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February 2011

Document No. 6702/952

ARD Assessment of Overburden and Coal from the South Galilee Coal Project

Contents

List of Tables (after text)

List of Figures (after tables)

List of Appendices (after figures)

Executive Summary

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by AMCI (Alpha) Pty Ltd to carry out acid rock drainage (ARD) assessment of overburden, interburden, floor rock and coal from the South Galilee Coal Project (SGCP). The overall objectives of the work were to assess the ARD potential and distribution of ARD rock types to assist planning of materials management.

Investigations involved the geochemical characterisation and ARD assessment of 186 samples, comparison of results with a previous (2009) assessment of 54 samples, and identification of any trends to assist segregation of ARD rock types.

Results of testing indicate that the bulk of the overburden and interburden material is likely to be NAF, and suggest the presence of a large continuous section of NAF material from surface down into the upper portion of the fresh Permian. The roof within 5m of the D1 seam appears to be the main PAF horizon of concern, with a number of other lower capacity PAF horizons associated with coal seams and also within interburden between Seams D1 and D2. Final pit floor material will mainly comprise D2 floor, which is likely to be PAF-LC. ROM coal and washery wastes are also likely to be mainly PAF. Salinity in overburden materials appeared to be related to pyrite oxidation, and hence control of ARD will largely control salinity.

Kinetic NAG and ABCC testing indicated that PAF materials are likely to be fast reacting, with little or no lag time (days to weeks) once exposed to atmospheric conditions. Water extract testing indicates that once acid conditions develop elevated concentrations of dissolved Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn are likely to occur.

Results have the following implications for materials management

- selective handling of PAF overburden and interburden materials is likely to be required for ARD control;
- mixing of lower capacity PAF horizons with higher ANC NAF materials may be sufficient to control ARD from these materials, but this would need to be confirmed with testing of blended materials and better definition of the distribution of ARD rock types in these horizons across the deposit;
- the roof horizon within 5m of Seam D1 is likely to require selective placement away from the dump outer slopes and deep burial, and may also require encapsulation in cells designed to minimise infiltration and implementation of an engineered cover system at closure;
- if washery wastes are disposed of in waste rock dumps they are likely to require similar management as the D1 roof material;
- engineered cover systems are likely to be required at closure for washery wastes placed in dedicated storage facilities;
- placed PAF overburden and washery wastes may require surface treatment with crushed limestone and/or lime water treatment of drainage to control ARD during operations;

- provision for collection and lime treatment of coal stockpile drainage may be required depending on ARD reaction rates and stockpile residence times;
- the final pit floor at the base of Seam D2 may require minor surface limestone treatment, addition of high ANC NAF and/or water treatment during operations depending on ARD reaction rates and acid loads;
- a programme of routine sampling and geochemical testing of waste materials should be carried out during operations to monitor variation in acid potential, reconcile the ARD prediction model and check ARD rock type materials handling and placement; and
- routine surface and groundwater monitoring should include analysis of pH, EC, acidity/alkalinity, Ca, Cl, K, Mg, Na, SO_4, Ag, Al, As, Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb and Zn.

The following further work is recommended to assist finalisation of ARD control strategies:

- Carry out more extensive testing of drillholes to:
  - better define the PAF and PAF-LC zones across the deposit;
  - better define variation and continuity of the zone of higher ANC fresh Permian overburden intercepted in hole SP142;
  - construct an ARD model suitable for predicting the distribution of these zones during mining; and
  - generate a production schedule based on geochemical type for long term planning.
- Further investigate criteria for routine ARD classification. Results to date indicate that total S alone may be suitable.
- Assess the ARD potential of lower capacity PAF/PAF-LC zone materials and the effects of operational mixing with NAF overburden to help determine whether additional controls are needed (such as blending with selected high ANC overburden or limestone).
- Better assess the sodicity potential of overburden materials.
- Carry out leach column testing of a range of material types to help assess reaction kinetics and leachate compositions.
- Review the S distribution in the various coal seams across the deposit and carry out more comprehensive ARD testing of coal and washery waste materials to better define the acid potentials.
- Carry out investigations into cover designs for long term control of ARD from PAF overburden and washery wastes.

1.0 Introduction

Environmental Geochemistry International Pty Ltd (EGi) were commissioned by AMCI (Alpha) Pty Ltd to carry out an acid rock drainage (ARD) assessment of overburden, interburden, floor rock and coal from the South Galilee Coal Project (SGCP), a thermal coal deposit occurring in the south eastern region of the Galilee Basin and located south-west of the township of Alpha in central Queensland. The proposed mining project would produce 15-20 million tonne per annum (Mtpa) from open cut and underground mining operations. The initial geochemical assessment work in this report has focussed on the open cut resource.

The overall objectives of the work were to assess the ARD potential and distribution of ARD rock types to assist planning of materials management.

Investigations involved: geochemical characterisation and ARD assessment of overburden, floor rock and coal samples; comparison of results with a previous assessment in 2009; and identification of any trends to assist segregation of ARD rock types. Previous work was also used to provide an overall indication of salinity and sodicity potential.

2.0 Background

Economic coal seams from the SGCP are hosted within the Late Permian Bandanna Formation, which consists of a fluvial dominated depositional sequence of carbonaceous shale, argillaceous and carbonaceous siltstone, micaceous-quartz-feldspathic sandstone, and coal. The Bandanna Formation contains multiple coal seams, which are generally known as Seam A through to Seam F. The primary target seams within the project area are D1 and D2. These seams are separated by approximately 13 to 15 m of sandstone and siltstone.

Most of the project area is covered by 15m to 50m of weathered Tertiary alluvial material (typically 30-35m), with the Permian host being weathered to a depth of 10m to 15m. The focus of the recent testing by EGi was on the fresh Permian overburden.

The proposed open cut would be developed using draglines and truck and shovel mining methods in multiple active pits, with out of pit dumping planned initially and in-pit dumping where practicable. Coal washing will be carried out on site, with washery wastes potentially placed within overburden dumps.

3.0 Sample Selection and Preparation

Samples for geochemical testing were provided from fully cored holes CK162, CK165C and SP142, drilled as part of a 2010 geotechnical drilling programme. A total of 186 samples were tested.

Continuous samples were collected from the available core for each hole from the base of the weathered Permian through to the D2 floor. D2 is the lowest coal seam to be mined in the proposed open cut, and the D2 floor would make up the vast majority of the final pit floor. There were gaps in the available core due to previous sampling for coal quality and geotechnical testing. Many of these coal quality and geotechnical samples were still available, and were provided to EGi to help fill in gaps in coverage. Missing intervals are shown in Table 1.

SGCP arranged for ALS (Emerald) to carry out sample preparation on overburden and interburden core samples available in the core trays as per the flow sheet shown in Figure 1, to produce 300-500g splits of -4mm crushed samples and -212µm pulverised samples, which were dispatched to EGi.

The geotechnical samples were provided separately to EGi as whole core, and EGi arranged sample preparation by Sydney Environmental Soil Laboratories (SESL), which was carried out in a similar fashion to Figure 1. Coal quality samples were provided as splits of already prepared -212µm samples.

4.0 Methodology

All samples were analysed for total S (Leco equivalent), which was used to selected a smaller subset for the following testing:

- acid neutralising capacity (ANC) – 142 samples; and
- single addition net acid generation (NAG) test – 100 samples.

In addition, specialised testing was carried out on selected samples to help resolve uncertainties in the above test results, as follows:

- extended boil and calculated NAG testing to account for high organic carbon contents (13 samples);
- sulphur speciation to obtain a guide to the proportion of pyritic S (11 samples);
- kinetic NAG testing of higher S samples to check pyrite reactivity and to indicate lag times (7 samples); and
- acid buffering characteristic curve (ABCC) testing to define the relative availability of the ANC measured (11 samples);
- multi-element testing of solids to assess elemental enrichment (15 samples); and
- multi-element testing of deionised water extracts at a ratio of 1 part solid to 2 parts water to assess initial elemental solubility (15 samples).

A general description of ARD test methods and calculations used is provided in Appendix A.

Crushed samples were used for deionised water extracts. Pulverised (-212µm) samples were used for all other tests.

The sulphur speciation procedure involved Leco total S, chromium reducible sulphur (CRS) and potassium chloride (KCl) digestion to help differentiate pyritic S, acid forming sulphate, non-acid forming sulphate and other lower risk S forms (including organic S, jarosite S and elemental S).

Total sulphur assays were carried out by SESL. CRS and multi-element analyses of sample solids were carried out by ALS Laboratory Group (Brisbane). Multi-element analysis of deionised water extracts were carried out by ALS Laboratory Group (Sydney). Analyses of NAG solutions and KCl digest solutions were carried out by Levay & Co. Environmental Services (Adelaide). All other analyses were carried out by EGi.

5.0 Previous Work

Matrixplus arranged geochemical testing of 54 samples from open holes BH99C and BH100C in early 2009. Results of the Matrixplus work are incorporated into this report.

It is understood that samples were collected by taking a scoop from chip piles collected each metre, and combining samples into composites according to lithological boundaries. Samples either side of the coal seams were collected in smaller intervals of 1-2m, and samples away from coal seams were collected in broader intervals of 5-10m. Not all samples were tested, with sample testing generally intermittent for BH99C, and more continuous for BH100C. The method of sampling used is suitable for providing a broad indication of ARD potential, but more representative and continuous sampling is required to define and correlate ARD horizons.

Standard geochemical characterisation was carried out by ALS Brisbane, and comprised

- pH and electrical conductivity (EC) of deionised water extracts at a ratio of 1 part solid to 5 parts water ($pH_{1:5}$ and $EC_{1:5}$);
- Leco total S;
- ANC; and
- single addition NAG test.

In addition, the exchangeable sodium percentage (ESP) was determined on a number of samples as a guide to sodicity and dispersion potential.

6.0 Standard Geochemical Characterisation Results

Results of standard geochemical characterisation of samples tested by EGi are presented in Table 1, comprising total S, maximum potential acidity (MPA), ANC, net acid production potential (NAPP), ANC/MPA ratio and single addition NAG. Previous geochemical results from holes BH99C and BH100C were supplied by SGCP and are reproduced in Table 2.

6.1 pH and EC

$pH_{1:5}$ and $EC_{1:5}$ testing was carried out in 2009 as part of the Matrixplus programme (Table 2). Results give an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

The $pH_{1:5}$ values ranged from 2.4 to 7.8, with approximately half the samples showing no inherent acidity with a pH greater than 6. Thirteen of the samples tested had an acidic pH of less than 4.0.

$EC_{1:5}$ values ranged from 0.04 to 3.13 dS/m with approximately half the samples falling within the non-saline to slightly saline range with an EC of 0.3 dS/m or less. Eleven of the remaining samples were saline (>0.6 dS/m).

Figure 2 is a plot of $pH_{1:5}$ and $EC_{1:5}$ versus total S, which shows that the lower $pH_{1:5}$ values and the higher $EC_{1:5}$ values are generally associated with higher S samples. This indicates that lower $pH_{1:5}$ and higher $EC_{1:5}$ values are the result of partial pyrite oxidation occurring between sample collection and sample testing.

Results indicate a general lack of immediately available acidity and salinity in the samples except where partial oxidation of pyrite has occurred. Pyrite oxidation would therefore be the main source of salinity in overburden materials.

6.2 Acid Base (NAPP) Results

Total S was carried out on a total of 240 samples from the EGi and Matrixplus datasets, with results ranging from below detection to 3.49%S. Figure 3 is a box plot of the distribution of S, split by material type. Samples are grouped into 3 materials types, Tertiary sediments, weathered Permian sediments and fresh Permian sediments. The plot shows that all Tertiary and weathered Permian samples had low total S values of less than 0.05%, and have a negligible risk of acid formation. The fresh Permian samples show a broad range of S values, but with 75% having relatively low values 0.2%S or less.

Figure 4 is a box plot of total S split by lithology for fresh Permian samples only. The plot shows that coal samples are significantly more enriched in S than other lithologies, with a median S of 1.2%S compared to medians of less than 0.2% for other lithologies. The non-coal lithologies cover a range of S values, with no strong lithological associations. The sandstone samples show the broadest range in S values, but also represent the most common rock type.

ANC was carried out on 196 samples and ranged up to 294 kg H_2SO_4/t. Figure 5 is a box plot of the distribution of ANC, split into Tertiary, weathered Permian and fresh Permian material types. The plot shows that ANC values are mostly low with median values of 5 kg H_2SO_4/t or less. All Tertiary and weathered Permian samples had low ANC of less than 10 kg H_2SO_4/t. Fresh Permian samples have a broader range but most (70%) have low ANC of 10 kg H_2SO_4/t or less.

Figure 6 is a box plot of ANC split by lithology for fresh Permian samples only. The plot shows that coal samples have low ANC of close to 10 kg H_2SO_4/t or less. Other lithologies do not show strong associations with ANC, with most showing a broad range in ANC values.

The net acid producing potential (NAPP) value is an acid-base account calculation using total S and ANC values. It represents the balance between the maximum potential acidity (MPA) and ANC. A negative NAPP value indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, a positive NAPP value indicates that the material may be acid generating.

Figure 7 is an acid-base account plot of ANC verses total S for fresh Permian samples. Figure 8 is the same as Figure 7, but re-scaled to exclude the high S samples and to better represent ANC below 50 kg H_2SO_4/t. The NAPP zero line is shown which defines the NAPP positive and NAPP negative domains, and the line representing an ANC/MPA ratio value of 2 is also plotted. Note that the NAPP = 0 line is equivalent to an ANC/MPA ratio of l. The ANC/MPA ratio is used as an indication of the relative factor of safety within the NAPP negative domain. Usually a ratio of 2 or more signifies a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to ARD.

The plot shows that S and ANC distribution in fresh Permian samples is mutually exclusive, i.e. moderate to high ANC (>20 kg H_2SO_4/t) samples have low S (<0.2%S) and moderate to high S values (>0.4%S) have low ANC (generally less than 10 kg H_2SO_4/t). Approximately half the samples tested were NAPP negative and half NAPP positive.

6.3 Single Addition NAG Results

Single addition NAG testing was carried out on 112 samples. Generally a NAGpH value less than 4.5 indicates a sample may be acid forming. However, samples with high organic carbon contents (such as coal and carbonaceous sedimentary materials) can cause interference with standard NAG tests due to partial oxidation of carbonaceous materials. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides.

More than half (65%) of the samples tested had a NAGpH value of less than 4.5, but many of these were associated with carbonaceous horizons and coal seams, and results are inconclusive in isolation due to potential organic acid effects.

NAG test results are used in conjunction with NAPP values to classify samples according to acid forming potential. Figure 9 is an ARD classi fication plot for fresh Permian samples showing NAGpH versus NAPP value. Potentially acid forming (PAF), non-acid forming (NAF) and uncertain (UC) classification domains are indicated. A sample is classified PAF when it has a positive NAPP and NAGpH < 4.5, and NAF when it has a negative NAPP and NAGpH ≥ 4.5. Samples are classified uncertain when there is an apparent conflict between the NAPP and NAG results, i.e. when the NAPP is positive and NAGpH ≥ 4.5, or when the NAPP is negative and NAGpH < 4.5.

The plot shows that most samples plot in the NAF and PAF domains, with 2 samples plotting in the upper right uncertain domain and 10 samples plotting in the lower left uncertain domain.

A total of 16 samples plot in the NAF domain, all of which have total S of less than 0.3%S.

A total of 63 samples plot in the PAF domain, of which 27 had low NAG values to pH 4.5 of 5 kg H_2SO_4/t or less and are expected to be PAF but with a lower capacity to generate acid.

Organic acid effects on the NAG test are apparent for a number of PAF domain samples, including a large difference between the $NAG_{(pH4.5)}$ and $NAG_{(pH7.0)}$ values, and $NAG_{(pH4.5)}$ values that exceed the MPA. Results indicate that the NAG results may overestimate the acid potential in these cases. Some samples have an MPA value of 5 or less and are likely to be PAF low capacity. Standard NAG test results affected by organic acids are highlighted in yellow in Table 1 and 2. Specialised testing (Section 7) was carried out to help resolve uncertainties in classification of these samples.

The 2 samples that plot in the upper right uncertain domain have low total S of 0.09 %S or less and the NAG test would normally account for all pyritic S in the sample. These samples are expected to be NAF in accordance with the NAG results.

One of the samples plotting in the bottom left hand uncertain domain has a low total S of 0.05%S and has a negligible risk of acid formation. The low NAGpH value of 3.8 is likely to be due to organic acid effects, and this sample is classified NAF. The NAGpH values for the remaining 9 samples in this uncertain domain show some possible organic acid effects, and further testing presented in Section 7 was required to help resolve classification for these samples.

7.0 Specialised Geochemical Characterisation Results

7.1 Extended Boil and Calculated NAG Results

Extended boil and calculated NAG testing was carried out on 13 fresh Permian samples to help resolve the uncertainty in ARD classification based on standard NAG test results, as discussed in the previous section. Results are shown in Table 1.

Results show that the NAGpH value increases after the extended boiling step, which confirms the effects of organic acids. Results for 8 samples have extended boil NAG values of less than 4.5, indicating these samples are likely to be acid producing.

Note that the extended boil NAGpH value can be used to confirm samples are PAF, but does not necessarily mean that samples with a pH greater than 4.5 are NAF, due to some loss of free acid during the extended boiling procedure. To address this issue, a calculated NAG value is determined from assays of anions and cations released to the NAG solution. A calculated NAG value of less than or equal to 0 kg H_2SO_4/t indicates the sample is likely to be NAF, and a value of more than 0 kg H_2SO_4/t indicates the sample may be PAF.

The calculated NAG values for 9 of the samples were positive, indicating that these samples are likely to be acid producing. Note that 2 of these samples (41404 and 41477) have low acid potentials of 1 kg H_2SO_4/t and are expected to be low capacity only.

The calculated NAG values for the remaining 4 samples were zero or less, indicating that all acid generated in the standard NAG test for these samples is organic, and that materials represented by these samples are unlikely to be acid producing under field conditions.

7.2 Acid Buffering Characteristic Curve (ABCC) Testing

Acid buffering characteristic curve (ABCC) testing was carried out on 11 selected fresh Permian samples to evaluate the availability of the ANC measured. The ABCC test involves slow titration of a sample with acid while measuring the solution pH. The acid buffering of a sample to pH 4 can be used as an estimate of the proportion of readily available ANC. Results are presented in Figures 10 to 17, with calcite, dolomite, ferroan dolomite and siderite standard curves as reference. Calcite and dolomite readily dissolve in acid and exhibit strongly buffered pH curves in the ABCC test, rapidly dropping once the ANC value is reached. The siderite standard provides very poor acid buffering, exhibiting a very steep pH curve in the ABCC test. Ferroan dolomite is between siderite and dolomite in acid buffering availability.

The ABCC profile for samples 41477 (Figure 10), 41404 (Figure 10), 41388 (Figure 11) and 41357 (Figure 13) plot close to the siderite standard curve, and indicate that less than 10% of the total ANC measured may be available for acid buffering.

Profiles for samples 41295 (Figure 11) and 41330 (Figure 12) plot close to the ferroan dolomite standard curve, indicating that approximately 25% of the total ANC is available for acid buffering but it will be slow reacting.

Profiles for the remaining samples plot close to the dolomite standard curves but drop below pH 4 before the total ANC is reached, indicating that 45% to 65% of the total ANC is readily available for acid buffering.

ABCC results indicate that the availability of the ANC in the SGCP overburden/interburden materials may be significantly less than the total ANC measured. The ABCC curves for samples with ANC values less than 30 kg H_2SO_4/t are typical of sideritic and ferroan carbonates, which may not provide buffering at the same rates as acid generation from pyrite oxidation. Hence ANC test results are not a reliable guide to the effective acid buffering in these samples. Once ANC values reach above 30 kg H_2SO_4/t the carbonate appears to be mainly dolomitic, but with a significant portion that is not readily available.

7.3 Kinetic NAG Testing

Kinetic NAG tests provide an indication of the kinetics of sulphide oxidation and acid generation for a sample. Figures 18 to 24 present kinetic NAG test results for 7 selected fresh Permian samples.

Typically, there will be a distinct temperature peak of greater than 50°C in the kinetic NAG profile for samples with pyritic S greater than 0.7%S. The kinetic NAG temperature profiles for samples 41347 and 41349 (Figures 21 and 22) show a distinct temperature peak, typical of samples with pyritic S of around 1.5%S. Results suggest that most of the total S measured in these samples is likely to be pyritic.

The remaining samples have S values of 0.83% to 1.60%S, but show only minor temperature increase. Results indicate that these samples have pyritic S contents of less than 0.7%S, and a significant proportion of non acid generating S forms. This was supported by S speciation test work (Section 7.4).

All samples tested show a rapid drop in pH with time and all had a start pH below 4, indicating lags before acid conditions develop of days to a week after exposure to atmospheric conditions.

Results indicate that pyritic materials represented by the samples tested are likely to show rapid pyrite reaction rates after exposure to atmospheric oxidation and short lag times of days to weeks before low pH conditions develop.

7.4 Sulphur Speciation

Sulphur speciation testing was carried out on 11 selected fresh Permian samples as a guide to the proportion of the total S present as pyrite. Results are shown in Table 3. Note that the pyritic S value should only be treated as a guide to the pyrite content in the sample due to issues with repeatability in the chromium reducible sulphur (CRS) method[1].

Results show that the estimated pyritic proportion varies from 14% to 62% in coal samples, with higher proportions in the non-coal samples of 66% to 100%.

Results confirm the presence of significant pyrite in Fresh Permian samples. The total S in non-coal samples is likely to be mainly pyritic, but much of the total S in coal samples (<0.5%S) is likely to be in non acid generating organic S forms (low risk S forms).

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[1] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008. www.acarp.com.au.

7.5 Multi-Element Analysis of Solids and Water Extracts

Multi-element scans of solids were carried out on 1 highly weathered and 14 fresh Permian samples. Results were compared to the median soil abundance (from Bowen, 1979[2]) to highlight enriched elements. The extent of enrichment is reported as the Geochemical Abundance Index (GAI), which relates the actual concentration with an average or median abundance on a log 2 scale. The GAI is expressed in integer increments where a GAI of 0 indicates the element is present at a concentration similar to, or less than, median soil abundance; and a GAI of 6 indicates approximately a 100-fold enrichment above median soil abundance. As a general rule, a GAI of 3 or greater signifies enrichment that warrants further examination.

Results of multi-element analysis of solids are presented in Table 4, and the corresponding GAI values are presented in Table 5. Results show that many samples are enriched in W, but this may be partly due to contamination from sample processing. Note that W is generally insoluble, and is not expected to be an environmental concern. A number of samples are enriched in S, which was discussed earlier in relation to acid forming potential. Be is slightly enriched in some samples and Ag is slightly enriched in two sandstone samples, but both are within normal ranges for soils. No significant enrichment is indicated for key elements of environmental concern such as As, Cd, Cu, Hg, Pb and Zn.

The same sample solids were subjected to water extraction at a solids:liquor ratio of 1:2. The compositions of the 15 water extractions are given in Table 6. The results of these water extracts provide an indication of readily mobilised elements, but are not necessarily a direct measure of water quality from overburden materials.

A number of samples have elevated Al and Fe concentrations at circum-neutral pH, which is most likely due to the presence of fine or colloidal particulates in the solution after filtering. Three of these samples (41301, 41308 and 41321) also have elevated Si of 25 to 56 mg/L, suggestive of the presence of fine particulates.

There are a number of samples with lower pH extract solutions of less than 4 that are likely to reflect partial oxidation of pyrite between sample collection and testing (consistent with the indicated short lag). These samples have elevated concentrations of a variety of metals/metalloids including Al, Co, Cu, Fe, Mn, Ni, and Zn.

Results indicate that initial metal/metalloid release associated with any ARD generated from pyritic Permian materials will include dissolved Al, Co, Cu, Fe, Mn, Ni, and Zn. However, the solubility of metals/metalloids will largely be determined by pH, and control of ARD should also control metal/metalloid release.

[2] Bowen, H.J.M. (1979) Environmental Chemistry of the Elements. Academic Press, New York, p 36-37.

7.6 Sodicity and Dispersion

Exchangeable sodium percentage (ESP) measurements were arranged by Matrixplus on 12 selected samples as part of the 2009 testing programme to provide a preliminary indication of any sodicity and dispersion issues. Samples were selected intermittently from surface of various lithologies, and results are included in Table 2.

Sodic materials tend to form low permeability soil horizons, accelerating erosion and inhibiting plant growth. Sodic soils are also dispersive and should not be used as construction materials since they are prone to tunnelling and collapse. The ESP is a measure of exchangeable Na as a percentage of the total effective cation exchange capacity (ECEC). The ESP can be used to classify samples according to sodicity as follows:

ESP < 6% - Non-Sodic
ESP 6-15% - Sodic
ESP 15-30% - Strongly Sodic
ESP >30% - Very Strongly Sodic

The ESP values for the two surface Tertiary soil samples were non sodic, but the weathered and fresh Permian samples were mainly sodic to strongly sodic, with one sample (2392) very strongly sodic. Although the ESP values for the Permian samples are elevated, the lithologies comprise mainly sandstone, and it may be that the ECEC is low, and hence the significance of the ESP is less. More details on soluble and exchangeable cations, and direct measurement of dispersibility (such as the modified dispersion percentage) would be required to better evaluate the sodic and dispersion potential.

8.0 Sample Classification and Distribution of ARD Rock Types

Results and discussions above were used to classify EGi tested samples as NAF, PAF, PAF low capacity (PAF-LC) or uncertain in Table 1. Provisional ARD classifications for the Matrixplus samples are also shown in Table 2 based on information provided. All samples with S values of less than or equal to 0.05%S were classified NAF due to the negligible risk of acid formation.

Results of Matrixplus testing (BH99 and BH100) suggest that Tertiary and weathered Permian materials are likely to be NAF. This should be confirmed with more representative testing, but the lack of any PAF samples in the 46 samples tested strongly support a low ARD risk for these materials.

EGi results indicate that the fresh Permian is likely to be dominated by NAF materials but will include PAF and PAF-LC materials. A total of 65% of fresh Permian samples tested by EGi were NAF. Note that the actual mineable proportion of fresh Permian NAF would require taking into account the spatial distribution of NAF materials and minimum mining block size.

Figure 25 shows down hole total S profiles for EGi tested holes and Matrixplus tested holes. In addition to total S, the plots also show: coal seams; base of weathering; sample ARD classification with NAF samples represented as blue symbols, PAF-LC samples as orange symbols, and PAF samples as red symbols; and zones of PAF and PAF-LC shown as pink shading.

Profiles for holes CK162 and SP142 represent the deepest portions of the planned pit, with collars located in the northern and southern parts of the pit and separated by approximately 5km. The distribution of NAF and PAF horizons in the two holes is reasonably consistent and shows a large block of continuous NAF overburden, made up of 40m to 50m of Tertiary and weathered Permian, and a large intercept of fresh Permian NAF. Below the NAF overburden are a number of PAF/PAF-LC zones that appear to be continuous:

- PAF-PAF-LC zone associated with Seam C in CK162 and an unknown seam in SP142 (equivalent to Seam C?);
- PAF-PAF-LC zone associated with Seam D1;
- PAF-PAF-LC zone within D1/D2 interburden; and
- PAF-PAF-LC zone associated with Seam D2.

Hole CK165C is located in the middle of the proposed pit and covers a shallower stratigraphic sequence to the east of holes CK162 and SP142. The thick NAF overburden zone in the deeper holes appears to continue into the shallower hole CK165C (with a reduced thickness). The PAF/PAF-LC zones in CK165C are also similar to the deeper holes.

The collar of hole BH99C was located close to that of hole CK165C and shows a similar trend but less distinct due to the intermittent sampling in this hole. Hole BH100C also shows similar broad trends, although much less of the fresh Permian was represented. Results from BH99C and BH100C were suitable for confirming continuity of trends from the other holes, but were not suitable for detailed correlation.

Of the interburden and overburden, the roof within 5m of the D1 seam appears to be the main PAF horizon of concern, having high S values of greater than 1%S. The other PAF/PAF-LC zones tend to have lower S of 0.5%S or less.

Note that portions of the lower capacity PAF/PAF-LC zones may be amenable to ARD control through mixing with high ANC NAF materials and/or addition of limestone. Note that ANC testing was not carried out on all samples, but ANC testing in hole SP142 (see Table 1) suggests a zone of higher ANC material within fresh Permian overburden, which may be useful in ARD control for operations as well as possible blending with lower capacity PAF/PAF-LC zones.

The coal seams appear to have the highest acid potential, with 8 out of 10 coal seam samples classified PAF. This suggests coal washery wastes are also likely to be PAF. Coal stockpiles may also be source of ARD, depending on reaction rates and stockpile residence times.

Results from all 5 holes indicate the final pit floor at the base of Seam D2 is likely to be PAF-LC. Minor surface limestone treatment, addition of NAF and/or water treatment may be required during operations to prevent ARD from the pit floor, depending on the rates of reaction and acid loads.

Figure 26 is a box plot showing total S distribution by ARD classification. The plot indicates that total S alone could potentially be used for routine classification into NAF, PAF-LC and PAF rock types using cut offs of 0.1%S and 0.3%S as shown on the graph. Note that the NAF criteria at 0.1%S or less separates 90% of the NAF samples but also includes 30% of PAF-LC. Further investigation into the ARD potential of PAF-LC in isolation and mixed with NAF would be required before applying these criteria.

9.0 Conclusions and Recommendations

Results of testing indicate that the bulk of the overburden and interburden material is likely to be NAF, and suggest the presence of a large continuous section of NAF material from surface down into the upper portion of the fresh Permian. The roof within 5m of the D1 seam appears to be the main PAF horizon of concern, with a number of other lower capacity PAF horizons associated with coal seams and also within interburden between Seams D1 and D2. Final pit floor material will mainly comprise D2 floor, which is likely to be PAF-LC. ROM coal and washery wastes are also likely to be mainly PAF. Salinity in overburden materials appeared to be related to pyrite oxidation, and hence control of ARD will largely control salinity.

Kinetic NAG and ABCC testing indicated that PAF materials are likely to be fast reacting, with little or no lag time (days to weeks) once exposed to atmospheric conditions. This is due to a combination of fast reacting pyrite forms and poorly reactive carbonate. Water extract testing indicates that once acid conditions develop elevated concentrations of dissolved Al, Co, Cu, Fe, Mn, Ni, SO_4 and Zn are likely to occur.

Results have the following implications for materials management

- selective handling of PAF overburden and interburden materials is likely to be required for ARD control;
- mixing of lower capacity PAF horizons with higher ANC NAF materials may be sufficient to control ARD from these materials, but this would need to be confirmed with testing of blended materials and better definition of the distribution of ARD rock types in these horizons across the deposit;
- the roof horizon within 5m of Seam D1 is likely to require selective placement away from the dump outer slopes and deep burial, and may also require encapsulation in cells designed to minimise infiltration and implementation of an engineered cover system a closure;
- if washery wastes are disposed of in waste rock dumps they are likely to require similar management as the D1 roof material;

- engineered cover systems are likely to be required at closure for washery wastes placed in dedicated storage facilities;
- placed PAF overburden and washery wastes may require surface treatment with crushed limestone and/or lime water treatment of drainage to control ARD during operations;
- provision for collection and lime treatment of coal stockpile drainage may be required depending on ARD reaction rates and stockpile residence times;
- the final pit floor at the base of Seam D2 may require minor surface limestone treatment, addition of high ANC NAF and/or water treatment during operations depending on ARD reaction rates and acid loads;
- a programme of routine sampling and geochemical testing of waste materials should be carried out during operations to monitor variation in acid potential, reconcile the ARD prediction model and check ARD rock type materials handling and placement; and
- routine surface and groundwater monitoring should include analysis of pH, EC, acidity/alkalinity, Ca, Cl, K, Mg, Na, SO_4, Ag, Al, As, Cd, Co, Cu, Fe, Mn, Mo, Ni, Pb and Zn.

The following further work is recommended to assist finalisation of ARD control strategies:

- Carry out more extensive testing of drillholes to:
  - better define the PAF and PAF-LC zones across the deposit;
  - better define variation and continuity of the zone of higher ANC fresh Permian overburden intercepted in hole SP142;
  - construct an ARD model (possibly based on a combinations of total S and lithology/weathering based criteria) suitable for predicting the distribution of these zones during mining; and
  - generate a production schedule based on geochemical type for long term planning.
- Further investigate criteria for routine ARD classification. Results to date indicate that total S alone may be suitable.
- Assess the ARD potential of lower capacity PAF/PAF-LC zone materials and the effects of operational mixing with NAF overburden to help determine whether additional controls are needed (such as blending with selected high ANC overburden or limestone). This work should include leach column testing. Results will provide an indication of the relative ARD hazard of the lower capacity PAF/PAF-LC zone materials, and will assist in refining criteria for routine site segregation of ARD rock types.
- Better assess the sodicity potential of overburden materials. The existing data are limited and may overestimate the sodicity potential.

- Carry out leach column testing of a range of material types to help assess reaction kinetics and leachate compositions.
- Review the S distribution in the various coal seams across the deposit and carry out more comprehensive ARD testing of coal and washery waste materials to better define the acid potentials.
- Carry out investigations into cover designs for long term control of ARD from PAF overburden and washery wastes.

Table 1: Acid forming characteristics of overburden, interburden and coal samples tested by EGi.

Hole Name	Depth (m) From	Depth (m) To	Depth (m) Interval	Stratigraphy	Lithology Code	Summary Lithology	Weathering	Seam	Comments	SGCP Sample No	EGi Sample No	ACID-BASE ANALYSIS Total %S	ACID-BASE ANALYSIS MPA	ACID-BASE ANALYSIS ANC	ACID-BASE ANALYSIS NAPP	ACID-BASE ANALYSIS ANC /MPA	NAG TEST NAGpH	NAG TEST $NAG_{(pH4.5)}$	NAG TEST $NAG_{(pH7.0)}$	Extended Boil NAGpH	Calculated NAG	ARD Classification
CK162	58.12	58.45	0.33	Weathered Permian	SS	Sandstone	HW				41376	0.03	1									NAF
CK162	58.45	59.67	1.22	Weathered Permian	S2	Sandstone	HW/FR		BHWE 58.71m	871	41408	0.02	0									NAF
CK162	59.67	65.57	5.90	Fresh Permian	S2	Sandstone	FR		Calcite	872/873	41409	0.02	1									NAF
CK162	65.57	65.85	0.28	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
CK162	65.85	66.17	0.32	Fresh Permian	S2	Sandstone	FR		Calcite, BHWL 66.17m	874	41411	0.05	1									NAF
CK162	66.17	68.74	2.57	Fresh Permian	S1	Sandstone	FR			875	41412	0.02	1									NAF
CK162	68.74	71.01	2.27	Fresh Permian	S2/MS	Sandstone	FR		Calcite	876	41413	0.04	1									NAF
CK162	71.01	72.28	1.27	Fresh Permian	S2	Sandstone	FR			877	41414	0.04	1									NAF
CK162	72.28	72.59	0.31	Fresh Permian	S2	Sandstone	FR		Geotech Sample		41377	0.02	1									NAF
CK162	72.59	77.50	4.91	Fresh Permian	S2	Sandstone	FR			878	41415	0.03	1									NAF
CK162	77.50	78.48	0.98	Fresh Permian	S2/CM	Sandstone	FR			879	41416	0.03	1									NAF
CK162	78.48	81.55	3.07	Fresh Permian	S2/CY	Sandstone	FR		Minor Calcite	880	41417	0.03	1									NAF
CK162	81.55	81.84	0.29	Fresh Permian	S1	Sandstone	FR		Geotech Sample		No Sample											
CK162	81.84	84.42	2.58	Fresh Permian	S1	Sandstone	FR			881	41418	0.03	1									NAF
CK162	84.42	86.49	2.07	Fresh Permian	S2/CM	Sandstone	FR			882	41419	0.02	1									NAF
CK162	86.49	86.75	0.26	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		41378	0.02	1									NAF
CK162	86.75	89.73	2.98	Fresh Permian	CM	Carb Mudstone	FR			883	41420	0.03	1				7.9	0	0			NAF
CK162	89.73	90.18	0.45	Fresh Permian	LO				Core Loss		No Sample											
CK162	90.18	93.82	3.64	Fresh Permian	MS/CY	Mudstone	FR		Calcite	884	41421	0.05	1									NAF
CK162	93.82	95.78	1.96	Fresh Permian	CM/CY	Carb Mudstone	FR		Calcite	885	41422	0.04	1									NAF
CK162	95.78	97.60	1.82	Fresh Permian	CM/CY	Carb Mudstone	FR		Minor Calcite	886	41423	0.09	3	18	-15	6.54	7.6	0	0			NAF
CK162	97.60	97.83	0.23	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		41379	0.06	2	13	-11	7.08	6.9	0	0			NAF
CK162	97.83	101.00	3.17	Fresh Permian	CM	Carb Mudstone	FR			887	41424	0.05	1									NAF
CK162	101.00	103.11	2.11	Fresh Permian	CM	Carb Mudstone	FR			888	41425	0.05	2	46	-44	30.07	8.2	0	0			NAF
CK162	103.11	103.55	0.44	Fresh Permian	CM/CY	Carb Mudstone	FR			889	41426	0.03	1									NAF
CK162	103.55	103.84	0.29	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		No Sample											
CK162	103.84	105.28	1.44	Fresh Permian	CM	Carb Mudstone	FR			890	41427	0.06	2	33	-31	19.61	8.5	0	0			NAF
CK162	105.28	107.77	2.49	Fresh Permian	CM	Carb Mudstone	FR		Minor Calcite	891	41428	0.12	4	11	-7	3.00	7.1	0	0			NAF
CK162	107.77	107.88	0.11	Fresh Permian	CM	Carb Mudstone	FR			892	41429	<0.01	0									NAF
CK162	107.88	108.00	0.12	Fresh Permian	CY	Claystone	FR			893	41430	0.05	2									NAF
CK162	108.00	109.03	1.03	Fresh Permian	CY/S2	Claystone	FR			894	41431	0.04	1	39	-38	31.86						NAF
CK162	109.03	109.12	0.09	Fresh Permian	Coal	Coal	FR	C			No Sample											
CK162	109.12	109.61	0.49	Fresh Permian	S1	Sandstone	FR			895	41432	0.83	25	0	25	0.00	2.6	13	25	3.5	23	PAF
CK162	109.61	109.84	0.23	Fresh Permian	S1	Sandstone	FR		Geotech Sample		41380	0.04	1	2	-1	1.63						NAF
CK162	109.84	114.00	4.16	Fresh Permian	S2	Sandstone	FR			896	41433	0.22	7	3	4	0.45	3.8	1	4			PAF-LC
CK162	114.00	118.42	4.42	Fresh Permian	S2	Sandstone	FR			897	41434	0.16	5	3	2	0.61	4.2	0.2	5			PAF-LC
CK162	118.42	118.72	0.30	Fresh Permian	S1	Sandstone	FR		Geotech Sample		No Sample											
CK162	118.72	122.88	4.16	Fresh Permian	S2	Sandstone	FR			898	41435	0.09	3	2	1	0.77	4.6	0	3			NAF
CK162	122.88	123.16	0.28	Fresh Permian	S2	Sandstone	FR		Geotech Sample		41381	0.04	1									NAF
CK162	123.16	124.80	1.64	Fresh Permian	S2	Sandstone	FR			899	41436	0.07	2	24	-22	12.07	6.9	0	0			NAF
CK162	124.80	125.90	1.10	Fresh Permian	CM	Carb Mudstone	FR			900	41437	0.46	14	6	8	0.43	3.4	2	9			PAF-LC
CK162	125.90	126.32	0.42	Fresh Permian	MS/CY	Mudstone	FR			901	41438	0.14	4	15	-11	3.50	7.1	0	0			NAF
CK162	126.32	126.69	0.37	Fresh Permian	S2	Sandstone	FR			902	41439	0.11	3	11	-8	3.27	4.0	0.2	3			UC(PAF-LC)
CK162	126.69	126.89	0.20	Fresh Permian	S2	Sandstone	FR			3287	41392	0.58	18	5	13	0.28	2.6	11	16			PAF
CK162	126.89	131.75	4.86	Fresh Permian	Coal	Coal	FR	D1		3288	41393	1.60	49	3	46	0.06	1.9	165	246	2.9	39	PAF
CK162	131.75	131.95	0.20	Fresh Permian	S1	Sandstone	FR			3289	41394	0.08	2	1	1	0.41	4.2	0.3	4			PAF-LC
CK162	131.95	132.50	0.55	Fresh Permian	S1/MS	Sandstone	FR			903	41440	0.05	1	1	0	0.73						NAF
CK162	132.50	132.74	0.24	Fresh Permian	S2	Sandstone	FR		Geotech Sample		41382	0.04	1									NAF
CK162	132.74	134.64	1.90	Fresh Permian	S2	Sandstone	FR			904	41441	0.05	1	1	0	0.73						NAF
CK162	134.64	137.06	2.42	Fresh Permian	S3	Sandstone	FR			905	41442	0.25	8	0	8	0.00	2.8	6	9			PAF
CK162	137.06	138.41	1.35	Fresh Permian	S2	Sandstone	FR			906	41443	0.12	4	5	-1	1.36	3.0	3	5			UC(PAF-LC)
CK162	138.41	138.72	0.31	Fresh Permian	S2	Sandstone	FR		Geotech Sample		41383	0.01	0									NAF
CK162	138.72	141.42	2.70	Fresh Permian	S2	Sandstone	FR			907	41444	0.13	4	0	4	0.00	2.9	3	5			PAF-LC
CK162	141.42	142.46	1.04	Fresh Permian	MS	Mudstone	FR			908	41445	0.50	15	0	15	0.00	2.7	6	13			PAF
CK162	142.46	144.64	2.18	Fresh Permian	S7/S3	Sandstone	FR			909	41446	0.03	1	0	1	0.00						NAF

Table 1: Acid forming characteristics of overburden, interburden and coal samples tested by EGi.

Hole Name	Depth (m) From	To	Interval	Stratigraphy	Lithology Code	Summary Lithology	Weathering	Seam	Comments	SGCP Sample No	EGi Sample No	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC /MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	Extended Boil NAGpH	Calculated NAG	ARD Classification
CK162	144.64	147.19	2.55	Fresh Permian	S3	Sandstone	FR			910	41447	0.02	0	0	0	0.00						NAF
CK162	147.19	147.47	0.28	Fresh Permian	S3	Sandstone	FR		Geotech Sample		41384	0.02	0									NAF
CK162	147.47	147.77	0.30	Fresh Permian	S3	Sandstone	FR			911	41448	0.02	1	2	-1	3.73						NAF
CK162	147.77	148.01	0.24	Fresh Permian	S3	Sandstone	FR		Geotech Sample		No Sample											
CK162	148.01	148.21	0.20	Fresh Permian	S3	Sandstone	FR			3290	41395	0.07	2	16	-14	7.47	4.4	0.1	6			UC(PAF-LC)
CK162	148.21	150.38	2.17	Fresh Permian	Coal	Coal	FR	D2ML		3291	41396	0.70	21	9	12	0.42	1.8	224	329			PAF
CK162	150.38	150.59	0.21	Fresh Permian	MS	Mudstone	FR			3292	41397	0.32	10	0	10	0.00	2.3	17	30	3.6	8	PAF
CK162	150.59	151.17	0.58	Fresh Permian	MS	Mudstone	FR			912	41449	0.13	4	0	4	0.00	3.9	0.1	2			PAF-LC
CK162	151.17	151.40	0.23	Fresh Permian	S2/MS	Sandstone	FR		Geotech Sample		41385	0.26	8	0	8	0.00	3.6	1	8			PAF-LC
CK162	151.40	152.36	0.96	Fresh Permian	S2	Sandstone	FR			913	41450	0.16	5	1	4	0.20	3.2	2	5			PAF-LC
CK165C	52.12	53.37	1.25	Weathered Permian	CY	Claystone	HW		BHWE 53.37	914	41451	<0.01	0									NAF
CK165C	53.37	55.00	1.63	Fresh Permian	CM	Carb Mudstone	FR			915	41452	0.09	3	6	-3	2.31	4.7	0	1			NAF
CK165C	55.00	57.02	2.02	Fresh Permian	CM	Carb Mudstone	FR			916	41453	0.06	2	2	0	1.19	7.1	0	0			NAF
CK165C	57.02	58.13	1.11	Fresh Permian	CM/CY	Carb Mudstone	FR			917	41454	0.07	2	3	-1	1.40	6.9	0	0			NAF
CK165C	58.13	60.00	1.87	Fresh Permian	CM/CY	Carb Mudstone	FR			918	41455	0.07	2	8	-6	3.73	7.2	0	0			NAF
CK165C	60.00	60.24	0.24	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		No Sample											
CK165C	60.24	62.62	2.38	Fresh Permian	CM/CY	Carb Mudstone	FR			919	41456	0.10	3	5	-2	1.63	6.4	0	0			NAF
CK165C	62.62	64.37	1.75	Fresh Permian	MS/CY/S2	Mudstone	FR		BHWL 62.82m, some IS	920	41457	0.10	3	5	-2	1.72	7.8	0	0			NAF
CK165C	64.37	67.00	2.63	Fresh Permian	SS	Sandstone	SW			921	41458	0.02	0									NAF
CK165C	67.00	68.95	1.95	Fresh Permian	SS	Sandstone	SW			922	41459	0.02	0									NAF
CK165C	68.95	70.46	1.51	Fresh Permian	S2	Sandstone	FR			923	41460	0.05	1									NAF
CK165C	70.46	70.76	0.30	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
CK165C	70.76	72.21	1.45	Fresh Permian	S2/CM	Sandstone	FR			924	41461	0.40	12	0	12	0.00	2.8	7	9			PAF
CK165C	72.21	74.46	2.25	Fresh Permian	S2	Sandstone	FR			925	41462	0.36	11	0	11	0.00	2.9	5	9			PAF-LC
CK165C	74.46	74.72	0.26	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
CK165C	74.72	77.50	2.78	Fresh Permian	S2	Sandstone	FR			926	41463	0.42	13	8	5	0.62	3.0	3	8			PAF-LC
CK165C	77.50	80.52	3.02	Fresh Permian	S2	Sandstone	FR			927	41464	0.06	2	6	-4	3.57	6.9	0	0			NAF
CK165C	80.52	80.84	0.32	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
CK165C	80.84	82.64	1.80	Fresh Permian	S2	Sandstone	FR			928	41465	0.19	6	15	-9	2.58	6.2	0	1			NAF
CK165C	82.64	82.93	0.29	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
CK165C	82.93	83.09	0.16	Fresh Permian	S3/CY	Sandstone	FR		Calcite	929	41466	0.03	1									NAF
CK165C	83.09	83.32	0.23	Fresh Permian	S3	Sandstone	FR		Calcite	3263	41398	0.10	3	4	-1	1.31	3.9	3	3			UC(PAF-LC)
CK165C	83.32	84.35	1.03	Fresh Permian	Coal	Coal	FR	D1		3264	41399	2.20	67	5	62	0.07	2.4	22	56			PAF
CK165C	84.35	84.55	0.20	Fresh Permian	CY	Claystone	FR	D1		3265	41400	0.25	8	9	-1	1.18	4.6	0	6			NAF
CK165C	84.55	85.62	1.07	Fresh Permian	Coal	Coal	FR	D1	Pyrite Vein	3266	41401	1.30	40	4	36	0.10	2.0	87	132			PAF
CK165C	85.62	85.81	0.19	Fresh Permian	CY	Claystone	FR	D1		3267	41402	0.13	4	4	0	1.01	3.2	3	13	7.1	-3	NAF
CK165C	85.81	89.58	3.77	Fresh Permian	Coal	Coal	FR	D1		3268	41403	1.60	49	1	48	0.02	1.9	163	237			PAF
CK165C	89.58	89.88	0.30	Fresh Permian	MS/Coal	Mudstone	FR			3269	41404	0.26	8	7	1	0.88	2.1	73	109	4.3	1	PAF-LC
CK165C	89.88	90.12	0.24	Fresh Permian	MS	Mudstone	FR			930	41467	0.08	2	0	2	0.00	2.3	24	43	7.1	-3	NAF
CK165C	90.12	90.54	0.42	Fresh Permian	S2	Sandstone	FR			931	41468	0.04	1	0	1	0.00						NAF
CK165C	90.54	91.79	1.25	Fresh Permian	S2	Sandstone	FR			932	41469	0.01	0	0	0	0.00						NAF
CK165C	91.79	93.55	1.76	Fresh Permian	S3	Sandstone	FR			933	41470	0.01	0									NAF
CK165C	93.55	93.82	0.27	Fresh Permian	S3	Sandstone	FR		Geotech Sample		No Sample											
CK165C	93.82	97.00	3.18	Fresh Permian	S3	Sandstone	FR			934	41471	0.07	2	0	2	0.00	3.8	0.4	3			PAF-LC
CK165C	97.00	100.82	3.82	Fresh Permian	S3	Sandstone	FR			935	41472	0.24	7	0	7	0.00	2.8	7	9			PAF
CK165C	100.82	101.06	0.24	Fresh Permian	S4	Sandstone	FR			936	41473	0.42	13	5	8	0.39	2.4	14	18			PAF
CK165C	101.06	101.35	0.29	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
CK165C	101.35	102.45	1.10	Fresh Permian	S2	Sandstone	FR			937	41474	0.06	2	0	2	0.00	3.1	2	5			PAF-LC
CK165C	102.45	103.15	0.70	Fresh Permian	CM	Carb Mudstone	FR			938	41475	0.40	12	0	12	0.00	2.9	8	11			PAF
CK165C	103.15	103.97	0.82	Fresh Permian	S2	Sandstone	FR			939	41476	0.05	1	1	0	0.73						NAF
CK165C	103.97	104.17	0.20	Fresh Permian	S3/S2	Sandstone	FR			3270	41405	0.06	2	1	1	0.54	3.9	1	6			PAF-LC
CK165C	104.17	107.01	2.84	Fresh Permian	Coal	Coal	FR	D2ML	Pyritic	3271	41406	1.20	37	2	35	0.05	1.9	170	249	3.3	17	PAF
CK165C	107.01	107.21	0.20	Fresh Permian	CM	Carb Mudstone	FR			3272	41407	0.12	4	0	4	0.00	2.3	21	38			UC(PAF-LC)
CK165C	107.21	107.52	0.31	Fresh Permian	CM/S2	Carb Mudstone	FR		Geotech Sample		No Sample											
CK165C	107.52	108.22	0.70	Fresh Permian	S2	Sandstone	FR			940	41477	0.13	4	6	-2	1.51	2.6	8	18	5.7	1	PAF-LC

Table 1: Acid forming characteristics of overburden, interburden and coal samples tested by EGi.

Hole Name	Depth (m)			Stratigraphy	Lithology Code	Summary Lithology	Weathering	Seam	Comments	SGCP Sample No	EGi Sample No	ACID-BASE ANALYSIS					NAG TEST			Extended Boil NAGpH	Calculated NAG	ARD Classification
	From	To	Interval									Total %S	MPA	ANC	NAPP	ANC /MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$			
CK165C	108.22	108.98	0.76	Fresh Permian	CM	Carb Mudstone	FR			941	41478	0.14	4	0	4	0.00	3.7	1	3			PAF-LC
SP142	36.81	37.04	0.23	Weathered Permian	ST	Siltstone	HW		Geotech Sample	10080262	41362	0.03	1	105	-104	137.25						NAF
SP142	37.04	38.58	1.54	Weathered Permian					NOT SAMPLED		No Sample											
SP142	38.58	39.35	0.77	Weathered Permian	Coal	Coal	SW	B	Tuff Parting, No Sample		No Sample											
SP142	39.35	40.23	0.88	Weathered Permian	CT	Siltstone	SW		Minor ST	801	41292	0.02	1	10	-9	16.34	6.3	0	4			NAF
SP142	40.23	40.54	0.31	Weathered Permian	ST	Siltstone	SW		Geotech Sample		No Sample											
SP142	40.54	41.68	1.14	Weathered Permian	ST	Siltstone	SW		BHWE 41.78m	802	41293	<0.01	0	4	-4	26.14						NAF
SP142	41.68	42.23	0.55	Fresh Permian	ST	Siltstone	FR		Minor TF	803	41294	0.02	1	5	-4	8.17						NAF
SP142	42.23	43.73	1.50	Fresh Permian	ST	Siltstone	FR		Minor TF	804	41295	0.08	2	9	-7	3.68	6.9	0	0			NAF
SP142	43.73	44.05	0.32	Fresh Permian	ST	Siltstone	FR			805	41296	0.01	0									NAF
SP142	44.05	44.29	0.24	Fresh Permian	ST	Siltstone	FR		Geotech Sample	10080263	41363	0.02	0									NAF
SP142	44.29	46.10	1.81	Fresh Permian	ST	Siltstone	FR			806	41297	0.02	1	19	-18	31.05	7.9	0	0			NAF
SP142	46.10	48.23	2.13	Fresh Permian	S2	Sandstone	FR		Minor CY	807	41298	<0.01	0	128	-128	836.60						NAF
SP142	48.23	48.50	0.27	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
SP142	48.50	49.66	1.16	Fresh Permian	S2	Sandstone	FR		Minor CY	808	41299	<0.01	0	53	-53	346.41						NAF
SP142	49.66	51.44	1.78	Fresh Permian	S2	Sandstone	FR		Calcite	809	41300	<0.01	0	77	-77	503.27						NAF
SP142	51.44	51.65	0.21	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
SP142	51.65	54.01	2.36	Fresh Permian	S2	Sandstone	FR		Calcite	810	41301	<0.01	0	294	-294	>50	8.3	0	0			NAF
SP142	54.01	55.01	1.00	Fresh Permian	S3	Sandstone	FR			811	41302	0.02	1	46	-45	75.16						NAF
SP142	55.01	55.35	0.34	Fresh Permian	S3	Sandstone	FR		Geotech Sample	10080264	41364	0.02	0									NAF
SP142	55.35	56.70	1.35	Fresh Permian	S2	Sandstone	FR			812	41303	0.01	0	227	-227	741.83						NAF
SP142	56.70	58.87	2.17	Fresh Permian	S2	Sandstone	FR			813	41304	0.01	0	31	-31	101.31						NAF
SP142	58.87	59.12	0.25	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
SP142	59.12	60.20	1.08	Fresh Permian	S2	Sandstone	FR			814	41305	<0.01	0	90	-90	588.24						NAF
SP142	60.20	61.88	1.68	Fresh Permian	S2/ST	Sandstone	FR			815	41306	<0.01	0	151	-151	986.93						NAF
SP142	61.88	62.15	0.27	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
SP142	62.15	63.51	1.36	Fresh Permian	S2	Sandstone	FR		Calcite, Minor CY	816	41307	0.01	0	235	-235	767.97						NAF
SP142	63.51	65.79	2.28	Fresh Permian	S2	Sandstone	FR		Minor CY	817	41308	0.01	0	68	-68	222.22	8.5	0	0			NAF
SP142	65.79	66.08	0.29	Fresh Permian	S2	Sandstone	FR		Geotech Sample	10080265	41365	0.01	0									NAF
SP142	66.08	66.67	0.59	Fresh Permian	S2	Sandstone	FR		Calcite, Minor CY	818	41309	<0.01	0	107	-107	699.35						NAF
SP142	66.67	68.93	2.26	Fresh Permian	S2	Sandstone	FR		Calcite, Minor CY	819	41310	0.02	1	81	-80	132.35						NAF
SP142	68.93	69.17	0.24	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
SP142	69.17	69.89	0.72	Fresh Permian	S2	Sandstone	FR		Calcite, Minor CY	820	41311	0.02	1	37	-36	60.46						NAF
SP142	69.89	71.46	1.57	Fresh Permian	S2/CY	Sandstone	FR			821	41312	0.02	1	211	-210	344.77						NAF
SP142	71.46	72.09	0.63	Fresh Permian	ST	Siltstone	FR			822	41313	0.04	1	100	-99	81.70						NAF
SP142	72.09	72.23	0.14	Fresh Permian	LO				Core Loss		No Sample											
SP142	72.23	72.41	0.18	Fresh Permian	ST	Siltstone	FR		BHWL 72.96m	823	41314	0.02	1									NAF
SP142	72.41	72.68	0.27	Fresh Permian	ST	Siltstone	FR		Geotech Sample		No Sample											
SP142	72.68	72.96	0.28	Fresh Permian	ST	Siltstone	FR		BHWL 72.96m	824	41315	0.02	1									NAF
SP142	72.96	75.95	2.99	Fresh Permian	S1	Sandstone	FR			825	41316	0.02	1	45	-44	73.53						NAF
SP142	75.95	76.25	0.30	Fresh Permian	S1	Sandstone	FR		Geotech Sample	10080266	41366	0.01	0									NAF
SP142	76.25	79.25	3.00	Fresh Permian	CM	Carb Mudstone	FR			826	41317	0.02	1	39	-38	63.73						NAF
SP142	79.25	79.59	0.34	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		No Sample											
SP142	79.59	80.50	0.91	Fresh Permian	CM	Carb Mudstone	FR			827	41318	0.02	1	31	-30	50.65						NAF
SP142	80.50	82.13	1.63	Fresh Permian	CM/CY	Carb Mudstone	FR			828	41319	0.01	0	80	-80	261.44						NAF
SP142	82.13	83.54	1.41	Fresh Permian	XT	Carb Siltstone	FR			829	41320	0.01	0	29	-29	94.77	8.2	0	0			NAF
SP142	83.54	83.85	0.31	Fresh Permian	XT	Carb Siltstone	FR		Geotech Sample		No Sample											
SP142	83.85	85.00	1.15	Fresh Permian	XT	Carb Siltstone	FR			830	41321	0.08	2	44	-42	19.17	8.1	0	0			NAF
SP142	85.00	87.35	2.35	Fresh Permian	XT	Carb Siltstone	FR		CM/CY and Calcite at base	831	41322	0.01	0	32	-32	104.58						NAF
SP142	87.35	87.56	0.21	Fresh Permian	MS	Mudstone	FR		Geotech Sample	10080267	41367	0.02	0	92	-92	200.44						NAF
SP142	87.56	89.09	1.53	Fresh Permian	CM	Carb Mudstone	FR		Calcite	832	41323	0.06	2	130	-128	70.81	8.5	0	0			NAF
SP142	89.09	89.39	0.30	Fresh Permian	CM	Carb Mudstone	FR		Calcite	833	41324	0.02	1									NAF
SP142	89.39	89.62	0.23	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		No Sample											
SP142	89.62	90.20	0.58	Fresh Permian	CM	Carb Mudstone	FR		Calcite	834	41325	0.02	1	25	-24	40.85						NAF
SP142	90.20	93.07	2.87	Fresh Permian	CM	Carb Mudstone	FR		Minor Calcite	835	41326	0.04	1	29	-28	23.69						NAF

Table 1: Acid forming characteristics of overburden, interburden and coal samples tested by EGi.

Hole Name	Depth (m) From	To	Interval	Stratigraphy	Lithology Code	Summary Lithology	Weathering	Seam	Comments	SGCP Sample No	EGi Sample No	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC /MPA	NAG TEST NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	Extended Boil NAGpH	Calculated NAG	ARD Classification
SP142	93.07	93.30	0.23	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		No Sample											
SP142	93.30	96.28	2.98	Fresh Permian	CM	Carb Mudstone	FR			836	41327	0.05	2	23	-21	15.03	7.6	0	0			NAF
SP142	96.28	97.88	1.60	Fresh Permian	CM/CY	Carb Mudstone	FR			837	41328	0.04	1	24	-23	19.61						NAF
SP142	97.88	98.17	0.29	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample	10080268	41368	0.21	6	13	-7	2.02	6.9	0	0			NAF
SP142	98.17	98.37	0.20	Fresh Permian	CM/CY	Carb Mudstone	FR			838	41329	0.04	1									NAF
SP142	98.37	99.39	1.02	Fresh Permian	CM/CY	Carb Mudstone	FR			839	41330	0.09	3	17	-14	6.17	7.3	0	0			NAF
SP142	99.39	100.40	1.01	Fresh Permian	CM	Carb Mudstone	FR			840	41331	0.11	3	15	-12	4.46	6.9	0	0			NAF
SP142	100.40	100.65	0.25	Fresh Permian	CM	Carb Mudstone	FR		Geotech Sample		No Sample											
SP142	100.65	101.60	0.95	Fresh Permian	CM	Carb Mudstone	FR			841	41332	0.10	3	9	-6	2.94	6.5	0	0			NAF
SP142	101.60	102.08	0.48	Fresh Permian	CY	Claystone	FR			842	41333	0.04	1	17	-16	13.89						NAF
SP142	102.08	102.23	0.15	Fresh Permian	LO				Core Loss		No Sample											
SP142	102.23	102.69	0.46	Fresh Permian	CY	Claystone	FR			843	41334	0.14	4	17	-13	3.97	7.2	0	0			NAF
SP142	102.69	103.31	0.62	Fresh Permian	S7	Sandstone	FR			844	41335	<0.01	0	1	-1	6.54						NAF
SP142	103.31	103.58	0.27	Fresh Permian	S7	Sandstone	FR		Geotech Sample		No Sample											
SP142	103.58	104.49	0.91	Fresh Permian	S7	Sandstone	FR			845	41336	0.01	0	0	0	0.00						NAF
SP142	104.49	104.66	0.17	Fresh Permian	Coal	Coal	FR	UN	No Sample		No Sample											
SP142	104.66	106.13	1.47	Fresh Permian	S2	Sandstone	FR			846	41337	0.27	8	0	8	0.00	2.8	8	9			PAF
SP142	106.13	106.36	0.23	Fresh Permian	S2	Sandstone	FR		Geotech Sample	10080269	41369	0.04	1									NAF
SP142	106.36	108.46	2.10	Fresh Permian	S2	Sandstone	FR			847	41338	0.08	2	0	2	0.00	3.2	2	3			PAF-LC
SP142	108.46	111.28	2.82	Fresh Permian	S2	Sandstone	FR			848	41339	0.08	2	2	0	0.82	4.2	0.3	3			PAF-LC
SP142	111.28	111.58	0.30	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
SP142	111.58	113.50	1.92	Fresh Permian	S2	Sandstone	FR			849	41340	0.43	13	0	13	0.00	3.1	5	11			PAF-LC
SP142	113.50	114.68	1.18	Fresh Permian	S2	Sandstone	FR			850	41341	0.45	14	8	6	0.58	2.9	5	16	3.9	14	PAF
SP142	114.68	114.97	0.29	Fresh Permian	S2	Sandstone	FR		Geotech Sample	10080270	41370	0.20	6	8	-2	1.31	4.2	1	7			UC(PAF-LC)
SP142	114.97	118.30	3.33	Fresh Permian	S1	Sandstone	FR		Calcite	851	41342	0.39	12	2	10	0.17	3.3	2	9			PAF-LC
SP142	118.30	118.57	0.27	Fresh Permian	S1	Sandstone	FR		Geotech Sample		No Sample											
SP142	118.57	119.41	0.84	Fresh Permian	S1	Sandstone	FR		Calcite	852	41343	0.03	1	9	-8	9.80						NAF
SP142	119.41	120.82	1.41	Fresh Permian	S1	Sandstone	FR		Calcite	853	41344	0.10	3	87	-84	28.43	7.7	0	0			NAF
SP142	120.82	121.83	1.01	Fresh Permian	CM	Carb Mudstone	FR			854	41345	0.40	12	8	4	0.65	3.6	2	9			PAF-LC
SP142	121.83	122.43	0.60	Fresh Permian	S2/CY	Sandstone	FR		Calcite	855	41346	0.17	5	9	-4	1.73	4.6	0	2			NAF
SP142	122.43	122.73	0.30	Fresh Permian	S2	Sandstone	FR		Geotech Sample		No Sample											
SP142	122.73	124.01	1.28	Fresh Permian	S2	Sandstone	FR		Calcite	856	41347	1.83	56	0	56	0.00	2.2	42	50			PAF
SP142	124.01	124.25	0.24	Fresh Permian	Coal	Coal	FR	UN	Pyrite Vein, No Sample		No Sample											
SP142	124.25	124.79	0.54	Fresh Permian	S1	Sandstone	FR			857	41348	1.62	50	0	50	0.00	2.3	28	37			PAF
SP142	124.79	125.04	0.25	Fresh Permian	S1	Sandstone	FR		Geotech Sample	10080271	41371	0.93	28	0	28	0.00	2.4	26	32			PAF
SP142	125.04	125.63	0.59	Fresh Permian	S1	Sandstone	FR			858	41349	2.05	63	4	59	0.06	2.2	45	53			PAF
SP142	125.63	126.28	0.65	Fresh Permian	S2	Sandstone	FR			859	41350	0.95	29	0	29	0.00	2.4	17	22			PAF
SP142	126.28	126.58	0.30	Fresh Permian	S2	Sandstone	FR	D1 roof		1695	41386	1.30	40	0	40	0.00	2.2	36	44			PAF
SP142	126.58	130.07	3.49	Fresh Permian	Coal	Coal	FR	D1	Pyritic	1696	41387	1.40	43	4	39	0.09	1.9	191	283	3.4	27	PAF
SP142	130.07	130.30	0.23	Fresh Permian	S2	Sandstone	FR	D1 floor		1697	41388	0.17	5	8	-3	1.54	2.3	23	43	5.9	-3	NAF
SP142	130.30	130.57	0.27	Fresh Permian	S1	Sandstone	FR		Geotech Sample	10080272	41372	0.04	1									NAF
SP142	130.57	133.28	2.71	Fresh Permian	S1	Sandstone	FR			860	41351	0.02	1	0	1	0.00	4.9	0	1			NAF
SP142	133.28	135.76	2.48	Fresh Permian	S1	Sandstone	FR			861	41352	0.13	4	0	4	0.00	4.3	0.4	3			PAF-LC
SP142	135.76	136.00	0.24	Fresh Permian	S1	Sandstone	FR		Geotech Sample	10080273	41373	0.03	1									NAF
SP142	136.00	138.08	2.08	Fresh Permian	S1	Sandstone	FR			862	41353	0.04	1	0	1	0.00						NAF
SP142	138.08	138.28	0.20	Fresh Permian	LO				Core Loss		No Sample											
SP142	138.28	139.12	0.84	Fresh Permian	S1-S3	Sandstone	FR			863	41354	0.50	15	0	15	0.00	2.6	11	14			PAF
SP142	139.12	139.40	0.28	Fresh Permian	S1-S3	Sandstone	FR		Geotech Sample		No Sample											
SP142	139.40	140.07	0.67	Fresh Permian	S1-S3	Sandstone	FR			864	41355	0.11	3	0	3	0.00	3.7	1	3			PAF-LC
SP142	140.07	141.77	1.70	Fresh Permian	S7	Sandstone	FR			865	41356	0.04	1	0	1	0.00						NAF
SP142	141.77	141.97	0.20	Fresh Permian	S7	Sandstone	FR		Geotech Sample	10080274	41374	0.02	0									NAF
SP142	141.97	143.18	1.21	Fresh Permian	S7	Sandstone	FR			866	41357	0.04	1	24	-23	19.61						NAF
SP142	143.18	144.23	1.05	Fresh Permian	LO				Core Loss		No Sample											
SP142	144.23	144.55	0.32	Fresh Permian	S7	Sandstone	FR			867	41358	0.09	3	0	3	0.00	3.4	1	3			PAF-LC
SP142	144.55	144.91	0.36	Fresh Permian	S3	Sandstone	FR	D2 roof		1698	41389	0.06	2	1	1	0.54	3.9	0.4	4			PAF-LC

Table 1: Acid forming characteristics of overburden, interburden and coal samples tested by EGi.

Hole Name	Depth (m)			Stratigraphy	Lithology Code	Summary Lithology	Weathering	Seam	Comments	SGCP Sample No	EGi Sample No	ACID-BASE ANALYSIS					NAG TEST			Extended Boil NAGpH	Calculated NAG	ARD Classification
	From	To	Interval									Total %S	MPA	ANC	NAPP	ANC /MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$			
SP142	144.91	147.28	2.37	Fresh Permian	Coal	Coal	FR	D2ML		1699	41390	1.50	46	3	43	0.07	1.8	213	310	3.5	25	PAF
SP142	147.28	147.51	0.23	Fresh Permian	MS	Mudstone	FR	D2 floor		1700	41391	0.07	2	0	2	0.00	3.2	2	5			PAF-LC
SP142	147.51	147.67	0.16	Fresh Permian	MS	Mudstone	FR			868	41359	0.08	2	0	2	0.00	2.7	11	24	6.9	0	NAF
SP142	147.67	147.95	0.28	Fresh Permian	MS	Mudstone	FR		Geotech Sample	10080275	41375	0.37	11	0	11	0.00	3.1	7	13			PAF
SP142	147.95	148.16	0.21	Fresh Permian	MS	Mudstone	FR			869	41360	0.17	5	0	5	0.00	3.3	3	7			PAF-LC
SP142	148.16	150.53	2.37	Fresh Permian	S1	Sandstone	FR			870	41361	0.25	8	1	7	0.13	3.4	1	4			PAF-LC

KEY

$pH_{1:2}$ = pH of 1:2 extract
$EC_{1:2}$ = Electrical Conductivity of 1:2 extract (dS/m)
MPA = Maximum Potential Acidity (kgH_2SO_4/t)
ANC = Acid Neutralising Capacity (kg H_2SO_4/t)
NAPP = Net Acid Producing Potential (kg H_2SO_4/t)

Siltstone

NAGpH = pH of NAG liquor
$NAG_{(pH4.5)}$ = Net Acid Generation capacity to pH 4.5 (kgH_2SO_4/t)
$NAG_{(pH7.0)}$ = Net Acid Generation capacity to pH 7.0 (kgH_2SO_4/t)

NAF = Non-Acid Forming
PAF = Potentially Acid Forming
PAF-LC = PAF - lower capacity
UC(NAF) = Uncertain but Expected to be NAF
UC(PAF) = Uncertain but Expected to be PAF
UC(PAF) = Uncertain but Expected to be PAF

Coal seam interval
Core loss or intervals collected for geotechnical sampling not available for testing
Standard NAG results overestimate acid potential due to organic acid effects

Lithology Codes

CL: CLAY
CM: CARBONACEOUS MUDSTONE
CT: CHLORITE SCHIST
CY: CLAYSTONE
FK: FERRICRETE
IS: IRONSTONE
LO: LOST CORE
MS: MUDSTONE

S1: SANDSTONE, VERY FINE GRAINED
S9: SANDSTONE, VERY COARSE GRAINED
S2: SANDSTONE, FINE GRAINED
S3: SANDSTONE, FINE TO MEDIUM GRAINED
S4: SANDSTONE, MEDIUM GRAINED
S5: SANDSTONE, COARSE TO VERY COARSE GRAINED
S6: SANDSTONE, INTERBEDDED,FINE AND COARSE G
S7: SANDSTONE, MEDIUM TO COARSE GRAINED

SA: SAND
SH: SHALE
SK: SILCRETE
SN: SANDY CLAY
SO: SOIL
SS: SANDSTONE
ST: SILTSTONE
XM: CARB MUDSTONE

Weathering Codes

EW: EXTREMELY WEATHERED
HW: HIGHLY WEATHERED
MW: MODERATELY WEATHERED
SW: SLIGHTY WEATHERED
FR: FRESH

Table 2: Acid forming characteristics for BH99 and BH100 supplied by SGCP.

Hole Name	Depth (m)			Stratigraphy	Lithology Code	Summary Lithology	Weathering	Seam	Comments	SGCP Sample No	$pH_{1:5}$	$EC_{1:5}$	ACID-BASE ANALYSIS					SINGLE ADDITION NAG			% ECEC Na (ESP)	ARD Classification
	From	To	Interval										Total %S	MPA	ANC	NAPP	ANC/MPA	NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$		
BH99C	0.00	0.15	0.15	Tertiary	SO	Soil	EW			2201											3	
BH99C	0.15	1.00	0.85	Tertiary	SO	Soil	EW															
BH99C	1.00	2.10	1.10	Tertiary	SN	Sandy Clay	EW															
BH99C	2.10	3.00	0.90	Tertiary	SA	Sand	EW															
BH99C	3.00	4.00	1.00	Tertiary	SN	Sandy Clay	EW															
BH99C	4.00	5.00	1.00	Tertiary	SN	Sandy Clay	EW			2202	7.8	0.12	<0.01	0	5	-5	30.72					NAF
BH99C	5.00	5.90	0.90	Tertiary	SN	Sandy Clay	EW															
BH99C	5.90	9.00	3.10	Tertiary	SA	Sand	EW		BUTE 9.00m													
BH99C	9.00	10.00	1.00	Weathered Permian	SN	Sandy Clay	EW															
BH99C	10.00	14.00	4.00	Weathered Permian	SS	Sandstone	EW															
BH99C	14.00	15.00	1.00	Weathered Permian	SS	Sandstone	EW			2204	7.8	0.18	<0.01	0	3	-3	21.57	5.9	0	5		NAF
BH99C	15.00	17.00	2.00	Weathered Permian	SS	Sandstone	EW															
BH99C	17.00	19.00	2.00	Weathered Permian	SN	Sandy Clay	EW															
BH99C	19.00	20.00	1.00	Weathered Permian	SN	Sandy Clay	EW			2205											24	
BH99C	20.00	21.00	1.00	Weathered Permian	SN	Sandy Clay	EW															
BH99C	21.00	22.00	1.00	Weathered Permian	FK	Ironstone	EW															
BH99C	22.00	24.00	2.00	Weathered Permian	SS	Sandstone	EW															
BH99C	24.00	25.00	1.00	Weathered Permian	SS	Sandstone	EW			2206	7.3	0.10	<0.01	0	5	-5	32.68					NAF
BH99C	25.00	27.00	2.00	Weathered Permian	SS	Sandstone	EW															
BH99C	27.00	29.00	2.00	Weathered Permian	SS	Sandstone	EW															
BH99C	29.00	30.00	1.00	Weathered Permian	SK	Silcrete	EW			2207	7.4	0.08	<0.01	0	5	-5	32.68					NAF
BH99C	30.00	33.00	3.00	Weathered Permian	SK	Silcrete	EW															
BH99C	33.00	34.00	1.00	Weathered Permian	SS	Sandstone	HW															
BH99C	34.00	35.00	1.00	Weathered Permian	CY	Claystone	HW			2208	7.6	0.08	0.01	0	2	-2	6.86					NAF
BH99C	35.00	39.00	4.00	Weathered Permian	CY	Claystone	HW															
BH99C	39.00	40.00	1.00	Weathered Permian	CY	Claystone	HW			2210	7.4	0.11	<0.01	0	7	-7	44.44					NAF
BH99C	40.00	43.00	3.00	Weathered Permian	CL	Clay	HW															
BH99C	43.00	44.00	1.00	Weathered Permian	CL	Clay	HW															
BH99C	44.00	45.00	1.00	Weathered Permian	CL	Clay	HW			2211											16	
BH99C	45.00	49.00	4.00	Weathered Permian	CL	Clay	HW															
BH99C	49.00	50.00	1.00	Weathered Permian	CL	Clay	HW			2212	7.1	0.08	0.02	1	7	-7	11.93					NAF
BH99C	50.00	52.00	2.00	Weathered Permian	CL	Clay	HW															
BH99C	52.00	52.90	0.90	Weathered Permian	CL	Clay	HW		BHWE 52.9m													
BH99C	52.90	54.00	1.10	Fresh Permian	CY	Claystone	FR															
BH99C	54.00	55.00	1.00	Fresh Permian	CY	Claystone	FR			2214	6.7	0.25	0.05	2	7	-5	4.38	3.8	2	9		NAF
BH99C	55.00	57.00	2.00	Fresh Permian	CY	Claystone	FR															
BH99C	57.00	62.00	5.00	Fresh Permian	CY	Claystone	FR															
BH99C	62.00	64.00	2.00	Fresh Permian	CY	Claystone	FR															
BH99C	64.00	65.00	1.00	Fresh Permian	SS	Sandstone	FR			2216	7.4	0.12	0.05	2	6	-5	4.18					NAF
BH99C	65.00	67.00	2.00	Fresh Permian	SS	Sandstone	FR															
BH99C	67.00	68.00	1.00	Fresh Permian	S1	Sandstone	FR															
BH99C	68.00	69.00	1.00	Fresh Permian	S1	Sandstone	FR			2218	4.0	0.48	0.09	3	0	3	0.00					UC(PAF-LC)
BH99C	69.00	74.00	5.00	Fresh Permian	S1	Sandstone	FR															
BH99C	74.00	75.00	1.00	Fresh Permian	S1	Sandstone	FR			2220	4.0	0.68	0.23	7	2	5	0.27					UC(PAF-LC)
BH99C	75.00	77.00	2.00	Fresh Permian	S1	Sandstone	FR															
BH99C	77.00	78.00	1.00	Fresh Permian	S1	Sandstone	FR			2221											16	
BH99C	78.00	79.00	1.00	Fresh Permian	S1	Sandstone	FR															
BH99C	79.00	80.00	1.00	Fresh Permian	S1	Sandstone	FR			2222	6.3	0.32	0.44	13	2	11	0.15					UC(PAF)
BH99C	80.00	81.00	1.00	Fresh Permian	S1	Sandstone	FR															
BH99C	81.00	82.00	1.00	Fresh Permian	SH	Shale	FR															
BH99C	82.00	83.00	1.00	Fresh Permian	S7	Sandstone	FR			2224	3.2	1.27	1.26	39	0	39	0.00					UC(PAF)
BH99C	83.00	84.00	1.00	Fresh Permian	S7	Sandstone	FR			2225	3.1	2.48	3.49	107	0	107	0.00	2.1	88	97		PAF
BH99C	84.00	85.00	1.00	Fresh Permian	S7	Sandstone	FR			2376	3.4	1.77	2.08	64	0	64	0.00				10	UC(PAF)
BH99C	85.00	86.00	1.00	Fresh Permian	Coal	Coal	FR	D1U		2377	5.6	0.87	1.22	37	11	27	0.29					UC(PAF)
BH99C	86.00	87.00	1.00	Fresh Permian	Coal/ST	Coal	FR	D1U		2378	6.0	0.61	1.22	37	8	30	0.21					UC(PAF)
BH99C	87.00	90.13	3.13	Fresh Permian	Coal	Coal	FR	D1L														
BH99C	90.13	91.00	0.87	Fresh Permian	S1	Sandstone	FR															
BH99C	91.00	91.50	0.50	Fresh Permian	S1	Sandstone	FR			2379	6.2	0.15	0.08	2	3	0	1.02					UC(NAF)
BH99C	91.50	92.00	0.50	Fresh Permian	S1	Sandstone	FR			2380	5.9	0.21	0.15	5	2	3	0.41	3.0	5	13		PAF-LC
BH99C	92.00	95.00	3.00	Fresh Permian	S2	Sandstone	FR															
BH99C	95.00	96.00	1.00	Fresh Permian	S2	Sandstone	FR			2381	4.9	0.29	0.09	3	2	0	0.87					UC(PAF-LC)

Table 2: Acid forming characteristics for BH99 and BH100 supplied by SGCP.

Hole Name	Depth (m) From	Depth (m) To	Depth (m) Interval	Stratigraphy	Lithology Code	Summary Lithology	Weathering	Seam	Comments	SGCP Sample No	$pH_{1:5}$	$EC_{1:5}$	ACID-BASE ANALYSIS Total %S	MPA	ANC	NAPP	ANC/MPA	SINGLE ADDITION NAG NAGpH	$NAG_{(pH4.5)}$	$NAG_{(pH7.0)}$	% ECEC Na (ESP)	ARD Classification
BH99C	96.00	99.00	3.00	Fresh Permian	S2	Sandstone	FR															
BH99C	99.00	100.00	1.00	Fresh Permian	S2	Sandstone	FR			2382	3.7	0.38	0.10	3	1	2	0.39					UC(PAF-LC)
BH99C	100.00	102.00	2.00	Fresh Permian	S2	Sandstone	FR			2383	3.5	0.47	0.18	6	1	5	0.18					UC(PAF-LC)
BH99C	102.00	103.00	1.00	Fresh Permian	Coal/S2/S1	Coal	FR	D2U		2384	5.9	0.28	0.11	3	4	-1	1.25					UC(NAF)
BH99C	103.00	105.36	2.36	Fresh Permian	Coal	Coal	FR	D2U/D2ML	Pyritic													
BH99C	105.36	105.50	0.14	Fresh Permian	CY	Claystone	FR															
BH99C	105.50	106.00	0.50	Fresh Permian	ST/CY	Siltstone	FR			2385	5.5	0.25	0.10	3	2	1	0.62				18	UC(PAF-LC)
BH99C	106.00	106.50	0.50	Fresh Permian	ST/S2	Siltstone	FR			2386	3.8	0.35	0.11	3	2	1	0.71	3.2	6	13		UC(PAF-LC)
BH99C	106.50	107.00	0.50	Fresh Permian	S2	Sandstone	FR															
BH99C	107.00	109.00	2.00	Fresh Permian	S8	Sandstone	FR															
BH99C	109.00	110.00	1.00	Fresh Permian	S8	Sandstone	FR			2387	4.7	0.21	0.08	2	2	1	0.69					UC(PAF-LC)
BH99C	110.00	112.00	2.00	Fresh Permian	S8	Sandstone	FR															
BH100C	0.00	0.15	0.15	Tertiary	SO	Soil	EW			2388											2	
BH100C	0.15	5.00	4.85	Tertiary	SN/SO	Sandy Clay	EW			2389	6.3	0.04	<0.01	0	5	-5	33.99					NAF
BH100C	5.00	10.00	5.00	Tertiary	IS/SN/SA	Ironstone	EW		BUTE 10.00m	2390	6.2	0.09	0.01	0	4	-3	11.44	5.6	0	5		NAF
BH100C	10.00	15.00	5.00	Weathered Permian	SS	Sandstone	EW			2391	5.9	0.37	0.02	1	5	-4	8.33					NAF
BH100C	15.00	20.00	5.00	Weathered Permian	SS	Sandstone	EW			2392	6.2	0.27	0.01	0	4	-4	13.73				35	NAF
BH100C	20.00	25.00	5.00	Weathered Permian	SS	Sandstone	EW			2393	6.9	0.19	<0.01	0	4	-4	28.76					NAF
BH100C	25.00	30.00	5.00	Weathered Permian	CY	Claystone	EW			2394	6.8	0.26	<0.01	0	2	-2	13.07	5.7	0	7		NAF
BH100C	30.00	33.00	3.00	Weathered Permian	CY	Claystone	EW			2395	6.8	0.30	0.01	0	6	-6	19.28					NAF
BH100C	33.00	35.00	2.00	Weathered Permian	CY	Claystone	EW			2396	6.8	0.32	<0.01	0	5	-4	30.07					NAF
BH100C	35.00	40.00	5.00	Weathered Permian	CL/SS	Clay	EW			2397	7.0	0.22	<0.01	0	8	-8	50.98					NAF
BH100C	40.00	45.00	5.00	Weathered Permian	SS/CL	Sandstone	HW			2398	6.9	0.12	<0.01	0	4	-3	22.88				27	NAF
BH100C	45.00	50.00	5.00	Weathered Permian	CL	Clay	HW			2399	6.9	0.18	<0.01	0	3	-3	18.30	5.6	0	6		NAF
BH100C	50.00	55.00	5.00	Weathered Permian	CL/S1	Clay	HW		BHWE 54.20m	2400	7.0	0.18	0.01	0	5	-5	16.34				27	NAF
BH100C	55.00	57.00	2.00	Fresh Permian	S1	Sandstone	FR			2401	3.0	1.58	0.44	13	2	11	0.16	2.8	8	14		PAF
BH100C	57.00	58.00	1.00	Fresh Permian	S1/XM/CY/Coal	Sandstone	FR		Pyrite Vein	2402	2.4	3.13	2.39	73	0	73	0.00					UC(PAF)
BH100C	58.00	59.00	1.00	Fresh Permian	CY/XM	Claystone	FR			2403	4.0	1.68	0.78	24	5	19	0.19					UC(PAF)
BH100C	59.00	60.00	1.00	Fresh Permian	XM/Coal	Coal	FR	D1U	Calcite, Pyrite Vein	2404	3.1	2.12	1.13	35	4	31	0.11					UC(PAF)
BH100C	60.00	63.00	3.00	Fresh Permian	Coal	Coal	FR	D1L	Pyrite Vein													
BH100C	63.00	63.50	0.50	Fresh Permian	Coal	Coal	FR	D1L	Pyrite Vein	2405	3.8	0.49	0.26	8	4	4	0.53					UC(PAF-LC)
BH100C	63.50	64.00	0.50	Fresh Permian	Coal	Coal	FR	D1L	Pyrite Vein	2406	6.3	0.21	0.07	2	4	-2	1.96	2.8	8	20		UC(PAF-LC)
BH100C	64.00	65.00	1.00	Fresh Permian	CY	Claystone	FR			2407	4.2	0.31	0.18	6	4	2	0.69				27	UC(PAF-LC)
BH100C	65.00	70.00	5.00	Fresh Permian	S2/S1	Sandstone	FR			2408	4.2	0.36	0.13	4	4	0	0.96					UC(NAF)
BH100C	70.00	72.00	2.00	Fresh Permian	S2	Sandstone	FR			2409	3.2	0.81	0.27	8	1	7	0.17					UC(PAF)
BH100C	72.00	73.00	1.00	Fresh Permian	S2	Sandstone				2410	3.4	0.56	0.23	7	5	3	0.64				24	UC(PAF-LC)
BH100C	73.00	74.00	1.00	Fresh Permian	S2	Sandstone	FR			2411	3.5	0.45	0.15	5	2	3	0.37					UC(PAF-LC)
BH100C	74.00	75.80	1.80	Fresh Permian	S2/S1/Coal	Sandstone	FR	D2U Part	Pyrite	2412	6.2	0.30	0.17	5	3	3	0.50	2.9	6	12		UC(PAF-LC)
BH100C	75.80	78.65	2.85	Fresh Permian	Coal	Coal	FR	D2U/D2ML	Pyrite													
BH100C	78.65	79.00	0.35	Fresh Permian	CY	Claystone	FR			2413	4.9	0.30	0.17	5	4	2	0.67	2.5	25	53		UC(PAF-LC)
BH100C	79.00	79.50	0.50	Fresh Permian	CY/ST	Claystone	FR			2414	4.4	0.29	0.21	6	4	3	0.59					UC(PAF-LC)
BH100C	79.50	81.00	1.50	Fresh Permian	ST	Siltstone	FR			2415	4.1	0.42	0.15	5	4	1	0.76					UC(PAF-LC)
BH100C	81.00	87.00	6.00	Fresh Permian	S8/S3	Sandstone	FR			2416	4.6	0.28	0.07	2	3	-1	1.31					UC(NAF)

Table 3: Sulphur speciation results for selected samples.

EGi Sample Number	Lithology Code	Total %S	Pyritic S (%)	Acid Sulphate %S	Non-Acid Sulphate %S	Low Risk S Forms (%)	Proportion Pyritic/Acid
41432	S1	0.90	0.63	0.03	0.11	0.16	73%
41393	Coal	1.51	0.81	0.02	0.08	0.62	55%
41397	MS	0.34	0.21	0.01	0.05	0.08	66%
41402	CY	0.10	0.10	0.00	0.02	0.00	100%
41404	MS/Coal	0.18	0.02	0.01	0.01	0.15	14%
41406	Coal	0.81	0.31	0.01	0.06	0.44	39%
41477	S2	0.10	0.06	0.04	0.01	0.03	103%
41341	S2	0.47	0.33	0.02	0.13	0.01	75%
41387	Coal	1.18	0.55	0.01	0.04	0.59	47%
41388	S2	0.05	0.03	0.01	0.00	0.02	72%
41390	Coal	1.26	0.76	0.01	0.07	0.43	62%

Pyritic S (%) = CRS (%)

Acid Sulphate S = KCl Acid Sulphate S

Non-Acid Sulphate S = KCl S – KCl Acid Sulphate S

Low Risk S Forms = Total S - (CRS + KCl S)

Table 4: Multi-element composition of selected sample solids (mg/kg except where shown).

Element	Detection Limit	Sample Number/Lithology-Weathering														
		41362	41297	41301	41308	41321	41323	41368	41337	41345	41347	41349	41386	41388	41354	41391
		ST-HW	ST-FR	S2-FR	S2-FR	XT-FR	CM-FR	CM-FR	S2-FR	CM-FR	S2-FR	S1-FR	S2-FR	S2-FR	S1/S2/S3-FR	MS-FR
Ag	0.02	0.06	0.11	0.14	0.07	0.08	0.16	0.10	0.65	0.20	0.36	0.19	0.06	0.06	0.60	0.06
Al	0.01%	8.21%	7.69%	7.09%	8.21%	8.24%	8.02%	8.78%	1.74%	7.87%	5.77%	5.92%	5.58%	10.20%	4.41%	3.45%
As	0.2	12.4	6.4	5.3	10.4	2.3	43.7	9.5	14.6	13	21	8.1	14	1.8	10.5	2.4
Ba	10	510	1110	400	440	400	380	700	130	330	270	300	280	420	240	260
Be	0.05	1.25	4.28	1.09	1.6	2.32	1.69	3.12	0.47	2.44	1.5	1.28	1.1	2.84	1.61	0.94
Bi	0.01	0.10	0.23	0.07	0.17	0.40	0.23	0.67	0.06	0.55	0.30	0.27	0.27	0.74	0.20	0.06
Ca	0.01%	3.05%	0.56%	8.13%	1.69%	1.05%	3.88%	0.37%	0.02%	0.29%	0.15%	0.07%	0.06%	0.07%	0.03%	0.01%
Cd	0.02	0.05	0.13	0.02	0.09	0.13	0.12	0.19	<0.02	0.3	0.27	0.09	0.13	0.06	0.08	<0.02
Ce	0.01	41.2	50.2	34.4	45.3	67.4	53.9	97	21.7	85.3	68.9	55.3	60	93.3	65.4	27.8
Co	0.1	18.7	39	19.7	15.6	12.8	7.9	16.8	32.6	15.2	21.4	12.9	9.7	3.7	23.8	9.4
Cr	1	30	39	25	42	38	10	36	9	63	43	39	54	72	28	49
Cs	0.05	2.86	6.07	2.77	5.18	8.47	3.3	11.2	1.93	8.77	4.36	4.81	3.78	15.8	4.93	2.18
Cu	0.2	23.4	53.4	71.4	51.3	51.4	153.5	46.4	125	52.7	89.2	62.5	12.1	28.6	115	13.1
Fe	0.01%	3.49%	5.11%	2.91%	3.95%	3.81%	3.47%	3.57%	0.58%	3.15%	3.06%	3.03%	2.43%	0.79%	1.23%	1.98%
Ga	0.05	18.7	20.1	16.1	19.4	21.9	18.1	23.5	4.2	21.8	14.9	14.2	12.8	29.8	12.4	13.5
Ge	0.05	<0.05	0.08	0.05	0.09	0.09	0.09	0.12	<0.05	0.07	0.08	0.05	0.07	<0.05	0.07	0.08
Hf	0.1	2.9	3.4	2.2	3.3	4.1	3.9	5.1	1.6	4.5	4.0	3.7	4.1	4.7	4.7	1.7
Hg	0.01	0.02	0.03	0.03	0.02	0.04	0.04	0.05	0.17	0.04	0.07	0.07	0.09	0.01	0.12	0.06
In	0.005	0.049	0.057	0.036	0.056	0.068	0.067	0.083	0.009	0.083	0.064	0.042	0.042	0.095	0.037	0.017
K	0.002%	1.94%	1.89%	1.52%	1.77%	2.06%	1.90%	1.79%	0.77%	1.58%	1.37%	1.64%	1.45%	2.28%	1.29%	1.27%
La	10	19	25	17	22	33	26	44	11	40	32	27	30	50	31	14
Li	0.2	27	20	18	23	26	10	37	10	42	23	25	24	42	18	19
Mg	0.002%	0.61%	1.05%	0.62%	1.15%	0.93%	1.09%	0.77%	0.07%	0.65%	0.34%	0.26%	0.20%	0.30%	0.18%	0.08%
Mn	1	921	655	1320	536	704	1460	612	30	183	115	161	113	37	53	109
Mo	0.1	1.2	1.0	0.9	1.1	1.2	1.5	2.1	1.5	2.5	5.4	1.6	2.2	0.3	1.8	1.3
Na	0.002%	1.09%	0.60%	0.86%	0.80%	0.51%	0.35%	0.24%	0.05%	0.18%	0.10%	0.07%	0.06%	0.08%	0.05%	0.05%
Nb	0.1	5.7	7.0	4.5	6.9	10.3	6.1	12.3	3.4	11.2	8.1	8.6	7.8	19.6	9.6	4.7
Ni	1	22	46	19	24	23	8	33	13	32	18	15	24	24	20	28
P	20	950	830	760	970	950	3050	290	60	400	270	170	160	100	80	40
Pb	2	12	16	12	13	21	18	31	10	29	21	20	18	35	20	17
Rb	0.1	74	92	64	85	121	66	125	47	111	88	93	81	174	88	75
S	0.001%	0.03%	0.02%	<0.01%	0.01%	0.08%	0.06%	0.21%	0.27%	0.40%	1.83%	2.05%	1.30%	0.17%	0.50%	0.07%
Sb	0.05	0.42	0.64	0.44	0.51	0.78	0.71	1.04	0.56	0.91	0.88	0.55	0.50	0.73	0.78	0.26
Sc	1	13	14	11	14	14	12	15	2	13	9	8	7	16	6	3
Se	0.01	<1	1	<1	1	1	1	1	<1	1	2	2	2	1	1	1
Sn	0.1	1.4	3.2	6.1	3.1	3.1	2.5	4.0	11.8	6.0	9.5	6.8	2.4	6.1	12.3	1.4
Sr	0.05	202	210	243	266	219	339	146	15.5	75.2	47	31.5	33.2	41.8	26.2	24.2
Ta	0.05	0.38	0.55	0.33	0.49	0.85	0.43	0.98	0.43	0.93	0.68	0.76	0.67	1.72	0.84	0.41
Th	0.2	5.3	7.8	4.7	7.4	12.3	6.3	17.2	4.2	15.7	11.4	11.2	11.4	24.4	11.9	5.5
Ti	0.01%	0.41%	0.40%	0.32%	0.42%	0.38%	0.43%	0.36%	0.08%	0.35%	0.27%	0.26%	0.25%	0.46%	0.22%	0.08%
Tl	0.02	0.47	0.47	0.37	0.41	0.60	0.79	0.82	0.76	0.77	1.06	0.90	1.22	0.86	0.64	0.51
U	0.01	1.30	2.00	1.10	1.90	3.00	1.90	4.70	0.90	3.40	3.20	2.20	2.30	5.20	2.40	1.20
V	2	108	108	95	117	102	136	90	10	105	88	65	59	82	43	10
W	0.1	1	4	39	5	2	2	3	222	8	106	52	47	5	128	85
Y	0.1	16	26	14	19	26	26	29	5	31	22	15	17	22	14	8
Zn	1	75	127	63	81	82	76	96	13	89	73	80	33	26	42	17
Zr	0.5	109	121	77	121	150	142	177	55	161	128	122	133	156	163	55

< element at or below analytical detection limit.

Table 5: Geochemical abundance indices (GAI) of selected sample solids. Values 3 and over are highlighted in yellow.

Element	Median Soil Abundance*	Sample Number/Lithology														
		41362	41297	41301	41308	41321	41323	41368	41337	41345	41347	41349	41386	41388	41354	41391
		ST-HW	ST-FR	S2-FR	S2-FR	XT-FR	CM-FR	CM-FR	S2-FR	CM-FR	S2-FR	S1-FR	S2-FR	S2-FR	S1/S2/S3-FR	MS-FR
Ag	0.05	-	1	1	-	-	1	-	3	1	2	1	-	-	3	-
Al	7.1%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
As	6	-	-	-	-	-	2	-	1	1	1	-	1	-	-	-
Ba	500	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Be	0.3	1	3	1	2	2	2	3	-	2	2	2	1	3	2	1
Bi	0.2	-	-	-	-	-	-	1	-	1	-	-	-	1	-	-
Ca	1.5%	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-
Cd	0.35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ce	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Co	8	1	2	1	-	-	-	-	1	-	1	-	-	-	1	-
Cr	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cs	4	-	-	-	-	-	-	1	-	1	-	-	-	1	-	-
Cu	30	-	-	1	-	-	2	-	1	-	1	-	-	-	1	-
Fe	4.0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ga	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ge	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hf	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hg	0.06	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
In	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
K	1.4%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
La	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Li	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg	0.5%	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Mn	1000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mo	1.2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
Na	0.5%	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nb	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ni	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P	800	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Pb	35	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rb	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S	0.07%	-	-	-	-	-	-	1	1	2	4	4	4	1	2	-
Sb	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sc	7	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Se	0.4	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1
Sn	4	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-
Sr	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ta	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Th	9	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Ti	0.50%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tl	0.2	1	1	-	-	1	1	1	1	1	2	2	2	2	1	1
U	2	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-
V	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W	1.5	-	1	4	1	-	-	-	7	2	6	5	4	1	6	5
Y	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zn	90	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Zr	400	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*Bowen H.J.M.(1979) Environmental Chemistry of the Elements.

Table 6: Chemical composition of water extracts for selected samples.

Parameter		Detection Limit	Sample Number/Lithology-Weathering/Total S in Solids														
			41362	41297	41301	41308	41321	41323	41368	41337	41345	41347	41349	41386	41388	41354	41391
			ST-HW	ST-FR	S2-FR	S2-FR	XT-FR	CM-FR	CM-FR	S2-FR	CM-FR	S2-FR	S1-FR	S2-FR	S2-FR	S1/S2/S3-FR	MS-FR
			0.03%	0.02%	<0.01%	0.01%	0.08%	0.06%	0.21%	0.27%	0.40%	1.83%	2.05%	1.30%	0.17%	0.50%	0.07%
pH		0.01	9.3	8.9	9.4	8.9	9.3	9.0	9.2	3.3	6.7	3.1	3.2	3.2	7.6	3.5	7.2
EC	dS/m	0.01	0.20	0.64	0.37	0.47	0.43	0.64	0.47	0.63	1.02	2.44	1.46	1.09	1.11	0.64	0.17
Alkalinity ($CaCO_3$)	mg/l	1	64	155	185	181	142	277	60		42				25		21
Acidity ($CaCO_3$)	mg/l	1								101		737	468	393		97	
Ag	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Al	mg/l	0.01	0.5	0.5	1.6	2.1	1.7	0.8	0.2	4.6	0.1	54.0	39.4	22.2	0.2	5.1	0.6
As	mg/l	0.001	0.084	0.002	0.054	0.058	0.017	0.018	0.004	0.029	0.003	0.017	0.008	0.011	0.005	0.012	0.002
B	mg/l	0.05	0.10	0.34	0.29	0.43	0.33	0.33	0.16	<0.05	0.05	<0.05	<0.05	<0.05	0.21	<0.05	<0.05
Ba	mg/l	0.001	0.544	0.320	1.060	0.972	0.973	0.844	0.592	0.039	0.025	0.010	0.005	0.008	0.181	0.018	0.006
Be	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	0.032	0.017	0.014	<0.001	0.017	<0.001
Ca	mg/l	1	2	21	4	8	4	13	4	30	41	206	78	58	<1	37	4
Cd	mg/l	0.0001	0.0001	0.0013	<0.0001	0.0001	<0.0001	<0.0001	0.0001	0.001	<0.0001	0.0289	0.0067	0.0063	<0.0001	0.0022	0.0002
Cl	mg/l	1	7	65	44	42	27	28	24	24	21	25	34	22	22	28	33
Co	mg/l	0.001	<0.001	0.149	0.003	0.016	0.005	0.008	<0.001	0.428	0.012	1.490	0.816	1.200	0.001	0.793	0.026
Cr	mg/l	0.001	0.002	<0.001	0.004	0.004	0.004	0.001	<0.001	0.012	<0.001	0.090	0.066	0.052	<0.001	0.013	<0.001
Cu	mg/l	0.001	0.006	0.005	0.006	0.008	0.011	0.012	0.004	0.045	0.004	0.297	0.186	0.124	<0.001	0.074	0.009
F	mg/l	0.1	0.4	1.1	1.0	1.0	0.8	0.9	0.6	0.2	<0.1	0.1	0.3	0.3	0.8	0.4	<0.1
Fe	mg/l	0.05	0.7	9.8	1.8	3.0	1.6	0.6	0.2	20.0	0.3	121.0	63.2	55.2	<0.05	12.5	1.5
Hg	mg/l	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
K	mg/l	1	5	9	5	9	8	12	9	1	25	<1	<1	1	2	2	10
Mg	mg/l	1	<1	18	1	4	2	5	2	18	19	173	79	50	<1	23	3
Mn	mg/l	0.001	0.005	2.290	0.032	0.170	0.023	0.070	0.006	3.660	0.170	6.940	10.800	4.930	0.010	2.290	0.063
Mo	mg/l	0.001	0.106	0.074	0.051	0.054	0.160	0.120	0.069	0.001	0.029	<0.001	<0.001	<0.001	0.015	<0.001	<0.001
Na	mg/l	1	47	96	96	107	104	136	104	17	180	12	2	3	27	22	22
Ni	mg/l	0.001	<0.001	0.297	0.003	0.033	0.008	0.020	0.002	1.190	0.019	2.080	1.570	1.010	0.002	1.440	0.014
P	mg/l	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pb	mg/l	0.001	0.001	<0.001	0.002	0.002	0.004	0.001	<0.001	0.012	<0.001	0.005	0.001	0.002	<0.001	0.010	0.001
Sb	mg/l	0.001	<0.001	0.001	<0.001	0.001	0.003	0.004	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Se	mg/l	0.01	<0.01	0.02	<0.01	0.01	0.04	0.02	0.06	<0.01	0.08	0.02	<0.01	0.01	0.02	<0.01	<0.01
Si	mg/l	0.1	13	2	39	25	56	5	8	1	2	5	3	3	8	2	2
Sn	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
SO4	mg/l	1	34	242	33	104	61	188	148	251	497	1920	917	627	14	274	31
Sr	mg/l	0.001	0.05	0.17	0.06	0.18	0.09	0.31	0.09	0.45	0.61	2.01	0.54	0.54	0.01	0.45	0.05
Th	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.012	0.003	0.001	0.002	0.002	<0.001
U	mg/l	0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.006	<0.001	0.028	0.009	0.007	<0.001	0.006	<0.001
Zn	mg/l	0.005	0.015	0.305	0.055	0.078	0.073	0.100	0.021	1.100	0.014	3.850	2.870	0.900	0.015	1.330	0.024

< element at or below analytical detection limit.

Flow Chart of Sample Preparation Carried Out for SGCP Diamond Hole Core Samples

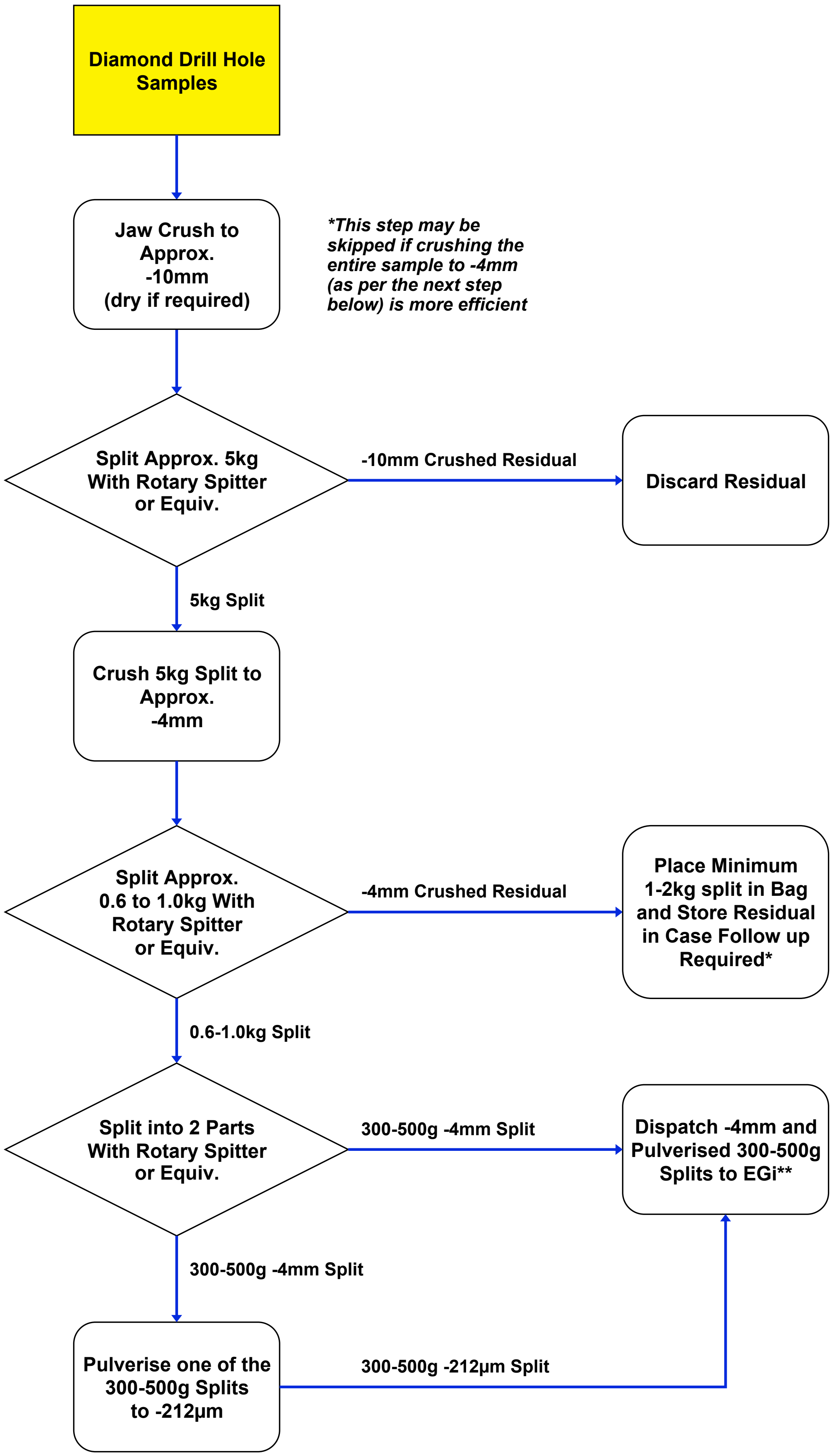

Figure 1: Flow chart of sample preparation carried out for SGCP diamond hole core samples.

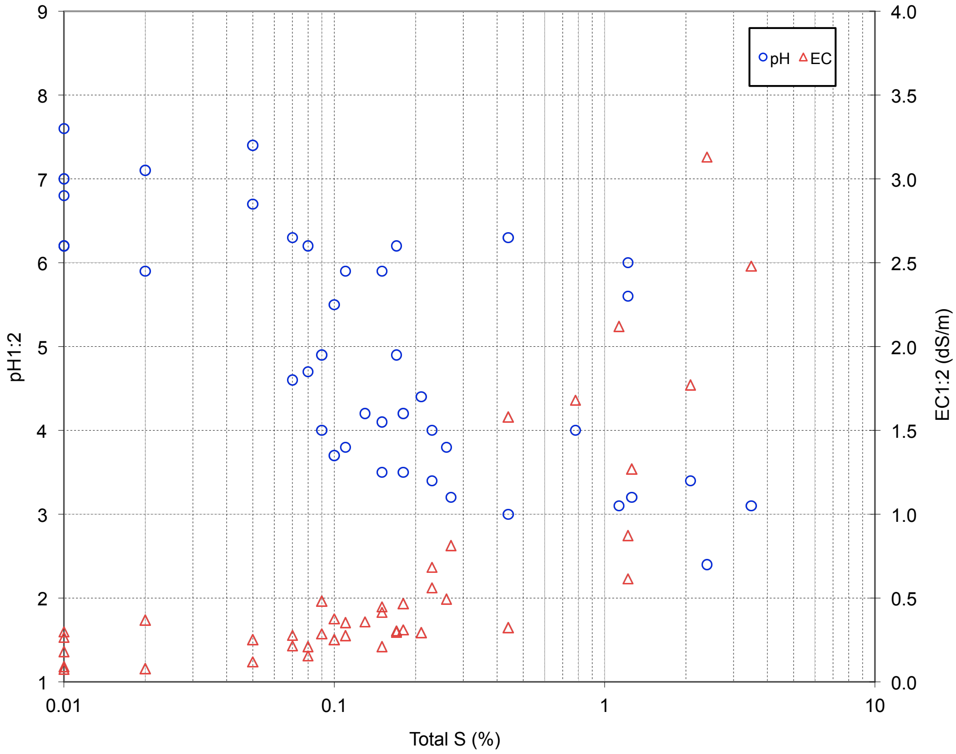

Figure 2: Plot showing pH1:2 and EC1:2 versus total S for Matrixplus samples.

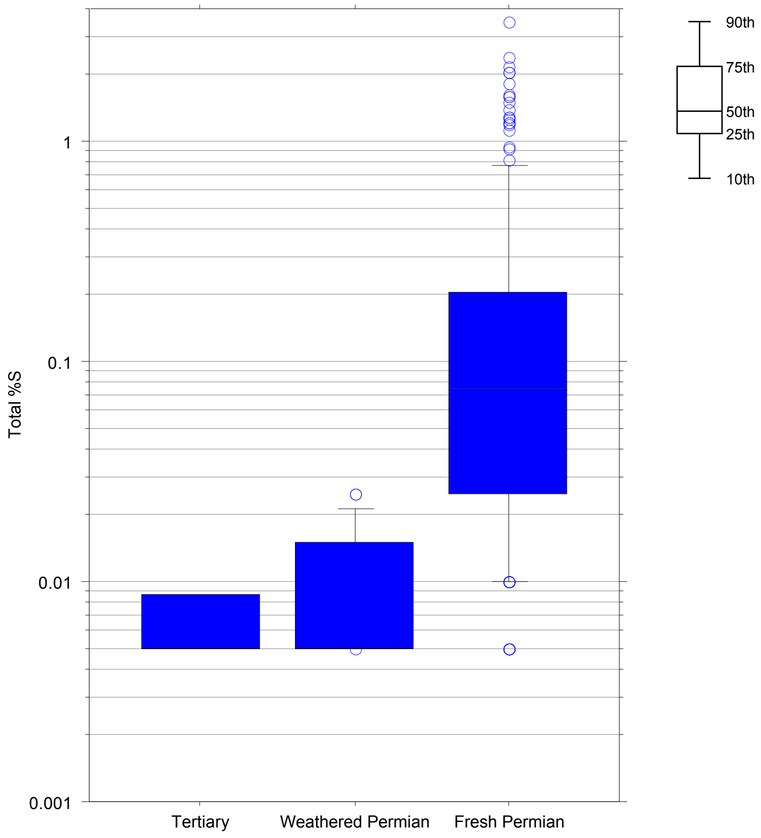

Figure 3: Box plot showing the distribution of S split by stratigraphy. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

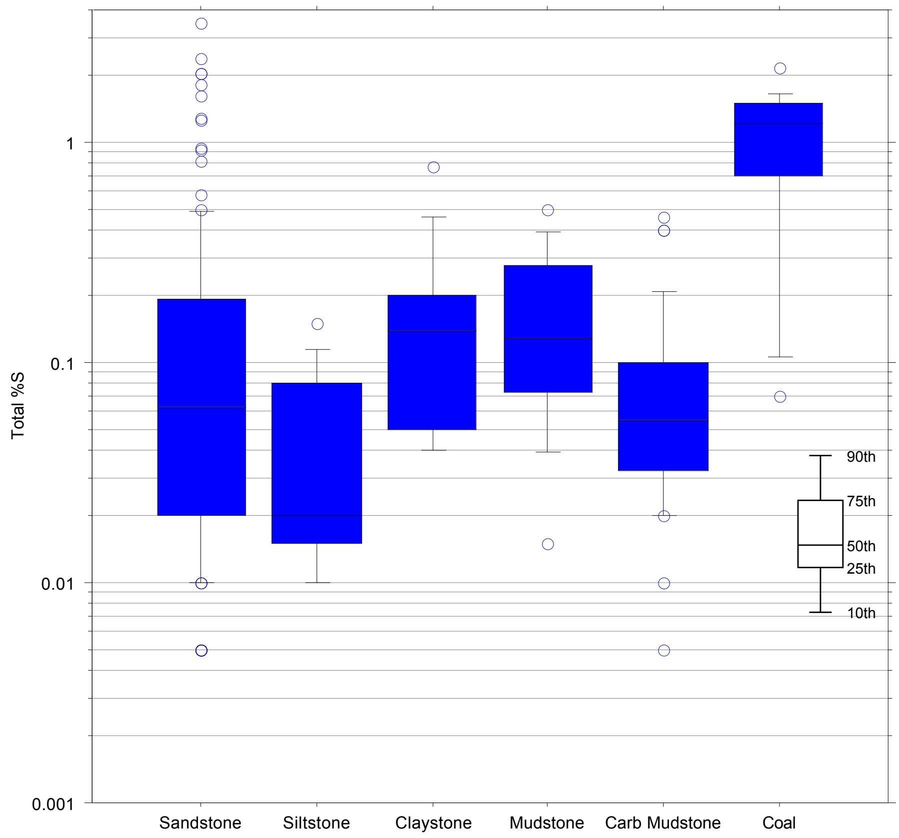

Figure 4: Box plot showing the distribution of S split by lithology for fresh Permian samples only. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

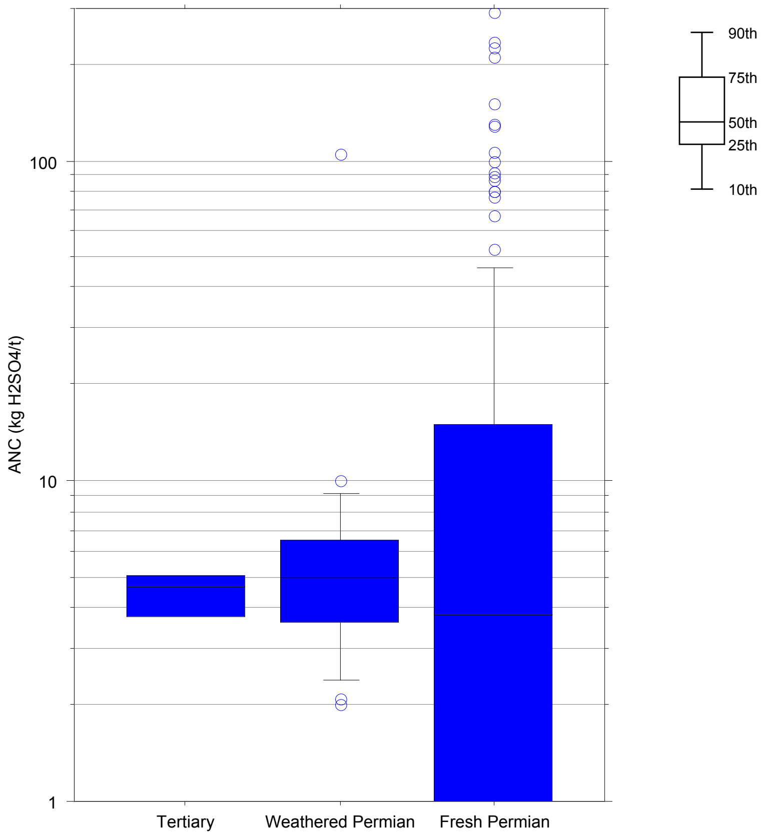

Figure 5: Box plot showing the distribution of ANC split by stratigraphy. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

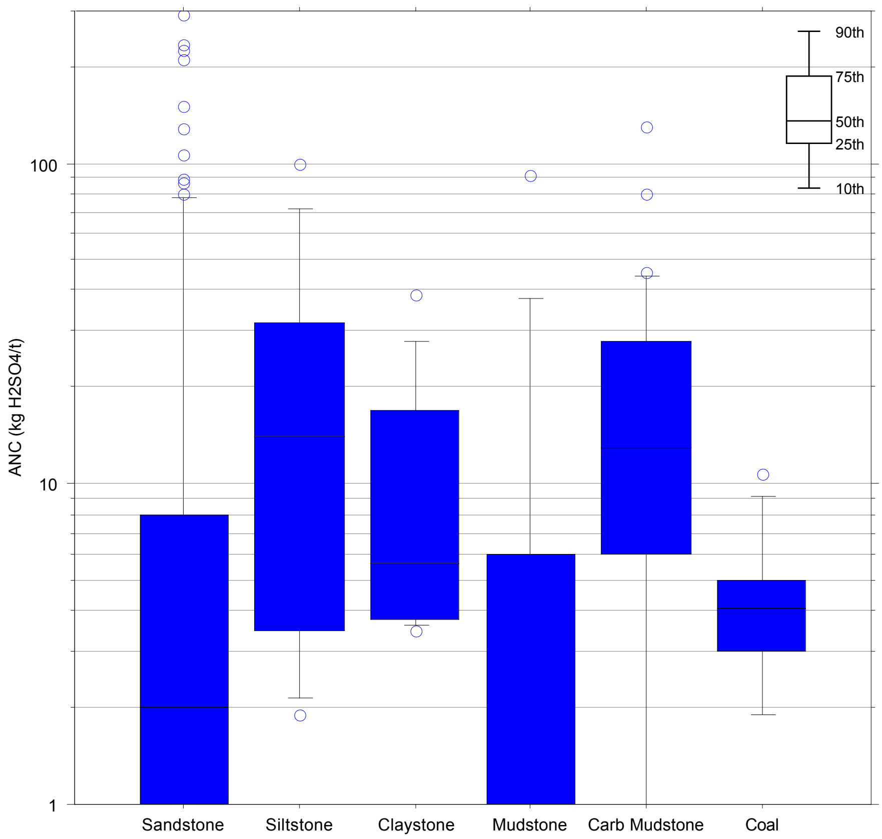

Figure 6: Box plot showing the distribution of ANC split by lithology for fresh Permian samples only. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

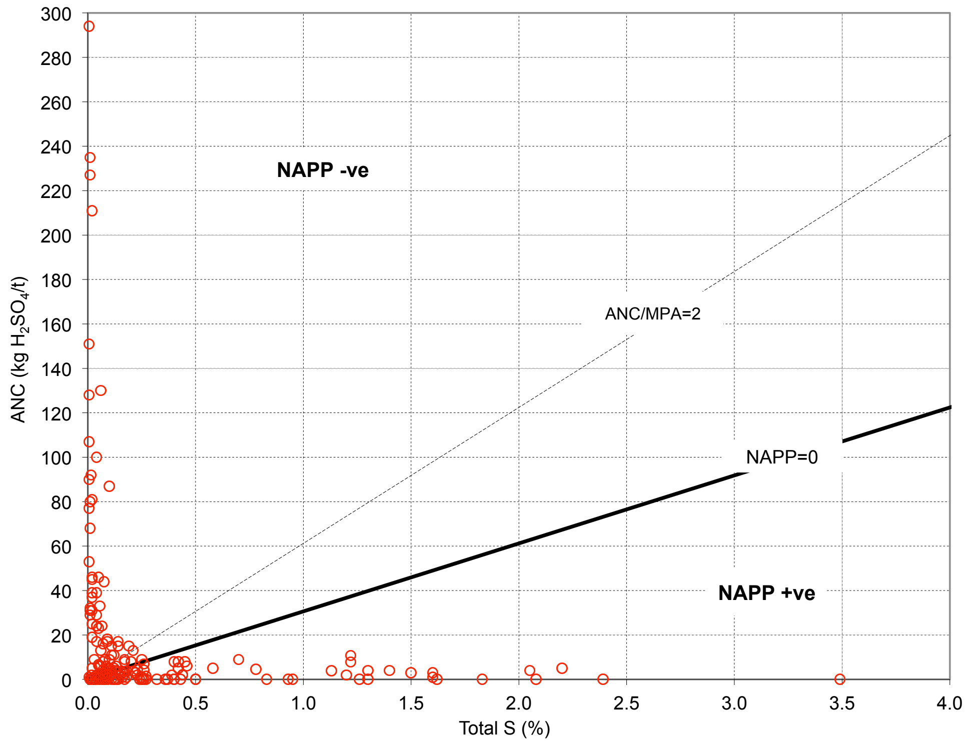

Figure 7: Acid-base account (ABA) plot showing ANC versus total S for fresh Permian samples.

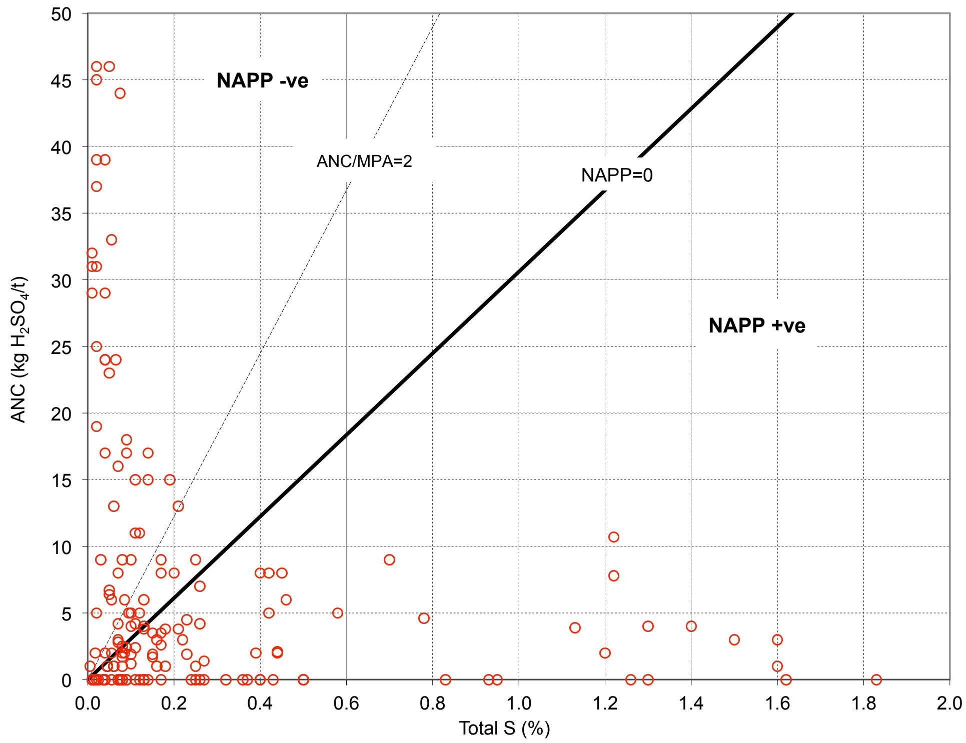

Figure 8: As for Figure 7 with expanded axes.

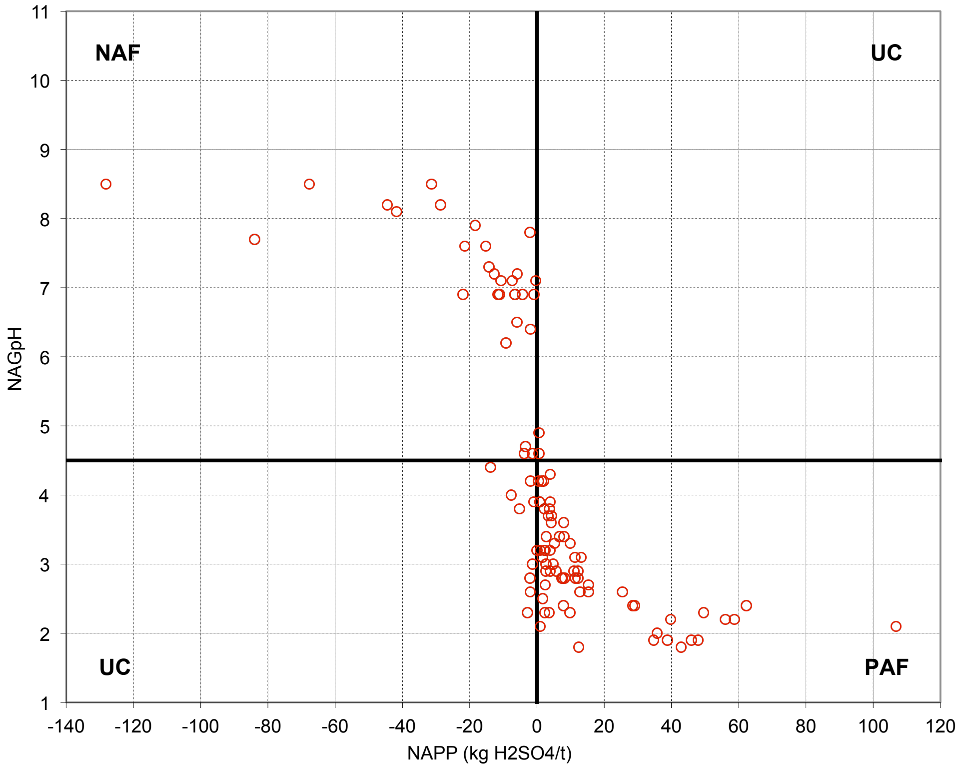

Figure 9: ARD classification plot showing NAGpH versus NAPP for fresh Permian samples, with ARD classification domains indicated.

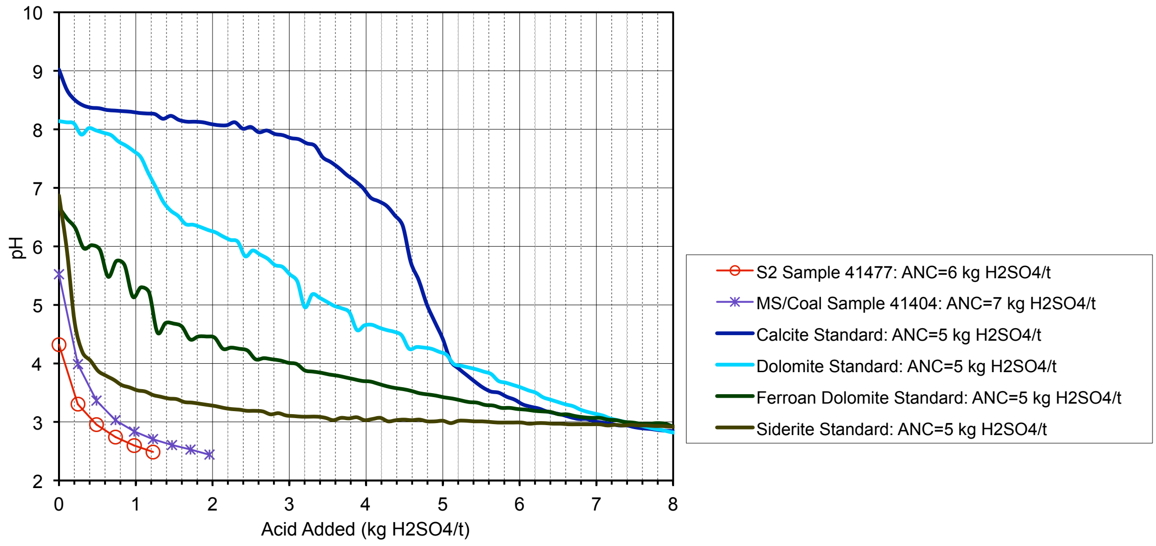

Figure 10: ABCC profile for samples with an ANC value close to 5 kg H_2SO_4/t. Carbonate standard curves are included for reference.

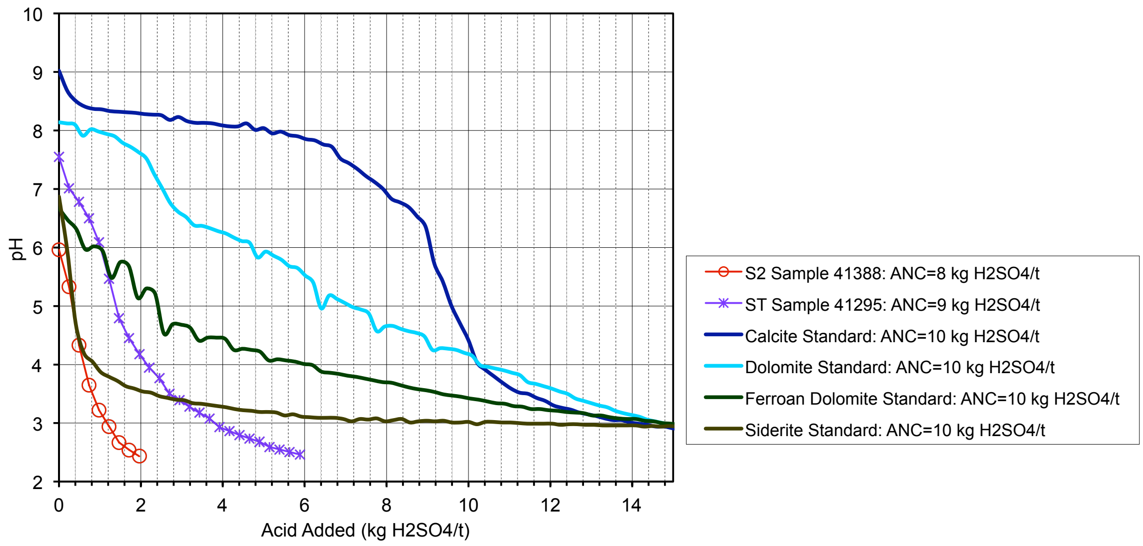

Figure 11: ABCC profile for samples with an ANC value close to 10 kg H_2SO_4/t. Carbonate standard curves are included for reference.

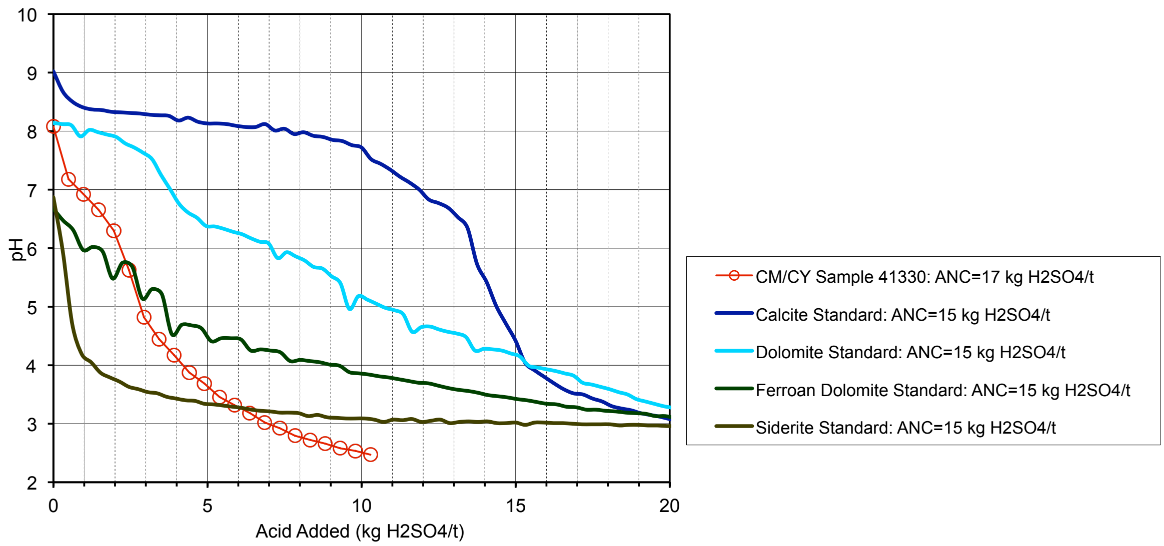

Figure 12: ABCC profile for sample 41330 with an ANC value close to 15 kg H_2SO_4/t. Carbonate standard curves are included for reference.

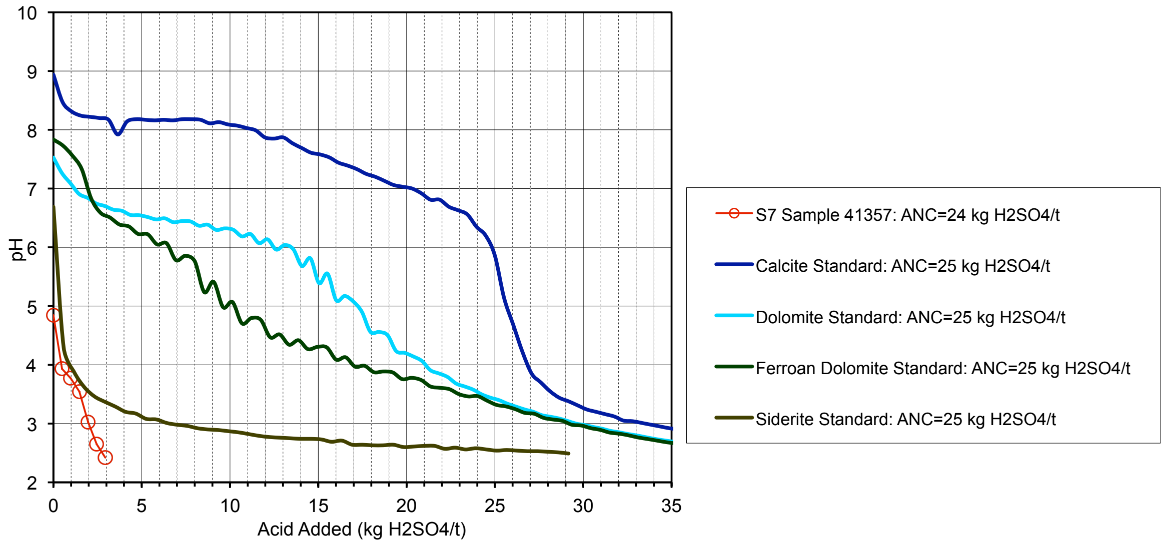

Figure 13: ABCC profile for sample 41357 with an ANC value close to 25 kg H_2SO_4/t. Carbonate standard curves are included for reference.

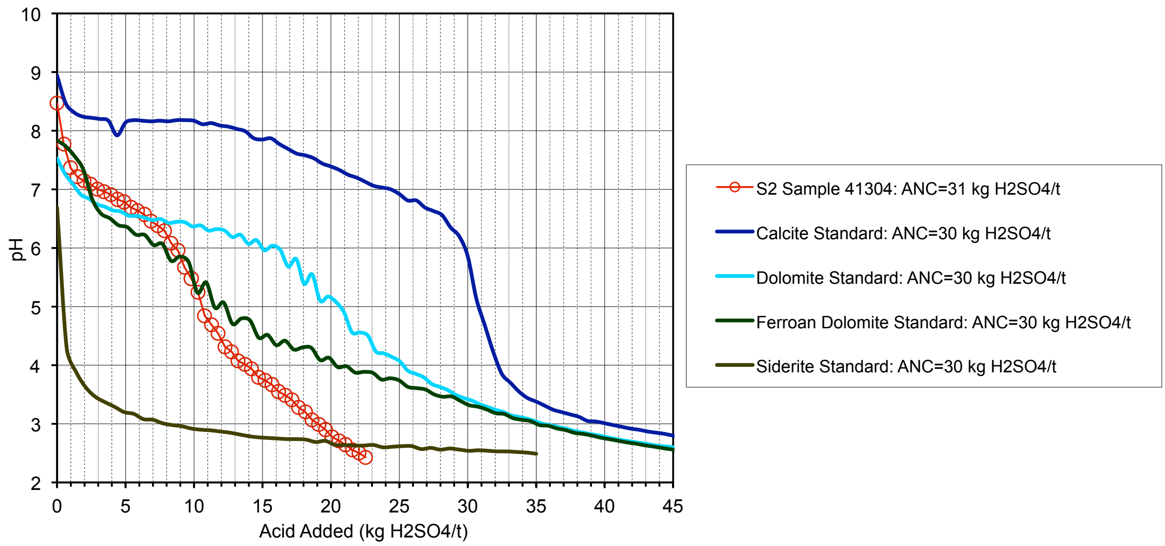

Figure 14: ABCC profile for sample 41304 with an ANC value close to 30 kg H_2SO_4/t. Carbonate standard curves are included for reference.

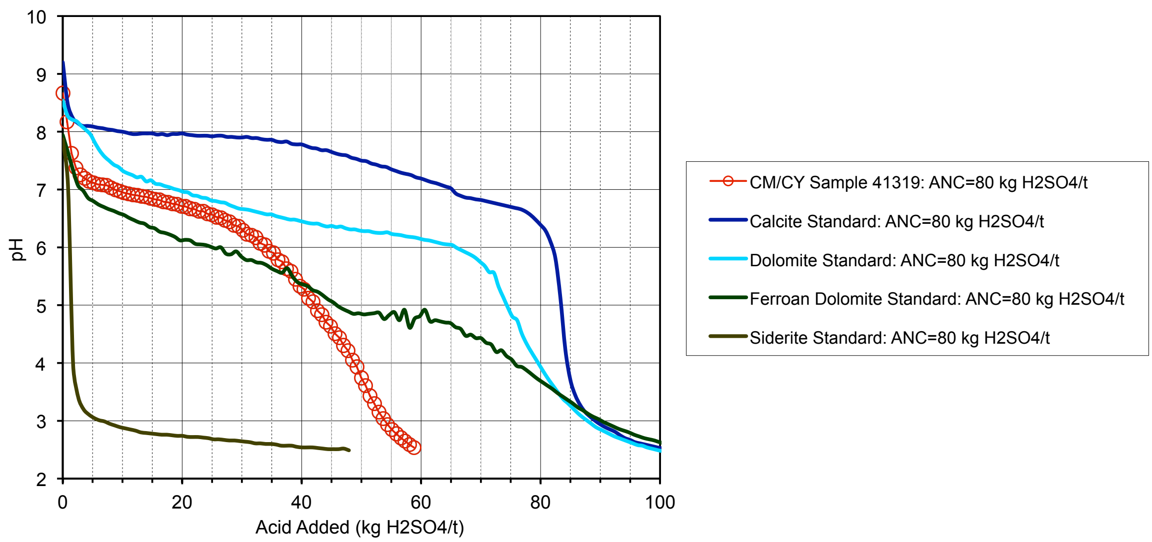

Figure 15: ABCC profile for sample 41319 with an ANC value of 80 kg H_2SO_4/t. Carbonate standard curves are included for reference.

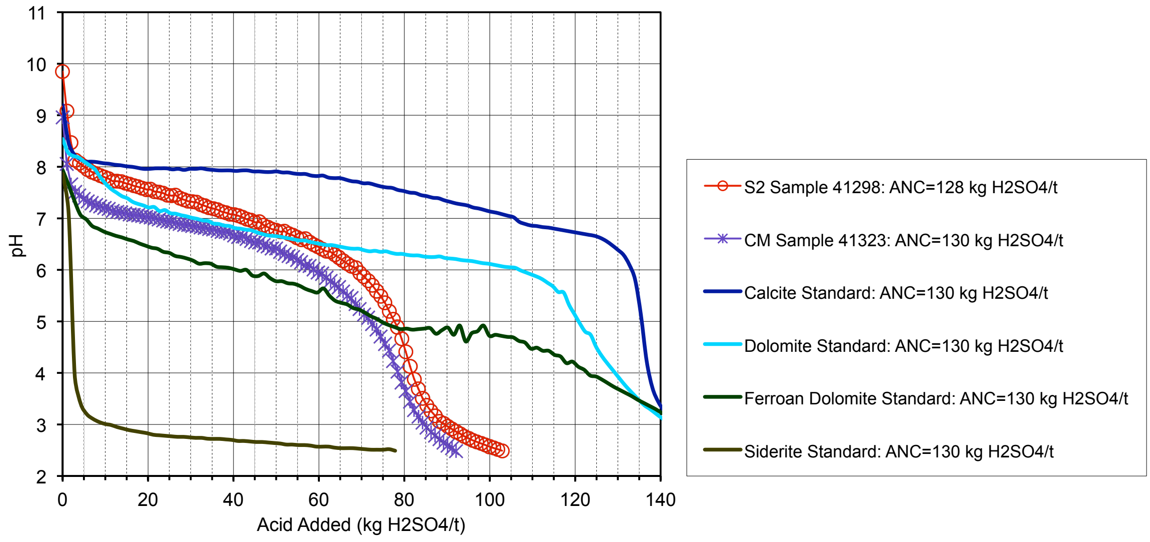

Figure 16: ABCC profile for samples with an ANC value close to 130 kg H_2SO_4/t. Carbonate standard curves are included for reference.

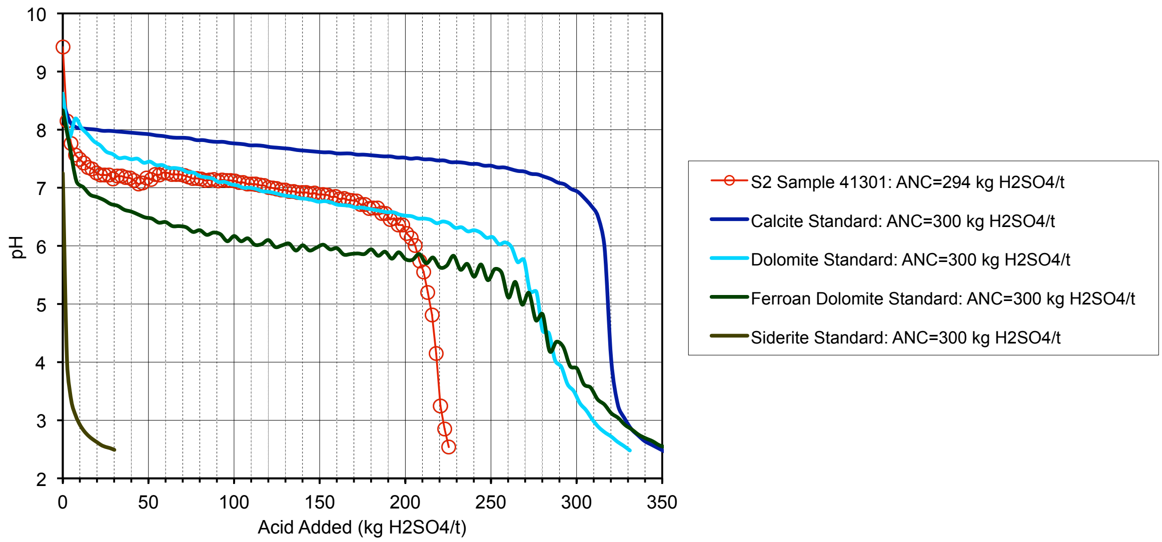

Figure 17: ABCC profile for sample 41301 with an ANC value close to 300 kg H_2SO_4/t. Carbonate standard curves are included for reference.

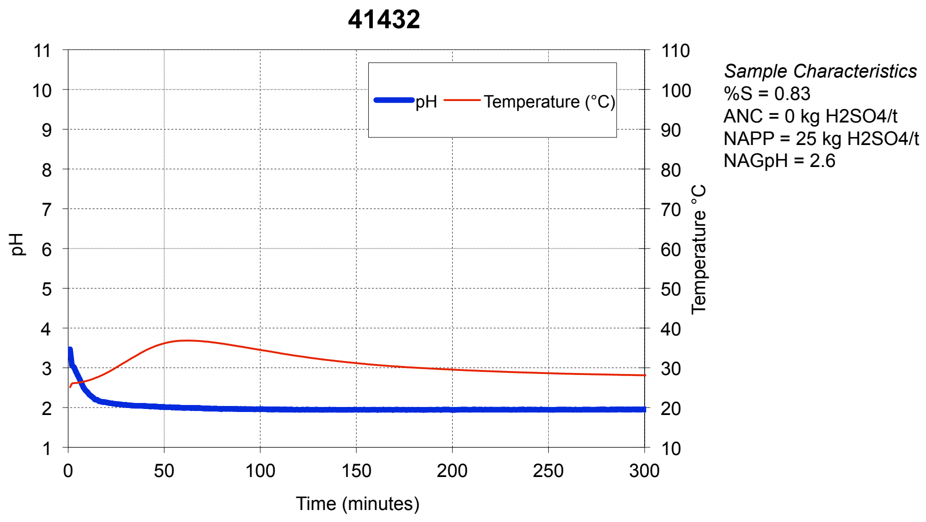

Figure 18: Kinetic NAG graph for sample 41432.

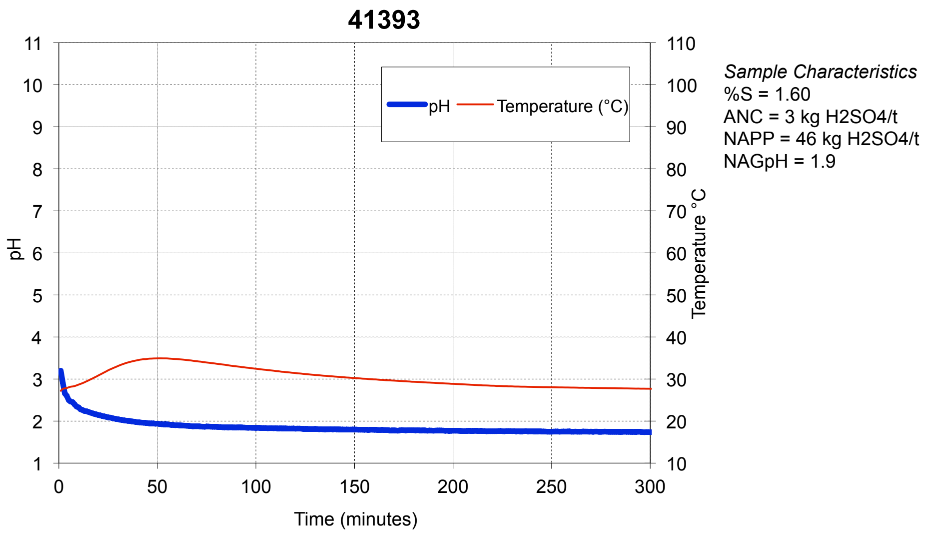

Figure 19: Kinetic NAG graph for sample 41393.

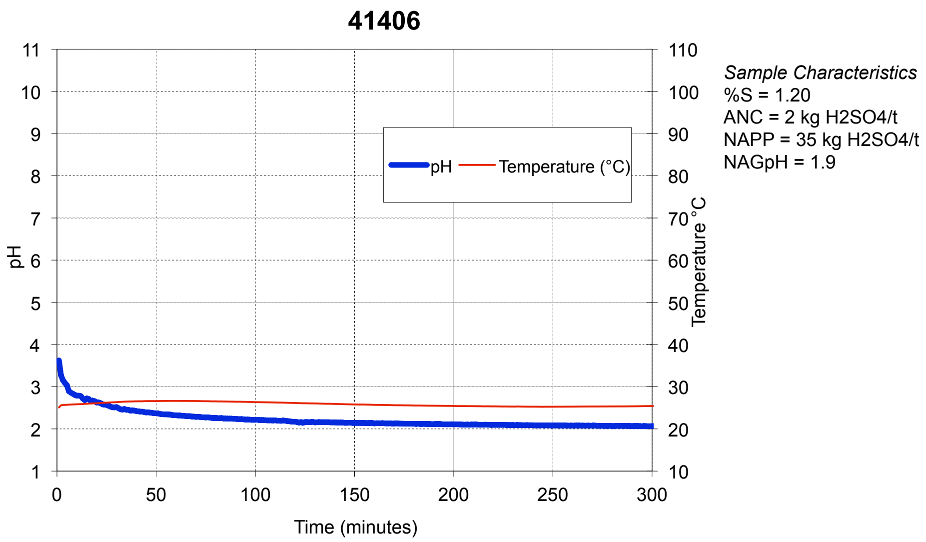

Figure 20: Kinetic NAG graph for sample 41406.

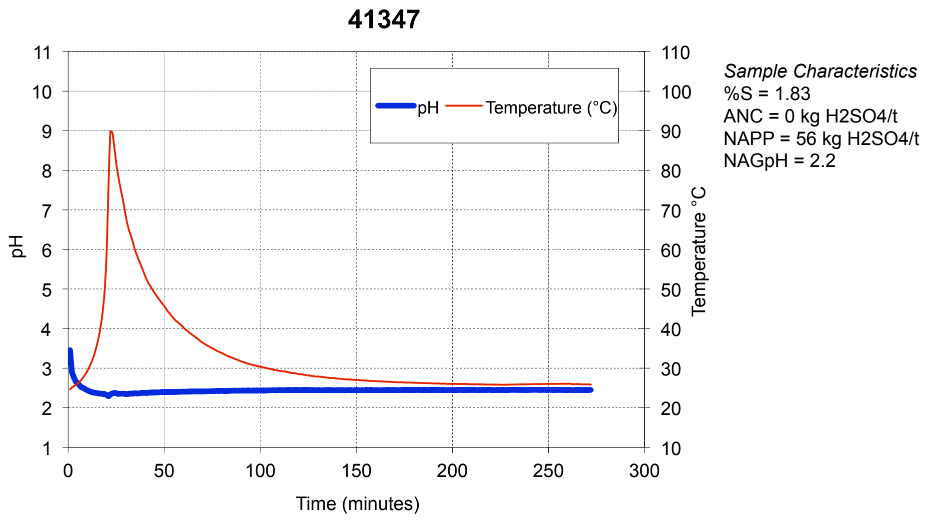

Figure 21: Kinetic NAG graph for sample 41347.

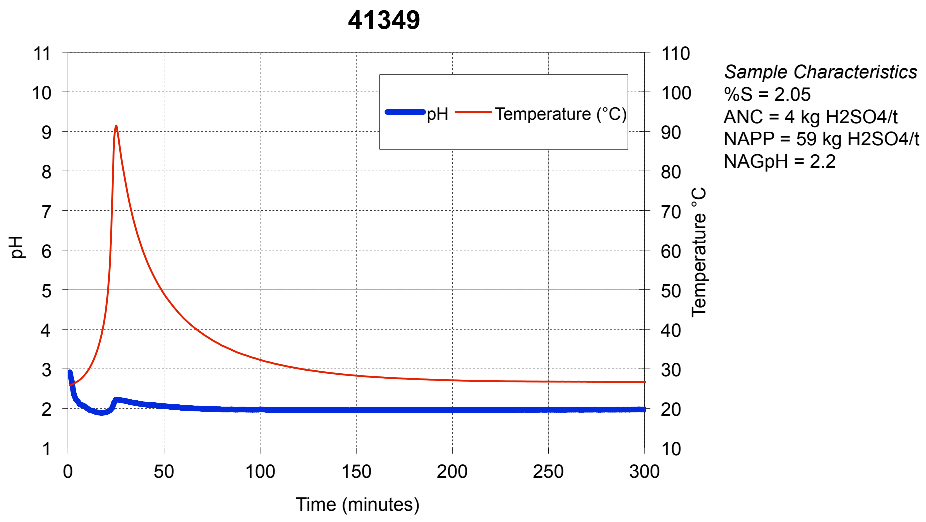

Figure 22: Kinetic NAG graph for sample 41349.

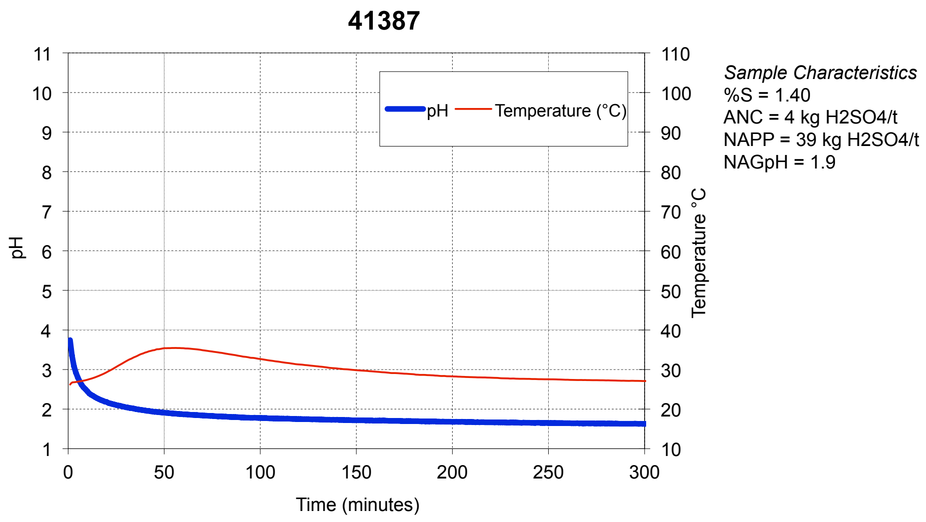

Figure 23: Kinetic NAG graph for sample 41387.

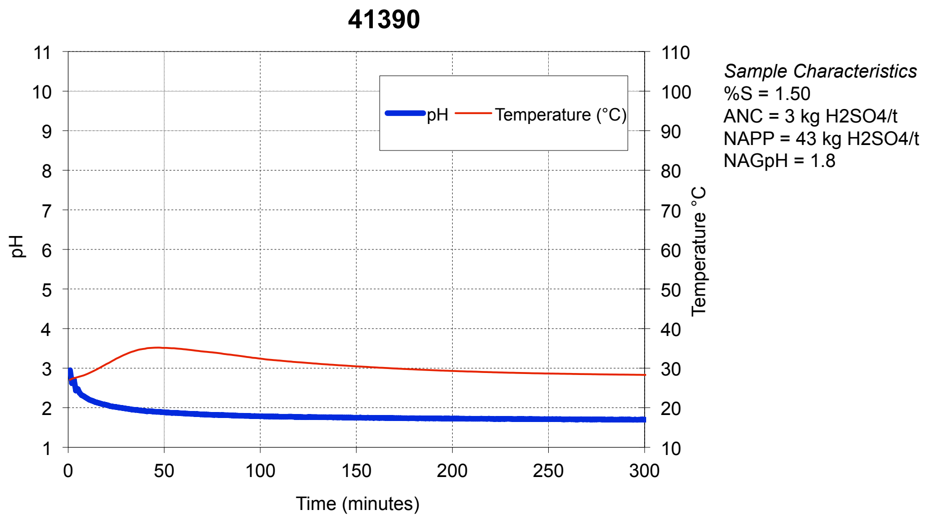

Figure 24: Kinetic NAG graph for sample 41390.

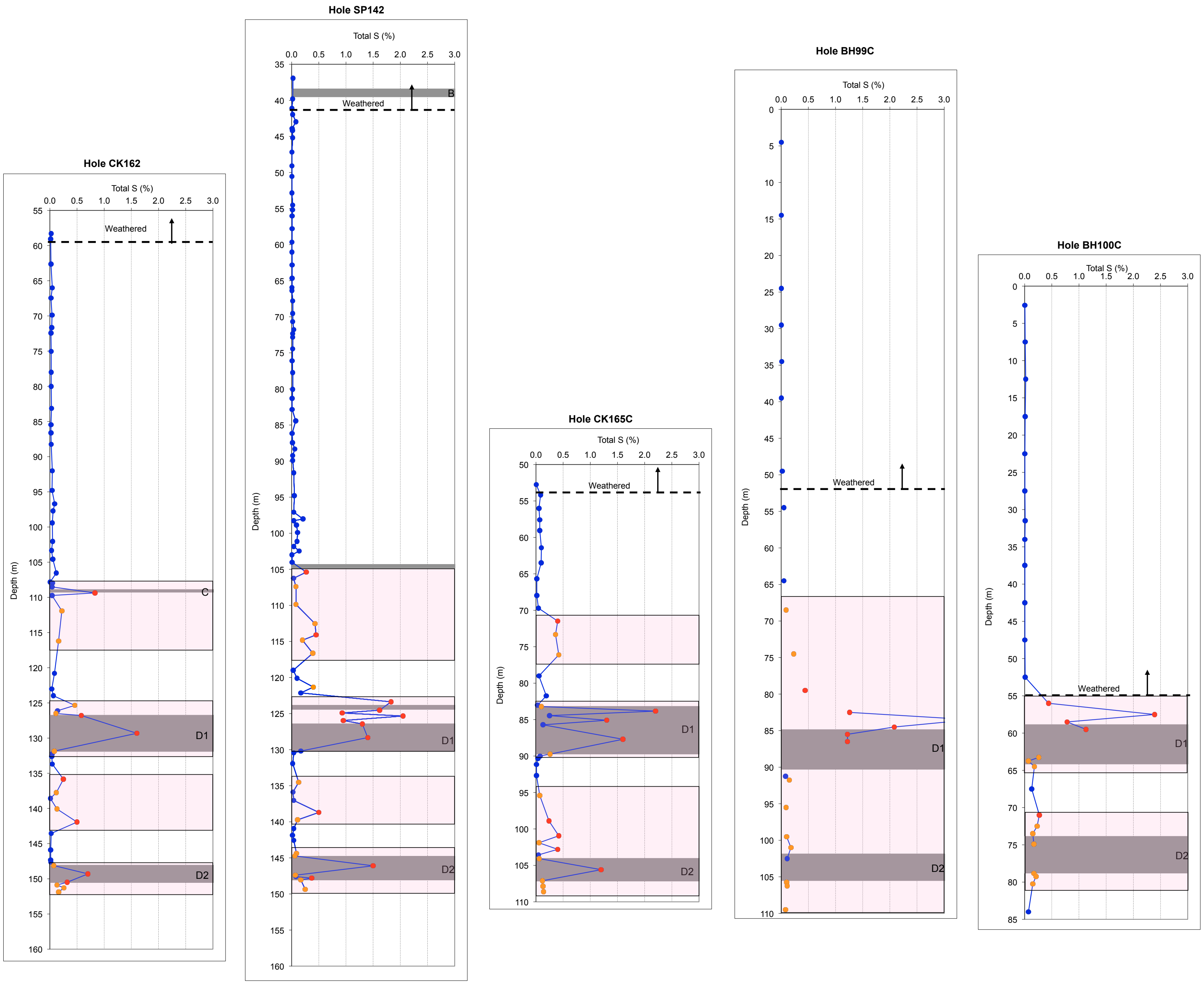

Figure 25: Plot of total S profiles for EGi tested holes (CK162, CK165C and SP142) and Matrixplus tested holes (BH99 and BH100). PAF samples are shown as red symbols, PAF-LC samples are shown as orange symbols and approximate zones of PAF and PAF-LC are shown as pink shading. Coal seam intervals and base of weathering are also shown in grey for reference.

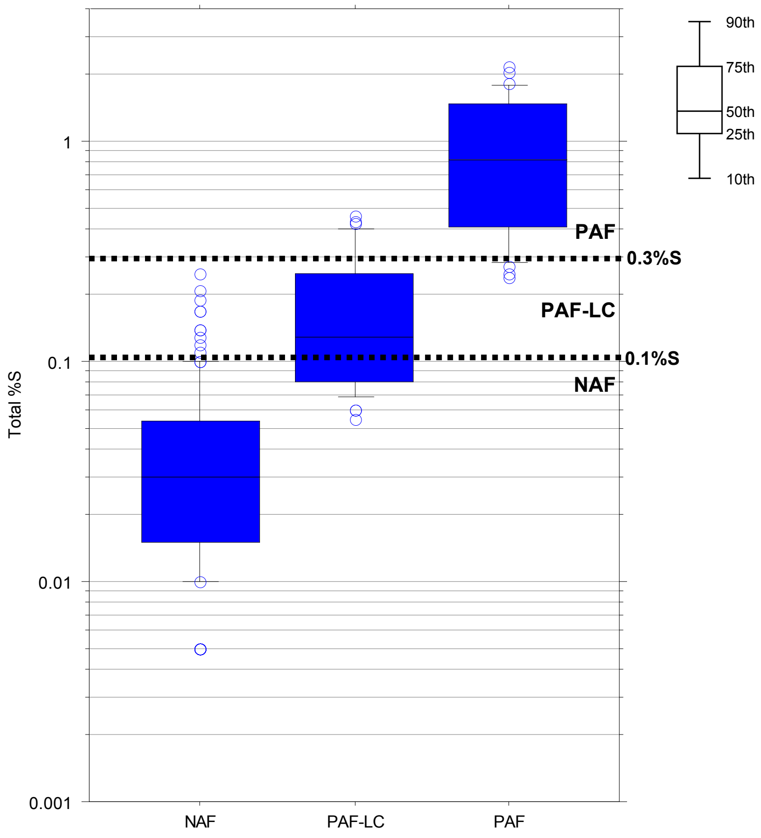

Figure 26: Box plot showing the distribution of S for fresh Permian samples tested by EGi split by ARD classification. Box plots have 10th, 25th, 50th (median), 75th and 90th percentiles marked.

APPENDIX A

Assessment of Acid Forming Characteristics

Assessment of Acid Forming Characteristics

Introduction

Acid rock drainage (ARD) is produced by the exposure of sulphide minerals such as pyrite to atmospheric oxygen and water. The ability to identify in advance any mine materials that could potentially produce ARD is essential for timely implementation of mine waste management strategies.

A number of procedures have been developed to assess the acid forming characteristics of mine waste materials. The most widely used methods are the Acid-Base Account (ABA) and the Net Acid Generation (NAG) test. These methods are referred to as static procedures because each involves a single measurement in time.

Acid-Base Account

The acid-base account involves static laboratory procedures that evaluate the balance between acid generation processes (oxidation of sulphide minerals) and acid neutralising processes (dissolution of alkaline carbonates, displacement of exchangeable bases, and weathering of silicates).

The values arising from the acid-base account are referred to as the potential acidity and the acid neutralising capacity, respectively. The difference between the potential acidity and the acid neutralising capacity value is referred to as the net acid producing potential (NAPP).

The chemical and theoretical basis of the ABA are discussed below.

Potential Acidity

The potential acidity that can be generated by a sample is calculated from an estimate of the pyrite (FeS_2) content and assumes that the pyrite reacts under oxidising conditions to generate acid according to the following reaction:

$$FeS_2 + 15/4\ O_2 + 7/2\ H_2O \Rightarrow Fe(OH)_3 + 2\ H_2SO_4$$

Based on the above reaction, the potential acidity of a sample containing 1 %S as pyrite would be 30.6 kilograms of H_2SO_4 per tonne of material (i.e. kg H_2SO_4/t). The pyrite content estimate can be based on total S and the potential acidity determined from total S is referred to as the maximum potential acidity (MPA), and is calculated as follows:

$$\text{MPA (kg } H_2SO_4\text{/t)} = (\text{Total \%S}) \times 30.6$$

The use of an MPA calculated from total sulphur is a conservative approach because some sulphur may occur in forms other than pyrite. Sulphate-sulphur, organic sulphur and native sulphur, for example, are non-acid generating sulphur forms. Also, some sulphur may occur as other metal sulphides (e.g. covellite, chalcocite, sphalerite, galena) which yield less acidity than pyrite when oxidised or, in some cases, may be non-acid generating. The total sulphur content is commonly used to assess potential acidity because of the difficulty, costs and uncertainty involved in routinely determining the speciation of sulphur forms within samples, and determining reactive sulphide-sulphur contents. However, if the sulphide mineral forms are known then allowance can be made for non- and lesser acid generating forms to provide a better estimate of the potential acidity.

Acid Neutralising Capacity (ANC)

The acid formed from pyrite oxidation will to some extent react with acid neutralising minerals contained within the sample. This inherent acid buffering is quantified in terms of the ANC.

The ANC is commonly determined by the Modified Sobek method. This method involves the addition of a known amount of standardised hydrochloric acid (HCl) to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated and expressed in the same units as the MPA (kg H_2SO_4/t).

Net Acid Producing Potential (NAPP)

The NAPP is a theoretical calculation commonly used to indicate if a material has potential to produce acidic drainage. It represents the balance between the capacity of a sample to generate acid (MPA) and its capacity to neutralise acid (ANC). The NAPP is also expressed in units of kg H_2SO_4/t and is calculated as follows:

$$\text{NAPP} = \text{MPA} - \text{ANC}$$

If the MPA is less than the ANC then the NAPP is negative, which indicates that the sample may have sufficient ANC to prevent acid generation. Conversely, if the MPA exceeds the ANC then the NAPP is positive, which indicates that the material may be acid generating.

ANC/MPA Ratio

The ANC/MPA ratio is frequently used as a means of assessing the risk of acid generation from mine waste materials. The ANC/MPA ratio is another way of looking at the acid base account. A positive NAPP is equivalent to an ANC/MPA ratio less than 1, and a negative NAPP is equivalent to an ANC/MPA ratio greater than 1. A NAPP of zero is equivalent to an ANC/MPA ratio of 1.

The purpose of the ANC/MPA ratio is to provide an indication of the relative margin of safety (or lack thereof) within a material. Various ANC/MPA values are reported in the literature for indicating safe values for prevention of acid generation. These values typically range from 1 to 3. As a general rule, an ANC/MPA ratio of 2 or more signifies that there is a high probability that the material will remain circum-neutral in pH and thereby should not be problematic with respect to acid rock drainage.

Acid-Base Account Plot

Sulphur and ANC data are often presented graphically in a format similar to that shown in Figure A-1. This figure includes a line indicating the division between NAPP positive samples from NAPP negative samples. Also shown are lines corresponding to ANC/MPA ratios of 2 and 3.

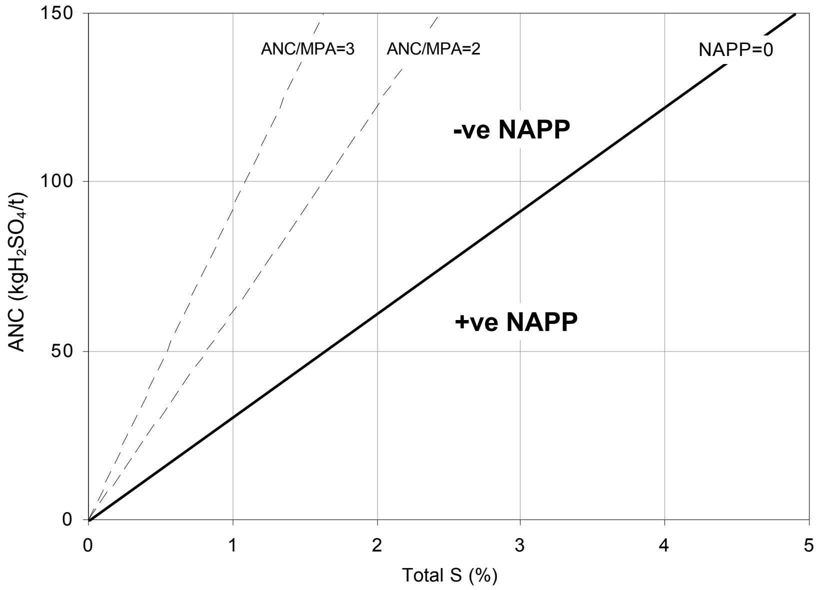

Figure A-1: Acid-base account (ABA) plot

Net Acid Generation (NAG) Test

The NAG test is used in association with the NAPP to classify the acid generating potential of a sample. The NAG test involves reaction of a sample with hydrogen peroxide to rapidly oxidise any sulphide minerals contained within a sample. During the NAG test both acid generation and acid neutralisation reactions can occur simultaneously. The end result represents a direct measurement of the net amount of acid generated by the sample. The final pH is referred to as the NAGpH and the amount of acid produced is commonly referred to as the NAG capacity, and is expressed in the same units as the NAPP (kg H_2SO_4/t).

Several variations of the NAG test have been developed to accommodate the wide geochemical variability of mine waste materials. The four main NAG test procedures currently used by EGi are the single addition NAG test, the sequential NAG test, the kinetic NAG test, and the extended boil and calculated NAG test.

Single Addition NAG Test

The single addition NAG test involves the addition of 250 ml of 15% hydrogen peroxide to 2.5 g of sample. The peroxide is allowed to react with the sample overnight and the following day the sample is gently heated to accelerate the oxidation of any remaining sulphides, then vigorously boiled for several minutes to decompose residual peroxide. When cool, the NAGpH and NAG capacity are measured.

An indication of the form of the acidity is provided by initially titrating the NAG liquor to pH 4.5, then continuing the titration up to pH 7. The titration value at pH 4.5 includes acidity due to free acid (i.e. H_2SO_4) as well as soluble iron and aluminium. The titration value at pH 7 also includes metallic ions that precipitate as hydroxides at between pH 4.5 and 7.

Sequential NAG Test

When testing samples with high sulphide contents it is not uncommon for oxidation to be incomplete in the single addition NAG test. This can sometimes occur when there is catalytic breakdown of the hydrogen peroxide before it has had a chance to oxidise all of the sulphides in a sample. To overcome this limitation, a sequential NAG test is often carried out. This test may also be used to assess the relative geochemical lag of PAF samples with high ANC.

The sequential NAG test is a multi-stage procedure involving a series of single addition NAG tests on the one sample (i.e. 2.5 g of sample is reacted two or more times with 250 ml aliquots of 15% hydrogen peroxide). At the end of each stage, the sample is filtered and the solution is used for measurement of NAGpH and NAG capacity. The NAG test is then repeated on the solid residue. The cycle is repeated until such time that there is no further catalytic decomposition of the peroxide, or when the NAGpH is greater than pH 4.5. The overall NAG capacity of the sample is then determined by summing the individual acid capacities from each stage.

Kinetic NAG Test

The kinetic NAG test is the same as the single addition NAG test except that the temperature and pH of the liquor are recorded. Variations in these parameters during the test provide an indication of the kinetics of sulphide oxidation and acid generation. This, in turn, can provide an insight into the behaviour of the material under field conditions. For example, the pH trend gives an estimate of relative reactivity and may be related to prediction of lag times and oxidation rates similar to those measured in leach columns. Also, sulphidic samples commonly produce a temperature excursion during the NAG test due to the decomposition of the peroxide solution, catalysed by sulphide surfaces and/or oxidation products.

Extended Boil and Calculated NAG Test

Organic acids may be generated in NAG tests due to partial oxidation of carbonaceous materials[1] such as coal washery wastes. This can lead to low NAGpH values and high acidities in standard single addition NAG tests unrelated to acid generation from sulphides. Organic acid effects can therefore result in misleading NAG values and misclassification of the acid forming potential of a sample.

The extended boil and calculated NAG tests can be used to account for the relative proportions of pyrite derived acidity and organic acidity in a given NAG solution, thus providing a more reliable measure of the acid forming potential of a sample. The procedure involves two steps to differentiating pyritic acid from organic derived acid:

Extended Boil NAG	decompose the organic acids and hence remove the influence of non-pyritic acidity on the NAG solution.
Calculated NAG	calculate the net acid potential based on the balance of cations and anions in the NAG solution, which will not be affected by organic acid.

The extended boiling test is carried out on the filtered liquor of a standard NAG test, and involves vigorous boiling of the solution on a hot plate for 3-4 hours. After the boiling step the solution is cooled and the pH measured. An extended boil NAGpH less than 4.5 confirms the sample is potentially acid forming (PAF), but a pH value greater than 4.5 does not necessarily mean that the sample is non acid forming (NAF), due to some loss of free acid during the extended boiling procedure. To address this issue, a split of the same filtered NAG solution is assayed for concentrations of S, Ca, Mg, Na, K and Cl, from which a calculated NAG value is determined[2].

The concentration of dissolved S is used to calculate the amount of acid (as H_2SO_4) generated by the sample and the concentrations of Ca, Mg, Na and K are used to estimate the amount of acid neutralised (as H_2SO_4). The concentration of Cl is used to correct for soluble cations associated with Cl salts, which may be present in the sample and unrelated to acid generating and acid neutralising reactions.

The calculated NAG value is the amount of acid neutralised subtracted from the amount of acid generated. A positive value indicates that the sample has excess acid generation and is likely to be PAF, and a zero or negative value indicates that the sample has excess neutralising capacity and is likely to be NAF.

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[1] Stewart, W., Miller, S., Thomas, J.E., and Smart R. (2003), 'Evaluation of the Effects of Organic Matter on the Net Acid Generation (NAG) Test', in *Proceedings of the Sixth International Conference on Acid Rock drainage (ICARD), Cairns, 12-18th July 2003*, 211-222.

[2] Environmental Geochemistry International, Levay and Co. and ACeSSS, 2008. *ACARP Project C15034: Development of ARD Assessment for Coal Process Wastes*, EGi Document No. 3207/817, July 2008.

Sample Classification

The acid forming potential of a sample is classified on the basis of the acid-base and NAG test results into one of the following categories:

- Barren;
- Non-acid forming (NAF);
- Potentially acid forming (PAF); and
- Uncertain (UC).

Barren

A sample classified as barren essentially has no acid generating capacity and no acid buffering capacity. This category is most likely to apply to highly weathered materials. In essence, it represents an 'inert' material with respect to acid generation. The criteria used to classify a sample as barren may vary between sites, but for hard rock mines it generally applies to materials with a total sulphur content ≤ 0.1 %S and an ANC ≤ 5 kg H_2SO_4/t.

Non-acid forming (NAF)

A sample classified as NAF may, or may not, have a significant sulphur content but the availability of ANC within the sample is more than adequate to neutralise all the acid that theoretically could be produced by any contained sulphide minerals. As such, material classified as NAF is considered unlikely to be a source of acidic drainage. A sample is usually defined as NAF when it has a negative NAPP and the final NAG pH ≥ 4.5.

Potentially acid forming (PAF)

A sample classified as PAF always has a significant sulphur content, the acid generating potential of which exceeds the inherent acid neutralising capacity of the material. This means there is a high risk that such a material, even if pH circum-neutral when freshly mined or processed, could oxidise and generate acidic drainage if exposed to atmospheric conditions. A sample is usually defined as PAF when it has a positive NAPP and a final NAGpH < 4.5.

Uncertain (UC)

An uncertain classification is used when there is an apparent conflict between the NAPP and NAG results (i.e. when the NAPP is positive and NAGpH > 4.5, or when the NAPP is negative and NAGpH ≤ 4.5). Uncertain samples are generally given a tentative classification that is shown in brackets e.g. UC(NAF).

Figure A-2 shows the format of the classification plot that is typically used for presentation of NAPP and NAG data. Marked on this plot are the quadrats representing the NAF, PAF and UC classifications.

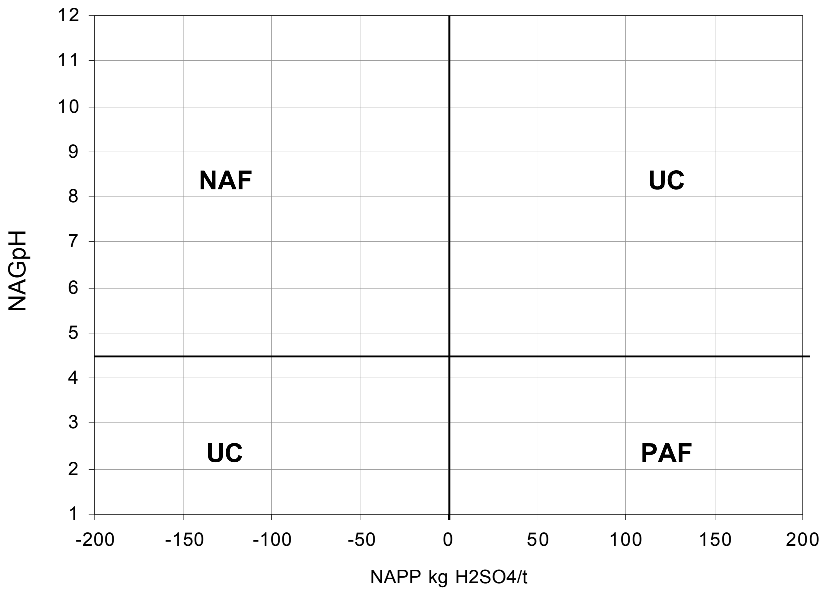

Figure A-2 ARD classification plot

Other Methods

Other test procedures may be used to define the acid forming characteristics of a sample.

pH and Electrical Conductivity

The pH and electrical conductivity (EC) of a sample is determined by equilibrating the sample in deionised water for a minimum of 12 hours (or overnight), typically at a solid to water ratio of 1:2 (w/w). This gives an indication of the inherent acidity and salinity of the waste material when initially exposed in a waste emplacement area.

Acid Buffering Characteristic Curve (ABCC) Test

The ABCC test involves slow titration of a sample with acid while continuously monitoring pH. These data provides an indication of the portion of ANC within a sample that is readily available for acid neutralisation.