATION OF

FLOTATION-TAILINGS-SLURRY SAMPLE

Implications for Flotation-Tailings Management

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Graeme Campbell & Associates Pty Ltd

1.0   INTRODUCTION

Perseus Mining Limited is developing the Central Ashanti Gold Project in Ghana.

Ore will be treated in the mill, and the resulting stream of Flotation-Tailings (in slurry form) discharged to an engineered, tailings-storage facility (TSF).

Graeme Campbell & Associates Pty Ltd (GCA) was commissioned to carry out geochemical testwork on a slurry sample of Flotation-Tailings derived from a bench-scale-metallurgical study.

The Static-Testwork Programme focused on the Acid-Formation Potential (AFP), Multi-Element Composition, and Mineralogy of the tailings-solids sample.[1] In addition, the quality (viz. major/minor-ion chemistry) of the tailings-slurry-water sample was determined. The Flotation-Tailings does not undergo leaching with cyanide.

The testwork results are presented and discussed in this report, and implications for Flotation-Tailings management highlighted.

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[1] A Static-Testwork Programme comprises "whole-rock" analyses and tests.

2.0   STUDY APPROACH

The Flotation-Tailings-Slurry sample was prepared by Ammtec Pty Ltd (Balcatta). Details of the bench-scale-metallurgical study are presented in Appendix A.

The Flotation-Tailings-Slurry sample was provided in a 20L-plastic-bucket which was approximately two-thirds filled with tailings-slurry. The height of the tailings-solids in the was approximately one-third of the total-slurry height.   The supernatant (viz. tailings-slurry-water) overlying the tailings-solids was decanted via siphoning, vacuum-filtered (0.45-μm-membrane), and preserved for specific analyses.

The "sandy" tailings-solids were passed through a 5-mm-nylon sieve, and then homogenised by hand-mixing. The resulting tailings-solids sample was <u>not</u> washed prior to testing.

The testwork methods employed in this study are based on recognised procedures for the geochemical characterisation of mine-waste materials, process-liquors and natural-waters (e.g. AMIRA 2002; Morin and Hutt 1997; Smith 1992; Coastech Research 1991; BC AMD Task Force 1989; APHA 1992).

Details of the testwork methods are presented in Appendix B, and the calculations and criteria employed for classifying the tailings-solids sample into an AFP category, are presented in Appendix C.

Part of the testwork was carried out by Genalysis Laboratory Services (Maddington), and SGS Environmental Services (Welshpool). Specialised testing (viz. auto-titrations and Net-Acid-Generation [NAG] Tests) was undertaken by Dr. Graeme Campbell in the GCA Testing-Laboratory (Bridgetown). The mineralogical work was performed by Dr. Roger Townend of Roger Townend & Associates (Malaga).

Copies of the laboratory and mineralogical reports are presented in Appendix D.

3.0 ACID-BASE CHEMISTRY OF TAILINGS-SOLIDS SAMPLE

The testwork results on the acid-base chemistry of the tailings-solids sample are presented in Table 1.

The tailings-solids sample was characterised by:

- a Sulphide-S content of 0.02 %;

- an ANC value of 39 kg H_2SO_4/tonne, and a CO_3-C value of 0.50-0.52 %; and,

- a NAG-pH value of 7.6, and a NAG value less than 0.5 kg H_2SO_4/tonne.

The shape of the pH-buffering curve (Figure 1) is consistent with ankerite being an accessory component of the tailings-gangue (Table 3).

The testwork results indicate that the Flotation-Tailings-Solids sample is devoid of sulphide-minerals (viz. Sulphide-S value less than 0.05 %), and has a calcareous-gangue.

4.0   MULTI-ELEMENT COMPOSITION AND MINERALOGY OF TAILINGS-SOLIDS SAMPLE

The multi-element composition and mineralogy of the tailings-solids sample are indicated by the data presented in Tables 2 and 3, respectively.[2] The corresponding element-enrichments in the sample, as indicated by the values of the Geochemical-Abundance Index (GAI), are also presented in Table 2.[3] It should be noted that these element-enrichments are relative enrichments, based on the element contents typically recorded for <u>unmineralised</u> soils, regoliths and bedrocks (Bowen 1979).

The tailings-solids sample was slightly enriched in As and Mo (Table 2).

The tailings-solids sample mainly comprised quartz, albites and muscovites (Table 3). Ankerites and chlorites were accessory components. Although "traces" of pyrite and arsenopyrite were identified in the mineralogical study, the Total-S and Total-As contents were only 0.03 % and 0.0041 %, respectively.

The analysis results indicate that, geochemically, the Flotation-Tailings-Solids sample was essentially "clean".

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[2] The suite of elements listed in Table 2 is grouped into (a) the major-elements (viz. Na, K, Mg, Ca, Al and Fe) making-up the lattices of primary-silicates, sulphides, clays, sesquioxides and carbonates, and (b) minor-elements. A distinction is made between minor-elements which, under neutral-to-alkaline conditions, occur (i) as cationic-hydrolysis forms (e.g. Cu), and (ii) as anions/oxyanions (e.g. As). Anionic forms may exhibit moderate solubility under neutral-to-alkaline conditions.

[3] The GAI is defined in Appendix B.

5.0   QUALITY OF TAILINGS-SLURRY-WATER SAMPLE

The analysis results for the tailings-slurry-water sample are presented in Table 4.

The tailings-slurry-water sample had a pH value of 8.3, and a salinity (as Total-Dissolved Solids, TDS) of 530 mg/L.[4]

The concentrations of minor-elements were below, or close to, the respective detection-limits.   The low concentrations of soluble metals attest to the efficiency of metal-sorption reactions under neutral-to-alkaline conditions (Sposito 1984).[5]

The analysis results indicate that the Flotation-Slurry-Water sample was mildly-alkaline (viz. pH 8-9), and of potable-salinity, with minor-element concentrations either below, or close to, the respective detection-limits.

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[4] Perth scheme-water was employed in the bench-scale-metallurgical study.
[5] Sorption reactions include both adsorption and precipitation reactions (Sposito 1984).

6.0   CONCLUSIONS

Based on the testwork results obtained in this study, it is concluded that the (sandy) Flotation-Tailings-Slurry stream to be produced by the mill should be geochemically benign.

It is recommended that, during Project operation, samples of the ex-mill-flotation-tailings stream are periodically tested to confirm the conclusions of this study.

7.0   REFERENCES

American Public Health Association, 1992, "Standard Methods for the Examination of Water and Wastewater", 18th Edition, Washington.

AMIRA International Ltd, 2002, "ARD Test Handbook", Prepared by Ian Wark Research Institute, and Environmental Geochemistry International Pty Ltd.

Bowen HJM, 1979, "Environmental Chemistry of the Elements", Academic Press, New York.

British Columbia Acid Mine Drainage Task Force Report, 1989, "Draft Acid Rock Drainage Technical Guide. Volume 1".

Coastech Research Inc., 1991, "Acid Rock Drainage Prediction Manual".

Morin KA and Hutt NM, 1997, "Environmental Geochemistry of Minesite Drainage: Practical Theory and Case Studies", MDAG Publishing, Vancouver.

Smith A, 1992, "Prediction of Acid Generation Potential", in Hutchison IPG and Ellison RD (eds), "Mine Waste Management", Lewis Publishers, Michigan.

TABLES

Table 1: **Acid-Base-Analysis and Net-Acid-Generation Results for Flotation-Tailings-Solids Sample**

| GCA-SAMPLE NO. | TOTAL-S (%) | SO_4-S (%) | Sulphide-S (%) | CO_3-C (%) | ANC | NAPP | NAG | NAG-pH | AFP CATEGORY |
					kg H_2SO_4/tonne				
GCA8166	0.03 (0.03)	<0.01 (<0.01)	0.02	0.50 (0.52)	39 (39)	nc	<0.5 (<0.5)	7.6 (7.6)	NAF

Notes:

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

Table 2:   **Multi-Element-Analysis Results for Flotation-Tailings-Solids Sample**

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %) GCA8166	AV.-CRUSTAL ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI) GCA8166
Al	6.6%	8.2%	0
Fe	1.2%	4.1%	2
Na	3.1%	2.3%	0
K	1.3%	2.1%	0
Mg	0.34%	2.3%	0
Ca	1.1%	4.1%	0
Ag	<0.2	0.07	0
Cu	9	50	0
Zn	27	75	0
Cd	<0.1	0.11	0
Pb	4	14	0
Cr	120	100	0
Ni	160	80	0
Co	4.0	20	0
Mn	170	950	0
Hg	<0.01	0.05	0
Sn	0.9	2.2	0
Sr	310	370	0
Ba	400	500	0
Th	1.9	12	0
U	0.61	2.4	0
Tl	0.24	0.6	0
V	31	160	0
As	41	1.5	**4**
Bi	0.07	0.048	0
Sb	1.2	0.2	2
Se	0.02	0.05	0
Mo	21	1.5	**3**
B	<50	10	0
P	270	1,000	0
F	300	950	0

Notes:

Average-Crustal-Abundances based on Bowen (1979), and Geochemical-Abundance Index (GAI) based on Förstner *et al.* (1993).

Bowen HJM, 1979, "Environmental Chemistry of the Elements", Academic Press, New York

Förstner U, Ahlf W and Calmano W, 1993, "Sediment Quality Objectives and Criteria Development in Germany", *Water Science & Technology*, <u>28</u>:307-316

Table 3:   **Mineralogical Results for Flotation-Tailings-Solids Sample**

GCA8166	
Component	**Abundance**
quartz albite	major
muscovite	minor
ankerite chlorite	accessory
pyrite **arsenopyrite**	trace

Notes:

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

Table 4: **Analysis Results for Flotation-Tailings-Slurry-Water Sample**

Note: All results in mg/L, except for pH and EC (µS/cm).

ELEMENT/ PARAMETER	Flotation-Tailings-Slurry-Water (GCA8166)	ELEMENT/ PARAMETER	Flotation-Tailings-Slurry-Water (GCA8166)
Major-Parameters		*Minor-Ions*	
pH	8.3	Fe	0.26
EC [µS/cm]	830	Cu	0.02
TDS(gravimetric)	530	Ni	0.08
		Zn	0.04
Major-Ions		Co	0.0004
		Al	0.07
Na	140	Cd	0.00004
K	21	Pb	<0.0005
Mg	12	Cr	0.03
Ca	35	Hg	<0.0001
Cl	170	As	0.062
SO_4	43	Sb	0.016
HCO_3	190	Bi	<0.000005
CO_3	<1	Se	0.0017
OH	<5	B	0.13
		Mo	0.052
Nitrogen-Forms		P	<0.1
		F	0.8
NH_3-N	<0.1	Ag	<0.00001
NO_3-N	0.23	Ba	0.016
		Sr	0.28
		Tl	0.00003
		V	<0.01
		Sn	<0.0001
		U	0.0023
		Th	0.000022
		Mn	0.07

Notes:
EC = Electrical Conductivity; TDS = Total-Dissolved Solids
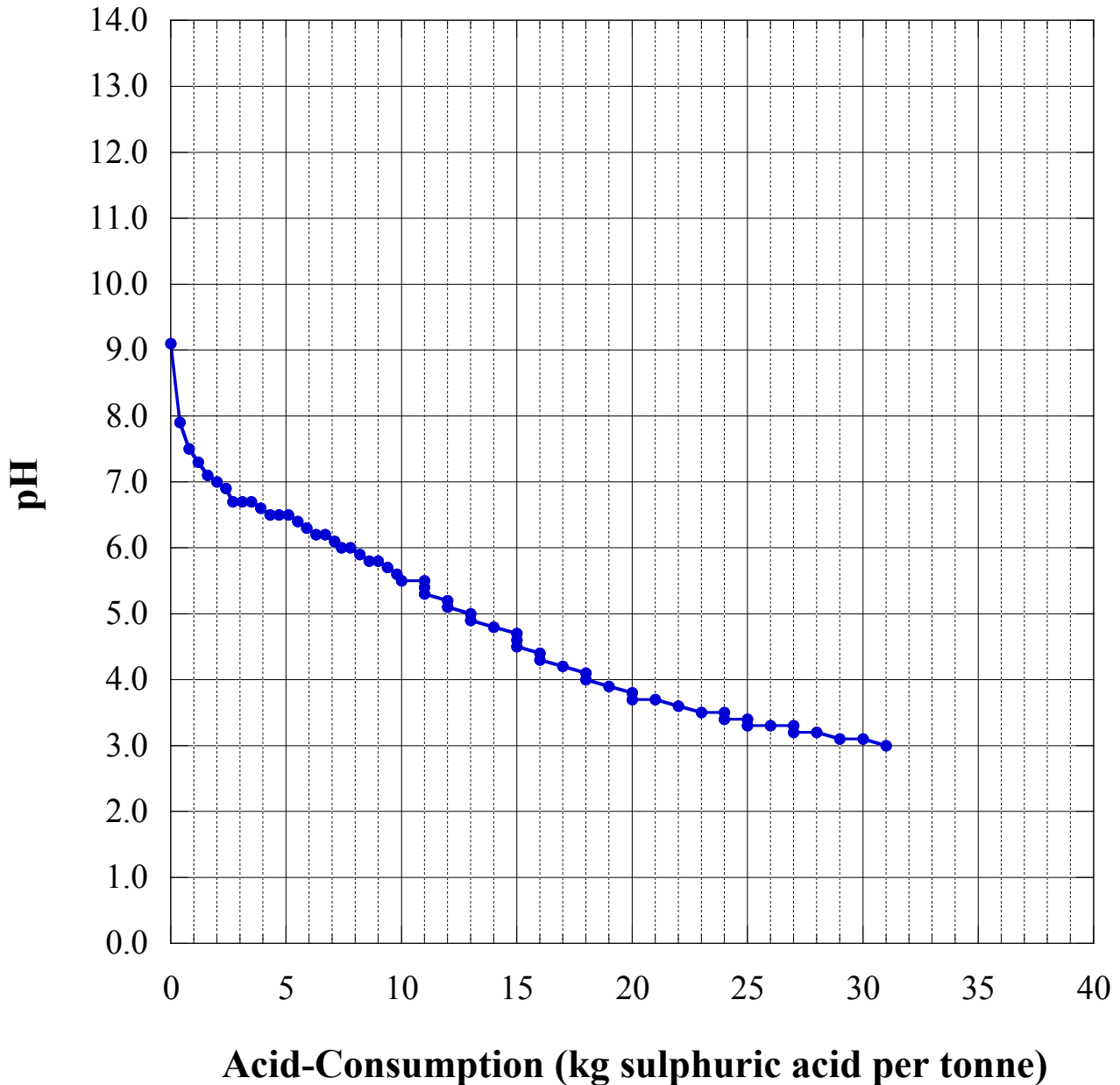
FIGURE

Figure 1

pH-Buffering Curve for Flotation-Tailings-Solids Sample

Note: The H_2SO_4-addition rate employed in the auto-titration corresponds to a sulphide-oxidation rate (SOR) of *c.* 1-2×10^5 mg SO_4/kg/flush (= *c.* 5-10×10^3 kg H_2SO_4/tonne/year for weekly flushing-drying-cycles) under weathering conditions near-optimal for sulphide-oxidation (viz. typical moisture/aeration-regimes, on a weekly basis, in which sulphide-oxidation is limited by neither the O_2-supply [via diffusion], nor H_2O-supply/flushing).

This SOR is therefore up to 10^4-10^5 **faster** than that typical for the circum-neutral weathering, under near-optimal conditions, of process-tailings-solids which contain "minute/trace-sulphides" that are not atypically reactive (e.g. framboidal-pyrites, and marcasites).

APPENDIX A

SAMPLE DETAILS

Memo

To: Brad Marwood

From: Jack Geelhoed

CC: Graeme Campbell

Date: 04/08/2009

Re: Super Bulk Primary Western Ore Composite Flotation Tailings Sample

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This sample has been treated at Ammtec Pty. Ltd. (Ammtec) using bulk sulphide flotation.

The sample head analysis is as follows:

Gold (g/t)	Sulphur (%)	Silver (g/t)	Copper (g/t)	Arsenic (g/t)
1.26	0.26	0.40	26 (calc. Head)	1510

Flotation parameters used during the test are as follows:

- Ore sample was grind in a laboratory scale grinding mill to a product P80 of 212μm.

- Grinding and flotation of this ore sample was conducted in Perth tap water.

- Potassium amyl xanthate and Interfroth IF55 were added during flotation at 10g/t and 492g/t dosages respectively.

- The slurry pH during flotation ranged from 8.0 to 8.2.

A sample of flotation test tailings has been dispatched to Graeme Campbell and Associates for further testing.

Analysis of a sub-sample of tailings dispatched to Graeme Campbell was not conducted, instead a sub-sample of the tailings sample from the flotation test was analysed with the following results:

Gold (g/t)	Sulphur (%)	Silver (g/t)	Copper (g/t)	Arsenic (g/t)
0.05	0.01	0.10	19	130

This sample represents the slurry, which reports to the flotation tailings storage facility. The tailings will be pumped to the tailings storage facility at a density of 37% w/w solids.

Please let me know if you require additional information on this test sample.

APPENDIX B

TESTWORK METHODS

APPENDIX B

TESTWORK METHODS

1.0   ACID-BASE-CHEMISTRY TESTWORK ON TAILINGS-SOLIDS SAMPLE

The acid-base chemistry of the sample was assessed by determining:

- Total-Sulphur (Total-S), and Sulphate-Sulphur (SO_4-S);
- Acid-Neutralisation-Capacity (ANC), CO_3-C, and pH-Buffering properties ;
- Net-Acid-Producing-Potential (NAPP); and,
- Net-Acid-Generation (NAG).

Relevant details of the testwork methods employed are discussed briefly below. Further details are presented in the laboratory reports (Appendix D).

1.1   Total-S, and SO_4-S Determinations

The Total-S value was measured by Leco combustion (@ 1300 ^{o}C) with detection of evolved $SO_{2(g)}$ by infra-red spectroscopy. Total-S values were also determined via various strong-acid digestions.

The SO_4-S values were determined by the Na_2CO_3-Extraction Method (Berigari and Al-Any 1994; Lenahan and Murray-Smith 1986).[1] The difference between the Total-S and SO_4-S values indicates the Sulphide-S (strictly Non-Sulphate-S) content.

1.2   Acid-Consuming Properties

1.2.1   Acid-Neutralisation Capacity

The ANC value was determined by a procedure based on that of Sobek *et al.* (1978). This procedure is essentially the "standard" method employed for estimating the ANC values of mine-wastes (AMIRA 2002; Morin and Hutt 1997; BC AMD Task Force 1989).

The sample was reacted with dilute HCl for *c.* 2 hours at 80-90 ^{o}C, followed by back-titration with NaOH to a pH=7 end-point to determine the amount of acid consumed.[2]

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[1] The Na_2CO_3-reagent extracts SO_4-S which occurs as soluble sulphates, and calcium sulphates (e.g. gypsum and anhydrite). It also extracts SO_4 sorbed to the surfaces of sesquioxides, clays and primary-silicates. However, SO_4 present as barytes ($BaSO_4$) is not extracted, and SO_4 associated with jarositic-type and alunitic-type compounds is incompletely extracted.

[2] A few drops of 30 % (w/w) H_2O_2 were added to the test mixtures as the pH=7 end-point was approached, so that Fe(II) forms released by the acid-attack of ferroan-carbonates and -silicates are

The simmering step for *c.* 2 hours differs slightly from the heating treatment of the Sobek *et al.* procedure wherein the test mixtures are heated to near boiling until reaction is deemed to be complete (viz. gas evolution not visually apparent), followed by boiling for one minute. In terms of the dissolution of carbonate-, primary-silicate- and oxyhydroxide-minerals, this variation to the Sobek *et al.* method is inconsequential.

The Sobek *et al.* (1978) procedure exposes mine-waste samples to both strongly-acidic conditions (e.g. pH of 1-2), and a near-boiling temperature. Provided excess acid is added, this method ensures that carbonate-minerals (including ferroan- and manganoan-varieties) are dissolved near-quantitatively, and that at least traces of ferro-magnesian silicates (e.g. amphiboles, pyroxenes, chlorites, and micas), and feldspars, are dissolved. However, at circum-neutral-pH (viz. pH 6-8) applicable to mine-waste management, the dissolution of ferro-magnesian silicates is extremely slow, and kinetically limiting (e.g. see review-monograph by White and Brantley [1995]). Near pH=7, the dissolution rates (under 'steady-state' conditions, and in the absence of inhibiting alteration-rims) of mafic-silicates and feldspars generally correspond to H_2SO_4-consumption rates 'of-the-order' $10^{-11}/10^{-12}$ moles/m^2/s (White and Brantley 1995). As a "first-pass" guide, for mineral-grains of sub-mm grading, such primary-silicate-dissolution rates correspond to Sulphide-Oxidation Rates (SORs) 'of-the-order' 1-10 mg SO_4/kg/week (= *c.* 0.1-1.0 kg H_2SO_4/tonne/year).[3] In practice, circum-neutral buffering through the dissolution of primary-silicates is therefore restricted to <u>both</u> "mineral-fines", <u>and</u> very-slow rates of sulphide-oxidation.

Despite the aggressive-digestion conditions employed, the ANC values determined by the Sobek *et al.* (1978) method allow an informed, initial "screening" of mine-wastes in terms of acid-consuming and pH-buffering properties, especially when due account is taken of groundmass-mineralogy (Morin and Hutt 1997). Jambor *et al.* (2000, 2002) have presented a compendium of 'Sobek-ANC' values for specific classes of primary-silicates, and assists interpretation of the ANC values recorded for mine-wastes of varying mineralogy.

1.2.2 CO_3-C Value

The CO_3-C value is the difference between the Total-C and Total-Organic-C (TOC) values. Total-C was measured by Leco combustion (@ 1300 ^{o}C) with detection of evolved $CO_{2(g)}$ by infra-red spectroscopy. TOC was determined by Leco combustion on a sub-sample which had been treated with strong HCl to decompose carbonate-minerals.

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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.

[3] 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 0.5 %) which are not atypically reactive, and so excludes *inter alia* framboidal-pyrites, and marcasites.

1.2.3   pH-Buffering Properties

The pH-Buffering properties of the sample were determined via a Metrohm$^{®}$ 736 Titrino auto-titrator, and 0.05 M-H_2SO_4.

The auto-titration comprised regular additions of the H_2SO_4 reagent to monotonically decrease the pH value of the test-suspension to 3.0.[4] The Start-pH values of the test-suspension was *c.* 9-10. Under the testwork conditions employed, the H_2SO_4-addition rate corresponds to a <u>very-rapid rate of acid addition</u>.

Further details of the auto-titration are presented in the laboratory reports (Appendix D).

1.3   NAPP Calculation

The NAPP values of mine-waste samples are usually calculated from the Total-S, SO_4-S and ANC values, assuming that **all** of the Non-Sulphate-S occurs in the form of pyrite. NAPP calculations serve as a starting point in the assessment of the acid-formation potential of mine-wastes which contain sulphide-minerals.

The complete-oxidation of pyrite may be described by:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O = 2H_2SO_4 + \text{"Fe(OH)}_3\text{"}$$
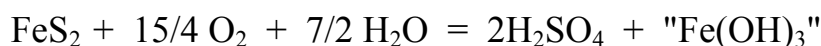
It may be shown that, if the Sulphide-S (in %S) occurs as pyrite, then the amount of acid (in kg H_2SO_4/tonne) produced through complete-oxidation is given by **30.6 x %S**.

> Note: The above treatment of oxidation-reaction stoichiometry is restricted to oxidation by 'atmospheric-O_2' 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-oxidation at the molecular-scale were recently reviewed by Rimstidt and Vaughan (2003).

1.4   NAG Test

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 the alkalinity-forms (chiefly carbonate-minerals) contributing to the ANC (AMIRA 2002; Miller *et al.* 1997, 1994).

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[4] It should be noted that, in titrating to a pH=3.0 end-point, any Fe(II) released through acid attack of ferroan-silicates and -carbonates is <u>not</u> quantitatively oxidised to Fe(III). Furthermore, under the conditions employed in the auto-titration, the equivalent of *c.* 0.5 kg H_2SO_4/tonne was required to decrease the pH of the "solution-only" (i.e. without tailings-solids sample) to pH=3.0. <u>No</u> correction was made for such "electrolyte-consumption" of the 0.05 M-H_2SO_4 titrant.

In this test, the sample is reacted with H_2O_2 to rapidly oxidise sulphide-minerals, and allow the produced acid to react with the acid-neutralising components (e.g. carbonate-minerals). The NAG Test supplements the NAPP-based assessment of the acid-formation potential of mine-wastes (Shaw 2005; Morin and Hutt 1997).

The procedure employed in this study is based on that for the 'Static-NAG Test' in its "single-addition" mode, and NaOH-titration to a pH=7 end-point (AMIRA 2002; Miller *et al.* 1994, 1997). The Start-pH of the 15 % (w/w) H_2O_2 solution (prepared from A.R.-grade H_2O_2) was adjusted to pH=4.5 using dilute NaOH. In addition, the boiling treatment to decompose residual, unreacted-H_2O_2 following overnight reaction was carried out in two stages (viz. boiling for *c.* 2 hours initially, cooling and addition of 1 mL of 0.02 M-$CuSO_4$ to the test mixtures, followed by boiling again for *c.* 2 hours). The addition of Cu(II) salts catalyses the decomposition of unreacted-H_2O_2, and thereby prevents "positive-blank" values being obtained (O'Shay *et al.* 1990).[5] Pulped K-feldspar was employed for the blanks run for the NAG testwork.

Prior to the boiling steps, the pH values of the test-mixture suspensions are measured, and invariably correspond to an "overnight-period" of reaction. Such pH values reflect buffering under ambient conditions <u>without accelerated dissolution of gangue-phases through boiling</u> to decompose any unreacted-H_2O_2. In the interpretation of NAG-testwork data, it is important to take note of the pH values recorded prior to the boiling steps, especially for mine-waste samples that have <u>both</u> Sulphide-S contents less than 1 %, <u>and</u> ANC values less than *c.* 10 kg H_2SO_4/tonne (as typically recorded for a felsic/mafic-gangue devoid of carbonate-minerals). Furthermore, oxidation by H_2O_2 is generally at least 10^3 faster than the SORs recorded during kinetic-testing (e.g. Weathering-Columns) of mine-waste samples. If circum-neutral-pH is to prevail during NAG testwork, then the rate of acid-consumption must be proportionately faster than that for 'ambient-weathering', and is essentially restricted to the dissolution of carbonate-minerals (e.g. calcites, dolomites and ankerites) that are not unduly ferroan (e.g. siderites). This aspect must also be borne in mind when interpreting NAG-testwork results, especially for mine-wastes that contain "trace-sulphides" in a carbonate-deficient gangue, since the <u>dissolution/hydrolysis kinetics of primary-silicates (both felsic- and mafic-silicates) are strongly pH-dependent</u>.

2.0 MULTI-ELEMENT ANALYSES ON TAILINGS-SOLIDS SAMPLES

The total content of a wide range of major- and minor-elements in the tailings-solids samples was determined through the use of various digestion and analytical techniques. The detection-limits employed in these analyses are appropriate for environmental investigations.

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[5] Where mine-waste samples contain sufficient Cu, then Cu(II) forms will be released to solution during the NAG Test, especially at low pH.

Element enrichments were identified using the *Geochemical Abundance Index (GAI)*.[6] The GAI quantifies an assay result for a particular element in terms of the average-crustal-abundance of that element.[7] The latter corresponds to the typical composition of soils, regoliths and bedrocks derived from <u>unmineralised</u> 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   ANALYSIS OF TAILINGS-SLURRY-WATER SAMPLE

The tailings-slurry-water sample was analysed for pH, Electrical Conductivity (EC), salinity (as Total-Dissolved Solids, TDS), alkalinity forms, Cl, SO_4, NO_3, NH_3-N, and a wide range of major- and minor-elements.

All analyses were performed on appropriately-preserved 'splits' for the determination of specific analytes (see Appendix D).

4.0   REFERENCES

AMIRA International Ltd, 2002, "ARD Test Handbook", Prepared by Ian Wark Research Institute, and Environmental Geochemistry International Pty Ltd

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[6] 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.

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

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APPENDIX C

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

APPENDIX C

ACID-FORMATION POTENTIAL (AFP):

CALCULATED PARAMETERS AND CLASSIFICATION CRITERIA

1.0   CALCULATED PARAMETERS

<u>Maximum-Potential-Acidity (MPA)</u> values (in kg H_2SO_4/tonne) of mine-waste 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 O_2 to "Fe(OH)$_3$" and H_2SO_4, and the different weight-based units of % and kg H_2SO_4/tonne.

<u>Net-Acid-Producing-Potential (NAPP)</u> values (in kg H_2SO_4/tonne) are calculated from the corresponding MPA and <u>Acid-Neutralisation-Capacity (ANC)</u> values (i.e. NAPP = MPA - ANC).

2.0   CLASSIFICATION CRITERIA

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

- •   <u>Non-Acid Forming (NAF)</u>

- •   <u>Potentially-Acid Forming (PAF)</u>

There are **no** unifying, "standard" criteria for classifying the AFP of mine-wastes (e.g. Price 2005; Campbell 2002a,b; Smith 1992), 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, and mineralogy, and <u>site-specific climate</u>.

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

- •   **NAF**:   Sulphide-S < 0.3 %. For Sulphide-S ≥ 0.3 %, <u>both</u> a negative NAPP value, <u>and</u> 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 the AFP of mine-wastes, there is consensus that lithotypes with Sulphide-S contents less than 0.3 % are unlikely to oxidise at rates fast enough to result in acidification (e.g. pH less than 4-5). This position assumes that the groundmass hosting

such "trace-sulphides" is <u>not</u> simply quartz, and/or clays (Price 2005; Price *et al.* 1997), and that for a carbonate-deficient groundmass, the sulphide-minerals are <u>not</u> unusually reactive (e.g. sulphide-oxidation rates [SORs] less than *c.* 20-40 mg SO_4/kg/flush) [= *c.* 1-2 kg SO_4/tonne/year for weekly flushing/drying-cycles].[1]

A "cut-off" of 0.3 % for Sulphide-S also accords with the findings of kinetic-testing (viz. Weathering-Columns) conducted, since the late-1980s, by Dr. Graeme Campbell for mine-wastes of diverse mineralogy in terms of AFP.

The ANC/MPA criteria for the NAF category reflects the need to compensate for less-than-perfect availability of alkalinity-forms (e.g. carbonate-minerals) for neutralisation of acid produced through sulphide-oxidation. A less-than-perfect availability of alkalinity-forms may arise from:

(a)   Restricted accessibility of acid to carbonate-grains;
(b)   Rate-limiting dissolution of carbonates-grains near pH=6-7; and,
(c)   Depletion of carbonate-minerals through rainfall-fed leaching within waste-rock-dumps.[2]

In terms of (a), restricted accessibility of acid to the surfaces of carbonate-grains may occur at different spatial-scales (viz. at the "whole-rock-scale" where rapid flows of Acid-Rock Drainage [ARD] by-pass the calcareous-matrix of rock-fragments [e.g. limestones] via preferential-flow pathways within a waste-dump, and at the "pore/grain-scale" in which the surfaces of carbonate-grains are "blinded/rimmed" by precipitates of Fe(III)-oxyhydroxides [e.g. ferrihydrite-type phases]). As shown by Li (1997), Fe-rich varieties of ferroan-carbonates are especially prone to "surface-armouring" effects (e.g. kinetic-testing of pyritic tailings-solids containing pyrite, ankerites and siderites resulted in acidic leachates when less than one-third of the carbonate-grains had dissolved). The effectiveness, or otherwise, of circum-neutral buffering is closely tied to inter alia the residence-time of pore-fluids in contact with carbonate-grain surfaces, and therefore a function of minesite climate. In water-limited settings where flushing from infiltration is infrequent, and where moisture dynamics mainly involve slow unsaturated-flow below "field-capacity" (c.f. regular, rapid flow rates near saturation in well-watered settings), longer residence-times favour diffusion of soluble-alkalinity forms across armoured carbonate-grains, and thereby promote neutralisation reactions.

To compensate for the effects of (a) to (c) above, some practitioners advocate that, for a mine-waste sample to be classified as NAF, it must have an ANC/MPA ratio of at least 3.0 (see review of earlier literature by Smith [1992]).

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[1] Although 'steady-state' SORs (at circum-neutral-pH) for Sulphide-S contents less than 0.3 % may indeed exceed 1-2 kg SO_4/tonne/year, such rates are generally restricted to either sedimentary forms (e.g. framboidal-pyrites, and marcasites), or hydrothermal-sulphides that are ultrafine-grained, and atypically reactive.
[2] Depletion of carbonate-minerals through dissolution in meteoric-waters is generally minimal in water-limited settings, especially within the "hydrologically-active-zone" (e.g. top 2-3 m) of a waste-dump, since re-precipitation occurs during evapo-concentration when strongly-desiccating conditions return after major wet-spells.

In recent years, fundamental-research (especially estimation of reaction-rates for diverse sulphide/gangue-mineral assemblages), and field-experience at mining operations in <u>well-watered settings</u> world-wide, have shown that the potential for ARD production is very low for mine-wastes with ANC/MPA ratios greater than 2.0 (AMIRA 2002; Price *et al.* 1997, Currey *et al.* 1997, and Murray *et al.* 1995).[3] This ANC/MPA ratio is employed in the present work, and is deemed conservative for the <u>water-limited setting</u> of the minesite.[4]

The risk posed by handling PAF-lithotypes during the active-lifetime of a deposit is governed primarily by the duration of the <u>lag-phase</u> (i.e. the period during which sulphide-oxidation occurs, but acidification does <u>not</u> develop, due to circum-neutral buffering by gangue-phases [chiefly carbonate-minerals]).[5] Although the duration of the lag-phase for mine-wastes at field-scale cannot be accurately predicted *a priori*, estimates (albeit approximate) may still be needed to identify threshold exposure-times for the safe handling of PAF-lithotypes, and so reduce ARD risk. Estimates of SORs, and lag-phase duration, may be obtained through programmes of kinetic-testing (viz. Weathering-Columns), and consideration of *inter alia* the moisture/aeration-regimes of exposed (i.e. uncovered) mine-wastes under the climatic conditions of the minesite (especially rainfall distribution in relation to Potential-Evapotranspiration [PET] rates, as discussed further below). In the absence of results from kinetic-testing, experience permits "first-pass" estimates of SORs and lag-phase duration to be made from the results of static-testing, and thereby used to further 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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[3] Such ANC/MPA ratios are consistent with those indicated from SORs, and carbonate-depletion rates, as reported in the International-Kinetic Database for mine-wastes from around the world (Morin and Hutt 1997).

[4] It should be noted that mining-regulators in Nevada (USA) classify a mine-waste sample as NAF, if it is characterised by an ANC/MPA ratio greater than 1.2 (US EPA 1994). This lower ANC/MPA ratio reflects the semi-arid conditions typically encountered at minesites in Nevada. Although utilised in the early-1990s, it is understood that an ANC/MPA ratio of 1.2 is still entertained by regulators in Nevada for "screening" PAF and NAF varieties of mine-wastes in semi-arid settings.

[5] SO_4 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 appreciably enriched in Total-Ni and Total-As to begin with.

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APPENDIX D

LABORATORY REPORTS
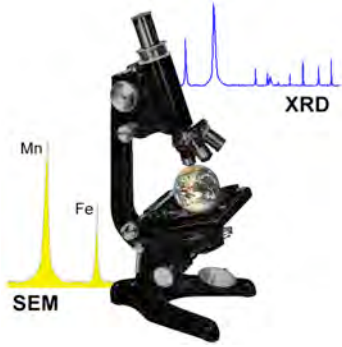
Graeme Campbell and Associates Pty Ltd,   16-10-2009

PO box 247,

Bridgetown

Western Australia 6254

Our reference 22547

Your reference

XRD/PLM/SEM analysis of one tailing

Roger Townend

RESULTS

XRD/PLM/SEM analysis

	GCA 8166
QUARTZ	MAJOR
PLAGIOCLASE (ALBITE)	MAJOR
MUSCOVITE	MINOR
CHLORITE	ACCESSORY
ANKERITE	ACCESSORY
PYRITE	TRACE
ARSENOPYRITE	TRACE

Ankerite composition MgO 10% ,CaO 27.4%, MnO 0.3%, FeO 18.9%

Dr G Campbell
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PO Box 247
BRIDGETOWN WA 6255

JOB INFORMATION

JOB CODE	**143/0907113**
No. of SAMPLES	1
CLIENT O/N	GCA0919/2
PROJECT	Central Ashanti Gold
STATE	WA
DATE RECEIVED	3/08/2009
DATE COMPLETED	20/08/2009

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 samples were received as mine waste and required crushing, drying, mixing, splitting and fine pulverising in a zirconia bowl.

Results of analysis on:

Element		S	S-SO4	C	TOC+C	C-CO3
Method		Ind/IR	Na2CO3/ GRAV	Ind/IR	HotAcidInd/ IR	/CALC
Detection		0.005	0.01	0.01	0.01	0.01
Units		%	%	%	%	%
Sample Name						
Control Blank		0.006	X	0.02	0.02	
GCA8166		0.023	X	0.51	0.01	0.5
GCA8166	check	0.023	X	0.55	0.03	0.52
MA-1b		1.181		2.41		
PD-1			4.29			
S_SO4_A			0.58			
S_SO4_B			1.29			

1. The C, S results were determined from the pulverised portion
2. The Carbon and Sulphur was determined according to Genalysis method number MPL_W043
3. S-SO4 was determined by precipitation of BaSO4 according to Genalysis method number ENV_W039
4. TOC+C (acid insoluble carbon compounds and elemental carbon) by a C&S analyser after removal of carbonates and soluble organic carbon according to Genalysis method number MPL_W046

Acid Neutralisation Capacity (ANC)

sample name		Fizz Rate	initial effervescence	HCl molarity	NaOH molarity	Colour Change	ANC soln pH	pH Drop	ANC (kg H2SO4/ tonne)
GCA8166		2	moderate	1.037	1.0020	Y	1.1	3.1	39
GCA8166	check	2	moderate	1.037	1.0020	Y	1	3.3	39

PO Box 144 Gosnells Western Australia 6990
T +61 (0) 8 9251 8100 | F +61 (0) 8 9251 8110
genalysis@genalysis.com.au | www.genalysis.com.au
ABN 32 008 787 237

Page 1 of 2

Notes:

1.   ANC was determined on 2g of the -2mm portion. Acid concentrations are as stated.
2.   Colour change: Y indicates the appearance of a green colouration as the pH=7 endpoint was approached. N no change. Two drops of 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 procedure according to Genalysis method number ENV_W035

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Company Accreditation Number 3244
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NATA Signatory: Ann Evers

Date: 20th August 2009

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NATA's accreditation requirements.

Graeme Campbell & Associates Pty Ltd

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 H2SO4/ tonne)
				pH	EC (µS/cm)		
GCA8166	3.0	Reaction peaked overnight	7.6	11.3	290	-	<0.5
GCA8166 (repeat)	3.0	Reaction peaked overnight	7.6	11.3	270	-	<0.5
BLANK2	3.0	Reaction peaked overnight	6.2	7.6	65	-	<0.5

Notes: Test conditions based on those described by Miller *et al.* (1997). The pH of the 15 % (v/v) H_2O_2 solution was adjusted to 4.5 using 0.1 M-NaOH prior to commencing the NAG Tests. Test mixtures boiled for *c.* 2 hours to accelerate reaction with H_2O_2. Then, after allowing the test mixtures to cool, 1.0 mL of 0.016 M-$CuSO_4$ 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 H_2O_2 in the test mixtures (O'Shay *et al.* 1990). K-Feldspar was employed for the Blank.

Dr GD Campbell
25th September 2009

pH-BUFFERING TESTWORK (GCA8166)

Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H_2SO_4/tonne)	pH	Cumulative Volume of Acid Added (mL)	Cumulative Acid Consumption (kg H_2SO_4/tonne)	pH
0.00	0.0	9.1	16.80	16	4.3
0.40	0.4	7.9	17.20	17	4.2
0.80	0.8	7.5	17.60	17	4.2
1.20	1.2	7.3	18.00	18	4.1
1.60	1.6	7.1	18.40	18	4.0
2.00	2.0	7.0	18.80	18	4.0
2.40	2.4	6.9	19.20	19	3.9
2.80	2.7	6.7	19.60	19	3.9
3.20	3.1	6.7	20.00	20	3.8
3.60	3.5	6.7	20.40	20	3.8
4.00	3.9	6.6	20.80	20	3.7
4.40	4.3	6.5	21.20	21	3.7
4.80	4.7	6.5	21.60	21	3.7
5.20	5.1	6.5	22.00	22	3.6
5.60	5.5	6.4	22.40	22	3.6
6.00	5.9	6.3	22.80	22	3.6
6.40	6.3	6.2	23.20	23	3.5
6.80	6.7	6.2	23.60	23	3.5
7.20	7.1	6.1	24.00	24	3.5
7.60	7.4	6.0	24.40	24	3.4
8.00	7.8	6.0	24.80	24	3.4
8.40	8.2	5.9	25.20	25	3.4
8.80	8.6	5.8	25.60	25	3.4
9.20	9.0	5.8	26.00	25	3.3
9.60	9.4	5.7	26.40	26	3.3
10.00	9.8	5.6	26.80	26	3.3
10.40	10	5.5	27.20	27	3.3
10.80	11	5.5	27.60	27	3.2
11.20	11	5.4	28.00	27	3.2
11.60	11	5.3	28.40	28	3.2
12.00	12	5.2	28.80	28	3.2
12.40	12	5.1	29.20	29	3.1
12.80	13	5.0	29.60	29	3.1
13.20	13	5.0	30.00	29	3.1
13.60	13	4.9	30.40	30	3.1
14.00	14	4.8	30.80	30	3.1
14.40	14	4.8	31.20	31	3.0
14.80	15	4.7	31.60	31	3.0
15.20	15	4.6			
15.60	15	4.5			
16.00	16	4.4			
16.40	16	4.4			

Note: Titration performed using a Metrohm[®] 736 Titrino auto-titrator, and 0.05 M-H_2SO_4. Equilibration time between titrant additions was 15 minutes. 5.00 g of pulped sample initially dispersed in 150 mL of deionised-water. Test mixture in contact with air, at ambient temperature, and continuously stirred.
Calibration of pH-Glass Electrode:
Immediately prior to titration: asymmetry potential = -15 mV (pH=7.00); slope-point = 147 mV (pH=4.00); 91.3 % of Nernstian response for 25 ^{o}C.
Immediately following titration: pH=7.00 buffer read pH=7.02 and pH=4.00 buffer read pH=4.03. These discrepancies represent drift in pH-Glass electrode response during course of auto-titration.

Dr GD Campbell
5th October 2009

ANALYTICAL REPORT

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AUSTRALIA

JOB INFORMATION

JOB CODE	: 143.0/0907114
No. of SAMPLES	: 1
No. of ELEMENTS	: 32
CLIENT O/N	: GCA0919/2 (Job 1 of 1)
SAMPLE SUBMISSION No. :	
PROJECT	: Central Ashanti Gold
STATE	: Ex-Pulp
DATE RECEIVED	: 03/08/2009
DATE COMPLETED	: 28/08/2009
DATE PRINTED	: 28/08/2009

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

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Jet Park, Gauteng, South Africa 1459

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SGS

Client Details			**Job Details**		
Client	:	**Graeme Campbell & Associates Pty Ltd**	Client Reference	:	Tailings Water Sample, GCA Job No 0919/2
Contact	:	Graeme Campbell	Report No	:	PE024733
Address	:	PO Box 247	Report Version	:	00
		BRIDGETOWN	Samples	:	Water
		PERTH WA 6255	Received	:	06/08/2009

Comments:

This report cancels and supercedes any preliminary results provided

For and on Behalf of SGS Environmental Services

Client Services Manager:	Matthew Deaves	Matthew.Deaves@sgs.com
Sample Receipt:	Cecilia Tadena	AU.Environmental.Perth@sgs.com
Laboratory Manager:	Said Hirad	Said.Hirad@sgs.com

Results Approved and/or Authorised by:

SAID HIRAD
NATA Signatory

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Page 1 of 5

WORLD RECOGNISED
ACCREDITATION

Water Analysis Client Reference Sample No Type of Sample	Units	GCA 8166 PE024733-1 Water
Date Extracted		7/08/2009
Date Analysed		7/08/2009
pH	pH Units	8.3
Conductivity @25°C	µS/cm	830
Total Dissolved Solids @ 180°C	mg/L	530
Chloride, Cl	mg/L	170
Sulphate, SO_4	mg/L	43
Bicarbonate, HCO_3	mg/L	190
Carbonate, CO_3	mg/L	<1
Hydroxide, OH	mg/L	<5
Fluoride, F	mg/L	0.8
Nitrate-Nitrogen, NO_3-N	mg/L	0.23
Ammonia Nitrogen NH_3-N	mg/L	<0.1

QUALTY CONTROL Water Analysis	UNITS	LOR	METHOD	Blank	Duplicate	Sample || Dup || %RPD	Spike	Spike % Recovery
Date Extracted				7/8/09	[NT]	[NT]	Control	7/8/09
Date Analysed				7/8/09	[NT]	[NT]	Control	7/8/09
pH	pH Units	0.1	AN101	<0.1	[NT]	[NT]	Control	100%
Conductivity @25°C	µS/cm	2	AN106	<2	[NT]	[NT]	Control	99%
Total Dissolved Solids @ 180°C	mg/L	10	AN113	<10	[NT]	[NT]	Control	100%
Chloride, Cl	mg/L	1	AN274	<1	[NT]	[NT]	Control	104%
Sulphate, SO_4	mg/L	1	AN275	<1	[NT]	[NT]	Control	102%
Bicarbonate, HCO_3	mg/L	5	AN135	<5	[NT]	[NT]	Control	98%
Carbonate, CO_3	mg/L	1	AN135	<1	[NT]	[NT]	[NR]	[NR]
Hydroxide, OH	mg/L	5	AN135	<5	[NT]	[NT]	[NR]	[NR]
Fluoride, F	mg/L	0.1	AN141	<0.1	[NT]	[NT]	Control	109%
Nitrate-Nitrogen, NO_3-N	mg/L	0.05	AN258	<0.05	[NT]	[NT]	Control	98%
Ammonia Nitrogen NH_3-N	mg/L	0.1	AN261	<0.1	[NT]	[NT]	Control	99%

Method ID	Methodology Summary
AN101	pH is measured electrometrically using a combination electrode (glass plus reference electrode) and is calibrated against 3 buffers purchased commercially. For soils, an extract with water is made at a ratio of 1:5 and the pH determined and reported on the extract. Reference APHA 4500-H+.
AN106	Conductivity is measured by meter with temperature compensation and is calibrated against a standard solution of potassium chloride. Conductivity is generally reported as µmhos/cm or µS/cm @ 25°C. For soils, an extract with water is made at a ratio of 1:5 and the EC determined and reported on the extract, or calculated back to the as-received sample. Salinity can be estimated from conductivity using a conversion factor, which for natural waters, is in the range 0.55 to 0.75. Reference APHA 2520 B.
AN113	A well-mixed filtered sample of known volume is evaporated to dryness at 180°C and the residue weighed. Approximate methods for correlating chemical analysis with dissolved solids are available. Reference APHA 2540 C.
AN274	Chloride reacts with mercuric thiocyanate forming a mercuric chloride complex. In the presence of ferric iron, highly coloured ferric thiocyanate is formed which is proportional to the chloride concentration. Reference APHA 4500Cl-
AN275	Sulphate is precipitated in an acidic medium with barium chloride. The resulting turbidity is measured photometrically at 405nm and compared with standard calibration solutions to determine the sulphate concentration in the sample. Reference APHA 4500-SO42-. Internal reference AN275.
AN135	The sample is titrated with standard acid to pH 8.3 (P titre) and pH 4.5 (T titre) and permanent and/or total alkalinity calculated. The results are expressed as equivalents of calcium carbonate or recalculated as bicarbonate, carbonate and hydroxide. Reference APHA 2320. Internal Reference AN135
AN141	A fluoride ion selective electrode and reference electrode combination, in the presence of a pH/complexation buffer, is used to determine the fluoride concentration. The electrode millivolt response is measured logarithmically against fluoride concentration. Reference APHA F- C.
AN258	In an acidic medium, nitrate is reduced quantitatively to nitrite by cadmium metal. This nitrite plus any original nitrite is determined as an intense red-pink azo dye at 540 nm following diazotisation with sulphanilamide and subsequent coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. Without the cadmium reduction only the original nitrite is determined. Reference APHA 4500-NO3- F.
AN261	Ammonium in a basic medium forms ammonia gas, which is separated from the sample matrix by diffusion through a polypropylene membrane. The ammonia is reacted with phenol and hypochlorite to form indophenol blue at an intensity proportional to the ammonia concentration. The blue colour is intensified with sodium nitroprusside and the absorbance measured at 630 nm. The sensitivity of the automated method is 10-20 times that of the macro method. Reference APHA 4500-NH3 H.

Result Codes

[INS]	:	Insufficient Sample for this Test	[RPD]	:	Relative Percentage Difference
[NR]	:	Not Required	*	:	Not part of NATA Accreditation
[NT]	:	Not Tested	[N/A]	:	Not Applicable
LOR	:	Limit of Reporting			

Report Comments

Samples analysed as received.
Solid samples expressed on a dry weight basis.

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http://www.sgs.com/terms_and_conditions.htm. Attention is drawn to the limitation of liability,
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unlawful and offenders may be prosecuted to the fullest extent of the law.

Quality Control Key
Method Blank (MB): An analyte free matrix to which all reagents are added in the same volume or proportions as used in sample processing.
The method blank should be carried through the complete sample preparation and analytical procedure. A method blank is prepared every
20 samples.
Duplicate (D): A separate portion of a sample being analysed that is treated the same as the other samples in the batch. One duplicate is
processed at least every 10 samples.
Surrogate Spike (SS): An organic compound which is similar to the target analyte(s) in chemical composition and behaviour in the analytical
process, but which is not normally found in environmental samples. Surrogates are added to samples before extraction to monitor extraction
efficiency and percent recovery in each sample.
Internal Standard (IS): Added to all samples requiring analysis for organics (where relevant) or metals by ICP after the extraction/digestion
process; the compounds/elements serve to give a standard instrument retention time and /or response, which is invariant from run-to-run.
Laboratory Control Sample (LCS): A known matrix spiked with compound(s) representative of the target analytes. The LCS is used to document
laboratory performance. When the results of the marix spike analysis indicates a potential problem due to the sample matrix itself, the LCS results
are used to verify that the laboratory can perform the analysis in a clean matrix.
Matrix Spike (MS): An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation
and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.
Relative Percentage Difference (RPD): The difference between an original and a duplicate result divided by the average of the original and
duplicate results, expressed as a percentage.

Quality Acceptance Criteria
The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found
here: http://www.au.sgs.com/sgs-mp-au-env-qu-022-qa-qc-plan-en-09.pdf

ANALYTICAL REPORT

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

JOB INFORMATION

JOB CODE	: 143.0/0907115
No. of SAMPLES	: 1
No. of ELEMENTS	: 31
CLIENT O/N	: GCA0919/2 (Job 1 of 1)
SAMPLE SUBMISSION No.	:
PROJECT	: Central Ashanti Gold
STATE	: Solutions
DATE RECEIVED	: 03/08/2009
DATE COMPLETED	: 20/08/2009
DATE PRINTED	: 21/08/2009

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

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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 $3.00 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 $75.00 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

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 sample, GCA8166, was received as being a 'tailings slurry water' which had
been filtered and acidified.

The results have been determined according to Genalysis methods numbers
ICP_W004 and ICP_W005.

The analysis included the assay of blanks and Genalysis in-house reference
standards. The results are expressed as milligrams or micrograms per litre
in the solution.

NATA Signatory: H Pham
ICP Chemist

Date: 20th August 2009

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

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ug/l	mg/l	ug/l	mg/l	ug/l	ug/l	mg/l	ug/l	ug/l	mg/l
DETECTION	0.01	0.01	0.1	0.01	0.05	0.005	0.01	0.02	0.1	0.01
DIGEST										
ANALYTICAL FINISH	/MS	/OES	/MS	/OES	/MS	/MS	/OES	/MS	/MS	/OES
SAMPLE NUMBERS										
0001 GCA8166	X	0.07	60.6	0.11	15.65	X	33.82	0.04	0.4	0.03
CHECKS										
0001 GCA8166	X	0.06	61.2	0.13	15.95	X	34.10	X	0.4	0.03
STANDARDS										
0001 Alcoa12-MS	5.08		29.0		6.05	5.140		5.51	556.5	
0002 AlcoaHi2-OES		49.29		19.54			905.87			21.63
BLANKS										
0001 Control Blank	X	X	X	X	X	X	0.03	X	X	X

ANALYSIS

ELEMENTS	Cu	Fe-Sol	Hg	K	Mg	Mn	Mo	Na	Ni	P
UNITS	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l	ug/l	mg/l	mg/l	mg/l
DETECTION	0.01	0.01	0.1	0.1	0.01	0.01	0.05	0.1	0.01	0.1
DIGEST										
ANALYTICAL FINISH	/OES	/OES	/MS	/OES	/OES	/OES	/MS	/OES	/OES	/OES
SAMPLE NUMBERS										
0001 GCA8166	0.02	0.26	X	21.0	11.08	0.07	50.66	132.9	0.08	X
CHECKS										
0001 GCA8166	0.02	0.26	X	21.0	11.08	0.07	51.49	132.2	0.08	X
STANDARDS										
0001 Alcoa12-MS			5.2				11.86			
0002 AlcoaHi2-OES	2.99	106.23		459.8	188.98	20.70		1841.0	22.14	52.2
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	0.01	X

ANALYSIS

ELEMENTS	Pb	Sb	Se	Si	Sn	Sr	Th	Tl	U	V
UNITS	ug/l	ug/l	ug/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l
DETECTION	0.5	0.01	0.5	0.05	0.1	0.02	0.005	0.01	0.005	0.01
DIGEST										
ANALYTICAL FINISH	/MS	/MS	/MS	/OES	/MS	/MS	/MS	/MS	/MS	/OES
SAMPLE NUMBERS										
0001 GCA8166	X	15.21	1.7	5.31	X	279.13	0.022	0.03	2.245	X
CHECKS										
0001 GCA8166	X	15.80	1.5	5.32	X	279.17	0.017	0.02	2.224	X
STANDARDS										
0001 Alcoa12-MS	5.6	5.86	33.1		6.0	534.18	5.760	5.66	5.806	
0002 AlcoaHi2-OES				118.69						20.70
BLANKS										
0001 Control Blank	X	0.02	X	X	X	0.03	X	0.02	X	X

ANALYSIS

ELEMENTS	Zn
UNITS	mg/l
DETECTION	0.01
DIGEST	
ANALYTICAL FINISH	/OES
SAMPLE NUMBERS	
0001 GCA8166	0.04

CHECKS	
0001 GCA8166	0.04

STANDARDS	
0001 Alcoa12-MS	
0002 AlcoaHi2-OES	21.36

BLANKS	
0001 Control Blank	X

METHOD CODE DESCRIPTION

/MS

No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Mass Spectrometry.

/OES

No digestion or other pre-treatment undertaken. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.