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AMD REVIEW

Balmoral South Iron Project

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REPORT

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Executive Summary

Australasian Resources Limited International Minerals (Pty) Ltd engaged Golder Associates (Pty) Ltd (Golder) to conduct a review on the potential for the rock types at the Balmoral South Iron Ore Project (Balmoral South) to generate Acid and Metaliferous Drainage (AMD). The Balmoral South Project is located approximately 80 km SW of Karratha in the Pilbara Region of Western Australia. The Project occupies the tenement directly SE of the Sino Iron Project (SIP) and comprises the same stratigraphy, separated by a fault line.

A geochemical assessment undertaken by Golder for the SIP was used as a basis for assessing likely AMD related properties for strata that will be mined at Balmoral South. This approach was based on the knowledge that the stratigraphy for the two projects is effectively continuous. Based on previous work (pers. Com. Dr. Bill Shaw), the strata of the Hamersley Group are relatively uniform and can thus be extrapolated laterally with respect to their geochemical characteristics. AMD characteristics are thus also likely to be similar for a given stratigraphic sequence in the SIP and Balmoral South project areas.

The objective for the work reported here is to assess available information and documentation for the SIP and Balmoral South Projects to provide input to the Balmoral South permitting and environmental management process, as outlined in the scope of work below.

The following tasks were outlined in the scope of work:

- Review available IM data relating to acid rock drainage (ARD) and geology, and provide a letter report indicating the suitability of using CPMM ARD data to interpolate ARD potential for the Balmoral South project.
- Undertake a data gap analysis and provide a proposal indicating time and cost to access or generate any additional data required to assess potential ARD risk.
- Generate information suitable for inclusion into the IM Public Environmental Review outlining the results of the ARD potential and the methodology utilised to generate these results.
- Review the IM Environmental Management Plan (EMP) in light of the ARD potential results determined above.
- Assess the suitability of the management strategies proposed by IM and provide alternative recommendations for strategies that are deemed to be unsuitable.

The SIP data on which this work is based can be summarised as follows with respect in terms of its scope:

- Static and kinetic geochemical tests were conducted to characterise the SIP wastes for AMD potential.
- Most lithologies and stratigraphic units were adequately sampled for this work from a statistical point of view, with a few exceptions. The findings were that major stratigraphy was adequately sampled to facilitate the development of management strategies.

Although the minor stratigraphy that is described for the Balmoral South project is subdivided differently to that described for the SIP, the two projects will both expose the same major stratigraphy and the overall AMD characteristics for a particular major stratigraphic unit should be similar between the two projects, despite local variability that might occur.

To facilitate the compilation of this report, IM supplied two sources of stratigraphic information, the first being a spreadsheet of AMD testing data (Ref 081103_AcidMineDrainageData.xls) and the second being a Technical Memo which provides an extract from the feasibility study report (Ref 081208_Section3_FS_GeologyExcerpt.pdf). These documents contained a summary of available static geochemical data and the pre-feasibility mine material balance.

The static testing undertaken to date for the Balmoral South Project, although limited, is in general agreement with the results obtained for the SIP project for the strata represented, i.e. Mount McRae Shale and Whaleback Shale. Samples for both the SIP and Balmoral South project were composites of a number of metres of core or chip materials from a given stratigraphic unit and are thus expected to be sufficiently representative of the materials in question.

In summary the following points are noted from the AMD assessment done for the SIP:

- AMD with associated metal leaching is likely from the Mount McRae Shale stratigraphic unit. The occasionally high concentrations of sulphur and the established correlation with sulphide minerals indicate that acid formation may be a risk from this material.
- Some AMD tendencies were indicated in the Dales Gorge and Whaleback Shale data as well. The measurement of relatively low reactive ANC concentrations implies that acidification potential may be significant in some these materials.
- A number of NAF samples contained measurable quantities of sulphide. This indicates that Neutral Metalliferous Drainage is likely to form in a significant proportion of the mined materials, even if Acid Metalliferous Drainage does not. Elements such as Mn and As may thus be mobilised in leachates and run-off.
- The majority of samples classified as Non Acid Forming according to standard ABA methodologies and many of them are likely to contain excess Acid Neutralising Capacity. The finding that reactive Acid Neutralising Capacity only makes up 5% to 40% (average 18.6%) of the measured Acid Neutralising Capacity for the SIP, however, requires that caution must be applied to the use of total Acid Neutralising Capacity as a measure of available neutralising capacity. This is particularly relevant when considering mixing or placement of Non Acid Forming and Potentially Acid Forming wastes.
- Most of the ore, consisting of Joffre Member for the SIP, was found to be NAF and should pose a relatively low AMD risk in the case of SIP. The same characteristics would be expected if the ore composition is similar for Balmoral South.

Based on the assumptions used for comparison of static geochemical data, the kinetic leach data acquired for the lithologies present at SIP can be considered relevant to the lithologies found at Balmoral South.

A number of potentially toxic elements were recorded in leachates from most samples submitted for leach testing and for the kinetic leaching columns used for the SIP. Under field conditions pore waters at the site may thus contain elevated metal concentrations (when compared to ANZECC 2000 95% trigger levels), particularly from the Mount McRae shale. This is important for groundwater and surface water management considerations.

The pre-feasibility material balance for the Balmoral South project indicates that the total proportion of PAF materials to be mined will be similar to the SIP. A much larger volume of the higher risk Mount McRae Shale and Whaleback Shale are, however, included in the Balmoral South tonnages calculated for the pre-feasibility study mine plan. The Weeli Wolli stratigraphy was only represented in a few samples for the SIP, as it was not planned to mine this unit for the SIP. The samples that were collected cannot be considered conclusive, but did not indicate that the Weeli Wolli is a high risk material.

Although the above assessment is likely to be a suitable generalised account of the risks posed by different materials that may be exposed at the SIP and thus the Balmoral South project, the following limitations should be borne in mind:

- Local geological variability is possible and should be accounted for when detailed mine and waste management planning is done. This requires the testing of a suitable number of locally collected samples.

- Pit designs, waste management practices and the locations of the relevant facilities can have a substantial influence on their potential to cause impacts and should thus be considered for mine planning purposes.
- Although the data for the two projects is not inconsistent, only 20 samples were analysed for a limited suite of static geochemical data for the Balmoral South project, although the samples were of the higher risk materials. There is thus little empirical data to confirm the assumptions on which this work is based, which requires reliance on regional geological experience of geologists that have worked on Hamersley Group stratigraphy.

RECOMMENDATIONS

Based on the findings of this project, Golder recommends the following work be undertaken before and during mining:

- Additional sampling should be conducted at Balmoral South to confirm the assumed correlation with AMD characteristics of the SIP and to define the local distribution of AMD characteristics for refinement of waste management practices. Sampling should be targeted at the materials that may be exposed and would best be done when a suitable level of data is available to optimise sample selection.
- Assess the mining profile for geological or geochemical controls on reactive mineral distribution, as such controls may have implications for reactivity and management options related to the material.
- Once a suitable database is available for AMD characterisation, assess to what extent correlations exist between elemental composition, mineralogy and ANC in the relevant materials. Also confirm that total sulphur is a suitable measure of Maximum Potential Acidity, as it is for the SIP. A version of the mine block model, along with additional grade control determinations, would be sufficient to construct a detailed waste management plan and could be used as an additional AMD risk identification tool if suitable correlations are found.
- Where the stratigraphy indicates a significant possibility of AMD generation or the spatial definition of ABA properties is uncertain, a selection of grade control drilling samples should be characterised for TS and appropriate measures of ANC. NAG tests can also be used as an additional tool for waste classification if necessary.
- If covers are likely to be used to rehabilitate waste materials; undertake geochemical and geotechnical characterisation studies of oxidised overburden to identify potential cover materials for revegetation and closure needs.
- Develop a detailed AMD Management Plan that will include but not be limited to:
    1) The development of a detailed waste rock block model, based on AMD potential.
    2) Including waste management in the material handling schedule to ensure that potentially problematic waste can be is isolated and is transported to the correct location according to the waste management plan.
    3) Inclusion of ABA classification criteria in the design considerations for the Waste dump and tailings facilities to minimise impacts from PAF waste and to utilise ANC in NAF waste appropriately to neutralise acidity. Note: Before utilising NAF waste to neutralise PAF waste, it must be demonstrated that the combination of the materials will result in an overall NAF waste. If NAF waste contains sulphur itself, mixing of such waste can increase the overall volume of PAF waste if insufficient ANC is present to maintain an overall NAF classification. Where such a risk exists, NAF waste should preferably be placed above or beside PAF waste, rather than below or as a mixture with the PAF waste.

4) Consideration of potential impacts associated with waste placement from a regional environmental point of view, including potential impacts from run-off and seepage to groundwater.

- If PAF materials are exposed during mining, utilise mine wall washing at exposure sites to derive geochemical field data for runoff geochemistry if possible. Such data can be compared with static and kinetic laboratory data to model run-off water quality more accurately.

If AMD is considered to be a significant risk according to the mining and waste management plan adopted install instrumentation in the waste facilities or constructed cells to collect more representative field data. The advantage of this approach is that physical parameters related to particle size distribution and climatic conditions are accurate and measured seepage quantities and qualities would thus be representative of field conditions. As the particle size of the material in the waste dumps has a significant effect on leachate chemistry and flow properties of water and oxygen, the results from field scale tests can be significantly different to laboratory assessments. These types of tests also allow for greater sample mass, thereby increasing the representivity of the test if appropriate materials are selected.

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1.0 INTRODUCTION

Australasian Resources Limited International Minerals (Pty) Ltd (IM) has engaged Golder Associates (Pty) Ltd (Golder) to conduct a review of the potential for Acid and Metalliferous Drainage (AMD) for the rock types at the Balmoral South Project based on a geochemical assessment undertaken by Golder for the adjacent Sino Iron Project (SIP). The major aim of the SIP geochemical assessment was to characterise the potential mine waste for Acid and Metaliferous Drainage (AMD) so that a conceptual AMD management plan could be developed for the project.

The SIP project objectives were to:

- Conduct static and kinetic geochemical tests to characterise the SIP wastes for AMD potential.
- Apply static and kinetic data to generate a conceptual management plan for handling of potential AMD generating materials.

The specific objective for this work is to assess the usability of information and data from the SIP and Balmoral South Projects to provide input to the Balmoral South permitting and environmental management process.

1.1 Scope of Work

The following scope of work was undertaken:

- Review available IM data relating to acid rock drainage (ARD) and geology, and provide a report indicating the suitability of using SIP ARD data to interpolate ARD potential for the Balmoral South project.
- Undertake a data gap analysis and provide a proposal indicating time and cost to access or generate any additional data required to assess potential ARD risk.
- Generate information suitable for inclusion into the IM Public Environmental Review outlining the results of the ARD potential and the methodology utilised to generate these results.
- Review the IM Environmental Management Plan (EMP) in light of the ARD potential results determined above.
- Assess the suitability of the management strategies proposed by IM and provide alternative recommendations for strategies that are deemed to be unsuitable.

2.0 PROJECT LOCATION

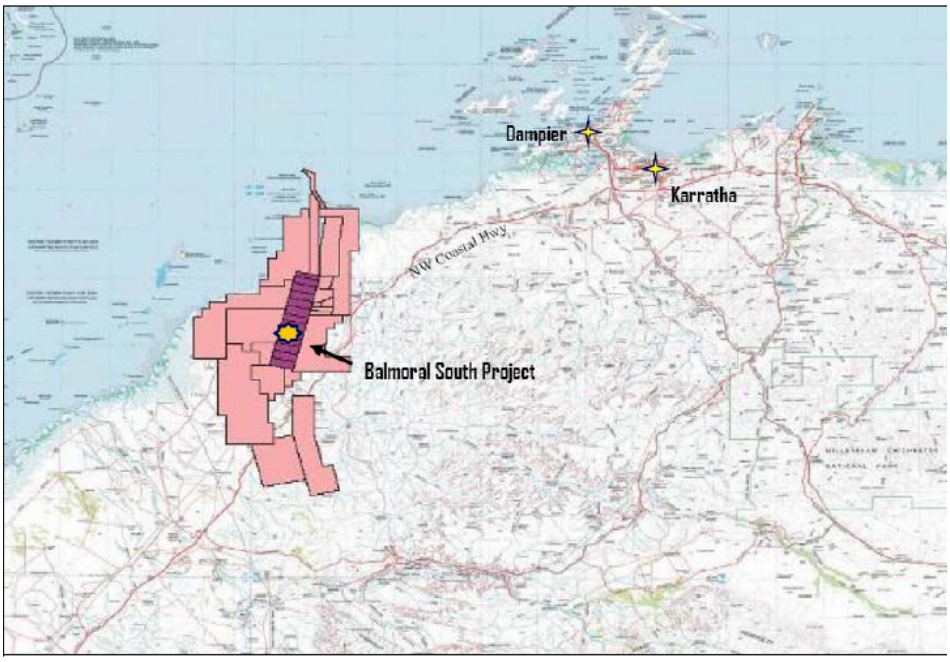

Figure 1: Location of Balmoral South Project

The Balmoral South Iron Ore Project (Balmoral South) is located approximately 80 km SW of Karratha in the Pilbara Region of Western Australia. The Balmoral South Project is formed by the tenement directly SE of the SIP which is shaded in purple in the above figure.

Due to their close proximity, the purpose of this study is to assess the usability of the data acquired for the SIP in regards to AMD risk for the same purpose for the Balmoral South project.

3.0 REGIONAL STRATIGRAPHY

The Hamersley Group (aged approximately 2400 to 2600 Ma) conformably overlies the Fortescue Group and is about 2.5 km thick. It consists of a sequence of banded iron formations (BIF), dolomites, pyroclastic and hemipelagic shales and felsic volcanics, and is intruded by dolerite sills and dykes. The BIF units of the Hamersley Group host the magnetite deposits of the SIP and the Balmoral South Project.

Fifteen stratigraphic units within the Hamersley group were identified and sampled for the SIP and assessed for their AMD potential. These are summarised in Table 1 below.

Table 1: Stratigraphy Described in the SIP Geological Logs

Code	Name	Number Analysed	Metres of Core Analysed
DOL	Dolerite	16	48
FZ	Fault Zone	3 (also classified as J5)	9
WW	Weeli Wolli	5	15
YS	Yandicoogina Shale	32	96
J6	Joffre Member	16	33
J5	Joffre Member	7	21
J4	Joffre Member	1	3
J3	Joffre Member	3	9
J2	Joffre Member	29	57
J1	Joffre Member	5	9
WS	Whaleback Shale	55	117
D4	Dales Gorge Member	31	75
D3	Dales Gorge Member	34	81
D2	Dales Gorge Member	10	21
D1	Dales Gorge Member	9	27
MS	Mount McRae Shale	11	33

3.1 Weeli Wolli Iron Formation

The Weeli Wolli Formation (WW) lies directly over the Brockman Iron Formation. It appears to have been intersected in some holes (e.g. 06RD039 and 06RD068) in the south eastern area of the SIP. An interpretation of this formation was not included in the SIP model due to lack of data.

3.2 Brockman Iron Formation

As a host for iron ore, the Brockman Iron Formation is the most economically important formation in the Hamersley Province. It is about 600 m thick in the Cape Preston area but the thickness varies across the Pilbara, from 500 m at Paraburdoo and the Newman area to 620 m at Mt Tom Price. It consists of an alternating sequence of BIF, shale and chert, and is subdivided into four Members outlined below:

The Yandicoogina Shale Member (YS) averages 70 to 80 m thick and is a sequence of interbedded chert and shale, in some places intruded by dolerite sills in its upper part. There were 61 samples of YS collected.

The Joffre Member (JF) averages 300 to 320 m thick and is a dominantly BIF sequence with thin (cm scale) minor shale interbeds that are not as laterally persistent as those of the Dales Gorge Member (see below). The Joffre Member was subdivided into six units at SIP based on overall shale content (J1 to J6). The J1, J3 and J5 units have a higher concentration of shale bands. The thickest units are J2 (average 100 m) and J6 (average 130 m).

The Whaleback Shale Member (WS) averages 60 to 70 m thick and can be divided into two zones:

- A lower zone consisting of a shale macroband about 10 m thick.
- An upper zone comprising numerous mesobands of chert, shale and BIF.

This subdivision has not been included in the present interpretation of the Whaleback Shale at the SIP project site. A total of 55 WS samples were collected for the SIP study.

The Dales Gorge Member (DG) averages 150 to 160 m thick and is an alternating assemblage of 17 BIF and 16 shale macrobands, which have been used to subdivide the Member into four units (D1-D4). A total of 84 samples of DG material were sampled for the SIP study.

3.3 Mount McRae Shale

The true thickness of the Mount McRae Shale (MS) is uncertain with drilling generally extending no more than 20 to 30 m into this unit. To check for fault repetition of the Joffre and Dales Gorge members a few holes (06RC001 and 06RD013) penetrated more than 200 m below the top of the MS. No interpretation of subdivisions has been attempted below the top of the MS, which forms the footwall to the major Brockman Iron Formation deposits of the region. There were 11 samples of MS collected for the SIP study.

3.4 Dolerite Dykes

As dolerite dykes are known to intrude the SIP banded iron formation sequence, 16 samples of dolerite were also included in the study.

3.5 Fault Zones

Fault zones have also been identified in the stratigraphic sequence and 3 samples of fault material, located in the J5 unit of the Joffre member, were also tested.

3.6 Balmoral South Project Stratigraphy

From the information received to date from Australasian Resources Limited International Minerals Pty Ltd, the interpretation of the geology in this area differs slightly from the SIP project with the main stratigraphic units being identified as follows:

Table 2: Balmoral South Project - Stratigraphic Units

Unit	Name
1	Mount McRae Shale
3	Dales Gorge BIF
4	Dales Gorge BIF
5	Dales Gorge BIF
6	Whaleback Shale
7	Joffre BIF
8	Joffre BIF

Unit	Name
9	Joffre BIF
10	Joffre BIF
11	Yandicoogina Shale
12	Weeli Wolli BIF
13	Weeli Wolli Dolerite
20	Dolerite Dykes

Golder noted that although the stratigraphy for both the SIP and Balmoral South Projects is similar, it has been described differently in each project. IM included four Joffre sub-units in the Balmoral South classification whereas SIP identified six. Discrepancies were also noted between the number of Dales Gorge units identified at Balmoral South, with either three or four units identified in different documents, i.e. a Technical Memo which provides an extract from the feasibility study report Ref 081208_Section3_FS_GeologyExcerpt.pdf (Table 2) and a spreadsheet of AMD testing data Ref 081103_AcidMineDrainageData.xls (Table 3).

Table 3: Stratigraphical Sub Units for Balmoral South Project – Excerpt from Technical Memo

Unit	Name
MS	Mount McRae Shale
D1	Dales Gorge Basal Shaley
D2	Lower Dales Gorge
D3	Dales Gorge Middle Shaley
D4	Upper Dales Gorge
WB	Whaleback Shale
J1	Joffre Basal Shaley
J2	Lower Joffre
J3	Joffre Middle Shaley
J4	Upper Joffre
YS	Yandicoogina Shale
WW	Weeli Wolli BIF
WD	Weeli Wolli Dolerite Sills

4.0 LITHOLOGY – SIP

Twelve lithological units have been identified and characterised from geological logs in the SIP study. The lithological units are listed in Table 4 below.

Table 4: Lithology Described in the SIP Geological Logs

Code of Rock/Soil Type	Description
ALL	Alluvium
BIF	Banded Iron Formation
CHT	Chert
CID	Channel Iron Deposit
CLY	Clay
DMT	Dolomite
DOL	Dolerite
FLT	Fault or Shear Zone
MIS	Massive Iron Stone
QTZ	Quartz
SBR	Silica Breccia
SHL	Shale

5.0 LITHOLOGY – BALMORAL SOUTH

No detailed lithological information has been provided for the Balmoral South units and therefore at present no comparison can be made with the SIP lithological data. The only descriptors provided for lithology are BIF, Shale and other:

Table 5: Balmoral South Stratigraphy Described by IM

Stratigraphy
BIF (Dales Gorge, Joffre and Weeli Wolli)
Shale (Yandicoogina, Whaleback and Mount McRae Shale)
Other (Dyke)

The descriptors provided in the AMD test data Ref 081103_AcidMineDrainageData.xls appear to be black shale (BSH), shale (SHL), chert (CHT), and banded ironstone formation (BIF).

Due to these inconsistencies in identifying which stratigraphic unit each lithological type belongs to, the data sets for SIP and Balmoral can only be compared by lithology.

6.0 TECHNICAL BACKGROUND

6.1 Approach for SIP

The approach applied to the SIP for assessing AMD was primarily based on Acid Base Accounting procedures described in (AMIRA, 2002 and Price, 1997) using Net Acid Production Potential (NAPP) and the MPA to ANC ratio as a function of total sulphur concentration and acid neutralising capacity (ANC) (Sobek, 1978 method).

Additional tests were conducted on 30 of the 264 samples to provide supplementary information for AMD classification. These included:

- the chromium reducible sulphur test (Ahearn et al. 2004a) to measure the sulphide portion of total sulphur;
- metal leaching potential (MLP) of representative samples using the USEPA synthetic precipitation leaching procedure (SPLP) method; and
- the single addition net acid generation (NAG) test as an independent test for acid generation potential.

The risk of acid generation is a function of various factors, primarily related to mineralogy. The evaluation of the static geochemical data is thus based on application of appropriate analytical methodologies to the available samples, as well as correlating analytical data with available literature values.

Using ABA data, the methods described in Price 1997 are used to classify the samples on the basis of Maximum Potential Acidity (MPA) and Acid Neutralising Capacity (ANC). Four categories exist for this classification, based on the ratios of MPA to ANC. They are defined in Table 6 below:

Table 6: ABA Classifications According to Price (1997)

AMD Classification	ANC/MAP Ratio
Likely acid forming	<1
Possibly acid forming	>1 and <2
Low probability of acid formation	2 to 4
Non Acid Forming	>4

Additional criteria that can be used for this data are also provided in Price (1997) and AMIRA (2002), namely:

- Rocks that are not highly depleted in base cations are unlikely to generate acid leachate if they contain less than 0.3% sulphur (Price, 1997).
- Where NAPP is <0 kg H_2SO_4 per ton (DoITR, 2007) or <-20kg/ton H_2SO_4 (Price 1997), AMD is unlikely.
- Where NAPP is >0 kg H_2SO_4 per ton and <5 kg H_2SO_4 per ton (DoITR, 2007), a low capacity for AMD exists.
- Where NAPP is >5 kg H_2SO_4 per ton (DoITR 2007), a significant potential for AMD exists.

Where NAG test data are available, the (DoITR.2007) classification scheme is used, i.e. the NAPP and NAG values are used to classify material into four categories (see Table 7), i.e:

- Potentially Acid Forming (PAF);

- Potentially Acid Forming-Low Capacity (PAF-LC);
- Non Acid Forming (NAF); and
- Uncertain (UC).

An additional classification of Acid Consuming (AC) included in the DoITR (2007) guidelines is not considered for this study, as this classification is considered to be controversial, as it raises the potential for misinterpretation as a neutralising material, which may be inappropriate in some cases. The classification does not consider an inherent risk that an acid load can be released from AC material itself if the material is mixed as a neutralising agent with an excessive quantity of PAF material.

It should also be noted that this classification is based solely on the NAPP calculated from ABA data and does not consider whether materials will behave as classified, nor the MPA to ANC ratio. To account for these deficiencies, the data are discussed in the context of the known mineralogy of the Hamersley Group strata.

Table 7: AMD Classification Scheme (DoITR, 2007), with Additional Criteria for AF and AC Materials

Category	NAPP Value (kg H_2SO_4 / tonne)	NAG pH	Description
Potentially Acid Forming (PAF)	> 10	<4.5	This material has a high probability of generating AMD.
Potentially Acid Forming Low capacity (PAF-LC)	0 to 10	<4.5	This material has the potential to generate AMD, depending on local site conditions, material properties and mineralogy.
Uncertain*	>0	≥4.5	This material has some potential to generate AMD, however, it is unlikely to be severe.
	<0	<4.5	This material has some potential to generate AMD, however, it is unlikely to be severe.
	>0	<4.5	This material has some potential to generate AMD, however, it is unlikely to be severe.
Non Acid Forming (NAF)	< 0	≥4.5	This material is unlikely to result in AMD, but may generate it under some circumstances, depending on site conditions and material properties. NMD is possible.

*Site –specific but typically in the range 5 to 20kg/ton H_2SO_4 equivalents.

The above classifications assume that full oxidation of sulphide minerals could occur, and that the measured acid neutralising capacity could be fully realised. Additionally, it is assumed that all sulphur is present as pyrite and that all ANC is present as calcite. These assumptions are not necessarily valid and must be verified with additional mineralogical data and appropriate tests such as reactive ANC titrations, which are also discussed.

It is important to note that certain field conditions may result in AMD processes that are non-stoichiometric with respect to reactions between acid neutralising materials and acidic drainage, thus justifying a more conservative approach than the AMIRA (2002) classification criteria. For this reason, the classification used by Price et al. 1997 is preferred for ABA data, although the AMIRA (2002) approach is also considered.

Some of the field conditions that may result in non stoichiometric reaction of Acidity and alkalinity include:

- Trapping of CO_2 gas that prevents the full consumption of alkalinity.

- Flushing of partially reacted alkalinity in mine decants or seepage discharges, thus resulting in only partial consumption. For complete reaction of carbonate alkalinity, acidity would have to consume ANC at a pH of 4.5, which only occurs under field conditions once the process of acidification is almost complete.
- Differential reaction kinetics, resulting in carbonate dissolving in water faster than sulphides react.
- Armouring of neutralising minerals.

These are only some of the potential influences on the effectiveness with which ANC neutralises acidity, but serve to provide some understanding of the requirement for ANC to be present in significant excess to MPA.

On a non-conservative basis, it is thus assumed that a stoichiometry of at least 2 kg H_2SO_4 ANC per ton should be available to neutralise 1 kg H_2SO_4 per ton of available acidity (typically MPA_{CRS}).

Taking the above considerations into account, changes to the classification may occur following from analysis of other static data and data from the kinetic weathering tests.

Both SIP and Balmoral South data were interpreted based on the above classifications.

6.2 Sampling Strategy

It should be noted that the way in which samples are collected can impact on the data acquired for each sample. Differing geochemical signatures may be recorded which are an artefact of the sampling methods rather than an expression of the variability of the rock chemistry.

For the SIP sample selection was based on lithology originally, but was later correlated to stratigraphy as well. Samples were collected throughout the stratigraphic profile. The excerpt from the Balmoral South Public Environmental Review (PER) document provided by IM mentions that the samples collected for AMD testing were selected based on their stratigraphy and sulphur content and that all samples were from depths of greater than 200 m.

For the sampling undertaken by IM for the Balmoral South project, not all lithologies have been sampled. The strategy adopted for sampling for Balmoral South appears to have focussed on the shale units and sulphur containing BIF. As a consequence of this, the degree to which it will be possible to discuss the use of waste material for blending any acid generating material as a management strategy will be limited to an extrapolation of the data acquired through the SIP investigation with little direct correlation to the Balmoral samples.

7.0 RESULTS

In the following sections, the results from the work undertaken for the SIP project are presented first and then a comparison to the data collected for the Balmoral South Project will be made.

7.1 Static Testing

7.1.1 Acid Base Accounting (ABA)

This section of the report summarises the results that were obtained for static tests on the basis of lithological and stratigraphic classifications that can be correlated to the geological block model and thus also the mine plan.

7.1.2 $pH_{1:5}$ Compare to Total Sulphur and ANC - SIP

Useful plots comparing pH with associated ABA data are reported from Figure 2 to Figure 3. The following can be observed from this data:

- Crushed $pH_{1:5}$ (pH at 1:5 solid to water ratio) values are generally alkaline, although there is a decrease in the pH with increasing sulphur concentration.
- The pH range at which buffering occurs indicates the presence of alkaline minerals, e.g. calcite, dolomite and/or ankerite. More alkaline minerals, buffering at high pH (>8.5) values, must be present in small quantities, as the buffering pH range reaches to pH 10 in some cases.
- Higher buffering $pH_{1:5}$ values are associated with samples containing more than approximately 30 to 40 kg H_2SO_4 per ton equivalents of ANC. This confirms that buffering is significant in the samples analysed.

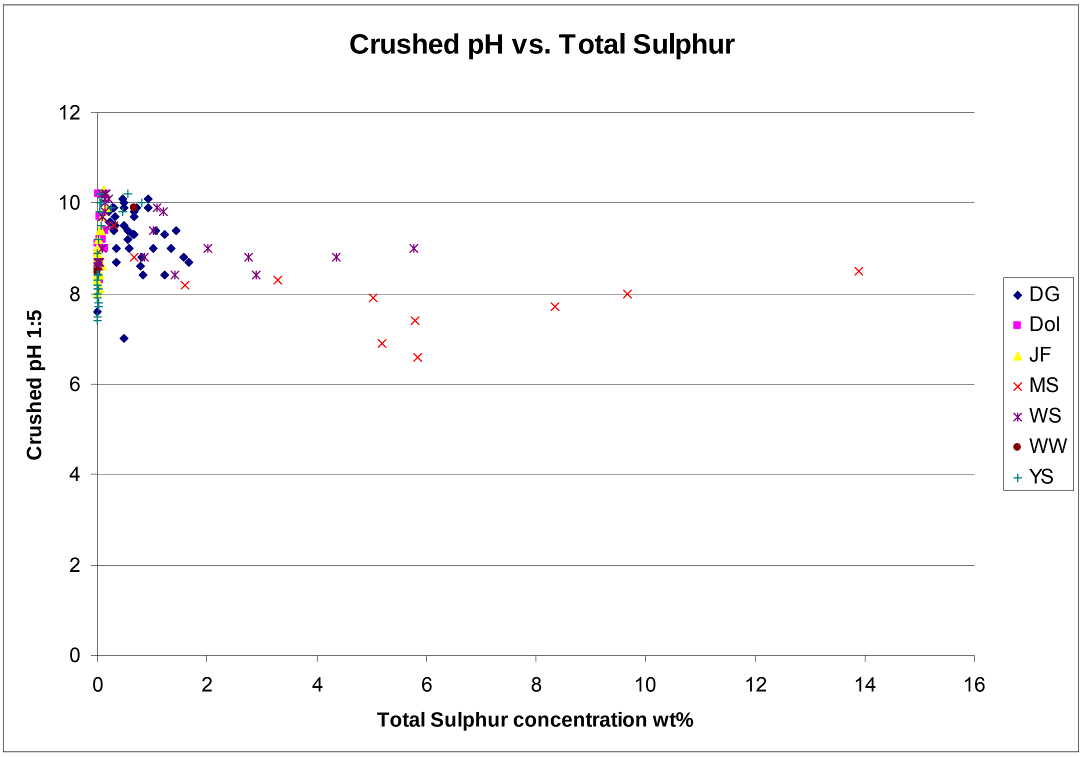

Figure 2: Total Sulphur wt% vs. Crushed $pH_{1:5}$

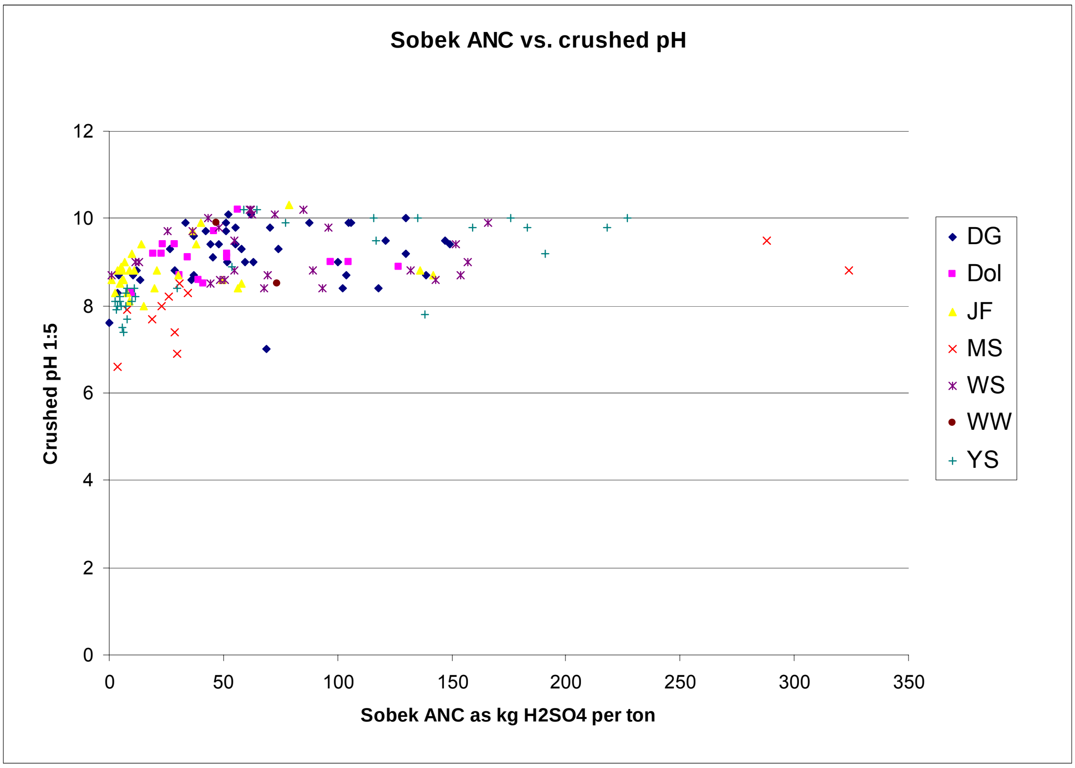

Figure 3: Sobek ANC vs. Crushed $pH_{1:5}$

7.1.3 Comparison of $pH_{1:5}$ to Total Sulphur and ANC – Balmoral South

From these data presented in Figure 4 and Figure 5, the following can be concluded:

- Crushed $pH_{1:5}$ values are generally alkaline.
- There is a slight decrease in pH with increasing sulphur content.
- The pH range at which buffering occurs indicates the presence of alkaline minerals, e.g. calcite, dolomite and/or ankerite. More alkaline minerals, buffering at high pH (>8.5) values, must be present in small quantities, as the buffering pH range reaches to pH 10 in some cases.
- All samples analysed have some buffering capacity.

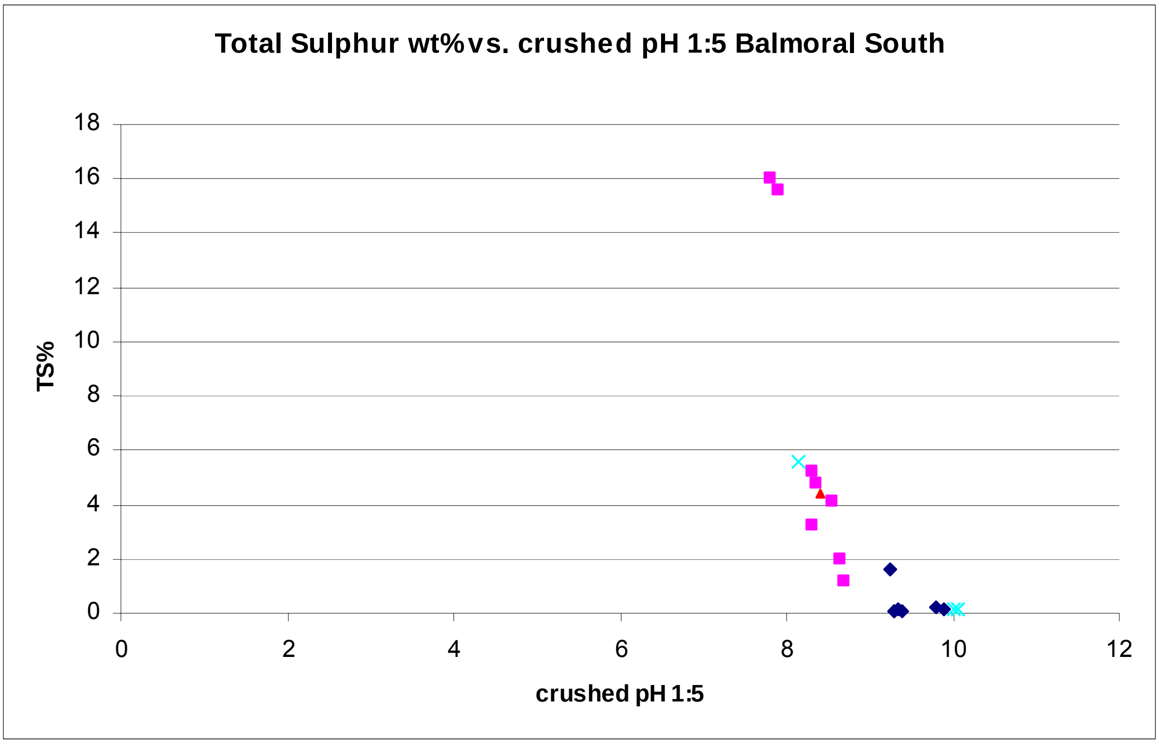

Figure 4: Total Sulphur wt % vs. Crushed $pH_{1:5}$

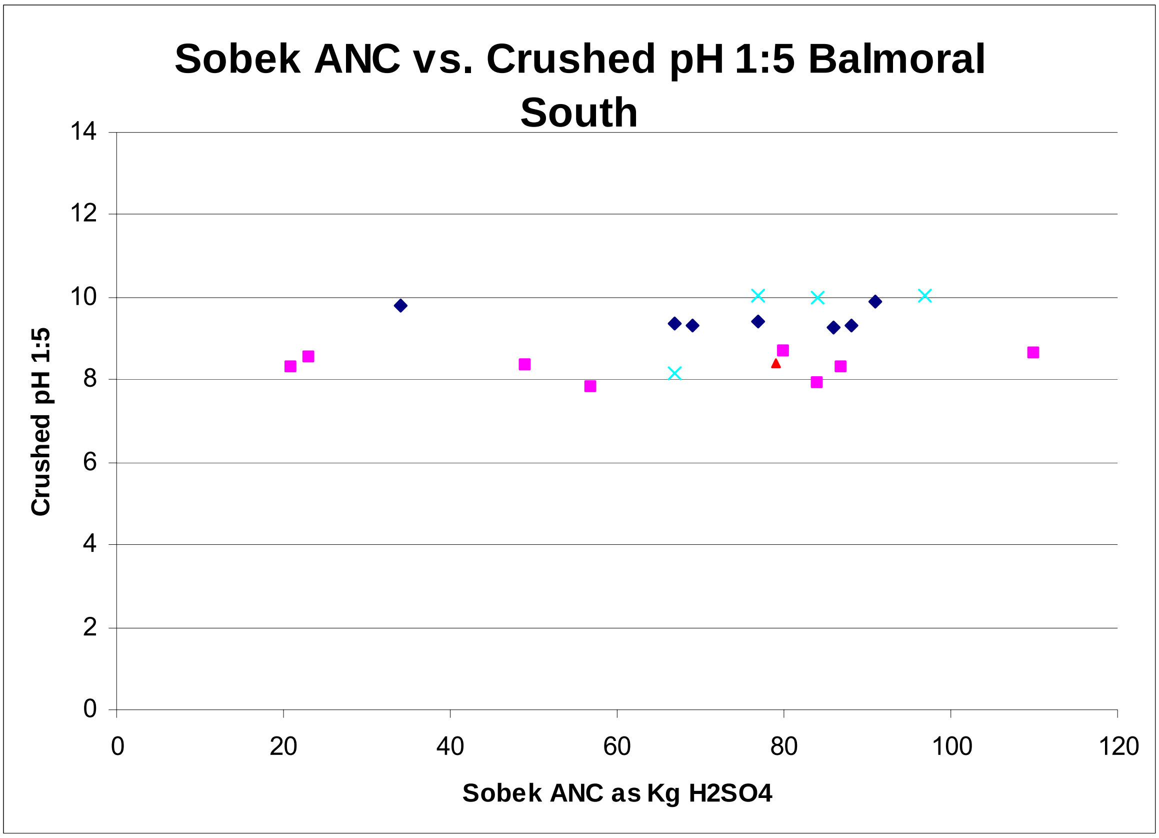

Figure 5: Sobek ANC vs. Crushed $pH_{1:5}$

7.1.4 Acid Formation and Acid Neutralising Capacity – SIP

7.1.4.1 ANC – SIP

The Acid Neutralising Capacity (ANC) of the SIP samples was assessed using a variety of techniques. In addition to the laboratory data, which included total ANC analysed using the modified Sobek method (ANC_{mSOBEK}), reactive ANC (ANC_{RT}) titrations and available mineralogical data; literature sources from Trendall and Blockley (1970), as well as Townsend (2008) were used to interpret the data.

7.1.4.2 Total Acid Neutralising Capacity and Net Acid Production Potential - SIP

The total acid neutralising capacity (ANC_{mSOBEK}) for the 264 samples collected for SIP ranged from 0 kg H_2SO_4 per tonne to 324 kg H_2SO_4 tonne with a mean value of 58 kg H_2SO_4 per tonne. The NAPP of the SIP materials analysed is highly variable, with a mean value of -41.6 kg H_2SO_4 per ton, a minimum of -303 kg H_2SO_4 per tonne and a maximum of 400 kg H_2SO_4 per tonne.

These data are indicative that the majority of samples are Non Acid Forming (NAF) or have a low capacity to produce acidity, although there is significant variability between likely Acid Forming (AF) and NAF material. These classifications must, however, be refined by applying the results of reactive ANC tests and mineralogy.

Considering the recorded Net Acid Production Potential (NAPP) distribution in the SIP samples it is evident that most SIP samples contain some neutralising capacity, although the use of ANC_{mSOBEK} is not suitable for demonstrating the ability of a sample to buffer acidity at environmentally acceptable levels, unless all the measured buffering capacity is contained in calcite or dolomite. It is thus necessary to correlate these results with mineralogical data and reactive ANC test data to obtain a conclusive understanding of available buffering capacity.

7.1.5 Total Sulphur - SIP

The Total Sulphur (TS) concentrations for the 264 samples ranged from <0.01 to 13.9 % with a mean value of 0.53%. MPA_{TS} results derived from total sulphur for the 264 samples ranged from 0 kg H_2SO_4/tonne to 425 kg H_2SO_4/tonne with an average value of 16 kg H_2SO_4/tonne. The distribution of total sulphur concentrations is shown in Figure 6. It can be seen from this data that most samples contain approximately 1% to 2% sulphur and that higher and lower concentrations are the exception, rather than the rule. The scatter plots in Figure 2 above show that these samples are all associated with the Mt. McRae Shale and Whaleback Shale stratigraphy.

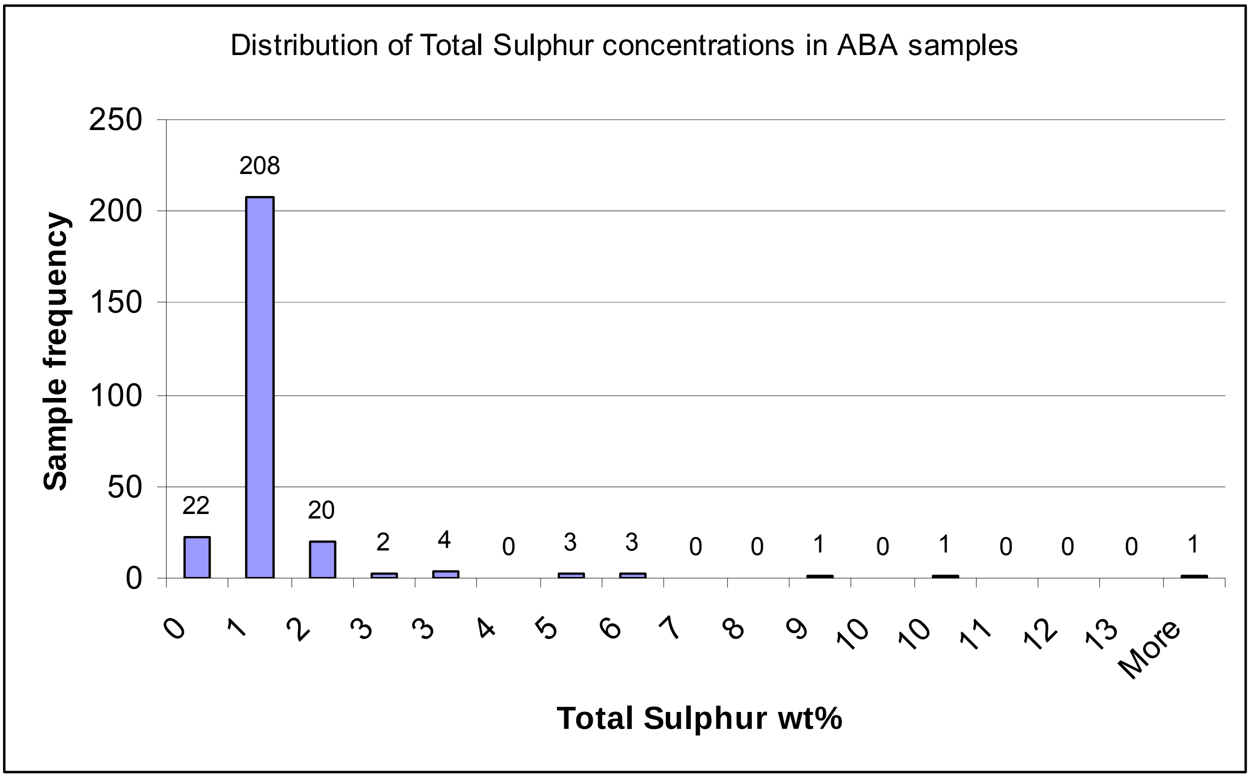

Figure 6: Total Sulphur Distribution for SIP Samples

Using the ANC/MPA criteria for acidic drainage, as set out in Price 1997, it can be seen from Figure 7 that most samples do not classify as likely acid forming at SIP, but are instead likely to be non acid forming (NAF). However, it is pertinent to note here that the statistical confidence level for lithologies where less than ten samples have been analysed is low. What this analysis also shows is that most samples with either high MPA or high ANC values are shales. Only shales and cherts appear to have highly variable ABA characteristics at SIP, although dolomite also varies between PAF and NAF classifications in the five samples analysed, which indicates that ANC is not as dominant in this material as might be expected from its lithological classification.

A plot of NAPP vs. TS wt% Figure 8 below supports the conclusions drawn and also indicates that most samples collected for the SIP for the various materials, except the MS, have negative NAPP values, i.e. more ANC than MPA. Additionally, it is notable that besides two WS samples, only MS samples have any NAPP values that exceed 20 kg H_2SO_4 per ton of material.

Other lithologies also vary considerably with respect to ABA characteristics at SIP, but are mostly NAF and contain lower MPA and ANC concentrations. Lithologies other than SHL, CHT and DMT all classify as having low or no likelihood of becoming acidic.

The scattered data indicates that both sulphur and neutralising minerals may be disseminated within the various lithologies at SIP. It is not known whether any controls exist that determine the distribution of reactive minerals, including either geochemically, stratigraphically or structurally determined mechanisms.

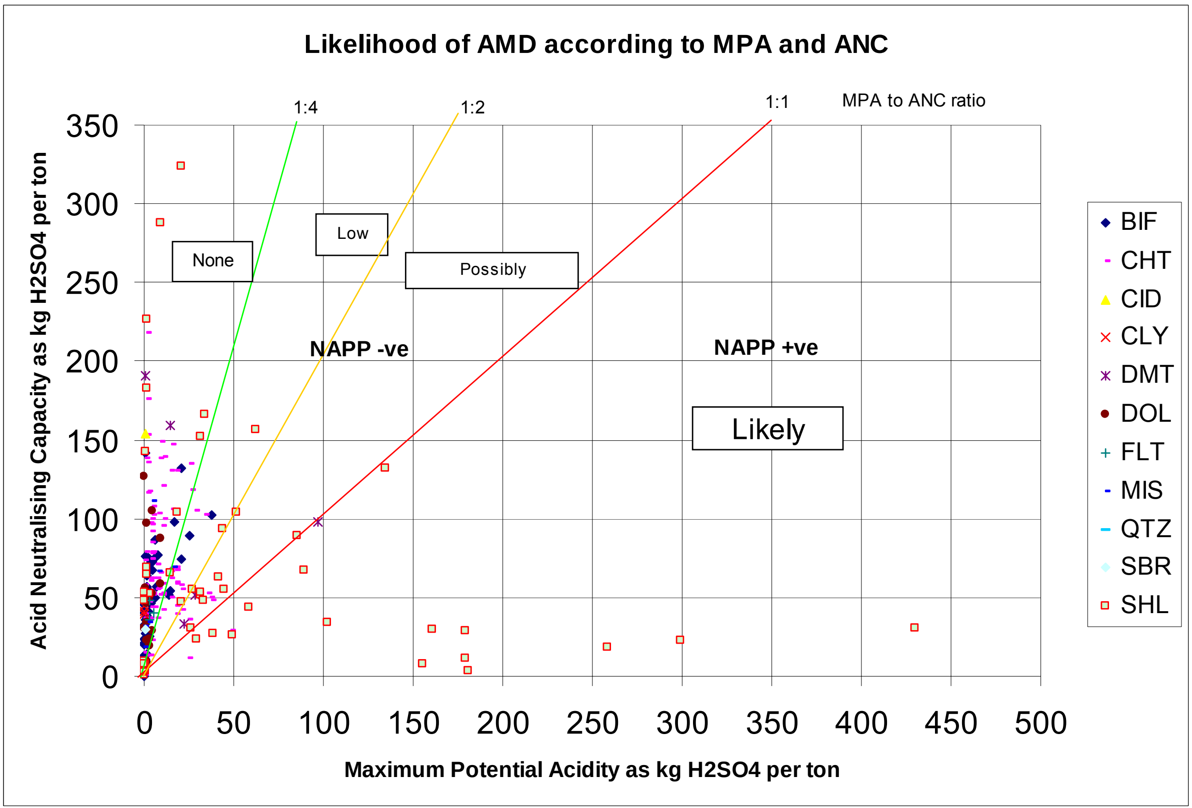

Figure 7: Likelihood of AMD According to Lithology (Price 1997 method) – SIP

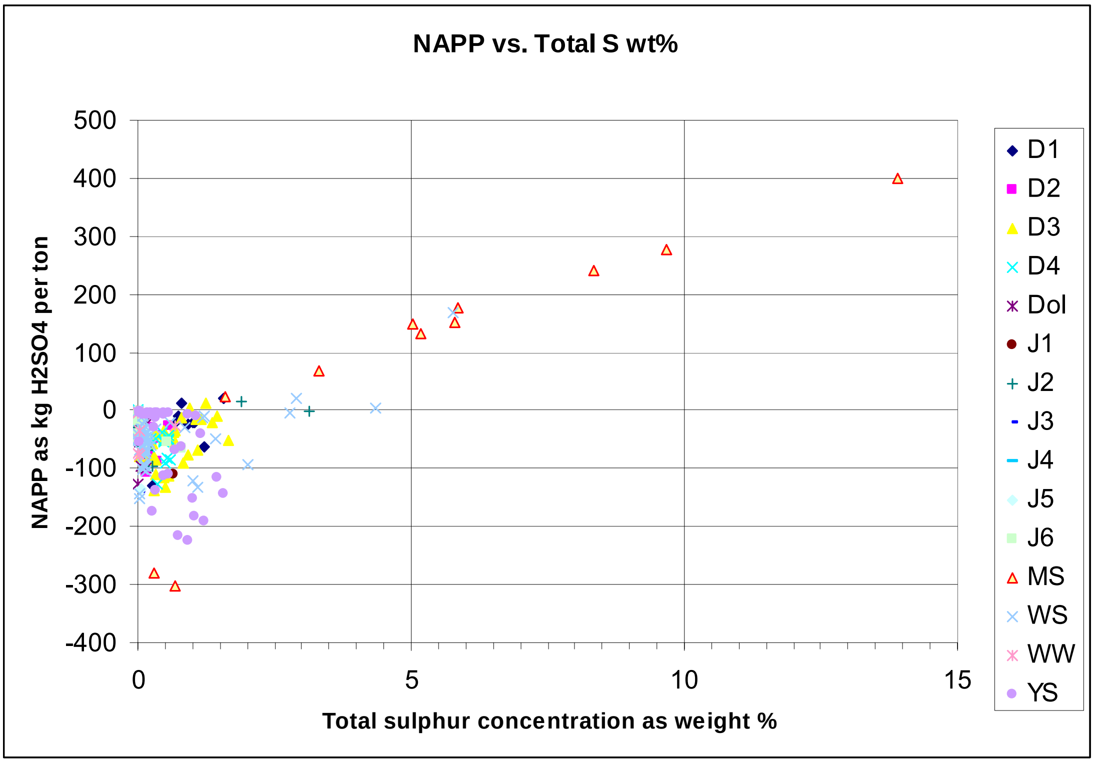

Figure 8: NAPP vs TS_5

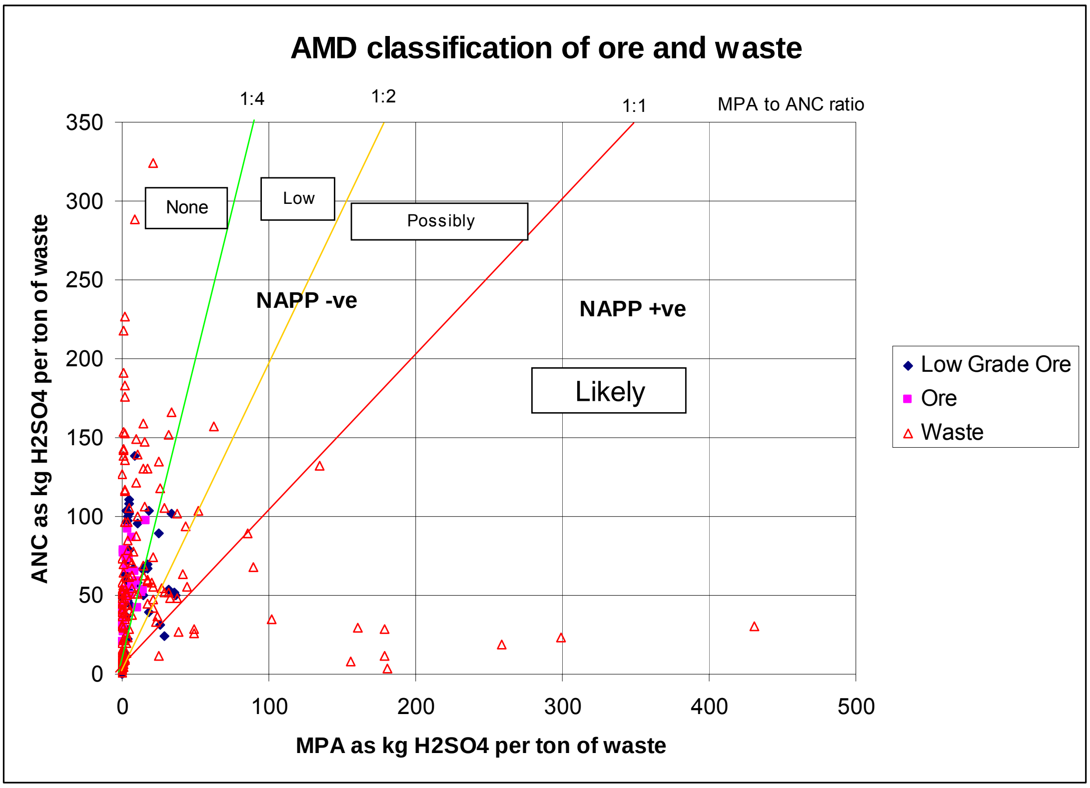

Figure 9: ABA Classification of Samples Using Davies Tube Recovery Test to Define Economic Classification of the SIP Samples According to Price 1997.

For the SIP investigation, overburden oxide samples were identified and classified according to the criteria of Price (1997), as shown in Figure 10. This data indicates that the majority of oxide overburden materials for SIP are NAF and that samples classifying in other fields contain relatively low sulphur concentrations, which may already be present as sulphate, rather than sulphide.

The only sample amongst the oxidised samples that classified as PAF for SIP was a dolerite sample, with a significant excess of ANC_{mSOBEK} present for most SIP samples.

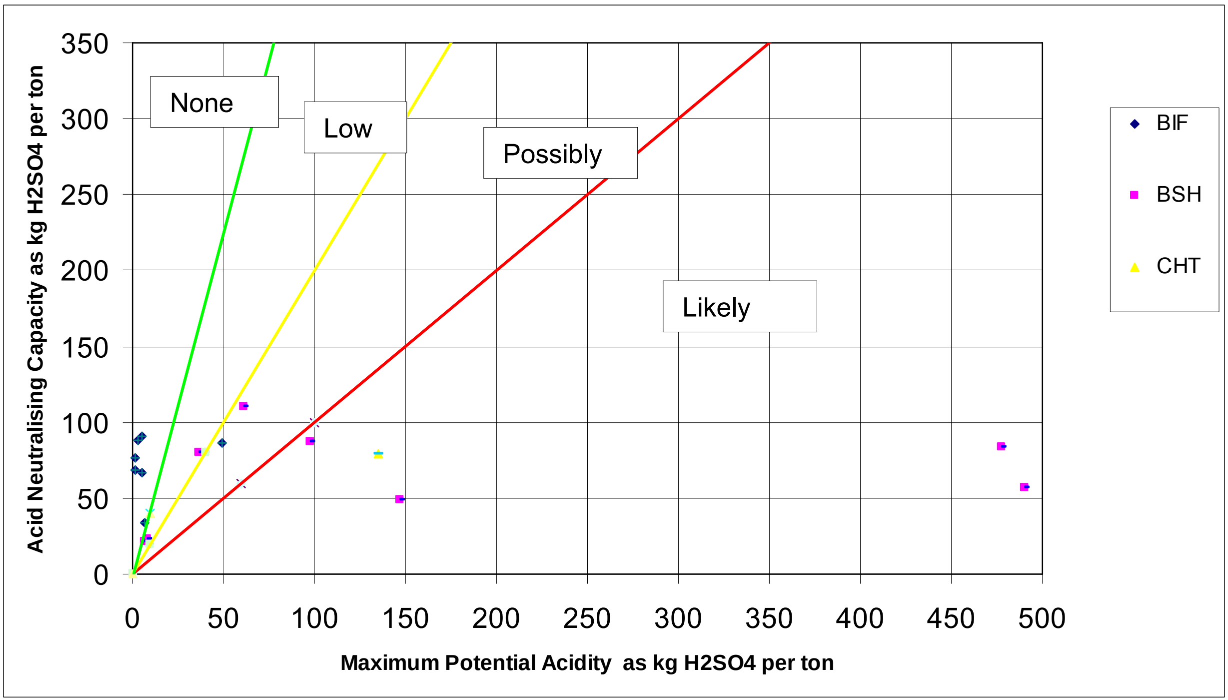

Figure 10: Likelihood of AMD in Oxide Overburden Material (Price 1997)

7.1.6 Acid Formation and Acid Neutralising Capacity – Balmoral South

The Total Sulphur (TS) concentrations for the 20 samples from Balmoral South ranged from <0.01% to 15.6% with a mean value of 3.4%. MPA_{TS} results derived from total sulphur for the 20 samples ranged from 1.2 kg H_2SO_4/tonne to 490 kg H_2SO_4/tonne with an average value of 104 kg H_2SO_4/tonne. Most samples contain approximately 1% to 2% sulphur with higher and lower concentrations being the exception rather than the rule. These data concur with the findings for SIP.

On closer inspection of these data, the higher TS values are all associated with the Mt. McRae Shale and Whaleback Shale stratigraphy. As a whole it should be noted that the data is skewed due to the sampling being based on sulphur content.

As undertaken for SIP samples, the ANC/MPA criteria of Price (1997) classify most Balmoral South samples outside the area of likely AMD formation, with most samples having an ANC/MPA ratio of 1:1. The low number of samples limits the confidence with which conclusions can be drawn from this data, however.

A plot of NAPP vs TS% for the Balmoral South samples analysed to date, supports the assertion that the lithologies analysed in this study have a relatively low likelihood of generating acidity with the exception of the highest sulphur bearing shales (Whaleback and Mt. McRae shale TS% 2-15.6). A correction for reactive ANC suggests that a lower TS% cut off of between 0.3% and 0.5% would be more appropriate than that implied by the use of NAPP, however.

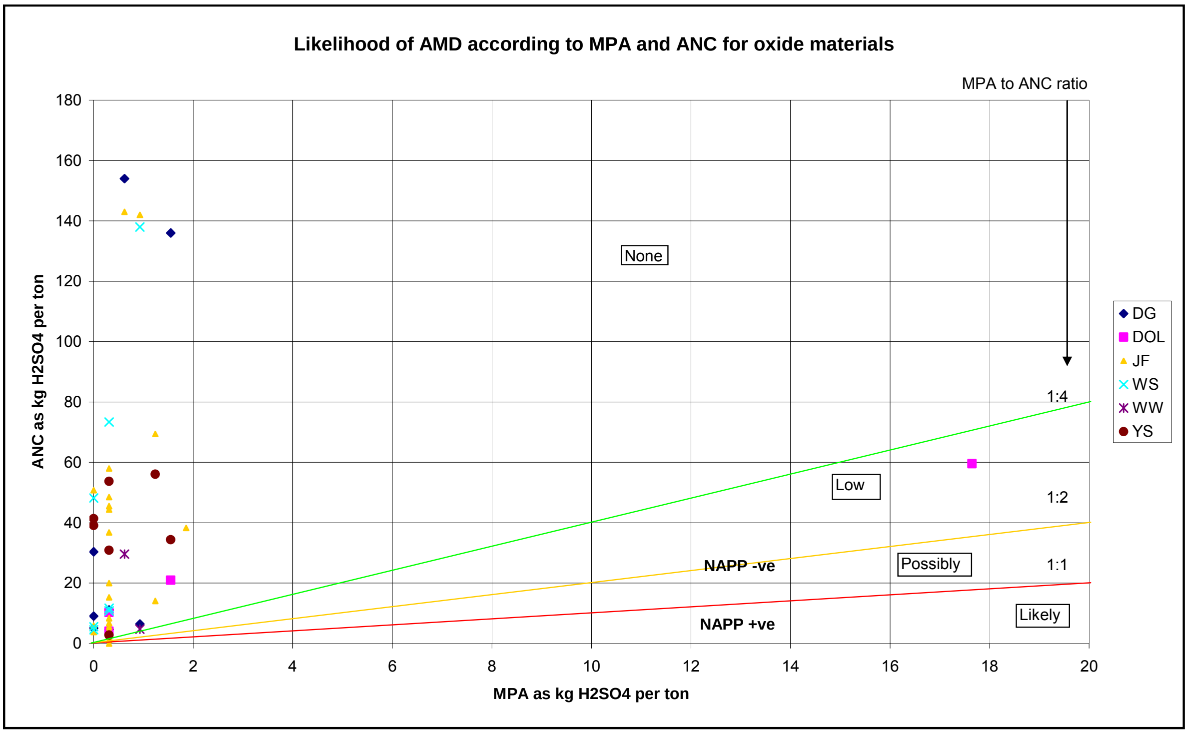

Figure 11: MPA vs ANC for Balmoral South

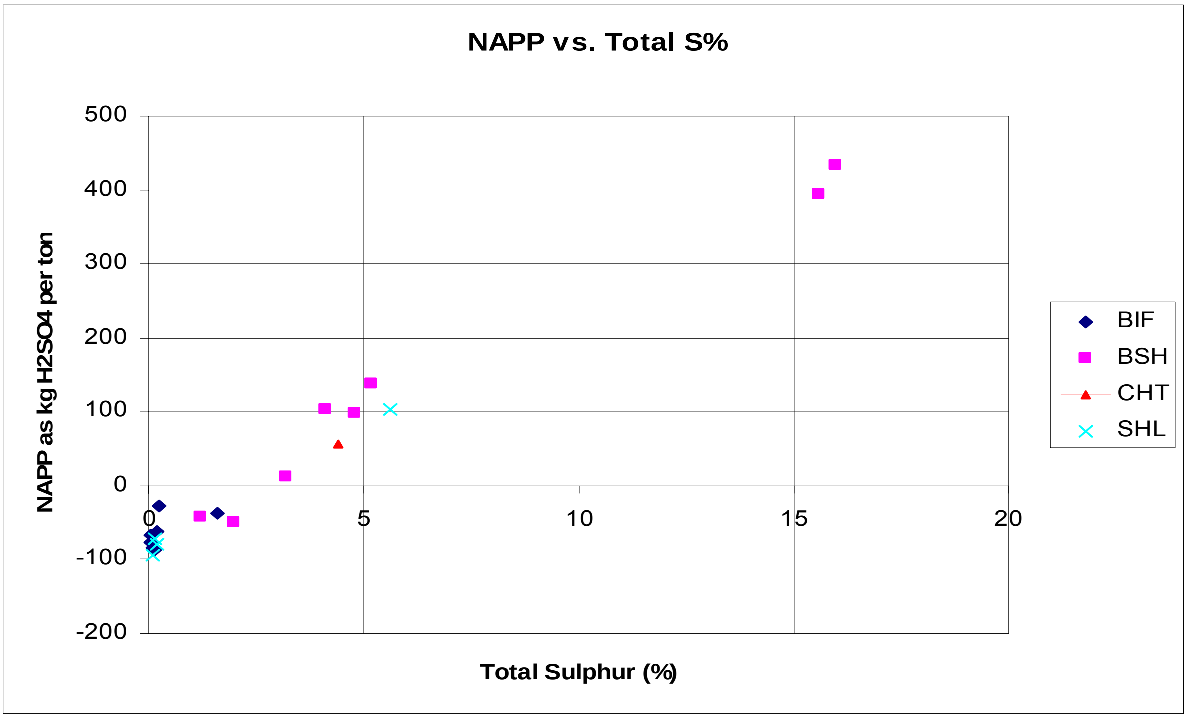

Figure 12: NAPP vs Total Sulphur for Balmoral South

7.1.7 Net Acid Generation (NAG) - SIP

NAG tests were included in the suite of 30 samples that were submitted for further analysis for SIP. The results for these tests are plotted against NAPP in Figure 13 according to the system reported in AMIRA (2002).

The results for this plot are indicative that most samples other than the MS are NAF, with only a few DG samples plotting outside the NAF field. The AF characteristics of the MS are confirmed by this plot.

It should be noted that the NAG tests conducted for these samples were the single addition NAG test, so it is possible that samples with more than 1% sulphide could be reported with a lower than actual NAG potential. In practice this implies that samples with more than 1%S could incorrectly classify as UC according to the NAG test results, when they are actually PAF. The interpretation of ABA characteristics must thus rely on other static and kinetic data to clarify the AMD characteristics of the materials. From inspection of plots containing TS (see Figure 6 and Figure 8), the samples containing above 1% S are in the minority, but include samples from the MS, WS and DG members of the Brockman Iron formation.

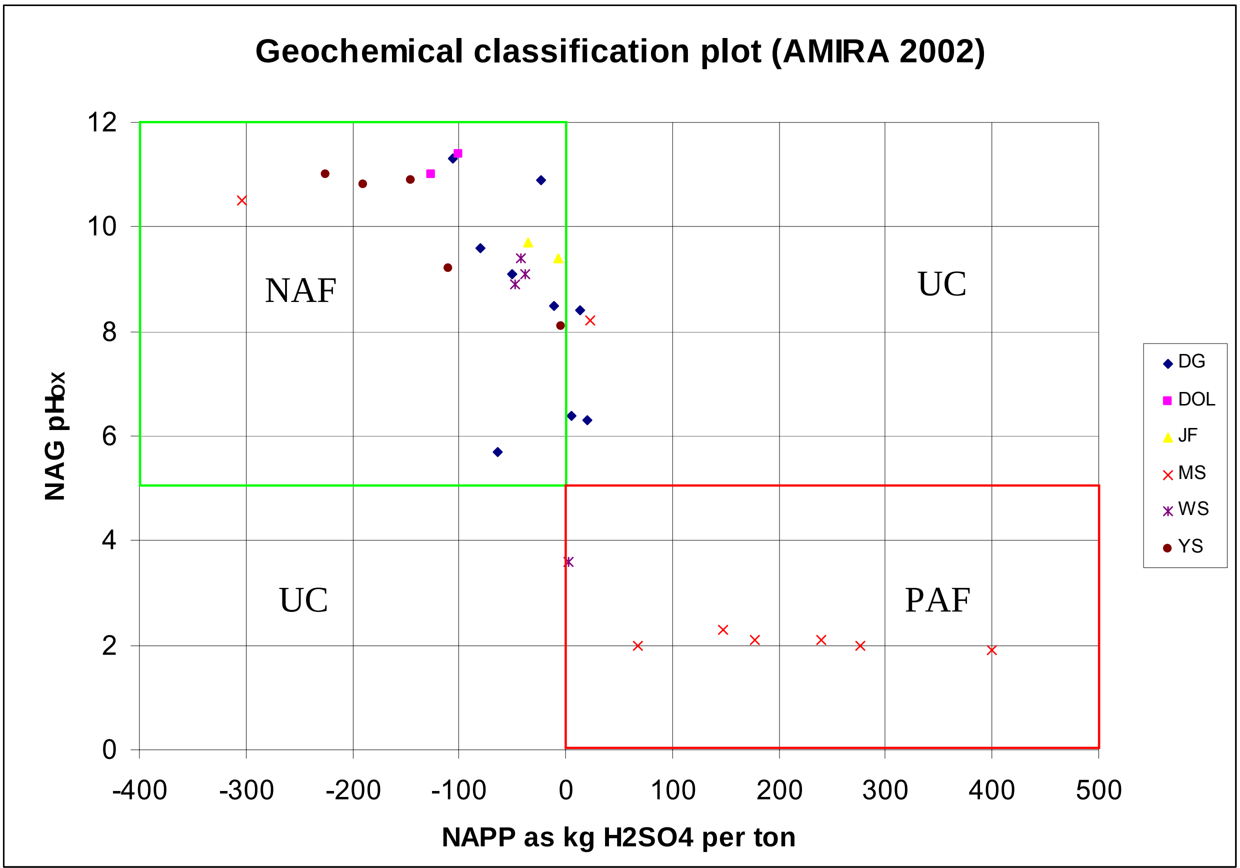

Figure 13: NAG vs. NAPP Plot for Selected SIP Samples

7.1.8 Net Acid Generation (NAG) – Balmoral South

According to the AMIRA (2002) classification scheme 6 of the 20 samples analysed for the Balmoral South project classify as PAF, 4 fewer than the classification provided by IM in the data set provided to Golder. As explained in the previous section, this discrepancy may be due to the test method, which discriminates against samples with more than 1%S, as well as differences in classification using different indicator criteria.

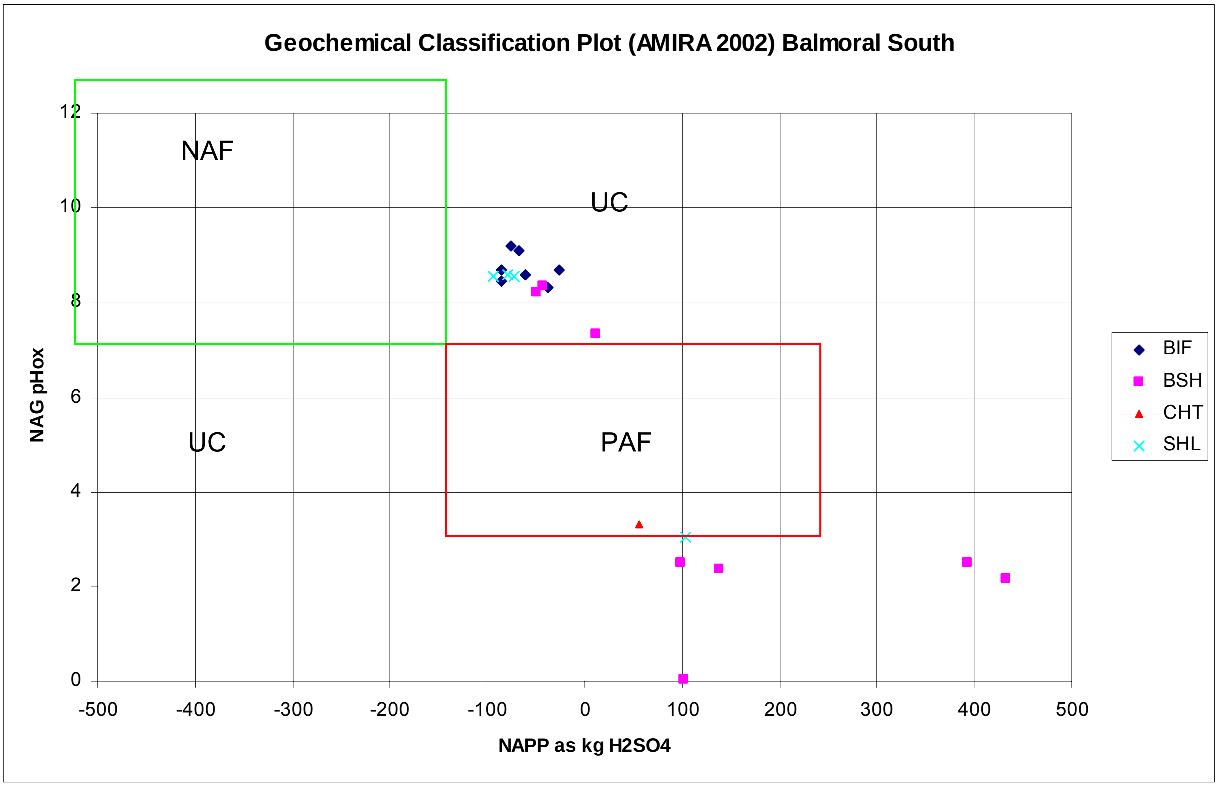

Figure 14: Geochemical Classification Following AMIRA 2002 for Balmoral South

7.2 Additional Analysis Undertaken on SIP Samples

Sulphur speciation and reactive ANC analysis was undertaken on a selection of SIP samples to further assess the likelihood of AMD formation by gaining a better understanding of the type of sulphur present in the samples and the availability of the neutralising capacity. The methods of assessing these are through chromium reducible sulphur (CRS) and ANC_{RT} respectively.

7.2.1 Sulphur Speciation Using CRS - SIP

Sulphur speciation was undertaken on 30 samples using the CRS method. A comparison of the CRS data and TS data for thirty samples shows a strong correlation, as can be seen by the proximity of most samples to the 1:1 ratio line in Figure 15. On a linear scale, an r^2 value of 0.97 is obtained for this data. A histogram of CRS to Total S ratios (Figure 16) indicates that most samples contain more than 80% as sulphide, although there are outliers.

Overall it is indicated that sulphur is present predominantly in the form of sulphide minerals, rather than other sulphur species. Some samples, mostly in the Dales Gorge member, contain significant concentrations of other sulphur species, most probably in the form of sulphate minerals.

The above observations thus imply that for practical purposes TS can be assumed to be attributable to sulphide minerals. Some exceptions to this rule may occur, particularly in the oxidised overburden, although insufficient samples were analysed to characterise all strata reliably. The assumption that all sulphur is present as sulphide is conservative, if not accurate, for the purposes of AMD assessment.

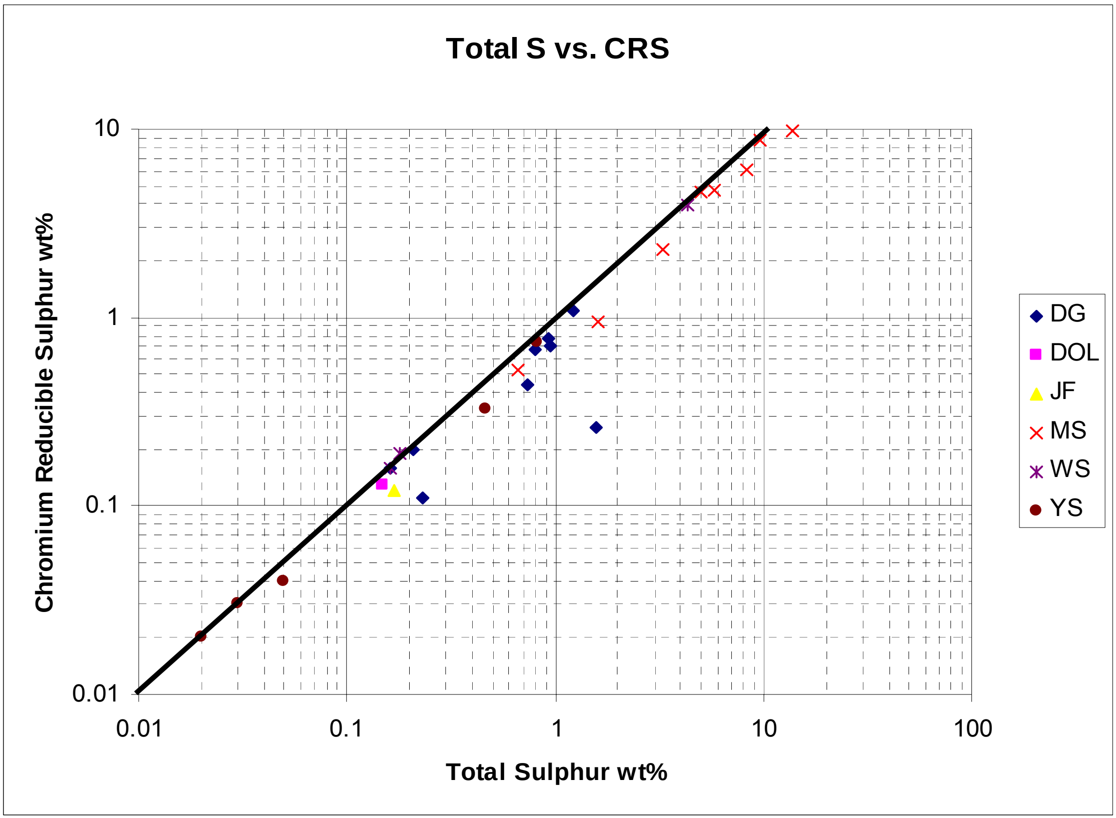

Figure 15: CRS wt% vs. TS wt%

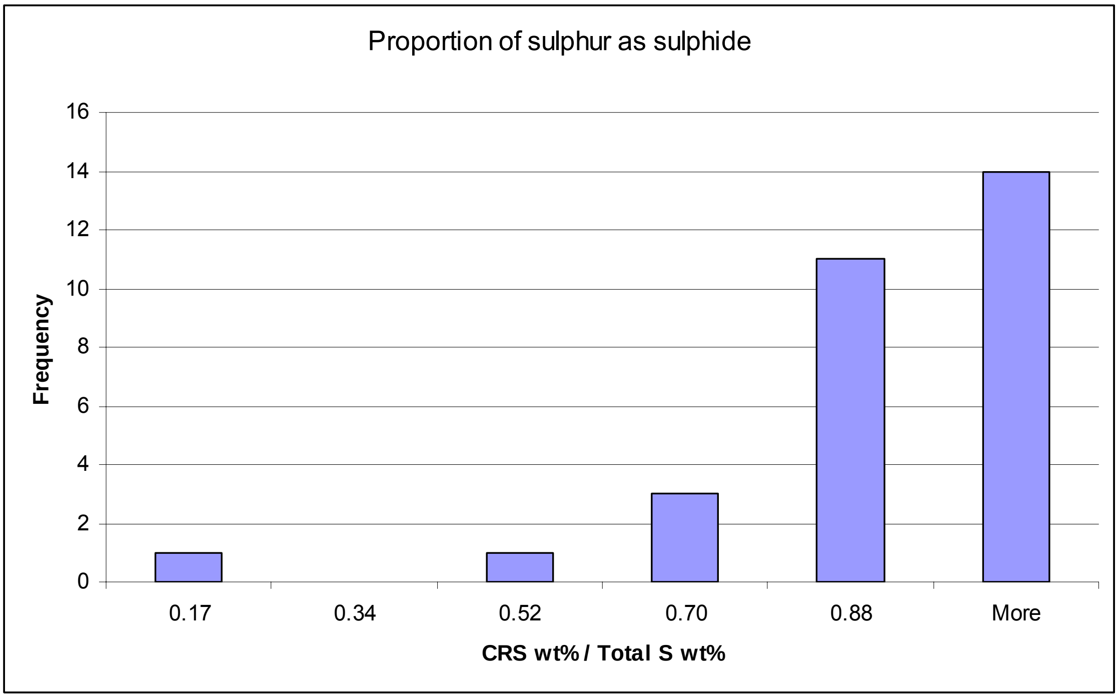

Figure 16: Proportion of Sulphur as Sulphide Minerals Calculated Through CRS/TS

7.2.2 Reactive ANC (ANC_{RT}) - SIP

The readily available or reactive proportion of ANC, identified as ANC_{RT}, is likely to provide immediate buffering of any acid generation.

Results of the ANC_{RT} tests done on 30 samples record that between 5% and 43 % of the total ANC measured using the ANC_{mSOBEK} method may be available as ANC_{RT}. The average values for reactive ANC per lithological unit are generally between 10% and 20%, with a mean of 18% for all samples tested. The following mean values for ANC_{RT}, as a percentage of ANC_{mSOBEK}, were obtained for each lithological unit tested: YS (19.5), JF (26.5), WS (17.8), DG (20.9), MS (15.6), DOL (11.5).

The measured values thus show that ANC_{RT} accounts for a minor proportion of the ANC_{mSOBEK}. This observation thus requires caution with respect to applying ANC_{mSOBEK} when classifying samples for ABA characteristics. The implications for these results are that some samples classify in the uncertain or NAF fields using ANC_{mSOBEK} but are PAF according to ANC_{RT}. In Figure 17and Figure 18 ABA plots are presented using measured ANC_{RT} values and values calculated through a correction using the means reported above for different strata respectively.

From these figures it can be deduced that according to ANC_{RT}:

- Mt. McRae Shale is PAF in all but two cases.
- Whaleback Shale classifies as NAF in most cases according to calculated values, but is generally PAF according to measured ANC_{RT}. Besides Mt. McRae Shale, Whaleback Shale has the highest MPA values of the various lithologies.
- D1 classifies as PAF in the majority of cases, with one sample in the low likelihood field.
- D2 varies between PAF and NAF, but is generally at or above a 1:1 ANC/MPA ratio.
- D3 has a significant tendency to be PAF, although the classification of these materials varies between PAF and NAF.
- D4 varies between PAF and possibly acid generating. It contains a relatively constant sulphur concentration for most samples. The ABA classification is more closely associated with variable ANC than MPA.
- Joffre Members are generally low in sulphides and classify as NAF in most cases.
- Yandicoogina shale remains predominantly NAF and tends to contain higher concentrations of ANC than other materials.

The implications of this are that the Dales Gorge and WS samples may also be PAF, along with the MS samples, albeit to a lesser extent. This is likely to be due to the occurrence of carbonate alkalinity in ankerite, rather than calcite or dolomite.

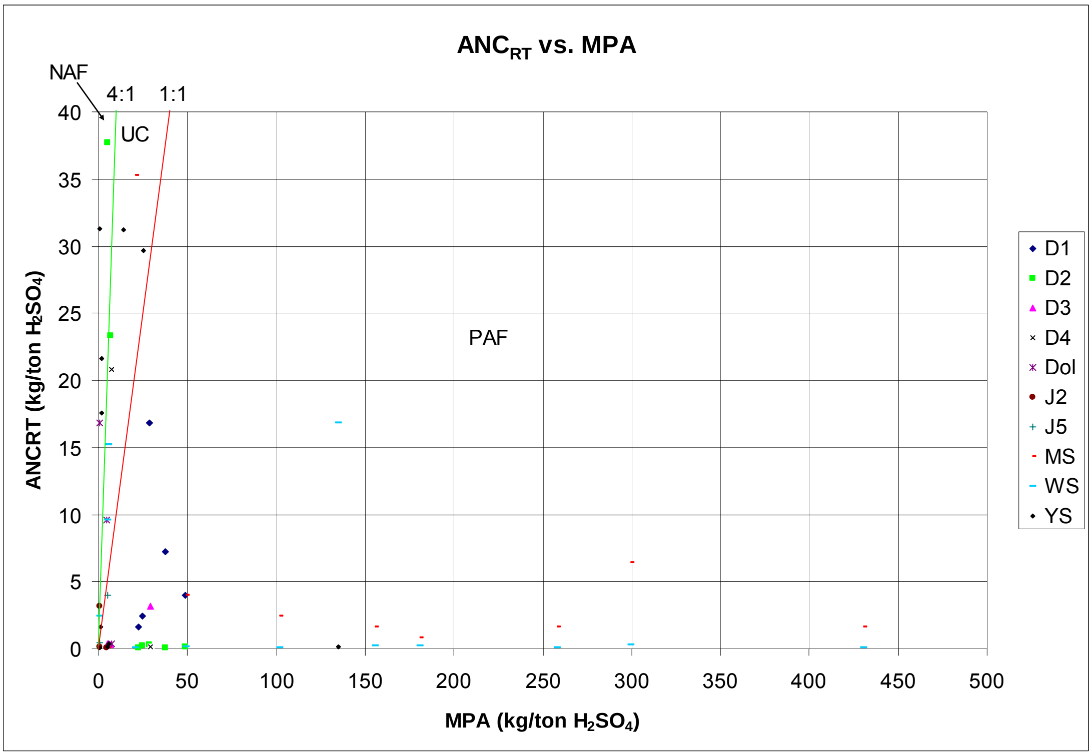

Figure 17: Measures ANC$_{RT}$ plotted against MPA according to Price (1997)

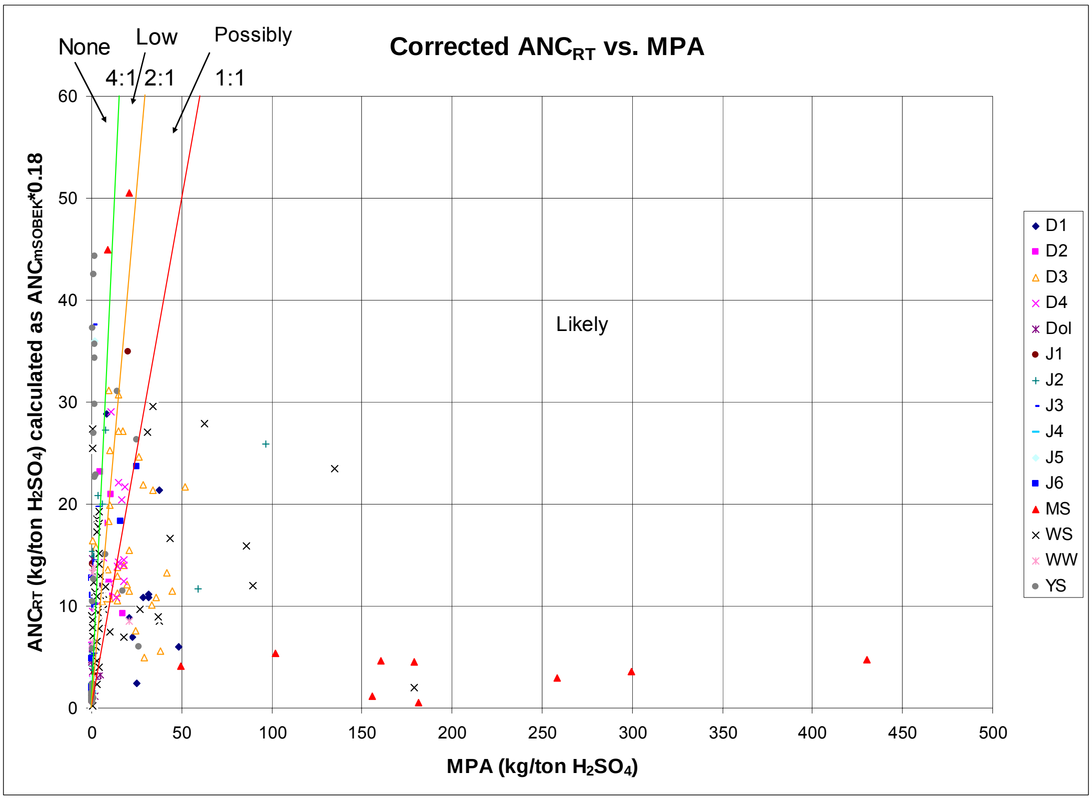

Figure 18: Calculated ANC$_{RT}$ plotted against MPA according to Price (1997)

It should be noted that the ANC_{RT} titrations are conducted at a relatively rapid rate and are likely to be conservative, especially if the major neutralising mineral in question is ankerite, although the level of conservatism is unknown with respect to field conditions, but provides an additional end-point from which to view the results obtained.

The data from Trendall and Blockley (1970) indicates widely variable carbonate mineralogy, mostly consisting of an intermediate composition between calcite ($CaCO_3$), magnesite ($MgCO_3$) and siderite ($FeCO_3$) end-members. Most of the carbonate is classified as ankerite $Ca(Fe^{2+},Mg, Mn^{2+})(CO_3)_2$. The mean carbonate compositions for each lithology type are included in Table 8 based on CaO, MgO and FeO composition, although it should be noted that the correlation between elemental composition and carbonate mineralogy was only considered valid by Trendall and Blockley (1970) where riebeckite and stilpnomelane were present in minor quantities. The presence of mica and chlorite will also affect this assumption. Correlating elemental composition with carbonate mineralogy is thus not necessarily universally applicable for the SIP geology.

The carbonate composition (predominantly ankerite) is confirmed by the petrographic examinations conducted for the SIP (Townend 2008). XRD mineralogical analyses conducted for the kinetic testing component of this work (Section 7.3) indicated a larger proportion of siderite, as well as some other aluminosilicate minerals that might contribute buffering capacity, e.g. mica.

Table 8: Carbonate Compositions According to Trendall and Blockley (1970)

Lithology	$CaCO_3$	$MgCO_3$	$FeCO_3$
BIF	25	38	37
CHT	27	33	40
Mesobands	38	25	36

Note: Mesobands are a subset of banded formations, but are not defined in detail in Trendall and Blockley (1970).

As siderite and ankerite are considered to be slow reacting, compared with calcite and dolomite, and also contribute less neutralising capacity, the reactive ANC analyses are likely to be good indicators of easily available neutralising capacity. In the longer term, more neutralising capacity is likely to be available; however, that attributable to ankerite is only likely to contribute approximately 50% to 60% of the neutralising capacity of calcite or dolomite for equivalent carbonate content, according to the values in Table 8. This is due to the fact that Fe^{2+} component of the mineral releases acidity when it oxidises to Fe^{3+}, thus generating as much acidity as the associated carbonate neutralises. Silicate minerals contributing buffering capacity generally buffer at low pH and are thus not important in preventing AMD impacts associated with acidity.

7.2.3 Whole Rock Chemistry - SIP

The Whole Rock Chemistry (WRC) results (see Appendix A) indicate that the SHL units are elevated in As when compared with the average crustal abundance for shales (AUSIMM, 1989). Of the 30 samples that were analysed for WRC, 19 samples had greater than 15 mg/kg As and 9 of these had greater than 50 mg/kg. Of the 19 samples with greater than 15 mg/kg, 10 were SHL, 3 were DMT, 3 were CHT, 2 were DOL and 1 one BIF. The highest arsenic concentration was recorded from a SHL sample (2030 mg/kg).

Samples containing elevated As were also elevated in Cd. All 30 samples had greater than the average Cd crustal abundance of 0.2 mg/kg for shales. Of the 30 samples 9 had greater than 100 mg/kg for SHL and three samples had greater than 300 mg/kg.

There were concentrations above the reported average crustal abundance for shales for other elements such as Ba, Co, Cu, Pb, Mn, Ni, Ti and V. However these concentrations are not considered significant in terms of the number or range of values that are above the average crustal abundance for these elements.

No Se or Ti were detected, although the detection limits for these elements were higher than their average crustal abundances.

It is widely recognised that the total concentration of an element does not relate directly to its environmental mobility or potential for adverse eco-toxicological impacts, however, its presence implies that it can be mobilised under a given set of geochemical conditions. In order to assess the mobility of the detected elements Synthetic Precipitation Leaching Procedure (SPLP) data are used in conjunction with column leach data.

7.2.4 Metal Leaching Potential (MLP) - SIP

Metal leaching potential was tested using the same 30 samples that were submitted for extended characterisation of ABA properties of the SIP materials. For this purpose the SPLP leachate concentrations were measured. Elements that showed a propensity for enrichment in whole rock analyses include As, Cd, Cu, Co, Mn, Mo, V and Zn. These elements would thus also be expected in any acidic drainage that may be generated, depending on the lithologies and mineralogy of materials exposed to the acidity. The final pH values obtained for the pH 5 and pH 3 SPLP tests indicate that the fresh samples contain adequate buffering capacity to neutralise the acidity in an SPLP leaching solution. In some samples the presence of pyrite oxidation products is also indicated, as pH values of <5 and <3 are recorded for the final solutions respectively.

The SPLP solutions do not display a strong correlation between pH and metal concentrations and are not consistent with respect to the trends observed for each sample in terms of pH. The cause of these discrepancies is not known, but limits the use of the data for quantifying leaching potential.

Despite these issues, the presence of specific metals and the predominant association of metals and shale allow one to conclude that AMD is likely to be predominantly associated with shales. Other materials are also able to leach metals if exposed to acid, although most of these materials are unlikely to acidify themselves according to the available data. The leaching potential of the SIP samples was further investigated via column leaching experiments, as discussed in Section 7.3.

7.2.5 Synopsis of Static Testing - SIP

As a result of the large number of static tests conducted, as well as the variable methods of interpretation, it is considered appropriate to provide a synopsis of the static test data collected for SIP and what these data mean in practice.

The high proportion of ankerite and siderite identified in the samples requires that some caution be used in interpreting measured ANC values. ANC_{RT} tests indicated that between 5% and 40% of ANC is available for neutralisation (mean of 18%). This corresponds well with the approximate average carbonate composition determined by Trendall and Blockley (1970). It should be noted that ANC titrations do not necessarily account for unoxidised Fe^{2+}, thus requiring caution when interpreting the data. The conservatism provided in the Price 1997 classification, however, is expected to remain valid with respect to AMD Risk assessment. Samples classified according the methodology from AMIRA 2002 are also considered acceptable although this classification does not consider non-stoichiometric reactions under field conditions and is inaccurate for sulphur concentrations of more than approximately 1% due to NAG test results not accounting for all the sulphide present.

Because of the screening nature of the tests conducted, it is not possible to classify most of the samples with certainty. Sufficient data is, however, considered to have been gathered to determine the following:

- AMD with associated metal leaching is likely from the MS stratigraphic unit. From the occasionally high concentrations of sulphur and the established correlation with sulphide minerals it is assessed that acid formation may be a risk from this material.

- Some AMD tendencies were noted in the DG and WS stratigraphic units, although they were much less significant than for the MS unit. The measurement of relatively low ANC_{RT} concentrations implies that acidification potential may be significant in some of these materials.
- A number of samples contained measurable quantities of sulphide. This indicates that neutral metalliferous drainage (NMD) is likely to form in a significant proportion of the mined materials, even if AMD does not. Elements such as Mn and As might thus be mobilised in leachates and run-off.
- The scattered nature of the data indicates that pyrite may be disseminated. No geochemical, structural or sedimentological controls aside from stratigraphic associations have been noted so far, however, they have also not been discounted.
- The majority of samples classified as NAF and many of them are likely to contain excess ANC. The finding that reactive ANC only makes up 5% to 40% (average 18.6%) of the measured ANC, however, cautions against the use of total ANC as a measure of available neutralising capacity. This is particularly relevant when considering mixing or placement of NAF and PAF wastes.

7.2.6 Synopsis of Static Testing - Balmoral South Project

The limitations of ANC and NAG testing as discussed above also apply to the data reported for Balmoral South Project if stratigraphic continuity is assumed. The static testing undertaken to date for the Balmoral Project is in general agreement with the results obtained for SIP. Stratigraphic units can be distinguished by their geochemistry, however, the chemistry of each unit is variable; e.g. sulphur concentrations for the Mt. McRae shale vary between <1% and approximately 15%. Consequently, to have a better understanding of the degree of variability in each stratigraphical unit, analysis of a sufficient number of samples is necessary to define variability to a statistically significant level. The limited data that is available for Balmoral South is consistent with data collected for SIP. However, additional sampling to that carried out to date would be required for Balmoral South to confirm the validity of material management planning based on the findings for SIP.

7.3 Kinetic Leach Tests - SIP

Kinetic leach column testing is used to confirm relative reaction rates of carbonate and sulphide mineral dissolution and to simulate other mineral reactions that control water quality associated with mine wastes.

Considering the apparent similarity in the results discussed above for the static data from both the SIP and Balmoral South projects, kinetic leach data acquired for the lithologies present in at SIP is likely to be indicative of leaching characteristics for the same lithologies found at the Balmoral South Project site.

Sample selection for SIP was undertaken following the completion of the static ABA testwork and kinetic testing was started in October 2007 at the Golder laboratory in Brisbane. Leaching of nine samples was conducted on a monthly basis over a period of 14 months.

7.3.1 Kinetic Sample Composition - SIP

At the time of sample selection for the SIP, limited stratigraphic information was available. As a consequence, samples selected for compositing were chosen based on lithology and economic potential, i.e. fresh waste, oxide overburden, low grade ore and ore. Five of the major lithological units are included in the kinetic program. Of the nine columns six contain single stratigraphic units. The material selected for the kinetic columns also represented the major rock types in the project area.

The nine columns and sub-samples that were included in each sample (in equal portions to make up 1kg of material) for each column, are included in Table 9. The table also presents the static ABA characteristics of each of the 24 individual samples. It is noted that samples with a low NAPP dominate the sample composition. This is largely a consequence of the large portion of this type of material present in the stratigraphy. Stratigraphy (based on available knowledge of for the SIP block model) for each sub-sample is also included to clarify the composition of the samples.

Table 9: Summary Characteristics of Kinetic Leach Column Samples

Column	Sample	Hole ID	Depth (m)	Stratigraphy		Lithology	Rock Type	TS (%)	MPA (kg H_2SO_4/tonne)	ANC (kg H_2SO_4/tonne)	NAPP (kg H_2SO_4/tonne)
				Major	Minor						
165153	GA17165	06RC028	33-36	Joffre	J2	BIF	Oxide OB	0.01	0.31	3	-3.09
	GA17153	06RC028	0-3	Joffre	J3	BIF	Oxide OB	0.03	0.93	142	-141.07
012327	GA17201	06RC028	132-135	Whaleback	WS	BIF	Low Grade Ore	0.12	3.72	47	-42.88
	GA17227	06RC028	201-204	Dales Gorge	D4	BIF	Ore	0.23	7.12	57	-49.78
	GA17223	06RC028	192-195	Dales Gorge	D4	BIF	Ore	0.44	13.62	52	-38.08
839590	GA14839	06RC046	0-3	Joffre	J2	CHT	Oxide OB	0.01	0.31	58	-57.69
	GA17590	06RD065	0-3	Weeli Wolli Iron	WW	CHT	Oxide OB	0.01	0.31	73	-73.09
818980	GA14881	06RC046	114-117	Whaleback	WS	CHT	Low Grade Ore	0.11	3.41	97	-93.69
	GA14880	06RC046	111-114	Whaleback	WS	CHT	Fresh Waste	0.13	4.02	96	-92.18
	GA14889	06RC046	135-138	Whaleback	WS	CHT	Low Grade Ore	0.14	4.33	102	-97.67
214408	GA14931	06RC046	252-255	Dales Gorge	D3	CHT	Fresh Waste	0.46	14.24	62	-47.86
	GA14908	06RC046	189-192	Dales Gorge	D4	CHT	Fresh Waste	0.49	15.17	106	-90.83
	GA14944	06RC046	288-291	Dales Gorge	D2	CHT	Fresh Waste	0.56	17.34	44	-26.86
260262	GA17262	06RC028	297-300	Dales Gorge	D1	DMT	Fresh Waste	0.73	22.60	33	-10.80
	GA17260	06RC028	291-294	Dales Gorge	D1	DMT	Fresh Waste	0.92	28.48	52	-23.52
909282	GA14292	06RC075	234-237	Dolerite	DOL	DOL	Fresh Waste	0.03	0.93	56	-55.27
	GA14282	06RC075	207-210	Dolerite	DOL	DOL	Fresh Waste	0.05	1.55	97	-95.25
	GA14290	06RC075	228-231	Dolerite	DOL	DOL	Fresh Waste	0.10	3.10	19	-16.30

Column	Sample	Hole ID	Depth (m)	Stratigraphy		Lithology	Rock Type	TS (%)	MPA (kg H_2SO_4/tonne)	ANC (kg H_2SO_4/tonne)	NAPP (kg H_2SO_4/tonne)
				Major	Minor						
747267	GA17274	06RC028	330-333	Mount McRae	MS	SHL	Fresh Waste	3.30	102.17	35	67.67
	GA17272	06RC028	324-327	Mount McRae	MS	SHL	Fresh Waste	5.79	179.26	29	150.56
	GA17267	06RC028	312-315	Mount McRae	MS	SHL	Fresh Waste	13.90	430.34	31	399.74
002699	GA14899	06RC046	162-165	Whaleback	WS	SHL	Fresh Waste	1.01	31.27	152	-120.73
	GA14926	06RC046	240-243	Dales Gorge	D3	SHL	Fresh Waste	1.44	44.58	55	-10.52
	GA14900	06RC046	165-168	Whaleback	WS	SHL	Fresh Waste	4.36	134.99	132	2.99

The following general observations can be made based on the results of the kinetic column leach test data:

- All nine columns leached neutral to alkaline leachate throughout the testing period, although pH values generally declined towards neutral values over time, in some cases from high values of around pH 10. High pH values were attributable to Na salts, which tended to leach at high concentrations. These salts are likely to be carbonates, rather than chlorides, as Cl^- did not leach at high concentrations when compared with Na. Leachate values between pH 7 and pH 9 are attributed to buffering by Ca-Mg carbonate species.

- The leaching behaviour of the columns is consistent with the ABA classifications for each of the wastes, although the Mt. McRae Shale did not acidify during the test period. As the most likely acid forming units, the Mt. McRae shale and the Whaleback shale were considered to be the two of most interest. The Mt. McRae shale was calculated to have lost approximately 15% of the total available ANC and most of the reactive ANC according to the reactive ANC tests conducted. This would account for an observed pH drop in the final leach, which is likely to indicate the start of acidification. Only 2% of the MPA was leached. The Whaleback shale also showed some tendency to lower pH values (around pH 7), but calculations showed that only 4% of ANC and 1% of MPA were leached. This indicates that the Whaleback shale column would likely continue for a period at circum neutral pH before possibly acidifying eventually and that the pH drop was likely only attributable to depletion of high pH buffering minerals.

- The electrical conductivity values of the leachates for all nine columns generally decreased over time, although slight increases were noted where SO_4 concentrations increased due to likely AMD reactions, often towards the end of the test period.

- All nine columns leached at least one element at concentrations exceeding ANZECC 2000 95% AE guidelines, thus indicating that pore waters will contain elevated concentrations of at least one metal under field conditions. It is expected that pore waters will generally be more concentrated than column leachates under field conditions due to larger solid to liquid ratios and longer timeframes. To calculate field pore water concentrations, unsaturated flow modelling and geochemical reaction modelling are necessary to quantify these aspects. Such models can be used to calculate impacts where necessary if coupled with hydrological models.

- Evidence of Ca-Mg buffering was seen in most columns, in some cases associated with likely AMD process, but also associated with leaching through interaction with the distilled water leaching solution where SO_4 concentrations are low, e.g. column 909282. The columns vary with respect to the trends for Ca/Mg ratio in leachates, thus indicating variability in the carbonate composition. In some columns a relatively constant, although variable Ca/Mg ratio is observed, thus indicating a dominant, relatively uniform carbonate composition. Considering the XRD analyses, this is likely to be ankerite. The variable Ca/Mg ratios, however, suggest that the ankerite composition varies between the different lithologies and strata. Where high Mg is indicated, magnesite may be present, with a high buffering pH also anticipated for this mineral. Increasing Ca trends suggest that calcite is the dominant mineral in the buffering process. The Ca/Mg trends for the various columns are summarised in Table 10 and illustrated in Figure 19. No clear associations with stratigraphy were noted for particular types of trends or for specific Ca/Mg ratios for these data.

- Higher concentrations of particularly metal species that were measured for the first leach event, were considered to indicate weathering reactions. Where sulphides are present the weathering products are likely to be associated with AMD reactions. For mobile elements, e.g. Na, high initial concentrations are more likely associated with freely available salts in the crushed sample than weathering reactions.

Table 10: Ca/Mg Ratio Trends for Leachates from Kinetic Column Leach Tests

Column No.	Composition	Major Ca/Mg trend	Ratio
165153	Joffre (oxidised)	Increasing Ca	Variable
839590	Joffre and Weeli Wolli	Increasing Ca	Variable
012327	Dales Gorge and Whaleback shale	Increasing Mg	Variable
214408	Dales Gorge	Steady	0.4 to 0.5
260262	Dales Gorge (dolomite)	Steady	0.2 with decrease at the end
909282	Dolerite	Increasing Ca	Variable
002699	Whaleback shale and Dales Gorge	Increasing Ca	Variable
747267	McRae shale	Steady	1.5
818980	Whaleback shale	Steady	0.5

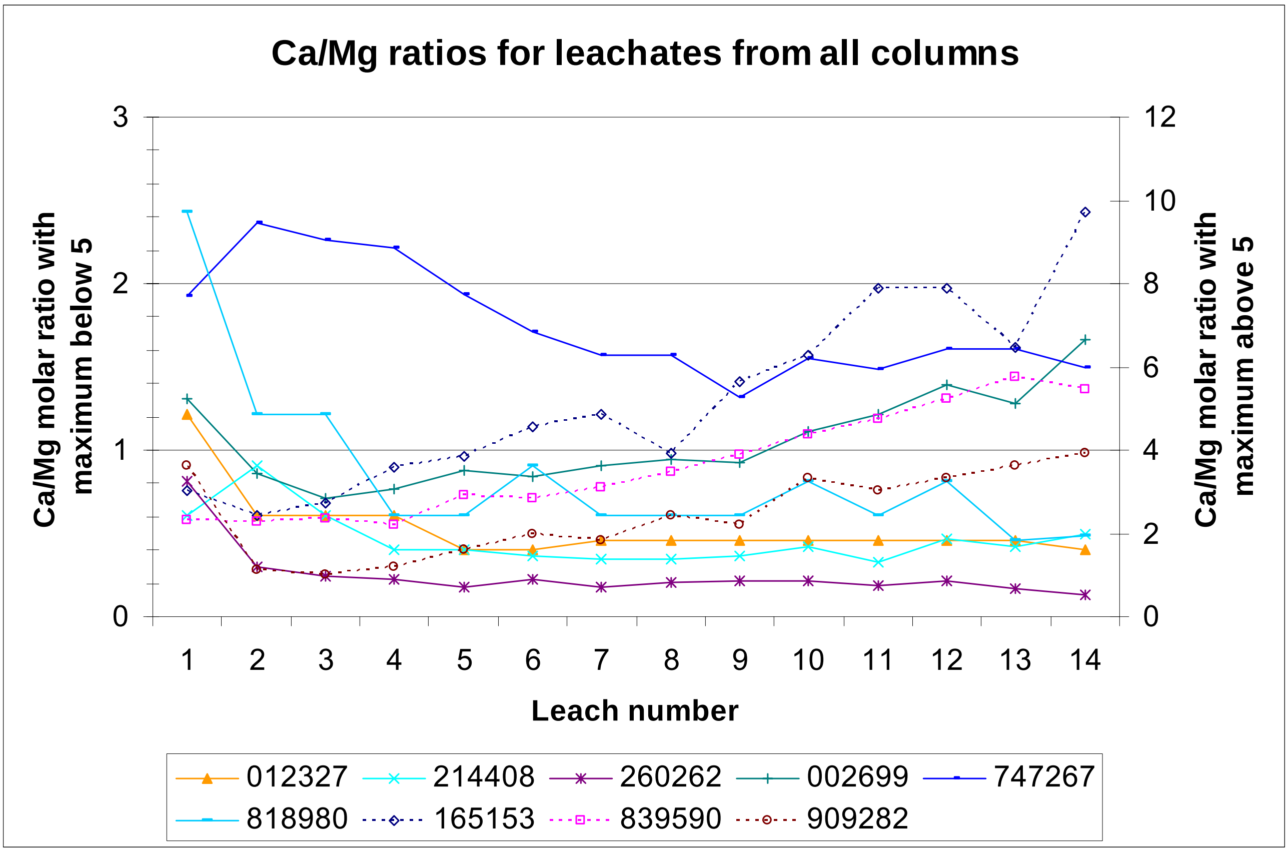

Figure 19: Ca/Mg Molar Ratios for Kinetic Leach Columns Over the Test Period, with Trends Exceeding 3 Plotted with Open Symbols and Dotted Lines on the Secondary Y Axis

8.0 WASTE ROCK BLOCK MODELLING

In order to develop an AMD Management it will be necessary to locate and classify waste within the deposit. This was achieved in the preliminary stages of the SIP project by developing a waste block model that utilised existing TS, CaO and MgO data. These data were assessed to identify the locations of likely high and low risk materials under the assumption that TS represented MPA and CaO and MgO were associated with ANC. The association of MPA with TS has been verified, however, the association of CaO and MgO with ANC has not.

Plots of TS, CaO and MgO from the SIP block model (Figure 20 to Figure 25), indicate that the SIP pit would includes minimal materials with elevated levels of either acid forming (sulphur bearing) or acid neutralising minerals (Ca or Mg bearing). These plots are also useful indicators of the chemical variability within the lithologies at SIP.

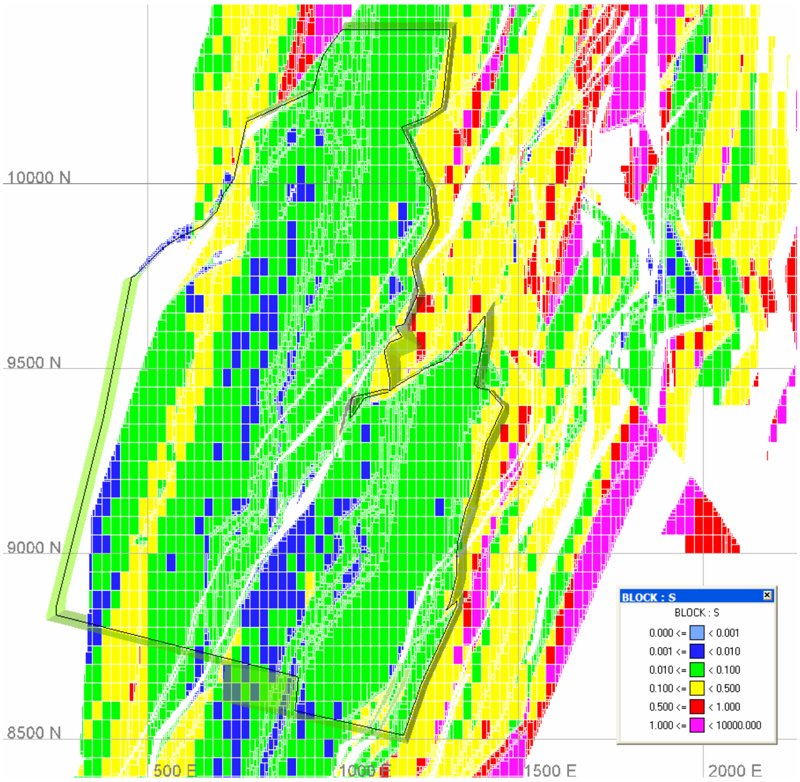

Figure 20: Sulphur Distribution (wt%) for SIP Pit Shell at -50 m RL

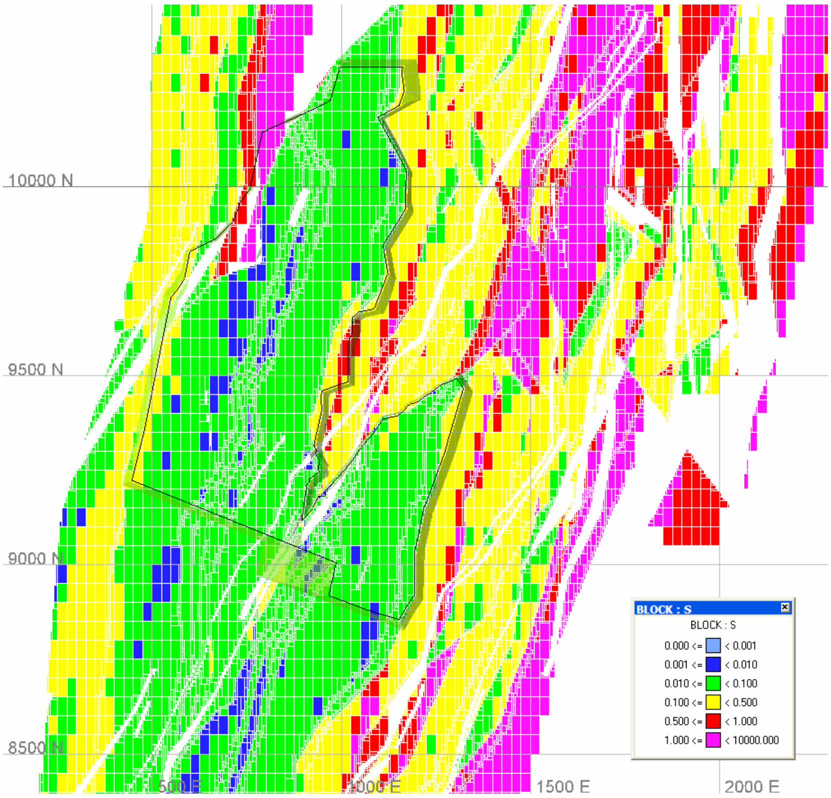

Figure 21: Sulphur Distribution (wt%) for SIP Pit Shell 23 at -150 m RL

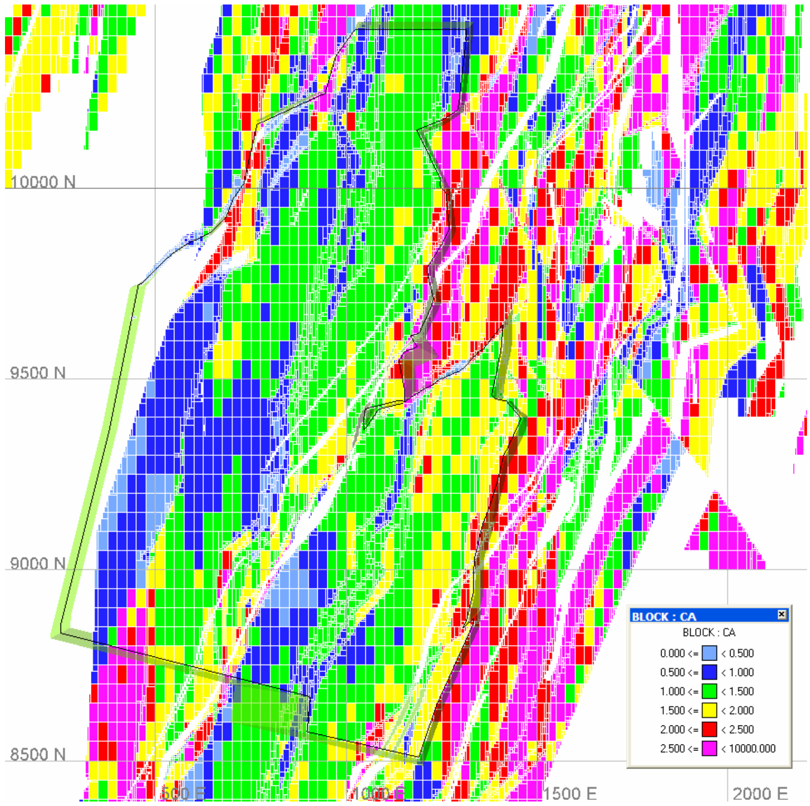

Figure 22: CaO (wt%) Distribution for SIP Pit Shell at -50 m RL

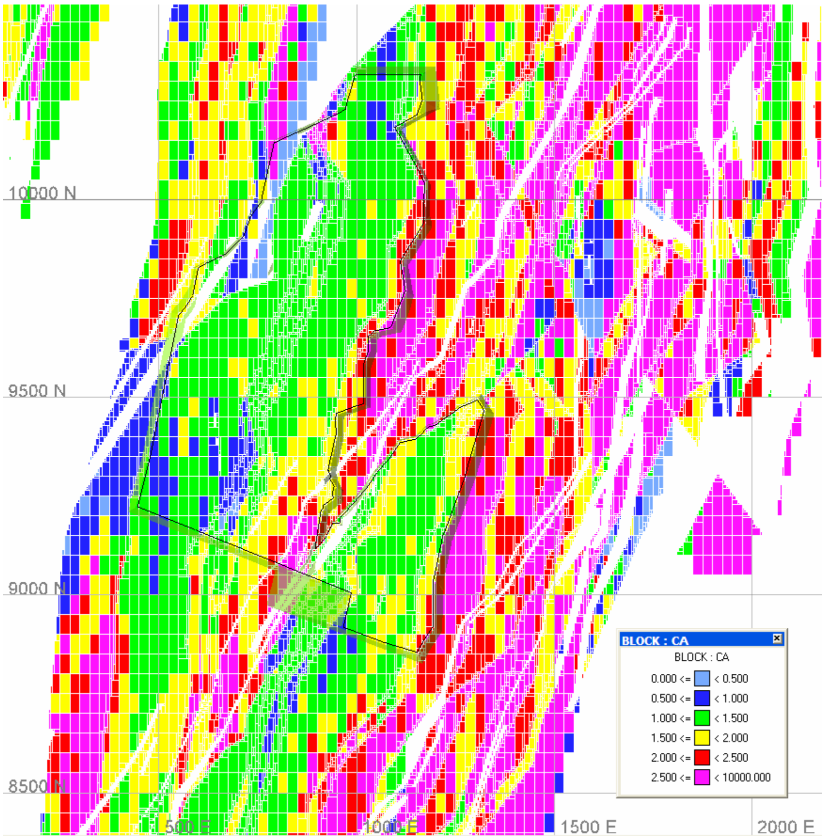

Figure 23: CaO (wt%) Distribution for SIP Pit Shell 23 at -150 m RL

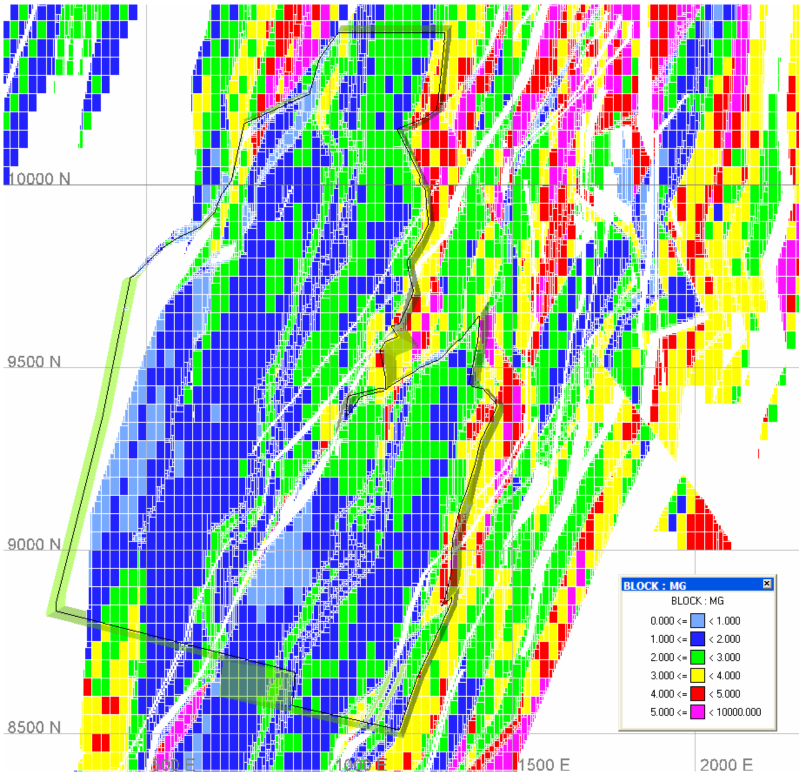

Figure 24: MgO (wt%) Distribution for SIP Pit Shell 23 at -150 m RL

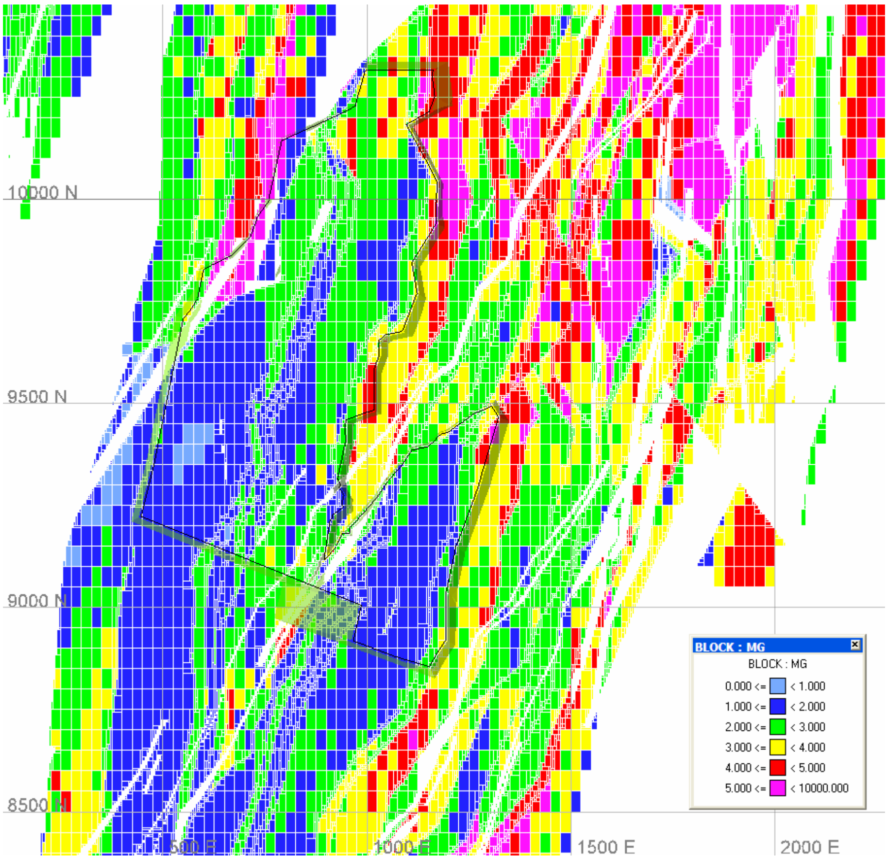

Figure 25: MgO (wt%) Distribution for SIP Pit Shell 23 at -150 m RL

Although the geochemistry of each lithological unit at SIP was variable, it is assessed that generally both acid forming and acid neutralising components appear to be concentrated in the margins of the pit. The distributions of acid generating material generally correspond to the locations of Mt. McRae shale, Dales Gorge and Whaleback shale outcrops as discussed above.

In general, correlation between AMD classification criteria and whole rock assay data can be sought to facilitate classification of waste using whole rock assay data in the geological database. The success with which this could be applied will be dependent on the mineralogy of the materials under consideration. Such an assessment should be conducted for Balmoral South when sufficient geological and geochemical information is available to construct a resource and waste block model.

For the block model created for the Balmoral South Project to date, it appears that no stratigraphical descriptors have been used, only the three lithological descriptors, making correlation of the model with the SIP data more complex than initially hoped.

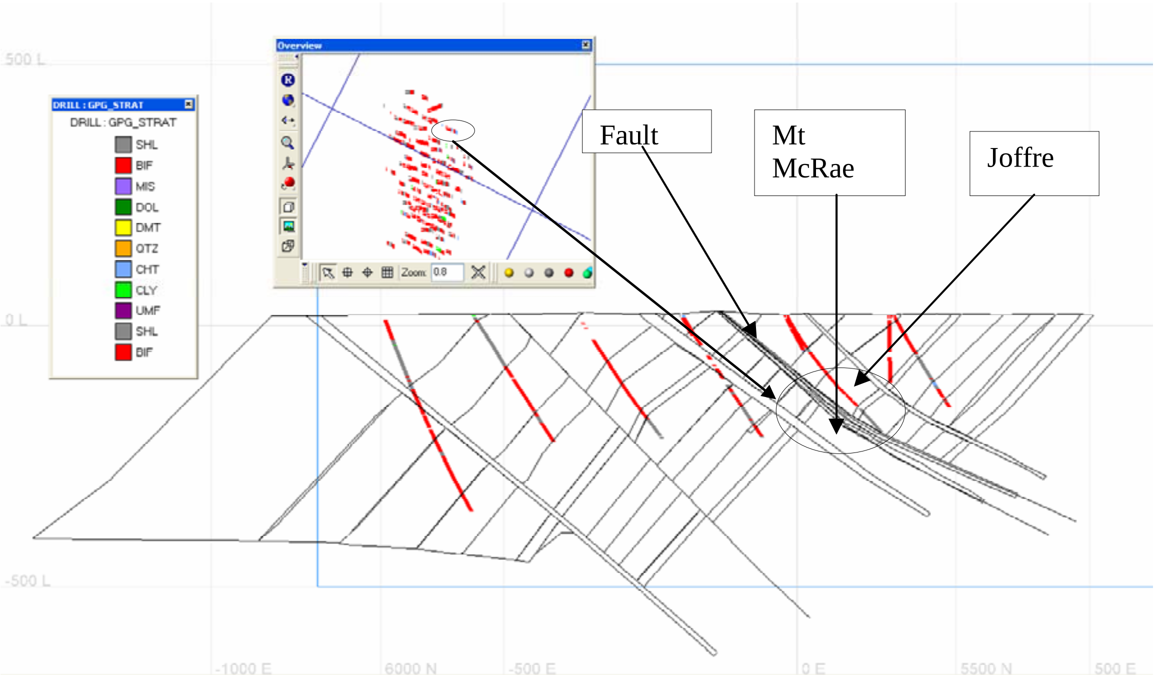

Figure 26: Block Model Output for Balmoral South - North East Quadrant

Nevertheless, when the data received by Golder from IM was graphically represented using VULCAN software, an interpretation of how each stratigraphical unit related to each other was then undertaken; these data were interpreted in concert with the information presented in the Technical Memorandum.

From this interpretation, it is assessed that Mt McRae shale is likely to form part of the pit wall in the north east quadrant of the pit. It is in this area that the Mt McRae Shale lies adjacent to the Joffre stratigraphy. As a consequence of this, although it is not planned to mine the Mt McRae Shale, it is possible that Mt McRae shale will be present in waste material generated at the site.

9.0 WASTE CLASSIFICATION

From a review of the block model results presented in the memo received from IM on 10 December 2008, and from the data received from IM and modelled by Golder, the overburden for the Balmoral South Project will consist of weathered (oxidised) and unweathered Yandicoogina Shale, Dolorite, and Weeli Wolli, material. The waste rock will likely also include the Mt. McRae Shale, Whaleback Shale and Dales Gorge lithologies as these are found adjacent to Joffre stratigraphy (refer to Section 8.0).

Extrapolating the results recorded for SIP, the overburden lithologies at Balmoral South are likely to be generally NAF. However, the overall mine waste will include Mt. McRae Shale, Whaleback Shale and Dales Gorge stratigraphy that have been recorded as PAF. A much larger volume of the Mt. McRae Shale and Whaleback Shale are included in the Balmoral South inventory calculated for the pre-feasibiliy study mine plan compared to the SIP (Table 11)

The Weeli Wolli stratigraphy was only represented in a few samples for the SIP, as it was not planned to mine this unit for the SIP. Consequently the samples that were collected cannot be considered conclusive, nevertheless, from an assessment of the limited data accrued for this lithology no indication has been recorded to date which would point to the Weeli Wolli as a high risk material.

Table 11: Balmoral South Mining Inventory Provided by IM

Accumulated	kBCM	kTonnes
McRae Shale	8,660	21,859
Dales Gorge BIF	3,458	10,903
Whaleback Shale	20,229	61,276
Joffre BIF	301,632	994,713
Yandicoognia Shale	67,863	185,300
Weeli Wolli BIF	14,176	42,310
Weeli Wolli Dolerite	42,727	108,847
Dolerite Dykes	20,200	57,423
TOTAL	**478,945**	**1,482,631**

10.0 CONCLUSIONS

Static geochemical results from SIP AMD Assessment recorded that most lithologies are NAF, although not all lithologies were well represented in the sampling programme. It is, however, notable that only the McRae Shale was recorded as having a high potential for acidification. Other PAF units were generally confined to shales, particularly the Whaleback Shale, with a few exceptions. Results presented from the Balmoral South Program concur with these data.

Besides the Mt. McRae Shale, other lithologies that classified as PAF using the Sobek 1978 ABA methodology, generally contained a higher ANC_{mSOBEK} and lower MPA and thus represented a lower risk of AMD. Considerable variability was noted within stratigraphic or lithological types, thus indicating that mineralisation is variable (refer to Figure 20 to Figure 25).

The sampling strategy adopted for Balmoral South appears to have focussed on the shale units and sulphur containing BIF. As a consequence of this, the degree to which it will be possible to discuss the use of waste material for blending any acid generating material as a management strategy will be limited to an extrapolation of the data acquired through the SIP investigation with little direct correlation to the Balmoral samples.

Despite this variability, it is considered that the general geochemical signatures of the main lithologies present in the Hamersley Region are apparent on a regional scale and thus the data from SIP can be extrapolated to be generally representative of the surrounding area.

The following conclusions are drawn for the analysis of the samples that were characterised in this report when SIP and Balmoral South data are assessed together as one data set:

- It is considered that the major stratigraphy has generally been adequately represented with respect to ABA testing, although some stratigraphic units were represented by less than ten samples. Given the stratigraphic and lithological continuity of the Brockman Iron Formation within the SIP project area and extending well beyond it, the samples selected and tested for SIP are considered by Golder to reasonably represent the expected material types that will be encountered during mining.
- Total sulphur can be used to measure MPA, which is a good estimate of actual available acidity from fresh (unweathered) samples as there is a strong correlation between MPA_{TS} and MPA_{CRS}. This assumption also considers that pyrite was the only significant sulphide mineral detected in XRD mineralogical analyses for SIP.
- The static ANC methods that have been used are suitable to measure total ANC but are not indicative of the actual or reactive ANC.
- It is assessed that from XRD analysis and literature (Trendall and Blockley 1970) that ANC is derived primarily from ankerite and will thus react more slowly than calcite and will only yield approximately 50% of the ANC of calcite on average for the equivalent carbonate content.
- The classification of a relatively small proportion of the ANC as reactive implies that some samples in the possible or low potential for acidification category (Price 1997) will be more prone to AMD than the ANC_{SOBEK} suggests. Only samples in the NAF category can be relatively confidently classified as having little potential for generating acidic drainage in the long-term according the static test results.
- Ore generally classifies as NAF, whereas PAF material is generally attributable to a portion of the waste.
- Static SPLP data suggests that the fresh waste rock types have a low capacity to leach metals at concentrations of potential environmental concern in the absence of AMD.
- According to the current waste characterisation breakdown, the majority of waste is designated as NAF. Additionally, any material recorded as PAF is mostly associated with the pit wall rock.

- Further static testing and comparison of data with the mine geochemical database will provide an indication of the most appropriate operational method for measuring ANC and thus evaluating ABA characteristics in more detail.

11.0 RECOMMENDATIONS

Based on the findings of the SIP project and the evaluation of available information for Balmoral South, Golder recommends the following work be undertaken before and during mining:

- Additional sampling should be conducted at Balmoral South to confirm the assumed correlation with AMD characteristics of the SIP and to define the local distribution of AMD characteristics for refinement of waste management practices. Sampling should be targeted at the materials that may be exposed and would best be done when the resource is well enough defined to optimise sample selection.
- Assess the mining profile for geological or geochemical controls on reactive mineral distribution, as such controls may have implications for reactivity and management options related to the material.
- Once a suitable database is available for AMD characterisation, assess to what extent correlations exist between elemental composition, mineralogy and ANC in the relevant materials. Also confirm that TS is a suitable measure of MPA, as it is for the SIP. A version of the mine block model, along with additional grade control determinations, would be sufficient to construct a detailed waste management plan and could be used as an additional AMD risk identification tool if suitable correlations are found.
- Where the stratigraphy indicates a significant possibility of AMD generation or the spatial definition of ABA properties is uncertain, a selection of grade control drilling samples should be characterised for TS and appropriate measures of ANC. NAG tests can also be used as an additional tool for waste classification if necessary.
- If covers are likely to be used to rehabilitate waste materials; undertake geochemical and geotechnical characterisation studies of oxidised overburden to identify potential cover materials for revegetation and closure needs.
- Develop a detailed AMD Management Plan that will include but not be limited to:
    1. The development of a detailed waste rock block model, based on AMD potential.
    2. Including waste management in the material handling schedule to ensure that potentially problematic waste can be is isolated and is transported to the correct location according to the waste management plan.
    3. Inclusion of ABA classification criteria in the design considerations for the Waste dump and tailings facilities to minimise impacts from PAF waste and to utilise ANC in NAF waste appropriately to neutralise acidity. *Note: Before utilising NAF waste to neutralise PAF waste, it must be demonstrated that the combination of the materials will result in an overall NAF waste. If NAF waste contains sulphur itself, mixing of such waste can increase the overall volume of PAF waste if insufficient ANC is present to maintain an overall NAF classification. Where such a risk exists, NAF waste should preferably be placed above or beside PAF waste, rather than below or as a mixture with the PAF waste*.
    4. Consideration of potential impacts associated with waste placement from a regional environmental point of view, including potential impacts from run-off and seepage to groundwater.
- If AMD is considered to be a significant risk according to the mining and waste management plan adopted install instrumentation in the waste facilities or constructed cells to collect more representative field data. The advantage of this approach is that physical parameters related to particle size distribution and climatic conditions are accurate and measured seepage quantities and qualities would thus be representative of field conditions. As the particle size of the material in the waste dumps has a significant effect on leachate chemistry and flow properties of water and oxygen, the results from field scale tests can be significantly different to laboratory assessments. These types of tests also allow for greater sample mass, thereby increasing the representivity of the test if appropriate materials are selected.

- If PAF materials are exposed during mining, utilise mine wall washing at exposure sites to derive geochemical field data for runoff geochemistry if possible. Such data can be compared with static and kinetic laboratory data to model run-off water quality more accurately.

12.0 LIMITATIONS

Your attention is drawn to the document ‘Limitations’, which is included in Appendix B of this report. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be, and to present you with recommendations on how to minimise the risks associated with the groundworks for this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

Report Signature Page

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APPENDIX A

Information Supplied by Client

Memorandum	
COMPILED:	Jacob Ricciardone
TO:	Karen Mackenzie (Golder Associates Pty Ltd)
DATE:	10 December 2008

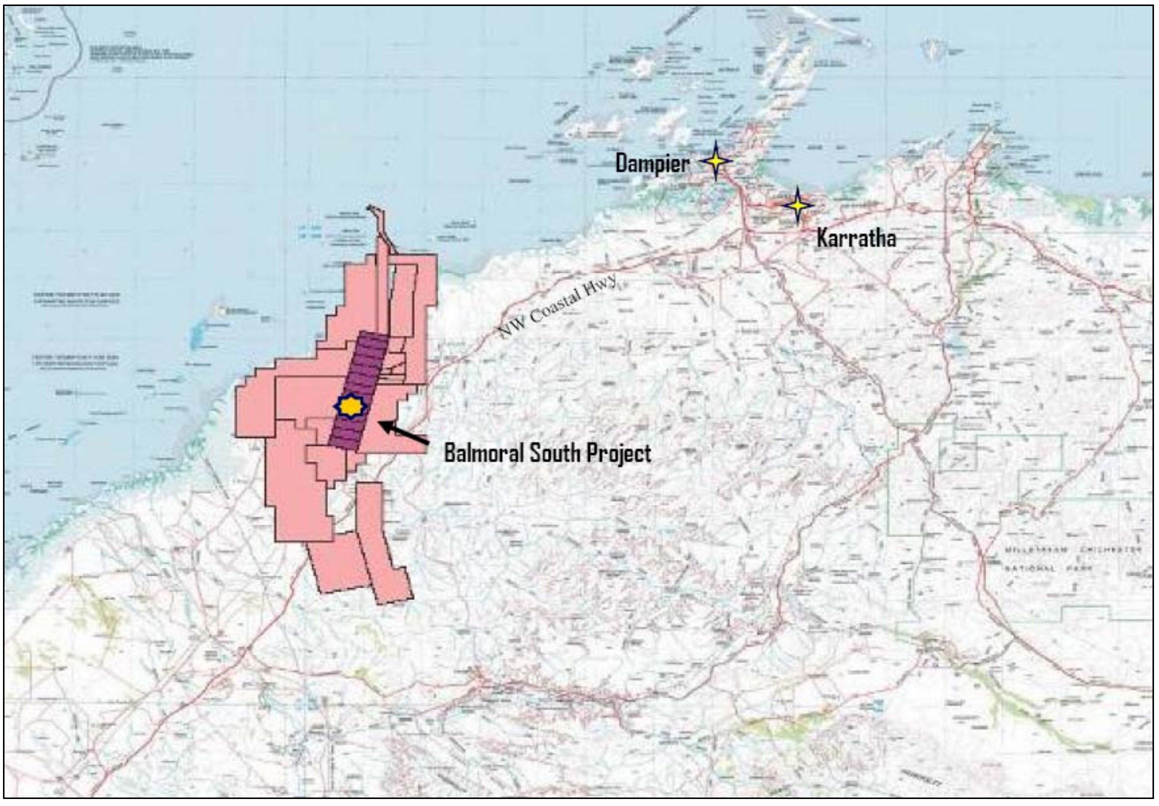
GEOLOGY AND RESOURCE

GEOLOGY AND INTERPRETATION

Location

The Balmoral South Iron Ore Project (the Project) is located approximately 80 km along the coastline south-west of Karratha in the Pilbara region of Western Australia. The Project is approximately 22 km from the coast and 30 km from the proposed port site at Cape Preston, as per Figure 0-1 below.

Figure 0-1: Balmoral South Regional Location



Geology

Introduction

The Balmoral South deposit is the most westerly outcrop of the iron ore formations in the Hamersley Basin. The deposit forms part of the Balmoral Magnetite Deposit which outcrops for some 22 km along strike and is divided into three distinct areas, the southern, central and northern blocks. The blocks are defined by creek drainage systems intersecting the deposit, with the creeks flowing into the Fortescue River. The outcrop forms a low ridge striking NNE approximately parallel to the Fortescue River, a regional river system in the Pilbara, with the northern most outcrop adjacent to the mouth of the Fortescue River.

The Balmoral South deposit is bounded locally by the Du Boulay creek system to the north and the east. The ridge gently slopes down to the west into a small creek which parallels the ridge, eventually connecting with the Du Boulay system to the north. The main channel of the Fortescue River is approximately three kilometres east of the Balmoral South deposit.

The Balmoral South deposit is hosted within the Brockman Iron Formation; local geology consists of a fault disrupted sequence of banded iron formation (BIF) and shales. Stratigraphically this sequences consists of; the Mt McRae Shale, the Dales Gorge Member (BIF), the Whaleback Shale, the Joffre Member (BIF), the Yandicoogina Shale, and the Weeli Wolli Formation (BIF and Dolerite Sills).

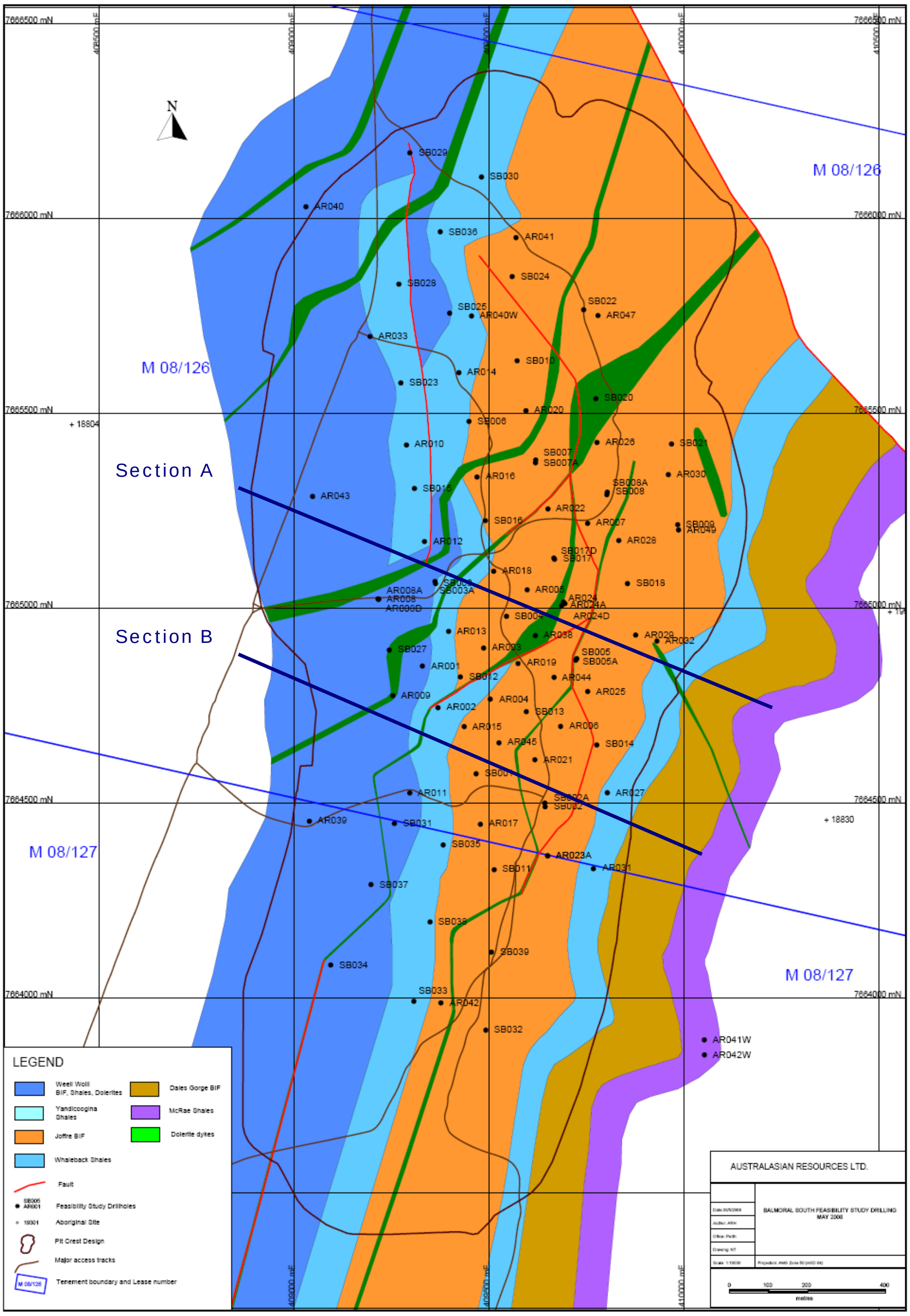
Locally, stratigraphy has been shown to have a consistent strike and dip, dipping 45 degrees to WNW. Major faulting, and congruent dolerite dykes, has been interpreted on two orientations trending NNW-SSE and NE-SW and dipping moderately to the east.

The Joffre and Dales Gorge Members both outcrop locally, with areas locally described as ‘Silica Breccias’ representing areas of outcropping shales. There is no outcropping dolerite in the local area.

Maps and Cross-Sections

Figure 0-2: Balmoral South Drilling and Geology

BALMORAL SOUTH FEASIBILITY STUDY DRILLING - MAY 2008



 Excerpt from 081208_Section3_FS_GeologyExerpt

Figure 0-3: Balmoral South Geology Section A - May 2008

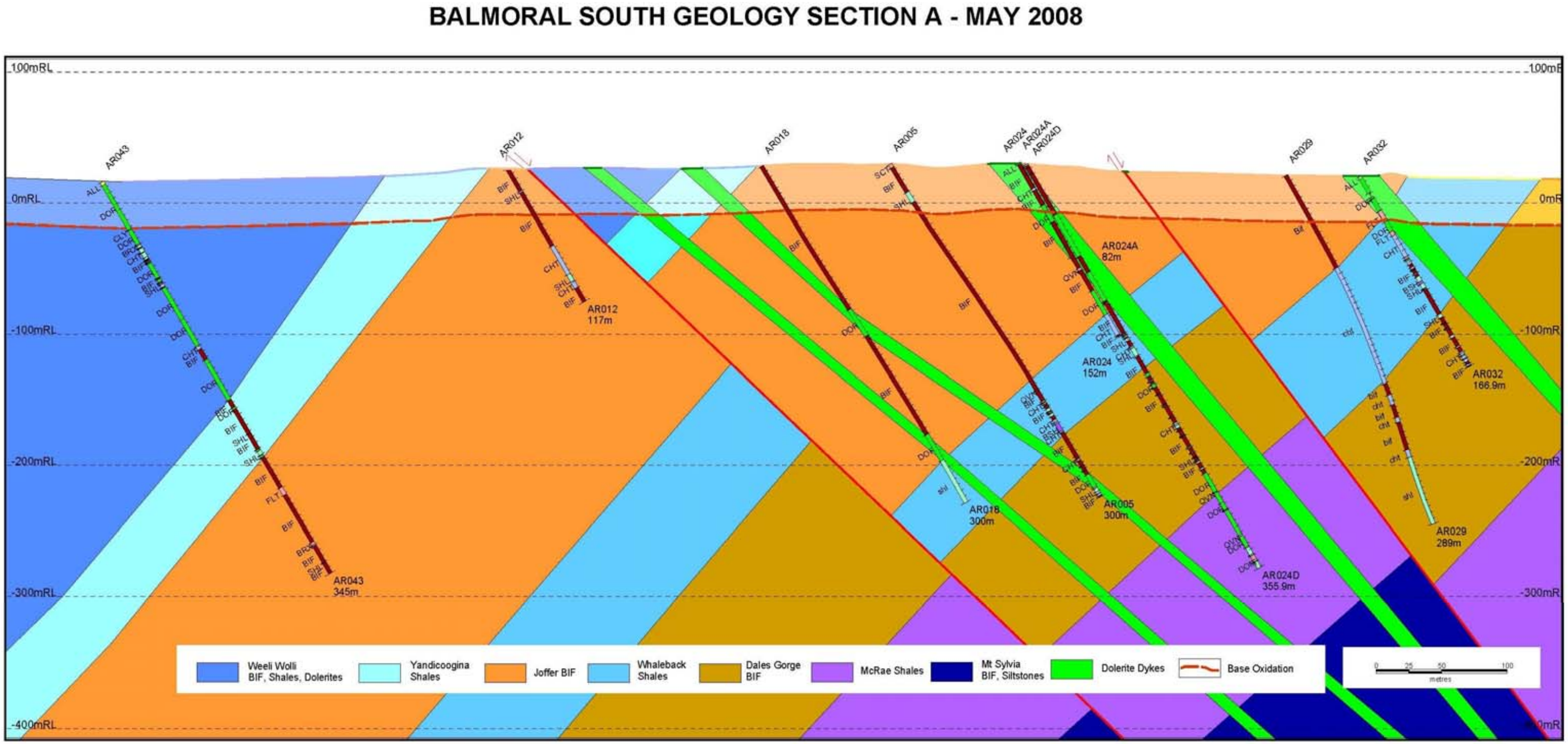
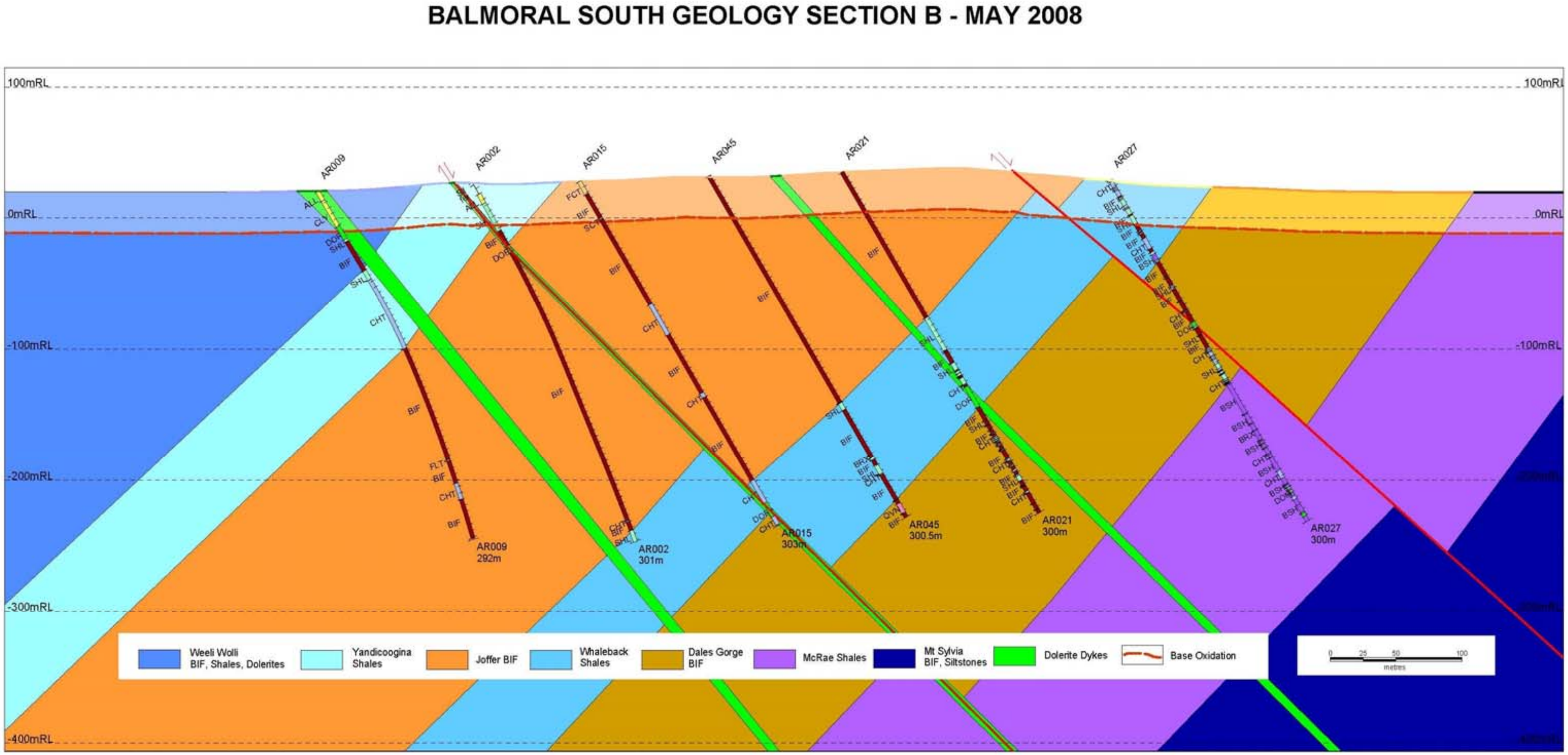


Figure 0-4: Balmoral South Geology Section B - May 2008



Interpretations

The geology of the deposit has been modelled several times in the past to facilitate resource estimation. Previous interpretations were guided by work done on the central block of the Balmoral Magnetite Deposit and assumed 45 degree dip to the stratigraphy with sub-vertical faulting and congruent dolerite dyke intrusions. As part of the study, the local geology was remodelled in light of all additional data available. This work was undertaken by the field geologists, responsible for logging of all holes drilled in the feasibility drilling programme. The programme also included re-logging of previous, SB series, RC holes. The new geological model was a significant departure from the previous interpretation, in the area of fault and dyke orientation.

The geological modelling process involved generation of hard copy section interpretations and logging validation through digital section interpretation and three dimensional wireframe modelling. During this process stratigraphic interpretation was completed to the sub-unit level and structural data from the geotechnical logging used to guide the interpretation.

The model was constructed via generation of cross-sections displaying hole traces, logged geology, gamma traces and assay data (if available). This allowed interpretation of the stratigraphic boundary positions. The stratigraphic sub-units used by van der Heyden (2007) were adopted (refer Table 0-1, Figure 0-5 and Figure 0-6).

Areas of inconsistency identified during this process were validated via re-logging if necessary, resulting in a set of validated records in the geology database.

Table 0-1: Balmoral South Stratigraphic Sub-Units

Stratigraphic Sub-Units	
Code	**Description**
MS	McRae Shale
D1	DG Basal Shaley
D2	Lower Dales Gorge
D3	DG Middle Shaley
D4	Upper Dales Gorge
WB	Whaleback Shale
J1	Joffre Basal Shaley
J2	Lower Joffre
J3	Joffre Middle Shaley
J4	Upper Joffre
YS	Yandicoogina Shale
WW	Weeli Wolli BIF
WD	Weeli Wolli Dolerite Sills

Figure 0-5: Mt Newman Iron Ore Stratigraphy and Gamma Log

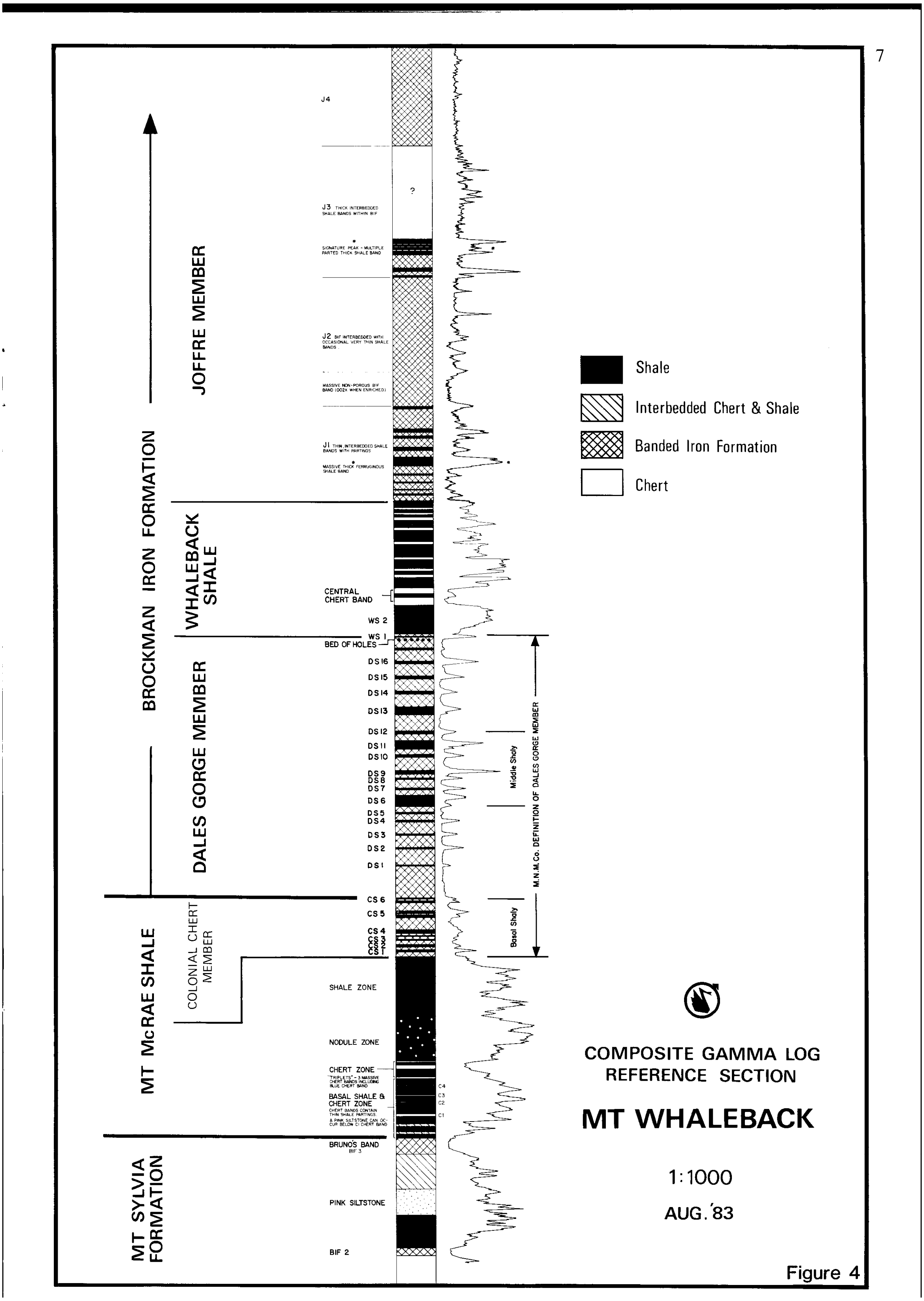
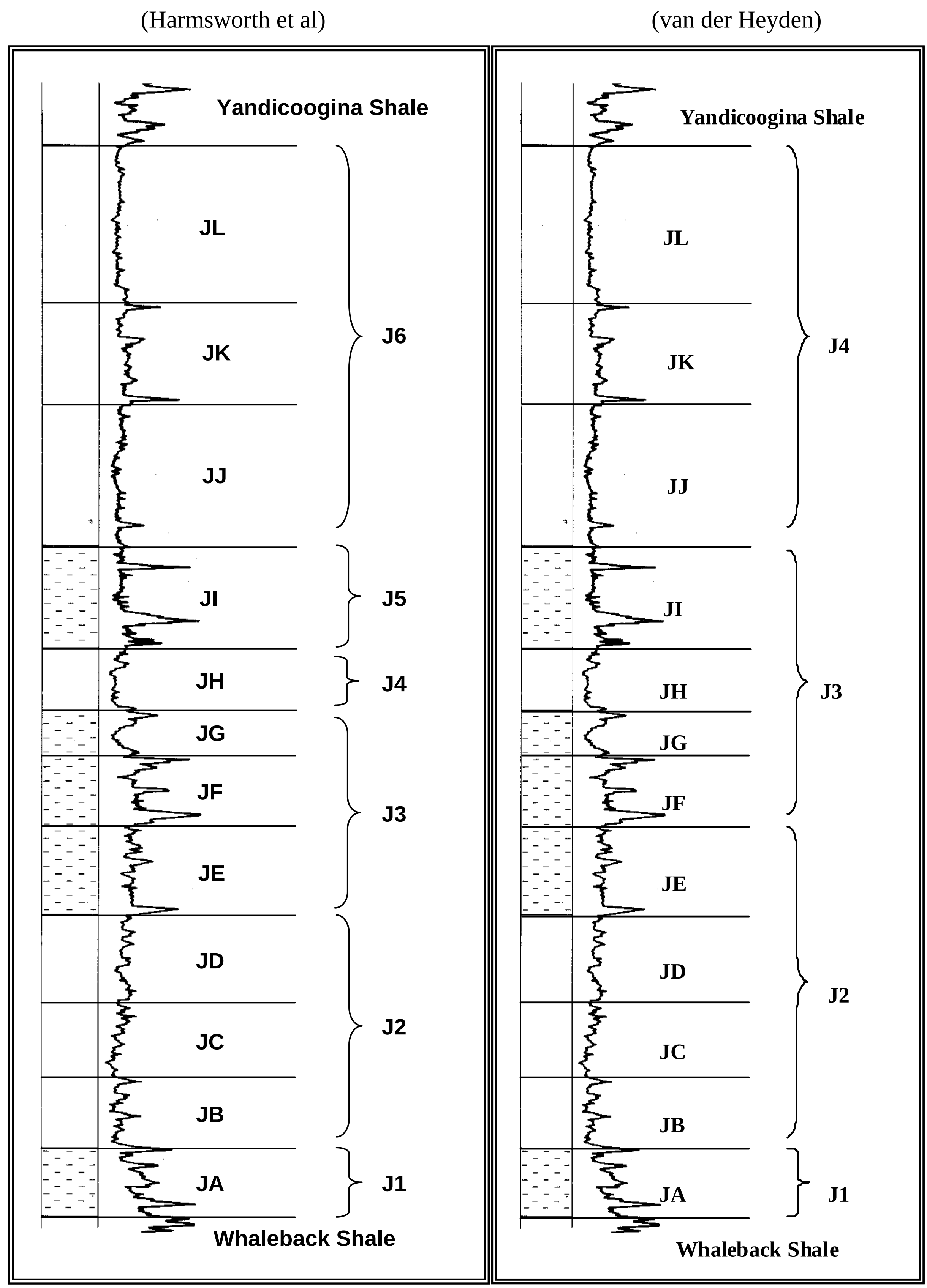


Figure 0-6: Joffre Stratigraphy and Gamma Log



Several geologists, who were involved in the logging of samples generated during the feasibility drilling programme, were involved in the initial sectional interpretation. Once a generally agreed viable interpretation was developed, Mr Ta Nguyen, the Project's Geotechnical Geologist constructed the 3D wireframe model using Gemcom's Surpac Software. The initial 3D model was reviewed by Mr Arnold van der Heyden (Resource Geologist) and Mr Todd Axford (Exploration Manager). Modifications to generate the final 3D geological model followed this review.

Comparison of the previous interpretation characterised by sub vertical faulting and sub vertical dolerite dykes, to the latest model shows consistency in terms of stratigraphy strike 025 degrees and dip 45 degrees west. The new model differs in that fault and dyke sets are now interpreted to dip moderately in an easterly direction. These faults and dykes fit two general orientations, NNW-SSE and NE-SW. This new interpretation fits the geological data and is supported by orientated geotechnical measurements. Consistent with any interpretation, there are alternatives; however the current model is generally accepted as the most realistic interpretation of the available data. Figure 0-7and Figure 0-8 show the model.

The geological model was provided to the Snowden geotechnical division for use in determining geotechnical parameters for the pit design. The model was also provided to Hellman & Schofield for use in the resource estimation process.

Figure 0-7: April 2008 Geological Model (rotated & looking north) and (rotated & looking east)

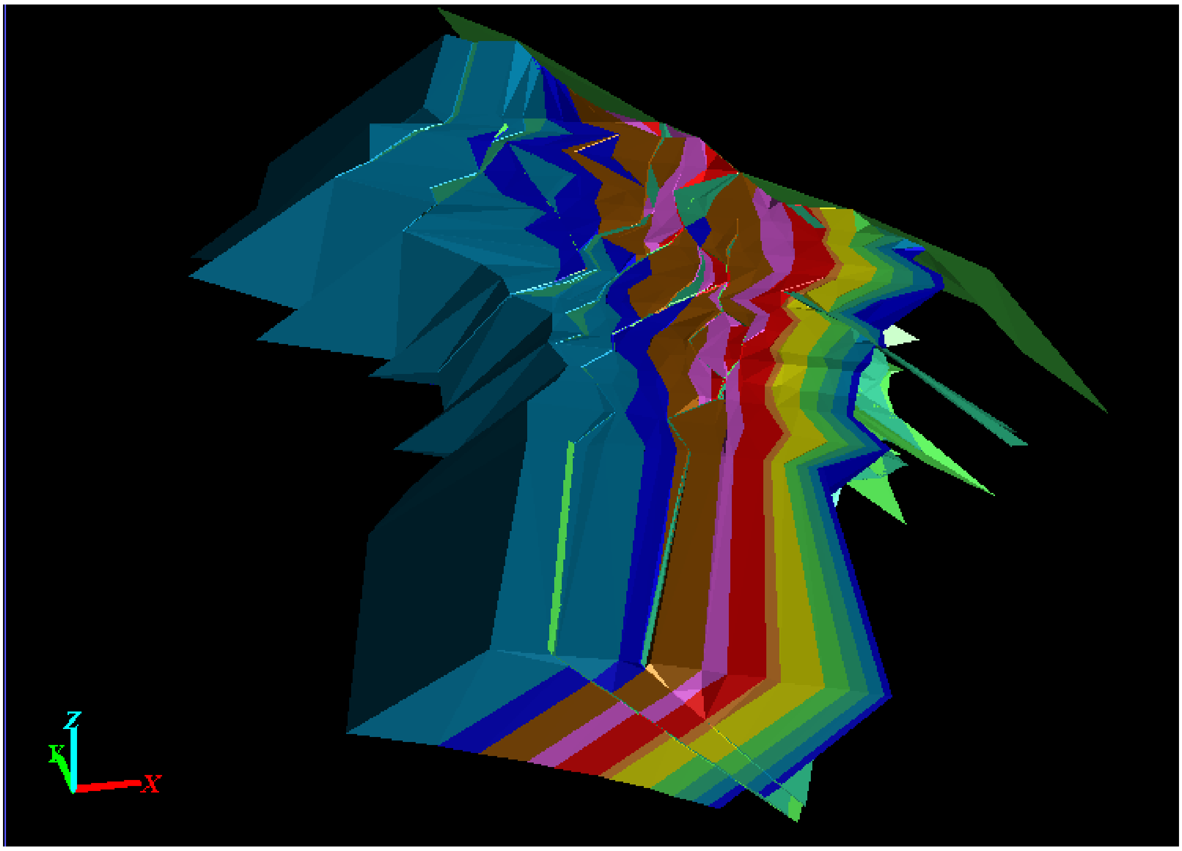
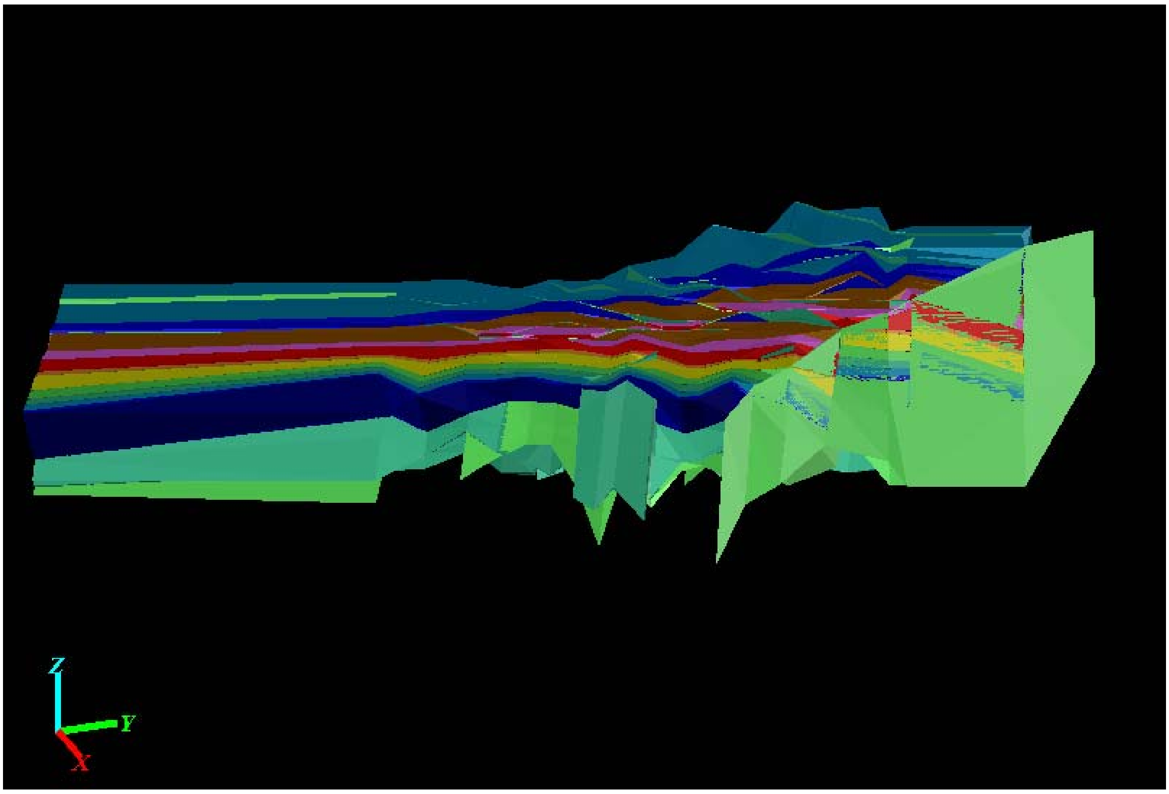


Figure 0-8: April 2008 Geological Model (rotated and looking west)



Mineralisation and Controls

Primary Mineralisation

The economic iron mineralisation in the Balmoral South orebody is magnetite. Magnetite is the primary iron mineral present in the banded iron formations (BIF) of the Brockman Iron Formation. The Dales Gorge BIF and Joffre BIF are the members of the Brockman Formation with the highest concentrations of magnetite bedding, and as such are the focus of drilling to define the orebody. Magnetite is variably present in lower levels within the Whale Back Shale and is also present in the Weeli Wolli BIF.

McConchie (1984) describes the Brockman Iron Formation in detail and his thesis describes the Dales Gorge unit as macro banded but containing numerous occurrences of smaller scale banding. Banding within the Joffre is typically of a mesoband scale but does range down to include micron scale banding. While the Dales Gorge is characterised by relatively thicker banding, magnetite bands do not exist in thicknesses anywhere near great enough for selective mining. Interband frequency is relatively consistent within the identified sub-units of Joffre and Dales Gorge BIFs.

The following comparison of the Joffre and Dales Gorge Members is taken from McConchie (1984):

- In the Joffre there is no direct equivalent of the macrobands which characterise the Dales Gorge Member.
- In contrast to the Dales Gorge Member which contains a diversity of mesoband types, almost all mesobands in the Joffre are either chert or chert-matrix, each of which makes up about half the total thickness.
- There is a difference in the degree of development and distribution of various structures defined by mesoband irregularity.

- Riebeckite in the Joffre is generally evenly disseminated through all mesobands whereas in the Dales Gorge Member it is concentrated in specific bands.

Impact of Weathering on Mineralisation

Oxidation of the BIFs at Balmoral South results in the conversion of Magnetite to Haemetite and Goethite. Interpretation of drilling data shows oxidation to typically extend to a depth of 40 metres from surface within the BIFs, with locally increased depth of oxidation likely to be associated with major faulting. Unlike other areas of outcropping Brockman Iron Formation where Haematite/Goethite has been concentrated with the removal of silica creating deposits of Direct Shipping Grade, the oxidised BIF horizons at Balmoral are not enriched. Haematite and Goethite exist with associated non iron oxide bands and are not magnetically recoverable; as a result oxidised areas of BIF are not treated as ore. The relatively low concentrations of Haematite and Goethite within the BIF, and the amount of grinding required to liberate these iron minerals combined with the difficulty to separate Haematite and Goethite, once ground to -45um, makes extraction and concentration uneconomic at this time.

Mineralisation Controls

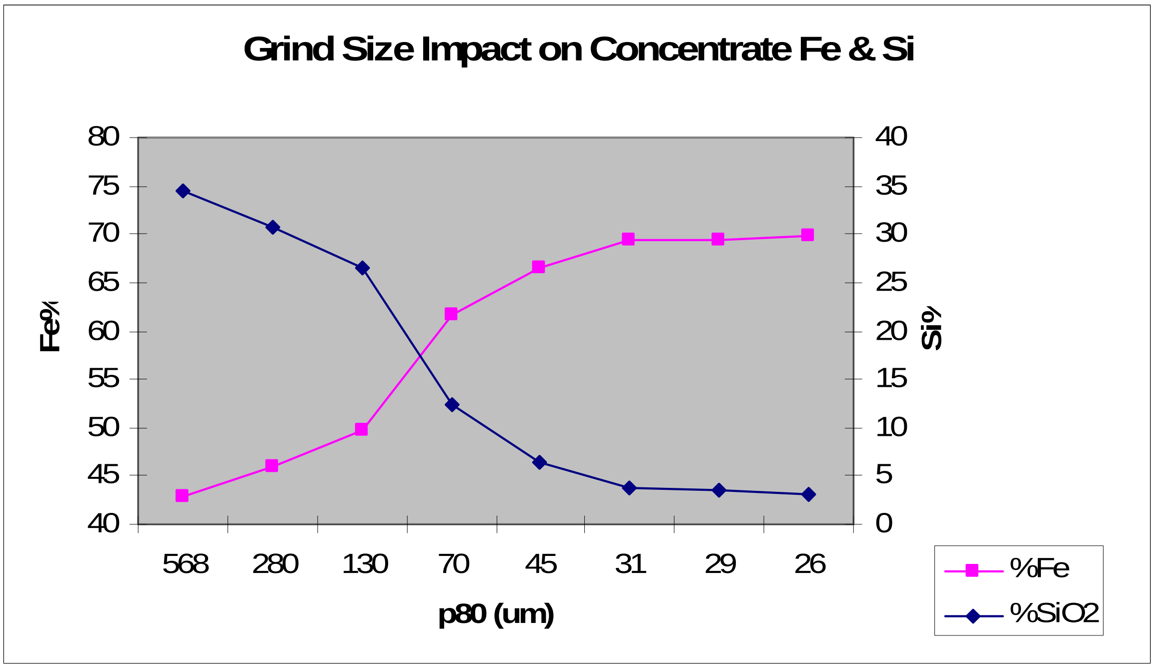
Controls on the Balmoral South Mineralisation can be discussed in two categories, macro scale controls and micro scale controls. Being a sedimentary orebody, macro scale controls on mineralisation are stratigraphic and structural. While micro scale controls refer to the distribution of the magnetite and its relationship to other minerals within the stratigraphy.

The Brockman Iron Formation has been shown to extend over hundreds of kilometres throughout the Pilbara (Mineralisation and Geology of the Pilbara Craton, Geological Survey of Western Australia, 2002). The Brockman Iron Formation can be described as a sequence of interbedded Magnetite, Chert, Jasper and Riebeckite, with tuffaceous zones present in the shaley units. Along strike variability is extremely low; however across strike variability is higher (due to bedding variation), which is reflected by the definition of sub-units within the BIF members.

Uninterrupted by faulting and dolerite dykes individual beds within the Brockman Iron Formation can be traced for tens or hundreds of kilometres (McConchie, 1984). Therefore a major control on distribution of mineralisation at Balmoral South is structural. This is reflected in the resource estimation where 14 structural domains were defined to constrain the estimation.

Given the intention to concentrate the Magnetite present within the BIF’s, it is worth considering the relationship of minerals/bands on the smaller scale. McConchie (1984) described a general trend for band contacts to be sharp on the micron scale and move to gradational as band thickness increases. This phenomenon was confirmed when logging core during the feasibility programme. This provides some basis to explain why such a fine grind is required to liberate significant quantities of ‘clean’ magnetite. Either the magnetite exists in discrete micron scale bands, it exists within coarser bands of magnetite (easily liberated), or it is interspersed with other minerals in the gradational band edges. Figure 0-9 below shows the relationship between grind sizes and concentrate chemistry.

Figure 0-9: Relationship of Grind size to Concentrate Chemistry



(Based on analysis of samples taken during generation of concentrate by Changsha Institute – Changsha draft report '4t concentrate produce report1.doc')

Petrographic analysis of the Balmoral BIFs shows magnetite to be present at grainsizes ranging from 0.05mm to 1.0mm, suggesting grinding to -45um is sufficient to liberate the magnetite within these BIFs. The magnetite is often closely related to the chert on a micron scale and analysis of the quartz/cherts shows grain sizes typically between 5um and 50um (McConchie, 1984). An observation which explains the relationship demonstrated in Figure 0-9 above. A programme of petrographic work, to confirm McConchie's findings, was proposed as part of the feasibility study scope. Due to the extreme demand for this type of work and lack of suitably experienced practitioners this work is yet to be completed and is still recommended to further understand mineralisation controls.

AMD section in PER

Waste Disposal Facilities

Mine waste rock and dewatered process tailings will be co-disposed in the designated disposal areas (WDF1 to the west of the pit and WDF2 to the east of the pit).

The tails stream produced from processing magnetite ore consists of inert materials comprising a fine and coarse fraction. The tails will be dewatered by pressure filtering, and conveyed to the WDFs for storage in overhead bins and subsequent truck haulage to either co-dispose with waste rock or dispose of in specific areas allocated to dry tails within the WDF disturbance area. Traditional tailings dams may be required if this process is not viable. However, the traditional tailings option is not a part of this approval assessment.

The bulk density of the filtered tails is approximately 2.00 t/m^3, with an estimated moisture content of 15%. The moisture content achievable in the tails is currently being tested.

A test work program was commissioned to investigate the potential for acid formation from the waste material encountered within the Balmoral South pit. The samples were initially categorised based on stratigraphy and sulphur content. Given the sulphur threshold value of 1.5%, approximately 0.9% of all the samples collected have the potential to produce acid. The Acid Mine Drainage analysis (AMD) test work also confirmed the limited acid neutralising capacity (ANC) of the samples selected; this is not to say that there is no material demonstrating some neutralising capacity within the ultimate pit limits but that suitable mineralogy is not present in the samples tested.

The higher sulphur material, assays greater than 3.0%, exist predominantly in the black shale bands of the Whaleback and McCrae Shale units, neither forming a significant tonnage with respect to the entire tonnage mined. The Whaleback Shale tonnage in the ultimate pit stands at approximately 0.5% of total material. The McCrae Shale is not likely to be mined in significant amounts except for local occurrences due to faulting and uplift. The occurrence the of high sulphur BIF material (>1.5% S) is extremely rare.

It is not anticipated that significant quantities of high sulphur material will be mined. However if any potential AMD waste is encountered it will be controlled by assessment and adding management actions in the PEMP. Essentially, it will be separately encapsulated in the waste disposal area, surrounded by low permeability material or blended with neutralising waste. In the long term the possibility of sourcing a suitable bulk waste material with ANC from material within the pit will be investigated. Monitoring bores will be installed around the WDFs to ensure performance of the AMD management actions.

In addition to the generally low occurrence of high sulphur samples, all of the samples identified as having likely potential for AMD were collected from a depth greater than 200 m below ground level. With the planned mining schedule, the mining landforms, infrastructure and mining procedures will be developed prior to any mining disturbance reaching the depths at which the AMD material is likely to be located.

The Pilbara region has the potential for asbestiform mineral occurrence. The Balmoral South Project is working closely with the Central Block Project to identify potential issues, and has developed management plans for safe work procedures.

The creation of a stable landform is an important design consideration for the proposed WDFs. The final land form will be used to encapsulate a number of materials including any potential acid generating waste, potential fibrous material and the fine tails fraction.

The WDFs' outer layers will be constructed with inert coarse mine waste, and only material suitable to form a long term stable slope will be used. In areas that may be exposed to frequent water action, rip-rap over size material (boulders > 1.0t) will be used to rock armour the WDF. Rock drains will be included on the WDF slope to absorb the energy of the runoff water.

Final batter slopes on the waste disposal area will be formed by dozing down to an 18^o slope as the dump is raised (*Figure Error! No text of specified style* **in document.**-1: Waste Disposal Facility Design Profile). The ultimate height for the WDF is 90 m above ground level, constructed in 30 m lifts.

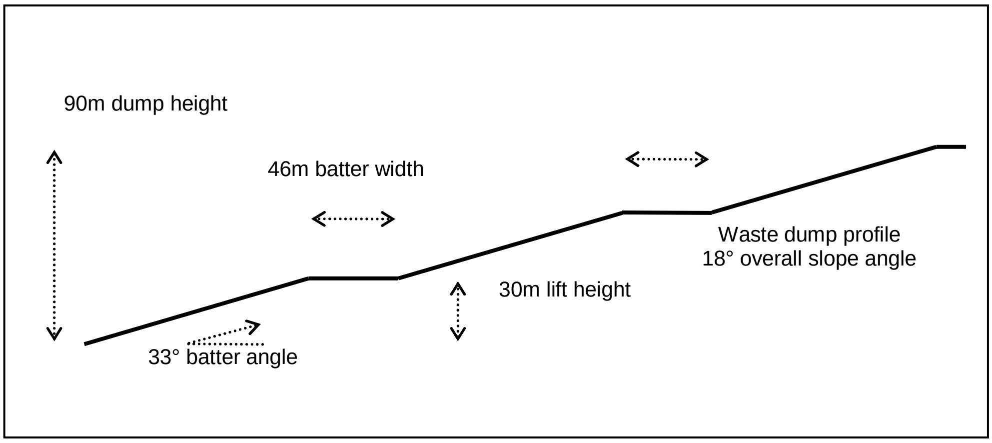


Figure Error! No text of specified style in document.**-1: Waste Disposal Facility Design Profile**

The interim and final profiles will be built to ensure that a stable (non-eroding) land form is created, and to shed as much surface water as possible, achieving two goals:

- help reduce the potential for acid mine drainage to develop. The more water that percolates through the waste layers, the greater the chance of oxidation of any potential acid forming waste and subsequent mobilisation of this contaminated water; and
- establishment of a stable land form to better withstand high intensity rainfall events in severe weather events, without serious degradation.

The plan is to cover the top surface of the dump in scree, raked out of the waste, so that the surface is dust free and contoured to provide drainage paths above relatively impermeable layers below the scree. In addition any available topsoil together with its inherent seed bank will be spread over the waste dump.

Given the availability of large rocks on the site, the runoff from the top of the dump will be directed to engineered watercourses comprised of large rocks, which can handle such flow, and short drops and pools for energy dissipation. This will be designed and built progressively during the life of the mine, and interim versions of the watercourse will be tested by storms, with adjustments made to the design if necessary. The runoff from the slopes on the waste dump will be similarly guided to ground level. The key to stable WDFs is correct engineering and construction of the water control works.

The visual impact of the rock covered WDFs will be similar to many rock covered slopes in the Pilbara, except that WDFs have a regular shape compared to generally irregular shapes of the natural slopes.

AMD section in PEMP

ACID ROCK MANAGEMENT

Context

The Balmoral South magnetite resources are contained within a Brockman Iron formation known as the Susan Palmer Deposit. This formation is overlain with a banded iron formation known as the Weeli Wolli, and underlain by Mount McCrae Shale. The Brockman Iron Formation consists of an alternating sequence of Banded Iron (BIF), shale and chert, with the iron rich bearing units being the Joffre and Dales Gorge members.

Analysis of these formations indicates that on a 0.5% total Sulphur cut-off, approximately 1% of the BIF, 21% of the Shale and 6% of the remaining material has acid generating potential. Taking the total volumes of each of these units into account, this equates to approximately 5% of total material moved having some acid generating potential.

Legislations and Relevant Standards

- *Department of Industry and Resources (2006), Mining Environmental Management Guidelines, Mining in Arid Environments*
- *Water Quality Protection Guidelines No. 9 Mining and Mineral Processing, Acid Mine Drainage (WRC, 2000)*
- *Water Quality Protection Guidelines No. 5 Mining and Mineral Processing, Minesite Water Quality Monitoring (WRC, 2000)*
- *Department of Industry and Resources, (2001), Environment Division, Environmental Notes on Mining, Waste Rock Landforms*
- *Relevant approved Environmental Management Plans (EMPs) prepared and submitted in accordance with Ministerial Statement 635 by Mineralogy (2005, 2006, 2007, 2008).*

Stakeholders Consultations

As required IM, or its contractors, will notify and consult relevant authorities in the event that inappropriate management of acid rock causes a potentially significant environmental impact. If necessary, IM shall seek advice on proper environmental remediation procedures from the relevant authorities.

Potential Sources and Impacts

Potential Sources

The potential issues that may impacts relevant to acid rock include:

- Potentially Acid Forming (PAF) material incorrectly identified and placed;
- Insufficient cover over PAF material allowing uncontrolled oxidation; and
- Exposure of PAF material within final void design

Potential Impacts

The potential impacts relevant to acid rock:

- Discharge of low pH runoff from storage areas impacting on soil and vegetation growth;
- Mobilisation of metals in concentrations greater than ANZECC guidelines;
- Contamination of surface or groundwater supplies; and
- Failure of rehabilitation due to unstable landforms or uncontrolled emissions

Environmental Management Objectives

EPA Objective

The objective is considered relevant to acid rock:

- To avoid, where practicable, serious or irreversible damages to the environment.

Balmoral South Project Management Objectives

The objective for the Balmoral South Project in relation to acid rock is to minimise any direct or indirect impact from the operations, including:

- To characterise waste rock prior to mining;
- To recognise and appropriately manage any potentially acid forming materials during mining operations;
- To control erosion/sedimentation from waste rock landform areas;
- To minimise the area of vegetation cleared;
- To monitor the effectiveness of controls; and
- To adaptively respond to inadequacies in controls.

Objectives will be met by implementing the key management actions listed in **Error! Reference source not found.**.

Management Actions

In order to avoid and reduce the potential impact of activities relevant to acid rock drainage, the key management actions that will be carried out to achieve the management objectives have been compiled in Table 1. This table also details at what stage of the development the actions will be implemented and the responsible person(s) for ensuring operational compliance with the management actions.

Table 1: Management Actions for Acid Rock

Item	Action	Timing	Responsibility
55.1	Induction procedures shall be conducted to notify third parties of the formation of Acid Rock Drainage (ARD) and the mitigation measures in place.	On-going	Mine Manager, SEO.
55.2	Conduct environmental training, as necessary ensuring compliance with acid rock management requirements.	On-going	Environmental Manager, SEO
55.3	Obtain Acid Base Accounting (ABA) data for underrepresented strata, or strata with significant compositional variability.	Design and operations	Mine Manager, Project Engineer
55.4	Develop and implement water management plans, including monitoring programs for surface and groundwater, which includes: • Monitor groundwater quality to assess potential occurrence of seepage from WDFs • Monitor surface water run-off to ensure no ARD is generated • Establishment of discharge criteria • Combine water balance and quality to obtain salt balance	Design and operations	Mine Manager, Environmental Manager, SEO
55.5	Develop block models and pit plans to identify problematic materials based on ABA data available.	Prior to mining	Mine Manager
55.6	Consideration will be given to separate and encapsulate high sulphur PAF and Acid Forming (AF) waste to minimise risk of acidic seepage.	Prior to mining	Mine Manager, Project Engineer, Contractor, SEO
55.7	Place and encapsulate / co-mingle AF and PAF waste (with Non Acid Forming (NAF)) as soon as possible at the Waste disposal facilities.	On-going	Mine Manager, Project Engineer, Contractor, SEO
55.8	Place NAF waste on top of any PAF waste to reduce the risk of plant toxicity and potentially increased volumes of ARD effected materials.	Operations, closure	Mine Manager, Project Engineer, Contractor, SEO.

Environmental Targets and Performance Indicators

The key environmental targets and performance indicators will be used to assess performance against the environmental objectives listed in the Section 22.3. Table 2 details environmental targets based on management objectives for acid rock and performance criteria to assist in assessing the achievement of these targets.

Table 2: Environmental Targets and Performance Indicators for Acid Rock Drainage

Management objective	Environmental Targets	Performance Indicator
To characterise waste rock prior to mining.	Problematic materials identified prior to mining.	Acid Base Accounting completed on representative samples of waste rock. Block model identifies problematic materials. Assessment of rehabilitation materials completed prior to mining.

Management objective	Environmental Targets	Performance Indicator
To recognise and appropriately manage any potentially acid forming materials during mining operations.	Water quality of leachates and runoff such that livestock water quality guidelines are met in surface runoff and groundwater.	Identification and management procedures in place for McCrae and Whaleback Shales. Audit of procedure implementation. Water control structures in place as landform is being constructed. Water monitoring shows acceptable water quality from site runoff.
To control erosion/sedimentation from waste rock landform areas.	No erosion or sedimentation effects beyond clearing perimeters.	Water control structures in place as landform is being constructed. Water monitoring shows acceptable water quality from site runoff. Environmental Incident Reports show no erosion or sedimentation effects beyond clearing perimeter. Waste rock rehabilitation surfaces constructed to be resilient to rainfall and grazing.
To monitor the effectiveness of controls.	Above targets are met.	Estimate of overall effectiveness through occasional assessment of performance of controls.
To adaptively respond to inadequacies in controls.	Acid rock management actions and procedures updated as required.	Extent to which updated WRMP addresses all issues.

Monitoring and Corrective Actions

In order to ensure progress toward the achievement of the management objectives outline in Section 22.3 of this PEMP, a monitoring programme that examines the performance of acid rock management actions for the construction phase of the development is detailed in Table 3.

Construction areas shall be subject to regular (or as required by IM in consultation with its environmental consultants) inspections during earthworks and construction. The SEO shall conduct these inspections. Construction Inspection Checklists shall be used and shall include assessment of waste management actions as listed in Table 1

Relevant documentation to be inspected includes the Environmental Incident Reports and previous inspection sheets to check whether problems or non-conformances to the waste management procedures have been rectified.

Table 3: Monitoring and Corrective Action Programme for Acid Rock Drainage

Item	Activity	Performance Indicator	Corrective Action	Frequency	Responsibility
57.1	Static testing of waste material	Confirm preliminary classifications and refine waste plans for optimisation of waste material handling.	Use additional testing data to update identified PAF waste Isolate and transport to the correct location Prevent mixing of PAF and NAF materials.	As required (e.g. based on visual observation and/or when insufficient data is available)	Project Engineer
57.2	Surface monitoring	Surface water quality does not exceed Water Quality Protection Guidelines (WRC, 2000) for Mining and Mineral Processing - Minesite water quality monitoring prior to disposal.	Storing and evaporating the water, then removal and disposal of the solids. Separating the affected water from other mine water and treating it separately Diluting prior to discharge.	Quarterly for the first year, then annually unless quality target levels are exceeded	SEO
57.3	Groundwater monitoring	Groundwater quality does not exceed Water Quality Protection Guidelines (WRC, 2000) for Mining and Mineral Processing - Minesite water quality monitoring.	Re-run of groundwater model Increase monitoring frequency Assess options to alter waste rock dump	Quarterly for the first year, then annually unless quality target levels are exceeded	SEO

Contingency Actions

Triggers will be monitored through the monitoring program.

The potential triggers are:

- ARD is identified from materials not classified or managed as PAF;
- Seepage pH is below six from NAF materials;
- Visible pyrite is observed in materials that are classified as NAF;
- An increased potential for AF and PAF waste rock is measured within major stratigrahic units;
- Changes in estimated volumes of AF, PAF, NAF waste are observed in the waste inventory; and

- Decreasing pH or increasing metal concentrations are observed in analytical data for water containment infrastructure.

Contingency actions will be initiated if monitoring shows that triggers may have been exceeded and may result in a level of environmental impact that requires mitigation. The contingency actions shall be implemented concurrently with environmental incident procedures.

The contingency actions for the potential trigger might be used:

- Investigate cause
- Rectify immediately if the cause is non-compliance with acid rock management actions;
- Conduct a review of procedures and/or implement further education of staff/contractors to ensure that all possible steps are taken to prevent any reoccurrence; and
- Complete an Environmental Incident Report.

Reporting

The presence and location of Potentially Acid Forming (PAF) material will be reported to the Department of Industry and Resources and Department of Environment and Conservation through the site Annual Environmental Report. Activities undertaken to prevent acid generation (such as encapsulation of PAF material) will be outlined. Where ARD has the potential to cause off-site environmental impacts, the relevant Department will be consulted to ensure adequate control measures are implemented.

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Analytical Report

Acid Mine Drainage Analysis

Job No : **082389**
Client: INTERNATIONAL MINERALS
Address: Level 4, 5 Mill Street
Perth
WA 6000

Approved Checker
Ben Carpenter

Approved Signatory
Nelly Liusnaini Hislop

Contact: Sandrine Guyot
E-mail:
Fax: 08 9324 2164
Client Reference: 1060
Date Sampled: Unknown
Date Received: 18/04/2008
Date Reported: 15/12/2008
Sampled By: Client
Location Unspecified

Test Method: Solid samples crushed and pulverised to a nominal 75 micron particle size prior to analysis. Total sulphur analysis by LECO combustion, NAG determined by titration on 1:100 peroxide digestion. ANC determined after reaction with Hydrochloric acid at 80 degrees Celsius. GAPP and the derived NAPP are corrected for soluble (1:5 extraction) sulphate.

This report replaces any issued previously

This document is issued in accordance with NATA's accreditation requirments. AN: 2220

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Date Printed 15/12/2008

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Analytical Report

Job No : 082389

Lab Id Units Method Ref. LQL	External Idents	pH (1:5) 0.05	ANC H2SO4 kg/ tonne 0.5	Total Sulphur % 0.001	Sulphate_S % 0.001	NAG pH 0.05	NAG kg/ tonne 1	GAPP H2SO4 kg/ tonne 0.3	NAPP H2SO4 kg/ tonne 1
082389-001	SB002A 289.88-290.90	7.90	84	15.6	0.072	2.50	76	470	390
082389-002	SB002A 292.00-292.94	7.80	57	16.0	0.089	2.15	200	490	430
082389-003	SB002A 302.10-303.10	8.30	87	3.2	0.009	7.35	<1	94	6
082389-004	AR006 261.40-262.40	9.35	67	0.18	0.008	8.60	<1	5.3	<1
082389-005	AR006 278.00-278.66	9.40	77	0.039	0.005	9.20	<1	0.9	<1
082389-006	AR017 195.15-196.15	10.05	97	0.12	0.010	8.55	<1	3.6	<1
082389-007	AR017 205.02-206.05	10.05	77	0.14	0.008	8.55	<1	3.8	<1
082389-008	AR021 261.35-261.93	9.25	86	1.6	0.032	8.30	<1	49	<1
082389-009	AR021 289.38-289.90	9.30	69	0.039	0.005	9.10	<1	<0.3	<1
082389-010	AR022 199.60-200.60	9.80	34	0.23	0.014	8.70	<1	6.7	<1
082389-011	AR022 208.70-209.70	10.00	84	0.17	0.013	8.60	<1	4.9	<1
082389-012	AR022 224.20-225.70	8.40	79	4.4	0.027	3.30	33	130	56
082389-013	AR022 225.70-227.00	8.15	67	5.6	0.044	3.05	41	170	100
082389-014	AR023 258.25-258.97	8.35	49	4.8	0.021	2.50	59	140	95
082389-015	AR038 303.14-303.85	8.65	110	2.0	0.008	8.20	<1	61	<1
082389-016	AR038 304.42-305.15	8.70	80	1.2	0.005	8.35	<1	37	<1
082389-017	AR038 306.92-307.73	8.30	21	5.2	0.018	2.35	98	160	140
082389-018	AR044 130.00-130.55	9.30	88	0.090	0.006	8.45	<1	2.2	<1
082389-019	AR017200.8-202.07	9.90	91	0.16	0.009	8.70	<1	4.8	<1

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Analytical Report

Job No : 082389

Lab Id	External Idents	pH (1:5)	ANC H2SO4	Total Sulphur	Sulphate_S	NAG pH	NAG pH	GAPP H2SO4	NAPP H2SO4
Units			kg/ tonne	%	%		kg/ tonne	kg/ tonne	kg/ tonne
Method Ref.									
LQL		0.05	0.5	0.001	0.001	0.05	1	0.3	1
082389-020	SB002A296.6-297.6	8.55	23	4.1	0.011	2.30	78	130	100
082389-001-DUP	SB002A 289.88-290.90	7.85	82	15.4	0.074	2.40	76	470	390

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Analytical Report

Job No : 082389

Report Comments

Result Comments

APPENDIX B

Limitations

LIMITATIONS

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