APPENDIX 9: GEOCHEMICAL CHARACTERISATION OF PROCESS-TAILINGS-SLURRY - GRAEME CAMPBELL & ASSOCIATES (2005)

TECTONIC RESOURCES NL

PHILLIPS RIVER PROJECT

GEOCHEMICAL CHARACTERISATION OF PROCESS-TAILINGS-SLURRY SAMPLES

['STATIC-TESTWORK']

Implications for Process-Tailings Management

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SUMMARY OF TECHNICAL TERMS EMPLOYED IN THIS REPORT

ACRONYM	PARAMETER	DEFINITION/DETERMINATION	UNIT
AFP	Acid-Formation Potential		
ARD	Acid-Rock Drainage		
Total-S	Total Sulphur	Analysis Result	% (w/w)
Sulphide-S	Sulphide Sulphur	Testwork Result [i.e. Sulphide-S = Total-S - Sulphate-S]	% (w/w)
ANC	Acid-Neutralisation Capacity	Testwork Result	kg H_2SO_4/tonne
MPA	Maximum-Potential Acidity	Calculation	kg H_2SO_4/tonne
NAPP	Net-Acid-Producing Potential	Calculation	kg H_2SO_4/tonne
NAG	Net-Acid Generation	Testwork Result	kg H_2SO_4/tonne
NAF	Non-Acid Forming	Calculation: • Sulphide-S < 0.3 % • Sulphide-S ≥ 0.3 %, and negative-NAPP value with ANC/MPA ≥ 2.0	kg H_2SO_4/tonne
PAF	Potentially-Acid Forming	Calculation: • Sulphide-S ≥ 0.3 %, and any positive-NAPP value • Sulphide-S ≥ 0.3 %, and a negative-NAPP value with ANC/MPA < 2.0	kg H_2SO_4/tonne
PAF-[SL]	PAF-[Short-Lag]	Estimation [e.g. inferred from 'kinetic' testing]	
PAF-[LL]	PAF-[Long-Lag]	Estimation [e.g. inferred from 'kinetic' testing]	
SOR	Sulphide-Oxidation Rate	Testwork Result [e.g. obtained from 'kinetic' testing]	mg SO_4/kg/week,
WSC	Water-Storage Capacity	Testwork Results	% (v/v), or mm/m

Notes:

The **PAF-[SL]** classification applies to (initially circum-neutral) PAF-materials that may acidify (viz. pH less than 5) within a matter of weeks-to-months when subjected to "aggressive-ambient-weathering", corresponding to periods of at least a few days during which unsaturated-conditions prevail (via drainage/evaporation processes) between successive inundations that, in turn, occur semi-regularly (e.g. weekly-to-fortnightly "on-average" during most of the annual hydrological-cycle).

The **PAF-[LL]** classification applies to PAF-materials where exposure to the atmosphere for years (even decades, or longer) may be needed before acidification develops. Circum-neutral-pH during the "lag-phase" for such lithotypes is chiefly due to buffering reactions involving carbonate-minerals.

Climate directly influences the duration of the "lag-phase", and a sulphide-gangue assemblage classified as PAF-[SL] in a "humid" environment where the SOR is controlled by **O_2-supply**, may instead be classified as PAF-[LL] in semi-arid/arid environments where the SOR is contolled by **water-supply** (viz. frequency of "flushing-episodes") [Campbell 2004]. The formation of "secondary-oxidation-products" (e.g. Fe-oxyhydroxides) as protective-coatings is generally enhanced during the "lag-phase-stage" of mine-waste weathering in semi-arid/arid environments, and so further curtails sulphide-oxidation rates.

1.0 INTRODUCTION

Tectonic Resources NL (Tectonic) is developing the Phillips River Project located near Hopetoun, Western Australia.

The Kundip and Trilogy Deposits are located *c*. 10 kms from each other. Ores from these Deposits will be treated for the recovery of gold, and copper (as a copper-sulphide concentrate), in the mill at the Rav8 Mine located near Ravensthorpe. The resulting stream of process-tailings (in slurry form) will be discharged to an In-Pit-Tailings-Storage Facility (IPTSF) at the Rav8 Mine.

The IPTSF will comprise both the Rav8 underground-workings, and the Rav8 Pit. It is proposed to initially discharge process-tailings into the underground-workings, so that the majority of the void-spaces are filled. Tailings-discharge will subsequently be made to the Pit. Depending on the final RL attained at the end of the Project, the surface of the (consolidated) tailings-bed may be below the watertable which recovers following cessation of mine-dewatering activities. In this case, the tailings-bed will become submerged by groundwater.

Graeme Campbell & Associates Pty Ltd (GCA) was commissioned to carry out geochemical testwork on tailings-slurry samples (viz. **Kundip-Oxide-Ore-Tailings**, **Trilogy-Oxide-Ore-Tailings**, and **Kundip-Primary-Ore-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 samples.[1] In addition, the quality (viz. major/minor-ion chemistry, and cyanide forms) of the tailings-slurry-waters, was determined.

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

The testwork results are presented and discussed in this report, and implications for process-tailings management highlighted.[2]

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[2] Related testing to assess the geochemical character of mine-waste materials derived from the Kundip and Trilogy Deposits is the subject of the GCA (2004) report.

2.0 STUDY APPROACH

Details of the sampling and testwork programmes, and the calculations and criteria employed for classifying the tailings-solid samples into AFP categories, are presented and discussed in the following sections.

2.1 Testwork Programme

2.1.1 Samples

The tailings-slurry samples submitted to GCA for testing are derived from a programme of bench-scale-metallurgical testwork performed by Ammtec Limited (Balcatta). Details of the metallurgical study are presented in Appendix A.

Each tailings-slurry sample was provided in a thick-walled, 4.5-L, plastic, tumbling-jar which was approximately one-half (Kundip-Oxide-Ore-Tailings and Trilogy-Oxide-Ore-Tailings), and approximately two-thirds (Kundip-Primary-Ore-Tailings), filled with slurry. The heights of the settled tailings-solids were approximately one-quarter of the total-slurry heights for all samples. The clear supernatants (viz. tailings-slurry-waters) overlying the settled tailings-solids were decanted via siphoning, and preserved for specific analyses.[3]

The 'sludge' of tailings-solids was removed from each tumbling-jar, and homogenised by hand-mixing. Although the top few mm of the tailings-solids-beds in the tumbling-jars were soft, the remainder was typically hard and coherent, so that the tailings-solids

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[3] Sub-samples of the 'raw' tailings-slurry-waters were employed for the analysis of major-parameters and metals, whereas NaOH-dosed sub-samples were used for the analysis of cyanide forms. The NaOH-dosed sub-samples were stored in 500-mL, black-plastic-bottles. The determination of NO_3-N and NH_3-N was performed on H_2SO_4-dosed sub-samples.

The multi-element composition of the tailings-slurry-waters was determined by analysing the *unacidified* waters, since acidification using HNO_3 often results in the formation of complex, insoluble compounds of cyanide and metals (especially when thiocyanate is present). Such precipitation reactions complicate both chemical analysis, and interpretation of the analysis results.

overall were worked-up by hand-mixing.[4] The tailings-solids samples were not washed prior to testing.

2.1.2 Testwork

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.

Part of the testwork was carried out by SGS Environmental Services [SGS] (Welshpool), and Genalysis Laboratory Services [GLS] (Maddington). The analyses performed by SGS and GLS have NATA endorsement.[5]

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 C.

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[4] It proved necessary to dewater (via vacuum-filtration and a Whatman-No.-2-filter-paper) the 'sludge' of tailings-solids for the Trilogy-Oxide-Ore-Tailings sample.

[5] NATA = National Association of Testing Authorities.

2.2 Calculated Parameters

The Maximum-Potential-Acidity (MPA) values (in kg H_2SO_4/tonne) of the tailings-solids samples were 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/pyrrhotite, by O_2 to "$Fe(OH)_3$" and H_2SO_4, and the different weight-based units of % and kg H_2SO_4/tonne.

The Net-Acid-Producing-Potential (NAPP) values (in kg H_2SO_4/tonne) of the tailings-solids samples were calculated from the corresponding MPA and Acid-Neutralisation-Capacity(ANC) values (i.e. NAPP = MPA - ANC).

2.3 Classification Criteria

In terms of AFP, mine-waste materials 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 mine-waste materials (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.

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 the AFP of mine-waste materials, there is general 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) [Soregaroli and Lawrence 1997]. This position assumes that the groundmass hosting such "trace-sulphides" is not simply quartz, and/or clays (Price *et al.* 1997), and that for a carbonate-deficient gangue, the sulphides are not unusually reactive (e.g. sulphide-oxidation rates [SORs] less than *c.* 20-40 mg SO_4/kg/week) [= *c.* 1-2 kg SO_4/tonne/year].[6] A "cut-off" of 0.3 % for Sulphide-S also accords with the findings of 'kinetic' testing conducted, since the late-1980s, by Dr. Graeme Campbell for mine-waste samples 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. carbonates) for neutralisation of acid produced through pyrite-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=7.

(c) Depletion of carbonate-minerals through rainfall-fed leaching within waste-dumps.[7]

Restricted accessibility of acid to the surfaces of carbonate-grains may occur at different spatial-scales (viz. at the "whole-rock-scale" in which Acid-Rock Drainage [ARD] "by-passes" carbonate-bearing materials via preferential-flow pathways within a waste-dump, and at the "pore/grain-scale" in which the surfaces of individual carbonate-grains are "blinded/rimmed" by precipitates of Fe(III)-oxyhydroxides [e.g. ferrihydrite-type phases]). As shown by Li (1997), ferroan-carbonates (especially "Fe-rich" varieties) are prone to "surface-armouring/rimming" during dissolution: weathering of tailings-solids containing pyrite, ankerites and Mg-siderites produced acidic leachates when less than one-third of the carbonate-grains had dissolved.

To compensate for the effects of (a) to (c) above, some authors 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]). In recent years, fundamental-research (especially estimation of reaction-rates for diverse sulphide/gangue-mineral assemblages), and field-experience at mining operations world-wide, have shown that the potential for ARD production is very low for mine-waste materials with ANC/MPA ratios greater than 2.0 (AMIRA 2002; Price *et al.* 1997, Currey *et al.* 1997, and Murray *et al.* 1995).[8] This ANC/MPA ratio is employed in the present work.[9]

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[6] 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-pyrite), or hydrothermal-sulphides that are atypically reactive.

[7] Depletion of carbonate-minerals through dissolution in meteoric-waters is minimal in semi-arid 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 desiccating conditions return after "wet-spells".

[8] Such ANC/MPA ratios are consistent with those indicated from SORs, and carbonate-depletion rates, as reported in the International-Kinetic Database for mine-waste materials from around the world (Morin and Hutt 1997).

[9] 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 mine-sites in Nevada. Although utilised in the

The risk posed by handling PAF-lithotypes during the working of a deposit 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 buffering near pH=7 by gangue-phases).[10] Although the "lag-phase" applicable to exposed mine-wastes at "field-scale" cannot be accurately predicted *a priori*, estimates (albeit approximate) are still needed to identify the exposure-times for the safe handling of PAF-lithotypes, and so reduce the risk for ARD production. Estimates of the "lag-phase" are invariably obtained through programmes of 'kinetic' testing (viz. Weathering-Columns). However, based on experience, "first-pass" estimates of the "lag-phase" may be made, and thereby used to further classify PAF-lithotypes into **PAF-[Short-Lag]** and **PAF-[Long-Lag]** sub-categories. Such "first-pass" estimates are necessarily provisional, and subject to revision, in the light of the outcomes of 'kinetic' testing, and field observations.

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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.

[10] SO_4 is still produced by sulphide-oxidation during the "lag-phase", and soluble-forms of minor-elements (e.g. As) may be released at circum-neutral-pH during the "lag-phase-stage" of mine-waste weathering.

3.0 ACID-BASE CHEMISTRY OF TAILINGS-SOLIDS SAMPLES

The testwork results on the acid-base chemistry of the tailings-solids samples are presented in Table 3.1, and shown on Figure 1. These results are discussed in the following sections.

3.1 Oxide-Ore-Tailings

N.B. The following sections apply to the Kundip-Oxide-Ore-Tailings-Solids and Trilogy-Oxide-Ore-Tailings-Solids samples.

3.1.1 Sulphur Forms

The tailings-solids samples had Total-S and SO_4-S values of 0.10-0.31 %, and 0.08-0.11 %, respectively (Table 3.1).

The testwork results indicate that the tailings-solids samples each contained minute/trace amounts of sulphide-minerals (viz. Sulphide-S contents less than 0.2-0.3 %).

3.1.2 Acid-Consuming Properties

The tailings-solids samples had ANC values of 4.2-6.5 kg H_2SO_4/tonne, and CO_3-C values of 0.07 % (Table 3.1).[11]

The testwork results indicate that the tailings-solids samples had a low capacity to consume acid, and reflects a paucity of carbonate-minerals.

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[11] ANC values of 4.2-6.5 kg H_2SO_4/tonne are equivalent to *c.* 0.42-0.65 % (as "$CaCO_3$").

3.1.3 Acid-Formation Potential

The tailings-solids samples had NAG-pH values of 6.8-7.1, and NAG values less than 0.5 kg H_2SO_4/tonne (Table 3.1).[12]

The testwork results indicate that the tailings-solids samples are classified as *<u>NAF</u>*.

3.2 Primary-Ore-Tailings

<u>N.B.</u> The following section apply to the Kundip-Primary-Ore-Tailings-Solids sample.

3.2.1 Sulphur Forms

The tailings-solids sample had Total-S and SO_4-S values of 9.1%, and 0.03 %, respectively (Table 3.1).

The sulphide-mineral suite was co-dominated by pyrite and pyrrhotite (Table 4.2).

The testwork results indicate that the tailings-solids sample contained sulphide-minerals (chiefly pyrite and pyrrhotite) as a minor component (viz. Sulphide-S content of 9-10 %).

3.2.2 Acid-Consuming Properties

The tailings-solids sample had an ANC value of 64 kg H_2SO_4/tonne, and a CO_3-C value of 0.54 % (Table 3.1).[13]

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[12] The NAG-testwork corresponds to the "Single-Addition" variant of the NAG Test (AMIRA 2002).

[13] An ANC value of 64 kg H_2SO_4/tonne is equivalent to *c.* 6.4 % (as "$CaCO_3$").

The "Carbonate-ANC" value, calculated from the CO_3-C value, was consistent with the ANC value, as measured based on the method of Sobek *et al.* (1978). The presence of reactive-carbonates (e.g. calcite) was indicated by the effervescence (i.e. "fizzing") produced upon the addition ('in-the-cold') of HCl during the ANC-testwork. Calcite was also identified in the mineralogical study (Table 4.2).

The pH-Buffering properties of the tailings-solids sample were determined via auto-titration, and 0.05 M-H_2SO_4. The H_2SO_4-addition rate employed during the auto-titration was *c.* 1-2 x 10^4 kg H_2SO_4/tonne/year, and corresponds to an SOR up to 10^2-10^3 faster than that typically observed for the weathering (at circum-neutral-pH) of "minor-sulphides". The pH-buffering curve (Figure 1) exhibited an "inflection-point" near pH=6-7, associated with the dissolution of reactive-carbonates (e.g. calcite).

The testwork results indicate that the tailings-solids sample had a high capacity to consume acid, due to reactive carbonate-minerals (viz. calcite).

3.2.3 Acid-Formation Potential

The tailings-solids sample had a NAPP value of 220 kg H_2SO_4/tonne (Table 3.1).

The sample had a NAG-pH value of 2.7-3.0, and a NAG value of 37-76 kg H_2SO_4/tonne (Table 3.1).

The testwork results indicate that the tailings-solids sample is classified as PAF-[Long-Lag].

Although difficult to project accurately, under the climatic conditions of the mine-site, it should take some years before acidic conditions developed in exposed (i.e. uncovered) surface-zone-tailings, assuming that the sulphide-minerals are not unusually reactive.[14]

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[14] A programme of 'kinetic' testing (viz. Weathering-Columns) would be needed to fully assess the SORs, and pH-buffering regime, and thereby better estimate the duration of the "lag-phase".

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

The multi-element composition and mineralogy of the tailings-solids samples are indicated by the data presented in Tables 4.1 and 4.2, respectively.[15] The corresponding element-enrichments in the samples, as indicated by the values of the Geochemical-Abundance Index (GAI), are also presented in Table 4.1.[16] It should be noted that these element-enrichments are relative enrichments, based on the element contents typically recorded for unmineralised soils, regoliths and bedrocks (Bowen 1979).

The tailings-solids samples were variously enriched in Ag, Cu, Pb, As, Bi, Se, Mo, and B (Table 4.1). The Cu content of 0.28 % stood-out for the Kundip-Oxide-Ore-Tailings-Solids sample, whereas the Pb content of 0.13 % stood-out for the Trilogy-Oxide-Ore-Tailings-Solids sample. The Kundip-Primary-Ore-Tailings-Solids sample was enriched in the most chalcophyles, and reflects its Sulphide-S content.

The tailings-solids samples have very similar mineralogies, save for sulphide-minerals and calcite in the Kundip-Primary-Ore-Tailings-Solids sample (Table 4.2). The sulphide-mineral suite in the latter sample was co-dominated by pyrite and pyrrhotite with subordinate marcasite, chalcopyrite and galena.

The analysis results indicate that the tailings-solids samples were variously enriched in chalcophyles (especially Cu and Pb), as expected from the nature of mineralisation within the Kundip and Trilogy Deposits.

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[15] The suite of elements listed in Table 4.1 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.

[16] The GAI is defined in Appendix B.

5.0 QUALITY OF TAILINGS-SLURRY-WATER SAMPLES

The analysis results for the tailings-slurry-water samples are presented in Table 5.1, and discussed in the following sections.

5.1 pH and Salinity

The samples had pH values of 8.4-8.8, and salinities (as Total-Dissolved Solids, TDS) of 25,000-29,000 mg/L (Table 5.1).[17]

The testwork results indicate that the tailings-water samples were mildly-alkaline (viz. pH 8-9), and saline.

5.2 Major/Minor-Ion Chemistry

The salts in the samples comprised NaCl (viz. "halite"), together with sulphates, Mg and Ca (Table 5.1).

The concentrations of most minor-elements were below, or close to, the respective detection-limits (Table 5.1). The low concentrations of soluble metals attest to the efficiency of metal-sorption reactions under neutral-to-alkaline conditions (Sposito 1984).[18]

The exceptions were cyanide-complexing metals (see Section 5.3).

The analysis results indicate that the tailings-slurry-water samples had concentrations of most minor-elements less than, or close to, the respective detection-limits. Exceptions are cyanide-complexing metals, especially Cu (see Section 5.3).

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[17] Site-water was employed in the bench-scale-metallurgical-testwork programme (Appendix A).

[18] Sorption reactions include both adsorption and precipitation reactions (Sposito 1984).

5.3 Cyanide Forms

The tailings-slurry-water samples had CN_{tot} and CN_{wad} concentrations of 210-640 mg/L and 200-480 mg/L, respectively (Table 5.1).[19] The SCN concentrations were 3.4-250 mg/L.

The main cyanide-complexing-metal in solution was Cu (viz. Cu concentrations of 120-410 mg/L). The Hg concentrations were 0.017-2.2 mg/L.

Although high NaCN-dosage rates were employed in the bench-scale-metallurgical-testwork programme, the Kundip and Trilogy Deposits are both known for their high cyanide-demands for gold extraction, due largely to cyanide-leachable forms of Cu (Mr Murray Hill, pers. commun., February 2005). Further metallurgical investigations are in hand to assess options for destroying cyanide forms, and precipitating Cu, so that the CN_{wad} *and Cu concentrations in the slurry-water of the 'ex-mill' stream of process-tailings are reduced.*

Monitoring of the decant-water will need to be undertaken to fully assess CN_{tot}*,* CN_{wad} *and Cu concentrations within the IPTSF.*

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[19] CN_{tot} = Total Cyanide; CN_{wad} = Weak-Acid-Dissociable Cyanide.

6.0 CONCLUSIONS

Based on the testwork results obtained in this study, it is concluded that:

- The Kundip-Oxide-Ore-Tailings-Solids and Trilogy-Oxide-Ore-Tailings-Solids samples are each classified as NAF.[20]

  The Kundip-Primary-Ore-Tailings-Solids sample is classified as PAF-[Long-Lag], and reflects minor-sulphides (chiefly pyrite/pyrrhotite) in a calcareous-gangue.[21]

- The tailings-solids samples were all variously enriched in chalcophyles (especially Cu and Pb).

- The tailings-slurry-water samples were alkaline, saline, and had low concentrations of most minor-elements. However, due to an abundance of cyanide-leachable-Cu forms in the ores, the soluble-Cu concentrations were 'of-the-order' 100 mg/L (c.f. 10 mg/L). Accordingly, the CN_{tot} and CN_{wad} concentrations each ranged up to several hundred mg/L, due to Cu-cyanide complexes.

In brief, the indications are that the tailings-solids derived from the Kundip-Oxide-Ore and Trilogy-Oxide-Ore should pose minimal geochemical concern for process-tailings management.

However, if the Kundip-Primary-Ore-Tailings-Solids occupy the surface-zone in the filled-IPTSF, and if the RL of the tailings-bed surface is above the regional-watertable level, then some form of (vegetated) store/release-cover system (see review by Campbell

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[20] NAF = Non-Acid Forming.

[21] PAF = Potentially-Acid Forming.

[2004]) will likely be required for closure.[22] *If the final tailings-bed surface is to "daylight" above the regional-watertable level, then ensuring that the surface-zone-tailings comprises Oxide-Ore-Tailings would greatly assist the covering works. This possibility – as governed by final-tailings-filling height – has important implications for milling schedules, especially during the last months of the Project.*

Until the metallurgical work has been completed on options for destroying cyanide forms, and precipitating Cu, it is not possible to project the likely ranges in CN_{wad} *and Cu concentrations within the decant-water of the IPTSF.*

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[22] IPTSF = In-Pit-Tailings-Storage Facility.

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TABLES

Table 3.1: Acid-Base-Analysis and Net-Acid-Generation Results for Tailings-Solids Samples

GCA-SAMPLE NO.	TAILINGS TYPE	MC (%, w/w)	TOTAL-S (%)	SO_4-S (%)	Sulphide-S (%)	CO_3-C (%)	ANC	NAPP	NAG	NAG-pH	AFP CATEGORY
							kg H_2SO_4/tonne				
GCA5251	Kundip-Oxide-Ore-Tailings	20.5	0.31	0.11	0.20	0.07	6.5	-0.3	<0.5	6.8	NAF
GCA5252	Trilogy-Oxide-Ore-Tailings	18.4	0.10	0.08	0.02	0.07	4.2 (4.3)	nc	<0.5	7.1	NAF
GCA5281	Kundip-Primary-Ore-Tailings	14.9	9.1	0.03	9.1	0.54	64	220	76 (37)	2.7 (3.0)	**PAF-[Long-Lag]**

Notes:
MC = Moisture-Content; ANC = Acid-Neutralisation Capacity; NAPP = Net-Acid-Producing Potential; NAG = Net-Acid Generation; MPA = Maximum-Potential Acidity; AFP = Acid-Formation Potential; NAF = Non-Acid Forming; PAF = Potentially-Acid Forming; nc = not calculated.
All results expressed on a dry-weight basis, except for NAG-pH.
MC value corresponds to water-weight divided by dry-solids-weight (after oven-drying at 105 °C for 24 hrs), and expressed as a percentage.
Values in parentheses represent duplicates.

Table 4.1: Multi-Element-Analysis Results for Tailings-Solids Samples

Note: Refer Appendix B for the definition of the Geochemical-Abundance-Index (GAI) indicated in this table.

ELEMENT	TOTAL-ELEMENT CONTENT (mg/kg or %)			AVERAGE-CRUSTAL-ABUNDANCE (mg/kg or %)	GEOCHEMICAL-ABUNDANCE INDEX (GAI)		
	Kundip-Oxide-Ore-Tailings (GCA5251)	Trilogy-Oxide-Ore-Tailings (GCA5252)	Kundip-Primary-Ore-Tailings (GCA5281)		Kundip-Oxide-Ore-Tailings (GCA5251)	Trilogy-Oxide-Ore-Tailings (GCA5252)	Kundip-Primary-Ore-Tailings (GCA5281)
Al	5.9%	1.6%	5.5%	8.2%	0	0	0
Fe	16.6%	2.2%	16.6%	4.1%	1	0	1
Na	0.31%	0.22%	0.55%	2.3%	0	0	0
K	0.87%	0.24%	0.74%	2.1%	0	0	0
Mg	2.5%	0.18%	2.7%	2.3%	0	0	0
Ca	0.088%	0.059%	1.9%	4.1%	0	0	0
Ag	3.7	16	3.5	0.07	**5**	**6**	**5**
Cu	2,800	780	1,900	50	**5**	**3**	**5**
Zn	190	80	290	75	1	0	1
Cd	0.2	0.1	1.1	0.11	0	0	**3**
Pb	200	1,300	440	14	**3**	**6**	**4**
Cr	160	320	310	100	0	1	1
Ni	140	180	300	80	0	1	1
Co	120	19	550	20	2	0	**4**
Mn	540	76	1,200	950	0	0	0
Hg	0.82	2.5	0.09	0.05	**3**	**5**	0
Sn	2.2	3.7	2.3	2.2	0	0	0
Sr	18	25	31	370	0	0	0
Ba	120	290	160	500	0	0	0
Th	3.1	7.9	2.6	12	0	0	0
U	2.0	2.8	2.4	2.4	0	0	0
Tl	0.13	1.2	3.8	0.6	0	0	2
V	76	19	75	160	0	0	0
As	140	520	37	1.5	**6**	**6**	**4**
Bi	4.0	150	5.0	0.048	**6**	**6**	**6**
Sb	0.77	56	0.73	0.2	1	**6**	1
Se	1.9	8.4	1.7	0.05	**5**	**6**	**5**
Mo	17	54	33	1.5	**3**	**5**	**4**
B	110	480	<50	10	**3**	**5**	0
P	400	110	390	1,000	0	0	0
F	210	170	170	950	0	0	0

Note: Average-crustal abundance of elements based on Bowen (1979).

Table 4.2: Mineralogical Results for Tailings-Solids Samples

Kundip-Oxide-Ore-Tailings (GCA5251)		**Trilogy-Oxide-Ore-Tailings (GCA5252)**		**Kundip-Primary-Ore-Tailings (GCA5281)**	
Component	**Abundance**	**Component**	**Abundance**	**Component**	**Abundance**
		quartz	dominant		
quartz chlorite	major			quartz chlorite	major
muscovite goethite	minor				
plagioclase	accessory	muscovite plagioclase goethite	accessory	**pyrite** **pyrrhotite** **calcite** feldspar muscovite	accessory
pyrite Ti-oxides graphite	trace	chlorite graphite	trace	**chalcopyrite** **marcasite** **galena** biotite epidote magnetite rutile	trace

Notes:

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

See mineralogical report in Appendix C for further information.

Table 5.1: Analysis Results for Tailings-Slurry-Water Samples

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

ELEMENT/ PARAMETER	Kundip-Oxide-Ore-Tailings-Slurry-Water (GCA5251)	Trilogy-Oxide-Ore-Tailings-Slurry-Water (GCA5252)	Kundip-Primary-Ore-Tailings-Slurry-Water (GCA5281)	ELEMENT/ PARAMETER	Kundip-Oxide-Ore-Tailings-Slurry-Water (GCA5251)	Trilogy-Oxide-Ore-Tailings-Slurry-Water (GCA5252)	Kundip-Primary-Ore-Tailings-Slurry-Water (GCA5281)
Major-Parameters				***Minor-Ions***			
pH	8.7	8.8	8.4	Fe	<1 (0.15)	2 (0.45)	2 (0.20)
EC [µS/cm]	39,000	37,000	40,000	Cu	400 (400)	410 (410)	120 (1.9?)
TDS(gravimetric)	26,000	25,000	29,000	Ni	<1 (0.60)	<1 (1.0)	1(0.45)
				Zn	2 (0.80)	6 (4.7)	8 (2.2)
Major-Ions				Co	0.60	0.20	0.49
				Al	<1	<1	<1
Na	7,900	7,600	9,200	Cd	0.0031	0.0056	0.091
K	68	110	150	Pb	0.15	0.34	0.14
Mg	950	970	1,100	Cr	<1	<1	<1
Ca	170	88	480	Hg	2.2	1.4	0.017
Cl	13,000	13,000	15,000	As	0.060 (0.057)	0.072 (0.086)	0.19 (0.056)
SO_4	2,400	2,300	3,300	Sb	0.0005	0.054	0.061
HCO_3	490	580	210	Bi	0.0004	0.0003	0.0002
CO_3	77	110	6.6	Se	0.17	0.15	0.69
OH	<1	<1	<1	B	3	4	2
				Mo	0.066	2.8	0.12
Nitrogen-Forms				P	11	26	<10
				F	0.15	2.1	<0.1
NH_3-N	2.3	2.9	<0.1	Ag	0.49	20	1.2
NO_3-N	0.8	25	<0.05	Ba	0.043	0.054	0.083
				Sr	0.82	0.50	3.4
Cyanide-Forms				Tl	<0.0002	0.0052	<0.0002
				V	<1	<1	<1
CN_{tot}	580	640	210	Sn	<0.002	<0.002	<0.002
CN_{wad}	450	480	200	U	0.0012	0.0074	0.0003
SCN	32	3.4	250	Th	0.0001	<0.0001	<0.0001
				Mn	<1	<1	<1

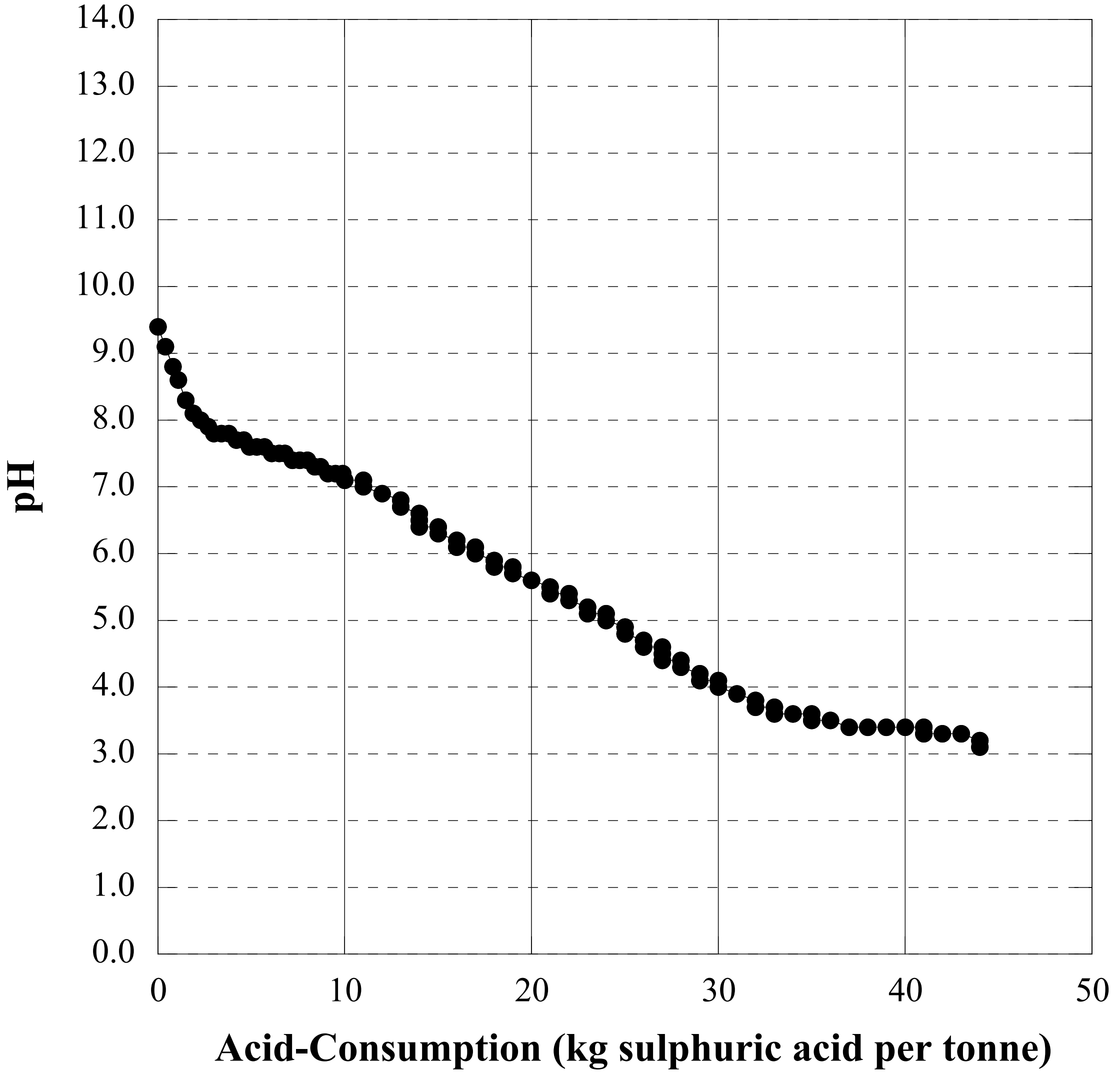
Notes: EC = Electrical Conductivity; TDS = Total-Dissolved Solids; CN_{tot} = Total Cyanide; CN_{wad} = Weak-Acid-Dissociable Cyanide; SCN = Thiocyanate.

Values for Fe, Cu, Ni, Zn and As in parentheses represent analyses by different laboratories (see Appendix C).

FIGURE

Figure 1

pH-Buffering Curve for Primary-Ore-Tailings-Solids Sample (Kundip Deposit)



Note: The H_2SO_4-addition rate employed in the auto-titration corresponds to a sulphide-oxidation rate (SOR) of *c.* 2-3 x 10^5 mg SO_4/kg/week (= *c.* 1-2 x 10^4 kg H_2SO_4/tonne/year).

This SOR is therefore up to 10^2-10^3 **faster** than those typical for the weathering (at circum-neutral-pH) of mine-waste materials that contain "minor-sulphides".

APPENDIX A

DETAILS OF BENCH-SCALE-METALLURGICAL-TESTWORK PROGRAMME

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Bridgetown
WA 6255

Graeme

RE: GEOCHEMICAL TESTING OF LEACH PULPS
TECTONIC RESOURCES : PHILLIPS RIVER PROJECT

As per discussions between yourself and Mr Murray Hill, representing Tectonic Resources NL, and Mr Chris Lane of Soil & Rock Engineering, samples of leach pulp and leach liquor are being sent to you along with this note for geochemical testing. These samples were generated from gravity separation and cyanidation leach testwork on the following ore composites :

- Kundip Oxide Overall Composite #2
- Trilogy Oxide Overall Composite #1

Three litres of leach pulp and one litre of leach liquor at as received pH and one litre of leach liquor after NaOH dosing is being sent for each composite. The slurry samples are supplied at a pulp density of 40% solids (w/w). Site bore water was utilised to generate these slurry samples. The Kundip composite is at a grind size p80 of 75µm whilst the Trilogy composite is at a grind size p80 of 106µm. The two leach pulps are at a pH range of 8.5-9.0 [hydrated lime] and solution sodium cyanide strength of 200-400ppm.

Please send your findings and any costs associated with the work directly to Murray Hill or Tectonic Resources.

Sincerely Yours

Hamid Sheriff
Laboratory Manager

21ST May 2004

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Graeme

RE: GEOCHEMICAL TESTING OF LEACH PULP - TECTONIC RESOURCES : PHILLIPS RIVER PROJECT

As per discussions between yourself and Mr Murray Hill, representing Tectonic Resources NL, and Mr Chris Lane of Soil & Rock Engineering, samples of leach pulp and leach liquor are being sent to you along with this note for geochemical testing. These samples were generated from cyanidation leach testwork on flotation tailing generated from the following ore composite :

- Kundip Sulphide Overall Composite #1

Three litres of leach pulp and one litre of leach liquor at as received pH and one litre of leach liquor after NaOH dosing is being sent. The slurry sample is supplied at a pulp density of 40% solids (w/w). Site bore water was utilised to generate the slurry sample. The flotation tailing was generated from flotation testwork at a grind size p80 of 75µm. The leach pulp is at a pH range of 8.5-9.0 [hydrated lime] and solution sodium cyanide strength of 200-400ppm.

Please send your findings and any costs associated with the work directly to Murray Hill or Tectonic Resources.

Sincerely Yours

Hamid Sheriff
Laboratory Manager

4TH June 2004

APPENDIX B

TESTWORK METHODS

APPENDIX B

TESTWORK METHODS

B1.0 ACID-BASE-CHEMISTRY TESTWORK ON TAILINGS-SOLIDS SAMPLES

The acid-base chemistry of the tailings-solids samples was assessed by determining:

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

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

B1.1 Total-S and SO_4-S Tests

The Total-S values were measured by Leco combustion (@ 1300 ^{o}C) with detection of evolved $SO_{2(g)}$ by infra-red spectroscopy. The SO_4-S values were determined by the Na_2CO_3-Extraction Method (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.

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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 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.

B1.2 ANC and pH-Buffering Tests

B1.2.1 ANC Tests

The ANC values were 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-waste materials (Morin and Hutt 1997; BC AMD Task Force 1989).

The samples were 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] 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 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 quantitatively, and that at least "traces" of ferro-magnesian-silicates (e.g. amphiboles, pyroxenes, chlorites, micas, etc.), and feldspars, are dissolved. However, under circum-neutral (viz. pH 6-8) conditions required for mine-waste and environmental management, the hydrolysis/dissolution of ferro-magnesian-silicates is kinetically extremely slow (e.g. see review-monograph by White and Brantley [1995]). Near pH=7, the hydrolysis/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 guide, for minerals of sub-mm grading, such silicate-dissolution rates correspond to Sulphide-Oxidation Rates (SORs) ranging

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[2] Two drops of 30 % (w/w) H_2O_2 were added to the test mixtures as the pH=7 end-point was approached, so that any 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 biased "on-the-high-side", due to the release of Fe(II) during the acidification/digestion step. Such potential bias in ANC values may be marked for mine-waste samples in which "Fe-rich" ferroan-carbonates (e.g. siderite) dominate acid consumption. The addition of the H_2O_2 reagent is not part of the methodology described by Sobek *et al.* (1978).

up to 'of-the-order' 1-10 mg SO_4/kg/week (= *c.* 0.1-1.0 kg H_2SO_4/tonne/year).[3] Maintenance of circum-neutral-pH through hydrolysis/dissolution of primary-silicates is therefore restricted to both "mineral-fines", and slow rates of sulphide-weathering.

Despite the aggressive-digestion conditions employed, the ANC values determined by the Sobek *et al.* (1978) method allow an informed, initial "screening" of mine-waste materials in terms of acid-consuming and pH-buffering properties, especially when due account is taken of gangue 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-waste materials of varying mineralogy.

B1.2.2 CO_3-C Values

The CO_3-C value is the difference between the Total-C and Total-Organic-C (TOC) values.

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

B1.2.3 pH-Buffering Properties

The pH-Buffering properties of the Kundip-Primary-Ore-Tailings-Solids sample were determined via a Metrohm® 736 Titrino auto-titrator, and 0.05 M-H_2SO_4.

The auto-titration comprised regular addition of the H_2SO_4 reagent to monotonically decrease the pH value of the test-suspension to 3.0.[4] The Start-pH value of the test-suspension was *c.* 9. Under the testwork conditions employed, the H_2SO_4-addition rate

---

[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 %).

[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 not 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. No correction was made for such "electrolyte-consumption" of the 0.05 M-H_2SO_4 titrant.

corresponds to an SOR 'of-the-order' 10^5 mg SO_4/kg/week (= *c.* 10^4 kg SO_4/tonne/year), and so represents a very-rapid rate of acid addition.

Further details of the auto-titrations are presented in the laboratory reports (Appendix C).

B1.3 NAPP Calculations

The NAPP values of the tailings-solids samples were 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/pyrrhotite. The NAPP calculations serve as a starting point in the assessment of the acid-formation potential of sulphide-bearing materials.

The complete oxidation of pyrite may be described by:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O = 2SO_4^{2-} + 4H^+ + \text{"}Fe(OH)_3\text{"}$$

The complete oxidation of pyrrhotite may be described by:

$$\text{"}FeS_{(s)}\text{"} + 9/2O_{2(g)} + 5/2H_2O_{(l)} = \text{"}Fe(OH)_{3(s)}\text{"} + 2SO_4{}^{2-}{}_{(aq)} + 2H^+{}_{(aq)}$$

Pyrrhotite is non-stoichiometric, so that expressing pyrrhotite as "FeS" in the above equation represents an approximation of the oxidation reaction (Belzile *et al.* 2004; Janzen *et al.* 2000). Elemental sulphur (as an intermediate-oxidation product) may also accumulate during pyrrhotite weathering (Nicholson and Scharer 1994), especially at low-pH. However, Elemental-S is ultimately oxidised to H_2SO_4 (albeit via a complex, microbially-mediated pathway involving thiosulphate and an array of polythionates).

It may be shown that, if the Sulphide-S (in %S) occurs as pyrite, and/or pyrrhotite, then the amount of acid (in kg H_2SO_4/tonne) produced through complete-oxidation is given by **30.6 x %S**.

The NAPP values of the tailings-solids samples were therefore calculated from the Sulphide-S content (in %S), and 30.6 as the 'conversion-factor' to estimate the amount of acid that may potentially be produced through the aerobic-oxidation of pyrite, and/or pyrrhotite.

> 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.

B1.4 NAG Tests

The NAG Test is a direct measure of a sample's potential to produce acid through sulphide oxidation, and also provides an indication of the reactivity of the sulphides, and the availability of the alkalinity-forms contributing to the ANC (Miller *et al.* 1997, 1994).

In this test, the sample is reacted with H_2O_2 to rapidly oxidise contained sulphides, and allow the produced acid to react with the acid-neutralising materials (e.g. carbonates). The NAG Test supplements the NAPP-based assessment of the acid-formation potential of mine-waste materials (Morin and Hutt 1997).

The procedure employed in this study is based on that for the 'Static-NAG Test', as described by 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 any unreacted-H_2O_2, and thereby prevents "positive-blank" values being obtained (O'Shay *et al.* 1990). 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 without accelerated dissolution of gangue-phases through boiling 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 both Sulphide-S contents less than *c.* 1 %, and ANC values less than *c.* 10 kg H_2SO_4/tonne (as typically recorded for a 'carbonate-deficient' gangue). Furthermore, oxidation by H_2O_2 is generally at least 10^4-10^5 faster than the SORs recorded during 'kinetic' testing (e.g. Weathering-Columns) of mine-waste samples. If circum-neutral conditions are to prevail during NAG testwork, then the rate of acid consumption by gangue-phases must be proportionately faster (c.f. rates for 'ambient-weathering'). This aspect must also be borne in mind when interpreting NAG-testwork data, especially for mine-waste materials that are devoid of carbonates, since the dissolution/hydrolysis kinetics of primary-silicates are strongly pH-dependent.

B2.0 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 are appropriate for environmental investigations.

Element enrichments were identified using the *Geochemical Abundance Index (GAI)*.[5]

The GAI quantifies an assay result for a particular element in terms of the average-crustal-abundance of that element.[6] 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

---

[5] 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.

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

which corresponds to a 96-fold, or greater, enrichment above average-crustal-abundances.

B3.0 ANALYSIS OF TAILINGS-SLURRY-WATER SAMPLES

The samples were 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 employing detection-limits appropriate for environmental investigations.

The concentrations of cyanide forms (viz. Total Cyanide, CN_{tot}; Weak-Acid-Dissociable Cyanide, CN_{wad}; and, Thiocyanate, SCN) in the samples were determined by standard methods (APHA 1992). Compared with CN_{wad}, SCN exhibits a reduced toxicity towards biota (Smith and Mudder 1991).

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

APPENDIX C

LABORATORY REPORTS

Roger Townend and
Associates
Consulting Mineralogists

G CAMPBELL AND AASOC, 24-6-2004

PO BOX 247,

BRIDGETOWN

WA

OUR REF. 21017

YOUR REF 0333/2

TWO XRD/PLM/SEM ANALYSES OF TWO TAILINGS

(PHILLIPS RIVER)

R TOWNEND

RESULTS.

XRD/PLM/SEM

	GCA 5251	GCA 5252
QUARTZ	MAJOR	DOMINANT
CHLORITE	MAJOR	TRACE
MUSCOVITE	MINOR	ACCESSORY
PLAGIOCLASE	ACCESSORY	ACCESSORY
GOETHITE	MINOR	ACCESSORY
TI OXIDES	TRACE	
PYRITE	TRACE	
GRAPHITE		TRACE

In GCA 5251 , the pyrite can show partial oxidation to goethite, and much of the goethite is ex pyrite.

Roger Townend and Associates
Consulting Mineralogists

G CAMPBELL AND ASSOC, 25-6-2004

PO BOX 247,

BRIDGETOWN

WA

OUR REF 21024

YOUR REF 0333/2

XRD/PLM/SEM ANALYSIS OF ONE TAILING

(PHILLIPS RIVER)

R TOWNEND

RESULTS

XRD/PLM/SEM

	GCA 5281
QUARTZ	MAJOR
CHLORITE	MAJOR
MUSCOVITE	ACCESSORY
FELDSPAR	ACCESSORY
BIOTITE	TRACE
CALCITE	ACCESSORY
EPIDOTE	TRACE
PYRITE	ACCESSORY
PYRRHOTITE	ACCESSORY
CHALCOPYRITE	TRACE
MARCASITE	TRACE
GALENA	TRACE
MAGNETITE	TRACE
RUTILE	TRACE

20 August, 2004

Graeme Campbell & Associates Pty Ltd
Attn: Dr G Campbell
PO Box 247
BRIDGETOWN WA 6255

Our Reference: 81498
Your Reference: GCA0333/2
NATA Accreditation: 2562(1705)

Dear Sir

On the 8th of June 2004 you forwarded testwork instructions for a tailings solids and tailings waters which were received on the 3rd of June 2004 at our laboratory. The samples were identified as follows:

GCA5251 and GCA5252: Raw waters in 2 x 250mL natural plastic bottles.

GCA5251 and GCA5252: NaOH-dosed waters in 500mL black plastic bottles.

GCA5251 and GCA5252: Moist filter cakes of tailings solids in 2 x 250mL plastic jars.

One of the moist residue solids jars and one of the raw waters bottles (vacuum filtered through 0.45µm membrane) for each sample were forwarded to Genalysis Laboratory Services as requested. 20-30 grams of moist tailings solid was forwarded to Dr. Roger Townend & Associates as requested. The filter cake sample retained was sub sampled for moisture and the dried sample pulped to a nominal 75µm particle size for sulphur and carbon forms analysis.

Results of all testwork performed follow:

Sample Number	Moisture Content @ 105°C (% w/w)	Total Carbon (% w/w)	Total Organic Carbon (% w/w)	Carbonate Carbon CO_3-C (% w/w)	Total Sulphur S (% w/w)	Sulphate Sulphur SO_4-S (Na_2CO_3) (% w/w)
GCA 5251	20.5	0.10	0.04	0.07	0.31	0.11
GCA 5252	18.4	0.32	0.26	0.07	0.10	0.08

CLIENT: **Graeme Campbell & Associates Pty Ltd** **OUR REFERENCE: 81498**
PROJECT NO: **GCA0333/2**

NOTES:

1. *Moisture content was determined on an as received sample as loss in weight after 24 hours drying at 105°C and is reported on the dried sample weight basis.*
2. *Sulphate sulphur was determined on an as received sample by Na_2CO_3 extraction, $BaSO_4$ precipitation with results reported back to the 105°C dried sample basis.*
3. *Total sulphur, total carbon and total organic carbon (noncarbonate or acid insoluble carbon) were determined on dried pulped sample by LECO induction furnace, IR detection, and is reported on that basis. This test work was performed by SGS Minerals Services, Welshpool, report number WM078588 (NATA1936).*

Acid Neutralisation Capacity (ANC):

Sample Number	Fizz Rating	Sample Weight (g)	Titre NaOH (mL)	Normality HCl/NaOH (N)	Initial Effervescence	Effervescence on Warming	ANC Solution pH	ANC (kg H_2SO_4/tonne)
GCA 5251	0-1	5.0799	19.70	0.1N	Nil	Nil	1.4	6.5
GCA 5252	0-1	5.0362	21.60	0.1N	Nil	Nil	1.2	4.2
Rpt GCA 5252	0-1	5.0840	21.50	0.1N	Nil	Nil	1.3	4.3
ANC Std20	-	2.0080	17.10	0.1N	-	-	1.4	19.4

NOTES:

1. *Acid neutralisation capacity was determined on as received moist sample with results corrected back to the 105°C sample weight basis. Unless otherwise stated, 25mL of HCl is used. Reagent blank titre of 0.1N NaOH was 25.10mL.*
2. *ANC Std20 is an internally produced standard of $CaCO_3$ and quartz pulped to a nominal 75µm particle size which has a nominal ANC of 20kg of H_2SO_4/tonne.*
3. *This procedure is based on Sobek et al, 1978.*

Results of the tailings waters analysis follow on a separate table.

Yours faithfully,

STEVEN EDMETT
Client Liaison Manager

JANICE VENNING
Manager, Perth

CLIENT: **Graeme Campbell & Associates Pty Ltd** **OUR REFERENCE: 81498**
PROJECT NO: **GCA0333/2**

LABORATORY REPORT

Your reference	**GCA**	**GCA**	
Our reference	**5251**	**5252**	
Sample type	**Water**	**Water**	
Units	**mg/L**	**mg/L**	**Method**
pH (pH Units)	8.7	8.8	PEI 001
Total Dissolved Solids (grav)	26000	25000	PEI 002
Electrical Conductivity @ 25°C (µS/cm)-Direct	39000	37000	PEI 032
Chloride, Cl	13000	13000	PEI 008
Sulphate, SO_4	2400	2300	PEI 034
Carbonate, CO_3	77	110	PEI 006
Bicarbonate, HCO_3	490	580	PEI 006
Hydroxide, OH	<1	<1	PEI 006
Fluoride, F	0.15	2.1	PEI 027
Nitrate, NO_3	0.8	25	PEI 020
Ammoniacal Nitrogen, NH_3-N	2.3	2.9	PEI 010
Iron, Fe (soluble)	0.15	0.45	PEM 001
Copper, Cu	400	410	PEM 001
Nickel, Ni	0.60	1.0	PEM 001
Zinc, Zn	0.80	4.7	PEM 001
Thiocyanate, SCN	32	3.4	PEI 025
Arsenic, As	0.057	0.086	PEM 004
Total Cyanide, CN	580	640	PEI 021/023
Weak Acid Dissociable Cyanide, WADCN	450	480	PEI 026/023

NOTES:

1. *Total and weak acid dissociable cyanide were analysed from the NaOH preserved bottle with the remainder of analyses taken from the raw water bottle.*

2. *Arsenic was analysed by SGS Minerals Services, their report number: WM078529*

20 August, 2004

Graeme Campbell & Associates Pty Ltd
Attn: Dr G Campbell
PO Box 247
BRIDGETOWN WA 6255

Our Reference: 81684
Your Reference: GCA0333/2
NATA Accreditation: 2562(1705)

Dear Sir

On the 16th of June 2004 you forwarded testwork instructions for a tailings solid and tailings water which were received that day at our laboratory. The samples were identified as follows:

GCA5281: Raw waters in 1 x 1000mL translucent-plastic-bottle.

GCA5281: NaOH-dosed water in 1000mL translucent-plastic-bottle.

GCA5281: Moist filter cakes of tailings solids in 2 x 250mL plastic jar.

One of the moist residue solids jars and 100-200mL of the raw water (vacuum filtered through 0.45µm membrane) were forwarded to Genalysis Laboratory Services as requested. 20-30g of the filter cake retained was sent to Roger Townend and Associates with the remaining filter cake being sub sampled for moisture and the dried sample pulped to a nominal 75µm particle size for sulphur and carbon forms analysis.

Results of all testwork performed follow:

Sample Number	Moisture Content @ 105°C (% w/w)	Total Carbon (% w/w)	Total Organic Carbon (% w/w)	Total Sulphur S (% w/w)	Sulphate Sulphur SO_4-S (Na_2CO_3) (% w/w)	Carbonate Carbon CO_3-C (% w/w)
GCA5281	14.91	0.58	0.04	9.04	0.03	0.54

NOTES:

1. *Moisture content was determined on an as received sample as loss in weight after 24 hours drying at 105°C and is reported on the dried sample weight basis.*
2. *Sulphate sulphur was determined on an as received sample by Na_2CO_3 extraction, $BaSO_4$ precipitation with results reported back to the 105°C dried sample basis.*

3. *Total sulphur, total carbon and total organic carbon (noncarbonate or acid insoluble carbon) were determined on dried pulped sample by LECO induction furnace, IR detection, and is reported on that basis. This test work was performed by SGS Minerals Services, Welshpool, report number WM078851 (NATA1936).*

Acid Neutralisation Capacity (ANC):

Sample Number	Fizz Rating	Sample Weight (g)	Titre NaOH (mL)	Normality HCl/NaOH (N)	Initial Effervescence	Effervescence on Warming	ANC Solution pH	ANC (kg H_2SO_4/tonne)
GCA5281*	1-2	2.1772	19.90	0.5N	Slight	Nil	1.0	64
ANC Std20		2.0248	17.20	0.1N			1.6	19.20

NOTES:

1. *Acid neutralisation capacity was determined on as received moist sample with results corrected back to the 105°C sample weight basis. Unless otherwise stated, 25mL of HCl is used. Reagent blank titre of 0.5N NaOH was 24.80mL.*
2. ** Indicates the appearance of a green colouration as the pH = 7 endpoint was approached. Two drops of hydrogen peroxide are added to each sample as the pH=7 end point is approached to oxidise any ferrous iron.*
3. *ANC Std20 is an internally produced standard of $CaCO_3$ and quartz pulped to a nominal 75µm particle size which has a nominal ANC of 20kg of H_2SO_4/tonne.*
4. *This procedure is based on Sobek et al, 1978.*

Results of the tailings waters analysis follow on a separate table.

Yours faithfully,

STEVEN EDMETT
Client Liaison Manager

JANICE VENNING
Manager, Perth

CLIENT: **Graeme Campbell & Associates Pty Ltd** **OUR REFERENCE: 81684**
PROJECT NO: **GCA0333/2**

LABORATORY REPORT

Your reference	**GCA5851**	
Our reference	**81684-1**	
Sample type	**Water**	
Units	**mg/L**	**Method**
pH (pH Units)	8.4	PEI 001
Total Dissolved Solids (grav)	29000	PEI 002
Electrical Conductivity @ 25°C (µS/cm)-Direct	40000	PEI 032
Chloride, Cl	15000	PEI 008
Sulphate, SO_4	3300	PEI 034
Carbonate, CO_3	6.6	PEI 006
Bicarbonate, HCO_3	210	PEI 006
Hydroxide, OH	<1	PEI 006
Fluoride, F	<0.1	PEI 027
Ammoniacal Nitrogen, NH_3-N	<0.1	PEI 010
Nitrate-Nitrogen, NO_3-N	<0.05	PEI 020
Iron, Fe (soluble)	0.20	PEM 001
Copper, Cu	120	PEM 001
Nickel, Ni	0.45	PEM 001
Zinc, Zn	2.2	PEM 001
Thiocyanate, SCN	250	PEI 025
Arsenic, As	0.056	PEM 004
Total Cyanide, CN	210	PEI 021/023
Weak Acid Dissociable Cyanide, WADCN	200	PEI 026/023

NOTES:

1. *Total and weak acid dissociable cyanide were analysed from the NaOH preserved bottle with the remainder of analyses taken from the raw water bottle.*
2. *Arsenic was analysed by SGS Minerals Services, Welshpool, report number, WM078735. (This analysis is not covered by the terms of our NATA accreditation).*

Graeme Campbell & Associates Pty Ltd

Laboratory Report

NET-ACID-GENERATION (NAG) TESTWORK

Sample Number	Sample Weight (g) [moist]	Sample Weight (g) [dry]	Comments	pH of Test Mixture Before Boiling Step	Test Mixture After Boiling Step		Titre [0.1 M-NaOH] (mL)	NAG (kg H_2SO_4/ tonne)
					pH	EC (µS/cm)		
GCA5251	5.4	4.3		6.4	6.8	390	0.30	<0.5
GCA5252	4.8	3.9		6.2	7.1	230	-	<0.5
GCA5281	1.9	1.6	Reaction peaked after 1st boiling-step	6.4	2.7	2,000	24.50	76
GCA5281 (Repeat)	2.2	1.9	Reaction peaked overnight	2.5	3.0	1,400	14.20	37
Blank-1	-	3.5		5.7	7.2	53	-	<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. NAG values expressed on a dry-weight basis.

Dr GD Campbell
4th August 2004

Graeme Campbell & Associates Pty Ltd

Laboratory Report

pH-BUFFERING TESTWORK (GCA5281)

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	9.4	14.00	13	6.7
0.40	0.4	9.1	14.40	14	6.6
0.80	0.8	8.8	14.80	14	6.5
1.20	1.1	8.6	15.20	14	6.4
1.60	1.5	8.3	15.60	15	6.4
2.00	1.9	8.1	16.00	15	6.3
2.40	2.3	8.0	16.40	16	6.2
2.80	2.7	7.9	16.80	16	6.2
3.20	3.0	7.8	17.20	16	6.1
3.60	3.4	7.8	17.60	17	6.1
4.00	3.8	7.8	18.00	17	6.0
4.40	4.2	7.7	18.40	17	6.0
4.80	4.6	7.7	18.80	18	5.9
5.20	4.9	7.6	19.20	18	5.8
5.60	5.3	7.6	19.60	19	5.8
6.00	5.7	7.6	20.00	19	5.8
6.40	6.1	7.5	20.40	19	5.7
6.80	6.5	7.5	20.80	20	5.6
7.20	6.8	7.5	21.20	20	5.6
7.60	7.2	7.4	21.60	21	5.5
8.00	7.6	7.4	22.00	21	5.5
8.40	8.0	7.4	22.40	21	5.4
8.80	8.4	7.3	22.80	22	5.4
9.20	8.7	7.3	23.20	22	5.3
9.60	9.1	7.2	23.60	22	5.3
10.00	9.5	7.2	24.00	23	5.2
10.40	9.9	7.2	24.40	23	5.1
10.80	10	7.1	24.80	24	5.1
11.20	11	7.1	25.20	24	5.0
11.60	11	7.0	25.60	24	5.0
12.00	11	7.0	26.00	25	4.9
12.40	12	6.9	26.40	25	4.8
12.80	12	6.9	26.80	25	4.8
13.20	13	6.8	27.20	26	4.7
13.60	13	6.7	27.60	26	4.6

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
28.00	27	4.6	37.60	36	3.5
28.40	27	4.5	38.00	36	3.5
28.80	27	4.4	38.40	36	3.5
29.20	28	4.4	38.80	37	3.4
29.60	28	4.3	39.20	37	3.4
30.00	29	4.2	39.60	38	3.4
30.40	29	4.2	40.00	38	3.4
30.80	29	4.1	40.40	38	3.4
31.20	30	4.1	40.80	39	3.4
31.60	30	4.0	41.20	39	3.4
32.00	30	4.0	41.60	40	3.4
32.40	31	3.9	42.00	40	3.4
32.80	31	3.9	42.40	40	3.4
33.20	32	3.8	42.80	41	3.4
33.60	32	3.8	43.20	41	3.4
34.00	32	3.7	43.60	41	3.3
34.40	33	3.7	44.00	42	3.3
34.80	33	3.7	44.40	42	3.3
35.20	33	3.6	44.80	43	3.3
35.60	34	3.6	45.20	43	3.3
36.00	34	3.6	45.60	43	3.3
36.40	35	3.6	46.00	44	3.2
36.80	35	3.5	46.40	44	3.1
37.20	35	3.5	46.80	44	3.1

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. 5.9 g of moist tailings-solids (= 5.1 g dry-solids) 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 = -9 mV (pH=7.00); slope-point = 164 mV (pH=4.00); 97.2 % of Nernstian response for 25 °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
4th August 2004

ANALYTICAL REPORT

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

JOB INFORMATION

JOB CODE : 143.0/0403570
No. of SAMPLES : 2
No. of ELEMENTS : 31
CLIENT O/N : GCA0333/2
SAMPLE SUBMISSION No. :
PROJECT : Phillips River Gold Project
STATE : Water
DATE RECEIVED : 09/06/2004
DATE COMPLETED : 05/07/2004
DATE PRINTED : 05/07/2004

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

MAIN OFFICE AND LABORATORY

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ADELAIDE SAMPLE PREPARATION DIVISION

124 Mooringe Avenue, North Plympton 5037, South Australia
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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 $1.50 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 $50.00 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 Accredition 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, GCA5251 and GCA5252 were received as being filtered tailings waters which contained cyanide forms.

The results have been determined according to Genalysis method numbers ICP_W004 and ICP_W005, following acidification with Nitric acid apart from the Ag results which were determined on the solution as received.

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

NATA Signatory: A P Evers

Date: 5th July 2004

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppb	mg/l	mg/l	mg/l	ug/l	ug/l	mg/l	ug/l	mg/l	mg/l
DETECTION	0.1	1	0.002	1	1	0.1	1	0.5	0.002	1
DIGEST		X/	X/	X/	X/	X/	X/	X/	X/	X/
ANALYTICAL FINISH	/MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA5251	486.6	X	0.060	3	43	0.4	170	3.1	0.595	X
0002 GCA5252	19547.5	X	0.072	4	54	0.3	88	5.6	0.198	X
CHECKS										
0001 GCA5251	501.2	X	0.055	X	39	0.3	167	4.1	0.604	X
STANDARDS										
0001 SOLN_BLEG_1	37.5									
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	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	1	1	2	10	1	1	1	10	1	10
DIGEST	X/	X/	X/	X/	X/	X/	X/	X/	X/	X/
ANALYTICAL FINISH	OES	OES	MS	OES	OES	OES	MS	OES	OES	OES
SAMPLE NUMBERS										
0001 GCA5251	398	X	2103	68	948	X	66	7896	X	11
0002 GCA5252	409	2	1334	102	963	X	2787	7582	X	26
CHECKS										
0001 GCA5251	396	X	2097	64	932	X	76	7807	X	15
STANDARDS										
0001 SOLN_BLEG_1										
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Pb	Sb	Se	Si	Sn	Sr	Th	Tl	U	V
UNITS	mg/l	ug/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l
DETECTION	0.01	0.2	0.01	5	2	0.5	0.1	0.2	0.1	1
DIGEST	X/	X/	X/	X/	X/	X/	X/	X/	X/	X/
ANALYTICAL FINISH	MS	MS	MS	OES	MS	MS	MS	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA5251	0.15	0.5	0.17	7	X	818.7	0.1	X	1.2	X
0002 GCA5252	0.34	53.1	0.15	7	X	492.7	X	5.2	7.4	X
CHECKS										
0001 GCA5251	0.15	0.7	0.15	5	X	817.5	X	X	1.1	X
STANDARDS										
0001 SOLN_BLEG_1										
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Zn
UNITS	mg/l
DETECTION	1
DIGEST	X/
ANALYTICAL FINISH	OES
SAMPLE NUMBERS	
0001 GCA5251	2
0002 GCA5252	6

CHECKS	
0001 GCA5251	2

STANDARDS	
0001 SOLN_BLEG_1	

BLANKS	
0001 Control Blank	X

METHOD CODE DESCRIPTION

/MS

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

X/MS

Client Specified Digestion or Extraction. Analysed by Inductively Coupled Plasma Mass Spectrometry.

X/OES

Client Specified Digestion or Extraction. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

ANALYTICAL REPORT

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

JOB INFORMATION

JOB CODE : 143.0/0403571
No. of SAMPLES : 2
No. of ELEMENTS : 32
CLIENT O/N : GCA0333/2
SAMPLE SUBMISSION No. :
PROJECT : Phillips River Gold Project
STATE : Taillings
DATE RECEIVED : 09/06/2004
DATE COMPLETED : 29/06/2004
DATE PRINTED : 29/06/2004

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

MAIN OFFICE AND LABORATORY

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ADELAIDE SAMPLE PREPARATION DIVISION

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Tel: +61 8 8376 7122 Fax: +61 8 8376 7144

SAMPLE DETAILS

DISCLAIMER

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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 $1.50 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 $50.00 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 Accredition 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 2 samples, GCA5251 and 5252, were received as being tailings solids.

The samples required drying at 45 degrees Celcius prior to being mixed and split to a 100g portion for pulverising in a zirconia bowl.

The results have been determined according to Genalysis method numbers :
SL_W001 (A/), SL_W007 (BP/), ENV_W012 (DH/SIE), SL_W013 (D/) and SL_W012 (CM/)
for the digests and ICP_W004 (/OES), ICP_W005 (/MS) and AAS_W004 (/CVAP).

The results included the assay of blanks and international reference standard SO-2 and WGB-1 and Genalysis in-house standards AE11 and HgSTD.

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

NATA Signatory: A Evers

Date: 29th June 2004

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	0.1	20	1	50	0.1	0.01	10	0.1	0.1	2
DIGEST	A/	A/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA5251	3.7	5.85%	133	102	111.1	3.96	879	0.2	113.4	153
0002 GCA5252	15.8	1.52%	514	475	287.7	140.70	583	0.1	18.3	314
CHECKS										
0001 GCA5251	3.6	5.82%	133	73	113.8	3.99	864	0.2	113.2	157
STANDARDS										
0001 AE12										
0002 HgSTD-3										
0003 SO-2										
0004 WGB-1	0.1	5.66%	X		850.0	0.03	10.27%	0.1	31.0	188
0005 WGB-1				242						
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
SAMPLE NUMBERS										
0001 GCA5251	2795	210	16.60	0.82	8697	2.49%	531	16.7	3076	139
0002 GCA5252	777	170	2.14	2.43	2346	1733	76	53.5	2177	175
CHECKS										
0001 GCA5251	2760	195	16.63	0.80	8620	2.46%	532	16.5	3079	139
STANDARDS										
0001 AE12										
0002 HgSTD-3				0.31						
0003 SO-2		506								
0004 WGB-1	105				7704	5.57%	1058	1.1	1.56%	75
0005 WGB-1			4.66							
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	20	2	10	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	A/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 GCA5251	400	195	3426	0.77	1.90	2.2	17.54	3.10	0.13	1.94
0002 GCA5252	104	1219	1124	55.76	8.32	3.7	24.67	7.83	1.14	2.78
CHECKS										
0001 GCA5251	416	194	3566	0.83	1.84	2.2	17.64	3.43	0.14	1.90
STANDARDS										
0001 AE12					0.57					
0002 HgSTD-3										
0003 SO-2										
0004 WGB-1	390	9	188	2.27		4.4	117.95	0.97	0.43	0.65
0005 WGB-1										
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
SAMPLE NUMBERS		
0001 GCA5251	76	186
0002 GCA5252	19	80
CHECKS		
0001 GCA5251	77	183
STANDARDS		
0001 AE12		
0002 HgSTD-3		
0003 SO-2		
0004 WGB-1	222	28
0005 WGB-1		
BLANKS		
0001 Control Blank	X	X

METHOD CODE DESCRIPTION

A/MS

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Mass Spectrometry.

A/OES

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

BP/MS

Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.

D/OES

Sodium peroxide fusion (Zirconium crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

DH/SIE

Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.

CM/CVAP

Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.

ANALYTICAL REPORT

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

JOB INFORMATION

JOB CODE : 143.0/0403767
No. of SAMPLES : 1
No. of ELEMENTS : 31
CLIENT O/N : GCA0333/2
SAMPLE SUBMISSION No. :
PROJECT : Phillips River Gold Project
STATE : Water
DATE RECEIVED : 16/06/2004
DATE COMPLETED : 08/07/2004
DATE PRINTED : 08/07/2004

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 STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

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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.

NOTES

*** NATA ENDORSED DOCUMENT ***

Company Accredition 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, GCA5281 was received as being filtered tailings water which contained cyanide forms.

The results have been determined according to Genalysis method numbers ICP_W004 and ICP_W005, following acidification with Nitric acid apart from the Ag results which were determined on the solution as received.

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

NATA Signatory: A P Evers

Date: 8th July 2004

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppb	mg/l	mg/l	mg/l	ug/l	ug/l	mg/l	ug/l	mg/l	mg/l
DETECTION	0.1	1	0.002	1	1	0.1	1	0.5	0.002	1
DIGEST		X/	X/	X/	X/	X/	X/	X/	X/	X/
ANALYTICAL FINISH	/MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA5281	1167.1	X	0.179	X	83	0.2	478	91.0	0.488	X
CHECKS										
0001 GCA5281	1161.0	X	0.189	2	80	X	469	87.8	0.479	X
STANDARDS										
0001 SOLN_BLEG_1	46.0									
BLANKS										
0001 Control Blank	X	1	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Cu	Fe	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	1	1	2	10	1	1	1	10	1	10
DIGEST	X/	X/	X/	X/	X/	X/	X/	X/	X/	X/
ANALYTICAL FINISH	OES	OES	MS	OES	OES	OES	MS	OES	OES	OES
SAMPLE NUMBERS										
0001 GCA5281	120	2	17	141	1001	X	115	9127	1	X
CHECKS										
0001 GCA5281	117	4	16	140	977	X	113	9048	X	X
STANDARDS										
0001 SOLN_BLEG_1										
BLANKS										
0001 Control Blank	X	2	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Pb	Sb	Se	Si	Sn	Sr	Th	Tl	U	V
UNITS	mg/l	ug/l	mg/l	mg/l	ug/l	ug/l	ug/l	ug/l	ug/l	mg/l
DETECTION	0.01	0.2	0.01	5	2	0.5	0.1	0.2	0.1	1
DIGEST	X/	X/	X/	X/	X/	X/	X/	X/	X/	X/
ANALYTICAL FINISH	MS	MS	MS	OES	MS	MS	MS	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA5281	0.14	5.7	0.65	9	X	3352.0	X	X	0.3	X
CHECKS										
0001 GCA5281	0.14	6.1	0.69	X	X	3319.0	X	X	0.3	X
STANDARDS										
0001 SOLN_BLEG_1										
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	Zn
UNITS	mg/l
DETECTION	1
DIGEST	X/
ANALYTICAL FINISH	OES
SAMPLE NUMBERS	
0001 GCA5281	8
CHECKS	
0001 GCA5281	8
STANDARDS	
0001 SOLN_BLEG_1	
BLANKS	
0001 Control Blank	X

METHOD CODE DESCRIPTION

/MS

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

X/MS

Client Specified Digestion or Extraction. Analysed by Inductively Coupled Plasma Mass Spectrometry.

X/OES

Client Specified Digestion or Extraction. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

ANALYTICAL REPORT

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

JOB INFORMATION

JOB CODE : 143.0/0403769
No. of SAMPLES : 1
No. of ELEMENTS : 32
CLIENT O/N : GCA0332/2
SAMPLE SUBMISSION No. :
PROJECT : Phillips River Gold Project
STATE : Taillings
DATE RECEIVED : 16/06/2004
DATE COMPLETED : 09/07/2004
DATE PRINTED : 12/07/2004

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 STORAGE DETAILS

GENERAL CONDITIONS

SAMPLE STORAGE OF SOLIDS

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SAMPLE STORAGE OF SOLUTIONS

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NOTES

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Company Accredition Number 3244

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

The sample, GCA5281, was received as being a tailings solid.

The samples required drying at 45 degrees Celcius prior to being mixed and split to a 100g portion for pulverising in a zirconia bowl.

The results have been determined according to Genalysis method numbers :
SL_W001 (A/), SL_W007 (BP/), ENV_W012 (DH/SIE), SL_W013 (D/) and SL_W012 (CM/)
for the digests and ICP_W004 (/OES), ICP_W005 (/MS) and AAS_W004 (/CVAP).

The results included the assay of blanks and international reference standard STSD-2 and SO-2 and Genalysis in-house standards AE12, TKCLOW-1 and HgSTD-3.

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

NATA Signatory: T K Chan

Date: 8th July 2004

ANALYSIS

ELEMENTS	Ag	Al	As	B	Ba	Bi	Ca	Cd	Co	Cr
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	0.1	20	1	50	0.1	0.01	10	0.1	0.1	2
DIGEST	A/	A/	A/	D/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	MS	OES	MS	OES	MS	MS	OES	MS	MS	OES
SAMPLE NUMBERS										
0001 GCA5281	3.4	5.33%	35	X	151.1	4.99	1.77%	1.0	547.0	309
CHECKS										
0001 GCA5281	3.5	5.47%	37	X	146.9	4.71	1.82%	1.1	518.0	267
STANDARDS										
0001 AE12										
0002 HgSTD-3										
0003 SO-2										
0004 TKCLOW-1				1277						
0005 WGB-1	0.3	5.82%	1		869.6	0.02	10.84%	0.1	29.5	282
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	2

ANALYSIS

ELEMENTS	Cu	F	Fe	Hg	K	Mg	Mn	Mo	Na	Ni
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	1	50	0.01	0.01	20	20	1	0.1	20	1
DIGEST	A/	DH/	D/	CM/	A/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	SIE	OES	CVAP	OES	OES	OES	MS	OES	OES
SAMPLE NUMBERS										
0001 GCA5281	1698	164	16.56	0.09	7172	2.60%	1157	32.5	5279	298
CHECKS										
0001 GCA5281	1824	155	16.61	0.09	7372	2.68%	1188	31.6	5457	300
STANDARDS										
0001 AE12										
0002 HgSTD-3				0.32						
0003 SO-2		591								
0004 TKCLOW-1			25.64							
0005 WGB-1	104				7544	5.48%	1038	1.0	1.54%	72
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	P	Pb	S	Sb	Se	Sn	Sr	Th	Tl	U
UNITS	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DETECTION	20	2	0.01	0.05	0.01	0.1	0.05	0.01	0.02	0.01
DIGEST	A/	A/	D/	A/	BP/	A/	A/	A/	A/	A/
ANALYTICAL FINISH	OES	MS	OES	MS	MS	MS	MS	MS	MS	MS
SAMPLE NUMBERS										
0001 GCA5281	385	431	8.94	0.73	1.58	2.3	30.42	2.51	3.76	2.31
CHECKS										
0001 GCA5281	385	418	9.11	0.72	1.68	2.3	30.07	2.34	3.64	2.10
STANDARDS										
0001 AE12					0.55					
0002 HgSTD-3										
0003 SO-2										
0004 TKCLOW-1			0.58							
0005 WGB-1	383	8		2.12		4.0	114.60	0.92	0.39	0.71
BLANKS										
0001 Control Blank	X	X	X	X	X	X	X	X	X	X

ANALYSIS

ELEMENTS	V	Zn
UNITS	ppm	ppm
DETECTION	2	1
DIGEST	A/	A/
ANALYTICAL FINISH	OES	OES
SAMPLE NUMBERS		
0001 GCA5281	70	281
CHECKS		
0001 GCA5281	75	276
STANDARDS		
0001 AE12		
0002 HgSTD-3		
0003 SO-2		
0004 TKCLOW-1		
0005 WGB-1	223	33
BLANKS		
0001 Control Blank	X	X

METHOD CODE DESCRIPTION

A/MS

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Mass Spectrometry.

A/OES

Multi-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon Beakers. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

BP/MS

Aqua-Regia digest followed by Precipitation and Concentration. Specific for Selenium. Analysed by Inductively Coupled Plasma Mass Spectrometry.

D/OES

Sodium peroxide fusion (Zirconium crucibles) and Hydrochloric acid to dissolve the melt. Analysed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry.

DH/SIE

Alkaline fusion (Nickel crucible) specific for Fluorine. Analysed by Specific Ion Electrode.

CM/CVAP

Low temperature Perchloric acid digest specific for Mercury. Analysed by Cold Vapour Generation Atomic Absorption Spectrometry.