REPORT NO. 432

Validation and Standardisation of Sequential Leaching Tests to Better Predict the Impact of Mining on Ground and Surface Water Quality

Results of research carried out as MRIWA Project M432

At ChemCentre

By

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EXECUTIVE SUMMARY

ChemCentre initiated a series of discussions with industry and WA regulatory authorities, in particular the Department of Water and Environmental Regulation (DWER, formerly: Department of Environment Regulation (DER), Office of Environmental Protection Authority (OEPA) and Department of Water (DoW)) and the Department of Mines, Industry Regulation and Safety (DMIRS) to identify knowledge gaps pertinent to the impact of mining, including iron ore mining, on ground and surface water quality. From these discussions and related activities, the consensus view emerged that the current chemical and mineralogical methodologies used to characterise mine wastes and to predict the long-term impact of mining on ground and surface water quality were either “unfit for purpose “or, in the case of long term kinetic leaching studies, take too long to complete and would unduly delay the Environmental Impact Assessment (EIA) process if the completion of such studies were mandatory.

Kinetic leaching studies are primarily used to predict the onset of Acid and Metalliferous Drainage (AMD), but more recently they have been used to predict the impact on ground and surface water quality. Whilst it has previously been suggested that these studies may only take twenty-six weeks, it is now recognised that for many rock types these studies should be conducted over a two-year period.

Accelerated sequential leaching methodologies, which typically involve the leaching of samples with a sequence of increasingly aggressive solvents, have been used to(i) elucidate the chemical speciation of elements in soils and rocks, (ii) characterise municipal wastes, soil, sediments and mineral processing wastes and (iii) more recently characterise waste rocks associated with the mining of base metals. The sequential leaching approach can be used as a screening tool to predict the likely order of species mobilisation and extent of extraction of metal ions and metalloids (metal oxyanions), with an understanding that the order may vary under conditions of very high salinity, acidity and redox (oxidising and reducing) potential and hence more objectively inform the potential impact on ground and surface water quality.

The key advantage of sequential leaching methodologies is that they are rapid, taking only weeks to complete, compared with longer term kinetic studies which can last for several years, and can be used to identify both the likely order of metal extraction through time and the potential metal /rock type associations that may impact on ground and surface water quality under different environmental conditions. The early identification of these metal/rock type risk factors can be used to support the EIA process and inform subsequent longer-term kinetic leaching studies to (i) validate predictions, (ii) better understand potential risks and (iii) better inform mining operation risk management strategies, including mine waste storage options and ultimately mine site closure.

Access to faster methodology will allow streamlining of the process in predicting the potential impact of mining operations on ground and surface water quality. This will lead to reduced operational costs associated with earlier identification of risks and better informed operation and mining plans.

This project proposed to investigate the potential use of sequential leaching methodologies to identify iron ore waste rock-metal/metalloid risk factors which can be used to inform and prioritise long-term and expensive kinetic testing and subsequent investigations as required. The main aim of this investigation was to research, develop and validate sequential leaching methodologies as a tool to better identify potential contamination risks to ground and surface water quality.

Key Findings and Project Outcomes

A sequential leaching procedure was developed and optimised to meet the requirements for assessing potentially problematic mine waste produced by iron ore mining activities, focusing on those that have low sulfur concentration and /or are of complex mineralogy.

The optimised sequential extraction procedure measures major ions, metals and metalloids in the following fractions:

1. Water-extractable, using reagent water as the extracting fluid;
2. Exchangeable, using ammonium acetate as the extracting fluid;
3. 'Carbonate', using dilute acetic acid as the extracting fluid;
4. Amorphous Fe/Mn oxide, using a solution of hydroxylamine in dilute hydrochloric acid as the extracting fluid;
5. Crystalline Fe/Mn oxide, using 4 M hydrochloric acid as the extracting fluid;
6. Easily oxidisable, using oxidation with a mixture of sodium chlorate and hydrochloric acid as the extracting fluid; and
7. Recalcitrant oxidisable, using oxidation with hydrogen peroxide solution as the extracting fluid.

The sequential leaching protocol developed in this project correctly indicated that six of the seven samples provided for the study would not give rise to metal leachate concentrations of concern and the subsequent long-term kinetic studies confirmed this assessment. The six samples were characterised by very low sulfur contents, a lack of acid neutralising minerals and unremarkable concentrations of metals and metalloids. Comparison of cumulative masses of solutes released after 24 months of the kinetic leach test with masses recovered by the optimised sequential extraction method demonstrated that the materials were not reactive, with most of the original soluble salts in the sample being recovered by 24 months of column leaching.

The sequential leaching protocol also correctly predicted that one of the seven samples (sample JN/OB25 Fresh) would give rise to copper leachate concentrations of potential concern, which was confirmed by the subsequent long-term kinetic study. The optimised sequential extraction method proved useful for understanding the geochemistry of sample JN/OB25 Fresh, a sample of fresh shale mine waste from the Jeerinah Formation at BHP's Orebody 25 deposit. Conventional AMD characterisation of this material classified it as non-acid forming (NAF) on the basis of acid formation potential calculated from the Total Oxidisable sulfur (TOS) concentration being less than the measured Acid Neutralising Capacity (ANC) value. Elemental analysis indicated significant geochemical enrichment by copper, with other environmentally significant metals and metalloids being similar to or less than average global crustal abundances. Under typical circumstances, samples of this nature would not normally be selected for kinetic leach testing. However, leachates from the kinetic column test exceeded the livestock drinking guideline values for copper and selenium, demonstrating the potential for this waste type to produce neutral metalliferous drainage (NMD).

Analysis of this sample by the optimised sequential extraction method indicated the copper in the kinetic test leachates were derived mainly from the exchangeable fraction, probably from displacement by calcium and magnesium solutes produced from reactive mineral phases. On the other hand, the source of leachable selenium was attributed to the oxidisable fraction, that is reduced forms of insoluble selenium that reacted slowly with atmospheric oxygen to produce soluble selenium oxyanions.

Although the sequential leaching test alone cannot predict quantitative water quality impacts due to the kinetic controls on mineral dissolution, when combined with kinetic column leaching tests it could be an effective tool to assess environmental risk associated with specific mine wastes. Therefore, chemical data derived from the optimised sequential leaching method will help to predict quantitatively immediate water quality impacts, as well as different amounts of metal release potential. If there were significant proportions of metals released in the first three steps (i.e. the labile fractions: water soluble, exchangeable and carbonate fractions) of the optimised sequential leaching method then kinetic studies can be performed to assess the environmental risk. Therefore, the sequential leaching procedure used here provides valuable insight information about the effect of external conditions on the metalliferous leachability/solubility, mobility and bioavailability for risk assessment. To identify the real environmental risk of metals under different conditions possible in nature now or in future this information is necessary.

The sequential extraction method may also be useful for identifying contaminants of environmental concern that may be released from specific mine waste types that may be exposed to saline, acidic/alkaline or low redox leach fluids from either waste types (as a consequence of either blending or depositing as a covering layer in a mine waste landform). For example;

- Elements present in the exchangeable fraction may not be mobilised by infiltrating rainwater, but may be mobilised by saline seepage.
- Elements present in the ‘carbonate’ fraction may not be mobilised by infiltrating rainwater, but may be mobilised by acidic seepage from overlying or mixed PAF mine wastes.
- Elements present in the amorphous Fe/Mn oxide fraction may not be mobilised by infiltrating rainwater, but may be mobilised by highly alkaline seepage, or seepage with a low redox potential.

Results from this study clearly demonstrate that the optimised sequential leaching procedure may be used as a supplementary “sample screening” tool to acid base accounting to classify mine waste. While conventional acid base accounting methodology using static tests is generally useful for identifying potentially acid forming (PAF) mine wastes, the sequential leach procedure is particularly useful for identifying mine wastes with potential to produce neutral mine drainage, that is circum-neutral seepage containing metals (notably copper, nickel, and manganese) and metalloid oxyanions (arsenic and selenium) at concentrations that can affect the quality of surface water and groundwater.

A decision support tool was developed for the application of the optimised sequential leaching test as a screening tool for early identification of risks that can be used to direct and prioritise longer term kinetic studies subsequent to, or as a condition of, the Environmental Impact Assessment, waste management and mine-site closure planning and approval.

Through a project scientific advisory panel, the MRIWA M432 study included input from the industry sponsor (BHP Billiton) and the WA regulatory agencies; Department of Water and Environmental Regulation (DWER, that includes the formerly OEPA and DER) and Department of Mines, Industry Regulation and Safety (DMIRS, formerly DMP).

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1 INTRODUCTION

ChemCentre initiated a series of discussions with industry and WA regulatory authorities, in particular the Department of Water and Environmental Regulation (DWER, formerly: Department of Environment Regulation (DER), Office of Environmental Protection Authority (OEPA) and Department of Water (DoW)) and the Department of Mines, Industry Regulation and Safety (DMIRS) to identify knowledge gaps pertinent to the impact of mining, including iron ore mining, on ground and surface water quality. Such data is needed to inform (i) Environmental Impact Assessments (EIA), (ii) mine waste management and storage and (iii) mine-site closure planning. A well designed waste rock dump based on segregation and preferential placement of different waste types can offer substantial cost savings for rehabilitation and mine closure. On the other hand, miss-information can lead to double handling of problematic waste types and can become a costly exercise for mine closure.

From these discussions and related activities, the consensus view emerged that the current chemical and mineralogical methodologies used to characterise mine wastes and to predict the long-term impact of mining on ground and surface water quality were either “unfit for purpose “or, in the case of long term kinetic leaching studies, take too long to complete and would unduly delay the EIA process if the completion of such studies were mandatory.

Kinetic leaching studies are primarily used to predict the timeframe for onset of Acid and Metalliferous Drainage (AMD), but more recently they have been used to predict the impact on ground and surface water quality. Whilst it has previously been suggested that these studies may only take twenty-six weeks, it is now recognised that for many rock types these studies should be conducted over a two-year period.

Accelerated sequential leaching methodologies, which typically involve the leaching of samples with a sequence of increasingly aggressive solvents, have been used to (i) elucidate the chemical speciation of elements in soils and rocks, (ii) characterise municipal wastes, soil, sediments and mineral processing wastes and (iii) more recently characterise waste rocks associated with the mining of base metals. The sequential leaching approach can be used as a screening tool to predict the likely order of species mobilisation and extent of extraction of metal ions and metalloids (metal oxyanions) under different chemical and environmental settings and hence more objectively inform the potential impact on ground and surface water quality. The key advantage of these methodologies is that they are rapid, taking only weeks to complete, compared with longer term kinetic studies which can last for several years, and can be used to identify both the likely order of metal extraction through time and the potential metal /rock type associations that may impact on ground and surface water quality. The early identification of these metal/rock type risk factors can be used to support the EIA process and inform subsequent longer-term kinetic leaching studies to validate predictions. The aim of this project was to demonstrate that an optimised sequential leaching procedure can be used as a sample screening tool to support EIA processes through the early identification of potential contaminants of concern, which may impact on future ground and surface water quality. Thus, better informing waste management and mine-site closure planning and approval.

The major objective of the project was to validate sequential leaching methodologies against a range of rock types representative of iron ore deposits, focusing on those that have low sulfur concentration and /or are of complex mineralogy. Step-wise sequential leaching methodologies are conducted to extract the maximum amount of information from each representative sample of each waste rock type. Typically, sequential leaching involves the successive application of increasingly aggressive solvents, with mass balance and reaction rate data being obtained for each leaching stage and respective analytes (salts, metals and metalloids) of environmental concern.

Although this project concentrates on applicability to the iron ore industry, sequential leaching methodologies may also be applicable as sample screening tools to assessing the leaching potential of metals including chromium, manganese, nickel and cobalt from ultramafic rocks associated with gold, nickel and other base metal deposits. The researchers would be very keen to explore this possibility at some stage, but for the purposes of the current project there was a need to restrict the project scope in accordance with the industry sponsor’s requirements.

2 BACKGROUND

ChemCentre initiated a series of discussions with industry and WA regulatory authorities, in particular the Department of Water and Environmental Regulation (DWER, formerly: Department of Environment Regulation (DER), Office of Environmental Protection Authority (OEPA) and Department of Water (DoW)) and the Department of Mines, Industry Regulation and Safety (DMIRS), to identify knowledge gaps pertinent to the impact of mining, including iron ore mining, on ground and surface water quality. The ChemCentre research team has also been keeping well informed on the application of emerging analytical methodologies for assessing the long-term leaching potential of mining related wastes on ground and surface water quality through the following activities;

- Ongoing meetings with technical experts from both industry and the regulatory agencies, in particular DWER and DMIRS;
- Membership of Standards Australia and of the International Organization of Standardization (ISO) and participation in technical expert committees on water quality and soil quality;
- Familiarity with the scientific literature, especially from international peak industry bodies such as:
    - The International Network for Acid Prevention (INAP) and GARD Guide which they publish and
    - Mine Environment Neutral Drainage (MEND) Program;
- Perusal of US EPA and European Union Technical Reports;
- Contract literature reviews recently undertaken for industry;
- Membership of CRC CARE (Contamination Assessment and Remediation of Environments); and
- Organisation and hosting of relevant workshops such as:
    - MRIWA-ChemCentre Workshop on Mine Wastes: Smarter Analytical Tools for Extracting Value and Managing Closure (14 November 2013); and
    - CRC CARE-ChemCentre Workshop on Mine Pit Lakes (2014).

From these activities and discussions with key industry stakeholders, the consensus view emerged that the current chemical and mineralogical methodologies used to characterise waste rocks and to predict the long-term impact of mining on ground and surface water quality were either “unfit for purpose“ or, in the case of long term kinetic leaching studies, take too long to complete and would unduly delay the Environmental Impact Assessment (EIA) if the completion of such studies were mandatory.

This project proposes to fully investigate the potential use of sequential leaching methodologies to identify waste rock-metal/metalloid risk factors which can be used to inform and prioritise long-term and expensive kinetic testing and subsequent investigations as required.

This approach was suggested to ChemCentre by technical experts within DWER (formerly DER, OEPA and DoW) and DMIRS and followed a series of meetings with the individual agencies and subsequently at a combined meeting to reach a consensus view of the key regulatory agency information needs and the tools that were needed to address these needs. Subsequent discussions with industry geochemists, in the iron ore and gold mining industry, confirmed the regulatory agency view and in particular the potential value of sequential leaching methodologies for the early identification of risks to the environment and for reducing costs of mine closure in response to more cost-effective mine waste management during operations and rehabilitation.

The MEND group in Canada has developed sequential leaching protocols and decision tree systems to predict the long-term leaching potential of partially oxidised waste rock under subaqueous storage. Canada leads the world in research related to sub-aqueous storage and practical adoption of the technology to achieve mine site closure. The US Geological Survey and the USEPA are undertaking similar investigations.

There are significant knowledge gaps and ongoing issues that have been identified by regulatory agencies in Western Australia (most notably the OEPA) and industry, which involve the accurate prediction and modelling of the impact of mining on the cost of mine waste management and on ground and surface water quality.

These research gaps include the leaching, sorption/desorption and order of metals/metalloid species mobilisation.

2.1 The Leaching, Sorption/desorption and Sequence of Metal/metalloid Mobilisation

The mobility of metals and metalloids released from waste materials may be assessed by using several risk assessment procedures including the Toxicity Characteristic Leaching Procedure (TCLP), among others (van der Sloot, 1996; Barna *et al*, 1997; USEPA, 1997). There are also many other approaches, such as static and kinetic testing of mine wastes that have been developed for acid and metalliferous drainage (AMD) prediction in the past 30 years (Sobek *et al,* 1978; Lawrence and Scheske 1997; Paktunc 1999; Blowes *et al*, 2003; Benzaazoua *et al*, 2004; Villeneuve *et al,* 2009; Plante *et al,* 2012; Bouzahzah *et al,* 2014). Moreover, acidic drainage resulting from the oxidation of sulfides from metalliferous mine wastes leads to the leaching of large quantities of cations including Fe^{2+}, Mn^{2+}, Pb^{2+}, Cu^{2+}, Zn^{2+}, etc. (Vega *et al*, 2006) to the environment. Thus, metal contamination and acid mine drainage are very important environmental concerns where mine wastes containing metal-rich sulfides have been stored or abandoned (Concas *et al*, 2006).

The toxicity and mobility of heavy metals and metalloids depend not only on total concentrations, but also on their specific chemical and mineral forms, their binding state, the geochemical properties, environmental factors and properties of the receiving environment regolith including pH, organic matter content and type, redox conditions and plant root or microbial exudates acting as chelating agents for specific metals (Nyamangara, 1998). Thus, heavy metals and metalloids are distributed in mine waste in various geochemical forms, nominally water-soluble, exchangeable, carbonate associated, Fe–Mn oxide-associated, oxidisable (associated with organic matter and/or sulfide minerals) and residual forms. Water-soluble and exchangeable fractions are highly bioavailable; oxide-, carbonate- and oxidisable- bound fractions may be potentially bioavailable; while the silicate mineral fraction is mainly not available to either plants or microorganisms (Ma and Rao, 1997; He *et al*, 2005). Figure 1 shows some of the physical and chemical factors that influence the magnitude and rate of leaching or transport of different phases within a solid regolith (soil or mine waste) particle. In many cases, both the chemical reaction and mass transport rates within a solid particle are sufficiently fast that quantitative information about leaching can be determined within a few hours or days in test procedures.

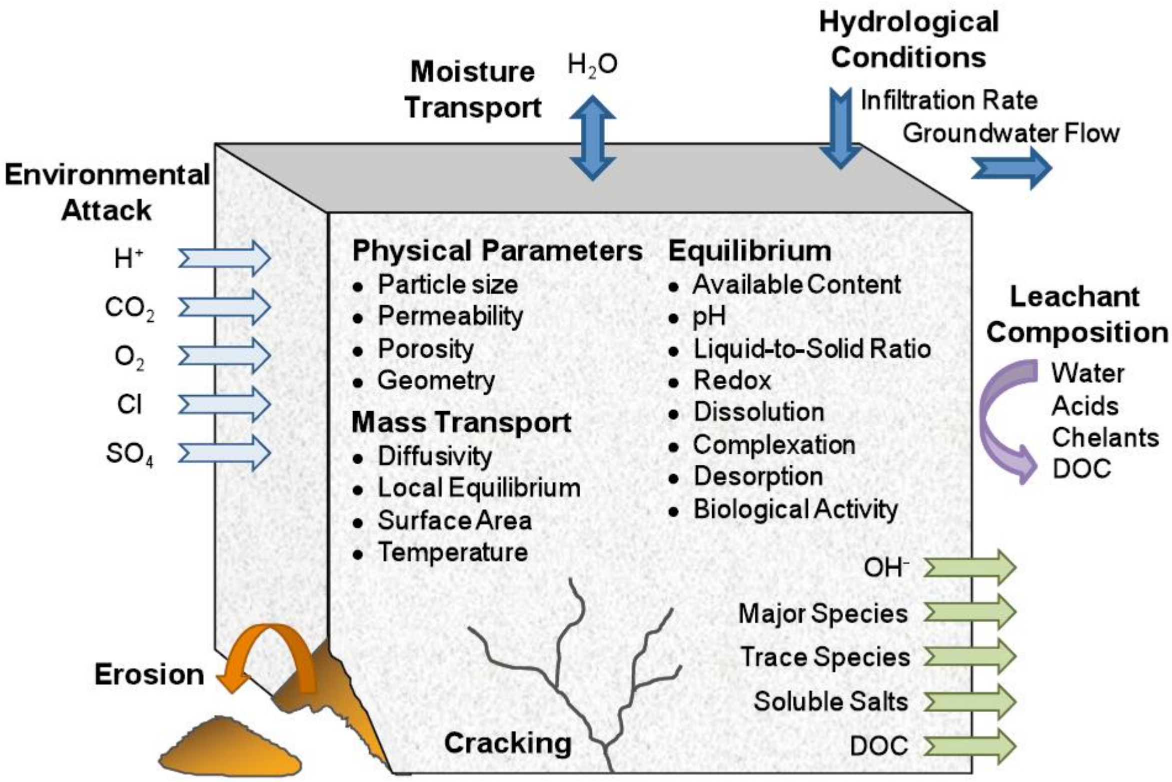

Figure 1: Internal and external factors that influence the extent and rate of leaching of a chemical constituent from a solid particle into a contacting aqueous solution (from Garrabrants *et al*, 2010).

Oxidation of exposed pyritic shale is a major source of acidity from iron ore operations in Western Australia and is hence either directly a source of environmental contaminants of potential concern or indirectly an initiator for the mobilisation of metals. These potential contaminants include cadmium, lead and mercury and metalloids, metal containing oxyanions (e.g. selenium, arsenic, chromium and species thereof) released from rocks with acid neutralising capacity. Many of these ions mobilised at acidic pH may also be soluble at circum-neutral and alkaline pH. The oxyanions of arsenic (As (III) and As (V)), selenium and various metal ions, including Cr (VI), are especially problematical in this respect. In some instances, mobilised metal ions or metalloid oxyanions may be either sorbed or deposited as secondary minerals. Factors influencing the remobilisation of these sorbed/precipitated minerals are also poorly understood. This is particularly true for rock samples taken from either un-weathered (fresh) rock or below the water table. Efforts to minimise the oxidation of pyritic shales, and hence potential contamination of ground and surface water quality, are largely focused on minimising the exposure of pyrite-containing stockpiles to air and water. Thus far, this has been achieved utilising research results relating to waste rock cover design and/or minimising the release of acidic metal containing seepage to the environment. However, the long-term effectiveness of current cover design systems (known as "store and release" systems) in minimising acid formation and release of acid metal containing seepage is poorly understood, as is the long-term potential impact on ground and surface water quality associated with and adjacent to mining operations.

Kinetic leaching studies are primarily used to predict the onset of Acid and Metalliferous Drainage (AMD), but more recently they have been used to predict the impact on ground and surface water quality. Whilst it has previously been suggested that these studies need only take twenty six weeks, it is now recognised that for many rock types kinetic leaching studies should be conducted over a two year period (Maest *et al,* 2005). Similarly, most silicates and some carbonate minerals weather more slowly than sulfides and, depending on the mineralogy and availability of minerals within the rock, and also environmental factors, the onset of AMD may be delayed in the field compared to the laboratory. It has been suggested (Robertson *et al,* 1995) that unless the rocks are high in sulfur, have low buffering capacity and/or are highly reactive, kinetic leaching tests should be run over two to three years.

For these problematic rock types, laboratory studies may under-estimate the concentrations of metals that may be leached into the environment and hence the potential impact on ground and surface water quality. It is in the interest of both government regulatory agencies and industry to obtain relevant information on the leaching characteristics of the rock types in the shortest time frame possible.

Given the impracticality of obtaining long-term kinetic leaching data as a prerequisite of the EIA process, the regulator needs better tools to assess the long-term impact of mining, in particular the impact of metalliferous drainage on ground and surface water quality. Understanding the solute leaching characteristics of mine waste prior to commencement of mining can inform mine waste landform design by identifying both problematic and potentially useful rock types. A well-designed and constructed mine waste landform can save large amounts of money that would otherwise be required for double handling of mine waste during rehabilitation and mine closure.

Sequential extraction techniques for contaminated soils and regolith wastes have been widely adopted over the last few decades (e.g., Tessier *et al*, 1979; Xiangdong *et al*, 1995; Singh *et al*, 1998; Leleyter and Probst, 1999; Dold, 2003; Aydin *et al*, 2009; Anju and Banerjee, 2011) to examine these physico-chemical forms, to better understand the processes that influence element recoverability, and to allow a better insight into the mechanisms of retention and release involved in the processes of migration and decontamination (Cabral and Lefebvre, 1998; Hisham and Randa, 2009). Sequential extraction procedures (Tessier *et al*, 1979; Schuman, 1985; Ure *et al*, 1995; Hall *et al*, 1996; Adamo *et al*, 1996; Dhoum and Evans, 1998; Moral *et al*, 2005; Patricia *et al*, 2011; Francisco *et al*, 2011) have been used to assess the chemical partitioning of trace metals in regolith.

A study by Al-Abed *et al*, (2006) involved a comparative evaluation of short-term leaching tests for heavy metal release from mineral processing wastes from a copper mine. These studies were undertaken to better understand the potential significance, mobilisation and mineral phase source of a range of metals and metalloids, including Cu, Pb, Zn and Se from different types of wastes. The partitioning of metals from four acid-generating mines was also investigated using sequential extraction methods to better understand the mineral phase source of heavy metals (Leinz *et al*, 2000). Similarly, Plante *et al*, (2010) investigated the sorption of nickel on waste rock surfaces to better understand metal mobility in neutral mine-drainage waters emanating from waste rocks of the Tio mine, which is a hematite-ilmenite deposit in Quebec, Canada.

A number of sequential leaching protocols have been described in the literature (for example Al-Abed *et al*, 2006). Typically, samples are leached with increasingly aggressive solvents and this establishes the following;

- The likely order of metal extraction, with an understanding that the order may vary under conditions of very high salinity, acidity, alkalinity and redox (reducing and oxidising) potential;
- The mineral phase which is the source of the metal ions for:
    - Water-soluble metals and salts;
    - Ion-exchangeable metals;
    - Metals associated with carbonates;
    - Metals and metalloids associated with amorphous iron and manganese oxides;
    - Metals and metalloids associated with crystalline iron oxides;
    - Metals associated with oxidisable materials, such as sulfide minerals and organic matter; and
    - Metals present in the silicate or resistant phase; and
- The mass balance and reaction rate data for each leaching step.

The major advantage of sequential leaching methodologies is that they can be completed within weeks compared to longer-term kinetic studies over two years. Sequential leaching data allows the early identification of potentially problematical metal-waste rock type associations under different environmental conditions, which in turn can be used to support the EIA. It also informs subsequent longer-term kinetic studies to better understand potential risks and mining operation risk management strategies, including mine waste storage options and ultimately mine site closure.

This project proposed to investigate the potential use of sequential leaching methodologies to identify iron ore waste rock-metal/metalloid risk factors which can be used to inform and prioritise long-term and expensive kinetic testing and subsequent investigations as required. The main aim of this investigation was to research, develop and validate sequential leaching methodologies to better identify potential contamination risks from iron ore mine waste to ground and surface water quality. The key research need that this project addressed is the leaching, sorption/desorption and order of metals/metalloid species mobilisation, particularly where metal/metalloid species mobilisation and the mobilisation of oxy-anions from iron ore mine waste is poorly understood. A better understanding of the order of mobilisation (desorption) of metal/metalloids from mineral surfaces, especially waste rock taken from either un-weathered or below water table areas, is needed. The findings will inform the EIA process and identify the need for further research, including the parameters involved in longer term (2-3 years) kinetic testing.

Access to faster methodology will allow streamlining of the process in predicting the potential impact of mining operations on ground and surface water quality. This will lead to reduced operational costs associated with earlier identification of risks and better informed operation and mining plans.

3 EXPERIMENTAL APPROACH

The aim of this project was to demonstrate that sequential leaching studies can be used to support EIAs through the early identification of contaminants of potential concern which may impact on future ground and surface water quality. The major objectives of the project were to validate sequential leaching methodologies against a range of rock types representative of iron ore deposits in Western Australia, focusing on those that have low sulfur concentration and /or are of complex mineralogy.

Various published sequential leaching methodologies were selected, validated and assessed against longer term kinetic leaching studies, which were conducted in parallel using seven representative rock types that were supplied by the industry sponsors from their respective iron ore operations. The rock samples were also tested using LEAF 1313 (pH dependence) tests.

3.1 Sample Collection and Preparation

Seven rock samples were selected in the present investigation from 21 rock samples submitted by the project sponsor. A description of the collected samples is summarised in Table 1. Samples were selected based on the criteria of: (i) low total S content (< 0.5%), (ii) the range of detectable elemental composition of elements including Cr, As, Cd, Pb, Mn, Mo, Se, Cu, (iii) the type of deposit and stratigraphy, (iv) representation of both weathered and unweathered material, and (v) different mineralogy considerations.

Submitted samples were air dried. If not possible, then the sample was dried at a maximum temperature of 40°C for 24 h or until a constant weight was reached. The bulk material was sieved through a 4 mm sieve and any oversize material was crushed until it all passed through the sieve. Three Kg of each sample was bowl milled to particle size 100 mesh (< 200 µm). The milled sample (< 200 µm) was then subjected to sequential leaching tests, LEAF 1313 testing and Kinetic column leaching (up to 24 months).

The elemental composition of the seven rock samples is presented in Section 5, Table 4. General descriptions of all seven samples selected for assessment by sequential leaching methodologies in terms of their chemical and mineralogical properties are summarised below.

- JN/OB25 Fresh, Jeerinah Formation shale. This sample is characterised by:
    - Being sourced from below the water table
    - the highest % S, high CRS value
    - high Cr and slightly elevated Mn and Pb
    - different mineralogy to the other samples in that there is very little goethite/hematite/maghemite and 50-60% mica-dioctahedral (Table 6), which can have some elemental associations with it.
- MM/OB29 Weathered Marra Mamba Iron Formation. This sample is characterised by:

  - mainly composed of goethite
  - slightly elevated As, Cd, Cr, Pb and relatively high Mn.
- MM/OB29 Transition Marra Mamba Iron Formation. This sample is characterised by:
  - consisting of mainly of goethite
  - slightly elevated As, Cd, Cr, Pb and relatively high Mn.
- W/OB25 Transition Whaleback shale. This sample is characterised by:
  - relatively high As, Mg and Mn.
- W/OB25 Fresh Whaleback shale This sample is characterised by:
  - relatively high As, Mg and Mn.
- WHB1333DG-49 Fresh Dales Gorge Formation shale and BIF. This sample is characterised by:
  - slightly elevated As, Cr and Pb.
- MMOB32 Transition Marra Mamba Iron Formation. This sample is characterised by:
  - representing a different member of the Marra Mamba Formation (Mt Newman member)
  - transition zone material (not fresh)
  - located below the water table.

Table 1: Description of rock samples collected from different iron ore deposits in Western Australia.

Sample No.	Stratigraphy Code.	Deposit	Sample number	Drill hole	Depth from (m)	Depth to (m)	Sample Weight (kg)	Weathering Code	Water Table Code
1	JN	OB25	C907244	HST0233DG	35	36.5	8.4	0	1
2	MM	OB29	N613801	EEG1172R	9	12	3.2	2	
3	MM	OB29	N613691	EEG1168R	18	21	7.7	1	0
4	W	OB25	N569611	FG4692R	18	21	3.5	1	0
5	W	OB25	N589264	FG5030R	33	36	3.4	0	
6	D1	Whaleback	WHB1333DG-49	WHB1333DG	123	126	2.9	0	0
7	MM	OB32	N572940	CA0223R	135	138	2.8	1	
	GN4	Callawa	V058009	CA0215R	12	15	2.2		
	GN4	Callawa	V058016	CA0215R	30	33	2.2		
	GN4	Callawa	V058035	CA0215R	30	33	2		
	GN4	Callawa	V058047	CA0216R	12	15	2.1		
	GN4	Callawa	V058056	CA0217R	30	33	2.1		
	J3	OB25	Y200083	PSB0577R	6	9	5.2	2	
	J5	OB25	Y214403	PSB0572R	3	6	4.5	1	
	J5	OB25	Y214405	PSB0572R	6	9	6.1	1	
	JN	OB25	N569026	HST0905R	81	84	1.8	1	1
	JN	OB32	C907245	HST0233DG	39.1	41.2	4.8	0	1
	JN	OB32	C907246	HST0233DG	73.8	75.4	8.5	0	1
	MM	OB29	N614568	EEG1135R	9	12	1.2	1	0
	W	OB25	N569613	FG4692R	21	24	2.9	1	0
	D1	Whaleback	WHB1341DG-42	WHB1341DG	102	105	2.2	1	0

Notes: Weathering code: 0- fresh, 1- transition, 2- weathered; Water table: 0- above, 1- below. Shaded rows denote samples selected for sequential leach test.

3.2 Long Term Kinetic Leaching Test Methodology

Static tests, submerged column and/or similar methods and sequential leaching protocols are used to inform the extent of release of metals/metalloids and acid production. Kinetic testing is then required to establish the rate of acid production and metal/metalloid leaching. The most commonly employed kinetic methodologies are;

1. Leach column - AMIRA 2002 -with alternate wetting and drying cycles, or

2. Humidity cell - ASTM method D5744-12, Option B.

The key disadvantages of these techniques are that they are not suited to the long term prediction of either the rate of acid production or metal/metalloid leaching from wastes continuously exposed to leaching solutions, as in the case of submerged materials. These tests are more suited to rocks which may be episodically exposed to water and as such typically use water as the leaching solution. By using distilled water as the test leaching solution, these methods do not mimic materials that are exposed to saline, hyper-saline, extremely hard or sodic solutions typically encountered in many parts of Australia.

For rocks continuously exposed to leaching solutions it is more appropriate to conduct long-term leaching trials using submerged columns of similar techniques where the rock is continuously exposed to fresh leaching solution. These tests commonly employ leaching solutions of varying pH, TDS and ionic strength (salinity, hyper-salinity, hardness and sodicity).

Oxygen consumption cell tests can be used as a direct measure of the oxygen consumption rate due to sulfide oxidation in a well sealed cell (Taylor, 2014). This test can be used as a direct measurement of the sulfide oxidation rate for a given test material, independent of effects from gypsum or jarosite formation and dissolution.

Much larger field kinetic tests can also be used to provide information on weathering rates and leachate chemistry in situ, under conditions of climate and microbial activity that resemble mine site conditions.

Submerged column techniques are primarily used to inform models to estimate long-term impact on water quality arising from the leaching of metal/metalloids from rocks exposed to leaching solutions (sub-aqueous storage, mine pit lake walls and/or backfilling).

With the exception of sequential extractions, the submerged column techniques are limited to simulating one environmental condition and thus one standard test cannot be applied to examine a range of receiving environments which may change through time.

Typically, experiments are run using a range of predicted (model) pH, TDS, salinity and redox potentials and can also be run under aerobic/anaerobic conditions.

Submerged column techniques are usually used on a case by case basis.

The kinetic test chosen for the present investigation has been widely used throughout Australia since 2002 to predict risk associated with acid formation from minerals, soils, and rocks which may be disturbed in a mining or soil excavation operation. The method adopted in the present investigation was from the AMIRA ARD Test Handbook Project 387A (2002). This method uses large Buchner funnels that can hold approximately 2 kg of crushed (< 4 mm) sample. A weekly wet-dry cycle is used. The wetting solution is deionised water which is added once per week and the filtrate collected every four weeks. The samples are then dried by exposure to heat lamps. The filtrates are analysed after collection.

Kinetic leaching tests were performed in duplicate for each of the selected seven rock samples over a period of 24 months.

3.2.1 Procedure

The method used for the kinetic column leaching test, based on the AMIRA method (AMIRA 2002), is summarised below:

a) Place filter medium on the perforated disk in the funnel and weigh the funnel (support in a tared tall form 2 L beaker). Add 1 kg of sample (milled to particle size < 200 µm) and re-weigh.

b) Place the funnel containing the sample into the stand. Place a pre-weighed 1 L container underneath the funnel. Duplicate columns were setup for each sample.

c) Start the test on a Friday by adding 800 mL (Note 1) of Milli-Q water from a separating flask onto the sample surface taking care not to stir up the sample. A filter paper on the sample surface will prevent this happening.

d) Allow to drain over the weekend. Collect the leachate on Monday morning prior to the heat lamps coming on and treat as in Step C. Weigh the container and record the weight. This is the Week 0 leachate. Preserve and store as recommended by the appropriate method e.g. for metal analyses a subsample of the leachate should be filtered through a 0.2 µm filter and acidified. Partial analyses (pH, EC) are done on the unfiltered unacidified leachate using calibrated multiprobe meters.

e) From Monday to Friday the heat lamps will cycle on and off to provide eight hours of heating on each day. The surface temperature of the sample should be between 30°C and 35°C when the lamps are on. (This will necessitate a distance of approximately 65 cm between the lamps (in every second holder) and the sample surface).

f) Each Friday add 200 mL of water after 15:00 hr (to reduce surface evaporation effects-heat lamps on cycle from 04:00 to 12:00 hr on that day). Place a collection container under the column although it is unlikely any leachate will be collected. Should leachate be collected, filter through a 0.2 µm filter and store. Composite with the other weekly leachates and the monthly leachate.

g) Continue this cycle for four weeks. On the fourth Friday weigh the funnel and sample prior to adding 800 mL of water.

h) Collect the leachate Monday morning prior to the heat lamps coming on (recording weight) and treat as in Step C. This sample is Week 4.

i) The cycle then continues for a recommended minimum of 24 weeks.

j) At the end of the trial the leached sample should be weighed, and appropriate analysis done on the rock samples.

3.2.2 Leachate Analysis

Filtered leachates were analysed by either Inductively Coupled Plasma – Atomic Emission Spectrometry (ICP-AES) or Inductively Coupled Plasma - Mass Spectrometry (ICP-MS):

- Major cations; Ca, Mg, Na and K
- Dissolved metals; Ag, Al, Ba, Be, Cd, Co, Cr, Cu, Fe, Li, Mn, Mo, Nb, Ni, Pb, V, and Zn
- Dissolved metalloids; As and Se
- Soluble P, S and Si (from 12 months samples onwards).

3.2.3 Data Analysis

Results for leachate analysis were recorded in tabular format in EXCEL, listing solution concentration data (mg/L) for the following sampling events:

- Week 0
- Weeks 1 to 3
- Months 1 to 12
- Quarterly sampling from Month 15 to 24.

For each analyte, the cumulative mass leached from each column was calculated from the solution concentrations of all leachates and the volumes of leachate collected from each column. Data from the duplicate columns were averaged and calculated results expressed on a mg/kg basis (mg of analyte for kg of dry sample).

3.3 Sequential Extraction Procedures Assessed

Although sequential leaching was foremost designed to elucidate the chemical speciation of elements in soils and rocks, sequential leaching methods have been used to investigate the leaching order and extent of metal and metalloid species leaching from municipal, industrial, secondary mineral and mine wastes. Various complicated sequential extraction procedures were used world-wide to provide more detailed information regarding different metal phase associations (Tessier *et al*, 1979; Bordas and Bourg, 1998; Templeton *et al*, 2001). In addition, heavy metal speciation in environmental media using sequential extraction is based on the selective extraction of heavy metals in different physicochemical fractions of material using specific solvents (Bruder-Hubscher *et al*, 2002).

Sequential leaching methodologies can be relatively straightforward; a simple example involves multiple sequential leaches using deionised water or local surface/groundwater can simulate an accelerated leach over time. Typically, each extraction fluid, once removed and replaced with fresh extractant, is analysed and extractions may be repeated seven or more times. Commonly, metals are extracted from several, or all of the following operationally-defined phases and in the given order: (1) metals present in water-soluble form; (2) ion-exchangeable metals; (3) metals associated with carbonates; (4) metals associated with amorphous iron and manganese oxides (Fe-MnOxam); (5) metals bound to crystalline iron oxides (FeOxcryst); (6) metals occurring as, or in sulfides or organic matter; and (7) the remaining metals not extracted in the preceding steps, referred to as the silicate or residual phase.

3.3.1 Critical Appraisal of Sequential Leach Fractions

3.3.1.1. Water Soluble Fraction

The water-soluble fraction of a soil or sediment is the first to be brought into solution in any sequential scheme. This fraction is usually negligible, except in samples where evaporite minerals from infiltrating rainwater or groundwater (such as halite, gypsum or epsomite) are present.

3.3.1.2. Exchangeable Fraction

This fraction involves weakly adsorbed metals retained on the solid surface by relatively weak electrostatic interaction, metals that can be released by ion-exchangeable processes. Remobilisation of metals can occur in this fraction due to adsorption/desorption reactions and lowering of pH (Ahnstorm and Parker, 1999). Exchangeable metals are a measure of those trace metals which are released most readily to the environment, especially by contact with saline solutions. Corresponding metals in the exchangeable fraction usually represent a small fraction of the total metal content in soil, sewage sludges, sediments and mine wastes, and can be replaced by neutral salts (Rauret, 1998). The exchangeable fraction is also known as non-specifically adsorbed fraction, it can be released by the action of cations such as K, Ca, Mg or (NH_4) displacing metals weakly bonded electro-statistically at organic or inorganic (clay mineral) sites (Beckett, 1989). The common reagents used for the extraction of metals in this fraction are moderately concentrated electrolyte solutions, such as $MgCl_2$ and sodium acetate (buffered to pH 5.4 by acetic acid) (Tessier *et al*, 1979

3.3.1.3. Carbonate Bound Fraction

Carbonate minerals tends to be a major adsorbent for many metals when there is reduction of iron oxides and/or manganese oxides (Fe-Mn oxides) and organic matter, especially in the aquatic system. The most commonly used reagent for the extraction of trace metals from carbonates phases in soils, sediments and mine waste is a weakly acidic solution, such as 1 M sodium acetate buffered to pH 5.0 with acetic acid (Tessier *et al*, 1979). The carbonate fraction is a loosely bound phase and bound to changes with environmental factors such as pH (Beck *et al*, 2001). The time lag for the complete solubilisation of carbonates depends on factors such as the type and amount of the carbonate in the sample and the particle size of the solid (Beck *et al*, 2001). Extraction of metals from carbonate phases enhances the leaching of metals specifically sorbed to organic and inorganic substrates (Tessier *et al*, 1979). In general, this fraction is sensitive to pH changes, and metal release is achieved through dissolution of a fraction of the solid material at pH close to 5.0 (Gleyzes *et al*, 2002).

3.3.1.4. Iron and Manganese Oxide Fractions

Hydrous oxides (sesquioxides) of iron and manganese (and also aluminium) provide reactive variably charged surfaces that are able to sorb various metals and metalloids. These hydrous secondary oxides are formed by oxidation of primary minerals and may occur as coating on mineral surfaces or as fine discrete particles. The sorption process is complex and usually occurs as a combination of precipitation, adsorption, surface complex formation and ion exchange (Hall and Pelchat, 1999).

Measurement of elements associated with this fraction usually involves extraction with a strong reducing reagent solution, typically salts of hydroxylamine (NH_2OH). There is a variation accounted for the extraction of metals in Fe-Mn oxide phases with 0.1 M hydroxylamine compared with 0.5 M hydroxylamine. Extraction with dilute solution (0.1 M) preferentially release elements from manganese oxides, whereas more concentrated (0.5 M) extraction results in greater dissolution of the iron oxide phase while still releasing metals from manganese oxide phase (Shuman, 1983). Solutions of other reducing agents have been used for metal extraction from Fe-Mg oxide phases, such as sodium dithionite in combination with sodium citrate and sodium bicarbonate in a varying concentration range (Beckett, 1989) which is widely used in soil studies. Extraction with ascorbic acid/ammonium oxalate reagent offers advantages over other extractions because the reagents are available at a higher degree of purity and the solutions do not attack silicate minerals. (Gleyzaes *et al*, 2002).

3.3.1.5. Oxidisable Fractions

This fraction includes the metals and metalloids bound to organic matter and sulfide minerals. The mode of action to measure elements associated with this fraction changes from reducing to oxidising and the results of a study of different attacks on sulfide minerals has been explained by Chao and

Sanzalone (1977). Under oxidising conditions, degradation of organic matter can lead to a release of soluble trace metals bound to this component as metal coordination complexes. The extracts obtained during this step also include metals and metalloids present as sulfide minerals. The organic fraction released in the oxidisable step is considered poorly bioavailable as it is thought to be associated with high molecular weight humic substances that form very stable associations with heavy metals. The most commonly used reagent for the extraction of metals in this fraction is hydrogen peroxide in conjunction with ammonium acetate to minimise adsorption or precipitation of released metals. Chao and Sanzalone (1977) compared the efficiency of the following reagents in the dissolution of nine sulfide minerals: aqua-regia; 4 M HNO_3; H_2O_2-ascorbic acid; oxalic acid; $KClO_3$ plus HCl; and $KClO_3$ plus HCl followed by 4 M HNO_3 with gentle boiling. Only with the last reagent mixture were all the sulfide minerals completely dissolved.

3.3.1.6. Residual Phase

The residual phase serves as a useful tool in the assessment of the long-term potential risk of heavy metal or toxic metals entering the biosphere. Digestion in strong acid (such as nitric acid, hydrochloric acid or aqua regia) do not dissolve the silicate matrix, but have been commonly used to leach out the recalcitrant metals that are bound to the sediment in the residual phase. Hence, the residual phase can give an estimate of the maximum amount of elements that are potentially mobilisable with changes in environmental conditions.

For the purposes of this study, the residual phase has been designed to represent the total concentration of elements remaining after sequential leaching. Hence, 4-acid digestion, using a mixture of hydrochloric, nitric, perchloric and hydrofluoric acids, was chosen to completely dissolve the silicate matrix and other recalcitrant minerals (such as zircon and rutile).

3.3.2 Sequential Extraction Procedures Assessed

Based on the requirements described in Section 3.3.1, four sequential extraction procedures were selected from an extensive list of published methods. The four tests were performed on seven samples (milled to particle size < 200 µm) in duplicate and with two blanks. The four procedures were:

- Pinto *et al*, (2014),
- Piatak *et al*, (2007),
- Leinz *et al*, (2000),
- An in-house procedure developed by Rio Tinto (2014) for its iron ore operations in Western Australia.

The detailed methodology for the four sequential extraction procedures (highlighted in green) is described in Table 2 together with other methods that were considered during the selection process.

Table 2: Four sequential extraction procedures (highlighted in green) performed on seven samples plus other methods from the literature.

Method (Reference)	Water Extractable	Exchangeable	Carbonate	Total Reducible		Total Oxidisable (Sulfide & Oxidiable)		Silicate (Residual)	Comments
				Amorphous Fe/Mn-oxide	Crystalline Fe/Mn-oxide	Easily Oxidisable	Recalcitrant Oxidisable		
Pinto, Al-**Abed** et al, 2014	1.75gm:35ml DI H_2O: 2hr; 25°C **(1)**	1M $MgCl_2$ pH7; 2hr: 25°C **(2)**	1M CH_3COONa; pH 5; 6hrs; 25°C **(3)**	0.04M NH_2OH. HCl in 25 % Acetic acid; 95°C; 6hr **(4)**	0.2M $NH_4OCOCONH_4.H_2O$ (Tamm reagent*); pH 3; 2hr **(5)**	0.7M NaOCl; pH 8.5; 6hr; 90°C **(6)**		HNO_3 **(7)**	Sulfidic mine tailings. Under oxic & anoxic conditions
Piatak et al, 2007 (US EPA)	1gm; 25 ml 0.1 M KH_2PO_4; 2hr **(1)**		25 ml 5 % CH_3COOH; 2hr **(2)** (Step 3 org fraction)	25 ml 0.25M NH_2OH. HCl in 0.1 M HCl; 30 min at 50°C **(3)**	20 ml 1M NH_2OH. HCl in 25 % CH_3COOH; 3hr; 90°C; rinse & repeat for 1.5 hr **(4)**	5g $KClO_3$, 10 ml Conc HCl; 45 min; rinse, 10 ml 4N HNO_3; 20 min at 90°C **(5)**		Conc Acids **(6)**	Mine waste, sediments, tailings. No data interptn
Leinz et al, 2000	1gm; 25ml DI H_2O + Si gel **(1)**	25 ml 1M CH_3COONa; 1hr **(2)**	25 ml 1M CH_3COONa pH <5; 2hr **(3)**	25 ml 0.25M NH_2OH.HCl in 0.25 M HCl at 50°C; 30 min **(4)**	25 ml 4M HCl 94°C; 30 min **(5)**	2g sod. chlorate+ 10 ml conc HCl after 45 min aqueous phase separated and dilute with 25 ml H_2O; Residue extracted 40 min 4M HNO_3 **(6)**		10ml HNO_3, $HClO_4$, HF at 220°C **(7)**	Mine waste dumps Jarosite
Rio Tinto, **RT** 2014	DI H_2O **(1)**	Acetic Acid; pH<3 **(2)**		Hydroxylamine.HCl; pH 3-4 (+ cryst. Mn_O) **(3)**	Hydroxylamine.HCl; Acetic acid; pH<2 (only cryst. Fe_O) **(4)**	Peroxide (NAG test); pH 3-4 **(5)**	Aqua regia; pH<1 (less readily oxidisable & acid extractable) **(6)**	4 acid digest; pH<1 **(7)**	Low S waste
Al-Hwaiti et al., 2014	1gm: 50 ml DI H_2O; pH 6.7-6.9; 16hr; 20°C	8ml 1M $MgCl_2$; pH 7; 1hr at 20°C **(2)**	8ml of 1M NaOAcetate pH 5 with HOAc; 5hrs; 20°C **(3)**	20 ml of 0.04 M NH_2OH.HCl in 25 % HOAC; 6hr; 96°C **(4)**		3ml of 0.02M HNO_3 and 5ml of 30% H_2O_2; pH 2; 2hr; 85°C (organic fraction) **(5)**		3ml conc HCl and 9ml Conc HNO_3 65-140°C **(6)**	Phosphate rock
Favas et al., 2011	1gm; DI H_2O; 1hr; 25°C **(1)**	1M Amm acetate; H 4.5; 2hr; 25°C **(2)**		0.2 M NH_4 oxalate; pH 3; 1hr; dark **(3)**	0.2 M NH_4 oxalate; 2hr; pH 3; in light; heat water bath for 2hr **(4)**	35 % H_2O_2; heat 1hr Add 1 M NH_4 Acetate; pH 4.5; 30 min **(5)**	Combination of $KClO_3$ and 12 M HCl. At 25°C for 30 min. 4MHNO_3 at 90°C for 20 min	HF+HNO_3+$HClO_4$ **(7)**	Tailings & soil

						(org fraction + secondary sulfides)	**(6)** (primary sulfides)		
Method (Reference)	**Water Extractable**	**Exchangeable**	**Carbonate**	**Total Reducible**		**Total Oxidisable** **(Sulfide & Oxidisable)**		**Silicate** **(Residual)**	**Comments**
				Amorphous Fe/Mn-oxide	**Crystalline Fe/Mn-oxide**				
Rodriguez et al, 2009	0.11 mol/l CH_3COOH; pH 2.85 **(1)**			0.5 mol/l $NH_2OH.HCl$; pH 1.5 **(2)**		8.8 mol/l H_2O_2+1 mol/l CH_3COONH_4; pH2 **(3)**		HCl+HNO_3 **(4)**	Tailings and soils around a Pb/Zn mine in spain
Al-Abed et al, 2006	1M $MgCl_2$; pH 7; 1hr; 25°C **(1)**		1M CH_3COONa; pH 5; 6hrs; 25°C **(2)**	0.04M NH_2OH. HCl in 25 % Acetic acid; 95°C; 6hr **(3)**		(Mixture of HNO_3 and H_2O_2) This step not done		HNO_3 **(4)**	Mine waste
Quejido et al, 2005	0.5 gm; 25 ml hot DI H2O; pH 6.7-6.9; 1hr **(1)**	8 ml 1 M NH_4Cl; pH 7; 1hr **(2)**	20 ml 1M amm acetate; pH 4.5 (HNO_3); 4hr at 85°C **(3)**	20 ml Tamn solution*; 4hr; dark **(4)**	30 ml 6M HCl; 2hr; at 85°C **(5)**	5 ml 8.8 M H_2O_2 pH 2 (HNO3); kept for 1hr at 25°C then at 85°C ; After cooling add 5 ml 8.8 M H_2O_2 pH 2 kept at 85°C for 1hr; Then add 25 ml 1M Amm acetate pH 2; 16hr **(6)**		HF/Aqua regia followed by $HClO_4$ **(7)**	U Mining. Fracture filling samples
Leinz et al, 2000 (Griffioen and Broers 1993)	1gm; 20ml DI H_2O; 2hr **(1)**			20 ml 0.25M $NH_2OH.HCl$ in 0.25 M HCl at 50°C; 30 min **(2)**	40 ml 0.2M Amm oxalate and oxalic acid and 0.1M Ascorbic acid; 2hr; 94°C **(3)**	10 ml Conc HNO_3; 2hr **Step (5)**		30 ml 10M HF + 5g Boric acid; 8hr **Step (4)**	Mine waste dumps Jarosite
Mend	1gm; 5ml DI H_2O; 30 min **(1)**	20ml of NaAcetate pH 5 with HOAc; 6hrs; 25°C **(2)**		30 ml of 0.5 M $NH_2OH.HCl$ in 25 % HOAc; 6hr; 96°C **(3)**		30 % H_2O_2 pH 2 with HNO_3; 5hr 85°C; Then agitate 30 min with 3.2 M NH_4OAc in 20 % HNO_3 **(4)**		Totals decomposition & Anal. **(5)**	Oxidised waste rock

* Tamm reagent = 10.9g/L oxalic acid + 16.1 g/L ammonium oxalate, pH 2.85.

3.3.3 Proposed Sequential Extraction Procedure

The proposed sequential extraction procedure is a combination of methods developed by Pinto, Al-Abed *et al,* (2014), Piatak *et al,* (2007) (US EPA), Leinz *et al,* (2000), Rio Tinto, RT (2014). The criteria considered when formulating the proposed method included:

- The chemical reagents and concentrations used in each step were considered appropriate based on current understanding of the mineralogy and petrology of regolith materials contributing to waste rock from iron ore mines in the Pilbara Region of Western Australia.
- The ionic composition and reagent solution strengths were suitable for use in modern ICP-AES and ICP-MS instruments. High reagent solution concentrations, especially those containing non-volatile solutes, tend to reduce the efficiency of solution nebuliser systems, resulting in poor precision and loss of sensitivity.
- Reagents selected are readily available in high purity forms. Concentrations of target analytes in reagent solutions ("reagent blanks") should preferably be below the method reporting limit.

Descriptions of each extraction step are presented below and a schematic diagram of the procedure is shown in Figure 2. The proposed sequential extraction procedure was performed on seven samples in duplicate and with two blanks. The full method procedure is "commercial in confidence" and it is only available to the sponsors of this project in a separate document (Appendix A).

The optimised sequential extraction procedure measures major ions, metals and metalloids in the following fractions:

1. Water-extractable, using reagent water as the extracting fluid;
2. Exchangeable, using ammonium acetate as the extracting fluid;
3. 'Carbonate', using dilute acetic acid as the extracting fluid;
4. Amorphous Fe/Mn oxide, using a solution of hydroxylamine in dilute hydrochloric acid as the extracting fluid;
5. Crystalline Fe/Mn oxide, using 4 M hydrochloric acid as the extracting fluid;
6. Easily oxidisable, using oxidation with a mixture of sodium chlorate and hydrochloric acid as the extracting fluid; and

Recalcitrant oxidisable, using oxidation with hydrogen peroxide solution as the extracting fluid.3.3.3.1. Water Extractable (F1)

The water-soluble fraction of a soil or sediment is the first to be brought into solution in any sequential scheme. For materials containing sparingly soluble salts such as gypsum, the results obtained are dependent on the sample to solution ratio adopted. Sample to solution extraction ratios of 1:20 are commonly used in standardised water extraction methods (such as the Australian Standard Leach Procedure, ASLP) and was adopted for the fraction extractions in this procedure.

Step 1. To 2 g of a finely milled sample in a 50-mL screw-cap centrifuge tube, add 40 ml of Milli-Q water and cap.

Step 2. Vortex contents for 5-10 s and place in a shaker for 2 h at 25°C.

Step 3**.** Centrifuge for 10-20 minutes at 3,000 rpm and decant supernatant liquid into a labelled test-tube. Rinse the residue with 5 mL of Milli-Q water, shaken/agitated for 10-15 minutes and centrifuged at 3,000 rpm; do this twice and add supernatant rinses to the labelled test-tube. Make the volume up to the 50 mL and filtered through a 0.45 μm membrane, and then retain for analysis. Retain residue for the next extraction step. (Note: centrifuge time can vary depending on the sample settlement).

3.3.3.2. Exchangeable Fraction (F2)

Exchangeable metals, those held through electrostatic attraction on exchange sites on the surface and interface of negatively charged complexes of soils and weathered regolith, also generally constitute a small proportion and can be replaced by neutral salts such as $MgCl_2$, $BaCl_2$, ammonium chloride or ammonium acetate. Ammonium acetate was selected as the preferred extractant as it is available in high purity, does not introduce an analyte of interest (such as magnesium, sodium or potassium) and enables very low detection limits with modern analytical instruments due to its volatility in a plasma.

3.3.3.3. Carbonate Fraction (F3)

The 'carbonate bound' fraction usually releases metals and metalloids that are incorporated in carbonate mineral lattices , or sorbed onto carbonate minerals, clays, organic matter.

The sum of the first three steps (F1, F2 and F3) in the sequential leaching process is called the 'labile fraction' (Ahumada *et al*, 2011) and involves the portion of contaminants that represent a greater potential environmental risk for groundwater and superficial water.

Acetic acid was selected as the extracting solution. It quantitatively dissolves reactive minerals such as calcite and aragonite, and slowly dissolves mixed carbonate minerals, such as dolomite, ankerite and ferroan calcite. Stronger mineral acids such as HCl were not used as they were considered to be too aggressive towards other mineral phases such as iron oxides, reactive silicates and clay minerals.

3.3.3.4. Reducible Phases

Amorphous Fe/Mn oxyhydroxide fraction (F4)

Easily reducible fraction ie the fraction bound to amorphous Fe and Mn oxides (metals bound to short range -order Fe, Al and Mn (oxy) hydroxides and poorly crystallised ferric hydroxysulfates.

Crystalline Fe/Mn oxyhydroxide fraction (F5)

Moderately reducible fraction i.e. the fraction bound to crystalline Fe and Mn oxides (metals bound to long-range-order Fe, Al and Mn (oxy) hydroxides and well-crystallised ferric hydroxysulfates).

3.3.3.5. Total Oxidisable (Sulfide and Oxidisable Organic Matter)

Easily Oxidisable Fraction(F6)

This fraction consists of metals bound to disseminated primary sulfides and humic substances.

Note that this step introduces sodium (from sodium chlorate used as the oxidising agent) into the scheme. Hence, the sodium data from this fraction cannot be included in the sequential leaching data assessment.

Recalcitrant oxidisable fraction (F7)

This fraction represents metals associated with very stable organic matter and crystalline primary sulfides.

3.3.3.6. Residual Fraction

For the purposes of this study, the residual phase has been designed to represent the total concentration of elements remaining after sequential leaching. Hence, 4-acid digestion was chosen to completely dissolve the silicate matrix.

Residual fraction represents metals strongly associated with crystalline structures of minerals and remaining resistant fractions that are unlikely to be released under the normally encountered conditions.

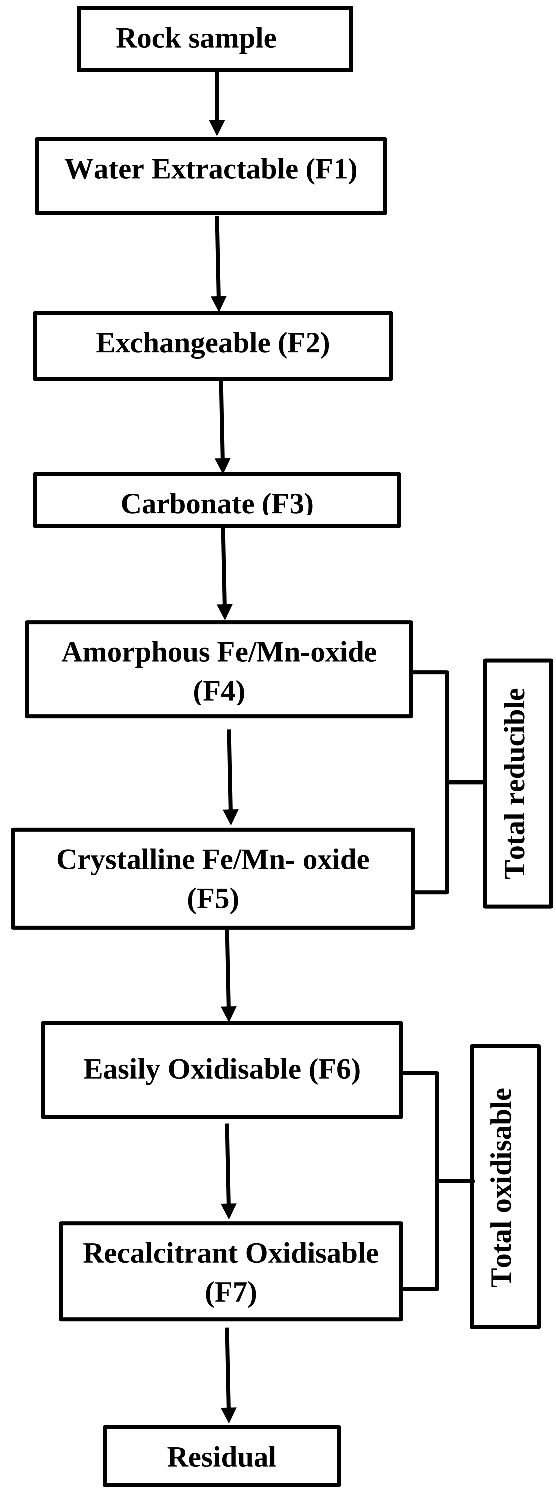

Figure 2: Proposed Sequential Leaching Method Schematic.

3.4 LEAF 1313 Tests

The LEAF 1313 test (USEPA SW-846 method 1313) is a leaching environmental assessment framework method 1313 that involves the liquid-solid partitioning as a function of extract pH using a parallel batch extraction procedure.

The LEAF 1313 test was performed on seven samples (milled to particle size < 200 µm) in duplicate.

3.4.1 Procedure

The procedure for this method consisted of nine parallel extractions of a solid material (the test sample) in dilute acid or base and reagent water. Particle-size of the material to be tested was < 200 µm. A schedule of acid and base additions was formulated from a pre-test titration curve indicating the required equivalents/g acid or base to be added to the series of extraction vessels so as to yield a series of eluates having specified pH values of 2.0, 4.0, 5.5, 7.0, 8.0, 9.0, 10.5, 12.0 and 13.0 ± 0.5. Also a sample natural pH extract was performed, i.e. no pH adjustment was performed on the sample. In addition to the ten test extractions, three method blanks without solid samples were carried through the procedure in order to verify that analyte interferences were not introduced as a consequence of reagent impurities or equipment contamination.
The thirteen bottles (i.e. nine test positions, natural sample pH and three method blanks) were extracted using the extraction parameters according to the sample particle size distribution, highlighted in yellow in Table 3. The Liquid to Solid (dry weight) ratio (L/S) was 10:1, taking into account reagent addition and moisture content of the solid. The tumbling apparatus was digitally set at 30.0 rpm and kept in a room at a constant temperature of 22 ± 5°C. Then, the liquid and solid phases were separated by centrifugation and filtration. Analytical samples of the filtered eluate were collected and preserved where appropriate for chemical analysis.

Table 3: Extraction Parameters as a Function of the Sample's Maximum Particle Size.

Particle Size (85% less than) (mm)	Minimum Dry Mass (g)	Contact Time (hours)
0.3	20 ± 0.02	24 ± 2
2.0	40 ± 0.02	48 ± 2
5.0	80 ± 0.02	72 ± 2

4 Analytical Methods

4.1 Sample Characterisation

Full sample characterisation was performed on the seven waste rock samples (milled to particle size < 200 µm) prior to the start of test work.

Mineral characterisation was performed by X-ray powder diffraction (XRPD) and scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM/EDX) A representative sub-sample was pulverised for examination using XRPD analysis. The results were refined using the results of supplementary examination using SEM/EDX.

Total elemental composition analysis (for Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, S, Se, Si, V and Zn) of the seven samples was performed by (i) X-ray fluorescence (XRF) and (ii) four acid digestion (HNO_3/$HClO_4$/HF/HCl) with analysis using inductively coupled plasma-atomic emission spectrometry (ICP-AES).

The seven samples were also subjected to Acid-base accounting and related analysis as listed below;

- Sulfate-S (S-SO4);
- Total oxidisable sulfur (TOS);
- Acid Neutralising Capacity (ANC);
- Chromium-reducible sulfur (CRS); and
- Net Acid Generation (NAG) and measuring NAG pH.

4.2 Chemical Analysis of Solutions and Leaching Residues

The analysis of all test solutions derived from the sequential leaching, LEAF 1313 test and kinetic leaching included pH, electrical conductivity (EC) and the determination of elemental concentrations (for Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, S, Se, Si, V and Zn) by ICP/AES and inductively coupled plasma-mass spectrometry (ICP-MS).

All analytical data were assessed for accuracy, precision using a quality control system involving duplicates and blanks during the analytical procedure.

The residue samples derived from all the sequential leaching tests were analysed for total elemental composition (for Ag, Al, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Li, Mg, Mn, Mo, Na, Nb, Ni, P, Pb, S, Se, Si, V and Zn) by four acid digestion (HNO_3/$HClO_4$/HF/HCl) with analysis using inductively coupled plasma-atomic emission spectrometry (ICP-AES).

4.3 Statistical Analysis

Statistical data analysis was performed using Excel to compare the predicted metal concentrations derived from the sequential leaching studies against the metal concentrations arising from the kinetic studies. Reproducibility data was obtained for quality control and quality assurance from performing kinetic leaching, sequential leaching and LEAF 1313 test in duplicate for each of the seven rock samples.

5 RESULTS AND DISCUSSION

5.1 Materials Characterisation

5.1.1 Elemental Composition

Results for total elemental analysis of seven rock samples are summarized in Table 4.

Included in Table 4 for comparative purposes are the average crustal abundances for each element (AIMM 2001). Minor elements presented in specific materials at concentration 12 times[1] greater than the average crustal abundance are considered to be "mineralised" on the basis of significant geochemical enrichment.

As expected, aluminium and iron were the predominant components in all samples. Elevated K and Mg concentrations were found in the JN/OB25 Fresh sample, followed by W/OB25 Fresh, while elevated manganese was noted in W/OB25 Fresh followed by MMOB32 Trans/BWT sample. All other samples had manganese concentrations between 50-200 mg/kg. JN/OB25 Fresh sample recorded higher concentrations of copper, chromium and vanadium compared to all other samples. Elevated lead was noted in W/OB25 Fresh, whereas all other rock samples contained less than 100 mg/kg.

5.1.2 Sulfur Speciation and Acid Formation Potential

The samples were analysed for the following forms of sulfur in order to assess the risk of acid formation:

- Total sulfur. This fraction includes all forms of inorganic (oxidised and reduced forms) and organic sulfur.
- Sulfate sulfur (SO_4-S). This fraction, measured as sulfur extraction by dilute hydrochloric acid solution, measures soluble, oxidised forms of sulfur. Apart from various sulfo salts such as jarosite and alunite, this form of sulfur does not produce acidity by weathering and leaching.

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[1] A significant geochemical enrichment factor of 12 is based on the global abundance index (GAI) methodology described by the International Network for Acid Prevention (INAP). The GAI (based on a log-2 scale) is expressed in integer increments from 0 to 6 (GARD Guide, INAP 2009). A GAI of 0 indicates that the content of the element is less than or up to three times the average crustal abundance; a GAI of 1 corresponds to a three to six fold enrichment; a GAI of 2 corresponds to a 6 to 12 fold enrichment and so forth, up to a GAI of 6, which corresponds to a 96-fold, or greater, enrichment above average crustal abundances. A GAI of 3 or more is generally considered significant and may warrant further investigation.

- Total Oxidisable Sulfur (TOS). TOS is considered to include all sulfide minerals, even though only some of these minerals are potentially acid forming when exposed to oxidising conditions.
- Chromium Reducible Sulfur (CRS). This method is a direct measure of acid volatile and reducible sulfide minerals, many of which are responsible for acid generation. Despite some limitations, this method is considered more specific than TOS as an indicator of potential acid generation.

Results for sulfur speciation and acid base accounting data are presented in Table 5.

JN/OB25 Fresh had the highest total sulfur concentration, followed by MM/OB29 Weathered, whereas all other samples recorded S concentrations between 20-470 mg/kg. In the JN/OB25 Fresh and MM/OB29 Weathered samples, most of the total S was present in the oxidisable S fraction, followed by the sulfate-sulfur fraction. Sulfate-sulfur was the major form of sulfur in MM/OB29 Trans S.

All samples were classified as Non Acid Forming (NAF) according to commonly adopted published criteria for acid formation potential (AMIRA 2002, INAP 2009, DIIS 2016).

The difference between TOS (0.33%) and CRS (0.02%) in sample JN/OB25 Fresh is noteworthy. For most rock types containing primary iron sulfides and their weathering products (for example, gypsum, jarosite and alunite), TOS and CRS results are in close agreement. Differences arise when the materials contain insoluble forms of sulfate, such as the sulfate compounds of barium (barite) and strontium (celestite) or sulfur associated with organic matter. The issue of using CRS values alone for the prediction of acid metalliferous drainage has been studied by the authors in a separate project (Black *et al,* 2015 and Allen *et al*, 2016).

5.1.3 Mineralogy

Mineralogical composition of seven rock samples is presented in Table 6. The crystalline Fe-oxide and Fe-hydroxysulfate minerals found in these samples included goethite [$FeOOH$] and hematite [Fe_2O_3] XRPD and SEM/EDX analysis showed that the main minerals present in the samples were quartz (SiO_2), mica-dioctahedral ("muscovite", $KAl_2(AlSi_3O_{10})$ (F, OH)$_2$), kaolinite (Al_2SiO_3 $(OH)_4$, hematite (Fe_2O_3) and goethite (FeO (OH). Anatase (TiO_2) and maghemite (γ-Fe_2O_3) were not detected by XRPD and SEM/EDX analysis.

Mineralogical analysis indicated the following:

- A high clay mineral content (mainly dioctahedral micas and kaolinite) with quartz and accessory goethite in JN/OB25 Fresh;
- MM/OB29 transition was a goethite iron ore with minor amounts of hematite and kaolinite clay. MM/OB29 Weathered had similar mineralogy, but with a lower goethite content;

- W/OB25 Transition was a slightly ferruginous sediment dominated by quartz (45-55%) and kaolinite clay (20-30%). The corresponding sample of unweathered material (W/OB25) contained dioctahedral mica (20-30%) and less (2-5%) kaolinite;
- D1/Whaleback Fresh was a moderately ferruginous quart-rich sediment (55-65% quartz) with minor kaolinite clay (5-10%); and
- MM/OB32 Transition (below water table) was a sample of banded BIF comprising 50-60% quartz and both hematite (1-15%) and goethite (28-36%) as iron oxide minerals.

Table 4. Results for total elemental composition of waste rock samples

Sample	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
	mg/kg											
JN/OB25 Fresh	0.7	120000	X	99	1.1	180	X	9	150	712	26700	36300
MM/OB29 Weathered	X	23900	4	225	1.2	500	1	16	40	32	510000	320
MM/OB29 Trans.	X	14200	X	X	1.1	155	2	27	10	18	623000	X
W/OB25 Trans.	X	52500	17	30	1.2	145	X	8	90	20	199000	340
W/OB25 Fresh	0.6	44700	281	172	1.5	210	X	19	55	51	136000	16300
D1/Whaleback Fresh	X	11000	21	9	1.0	135	X	20	20	21	268000	110
MMOB32 Trans/BWT	<0.5	1930	4	160	<0.5	135	<1	<1	<10	6	327000	<100
Average Crustal	0.07	82000	25	425	0.17	41000	0.11	20	100	50	41000	21000

Sample	Li	Mg	Mn	Mo	Na	Ni	P	Pb	S	Se	V	Zn
	mg/kg											
JN/OB25 Fresh	30	8000	54	X	400	15	145	83	3250	X	195	24
MM/OB29 Weathered	X	195	181	X	620	14	580	14	1110	X	42	58
MM/OB29 Trans.	1	315	168	6	180	10	795	11	470	X	9	78
W/OB25 Trans.	2	250	80	X	165	14	1360	20	225	X	61	24
W/OB25 Fresh	20	3200	3260	8	275	23	350	723	145	X	52	147
D1/Whaleback Fresh	1	95	56	X	X	5	395	6	220	X	22	15
MMOB32 Trans/BWT	4	270	1180	7	<50	<5	385	<5	<20	<10	<1	8
Average Crustal	20	23000	950	1.5	23000	75	1000	14	420	0.2	135	70

Notes: *X denotes values below the method reporting limit.*

Table 5. Results for sulfur speciation and acid base accounting calculations

Sample	S	SO_4-S	TOS	CRS	ANC	AP	NAPP	NAG	NAGpH	Classification
	%				kg H_2SO_4/t					
JN/OB25 Fresh	0.35	0.02	0.33	0.017	1.7	0.5*	-1.2*	<0.5	5.8	NAF
MM/OB29 Weathered	0.09	0.04	0.05	<0.005	2.3	<0.2	-2.3	<0.5	6.0	NAF
MM/OB29 Trans.	0.03	0.03	<0.01	<0.005	1.9	<0.2	-1.9	<0.5	5.9	NAF/Barren
W/OB25 Trans.	0.02	0.01	0.01	0.006	1.9	0.2	-1.7	<0.5	5.3	NAF/Barren
W/OB25 Fresh	0.02	0.01	0.01	<0.005	2.1	<0.2	-1.9	<0.5	6.8	NAF/Barren
D1/Whaleback Fresh	0.02	0.01	0.01	<0.005	<0.5	<0.2	-	<0.5	5.2	NAF/Barren
MMOB32 Trans/BWT	<0.01	<0.01	<0.01	0.03	1.5	1.0	-0.5	<0.5	6.5	NAF/Barren

Notes: *TOS - total oxidisable sulfur, calculated as difference between total sulfur and sulfate sulfur (SO_4-S)*

CRS – chromium reducible sulfur

ANC – Acid Neutralising Capacity

AP – Acid Potential, calculated from CRS (by multiplying by a factor of 30.6)

NAPP – Net acid Producing Potential, calculated as difference between AP and ANC

NAG – Net Acid Generation, measured by titration of acidity produced by oxidation with hydrogen peroxide (AMIRA 2002)

Classification – samples classified as Non Acid Forming (NAF) if NAPP values are negative and NAG pH values are greater than 4.5. May be further sub classified as 'Barren' if total sulfur <0.05% and ANC < 5 kg H_2SO_4/t

* Sample JN/OB25 Fresh was classified as NAF based on a negative value for NAPP calculated from CRS, and a NAG pH value greater than 4.5. The sample would have been classified as "Uncertain" using a NAPP value calculated from TOS. In this case, a calculated positive NAPP value of 8.4 kg H2SO4/t indicates an excess of acid-forming sulfide minerals over acid consuming minerals, suggesting PAF classification. This was not supported by a NAG pH value of 5.8, indicating minimal acid acid production under strongly oxidising conditions. According the AMIRA 2002 acid formation potential classification criteria, such a material would be classified as "Uncertain".

Table 6. Minerals identified by XRPD and SEM/EDX

Sample	Quartz %	Mica dioctahdral %	Kaolinite %	Anatase %	Hematite %	Goethite %	Maghemite %
JN/OB25 Fresh	15-25	50-60	15-25	<2	<2	2-4	nd
MM/OB29 Weathered	5-10	nd	5-10*	nd	<2	65-75	nd
MM/OB29 Trans.	<1	nd	5-10	nd	5-10	80-90	nd
W/OB25 Trans.	45-55	nd	20-30	nd	10-15	5-10	nd
W/OB25 Fresh	50-60	20-30	2-5	nd	5-10	5-10	nd
D1/Whaleback Fresh	55-65	nd	5-10	nd	20-25	5-10	nd
MMOB32 Trans/BWT	50-60	nd	nd	nd	10-15	28-36	nd

Notes: *nd – not detected;*

** - the amount of crystalline quartz and kaolinite observed in this sample are insufficient to account for the concentrations of alumina and silica found by EDX analysis.*

5.2 Long Term Kinetic Test

Results for the concentrations of solutes (with pH and EC data) from the long-term leaching of seven rock samples with deionised water (DI water) over 24 months are presented in Appendices 1 and 2:

- Appendix 1 presents leachate analysis results (mg/L) for all leachate solutions collected over 24 months from duplicate columns of each sample. Freshwater aquatic ecosystem trigger values and livestock drinking water guidelines (ANZECC 2000) are included comparators to provide context for the results. Exceeding these values does not imply a significant environmental risk as site-specific factors must be considered for each mining project.

- Appendix 2 presents the cumulative mass of each solute leached from each sample (mean values in mg/kg) for each sampling event. Calculated values are present as both tables and charts for each sample.

Decreasing pH values were noted for JN/OB25 Fresh, W/OB25 Trans, W/OB25 Fresh sample, while a minor increase occurred for D1/Whaleback Fresh over 24 months (Appendix 1). There was no significant change in pH values for MM/OB29 Weathered and MM/OB29 Trans over 24 months (Appendix 1).

The only exceedances of livestock drinking water guidelines (ANZECC 2000) were for copper (after 9 months) and selenium (after 4 months) in leachates from sample JN/OB25 – a sample of shale from the Jeerinah Formation at Orebody 25. As stated previously, this does not imply that seepage from waste rock stockpiles containing this type of waste will present a significant environmental risk.

Results for each sample relevant to this investigation are described in more detail in the following sections.

5.2.1 JN/OB25 (Fresh Jeerinah Shale):

Leachate pH values were circum-neutral to slightly acidic throughout the 24 month experiment and generally indicated a decreasing trend. Mean values decreased from 7.6 at week 0 to 6.1 at month 24.

Leachate salinity was variable, as indicated by mean EC values ranging from 3.2 to 73 mS/m (indicating slightly brackish water quality). Sodium was the dominant cation in the week 0 leachate (29.7 mg/L in column 1), and concentrations decreased thereafter, indicating a “solute wash-out” trend. On the other hand, calcium, magnesium and potassium generally increased. Sulfur concentrations also increased over time, ranging from 19 mg/L at week 0 to 42 mg/L at month 24 (column 1). These results provide evidence for formation of calcium and magnesium sulfate salts by oxidation of small amount of sulfide minerals in this material (Section 5.1.2).

Concentrations of several metals and metalloids increased steadily over time, with concentrations of copper and selenium exceeding livestock drinking water quality guidelines after months 9 and 4, respectively. Maximum concentrations (from column 1) were 7.5 mg/L (month 24) and 0.19 mg/L (month 21), respectively.

Maximum concentrations of other environmentally important metals and metalloids (from column 1) were:

- Cadmium, 0.0006 mg/L at month 24 (exceeding the ANZECC 2000 freshwater guideline value of 0.0002 mg/L).
- Cobalt, 0.14 mg/L at month 21 ((exceeding the low reliability ANZECC 2000 freshwater guideline value of 0.0014 mg/L).
- Nickel, 0.032 mg/L at month 24 (exceeding the ANZECC 2000 freshwater guideline value of 0.011 mg/L).
- Zinc, 0.22 mg/L at month 24 (exceeding the ANZECC 2000 freshwater guideline value of 0.008 mg/L).

Concentrations of iron, manganese, chromium and vanadium were generally very low, indicating moderately oxic conditions within the column.

5.2.2 W/OB25 Transitional:

Leachate pH values of this sample were variable over time. Initial values were circum-neutral (mean value 6.5 at week 0), but then became increasingly acidic (minimum pH 4.75 at month 3), before increasing at stabilising within the range 5.8 to 6.2.

Leachate salinity was variable, as indicated by mean EC values ranging from 78 to 8.8 mS/m (indicating generally fresh water quality). All major ions (Na, Ca, Mg, K and S) showed decreasing trends, indicating “wash-out” of solutes present in the supplied sample.

Concentrations of metals and metalloids were consistently very low and showed no systematic increasing or decreasing concentration trends over time.

Concentrations of iron, manganese, chromium and vanadium were very low, indicating moderately oxic conditions within the column.

5.2.3 W/OB25 Fresh:

Leachate pH values showed little variation, ranging from 7.15 at week 0 to 6.65 at month 2, to a final value of 6.75 after 24 months.

Leachate salinity was very low, as indicated by mean EC values ranging from 28 to 2.8 mS/m (indicating fresh water quality). All major ions (Na, Ca, Mg, K and S) showed decreasing trends, indicating "wash-out" of solutes present in the supplied sample.

Concentrations of metals and metalloids were consistently very low and showed no systematic increasing or decreasing concentration trends over time.

Despite this sample being enriched in lead (723 mg/kg, Table 4), concentrations in leachate were generally below the method reporting limit of 0.0001 mg/L. The highest concentration was 0.0004 mg/L recorded in leachate from column 1 in month 21.

Concentrations of iron, manganese, chromium and vanadium were very low, indicating moderately oxic conditions within the column.

5.2.4 MM/OB29 Transition:

The was very little variation in pH values of leachates from this sample from the sample of transition zone of the Marra Mamba Formation. The initial mean pH (week 0) was 6.9, while the leachate from month 24 had a pH of mean pH of 6.7. The lowest mean pH was 6.55 in the leachate from month 21.

Leachate salinity was generally low, as indicated by mean EC values ranging from 186 to 9.9 mS/m (indicating brackish to fresh water quality). All major ions (Na, Ca, Mg, K and S) showed decreasing trends, indicating "wash-out" of solutes present in the supplied sample.

Concentrations of metals and metalloids were consistently very low and showed no systematic increasing or decreasing concentration trends over time.

Concentrations of iron, manganese, chromium and vanadium were very low, indicating moderately oxic conditions within the column.

5.2.5 MM/OB29 Weathered:

The corresponding weathered sample of Marra Mamba Formation (MM/OB29 Weathered) recorded slightly higher leachate pH values than the transition zone sample, with values ranging from7.9 (week 0) to 7.05 (month 24); there was no discernible trend over time.

Leachate salinity was generally low, as indicated by mean EC values ranging from 186 to 9.9 mS/m (indicating brackish to fresh water quality), with monthly values being similar to those of the corresponding transition zone sample. All major ions (Na, Ca, Mg, K and S) showed decreasing trends, indicating "wash-out" of solutes present in the supplied sample.

With a minor exception of copper, concentrations of metals and metalloids were consistently very low and showed no systematic increasing or decreasing concentration trends over time. Copper concentrations in leachate from column 1 increased from <0.001 mg/L at week 1 to 0.0053 mg/L at month 24, with all values well below the livestock drinking water guideline of 1 mg/L. The maximum value was 0.012 mg/L in leachate collected at month 10. All leachate samples collected from month 9 forward recorded copper concentrations above the conservative freshwater aquatic guideline of 0.0014 mg/L (ANZECC 2000).

Concentrations of iron, manganese, chromium and vanadium were very low, indicating moderately oxic conditions within the column.

5.2.6 D1/Whaleback Fresh:

Water leachates of this material were circum-neutral to slightly alkaline, with mean pH values ranging from 8.05 (week 0) to 7.5 at month 24.

Leachate salinity was generally low, as indicated by mean EC values ranging from 120 to 6.8 mS/m (indicating brackish to fresh water quality), with monthly values being similar to those of the corresponding transition zone sample. All major ions (Na, Ca, Mg, K and S) showed decreasing trends, indicating “wash-out” of solutes present in the supplied sample. Leachates from the last 6 months of the trial were close to rainwater quality.

This sample was the only one to provide leachates with measurable concentrations of arsenic. Concentrations increased from 0.002 mg/L at week 0 to a maximum of 0.017 mg/L at month 18, with all concentrations being well below the livestock drinking water guideline and freshwater aquatic guideline values of 0.5 and 0.024 mg/L (As III), respectively. Several samples exceeded the lower aquatic freshwater trigger value of 0.013 mg/L for pentavalent arsenic (As V).

Slightly elevated concentrations of molybdenum were present in leachates of this sample. Concentrations in leachates from column 1 ranged from 0.003 mg/L (month 1) to 0.047 mg/L (month 9), although there was no discernible trend over the full 24 months. All concentrations were well below the livestock drinking water guideline of 0.15 mg/L.

Despite slightly elevated concentrations of arsenic and molybdenum oxyanions, concentrations of selenium were very low. Traces of soluble chromium were also noted, with a maximum concentration of 0.033 mg/L in leachate collected from month 18. As trivalent chromium is effectively insoluble at circum-neutral pH, the soluble chromium may be present in the hexavalent form, for which the aquatic freshwater guideline value is 0.001 mg/L.

Concentrations of iron, manganese and vanadium were generally low, indicating moderately oxic conditions within the column. Slightly elevated (0.23 mg/L) of iron was recorded towards the end of the trial.

5.2.7 MMOB32 Trans/BWT:

The initial (week 0) leachate of this sample was slightly acidic, with a mean pH of 5.55. Thereafter, most pH values indicate circum-neutrality as indicated by a range from 6.8 (week 1) to 7.6 (months 9 and 10).

Leachates of this material were typically less saline than those from other samples, with EC values decreasing from a mean value of 35 mS/m at week to 2.55 mS/m at month 12, indicating close to rainwater quality.

Concentrations of metals and metalloids were consistently very low and showed no systematic increasing or decreasing concentration trends over time.

Concentrations of iron, manganese, chromium and vanadium were very low, indicating moderately oxic conditions within the column.

5.3 Sequential Leaching Study

5.3.1 Comparison of Literature Methods

The four sequential extraction procedures studied are summarised in Table 2 (highlighted in green), section 3.3.2.

The metal concentrations found in each operationally defined fraction are expressed as the fraction of the total extracted amount (as percentage) and also in the actual concentration found in each fraction. In the present investigation, the results (mean of duplicates) of the sequential extraction of the seven rock samples by four published sequential extraction procedures are presented in Appendix 3 as followed:

- Table A3-1 and Figure A3-1 of Appendix 3 present the results for the fractionation procedure of Pinto, Abed *et al,* 2014.
- Table A3-2 and Figure A3-2 of Appendix 3 present the results for the fractionation procedure of Piatek *et al,* 2007.
- Table A3-3 and Figure A3-3 of Appendix 3 present the results for the fractionation procedure of Leinz *et al,* 2000
- Table A3-4 and Figure A3-4 of Appendix 3 present the results for the fractionation procedure of Rio Tinto 2014.

A comparison between the results from four acid digests of the original sample (Pseudo total) and the values from different extraction steps of four methods (∑Extraction steps + four acid extractable from residual) was carried out (Table A3-5 of Appendix 3). The recovery of the sequential extraction was calculated as follows: recovery = [(Total of all fractions + residual)/pseudo total] ×100. As can be seen the percent recovery varies from 65 % -110 % for all the metals and metalloids extractions using four different methods on seven rock samples.

5.3.2 Reagent Blanks

Samples of the extracting solutions (reagent blanks) for each step of all four sequential leach procedures assessed were included with each batch of extractant solutions for analysis by ICP-AES or ICP-MS.

Several reagents contained either major constituent elements or contaminants that may potentially limit the quality of results. Table 7 presents results for analysis of all extracting solutions used in the four methods. Results that may affect the overall quality of data are summarised below:

- Magnesium is introduced into the method of Abed *et al,* (2014) in the second step ('exchangeable'). This is undesirable as the residual solution from this step may cause carry over of magnesium into the following step ('carbonate'). Quantitation of magnesium in the 'carbonate' step is important because dissolution of calcium and magnesium carbonates is an important source of solute release in many WA mine waste materials.
- Sodium is present as a constituent of the following extracting solutions:
  - The acidic sodium acetate buffer used to measure 'carbonate' fraction solutes in the method of Abed *et al,* (2014).
  - Sodium hypochlorite used to measure 'oxidisable' fraction solutes in the method of Abed *et al,* (2014).
  - The sodium acetate solution used to measure 'exchangeable' fraction solutes in the method of Leinz *et al,* (2000).
  - Sodium hypochlorite used to measure 'oxidisable' fraction solutes in the method of Leinz *et al,* (2000).
  - The acidic sodium acetate buffer used to measure 'carbonate' fraction solutes in the method of Leinz *et al,* (2000).
  - Sodium chlorate used to measure 'oxidisable' fraction solutes in the method of Leinz *et al,* (2000).
  - Potassium and phosphorus in the potassium dihydrogen phosphate solution used to measure 'soluble and exchangeable' fraction solutes in the method of Piatek *et al*, (2007).
  - Potassium chlorate used to measure 'oxidisable' fraction solutes in the method of Piatek *et al*, (2007).

- Barium contaminants of the sodium acetate reagent used to measure 'exchangeable' and 'carbonate' fractions solutes in the method of Leinz *et al,* (2003).

- Silver in the hydroxylamine/HCl solution used to measure amorphous Fe/Mn oxide fractions in the methods of Piatek *et al*, (2007) and Rio Tinto (2014).

- Iron in the potassium dihydrogen phosphate solution used to measure 'soluble and exchangeable' fraction solutes and in the acetic acid solution used to measure 'carbonate' fraction solutes in the method of of Piatek *et al*, (2007).

- Copper in the aqua regia solution used to measure 'oxidisable' fractions fraction solutes in the method of Rio Tinto (2014).

- Chromium in the hydrogen peroxide solution used to measure 'oxidisable' fraction solutes in the method of Rio Tinto (2014).

- Manganese in the magnesium chloride used to measure 'exchangeable' fractions fraction solutes in the method of Abed *et al,* (2014).

- Niobium in the ammonium oxalate solution used to measure crystalline Fe/Mn oxide fractions in the method of Abed *et al,* (2014).

- Magnesium and sodium in the potassium dihydrogen phosphate solution used to measure 'soluble and exchangeable' fraction solutes in the method of Piatek *et al*, (2007).

- Phosphorus in the hydrogen peroxide solution used to measure 'oxidisable' fractions fraction solutes in the method of Rio Tinto (2014).

Table 7: Concentrations of Contaminating Elements in Extracting Solutions for Four SLP Methods

Method	Extractant	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Abed	1) H_2O	<0.0001	<0.005	<0.001	0.0005	<0.0001	<0.1	<0.0001	<0.0001	<0.0005	<0.0001	<0.005
	2) 1M $MgCl_2$ pH 7	<0.0020	<0.050	<0.020	0.0045	<0.0020	<1.0	<0.0020	<0.0020	<0.010	0.0083	<0.050
	3) 1M NaAc pH 5	<0.0010	<0.050	<0.010	0.034	<0.0010	<1.0	0.0012	<0.0010	<0.0050	0.0012	<0.050
	4) 0.04M $NH_2OH.HCl/HOAc$	0.0004	<0.005	<0.001	0.0005	<0.0001	<0.1	<0.0001	<0.0001	0.0034	0.0004	0.007
	5) 0.2M NH_4Oxal/Hoxal* pH 3	<0.0005	0.016	<0.005	0.005	<0.0005	<0.1	<0.0005	<0.0005	0.0047	<0.0005	0.027
	6) 0.7M NaOCl pH 8.5	<0.0010	0.085	<0.010	0.0021	<0.0010	<1.0	0.0013	<0.0010	<0.0050	0.0028	<0.050
Leinz	1) H_2O	<0.0010	<0.005	<0.010	<0.0010	<0.0010	<0.1	<0.0010	<0.0010	<0.0050	<0.0010	<0.005
	2) 1M NaAc	<0.0010	<0.050	<0.010	0.033	<0.0010	<1.0	0.0026	<0.0010	<0.0050	<0.0010	<0.050
	3) 1M NaAc pH <5	<0.0010	<0.050	<0.010	0.042	<0.0010	<1.0	0.0022	<0.0010	<0.0050	0.0012	<0.050
	4) 0.25M $NH_2OH.HCl/HCl$	<0.0020	<0.050	<0.020	<0.0020	<0.0020	<1.0	<0.0020	<0.0020	<0.010	<0.0020	<0.050
	5) 4M HCl	<0.0010	<0.050	<0.010	0.0029	<0.0010	<1.0	0.0014	<0.0010	<0.0050	<0.0010	<0.050
	6) $NaClO_3/HCl/HNO_3$	<0.0010	<0.050	<0.010	<0.0010	<0.0010	<1.0	0.0016	<0.0010	0.0091	<0.0010	<0.050
Piatak	1) 1M KH_2PO_4	<0.0010	0.031	<0.010	0.0015	<0.0010	3.7	0.0012	<0.0010	<0.0050	0.0011	0.14
	2) 5% HOAc	<0.0010	<0.050	<0.010	0.0014	<0.0010	<1.0	<0.0010	<0.0010	<0.0050	<0.0010	0.12
	3) 0.25M $NH_2OH.HCl/HCl$	<0.0010	<0.050	<0.010	<0.0010	<0.0010	<1.0	<0.0010	<0.0010	<0.0050	<0.0010	<0.050
	4) 1M $NH_2OH.HCl/HOAc$	0.0033	<0.050	<0.010	0.0022	<0.0010	<1.0	<0.0010	0.0018	<0.0050	<0.0010	<0.050
	5) $KClO_3/HCl/HNO_3$	<0.0010	<0.050	<0.010	<0.0010	<0.0010	<1.0	0.002	<0.0010	<0.0050	0.004	<0.050
Rio Tinto	1) H_2O	<0.0001	<0.005	<0.001	0.0002	<0.0001	<0.1	<0.0001	<0.0001	<0.0005	0.0042	<0.005
	2) HOAc pH <3	0.0004	<0.050	<0.001	0.0008	<0.0001	<1.0	0.0004	<0.0001	0.0011	0.0012	<0.050
	3) $NH_2OH.HCl/HCl$ pH 3-4	<0.0010	<0.050	<0.010	<0.0010	<0.0010	<1.0	<0.0010	<0.0010	<0.0050	<0.0010	<0.050
	4) $NH_2OH.HCl/HOAc$ pH <2	0.0034	<0.050	<0.010	<0.0010	<0.0010	<1.0	<0.0010	<0.0010	<0.0050	<0.0010	<0.050
	5) H_2O_2 (NAG)	<0.0001	0.058	<0.001	0.0013	<0.0001	<0.1	0.0022	0.0002	0.0061	0.0027	0.047
	6) Aqua regia pH <1	<0.0010	0.34	<0.010	0.0026	<0.0010	<1.0	<0.0010	0.0012	<0.0050	0.12	0.062

Method	Extractant	K	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Abed	1) H_2O	<0.1	<0.0001	<0.1	<0.0001	<0.001	<0.1	<0.0002	<0.001	<0.1	<0.0001
	2) 1M $MgCl_2$ pH 7	<1.0	<0.0020	19300	0.11	<0.020	1.7	<0.0040	<0.020	<1.0	0.035
	3) 1M NaAc pH 5	<1.0	<0.0010	<1.0	0.016	<0.010	17600	<0.0020	<0.010	<1.0	<0.0010
	4) 0.04M $NH_2OH.HCl/HOAc$	<0.1	<0.0001	<0.1	0.0005	<0.001	0.2	<0.0002	<0.001	<0.1	0.0025
	5) 0.2M NH_4Oxal/Hoxal* pH 3	0.1	<0.0005	<0.1	0.021	<0.005	<0.1	0.018	<0.005	<0.1	0.0027
	6) 0.7M NaOCl pH 8.5	<1.0	<0.0010	<1.0	<0.0010	<0.010	10700	<0.0020	<0.010	<1.0	<0.0010
Leinz	1) H_2O	<0.1	<0.0010	<0.1	<0.0010	<0.010	<0.1	<0.0020	<0.010	<0.1	<0.0010
	2) 1M NaAc	<1.0	<0.0010	<1.0	0.012	<0.010	17800	<0.0020	<0.010	<1.0	<0.0010
	3) 1M NaAc pH <5	1.1	<0.0010	<1.0	0.013	<0.010	17500	<0.0020	<0.010	<1.0	<0.0010
	4) 0.25M $NH_2OH.HCl/HCl$	<1.0	<0.0020	<1.0	0.0021	<0.020	1.4	<0.0040	<0.020	<1.0	<0.0020
	5) 4M HCl	<1.0	<0.0010	<1.0	0.0086	<0.010	1.5	<0.0020	<0.010	<1.0	<0.0010
	6) $NaClO_3/HCl/HNO_3$	1.8	<0.0010	<1.0	0.0044	<0.010	7860	<0.0020	<0.010	<1.0	<0.0010
Piatak	1) 1M KH_2PO_4	2980	<0.0010	0.5	0.0018	<0.010	4.3	<0.0020	<0.010	2500	<0.0010
	2) 5% HOAc	<1.0	<0.0010	<1.0	<0.0010	<0.010	<1.0	<0.0020	<0.010	<1.0	0.0013
	3) 0.25M $NH_2OH.HCl/HCl$	<1.0	<0.0010	<1.0	0.0018	<0.010	<1.0	<0.0020	<0.010	<1.0	<0.0010
	4) 1M $NH_2OH.HCl/HOAc$	<1.0	<0.0010	<1.0	0.0074	<0.010	<1.0	<0.0020	<0.010	<1.0	0.0039
	5) $KClO_3/HCl/HNO_3$	4470	<0.0010	<1.0	0.0014	<0.010	<1.0	<0.0020	<0.010	<1.0	<0.0010
Rio Tinto	1) H_2O	0.4	<0.0001	<0.1	<0.0001	<0.001	<0.1	<0.0002	<0.001	<0.1	0.069
	2) HOAc pH <3	<1.0	<0.0001	<1.0	0.0003	<0.001	<1.0	<0.0002	<0.001	<1.0	0.0015
	3) $NH_2OH.HCl/HCl$ pH 3-4	<1.0	<0.0010	<1.0	<0.0010	<0.010	<1.0	<0.0020	<0.010	<1.0	<0.0010
	4) $NH_2OH.HCl/HOAc$ pH <2	<1.0	<0.0010	<1.0	<0.0010	<0.010	<1.0	<0.0020	<0.010	<1.0	0.0041
	5) H_2O_2 (NAG)	0.2	<0.0001	<0.1	0.0091	<0.001	24.1	0.0032	0.003	8	0.0034
	6) Aqua regia pH <1	<1.0	<0.0010	<1.0	<0.0010	<0.010	<1.0	<0.0020	<0.010	<1.0	0.019

Method	Extractant	S	Se	V	pH	EC
		mg/L	mg/L	mg/L		mS/m
Abed	1) H_2O	<0.1	<0.001	<0.0001	6.4	1.8
	2) 1M $MgCl_2$ pH 7	<1.0	<0.020	<0.0020	5.7	9330
	3) 1M NaAc pH 5	<1.0	<0.010	<0.0010	5.0	4720
	4) 0.04M $NH_2OH.HCl/HOAc$	0.4	<0.001	0.001	1.8	469
	5) 0.2M NH_4Oxal/Hoxal* pH 3	0.1	<0.005	0.0005	2.9	1640
	6) 0.7M NaOCl pH 8.5	<1.0	<0.010	<0.0010	4.4	4290
Leinz	1) H_2O	<0.1	<0.010	<0.0010	5.5	1
	2) 1M NaAc	<1.0	<0.010	<0.0010	8.3	4270
	3) 1M NaAc pH <5	<1.0	<0.010	0.0012	5.1	4100
	4) 0.25M $NH_2OH.HCl/HCl$	<1.0	<0.020	<0.0020	0.9	8360
	5) 4M HCl	<1.0	<0.010	<0.0010	<0.1	
	6) $NaClO_3/HCl/HNO_3$	<1.0	<0.010	<0.0010	<0.1	
Piatak	1) 1M KH_2PO_4	0.9	<0.010	0.0011	4.6	730
	2) 5% HOAc	<1.0	<0.010	<0.0010	2.2	191
	3) 0.25M $NH_2OH.HCl/HCl$	<1.0	<0.010	<0.0010	1.2	4410
	4) 1M $NH_2OH.HCl/HOAc$	<1.0	<0.010	<0.0010	1.4	4720
	5) $KClO_3/HCl/HNO_3$	<1.0	<0.010	<0.0010	<0.1	
Rio Tinto	1) H_2O	<0.1	<0.001	<0.0001	5.5	1.4
	2) HOAc pH <3	<1.0	<0.001	0.0003	2.1	176
	3) $NH_2OH.HCl/HCl$ pH3-4	<1.0	<0.010	<0.0010	1.2	3950
	4) $NH_2OH.HCl/HOAc$ pH<2	<1.0	<0.010	<0.0010	1.4	4550
	5) H_2O_2 (NAG)	<0.1	<0.001	<0.0001	4.4	12.5
	6) Aqua regia pH <1	<1.0	<0.010	<0.0010	<0.1	

5.3.3 Comparison of Methods – Key Findings

Results for concentrations of elements in each fraction from seven samples using the four sequential leaching methods are presented in Appendix 3. Measured concentrations, expressed as mg/kg, are presented in table format. Percentages of each element in each fractions percentage of the corresponding total concentrations are also presented in chart format.

As the chemical principles underlying the formulation of each extracting solution for the four methods are similar, the overall distributions of specific elements in the various fractions for each element were comparable. More detailed descriptions on the partitioning of specific elements is provided in Section 5.3.4 with respect to the optimised sequential leach method.

Common to each method were the very high percentages of elements presenting as the 'silicate (residual)' fraction, notably lithophile elements including aluminium, chromium, iron, manganese and vanadium.

This Section focuses on potentially significant differences in methodology adopted to measure elements associated with the following fractions:

- Carbonate fraction. Calcium and magnesium have been selected as key elements to assess methodologies to measure this fraction.
- Hydrous Fe/Mn oxide fractions. Iron has been selected a as key element to assess methodologies to measure this fraction.
- Total oxidisable fraction. Sulfur has been selected as key element to assess methodologies to measure this fraction.

The water soluble fraction is not discussed further in this section as all methods use reagent water as the extracting fluid, with the only method difference being the adopted sample to solution ratio. Also, the exchangeable fraction is not discussed further as a consequence of the specific methods only differing in the nature of the cation displacing solutions.

5.3.3.1 Carbonate Fraction

Results for analysis of the 'carbonate' fraction extracts for calcium and magnesium in the seven samples by the four methods are presented in Figure 3 and Figure 4, respectively. From these results, it is concluded that:

- Concentrations of calcium and magnesium in the carbonate fractions are generally very low. This is concentration with the circum-neutral pH of these samples (conditions under which calcium and magnesium carbonates are not stable) and the highly weathered state.
- There is reasonable agreement for calcium measured by the Leinz *et al,* (2000), Abed *et al,* (2014) and Piatek *et al,* (2007) methods, while the Rio Tinto (2014) method results are significantly higher. However, the Rio Tinto (2014) method for this fraction also includes the 'exchangeable' fraction, in which calcium concentrations are significant.

- There is reasonable agreement for magnesium measured by the Leinz *et al,* (2000) and Piatek *et al,* (2007) methods, while the Abed *et al,* (2014) results are significantly higher. This difference is attributed to carry over of the preceding 'exchangeable' fraction in which 1 M $MgCl_2$ is used as the extracting solution. However, the Rio Tinto (2014) method for this fraction also includes the 'exchangeable' fraction, in which magnesium concentrations are significant.
- Measured concentrations of magnesium in the 'carbonate' fraction by the Rio Tinto (2014) method are also higher than those measured by the Leinz *et al,* (2000) and Piatek *et al,* (2007) methods. This difference is attributed to the presence of 'exchangeable' magnesium included in this fraction.

Based on these findings, the Piatek *et al,* (2007) method, using dilute acetic acid as the extracting solution, is the preferred method for the carbonate fraction. Note however, that the method requires further assessment using samples containing significant amounts of carbonate minerals to properly validate the method for other waste rock types.

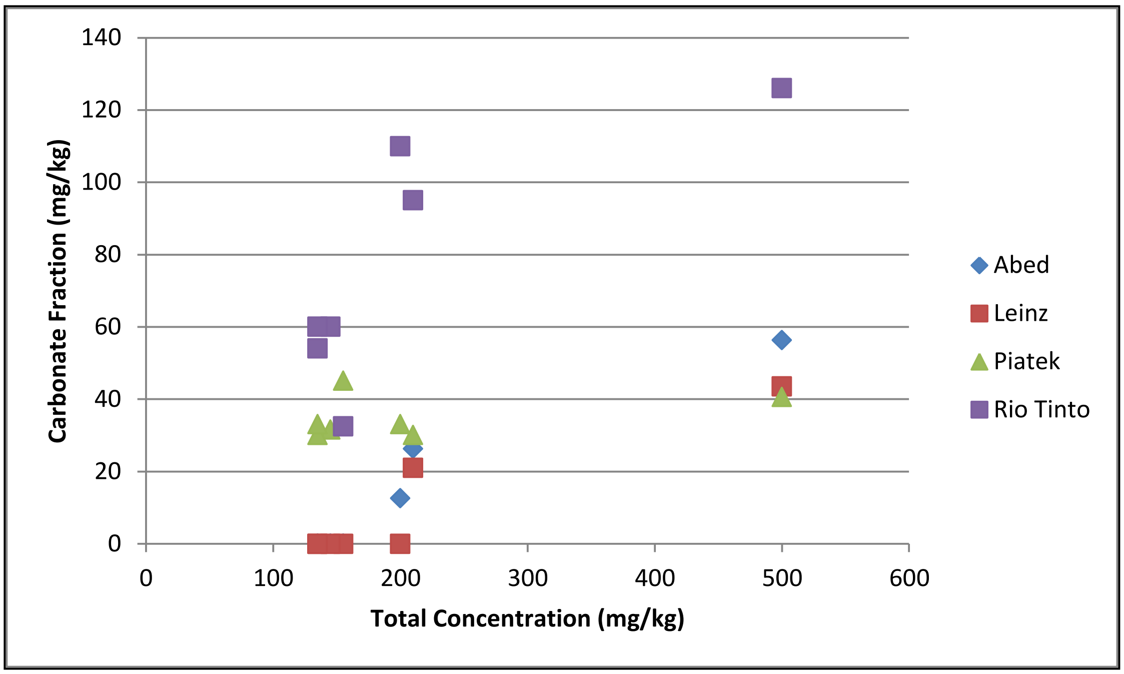


Figure 3: Comparison of Calcium in Carbonate Fraction Measured in the Seven Samples by Four Methods.

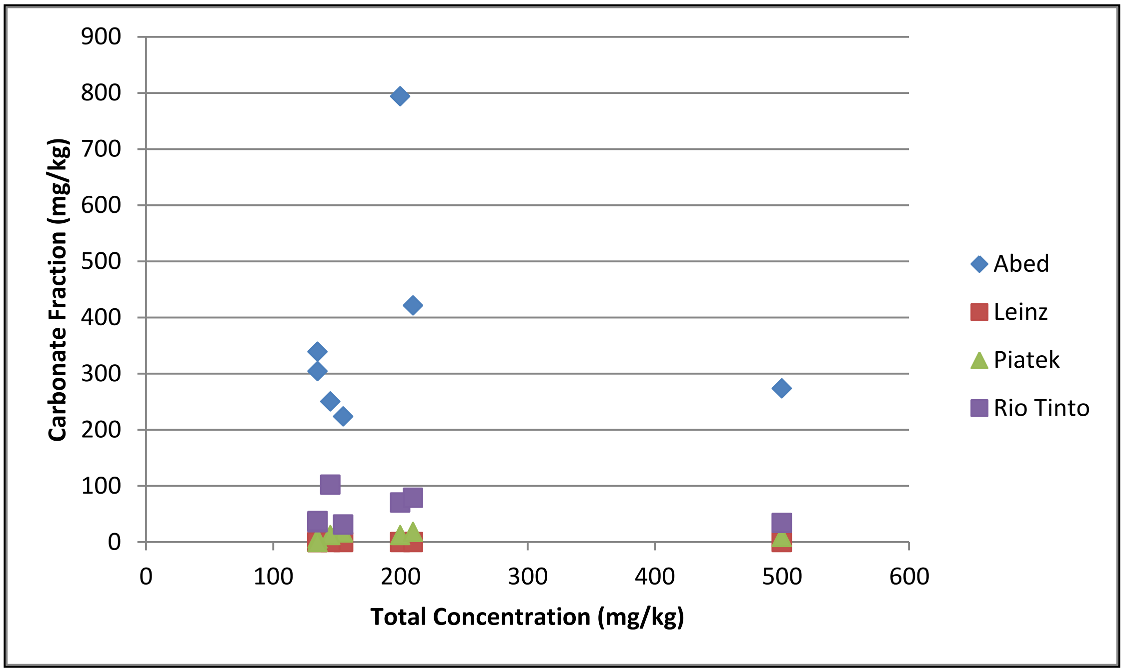


Figure 4: Comparison of Magnesium in Carbonate Fraction Measured in the Seven Samples by Four Methods.

5.3.3.2 Amorphous and Crystalline Fe/Mn Oxide Fractions

Results for analysis of iron in the 'amorphous Fe/Mn oxide' and 'crystalline Fe/Mn oxide' fraction extracts in the seven samples by the four methods are presented in Figures 5 and 6, respectively. From these results, it is concluded that:

- The Leinz *et al,* (2000) and Piatek *et al,* (2007) methods provided the lowest recoveries of iron in the amorphous Fe/Mn oxide fraction. This was as expected as the methods for this fraction are identical, the only source of difference being artefacts from prior fractions.
- The highest recoveries of iron in the amorphous Fe/Mn oxide fraction were provided by the Abed *et al,* (2014) method. The increased extraction efficiency is probably a result of the elevated extraction temperature (95°C; compared to 50°C in the Leinz *et al,* (2000) and Piatek *et al,* (2007) methods).
- Recoveries of iron in the amorphous Fe/Mn oxide fraction using the Rio Tinto (2014)method were between those of the Leinz/Piatek *et al,* (2000, 2007) and Abed *et al,* (2014)methods.
- Very low recoveries of iron in the crystalline Fe/Mn oxide fraction were provided by the Abed *et al,* (2014) method. This observation suggests that some of the iron in this fraction was recovered in the preceding step (amorphous Fe/Mn oxide).
- The highest recoveries of iron in the crystalline Fe/Mn oxide fraction were provided by the Leinz *et al,* (2000) method. This method was the only one that did not include a reducing agent (hydroxylamine) or a ferric iron chelating agent (oxalic acid) in the extracting solution.
- The sum of iron present in the amorphous and crystalline iron oxide fractions was only a small proportion of total iron. This indicates that much of the iron present in iron oxides such as goethite

and hematite is not extracted in either fraction, and most likely contributes significantly to the silicate (residual fraction). It was noted, however, that substantial percentages of total iron were recovered as "total oxidisable" iron in the aqua regia digestion step of the Rio Tinto (2014) method.

The low recoveries of iron from these highly ferruginous samples using these methods are not considered as a shortcoming of the methodology; use of more aggressive reagents to recover iron and associated elements in these fraction is expected to over-estimate potential for leaching under reducing conditions that may be present in a waste rock landform containing these mine wastes.

Based on these observations, the preferred methods for fractionation of elements within the Fe/Mn oxide fractions are:

- 0.25 M hydroxylamine in dilute hydrochloric acid at 50°C (Leinz *et al,* (2000) and Piatek *et al,* (2007) methods for the amorphous fraction.
- 4 M HCl extraction at 94°C (Leinz *et al,* (2000) method) for the crystalline fraction.

It is recognised that the 4 M HCl extraction method may also dissolve iron from reactive sulfide minerals such as pyrrhotite and mackinawite (a constituent of acid sulfate soils). The 90°C simmer with hydroxylamine / acetic acid solution used by Piatek *et al*, (2007) may be better suited for measuring elements in the crystalline Fe/Mn oxide fraction for sulfidic materials.

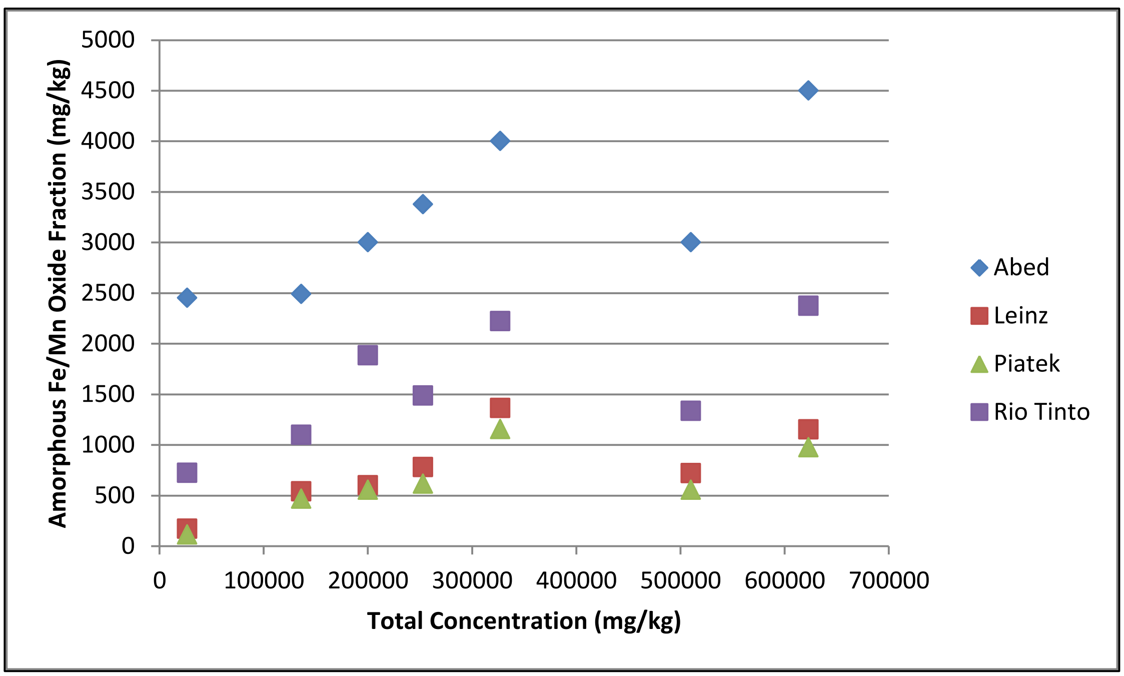


Figure 5: Comparison of Iron in Amorphous Fe/Mn Oxide Fraction Measured in the Seven Samples by Four Methods.

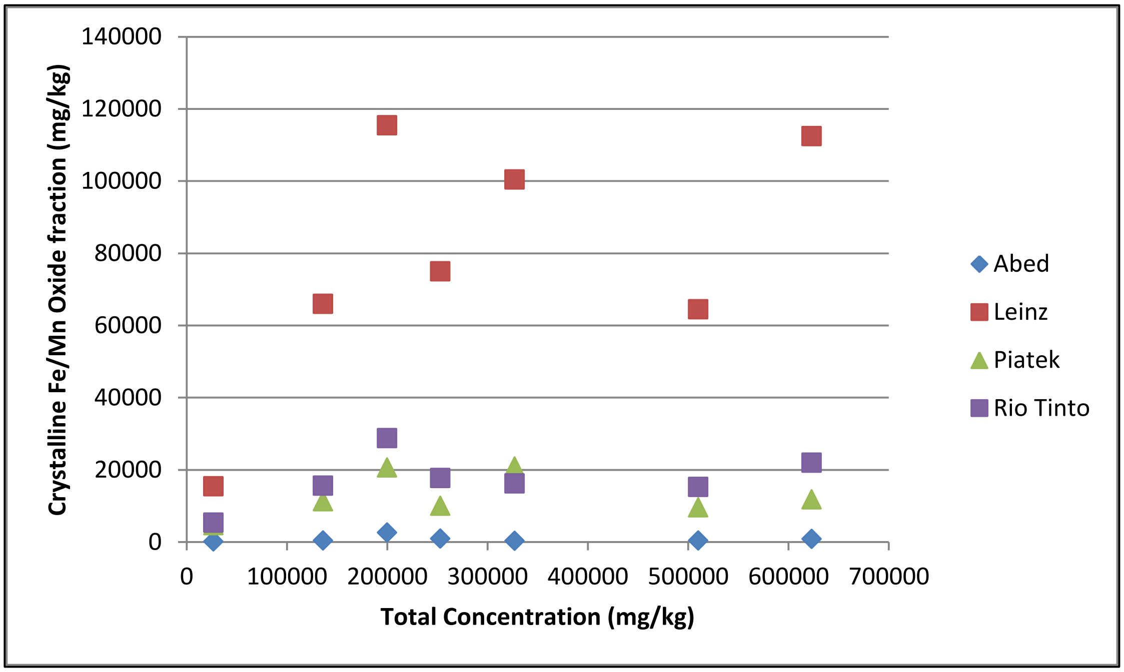


Figure 6: Comparison of Iron in Crystalline Fe/Mn Oxide Fraction Measured in the Seven Samples by Four Methods.

5.3.3.3 Total Oxidisable Fractions

Results for analysis of sulfur in the 'total oxidisable' fraction extracts in the seven samples by the four methods are presented in Figure 7. From these results, it is concluded that:

- Sulfur present in this fraction was either zero, or a very low proportion of total sulfur (that is, most of the sulfur is present in oxidised forms, which would be recoverable in preceding water-soluble, exchangeable and carbonate fractions.
- When sulfidic sulfur was present in the samples, the highest recoveries were provided by the Rio Tinto (2014) method.
- For the sample containing the highest concentration of sulfidic sulfur (JN/OB25; shale);
  - Results from the sum of both fractions in the Rio Tinto (2014) method and the Leinz *et al,* (2000) were close.
  - The result obtained using the Abed *et al,* (2014) was significantly less than those obtained by the other three methods. The oxidising agent, 0.7 M sodium hypochlorite, is considered less vigorous than the other oxidising agents.

Based on these observations, it was suggested that two steps be used to differentiate elements associated with sulfide (and/or oxidisable organic matter) minerals:

- Using a mild oxidising agent, such as sodium chlorate in HCl solution used by the Leinz *et al,* (2000), it would be expected to identify elements associated with reactive sulfide minerals such as pyrrhotite and microcrystalline pyrite.

- A stronger oxidising agent, such as hydrogen peroxide, which is used as the oxidising agent in the widely used NAG test. This reagent is effective for oxidising less reactive sulfide minerals such as arsenopyrite, cinnabar, molybdenite and coarsely crystalline pyrite. The aqua regia reagent used by Rio Tinto (2014) was not considered as it may also dissolve silicate minerals and highly crystalline iron oxide minerals, that would otherwise report to the 'silicate' (residual) fraction.

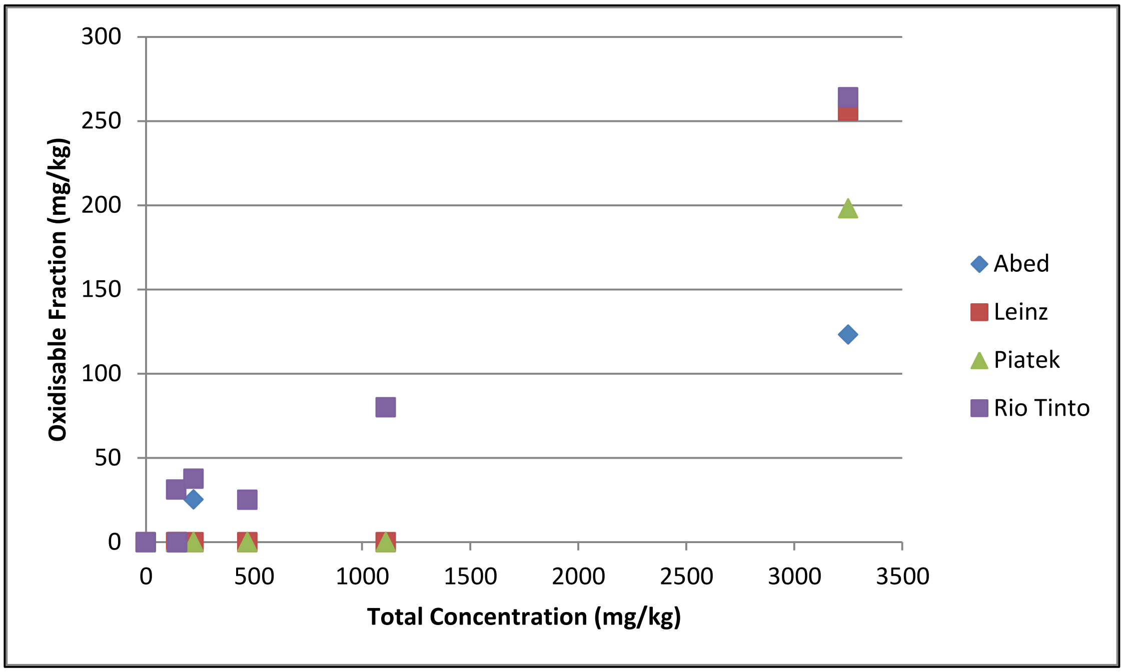


Figure 7: Comparison of Sulfur in Crystalline Total Oxidisable Measured in the Seven Samples by Four Methods.

5.3.4 Elemental Partitioning as Measured by the Optimised Method

Samples of the extracting solutions (reagent blanks) for each step of the optimised sequential leaching procedure were included with each batch of extractant solutions for analysis by ICP-AES or ICP-MS.

In comparison with the quality of the reagent blanks from the four literature sequential leaching methods (Section 5.3.2 and Table 7), the reagent blanks from the optimised method (Appendix 4, Table A4-1) were of much better quality, showing no elements detected except for; (i) sodium, potassium and chromium in the last two fractions (easily and recalcitrant oxidisable) and (ii) zinc (0.013 to 0.083 mg/L) in five out of seven fractions.

As the volume of data resulting from analysis of seven samples for 26 elements in eight fractions is extremely large, discussion in this section on the partitioning of elements is limited to two samples:

- JN/OB25 fresh. This sample is of particular interest as it is the only material containing significant amounts of sulfide-sulfur that released solutes by oxidation during the 24 month kinetic leach test.

- W/OB25 Fresh. Although this sample was similar to other samples in that it contained effectively no sulfides and carbonate minerals, it did contain elevated amounts of potentially problematic arsenic and lead.

Results for analysis of all samples using the optimised method are presented in Table A4-2 of Appendix 4.

5.3.4.1 Sample JN/OB25 (Shale)

Despite this sample releasing significant concentrations of some elements in the 24 month kinetic leach test, very high proportions of total elements were present in the silicate (residual fraction) as indicated below:

- >90%: Aluminium (99%), arsenic (96%), barium (93%), beryllium (94%), chromium (96%), potassium (99%), lithium (99.7%), magnesium (99%), manganese (95%), niobium (99%), nickel (97%), lead (97%) and vanadium (96%).
- 50% to 90%: Cobalt (53%), iron (56%), phosphorus (53%), sulfur (90%).
- <50%: Silver (nil), calcium (nil), cadmium (nil), copper (4.1%), molybdenum (nil), selenium (nil) and zinc (41%).

Figure 8 shows the relative amounts of each element in seven fractions excluding that present in the silicate (residual) fraction. From these results, the followed conclusions are noted:

- Almost all of the non-silicate silver is present in the crystalline Fe/Mn oxide fraction.
- Most (approximately 80%) of the non-silicate aluminium is present in the crystalline Fe/Mn oxide fraction. Aluminium commonly substitutes for iron in crystalline oxides such as hematite and goethite and would therefore be recoverable as soluble aluminium upon dissolution of these minerals. Smaller proportions are present in the amorphous Fe/Mn and carbonate fractions.
- Most (approximately 85%) of the non-silicate arsenic is present in the recalcitrant oxidisable fraction (possibly as traces of arsenopyrite or mixed Cu-As sulfide minerals).
- Barium is represented in significant proportions in all but the water-extractable fraction, with the highest proportion (approximately 55%) present in the crystalline Fe/Mn oxide fraction. Note however that barium may be present as the sparingly soluble sulfate mineral, barite. Barite is slightly soluble in strong acid solutions. Evidence for his hypothesis is that the Leinz *et al,* (2000) method, which uses the 4 M HCl reagent included in the optimised method, extracted more barium than the procedures used by the other three methods.
- Most of the trace amounts of non-silicate beryllium were recovered in the carbonate fraction.
- Most of the non-silicate calcium was recovered in the exchangeable fraction (approximately 80%), with smaller proportions in the water-extractable and carbonate fractions. This main be explained by the presence of weathering product minerals such as gypsum (or anhydrite), jarosite or alunite in which sulfate-sulfur is present in sparingly soluble forms.
- All results for cadmium, including total cadmium, were below the method reporting limits.

- Cobalt was distributed among four fractions; silicate/residual (53%), crystalline Fe/Mn oxides (15%), carbonate (15%) and exchangeable (14%). Very little (0.5%) was present in the oxidisable fractions.
- Non-silicate chromium was mainly present in the crystalline Fe/Mn oxide fraction. Chromium has a high affinity for forming mixed iron oxide species, including the mineral chromite ((Fe_2CrO_4).
- Copper is the primary element of interest in this sample as leachate from the kinetic column test contained levels greater than the livestock drinking water guideline. Very little copper was present in the silicate/residual fraction (4.1%). The non-silicate copper was associated with the crystalline Fe/Mn oxide fraction (43.6%, possibly as a copper oxide mineral such as cuprite (Cu_2O) or tenorite (CuO)), and the carbonate fraction (23.4%), with lesser proportions in the exchangeable (16%) and amorphous Fe/Mn oxide fraction (11%). These observations suggest that copper is present as secondary minerals, possibly those produced by oxidation of primary copper sulfide minerals over geological time.
- Almost all of the lithium (99.7%) is present in the silicate/residual fraction, suggesting its presence is associated with primary aluminosilicate minerals (such as spodumene or petalite).
- Not surprisingly, most of the non-silicate iron was present in the crystalline Fe/Mn oxide fraction.
- Almost all of the potassium (99%) is present in the silicate/residual fraction. Potassium is a component of the mica mineral muscovite, one of the dioctahedral mica clays which are the dominant mineral phase in this sample.
- Almost all of the magnesium (99%) is present in the silicate/residual fraction. Of the non-silicate fractions, most of the magnesium is present in the exchangeable fraction. Magnesium is commonly the major exchangeable cation in non-sodic weathered regolith in WA.
- Most of the non-silicate manganese was recovered in three fractions; crystalline Fe/Mn oxides, carbonate and exchangeable.
- This sample contained very little molybdenum (0.59 mg/kg), all of which was present in the silicate/.residual fraction
- Fractionation of sodium in this sample has not been presented in Figure 8 because of the complication arising from the large amount of sodium introduced in the easily oxidisable fraction (from sodium chlorate). Of the 400 mg/kg total sodium, 25 mg/kg was present as soluble sodium. The remainder was probably present in the silicate/residual fraction associated with small amounts of primary feldspar minerals such as albite.
- Not surprisingly, most of the non-silicate niobium was present in the silicate/resistant fraction. Niobium mineral phases are generally very stable to oxidation, reduction, acidity and alkalinity.
- Non-silicate nickel was equally partitioned between the carbonate and recalcitrant oxidisable fractions.
- Almost all of the non-silicate phosphorus was present in the recalcitrant oxidisable fraction. This observation may, however, be an artefact of the fractionation procedure as a contaminant of the hydrogen peroxide reagent used in this step. Some sources of commercial hydrogen peroxide use low levels of phosphate as a preservative.

- Most of the lead (97%) was present in the silicate/residual fraction, and therefore not associated with primary sulfide minerals such as galena (PbS).
- The portioning of sulfur in this sample is of particular interest. As discussed in Section 5.1.2, sulfur is generally present in regolith materials as either primary sulfides or their oxidation products (sulfate salts of calcium, magnesium, iron and aluminium). The results of the sequential leach test indicate:
    - Low concentrations of sulfur in the water-extractable, exchangeable, carbonate and amorphous Fe/Mn oxide fractions; this observation is consistent with the sulfate-sulfur concentration of 0.02% from the acid base accounting methodology.
    - Approximately 7.5% of total sulfur was found to be present is easily oxidisable sulfur (plus an additional 0.7% of total sulfur in the recalcitrant oxidisable sulfur fraction). This is consistent with the value of 0.017% for CRS (Section 5.1.2).
    - Unexpectedly, a very high proportion (90%) of total sulfur was present in the silicate/resistant fraction. As discussed in Section 5.1.2, this may be explained by the presence of insoluble sulfate minerals, which include barite and celestite. The contribution of organic sulfur was discounted as it was expected to report to the two oxidisable fractions. Barite is unlikely to be a major sulfate mineral, based on the relatively low total barium concentration of 99 mg/kg. Strontium was not measured as a part of the elemental composition of this sample and so the presence of celestite cannot be confirmed (it was not identified as a crystalline phase of the original sample by XRD analysis). Further analyses of the final residue from the procedure will be required to further characterise the mineral forms of sulfur in this fraction.
- Almost all of the total selenium was recovered in the oxidisable fractions, suggesting the presence of trace amounts of reduced oxidation state inorganic or organic selenium compounds, as opposed to oxidised Se(IV) and Se(VI) species, which are known to have a high affinity for Fe/Mn oxide surfaces.
- 96.6% of total vanadium was present in the silicate/resistant fraction, with most of the remainder recovered by the crystalline Fe/Mn oxide fraction. These observations are consistent with the geochemistry of oxidised vanadium compounds, which have a high affinity of iron.
- 41% of total zinc was present in silicate/resistant fraction. The balance was distributed in the easily oxidisable (32%), amorphous Fe/Mn oxide (13), and carbonate fraction (6%). Some zinc was also present in the water-extractable (1.5%) and exchangeable (3.1%) fractions. These results indicate an original source of zinc in primary sulfide minerals (sphalerite, ZnS) and zinc silicate minerals. Partial oxidation of the sulfide fraction has resulted in re-distribution of zinc into more labile fractions.

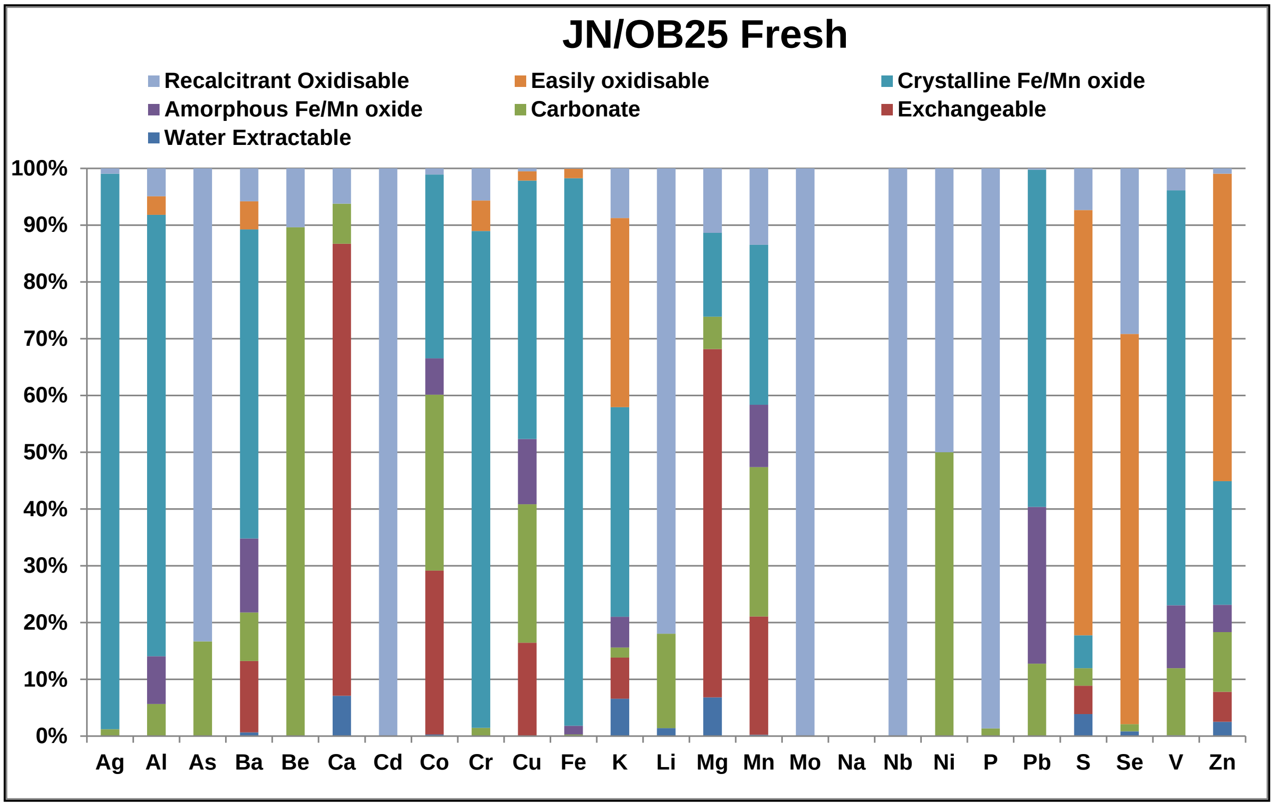


Figure 8: Partitioning of Elements in Sample JN/OB25 in Seven Fractions (Silicate/Residual Fraction Omitted)

5.3.4.2 Sample WB/OB25

This sample was selected as being representative of most of the geochemically benign, highly ferruginous waste rock mined from iron ore operations in the Pilbara region of WA. Quartz is the dominant mineral (Table 6, Section 5.1.3), with some of the dioctahedral mica clays that are present in sample JN/OB25 Fresh. Despite the expected inert nature of the material, there were varying proportions of specific elements in the silicate/resistant fraction and the other fractions of the sequential leaching protocol:

- >90%: Aluminium (95%), potassium (95%), lithium (97%), and magnesium (96%).
- 50% to 90%: Arsenic (67%, beryllium (83%), copper (75%), iron (53%), molybdenum (56%), nickel (84%), phosphorus (61%), sulfur (67%), vanadium (76%) and zinc (74%).
- <50%: Silver (nil), barium (41%), calcium (28%), cadmium (nil), cobalt (17%), copper (4.1%), manganese (2%), niobium (nil), lead (22%) and selenium (nil).

Figure 9 shows the relative amounts of each element in seven fractions excluding that present in the silicate (residual) fraction. From these results, the followed conclusions are noted:

- The small amount of total silver (0.6 mg/kg) is mainly present in the amorphous Fe/Mn oxide fraction.

- A substantial proportion (approximately 70%) of the non-silicate aluminium is present in the crystalline Fe/Mn oxide fraction. Aluminium commonly substitutes for iron in crystalline oxides such as hematite and goethite and would therefore be recoverable as soluble aluminium upon dissolution of these minerals. Smaller proportions are present in the amorphous Fe/Mn and carbonate fractions. This sample resembles JN/OB25 Fresh with respect to aluminium fractionation.
- Most of the non-silicate arsenic is present in the crystalline Fe/Mn oxide fraction, representing a moderately stable form of arsenic to leaching under oxic conditions.
- Barium is represented in significant proportions in all but the water-extractable and easily oxidisable fractions, with the highest proportion (approximately 53%) present in the crystalline Fe/Mn oxide fraction. This sample resembles JN/OB25 Fresh with respect to barium fractionation.
- Most of the trace amounts of non-silicate beryllium were recovered in the crystalline Fe/Mn oxide (compared to the carbonate fraction for sample JN/OB25).
- Most of the non-silicate calcium was recovered in the exchangeable fraction (approximately 60%), with smaller proportions in the crystalline Fe/Mn oxide and carbonate fractions.
- The sample contained very little cadmium (< 1 mg/kg), with only the amorphous Fe/Mn oxide (92.4%), carbonate (5%) and recalcitrant oxidisable (2.5%) containing measureable concentrations.
- Cobalt was distributed among four fractions; silicate/residual (17%), amorphous Fe/Mn oxides (43%), carbonate (30%) and crystalline Fe/Mn oxides (8%). Very little (0.04%) was present in the oxidisable fractions. This sample resembles JN/OB25 Fresh with respect to cobalt fractionation.
- Non-silicate chromium was mainly present in the crystalline Fe/Mn oxide fraction. This sample resembles JN/OB25 Fresh with respect to chromium fractionation.
- Most of the copper present in this sample was distributed between the silicate/resistant (75%) and crystalline Fe/Mn oxide (21%) fractions. Unlike the elevated copper sample JN/OB25, very little copper was present in the exchangeable and carbonate fractions.
- As for sample JN/OB25, nearly all of the lithium (97%) is present in the silicate/residual fraction, suggesting its presence is associated with primary aluminosilicate minerals.
- Iron was almost equally distributed between the silicate/resistant (53%) and crystalline Fe/Mn oxide (46%) fractions.
- Almost all of the potassium (95%) is present in the silicate/residual fraction. Potassium is a component of the mica mineral muscovite, one of the dioctahedral mica clays which are the significant mineral phase in this sample.
- Almost all of the magnesium (96%) is present in the silicate/residual fraction. Of the non-silicate fractions, most of the magnesium is present in the exchangeable fraction. Magnesium is commonly the major exchangeable cation in non-sodic weathered regolith in WA. This sample resembles JN/OB25 Fresh with respect to magnesium fractionation.
- This sample contained the highest concentration of manganese (3,260 mg/kg) of all seven samples. Most of the manganese (93%) was recovered in amorphous Fe/Mn oxide fraction.
- This sample contained significant molybdenum (8 mg/kg), which was distributed between the silicate/residual fraction (56%) and the crystalline Fe/Mn oxide. This observation suggested that

the molybdenum is in an oxidised state, most likely the molybdite ion Mo(VI), rather than primary sulfide minerals such as molybdenite (MoS_2). As with other metal oxy-anions, molybdite ions have a high affinity for Fe/Mn oxide surfaces.

- Fractionation of sodium in this sample has not been presented in Figure 8 because of the complication arising from the large amount of sodium introduced in the easily oxidisable fraction (from sodium chlorate).
- Non-silicate nickel was mainly present in the crystalline Fe/Mn oxide fraction; a distinct difference to its portioning in sample JN/OB25 (where it partitioned between the carbonate and recalcitrant oxidisable fractions).
- As noted earlier, one reason for the detailed assessment of this sample related to its enrichment in lead (723 mg total lead). Most of the lead was associated with the Fe/Mn oxide fractions (69% and 8% in the amorphous and crystalline fractions, respectively), with the remainder (22%) present in the silicate/resistant fraction. On this basis, the lead is expected to be strongly bound and unlikely to be mobilised by oxidation.
- Most of the non-silicate phosphorus was present in the recalcitrant oxidisable fraction. As noted in discussion of the previous sample, the presence of phosphorus in this fraction may be an artefact of the fractionation procedure as a contaminant of the hydrogen peroxide reagent used in this step. 10% of total phosphorus was also present in the crystalline Fe/Mn oxide fraction. Phosphorus is a known contaminant of many iron deposits in WA; its presence being attributed to the high affinity of phosphorus for iron oxide surfaces during formation of iron ore deposits oxidative precipitation in shallow seas during the Archean era.
- Unlike sample JN/OB25, this sample contained very little sulfur (145 mg/kg, Section 5.1.2), none of which was present in either oxidisable fractions (which is consistent with very low results for TOS and CRS presented in Table 5 (Section 5.1.2). 67% of total sulfur was present in the silicate/resistant fraction, with the remainder in water-extractable (20%), exchangeable (7%) and carbonate (7%) fractions.
- All of the total selenium was recovered in the oxidisable fractions, suggesting the presence of trace amounts of rediced oxidation state selenium compounds, as was observed for sample JN/OB25.
- 78% of total vanadium was present in the silicate/resistant fraction, with most of the remainder recovered by the crystalline Fe/Mn oxide fraction. This sample resembles JN/OB25 Fresh with respect to vanadium fractionation.
- A higher proportion (74%) of total zinc was present in silicate/resistant fraction compared to that of the preceding sample (JN/OB25; 41%). The balance was distributed in the crystalline Fe/Mn oxide (13%), and carbonate fraction (6%), but differed from JN/OB25 in that it contained only a small proportion (4%) in the oxidisable fractions

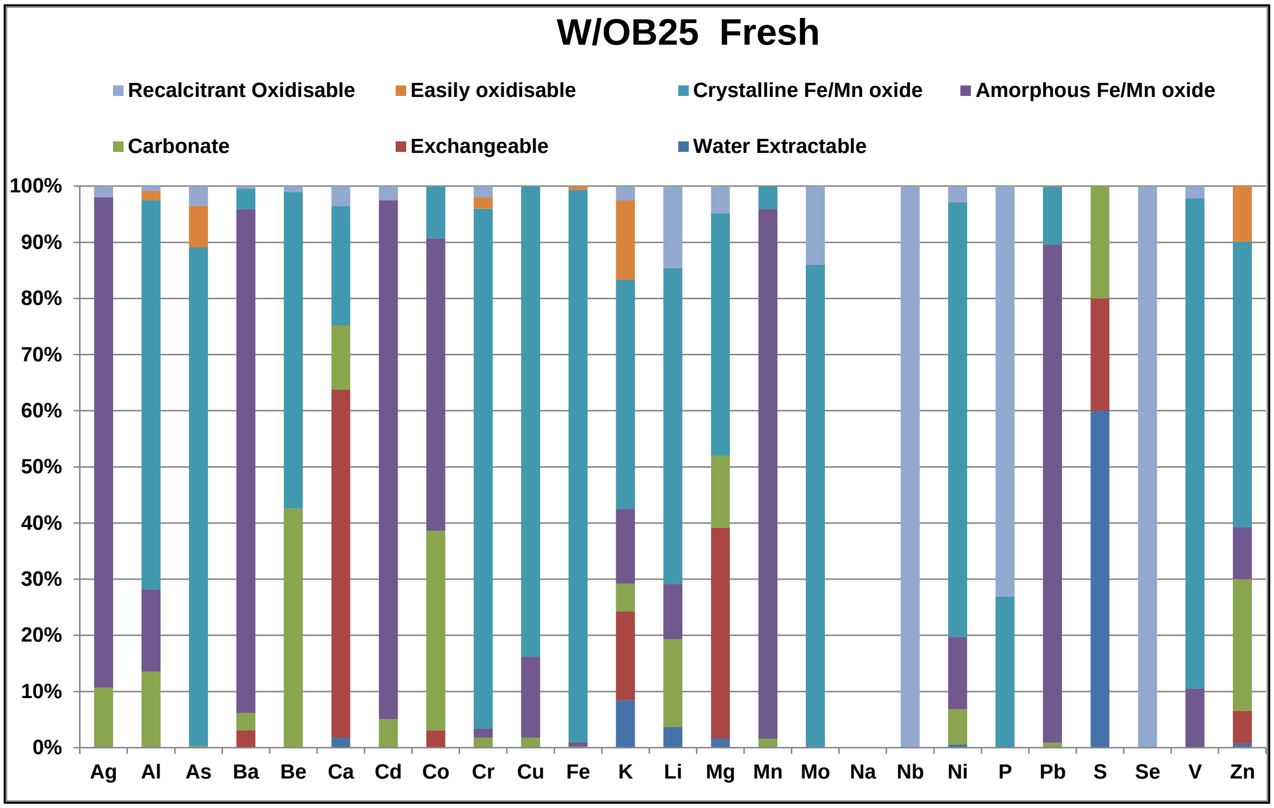


Figure 9: Partitioning of Elements in Sample WB/OB25 in Seven Fractions (Silicate/Residual Fraction Omitted)

5.3.5 LEAF 1313 Test - pH Dependence Test

All samples were also analysed by LEAF Method 1313, which provides a measure of dissolution of metals and metalloids as a function of final solution pH over the range pH 2 to 13, at a liquid to solid ratio of 10 : 1. The results are presented in Table A6-1 and charts in Appendix 6.

As a consequence of the circum-neutral character of all samples and the limited solubility of most metals and metalloids over the pH range of 6 to 8, the LEAF test was not considered as a precision tool for these samples. In general, the water-extractable concentrations provided by the sequential leach test were consistent with those from LEAF Method 1313 with final pH values between 6 and 7.5.

Figure 10 compares the labile fraction (labile fraction = water-soluble, easily exchangeable and carbonate fractions) measured by the sequential leach test (mg/kg) with concentrations of solute (mg/kg) extracted at the most acid solution by the LEAF 1313 test. Although both methods are expected to extract common metals (Cu, Cr, Co, Ni, Pb and Zn) present as water-soluble, easily exchangeable and carbonate forms, the relationships were generally poor. For these metals, the labile fraction concentrations measured by the sequential leaching method were generally significantly higher.

As none of the samples were alkaline, it was not possible to compare the solubility of amphoteric metals and oxyanions of common metalloids using the sequential leach test over the alkaline range of LEAF Method 1313. None of the sequential leach solutions are alkaline.

Another advantage of the sequential leach test over LEAF Method 1313 is coverage of both strongly reducing conditions (by the use of the hydroxylamine reagent in the Fe/Mn fractions) and strongly oxidising conditions (sodium chlorate and hydrogen peroxide in the easily and recalcitrant oxidisable fractions, respectively). The optimised sequential leach test was able to predict the dissolution of selenium (by oxidation) from the reactive JN/OB25 Fresh sample (5.3.4), where LEAF Method 1313 predicted selenium dissolution at elevated (alkaline) pH.

Overall, the sequential leach method is a better predictor of the leaching characteristics of metals and metalloids for these samples than LEAF Method 1313. Note however that the use of geochemical speciation modelling in conjunction with LEAF may improve its predictive capacity under different redox conditions.

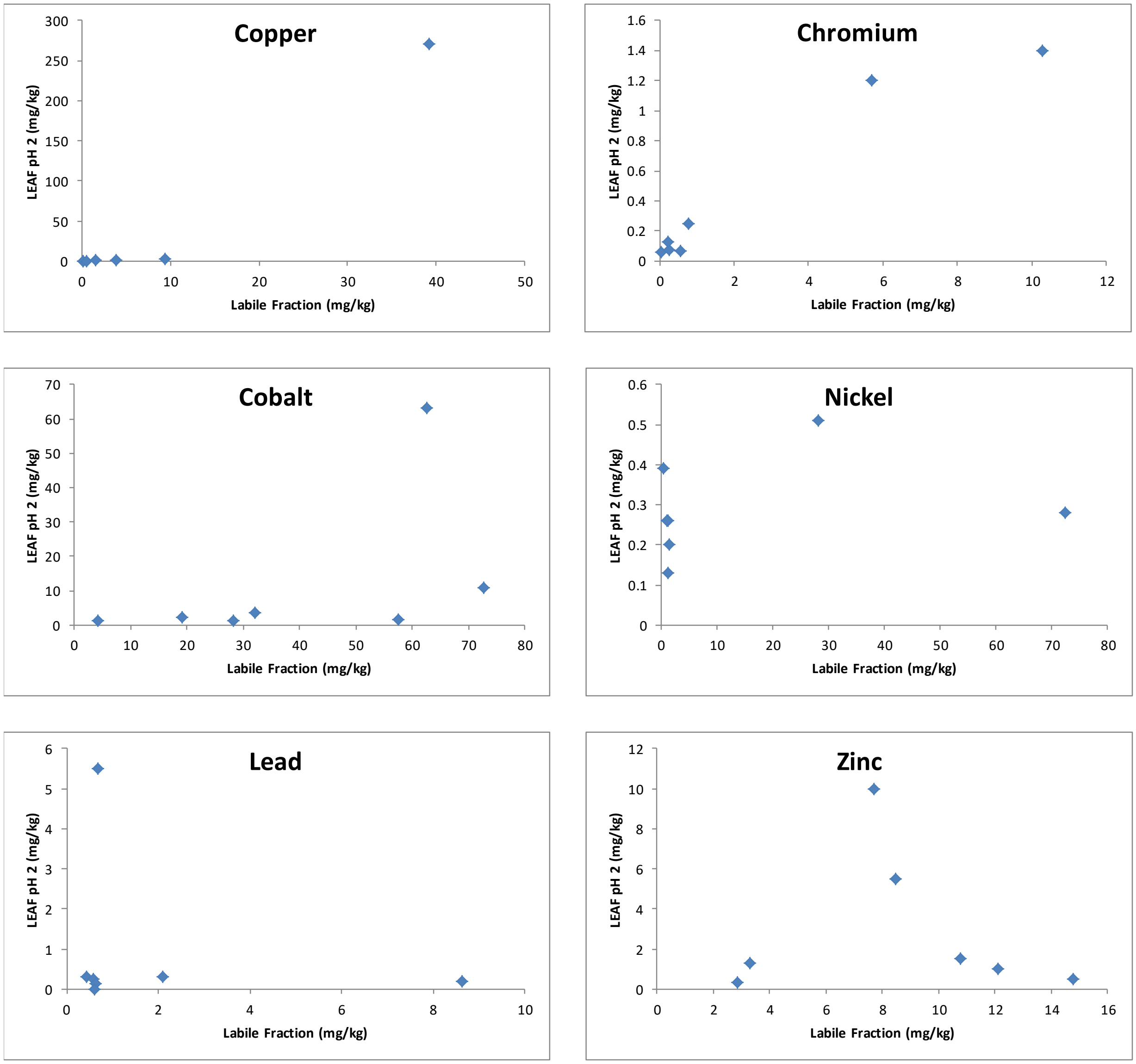


Figure 10: Comparison of (i) Labile Fraction Concentrations Measured by the Sequential Leach Test with (ii) concentrations measured at pH 2 by the LEAF 1313 Method.

5.3.6 Comparison of the Optimised Sequential Leaching Protocols and Long Term Kinetic Test

One of the challenges of this study is how consistent relations can be identified between the eight-stage sequential extraction scheme and the kinetic leaching tests applied to assess the behaviour of different metals and metalloids in terms of mobility and environmental concern. The challenge relates to the large volume of data comprising results from analysis of eight sequential leach fractions of seven samples for 26 analytes, with a similar number of analytes in kinetic column leachates collected at 20 time intervals from the same samples in duplicate.

The proposed use of sequential extraction procedures is predicated on their ability to generate useful information relating to potential contaminants of interest to be mobilised under different environmental conditions. The optimised sequential leach procedure was designed such that the mobility and bioavailability of elements of interest decrease approximately in the order of the extraction sequence. Hence the water soluble, exchangeable and carbonate fractions (referred to as the 'Labile fractions') may indicate which elements are more mobile and may release into the environment.

To facilitate comparison of results from the optimised sequential leaching procedure with those from the 24 kinetic leach test, the following methodology was adopted:

- The potentially "labile" fraction of each analyte for each sample was defined as the sum of the concentrations of the water-soluble, exchangeable and "carbonate" fractions.
- These results are compared with the cumulative mass of each analyte leached under conditions of the kinetic leach test after 24 months. These results are presented in Table A5-1 of Appendix 5.
- Charts were prepared for each sample to present concentrations of each analyte presenting to each sequential leaching fraction as column graph. Included on each chart were the cumulative masses of each analyte leached from the kinetic leach columns after 1, 6, 12 and 24 months. These charts are presented for each element as:
    - Figure A5-1 for sample JN/OB25 Fresh (shale).
    - Figure A5-2 for sample MM/OB29 Weathered
    - Figure A5-3 for sample MM/OB29 Transition.
    - Figure A5-4 for sample W/OB25 Transition.
    - Figure A5-5 for sample W/OB25 Fresh.
    - Figure A5-6 for sample D1/Whaleback Fresh
    - Figure A5-7 for sample MM/OB32 Transition BWT (below water table).

Review of data presented in this fashion demonstrates that for most samples (JN/OB25 being a notable exception), the mass of solute leached from the kinetic leach columns after 24 months is similar to or slightly less than the mass of solute in the water-extractable fraction of the optimised sequential leaching procedure. In effect, this observation suggests that the kinetic test method for these inert materials represents an inefficient means of leaching soluble salts naturally present in the test sample. Inclusion of the LEAF Method 1313 (pH dependence test) provides useful data for identifying analytes that are expected to be mobilise when in contact with acidic or, less likely, strongly alkaline seepage. The sequential leaching procedure, however, is considered superior for assessment of iron ore wastes in that it has additional predictive capacity for identifying analytes that may be mobilised under both oxidising and reducing redox conditions.

Sample JN/OB25 Fresh (shale) exhibited different behaviours to those of the other six samples in that the masses of solutes recovered after 24 months of leaching were significantly higher than those present in the water-extractable fraction, thereby indicating geochemical reactions between reactive mineral phases in the sample with air and water in the column. Thus, further discussion on this sample is presented below.

5.3.6.1 Sample JN/OB25 Fresh (Shale)

5.3.6.1.1 Major Ions

Comparative sequential leach and kinetic leach data for the major cations, calcium, magnesium and sodium (as well as phosphorus) for sample JN/OB25 are presented in Figure 11.

The mass of sodium leached from the kinetic column after 24 months (23.9 mg/kg) was effectively the same as the mass of sodium in the water-extractable fraction. As discussed above, this is consistent with the “wash-out” behaviour of sodium in the original sample.

Masses of calcium and magnesium reporting as leachate from the kinetic column exceeded the masses of water-extractable forms in the original sample after six months. The column continued to release additional calcium and magnesium for the remainder of the 24 month test. However, the mass of leached calcium and magnesium released by the column after 24 months was still significantly less than the amount present in the exchangeable fraction. This suggests that calcium and magnesium released by reaction of reactive mineral phases in the column sample cannot be adsorbed to negatively charged clay minerals in the material and therefore report to column leachate.

5.3.6.1.2 Lithophile Elements, Copper and Sulfur

Comparative sequential leach and kinetic leach data for copper and the lithophile elements, including aluminium and silicon, for sample JN/OB25 are presented in Figure 12.

The mass of potassium recovered from the leachates from the kinetic leach columns after 24 months was 33/mg/kg, slightly higher than the 28 mg/kg present in the water-extractable fraction. In this respect, the behaviour of the highly mobile potassium ion is similar to that described for sodium in the previous section.

The mass of sulfur recovered from the leachates from the kinetic leach columns after 24 months was 135/mg/kg, considerably higher than the 12 mg/kg present in the water-extractable fraction. The mass leached from the kinetic column was also higher than the ‘labile fraction” defined above, in this case

39/mg/kg. As the difference between the leached amount of "labile fraction" (96 mg/kg) is greater than that present in the Fe/Mn oxide fractions (19 mg/kg), the most like source of this additional sulfur is from the oxidisable fractions. Also, the mass of sulfur recovered in leachate (135 mg/kg) is slightly less than the amount of CRS (0.017%, 170 mg/kg), but very much less than TOS (0.33%, 3,300 mg/kg).

Concentrations of aluminium and iron in the water-extractable fractions were below the method reporting limits, which is consistent with the geochemical properties of these elements under circum-neutral conditions. The cumulative masses of these elements from the kinetic leach columns were also extremely low (0.007 mg/kg for both elements).

The concentration of silicon in the water-extractable fraction was 9.75 mg/kg. As silicon was not measured on leachates from the kinetic leach columns until month 12, a definitive comparison between the two methods is not possible. However, the cumulative mass of silicon recovered from the kinetic leach columns between months 12 and 24 was 4.8 mg/kg, approximately 50% of the water-extractable fraction.

The mass of copper recovered from the leachates from the kinetic leach columns after 24 months was 4.7 mg/kg, considerably higher than the 0.016 mg/kg present in the water-extractable fraction. Unlike sulfur, the mass leached from the kinetic column was much less than the 'labile fraction" defined above, in this case 403 mg/kg (comprising 162 mg/kg in the exchangeable fraction and 241 mg/kg in the carbonate fraction). This behaviour is interpreted as a result of formation of exchangeable cations (calcium and magnesium) from reactive mineral phases in the sample competing for cation exchange sites of the (dioctahedral) mica clay minerals. These cations may have subsequently displaced some of the copper occupying these exchange sites.

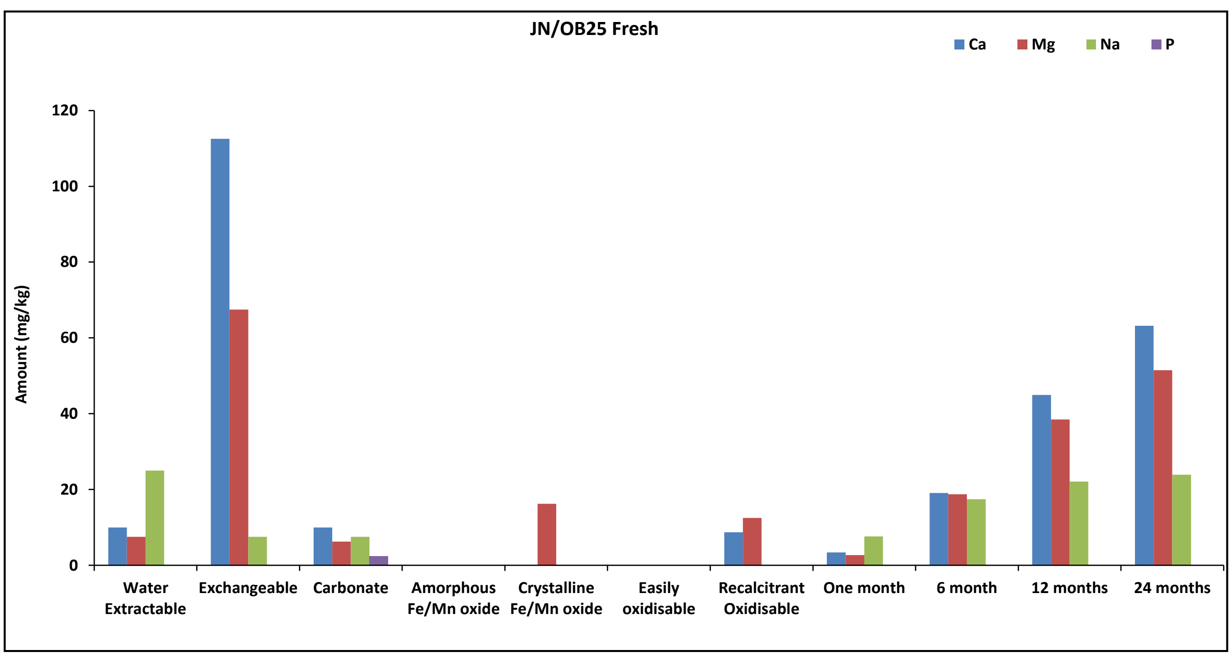


Figure 11: Comparison for Sequential Leach and Kinetic Column Data for JN/OB25 Fresh: Major Ions.

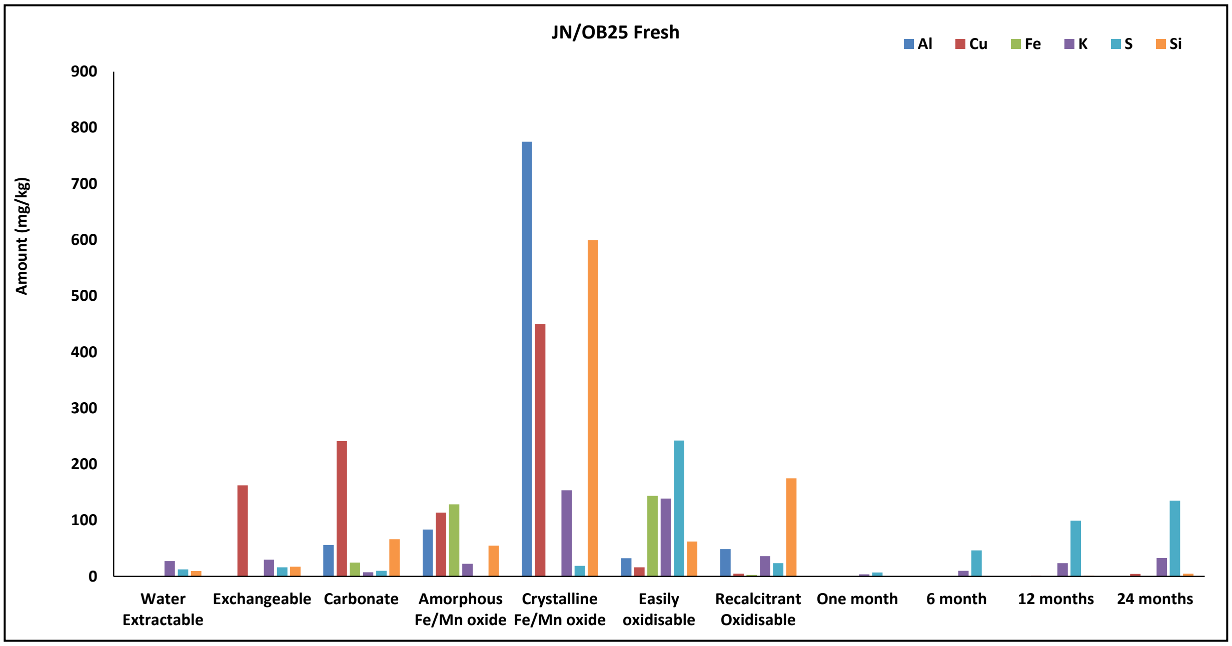


Figure 12: Comparison for Sequential Leach and Kinetic Column Data for JN/OB25 Fresh: Lithophile Elements Copper and Sulfur.

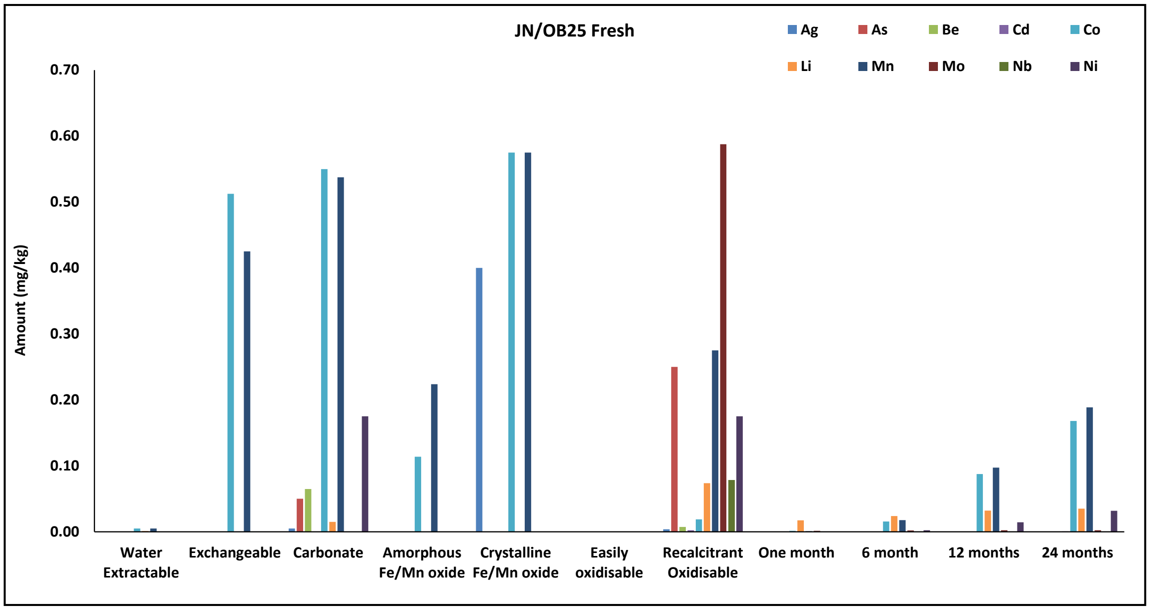
5.3.6.1.3 Metals and Metalloids

Comparative sequential leach and kinetic leach data for other metals and metalloids are presented in two charts in Figure 13.

Of these elements, those reporting to kinetic column leachates after 24 months in significant masses were cobalt (0.17 mg/kg) and manganese (0.19 mg/kg). It is noted that concentrations of manganese in all kinetic column leachate, and the water-extractable fraction were well below the ANZECC freshwater aquatic ecosystem trigger value of 1.9 mg/L and therefore unlikely to present a problem to the receiving environment. Due to very low chronic and acute toxicity of manganese, there is no guideline value for livestock drinking water quality. On the other hand, concentrations of cobalt in all kinetic column leachates exceeded the (low reliability) ANZECC freshwater aquatic ecosystem trigger value of 0.0014 mg/L (Table A1-1 of Appendix 1), but were well below the livestock drinking water guideline of 1 mg/L.

As shown in Figure 13, both the exchangeable and “carbonate” fractions contribute equally to the “labile fraction” for cobalt. The behaviour of cobalt is therefore likely to mirror that of copper described in Section 5.3.6.1.2. Nickel also followed similar behaviour; the cumulative mass of nickel from the kinetic leach column (0.032 mg/kg) was higher than that present in both the water-soluble and exchangeable fractions (both <0.001 mg/kg). In this case, the additional nickel may have originated from either the ‘carbonate fraction (0.18 mg/kg) or, less likely, the recalcitrant oxidisable fraction (0.18 mg/kg).

Apart from copper, selenium was the only other element to exceed livestock drinking water guidelines in kinetic column leachates. The mass of selenium recovered in kinetic leach test leachates after 24 months was 0.31 mg/kg; considerably higher than the mass of selenium present in the water-extractable (0.05 mg/kg) and 'labile' (0.012 mg/kg). As there is very little oxidised selenium present in the Fe/Mn oxide fractions, the additional selenium must come from the oxidisable fractions, i.e. by the oxidation of insoluble reduced forms of selenium in the sample. in this respect, the behaviour of selenium mirrors that of sulfur (Section 5.3.6.1.2), which is consistent with the properties of Group VI elements in the chemical periodic table.



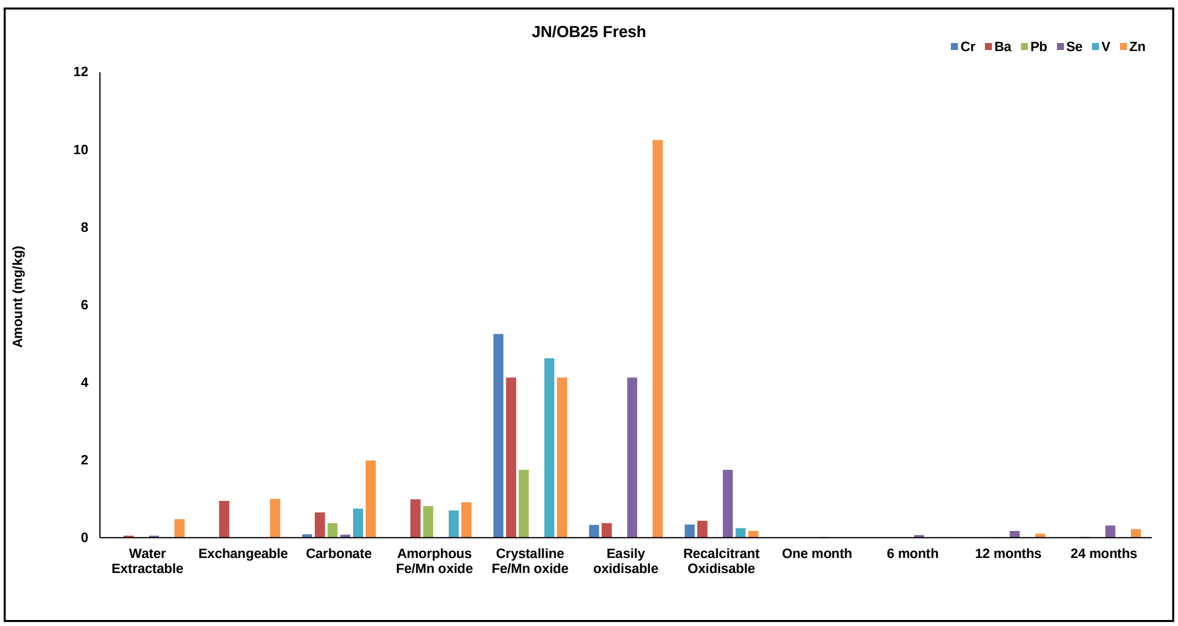


Figure 13: Comparison for Sequential Leach and Kinetic Column Data for JN/OB25 Fresh: Metals and Metalloids.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Key Findings

Sequential leaching methodologies were validated and assessed against longer term kinetic leaching studies which was conducted in parallel using seven representative rock types that was supplied by the industry sponsors from their respective iron ore operations.

An optimised sequential extraction method specific to these types of mine wastes was developed following assessment of four published methods (Pinto, Al Abed *et al*, 2014; Piatak *et al*, 2007; Leinz *et al*, 2000) and Rio Tinto 2014). The optimised procedure incorporated fractions to provide the greatest amount of useful information relating to the geochemical characteristics of the materials. The chemical reagents used for each extracting solution were selected on the basis of very low levels of impurities and compatibility with modern multi-element analytical instruments such as ICP-AES and ICP-MS.

The optimised sequential extraction procedure measures major ions, metals and metalloids in the following fractions:

7. Water-extractable, using reagent water as the extracting fluid;
8. Exchangeable, using ammonium acetate as the extracting fluid;
9. ‘Carbonate’, using dilute acetic acid as the extracting fluid;
10. Amorphous Fe/Mn oxide, using a solution of hydroxylamine in dilute hydrochloric acid as the extracting fluid;
11. Crystalline Fe/Mn oxide, using 4 M hydrochloric acid as the extracting fluid;
12. Easily oxidisable, using oxidation with a mixture of sodium chlorate and hydrochloric acid as the extracting fluid; and
13. Recalcitrant oxidisable, using oxidation with hydrogen peroxide solution as the extracting fluid.

The sequential leaching protocol developed in this project correctly indicated that six of the seven samples provided for the study would not give rise to metal leachate concentrations of concern and the subsequent long-term kinetic studies confirmed this assessment. The six samples were characterised by very low sulfur contents, a lack of acid neutralising minerals and unremarkable concentrations of metals and metalloids. Comparison of cumulative masses of solutes released after 24 months of the kinetic leach test with masses recovered by the optimised sequential extraction method demonstrated that the materials were not reactive, with most of the original soluble salts in the sample being recovered by 24 months of column leaching.

The sequential leaching protocol also correctly predicted that one of the seven samples (sample JN/OB25 Fresh) would give rise to copper leachate concentrations of potential concern, which was confirmed by the subsequent long-term kinetic study. The optimised sequential extraction method proved useful for understanding the geochemistry of sample JN/OB25 Fresh, a sample of fresh shale mine waste from the Jeerinah Formation at BHP's Orebody 25 deposit. Conventional AMD characterisation of this material classified it as non-acid forming (NAF[2]) on the basis of acid formation potential calculated from the Chromium Reducible sulfur (CRS) concentration being less than the measured Acid Neutralising Capacity (ANC) value. Elemental analysis indicated significant geochemical enrichment by copper, with other environmentally significant metals and metalloids being similar to or less than average global crustal abundances. Under typical circumstances, samples of this nature would not normally be selected for kinetic leach testing. However, leachates from the kinetic column test exceeded the livestock drinking guideline values for copper and selenium, demonstrating the potential for this waste type to produce neutral metalliferous drainage (NMD).

Analysis of the sample by the optimised sequential extraction method indicated the copper in the kinetic test leachates was derived from the exchangeable fraction, probably from displacement by calcium and magnesium solutes produced from reactive mineral phases. On the other hand, the source of leachable selenium was attributed to the oxidisable fraction, i.e. reduced forms of insoluble selenium that reacted slowly with atmospheric oxygen to produce soluble selenium oxyanions.

Although the sequential leaching test alone cannot predict quantitative water quality impacts due to the kinetic controls on mineral dissolution, when combined with kinetic column leaching tests it could be an effective tool to assess environmental risk associated with rock samples. Therefore, chemical data derived from the optimised sequential leaching method will help to predict quantitatively immediate water quality impacts, as well as different amounts of metal release potential. If there were significant proportions of metals released in the 1st three steps (water soluble, exchangeable and carbonate fractions, i.e. the 'labile fractions') of the optimised sequential leaching method then kinetic studies can be performed to assess the environmental risk. Therefore, the sequential leaching procedure used here provides valuable insight information about the effect of external conditions on the metalliferous leachability/solubility, mobility and bioavailability for risk assessment. To identify the real environmental risk of metals under different conditions possible in nature now or in future this information is necessary.

The sequential extraction method may also be useful for identifying contaminants of environmental concern that may be released from specific mine waste types that may be exposed to saline, acidic/alkaline or low redox leach fluids from either waste types (as a consequence of either blending or depositing as a covering layer in a mine waste landform). For example;

- Elements present in the exchangeable fraction may not be mobilised by infiltrating rainwater, but may be mobilised by saline seepage.
- Elements present in the 'carbonate' fraction may not be mobilised by infiltrating rainwater, but may be mobilised by acidic seepage from PAF mine wastes.

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[2] This sample was also classified as 'Uncertain' using the TOS acid base accounting method (Section 5.1.2). There was a wide discrepancy between TOS (0.33%) and CRS (0.017%), indicating unusual sulfur speciation in this sample (consistent with sequential leach test results).

- Elements present in the amorphous Fe/Mn oxide fraction may not be mobilised by infiltrating rainwater, but may be mobilised by highly alkaline seepage, or seepage with a low redox potential.

6.2 Decision Tree

The proposed sequential extraction method may be incorporated into a decision making tool (decision tree) for classifying mine wastes in baseline studies required for the EIA process. Figure 14 illustrates an example of a decision tree incorporating the sequential extraction method for mine waste classification.

The principles of this decision tree include:

- Preliminary assignment of total sulfur threshold values (as a screening tool) for each waste type. The assigned value must consider factors such as the environmental setting and nature of sulfur minerals. For example, a low threshold value of 0.05% S may be applicable for sedimentary mine waste containing finely divided pyrite for a coal mine in a high rainfall environment. On the other hand, a value of 0.2% total sulfur may be appropriate for mine waste containing small amounts of coarsely crystalline pyrite for a hard rock mine in arid to semi-arid regions of WA.
- Mine waste can be classified and subsequently managed as either:
    - Benign waste, which may be used for construction/rehabilitation purposes or randomly deposited in a mine waste landform.
    - Managed waste, which needs to be segregated at source and deposition in a mine waste landform managed in such as fashion as to ensure it is covered by several metres of benign waste at mine closure.
    - Problematic (PAF) waste which requires encapsulation with low permeability materials to minimise ingress of air and water.
- Selected samples below the sulfur threshold are subsequently analysed for elemental composition. Non-mineralised materials may then be managed as benign waste, or if they have desirable physical properties, may be segregated for construction (eg, road base) or rehabilitation use.
- Samples above the sulfur threshold are subsequently analysed for elemental composition and acid base accounting.
- Mineralised samples with sulfur concentrations below the threshold (and therefore unlikely to produce acidic seepage) are then selected for analysis by the sequential extraction method to assess their potential for producing NMD.
- Samples above the sulfur threshold, but classified as NAF or Uncertain by acid base accounting are subsequently assessed for NMD potential using the sequential extraction method. If significant concentrations are found to be present in oxidisable fraction, kinetic tests may be required to estimate the rates of release of contaminants of potential concern.
- Samples requiring assessment by kinetic tests are selected from materials:

- Classified as potentially acid forming by acid base accounting methods.
- Classified as NAF or Uncertain by acid base accounting methods, but contain substantial concentrations of potential contaminants in oxidisable fractions.

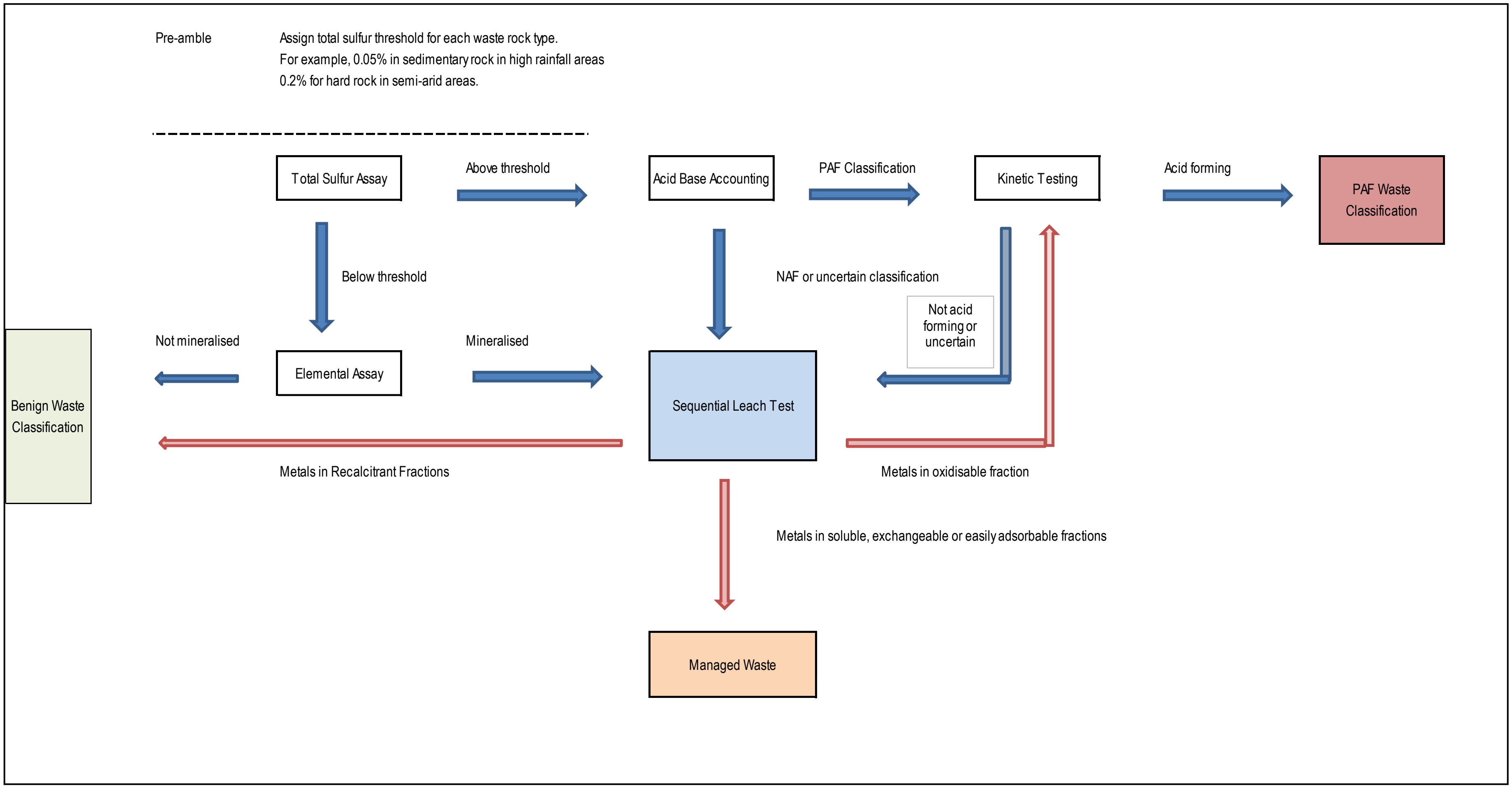

Figure 14: Example of a Decision Tree Using the Sequential Leaching Test to Classify Mine Waste

6.3 Summary

From this study, a sequential leaching procedure has been developed and customised for variably weathered, low sulfur and/or complex mineralogy iron ore waste rock from BHP Billiton's operations in the Pilbara Region of Western Australia.

Seven waste rock samples considered representative of BHP Billiton's iron ore deposits were initially analysed using four published selective extraction methods. An optimal method for these mine waste types has subsequently been developed. The predictive value (metal/rock type risk identification) of the optimised sequential leaching test, complemented by results from static waste rock characterisation tests and mineralogy by XRD, was compared against longer term (up to two years) kinetic leaching column testing.

Results from this study clearly demonstrate that the optimised sequential leaching procedure may be used as a supplementary "sample screening" tool to acid base accounting to classify mine waste. While conventional acid base accounting methodology using static tests is generally useful for identifying potentially acid forming mine wastes, the sequential leach procedure is particularly useful for identifying mine wastes with potential to produce neutral mine drainage, i.e. circum-neutral seepage containing metals (notably copper, nickel, and manganese) and metalloid oxyanions (e.g. arsenic and selenium) at concentrations that can affect the quality of surface water and groundwater.

A decision support tool was developed as an example for the application of the optimised sequential leaching test as a sample screening tool for early identification of risks that can be used to direct and prioritise the testing of materials and the possible longer term kinetic studies to better inform waste management and mine-site closure planning and approval.

Through a project scientific advisory panel, the MRIWA M432 study had input from the industry sponsor (BHP Billiton) and the WA regulatory agencies; Department of Water and Environmental Regulation (DWER, that includes the formerly OEPA and DER) and Department of Mines, Industry Regulation and Safety (DMIRS, formerly DMP).

6.4 Recommendations

6.4.1 Iron Ore

As this validation study was based on a small number of test materials (seven waste rock samples) from one iron ore company, both industry and government participants agreed with ChemCentre that this study should be extended to validate the optimised sequential leaching procedure against a larger number of samples more widely representative of the range of lithologies encountered by the iron ore industry.

The method adopted was optimised to meet the requirements of assessing potentially problematic mine waste produced by mining iron ore. These waste types are characterised by very high iron content, slightly elevated sulfur contents (much of which is associated with insoluble sulfate minerals, such as barite and celestite - a complication for conventional acid base accounting) and slightly elevated concentrations of metals and metalloids (notably selenium). Unlike base metal mine waste, the associated metals are mainly present in oxidised forms, rather than reduced forms as in base metal sulfides. As such, their potential for mobilisation is not solely based on oxidation of the mine waste, but other processes including interaction with saline or slightly acidic seepage for other types of mine waste.

6.4.2 Gold and Base Metals

In its current form, the method is anticipated to provide useful information on gold mine wastes, especially for waste generated from the oxide and transition weathering zones. However, further validation of the method with these waste types will be required before being recommended as a routine waste characterisation tool.

Modifications to the optimised sequential leaching method may be required for assessing sulfidic mine waste from base metal deposits. The 4 M HCl reagent used for the crystalline Fe/Mn oxide fraction may result in loss of sulfur as H_2S by reaction with reactive sulfide minerals. 4 M HCl was originally selected as the reagent of choice as it does not dissolve pyrite (FeS_2), the dominant sulfide mineral in iron ore waste. It does, however, react with more reactive iron and nickel sulfides to produce H_2S gas.

Sulfide minerals also vary in their reactivity towards oxygen and water. Finely divided pyrite and pyrrhotite can react violently under certain circumstances, resulting in spontaneous combustion of mine waste stockpiles. Other sulfides, notably arsenopyrite, molybdenite and cinnabar react extremely slowly. For this reason, a two stage oxidation step was incorporated into the optimised method. Further work will be required to validate the choice of reagents to ensure that it is suitable for discriminating between reactive and unreactive sulfide minerals in base metal mine waste.

6.4.3 Coal

The optimised method may also be useful for classifying mine waste with high organic matter content, such as coal mine and mineral sand mine wastes. Further work will be required to validate its application for assessment of these waste types.

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9 GLOSSARY

Term	Explanation
AC	Acid consuming material. Defined as NAF material which has a NAPP value in excess of –100 kg H_2SO_4/t
ABA	Acid base accounting.
Alunite	A hydrated aluminium potassium sulfate mineral $KAl_3(SO4)_2(OH)_6$. The aluminium analogue of the hydrous iron sulfate mineral jarosite.
AMD	Acid and metalliferous drainage.
AMIRA	Australian Mineral Industries Research Association
ANC	Acid Neutralising Capacity. A process where a sample is reacted with excess 0.5M HCl at a pH of about 1.5, for 2-3 hours at 80-90ºC followed by back-titration to pH=7 with sodium hydroxide. This determines the acid consumed by soluble materials in the sample.
Ankerite	A calcium, iron, magnesium, manganese carbonate mineral of general formula $Ca(Fe,Mg,Mn)(CO_3)_2$. In composition it is closely related to dolomite, but differs from this in having magnesium replaced by varying amounts of iron(II) and manganese.
AP	Acid Potential. Calculated by multiplying the sulfide-sulfur content (calculated as TOS as the difference between total and sulfate forms of sulfur, or measured directly as CRS) by a factor of 30.6 (kg H_2SO_4/t).
Barite	A naturally occurring barium sulfate mineral, $BaSO_4$. Barite is one of few sulfate salts and minerals that is insoluble in both water and dilute acid solution.
Basalt	A dark coloured fine grained mafic extrusive igneous rock composed chiefly of calcium plagioclase and pyroxene. Extrusive equivalent of gabbro underlies the ocean basins and comprises oceanic crust.
BIF	Banded Iron Formation. Layered rock formed from banded deposits of iron rich sediment laid down at the bottom of primordial oceans.
Celestite	A naturally occurring strontium sulfate mineral, $SrSO_4$. Celestite is one of few sulfate salts and minerals that is insoluble in both water and dilute acid solution.
Chalcophile	Metal and metalloid elements with a high affinity for sulfur. Examples include mercury, copper, lead, zinc, arsenic and selenium.
chromite	A mixed chromium iron oxide mineral with the formula $FeCr_2O_4$.
CRS	Chromium reducible sulfur.
dolomite	Calcium magnesium carbonate $CaMg(CO_3)_2$.
calcite	Calcium carbonate $CaCO_3$.
Circum-neutral pH	pH value near 7.
Galena	Lead sulfide mineral, PbS
Goethite	A hydrated iron oxide mineral with the formula FeOOH. Goethite is the major mineral in a yellow-brown iron ore known as limonite.
Hematite	A common iron oxide mineral with the formula Fe_2O_3.
INAP	International Network for Acid Prevention.

Term	Explanation
Jarosite	A hydrated potassium potassium sulfate mineral $KAl_3(SO4)_2(OH)_6$, often formed as an oxidation product of pyrite and related iron sulfide minerals. The potassium ions may be substituted by sodium ions (natro-jarosite) or hydronium (H_3O^+) ions.
Lithophile	Major elements present in most igneous, sedimentary and metamorphic rock types as a consequence of their high affinity for oxygen. Examples include iron, aluminium, calcium, magnesium and silicon.
Mackinawite	A metastable iron sulfide mineral, $Fe_{(1+x)}S$, usually associated with micro-crystalline pyrite in acid sulfate soils.
Maghemite	An iron oxide mineral with the formula Fe2O3. It has the same chemical composition as hematite, but a different crystal structure.
Molybdenite	A naturally occur molybdenum sulfide mineral, MoS_2.
MPA	Maximum Potential Acidity. A calculation where the total sulfur in the sample is assumed to all be present as pyrite. This value is multiplied by 30.6 to produce a value known as the Maximum Potential Acidity reported in units of kg H_2SO_4/t.
NAF	Non Acid Forming.
NAG	Net Acid Generation. A process where a sample is reacted with 15% hydrogen peroxide solution at pH = 4.5 to oxidise all sulfides and then time allowed for the solution to react with acid soluble materials. This is a direct measure of the acid generating capacity of the sample but can be affected by the presence of organic materials.
NAG pH	The pH after the NAG test with hydrogen peroxide and heating is completed i.e. oxidation of all sulfides.
NAPP	Net Acid Producing Potential. NAPP (kg H_2SO_4/t) = AP – ANC.
PAF	Potentially Acid Forming.
PAF-LC	Potentially Acid Forming – Low Capacity. Waste rock classification for samples with NAPP values less than or equal to 10 kg H_2SO_4/t.
PAF-HC	Potentially Acid Forming – High Capacity. Waste rock classification for samples with NAPP values greater than 10 kg H_2SO_4/t.
Pyrite	Iron (II) sulfide, FeS_2. Pyrite is the most common sulfide minerals and the major acid forming mineral oxidising to produce sulfuric acid.
Pyrrhotite	An iron sulfide mineral, $Fe_{(1-x)}S$. Similar in appearance to pyrite and marcasite, but more commonly associated with mafic and igneous rocks and nickel sulfide mineralisation.
Sphalerite	A zinc sulfide mineral, ZnS
TOS	Total oxidisable sulfur. Defined in this study as the difference between total sulfur and sulfate-S, usually measured by extraction by dilute HCl.

10 APPENDICES

APPENDIX 1: KINETIC COLUMN TEST – LEACHATE CONCENTRATIONS (mg/L)

Notes to Appendix 1.

Freshwater quality guidelines refer to protection of freshwater species in slightly to moderately disturbed aquatic ecosystems, ANZECC 2000. Low reliability values for selected elements are presented in parentheses.

Livestock drinking water guidelines are derived from ANZECC 2000.

Leachates containing concentrations above the livestock drinking water guidelines are denoted by yellow shading.

Table A1-1: Leachate Concentrations

Sample JN/OB25 Fresh, Column 1

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	30.5	7.6	0	0	0	0.002	0	9	0	0.0032	0	0.0035	0	14
Week 1	13.2	6.7	0	0	0	0.0007	0	3.9	0	0.0037	0	0.0013	0	6.6
Week 2	3.7	7.1	ISS	0	0	0.0022	0	2.3	0	0.0025	0	0.003	0	1.6
Week 3	32.5	7.4	0.0003	0	0	0.0026	0	14.3	0	0.0038	0	0.0079	0	10.2
Month 1	4.7	6.9	0.0001	0	0	0.0019	0	2.3	0	0.0021	0	0.0061	0	2.3
Month 2	3.6	6.7	0	0	0	0.0006	0	2.1	0	0.0014	0	0.015	0	1.1
Month 3	ISS	ISS	0	0	0	0.0033	0	15.7	0	0.0069	0	0.022	0	4.2
Month 4	67.5	6.9	0	0	0	0.0056	0	42.9	0.0001	0.027	0	0.066	0	13.8
Month 5	46.1	6.9	0	0	0	0.0066	0	29.6	0.0002	0.03	0	0.098	0	13.1
Month 6	40.3	6.7	0	0	0	0.0087	0	25	0.0001	0.039	0	0.16	0	12.2
Month 7	35.9	6.8	0	0	0	0.006	0	20.7	0.0001	0.043	0	0.26	0	10.3
Month 8	32.4	6.7	0	0	0	0.0047	0	20.8	0.0002	0.045	0	0.35	0.009	10.9
Month 9	33.6	6.4	0	0	0	0.0051	0	22.2	0.0001	0.064	0	0.67	0	10.9
Month 10	32.8	6.3	0	0.005	0	0.015	0	22.6	0.0002	0.067	0	0.88	0	10.2
Month 11	45	6.3	0	0	0	0.0066	0	30.1	0.0003	0.096	0	1.7	0	12.4
Month 12	37.2	6.2	0	0	0	0.0069	0	24.8	0.0003	0.092	0	2.0	0	11.9
Month 15	47.1	5.6	0	0.018	0	0.0071	0	30.5	0.0004	0.11	0.0009	3.2	0.046	12.3
Month 18	44.1	6.2	0	0	0	0.0079	0	28	0.0004	0.12	0	4.8	0	17.3
Month 21	40.9	5.5	0	0	0	0.01	0	24	0.0004	0.14	0	6.0	0	14
Month 24	32.1	6.1	0	0.015	0	0.0087	0	19	0.0006	0.13	0	7.5	0	11.3

Sample JN/OB25 Fresh, Column 1

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.03	7.5	0.0018	0.005	29.7	0	0.001	0	0	19	0.038	0.0007	0.001	
Week 1	0.038	3	0.0025	0.003	9.1	0	0	0	0	8.8	0.016	0.0002	0.007	
Week 2	0.019	1.2	0.0011	0	1.2	0	0	0	0	2.7	0.004	0	0	
Week 3	0.02	11.7	0.0029	0.007	21.6	0	0	0	0	32	0.051	0.0005	0	
Month 1	0.025	1.6	0.0024	0.001	2.1	0	0	0	0	3.4	0.007	0.0002	0.003	
Month 2	0.0086	1.1	0.0014	0	1.2	0	0	0	0	3.2	0.005	0.0002	0.003	
Month 3	0.035	7.2	0.0096	0	4	0	0	0	0	23	0.018	0	0.055	
Month 4	0.013	35.7	0.034	0.002	24.5	0	0.003	0	0	95	0.10	0.0003	0.012	
Month 5	0.0084	25	0.036	0.001	12.2	0	0.004	0	0	66	0.06	0.0003	0.013	
Month 6	0.01	19.9	0.045	0.001	7.3	0	0.005	0	0	54	0.05	0.0004	0.026	
Month 7	0.0061	17.5	0.049	0	6.4	0	0.006	0	0	46	0.07	0.0002	0.036	
Month 8	0.0078	17	0.05	0	5.8	0	0.007	0	0	43	0.061	0.0001	0.11	
Month 9	0.0067	17.3	0.065	0	6.7	0	0.009	0	0	44	0.07	0.0002	0.077	
Month 10	0.0055	17	0.072	0	3.4	0	0.01	0	0.0001	47	0.07	0.0001	0.078	
Month 11	0.011	26	0.11	0	7.3	0	0.014	0	0	70	0.12	0.0001	0.1	
Month 12	0.0054	19.2	0.099	0	4.1	0	0.014	0	0	54	0.09	0.0001	0.1	5.2
Month 15	0.0041	24.3	0.13	0	3.4	0	0.018	0	0.0014	57	0.14	0	0.14	4.2
Month 18	0.0052	21.9	0.13	0	2.9	0	0.023	0	0.0002	61	0.18	0.0001	0.16	5.9
Month 21	0.0041	17.7	0.14	0	5.9	0	0.029	0	0.0078	53	0.19	0	0.19	5.3
Month 24	0.0035	13.5	0.13	0	1.4	0	0.032	0	0.0018	42	0.15	0	0.22	5

Sample JN/OB25 Fresh, Duplicate Column

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	39.6	7.6	0	0	0	0.0031	0	11	0.0002	0.0041	0.0018	0.0073	0	16.9
Week 1	6.3	7.1	0.0001	0	0	0.0021	0	2.4	0	0.0008	0	0.0023	0	2.5
Week 2	4.3	7.1	0	0	0	0.0006	0	2.7	0	0.0014	0	0.0004	0	1.5
Week 3	3.9	7.0	0	0	0	0.0003	0	2.2	0	0.0008	0	0.0029	0	1.7
Month 1	3.4	6.8	0	0	0	0.0006	0	2	0	0.0015	0	0.0054	0	1.1
Month 2	3.2	6.9	0	0	0	0.0006	0	1.9	0	0.0012	0	0.007	0	1.4
Month 3	3.2	6.7	0	0.007	0	0.0013	0	1.7	0	0.0027	0	0.055	0	0.7
Month 4	78.1	6.7	0	0	0	0.0056	0	30	0.0002	0.02	0	0.1	0	10.5
Month 5	62.4	6.8	0	0.012	0	0.0059	0	34.4	0.0001	0.031	0	0.13	0	15.3
Month 6	41.3	6.7	0	0	0	0.0066	0	21.9	0.0001	0.027	0	0.15	0	10.9
Month 7	38.6	6.7	0	0	0	0.0059	0	22.6	0.0001	0.043	0	0.22	0	12.1
Month 8	33.9	6.7	0	0	0	0.0046	0	21.8	0.0001	0.047	0	0.34	0	14
Month 9	42.3	6.4	0	0	0	0.0076	0	31.3	0.0002	0.082	0	1.2	0	17.1
Month 10	31.7	6.3	0	0	0	0.0084	0	22.8	0.0002	0.066	0	1.1	0	12.5
Month 11	27.5	6.4	0	0	0	0.0062	0	19.3	0.0003	0.056	0	1.3	0	11.1
Month 12	29.1	6.4	0	0	0	0.0068	0	21.2	0.0003	0.071	0	1.9	0	11.8
Month 15	42.2	6.0	0	0	0	0.0087	0	28.4	0.0004	0.1	0	3.4	0	12.3
Month 18	36.1	6.4	0	0	0	0.0089	0	26.2	0.0004	0.096	0	4.6	0	15.3
Month 21	29.5	6.1	0	0	0	0.0076	0	21.3	0.0003	0.094	0	3.3	0	10.2
Month 24	26.4	6.2	0	0.031	0	0.0089	0	18	0.0003	0.088	0	6.0	0.006	9.8

Sample JN/OB25 Duplicate Column

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.091	10	0.0034	0.005	40	0	0.003	0	0	24	0.048	0.0008	0.013	
Week 1	0.052	1.6	0.001	0.002	3.1	0	0	0	0	3.6	0.005	0.0003	0.002	
Week 2	0.014	1.4	0.0005	0	1.9	0	0	0	0	3.5	0.006	0.0001	0	
Week 3	0.012	1.3	0	0.001	1.6	0	0	0	0	3.2	0.005	0.0003	0	
Month 1	0.019	1	0.0018	0	1.4	0	0	0	0	3	0.004	0.0001	0.006	
Month 2	0.0055	1.2	0.0017	0.001	0.8	0	0	0	0	2.7	0.006	0.0002	0.004	
Month 3	0.012	0.8	0.0066	0	0.5	0	0	0	0.0004	2.3	0.003	0.0001	0.015	
Month 4	0.0093	50.7	0.023	0	37.4	0	0.003	0	0	110	0.21	0.0002	0.013	
Month 5	0.011	35.6	0.034	0	22.2	0	0.006	0	0	86	0.11	0.0003	0.015	
Month 6	0.019	22.4	0.03	0.001	8.4	0	0.005	0	0	54	0.07	0.0002	0.026	
Month 7	0.022	19.8	0.047	0.002	5.3	0	0.01	0	0	51	0.082	0.0002	0.035	
Month 8	0.0049	17.8	0.052	0	2.9	0	0.009	0	0	44	0.067	0.0002	0.085	
Month 9	0.0065	21.7	0.086	0	4.6	0	0.014	0	0	57	0.15	0.0002	0.088	
Month 10	0.0037	15.4	0.076	0	1.7	0	0.012	0	0	43	0.12	0.0001	0.087	
Month 11	0.004	12.3	0.063	0	1.5	0	0.012	0	0	35	0.12	0.0001	0.075	
Month 12	0.0046	13.5	0.083	0	1.3	0	0.014	0	0	41	0.14	0.0001	0.091	5.5
Month 15	0.0044	21.4	0.13	0	1.5	0	0.022	0	0	50	0.22	0.0001	0.13	4.7
Month 18	0.0045	15.4	0.11	0	1.3	0	0.021	0	0	48	0.24	0.0001	0.16	5.7
Month 21	0.0042	12.4	0.12	0	1.3	0	0.023	0	0.0032	40	0.23	0	0.16	4
Month 24	0.0036	9.3	0.11	0	1.1	0	0.025	0	0.0021	34	0.22	0	0.19	5.1

Sample MM/OB29 Weathered, Column 1

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	127	7.9	0	0.008	0	0.05	0	45.9	0	0.012	0	0.0003	0	12.2
Week 1	40.3	7.2	0.0002	0	0	0.14	0	8	0	0.0002	0	0	0	4.6
Week 2	52.9	7.7	0	0	0	0.077	0	14.2	0	0.0002	0	0.0003	0	6.1
Week 3	39.3	7.3	0	0	0	0.073	0	11.4	0	0.0001	0	0.0005	0	3.6
Month 1	40.1	7.3	0	0	0	0.056	0	13.8	0	0.0002	0	0.0014	0	2.9
Month 2	41.9	7.3	0	0	0	0.022	0	13.6	0	0.0001	0	0.0017	0	3.1
Month 3	37.9	7.5	0	0	0	0.028	0	11.0	0	0.0001	0	0.0014	0.006	4.1
Month 4	29.0	7.5	0	0	0	0.038	0	7.8	0.0002	0.0002	0	0.0025	0.014	2.6
Month 5	23.3	7.5	0	0	0	0.034	0	5.6	0	0.0001	0	0.0018	0.005	3.2
Month 6	20.6	7.6	0	0	0	0.046	0	4.3	0	0.0002	0	0.0039	0	2.4
Month 7	18.1	7.6	0	0	0	0.041	0	3.1	0	0.0002	0	0.0058	0	2.4
Month 8	14.3	7.5	0	0	0	0.04	0	2.8	0	0.0001	0	0.0043	0.006	2.4
Month 9	14.5	7.7	0	0	0	0.042	0	2.5	0	0.0002	0	0.0098	0	2.3
Month 10	11.5	7.4	0	0.008	0	0.042	0	2.3	0	0.0003	0	0.012	0.007	1.2
Month 11	13.1	7.6	0	0	0	0.075	0	2.4	0	0.0002	0	0.0053	0.006	1.8
Month 12	11.2	7.6	0	0	0	0.056	0	1.9	0	0.0001	0	0.007	0.007	1.8
Month 15	13.4	7.6	0	0	0.001	0.05	0	2.1	0	0.0002	0	0.010	0	2.1
Month 18	13.5	7.6	0	0	0.002	0.047	0	1.8	0	0.0002	0.0008	0.023	0.010	2.3
Month 21	8.2	7.3	0	0.006	0	0.05	0	1.2	0	0.0002	0	0.013	0.037	1.1
Month 24	7.6	7.1	0	0.016	0.001	0.053	0	1.3	0	0.0002	0	0.0053	0.05	1.0

Sample MM/OB29 Weathered, Column 1

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.0029	14.9	0.0021	0	185	0	0	0	0	130	0.011	0	0.006	
Week 1	0.010	1.7	0	0	60.5	0	0	0	0	40	0.003	0	0.003	
Week 2	0.043	3.0	0	0	81.1	0	0	0	0	54	0.005	0	0.003	
Week 3	0.014	2.4	0	0.002	58.0	0	0	0	0	39	0.004	0	0	
Month 1	0.0074	3.0	0.0008	0.002	53.5	0	0	0	0	40	0.004	0	0	
Month 2	0.0043	3.0	0.0005	0.004	60.5	0	0	0	0	42	0.004	0	0.001	
Month 3	0.011	2.5	0.0004	0.003	57.1	0	0	0	0	35	0.003	0	0	
Month 4	0.030	1.7	0.0004	0.004	39.7	0	0	0	0	26	0.002	0	0.004	
Month 5	0.0063	1.2	0	0.005	38.5	0	0	0	0	23	0.001	0	0	
Month 6	0.0036	0.9	0.0001	0.006	32.2	0	0	0	0	19	0	0.0001	0.004	
Month 7	0.0038	0.7	0.0001	0.006	29.2	0	0	0	0	15	0	0	0.004	
Month 8	0.0056	0.6	0.0002	0.005	26.1	0	0	0	0	12	0	0	0.023	
Month 9	0.0042	0.5	0.0002	0.005	28.2	0	0	0	0	12	0	0	0.008	
Month 10	0.0031	0.5	0.0003	0.005	19.9	0	0	0	0	9.4	0	0	0.006	
Month 11	0.0033	0.5	0.0001	0.006	23.0	0	0	0	0	9.7	0	0	0.001	
Month 12	0.0026	0.4	0	0.006	19.6	0	0	0	0	7.5	0	0	0	8.2
Month 15	0.0026	0.4	0.0001	0.006	20.8	0	0	0	0	7.1	0	0	0	7.5
Month 18	0.0044	0.4	0	0.007	23.7	0	0	0	0	7.9	0	0	0.001	8.7
Month 21	0.0076	0.2	0.0001	0.007	14.4	0	0	0	0.0007	5.1	0	0	0.002	8.4
Month 24	0.0032	0.3	0.0009	0.007	12.9	0	0	0	0.0003	5.8	0	0	0.002	7.7

Sample MM/OB29 Weathered, Duplicate Column

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	169	6.7	0.0001	0.029	0	0.046	0	42.7	0.0001	0.013	0	0	0.017	13.4
Week 1	57.4	6.9	0	0	0	0.027	0	20.7	0	0.0002	0	0	0	5.5
Week 2	58.9	7.0	0	0	0	0.019	0	18.9	0	0.0001	0	0	0	8.0
Week 3	52.4	6.8	0	0	0	0.023	0	16.8	0	0.0001	0	0.0002	0	6.5
Month 1	44.7	6.8	0	0	0	0.026	0	12.3	0	0.0001	0	0.0002	0	5.7
Month 2	44.6	6.5	0	0	0	0.021	0	12.5	0	0.0001	0	0.0012	0	5
Month 3	39.2	6.8	0	0	0	0.016	0	8.2	0.0002	0	0	0.0003	0	5.8
Month 4	44.0	6.8	0	0	0	0.021	0	8.7	0	0	0	0.0009	0	5.2
Month 5	28.0	6.9	0	0	0	0.025	0	6.8	0	0	0	0.0003	0	4.7
Month 6	26.9	7.1	0	0	0	0.045	0	7.7	0	0	0	0.0004	0	4.1
Month 7	27.3	6.8	0	0	0	0.039	0	6.5	0	0	0	0.0007	0	3.9
Month 8	15.5	6.8	0	0	0	0.030	0	5.5	0	0	0	0	0	3.0
Month 9	18.2	6.9	0	0	0	0.033	0	5.8	0	0	0	0.0033	0	3.4
Month 10	13.8	6.7	0	0	0	0.037	0	5.2	0	0	0	0.0057	0	2.0
Month 11	13.6	6.8	0	0	0	0.052	0	5.1	0.0001	0	0	0.0048	0	2.5
Month 12	10.9	6.8	0	0	0	0.051	0	4.7	0	0	0	0.0033	0	2.4
Month 15	11.6	7.0	0	0	0	0.039	0	4.5	0	0	0	0.0049	0	3.4
Month 18	10.5	6.9	0	0	0	0.036	0	3.9	0	0	0	0.003	0	2.8
Month 21	10.7	6.5	0	0	0	0.053	0	4.6	0	0.0001	0	0.017	0	1.7
Month 24	10.4	6.6	0	0.011	0	0.052	0	4.7	0	0	0	0	0	1.6

Sample MM/OB29 Weathered, Duplicate Column

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.037	41.7	0.0084	0	201	0	0.001	0	0	49	0.002	0	0.003	
Week 1	0.022	12.6	0.0002	0	61.4	0	0	0	0	41	0.002	0	0.003	
Week 2	0.024	12.8	0	0	68.1	0	0	0	0	44	0.003	0	0	
Week 3	0.019	11.7	0	0	60.2	0	0	0	0	42	0.003	0	0	
Month 1	0.013	8.8	0.0007	0	50.5	0	0	0	0	35	0.002	0	0	
Month 2	0.017	10.9	0.0010	0	50.9	0	0	0	0	39	0.003	0	0.002	
Month 3	0.011	9.0	0.0005	0	48.8	0	0	0	0	33	0.002	0	0	
Month 4	0.022	11.2	0.0006	0	51.7	0	0	0	0	36	0.003	0	0.004	
Month 5	0.0062	6.9	0.0004	0	33.2	0	0	0	0	24	0.002	0	0	
Month 6	0.0058	6.6	0.0005	0	25.8	0	0	0	0	23	0.002	0	0.004	
Month 7	0.0054	7.1	0.0004	0	27.0	0	0	0	0	21	0.002	0	0.003	
Month 8	0.0036	4.8	0.0003	0	13.2	0	0	0	0	14	0	0	0.008	
Month 9	0.0045	5.4	0.0003	0	18.2	0	0	0	0	16	0.001	0	0.010	
Month 10	0.0036	4.7	0.0004	0	10.9	0	0	0	0	12	0	0	0.008	
Month 11	0.0033	4.1	0.0001	0	10.5	0	0	0	0	11	0	0	0.002	
Month 12	0.0033	3.4	0.0001	0	7.2	0	0	0	0	9.3	0	0	0	5.6
Month 15	0.0028	3.4	0.0002	0	8.1	0	0	0	0	9.6	0	0	0	5.1
Month 18	0.0031	2.9	0	0	6.6	0	0	0	0	7.6	0	0	0.002	5.2
Month 21	0.0051	3.2	0.0002	0	5.0	0	0	0	0.0023	7.9	0	0	0.007	6.0
Month 24	0.0066	3.3	0.0006	0	4.3	0	0	0	0.0009	6.8	0	0	0.024	5.6

Sample MM/OB29 Transition, Column 1

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	202	7.1	0.0002	0.028	0	0.061	0	58.4	0.0004	0.011	0	0.0029	0.011	15.6
Week 1	67.3	6.8	0.0001	0	0	0.031	0	23.6	0	0.0002	0	0	0	7.2
Week 2	67.7	6.9	0	0	0	0.021	0	23.5	0	0.0002	0	0	0	8.7
Week 3	52.0	6.7	0	0	0	0.021	0	18.6	0	0.0001	0	0	0	6.3
Month 1	49.0	6.6	0	0	0	0.019	0	16.9	0	0.0002	0	0.0019	0	5.3
Month 2	11.2	6.8	0	0	0	0.017	0	17.6	0	0.0001	0	0.0006	0	6.8
Month 3	40.8	6.8	0	0	0	0.012	0	11.2	0	0	0	0.0003	0	7.1
Month 4	36.1	6.7	0	0	0	0.018	0	10.7	0.0003	0	0	0.0006	0	5.4
Month 5	27.9	6.9	0	0	0	0.021	0	8.0	0	0	0	0.0003	0	5.4
Month 6	24.7	7.0	0	0	0	0.029	0	7.1	0	0	0	0.0007	0	4.1
Month 7	24.8	7.0	0	0	0	0.050	0	6.5	0	0	0	0.0006	0	4.5
Month 8	19.9	6.9	0	0	0	0.034	0	6.8	0	0	0	0.0002	0	4.0
Month 9	17.7	6.9	0	0	0	0.024	0	5.7	0	0	0	0.0023	0	3.6
Month 10	18.3	6.8	0	0	0	0.035	0	6.6	0	0.0001	0	0.0057	0	2.6
Month 11	18.3	6.9	0	0	0	0.043	0	6.1	0.0002	0	0	0.0008	0	3.5
Month 12	14.3	6.9	0	0	0	0.038	0	5.0	0	0.0001	0	0.0021	0	3.3
Month 15	16.0	7.0	0	0.005	0	0.019	0	4.9	0	0	0	0.0083	0.006	3.9
Month 18	14.6	6.9	0	0	0	0.027	0	4.5	0	0	0	0.0050	0	3.8
Month 21	9.3	6.6	0	0	0	0.036	0	3.4	0	0	0	0.0049	0	1.4
Month 24	9.4	6.8	0	0.013	0	0.04	0	3.5	0	0	0	0.0059	0	1.4

Sample MM/OB29 Transition, Column 1

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.028	52.5	0.011	0	257	0	0.004	0	0.0007	60	0.003	0	0.018	
Week 1	0.015	15.2	0.0004	0	72.7	0	0	0	0	54	0.003	0	0.001	
Week 2	0.017	15.8	0.0004	0	75.3	0	0.002	0	0	58	0.004	0	0.001	
Week 3	0.012	13.3	0	0	58.3	0	0.002	0	0	49	0.003	0	0	
Month 1	0.0092	11.8	0.0014	0	47.4	0	0	0	0	44	0.003	0	0.001	
Month 2	0.012	12.9	0.0013	0	57.3	0	0	0	0	45	0.003	0	0.004	
Month 3	0.0073	9.2	0.0007	0	45.9	0	0	0	0	33	0.002	0	0	
Month 4	0.013	9.2	0.0008	0	36.4	0	0	0	0	30	0.002	0	0.003	
Month 5	0.0067	6.8	0.0003	0	30.7	0	0	0	0	25	0.002	0	0	
Month 6	0.0068	6.4	0.0005	0	23.2	0	0	0	0	23	0.002	0	0.005	
Month 7	0.0054	5.7	0.0006	0	24.5	0	0	0	0	19	0.002	0	0.007	
Month 8	0.0039	6.2	0.0005	0	19.0	0	0	0	0	19	0.002	0	0.014	
Month 9	0.0035	5.2	0.0004	0	17.3	0	0	0	0	17	0.001	0	0.006	
Month 10	0.003	6.3	0.0005	0	15.2	0	0	0	0	18	0.001	0	0.015	
Month 11	0.0036	5.3	0.0003	0	16.0	0	0	0	0	17	0.001	0	0.004	
Month 12	0.005	4.0	0.0004	0	11.4	0	0	0	0	13	0	0	0.003	6.4
Month 15	0.0037	4.1	0.0011	0	10.6	0	0	0	0.0003	11	0.001	0	0.005	5.3
Month 18	0.0031	3.7	0	0	9.8	0	0	0	0	10	0	0	0.001	6.4
Month 21	0.003	2.6	0.0003	0	4.8	0	0	0	0.0007	6.5	0	0	0.003	6.2
Month 24	0.004	3.0	0.0002	0	4.6	0	0	0	0.0001	6.4	0	0	0.006	8.2

Sample MM/OB29 Transition, Duplicate Column

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	54.9	6.3	0	0	0	0.014	0	3.8	0.0004	0.0036	0	0	0	3.7
Week 1	32.7	6.6	0	0	0	0.016	0	3.4	0	0.002	0	0.0016	0	3.1
Week 2	46.5	6.1	0	0	0	0.020	0	4.9	0	0.0032	0	0	0	4.8
Week 3	9.7	6.3	0	0	0	0.0054	0	1.1	0	0.0007	0	0.0008	0	1.3
Month 1	33.6	6.0	0	0	0	0.018	0	3.7	0	0.0025	0	0.0011	0	3.5
Month 2	31.0	5.9	0	0	0	0.015	0	3.5	0	0.0023	0	0.0008	0	2.8
Month 3	69.6	4.8	0	0.038	0	0.037	0	8.2	0.0016	0.0051	0	0.0009	0	5.1
Month 4	48.2	4.7	0	0.084	0	0.031	0	5.7	0.0001	0.0047	0	0.010	0.006	4.5
Month 5	25.5	5.2	0	0.057	0	0.018	0	2.9	0.0001	0.0024	0	0.0059	0	3.4
Month 6	20.0	6.1	0	0.010	0	0.017	0	2.2	0.0001	0.0026	0	0.0027	0	2.8
Month 7	17.3	6.0	0	0	0	0.017	0	2.0	0	0.0017	0	0.0014	0	2.8
Month 8	22.0	6.0	0	0	0	0.017	0	2.6	0	0.0012	0	0.0004	0	3.7
Month 9	21.7	6.0	0	0.009	0	0.019	0	2.8	0	0.0019	0	0.0063	0	4.1
Month 10	16.1	5.8	0	0	0	0.019	0	2.2	0	0.0018	0	0.017	0	3.0
Month 11	13.7	5.9	0	0	0	0.014	0	1.8	0.0003	0.0012	0	0.0043	0	2.8
Month 12	9.9	6.1	0	0	0	0.013	0	1.4	0	0.0011	0	0.0064	0	2.4
Month 15	10.3	6.2	0	0	0	0.015	0	1.5	0	0.0010	0	0.013	0	2.1
Month 18	10.6	5.9	0	0	0	0.017	0	1.7	0	0.0006	0	0.017	0	2.8
Month 21	8.4	6.1	0	0	0	0.016	0	1.6	0	0.0009	0.001	0.015	0	2.1
Month 24	8.6	5.9	0	0.012	0	0.018	0	1.6	0	0.0014	0	0.0013	0	2.3

Sample MM/OB29 Transition ,Duplicate Column

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.0025	9.6	0.021	0	71.9	0	0.067	0	0	24	0.002	0	0.001	
Week 1	0.0056	6.7	0.016	0	44.5	0	0.002	0	0	22	0.001	0	0.006	
Week 2	0.0075	10.8	0.026	0	62.4	0	0.002	0	0	27	0.002	0	0.003	
Week 3	0.0054	2.3	0.005	0	12.1	0	0	0	0	6.8	0	0	0	
Month 1	0.0024	8.2	0.022	0	45.3	0	0.001	0	0	23	0.002	0	0.004	
Month 2	0.0016	8.5	0.02	0	38.4	0	0	0	0	20	0.002	0	0.003	
Month 3	0.0052	20.7	0.046	0	88.1	0	0.002	0	0	46	0.003	0	0.002	
Month 4	0.0073	12.8	0.039	0	56.6	0	0.002	0	0	43	0.003	0	0.012	
Month 5	0.0036	6.2	0.018	0	33.0	0	0.001	0	0	27	0.002	0	0.004	
Month 6	0.0028	4.8	0.019	0	22.0	0	0.001	0	0	21	0.002	0	0.012	
Month 7	0.0012	4.3	0.014	0	19.4	0	0	0	0	18	0.001	0	0.007	
Month 8	0.0012	5.7	0.013	0	27.9	0	0	0	0	25	0.002	0	0.008	
Month 9	0.0011	6.3	0.018	0	29.8	0	0	0	0	26	0.002	0	0.006	
Month 10	0.0007	5.0	0.016	0	18.2	0	0	0	0	20	0.002	0	0.009	
Month 11	0.0008	4.0	0.011	0	14.5	0	0	0	0	16	0.001	0	0.012	
Month 12	0.0008	3.0	0.011	0	10.0	0	0	0	0	12	0	0	0.002	12
Month 15	0.0009	3.2	0.0087	0	8.6	0	0	0	0	9.9	0	0	0.003	9.3
Month 18	0.0008	3.8	0.005	0	7.9	0	0	0	0.0002	12	0	0	0.003	11
Month 21	0.001	3.3	0.0049	0	4.6	0	0	0	0.0003	9.5	0.001	0	0.003	11
Month 24	0.0008	3.2	0.012	0	3.9	0	0	0	0.0008	8.7	0	0	0.008	9.7

Sample W/OB25 Transition, Column 1

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	101	6.7	0	0	0	0.029	0	8.6	0	0.0060	0	0	0	8.0
Week 1	42.5	6.5	0	0	0	0.016	0	3.7	0	0.0024	0	0	0	3.9
Week 2	53.7	6.1	0.0001	0	0	0.024	0	5.7	0	0.0027	0	0	0	4.8
Week 3	53.9	6.0	0	0	0	0.023	0	5.9	0	0.0034	0	0	0	5.1
Month 1	52.9	6.0	0	0	0	0.023	0	5.7	0	0.0031	0	0.0016	0	4.9
Month 2	58.5	5.9	0	0	0	0.032	0	7.0	0.0001	0.0047	0	0.0013	0	5.5
Month 3	69.0	4.7	0	0.065	0	0.033	0	7.6	0	0.0058	0	0.0026	0	5.9
Month 4	41.0	4.9	0	0.054	0	0.025	0	4.9	0.0002	0.0039	0	0.0063	0.008	4.0
Month 5	27.6	5.3	0	0.035	0	0.022	0	3.3	0.0003	0.0027	0	0.0057	0.007	3.3
Month 6	28.8	6.3	0	0.008	0	0.022	0	3.2	0.0002	0.003	0	0.0071	0	3.4
Month 7	24.1	6.0	0	0	0	0.017	0	2.5	0	0.0019	0	0.0024	0	3.4
Month 8	21.4	6.1	0	0	0	0.015	0	2.4	0	0.0015	0	0.0007	0	3.7
Month 9	15.9	6.1	0	0	0	0.015	0	2.1	0	0.0013	0	0.0026	0	3.6
Month 10	11.4	5.9	0	0	0	0.015	0	1.7	0	0.0012	0	0.017	0.005	2.6
Month 11	8.9	6.2	0	0	0	0.012	0	1.2	0.0002	0.0009	0	0.0018	0	2.1
Month 12	9.5	6.2	0	0	0	0.014	0	1.4	0	0.0010	0	0.0035	0	2.5
Month 15	10.5	6.2	0	0	0	0.018	0	1.6	0	0.0011	0.0007	0.0067	0	2.3
Month 18	11.4	6.0	0	0	0	0.021	0	1.9	0	0.0008	0	0.010	0	3.4
Month 21	9.2	6.0	0	0	0	0.017	0	1.6	0	0.0013	0.0007	0.0021	0	2.3
Month 24	10.8	5.8	0	0.10	0	0.021	0	1.8	0	0.0015	0	0.0004	0	2.7

Sample W/OB25 Transition, Column 1

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.011	21	0.029	0	145	0	0.002	0	0	41	0.003	0	0.003	
Week 1	0.0097	8.0	0.017	0	58.6	0	0	0	0	24	0.002	0	0.002	
Week 2	0.0093	12.8	0.027	0	71.7	0	0.002	0	0	33	0.001	0	0.007	
Week 3	0.0089	12.6	0.033	0	72.1	0	0.001	0	0	37	0.003	0	0	
Month 1	0.0043	12.4	0.034	0	70.4	0	0.001	0	0	37	0.003	0	0.002	
Month 2	0.0045	16.2	0.038	0	76.4	0	0.002	0	0	48	0.004	0	0.005	
Month 3	0.0054	18.0	0.045	0	90.3	0	0.002	0	0	48	0.003	0	0.005	
Month 4	0.0061	10.9	0.031	0	48.7	0	0.001	0	0	35	0.003	0	0.011	
Month 5	0.0027	7.1	0.020	0	35.5	0	0.001	0	0	26	0.002	0	0.003	
Month 6	0.0033	7.1	0.024	0	33.8	0	0.001	0	0	25	0.002	0	0.014	
Month 7	0.0014	5.7	0.016	0	30.3	0	0	0	0	24	0.002	0	0.008	
Month 8	0.001	5.1	0.014	0	28.2	0	0	0	0	25	0.002	0	0.013	
Month 9	0.001	4.6	0.014	0	19.9	0	0	0	0	19	0.001	0	0.013	
Month 10	0.0006	3.4	0.01	0	12.0	0	0	0	0	13	0.001	0	0.007	
Month 11	0.0007	2.7	0.008	0	8.8	0	0	0	0	9.5	0	0	0.002	
Month 12	0.0007	2.9	0.010	0	9.2	0	0	0	0	11	0	0	0.003	12
Month 15	0.0007	3.4	0.011	0	8.2	0	0	0	0	9.7	0.001	0	0.003	10
Month 18	0.0008	4.0	0.008	0	8.0	0	0	0	0	12	0	0	0.004	13
Month 21	0.0006	3.5	0.0098	0	4.9	0	0	0	0.0009	10	0	0	0.004	11
Month 24	0.0006	4.0	0.013	0	5.7	0	0	0	0.0007	10	0.001	0	0.006	10

Sample W/OB25 Transition, Duplicate Column

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	54.9	6.3	0	0	0	0.014	0	3.8	0.0004	0.0036	0	0	0	3.7
Week 1	32.7	6.6	0	0	0	0.016	0	3.4	0	0.0020	0	0.0016	0	3.1
Week 2	46.5	6.1	0	0	0	0.020	0	4.9	0	0.0032	0	0	0	4.8
Week 3	9.7	6.3	0	0	0	0.0054	0	1.1	0	0.0007	0	0.0008	0	1.3
Month 1	33.6	6.0	0	0	0	0.018	0	3.7	0	0.0025	0	0.0011	0	3.5
Month 2	31.0	5.9	0	0	0	0.015	0	3.5	0	0.0023	0	0.0008	0	2.8
Month 3	69.6	4.8	0	0.038	0	0.037	0	8.2	0.0016	0.0051	0	0.0009	0	5.1
Month 4	48.2	4.7	0	0.084	0	0.031	0	5.7	0.0001	0.0047	0	0.010	0.006	4.5
Month 5	25.5	5.2	0	0.057	0	0.018	0	2.9	0.0001	0.0024	0	0.0059	0	3.4
Month 6	20.0	6.1	0	0.010	0	0.017	0	2.2	0.0001	0.0026	0	0.0027	0	2.8
Month 7	17.3	6.0	0	0	0	0.017	0	2.0	0	0.0017	0	0.0014	0	2.8
Month 8	22.0	6.0	0	0	0	0.017	0	2.6	0	0.0012	0	0.0004	0	3.7
Month 9	21.7	6.0	0	0.009	0	0.019	0	2.8	0	0.0019	0	0.0063	0	4.1
Month 10	16.1	5.8	0	0	0	0.019	0	2.2	0	0.0018	0	0.017	0	3.0
Month 11	13.7	5.9	0	0	0	0.014	0	1.8	0.0003	0.0012	0	0.0043	0	2.8
Month 12	9.9	6.1	0	0	0	0.013	0	1.4	0	0.0011	0	0.0064	0	2.4
Month 15	10.3	6.2	0	0	0	0.015	0	1.5	0	0.0010	0	0.013	0	2.1
Month 18	10.6	5.9	0	0	0	0.017	0	1.7	0	0.0006	0	0.017	0	2.8
Month 21	8.4	6.1	0	0	0	0.016	0	1.6	0	0.0009	0.001	0.015	0	2.1
Month 24	8.6	5.9	0	0.012	0	0.018	0	1.6	0	0.0014	0	0.0013	0	2.3

Sample W/OB25 Transition, Duplicate Column

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.0025	9.6	0.021	0	71.9	0	0.067	0	0	24	0.002	0	0.001	
Week 1	0.0056	6.7	0.016	0	44.5	0	0.002	0	0	22	0.001	0	0.006	
Week 2	0.0075	10.8	0.026	0	62.4	0	0.002	0	0	27	0.002	0	0.003	
Week 3	0.0054	2.3	0.005	0	12.1	0	0	0	0	6.8	0	0	0	
Month 1	0.0024	8.2	0.022	0	45.3	0	0.001	0	0	23	0.002	0	0.004	
Month 2	0.0016	8.5	0.020	0	38.4	0	0	0	0	20	0.002	0	0.003	
Month 3	0.0052	20.7	0.046	0	88.1	0	0.002	0	0	46	0.003	0	0.002	
Month 4	0.0073	12.8	0.039	0	56.6	0	0.002	0	0	43	0.003	0	0.012	
Month 5	0.0036	6.2	0.018	0	33.0	0	0.001	0	0	27	0.002	0	0.004	
Month 6	0.0028	4.8	0.019	0	22.0	0	0.001	0	0	21	0.002	0	0.012	
Month 7	0.0012	4.3	0.014	0	19.4	0	0	0	0	18	0.001	0	0.007	
Month 8	0.0012	5.7	0.013	0	27.9	0	0	0	0	25	0.002	0	0.008	
Month 9	0.0011	6.3	0.018	0	29.8	0	0	0	0	26	0.002	0	0.006	
Month 10	0.0007	5.0	0.016	0	18.2	0	0	0	0	20	0.002	0	0.009	
Month 11	0.0008	4.0	0.011	0	14.5	0	0	0	0	16	0.001	0	0.012	
Month 12	0.0008	3.0	0.011	0	10.0	0	0	0	0	12	0	0	0.002	12
Month 15	0.0009	3.2	0.0087	0	8.6	0	0	0	0	9.9	0	0	0.003	9.3
Month 18	0.0008	3.8	0.005	0	7.9	0	0	0	0.0002	12	0	0	0.003	11
Month 21	0.0010	3.3	0.0049	0	4.6	0	0	0	0.0003	9.5	0.001	0	0.003	11
Month 24	0.0008	3.2	0.012	0	3.9	0	0	0	0.0008	8.7	0	0	0.008	9.7

Sample W/OB25, Fresh, Column 1

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	15.9	7.1	0.0003	0.33	0	0.0058	0	0	0	0.12	0	0.0038	0	3.9
Week 1	22.9	7.0	0	0	0	0.017	0	5.3	0	0.036	0	0.0013	0	3.6
Week 2	29.1	6.8	0	0	0	0.019	0	8.8	0	0.062	0	0.001	0	4.2
Week 3	17.5	6.9	0	0	0	0.012	0	4.9	0	0.038	0	0.001	0	3.1
Month 1	5.9	6.9	0	0	0	0.0038	0	1.3	0	0.011	0	0.0005	0	1.3
Month 2	0	6.5	0	0	0	0.0082	0	3.5	0	0.023	0	0.0006	0	2.5
Month 3	10.4	6.8	0	0	0	0.0073	0	2.5	0	0.014	0	0.0004	0	1.8
Month 4	6.1	6.8	0	0	0	0.0049	0	1.9	0.0001	0.010	0	0.0006	0	1.9
Month 5	4.4	6.9	0	0	0	0.0038	0	1.4	0.0001	0.0067	0	0.0004	0	2.0
Month 6	4.4	7.1	0	0	0	0.0041	0	1.4	0	0.0065	0	0.0003	0	2.0
Month 7	3.0	6.9	0	0	0	0.0032	0	1.1	0	0.0045	0	0.0005	0	1.4
Month 8	4.0	6.9	0	0	0	0.0033	0	1.6	0	0.0061	0	0	0	2.0
Month 9	3.3	7.1	0	0	0	0.0046	0	1.5	0	0.0053	0	0.0014	0	1.9
Month 10	2.9	7.0	0	0	0	0.0035	0	1.3	0	0.0033	0	0.0044	0	1.6
Month 11	2.5	7.0	0	0	0	0.0038	0	1.0	0.0003	0.0032	0	0.0002	0.005	1.4
Month 12	3.1	7.1	0	0	0	0.0023	0	1.3	0	0.0029	0	0.0019	0.007	1.8
Month 15	3.5	7.1	0	0	0	0.0024	0	1.4	0	0.0030	0	0.0021	0	1.6
Month 18	4.2	7.1	0	0	0	0.0024	0	2.0	0	0.0016	0	0.005	0	2.2
Month 21	4.0	6.9	0	0	0	0.0029	0	2.1	0	0.0031	0	0.003	0.008	1.6
Month 24	3.8	7.0	0	0.034	0	0.0045	0	2.4	0	0.003	0	0.0068	0.005	1.5

Sample W/OB25, Column 1

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.019	0	0.046	0	23.2	0	0.002	0	0	6.1	0.001	0	0.011	
Week 1	0.023	5.0	0.43	0	23.8	0	0	0	0	13	0.002	0	0.002	
Week 2	0.011	7.7	0.66	0	30.4	0	0	0	0	26	0.004	0	0.002	
Week 3	0.011	4.3	0.50	0	18.8	0	0	0	0	19	0.003	0	0	
Month 1	0.0063	1.3	0.16	0	6.0	0	0	0	0	6.3	0	0	0	
Month 2	0.0062	3.2	0.29	0	9.7	0	0	0	0	13	0.002	0	0.002	
Month 3	0.0099	2.4	0.18	0	7.6	0	0	0	0	11	0.001	0	0	
Month 4	0.0081	1.6	0.14	0.001	4.7	0	0	0	0	5.7	0	0.0002	0.005	
Month 5	0.0032	1.3	0.10	0	3.5	0	0	0	0	4.1	0	0.0002	0	
Month 6	0.0040	1.3	0.10	0.001	2.7	0	0	0	0	3.6	0	0.0003	0.002	
Month 7	0.0024	0.9	0.063	0	1.8	0	0	0	0	2.2	0	0.0002	0.005	
Month 8	0.0014	1.3	0.079	0	2.3	0	0	0	0	3.2	0	0.0001	0.007	
Month 9	0.0007	1.3	0.060	0	2.1	0	0	0	0	2.9	0	0.0002	0.003	
Month 10	0.0003	1.1	0.036	0	1.2	0	0	0	0	1.9	0	0.0002	0.008	
Month 11	0.0005	0.9	0.028	0	1.3	0	0	0	0	1.4	0	0.0001	0.003	
Month 12	0.0005	1.1	0.034	0	1.8	0	0	0	0	2.2	0	0.0002	0.001	11
Month 15	0.0007	1.2	0.016	0	1.6	0	0	0	0	2.2	0	0.0001	0.002	10
Month 18	0.0003	1.5	0.010	0	1.7	0	0	0	0	2.8	0	0.0002	0.002	14
Month 21	0.0004	1.5	0.023	0	1.2	0	0	0	0.0004	2.7	0	0.0002	0.002	12
Month 24	0.0003	1.7	0.029	0	1.0	0	0	0	0.0003	2.3	0	0.0002	0.010	11

Sample W/OB25, Fresh, Duplicate Column

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	22.3	7.2	0.0001	0.015	0	0.0077	0	1.9	0	0.20	0	0.011	0	4.6
Week 1	21.6	7.2	0	0	0	0.014	0	5.7	0	0.036	0	0.0068	0	3.0
Week 2	25.9	7.0	0	0	0	0.017	0	7.2	0	0.047	0	0	0	3.8
Week 3	15.4	6.9	0	0	0	0.010	0	3.9	0	0.031	0	0.0002	0	2.7
Month 1	12.0	7.0	0	0	0	0.0074	0	2.8	0	0.023	0	0.0004	0	2.4
Month 2	11.5	6.8	0	0	0	0.0094	0	3.5	0	0.025	0	0.0006	0	2.8
Month 3	6.1	6.7	0	0	0	0.0051	0	1.7	0	0.011	0	0.0003	0	1.9
Month 4	5.4	6.8	0	0	0	0.0049	0	1.8	0	0.0095	0	0.0008	0.008	1.7
Month 5	3.5	6.8	0	0	0	0.0030	0	1.1	0	0.0067	0	0.0011	0	1.5
Month 6	4.3	7.2	0	0	0	0.0043	0	1.4	0	0.0069	0	0.0005	0	1.8
Month 7	3.0	6.8	0	0	0	0.0032	0	0.9	0	0.005	0	0.0006	0	1.6
Month 8	3.4	6.8	0	0	0	0.0028	0	1.2	0	0.0054	0	0	0	2.0
Month 9	2.8	6.8	0	0	0	0.0027	0	1.1	0	0.0048	0	0.0008	0	2.0
Month 10	2.9	6.8	0	0	0	0.0032	0	1.1	0	0.0044	0	0.0038	0	1.7
Month 11	3.0	6.9	0	0	0	0.0029	0	1.2	0.0002	0.0039	0	0.0008	0	1.7
Month 12	2.7	6.9	0	0	0	0.0022	0	1.0	0	0.0035	0	0.0022	0	1.8
Month 15	3.8	6.9	0	0	0	0.0031	0	1.4	0	0.0048	0	0.0007	0	2.0
Month 18	3.0	6.8	0	0	0	0.0025	0	1.2	0	0.0041	0	0.0020	0	1.8
Month 21	3.2	6.7	0	0	0	0.0030	0	1.2	0	0.0043	0	0.013	0.009	1.6
Month 24	3.5	6.5	0	0.018	0	0.0035	0	1.5	0	0.0074	0	0.0049	0.013	1.6

Sample W/OB25, Duplicate Column

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.038	1.5	0.034	0	34.0	0	0.004	0	0.0007	7.3	0.002	0	0.014	
Week 1	0.026	4.7	0.41	0	21.0	0	0.001	0	0	14	0.002	0	0.002	
Week 2	0.032	6.5	0.77	0	28.2	0	0	0	0	24	0.004	0	0	
Week 3	0.018	3.6	0.43	0	17.1	0	0	0	0	17	0.003	0	0	
Month 1	0.025	2.5	0.34	0	12.9	0	0	0	0	13	0.002	0	0	
Month 2	0.053	3.2	0.38	0	10.4	0	0	0	0	14	0.002	0	0.004	
Month 3	0.013	1.6	0.16	0	4.7	0	0	0	0	6.0	0	0	0	
Month 4	0.037	1.6	0.15	0	3.8	0	0	0	0	5.1	0	0.0001	0.004	
Month 5	0.0072	1.0	0.083	0	2.8	0	0	0	0	3.3	0	0.0002	0	
Month 6	0.0056	1.2	0.11	0.001	2.7	0	0	0	0	3.7	0	0.0002	0.007	
Month 7	0.0041	0.9	0.037	0	1.9	0	0	0	0	2.2	0	0.0002	0.007	
Month 8	0.0017	1.0	0.08	0	2.1	0	0	0	0	2.8	0	0.0003	0.005	
Month 9	0.0017	1.0	0.069	0.001	1.7	0	0	0	0	2.5	0	0.0002	0.003	
Month 10	0.0007	1.0	0.055	0.001	1.2	0	0	0	0	2.2	0	0.0002	0.009	
Month 11	0.0005	1.0	0.055	0	1.3	0	0	0	0	1.8	0	0.0002	0	
Month 12	0.0007	0.9	0.050	0.001	1.0	0	0	0	0	1.9	0	0.0002	0.003	12
Month 15	0.0011	1.1	0.066	0.001	1.3	0	0	0	0	2.2	0	0.0002	0.003	11
Month 18	0.0021	0.9	0.040	0.001	0.7	0	0	0	0	2.0	0	0.0002	0	11
Month 21	0.0011	1.0	0.035	0.001	0.6	0	0	0	0.0064	2.2	0	0.0002	0.009	11
Month 24	0.0008	1.1	0.072	0	0.5	0	0	0	0.0003	2.4	0	0.0001	0.008	9.3

Sample D1/Whaleback Fresh, Column 1

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	35	5.3	0	0.009	0	0.12	0	16.4	0	0.047	0	0.0005	0.006	4.8
Week 1	15.9	6.7	0	0	0	0.027	0	6.6	0	0.0011	0.0011	0.0031	0.006	3.0
Week 2	18.4	6.9	0	0	0	0.030	0	7.8	0	0.0008	0.0009	0.0030	0.012	3.8
Week 3	16.2	7.3	0	0	0	0.025	0	6.1	0	0.0005	0.0006	0.0002	0	3.7
Month 1	11.1	7.5	0	0	0	0.016	0	3.9	0	0.0003	0.0015	0.0006	0.024	3.0
Month 2	6.7	7.5	0	0	0	0.013	0	2.9	0	0.0002	0.0016	0.0002	0.038	2.3
Month 3	5.2	7.3	0	0	0	0.009	0	2.1	0	0.0002	0.0022	0.0004	0.059	1.9
Month 4	4.4	7.3	0	0	0	0.009	0	2.4	0	0.0002	0.0024	0.0004	0.043	1.8
Month 5	4.2	7.4	0	0	0	0.010	0	2.4	0	0.0002	0.0033	0.0005	0.059	1.3
Month 6	4.0	7.5	0	0	0	0.009	0	2.5	0	0.0002	0.0028	0.0003	0.08	1.1
Month 7	3.8	7.4	0	0	0	0.011	0	2.5	0	0.0002	0.0032	0	0.16	1.1
Month 8	3.3	7.6	0	0	0.002	0.010	0	2.6	0	0.0002	0.0029	0	0.14	1.0
Month 9	4.0	7.6	0	0	0	0.010	0	1.8	0	0.0002	0.0028	0	0.16	1.1
Month 10	3.6	7.7	0	0	0	0.011	0	2.7	0	0.0003	0.0028	0.0001	0.14	1.0
Month 11	3.1	7.4	0	0.006	0	0.011	0	2.4	0	0.0003	0.0031	0	0.11	0.6
Month 12	2.7	7.3	0	0	0	0.009	0	2.0	0	0.0003	0.0043	0.0002	0.061	0.6
Month 15	3.5	7.1	0	0	0	0.009	0	2.1	0	0.0006	0.0046	0.0009	0.14	0.8
Month 18	5.0	7.1	0	0.014	0	0.012	0	3.3	0	0.0005	0.0058	0.0004	0.39	0.4
Month 21	4.7	7.2	0	0.020	0	0.015	0	2.5	0	0.0006	0.014	0.0011	0.13	0.8
Month 24														

Sample D1/Whaleback Fresh, Column 1

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.047	10	0.33	0	31	0	0.002	0	0	4.5	0	0	0.016	
Week 1	0.046	3.9	0.052	0.001	15.4	0	0	0	0	7.2	0	0	0.007	
Week 2	0.041	4.3	0.046	0.002	17.6	0	0	0	0	7.8	0	0	0.015	
Week 3	0.022	3.2	0.027	0.003	16.3	0	0	0	0	6.8	0	0	0	
Month 1	0.015	2.0	0.005	0.004	10.6	0	0	0	0	4.5	0	0	0.009	
Month 2	0.015	1.6	0.006	0.004	6.5	0	0	0	0	3.1	0	0	0.004	
Month 3	0.013	1.2	0.011	0.006	4.3	0	0	0	0	2.2	0	0	0.002	
Month 4	0.013	1.3	0.011	0.004	3.2	0	0	0	0	1.5	0	0	0.028	
Month 5	0.016	1.4	0.009	0.005	2.6	0	0	0	0	1.4	0	0	0.016	
Month 6	0.010	1.4	0.007	0.005	1.6	0	0	0	0	0.6	0	0.0001	0.002	
Month 7	0.017	1.5	0.004	0.005	1.4	0	0	0	0	0.5	0	0	0	
Month 8	0.008	1.4	0.003	0.005	1.1	0	0	0	0	0.3	0	0	0	7.3
Month 9	0.0069	1.5	0.002	0.004	0.9	0	0	0	0	0.2	0	0	0.001	6.7
Month 10	0.0069	1.5	0.002	0.004	0.7	0	0	0	0	0.2	0	0	0	6.9
Month 11	0.0065	1.3	0.002	0.004	0.5	0	0	0	0	0.1	0	0	0	6.9
Month 12	0.0055	1.1	0.002	0.006	0.5	0	0	0	0	0.2	0	0	0.003	7.4
Month 15	0.0034	1.2	0.002	0.006	0.6	0	0	0	0.0004	0.4	0	0	0.03	6.6
Month 18	0.0079	1.8	0.009	0.009	0.6	0	0	0	0.0014	0.7	0	0	0.009	11
Month 21	0.0091	1.2	0.019	0.009	0.9	0	0	0	0.0005	0.7	0	0	0.006	8.0
Month 24														

Sample D1/Whaleback Fresh, Duplicate Column

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	97.9	7.9	0	0.009	0.003	0.0077	0	12.3	0.0001	0.0031	0.0036	0.0011	0	75.6
Week 1	69.7	7.6	0	0.007	0.003	0.0044	0	7.8	0	0.0018	0.0025	0.0009	0	52.5
Week 2	61.3	7.5	0	0.006	0.003	0.0048	0	8.2	0	0.0024	0.0033	0	0	46.8
Week 3	27.2	7.5	0	0.009	0.003	0.0017	0	2.6	0	0.0016	0.0034	0.0001	0	23.7
Month 1	29.2	7.7	0	0.014	0.006	0.002	0	2.7	0	0.001	0.0053	0.0018	0.0600	25.2
Month 2	21.9	7.4	0	0.025	0.008	0.0021	0	2.7	0	0.0007	0.0037	0.0011	0.018	19.7
Month 3	22.6	7.6	0	0.010	0.008	0.0017	0	2.2	0	0.0010	0.0036	0.0012	0	22.4
Month 4	18.0	7.6	0	0.009	0.012	0.0013	0	1.6	0.0001	0.0010	0.0042	0.0008	0.007	18.8
Month 5	13.3	7.7	0	0.018	0.007	0.0017	0	0.7	0.0002	0.0006	0.0035	0.0019	0.035	11.5
Month 6	11.8	7.7	0	0.008	0.016	0.0004	0	0.7	0	0.0005	0.0065	0.0001	0.02	14.6
Month 7	9.1	7.8	0	0	0.013	0.0003	0	0.5	0	0.0003	0.011	0.0001	0.016	12.8
Month 8	8.3	7.6	0	0.007	0.014	0.0001	0	0.6	0	0.0003	0.016	0.0001	0.014	13.2
Month 9	7.5	7.7	0	0.009	0.016	0.0005	0	0.5	0	0.0004	0.017	0.002	0.014	13.4
Month 10	6.8	7.6	0	0.008	0.018	0.0005	0	0.5	0	0.0003	0.018	0	0.019	11.2
Month 11	8.5	7.9	0	0.011	0.008	0.0009	0	0.7	0.0001	0.0004	0.018	0	0.048	13.5
Month 12	6.6	7.7	0	0.022	0.006	0.0005	0	0.7	0	0.0002	0.013	0.0002	0.048	10.9
Month 15	9.0	7.9	0	0.019	0.014	0.0011	0	0.8	0	0.0005	0.020	0.0005	0.030	12.6
Month 18	8.5	7.7	0	0.044	0.016	0.0007	0	0.7	0	0.0006	0.028	0.004	0.16	14.0
Month 21	9.9	7.5	0	0.019	0.011	0.0007	0	1.0	0	0.0007	0.027	0.016	0.051	15.9
Month 24	7.8	7.4	0	0.074	0.017	0.0023	0	0.9	0	0.0007	0.015	0.0033	0.11	13.0

Sample D1/Whaleback Fresh, Duplicate Column

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.061	13.9	0.013	0.004	103	0	0	0	0	36	0.005	0	0.002	
Week 1	0.023	8.0	0.0086	0.01	68.1	0	0	0	0	26	0.004	0	0.002	
Week 2	0.027	8.8	0.018	0.019	63.5	0	0	0	0	28	0.004	0	0	
Week 3	0.025	2.9	0.013	0.019	30.7	0	0	0	0.0001	13	0.002	0	0	
Month 1	0.023	3.0	0.0056	0.027	31.1	0	0	0	0.0002	13	0.002	0	0	
Month 2	0.022	3.0	0.0038	0.024	21.9	0	0	0	0.0004	10	0.002	0	0.006	
Month 3	0.0074	2.7	0.0041	0.026	23.8	0	0	0	0	10	0.002	0	0	
Month 4	0.0074	1.8	0.0036	0.028	17.9	0	0	0	0	6.7	0.001	0.0002	0.004	
Month 5	0.0055	0.7	0.0035	0.020	9.8	0	0	0	0.0004	2.6	0	0.0001	0	
Month 6	0.0023	0.8	0.001	0.037	11.7	0	0	0	0.0001	3.2	0	0.0003	0.004	
Month 7	0.0046	0.6	0.0004	0.042	9.1	0	0	0	0	1.6	0	0.0001	0.003	
Month 8	0.0044	0.6	0.0009	0.046	8.6	0	0	0	0	1.5	0	0	0.004	
Month 9	0.0019	0.6	0.0016	0.043	8.1	0	0	0	0	1.5	0	0	0.004	
Month 10	0.0010	0.5	0.0008	0.046	6.1	0	0	0	0	0.9	0	0	0.017	
Month 11	0.0011	0.8	0.003	0.048	7.2	0	0	0	0.0006	0.6	0	0	0	
Month 12	0.011	0.7	0.002	0.031	5.8	0	0	0	0.0003	0.4	0	0	0.003	10
Month 15	0.0015	0.8	0.002	0.045	7.0	0	0	0	0.0002	0.8	0	0	0.004	10
Month 18	0.0009	0.7	0.004	0.045	6.8	0	0	0	0.0008	0.8	0	0	0.003	10
Month 21	0.0007	1.0	0.0021	0.044	7.0	0	0.001	0	0.0046	1.3	0	0	0.011	10
Month 24	0.0005	0.8	0.0038	0.037	4.9	0	0	0	0.0021	0.7	0	0.0003	0.007	9.7

Sample D1/Whaleback Fresh BWT, Column 1

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0	35	5.3	0	0.009	0	0.12	0	16.4	0	0.047	0	0.0005	0.006	4.8
Week 1	15.9	6.7	0	0	0	0.027	0	6.6	0	0.0011	0.0011	0.0031	0.006	3.0
Week 2	18.4	6.9	0	0	0	0.030	0	7.8	0	0.0008	0.0009	0.003	0.012	3.8
Week 3	16.2	7.3	0	0	0	0.025	0	6.1	0	0.0005	0.0006	0.0002	0	3.7
Month 1	11.1	7.5	0	0	0	0.016	0	3.9	0	0.0003	0.0015	0.0006	0.024	3.0
Month 2	6.7	7.5	0	0	0	0.013	0	2.9	0	0.0002	0.0016	0.0002	0.038	2.3
Month 3	5.2	7.3	0	0	0	0.009	0	2.1	0	0.0002	0.0022	0.0004	0.059	1.9
Month 4	4.4	7.3	0	0	0	0.009	0	2.4	0	0.0002	0.0024	0.0004	0.043	1.8
Month 5	4.2	7.4	0	0	0	0.010	0	2.4	0	0.0002	0.0033	0.0005	0.059	1.3
Month 6	4.0	7.5	0	0	0	0.009	0	2.5	0	0.0002	0.0028	0.0003	0.08	1.1
Month 7	3.8	7.4	0	0	0	0.011	0	2.5	0	0.0002	0.0032	0	0.16	1.1
Month 8	3.3	7.6	0	0	0.002	0.010	0	2.6	0	0.0002	0.0029	0	0.14	1.0
Month 9	4.0	7.6	0	0	0	0.010	0	1.8	0	0.0002	0.0028	0	0.16	1.1
Month 10	3.6	7.7	0	0	0	0.011	0	2.7	0	0.0003	0.0028	0.0001	0.14	1.0
Month 11	3.1	7.4	0	0.006	0	0.011	0	2.4	0	0.0003	0.0031	0	0.11	0.6
Month 12	2.7	7.3	0	0	0	0.009	0	2.0	0	0.0003	0.0043	0.0002	0.061	0.6
Month 15	3.5	7.1	0	0	0	0.009	0	2.1	0	0.0006	0.0046	0.0009	0.14	0.8
Month 18	5.0	7.1	0	0.014	0	0.012	0	3.3	0	0.0005	0.0058	0.0004	0.39	0.4
Month 21	4.7	7.2	0	0.020	0	0.015	0	2.5	0	0.0006	0.014	0.0011	0.13	0.8
Month 24														

Sample D1/Whaleback Fresh BWT, Column 1

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.047	10	0.33	0	31	0	0.002	0	0	4.5	0	0	0.016	
Week 1	0.046	3.9	0.052	0.001	15.4	0	0	0	0	7.2	0	0	0.007	
Week 2	0.041	4.3	0.046	0.002	17.6	0	0	0	0	7.8	0	0	0.015	
Week 3	0.022	3.2	0.027	0.003	16.3	0	0	0	0	6.8	0	0	0	
Month 1	0.015	2.0	0.005	0.004	10.6	0	0	0	0	4.5	0	0	0.009	
Month 2	0.015	1.6	0.006	0.004	6.5	0	0	0	0	3.1	0	0	0.004	
Month 3	0.013	1.2	0.011	0.006	4.3	0	0	0	0	2.2	0	0	0.002	
Month 4	0.013	1.3	0.011	0.004	3.2	0	0	0	0	1.5	0	0	0.028	
Month 5	0.016	1.4	0.009	0.005	2.6	0	0	0	0	1.4	0	0	0.016	
Month 6	0.01	1.4	0.007	0.005	1.6	0	0	0	0	0.6	0	0.0001	0.002	
Month 7	0.017	1.5	0.004	0.005	1.4	0	0	0	0	0.5	0	0	0	
Month 8	0.008	1.4	0.003	0.005	1.1	0	0	0	0	0.3	0	0	0	7.3
Month 9	0.0069	1.5	0.002	0.004	0.9	0	0	0	0	0.2	0	0	0.001	6.7
Month 10	0.0069	1.5	0.002	0.004	0.7	0	0	0	0	0.2	0	0	0	6.9
Month 11	0.0065	1.3	0.002	0.004	0.5	0	0	0	0	0.1	0	0	0	6.9
Month 12	0.0055	1.1	0.002	0.006	0.5	0	0	0	0	0.2	0	0	0.003	7.4
Month 15	0.0034	1.2	0.002	0.006	0.6	0	0	0	0.0004	0.4	0	0	0.030	6.6
Month 18	0.0079	1.8	0.009	0.009	0.6	0	0	0	0.0014	0.7	0	0	0.009	11
Month 21	0.0091	1.2	0.019	0.009	0.9	0	0	0	0.0005	0.7	0	0	0.006	8.0
Month 24														

Sample D1/Whaleback Fresh BWT, Duplicate Column

Time	EC	pH	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
Limit of Reporting			0.0001	0.005	0.001	0.0001	0.0001	0.1	0.0001	0.0001	0.0005	0.0001	0.005	0.1
Units		mS/m	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			0.00005	0.055	0.024		(0.0007)		0.0002	(0.0014)	(0.0033)	0.0014		
Livestock Guideline				5	0.5				0.01	1	1	1		
Week 0			0	0.009	0	0.089	0	18.1	0	0.031	0	0.0018	0	3.7
Week 1			0	0.006	0	0.034	0	10.4	0	0.0009	0.0015	0.0014	0	3.8
Week 2			0	0	0	0.034	0	9.1	0	0.0007	0.0012	0.0009	0	3.7
Week 3			0	0	0	0.024	0	5.8	0	0.0004	0.0009	0.0002	0	3.2
Month 1			0	0	0	0.015	0	3.6	0	0.0003	0.0017	0.0003	0.019	2.7
Month 2			0	0	0	0.012	0	3.0	0	0.0002	0.0019	0.0001	0.015	2.1
Month 3			0	0	0	0.008	0	2.0	0	0.0001	0.0025	0.0002	0.039	1.8
Month 4			0	0	0	0.008	0	2.3	0	0.0001	0.0026	0.0003	0.034	1.6
Month 5			0	0	0	0.009	0	2.3	0	0.0001	0.0037	0.0005	0.050	1.2
Month 6			0	0	0	0.009	0	2.6	0	0.0002	0.0037	0.0002	0.068	1.1
Month 7			0	0	0	0.009	0	2.4	0	0.0002	0.0038	0	0.12	1.0
Month 8			0	0	0.001	0.010	0	2.5	0	0.0002	0.0029	0	0.077	1.0
Month 9			0	0	0	0.010	0	1.7	0	0.0002	0.0032	0	0.10	1.0
Month 10			0	0	0	0.011	0	2.7	0	0.0002	0.0029	0.0001	0.14	0.9
Month 11			0	0	0	0.011	0	2.4	0	0.0003	0.0035	0	0.092	0.5
Month 12			0	0	0	0.008	0	1.9	0	0.0002	0.0041	0.0002	0.053	0.5
Month 15			0	0	0	0.010	0	2.3	0	0.0003	0.0049	0.0005	0.14	0.7
Month 18			0	0.014	0	0.013	0	3.7	0	0.0004	0.0046	0.0004	0.28	0.3
Month 21			0	0.10	0	0.016	0	3.3	0	0.0013	0.0086	0.0006	0.053	0.7
Month 24														

Sample D1/Whaleback Fresh BWT, Duplicate Column

Time	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn	Si
Limit of Reporting	0.0001	0.1	0.0001	0.001	0.1	0.0002	0.001	0.1	0.1	0.1	0.001	0.0001	0.001	0.1
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Freshwater Guideline			1.9	(0.0034)			0.011				0.011	(0.006)	0.008	
Livestock Guideline				0.15			1		1000	1000	0.02		20	
Week 0	0.071	10.4	0.1	0	30.2	0	0.001	0	0.0003	5.0	0	0	0.016	
Week 1	0.16	5.8	0.015	0.003	25.3	0	0	0	0	11	0	0	0.009	
Week 2	0.11	4.8	0.034	0.004	20.0	0	0	0	0	9.6	0	0	0.005	
Week 3	0.037	3.0	0.018	0.004	14.5	0	0	0	0	7.3	0	0	0	
Month 1	0.023	1.9	0.008	0.005	8.6	0	0	0	0	4.3	0	0	0.004	
Month 2	0.017	1.5	0.005	0.006	5.6	0	0	0	0	2.7	0	0	0.003	
Month 3	0.014	1.1	0.004	0.007	3.7	0	0	0	0	1.8	0	0	0.002	
Month 4	0.007	1.2	0.003	0.005	2.2	0	0	0	0	0.9	0	0	0.013	
Month 5	0.0067	1.3	0.001	0.006	1.8	0	0	0	0	0.8	0	0	0.016	
Month 6	0.0071	1.4	0.002	0.006	1.3	0	0	0	0	0.4	0	0	0.002	
Month 7	0.0050	1.3	0.002	0.006	1.1	0	0	0	0	0.2	0	0	0	
Month 8	0.0095	1.4	0.001	0.006	0.9	0	0	0	0	0.2	0	0	0.001	7.1
Month 9	0.0058	1.4	0.001	0.005	0.7	0	0	0	0	0.1	0	0	0.005	6.6
Month 10	0.0038	1.4	0.002	0.005	0.6	0	0	0	0	0.1	0	0	0	6.8
Month 11	0.0038	1.3	0.002	0.005	0.5	0	0	0	0	0.1	0	0	0.007	7.6
Month 12	0.0029	1.0	0.002	0.007	0.4	0	0	0	0	0.1	0	0	0.005	7.3
Month 15	0.0027	1.3	0.002	0.007	0.5	0	0	0	0.0006	0.4	0	0	0.035	6.6
Month 18	0.025	1.9	0.004	0.008	0.5	0	0	0	0.0008	0.3	0	0	0.008	10
Month 21	0.0074	1.5	0.045	0.009	0.6	0	0	<0.1	0.0004	0.3	0	0	0	8.9
Month 24														

APPENDIX 2: KINETIC COLUMN TEST – CUMULATIVE LEACH CONCENTRATIONS (mg/Kg)

Sample JN/OB25 Fresh

Time	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Week 0	0.000	0.000	0.000	0.000	0.000	1.46	0.000	0.001	0.000	0.001	0.000	2.25	0.008
Week 1	0.000	0.000	0.000	0.000	0.000	1.67	0.000	0.001	0.000	0.001	0.000	2.56	0.011
Week 2	0.000	0.000	0.000	0.001	0.000	1.81	0.000	0.001	0.000	0.001	0.000	2.64	0.012
Week 3	0.000	0.000	0.000	0.001	0.000	3.14	0.000	0.001	0.000	0.002	0.000	3.60	0.015
Month 1	0.000	0.000	0.000	0.001	0.000	3.41	0.000	0.001	0.000	0.003	0.000	3.78	0.017
Month 2	0.000	0.000	0.000	0.001	0.000	3.67	0.000	0.002	0.000	0.004	0.000	3.94	0.018
Month 3	0.000	0.000	0.000	0.001	0.000	3.74	0.000	0.002	0.000	0.004	0.000	3.96	0.018
Month 4	0.000	0.000	0.000	0.002	0.000	10.58	0.000	0.006	0.000	0.020	0.000	6.24	0.021
Month 5	0.000	0.001	0.000	0.003	0.000	15.95	0.000	0.011	0.000	0.039	0.000	8.62	0.022
Month 6	0.000	0.001	0.000	0.004	0.000	19.10	0.000	0.016	0.000	0.060	0.000	10.17	0.024
Month 7	0.000	0.001	0.000	0.005	0.000	22.93	0.000	0.023	0.000	0.102	0.000	12.16	0.026
Month 8	0.000	0.001	0.000	0.006	0.000	26.56	0.000	0.031	0.000	0.161	0.001	14.27	0.028
Month 9	0.000	0.001	0.000	0.007	0.000	31.79	0.000	0.045	0.000	0.345	0.001	17.02	0.029
Month 10	0.000	0.001	0.000	0.009	0.000	34.87	0.000	0.054	0.000	0.482	0.001	18.59	0.029
Month 11	0.000	0.001	0.000	0.010	0.000	39.88	0.000	0.070	0.000	0.785	0.001	20.95	0.031
Month 12	0.000	0.001	0.000	0.012	0.000	44.93	0.000	0.088	0.000	1.213	0.001	23.56	0.032
Month 15	0.000	0.003	0.000	0.013	0.000	51.63	0.000	0.112	0.000	1.963	0.006	26.35	0.033
Month 18	0.000	0.003	0.000	0.015	0.000	56.81	0.000	0.132	0.000	2.861	0.006	29.47	0.034
Month 21	0.000	0.003	0.000	0.016	0.000	60.32	0.001	0.151	0.000	3.621	0.006	31.39	0.035
Month 24	0.000	0.007	0.000	0.018	0.000	63.21	0.001	0.168	0.000	4.681	0.007	33.04	0.035

Sample JN/OB25 Fresh

Time	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Week 0	1.26	0.000	0.001	5.03	0.000	0.000	0.000	0.000	3.12	0.006	0.000	0.001
Week 1	1.42	0.000	0.001	5.44	0.000	0.000	0.000	0.000	3.54	0.007	0.000	0.001
Week 2	1.49	0.001	0.001	5.52	0.000	0.000	0.000	0.000	3.71	0.007	0.000	0.001
Week 3	2.55	0.001	0.002	7.43	0.000	0.000	0.000	0.000	6.58	0.012	0.000	0.001
Month 1	2.70	0.001	0.002	7.63	0.000	0.000	0.000	0.000	6.98	0.012	0.000	0.002
Month 2	2.85	0.001	0.002	7.76	0.000	0.000	0.000	0.000	7.36	0.013	0.000	0.002
Month 3	2.88	0.001	0.002	7.78	0.000	0.000	0.000	0.000	7.47	0.013	0.000	0.003
Month 4	10.94	0.007	0.002	13.55	0.000	0.001	0.000	0.000	26.62	0.042	0.000	0.005
Month 5	16.02	0.013	0.002	16.43	0.000	0.002	0.000	0.000	39.36	0.056	0.000	0.007
Month 6	18.77	0.018	0.002	17.45	0.000	0.002	0.000	0.000	46.49	0.064	0.000	0.011
Month 7	22.07	0.026	0.002	18.48	0.000	0.004	0.000	0.000	55.09	0.077	0.000	0.017
Month 8	25.04	0.035	0.002	19.23	0.000	0.005	0.000	0.000	62.50	0.088	0.000	0.034
Month 9	28.83	0.050	0.002	20.30	0.000	0.007	0.000	0.000	72.35	0.110	0.000	0.050
Month 10	31.01	0.060	0.002	20.63	0.000	0.009	0.000	0.000	78.40	0.123	0.000	0.061
Month 11	34.91	0.077	0.002	21.53	0.000	0.012	0.000	0.000	89.08	0.148	0.001	0.079
Month 12	38.50	0.097	0.002	22.13	0.000	0.015	0.000	0.000	99.50	0.173	0.001	0.100
Month 15	43.70	0.127	0.002	22.69	0.000	0.019	0.000	0.000	111.69	0.214	0.001	0.130
Month 18	47.27	0.150	0.002	23.09	0.000	0.023	0.000	0.000	122.11	0.254	0.001	0.161
Month 21	49.66	0.170	0.002	23.73	0.000	0.027	0.000	0.001	129.45	0.285	0.001	0.188
Month 24	51.46	0.189	0.002	23.92	0.000	0.032	0.000	0.001	135.41	0.314	0.001	0.220

Sample WB/OB25 Transition

Time	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Week 0	0.000	0.000	0.000	0.005	0.000	1.30	0.000	0.001	0.000	0.000	0.000	1.23	0.001
Week 1	0.000	0.000	0.000	0.006	0.000	1.69	0.000	0.001	0.000	0.000	0.000	1.61	0.002
Week 2	0.000	0.000	0.000	0.008	0.000	2.08	0.000	0.001	0.000	0.000	0.000	1.97	0.003
Week 3	0.000	0.000	0.000	0.009	0.000	2.35	0.000	0.002	0.000	0.000	0.000	2.21	0.003
Month 1	0.000	0.000	0.000	0.010	0.000	2.64	0.000	0.002	0.000	0.000	0.000	2.47	0.004
Month 2	0.000	0.000	0.000	0.012	0.000	3.08	0.000	0.002	0.000	0.000	0.000	2.82	0.004
Month 3	0.000	0.003	0.000	0.014	0.000	3.56	0.000	0.002	0.000	0.000	0.000	3.15	0.004
Month 4	0.000	0.009	0.000	0.017	0.000	3.99	0.000	0.003	0.000	0.001	0.001	3.49	0.005
Month 5	0.000	0.012	0.000	0.018	0.000	4.21	0.000	0.003	0.000	0.001	0.001	3.73	0.005
Month 6	0.000	0.013	0.000	0.019	0.000	4.40	0.000	0.003	0.000	0.002	0.001	3.95	0.005
Month 7	0.000	0.013	0.000	0.022	0.000	4.79	0.000	0.003	0.000	0.002	0.001	4.49	0.005
Month 8	0.000	0.013	0.000	0.025	0.000	5.22	0.000	0.004	0.000	0.002	0.001	5.13	0.006
Month 9	0.000	0.013	0.000	0.028	0.000	5.64	0.000	0.004	0.000	0.003	0.001	5.78	0.006
Month 10	0.000	0.013	0.000	0.031	0.000	6.01	0.000	0.004	0.000	0.006	0.001	6.33	0.006
Month 11	0.000	0.013	0.000	0.034	0.000	6.29	0.000	0.004	0.000	0.007	0.001	6.78	0.006
Month 12	0.000	0.013	0.000	0.037	0.000	6.61	0.000	0.005	0.000	0.008	0.001	7.33	0.006
Month 15	0.000	0.013	0.000	0.040	0.000	6.94	0.000	0.005	0.000	0.010	0.001	7.80	0.006
Month 18	0.000	0.013	0.000	0.043	0.000	7.23	0.000	0.005	0.000	0.012	0.001	8.30	0.006
Month 21	0.000	0.013	0.000	0.046	0.000	7.51	0.000	0.005	0.000	0.014	0.001	8.68	0.007
Month 24	0.000	0.023	0.000	0.050	0.000	7.80	0.000	0.005	0.000	0.014	0.001	9.11	0.007

Sample WB/OB25 Transition

Time	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Week 0	3.22	0.005	0.000	22.78	0.000	0.007	0.000	0.000	6.82	0.001	0.000	0.000
Week 1	4.01	0.007	0.000	28.37	0.000	0.007	0.000	0.000	9.30	0.001	0.000	0.001
Week 2	4.88	0.009	0.000	33.33	0.000	0.007	0.000	0.000	11.52	0.001	0.000	0.001
Week 3	5.46	0.010	0.000	36.58	0.000	0.007	0.000	0.000	13.20	0.001	0.000	0.001
Month 1	6.10	0.012	0.000	40.18	0.000	0.007	0.000	0.000	15.07	0.001	0.000	0.001
Month 2	7.13	0.015	0.000	44.98	0.000	0.007	0.000	0.000	17.92	0.001	0.000	0.002
Month 3	8.31	0.017	0.000	50.41	0.000	0.008	0.000	0.000	20.79	0.002	0.000	0.002
Month 4	9.26	0.020	0.000	54.63	0.000	0.008	0.000	0.000	23.91	0.002	0.000	0.003
Month 5	9.73	0.022	0.000	57.06	0.000	0.008	0.000	0.000	25.79	0.002	0.000	0.003
Month 6	10.16	0.023	0.000	59.05	0.000	0.008	0.000	0.000	27.43	0.002	0.000	0.004
Month 7	11.02	0.026	0.000	63.35	0.000	0.008	0.000	0.000	31.07	0.002	0.000	0.005
Month 8	11.95	0.028	0.000	68.18	0.000	0.008	0.000	0.000	35.38	0.003	0.000	0.007
Month 9	12.88	0.031	0.000	72.42	0.000	0.008	0.000	0.000	39.21	0.003	0.000	0.009
Month 10	13.68	0.033	0.000	75.31	0.000	0.008	0.000	0.000	42.37	0.003	0.000	0.010
Month 11	14.31	0.035	0.000	77.49	0.000	0.008	0.000	0.000	44.75	0.003	0.000	0.012
Month 12	14.97	0.037	0.000	79.64	0.000	0.008	0.000	0.000	47.32	0.003	0.000	0.012
Month 15	15.68	0.039	0.000	81.44	0.000	0.008	0.000	0.000	49.42	0.003	0.000	0.013
Month 18	16.31	0.041	0.000	82.72	0.000	0.008	0.000	0.000	51.36	0.003	0.000	0.013
Month 21	16.89	0.042	0.000	83.54	0.000	0.008	0.000	0.000	53.05	0.004	0.000	0.014
Month 24	17.51	0.044	0.000	84.36	0.000	0.008	0.000	0.000	54.65	0.004	0.000	0.015

Sample WB/OB25 Fresh

Time	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Week 0	0.000	0.011	0.000	0.000	0.000	0.07	0.000	0.011	0.000	0.001	0.000	0.30	0.002
Week 1	0.000	0.011	0.000	0.002	0.000	0.79	0.000	0.016	0.000	0.001	0.000	0.73	0.005
Week 2	0.000	0.011	0.000	0.005	0.000	1.93	0.000	0.024	0.000	0.001	0.000	1.30	0.008
Week 3	0.000	0.011	0.000	0.007	0.000	2.56	0.000	0.029	0.000	0.001	0.000	1.71	0.010
Month 1	0.000	0.011	0.000	0.008	0.000	2.89	0.000	0.032	0.000	0.001	0.000	2.01	0.013
Month 2	0.000	0.011	0.000	0.009	0.000	3.43	0.000	0.035	0.000	0.001	0.000	2.42	0.018
Month 3	0.000	0.011	0.000	0.010	0.000	3.72	0.000	0.037	0.000	0.001	0.000	2.67	0.019
Month 4	0.000	0.011	0.000	0.010	0.000	4.00	0.000	0.038	0.000	0.002	0.001	2.95	0.023
Month 5	0.000	0.011	0.000	0.011	0.000	4.18	0.000	0.039	0.000	0.002	0.001	3.19	0.023
Month 6	0.000	0.011	0.000	0.012	0.000	4.37	0.000	0.040	0.000	0.002	0.001	3.46	0.024
Month 7	0.000	0.011	0.000	0.012	0.000	4.52	0.000	0.041	0.000	0.002	0.001	3.68	0.024
Month 8	0.000	0.011	0.000	0.013	0.000	4.84	0.000	0.042	0.000	0.002	0.001	4.14	0.025
Month 9	0.000	0.011	0.000	0.014	0.000	5.14	0.000	0.044	0.000	0.002	0.001	4.60	0.025
Month 10	0.000	0.011	0.000	0.014	0.000	5.43	0.000	0.044	0.000	0.003	0.001	4.99	0.025
Month 11	0.000	0.011	0.000	0.015	0.000	5.60	0.000	0.045	0.000	0.003	0.001	5.23	0.025
Month 12	0.000	0.011	0.000	0.016	0.000	5.94	0.000	0.046	0.000	0.004	0.002	5.76	0.026
Month 15	0.000	0.011	0.000	0.016	0.000	6.32	0.000	0.047	0.000	0.004	0.002	6.24	0.026
Month 18	0.000	0.011	0.000	0.017	0.000	6.68	0.000	0.048	0.000	0.005	0.002	6.70	0.026
Month 21	0.000	0.011	0.000	0.018	0.000	7.05	0.000	0.049	0.000	0.007	0.004	7.07	0.026
Month 24	0.000	0.018	0.000	0.019	0.000	7.55	0.000	0.050	0.000	0.008	0.006	7.47	0.026

Sample JN/OB25 Fresh

Time	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Week 0	0.06	0.003	0.000	2.04	0.000	0.000	0.000	0.000	0.47	0.000	0.000	0.001
Week 1	0.69	0.057	0.000	4.93	0.000	0.000	0.000	0.000	2.23	0.000	0.000	0.001
Week 2	1.70	0.160	0.000	9.12	0.000	0.000	0.000	0.000	5.80	0.001	0.000	0.001
Week 3	2.26	0.226	0.000	11.69	0.000	0.000	0.000	0.000	8.37	0.001	0.000	0.001
Month 1	2.57	0.266	0.000	13.21	0.000	0.000	0.000	0.000	9.92	0.002	0.000	0.001
Month 2	3.06	0.318	0.000	14.76	0.000	0.000	0.000	0.000	12.01	0.002	0.000	0.002
Month 3	3.34	0.341	0.000	15.60	0.000	0.000	0.000	0.000	13.17	0.002	0.000	0.002
Month 4	3.58	0.364	0.000	16.26	0.000	0.000	0.000	0.000	14.01	0.002	0.000	0.002
Month 5	3.75	0.377	0.000	16.70	0.000	0.000	0.000	0.000	14.53	0.002	0.000	0.002
Month 6	3.92	0.391	0.000	17.08	0.000	0.000	0.000	0.000	15.04	0.002	0.000	0.003
Month 7	4.05	0.398	0.000	17.35	0.000	0.000	0.000	0.000	15.36	0.002	0.000	0.004
Month 8	4.32	0.417	0.000	17.86	0.000	0.000	0.000	0.000	16.06	0.002	0.000	0.005
Month 9	4.58	0.432	0.000	18.30	0.000	0.000	0.000	0.000	16.68	0.002	0.000	0.006
Month 10	4.84	0.443	0.000	18.59	0.000	0.000	0.000	0.000	17.18	0.002	0.000	0.008
Month 11	4.98	0.449	0.000	18.79	0.000	0.000	0.000	0.000	17.42	0.002	0.000	0.008
Month 12	5.28	0.461	0.001	19.21	0.000	0.000	0.000	0.000	18.03	0.002	0.000	0.009
Month 15	5.59	0.471	0.001	19.60	0.000	0.000	0.000	0.000	18.61	0.002	0.000	0.010
Month 18	5.86	0.478	0.001	19.87	0.000	0.000	0.000	0.000	19.17	0.002	0.000	0.010
Month 21	6.15	0.484	0.001	20.07	0.000	0.000	0.000	0.001	19.73	0.002	0.000	0.011
Month 24	6.51	0.498	0.001	20.26	0.000	0.000	0.000	0.001	20.34	0.002	0.001	0.013

Sample MM/OB29 Transition

Time	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Week 0	0.000	0.004	0.000	0.008	0.000	7.14	0.000	0.002	0.000	0.000	0.002	2.05	0.005
Week 1	0.000	0.004	0.000	0.013	0.000	11.47	0.000	0.002	0.000	0.000	0.002	3.29	0.008
Week 2	0.000	0.004	0.000	0.016	0.000	14.48	0.000	0.002	0.000	0.000	0.002	4.48	0.011
Week 3	0.000	0.004	0.000	0.018	0.000	16.38	0.000	0.002	0.000	0.000	0.002	5.18	0.013
Month 1	0.000	0.004	0.000	0.021	0.000	17.91	0.000	0.002	0.000	0.000	0.002	5.77	0.014
Month 2	0.000	0.004	0.000	0.024	0.000	19.87	0.000	0.002	0.000	0.000	0.002	6.53	0.016
Month 3	0.000	0.004	0.000	0.025	0.000	20.79	0.000	0.002	0.000	0.000	0.002	7.15	0.017
Month 4	0.000	0.004	0.000	0.027	0.000	21.75	0.000	0.002	0.000	0.001	0.002	7.68	0.019
Month 5	0.000	0.004	0.000	0.031	0.000	23.14	0.000	0.002	0.000	0.001	0.002	8.63	0.020
Month 6	0.000	0.004	0.000	0.038	0.000	24.48	0.000	0.002	0.000	0.001	0.002	9.37	0.021
Month 7	0.000	0.004	0.000	0.046	0.000	25.69	0.000	0.002	0.000	0.001	0.002	10.15	0.022
Month 8	0.000	0.004	0.000	0.052	0.000	26.83	0.000	0.002	0.000	0.001	0.002	10.80	0.023
Month 9	0.000	0.004	0.000	0.057	0.000	27.84	0.000	0.002	0.000	0.001	0.002	11.41	0.024
Month 10	0.000	0.004	0.000	0.064	0.000	28.98	0.000	0.002	0.000	0.002	0.002	11.85	0.024
Month 11	0.000	0.004	0.000	0.074	0.000	30.09	0.000	0.002	0.000	0.003	0.002	12.45	0.025
Month 12	0.000	0.004	0.000	0.082	0.000	31.03	0.000	0.002	0.000	0.004	0.002	12.99	0.026
Month 15	0.000	0.004	0.000	0.088	0.000	31.94	0.000	0.002	0.000	0.005	0.003	13.70	0.026
Month 18	0.000	0.004	0.000	0.094	0.000	32.72	0.000	0.002	0.000	0.006	0.003	14.31	0.027
Month 21	0.000	0.004	0.000	0.102	0.000	33.46	0.000	0.002	0.000	0.008	0.003	14.60	0.028
Month 24	0.000	0.009	0.000	0.118	0.000	34.82	0.000	0.002	0.000	0.009	0.003	15.12	0.029

Sample MM/OB29 Transition

Time	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Week 0	6.65	0.001	0.000	32.34	0.000	0.000	0.000	0.000	7.69	0.000	0.000	0.002
Week 1	9.37	0.001	0.000	45.44	0.000	0.000	0.000	0.000	16.97	0.001	0.000	0.002
Week 2	11.39	0.001	0.000	55.70	0.000	0.000	0.000	0.000	24.16	0.001	0.000	0.002
Week 3	12.74	0.001	0.000	62.15	0.000	0.001	0.000	0.000	29.04	0.002	0.000	0.002
Month 1	13.82	0.002	0.000	67.38	0.000	0.001	0.000	0.000	33.19	0.002	0.000	0.002
Month 2	15.38	0.002	0.000	74.52	0.000	0.001	0.000	0.000	38.73	0.002	0.000	0.002
Month 3	16.26	0.002	0.000	79.13	0.000	0.001	0.000	0.000	41.92	0.003	0.000	0.002
Month 4	17.28	0.002	0.000	83.55	0.000	0.001	0.000	0.000	45.22	0.003	0.000	0.003
Month 5	18.57	0.002	0.000	89.59	0.000	0.001	0.000	0.000	49.84	0.003	0.000	0.003
Month 6	19.75	0.002	0.000	94.04	0.000	0.001	0.000	0.000	54.01	0.004	0.000	0.004
Month 7	20.95	0.002	0.000	98.84	0.000	0.001	0.000	0.000	57.74	0.004	0.000	0.004
Month 8	21.97	0.002	0.000	101.81	0.000	0.001	0.000	0.000	60.78	0.004	0.000	0.006
Month 9	22.90	0.002	0.000	104.93	0.000	0.001	0.000	0.000	63.68	0.004	0.000	0.008
Month 10	23.96	0.002	0.000	107.44	0.000	0.001	0.000	0.000	66.56	0.004	0.000	0.010
Month 11	24.89	0.002	0.000	110.06	0.000	0.001	0.000	0.000	69.33	0.004	0.000	0.011
Month 12	25.60	0.002	0.000	111.84	0.000	0.001	0.000	0.000	71.46	0.004	0.000	0.011
Month 15	26.33	0.003	0.000	113.64	0.000	0.001	0.000	0.000	73.46	0.005	0.000	0.011
Month 18	26.94	0.003	0.000	115.16	0.000	0.001	0.000	0.000	75.09	0.005	0.000	0.012
Month 21	27.47	0.003	0.000	116.05	0.000	0.001	0.000	0.000	76.41	0.005	0.000	0.013
Month 24	28.57	0.003	0.000	117.67	0.000	0.001	0.000	0.000	78.74	0.005	0.000	0.017

Sample MM/OB29 Weathered

Time	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Week 0	0.000	0.001	0.000	0.009	0.000	9.29	0.000	0.001	0.000	0.000	0.000	1.86	0.003
Week 1	0.000	0.001	0.000	0.026	0.000	10.12	0.000	0.001	0.000	0.000	0.000	2.39	0.004
Week 2	0.000	0.001	0.000	0.036	0.000	11.21	0.000	0.001	0.000	0.000	0.000	2.92	0.008
Week 3	0.000	0.001	0.000	0.044	0.000	12.11	0.000	0.001	0.000	0.000	0.000	3.26	0.009
Month 1	0.000	0.001	0.000	0.051	0.000	13.31	0.000	0.001	0.000	0.001	0.000	3.59	0.010
Month 2	0.000	0.001	0.000	0.054	0.000	14.58	0.000	0.001	0.000	0.001	0.000	3.91	0.010
Month 3	0.000	0.001	0.000	0.058	0.000	15.40	0.000	0.001	0.000	0.001	0.000	4.26	0.011
Month 4	0.000	0.001	0.000	0.062	0.000	16.01	0.000	0.001	0.000	0.001	0.001	4.50	0.013
Month 5	0.000	0.001	0.000	0.069	0.000	16.87	0.000	0.001	0.000	0.002	0.003	5.08	0.014
Month 6	0.000	0.001	0.000	0.079	0.000	17.59	0.000	0.001	0.000	0.002	0.003	5.52	0.014
Month 7	0.000	0.001	0.000	0.087	0.000	18.14	0.000	0.001	0.000	0.003	0.003	5.96	0.015
Month 8	0.000	0.001	0.000	0.095	0.000	18.60	0.000	0.001	0.000	0.004	0.005	6.37	0.015
Month 9	0.000	0.002	0.000	0.104	0.000	19.04	0.000	0.001	0.000	0.005	0.005	6.81	0.016
Month 10	0.000	0.003	0.000	0.113	0.000	19.44	0.000	0.002	0.000	0.008	0.007	7.05	0.016
Month 11	0.000	0.003	0.000	0.129	0.000	19.89	0.000	0.002	0.000	0.008	0.008	7.42	0.017
Month 12	0.000	0.003	0.000	0.141	0.000	20.26	0.000	0.002	0.000	0.010	0.010	7.77	0.017
Month 15	0.000	0.003	0.000	0.152	0.000	20.67	0.000	0.002	0.000	0.012	0.010	8.18	0.017
Month 18	0.000	0.003	0.001	0.162	0.000	20.99	0.000	0.002	0.000	0.016	0.013	8.62	0.018
Month 21	0.000	0.005	0.001	0.170	0.000	21.19	0.000	0.002	0.000	0.017	0.018	8.75	0.019
Month 24	0.000	0.009	0.001	0.180	0.000	21.41	0.000	0.002	0.000	0.019	0.028	8.95	0.019

Sample MM/OB29 Weathered

Time	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Week 0	2.70	0.000	0.000	33.07	0.000	0.000	0.000	0.000	23.78	0.002	0.000	0.001
Week 1	2.89	0.000	0.000	40.00	0.000	0.000	0.000	0.000	28.09	0.002	0.000	0.001
Week 2	3.12	0.000	0.000	47.08	0.000	0.000	0.000	0.000	32.46	0.003	0.000	0.002
Week 3	3.31	0.000	0.000	52.47	0.000	0.000	0.000	0.000	35.77	0.003	0.000	0.002
Month 1	3.57	0.000	0.001	58.07	0.000	0.000	0.000	0.000	39.57	0.003	0.000	0.002
Month 2	3.85	0.000	0.001	64.25	0.000	0.000	0.000	0.000	43.74	0.004	0.000	0.002
Month 3	4.04	0.000	0.002	69.10	0.000	0.000	0.000	0.000	46.55	0.004	0.000	0.002
Month 4	4.18	0.000	0.002	72.70	0.000	0.000	0.000	0.000	48.68	0.004	0.000	0.002
Month 5	4.37	0.000	0.003	79.16	0.000	0.000	0.000	0.000	52.32	0.004	0.000	0.002
Month 6	4.53	0.000	0.004	85.03	0.000	0.000	0.000	0.000	55.62	0.004	0.000	0.003
Month 7	4.65	0.000	0.005	90.48	0.000	0.000	0.000	0.000	58.36	0.004	0.000	0.004
Month 8	4.75	0.000	0.006	95.04	0.000	0.000	0.000	0.000	60.39	0.004	0.000	0.007
Month 9	4.84	0.001	0.007	100.52	0.000	0.000	0.000	0.000	62.64	0.004	0.000	0.008
Month 10	4.93	0.001	0.008	104.37	0.000	0.000	0.000	0.000	64.41	0.004	0.000	0.009
Month 11	5.02	0.001	0.009	109.14	0.000	0.000	0.000	0.000	66.35	0.004	0.000	0.009
Month 12	5.11	0.001	0.011	113.07	0.000	0.000	0.000	0.000	67.82	0.004	0.000	0.010
Month 15	5.19	0.001	0.012	117.11	0.000	0.000	0.000	0.000	69.13	0.004	0.000	0.010
Month 18	5.26	0.001	0.013	121.51	0.000	0.000	0.000	0.000	70.56	0.004	0.000	0.010
Month 21	5.29	0.001	0.014	123.26	0.000	0.000	0.000	0.000	71.19	0.004	0.000	0.011
Month 24	5.34	0.001	0.015	125.59	0.000	0.000	0.000	0.000	72.18	0.004	0.000	0.011

D1/Whaleback Fresh

Time	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Week 0	0.000	0.003	0.001	0.003	0.000	4.08	0.000	0.001	0.001	0.000	0.000	23.36	0.017
Week 1	0.000	0.004	0.001	0.003	0.000	5.10	0.000	0.001	0.001	0.000	0.000	30.43	0.021
Week 2	0.000	0.004	0.001	0.004	0.000	6.12	0.000	0.002	0.002	0.000	0.000	35.72	0.025
Week 3	0.000	0.005	0.002	0.004	0.000	6.84	0.000	0.002	0.002	0.000	0.000	39.69	0.027
Month 1	0.000	0.008	0.003	0.004	0.000	7.02	0.000	0.002	0.002	0.000	0.011	41.75	0.029
Month 2	0.000	0.010	0.004	0.005	0.000	7.81	0.000	0.002	0.003	0.001	0.013	45.04	0.031
Month 3	0.000	0.010	0.005	0.005	0.000	8.11	0.000	0.002	0.003	0.001	0.013	47.28	0.032
Month 4	0.000	0.012	0.006	0.005	0.000	8.29	0.000	0.002	0.004	0.001	0.014	49.05	0.033
Month 5	0.000	0.014	0.006	0.005	0.000	8.36	0.000	0.002	0.004	0.001	0.018	50.23	0.033
Month 6	0.000	0.017	0.009	0.005	0.000	8.51	0.000	0.003	0.005	0.001	0.025	53.04	0.034
Month 7	0.000	0.019	0.011	0.005	0.000	8.59	0.000	0.003	0.007	0.001	0.034	55.40	0.035
Month 8	0.000	0.021	0.013	0.006	0.000	8.71	0.000	0.003	0.011	0.001	0.037	57.85	0.035
Month 9	0.000	0.022	0.016	0.006	0.000	8.80	0.000	0.003	0.014	0.001	0.040	60.43	0.036
Month 10	0.000	0.023	0.020	0.006	0.000	8.90	0.000	0.003	0.019	0.001	0.045	63.11	0.036
Month 11	0.000	0.026	0.022	0.006	0.000	9.01	0.000	0.003	0.022	0.002	0.055	65.63	0.036
Month 12	0.000	0.030	0.024	0.006	0.000	9.15	0.000	0.003	0.026	0.002	0.066	68.37	0.038
Month 15	0.000	0.033	0.027	0.006	0.000	9.29	0.000	0.003	0.032	0.003	0.073	70.95	0.038
Month 18	0.000	0.043	0.030	0.006	0.000	9.43	0.000	0.003	0.038	0.004	0.107	73.82	0.038
Month 21	0.000	0.048	0.032	0.007	0.000	9.55	0.000	0.003	0.043	0.006	0.128	75.84	0.038
Month 24	0.000	0.071	0.038	0.007	0.000	9.86	0.000	0.003	0.047	0.007	0.155	80.08	0.038

D1/Whaleback Fresh

Time	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Week 0	4.52	0.005	0.001	31.85	0.000	0.000	0.000	0.000	11.63	0.002	0.000	0.001
Week 1	5.54	0.006	0.003	40.90	0.000	0.000	0.000	0.000	15.27	0.002	0.000	0.001
Week 2	6.61	0.007	0.005	48.00	0.000	0.000	0.000	0.000	18.33	0.002	0.000	0.001
Week 3	7.43	0.009	0.007	53.36	0.000	0.000	0.000	0.000	20.63	0.003	0.000	0.001
Month 1	7.63	0.009	0.010	55.72	0.000	0.000	0.000	0.000	21.62	0.003	0.000	0.001
Month 2	8.57	0.010	0.013	60.42	0.000	0.000	0.000	0.000	23.87	0.003	0.000	0.002
Month 3	8.95	0.011	0.016	63.20	0.000	0.000	0.000	0.000	25.04	0.004	0.000	0.002
Month 4	9.14	0.011	0.018	65.00	0.000	0.000	0.000	0.000	25.72	0.004	0.000	0.002
Month 5	9.22	0.011	0.020	66.06	0.000	0.000	0.000	0.000	25.99	0.004	0.000	0.002
Month 6	9.37	0.012	0.028	68.49	0.000	0.000	0.000	0.000	26.58	0.004	0.000	0.004
Month 7	9.48	0.012	0.035	70.16	0.000	0.000	0.000	0.000	26.83	0.004	0.000	0.004
Month 8	9.58	0.012	0.044	71.80	0.000	0.000	0.000	0.000	27.08	0.004	0.000	0.006
Month 9	9.70	0.013	0.053	73.41	0.000	0.000	0.000	0.000	27.33	0.004	0.000	0.008
Month 10	9.81	0.013	0.064	74.93	0.000	0.000	0.000	0.000	27.48	0.004	0.000	0.011
Month 11	9.94	0.013	0.073	76.26	0.000	0.000	0.000	0.000	27.57	0.004	0.000	0.011
Month 12	10.08	0.014	0.082	77.69	0.000	0.000	0.000	0.000	27.66	0.004	0.000	0.011
Month 15	10.23	0.014	0.091	79.13	0.000	0.000	0.000	0.000	27.78	0.004	0.000	0.012
Month 18	10.36	0.015	0.100	80.57	0.000	0.000	0.000	0.001	27.92	0.004	0.000	0.012
Month 21	10.47	0.015	0.106	81.49	0.000	0.000	0.000	0.001	28.05	0.004	0.000	0.014
Month 24	10.72	0.017	0.117	83.06	0.000	0.000	0.000	0.002	28.24	0.004	0.000	0.016

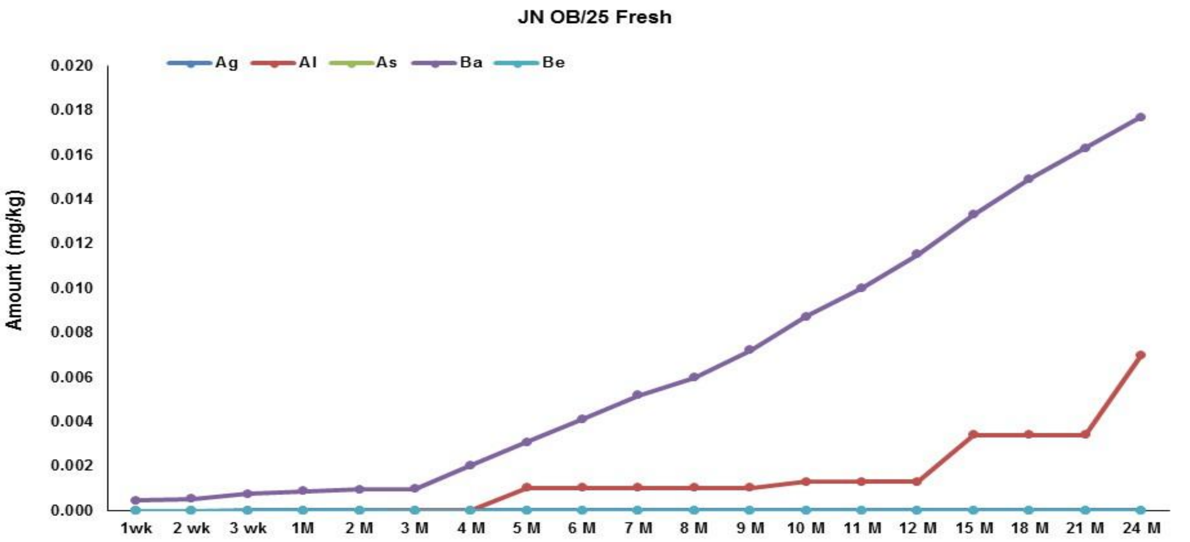
Sample D1/Whaleback Fresh BWT

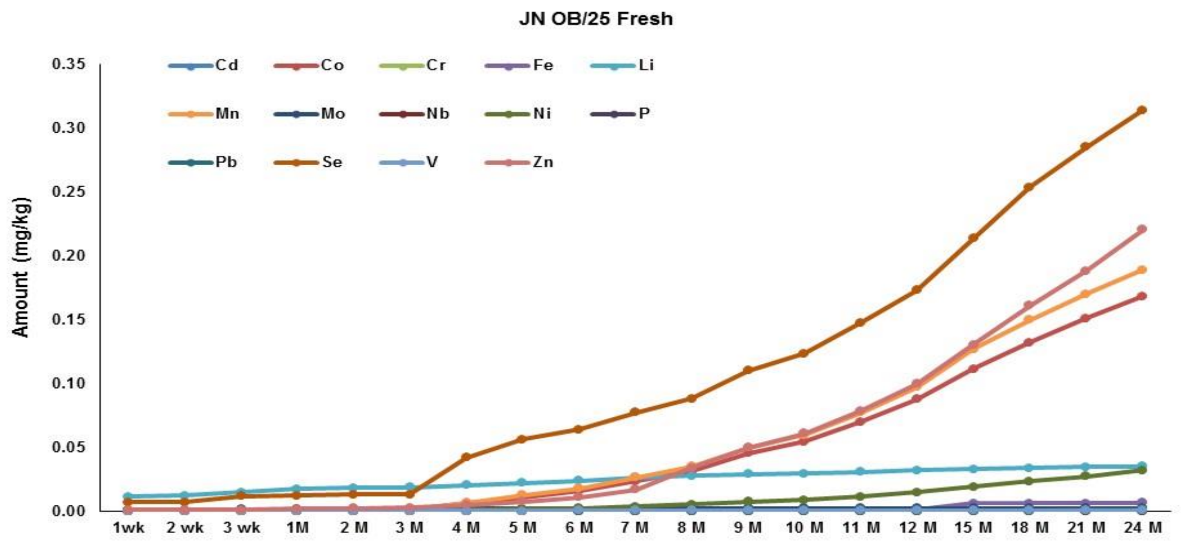
Time	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Li
Week 0	0.000	0.001	0.000	0.014	0.000	2.28	0.000	0.005	0.000	0.000	0.000	0.56	0.008
Week 1	0.000	0.001	0.000	0.017	0.000	3.12	0.000	0.005	0.000	0.000	0.001	0.89	0.018
Week 2	0.000	0.001	0.000	0.019	0.000	3.80	0.000	0.005	0.000	0.001	0.001	1.19	0.025
Week 3	0.000	0.001	0.000	0.023	0.000	4.81	0.000	0.005	0.000	0.001	0.001	1.78	0.030
Month 1	0.000	0.001	0.000	0.026	0.000	5.39	0.000	0.005	0.001	0.001	0.004	2.21	0.032
Month 2	0.000	0.001	0.000	0.029	0.000	6.12	0.000	0.005	0.001	0.001	0.011	2.76	0.036
Month 3	0.000	0.001	0.000	0.031	0.000	6.61	0.000	0.005	0.002	0.001	0.023	3.20	0.040
Month 4	0.000	0.001	0.000	0.033	0.000	7.17	0.000	0.006	0.002	0.001	0.032	3.61	0.042
Month 5	0.000	0.001	0.000	0.035	0.000	7.77	0.000	0.006	0.003	0.001	0.046	3.93	0.045
Month 6	0.000	0.001	0.000	0.037	0.000	8.30	0.000	0.006	0.004	0.001	0.061	4.15	0.047
Month 7	0.000	0.001	0.000	0.039	0.000	8.83	0.000	0.006	0.005	0.001	0.092	4.38	0.049
Month 8	0.000	0.001	0.000	0.042	0.000	9.41	0.000	0.006	0.005	0.001	0.116	4.61	0.051
Month 9	0.000	0.001	0.000	0.044	0.000	9.78	0.000	0.006	0.006	0.001	0.144	4.83	0.052
Month 10	0.000	0.001	0.000	0.046	0.000	10.38	0.000	0.006	0.006	0.001	0.174	5.04	0.054
Month 11	0.000	0.002	0.000	0.049	0.000	10.96	0.000	0.006	0.007	0.001	0.199	5.18	0.055
Month 12	0.000	0.002	0.000	0.051	0.000	11.40	0.000	0.006	0.008	0.001	0.212	5.30	0.056
Month 15	0.000	0.002	0.000	0.053	0.000	11.90	0.000	0.006	0.009	0.001	0.243	5.47	0.056
Month 18	0.000	0.006	0.000	0.056	0.000	12.74	0.000	0.006	0.011	0.001	0.323	5.55	0.060
Month 21	0.000	0.018	0.000	0.059	0.000	13.36	0.000	0.006	0.013	0.001	0.343	5.71	0.062
Month 24													

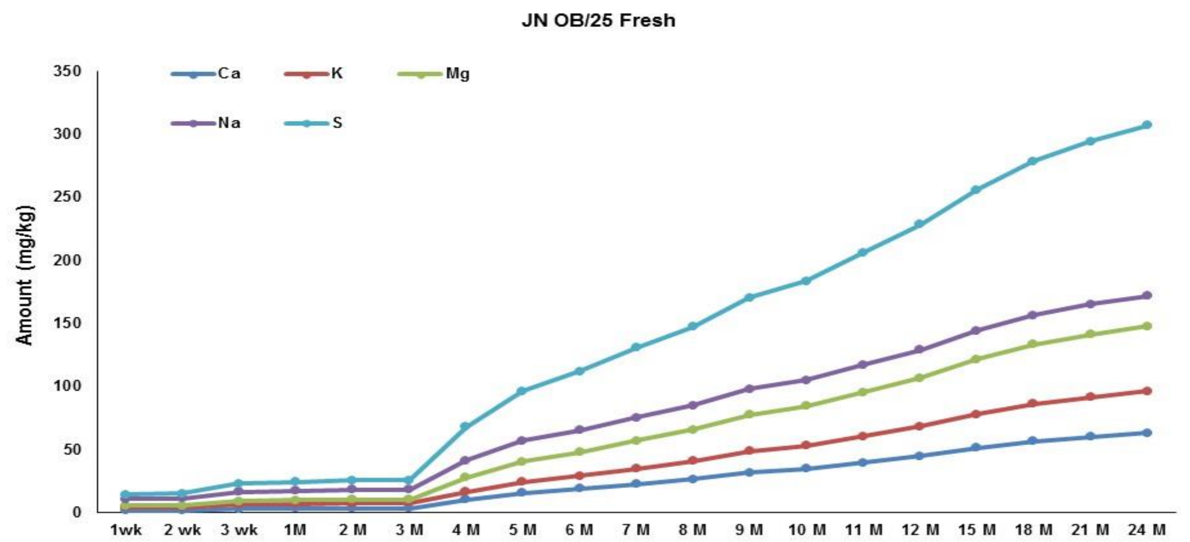
Sample D1/Whaleback Fresh BWT

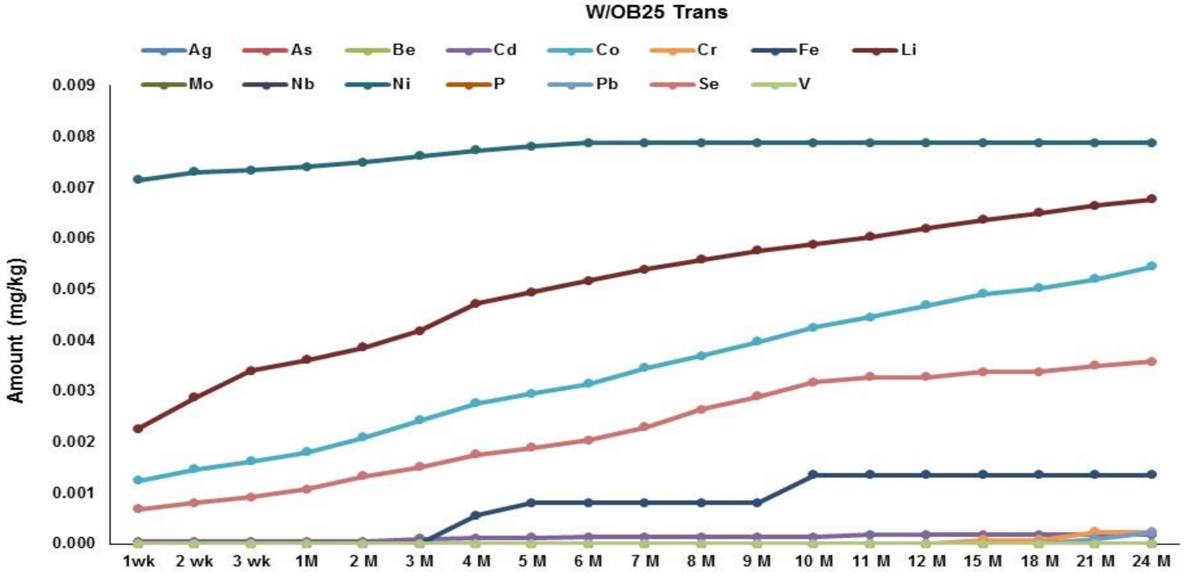
Time	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Week 0	1.35	0.028	0.000	4.04	0.000	0.000	0.000	0.000	0.63	0.000	0.000	0.000
Week 1	1.83	0.031	0.000	6.05	0.000	0.000	0.000	0.000	1.53	0.000	0.000	0.000
Week 2	2.19	0.034	0.000	7.56	0.000	0.000	0.000	0.000	2.23	0.000	0.000	0.000
Week 3	2.72	0.038	0.001	10.17	0.000	0.000	0.000	0.000	3.43	0.000	0.000	0.000
Month 1	3.02	0.039	0.002	11.65	0.000	0.000	0.000	0.000	4.10	0.000	0.000	0.000
Month 2	3.40	0.040	0.003	13.14	0.000	0.000	0.000	0.000	4.82	0.000	0.000	0.000
Month 3	3.67	0.042	0.005	14.10	0.000	0.000	0.000	0.000	5.30	0.000	0.000	0.000
Month 4	3.98	0.044	0.006	14.75	0.000	0.000	0.000	0.000	5.59	0.000	0.000	0.000
Month 5	4.32	0.045	0.007	15.30	0.000	0.000	0.000	0.000	5.86	0.000	0.000	0.000
Month 6	4.61	0.046	0.008	15.60	0.000	0.000	0.000	0.000	5.97	0.000	0.000	0.000
Month 7	4.91	0.047	0.009	15.88	0.000	0.000	0.000	0.000	6.04	0.000	0.000	0.000
Month 8	5.23	0.047	0.011	16.10	0.000	0.000	0.000	0.000	6.10	0.000	1.619	0.000
Month 9	5.54	0.047	0.012	16.27	0.000	0.000	0.000	0.000	6.13	0.000	3.047	0.000
Month 10	5.86	0.048	0.013	16.41	0.000	0.000	0.000	0.000	6.16	0.000	4.552	0.000
Month 11	6.17	0.048	0.014	16.54	0.000	0.000	0.000	0.000	6.19	0.000	6.320	0.000
Month 12	6.41	0.049	0.015	16.64	0.000	0.000	0.000	0.000	6.22	0.000	7.997	0.000
Month 15	6.69	0.049	0.017	16.76	0.000	0.000	0.000	0.000	6.31	0.000	9.476	0.000
Month 18	7.14	0.051	0.019	16.89	0.000	0.000	0.000	0.000	6.43	0.000	11.984	0.000
Month 21	7.43	0.058	0.021	17.05	0.000	0.000	0.000	0.000	6.54	0.000	13.792	0.000
Month 24												

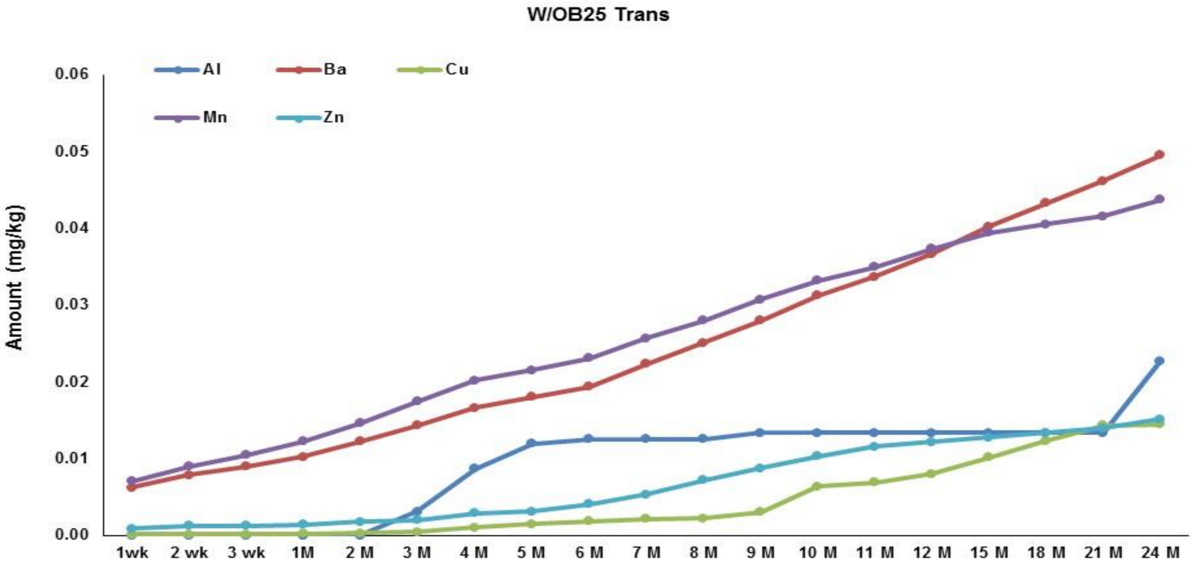
Appendix 2 Figures: Cumulative Release of Solute over 24 Months

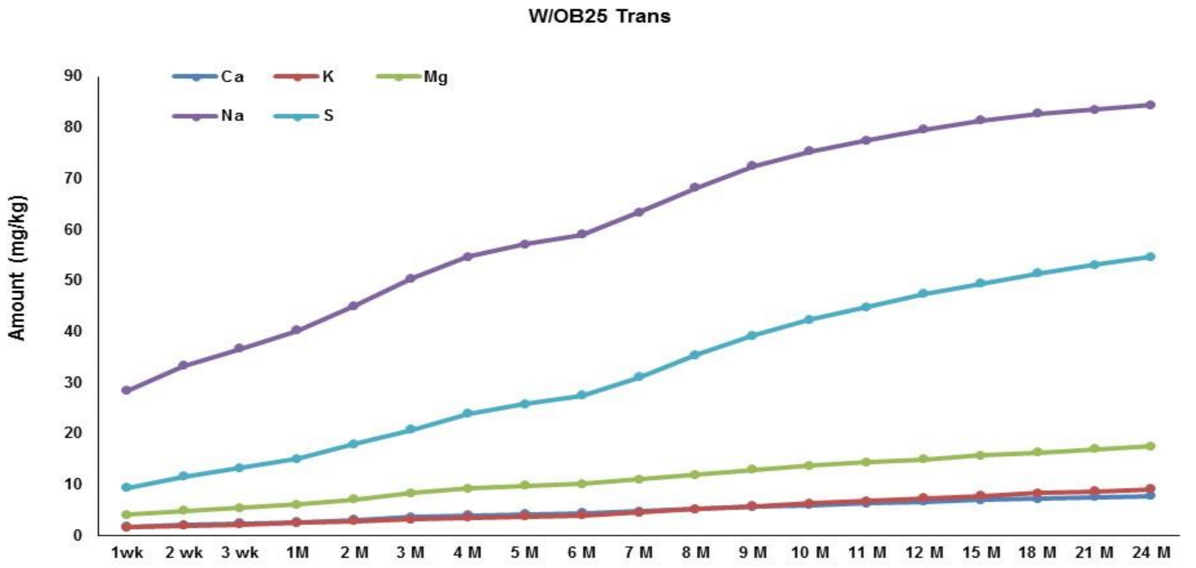

JN OB/25 Fresh
Ag
Al
As
Ba
Be
Amount (mg/kg)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M

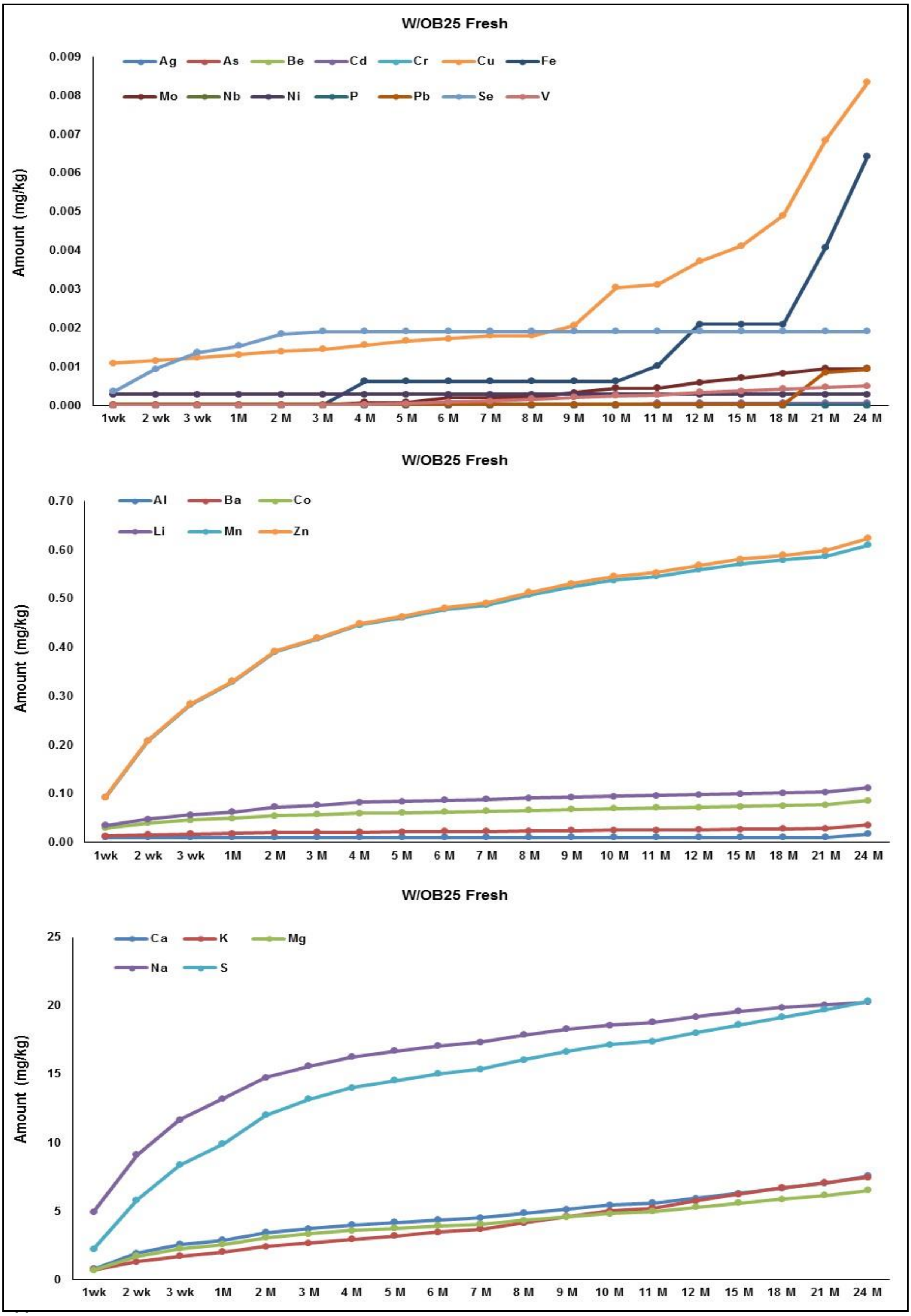

JN OB/25 Fresh
Cd
Co
Cr
Fe
Li
Mn
Mo
Nb
Ni
P
Pb
Se
V
Zn
Amount (mg/kg)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M

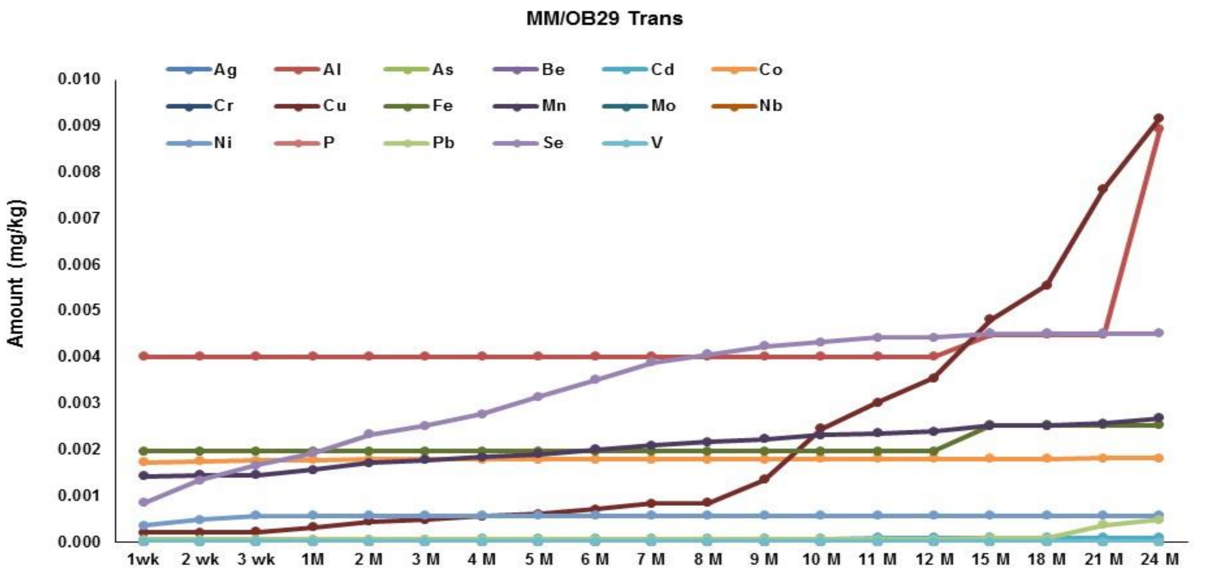

JN OB/25 Fresh
Ca
K
Mg
Na
S
Amount (mg/kg)
350
300
250
200
150
100
50
0
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M

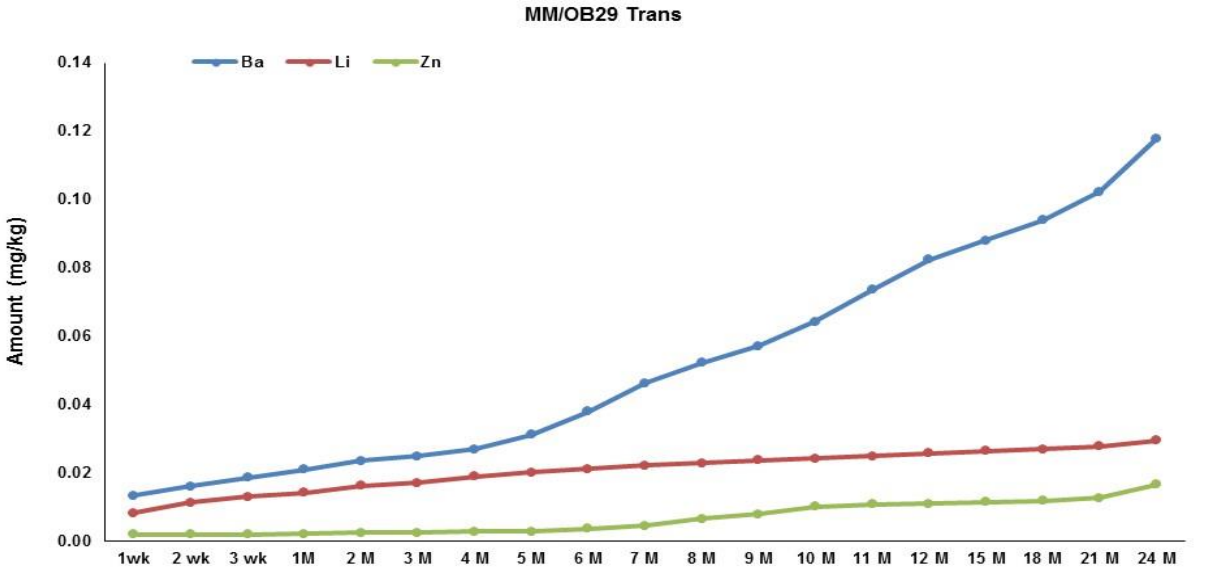

W/OB25 Trans
Ag
As
Be
Cd
Co
Cr
Fe
Li
Mo
Nb
Ni
P
Pb
Se
V
Amount (mg/kg)
0.000
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M

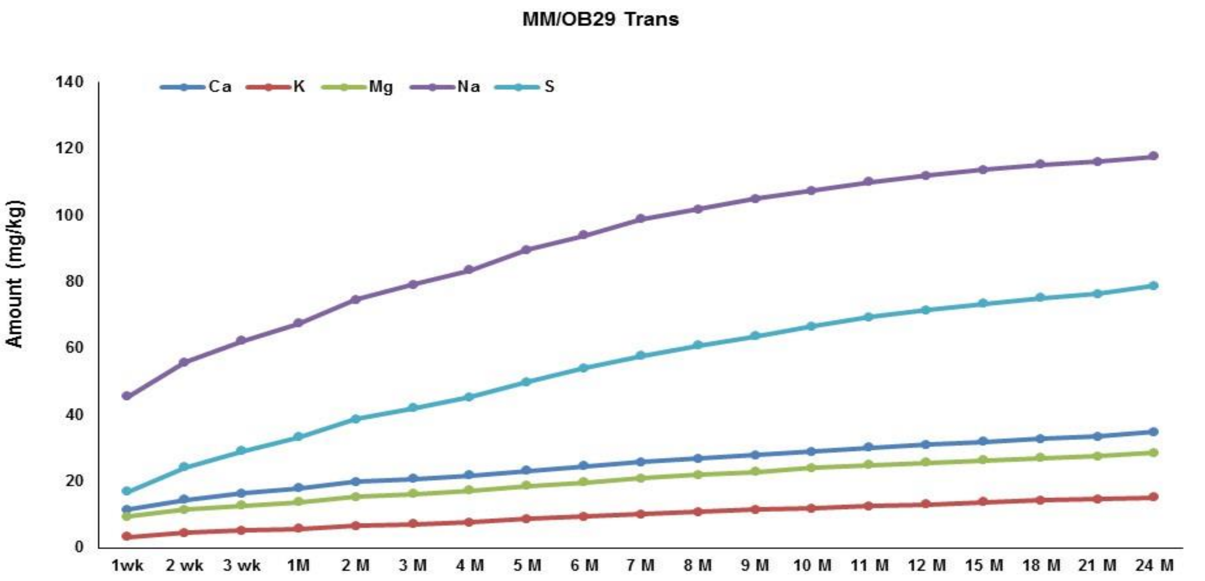

W/OB25 Trans
Al
Ba
Cu
Mn
Zn
Amount (mg/kg)
0.00
0.01
0.02
0.03
0.04
0.05
0.06
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M

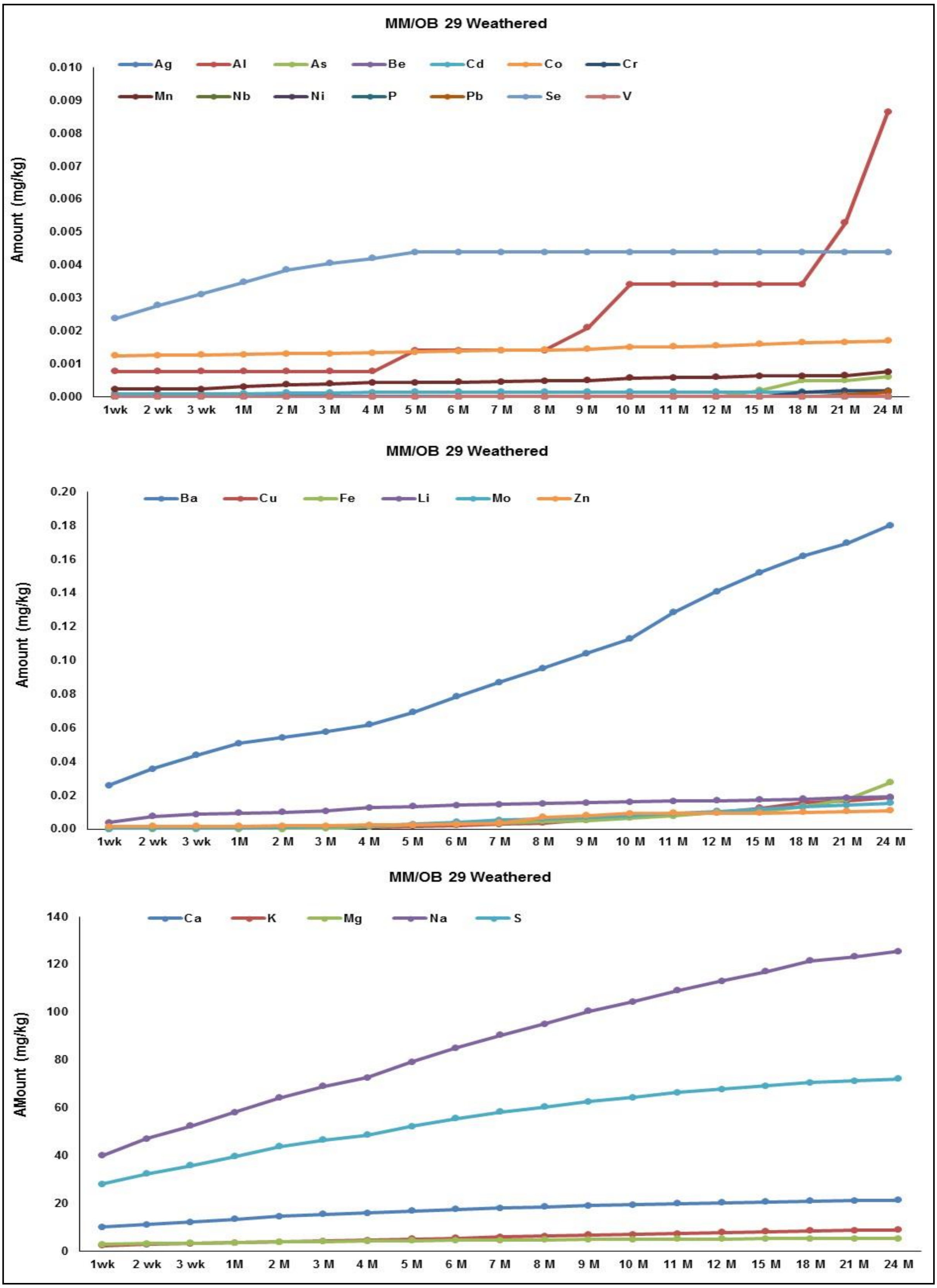

W/OB25 Trans
Ca
K
Mg
Na
S
Amount (mg/kg)
0
10
20
30
40
50
60
70
80
90
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M

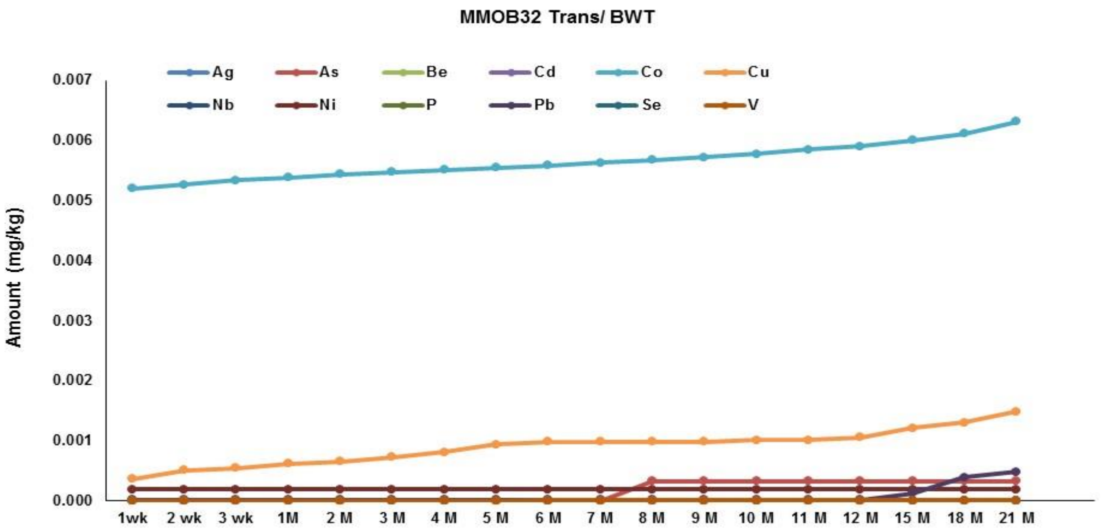

W/OB25 Fresh
Ag
As
Be
Cd
Cr
Cu
Fe
Mo
Nb
Ni
P
Pb
Se
V
Amount (mg/kg)
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M
W/OB25 Fresh
Al
Ba
Co
Li
Mn
Zn
Amount (mg/kg)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
W/OB25 Fresh
Ca
K
Mg
Na
S
Amount (mg/kg)
25
20
15
10
5
0

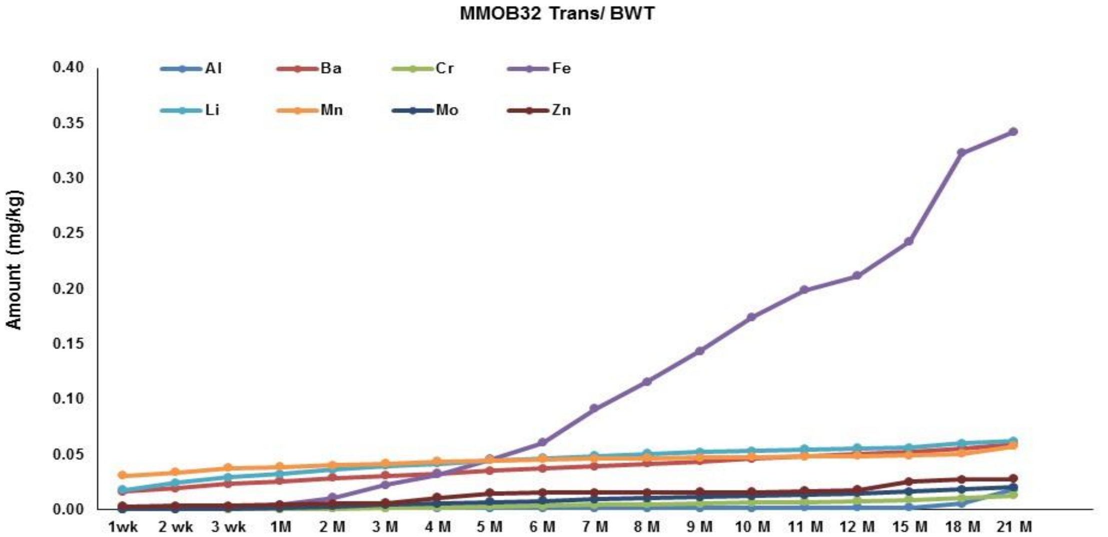

MM/OB29 Trans
Ag
Al
As
Be
Cd
Co
Cr
Cu
Fe
Mn
Mo
Nb
Ni
P
Pb
Se
V
Amount (mg/kg)
0.010
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M

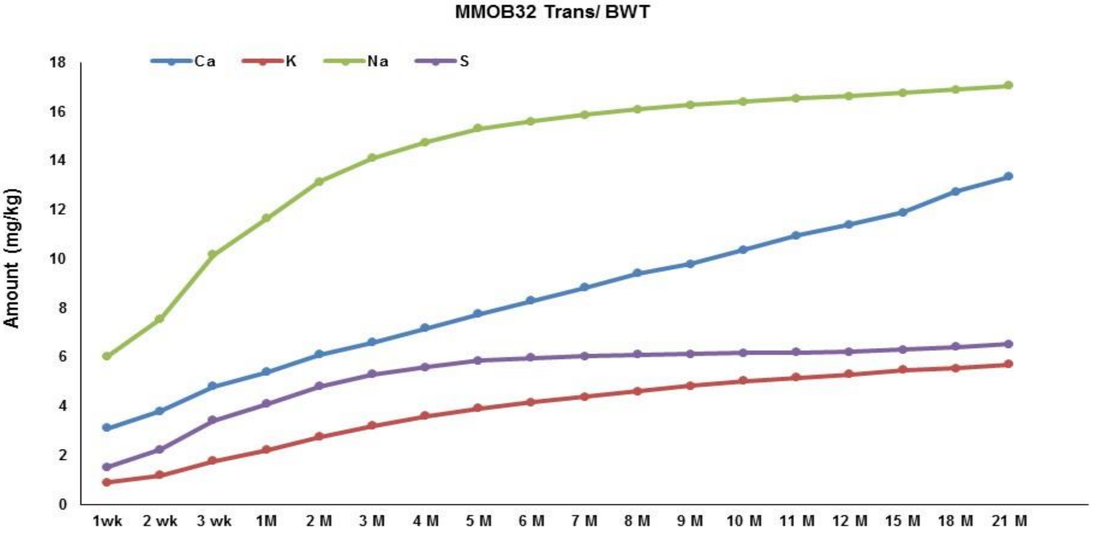

MM/OB29 Trans
Ba
Li
Zn
Amount (mg/kg)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M


MM/OB29 Trans
Ca
K
Mg
Na
S
Amount (mg/kg)
140
120
100
80
60
40
20
0
1wk
2 wk
3 wk
1M
2 M
3 M
4 M
5 M
6 M
7 M
8 M
9 M
10 M
11 M
12 M
15 M
18 M
21 M
24 M


MM/OB 29 Weathered
Ag Al As Be Cd Co Cr
Mn Nb Ni P Pb Se V
Amount (mg/kg)
0.000 0.001 0.002 0.003 0.004 0.005 0.006 0.007 0.008 0.009 0.010
1wk 2 wk 3 wk 1M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M 10 M 11 M 12 M 15 M 18 M 21 M 24 M
MM/OB 29 Weathered
Ba Cu Fe Li Mo Zn
Amount (mg/kg)
0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16 0.18 0.20
1wk 2 wk 3 wk 1M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M 10 M 11 M 12 M 15 M 18 M 21 M 24 M
MM/OB 29 Weathered
Ca K Mg Na S
AMount (mg/kg)
0 20 40 60 80 100 120 140
1wk 2 wk 3 wk 1M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M 10 M 11 M 12 M 15 M 18 M 21 M 24 M


MMOB32 Trans/ BWT
Ag As Be Cd Co Cu
Nb Ni P Pb Se V
Amount (mg/kg)
0.007 0.006 0.005 0.004 0.003 0.002 0.001 0.000
1wk 2 wk 3 wk 1M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M 10 M 11 M 12 M 15 M 18 M 21 M


MMOB32 Trans/ BWT
Al Ba Cr Fe
Li Mn Mo Zn
Amount (mg/kg)
0.40 0.35 0.30 0.25 0.20 0.15 0.10 0.05 0.00
1wk 2 wk 3 wk 1M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M 10 M 11 M 12 M 15 M 18 M 21 M


MMOB32 Trans/ BWT
Ca K Na S
Amount (mg/kg)
18 16 14 12 10 8 6 4 2 0
1wk 2 wk 3 wk 1M 2 M 3 M 4 M 5 M 6 M 7 M 8 M 9 M 10 M 11 M 12 M 15 M 18 M 21 M

APPENDIX 3: SEQUENTIAL LEACH TESTS – PUBLISHED METHODS

Table A3-1. Elemental concentrations (mg/kg) in sequential extraction fraction using the method of Pinto, Al-Abed et al., 2014

			Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Ni	P	Pb	S	V	Zn	Cd	Mo
Water Soluble	JN/OB25 Fresh	Mean	0.50	0.00	0.00	7.5	0.01	0.00	0.07	0.00	0.00	0.01	0.00	0.00	0.00	10.0	0.01	0.22	0.00	0.11
		SE	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	0.22	4.61	0.00	45.0	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	71.2	0.00	0.26	0.00	0.00
		SE	0.03	0.12	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.04	0.00	0.00
	MM/OB29 Trans	Mean	0.00	0.47	0.00	37.5	0.00	0.00	0.00	0.31	0.02	0.01	0.00	0.00	0.00	65.0	0.00	0.24	0.00	0.01
		SE	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.01
	W/OB25 trans	Mean	0.21	0.03	0.00	7.50	0.01	0.00	0.01	0.42	0.01	0.02	0.30	0.00	0.00	48.7	0.00	0.31	0.00	0.09
		SE	0.06	0.01	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.30	0.00	0.00	1.24	0.00	0.14	0.00	0.09
	W/OB25 Fresh	Mean	1.59	0.01	0.00	5.00	0.01	0.00	0.00	0.62	0.04	0.22	0.00	0.00	0.05	27.5	0.00	0.60	0.00	0.02
		SE	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.27	0.00	0.00
	D1/Whaleback fresh	Mean	0.16	0.04	0.00	7.50	0.61	0.00	0.01	0.00	0.01	0.32	0.00	0.00	0.00	10.0	0.00	0.32	0.00	0.00
		SE	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00
Exchangeable	JN/OB25 Fresh	Mean	0.00	0.22	0.00	109	0.67	0.00	23.8	0.00	0.00	0.12	0.00	0.00	-0.80	0.00	0.00	0.27	0.00	0.00
		SE	0.00	0.04	0.00	1.26	0.00	0.00	1.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
	MM/OB29 Weathered	Mean	0.00	160	0.00	106	0.50	0.00	ND	0.00	0.00	ND	0.00	0.00	-0.87	46.2	0.00	ND	0.00	0.00
		SE	0.00	0.01	0.00	6.24	0.00	0.00	ND	0.00	0.00	ND	0.00	0.00	0.00	1.25	0.00	ND	0.00	0.00
	MM/OB29 Trans	Mean	0.00	4.76	0.00	55.0	0.29	0.00	ND	0.00	0.00	0.62	0.00	0.00	ND	35.0	0.00	ND	0.00	0.00
		SE	0.00	0.12	0.00	2.50	0.01	0.00	ND	0.00	0.00	0.37	0.00	0.00	ND	0.00	0.00	ND	0.00	0.00
	W/OB25 trans	Mean	0.00	2.24	0.00	90.0	0.64	0.00	ND	0.00	0.00	0.87	0.00	0.00	ND	42.5	0.00	0.16	0.00	0.00
		SE	0.00	0.07	0.00	5.01	0.01	0.00	ND	0.00	0.00	0.12	0.00	0.00	ND	0.00	0.00	0.01	0.00	0.00
	W/OB25 Fresh	Mean	0.00	0.90	0.00	93.7	1.41	0.00	ND	0.00	0.09	1.87	0.00	0.00	ND	0.00	0.14	1.72	0.00	0.00
		SE	0.00	0.04	0.00	6.25	0.06	0.00	ND	0.00	0.01	0.37	0.00	0.00	ND	0.00	0.14	0.00	0.00	0.00
	D1/Whaleback fresh	Mean	0.00	1.65	0.00	77.5	7.12	0.00	0.90	0.00	0.00	10.6	0.00	0.00	ND	0.00	0.00	ND	0.00	0.00
		SE	0.00	0.06	0.00	5.00	0.12	0.00	0.01	0.00	0.00	0.13	0.00	0.00	ND	0.00	0.00	ND	0.00	0.00
Carbonate bound	JN/OB25 Fresh	Mean	31.2	0.70	0.00	12.5	0.29	0.00	174	0.00	0.00	0.37	0.00	0.00	0.74	0.00	0.01	1.00	0.00	0.00
		SE	1.25	0.13	0.00	56.2	0.01	0.00	8.74	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.01	0.05	0.00	0.00
	MM/OB29 Weathered	Mean	57.5	29.15	0.00	3.75	0.64	0.00	0.09	14.62	0.00	0.92	0.00	0.00	0.30	0.00	0.00	0.05	0.00	0.00
		SE	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.12	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
	MM/OB29 Trans	Mean	19.6	1.04	0.03	0.00	0.26	0.00	0.00	4.37	0.00	0.59	0.26	0.00	0.36	0.00	0.00	ND	0.00	0.00
		SE	0.62	0.04	0.00	0.00	0.01	0.00	0.00	0.12	0.00	0.01	0.26	0.00	0.06	0.00	0.00	ND	0.00	0.00
	W/OB25 trans	Mean	32.5	1.17	0.00	0.00	0.20	0.00	0.21	0.00	0.00	0.47	0.00	0.00	0.32	0.00	0.00	ND	0.00	0.00
		SE	0.00	0.05	0.00	26.2	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00
	W/OB25 Fresh	Mean	92.5	3.77	0.03	1.25	1.22	0.14	0.15	2.62	0.06	7.85	0.00	0.00	1.40	0.00	0.00	3.67	0.00	0.00
		SE	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.13	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00
	D1/Whaleback fresh	Mean	65.0	0.89	0.03	0.00	2.35	0.80	0.81	67.5	0.00	19.1	0.00	0.00	0.44	0.00	0.00	0.17	0.00	0.00
		SE	0.00	0.01	0.00		0.03	0.05	0.01	10.0	0.00	0.50	0.00	0.00	0.01	0.00	0.00	0.02	0.00	0.00
Amorphous Iron Oxide	JN/OB25 Fresh	Mean	211	1.82	0.05	13.7	0.15	0.73	129	2450	0.06	0.61	0.37	0.00	1.04	8.75	2.14	4.00	0.00	0.02
		SE	8.76	0.01	0.00	1.25	0.00	0.01	1.24	50.1	0.00	0.12	0.00	0.00	0.08	1.25	0.04	4.25	0.00	0.02
	MM/OB29 Weathered	Mean	437	10.7	0.04	18.7	1.26	0.41	0.54	3000	0.02	4.49	0.27	0.00	0.75	8.75	0.24	ND	0.001	0.00
		SE	12.5	0.25	0.00	1.25	0.01	0.00	0.00	0.22	0.00	0.25	0.00	0.00	0.04	1.25	0.01	ND	0.001	0.00
	MM/OB29 Trans	Mean	325	0.92	0.08	10.0	0.95	0.31	0.40	4498	0.03	4.74	0.41	0.00	0.97	2.50	0.02	3.37	0.005	0.02
		SE	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.25	0.01	0.00	0.01	0.00	0.00	3.87	0.000	0.02

			Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Ni	P	Pb	S	V	Zn	Cd	Mo
	W/OB25 trans	Mean	450	1.37	0.02	7.50	0.30	1.66	0.81	2999	0.01	2.01	0.07	12.50	1.44	2.50	1.39	3.12	0.000	0.00
		SE	0.04	0.06	0.02	0.00	0.13	0.75	0.30	0.30	0.01	0.72	0.07	0.00	0.20	0.00	0.66	3.62	0.000	0.00
	W/OB25 Fresh	Mean	575	81.2	0.06	22.5	3.50	0.75	1.63	2487	0.13	2399	0.40	0.00	425	12.50	0.44	6.12	0.06	0.00
		SE	0.01	1.25	0.01	0.00	0.00	0.01	0.29	12.4	0.00	49.9	0.00	0.00	0.01	0.00	0.01	0.38	0.00	0.00
	D1/Whaleback fresh	Mean	412	1.09	0.07	12.50	1.94	1.48	4.86	3374	0.02	9.86	0.31	2.50	0.84	5.00	1.52	ND	0.00	0.02
		SE	12.5	0.00	0.00	0.00	0.01	0.01	0.13	125	0.00	0.12	0.01	0.00	0.03	0.00	0.05	ND	0.00	0.02
Crystalline Iron Oxide	JN/OB25 Fresh	Mean	59.6	0.87	0.00	0.00	0.00	0.03	81.2	143	0.00	-0.01	0.00	0.00	0.23	3.75	0.29	0.04	0.00	0.00
		SE	0.00	0.15	0.00	0.00	0.00	0.01	6.25	16.2	0.00	0.01	0.00	0.00	0.02	1.25	0.02	0.11	0.00	0.00
	MM/OB29 Weathered	Mean	77.1	1.01	0.00	0.00	0.02	0.01	0.18	387	0.00	0.05	0.00	0.00	0.06	15.00	0.16	ND	0.00	0.00
		SE	0.01	0.01	0.00	0.00	0.00	0.00	0.12	12.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00
	MM/OB29 Trans	Mean	50.8	0.56	0.00	0.00	0.04	0.00	0.06	862	0.00	0.11	0.00	2.50	0.00	7.50	0.05	0.35	0.00	0.15
		SE	1.25	0.04	0.00	0.00	0.00	0.00	0.00	12.5	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00
	W/OB25 trans	Mean	183	0.64	0.00	0.00	0.00	1.21	0.06	2624	0.00	0.04	0.00	102	0.14	2.50	4.24	ND	0.00	0.37
		SE	1.23	0.01	0.00	0.00	0.00	0.03	0.00	125	0.00	0.01	0.00	0.01	0.00	0.00	0.00	ND	0.00	0.07
	W/OB25 Fresh	Mean	64.6	3.50	0.00	0.00	0.02	0.11	0.08	374	0.00	4.60	0.00	5.00	17.18	2.50	0.47	ND	0.00	0.35
		SE	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.12	0.00	0.00	0.75	0.00	0.01	ND	0.00	0.10
	D1/Whaleback fresh	Mean	74.6	0.82	0.00	0.00	0.03	0.24	0.11	937	0.00	0.07	0.00	16.25	0.10	5.00	1.76	ND	0.00	0.21
		SE	0.00	0.02	0.00	0.00	0.00	0.01	0.00	37.5	0.00	0.00	0.00	1.25	0.02	0.00	0.03	ND	0.00	0.01
Sulfides	JN/OB25 Fresh	Mean	93.29	0.82	0.02	0.00	0.05	0.24	440	22.0	0.07	0.29	0.27	0.00	0.26	123	0.01	0.03	0.00	0.21
		SE	3.00	0.00	0.00	0.00	0.00	0.00	40.0	2.00	0.01	0.01	0.01	0.00	0.00	5.01	0.01	0.47	0.00	0.21
	MM/OB29 Weathered	Mean	ND	3.76	0.00	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
		SE	ND	0.20	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00
	MM/OB29 Trans	Mean	ND	0.25	0.00	22.0	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		SE	ND	0.01	0.00	22.0	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00
	W/OB25 trans	Mean	0.19	0.60	0.00	0.00	0.00	3.40	0.96	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.01	0.00
		SE	0.03	0.02	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	W/OB25 Fresh	Mean	-0.05	1.56	0.00	0.00	0.00	1.15	ND	0.00	0.04	0.00	0.00	0.00	0.51	0.00	0.00	ND	0.00	0.00
		SE	0.07	0.00	0.00	0.00	0.00	0.01	ND	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	ND	0.00	0.00
	D1/Whaleback fresh	Mean	3.07	0.36	0.00	0.00	0.00	0.74	0.52	0.00	0.00	0.00	0.00	0.00	0.00	25.0	0.00	0.27	0.00	0.00
		SE	2.83	0.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.01	0.00	0.00
Residue	JN/OB25 Fresh	Mean	107000	97.5	1.10	75.0	2.00	140	98.5	18150	32.0	53.5	18.0	103	77.5	3255	197	19.5	0.00	0.00
		SE	2000	1.50	0.00	0.00	0.00	5.00	8.50	750	0.00	1.50	1.00	2.50	1.50	5.00	2.50	2.50	0.00	0.00
	MM/OB29 Weathered	Mean	20600	24.5	1.20	333	3.00	45.0	32.00	472000	1.00	163	27.5	503	17.0	1008	26.5	57.0	0.00	0.00
		SE	1900	1.50	0.10	2.50	0.00	5.00	0.00	21000	0.00	1.00	0.50	22.50	1.00	62.50	1.50	3.00	0.00	0.00
	MM/OB29 Trans	Mean	12550	0.00	1.05	90.0	10.00	15.0	19.50	615000	2.00	168	18.0	720	15.0	325	ND	79.0	0.00	8.50
		SE	50	0.00	0.05	0.00	0.00	0.00	0.50	6000	0.00	3.50	7.00	10.00	1.00	5.00	0.00	3.00	0.00	0.50
	W/OB25 trans	Mean	46800	28.0	1.10	67.50	ND	82.5	16.50	185500	2.00	81.5	17.5	1195	16.5	35.0	46.0	13.5	0.00	0.00
		SE	2500	1.00	0.00	2.50	ND	2.50	0.50	1500	0.00	1.50	2.50	15.00	0.50	5.00	1.00	0.50	0.00	0.00
	W/OB25 Fresh	Mean	35950	62.5	1.45	75.00	2.00	47.5	51.50	130500	20.0	124	30.5	310	165	70.0	48.5	120	0.00	10.00
		SE	1050	1.50	0.05	0.00	0.00	2.50	0.50	1500	0.00	3.00	2.50	0.00	2.00	5.00	1.50	2.50	0.00	0.00
	D1/Whaleback fresh	Mean	13850	8.00	0.85	65.00	2.00	25.0	13.00	224000	2.00	27.5	12.0	330	ND	220	18.0	8.50	0.00	0.00
		SE	450	0.00	0.05	0.00	0.00	0.00	0.00	7000	0.00	1.50	0.00	0.00	0.00	10.00	1.00	0.50	0.00	0.00

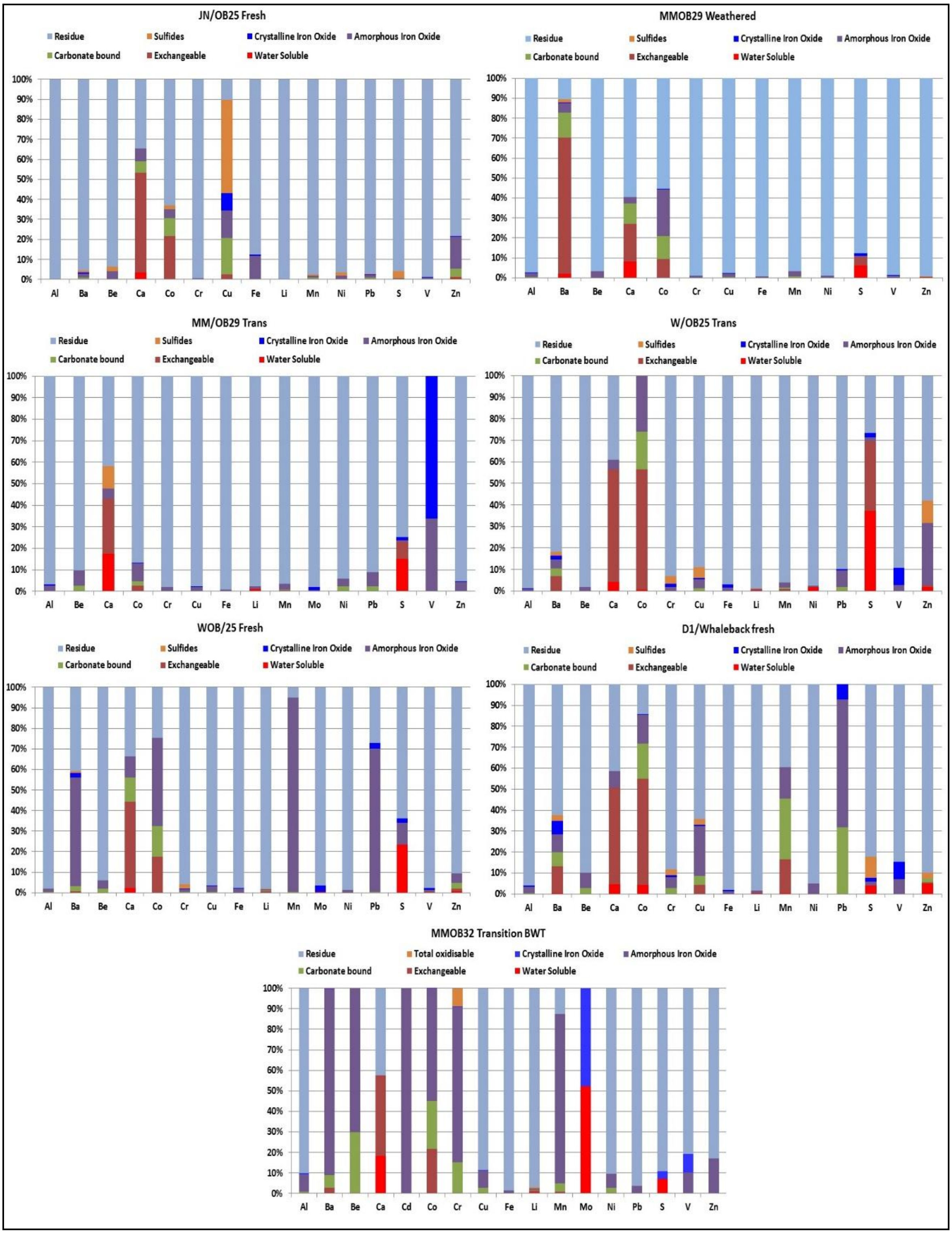


Figure A3-1. Distribution of metals in the several phases of the seven rock samples according to the method of Pinto, Al-Abed et al., 2014

Table A3-2. Elemental concentrations (mg/kg) in sequential extraction fraction using the method of by Leinz et al., 2000

			Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Nb	Ni	P	Pb	S	V	Zn	Ag	As	Cd	Mo	Se
Water Soluble	JN/OB25 Fresh	Mean	0.00	0.07	0.00	31.47	0.07	0.00	0.06	0.00	0.00	0.05	0.00	0.00	0.00	0.00	8.99	0.00	ND	0.00	0.00	0.00	0.00	0.00
		SE	0.00	0.06	0.00	1.52	0.06	0.00	0.08	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.01	0.00	ND	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	0.05	7.19	0.00	62.99	0.01	0.00	0.03	0.00	0.00	0.07	0.00	0.00	0.00	0.00	56.99	0.00	ND	0.00	0.00	0.00	0.00	0.00
		SE	0.10	0.00	0.00	0.01	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	ND	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Trans	Mean	-0.30	0.98	0.00	44.98	0.02	0.00	-0.02	0.00	0.02	0.15	0.00	0.00	0.00	0.00	38.99	0.00	ND	0.00	0.00	0.00	0.00	0.00
		SE	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
	W/OB25 trans	Mean	-0.15	0.06	0.00	14.99	0.03	0.00	ND	0.00	0.00	0.07	0.00	0.00	0.00	0.00	34.48	0.00	ND	0.00	0.00	0.00	0.06	0.00
		SE	0.15	0.07	0.00	0.00	0.02	0.00	ND	0.00	0.00	0.06	0.00	0.00	0.00	0.00	1.49	0.00	ND	0.00	0.00	0.00	0.06	0.00
	W/OB25 Fresh	Mean	-0.300	0.000	0.00	11.996	0.027	0.000	ND	0.00	0.063	0.315	0.000	0.000	0.000	0.000	20.992	0.000	ND	0.000	0.000	0.000	0.180	0.000
		SE	0.000	0.000	0.00	0.001	0.000	0.000	ND	0.00	0.000	0.015	0.000	0.000	0.000	0.000	0.002	0.000	ND	0.000	0.000	0.000	0.030	0.000
	D1/Whaleback fresh	Mean	0.00	0.28	0.00	26.99	3.30	0.00	-0.01	0.00	0.01	2.76	0.00	0.03	0.00	0.00	6.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
		SE		0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
Carbonate	JN/OB25 Fresh	Mean	35.97	1.75	0.00	0.00	0.60	0.00	136.33	0.76	0.00	0.60	0.00	0.00	0.00	0.21	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00
		SE	0.03	0.73	0.00	0.00	0.03	0.00	7.38	0.76	0.00	0.09	0.00	0.00	0.00	0.02	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	52.49	58.88	0.00	43.49	0.85	0.00	0.09	24.00	0.00	1.26	0.00	0.00	0.00	0.04	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
		SE	1.49	0.01	0.00	1.51	0.01	0.00	0.04	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Trans	Mean	25.64	2.04	0.00	0.00	0.36	0.00	0.01	16.94	0.00	1.00	0.00	0.00	0.00	0.05	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
		SE	0.15	0.15	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
	W/OB25 trans	Mean	53.97	3.24	0.00	0.00	0.48	0.00	0.19	0.00	0.00	1.29	0.00	0.00	0.00	0.07	0.00	0.00	0.27	0.00	0.00	-0.01	0.00	0.00
		SE	3.01	0.75	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00
	W/OB25 Fresh	Mean	94.464	3.989	0.00	20.991	2.159	0.000	0.105	8.40	0.043	14.2	0.000	0.000	0.000	1.230	0.000	0.000	5.218	0.000	0.480	-0.001	0.000	0.000
		SE	1.492	0.000	0.00	20.991	0.030	0.000	0.000	0.00	0.008	0.001	0.000	0.000	0.000	0.030	0.000	0.000	0.150	0.000	0.000	0.001	0.000	0.000
	D1/Whaleback fresh	Mean	74.98	1.63	0.00	0.00	5.40	0.37	1.19	41.8	0.00	12.45	0.00	0.00	0.00	0.08	0.00	0.03	0.21	0.00	0.00	-0.01	0.00	0.00
		SE	0.01	0.05	0.00	0.00	0.00	0.04	0.00	12.14	0.00	2.40	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Exchangeable	JN/OB25 Fresh	Mean	0.00	0.58	0.00	95.91	0.15	0.00	0.90	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
		SE	0.00	0.04	0.00	8.92	0.01	0.00	0.06	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	0.00	106.93	0.00	80.99	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	37.49	0.00	ND	0.00	0.00	0.00	0.27	0.00
		SE	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	1.50	0.00	ND	0.00	0.00	0.01	0.27	0.00
	MM/OB29 Trans	Mean	0.00	3.90	0.00	17.99	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	53.98	0.00	ND	0.00	0.00	-0.01	0.00	0.00
		SE	0.00	0.15	0.00	17.99	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.00

			Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Nb	Ni	P	Pb	S	V	Zn	Ag	As	Cd	Mo	Se
	W/OB25 trans	Mean	0.00	0.73	0.00	59.97	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	47.97	0.00	0.93	0.00	0.00	-0.01	0.00	0.00
		SE	0.00	0.04	0.00	2.99	0.00	0.00	0.00	0.00	0.00	ND	0.00	0.00	0.00	0.00	0.01	0.00	1.80	0.00	0.00	0.01	0.00	0.00
	W/OB25 Fresh	Mean	0.000	2.114	0.00	79.470	0.075	0.000	0.000	0.00	0.000	0.975	0.000	0.000	0.000	0.000	0.000	0.000	ND	0.000	0.000	0.000	0.000	0.000
		SE	0.000	0.435	0.00	1.493	0.006	0.000	0.000	0.00	0.000	0.015	0.000	0.000	0.000	0.000	0.000	0.000	ND	0.000	0.000	0.000	0.000	0.000
	D1/Whaleback fresh	Mean	0.00	1.59	0.00	41.99	0.43	0.00	0.00	0.00	0.00	2.35	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	-0.01	0.00	0.00
		SE	0.00	0.03	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00
Amorphous Fe/Mn Oxide	JN/OB25 Fresh	Mean	94.42	1.32	0.00	0.00	0.27	0.00	179	172	0.00	0.60	0.00	0.00	0.00	0.57	0.00	1.29	0.84	0.00	0.00	0.00	0.00	0.00
		SE	1.57	0.06	0.00	0.00	0.01	0.00	28.62	25.61	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.09	0.03	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	259.45	32.99	0.00	0.00	1.39	0.00	0.22	720	0.00	2.91	0.00	0.00	0.00	0.24	0.00	0.31	0.70	0.00	0.00	0.00	0.00	0.00
		SE	1.47	0.00	0.00	0.00	0.02	0.00	0.01	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.08	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Trans	Mean	164.94	0.76	0.00	0.00	1.03	0.00	0.22	1155	0.00	2.28	0.00	0.00	0.00	0.36	0.00	0.12	1.80	0.00	0.00	0.00	0.00	0.00
		SE	0.01	0.01	0.00	0.00	0.02	0.00	0.01	14.94	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00
	W/OB25 trans	Mean	241.37	1.23	0.00	0.00	0.57	0.40	0.66	600	0.00	1.96	0.00	0.00	0.00	0.94	0.00	2.55	2.02	0.00	0.00	0.00	0.00	0.00
		SE	10.53	0.15	0.00	0.00	0.00	0.05	0.00	60.06	0.00	0.08	0.00	0.00	0.00	0.05	0.00	0.06	0.26	0.00	0.00	0.00	0.00	0.00
	W/OB25 Fresh	Mean	524.804	80.970	0.073	0.000	5.698	0.840	2.069	540	0.106	2474	0.000	0.000	0.000	450	0.000	1.305	6.478	0.234	0.000	0.105	0.000	0.000
		SE	15.034	0.006	0.005	0.000	0.000	0.000	0.030	0.04	0.011	14.8	0.000	0.000	0.000	0.034	0.000	0.015	0.000	0.006	0.000	0.006	0.000	0.000
	D1/Whaleback fresh	Mean	242.93	0.69	0.00	0.00	3.00	1.05	5.80	780	0.00	20.84	0.00	0.00	0.00	0.72	0.00	1.81	1.20	0.00	0.00	0.00	0.00	0.00
		SE	6.02	0.09	0.00	0.00	0.00	0.09	3.19	29.91	0.00	4.95	0.00	0.00	0.00	0.30	0.00	0.11	0.06	0.00	0.00	0.00	0.00	0.00
Crystalline Fe/Mn Oxide	JN/OB25 Fresh	Mean	704.35	2.83	0.00	0.00	0.00	3.90	644	15437	0.00	ND	0.00	0.00	0.00	2.17	64.42	6.74	ND	0.00	0.00	0.00	0.00	0.00
		SE	14.42	0.04	0.00	0.00	0.00	0.30	44.4	762	0.00	ND	0.00	0.00	0.00	0.14	28.42	0.45	ND	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	1949.66	7.50	0.00	44.99	0.75	4.05	4.23	64489	0.00	14.55	0.00	0.00	53.99	1.69	103.48	3.90	3.75	0.00	0.00	0.00	0.00	0.00
		SE	29.75	0.90	0.00	0.01	0.09	0.15	1.47	1492	0.00	0.30	0.00	0.00	0.01	0.05	1.51	0.30	1.35	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Trans	Mean	2234.22	0.00	0.00	0.00	1.99	0.00	2.34	112461	0.00	27.74	0.00	0.00	89.97	1.65	52.48	0.97	10.95	0.00	0.00	0.00	0.00	0.00
		SE	14.88	0.00	0.00	0.00	0.04	0.00	0.09	1494	0.00	0.30	0.00	0.00	2.99	0.03	1.50	0.01	0.15	0.00	0.00	0.00	0.00	0.00
	W/OB25 trans	Mean	2338.70	1.06	0.00	0.00	0.00	49.47	3.75	115436	0.00	26.39	0.00	0.00	659.63	3.15	0.00	27.43	5.85	0.00	0.00	0.00	0.00	0.00
		SE	119.58	0.37	0.00	0.00	0.00	1.49	0.15	4480	0.00	0.75	0.00	0.00	29.88	0.15	0.00	0.75	1.65	0.00	0.00	0.00	0.00	0.00
	W/OB25 Fresh	Mean	1439.46	2.14	0.00	31.49	0.33	18.59	9.75	65975.26	0.00	81.42	0.00	0.00	62.98	38.99	0.00	8.70	10.20	0.00	80.97	0.00	0.00	0.00
		SE	0.108	0.045	0.000	1.497	0.330	0.301	0.151	4.95	0.000	1.51	0.000	0.000	0.005	0.003	0.000	0.001	1.500	0.000	0.006	0.000	0.000	0.000

			Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Nb	Ni	P	Pb	S	V	Zn	Ag	As	Cd	Mo	Se
	D1/Whaleback fresh	Mean	914.72	0.91	0.00	0.00	1.11	12.90	6.90	74977	0.00	7.50	0.00	0.00	115.46	0.78	41.99	13.65	3.90	0.00	0.00	0.00	0.00	0.00
		SE	14.90	0.14	0.00	0.00	0.09	0.90	0.30	2992	0.00	0.45	0.00	0.00	4.49	0.12	2.99	0.75	0.60	0.00	0.00	0.00	0.00	0.00
Total oxidisable	JN/OB25 Fresh	Mean	525.34	0.00	0.00	0.00	0.00	0.00	14.29	629	0.00	0.58	0.00	0.00	0.00	0.00	255.54	0.00	4.39	0.00	0.00	0.00	0.00	0.00
		SE	19.65	0.00	0.00	0.00	0.00	0.00	5.51	27.98	0.00	0.58	0.00	0.00	0.00	0.00	19.44	0.00	6.59	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	366.24	2.17	0.00	0.00	0.00	0.00	0.00	3159	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.45	0.00	0.00	0.00	0.00	0.00
		SE	2.80	0.30	0.00	0.00	0.00	0.00	0.00	193	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	0.00	0.00	0.00
	MM/OB29 Trans	Mean	305.69	0.00	0.00	0.00	0.00	0.00	0.00	10718	0.00	2.61	0.00	0.00	0.00	0.00	0.00	0.00	21.44	0.00	0.00	0.00	0.00	0.00
		SE	8.26	0.00	0.00	0.00	0.00	0.00	0.00	275	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	9.90	0.00	0.00	0.00	0.00	0.00
	W/OB25 trans	Mean	792.12	0.00	0.00	0.00	0.00	0.00	0.00	12915	0.00	2.94	0.00	0.00	112.69	0.00	0.00	1.32	16.49	0.00	0.00	0.00	0.00	0.00
		SE	27.60	0.00	0.00	0.00	0.00	0.00	0.00	1926	0.00	0.19	0.00	0.00	8.26	0.00	0.00	0.05	0.55	0.00	0.00	0.00	0.00	0.00
	W/OB25 Fresh	Mean	569.584	0.000	0.000	0.000	0.000	0.000	0.000	4313	0.000	2.254	0.000	0.000	0.000	2.941	0.000	0.000	16.219	0.000	21.442	0.000	0.000	0.000
		SE	30.196	0.000	0.000	0.000	0.000	0.000	0.000	138	0.000	0.055	0.000	0.000	0.000	0.193	0.000	0.000	5.224	0.000	1.101	0.000	0.000	0.000
	D1/Whaleback fresh	Mean	313.96	0.00	0.00	0.00	0.00	0.00	0.00	4066	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.92	0.00	0.00	0.00	0.00	0.00
		SE	0.03	0.00	0.00	0.00	0.00	0.00	0.00	110	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.00
Residue	JN/OB25 Fresh	Mean	104000.00	92.00	0.95	ND	2.00	132.50	40.00	10750	31.00	53.00	15.00	16.50	95.00	76.00	3510.00	197.50	19.50	0.00	4.50	0.00	0.00	0.00
		SE	3000.00	5.00	0.05	0.00	0.00	2.50	1.00	250	1.00	0.00	0.00	0.50	0.00	0.00	60.00	3.50	0.50	0.00	1.50	0.00	0.00	0.00
	MM/OB29 Weathered	Mean	25700.00	21.00	1.00	345.00	3.00	42.50	31.50	412000	1.00	158.50	0.00	21.50	460.00	16.00	1170.00	28.00	49.00	0.00	7.50	0.00	0.00	0.00
		SE	800.00	2.00	0.00	5.00	0.00	2.50	0.50	3000	0.00	3.50	0.00	3.50	0.00	0.00	20.00	1.00	1.00	0.00	0.50	0.00	0.00	0.00
	MM/OB29 Trans	Mean	16200.00	0.00	1.10	102.50	10.50	17.50	22.00	586000	2.00	164	0.00	20.50	762.50	15.00	372.50	ND	71.00	0.60	5.50	0.00	9.00	15.00
		SE	100.00	0.00	0.00	2.50	0.50	2.50	1.00	3000	0.00	1.00	0.00	0.50	7.50	0.00	2.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00
	W/OB25 trans	Mean	53250.00	30.00	0.95	72.50	ND	20.00	16.00	61200	3.00	41.50	0.00	20.00	432.50	16.50	30.00	11.00	15.50	0.00	15.00	0.00	0.00	0.00
		SE	1450.00	1.00	0.05	2.50	0.00	0.00	3.00	2800	0.00	1.50	0.00	2.00	12.50	1.50	0.00	1.00	0.50	0.00	1.00	0.00	0.00	0.00
	W/OB25 Fresh	Mean	40050.000	67.000	1.300	62.500	2.000	30.000	40.500	65700	22.000	56.0	0.00	26.000	242.500	130.000	65.000	42.000	98.500	ND	204.500	0.00	6.000	0.00
		SE	1150.000	2.000	0.000	2.500	0.000	0.000	0.500	500	0.000	0.000	0.00	4.000	2.500	3.000	5.000	0.000	0.500	0.00	1.500	0.00	0.000	0.00
	D1/Whaleback fresh	Mean	15150.00	7.00	0.65	70.00	1.00	ND	6.50	168500	1.50	22.00	0.00	26.00	205.00	ND	202.50	2.00	8.50	0.00	17.00	0.00	0.00	0.00
		SE	50.00	0.00	0.05	0.00	0.00	0.00	0.50	3500	0.50	0.00	0.00	13.00	0.00	0.00	12.50	0.00	0.50	0.00	2.00	0.00	0.00	0.00

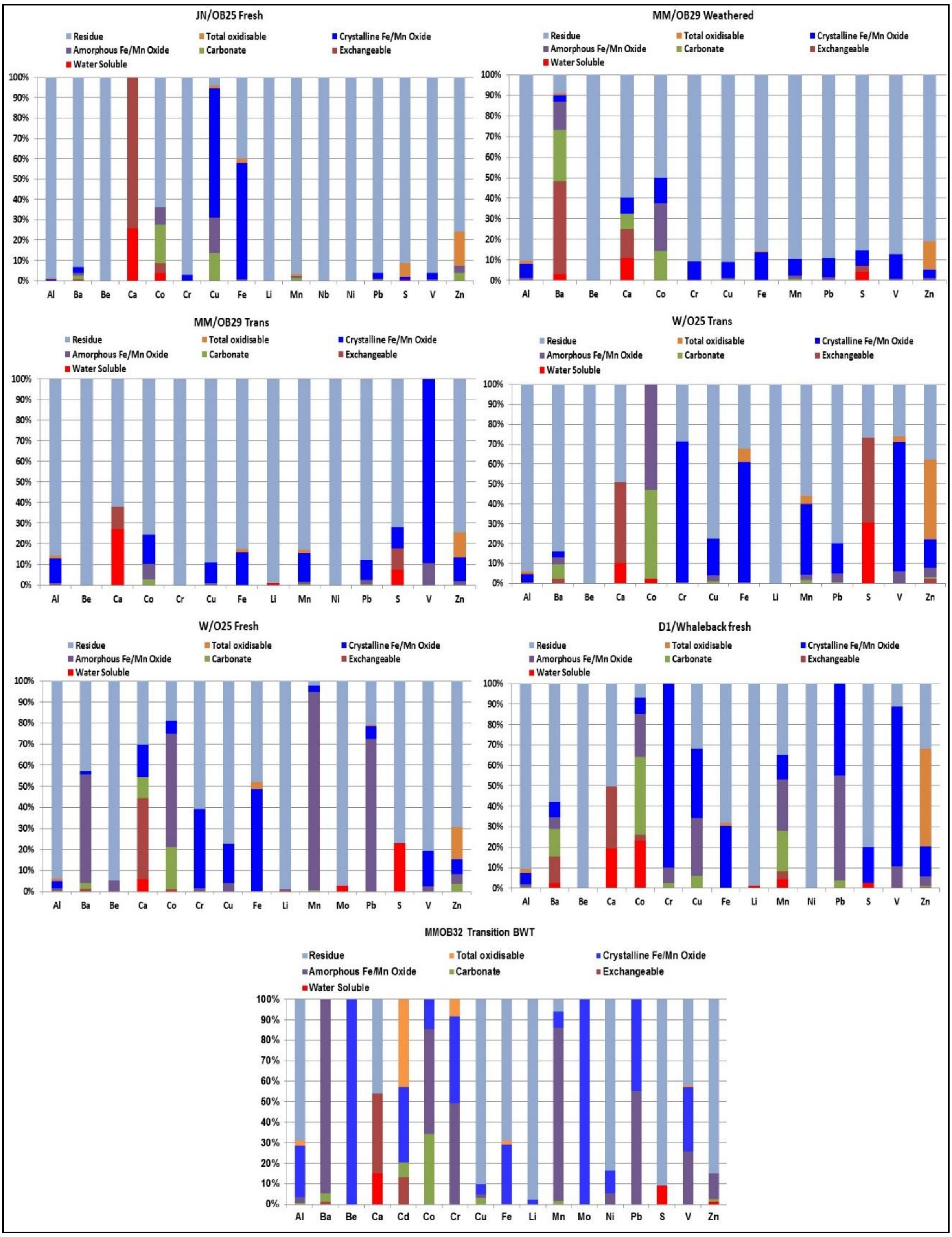


Figure A3-2. Distribution of metals in the several phases of the seven rock samples according to the method of Leinz et al., 2000

Table A3-3. Elemental concentrations (mg/kg) in sequential extraction fraction using the method of Piatak et al., 2007

		Ag	Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	P	Pb	S	V	Zn	As	Cd	Mo	Nb	Ni	Se
Amorphous Fe/Mn oxide	Mean JN/OB25 Fresh	0.03	66.0	1.10	0.00	0.00	0.06	0.00	100	111	0.00	0.15	0.00	0.81	0.00	0.57	-0.07	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.49	2.99	0.00	0.04	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Weathered	0.00	97.5	124	0.00	0.00	0.64	0.00	0.16	555	0.00	1.44	84.0	0.27	16.5	0.21	-0.24	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	1.51	1.51	0.00	0.00	0.02	0.00	0.00	14.9	0.00	0.01	0.01	0.00	16.5	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Trans	0.00	84.0	1.19	0.00	0.00	0.66	0.18	0.20	975	0.00	1.02	144	0.40	0.00	0.07	2.10	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	0.00	0.06	0.00	0.00	0.00	0.01	0.05	15.0	0.00	0.01	12.0	0.02	0.00	0.01	1.80	0.00	0.00	0.00	0.00	0.00	0.00
	Mean W/OB25 trans	0.00	198	1.49	0.00	0.00	0.17	0.25	0.40	555	0.00	0.75	150	0.90	0.00	1.63	2.70	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	6.01	0.06	0.00	0.00	0.02	0.02	0.05	15.0	0.00	0.01	3.01	0.03	0.00	0.01	0.30	0.00	0.00	0.00	0.00	0.00	0.00
	Mean W/OB25 Fresh	0.24	300	79.4	0.03	0.00	4.35	0.49	1.92	465	0.07	2430	76.5	450	0.00	1.00	2.55	1.32	0.12	0.00	0.00	0.00	0.00
	SE	0.01	0.00	1.50	0.00	0.00	0.15	0.01	0.00	15.0	0.00	0.00	7.50	0.00	0.00	0.01	0.15	0.00	0.01	0.00	0.00	0.00	0.00
	Mean D1/Whaleback fresh	0.05	106	1.06	0.00	0.00	0.79	0.55	1.38	615	0.00	20.7	100	0.64	0.00	1.09	3.09	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	1.51	0.02	0.00	0.00	0.02	0.19	0.00	75.0	0.00	15.3	4.51	0.14	0.00	0.01	2.01	0.00	0.00	0.00	0.00	0.00	0.00
Carbonate	Mean JN/OB25 Fresh	-0.01	59.99	1.72	0.05	32.99	0.23	0.05	230.95	17.40	0.01	0.69	244.46	0.19	0.00	0.58	0.60	0.09	0.00	0.00	0.00	0.13	0.09
	SE	0.00	0.00	0.18	0.00	0.00	0.00	0.00	2.98	0.30	0.00	0.00	4.52	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.01	0.00
	Mean MM/OB29 Weathered	-0.01	215.95	71.97	0.04	40.49	0.99	0.08	0.14	85.48	0.01	2.25	224.94	0.02	6.00	0.05	-0.12	0.04	0.00	0.00	0.00	0.06	0.00
	SE	0.00	0.02	0.01	0.00	1.50	0.00	0.00	0.02	1.49	0.00	0.03	3.02	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Trans	-0.01	116.99	5.98	0.09	45.00	0.57	0.06	0.10	95.99	0.01	1.98	176.98	0.08	0.00	0.02	-0.33	0.03	0.00	0.03	0.00	0.09	0.00
	SE	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02	2.99	0.00	0.06	36.01	0.01	0.00	0.00	0.21	0.00	0.00	0.03	0.00	0.00	0.00
	Mean W/OB25 trans	-0.01	191.97	2.49	0.07	31.50	0.66	0.12	0.65	23.25	0.01	1.27	407.94	0.07	0.00	0.37	0.75	0.09	0.00	0.13	0.00	2.34	0.00
	SE	0.00	3.01	0.01	0.00	1.50	0.03	0.01	0.00	1.05	0.00	0.04	0.02	0.01	0.00	0.03	0.30	0.00	0.00	0.02	0.00	2.16	0.00
	Mean W/OB25 Fresh	-0.01	329.97	5.23	0.10	30.00	1.36	0.26	0.28	49.50	0.07	28.80	317.97	2.51	0.00	0.02	8.25	0.88	0.01	0.01	0.00	0.21	0.00
	SE	0.00	0.00	0.15	0.01	3.00	0.01	0.00	0.00	1.50	0.01	0.00	30.00	0.03	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.03	0.00
	Mean D1/Whaleback fresh	-0.01	236.92	2.32	0.08	29.99	2.16	0.98	2.55	286.41	0.01	26.39	296.91	0.05	0.00	0.71	0.33	0.24	0.00	0.06	0.00	0.22	0.00
	SE	0.00	0.02	0.03	0.00	0.00	0.06	0.00	0.02	13.52	0.00	3.60	21.02	0.00	0.00	0.02	0.42	0.00	0.00	0.06	0.00	0.02	0.00
Crystalline Fe/Mn oxide	Mean JN/OB25 Fresh	0.40	241.96	1.26	0.00	0.00	0.10	1.43	239.15	4674.18	0.00	-0.16	0.00	1.08	0.00	2.30	0.66	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.01	16.48	0.00	0.00	0.00	0.00	0.00	13.73	0.35	0.00	0.11	0.00	0.00	0.00	0.05	0.22	0.00	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Weathered	0.02	505.87	10.17	0.00	0.00	0.35	0.80	0.66	9622.57	0.00	2.50	93.48	0.36	71.48	0.51	1.48	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	5.45	0.27	0.00	0.00	0.01	0.03	0.11	273.97	0.00	0.30	0.01	0.00	0.01	0.03	0.27	0.00	0.00	0.00	0.00	0.00	0.00

		Ag	Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	P	Pb	S	V	Zn	As	Cd	Mo	Nb	Ni	Se
	Mean MM/OB29 Trans	0.00	393.21	0.50	0.00	0.00	0.55	0.46	0.36	11823.80	0.00	2.94	151.23	0.31	0.00	0.06	2.31	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	8.23	0.05	0.00	0.00	0.00	0.04	0.02	274.38	0.00	0.14	2.74	0.00	0.00	0.01	0.55	0.00	0.00	0.00	0.00	0.00	0.00
	Mean W/OB25 trans	0.06	687.40	1.21	0.00	0.00	0.19	17.32	1.79	20621.92	0.00	4.12	261.21	0.75	0.00	11.76	3.41	0.00	0.00	0.00	0.25	0.00	0.00
	SE	0.00	27.53	0.11	0.00	0.00	0.01	0.83	0.03	275.99	0.00	0.17	19.26	0.06	0.00	0.28	1.65	0.00	0.00	0.00	0.02	0.00	0.00
	Mean W/OB25 Fresh	0.03	406.96	1.92	0.00	0.00	0.23	3.71	1.65	11273.87	0.07	62.42	76.99	19.56	0.00	1.67	2.03	8.25	0.00	0.91	0.00	0.80	0.00
	SE	0.00	0.00	0.00	0.00	0.00	0.01	0.03	0.00	274.97	0.00	2.75	5.50	0.00	0.00	0.03	0.27	0.00	0.00	0.03	0.00	0.03	0.00
	Mean D1/Whaleback fresh	0.10	267.37	-0.02	-0.01	-109.46	0.27	4.91	-12.47	10046.45	-0.01	4.01	-38905.18	0.30	-22.49	5.34	2.08	-0.06	-0.01	0.00	0.00	-0.09	-0.09
	SE	0.02	95.54	0.79	0.01	109.46	0.60	1.69	17.64	3150.25	0.01	1.76	39009.65	0.01	22.49	1.74	0.23	0.06	0.01	0.00	0.00	0.09	0.09
Exchangeable	Mean JN/OB25 Fresh	0.00	22.32	1.21	0.00	106.48	0.79	-0.01	32.94	-28.94	0.03	0.27	2999.48	0.00	18.00	0.26	3.79	0.04	0.00	-0.21	0.00	0.18	0.18
	SE	0.00	0.00	0.08	0.00	1.51	0.02	0.00	0.00	0.00	0.00	0.02	0.22	0.01	0.00	0.00	3.40	0.02	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Weathered	0.00	12.27	1.20	-0.01	149.96	0.72	-0.05	-0.05	-28.67	0.02	0.12	0.00	-0.01	70.48	-0.01	0.02	0.06	0.00	-0.21	0.00	0.00	0.00
	SE	0.00	1.05	0.06	0.00	11.98	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	4.49	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Trans	0.00	4.47	1.00	0.00	37.50	0.14	-0.06	-0.05	-27.81	0.04	0.13	1499.78	-0.01	92.99	-0.03	-0.07	0.07	0.00	0.01	0.00	0.04	0.00
	SE	0.00	0.15	0.07	0.00	1.50	0.01	0.00	0.00	0.06	0.00	0.00	1499.78	0.00	0.00	0.00	0.02	0.02	0.00	0.22	0.00	0.04	0.00
	Mean W/OB25 trans	0.00	9.12	0.82	-0.01	41.99	0.28	-0.06	-0.04	-29.17	0.02	0.42	1499.85	-0.01	91.49	-0.02	-0.03	0.18	0.00	-0.21	0.00	0.06	0.00
	SE	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	1499.85	0.00	1.50	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00
	Mean W/OB25 Fresh	0.00	14.82	0.73	0.00	79.49	1.77	-0.01	-0.03	-29.16	0.11	4.42	1499.85	-0.01	30.00	-0.01	1.71	2.62	0.01	0.21	0.00	0.09	0.00
	SE	0.00	0.60	0.10	0.00	1.50	0.03	0.00	0.00	0.09	0.01	0.00	1499.85	0.00	0.00	0.00	0.12	0.22	0.00	0.30	0.00	0.00	0.00
	Mean D1/Whaleback fresh	0.00	14.67	0.93	0.00	52.48	9.45	-0.04	0.22	-28.85	0.03	4.12	2999.03	-0.01	25.49	0.02	0.09	0.33	0.01	-0.09	0.00	0.15	0.00
	SE	0.00	0.15	0.06	0.00	1.50	0.15	0.00	0.00	0.00	0.00	0.30	0.22	0.00	1.50	0.00	0.06	0.03	0.00	0.12	0.00	0.06	0.00
Residue	Mean JN/OB25 Fresh	ND	103150.00	75.50	1.00	117.50	2.50	195.00	53.50	21600.00	30.50	49.50	90.00	75.00	2250.00	161.50	15.50	5.50	0.00	9.00	25.00	20.00	0.00
	SE	0.00	4850.00	2.50	0.00	67.50	0.50	0.00	1.50	300.00	0.50	0.50	0.00	4.00	90.00	1.50	0.50	0.50	0.00	0.00	0.00	3.00	0.00
	Mean MM/OB29 Weathered	0.00	25650.00	21.50	1.00	422.50	3.00	40.00	27.50	430500.00	2.00	160.00	465.00	21.00	1125.00	38.50	48.50	8.00	0.00	7.00	0.00	20.50	0.00
	SE	0.00	250.00	1.50	0.00	42.50	0.00	0.00	0.50	3500.00	0.00	1.00	10.00	1.00	15.00	0.50	0.50	0.00	0.00	1.00	0.00	0.50	0.00
	Mean MM/OB29 Trans	0.00	14300.00	0.00	1.00	112.50	12.50	ND	17.50	595500.00	2.00	173.50	782.50	20.00	370.00	8.50	75.50	6.00	1.00	14.00	0.00	20.00	0.00
	SE	0.00	1900.00	0.00	0.00	2.50	1.50	0.00	0.50	7500.00	0.00	6.50	52.50	0.00	10.00	0.50	4.50	1.00	0.00	1.00	0.00	1.00	0.00
	Mean W/OB25 trans	0.00	51000.00	26.00	1.00	87.50	1.00	45.00	15.50	129500.00	2.00	61.50	815.00	20.00	45.00	34.00	13.50	19.00	0.00	5.00	0.00	18.50	0.00
	SE	0.00	2000.00	1.00	0.00	7.50	0.00	0.00	1.50	3500.00	0.00	3.50	35.00	0.00	5.00	2.00	1.50	0.00	0.00	0.00	0.00	0.50	0.00
	Mean W/OB25 Fresh	ND	43100.00	57.50	1.25	70.00	2.00	35.00	40.00	92500.00	19.50	82.50	247.50	159.50	70.00	41.00	85.50	228.50	0.00	9.50	0.00	20.00	0.00
	SE	0.00	500.00	2.50	0.05	5.00	0.00	0.00	1.00	2700.00	0.50	2.50	2.50	1.50	5.00	1.00	1.50	5.50	0.00	0.50	0.00	1.00	0.00

		Ag	Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	P	Pb	S	V	Zn	As	Cd	Mo	Nb	Ni	Se
	Mean D1/Whaleback fresh	0.00	18700.00	8.00	0.70	77.50	1.00	15.00	10.00	175500.00	1.00	28.00	242.50	7.50	260.00	16.50	8.00	18.00	0.00	0.00	0.00	13.50	0.00
	SE	0.00	100.00	0.00	0.00	2.50	0.00	0.00	0.00	3500.00	0.00	0.00	2.50	1.50	5.00	0.50	1.00	1.00	0.00	0.00	0.00	2.50	0.00
Total Oxidisable	Mean JN/OB25 Fresh	0.00	147.44	0.00	0.00	0.00	0.00	0.00	218.21	899.84	0.00	-0.94	0.00	0.00	197.96	0.00	-12.60	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	2.24	0.00	0.00	0.00	0.00	0.00	15.73	44.92	0.00	0.00	0.00	0.00	8.98	0.00	3.60	0.00	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Weathered	0.00	255.40	2.43	0.00	0.00	0.00	0.00	0.00	4948.76	0.00	0.72	0.00	0.00	0.00	0.00	3.37	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	2.27	0.27	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.14	0.00	0.00	0.00	0.00	4.27	0.00	0.00	0.00	0.00	0.00	0.00
	Mean MM/OB29 Trans	0.00	291.44	0.00	0.00	0.00	0.00	0.00	0.00	14173.62	0.00	2.23	166.48	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	6.76	0.00	0.00	0.00	0.00	0.00	0.00	675.64	0.00	0.02	4.51	0.00	0.00	0.00	1.12	0.00	0.00	0.00	0.00	0.00	0.00
	Mean W/OB25 trans	0.00	874.09	0.00	0.00	0.00	0.00	20.02	2.20	42518.75	0.00	9.40	409.44	0.00	0.00	4.95	-6.75	0.00	0.00	0.00	0.00	0.00	0.00
	SE	0.00	22.54	0.00	0.00	0.00	0.00	2.03	0.00	2476.75	0.00	0.90	13.52	0.00	0.00	0.45	4.95	0.00	0.00	0.00	0.00	0.00	0.00
	Mean W/OB25 Fresh	0.00	327.43	0.00	0.00	0.00	0.00	0.00	1.08	7424.26	0.00	7.60	0.00	4.88	0.00	0.00	-8.32	16.20	0.00	0.00	0.00	0.00	0.00
	SE	0.00	6.75	0.00	0.00	0.00	0.00	0.00	0.13	224.98	0.00	1.35	0.00	0.97	0.00	0.00	3.37	2.25	0.00	0.00	0.00	0.00	0.00
	Mean D1/Whaleback fresh	0.00	164.81	-0.96	-0.02	-16.49	-0.12	-0.06	-115.80	9138.30	-0.01	-0.30	-109.46	-0.11	-4.50	0.99	0.60	-0.04	0.00	0.00	0.00	-0.07	-0.04
	SE	0.00	65.85	0.96	0.02	16.49	0.12	0.06	117.33	1659.00	0.01	0.39	109.46	0.11	4.50	0.54	10.50	0.04	0.00	0.00	0.00	0.07	0.04

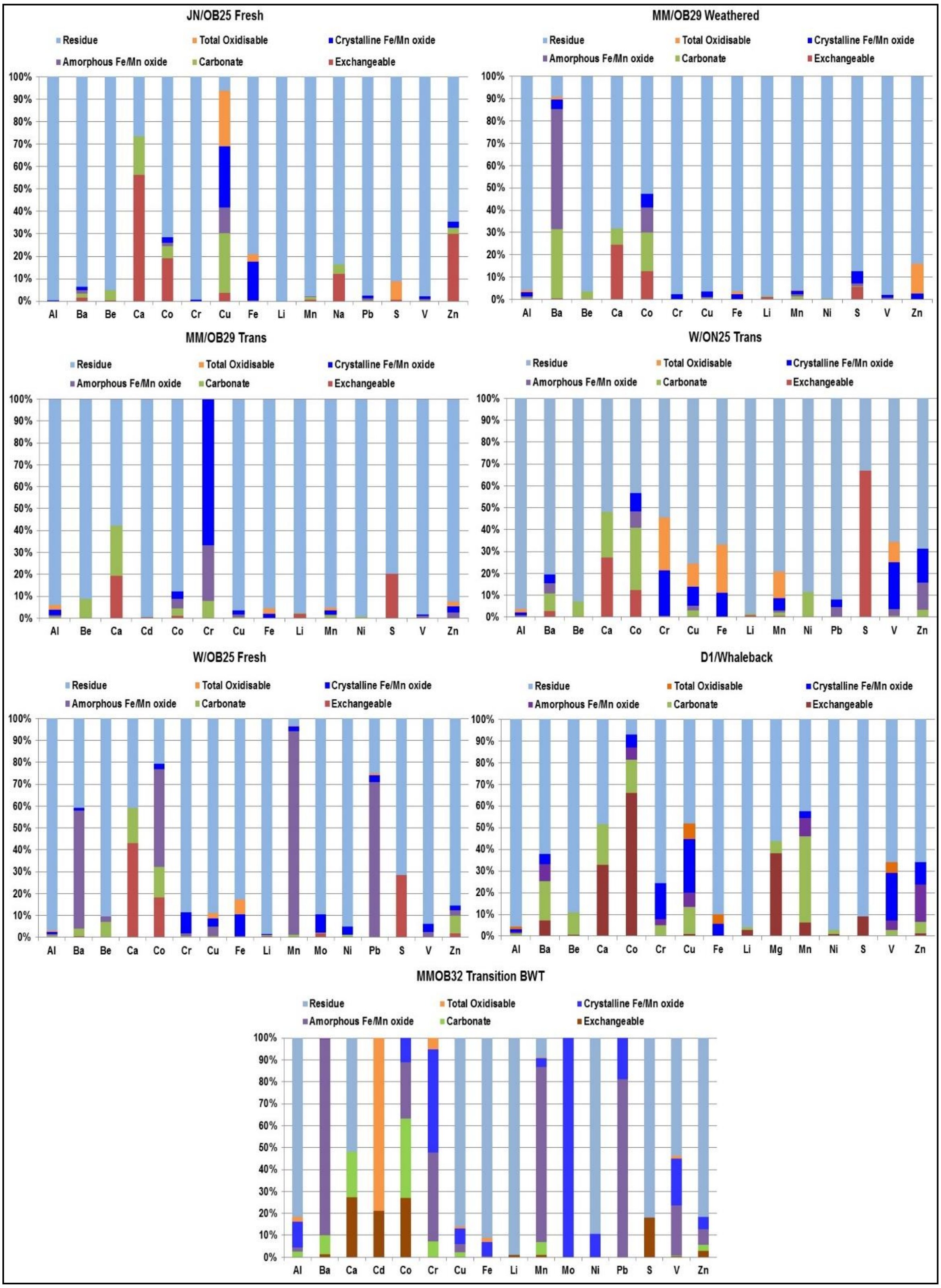


Figure A3-3. Distribution of metals in the several phases of the seven rock samples according to the method of Piatek et al., 2007

Table A3-4. Elemental concentrations (mg/kg) in sequential extraction fraction using the method of Rio Tinto 2014

			Ag	Al	As	Ba	Be	Ca	Co	Cd	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
Water Soluble	D1/Whaleback fresh	Mean	0.00	0.00	0.00	0.10	0.00	12.5	1.69	0.00	0.00	0.01	0.00	10.0	0.01	10.0	0.62	0.00	15.0	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.00
		SE	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	JN/OB25 Fresh	Mean	0.00	0.00	0.00	0.10	0.00	15.0	0.02	0.00	0.00	0.03	0.00	32.5	0.01	12.5	0.02	0.00	22.5	0.00	0.00	0.00	0.00	10.0	0.02	0.00	0.00
		SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	MM/OB29 Trans	Mean	0.00	48.7	0.00	3.18	0.05	36.2	0.56	0.00	0.06	0.04	122	5.00	0.02	31.24	1.05	0.00	47.5	0.00	0.07	0.00	0.10	16.2	0.00	0.01	1.09
		SE	0.00	48.7	0.00	2.81	0.05	6.25	0.54	0.00	0.06	0.04	122	5.00	0.01	6.25	0.97	0.00	25.0	0.00	0.07	0.00	0.10	16.2	0.00	0.01	1.14
	MM/OB29 Weathered	Mean	0.00	0.00	0.00	4.49	0.00	40.0	0.01	0.00	0.00	0.00	0.00	12.5	0.00	10.0	0.03	0.00	92.5	0.00	0.06	0.00	0.00	50.0	0.00	0.00	ND
		SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.00	0.00	0.01	0.00	0.00	ND
	W/OB25 Fresh	Mean	0.00	0.00	0.00	0.00	0.00	7.50	0.01	0.00	0.00	0.01	0.00	102	0.04	7.50	0.07	0.00	65.0	0.00	0.00	0.00	0.00	20.0	0.00	0.00	ND
		SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	ND
	W/OB25 trans	Mean	0.00	0.00	0.03	0.00	10.00	0.01	0.00	0.00	0.00	20.0	0.03	100.0	0.00	0.00	31.2	0.00	ND	6.85	3.60	0.00	0.00	12.50	0.00	0.00	0.00
		SE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	1.26	0.00	ND	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Exchangeable and carbonate	D1/Whaleback fresh	Mean	0.00	192	0.07	2.46	0.11	60.0	10.87	0.00	1.02	2.62	287	0.00	0.03	35.0	27.5	0.00	0.00	0.00	0.27	0.00	0.15	0.00	0.00	0.50	0.74
		SE	0.00	0.0	0.00	0.01	0.00	0.00	0.13	0.00	0.09	0.13	12.5	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.09
	JN/OB25 Fresh	Mean	ND	58.7	0.05	1.06	0.07	110	1.16	0.00	0.07	202	24.1	33.7	0.03	70.0	1.04	0.00	0.00	0.00	0.32	0.00	0.30	0.00	0.05	0.87	1.32
		SE	0.00	1.2	0.00	0.04	0.00	2.49	0.01	0.00	0.00	0.01	0.12	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.00	0.04	0.25
	MM/OB29 Trans	Mean	0.00	48.7	0.00	3.29	0.06	38.7	0.57	0.00	0.01	0.05	125	5.00	0.02	31.2	0.97	0.00	58.7	0.00	0.06	0.00	0.07	16.2	0.00	0.00	ND
		SE	0.00	48.7	0.00	2.94	0.06	6.25	0.55	0.00	0.06	0.05	125	5.00	0.01	6.25	0.92	0.00	26.2	0.00	0.06	0.00	0.10	16.25	0.00	0.01	ND
	MM/OB29 Weathered	Mean	0.00	189	0.00	93.7	0.04	126	1.85	0.00	0.10	0.14	164	32.5	0.03	33.7	2.23	0.00	101	0.00	0.14	0.00	0.06	0.00	0.00	0.02	2.81
		SE	0.00	1.3	0.00	1.26	0.00	3.73	0.08	0.00	0.00	0.02	3.77	0.00	0.00	1.25	0.06	0.00	1.26	0.00	0.01	0.00	0.00	0.00	0.00	0.00	2.26
	W/OB25 Fresh	Mean	ND	325	0.26	6.60	0.12	95.0	4.25	0.01	0.43	0.29	111.2	187	0.20	78.7	32.5	0.00	27.5	0.00	0.29	0.00	5.84	0.00	0.00	ND	14.07
		SE	ND	0.0	0.01	0.13	0.00	2.50	0.50	0.00	0.00	0.00	1.26	0.01	0.00	1.25	0.00	0.00	0.00	0.00	0.01	0.00	0.13	0.00	0.00	ND	1.25
	W/OB25 trans	Mean	144	0.0	2.38	0.08	60.0	1.06	0.70	0.18	57	102	1.69	0.00	0.00	0.16	0.00	0.10	2.07	2.20	179	0.00	0.00	0.00	0.02	0.00	0.00
		SE	1.27	0.0	0.08	0.00	0.01	0.01	0.01	0.01	2.51	0.02	0.05	0.00	0.00	0.03	0.00	0.00	0.50	0.10	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Amorphous Fe/Mn oxide	D1/Whaleback fresh	Mean	0.07	220	0.00	0.85	0.01	0.00	1.74	0.00	0.81	2.75	1487	0.00	0.00	0.00	18.6	0.00	0.00	0.00	0.27	0.00	0.75	0.00	0.00	2.50	0.89
		SE	0.00	0.0	0.00	0.00	0.01	0.00	0.01	0.00	0.11	0.00	37.5	0.00	0.00	0.00	1.62	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.04
	JN/OB25 Fresh	Mean	0.11	116	0.00	1.63	0.00	0.00	0.19	0.00	0.40	207	725	33.7	0.01	0.00	0.52	0.00	0.00	0.00	0.15	0.00	1.11	0.00	0.00	1.59	1.95
		SE	0.00	3.8	0.00	0.22	0.00	0.00	0.04	0.00	0.02	4.99	25.0	1.25	0.01	0.00	0.07	0.00	0.00	0.00	0.15	0.00	0.16	0.00	0.00	0.19	0.72
	MM/OB29 Trans	Mean	0.00	197	0.00	1.49	0.02	0.00	0.86	0.00	0.32	0.24	2374	0.00	0.00	35.0	2.45	0.00	0.00	0.00	0.35	0.00	0.39	0.00	0.00	0.08	1.10
		SE	0.00	0.0	0.00	0.01	0.02	0.00	0.01	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03
	MM/OB29 Weathered	Mean	0.00	215	0.00	117	0.00	0.00	0.77	0.00	0.27	0.41	1337	0.00	0.00	0.00	2.37	0.00	101	0.00	0.00	0.00	0.31	0.00	0.00	0.39	1.17
		SE	0.00	0.0	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.16	12.7	0.00	0.00	0.00	0.10	0.00	1.24	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.10
	W/OB25 Fresh	Mean	0.24	387	0.00	82.4	0.05	0.00	4.37	0.10	0.99	2.09	1100	169	0.13	0.00	2475	0.00	0.00	0.00	0.54	0.00	450	0.00	0.00	1.44	3.67
		SE	0.00	12.5	0.00	0.00	0.00	0.00	0.13	0.00	0.11	0.14	25.1	1.26	0.00	0.00	0.12	0.00	0.00	0.00	0.04	0.00	0.02	0.00	0.00	0.04	0.00

	W/OB25 trans	Mean	325	0.0	1.69	0.00	0.00	0.30	0.66	0.76	1887	0.00	1.87	0.00	0.00	1.20	0.00	3.12	2.55	1.25	4920	0.03	0.00	0.00	0.00	0.00	0.00
		SE	0.06	0.0	0.04	0.00	0.00	0.00	0.01	0.01	12.83	0.00	0.05	0.00	0.00	0.10	0.00	0.13	0.13	0.05	10.0	0.00	0.00	0.00	0.00	0.00	0.00
Crystalline Fe/Mn oxide	D1/Whaleback fresh	Mean	0.02	387	0.97	0.54	0.00	0.00	0.42	0.00	8.00	4.54	17745	0.00	0.00	0.00	3.73	0.00	0.00	0.00	0.00	37.5	0.28	38.7	0.00	7.87	1.07
		SE	0.01	12.5	0.12	0.04	0.00	0.00	0.02	0.00	0.75	0.62	0.44	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	2.50	0.05	1.25	0.00	0.62	0.12
	JN/OB25 Fresh	Mean	0.44	250	0.00	1.22	0.00	0.00	0.16	0.00	2.06	246	5374	42.5	0.06	0.00	0.30	0.00	0.00	0.00	0.85	0.00	1.00	35.0	0.00	3.50	0.70
		SE	0.01	0.0	0.00	0.02	0.00	0.00	0.00	0.00	0.04	3.76	125	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
	MM/OB29 Trans	Mean	0.01	512	0.00	0.32	0.00	0.00	0.64	0.00	0.66	0.69	21993	0.00	0.00	0.00	8.85	0.59	0.00	0.00	0.94	0.00	0.38	67.5	0.00	0.22	3.45
		SE	0.00	12.5	0.00	0.05	0.00	0.00	0.04	0.00	0.04	0.05	751	0.00	0.00	0.00	0.75	0.06	0.00	0.00	0.06	0.00	0.05	2.50	0.00	0.01	0.00
	MM/OB29 Weathered	Mean	0.00	587	0.00	3.50	0.00	0.00	0.25	0.00	1.41	1.24	15246	0.00	0.00	0.00	5.60	0.00	93.7	0.00	0.72	0.00	0.45	81.2	0.00	1.09	1.45
		SE	0.00	12.4	0.00	0.25	0.00	0.00	0.00	0.00	0.01	0.13	1.91	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.00	0.01	1.26	0.00	0.01	0.00
	W/OB25 Fresh	Mean	0.04	412	14.5	1.97	0.06	0.00	0.29	0.00	7.75	3.66	15623	61.2	0.13	0.00	64.8	1.41	0.00	0.15	1.44	0.00	20.7	15.0	0.00	3.00	4.70
		SE	0.00	12.5	1.00	0.20	0.00	0.00	0.01	0.00	0.50	0.25	626	1.25	0.01	0.00	2.50	0.11	0.00	0.02	0.09	0.00	1.25	15.00	0.00	0.25	0.25
	W/OB25 trans	Mean	700	0.00	0.74	0.00	0.00	0.08	1.53	22.50	28745	0.00	6.73	0.00	134	0.75	51.2	12.4	1.57	1.25	5315	0.02	0.00	0.00	0.00	0.00	0.36
		SE	24.9	0.00	0.11	0.00	0.00	0.01	0.09	2.25	1245	0.00	0.62	0.00	3.73	0.09	1.26	1.12	0.13	0.05	15.00	0.01	0.00	0.00	0.00	0.00	0.04
NAG	D1/Whaleback fresh	Mean	0.02	3.87	0.62	0.17	0.00	0.00	0.00	0.11	ND	0.10	11.1	0.00	0.00	0.00	ND	0.37	0.00	0.11	0.00	ND	ND	37.5	0.00	0.61	1.44
		SE	0.02	0.12	0.00	0.01	0.00	0.00	0.00	0.01	ND	0.01	0.63	0.00	0.01	0.00	ND	0.00	6.25	0.01	0.12	ND	ND	0.00	0.00	0.01	1.44
	JN/OB25 Fresh	Mean	0.03	11.0	0.25	0.14	0.00	0.00	0.04	0.10	0.00	181	4.69	0.00	0.01	0.00	0.00	0.50	ND	0.19	0.00	12.5	0.00	131	3.94	0.32	0.00
		SE	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	43.74	1.44	0.00	0.00	0.00	0.01	0.00	119	0.01	0.00	12.5	0.00	6.26	0.19	0.02	0.06
	MM/OB29 Trans	Mean	0.00	ND	0.00	0.11	0.00	0.00	0.01	0.05	ND	ND	ND	0.00	0.00	0.00	ND	0.44	ND	0.12	0.00	0.00	ND	25.0	0.00	0.02	ND
		SE	0.00	ND	0.00	0.01	0.00	0.00	0.01	0.00	ND	ND	ND	0.00	0.00	0.00	ND	0.06	ND	0.00	0.00	6.24	ND	0.00	0.00	0.01	ND
	MM/OB29 Weathered	Mean	0.01	4.44	0.00	0.62	0.00	0.00	0.00	0.06	0.00	0.01	0.87	0.00	0.00	0.00	-0.12	0.19	ND	0.17	0.00	ND	ND	12.5	0.00	0.07	ND
		SE	0.01	0.56	0.00	0.02	0.00	0.00	0.00	0.02	0.01	0.02	0.37	0.00	0.00	0.00	0.01	0.06	ND	0.01	0.00	ND	0.00	0.00	0.00	0.00	ND
	W/OB25 Fresh	Mean	0.00	6.06	6.81	0.04	0.00	0.00	0.00	0.02	0.22	ND	14.87	0.00	0.01	0.00	ND	0.50	ND	0.15	0.00	0.00	ND	0.00	0.12	0.30	ND
		SE	0.00	0.44	0.06	0.02	0.00	0.00	0.00	0.04	0.01	ND	0.63	0.00	0.00	0.00	ND	0.00	ND	0.01	0.06	6.25	ND	0.00	0.00	0.01	ND
	W/OB25 trans	Mean	0.25	0.00	0.23	0.00	0.00	0.04	1.14	0.25	3.94	0.00	ND	ND	ND	ND	31.2	2.37	1.12	3.15	10.8	0.03	0.11	0.00	0.00	0.50	0.15
		SE	0.50	0.00	0.04	0.00	0.00	0.01	0.18	0.09	6.56	0.00	ND	ND	ND	ND	6.24	0.13	0.13	0.05	1.10	0.02	0.00	0.00	0.00	0.00	0.04
Aqua Regia	D1/Whaleback fresh	Mean	0.00	1106	0.00	1.53	0.00	0.00	0.00	0.00	9.00	4.20	62978	0.00	0.00	0.00	5.58	0.00	34.5	0.00	0.00	259	1.26	0.00	0.00	5.25	4.35
		SE	0.00	0.03	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	0.30	0.00	1.50	0.00	0.00	4.51	0.06	0.00	0.00	0.15	0.75
	JN/OB25 Fresh	Mean	0.00	2036	0.00	3.43	0.00	0.00	0.37	0.00	6.00	144	13793	988	0.85	186	2.62	0.00	51.0	0.00	0.00	114	3.60	133	0.00	6.45	8.10
		SE	0.00	240	0.00	0.46	0.00	0.00	0.37	0.00	1.20	15.0	599	97.4	0.13	27.0	0.85	0.00	3.00	0.00	0.00	0.01	0.60	10.5	0.00	0.75	4.50
	MM/OB29 Trans	Mean	0.00	2230	0.00	0.00	0.00	0.00	1.84	0.00	0.00	2.89	106463	0.00	0.00	75.0	33.8	0.00	0.00	0.00	0.00	420	2.88	0.00	0.00	0.90	15.4
		SE	0.00	14.9	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.10	1494	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.02	0.06	0.00	0.00	0.03	1.95
	MM/OB29 Weathered	Mean	0.00	2275	0.00	6.45	0.00	46.5	0.00	0.00	4.80	3.45	49481	0.00	0.00	36.0	14.6	0.00	90.0	0.00	0.00	216	2.58	67.5	0.00	4.50	7.95
		SE	0.00	150	0.00	0.75	0.00	1.49	0.00	0.00	0.30	0.45	4493	0.00	0.00	2.99	0.90	0.00	3.01	0.00	0.00	5.97	0.18	7.49	0.00	0.30	0.15
	W/OB25 Fresh	Mean	0.00	1796	115	2.97	0.00	31.5	0.00	0.00	19.65	12.45	61485	622	0.82	85.5	45.8	0.00	52.5	0.00	0.00	240	37.49	0.00	0.00	8.10	15.4
		SE	0.00	180	7.49	0.03	0.00	1.50	0.00	0.00	0.45	0.45	4496	49.5	0.02	10.5	1.50	0.00	7.50	0.00	0.00	0.01	1.50	0.00	0.00	0.30	1.95
	W/OB25 trans	Mean	4645	11.5	2.01	0.00	0.00	0.00	5.70	54.0	127473	16.5	38.3	34.5	1155	5.25	0.00	26.4	2.70	0.00	69350	0.00	0.00	0.00	0.00	0.00	0.00

		SE	151	0.45	0.18	0.00	0.00	0.00	0.00	0.01	1522	16.5	0.01	1.49	15	0.15	0.00	0.30	1.20	0.00	550	0.00	0.00	0.00	0.00	0.00	0.00
Residue	D1/Whaleback fresh	Mean	ND	14000	17.5	7.50	0.70	70.0	1.00	ND	ND	7.00	180500	125	2.00	70.0	26.0	ND	85.0	ND	8.00	248	ND	185	ND	3.50	20.00
		SE	ND	100	1.50	0.50	0.00	0.00	0.00	ND	ND	0.00	500	5.00	0.00	0.00	2.00	ND	0.00	ND	1.00	2.50	ND	5.00	ND	0.50	ND
	JN/OB25 Fresh	Mean	ND	110000	6.50	94.0	1.00	ND	2.00	ND	110	32.0	9685	43300	31.0	9005	52.5	ND	420	15.0	17.5	120	74.0	3255	ND	195	15.5
		SE	ND	4000	3.50	3.00	0.00	ND	0.00	ND	5.00	2.00	615	600.00	0.00	125	1.50	ND	5.00	0.00	1.50	10.0	0.00	145	ND	1.50	0.50
	MM/OB29 Trans	Mean	ND	13550	5.00	ND	1.10	87.5	11.0	ND	15.00	20.50	603000	ND	2.00	273	161	9.00	108	ND	15.5	845	13.0	355	ND	ND	73.5
		SE	ND	850	0.00	ND	0.00	2.50	0.00	ND	0.00	0.50	3000	ND	0.00	7.50	1.00	0.00	17.5	ND	4.50	15.0	0.00	10.0	ND	ND	1.50
	MM/OB29 Weathered	Mean	ND	19600	8.50	23.0	1.30	323	3.00	ND	42.5	32.5	486000	265	1.00	155	165	ND	245	ND	30.0	553	16.5	990	ND	22.5	57.5
		SE	ND	100	0.50	4.00	0.00	2.50	0.00	ND	2.50	0.50	2000	35.00	0.00	5.00	3.00	ND	10.00	ND	2.00	12.5	0.50	10.0	ND	0.50	0.50
	W/OB25 Fresh	Mean	ND	43750	213	71.0	1.40	65.0	2.00	ND	30	38.5	64200	21100	23	3990	52.5	7.00	245	ND	28.5	270	129	55.0	ND	43.5	111
		SE	ND	1650	1.00	4.00	0.00	0.00	0.00	ND	0.00	1.50	1700	500	0.50	100.00	0.50	0.00	10.0	ND	1.50	0.00	3.50	0.00	ND	1.50	5.50
	W/OB25 trans	Mean	54050	11.0	32.0	0.95	65.0	ND	13.0	15.0	49100	148	38.0	110	378	14.0	20.0	8.50	12.0	ND	ND	ND	ND	485	3.00	ND	ND
		SE	1550	1.00	0.00	0.05	0.00	ND	0.00	0.00	1300	2.50	0.00	10.0	2.50	0.00	ND	0.50	0.00	ND	ND	ND	ND	5.00	0.00	ND	ND

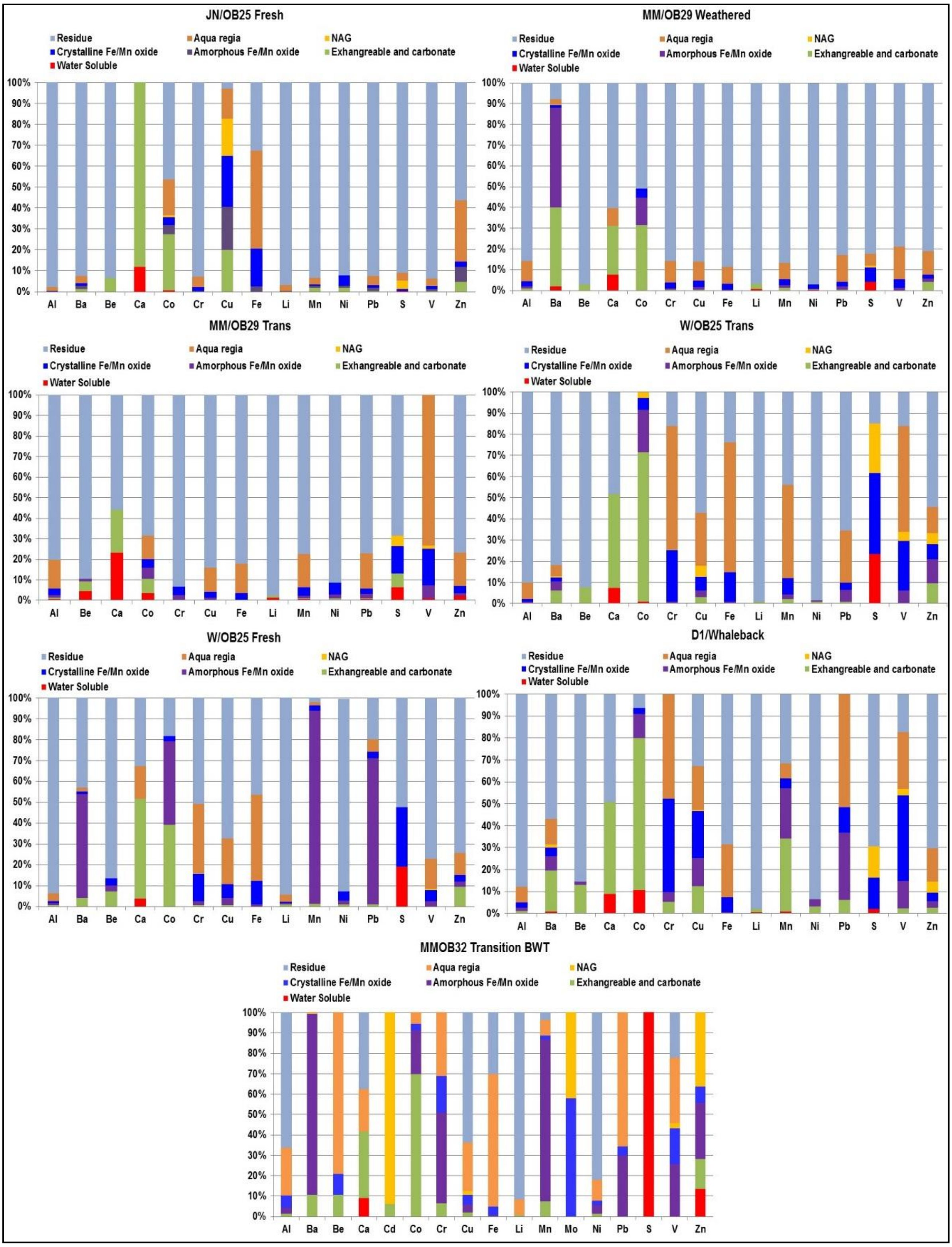


Figure A3-4. Distribution of metals in the several phases of the seven rock samples according to the method of Rio Tinto 2014

Table A3-5. Percent recovery obtained for all elements in sequentially extraction procedures performed by all four methods for seven rock samples.

		Fraction	Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Ni	Pb	S	V	Zn
JN/OB25 Fresh	Abed	Total of all fraction	107396	102	1.17	217	3.17	141	946	20765	32.1	54.9	18.6	79.0	3400	199	25.1
		Pseudo total	120000	99.0	1.10	180	9.00	150	712	26700	30.0	54.0	15.0	83.0	3250	195	24.0
		Recovery (%)	89	103	107	121	35	94	133	78	107	102	124	95	105	102	104
	Leinz	Total of all fractions	105360	98.6	0.95	127	3.09	136	1014	26989	31.0	54.8	16.5	79.0	3839	206	25.7
		Pseudo total	120000	99.0	1.10	180	9.00	150	712	26700	30.0	54.0	15.0	83.0	3250	195	24.0
		% Recovery	88	100	86	71	34	91	142	101	103	102	110	95	118	105	107
	Piatak	Total of all fractions	103688	80.8	1.05	257	3.69	196	875	27273	30.5	49.5	20.3	77.1	2466	165	7.88
		Pseudo total	120000	99.0	1.10	180	9.00	150	712	26700	30.0	54.0	15.0	83.0	3250	195	24.0
		%recovery	86	82	96	143	41	131	123	102	102	92	135	93	76	85	33
	RT	Total of all fractions	112472	102	1.07	125	3.95	118	1013	29607	32.0	56.9	18.8	79.9	3565	207	27.5
		Pseudo total	120000	99.0	1.10	180	9.00	150	712	26700	30.0	54.0	15.0	83.0	3250	195	24.0
		% Recovery	94	103	97	69	44	79	142	111	107	105	125	96	110	106	115
MM/OB29 Weathered	Abed	Total of all fractions	21172	234	1.24	559	5.42	45.4	32.8	475401	1.02	168.5	27.8	17.2	1149	26.90	57.4
		Pseudo total	23900	225	1.20	500	16.0	40.0	32.0	510000	<1	181	14.0	14.0	1110	42.00	58.0
		Recovery (%)	89	104	103	112	34	114	102	93	!	93	198	123	103	64	99
	Leinz	Total of all fractions	28328	237	1.00	577	6.01	46.5	36.1	480391	1.00	177.3	21.5	18.0	1368	32.21	63.9
		Pseudo total	23900	225	1.20	500	16.0	40.0	32.0	510000	<1	181.0	14.0	14.0	1110	42.00	58.0
		% Recovery	119	105	83	115	38	116	113	94		98	154	128	123	77	110
	Piatak	Total of all fractions	26737	232	1.03	613	5.70	40.8	28.4	445683	2.03	167.0	20.6	21.6	1289	39.27	53.0
		Pseudo total	23900	225	1.20	500	16.0	40.0	32.0	510000	<1	181.0	14.0	14.0	1110	42.00	58.0
		%recovery	112	103	86	123	36	102	89	87		92	147	155	116	93	91
	RT	Total of all fractions	22871	249	1.34	535	5.88	49.0	37.8	552228	1.03	189.7	30.8	19.8	1201	28.57	70.6
		Pseudo total	23900	225	1.20	500	16.0	40.0	32.0	510000	<1	181.0	14.0	14.0	1110	42.00	58.0
		% Recovery	96	111	112	107	37	122	118	108		105	220	142	108	68	122
MM/OB29 Trans	Abed	Total of all fractions	12945	#DIV/0!	1.16	214	11.5	15.3	20.0	620364	2.05	173.6	18.7	16.3	435	0.07	83.0
		Pseudo total	14200	<5	1.10	155	27.0	10.0	18.0	623000	1.00	168.0	10.0	11.0	470	9.00	78.0
		Recovery (%)	91	#DIV/0!	106	138	43	153	111	100	205	103	187	149	93	1	106

		Fraction	Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Ni	Pb	S	V	Zn
	Leinz	Total of all fractions	18930	#DIV/0!	1.10	165	13.9	17.5	24.5	710350	2.02	197.8	20.5	17.1	518	1.09	105
		Pseudo total	14200	<5	1.10	155	27.0	10.0	18.0	623000	1.00	168.0	10.0	11.0	470	9.00	78.0
		% Recovery	133	#DIV/0!	100	107	52	175	136	114	202		205	155	110	12	135
	Piatak	Total of all fractions	15190	#DIV/0!	1.09	195	14.4	0.6	18.1	622541	2.05	182	20.1	20.8	463	8.62	80.2
		Pseudo total	14200	<5	1.10	155	27.0	10.0	18.0	623000	1.00	168	10.0	11.0	470	9.00	78.0
		%recovery	107	#DIV/0!	99	126	53	6	101	100	205	108	201	189	99	96	103
	RT	Total of all fractions	16586	8.40	1.23	162	15.5	15.9	24.4	734075	2.05	208	16.9	16.7	480	1.22	94.0
		Pseudo total	14200	<5	1.10	155	27.0	10.0	18.0	623000	1.00	168	10.0	11.0	470	9.00	78.0
		% Recovery	117	#VALUE!	112	105	57	159	136	118	205	124	169	152	102	14	120
W/OB25 trans	Abed	Total of all fractions	47466	34.0	1.12	172	1.14	88.8	18.6	191123	2.03	84.9	17.9	18.4	131	51.63	19.5
		Pseudo total	52500	30.0	1.20	145	8.00	90.0	20.0	199000	2.00	80.0	14.0	20.0	225	61.00	24.0
		Recovery (%)	90	113	93	119	14	99	93	96	101	106	128	92	58	85	81
	Leinz	Total of all fractions	56676	36.3	0.95	147	1.08	69.9	20.6	190151	3.00	74.2	20.0	20.7	112	42.31	41.1
		Pseudo total	52500	30.0	1.20	145	8.00	90.0	20.0	199000	2.00	80.0	14.0	20.0	225	61.00	24.0
		% Recovery	108	121	79	102	13	78	103	96	150	93	143	103	50	69	171
	Piatak	Total of all fractions	52961	32.0	1.07	161	2.30	82.7	20.5	193190	2.03	77.5	20.9	21.7	136	52.69	13.6
		Pseudo total	52500	30.0	1.20	145	8.00	90.0	20.0	199000	2.00	80.0	14.0	20.0	225	61.00	24.0
		%recovery	101	107	89	111	29	92	103	97	101	97	149	109	61	86	57
	RT	Total of all fractions	59864	39.1	1.03	135	1.50	92.7	22.7	207266	3.03	86.5	27.3	21.3	134	52.87	22.0
		Pseudo total	52500	30.0	1.20	145	8.00	90.0	20.0	199000	2.00	80.0	14.0	20.0	225	61.00	24.0
		% Recovery	114	130	86	93	19	103	114	104	151	108	195	106	59	87	92
W/OB25 Fresh	Abed	Total of all fractions	36683	153	1.54	222	8.17	49.6	53.4	133364	20.37	2538	30.9	609	112	49.55	132
		Pseudo total	44700	172	1.50	210	19.0	55.0	51.0	136000	20.00	3260	23.0	723	145	52.00	147
		Recovery (%)	82	89	103	106	43	90	105	98	102	78	134	84	78	95	90
	Leinz	Total of all fractions	42678	156	1.37	206	10.3	49.4	52.4	136536	22.21	2629	26.00	623	86	52.00	137
		Pseudo total	44700	172	1.50	210	19.0	55.0	51.0	136000	20.00	3260	23.00	723	145	52.00	147
		% Recovery	95	91	92	98	54	90	103	100	111	81	113	86	59	100	93
	Piatak	Total of all fractions	44479	145	1.38	179	9.72	39.5	44.9	111683	19.82	2615	21.1	636	100	43.69	91.7
		Pseudo total	44700	172	1.50	210	19.0	55.0	51.0	136000	20.00	3260	23.0	723	145	52.00	147
		%recovery	100	84	92	85	51	72	88	82	99	80	92	88	69	84	62

		Fraction	Al	Ba	Be	Ca	Co	Cr	Cu	Fe	Li	Mn	Ni	Pb	S	V	Zn
	RT	Total of all fractions	46677	165	1.62	199	10.9	59.0	57.0	142534	23.84	2670	30.6	642	90	56.33	148
		Pseudo total	44700	172	1.50	210	19.0	55.0	51.0	136000	20.00	3260	23.0	723	145	52.00	147
		% Recovery	104	96	108	95	57	107	112	105	119	82	133	89	62	108	101
D1/Whaleback fresh	Abed	Total of all fractions	14405	12.8	0.95	162	14.0	28.3	20.2	228378	2.03	67.5	12.3	1.37	265	21.29	9.27
		Pseudo total	11000	9.0	1.00	135	20.0	20.0	21.0	268000	1.00	56.0	5.00	6.00	220	22.00	15.0
		Recovery (%)	131	143	95	120	70	141	96	85	203	120	246	23	120	97	62
	Leinz	Total of all fractions	16697	12.1	0.65	139	14.2	14.3	20.4	248365	1.51	67.9	26.0	1.58	250	17.49	26.9
		Pseudo total	11000	9.0	1.00	135	20.0	20.0	21.0	268000	1.00	56.0	5.00	6.00	220	22.00	15.0
		% Recovery	152	135	65	103	71	72	97	93	151	121	521	26	114	79	179
	Piatak	Total of all fractions	19490	11.3	0.76	34	13.6	21.3	-114.1	195557	1.02	82.9	13.7	8.37	259	24.67	14.2
		Pseudo total	11000	9.0	1.00	135	20.0	20.0	21.0	268000	1.00	56.0	5.00	6.00	220	22.00	15.0
		%recovery	177	126	76	25	68	107	-543	73	102	148	274	140	118	112	95
	RT	Total of all fractions	15909	13.2	0.82	142	15.7	18.7	21.2	263008	2.03	81.8	8.42	2.37	266	20.23	28.5
		Pseudo total	11000	9.0	1.00	135	20.0	20.0	21.0	268000	1.00	56.0	5.00	6.00	220	22.00	15.0
		% Recovery	145	146	82	106	79	94	101	98	203	146	168	39	121	92	190
MMOB32 Trans/BWT	Abed	Total of all fraction	2514	148	0.05	130	7.79	4.0	9.05	293354	4.64	969	9.41	43.6	70.0	8.67	10.2
		Pseudo total	1930	160	<0.5	135	<1	<10	6.00	327000	4.00	1180	<5	<5	<20	<1	8.00
		Recovery (%)	130	92		96			151	90	116	82					128
	Leinz	Total of all fractions	3234	160	0.13	119	7.03	6.04	46.6	346970	5.11	1120	12.6	0.70	66.0	9.52	16.5
		Pseudo total	1930	160	<0.5	135	<1	<10	6.00	327000	4.00	1180	<5	<5	<20	<1	8.00
		Recovery (%)	168	100		88				106	128	95					206
	Piatak	Total of all fractions	3127	163		159	7.35	4.90	12.8	318720	4.04	1148	6.71	0.55	33.5	9.27	10.4
		Pseudo total	1930	160		135	<1	<10	6.00	327000	4.00	1180	<5	<5	<20	<1	8.00
		Recovery (%)	162	102		118				97	101	97					130
	RT	Total of all fraction	4469	162	0.27	165	8.43	6.18	14.1	376848	5.45	1137	17.9	1.60	4.99	8.94	10.6
		Pseudo total	1930	160	<0.5	135	<1	<10	6.00	327000	4.00	1180	<5	<5	<20	<1	8.00
		Recovery (%)		102		122				115	136	96					133

APPENDIX 4: SEQUENTIAL LEACH TESTS – OPTIMISED METHOD

Table A4-1. Elemental composition of extractant blank solutions in the optimised sequential extraction method

	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Water extractable	<0.0001	0.02	<0.001	0.00215	<0.0001	<0.1	<0.0001	<0.0001	<0.0005	0.00125	<0.005	0.1
Exchangeable (NH_4OAC)	<0.0020	<0.005	<0.020	<0.0020	<0.001	<0.1	<0.0020	<0.0020	<0.001	<0.0020	<0.005	<0.1
Carbonate (HOAC)	0.0026	<0.005	<0.001	0.0001	<0.0001	<0.1	<0.0001	<0.0001	<0.001	0.0003	<0.005	<0.1
Amorphous Fe/Mn oxide (NH_2OH/0.25M HCl)	<0.0020	<0.025	<0.020	<0.0020	<0.0020	<0.5	<0.0020	<0.0020	<0.005	<0.0020	<0.025	<0.5
Crystalline Fe/Mn oxide (4M HCl)	<0.010	<0.050	<0.10	<0.010	<0.010	<1.0	<0.010	<0.010	<0.010	<0.010	<0.050	<1.0
Easily oxidisable ($NaClO_3$ + Conc. HCl)	<0.010	0.0675	<0.10	<0.010	<0.010	<1.0	<0.010	<0.010	0.015	<0.010	<0.050	3.7
Recalcitrant Oxidisable (H_2O_2/ HNO_3)	<0.0001	<0.050	<0.001	0.0003	<0.0001	<0.1	<0.0001	0.0001	0.007	0.0002	0.0325	0.3

	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Water extractable	<0.0001	<0.1	0.0003	<0.001	<0.1	<0.0002	0.002	<0.1	0.0545	<0.1	<0.001	0.0005	0.013
Exchangeable (NH_4OAC)	<0.0020	<0.1	<0.0020	<0.020	<0.1	<0.0040	<0.020	<0.1	<0.0020	0.1	<0.020	<0.0020	0.051
Carbonate (HOAC)	<0.0001	<0.1	0.0003	<0.001	<0.1	<0.0002	<0.001	<0.1	0.0024	0.3	<0.001	0.0001	0.056
Amorphous Fe/Mn oxide (NH_2OH/0.25M HCl)	<0.0020	<0.5	<0.0020	<0.020	<0.5	<0.0040	<0.020	<0.5	<0.0020	<0.5	<0.020	<0.0020	<0.025
Crystalline Fe/Mn oxide (4M HCl)	<0.010	<1.0	<0.010	<0.10	<1.0	<0.020	<0.10	<1.0	<0.010	<1.0	<0.10	<0.010	0.05
Easily oxidisable ($NaClO_3$ + Conc. HCl)	<0.010	<1.0	<0.010	<0.10	17250	<0.020	<0.10	<1.0	<0.010	<1.0	<0.10	<0.010	0.083
Recalcitrant Oxidisable (H_2O_2/ HNO_3)	0.0001	<0.1	0.0008	<0.001	12.35	0.0014	0.004	11	0.0002	<0.1	<0.001	<0.0001	<0.005

Table 4-2. Elemental concentrations (mg/kg) in sequential extraction fraction using the optimised method

		Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
JN/OB25 Fresh	Water Extractable	0.00	0.00	0.00	0.05	0.00	10.00	0.00	0.01	0.00	0.02	0.00	27.50
	Exchangeable	0.00	0.00	0.00	0.95	0.00	112.50	0.00	0.51	0.00	163	0.00	30.00
	Carbonate	0.01	56.25	0.05	0.65	0.07	10.00	0.00	0.55	0.09	241	24.75	7.50
	Amorphous Fe/Mn oxide	0.00	83.75	0.00	0.99	0.00	0.00	0.00	0.11	0.00	114	129	22.50
	Crystalline Fe/Mn oxide	0.40	775.00	0.00	4.13	0.00	0.00	0.00	0.58	5.25	450	8125	153.75
	Easily oxidisable	0.00	32.50	0.00	0.38	0.00	0.00	0.00	0.00	0.33	16.25	144	138.75
	Recalcitrant Oxidisable	0.00	48.75	0.25	0.44	0.01	8.75	0.00	0.02	0.34	4.88	2.75	36.25
	Residue	0.00	98750	8.00	93.50	1.05	0.00	0.00	2.00	165	42.50	10800	41600
	Total of all fractions	0.41	99746	8.30	101	1.12	141	0.00	3.78	171	1031	19225	42016
	Total	0.70	120000	<3	99	1.10	180	<1	9.00	150	712	26700	36300
	Recovery (%)	58.39	83.12		102	102	78.47		41.94	114	145	72.00	116
MM/OB29 weathered	Water Extractable	0.00	0.00	0.00	4.00	0.00	35.00	0.00	0.00	0.00	0.00	0.00	8.75
	Exchangeable	0.00	0.00	0.00	130	0.00	116	0.00	0.00	0.00	0.00	0.00	57.50
	Carbonate	0.03	191.25	0.00	43.75	0.03	15.00	0.00	1.29	0.10	0.08	166	6.25
	Amorphous Fe/Mn oxide	0.00	128.75	0.00	35.00	0.00	0.00	0.00	0.81	0.14	0.00	525	0.00
	Crystalline Fe/Mn oxide	0.00	1912.50	0.00	10.50	0.00	40.00	0.00	1.14	4.88	3.13	53750	30.00
	Easily oxidisable	0.00	30.00	0.00	1.59	0.00	0.00	0.00	0.00	0.35	0.00	275	93.75
	Recalcitrant Oxidisable	0.00	35.00	0.00	0.90	0.00	10.00	0.00	0.01	0.30	0.01	0.98	10.00
	Residue	0.00	18000	8.00	20.00	0.95	283	0.00	3.50	35.00	49	323500	190
	Total of all fractions	0.03	20298	8.00	246	0.98	499	0.00	6.75	40.76	52	378217	396
	Total	<0.5	23900	4.00	225	1.20	500	1.00	16.00	40.00	32	510000	320
	Recovery (%)		85	200.00	109	81.46	99.75	0.00	42.16	101.91	162	74.16	124
MM/OB29 Trans.	Water Extractable	0.00	0.00	0.00	0.49	0.00	32.50	0.00	0.00	0.00	0.00	0.00	10.00
	Exchangeable	0.00	0.00	0.00	4.88	0.00	40.00	0.00	0.00	0.00	0.00	0.00	10.00
	Carbonate	0.04	87.50	0.00	1.08	0.10	10.00	0.00	0.73	0.08	0.06	189	0.00
	Amorphous Fe/Mn oxide	0.00	106	0.00	0.68	0.00	0.00	0.00	0.70	0.21	0.00	950	0.00
	Crystalline Fe/Mn oxide	0.00	2088	0.00	0.73	0.00	0.00	0.00	2.33	2.39	2.41	91250	0.00

		Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Easily oxidisable	0.00	11.50	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	350	46.25
	Recalcitrant Oxidisable	0.00	14.63	0.00	0.50	0.00	6.25	0.00	0.02	0.26	0.01	0.94	8.75
	Residue	0.00	10350	0.00	0.00	0.90	50.00	0.00	14.00	10.00	41.50	366500	0.00
	Total of all fractions	0.04	12657	0.00	8.34	1.01	139	0.00	17.77	13.13	43.98	459240	75.00
	Total	<0.5	14200	<3	<5	1.10	155	2.00	27.00	10.00	18.00	623000	<100
	Recovery (%)		89			91.36	89.52	0.06	65.82	131.25	244.35	73.71	
W/OB25 trans.	Water Extractable	0.00	1.29	0.00	0.04	0.00	7.50	0.00	0.01	0.00	0.00	0.00	10.00
	Exchangeable	0.00	0.00	0.00	1.91	0.00	60.00	0.00	0.00	0.00	0.00	0.00	10.00
	Carbonate	0.00	141.25	0.05	1.39	0.07	12.50	0.00	0.85	0.20	0.88	40.00	0.00
	Amorphous Fe/Mn oxide	0.08	212.50	0.00	0.78	0.00	0.00	0.00	0.33	0.46	0.46	838	0.00
	Crystalline Fe/Mn oxide	0.00	2387.50	5.50	1.76	0.00	0.00	0.00	0.30	61.25	4.00	107500	0.00
	Easily oxidisable	0.00	62.50	0.00	0.00	0.00	0.00	0.00	0.00	1.39	1.19	1638	97.50
	Recalcitrant Oxidisable	0.00	35.00	0.01	0.46	0.00	2.50	0.00	0.01	1.74	0.02	1.14	7.50
	Residue	0.00	46450	15.00	29.00	1.05	0.00	0.00	0.00	30.00	16.00	86800	365
	Total of all fractions	0.08	49290	20.56	35.34	1.12	82.50	0.00	1.49	95.04	22.55	196816	490
	Total	<0.5	52500	17.00	30.00	1.20	145	<1	8.00	90.00	20.00	199000	340
	Recovery (%)		93.89	120.96	118	93.65	56.90		18.58	105.60	112.74	98.90	144
W/OB25 fresh	Water Extractable	0.00	0.00	0.00	0.02	0.00	2.50	0.00	0.00	0.00	0.00	0.19	82.50
	Exchangeable	0.00	0.00	0.00	3.00	0.00	87.50	0.00	0.30	0.00	0.00	0.00	155
	Carbonate	0.04	300	0.25	3.00	0.10	16.25	0.01	3.50	0.45	0.25	106	48.75
	Amorphous Fe/Mn oxide	0.34	325	0.00	87.50	0.00	0.00	0.09	5.13	0.40	2.03	488	131
	Crystalline Fe/Mn oxide	0.00	1538	93.75	3.63	0.14	30.00	0.00	0.91	23.00	11.75	62500	400
	Easily oxidisable	0.00	36	7.75	0.00	0.00	0.00	0.00	0.00	0.50	0.00	400	139
	Recalcitrant Oxidisable	0.01	18.63	3.75	0.40	0.00	5.00	0.00	0.01	0.50	0.01	0.85	25.00
	Residue	0.00	38167	218.00	68.00	1.20	55.00	0.00	2.00	33.33	42.33	71467	18533
	Total of all fractions	0.39	40384	323.50	166	1.44	196	0.10	11.85	58.18	56.37	134961	19515
	Total	0.60	44700	281.00	172	1.50	210	<1	19.00	55.00	51.00	136000	16300
	Recovery (%)	64.38	90.34	115.12	96.24	96.25	93.45		62.34	105.79	110.53	99.24	120
D1/Whaleback	Water Extractable	0.00	0.00	0.00	0.05	0.00	7.50	0.00	0.25	0.00	0.00	0.00	7.50

		Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
		mg/kg	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
	Exchangeable	0.00	0.00	0.00	2.29	0.00	60.00	0.00	3.50	0.00	0.61	0.00	7.50
	Carbonate	0.01	200	0.08	0.73	0.09	12.50	0.00	6.75	1.03	2.26	300	0.00
	Amorphous Fe/Mn oxide	0.17	140	0.00	0.64	0.00	0.00	0.00	2.03	0.41	1.40	613	0.00
	Crystalline Fe/Mn oxide	0.00	988	6.50	1.93	0.16	0.00	0.00	1.89	16.38	11.75	71250	0.00
	Easily oxidisable	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.15
	Recalcitrant Oxidisable	0.00	23.50	0.21	0.39	0.00	2.50	0.00	0.01	0.19	0.04	0.53	7.50
	Residue	0.00	11850	15.00	8.00	0.70	55.00	0.00	0.00	0.00	14.50	163000	115
	Total of all fractions	0.18	13201	21.79	14.02	0.96	138	0.00	14.42	18.00	30.56	235164	138
	Total	<0.5	11000	21.00	9.00	1.00	135	<1	20.00	20.00	21.00	268000	110
	Recovery (%)		120	103.75	156	95.50	102		72.11	90.00	145.54	87.75	125
MM/OB32 Trans /BWT	Water Extractable	0.00	0.00	0.00	0.10	0.00	17.50	0.00	0.01	0.00	0.00	0.00	2.50
	Exchangeable	0.00	0.00	0.00	5.00	0.00	45.00	0.00	0.10	0.00	0.00	0.00	2.50
	Carbonate	0.03	65.00	0.03	15.13	0.04	12.50	0.00	5.00	0.58	0.31	275	0.00
	Amorphous Fe/Mn oxide	0.06	75.00	0.00	154	0.00	0.00	0.00	2.04	2.49	0.38	1138	20.00
	Crystalline Fe/Mn oxide	0.00	700	0.00	0.84	0.00	0.00	0.00	1.03	1.93	2.01	71250	0.00
	Easily oxidisable	0.00	5.75	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	525	93.75
	Recalcitrant Oxidisable	0.00	6.13	0.00	0.43	0.00	5.00	0.00	0.01	0.18	0.01	0.56	7.50
	Residue	0.00	1310	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.50	227500	0.00
	Total of all fractions	0.09	2162	0.03	175	0.05	80.00	0.00	8.18	5.56	21.21	300688	126
	Total	<0.5	1930	4.00	160	<0.5	135.00	<1	<1	<10	6.00	327000	<100
	Recovery (%)		112	0.63	110		59.26				353.42	91.95	

		Li	Mg	Mn	Mo	Nb	Ni	P	Pb	S	Se	V	Zn	Na
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
JN/OB25 Fresh	Water Extractable	0.00	7.50	0.01	0.00	0.00	0.00	0.00	0.00	12.50	0.05	0.01	0.48	25.00
	Exchangeable	0.00	67.50	0.43	0.00	0.00	0.00	0.00	0.00	16.25	0.00	0.00	1.00	7.50
	Carbonate	0.02	6.25	0.54	0.00	0.00	0.18	2.50	0.38	10.00	0.08	0.75	1.99	7.50
	Amorphous Fe/Mn oxide	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.81	0.00	0.00	0.70	0.91	0.00
	Crystalline Fe/Mn oxide	0.00	16.25	0.58	0.00	0.00	0.00	0.00	1.75	18.75	0.00	4.63	4.13	0.00
	Easily oxidisable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	243	4.13	0.00	10.25	423750
	Recalcitrant Oxidisable	0.07	12.50	0.28	0.59	0.08	0.18	183	0.01	24	1.75	0.25	0.18	2448
	Residue	32.00	8135	36.00	0.00	15.00	12.50	213	84.00	2890	0.00	181.00	13.00	408
	Total of all fractions	32.09	8245	38.04	0.59	15.08	12.85	398	86.95	3214	6.00	187.33	31.93	426645
	Total	30.00	8000	54.00	<5	15.00	15.00	145	83.00	3250	<10	195.00	24.00	400
	Recovery (%)	107	103	70.45		101	85.67	274	105	98.88		96.07	133	106661
MM/OB29 weathered	Water Extractable	0.00	7.50	0.00	0.00	0.00	0.00	0.00	0.00	62.50	0.00	0.00	0.26	100
	Exchangeable	0.00	25.00	0.00	0.00	0.00	0.00	0.00	0.00	32.50	0.00	0.00	0.89	150
	Carbonate	0.01	11.25	2.75	0.00	0.00	0.08	0.00	0.10	10.00	0.00	0.01	1.28	30.00
	Amorphous Fe/Mn oxide	0.00	0.00	2.96	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.27	0.00	27.50
	Crystalline Fe/Mn oxide	0.00	43.75	18.13	0.00	0.00	0.00	48.75	2.26	102.50	0.00	4.63	10.63	63.75
	Easily oxidisable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.28	422500
	Recalcitrant Oxidisable	0.01	0.00	0.10	0.08	0.01	0.11	126	0.00	5.00	0.10	0.06	0.11	1113
	Residue	1.50	143	147	0.00	0.00	16.00	615	13.50	860	0.00	30.00	57.50	215
	Total of all fractions	1.52	230	170	0.08	0.01	16.19	790	16.20	1073	0.10	34.97	72.94	424199
	Total	<1	195	181	<5	<10	14.00	580	14.00	1110	<10	42.00	58.00	620
	Recovery (%)		118	94.16			116	136	115.69	96.62		83.26	126	68419
MM/OB29 Trans.	Water Extractable	0.01	25.00	0.01	0.00	0.00	0.08	0.00	0.00	58.75	0.00	0.00	0.28	92.50
	Exchangeable	0.00	22.50	0.00	0.00	0.00	0.00	0.00	0.00	33.75	0.00	0.00	1.18	26.25
	Carbonate	0.02	15.00	1.78	0.00	0.00	0.14	0.00	0.23	8.75	0.00	0.00	1.28	11.25
	Amorphous Fe/Mn oxide	0.00	17.50	1.29	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.04	0.85	0.00
	Crystalline Fe/Mn oxide	0.00	80.00	32.50	0.00	0.00	2.88	81.25	2.03	38.75	0.00	0.99	21.88	0.00
	Easily oxidisable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.38	213750
	Recalcitrant Oxidisable	0.01	2.50	0.28	0.46	0.01	0.13	18.75	0.02	2.50	0.00	0.00	0.16	705.00

		Li	Mg	Mn	Mo	Nb	Ni	P	Pb	S	Se	V	Zn	Na
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Residue	1.50	240	138.50	6.50	0.00	13.50	895.00	8.50	270.00	0.00	3.50	69.00	55.00
	Total of all fractions	1.54	403	174.35	6.96	0.01	16.71	995.00	11.14	412.50	0.00	4.53	95.99	214640
	Total	1.00	315	168.00	6.00	<10	10.00	795.00	11.00	470.00	<10	9.00	78.00	180
	Recovery (%)	153.63	128	103.78	116		167.13	125.16	101.27	87.77		50.35	123.06	119244
W/OB25 trans.	Water Extractable	0.00	15.00	0.02	0.00	0.00	0.00	0.00	0.00	42.50	0.00	0.00	0.21	105
	Exchangeable	0.00	103	0.20	0.00	0.00	0.00	0.00	0.00	42.50	0.00	0.00	0.28	15.00
	Carbonate	0.01	7.50	1.81	0.00	0.00	0.24	2.50	0.13	7.50	0.00	0.07	2.59	7.50
	Amorphous Fe/Mn oxide	0.00	0.00	1.30	0.00	0.00	0.00	13.75	1.35	0.00	0.00	2.75	1.65	0.00
	Crystalline Fe/Mn oxide	0.00	0.00	31.25	0.00	0.00	0.00	625.00	4.00	0.00	0.00	32.50	14.63	0.00
	Easily oxidisable	0.00	0.00	0.38	0.00	0.00	0.00	47.50	0.00	28.75	0.00	0.33	3.88	428750.00
	Recalcitrant Oxidisable	0.02	0.00	0.38	0.48	0.02	0.06	60.00	0.00	0.00	0.00	1.23	0.00	1913.75
	Residue	2.50	120	39.50	0.00	0.00	15.50	873	16.00	40.00	0.00	16.00	13.00	55.00
	Total of all fractions	2.53	245	74.83	0.48	0.02	15.80	1621	21.49	161	0.00	52.87	36.23	430846.25
	Total	2.00	250	80.00	<5	<10	14.00	1360	20.00	225	<10	61.00	24.00	165.00
	Recovery (%)	126.63	98.00	93.54			112.86	119.21	107.43	71.67		86.67	150.94	261118.94
W/OB25 fresh	Water Extractable	0.03	2.50	0.03	0.01	0.00	0.03	0.00	0.00	22.50	0.00	0.00	0.30	68.75
	Exchangeable	0.00	58.75	0.84	0.00	0.00	0.00	0.00	0.00	7.50	0.00	0.00	2.36	22.50
	Carbonate	0.11	20.00	40.00	0.00	0.00	0.28	0.00	4.25	7.50	0.00	0.00	9.50	11.25
	Amorphous Fe/Mn oxide	0.07	0.00	2375.00	0.00	0.00	0.56	0.00	437.50	0.00	0.00	1.16	3.75	17.50
	Crystalline Fe/Mn oxide	0.40	67.50	101.25	4.75	0.00	3.38	65.00	51.25	0.00	0.00	9.63	20.63	0.00
	Easily oxidisable	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	4.00	416250.00
	Recalcitrant Oxidisable	0.10	7.50	0.55	0.78	0.05	0.13	176.25	0.02	0.00	0.58	0.24	0.00	1508.75
	Residue	21.67	3453	49	7.00	0.00	22.33	376.67	140.33	76.67	0.00	38.00	117	185.00
	Total of all fractions	22.38	3610	2567	12.54	0.05	26.70	618	633.79	114.17	0.58	49.03	158	418063.75
	Total	20.00	3200	3260	8.00	<10	23.00	350	723.00	145.00	<10	52.00	147	275.00
	Recovery (%)	111.89	113	78.74	156.72		116.07	177	87.66	78.74		94.29	107	152023.18
D1/Whaleback	Water Extractable	0.00	5.00	0.18	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.31	20.00
	Exchangeable	0.00	36.25	10.13	0.00	0.00	0.00	0.00	0.00	17.50	0.00	0.00	0.23	7.50
	Carbonate	0.02	5.00	18.00	0.00	0.00	0.26	0.00	0.15	8.75	0.00	0.40	1.79	7.50

		Li	Mg	Mn	Mo	Nb	Ni	P	Pb	S	Se	V	Zn	Na
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Amorphous Fe/Mn oxide	0.00	0.00	5.50	0.00	0.00	0.00	0.00	0.60	0.00	0.00	1.73	0.89	0.00
	Crystalline Fe/Mn oxide	0.00	0.00	10.00	0.00	0.00	0.00	123	1.03	42.50	0.00	16.75	9.50	0.00
	Easily oxidisable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.02	686
	Recalcitrant Oxidisable	0.01	0.00	0.09	0.23	0.02	0.10	164	0.00	0.00	0.05	0.09	0.00	1050
	Residue	1.00	60.00	14.00	0.00	0.00	0.00	330	0.00	142.50	0.00	2.50	6.50	80.00
	Total of all fractions	1.03	106	57.89	0.23	0.02	0.36	616	1.78	221.30	0.05	21.46	19.23	1851.00
	Total	1.00	95.00	56.00	<5	<10	5.00	395	6.00	220.00	<10	22.00	15.00	<50
	Recovery (%)	103.00	112	103.38			7.25	156	29.65	100.59	!	97.55	128.19	
MM/OB32 Trans /BWT	Water Extractable	0.01	10.00	0.04	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	0.14	15.00
	Exchangeable	0.00	18.75	0.83	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.00	1.05	7.50
	Carbonate	0.02	15.00	87.50	0.00	0.00	0.30	0.00	0.01	10.00	0.00	0.00	2.05	7.50
	Amorphous Fe/Mn oxide	0.00	20.00	900.00	0.00	0.00	0.65	0.00	0.58	0.00	0.00	2.48	0.80	0.00
	Crystalline Fe/Mn oxide	0.00	78.75	70.00	0.00	0.00	0.00	114	0.25	0.00	0.00	2.88	9.13	0.00
	Easily oxidisable	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.71	427500
	Recalcitrant Oxidisable	0.01	2.50	1.04	0.39	0.00	0.11	106	0.00	0.00	0.00	0.06	0.00	703
	Residue	4.00	158	76.50	0.00	0.00	0.00	420	0.00	0.00	0.00	0.00	6.00	0
	Total of all fractions	4.04	303	1136	0.39	0.00	1.06	640	0.83	20.00	0.00	5.41	21.88	428233
	Total	4.00	270	1180	7.00	<10	<5	385	<5	<20	<10	<1	8.00	<50
	Recovery (%)	100.91	112	96	5.54			166					273.44	

Figure A4-1. Distribution of metals in the several phases of the seven rock samples according to the Optimised Method

APPENDIX 5: COMPARISON OF OPTIMISED SLP AND KINETIC TESTS

Table A5-1. Percent of elements in different phases of the optimised sequential leaching procedure and kinetic leach over 24 months.

	Phase	Al	As	Ba	Be	Ca	Co	Cr	Cu	Fe	K	Li	Mg	Mn	Mo	Ni	P	Pb	S	V	Zn	Cd	Se
JN/OB25 Fresh	Labile	0.06	0.60	1.63	5.79	93.8	28.3	0.05	39.2	0.13	0.15	0.05	0.99	2.54	0.00	1.36	0.63	0.43	1.21	0.40	10.8	0.00	2.08
	KLP	0.00	0.00	0.02	0.00	44.8	4.45	0.00	0.45	0.00	0.08	0.11	0.62	0.50	0.38	0.25	0.00	0.00	4.21	0.00	0.69	23.95	5.23
	Reducing	0.86	0.00	5.06	0.00	0.00	18.2	3.07	54.7	42.9	0.42	0.00	0.20	2.10	0.00	0.00	0.00	2.95	0.58	2.84	15.8	0.00	0.00
	Oxidised	0.08	3.01	0.80	0.67	6.19	0.50	0.39	2.05	0.76	0.42	0.23	0.15	0.72	100.0	1.36	45.9	0.01	8.28	0.13	32.7	100	97.9
	Residue	99.0	96.4	92.5	93.5	0.0	53.0	96.5	4.1	56.2	99.0	99.7	98.7	94.6	0.0	97.3	53.5	96.6	89.9	96.6	40.7	0.0	0.0
MM/OB29 Weathered	Labile	0.94	0.00	72.3	2.81	33.3	19.1	0.25	0.16	0.04	18.3	0.74	19.0	1.61	0.00	0.46	0.00	0.59	9.79	0.03	3.32	ND	0.00
	KLP	0.00	0.01	0.07	0.00	4.29	0.03	0.00	0.04	0.00	2.26	1.25	2.32	0.00	20.6	0.00	0.00	0.00	6.73	0.00	0.02	ND	13.5
	Reducing	10.1	0.00	18.5	0.00	8.02	28.9	12.30	6.04	14.4	7.57	0.00	19.02	12.4	0.00	0.00	6.17	16.1	9.56	14.0	14.6	ND	0.00
	Oxidised	0.32	0.00	1.01	0.00	2.01	0.11	1.59	0.02	0.07	26.2	0.49	0.00	0.06	100	0.69	16.0	0.01	0.47	0.18	3.27	ND	308
	Residue	88.7	100	8.1	97.2	56.6	51.9	85.9	93.8	85.5	47.9	98.8	62.0	86.0	0.0	98.8	77.8	83.4	80.2	85.8	78.8	ND	0.0
MM/OB29 Trans	Labile	0.69	ND	77.2	10.3	59.5	4.08	0.57	0.14	0.04	26.7	1.63	15.5	1.02	0.00	1.27	0.00	2.09	24.5	0.00	2.84	0.00	ND
	KLP	0.00	ND	1.41	0.00	25.1	0.01	0.00	0.02	0.00	20.16	1.91	7.10	0.00	0.00	0.00	0.00	0.00	19.1	0.00	0.02	7.23	ND
	Reducing	17.3	ND	16.8	0.00	0.00	17.0	19.8	5.5	20.1	0.00	0.00	24.2	19.4	0.00	17.20	8.17	21.4	9.39	22.7	23.7	0.00	ND
	Oxidised	0.21	ND	6.00	0.12	4.50	0.13	3.43	0.02	0.08	73.3	0.73	0.62	0.16	6.64	0.75	1.88	0.18	0.61	0.06	1.60	100	ND
	Residue	81.8	ND	0.0	89.6	36.0	78.8	76.2	94.4	79.8	0.0	97.6	59.6	79.4	93.4	80.8	89.9	76.3	65.5	77.2	71.9	0.00	ND
W/OB25 trans.	Labile	0.29	0.24	9.46	6.34	97.0	57.5	0.21	3.88	0.02	4.08	0.54	51.0	2.71	0.00	1.50	0.15	0.62	57.4	0.13	8.49	ND	
	KLP	0.00	0.00	0.14	0.00	9.46	0.37	0.00	0.06	0.00	1.86	0.27	7.15	0.06	0.00	0.05	0.00	0.00	33.9	0.00	0.04	ND	ND
	Reducing	5.27	26.7	7.18	0.00	0.00	42.1	64.9	19.8	55.0	0.00	0.00	0.00	43.5	0.00	0.00	39.4	24.9	0.00	66.7	44.9	ND	ND
	Oxidised	0.20	0.06	1.31	0.22	3.03	0.42	3.29	5.37	0.83	21.4	0.74	0.00	1.00	100.0	0.40	6.63	0.02	17.8	2.93	10.7	ND	ND
	Residue	94.2	72.9	82.1	93.4	0.0	0.0	31.6	71.0	44.1	74.5	98.7	49.0	52.8	0.0	98.1	53.8	74.5	24.8	30.3	35.9	ND	ND
W/OB25 Fresh	Labile	0.74	0.08	3.63	7.19	54.1	32.1	0.77	0.44	0.08	1.47	0.61	2.25	1.59	0.10	1.12	0.00	0.67	32.8	0.00	7.70	5.06	0.00
	KLP	0.00	0.00	0.01	0.00	3.85	0.42	0.00	0.01	0.00	0.04	0.12	0.18	0.02	0.01	0.00	0.00	0.00	17.81	0.00	0.01	0.05	0.33
	Reducing	4.61	29.0	55.0	9.52	15.3	51.0	40.2	24.4	46.7	2.72	2.10	1.87	96.5	37.9	14.7	10.5	77.1	0.00	22.0	15.4	92.4	0.00
	Oxidised	0.14	3.55	0.24	0.17	2.55	0.04	1.72	0.02	0.30	0.84	0.46	0.21	0.03	6.18	0.47	28.52	0.07	0.00	0.49	2.53	2.53	100
	Residue	94.5	67.4	41.1	83.1	28.0	16.9	57.3	75.1	53.0	95.0	96.8	95.7	1.9	55.8	83.7	61.0	22.1	67.2	77.5	74.3	0.00	0.00
D1/Whaleback	Labile	1.52	0.34	21.87	9.69	58.2	72.8	5.69	9.41	0.13	10.9	1.94	43.5	48.9	0.00	72.4	0.00	8.64	16.4	1.86	12.1	ND	0.00
	KLP	0.00	0.17	0.05	0.00	7.17	0.02	0.26	0.02	0.00	58.2	3.73	10.1	0.03	52.0	0.02	0.00	0.11	12.76	0.00	0.08	ND	7.33
	Reducing	8.54	29.8	18.3	17.0	0.00	27.1	93.3	43.0	30.6	0.00	0.00	0.00	26.8	0.00	0.00	19.9	91.4	19.2	86.1	54.0	ND	0.00
	Oxidised	0.18	0.98	2.76	0.00	1.82	0.07	1.05	0.13	0.00	5.56	0.97	0.00	0.16	100.0	27.6	26.6	0.00	0.02	0.40	0.08	ND	100
	Residue	89.8	68.8	57.1	73.3	40.0	0.0	0.0	47.4	69.3	83.5	97.1	56.5	24.2	0.0	0.0	53.5	0.0	64.4	11.6	33.8	ND	0.00
MM/OB32 Trans BWT	Labile	3.01	100	11.5	97.2	93.8	62.5	10.3	1.47	0.09	3.96	0.65	14.5	7.78	0.00	28.2	0.00	0.60	100.0	0.00	14.8	ND	ND
	KLP	0.00	1.34	0.03	0.00	15.9	0.07	0.19	0.01	0.00	4.40	1.50	2.36	0.00	4.81	0.02	0.00	0.05	32.14	0.00	0.12	ND	ND
	Reducing	35.8	0.00	88.2	0.00	0.00	37.5	79.3	11.3	24.1	15.8	0.00	32.6	85.4	0.00	61.2	17.8	99.1	0.00	98.8	45.4	ND	ND
	Oxidised	0.55	0.00	0.24	2.78	6.25	0.06	10.3	0.02	0.17	80.2	0.25	0.83	0.09	100.0	10.6	16.6	0.30	0.00	1.18	12.4	ND	ND
	Residue	60.6	0.00	0.00	0.00	0.00	0.00	0.00	87.2	75.7	0.00	99.1	52.1	6.73	0.00	0.00	65.6	0.00	0.00	0.00	27.4	ND	ND

Note: ND- not detected; Labile: Water soluble+ exchangeable + carbonate; Reducing: amorphous Fe/Mn oxide + crystalline Fe/Mn oxide; Oxidising: Easily oxidisable + Recalcitrant oxidisable: KLP – kinetic leach procedure over 24 months

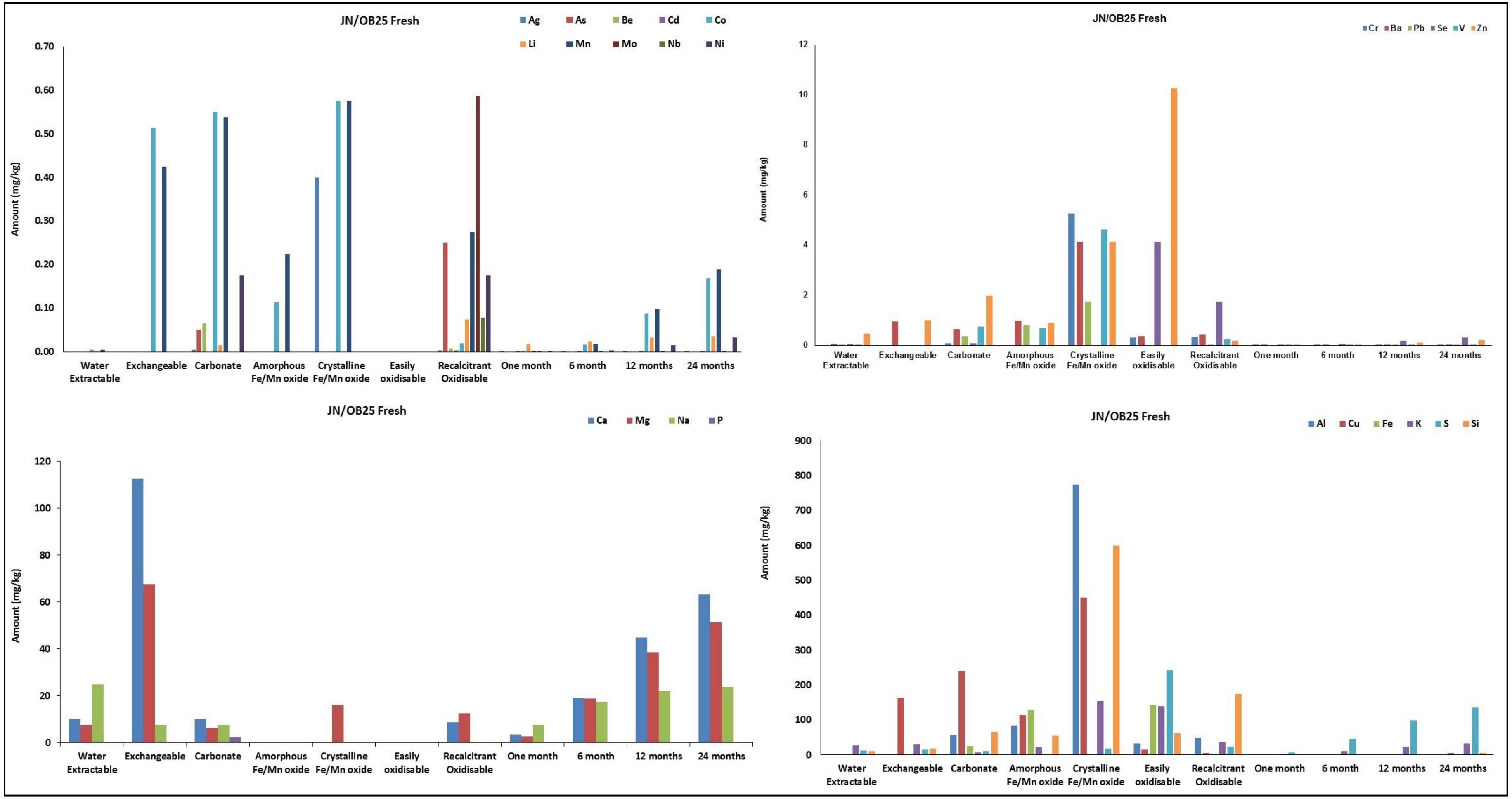


Figure A5-1 Comparison of Sequential leaching procedure and kinetic leaching test for JN/OB25 Fresh.

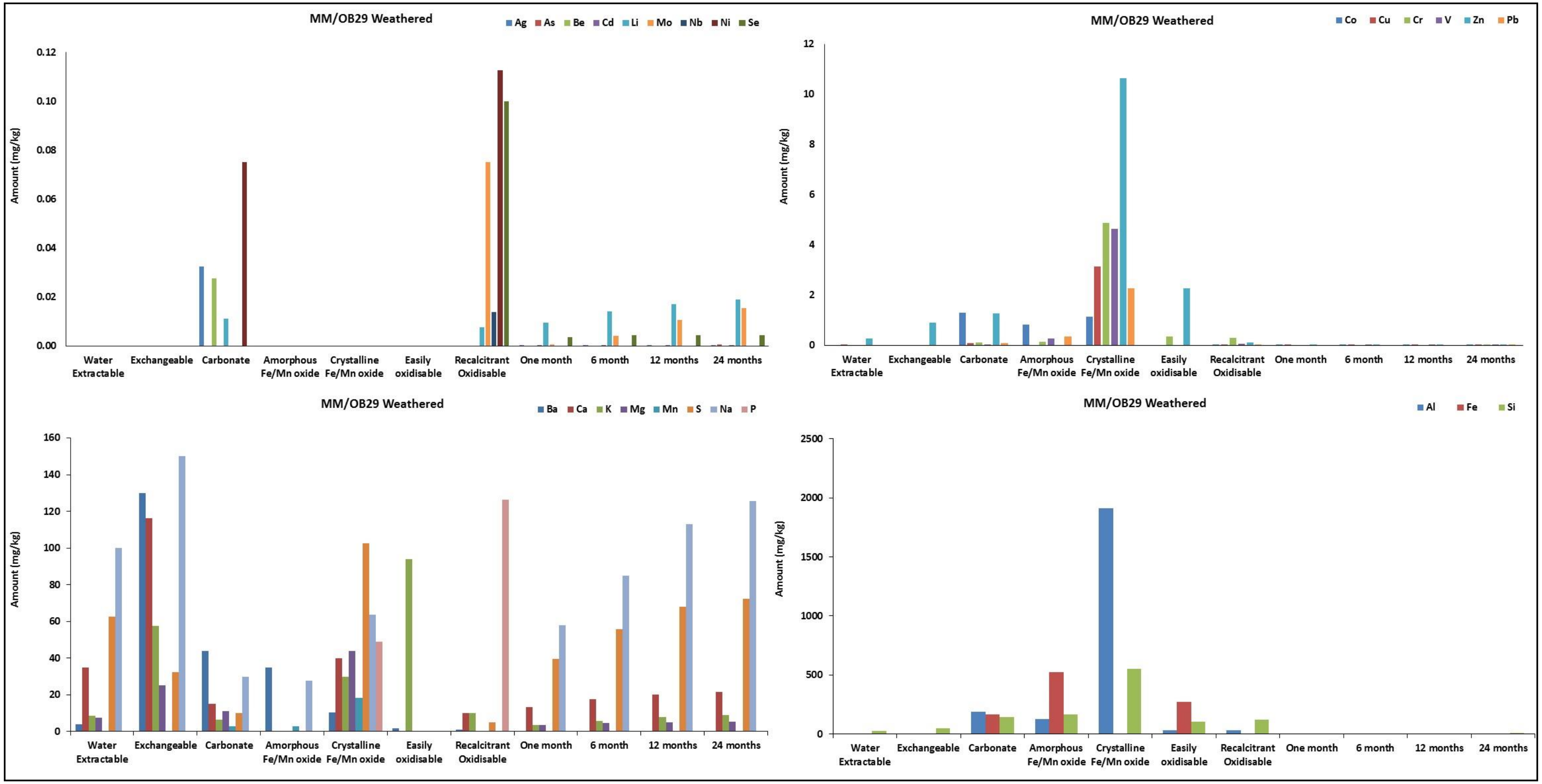


Figure A5-2 **Comparison of Sequential leaching procedure and kinetic leaching test for MM/OB29 Weathered.**

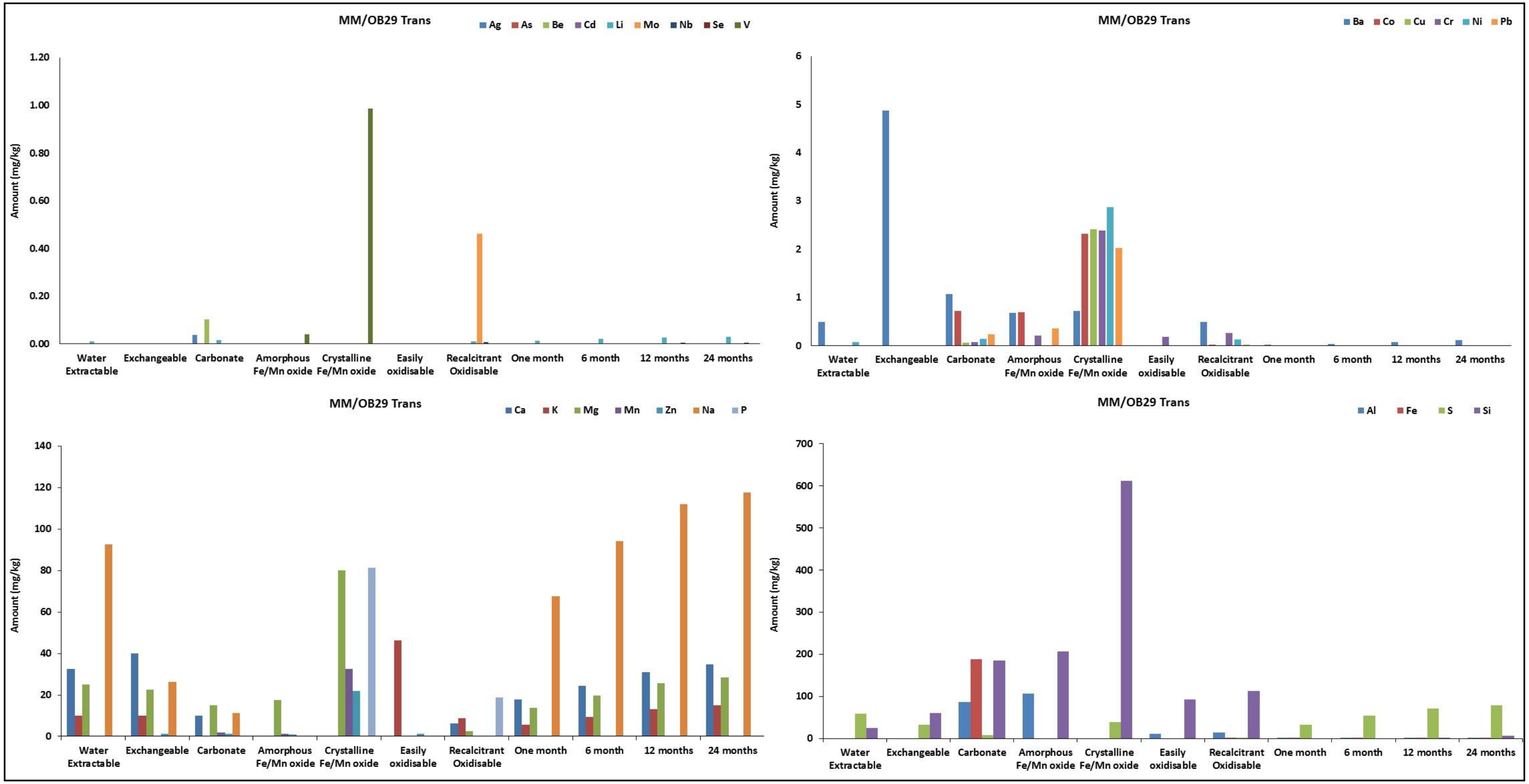


Figure A5-3 Comparison of Sequential leaching procedure and kinetic leaching test for MM/OB29 Trans.

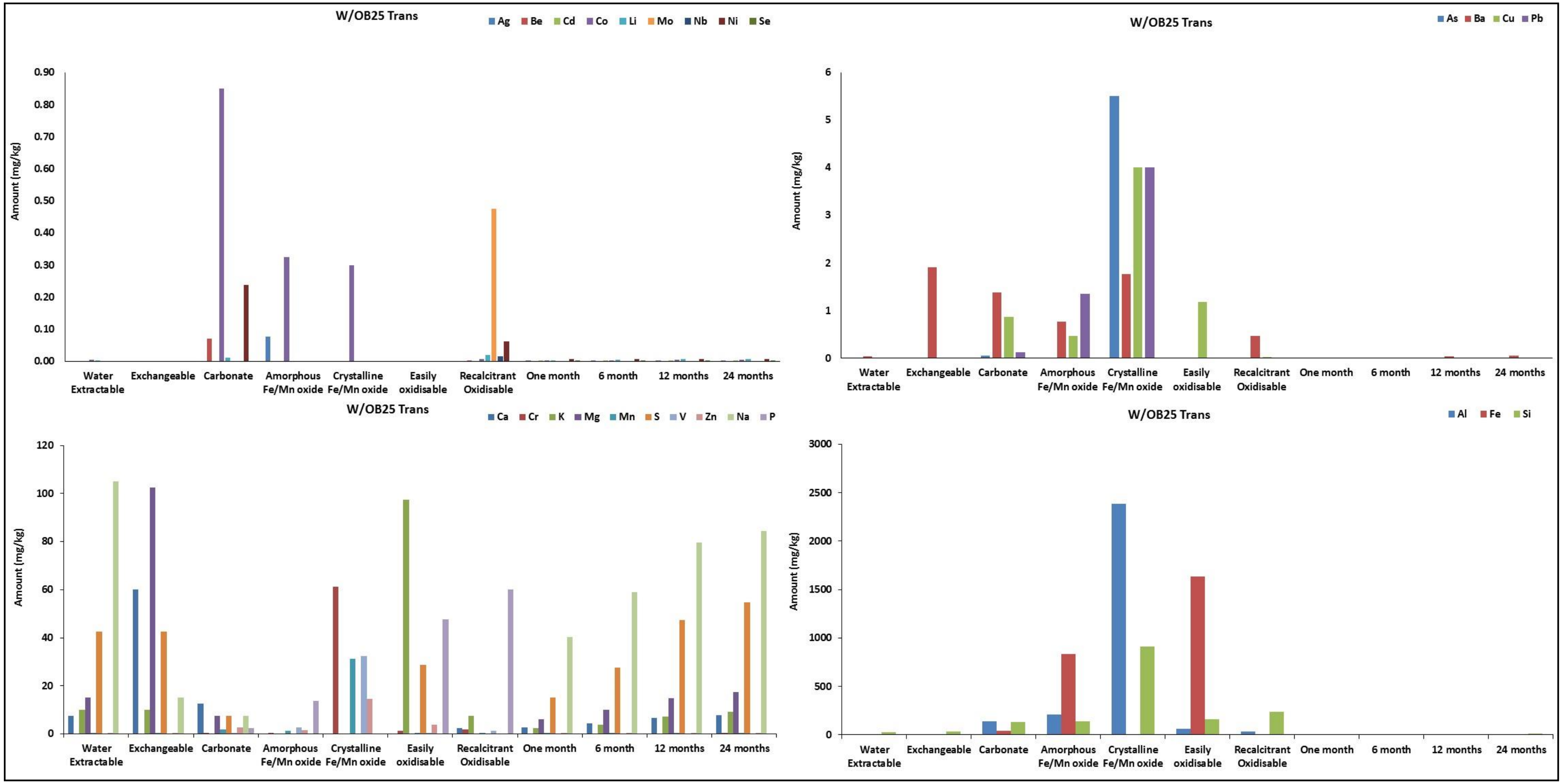


Figure A5-4 **Comparison of Sequential leaching procedure and kinetic leaching test W/OB25 Trans.**

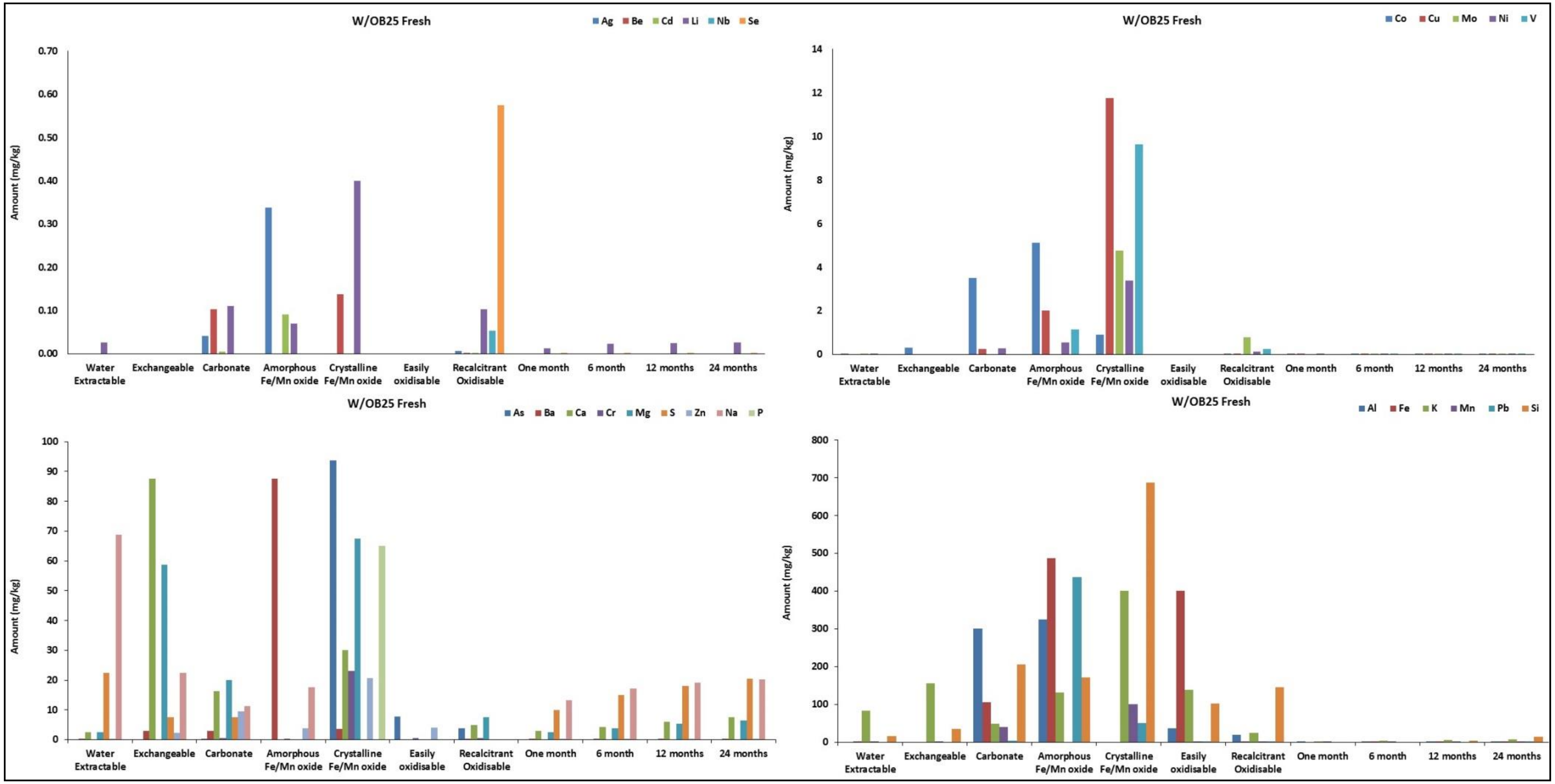


Figure A5-5 **Comparison of Sequential leaching procedure and kinetic leaching test W/OB25 Fresh.**

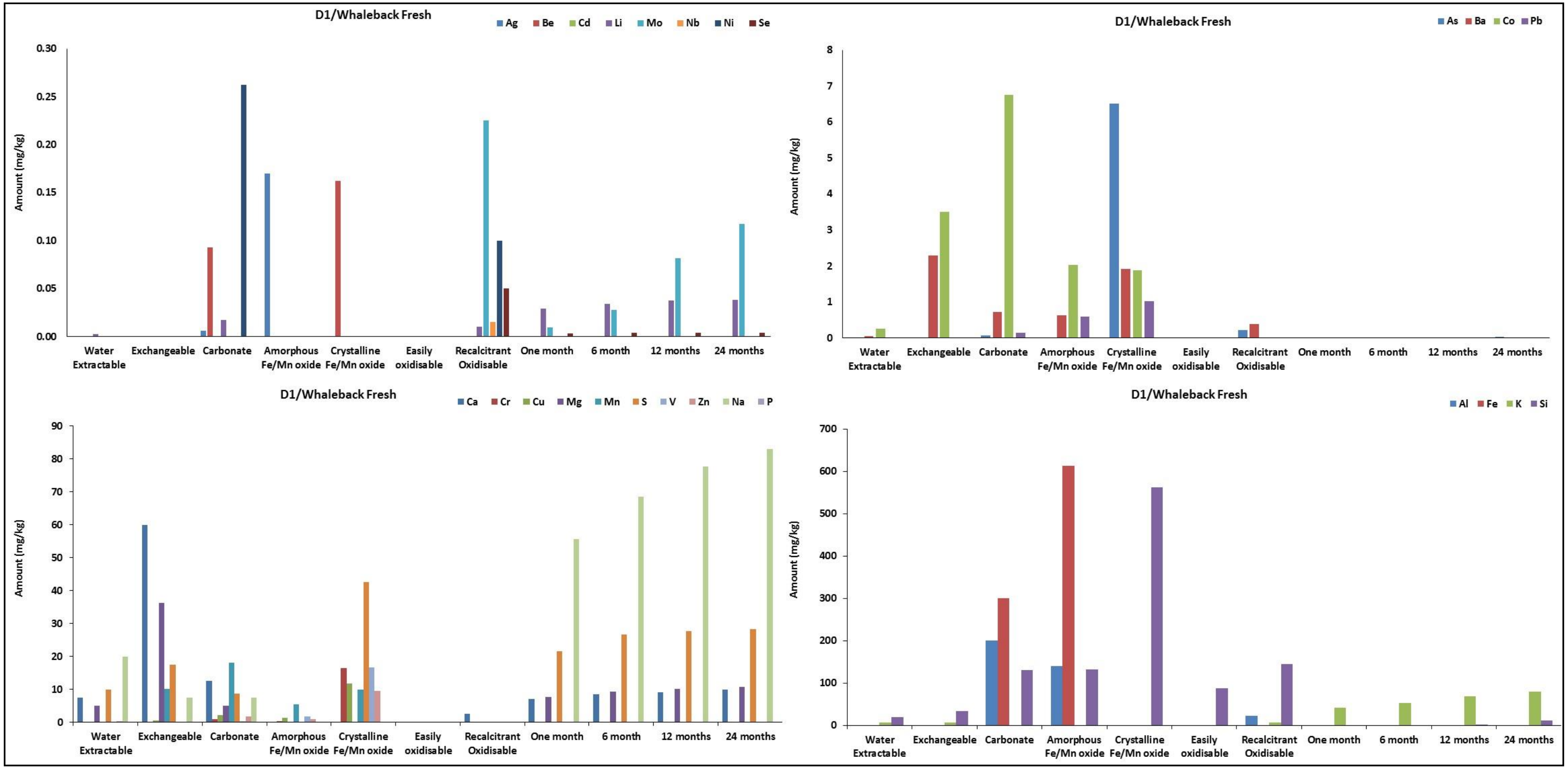


Figure A5-6 **Comparison of Sequential leaching procedure and kinetic leaching test D1/Whaleback Fresh.**

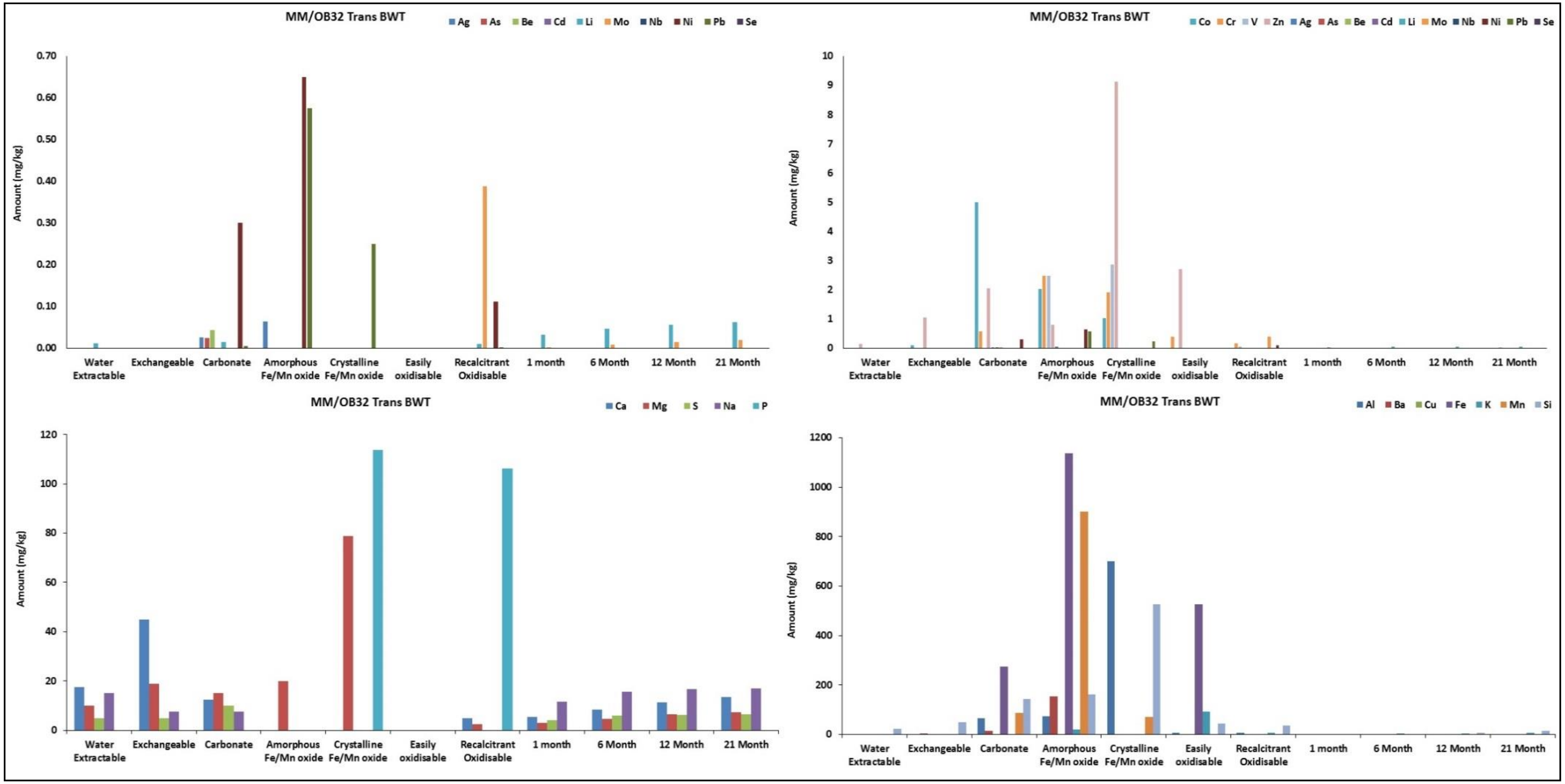


Figure A5-7 **Comparison of Sequential leaching procedure and kinetic leaching test MMOB32 Trans/BWT.**

APPENDIX 6: LEAF METHOD 1313 RESULTS

Table A6-1 Results for Analysis of Samples Using LEAF Method 1313

		Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
JN/OB25 Fresh	pH 13.1	<0.01	140	<0.10	0.03	<0.010	<1	<0.010	<0.010	<0.050	3.2	0.4	43200
	pH 12.0	0.02	76	0.03	0.036	<0.001	<1	<0.001	<0.001	0.011	0.083	0.27	4630
	pH 10.7	<0.001	17	0.02	<0.001	<0.001	<1	<0.001	<0.001	0.006	0.017	0.07	641
	pH 8.7	<0.001	20	0.02	0.008	<0.001	4	0.002	0.003	0.006	0.1	0.41	451
	pH 7.2	0.002	0.18	<0.01	0.046	<0.001	5	<0.001	0.002	<0.005	0.019	0.05	52
	pH 6.9	0.002	0.11	<0.01	0.031	<0.001	37	0.042	0.11	<0.005	0.23	<0.05	39
	pH 5.2	<0.001	2.2	<0.01	0.13	0.003	83	0.004	0.43	<0.005	42	<0.05	50
	pH 3.6	<0.001	37	<0.01	0.7	0.023	117	0.003	0.91	0.022	210	4.3	371
	pH 2.3	<0.001	79	<0.01	0.99	0.033	118	0.007	0.67	0.055	270	25	65
MM/OB29 Weathered	pH 13.0	<0.01	440	0.18	0.11	<0.010	<1	<0.010	<0.010	<0.050	0.013	0.51	40800
	pH 12.0	<0.001	140	0.09	0.1	<0.001	3	0.005	0.002	0.006	0.007	0.3	4180
	pH 10.4	<0.001	21	0.03	1	<0.001	1	<0.001	0.009	0.009	0.008	86	563
	pH 9.0	0.003	3.3	0.02	0.24	<0.001	5	0.008	0.001	<0.005	0.009	0.33	276
	pH 8.4	<0.001	5.5	0.02	0.35	<0.001	2	<0.001	0.004	<0.005	0.003	25	282
	pH 7.4	<0.001	0.06	<0.01	1.4	<0.001	55	<0.001	<0.001	<0.005	<0.001	0.06	9
	pH 5.0	<0.001	1.4	<0.01	10	0.002	134	0.002	1.2	<0.005	<0.001	0.91	25
	pH 4.1	<0.001	0.24	<0.01	2.7	<0.001	100	<0.001	0.073	<0.005	0.002	0.15	25
	pH 2.3	<0.001	240	<0.01	150	0.016	159	0.011	2.6	0.074	0.11	250	46
MM/OB29 Transition	pH 13.1	<0.010	170	0.24	0.022	<0.010	<1	<0.010	<0.010	<0.050	0.015	2.1	42400
	pH 12.0	0.003	87	0.13	0.15	0.003	2	0.001	0.064	0.036	0.05	1400	5070
	pH 9.8	<0.001	36	0.02	0.12	0.002	2	<0.001	0.059	0.037	0.036	1300	673
	pH 9.5	0.004	12	0.02	0.055	<0.001	2	<0.001	0.02	0.01	0.011	380	528
	pH 8.4	<0.001	0.32	<0.01	1.6	<0.001	51	0.003	0.009	<0.005	0.002	0.67	87
	pH 7.1	<0.001	<0.05	<0.01	0.55	<0.001	31	0.006	<0.001	<0.005	<0.001	0.1	33
	pH 6.3	<0.001	<0.05	<0.01	1.8	<0.001	56	<0.001	0.017	<0.005	<0.001	<0.05	12
	pH 4.8	<0.001	0.34	<0.01	3.6	0.002	68	<0.001	0.34	<0.005	0.007	1.8	22
	pH 4.3	<0.001	5.2	<0.01	4.5	0.015	71	0.001	0.85	<0.005	0.003	12	16
	pH 2.0	0.005	150	0.01	5.5	0.051	75	0.01	1.3	0.065	0.19	360	45

		Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
W/OB25 Transition	pH 12.8	<0.005	380	0.85	<0.005	<0.005	<1	<0.005	<0.005	0.12	0.008	1.8	26200
	pH 11.9	<0.001	220	0.66	0.1	0.006	3	0.006	0.047	4.8	0.049	4900	3950
	pH 9.5	<0.001	170	0.46	0.22	0.01	5	0.002	0.061	7.7	0.065	9800	862
	pH 8.8	<0.001	79	0.31	0.094	0.006	3	0.004	0.037	4.3	0.039	4300	474
	pH 7.1	<0.001	16	0.06	0.021	0.002	2	<0.001	0.009	0.67	0.061	980	206
	pH 6.9	<0.001	5.7	0.02	0.008	<0.001	<1	<0.001	0.003	0.22	0.002	320	165
	pH 5.0	<0.001	1.2	<0.01	0.78	0.001	34	0.001	0.35	<0.005	0.009	0.11	15
	pH 4.0	<0.001	22	<0.01	2.1	0.009	62	<0.001	0.84	<0.005	0.06	4.1	18
	pH 2.2	<0.001	200	<0.01	3.3	0.034	71	0.007	1.3	0.13	0.74	42	21
W/OB25 Fresh	pH 13.0	<0.010	260	7.6	<0.010	<0.010	<1	<0.010	<0.010	0.14	<0.010	0.3	37500
	pH 12.1	<0.001	140	4.3	<0.001	<0.001	<1	<0.001	0.001	0.081	0.005	0.52	6300
	pH 10.4	<0.001	15	1.7	0.004	<0.001	<1	<0.001	0.001	0.03	<0.001	1.5	888
	pH 8.6	<0.001	13	1.2	0.011	<0.001	<1	0.004	0.002	0.024	0.003	1.1	342
	pH 7.1	<0.001	0.28	0.03	0.001	<0.001	6	<0.001	0.002	0.017	<0.001	<0.05	129
	pH 6.9	<0.001	0.17	<0.01	0.073	<0.001	11	<0.001	0.004	0.013	<0.001	0.35	110
	pH 5.2	<0.001	2.8	<0.01	0.61	0.004	83	0.008	2.3	<0.005	0.006	<0.05	211
	pH 4.2	<0.001	39	<0.01	2.1	0.018	97	0.005	3.3	0.005	0.023	<0.05	229
	pH 2.4	0.004	340	0.03	7.2	0.051	98	0.013	3.8	0.27	0.26	29	284
D1/Whaleback	pH 13.0	<0.005	440	1.3	<0.005	<0.005	<1	<0.005	<0.005	0.085	<0.005	0.28	36100
	pH 11.9	<0.001	190	0.5	0.027	<0.001	<1	<0.001	<0.001	0.03	0.002	0.1	4720
	pH 10.4	<0.001	29	0.21	0.004	<0.001	<1	<0.001	0.012	0.028	0.005	32	543
	pH 9.7	0.008	25	0.29	0.015	<0.001	<1	<0.001	0.007	0.014	0.002	12	431
	pH 7.1	<0.001	0.06	<0.01	0.02	<0.001	3	<0.001	0.041	<0.005	<0.001	0.17	40
	pH 7.1	<0.001	0.08	<0.01	0.016	<0.001	3	<0.001	0.014	<0.005	<0.001	<0.05	93
	pH 6.7	<0.001	<0.05	<0.01	0.065	<0.001	10	0.001	0.61	<0.005	0.002	<0.05	8
	pH 4.5	<0.001	14	0.02	1.7	0.019	50	0.001	12	<0.005	0.86	51	20
	pH 2.2	<0.002	240	0.03	2.2	0.066	64	0.006	13	0.92	3.1	430	17
MM/OB32 Trans /BWT	pH 12.8	<0.010	120	0.41	0.024	<0.010	<1	<0.010	<0.010	0.15	0.018	0.25	40000
	pH 11.6	<0.001	58	0.24	0.31	<0.001	1	0.001	0.08	0.088	0.022	250	3540
	pH 10.0	<0.001	5.8	0.08	0.15	<0.001	<1	<0.001	0.028	0.034	0.008	92	444

	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
pH 9.7	<0.001	5.0	0.06	0.19	<0.001	<1	<0.001	0.03	0.032	0.008	120	288
pH 7.3	<0.001	1.9	0.02	0.068	<0.001	<1	<0.001	0.016	0.025	0.003	58	125
pH 6.9	<0.001	<0.05	<0.01	0.021	<0.001	19	<0.001	<0.001	0.016	<0.001	0.07	3
pH 6.7	<0.001	<0.05	<0.01	3	<0.001	56	<0.001	1	<0.005	<0.001	<0.05	5
pH 3.2	<0.001	48	0.02	19	0.013	59	<0.001	6.3	0.2	0.12	1.4	11
pH 2.3	0.001	100	0.02	30	0.024	69	0.006	6.8	0.93	0.58	310	9

		Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
JN/OB25 Fresh	pH 13.1	<0.010	<1	<0.010	<0.10	24	<0.020	<0.10	2	<0.010	110	0.98	1.6	0.13
	pH 12.0	<0.001	<1	<0.001	0.05	21	<0.002	<0.01	<1	<0.001	36	0.48	1.4	0.02
	pH 10.7	<0.001	<1	<0.001	0.04	18	<0.002	<0.01	<1	<0.001	19	0.29	0.86	<0.01
	pH 8.7	<0.001	<1	0.003	0.04	17	<0.002	<0.01	<1	0.002	19	0.23	0.94	0.26
	pH 7.2	0.004	4	0.001	0.02	20	<0.002	<0.01	<1	<0.001	12	0.05	0.01	0.01
	pH 6.9	0.017	28	0.088	<0.01	21	<0.002	0.04	<1	<0.001	9	0.03	0.001	0.11
	pH 5.2	0.029	57	0.34	<0.01	23	<0.002	0.13	<1	0.002	5	0.02	<0.001	0.94
	pH 3.6	0.032	80	0.77	<0.01	22	<0.002	0.22	2	0.035	3	0.02	<0.001	1.4
	pH 2.3	0.038	81	0.74	<0.01	23	<0.002	0.25	2	0.24	<1	<0.01	0.19	1.6
MM/OB29 Weathered	pH 13.0	<0.010	<1	<0.010	<0.10	185	<0.020	<0.10	6	<0.010	180	<0.10	0.24	0.14
	pH 12.0	<0.001	<1	0.002	0.05	150	<0.002	<0.01	3	<0.001	120	0.02	0.12	0.02
	pH 10.4	<0.001	<1	0.037	0.05	130	<0.002	<0.01	1	0.007	92	0.01	0.041	0.03
	pH 9.0	0.001	<1	0.001	0.04	131	<0.002	<0.01	<1	<0.001	89	<0.01	0.01	0.02
	pH 8.4	0.001	<1	0.011	0.04	129	<0.002	<0.01	<1	0.002	82	<0.01	0.011	0.03
	pH 7.4	0.007	13	0.001	<0.01	126	<0.002	0.01	<1	<0.001	64	<0.01	<0.001	0.02
	pH 5.0	0.019	39	0.77	<0.01	197	<0.002	0.04	<1	<0.001	10	<0.01	<0.001	0.04
	pH 4.1	0.014	29	0.069	<0.01	169	<0.002	0.02	<1	0.002	39	<0.01	<0.001	0.03
	pH 2.3	0.019	47	2.6	<0.01	226	<0.002	0.1	<1	0.12	<1	<0.01	<0.001	0.22
MM/OB29 Transition	pH 13.1	<0.010	<1	<0.010	0.18	55	<0.020	<0.10	12	<0.010	93	<0.10	0.081	0.34
	pH 12.0	0.001	3	0.61	0.23	53	0.004	0.06	9	0.03	89	0.02	0.059	0.26
	pH 9.8	0.004	3	0.57	0.16	61	<0.002	0.05	3	0.023	83	<0.01	0.012	0.2
	pH 9.5	0.004	1	0.18	0.16	56	<0.002	0.02	3	0.009	86	0.02	0.005	0.16
	pH 8.4	0.036	44	0.051	<0.01	100	<0.002	<0.01	<1	0.002	31	<0.01	<0.001	0.05
	pH 7.1	0.03	25	0.003	<0.01	90	<0.002	<0.01	<1	<0.001	68	<0.01	<0.001	0.01
	pH 6.3	0.034	50	0.092	<0.01	106	<0.002	0.01	<1	<0.001	28	<0.01	<0.001	0.01
	pH 4.8	0.036	58	0.71	<0.01	111	<0.002	0.05	<1	<0.001	2	<0.01	<0.001	0.04
	pH 4.3	0.038	62	1.2	<0.01	110	<0.002	0.07	<1	0.003	<1	<0.01	<0.001	0.07
	pH 2.0	0.044	71	1.9	<0.01	111	<0.002	0.16	<1	0.31	<1	<0.01	<0.001	0.44
W/OB25 Transition	pH 12.8	<0.005	<1	<0.005	0.25	78	<0.010	<0.05	110	<0.005	85	0.06	3.2	0.11
	pH 11.9	<0.001	5	0.88	0.32	74	0.086	0.02	100	0.16	84	0.05	4.4	0.23

		Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	pH 9.5	<0.001	8	2.1	0.26	64	0.13	0.03	87	0.28	74	0.02	3.9	0.06
	pH 8.8	<0.001	4	0.74	0.24	63	0.078	0.02	52	0.13	74	0.02	2	0.07
	pH 7.1	<0.001	2	0.18	0.09	78	0.02	<0.01	8	0.028	60	<0.01	0.29	0.16
	pH 6.9	0.002	2	0.056	0.05	79	0.013	<0.01	3	0.008	56	<0.01	0.099	<0.01
	pH 5.0	0.017	66	0.78	<0.01	110	<0.002	0.07	<1	<0.001	9	<0.01	<0.001	0.13
	pH 4.0	0.018	112	1.7	<0.01	111	<0.002	0.12	<1	0.001	2	<0.01	<0.001	0.52
	pH 2.2	0.026	121	2.7	<0.01	115	<0.002	0.2	<1	0.18	<1	<0.01	<0.001	1.6
W/OB25 Fresh	pH 13.0	<0.010	<1	<0.010	0.2	71	<0.020	<0.10	6	<0.010	31	<0.10	0.81	0.26
	pH 12.1	0.001	<1	0.011	0.16	69	<0.002	<0.01	4	0.002	27	0.03	0.53	0.03
	pH 10.4	0.009	<1	0.11	0.12	67	<0.002	<0.01	1	0.02	25	0.02	0.15	0.01
	pH 8.6	0.008	<1	0.16	0.11	55	<0.002	<0.01	1	0.03	24	0.02	0.12	0.06
	pH 7.1	0.041	6	0.005	0.07	73	<0.002	<0.01	<1	<0.001	23	<0.01	<0.001	0.02
	pH 6.9	0.05	11	0.014	0.04	82	<0.002	<0.01	<1	<0.001	25	<0.01	<0.001	0.02
	pH 5.2	0.12	66	8.4	<0.01	89	<0.002	0.11	<1	0.003	6	<0.01	<0.001	4.8
	pH 4.2	0.12	80	13	<0.01	92	<0.002	0.12	<1	0.022	2	<0.01	<0.001	8
	pH 2.4	0.17	86	58	<0.01	92	<0.002	0.24	<1	5.1	<1	<0.01	<0.001	11
D1/Whaleback	pH 13.0	<0.005	<1	0.012	0.16	22	<0.010	<0.05	12	<0.005	85	0.07	2.3	<0.05
	pH 11.9	<0.001	<1	<0.001	0.1	13	<0.002	<0.01	6	<0.001	44	0.04	1.3	<0.01
	pH 10.4	<0.001	<1	0.007	0.08	12	<0.002	<0.01	4	0.002	27	0.02	0.53	<0.01
	pH 9.7	<0.001	<1	0.003	0.09	12	<0.002	<0.01	4	0.002	24	0.03	0.48	0.09
	pH 7.1	0.005	3	0.11	0.01	16	<0.002	<0.01	<1	<0.001	10	<0.01	<0.001	0.02
	pH 7.1	0.004	3	0.069	0.02	16	<0.002	<0.01	<1	<0.001	11	<0.01	0.001	0.04
	pH 6.7	0.009	8	0.81	<0.01	16	<0.002	0.02	<1	<0.001	7	<0.01	<0.001	0.08
	pH 4.5	0.021	33	13	<0.01	17	<0.002	0.13	<1	0.004	<1	<0.01	<0.001	0.41
	pH 2.0	0.037	43	29	<0.02	19	<0.004	0.39	<1	0.24	<1	<0.02	<0.002	1.3
MM/OB32 Trans /BWT	pH 12.8	<0.010	<1	0.055	0.42	16	<0.020	<0.10	36	<0.010	9	<0.10	1.9	0.15
	pH 11.6	0.002	<1	2.4	0.39	15	<0.020	0.01	25	0.003	7	<0.01	1.2	0.09
	pH 10.0	0.005	<1	1.1	0.29	12	0.023	<0.01	10	<0.001	6	<0.01	0.32	0.03
	pH 9.7	0.005	<1	1.7	0.28	11	0.011	<0.01	9	<0.001	6	<0.01	0.22	0.02
	pH 7.3	0.01	<1	0.49	0.24	12	<0.002	<0.01	3	<0.001	6	<0.01	0.019	0.01

	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
	mg/kg	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
pH 6.9	0.034	11	0.012	0.01	14	<0.002	<0.01	<1	<0.001	6	<0.01	<0.001	<0.01
pH 6.7	0.044	40	13	<0.01	15	<0.002	0.1	<1	<0.001	<1	<0.01	<0.001	<0.01
pH 3.2	0.032	42	120	<0.01	15	<0.002	0.25	<1	<0.001	<1	<0.01	<0.001	0.41
pH 2.3	0.047	55	190	<0.01	16	<0.002	0.76	<1	0.002	<1	<0.01	<0.001	0.62

Duplicate Samples:

		Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
JN/OB25 Fresh	pH 13.0	<0.010	140	0.11	0.11	<0.010	<1	<0.010	<0.010	<0.050	4.6	0.15	38100
	pH 11.8	<0.001	69	0.04	0.001	<0.001	<1	<0.001	<0.001	0.012	0.019	0.2	3880
	pH 10.3	<0.001	17	0.02	<0.001	<0.001	<1	<0.001	0.002	0.005	0.03	0.22	623
	pH 9.5	<0.001	17	0.02	0.002	<0.001	1	<0.001	0.007	0.014	0.091	13	381
	pH 7.0	<0.001	0.07	<0.01	0.001	<0.001	16	<0.001	0.015	<0.005	0.032	<0.05	30
	pH 6.8	<0.001	<0.05	<0.01	0.018	<0.001	37	0.002	0.14	<0.005	0.19	<0.05	38
	pH 5.8	<0.001	0.12	<0.01	0.068	<0.001	65	0.001	0.43	<0.005	8.5	<0.05	211
	pH 4.9	<0.001	1.8	<0.01	0.14	0.003	90	0.003	0.88	<0.005	60	<0.05	51
	pH 2.1	<0.001	80	<0.01	0.95	0.032	125	0.004	1.2	0.059	350	32	66
MM/OB29 Weathered	pH 13.0	<0.005	400	0.2	0.082	<0.005	<1	<0.005	<0.005	<0.025	0.008	1.1	35500
	pH 11.9	<0.001	140	0.08	1.1	<0.001	1	<0.001	0.024	0.017	0.011	190	4070
	pH 9.6	<0.001	8.1	0.02	0.52	<0.001	1	<0.001	0.004	<0.005	0.002	25	430
	pH 8.1	<0.001	2.8	0.01	0.22	<0.001	6	<0.001	0.002	<0.005	0.002	0.53	322
	pH 7.9	0.001	1	<0.01	1.3	<0.001	48	<0.001	<0.001	<0.005	0.006	0.06	124
	pH 7.5	<0.001	0.31	<0.01	2.1	<0.001	24	<0.001	<0.001	<0.005	<0.001	<0.05	244
	pH 6.7	<0.001	<0.05	<0.01	3	<0.001	103	0.014	0.13	<0.005	<0.001	<0.05	17
	pH 4.7	<0.001	3.1	<0.01	13	0.003	148	0.001	1.6	<0.005	<0.001	1.8	26
	pH 2.1	<0.001	250	<0.01	160	0.015	164	0.004	2.4	0.073	0.11	260	46
MM/OB29 Transition	pH 13.0	<0.010	160	0.27	<0.010	<0.010	<1	0.012	<0.010	<0.050	<0.010	3.5	42700
	pH 12.0	<0.001	60	0.11	0.081	0.002	2	<0.001	0.039	0.019	0.018	720	4970
	pH 10.9	<0.001	17	0.04	0.055	<0.001	<1	<0.001	0.019	0.01	0.058	310	918
	pH 8.8	<0.001	5.5	<0.01	0.049	<0.001	3	<0.001	0.01	<0.005	<0.001	180	959
	pH 8.1	<0.001	0.05	<0.01	0.21	<0.001	13	<0.001	<0.001	<0.005	<0.001	0.44	499
	pH 7.2	<0.001	<0.05	<0.01	0.63	<0.001	36	0.003	<0.001	<0.005	<0.001	<0.05	47
	pH 6.2	<0.001	<0.05	<0.01	3	<0.001	58	<0.001	0.016	<0.005	<0.001	<0.05	263
	pH 4.2	<0.001	7.9	<0.01	4.8	0.017	76	0.001	0.5	<0.005	<0.001	11	18
	pH 2.0	<0.001	130	<0.01	7.9	0.052	83	0.038	1.4	0.063	0.093	320	18
W/OB25 Transition	pH 12.9	<0.005	380	1.1	<0.005	<0.005	<1	<0.005	<0.005	0.14	0.006	<0.05	29000

		Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	pH 12.0	<0.001	180	0.55	0.06	0.003	2	0.001	0.027	2.9	0.024	2800	4000
	pH 8.8	<0.001	59	0.21	0.065	0.004	2	0.001	0.026	2.9	0.025	3300	934
	pH 8.5	<0.001	28	0.14	0.028	0.002	2	<0.001	0.014	1.1	0.013	1500	651
	pH 7.0	<0.001	<0.05	<0.01	0.017	<0.001	3	<0.001	0.009	<0.005	<0.001	0.07	84
	pH 6.8	<0.001	0.07	<0.01	0.1	<0.001	12	0.001	0.018	<0.005	<0.001	0.08	20
	pH 5.1	<0.001	0.97	<0.01	1.1	<0.001	33	<0.001	0.32	<0.005	0.005	0.1	15
	pH 4.0	<0.001	22	<0.01	3.1	0.008	62	<0.001	1.1	<0.005	0.072	4.9	18
	pH 2.3	<0.001	180	<0.01	4.2	0.033	68	0.002	1.5	0.13	0.48	35	20
W/OB25 Fresh	pH 13.0	<0.005	250	8.7	<0.005	<0.005	<1	<0.005	<0.005	0.12	0.008	0.63	36200
	pH 12.3	<0.001	140	4.4	0.005	<0.001	<1	<0.001	0.002	0.078	0.004	0.78	6650
	pH 10.2	<0.001	26	1.9	0.016	<0.001	<1	<0.001	0.003	0.038	0.003	9.3	755
	pH 8.3	<0.001	16	1.1	0.059	<0.001	2	<0.001	0.011	0.043	0.009	35	343
	pH 7.0	<0.001	0.19	0.01	0.004	<0.001	10	<0.001	0.004	0.015	<0.001	0.15	107
	pH 6.6	<0.001	<0.05	<0.01	0.034	<0.001	38	<0.001	0.13	<0.005	<0.001	<0.05	154
	pH 5.5	<0.001	1.4	<0.01	0.35	0.002	77	0.002	2.0	<0.005	0.002	<0.05	204
	pH 4.0	<0.001	86	<0.01	3.8	0.028	96	0.006	4.4	0.017	0.042	0.06	267
	pH 2.5	0.005	320	0.03	8.4	0.047	97	0.012	3.7	0.25	0.23	18	273
D1/Whaleback	pH 13.0	<0.005	420	0.9	<0.005	<0.005	<1	<0.005	<0.005	0.045	<0.005	0.4	35800
	pH 12.1	<0.001	190	0.47	<0.001	<0.001	<1	<0.001	<0.001	0.023	<0.001	0.23	4800
	pH 10.2	<0.001	23	0.24	0.004	<0.001	1	<0.001	0.014	0.017	0.002	30	422
	pH 7.5	<0.001	0.49	0.01	0.002	<0.001	2	<0.001	0.001	<0.005	<0.001	1.4	109
	pH 7.4	<0.001	1.4	0.06	<0.001	<0.001	<1	<0.001	0.002	<0.005	<0.001	2.8	101
	pH 7.2	<0.001	0.11	<0.01	0.011	<0.001	3	<0.001	0.01	<0.005	<0.001	<0.05	107
	pH 7.1	<0.001	0.12	<0.01	0.059	<0.001	10	<0.001	0.47	<0.005	<0.001	<0.05	19
	pH 4.5	<0.001	9.5	0.01	1.9	0.015	59	0.001	11	<0.005	0.82	52	15
	pH 2.1	<0.001	230	0.02	3.3	0.05	67	0.005	11	1.2	4	420	17
MM/OB32 Trans /BWT	pH 12.8	<0.010	130	0.41	0.024	<0.010	<1	<0.010	<0.010	0.14	<0.010	0.25	41200
	pH 11.6	<0.001	65	0.25	0.39	<0.001	<1	0.001	0.082	0.094	0.024	270	3560
	pH 10.4	<0.001	11	0.1	0.18	<0.001	<1	<0.001	0.048	0.043	0.007	120	555
	pH 8.8	<0.001	4.2	0.04	0.15	<0.001	<1	<0.001	0.038	0.034	0.005	99	201

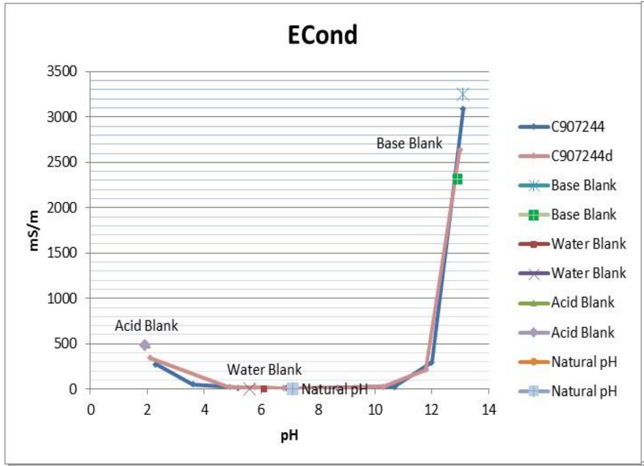
	Ag	Al	As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K
	mg/kg	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**	**mg/kg**
pH 7.4	<0.001	1.8	<0.01	0.066	<0.001	2	<0.001	0.017	0.025	0.003	50	107
pH 6.8	<0.001	<0.05	<0.01	0.027	<0.001	20	<0.001	0.002	0.016	<0.001	<0.05	3
pH 6.7	<0.001	<0.05	<0.01	3	<0.001	54	<0.001	1.1	<0.005	<0.001	<0.05	4
pH 3.6	<0.001	35	0.01	14	0.015	61	<0.001	6.0	0.034	0.034	0.18	7
pH 2.3	0.001	92	0.02	33	0.021	65	0.004	6.3	1.4	0.68	310	10

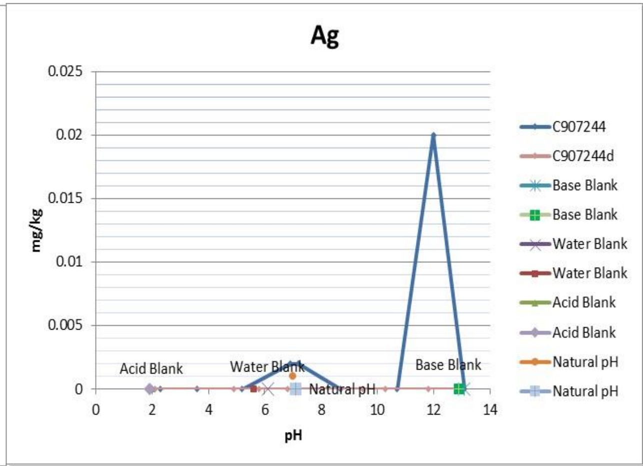
		Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
JN/OB25 Fresh	pH 13.0	<0.010	<1	<0.010	<0.10	25	<0.020	<0.10	1	<0.010	250	1.7	2.1	0.11
	pH 11.8	<0.001	<1	0.01	0.05	20	<0.002	<0.01	<1	0.001	54	0.63	1.3	0.05
	pH 10.3	<0.001	<1	0.002	0.04	18	<0.002	<0.01	<1	<0.001	18	0.27	0.96	0.23
	pH 9.5	0.002	<1	0.007	0.05	19	<0.002	<0.01	<1	0.004	19	0.25	0.77	0.05
	pH 7.0	0.008	13	0.01	0.01	22	<0.002	<0.01	<1	<0.001	13	0.05	0.005	0.01
	pH 6.8	0.015	29	0.091	<0.01	23	<0.002	0.02	<1	<0.001	12	0.04	0.001	0.06
	pH 5.8	0.022	46	0.3	<0.01	22	<0.002	0.09	<1	<0.001	8	0.03	<0.001	0.55
	pH 4.9	0.026	60	0.51	<0.01	24	<0.002	0.13	<1	0.002	7	0.03	<0.001	1.0
	pH 2.1	0.036	84	0.89	<0.01	24	<0.002	0.26	3	0.31	2	0.01	0.38	1.5
MM/OB29 Weathered	pH 13.0	<0.005	<1	0.012	0.16	22	<0.010	<0.05	12	<0.005	85	0.07	2.3	<0.05
	pH 11.9	<0.001	<1	<0.001	0.1	13	<0.002	<0.01	6	<0.001	44	0.04	1.3	<0.01
	pH 10.4	<0.001	<1	0.007	0.08	12	<0.002	<0.01	4	0.002	27	0.02	0.53	<0.01
	pH 9.7	<0.001	<1	0.003	0.09	12	<0.002	<0.01	4	0.002	24	0.03	0.48	0.09
	pH 7.1	0.005	3	0.11	0.01	16	<0.002	<0.01	<1	<0.001	10	<0.01	<0.001	0.02
	pH 7.1	0.004	3	0.069	0.02	16	<0.002	<0.01	<1	<0.001	11	<0.01	0.001	0.04
	pH 6.7	0.009	8	0.81	<0.01	16	<0.002	0.02	<1	<0.001	7	<0.01	<0.001	0.08
	pH 4.5	0.021	33	13	<0.01	17	<0.002	0.13	<1	0.004	<1	<0.01	<0.001	0.41
	pH 2.0	0.037	43	29	<0.02	19	<0.004	0.39	<1	0.24	<1	<0.02	<0.002	1.3
MM/OB29 Transition	pH 13.0	<0.010	<1	<0.010	0.22	61	<0.020	<0.10	12	<0.010	96	<0.10	0.099	<0.10
	pH 12.0	<0.001	2	0.32	0.2	55	<0.002	0.03	8	0.013	90	0.02	0.05	0.21
	pH 10.9	0.002	1	0.16	0.14	50	<0.002	0.01	4	0.006	85	0.02	0.02	0.07
	pH 8.8	0.011	<1	0.084	0.1	83	<0.002	<0.01	<1	0.005	87	<0.01	<0.001	0.08
	pH 8.1	0.022	6	<0.001	<0.01	96	<0.002	<0.01	<1	<0.001	88	<0.01	<0.001	<0.01
	pH 7.2	0.029	27	0.004	<0.01	99	<0.002	<0.01	<1	<0.001	74	<0.01	<0.001	0.02
	pH 6.2	0.033	50	0.09	<0.01	108	<0.002	0.01	<1	<0.001	27	<0.01	<0.001	0.01
	pH 4.2	0.036	64	1.1	<0.01	115	<0.002	0.06	<1	0.003	<1	<0.01	<0.001	0.05
	pH 2.0	0.048	72	2.7	<0.01	118	<0.002	0.13	<1	0.3	<1	<0.01	<0.001	0.33
W/OB25 Transition	pH 12.9	<0.005	<1	<0.005	0.31	84	<0.010	<0.05	120	<0.005	89	0.08	3.6	<0.05
	pH 12.0	<0.001	3	0.51	0.28	74	0.052	0.01	89	0.091	83	0.05	3.6	0.10
	pH 8.8	<0.001	3	0.54	0.18	71	0.062	0.01	41	0.092	69	0.01	1.4	0.04

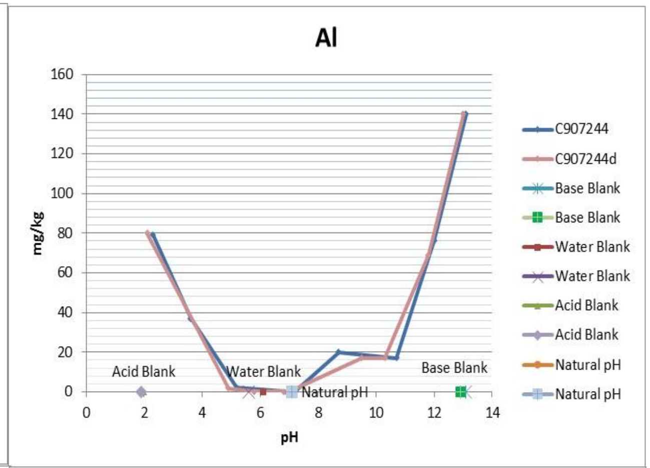
		Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	pH 8.5	<0.001	1	0.27	0.17	80	0.029	<0.01	25	0.042	72	0.01	0.49	0.05
	pH 7.0	0.003	8	0.03	<0.01	101	<0.002	<0.01	<1	<0.001	52	<0.01	<0.001	0.02
	pH 6.8	0.008	25	0.081	<0.01	106	<0.002	<0.01	<1	<0.001	36	<0.01	<0.001	0.02
	pH 5.1	0.017	62	1.1	<0.01	106	<0.002	0.06	<1	<0.001	10	<0.01	<0.001	0.23
	pH 4.0	0.019	112	2.3	<0.01	112	<0.002	0.12	<1	0.002	2	<0.01	<0.001	1.0
	pH 2.3	0.026	118	3.2	<0.01	113	<0.002	0.20	<1	0.13	<1	<0.01	<0.001	5.5
W/OB25 Fresh	pH 13.0	<0.005	<1	<0.005	0.18	71	<0.010	<0.05	6	<0.005	28	<0.05	0.71	0.16
	pH 12.3	0.002	<1	0.11	0.16	71	<0.002	<0.01	4	0.02	28	0.03	0.52	0.01
	pH 10.2	0.007	<1	0.29	0.13	64	0.006	<0.01	2	0.066	25	0.02	0.21	<0.01
	pH 8.3	0.009	<1	1.2	0.13	61	0.004	<0.01	2	0.28	25	0.02	0.14	0.15
	pH 7.0	0.044	9	0.018	0.05	77	<0.002	<0.01	<1	<0.001	24	<0.01	<0.001	0.01
	pH 6.6	0.075	36	1.2	<0.01	87	<0.002	<0.01	<1	<0.001	21	<0.01	<0.001	0.09
	pH 5.5	0.12	63	8.3	<0.01	91	<0.002	0.08	<1	0.001	10	<0.01	<0.001	3.1
	pH 4.0	0.14	79	17	<0.01	90	<0.002	0.17	<1	0.046	2	<0.01	<0.001	10
	pH 2.5	0.16	83	58	<0.01	88	<0.002	0.26	<1	5.5	<1	<0.01	<0.001	10
D1/Whaleback	pH 13.0	<0.005	<1	0.017	0.12	22	<0.010	<0.05	12	<0.005	91	<0.05	1.7	0.09
	pH 12.1	<0.001	<1	0.004	0.1	15	<0.002	<0.01	6	<0.001	50	0.04	1.6	<0.01
	pH 10.2	<0.001	<1	0.013	0.09	16	<0.002	<0.01	4	0.003	26	0.03	0.47	0.14
	pH 7.5	0.002	1	0.01	0.03	17	<0.002	<0.01	<1	<0.001	15	<0.01	0.004	0.01
	pH 7.4	0.002	<1	<0.001	0.05	13	<0.002	<0.01	1	<0.001	17	<0.01	0.02	0.08
	pH 7.2	0.003	2	0.032	0.02	16	<0.002	<0.01	<1	<0.001	11	<0.01	0.001	0.03
	pH 7.1	0.009	9	1.4	<0.01	16	<0.002	<0.01	<1	<0.001	7	<0.01	<0.001	<0.01
	pH 4.5	0.023	38	17	<0.01	19	<0.002	0.13	<1	0.002	<1	<0.01	<0.001	0.35
	pH 2.1	0.031	44	37	0.01	19	<0.002	0.28	<1	0.2	<1	<0.01	<0.001	1.0
MM/OB32 Trans /BWT	pH 12.8	<0.010	<1	0.23	0.41	16	0.039	<0.10	38	<0.010	9	<0.10	2	0.11
	pH 11.6	0.003	<1	3	0.4	12	0.005	0.01	26	0.006	7	<0.01	1.3	0.11
	pH 10.4	0.004	<1	1.4	0.3	11	0.031	<0.01	12	<0.001	6	<0.01	0.45	0.02
	pH 8.8	0.007	<1	1.2	0.25	12	0.003	<0.01	7	<0.001	6	<0.01	0.1	0.02
	pH 7.4	0.013	<1	0.49	0.22	13	<0.002	<0.01	1	<0.001	6	<0.01	0.009	0.01
	pH 6.8	0.034	11	0.064	0.01	14	<0.002	<0.01	<1	<0.001	6	<0.01	<0.001	<0.01

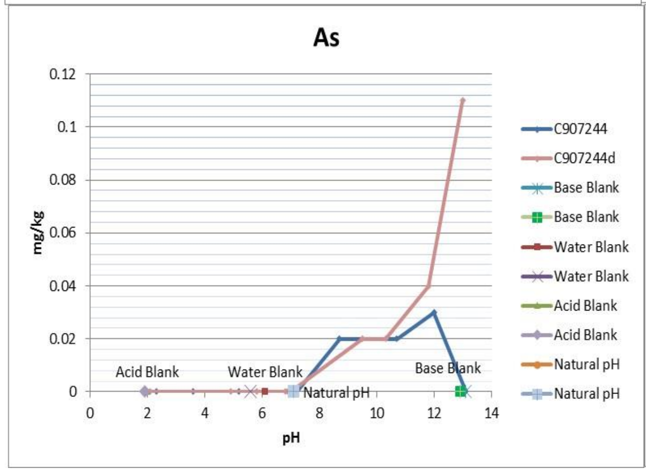
	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	S	Se	V	Zn
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
pH 6.7	0.041	37	13	<0.01	14	<0.002	0.1	<1	<0.001	<1	<0.01	<0.001	0.01
pH 3.6	0.027	40	77	<0.01	14	<0.002	0.26	<1	<0.001	<1	<0.01	<0.001	0.39
pH 2.3	0.045	52	220	<0.01	16	<0.002	0.51	<1	0.003	<1	<0.01	<0.001	0.52

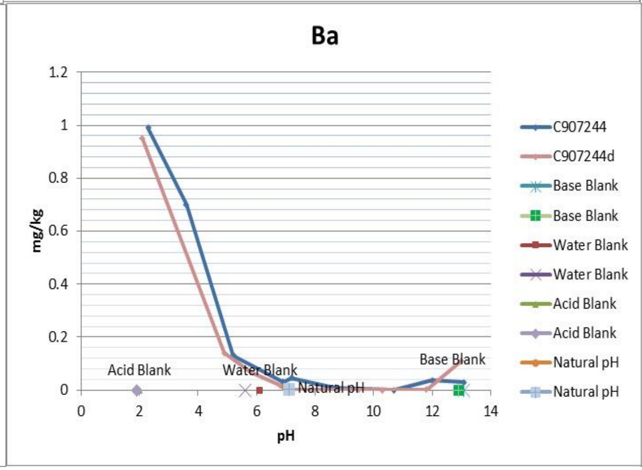
JN/OB25 Fresh (C907244)

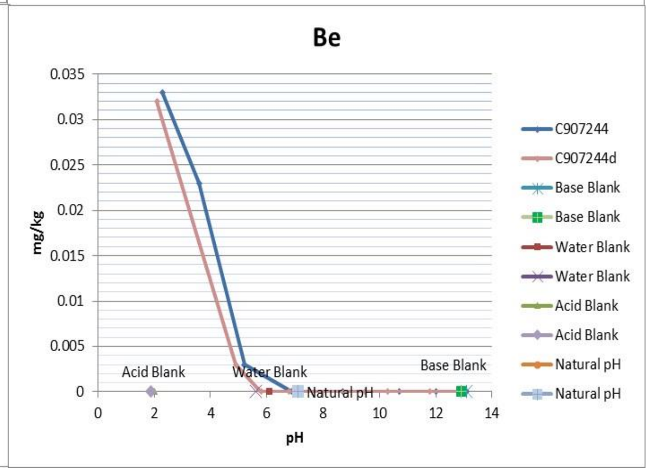












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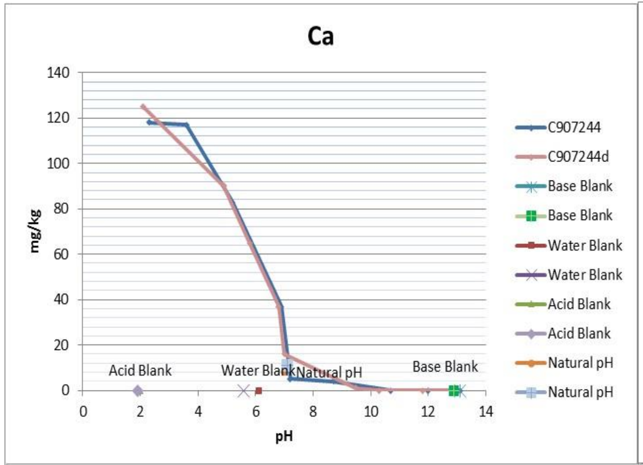

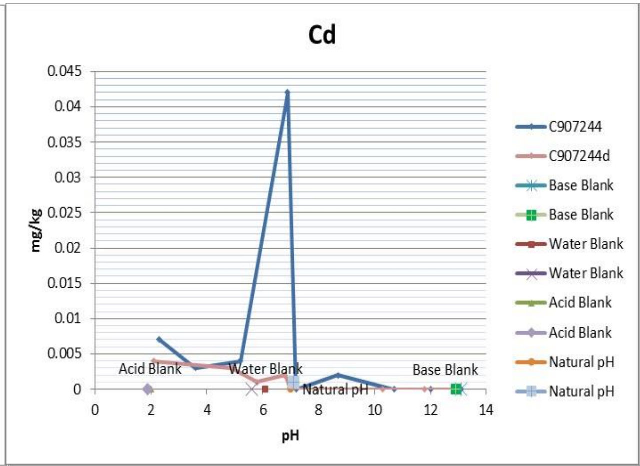

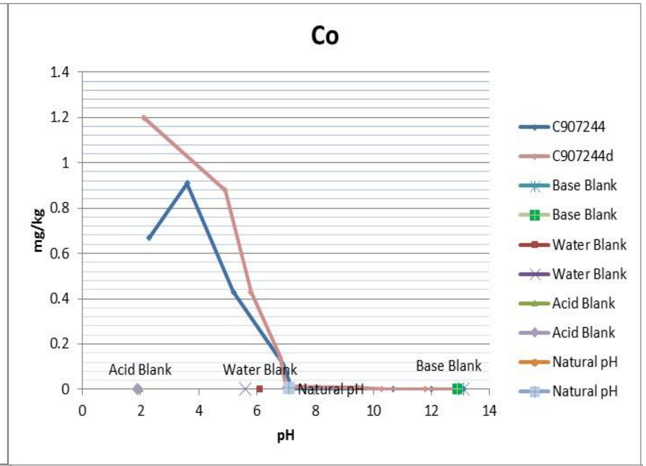

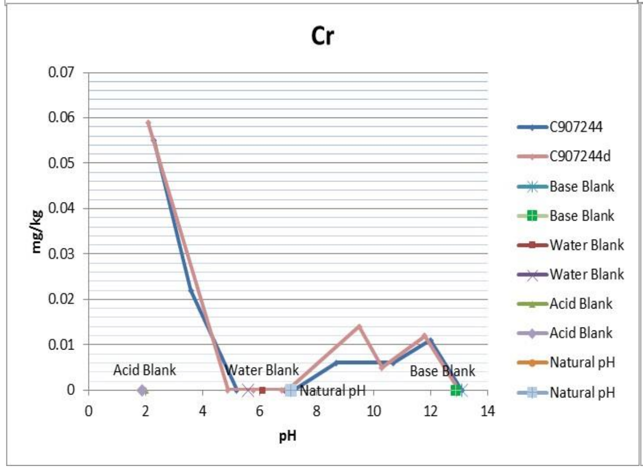

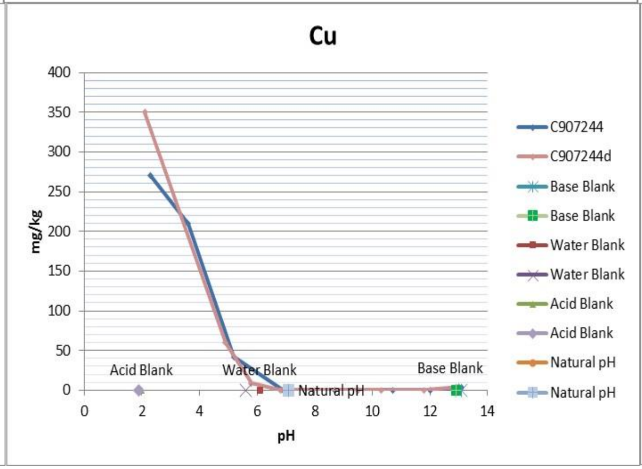

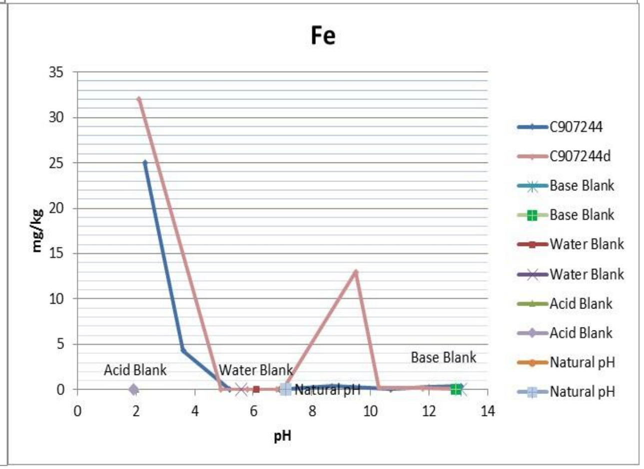

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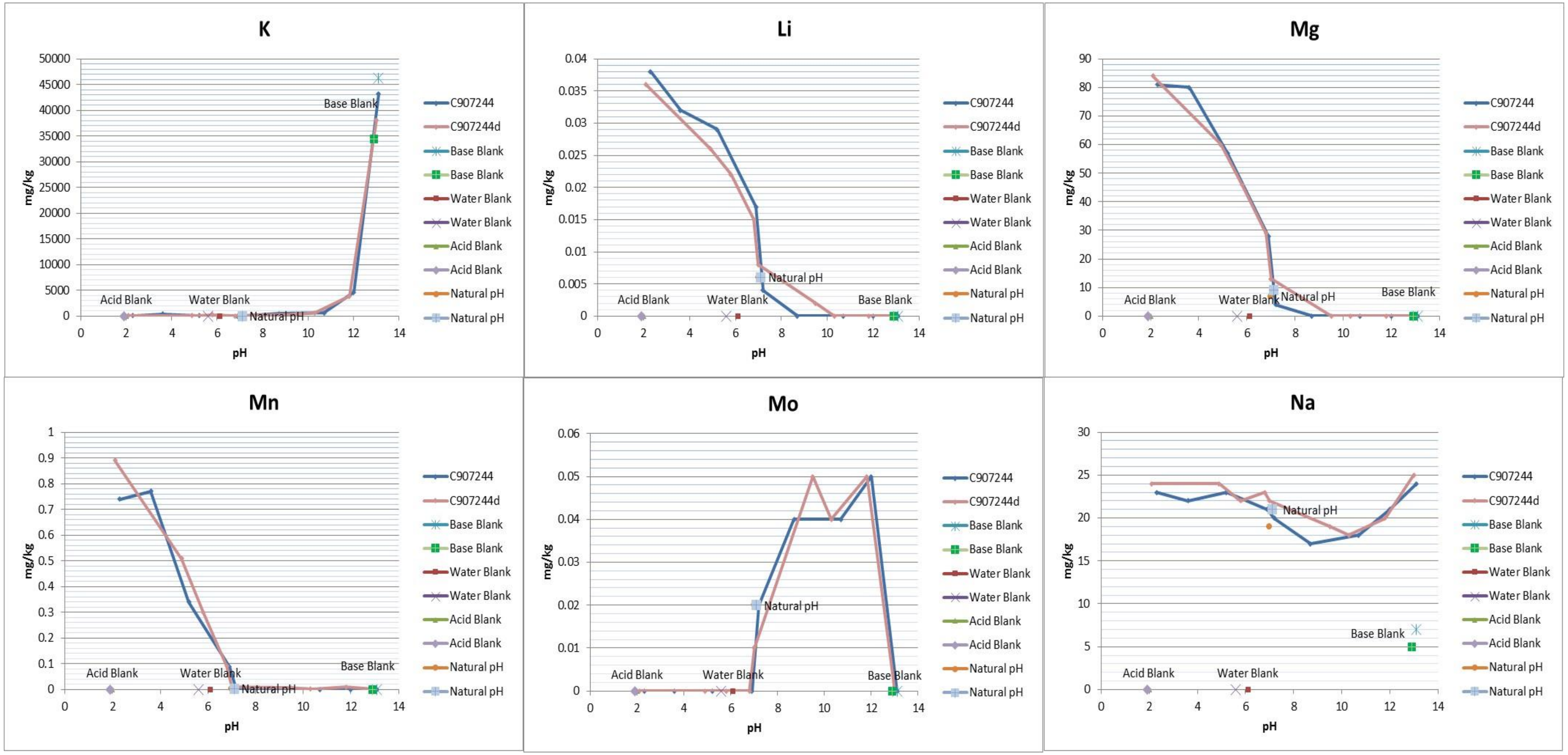

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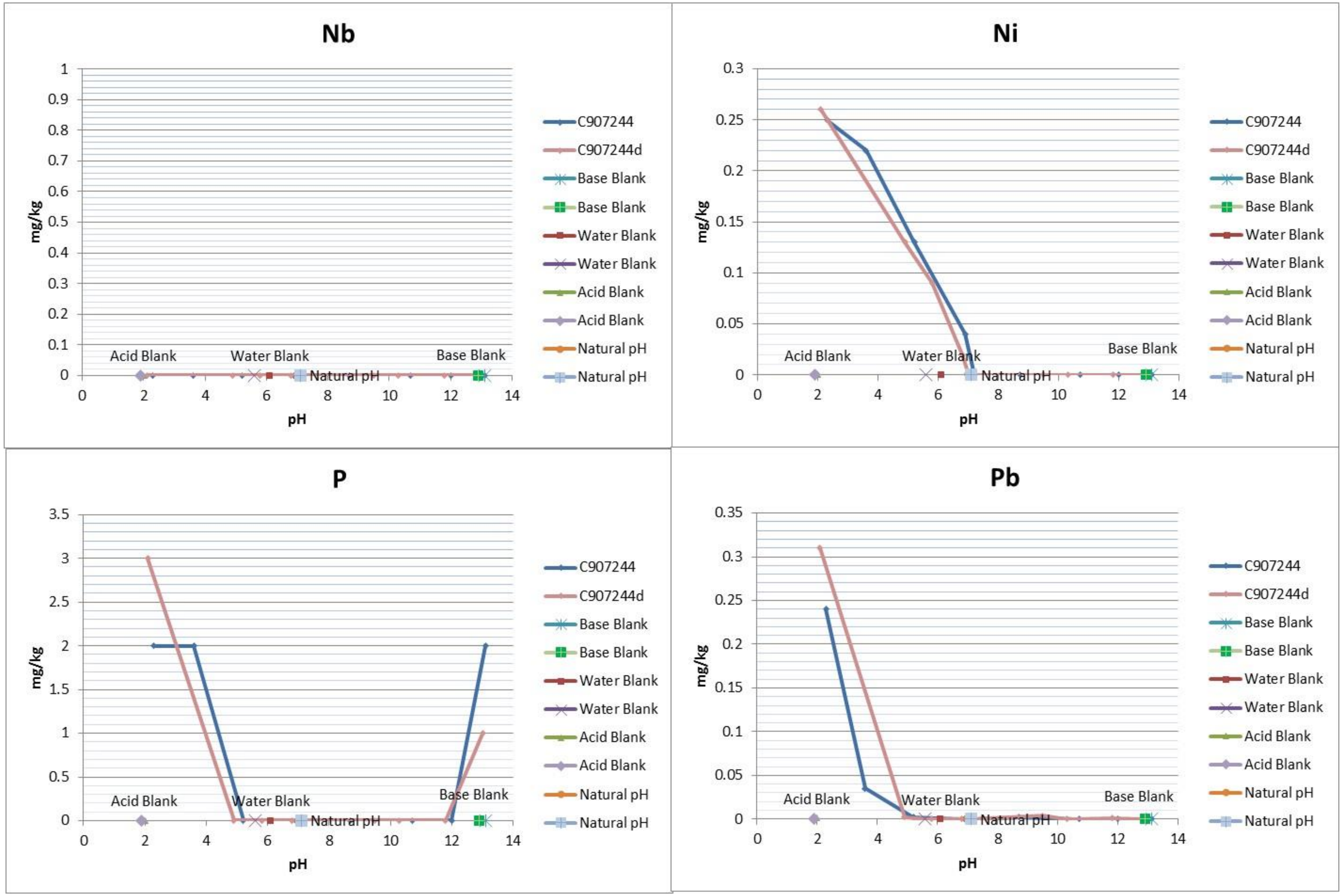

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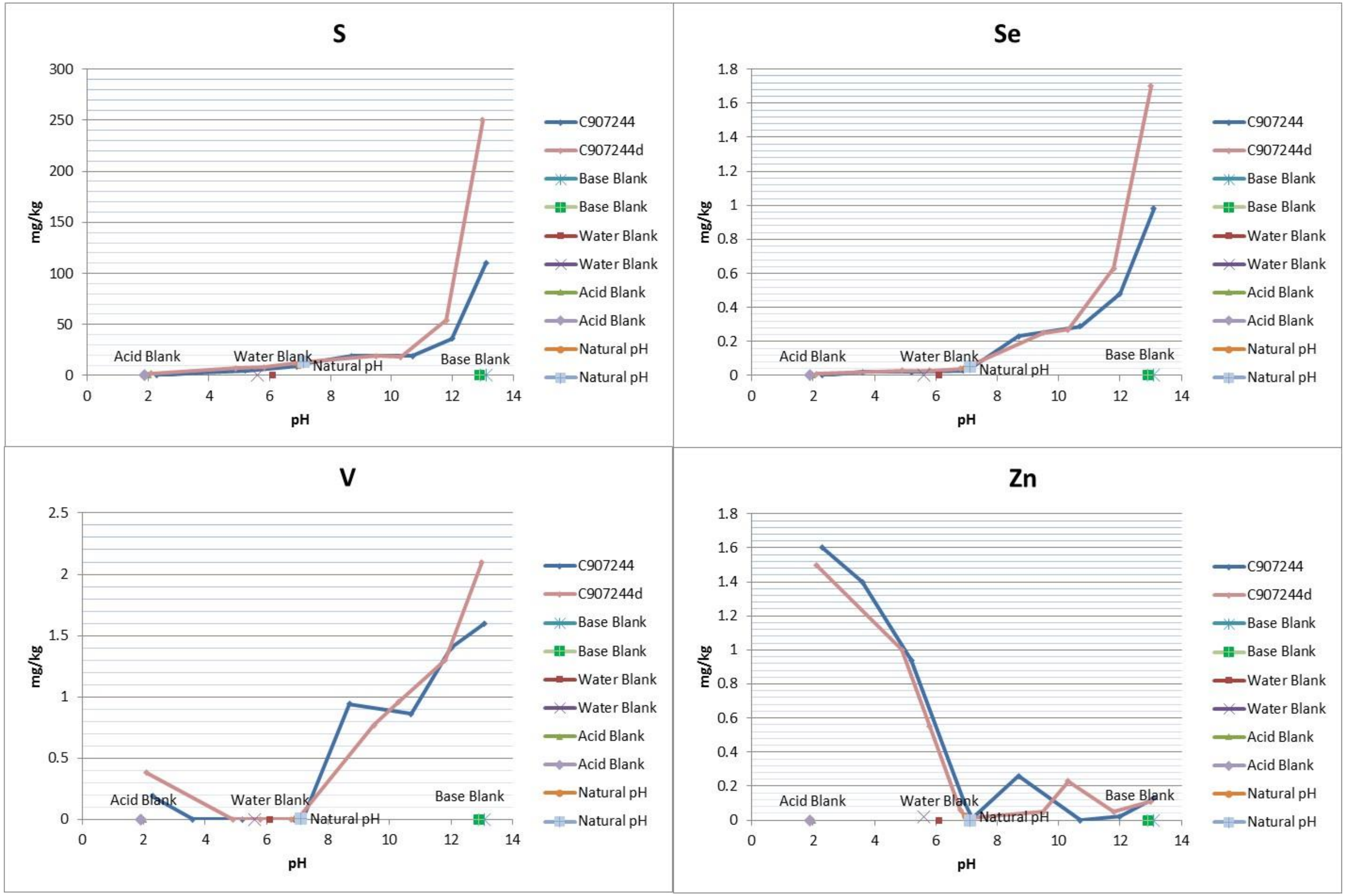

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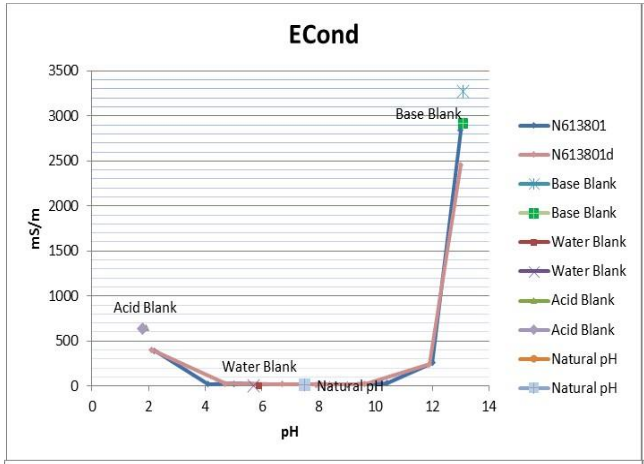

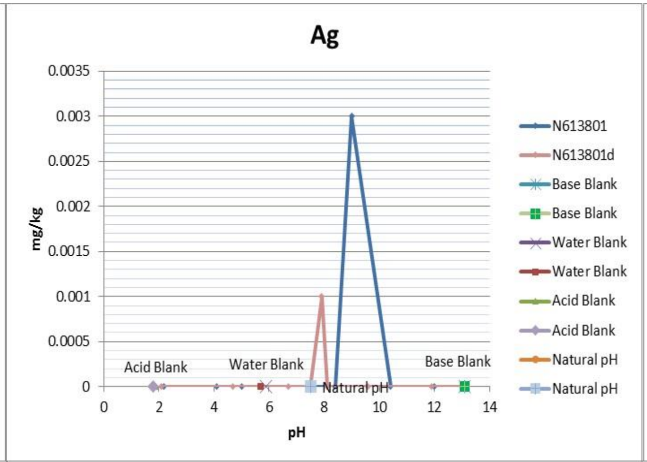

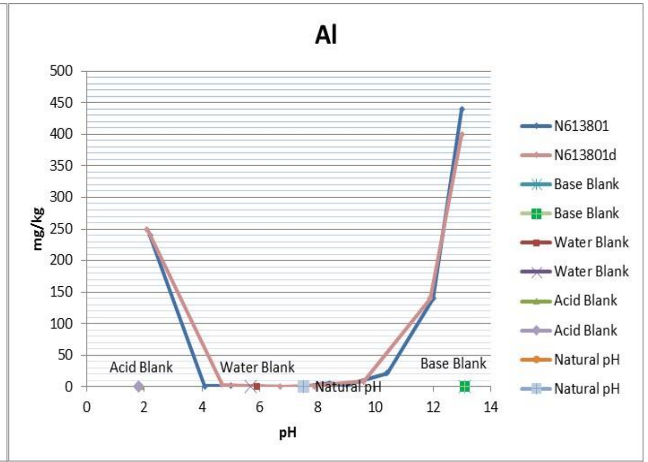

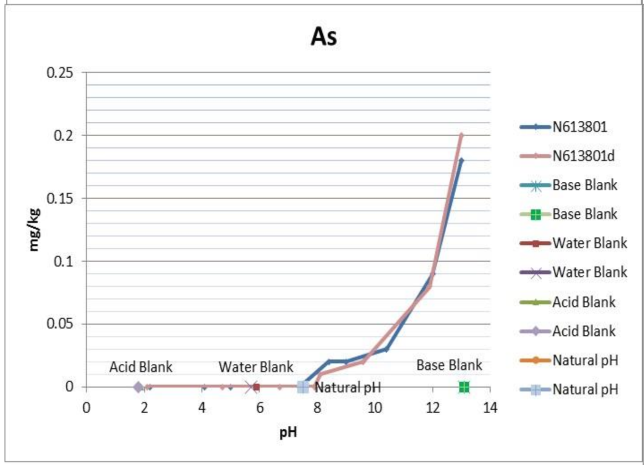

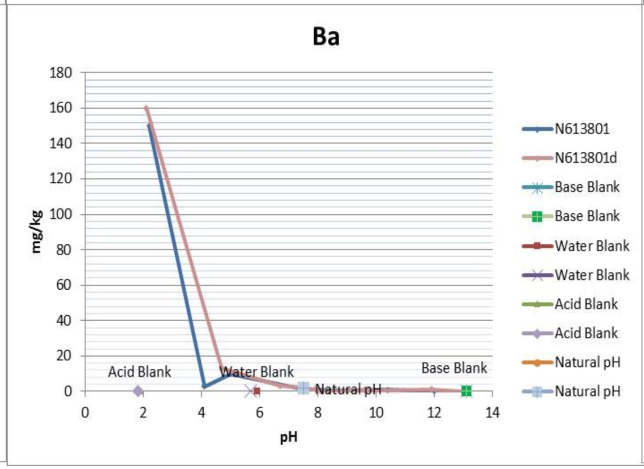

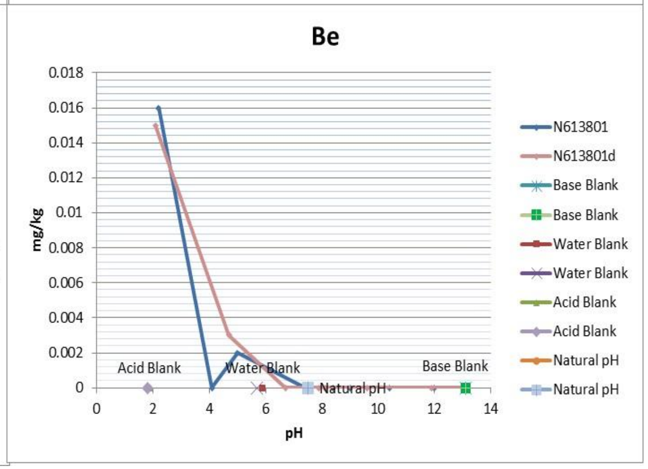

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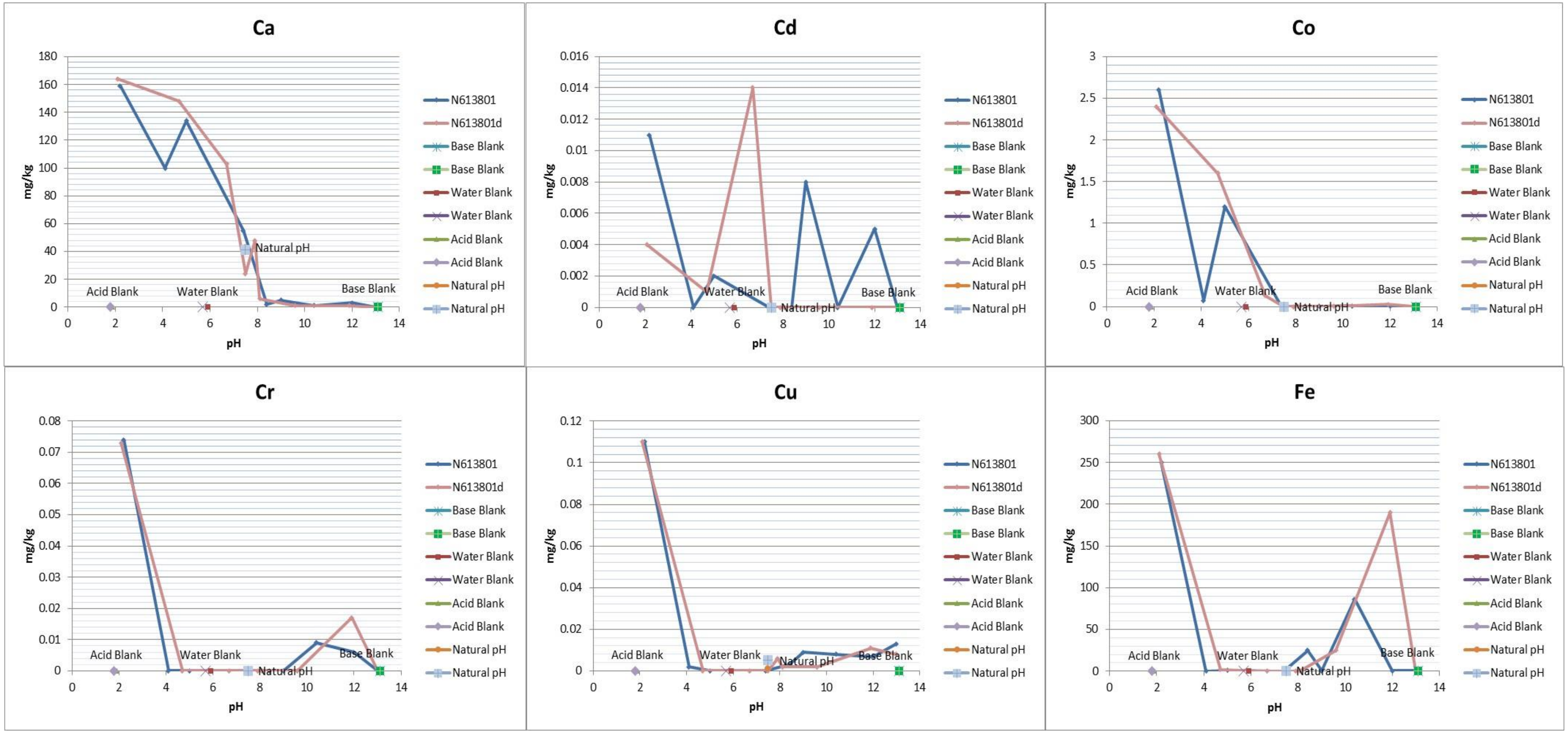

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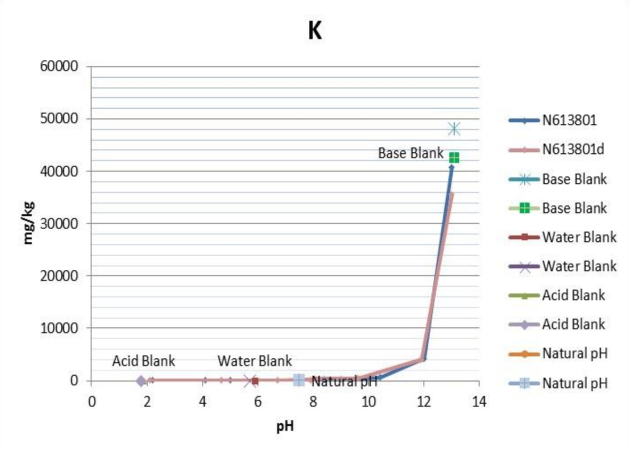

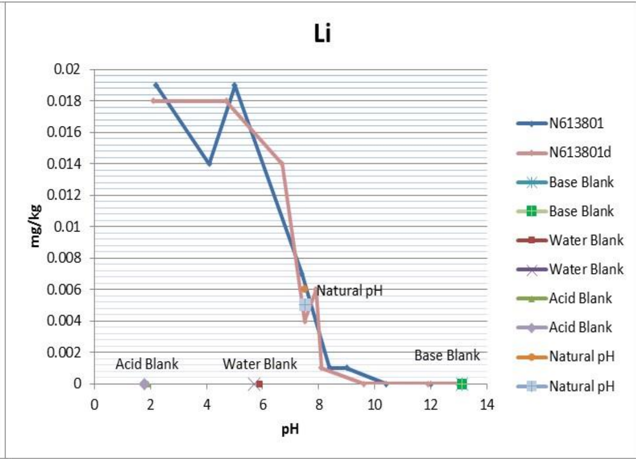

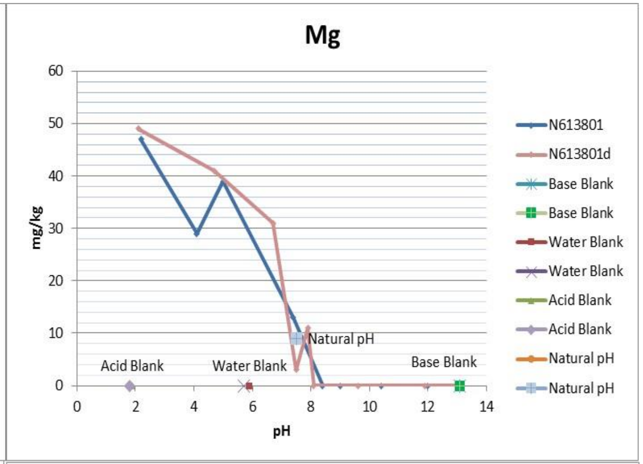

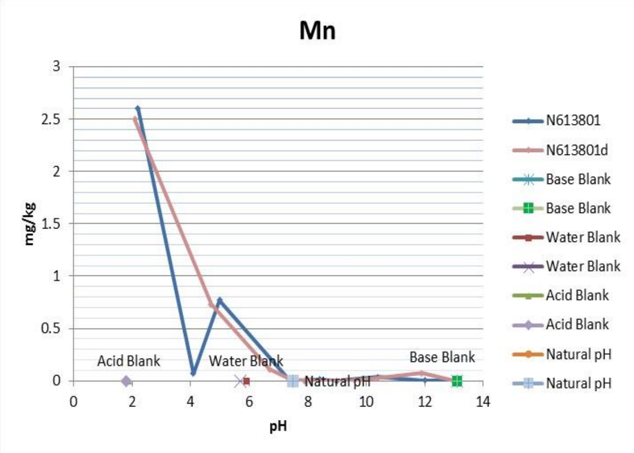

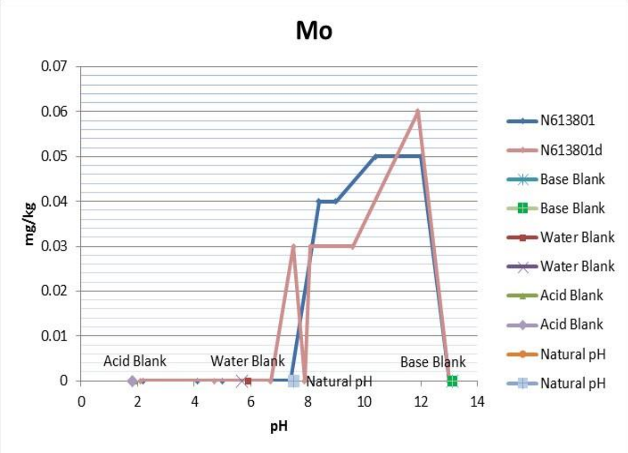

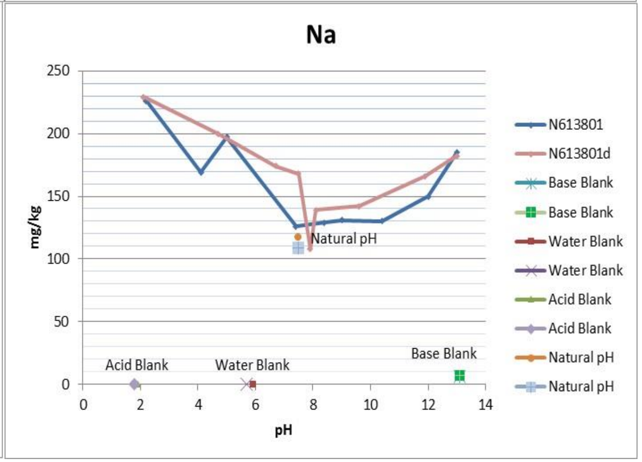

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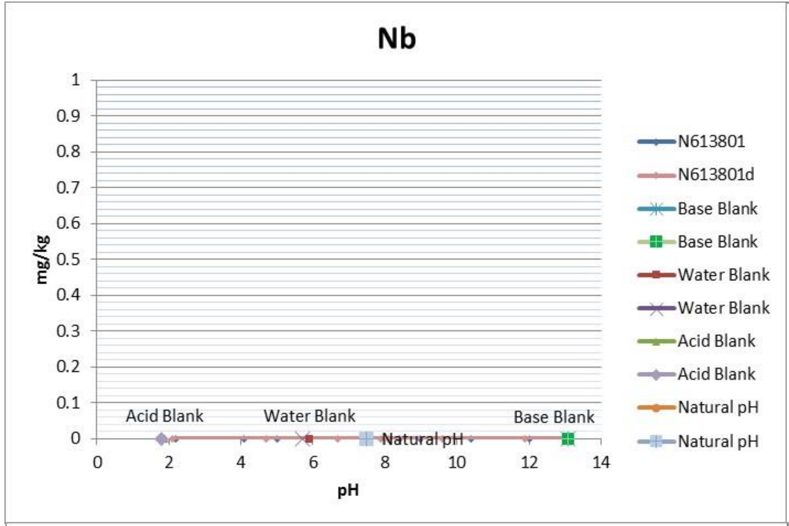

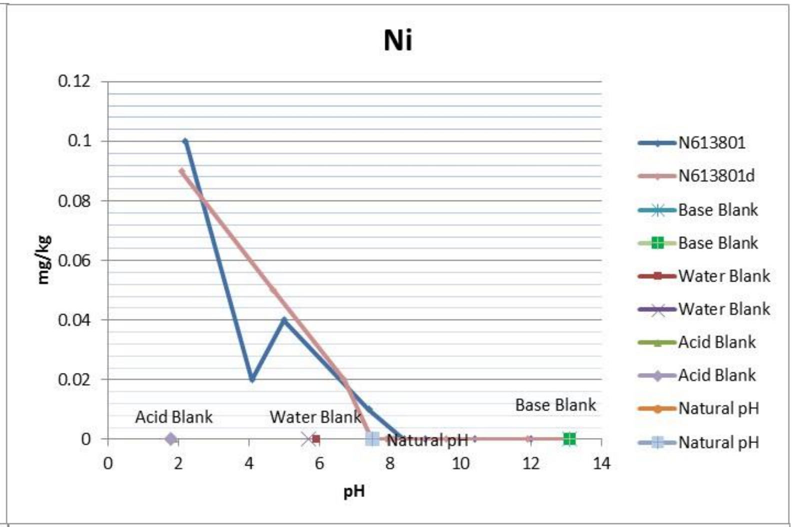

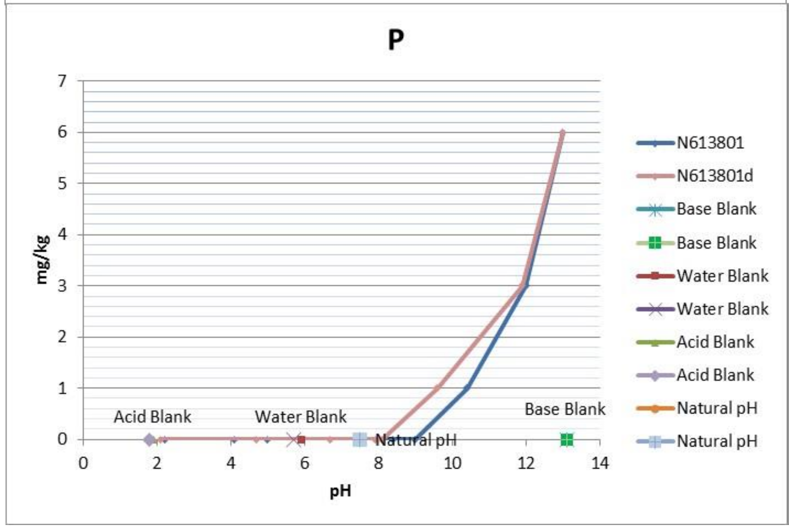

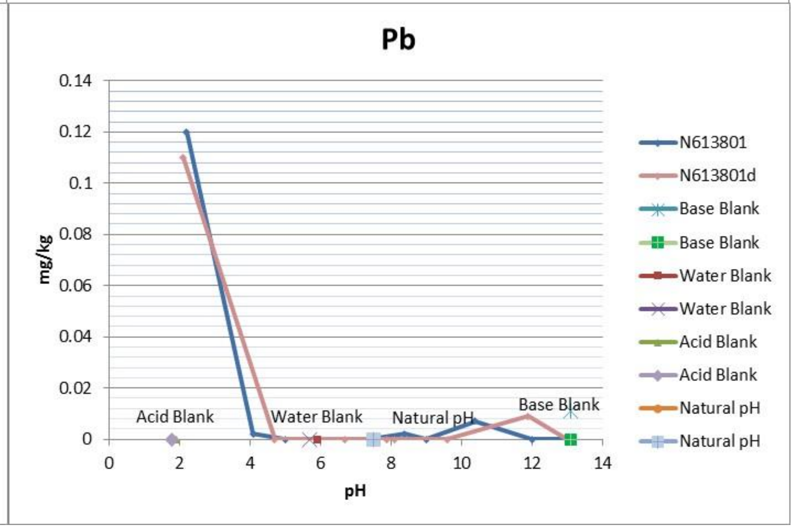

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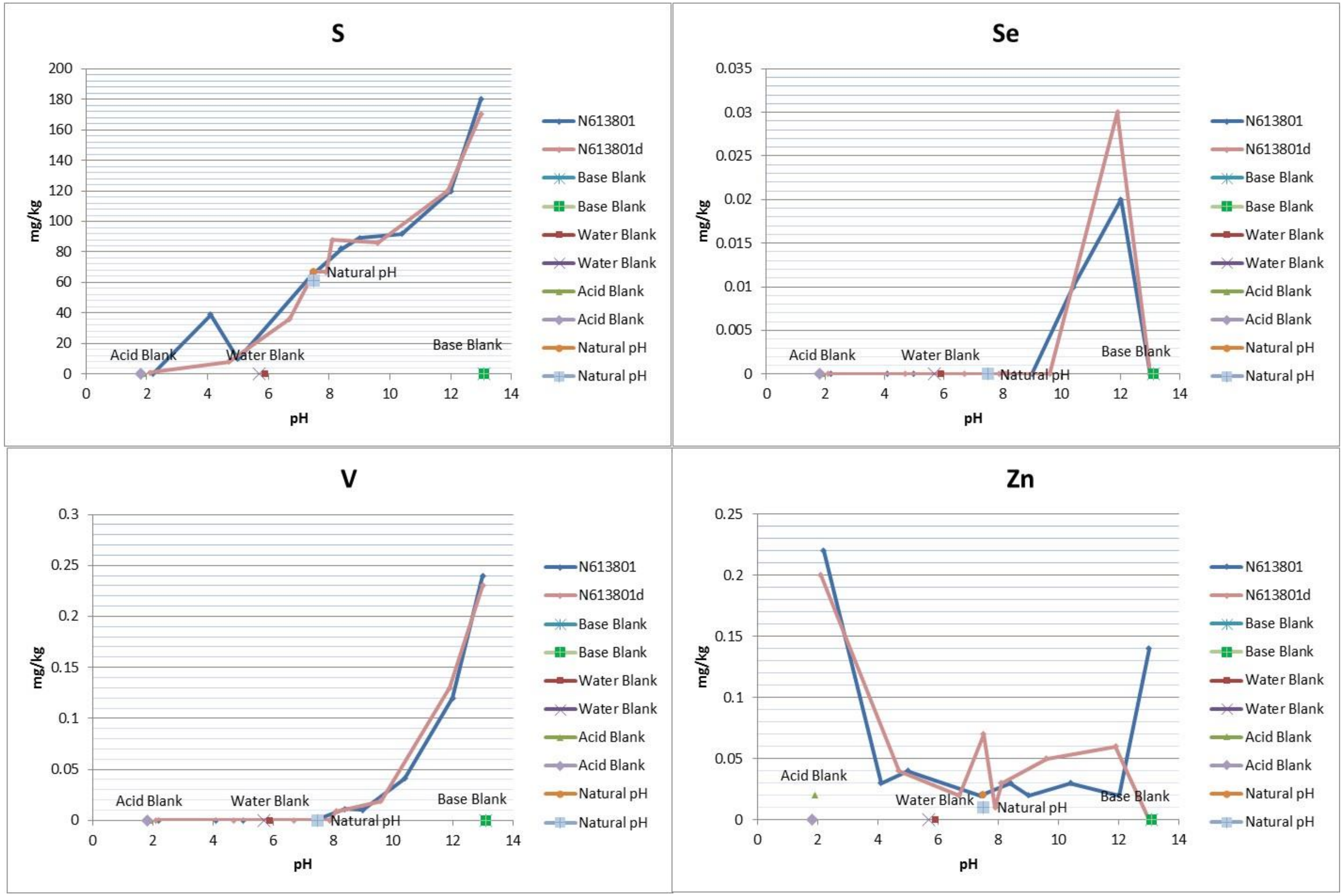
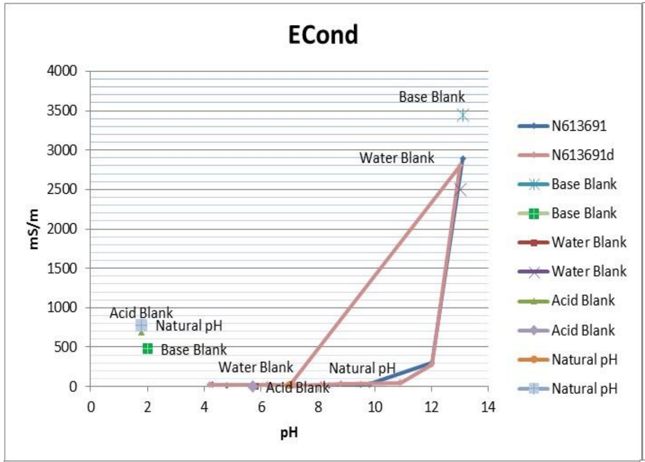
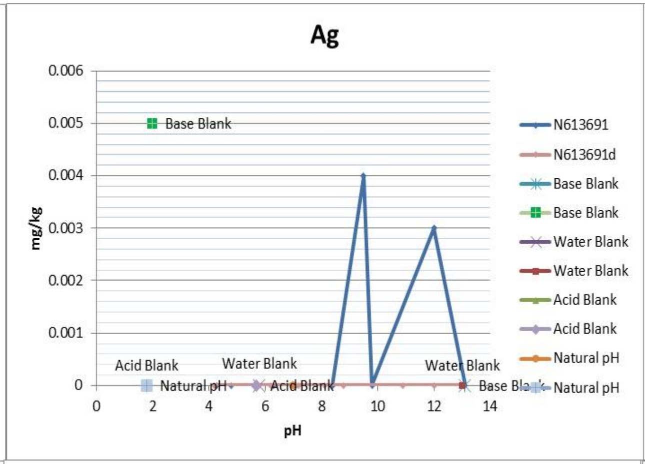
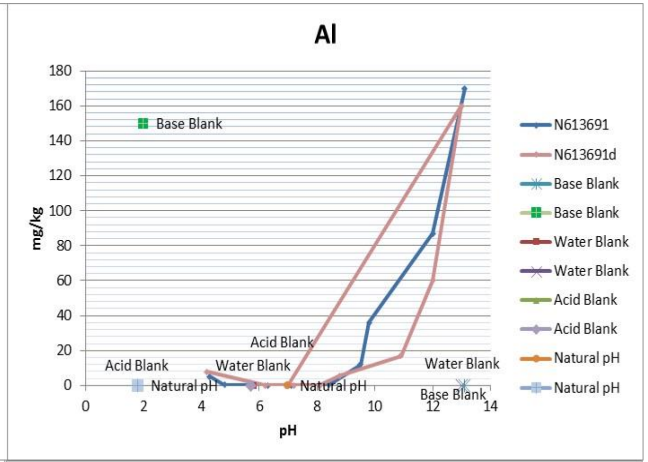
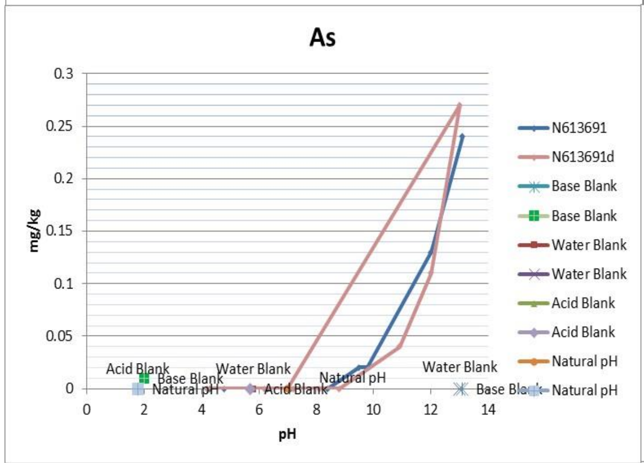


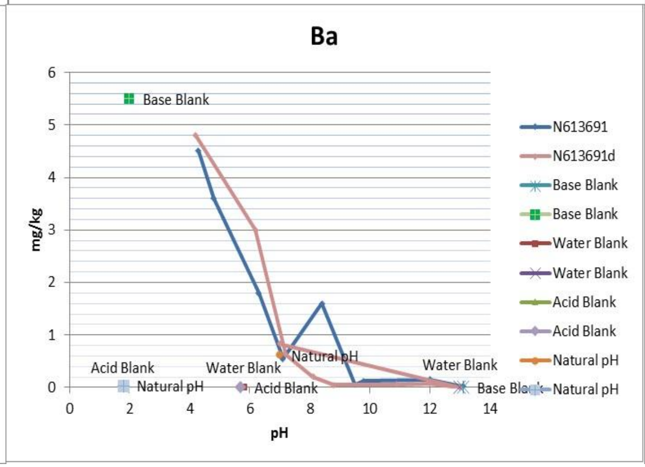
MM/OB29 Trans (N613691)

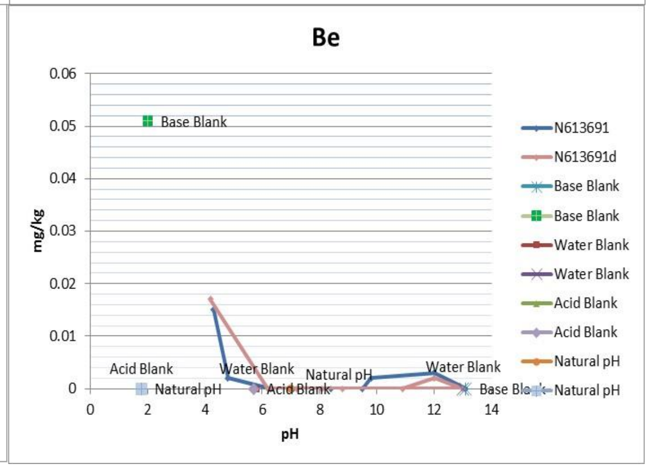












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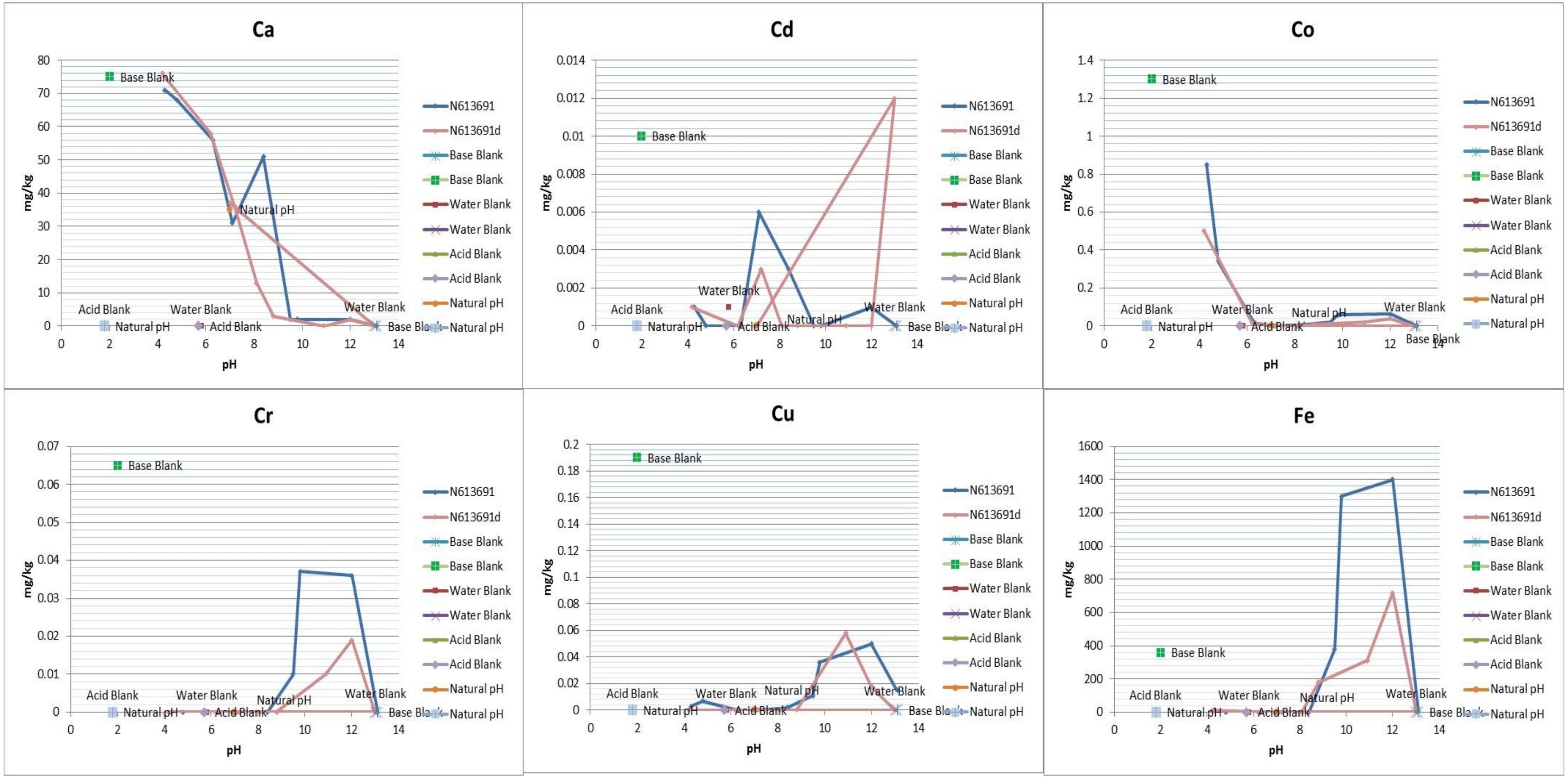

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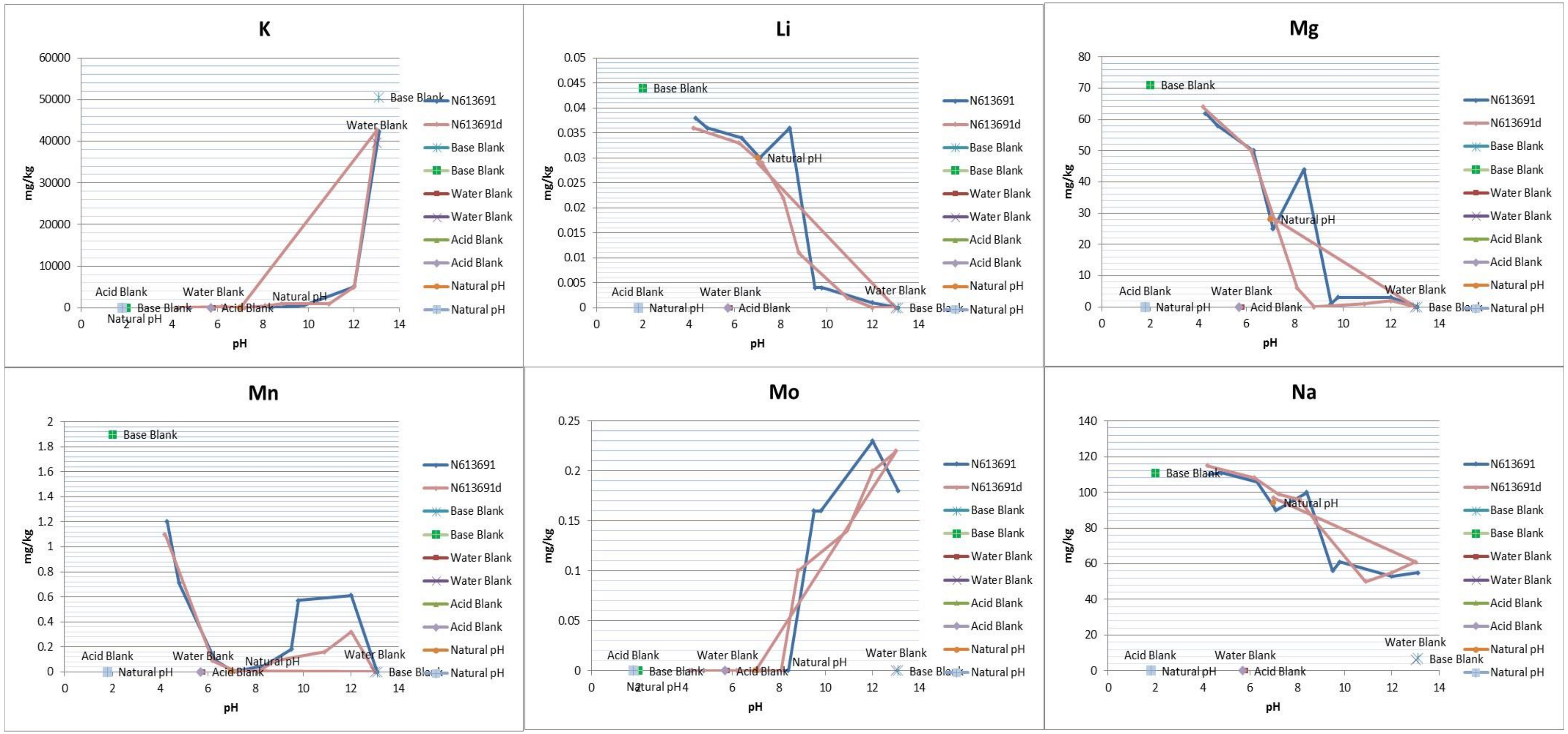

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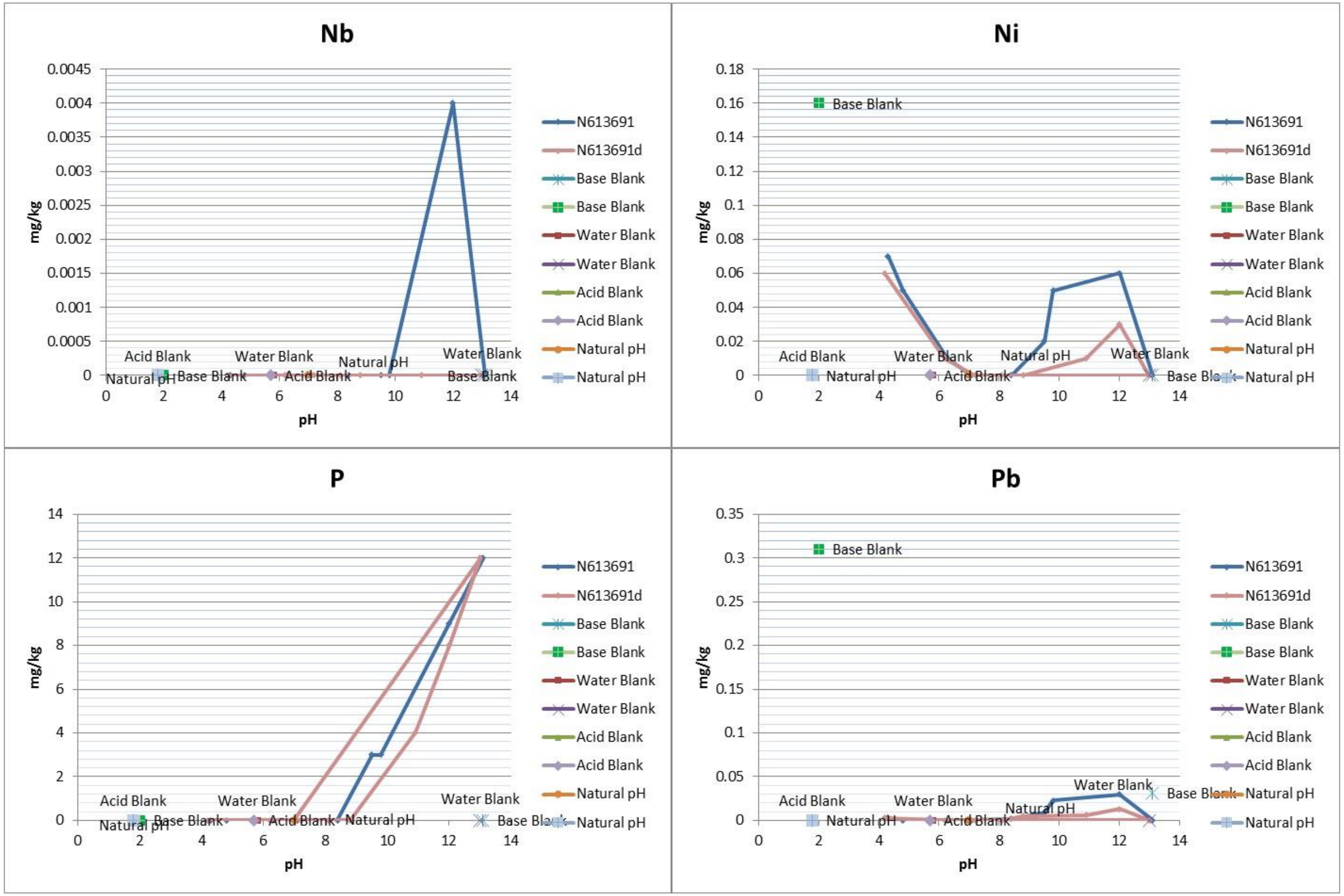

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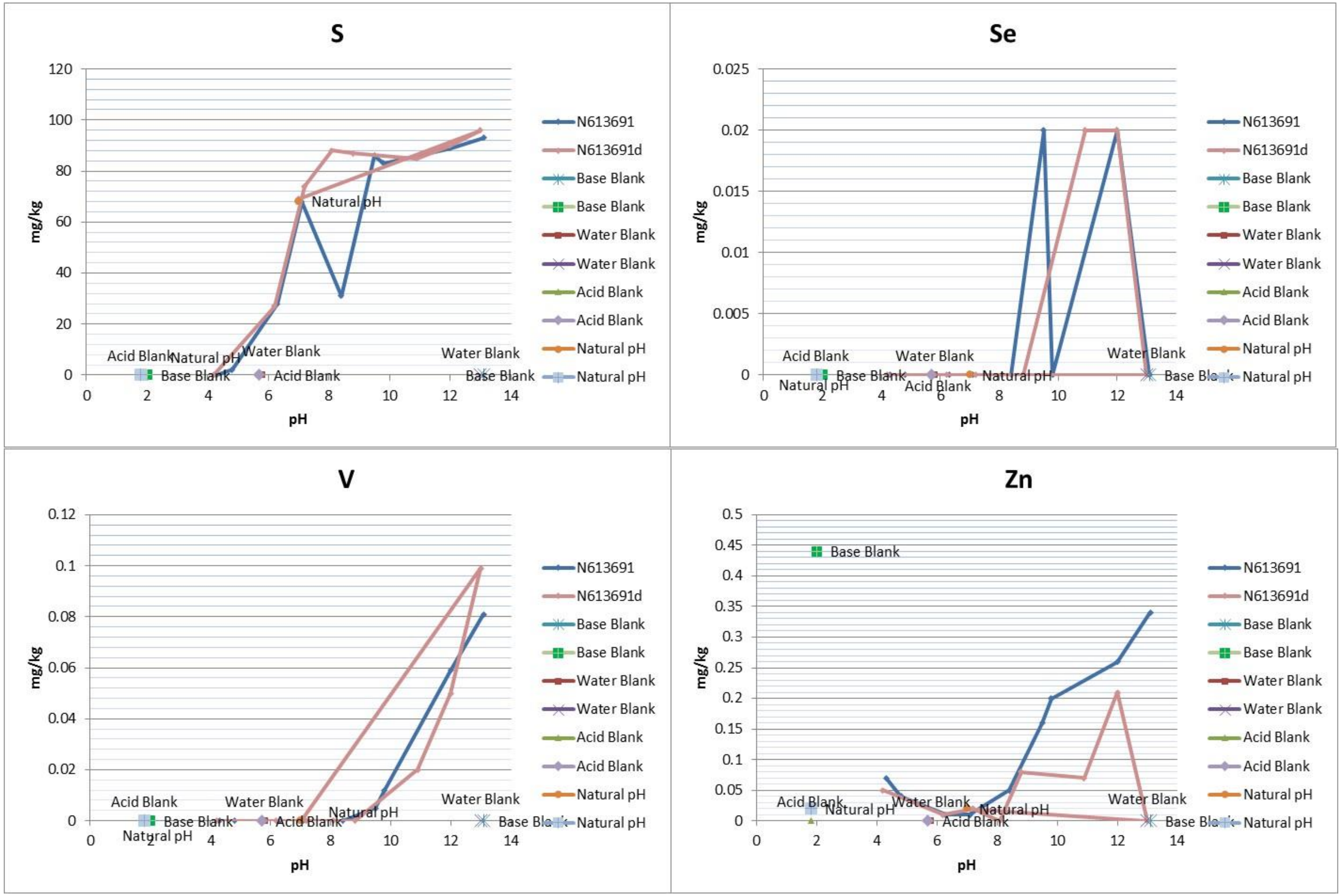
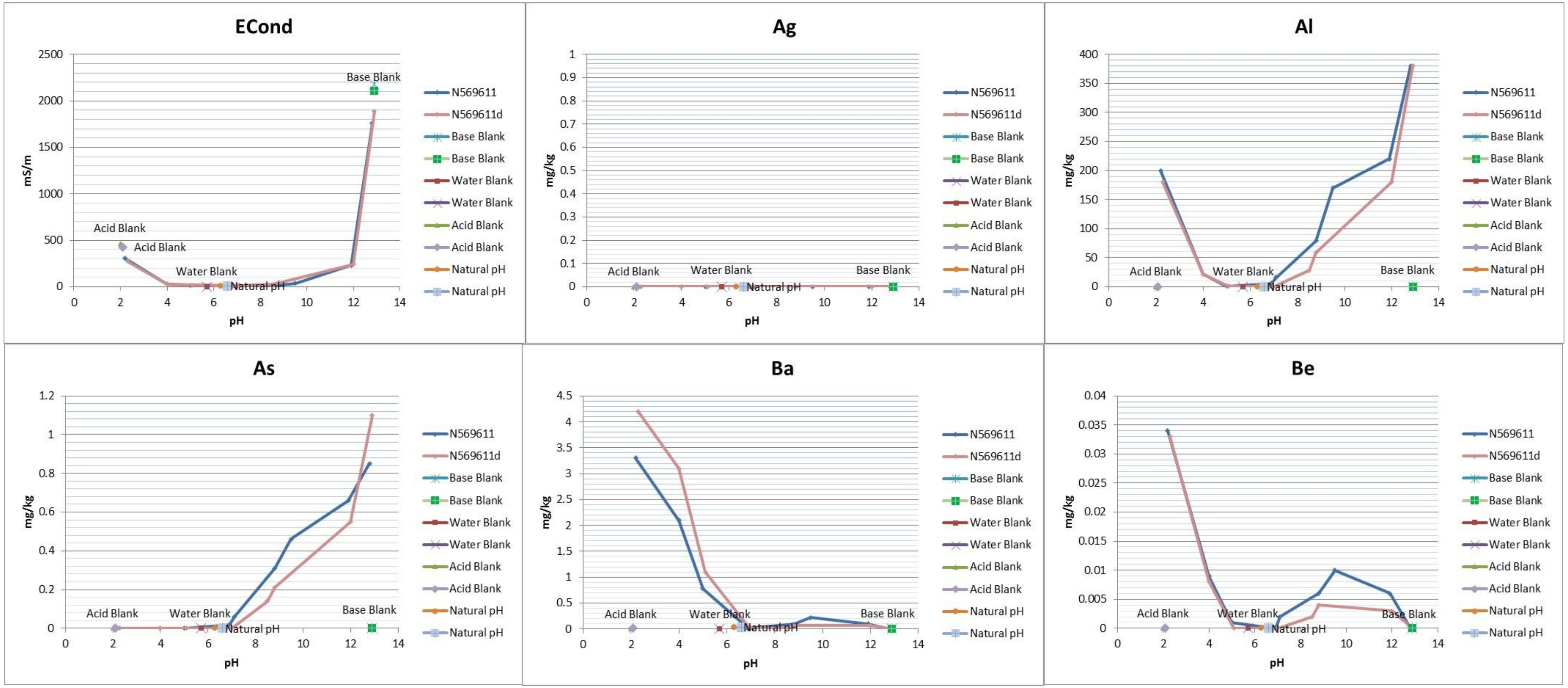


W/OB25 trans (N569611)



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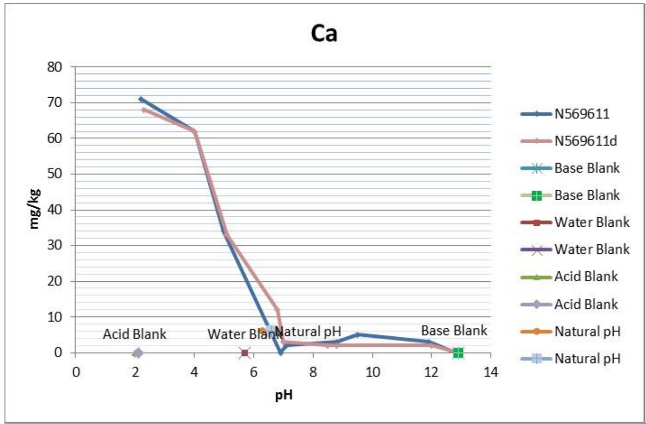

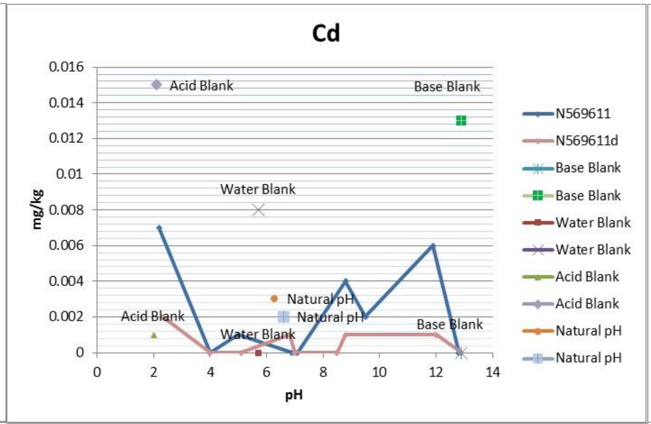

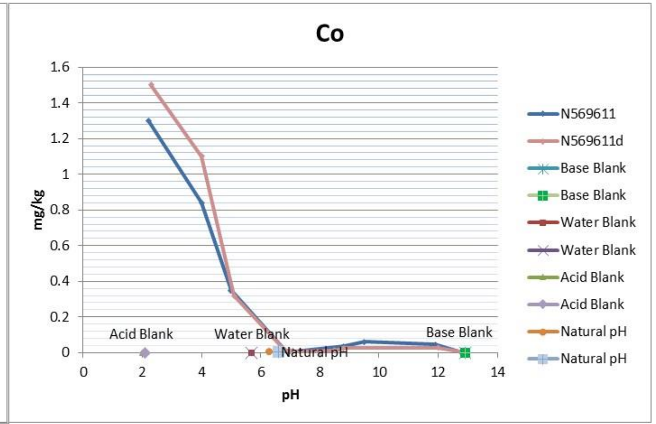

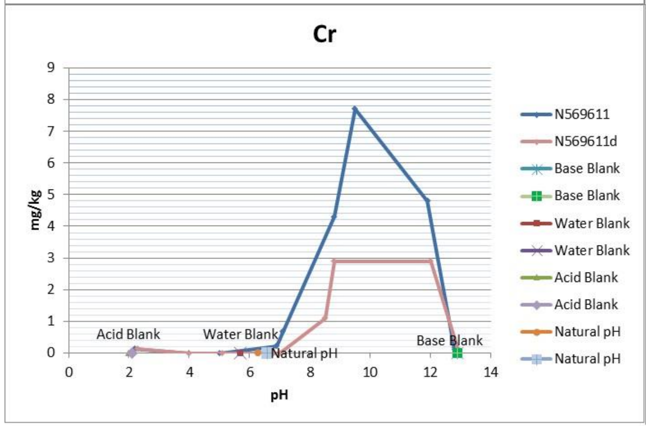

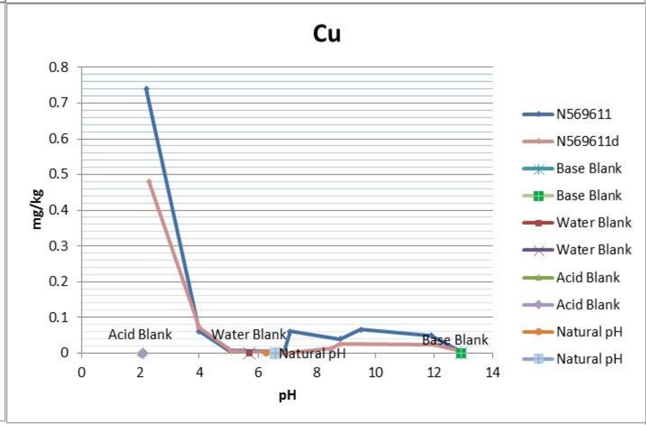

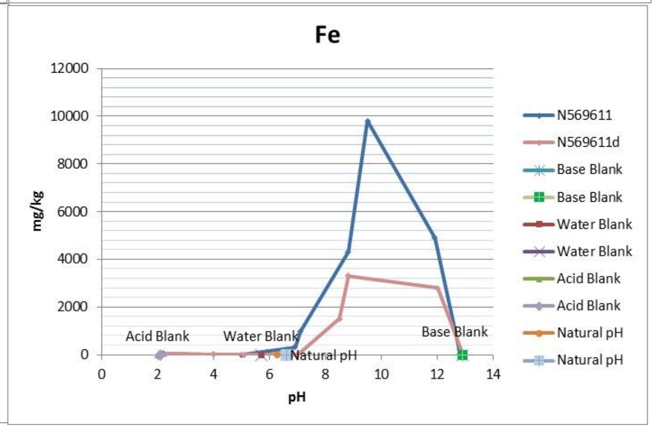

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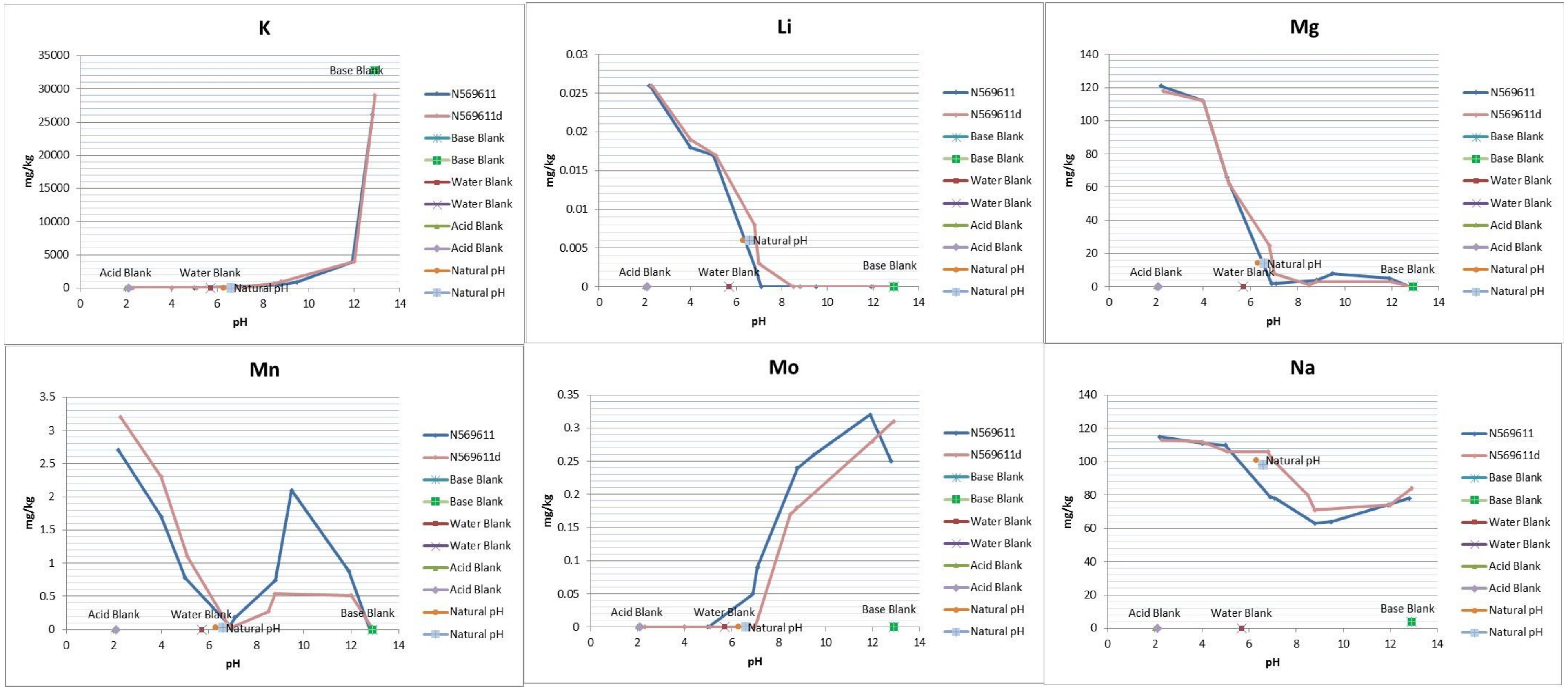

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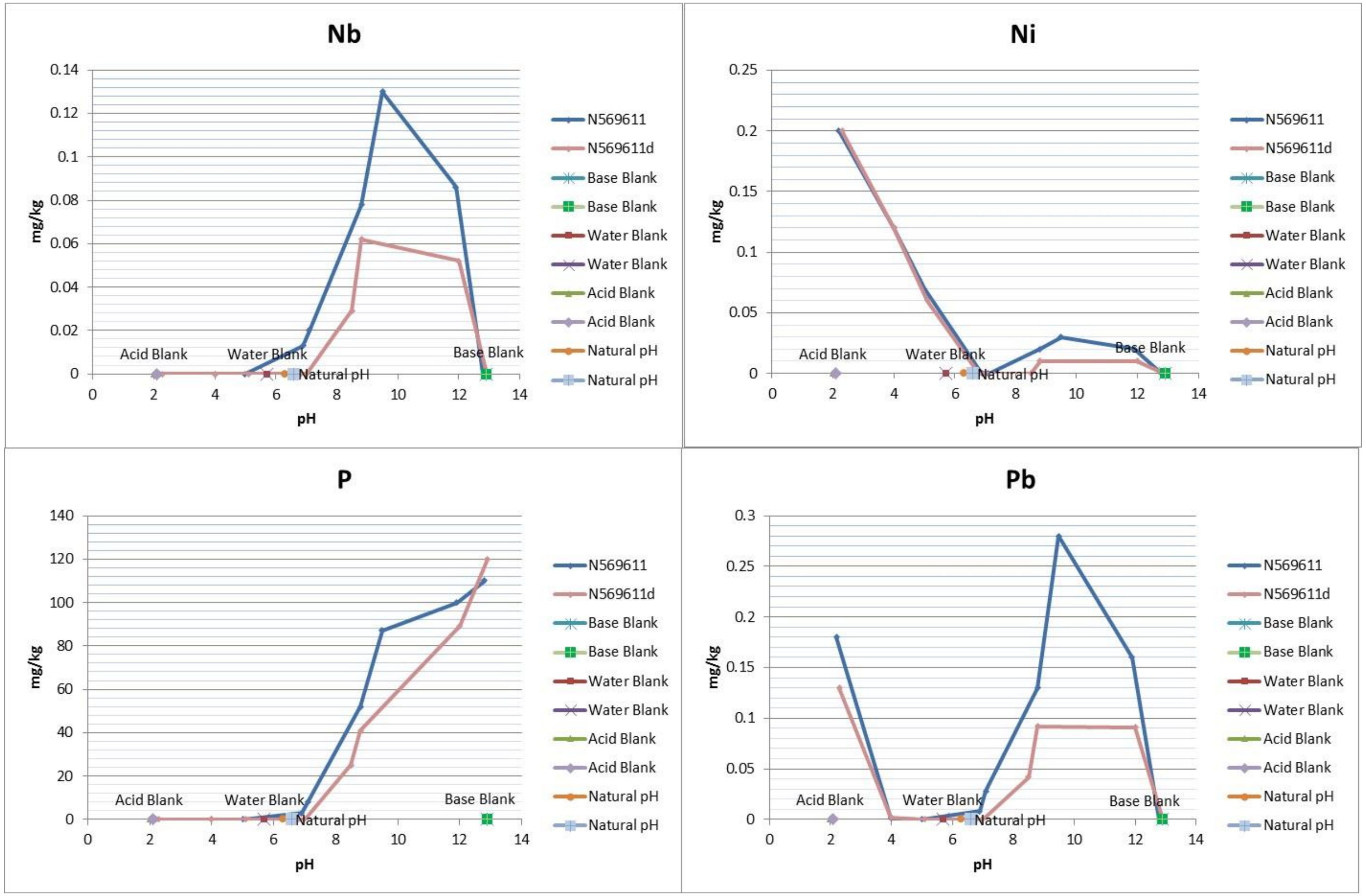

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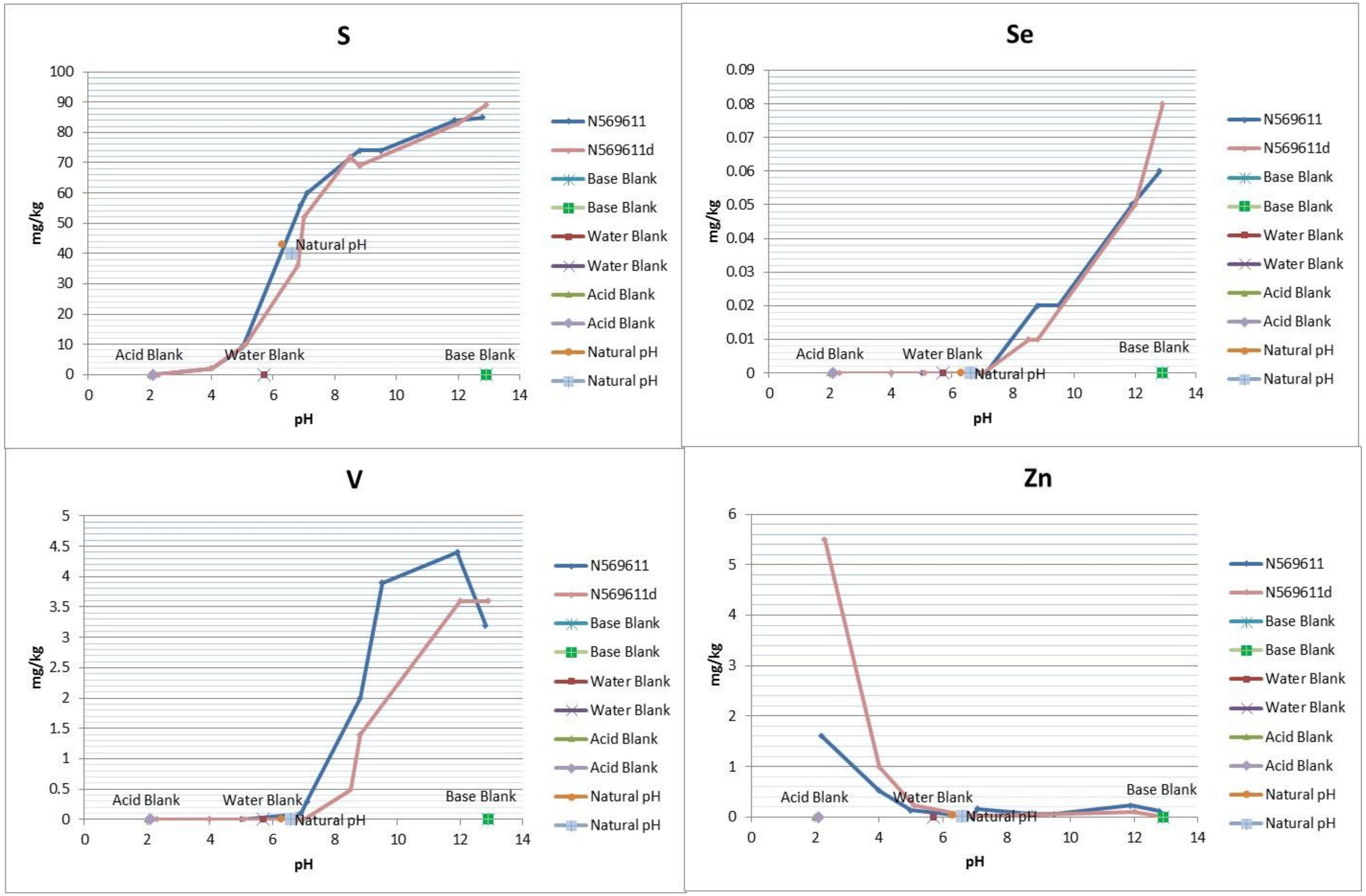
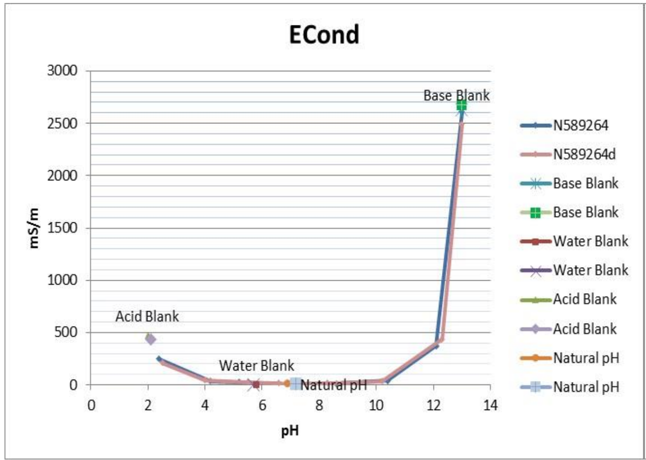
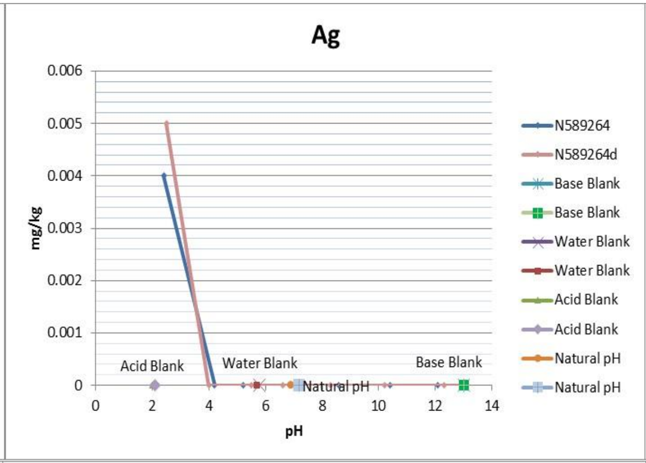
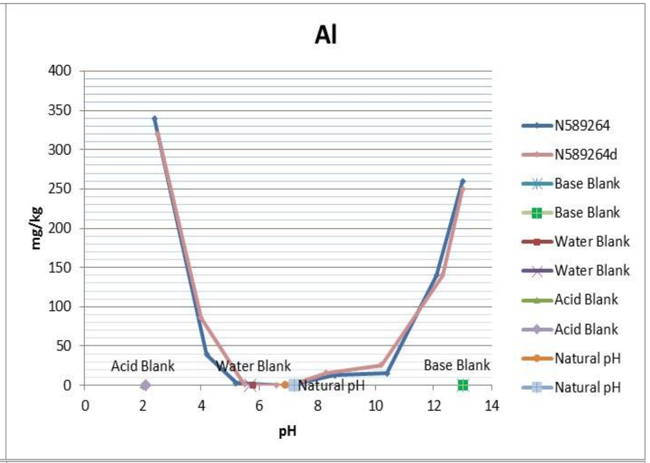
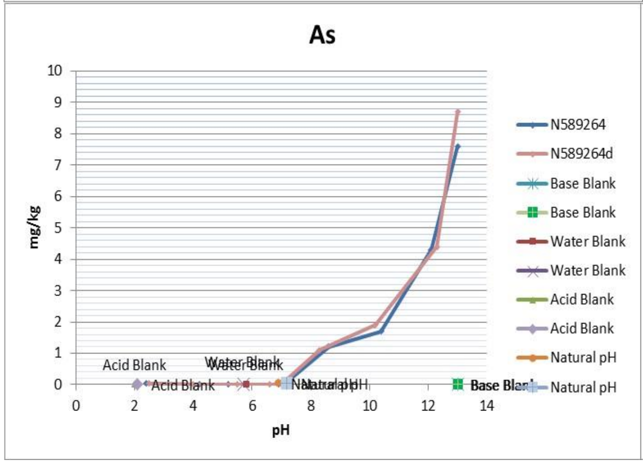


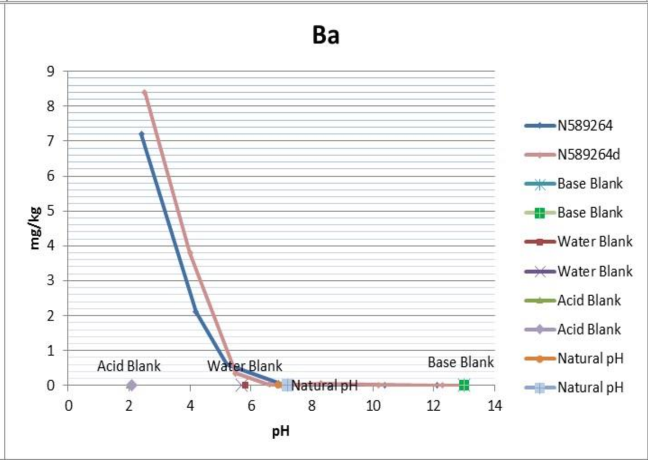
W/OB25 Fresh (N589264)

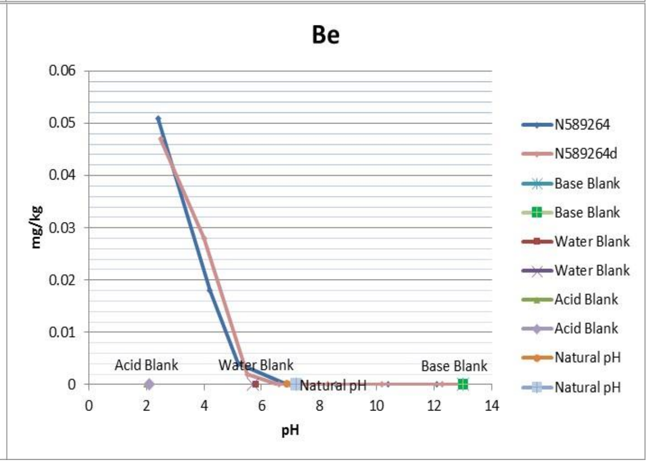












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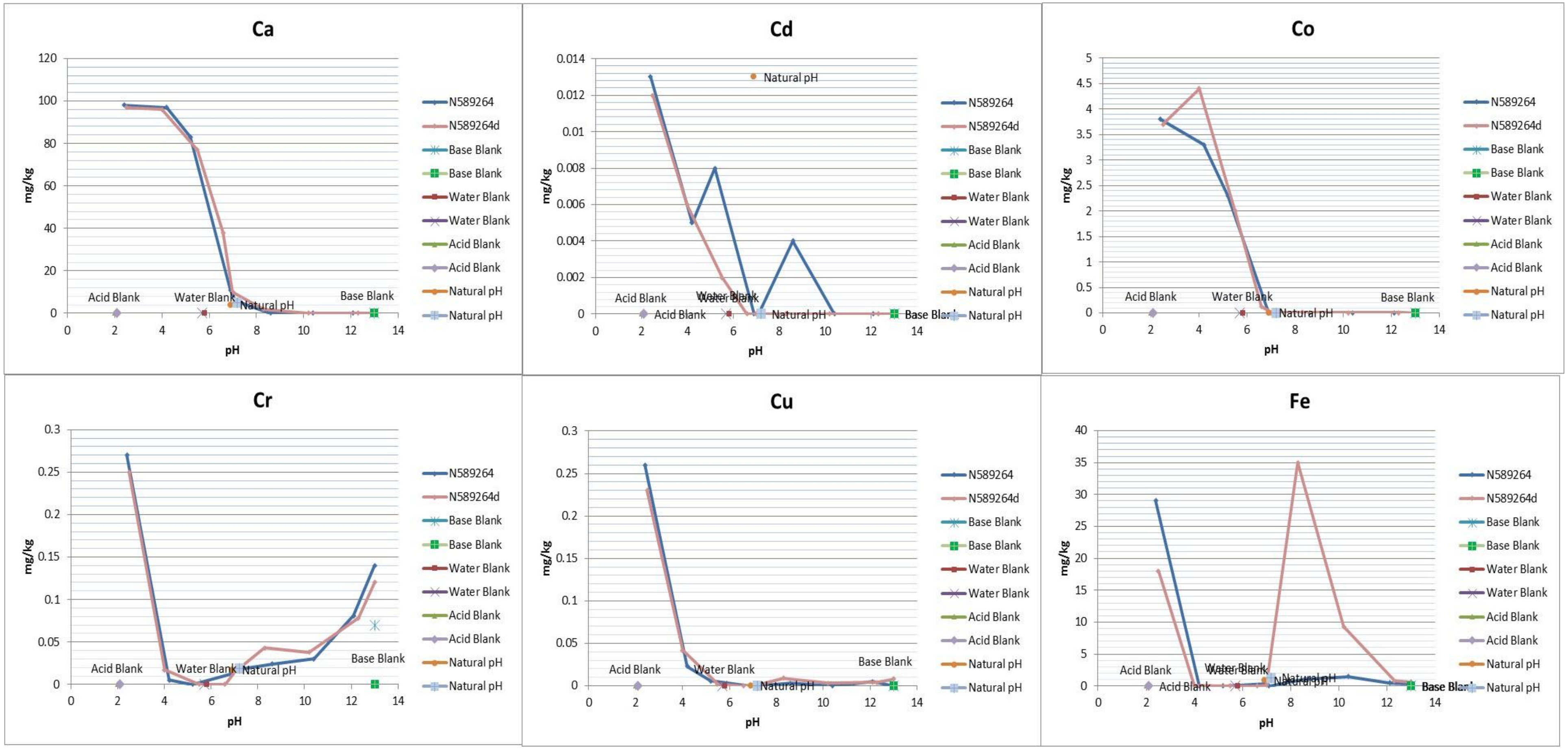

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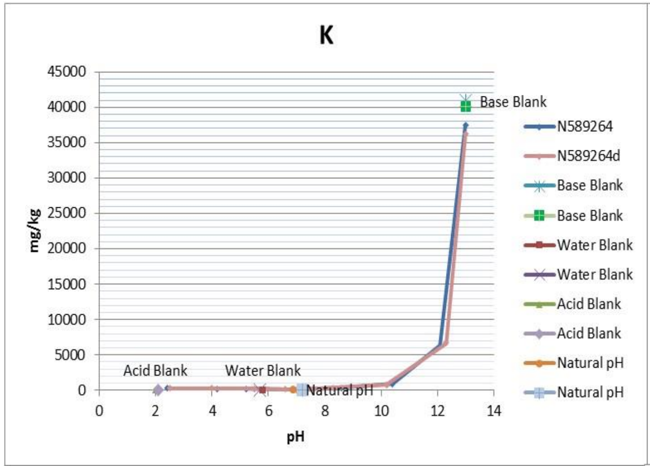

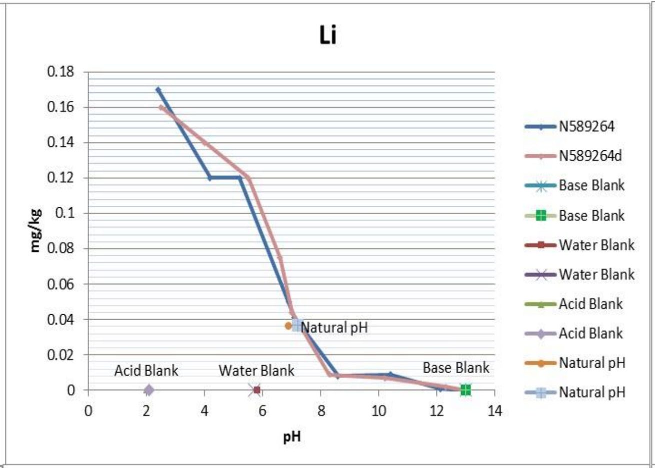

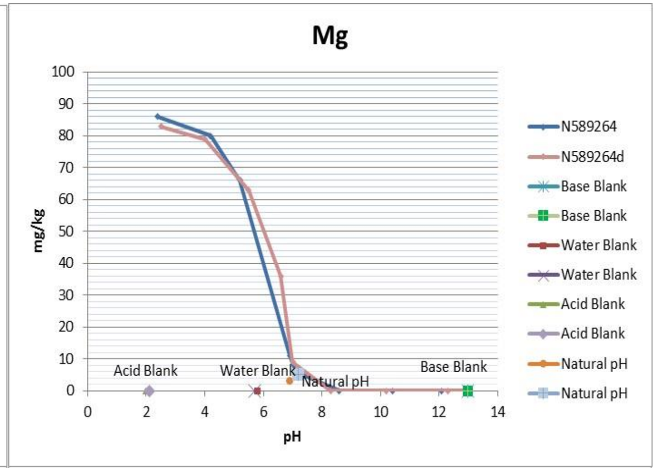

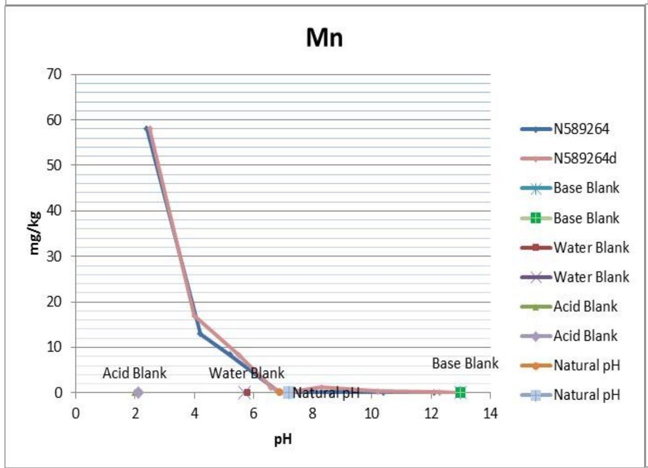

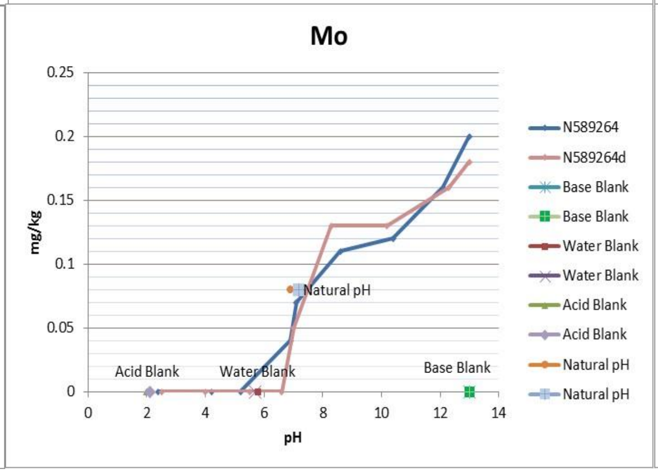

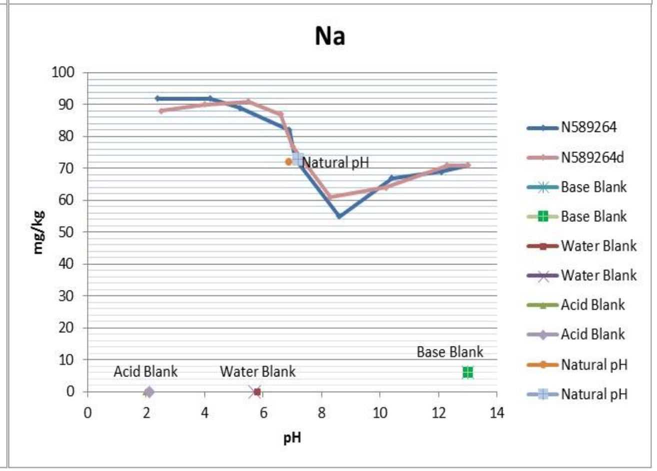

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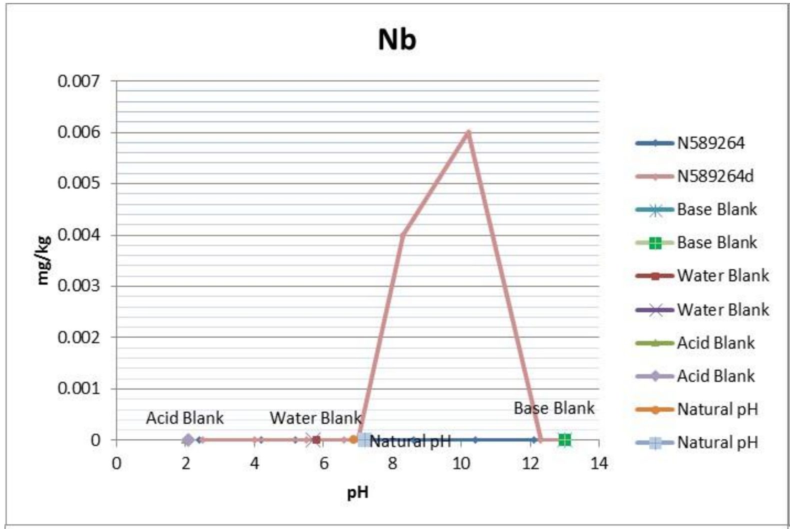

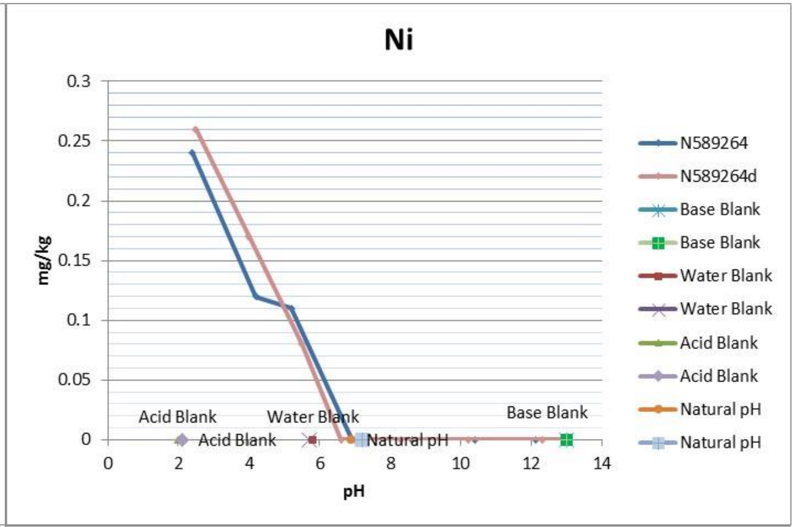

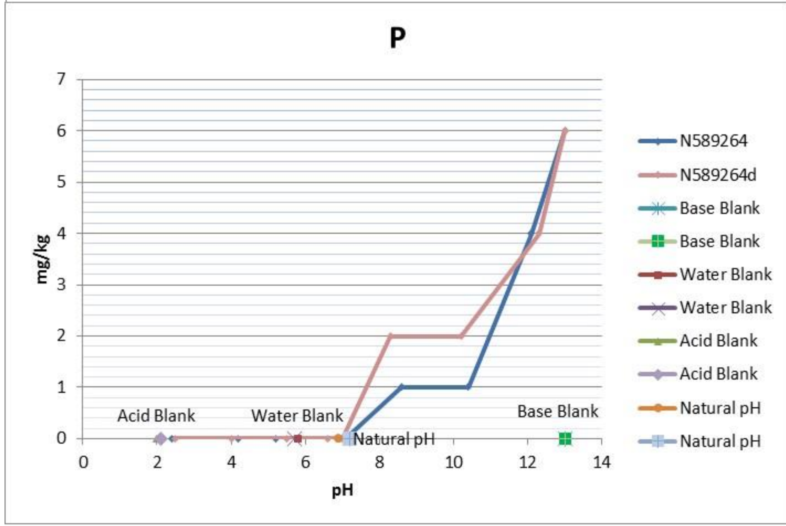

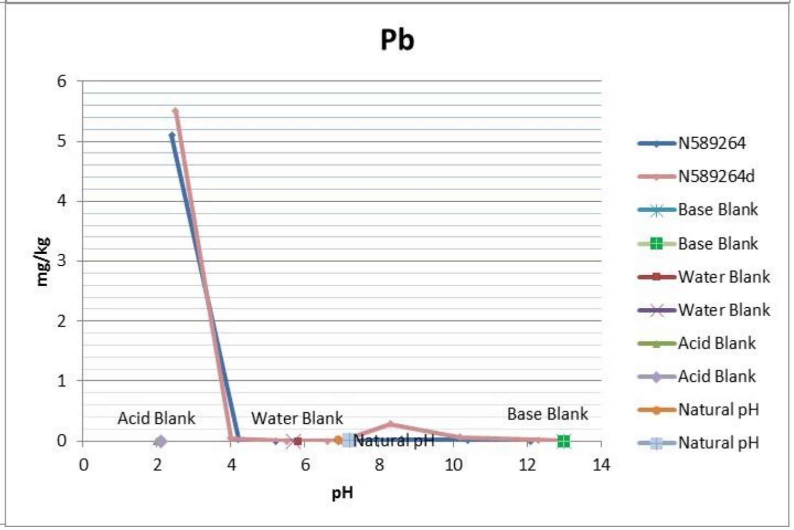

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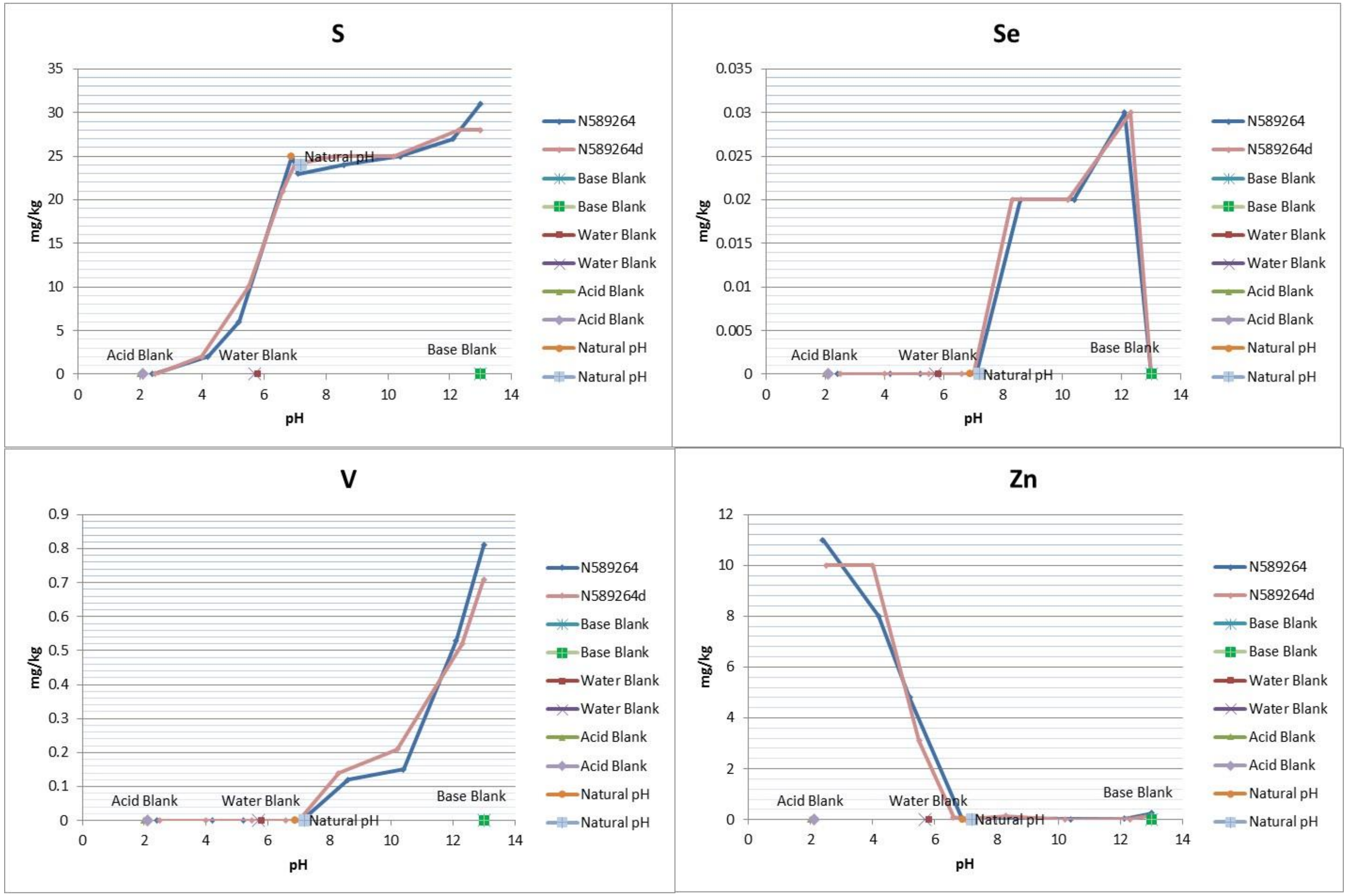

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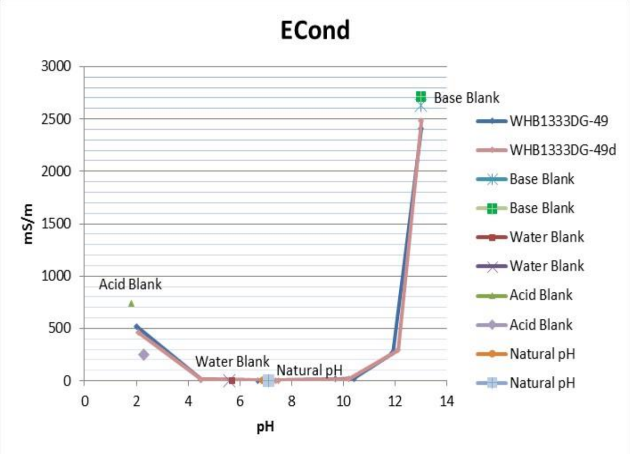

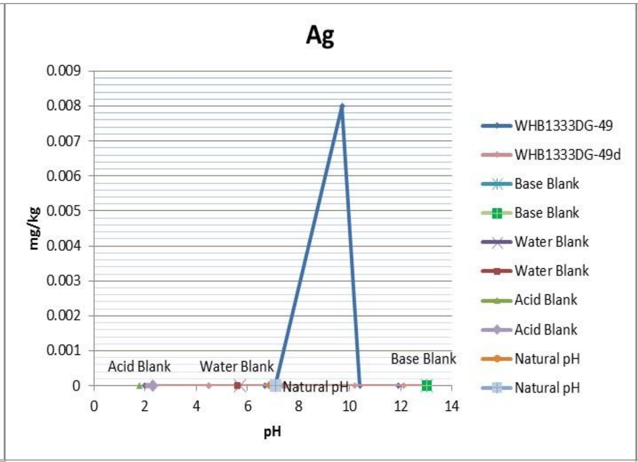

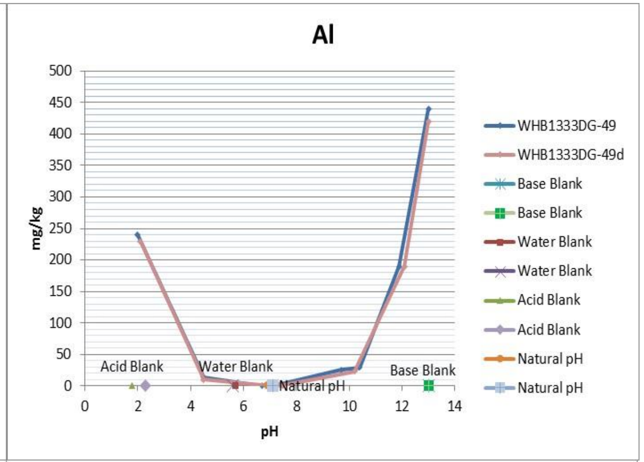

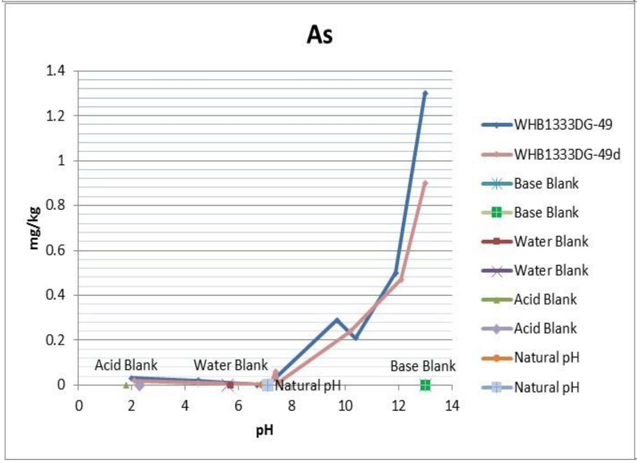

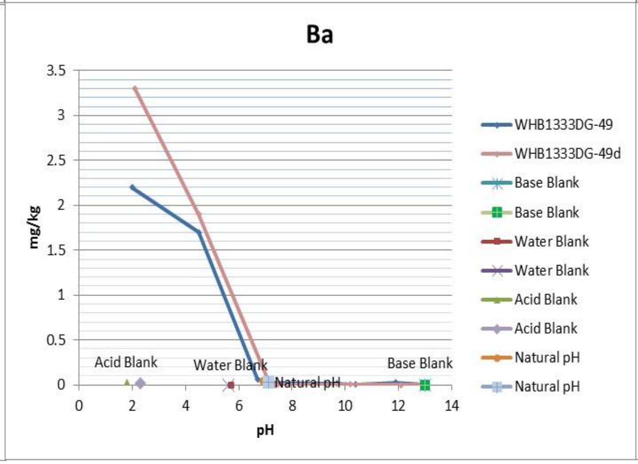

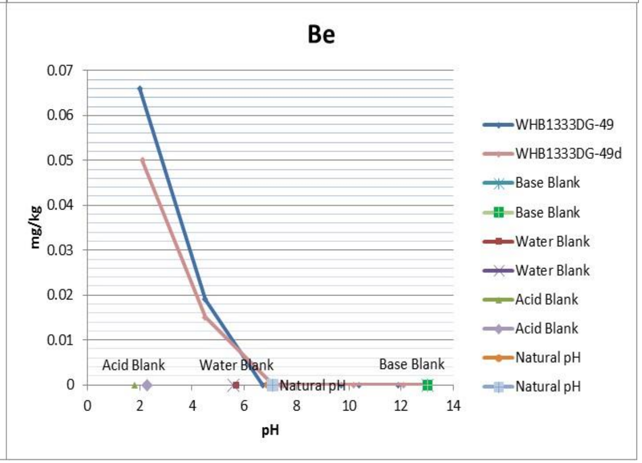

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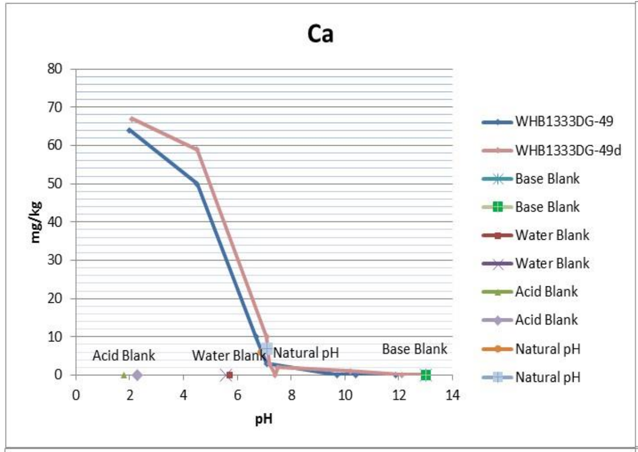

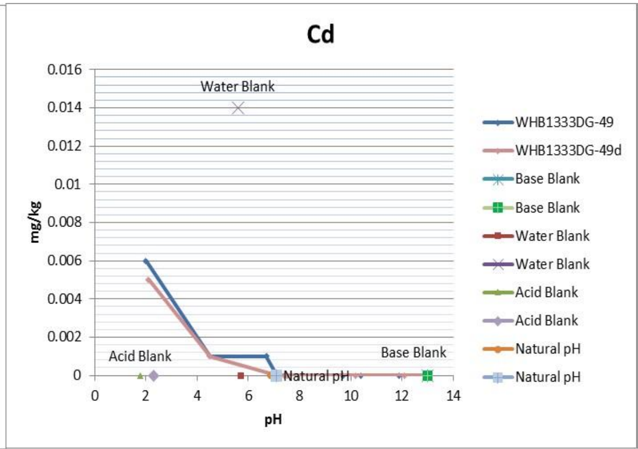

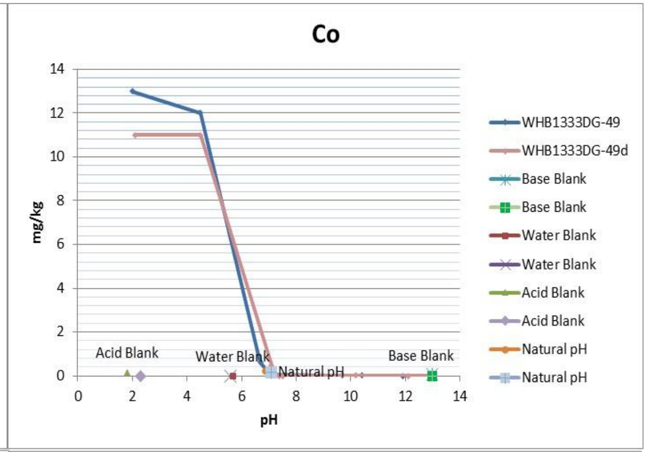

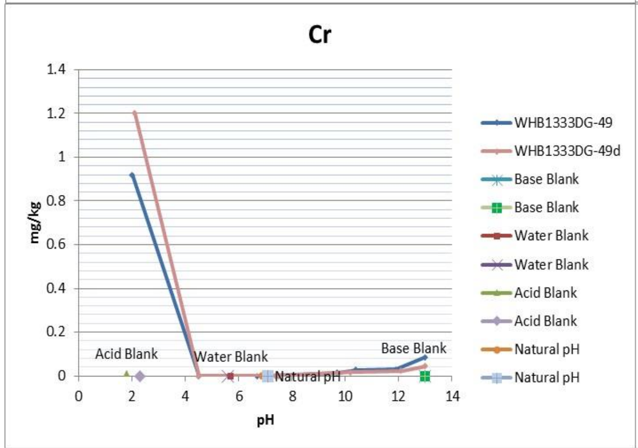

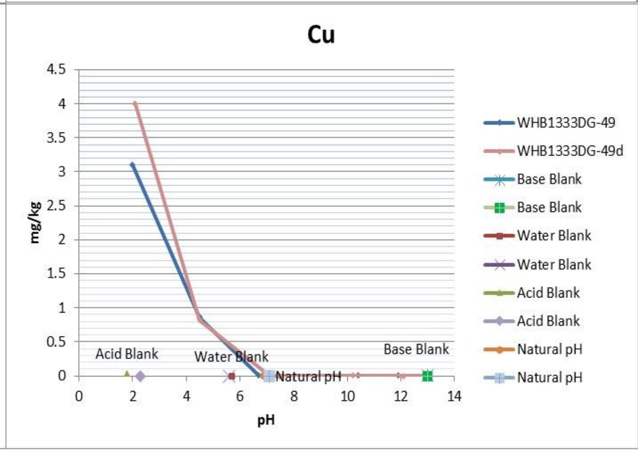

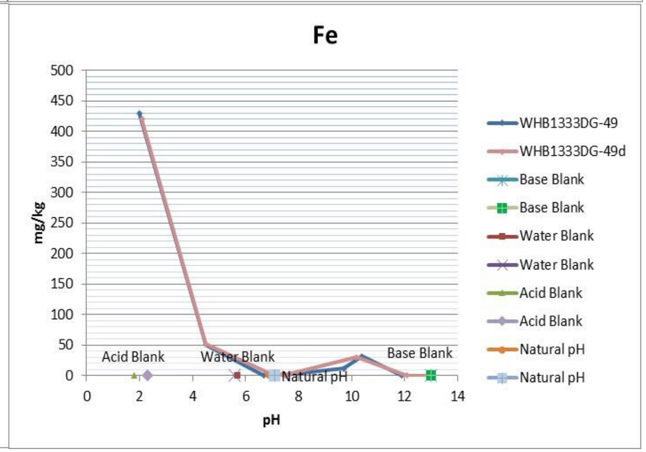

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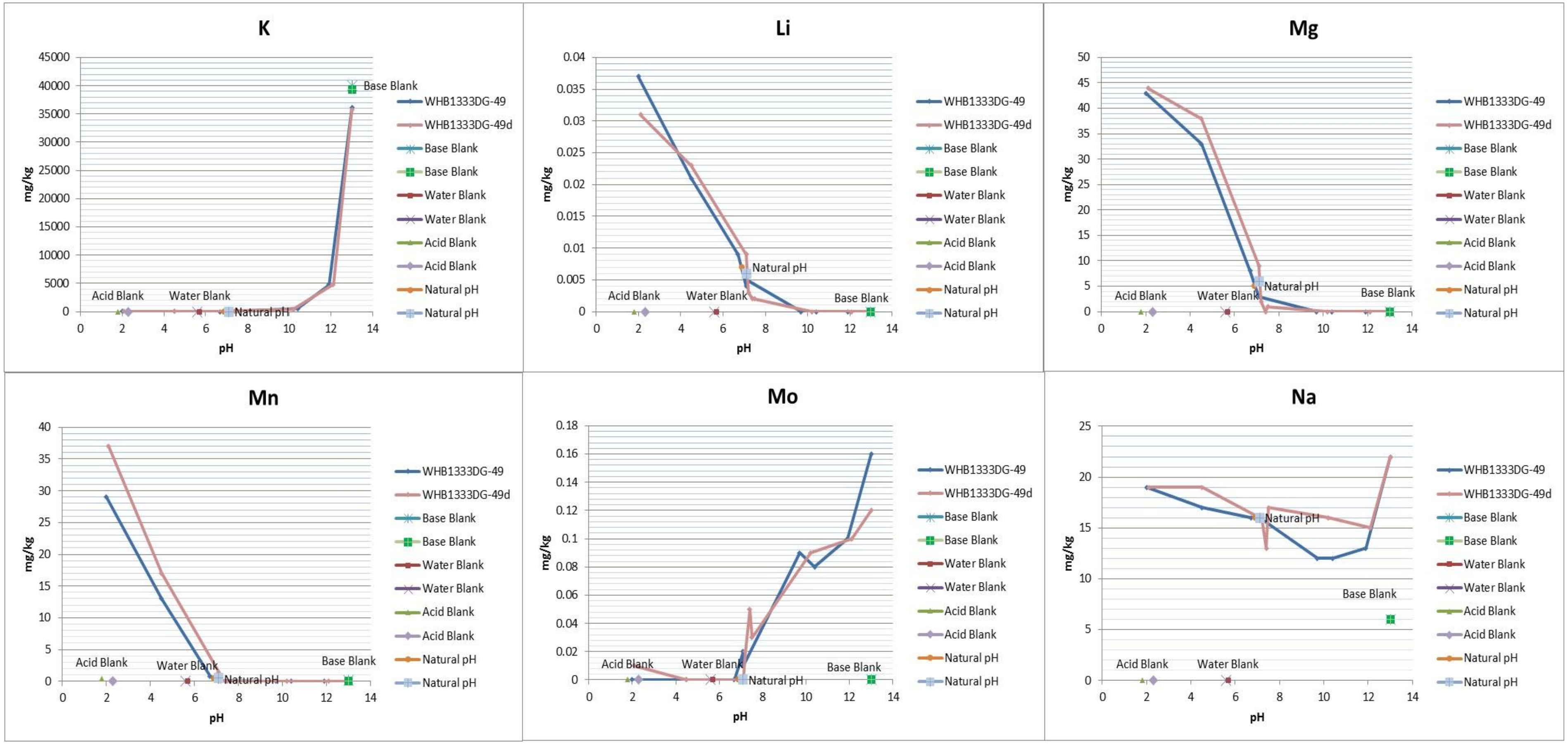

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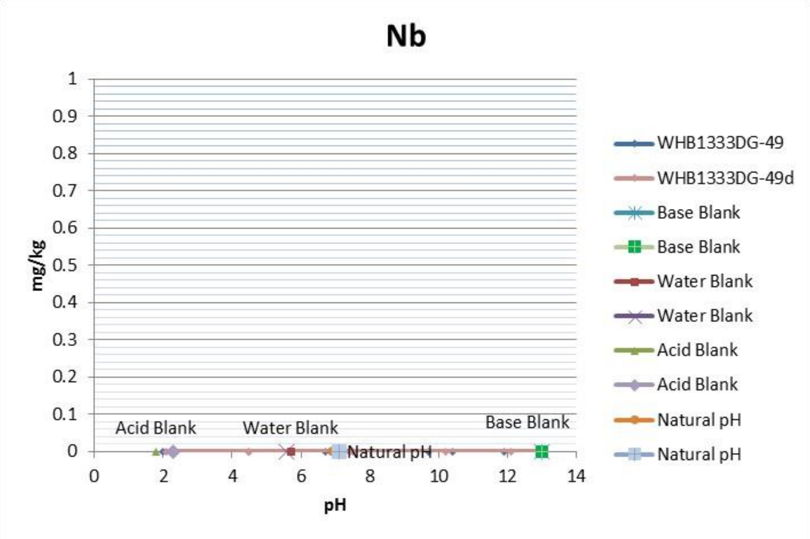

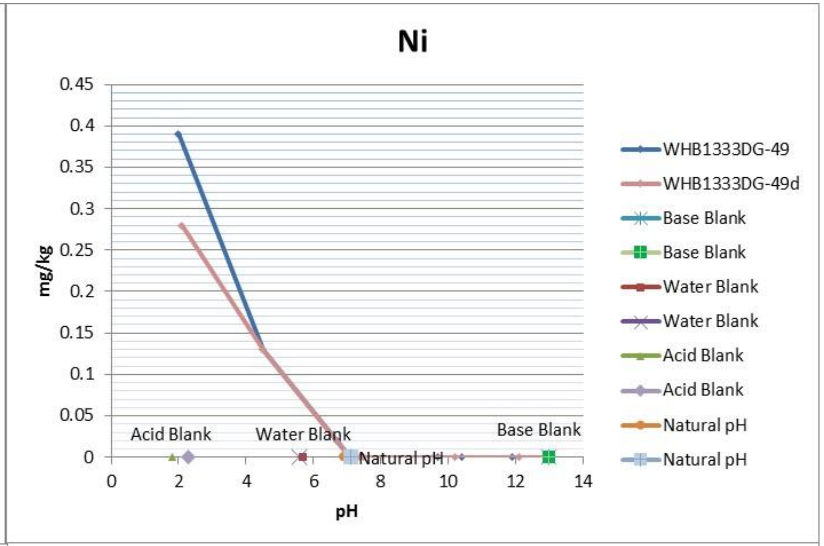

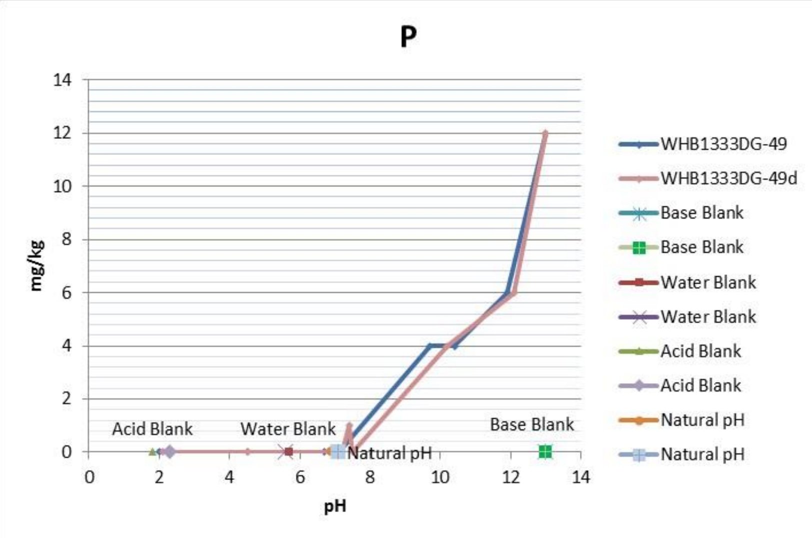

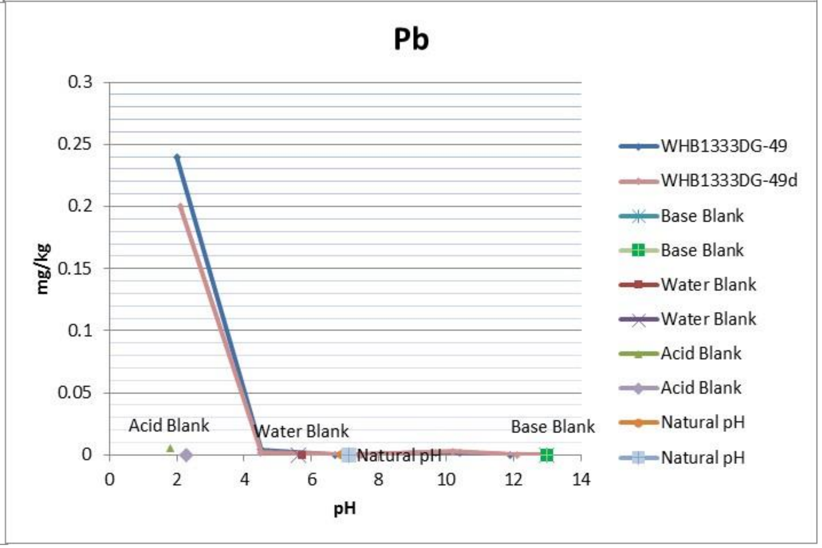

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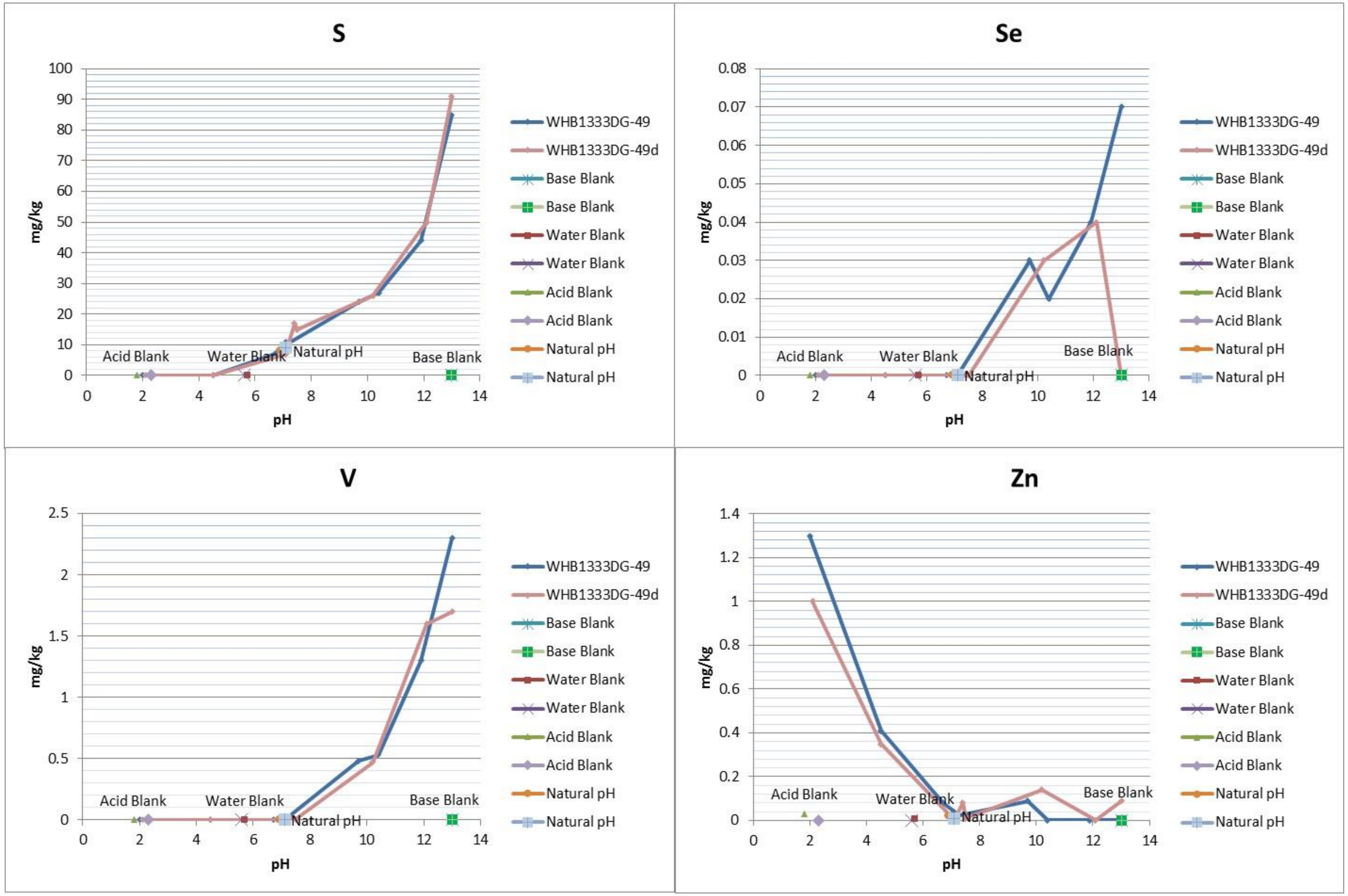

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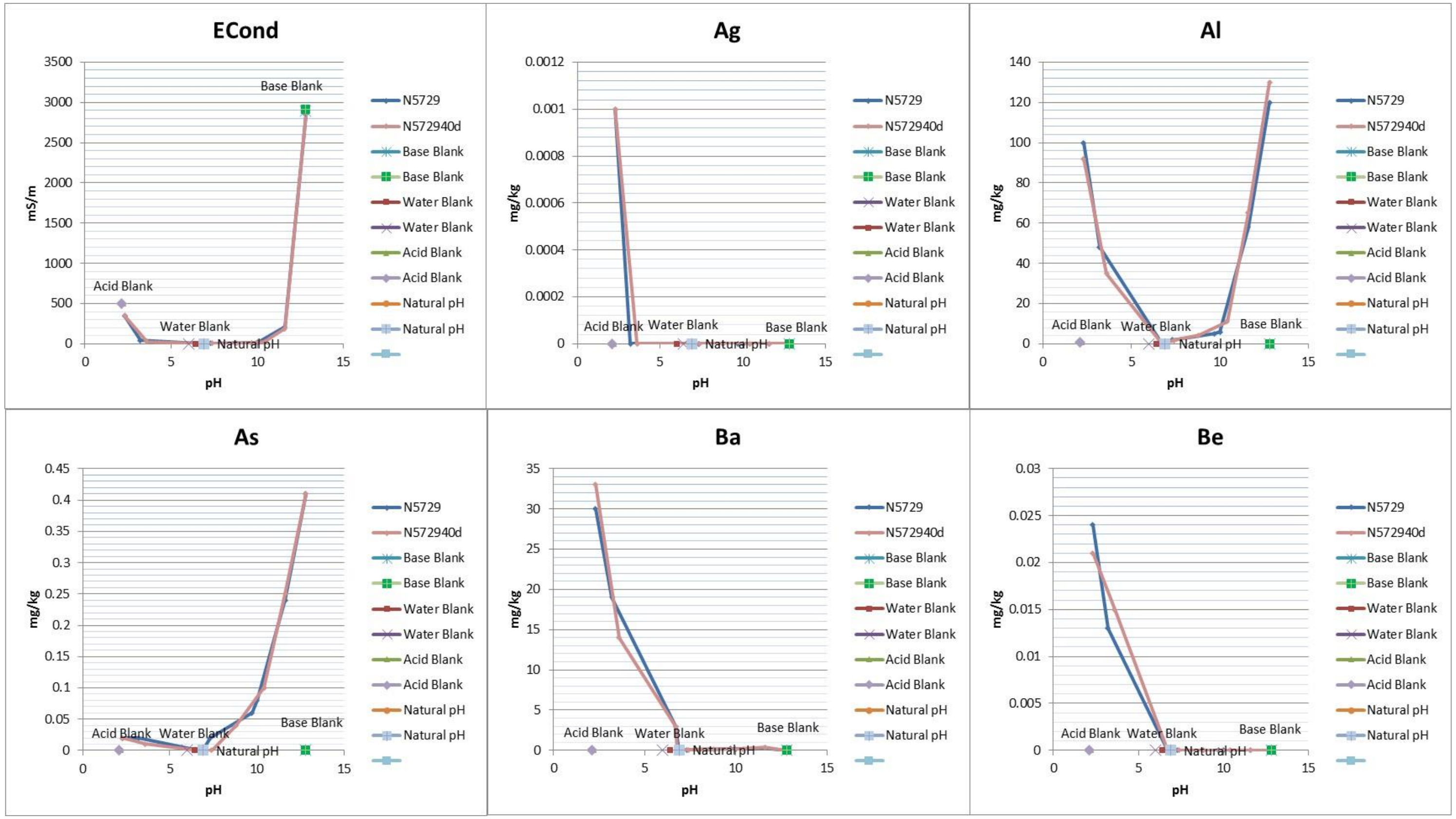

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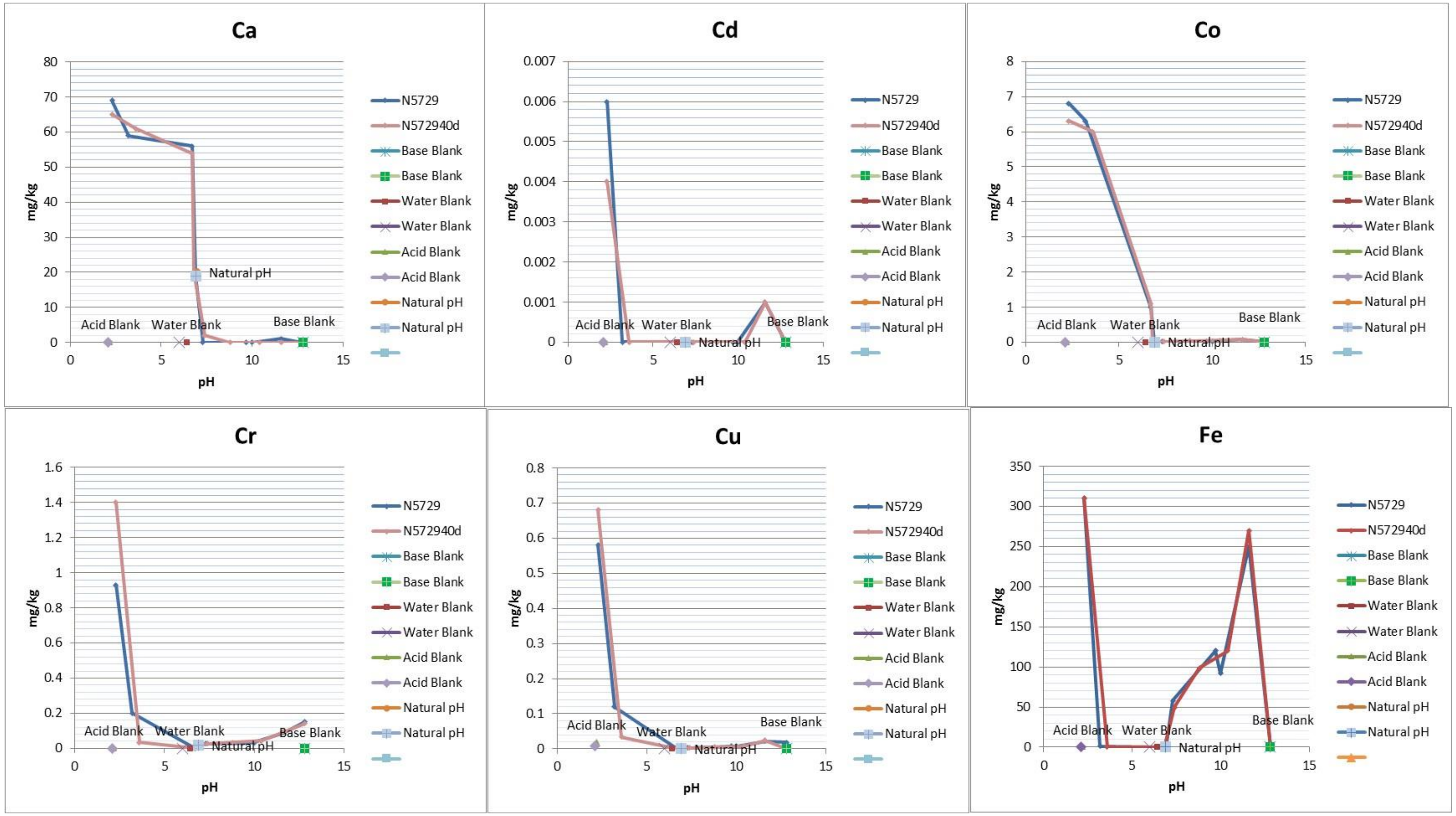

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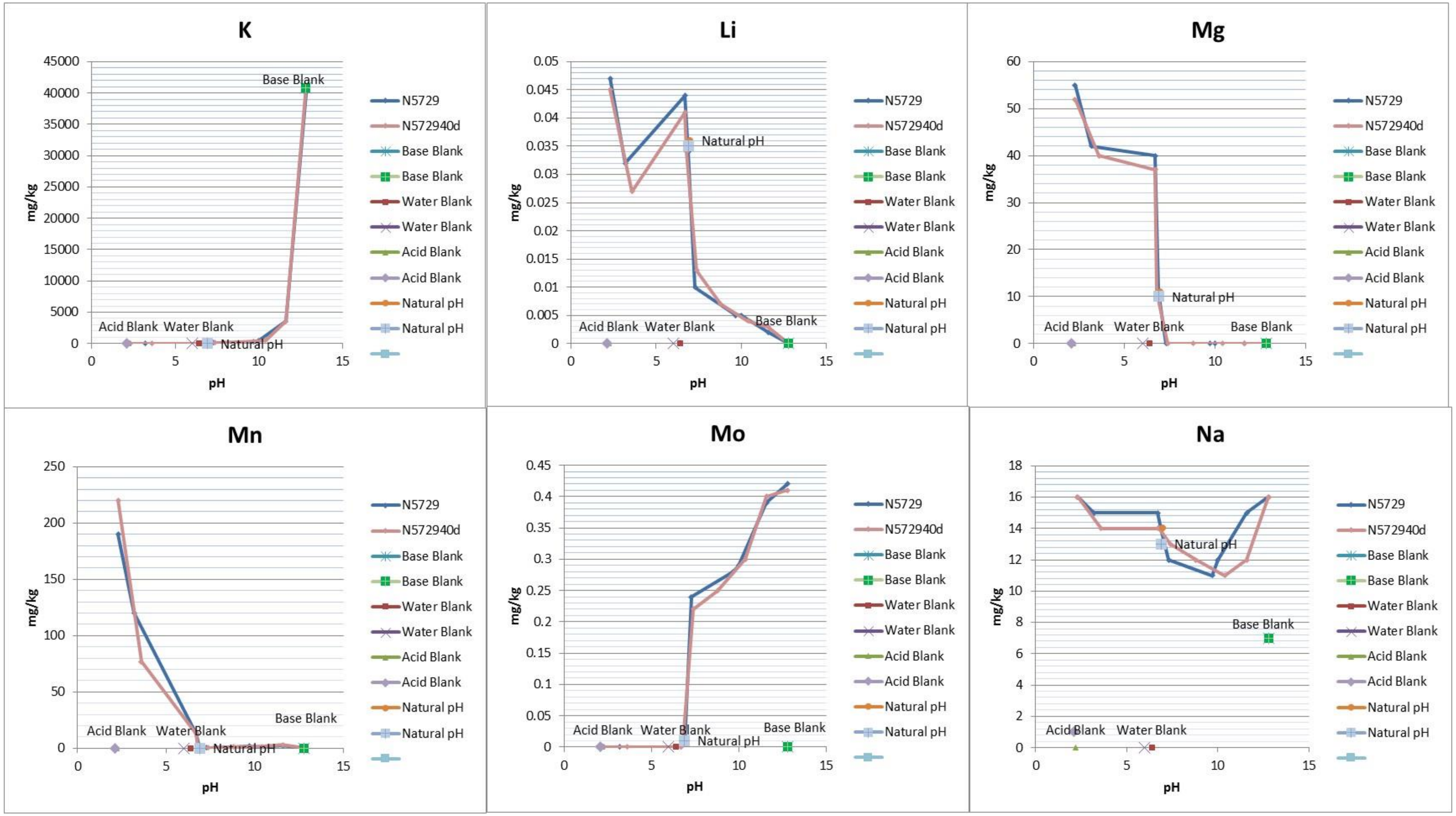

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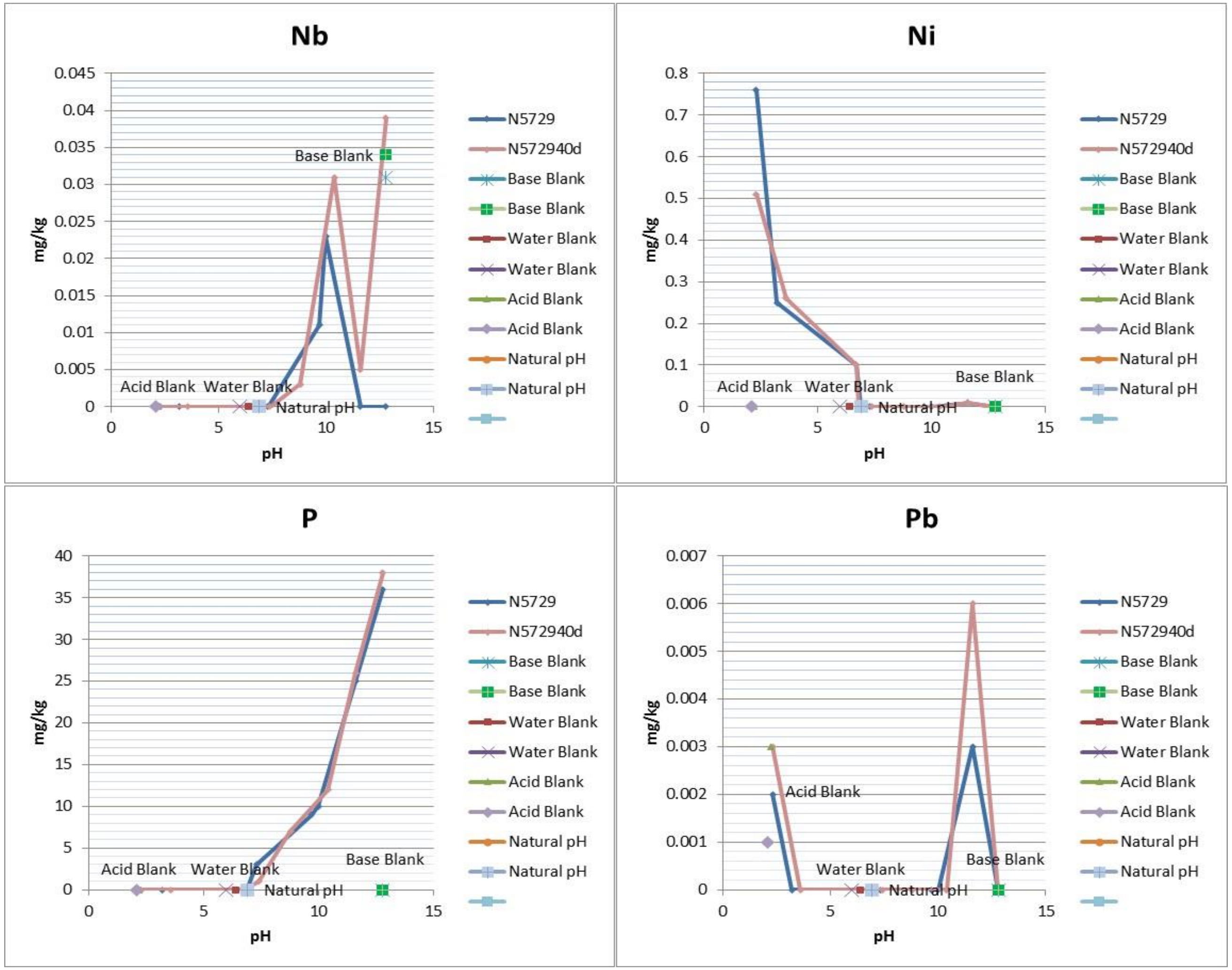

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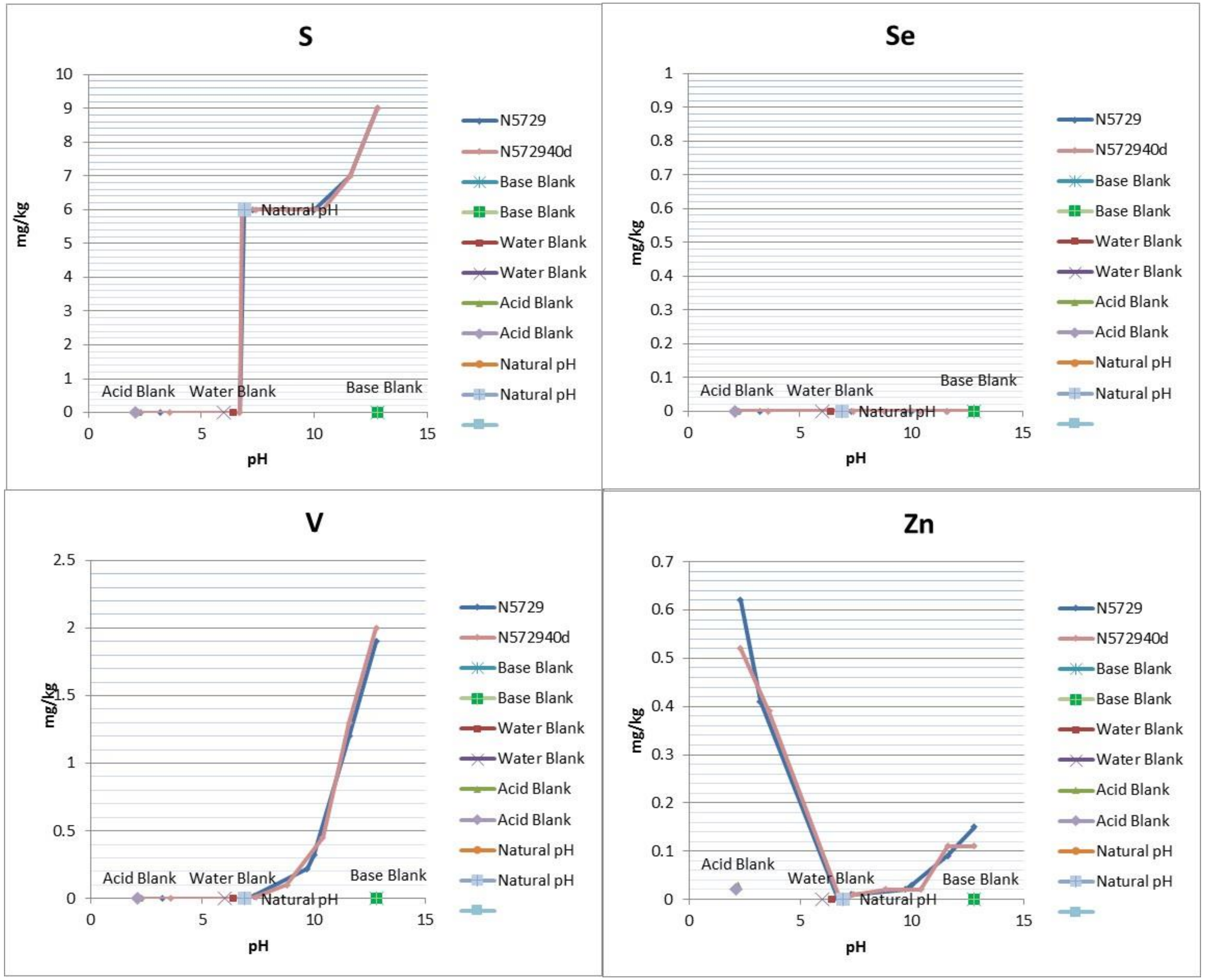

GOVERNMENT OF WESTERN AUSTRALIA

MRIWA Report No 432

Validation and Standardisation of Sequential Leaching Tests to Better Predict the Impact of Mining on Ground and Surface Water Quality

MRIWA Project No 432 2015 – 2018

FINAL REPORT

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