GEOCHEMICAL AND MINERALOGICAL CHARACTERIZATION OF THE LITHOLOGICAL UNITS OF THE GEODEHOOP COLLIERY IN THE WITBANK COALFIELD TO FATHOM THE SOURCE AND THE RECEPTOR OF METALS IN THE RIET-OLIFANTS CATCHMENT, SOUTH AFRICA

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DECLARATION

The contents of this dissertation are the result of my doctoral research at the University of the Free State. This work has never been submitted for a degree at this or any other institution. The work of others is acknowledged through citations.



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PREFACE

This thesis was written as the author's doctoral dissertation at the University of the Free State. The study was conducted in the Witbank coalfield restricted to the ROC, a sub catchment of the OPC, which is located on the western side of Mpumalanga Province, and consists of the towns of Emalahleni, Middleburg, Kriel, Hendrina, Bethal, and Arnot. Understanding the fate of metals from their geological source to the receiving environment is the primary objective of this study. Understanding the processes for metal receipt in water streams from anthropogenic and/or geogenic sources and developing techniques for mitigation and, if feasible, avoidance of the increasing element load are the intents of the present work. It is also meant to stimulate a discussion on the possibility of amending section 36 of the Mineral and Petroleum Resources Development Act No. 28 of 2008 and section 24 (1) of the National Environment Management Act of 1998, in order to compel the characterization of geological units and receptor realm, to be encountered during exploitation, prior to the granting of mining rights to a potential applicant. The study has achieved its objective, highlighting that characterization of the lithogical units, receptor realm, and understanding of the deportment processes can be used to assign a potential source of metals in the receptor environment. The wastes resulting from the lithological units, can be classified according to the level of management required, and allow metal input in the receptor realm that does not exceed the determined standards. Continuous monitoring has been highly recommended. The author studied part-time at the University of the Free State for more than five years. The first three years of the project were devoted to data mining, fieldwork, and analysis. Humidity cell leach, a kinetic test of 31 weeks had been conducted at the fifth year. The study was presented abroad, resulting in 3 peer-reviewed papers and 1 book chapter (referenced); further publications are expected. The author supervised and directed MSc project under restricted promoter monitoring as part of the learning process for autonomous scientific activity. This text contains the subsequent chapters: 1) introduction; 2) geological setting of ROC; 3) petrography and geochemistry of the source rock; 3) mine drainage: case study Geodehoop colliery; 5) stream sediments geochemistry; 6) summary and recommendations; 7) waste management framework guideline proposal.

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I want to thank Prof D. Vermeulen from the University of the Free, Institute for Groundwater Studies department for sponsoring the 31-week humidity cell analytical experiment with full support. I am very grateful to be part of the Council for Geoscience family led by Mr Mosa Mabuza, who offered their full support on the project's funding from start to finish. By expressing thanks to the Council for Geoscience and the University of the Free State, I am beholden to thank the South Africans for allowing me to contribute at the highest level of education and add in providing the solutions that trouble our country, like mine drainage. It is a piece of public knowledge that water is a scarce resource in South Africa. If contaminated, it also threatens the socio-economic development of the country. It is, therefore, essential to protect and preserve this resource for the future generations of our people. Mr J.H. Elsenbroek, the late Mr S. Strauss, the late Mr E.M. Nkosi, Mr A.E. Mulovhedzi, Dr V. Nxumalo, Mr S. Hlatshwayo, Mr K. Nedzingahe, Mr M. Bensid, and Dr T. Dansay (Manager: Minerals and

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This dissertation is a testament to my family that future generations will cherish: my wife, Tendani Shumani; my children, Ndiene Mukundi, Mulanga Vhuthuhawe, Wamashudu Tshamaano, Tendani, Mpho, Adivhaho, Khavharendwe, Muruli, Murunwa, Orita, and Thimulitshi; my parents, mothers include Marubini Mercy, Christinah, Grace, and Violet, and my father Tshamaano David Philemon. I am grateful to my parents and the rest of my family for believing in me through thanksgiving prayers to Yahavee, persistence and support in my academic pursuits. This thesis would be the paper tying our grandkids to us and future generations. I hope that our family will continue to serve the people of the planet in which we reside.

Praise “Yahavee” the creator, who has shown compassion for humanity by giving hope to the rejected. “Yahavee” have shown mercy in all my lacks and forgiven me, and I sincerely believe in the greatest sacrifice, “Yeshua the Messiah”. I am indebted to the late Rev M.P. Kruger and his family for their upbringing and guidance. Rev N. Mundalamo for his ceaseless prayers, constant guidance, and availability with the entire Reformed Church, Synod Soutpansberg family. Regarding the time of my studies, I would like to thank Mr Nndwakhulu Tshishonga in UKZN and his family in Cape Town for their tremendous emotional support and encouragement.

Netshitungulwane-Tshishonga-Mundalamo: Tshitungulwane tsha Mapfulagatsha-zhinda la Tshishonga Lugongolo, muduhulu wa Dimbanyika, le la wela mulambo wa Luvuvhu na Mabadahanya, Muila na Mmbooi la yo thukha thavhani dza Tshitee, Lumawe, Musukhomu, Madzivhanombe, Tshivhulani, Tshilaphala, Mpaladzi, Tshiendeulu na dzinwe. Mapfulagatsha, mapfula misevhe wa tshanda tsha danda tsha u pfula vhathu na phukha. Tshitungulwane tsha Mangumane, Tshitungulwane tsha Khashane, Tshitungulwane tsha Muvhi, Tshitungulwane tsha Makwarela, ane vha tshi murenda vhe “Makwarela pesa la nwenda line la kheruwa, ri a tanganya”. Tshitungulwane tsha Piet-Mawelewele; Ntavhanyeni Johannes; Mufhiri-William; Rasiwela-Jackson; Fhedzisani-Simon; Tshamaano (Tambaulate); Erasmus-Mundalamo; Ntshavheni-Ntsieni. Muila mutshila wa mbudzi.

EXECUTIVE SUMMARY

The study aims to understand the element deportment's geochemical characteristics from the source, pathway and receptor realm in the Riet-Olifants catchment (ROC) drainage system. The ROC is part of the Olifants primary catchment (OPC) area that extends over the border between South Africa and Mozambique and covers a total area of approximately 87000 km^2. The ROC is the area most influenced by coal mining activities surrounding the major towns of Emalahleni (formerly Witbank) and Middleburg. The geological units of the Vryheid Formation, Ecca Group of the Karoo Supergroup dominate the area, with the Witbank coalfield being the primary resource for coal. The focus herein is directed on identifying the geochemical characteristics of the source rocks, the pathways of mobilization and transport and the receiving environment. The key to this study is to identify the mobile elements in minerals occurring in different sedimentary units of the source rock geological units, with the assessment of its contribution to the elevated metal concentrations in the receiving environment of the drainage area. The results are also tested in determining the geogenic element entry of naturally occurring source rocks from an anthropogenic source. In recent years, the area has been under regulatory verification over high pollution levels through coal mine drainage (MD). Previous studies show that although the land use of industrial and agricultural activities is also essential, the contribution to water and sediment contamination from the mining activities within the catchment is significant and yet needs to be fully understood.

The lithological units of the Witbank coalfield consist of sandstones, coal, shale, dolerite, tillites, and basement granite. Coal seams contain the following minerals: kaolinite, quartz, pyrite, calcite, dolomite, siderite, anatase, and mica. Notably, the pyrite content in coal ranges from 4 to 51 wt.%. Sandstones/siltstones and shales make up the hanging and footwalls of coal seams. Clay group (kaolinite/chlorite, smectite), carbonates group (calcite, dolomite, and siderite), quartz, potassium feldspar, plagioclase, pyrite, mica minerals, hematite, anatase as an accessory. The classification schemes of terrigenous shales and sandstones using Fe_2O_3/K_2O vs SiO_2/Al_2O_3 reveals that the majority of the sediments are shales with minor Fe-rich, arkose with minor subarkose, wacke and minor litharenite.

The ABA and kinetic test of lithological units were used to determine the MD generating potential. A total of 65 samples were assessed represented by borehole ZFN1510. The samples were assessed based on the NPR vs. Sulphur, NNP vs. paste pH and AP vs. NP. With the exception of coal seam number 5, coal seams 4, 3 and 2 can generate acid MD. Coal seam number 5 contains an excess of carbonate minerals, making up 19% of its modal mineralogy. The shale units and sandstones above or below the coal seams are classified into areas with acid MD production uncertainty. These units have the potential to strongly increase the acid generation while excess carbonates minerals act as a buffer in the process. The humidity cell leach test confirms a continuous leaching of metals during the 31-week experiment, modelled over 100 years. The reaction processes involved in the transportation of elements include but not limited to: sulphide oxidation, acid neutralization and alkalinity, ion exchange or adsorption, precipitation metal hydroxides and salts, and hydrolysis. Metal influxes and effluxes from GWB and calculated metal loads ($mg.kg^{-2}.yr$) reveals that the metal contributions to the receptor realm is largely from the coal seams and above or below lithological units.

A total of 246 stream sediments samples were collected to represent the receiving environment at a scale of three samples per 10 km^2 to assess metal accumulation. The bedrock geology partly controls the downstream sediment geochemistry. The major elements of Ca, Na, K, and Mg, are enriched in the stream sediments due to their mobility as they are leached, transported and precipitated. The trace elements of As, Br, Co, Hf, Nb, Nd, Ni, Se, Sm, Ta, Pb, Zn, U, V and Yb are also enriched in the stream sediments. Pb, Zn, As, and U exhibit abnormal concentrations in Karoo sandstones, and probability plots of element concentrations indicate multiple populations, which may indicate a geogenic input. Positive correlations exist between U and Nd, Nb, W, Hf, Br, Se, Yb, Cs, and Co, whereas As has a significant relationship with Sm, Ta, Mo, Ge, Pb, Cs, and Zn. Elements with high aqueous mobility towards the sedimentary sink, such as Pb and Zn, each with an enrichment factor (EF) greater than 1.5, show a significant correlation with Ta, Mo, and Ge. Pb and Zn are very valuable for recognizing the human effect on a river, such as urban runoff and mining input. However, their EF implies a nearby geological origin. Certainly, As, Pb, Cd, Tl, and other metals are derived from the biological content of the coal seams when they are leached by mining.

The bedrock contribution, also on average, in the study area to the average downstream sediment concentrations can be qualified. The possible coal seam, above and below lithological units's contributions to the downstream sediment geochemistry include Ca, Na, K, Mn, Mg and SO_4^{2-} (also contributions by chalcophile elements such as As, Fe, Cu and Zn). The large quantity of these elements is from the coal seams. As, shows a significant increase from the maximum value of 36 ppm on average bedrock to the maximum of 680 ppm in average stream sediment. The possible source of the hanging and footwall of the coal seams include U from the maximum concentrations of 11 ppm in the average bedrock to 1898 ppm in the average stream sediments. Pb in the hanging and footwall of the coal seam shows significant concentrations increase from the maximum concentrations of 38 ppm on average bedrock to 98 ppm in average stream sediments. The other elements, which are possibly sourced from a mafic source include V, Cr and Co as reflected by the significant increase of concentrations from the maximum value of 489 ppm, 189 ppm, 42 ppm in average bedrock to the maximum value of 1028 ppm, 3207 ppm, 1273 ppm in average stream sediments, respectively. The latter mafic element input in the streams may be anticipated for base metals and steel refining metals, for anthropogenic input.

The source, pathway and receiving environment approach adopted herein representing the ROC aims at achieving the objectives set in this study has been successful. To ensure minimal contamination, it is necessary to group materials with similar geochemical properties, as some may demand a greater level of treatment than others.

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(-1.280 and +2.945 std.-dev), population 2 indicate the mean of 6.517 (-4.632 and +9.169 std.-dev) and population 3 indicate the mean of 18.846 (-13.830 and +25.680). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.844 wt.% and maximum of 4.467 wt.%, population 2 minimum of 3.293 wt.% and maximum of 12.900 wt.% and population 3 minimum of 10.150 wt.% and the maximum of 34.993 wt.%. 171
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GLOSSARY

Acid Base Accounting (ABA)
Acid potential (AP)
Acid Rock Drainage (ARD)
American Society for Testing and Materials (ASTM)
Circumneutral mine waters (CMW)
Council for Geoscience (CGS)
Crossed polar (XPL)
Department of Forestry, Fisheries and the Environment (DFFE)
Department of Minerals Resources and Energy (DMRE)
Department of Water Affairs and Forestry (DWAF)
Energy-dispersive X-ray spectroscopy (EDS)
Enrichment factor (EF)
Environmental Impact Assessment (EIA)
Environmental Management Plan (EMP)
Environmental Protection Agency (US EPA)
Geochemist's Workbench (GWB)
Humidity Cell Leach (HCL)
Institute for Groundwater Studies (IGS)
Loss of Ignition (LOI)
Masters of Science (MSc)
Mine Drainage (MD)
Mine Environment Neutral Drainage (MEND)
Mineral and Petroleum Resources Development Act (MPRDA)
National Environment Management Act (NEMA)
National Environmental Policy Act (NEPA)
Net neutralization potential (NNP)
Net potential ratio (NPR)
Neutralization potential (NP)
Olifants Primary catchment (OPC)
Plane polarised light (PPL)
Riet-Olifants catchment (ROC)
Simultaneous X-ray Fluorescence Spectrometer (SXRF)
South African Mineral Database (SAMINDABA)
Standard deviation (std.-dev.)
Sediment Quality Guidelines (SQG)
The Lower Limit of Detection (LLD)
University of the Free State (UFS)
X-Ray Diffraction (XRD)
X-ray Fluorescence Spectrometer (XRF)

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1 INTRODUCTION

The introduction part covers the motivation of the research, the introduction to the study area, research background, geological context, and a summary of prior work through a literature search.

1.1 RESEARCH MOTIVATION

Transport of metals from the source to the receiving environment in active and remediated mines may be done by elucidating the mobilization processes involved and predicting mine drainage (MD), which plays a role in the area of investigation, in this example, the Riet-Olifants catchment (ROC). As per the Mineral and Petroleum Resources Development Act (MPRDA) of 2008, the prediction of MD is not required for the development or exploitation of a mineral deposit in South Africa. The management requirements for environmental impacts are stipulated in the National Environment Management Act (NEMA) of 1998. However section 36 of the MPRDA Act of 2008, the minister of Department of Mineral Resources and Energy (DMRE), in consultation with the minister of Department of Forestry, Fisheries and the Environment (DFFE) may intervene when there is identified impact during prospecting, mining, reconnaissance, exploration or production operations or activities incidental thereto cause or results in ecological degradation. According to section 24 (1) of the NEMA Act of 1998, mining licenses in South Africa must be issued prior to the submission of an MD report, which includes detailing all potential consequences and the management thereof. However, MD assessment is not explicitly defined as a method or technique for identifying the environmental consequences caused by the extraction of mineral resources. In "developed nations" such as Canada, it is doubtful that a mining licence would be issued if the MD issues are not adequately handled (MEND, 1995; 1996). Notably, the latter criterion was also a requirement of the Environmental Impact Assessment (EIA) law of the National Environmental Policy Act (NEPA) in the United States at the end of 1969.

In succeeding years, this trend continued (https://www.westerncape.gov.za/eadp/files/atoms/files/EIA 2015.pdf):

- Administrative steps by Japan in 1972 (EIA guidelines only; law not enacted until 1997), Canada in 1973 (Federal Directive), and New Zealand in 1974 (Cabinet Minute).
- Legislation: 1974 for Australia, 1974 for Colombia, 1975 for West Germany, and 1991 for all of Germany

More than a hundred countries assess mine drainage (MD) as part of their Environmental Impact Assessment (EIA) or Environmental Management Plan (EMP) procedures, in terms of mining law (MEND, 1995; 1996). Environmentally competent waste rock management plans are necessary to effectively, economically, and efficiently estimate the quality of drainage generated by the lithologies or rock units mined to reach the ore and the possibility for future unfavorable effects (MEND, 1995). As prevention is preferable to treatment, failure to apply this method has shown to cost governments billions of rands to remedy the environmental effects created.

In South Africa, the issues associated with MD are enormous. Many gold mines in the Witwatersrand Basin and the coalfields, for instance, are abandoned and ownerless, with or without monitoring or water treatment. These mines constantly contribute metals and acidity to the receiving environment or waterways. Environmental worries have been expressed for the future of mining in the Witbank coalfield, which greatly contributes to the country's economic growth (McCarthy and Pretorius, 2009). The abandoned mines are flooded, and metals are transported through seeping into the receptor zone as sediments and water are enriched (Netshitungulwana *et al.*, 2013).

This research focuses mostly on the ROC, which is dominated by rocks of the Karoo Supergroup, with the Witbank coalfield serving as key coal resource in the investigation area. Similar initiatives have been a subject of preliminary research in the Witbank coalfield. Recent research by Pinetown and Boer (2006) focuses more on the quantitative evaluation of minerals in coal and the possibility for acid production, but does not dispute the quantity and mobility

of the metals connected with the geological units of the Witbank coalfield and the receptor. This study is new in that it examines the fate of metal transport from its origins to its receiving environment. This thesis discusses the geochemical characterisation of the Witbank coalfield geological strata and the geochemistry of stream sediments representing the receiving environment.

The results of this study should inspire future mining in South Africa to integrate a prediction of the future environmental effect associated with element mobility from geological units that would be encountered during the value chain of mineral exploitation. As severe pollution has detrimental effects on socio-economic progress and the ecology, the findings of this study can also serve as a guide for the government entities in amending the applicable laws of MPRDA and NEMA so that South Africa can become one of the countries with little or no pollution.

1.2 THE STUDY AREA

The Witbank coalfield is situated in the ROC, a sub catchment in the upper reaches of the Olifants primary catchment (OPC). The Witbank coalfield is located on the western side of Mpumalanga Province, which consists of the towns of Witbank, Middleburg, Kriel, Hendrina, Bethal, and Arnot (Figure 1-1). The Little Olifants-Riet sub-catchments include the area drained by the upper sections of the Olifants, Little Olifants, and Riet rivers and its tributaries, down to where the Olifants River joins the Wilge River at the Loskop dam (Ashton *et al.*, 2001). The sub-catchment receives additional water from the Vaal and Crocodile/Komati catchments through three inter-basin transfer projects (Ashton *et al.*, 2001). All rivers or streams within this sub-catchment are perennial, and each river or stream has several tiny wetlands (Ashton *et al.*, 2001; Marneweck *et al.*, 2001). Currently, the Witbank coalfield is the most important producing coalfield in the country. The coalfied extend 180 kilometers from Brakpan to the Springs region in the west, to Belfast in the east, and roughly 40 kilometers north to south. The watershed sits inside the Karoo basin's Witbank and Highveld coalfields. These coalfields generate 48% of the nation's total electrical generating capacity (Hobbs *et al.*, 2008). With over 55 collieries, the Witbank coalfield is the most significant center of South

Africa's contemporary coal mining activities (Banks *et al.*, 2011). In the Mpumalanga Province of South Africa, near Witbank and (to the northeast) Middelburg are several coal-related and other resources.

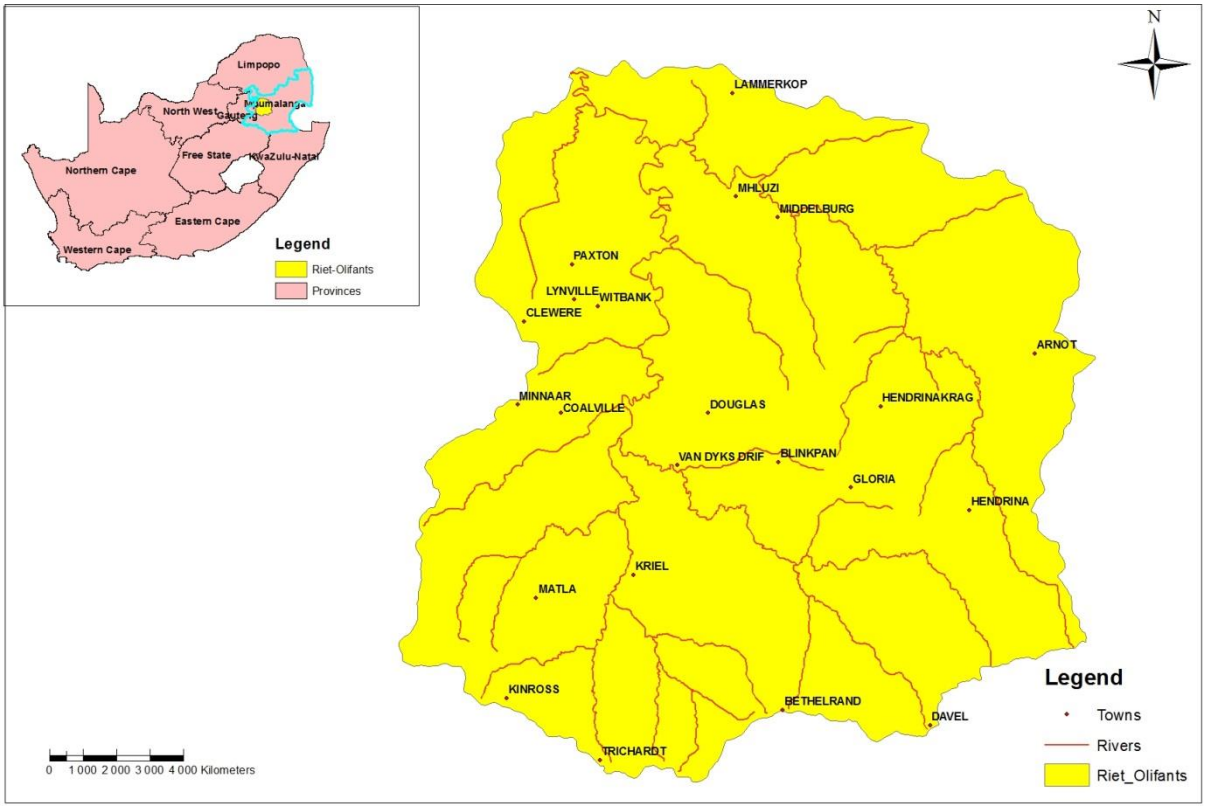


Figure 1-1: A map of the research region, the ROC, Mpumalanga Province highlighted in blue.

According to the most recent study by the DMRE, more than 75% of South Africa's residual coal deposits are located in the Highveld and Witbank coalfields. Nonetheless, these resources will be depleted within the next century (Ratshomo and Nembahe, 2016). Historically, the Witbank coalfield's No. 2 seam was the primary objective for mining. However, its reserves have diminished dramatically over the past two decades, causing the No. 4 Seam to become the principal export source (Figure 1-2). The seam No. 4 in situ coal is reported to have more ash and inertinite than, for instance, the No. 2 seam in situ coal (Pinetown and Boer, 2006).

Industrial and agricultural land usage in the region is diverse and extensive. The Highveld Steel and vanadium processing factory located west of Witbank and the stainless steel mill in Middelburg are the most noteworthy (Banks *et al.*, 2011). Several Eskom power plants, including Kendal, Matla, Kriel, Duvha, Arnot, Hendrina, and Komati, get coal from nearby mines. Energy content is a major factor in determining the price of coal (Banks *et al.*, 2011). The majority of the converted natural land is under agriculture, including commercial plantations, and maize is the primary crop produced in the catchment region. Some sections are used for mixed agricultural, including cattle, dairy, poultry, corn, and potatoes (Banks *et al.*, 2011).

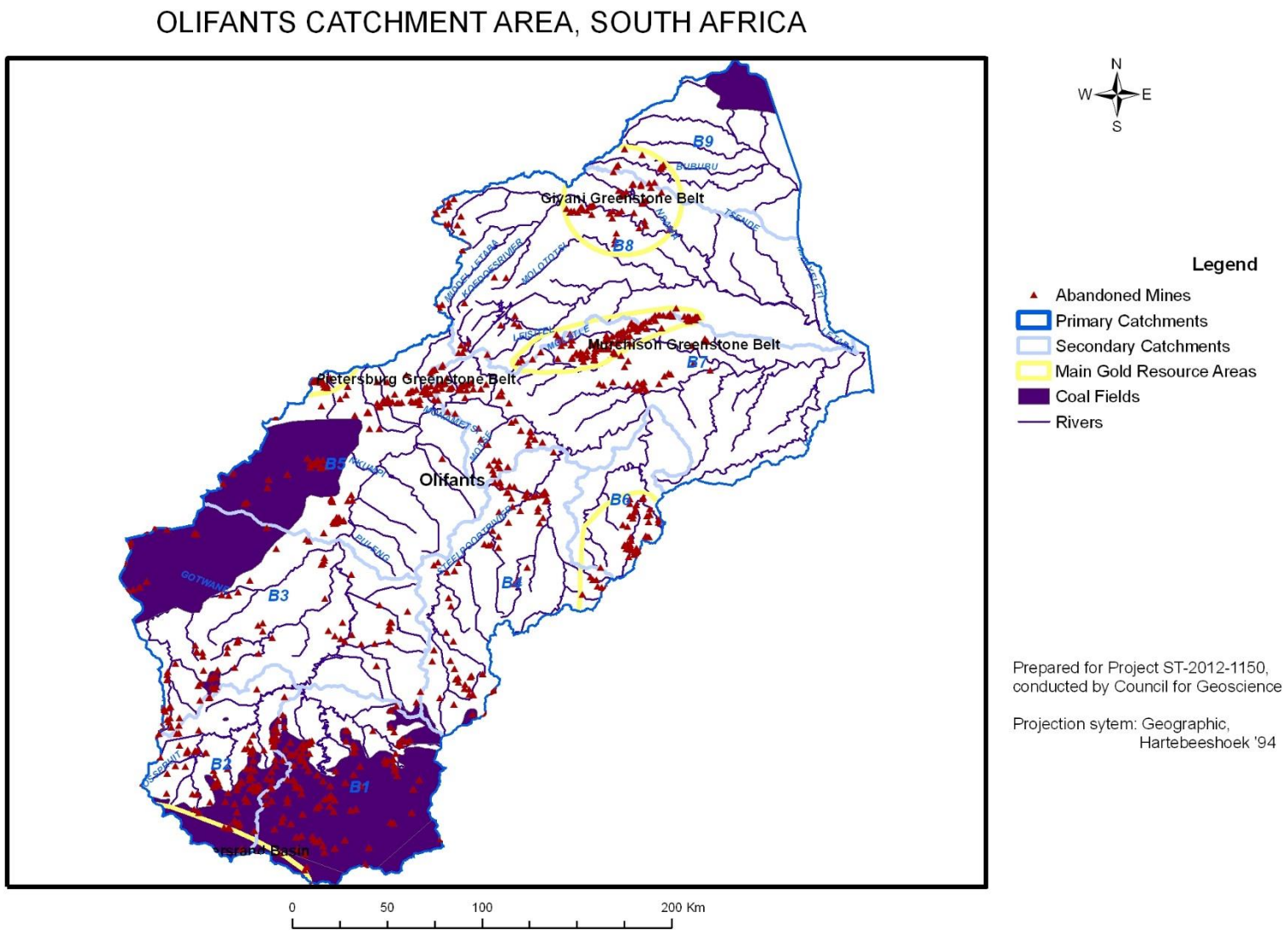


Figure 1-2: A map showing a location for the OPC area, South Africa.

1.3 RESEARCH BACKGROUND

The ROC is part of the OPC area, which includes nine sub-catchments labeled B1 through B9 and stretches over the South African and Mozambican borders (Ashton *et al.*, 2001; Netshitungulwana *et al.*, 2015; Netshitungulwana and Yibas, 2012). It has an approximate overall size of 87,000 km^2. The ROC is designated as a B1 catchment, where the majority of mining activity are concentrated around the cities of Witbank (Emalahleni) and Middleburg, which in turn straddles the provinces of Mpumalanga and Limpopo (Netshitungulwana *et al.*, 2015). In South Africa, the OPC region is home to extensive mining operations for a variety of minerals, including coal, gold, and base metals. It is comprised of nine subcatchments (Figure 1-2). In recent years, the watershed has been scrutinized for its high degree of metal pollution. Although industrial and agricultural activities are also significant, the contribution of contamination to the OPC from mining activities within the catchment is significant as a result of intense coal, gold, and base metals mining and from ferrochrome and Vanadium processing plants located in Emalahleni and Middleburg towns within the catchment area (Figure 1-2) and has not yet been fully quantified (Netshitungulwana and Yibas, 2012).

Recently, the OPC have been the subject of intense public criticism. Despite clear indications that the Olifants river's water quality has been decreasing due to industrial, mining, and agricultural operations, the cause of periodic fish and crocodile mortality in the river system remains unknown (de Villiers and Mkwelo, 2009; Yibas *et al.*, 2013; Netshitungulwana and Yibas, 2012). The effects are visible in the Witbank region, where there are several operational, abandoned, and ownerless coal mines. The asbestos mining areas (not active) of the Penge and other areas in Mpumalanga, the heavy mineral sand operations (not active), and areas of extensive smaller-scale mining such as the Barberton and Giyani greenstone belts and the Pilgrim's Rest Goldfield as potential pollution contributors all drain into the OPC (Netshitungulwana and Yibas, 2012).

Using a catchment-by-catchment methodology, the Council for Geoscience (CGS) and the DMRE initiated a research in 2012 to examine the severity of the mining impacts on the

country's water resources and ecology (Yibas *et al.*, 2013). The OPC area has been prioritized for study because of the high concentration of mining activities within its territory (Yibas *et al.*, 2013). Although contamination has been investigated, little or no effort has been made to comprehend the fate of metal transport from sources to the receiving environment. Understanding the geological and geochemical processes of the various geological units can aid in better managing the element load discharged by present and future mining. As implemented by the United States Environmental Protection Agency (US EPA), the outcome of this reseach can benefit the government in formulating coal mining effluent guidelines and regulations. For a little to no-contamination strategy, it is necessary to characterize in the new coal-mining areas. In so-called "intelligent cities," a zero-waste / zero-contamination attitude is currently on the rise (https://www.epa.gov/transforming-waste-tool/how-communities-have-defined-zero-waste). In order to reach such aims in coal mining in South Africa, it is essential to comprehend the relevant geological processes as highlighted above. Consequently, this research is the initial step towards reaching such objectives.

The processes that lead to contamination are mainly enhanced by weathering processes of the geological materials. Under conditions of element leach through oxidation and weathering, the impact of released metals on the hydrosphere and atmosphere may be minimal. In a mining-related scenario of ground disturbance, leaching and mobility of coalbed-contained elements increase due to exposure to environmental conditions such as air infiltration and oxidation. With the aid of water and air, mine drainage occurs, damaging the receiving environment. The transport medium may be seepage to subsurface water or runoff.

1.4 RESEARCH OBJECTIVES

The research focuses on the ROC region, which is situated in the upper parts of the OPC. The primary objective is to identify components in the source rocks and stream sediments of the drainage area that are enriched relative to their naturally occurring source rocks and represent an anthropogenic vs a geogenic input. To fulfill the primary goals, threshold determination of stream sediments and static and kinetic testing for acid base accounting of coalbed core samples will be employed. The specific goals are as follows:

- Determine the geochemistry, mineralogy, and petrology of the source rocks by deciphering the lithological units of the drilled core at the Goedehoep Colliery (chapter 3).

- To determine the mine drainage capability of the lithological units of the source rock utilizing the drilled core of the Goedehoop coal mine and conducting static tests and 31 weeks of kinetic test leaching experiments (chapter 4).

- Determine the element concentrations of the stream sediments and differentiate between background concentrations and anomalies (anthropogenic and geogenic enrichment) using conventional geochemical exploration techniques (chapter 5).

- Outline a framework for the management of mine waste deposits in the Emalahleni coalfields of South Africa (chapter 7).

1.5 CONCEPTUAL MODEL

To fulfill this study's primary objective, it is necessary to understand the source, pathway, and receptors of elements in the source rocks, stream flows, and sediments of the ROC as shown in Figure 1-3. The paradigm is depicted in Figure 1-4 (after Morin and Hutt, 1999), which investigates the paths of element transport in the context of mine drainage chemistry prediction. For environmental concerns, Morin and Hutt (1999) identify three fundamental aspects that must be addressed for each risk:

- A pollutant (source) is a substance in, on, or under the lithosphere that has the potential to cause harm or contamination to the surrounding environment.
- A pathway is "a conduit for the movement of contaminants, including geological features, hydrogeology, and surface water streams."
- The presence of a pollutant affects a receptor.

1.6 HYPOTHESIS

The sediment-water interaction mechanisms include dissolution or chemical weathering, element complexation in addition to sediment particle adsorption or precipitation. To appreciate these processes, it is necessary to know the geological and geochemical processes of element leaching of the geological units of the Witbank coalfield. The stratigraphic sequence in the Witbank coalfield show uniformity in the cross section, and is syngenetic. In this study it is represented by the stratigraphic core from the Goedehoop region. This may be accomplished by determining the element concentrations in sediments in the receiving environment. The Witbank coalfield is composed of five coal seams (seams 1 through 5), which were formed under oxidizing conditions and are distinguished by the presence of inertinite, vitrite, and sulphide minerals. The hanging and footwall units comprise sandstones and shales composed of sulphide minerals. S, As, and F elements from coal and subsequent stratigraphic units may be leached and concentrate in effluent and receptor. Under favorable environmental conditions (oxidation or reduction), mobile elements can be complexed, transported, and subsequently precipitated or adsorbed by clay or fine sediments. Two significant aquifers, the upper and lower Ecca aquifers, interact continuously with the stratigraphic strata. The water dissolves, complex, and transports elements to recharge neighboring streams and bodies of water. The processes of desorption/dissolution and precipitation/adsoption are particularly applicable to the coal waste rock dumps and tailing facilities in the catchment area. In order to characterize the aforementioned process and enable the prediction of mine drainage, this thesis will focus on the assessment, development, and implementation (Figure 1-3) of static and kinetic leaching studies of coal beds and related rocks as well as on stream sediment composition.

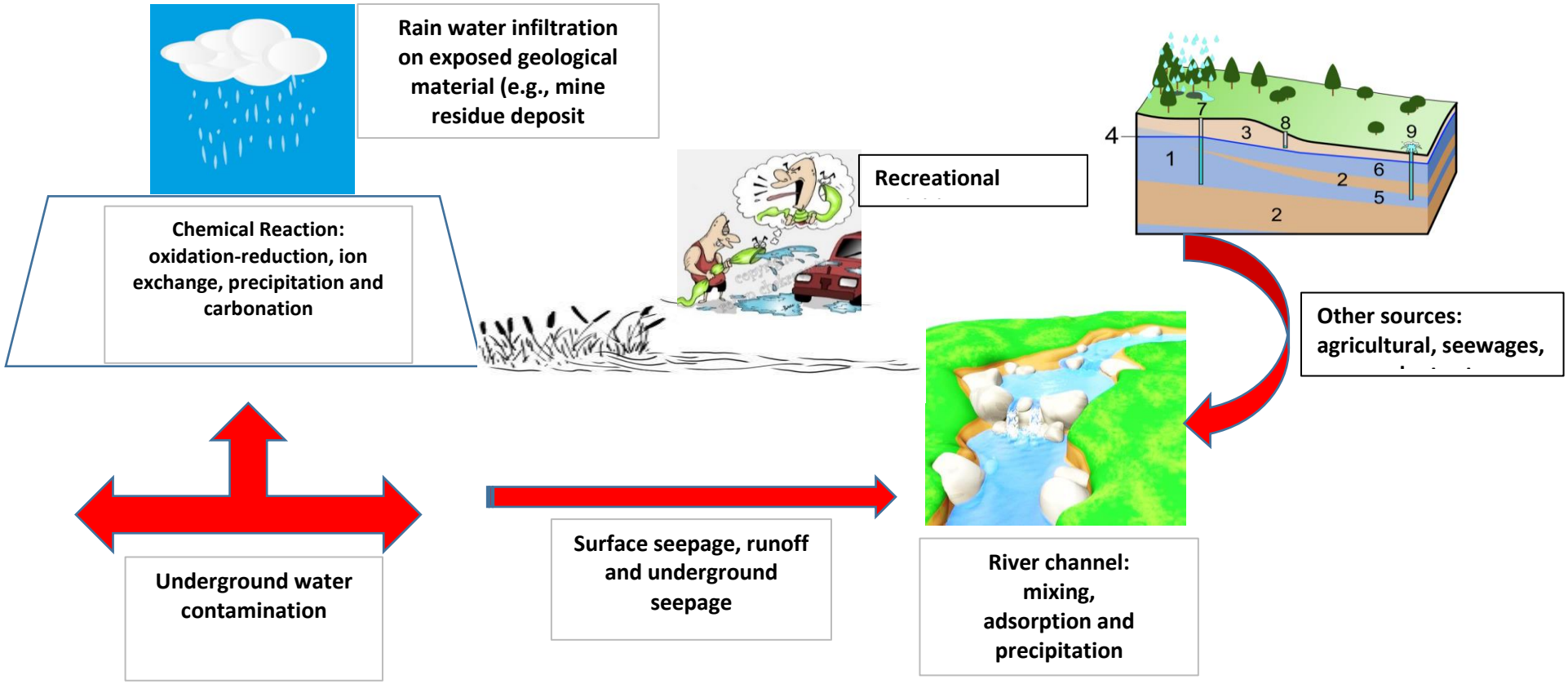


Figure 1-3: Simplified conceptual model highlighting the sources pathways and receptor environment for the metals.

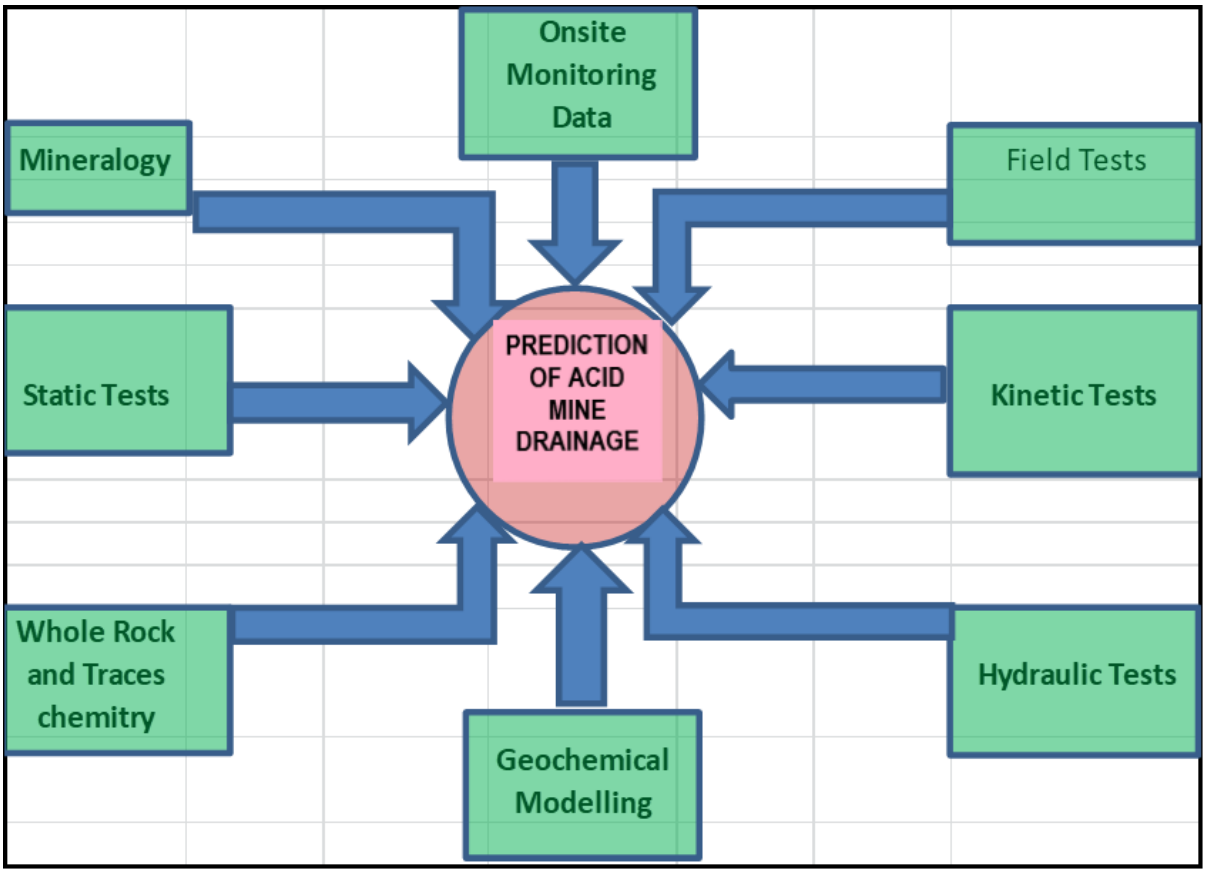


Figure 1-4: The mine drainage chemical prediction wheel (adapted from Morin and Hutt, 1999).

2 GEOLOGICAL SETTING OF THE ROC

As indicated in Figure 2-1, the Vryheid Formation of the Ecca Group, Karoo Supergroup is the predominant geology in the ROC. These rocks sit on pre-Karoo basement rocks. The dolomite rocks of the Transvaal Supergroup are exposed south of Delmas. In the core region of Emalahleni, the exposed Bushveld felsites and granites on the eastern side of Emalahleni town, as well as the Transvaal sedimentary rocks, are visible.

2.1 PRE-KAROO GEOLOGY

The Pretoria Group (2.4 to 2.1 Ga) contains the ROC's oldest shale and quartzite rocks (2.4 to 2.1 Ga) (Martini, 1998; Eriksson *et al.*, 1995). The Rooiberg Group overlies the Pretoria Group, possibly disconformably (Cheney and Twist, 1991) and is composed of volcanics with a slight sedimentary disconformity composed of shale and greywacke (Twist and French, 1983; Twist, 1985; Harmer and Farrow, 1995; Schweitzer *et al.*, 1995; Hatton and Schweitzer, 1995). In the eastern portion of the Cullinan-Witbank basin, the Rooiberg Group conformably grades into the Loskop Formation, which consists of 1100 m of red shale intercalated with conglomerate in the lower portion and mostly impure quartzite in the top portion (Clubley-Armstrong, 1977).

The Loskop Formation series was considered to be part of the Rooiberg Group. It was deposited in a continental environment (Eriksson *et al.*, 1995). It consists of minor lava flows and granophyre intrusions across the stratigraphic Formation. Similar to the Loskop Formation, the earliest portion of the Waterberg Group consists of red beds.

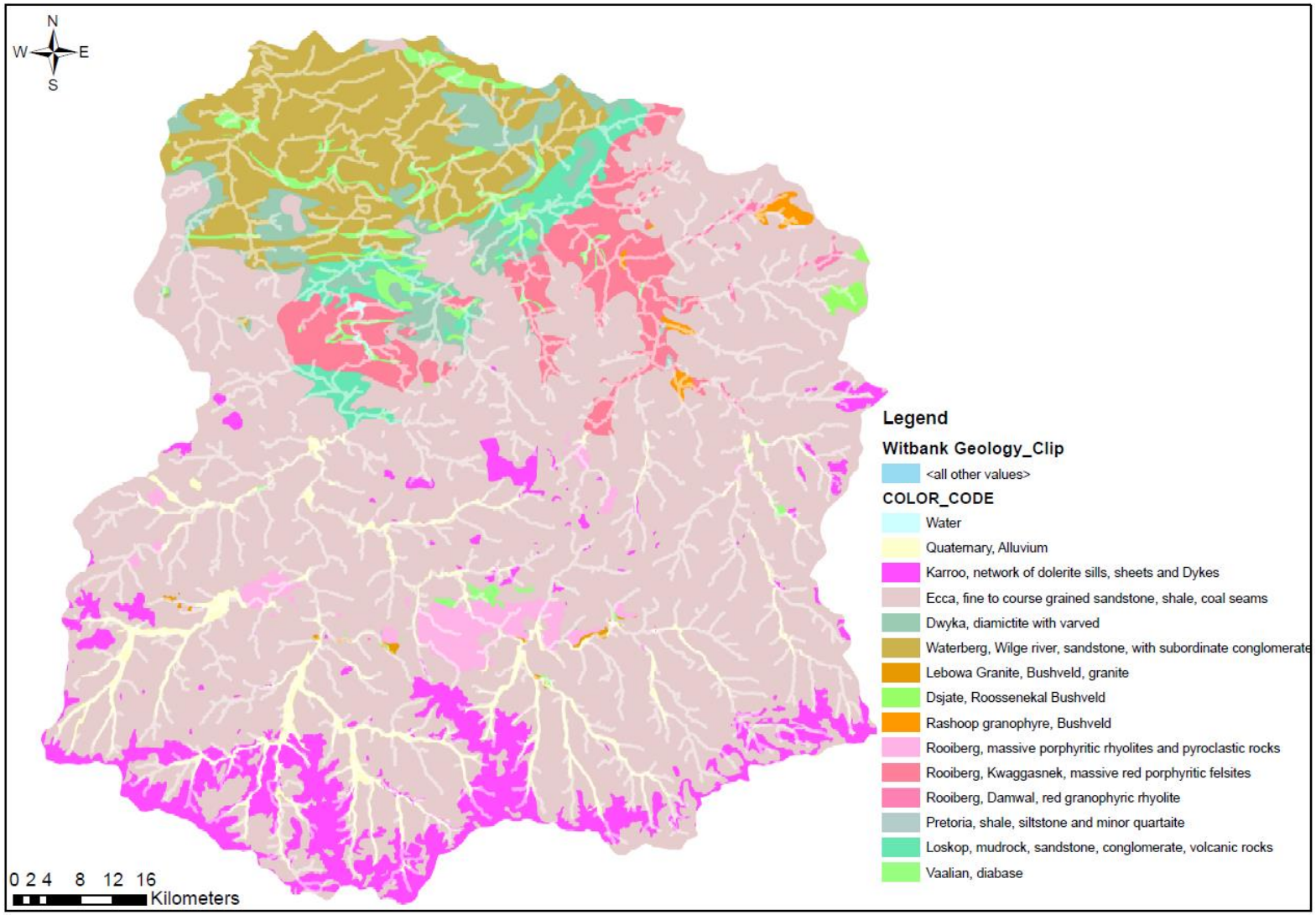


Figure 2-1: The regional geological map of the ROC.

The Loskop Formation is dated between 2.0 and 1.7 Ga and is unconformable with all earlier stratigraphic levels (Jansen, 1982; Cheney and Twist, 1986; Cheney and Twist, 1991). The Bushveld Complex is also present in this research, as seen in Figure 2-1. In this research, the Bushveld Complex is represented by two major lithological units: ultramafic to mafic rocks of the Rustenburg Layered Suite and granophyric to felsic volcanic rocks of the Bushveld granites to granophyres and Rooiberg felsites.

The Witbank coalfield in South Africa's Mpumalanga Province is situated in the northern portion of the major Karoo Basin, which was invaded by dolerite dykes and sills during the early stage of Gondwana breakup (Du Plessis, 2008). The Karoo basin's layers are predominantly composed of sandstone, carbonaceous shale, siltstone, minor conglomerate, and many coal seams (Cairncross, 2001; Schmidt, 2006). Figure 2-2 and Table 2-1 demonstrate stratigraphic columns for several regions of the coalfield. This diverse array of sedimentary and structural environments, in which coal seams were formed, has a variety of ages (see Table 2-1).

The Palaeoproterozoic (2.06 Ga) Rooiberg Group is characterized by exceptionally high-grade lavas and ignimbrites (Buchanan and Reimold, 1998; Lenhardt *et al.*, 2017). It forms the basis of the strata of the Witbank coalfield. The regional stratigraphy is also established based on geochemistry (chemostratigraphy) as follows; the volcanic rocks of Rooiberg have been split into base rhyolite, high-Ti basalt, low-Ti basaltic andesite, high-Fe-Ti-P andesite, high-Mg and low-Mg felsite, and high-Fe-Ti-P andesite (Schweitzer *et al.*, 1995; Hatton and Schweitzer, 1995).

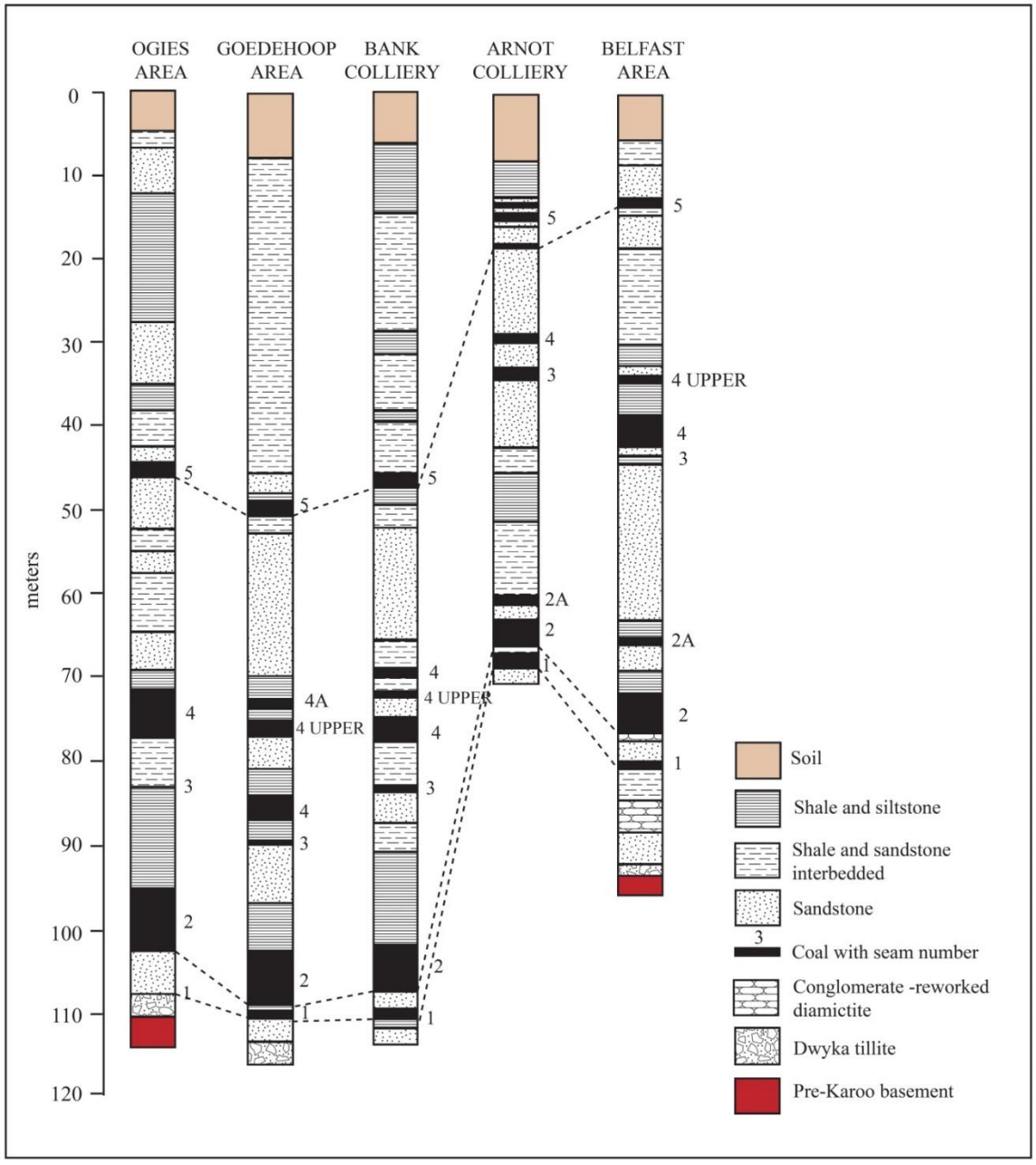


Figure 2-2: Generalized stratigraphic columns of the Witbank coalfield (after Smith and Whittaker, 1986).

Table 2-1: Classification of the Karoo Supergroup's lithostratigraphy (after Azzie, 2002).

Supergroup	Age (Ma)		Group	Formation
Karoo	140	Jurassic and Upper Triassic	Drakensberg	Drakensberg
	195			Clarens
	225	Triassic		Elliot
	230	Upper Permian and lower Triassic	Beaufort	Burgersdop
				Katberg
				Balfour
				Koonap & Middleton
	260	Middle Permian	Upper Ecca	Volksrust
			Middle Ecca	Vryheid
			Lower Ecca	Pietmaritzburg
	300	Late Carboniferous	Dwyka	

According to Hatton and Schweitzer (1995), "petrographic examinations of these rocks show that the majority of Dullstroom Formation units are metavolcanics and consist of fine-grained groundmass with filled amygdales and phenocrysts. Common constituents of the fine-grained groundmass are green pleochroic amphibole, lath-shaped feldspar, opaques, and quartz. The majority of phenocrysts are sericitized feldspars. Amygdales are composed of green, pleochroic amphibole encircled by quartz; amphibole in amygdales is petrographically identical to amphibole in the groundmass, but with bigger grains. Occasionally, secondary carbonates are present in amygdala. High-Ti basalts often have a higher percentage of opaques than other Dullstroom types. In certain localities, Dullstroom Formation units contain considerable amounts of biotite.

Schweitzer *et al.* (1995) state that “the lowest portion of the Damwal Formation consists of low-Mg felsites as flows and pyroclastic units intercalated with metasediments and high-Fe, Ti, P volcanics. Petrographic investigations reveal that these units are mostly fine-grained, with pyroclastic, spherulitic, or glassy textures, and are infrequently flow-banded. Some units contain zoned amygdales or secondary quartz veins". Eriksson *et al.* (1995) have characterized and mapped sedimentary units, which are often metamorphosed and include quartzites. This formation is exclusive to the eastern regions of the Bushveld Complex (Eriksson *et al.*, 1995).

Kwaggasnek Formation is found across the Bushveld Complex and consists mostly of low-Mg felsites intercalated with sedimentary layers (Buchanan and Reimold, 1998). According to Buchanan and Reimold (1998), "volcanic units are often fine-grained and may exhibit pyroclastic textures, such as lapilli tuffs, spherulitic textures, zonal amygdales, or flow-banding." Several of these units consist of volcanic breccias. Many of the volcanic units feature euhedral to subhedral feldspar phenocrysts that are partly or fully sericitized. Fractures filled with secondary quartz are seen throughout the formation, indicating post-crystallization silicification. The Union Tin Member, which consists of an agglomeration layer overlying a shale, marks the top of the Kwaggasnek Formation.

The Waterberg Group's geochemistry has been carefully researched (Faure 1993; Stratten 1986). Clay minerals (kaolinite and montmorillonite or illite), quartz, iron carbonates and iron sulphides, calcite, and trace minerals comprise the mineralogy. Traces of apatite, ankerite, microcline, and anatase were discovered (Faure, 1993). The proximal facies of this slowly sinking shelf platform is coarse, fluviodeltaic sandstone, which wedges out into siltstone and mudstone facies (Pietermaritzburg and Volksrust Formation) in the south (Snyman, 1998). The formation is predominantly formed of coarse-grained arkose, conglomerate, micaceous siltstone, carbonaceous shale, coal seams, and thin layers of limestone (Stratten, 1986). Clay assemblages dominate the mineralogical components of coal samples and are significantly more prevalent in most sedimentary regions. In the Witbank coalfield, these assemblages vary from kaolinite-free to kaolinite-dominated, with subordinate mica and chlorite and small signs of illite/smectite interstratification (Pinetown and Boer, 2006).

Examining the link between clay and non-clay fractions based on the presence or lack of kaolinite. Potassium feldspar is more prevalent in kaolinite-rich samples, whereas plagioclase proportions are greater in kaolinite-free samples (Pinetown and Boer, 2006).

There is no direct relationship between pyrite and clay minerals, however the presence of pyrite indicates maritime impact or a reducing environment. Mica and chlorite are both considered to be detrital components that originated under conditions of poor chemical weathering, which

resulted in the lack of kaolinite in an environment containing sea water. The presence of fresh water caused illite/chlorite and smectite to convert into kaolinite (Bühmann & Bühmann, 1988). Apatite and a variety of alumino-phosphate minerals are the most prevalent phosphates in coal and have been detected in a number of coal seams across the world, sometimes in large quantities in certain coal bed sub-sections (Ward *et al.*, 1996; Rao and Walsh, 1997; 1999; Dai *et al.*, 2007). In the cell and pore infillings, apatite and Sr-Ba-Ca-aluminophosphate minerals, occasionally interacting with clay minerals, predominate (Zhao, 2012).

At general, accessory minerals occur in modest quantities. Some may be undetectable by XRD and can only be noticed by optical and electron microscopy. In some parts of coal seams, however, accessory minerals may sometimes exist in substantial amounts. Other than iron sulphides, sulphide and associated minerals in coal include sphalerite, galena, millerite, stibnite, chalcopyrite and clausthalite (Spears and Caswell, 1986; Hower *et al.*, 2001; Lawrence *et al.*, 1960; Karayigit *et al.*, 2000; Cressey and Cressey, 1988; Kolker and Finkelman, 1998; Dai *et al.*, 2007). Typically, these minerals precipitate as epigenetic veins generated later in the diagenetic stage, as well as syngenetically in cell and pore lumens, and as discrete crystals in macerals. Boehmite, diaspore, and gibbsite have been detected in coals as Bauxite-group minerals. Al-rich solutions in peat can precipitate gibbsite (Ward, 2002).

The Witbank coalfield is located in South Africa's Mpumalanga Province. It is found in the Karoo Basin, which was invaded by dolerite dykes and sills during the earliest stage of Gondwana's disintegration in the Jurassic (about 180 million years ago) (Du Plessis, 2008). The geological units consist of sandstone, carbonaceous shale, siltstone, a small amount of conglomerate, and multiple coal seams (Graham and Lategan, 1931b; Viljoen and Reimold, 1999; Cairncross, 2001; Vorster, 2003). In Figure 2-3, stratigraphic columns are depicted. This large variety of sedimentary and structural contexts was deposited under a variety of ages, climates, and plant life, which resulted in various variances in terms of organic and inorganic content, as well as the degree of maturity of the coal seams (Winter, 1985; Falcon, 1986).

The Ecca Group of the Karoo Supergroup sediments were formed on an undulating Karoo floor, which impacted the distribution and thickness of the sedimentary layers as well as the

coal seams (Pinetown and Boer, 2006). Even though post-Karoo erosion has removed considerable quantities of coal, no more than 180 meters of Karoo strata have been retained. In the region where the thickest Dwyka deposits are found in the deepest palaeo valley, many main glacial valleys are known.

Numerous ridges, composed primarily of igneous rocks, with the felsite-lithified ridge forming the southern edge of the coalfield (Pinetown and Boer, 2006). The five seams are confined inside a 70-meter sequence, and the thickness of the separation between seams is rather consistent across the field (Smith and Whittaker, 1986).

In the Witbank coalfield, sediments above sills have been moved and raised, whereas layers under sills have remained untouched. The dolerite dykes of the Witbank region display modest vertical displacement. The heat emitted by dolerite dykes and sills hastened metamorphism and depleted coal seams' volatile components. The coal reserves of the Witbank coalfield are found in the Vryheid formation, Ecca group, and Karoo Supergroup. Normal seams in the Witbank Coal Basin are numbered 1 through 5. Typically, coal seams weaken toward minor palaeoridges and finally pinch out against major palaeoridges (Snyman, 1998). Seals interlayers (15-50 m) transgress seams; dykes of 0-1 m thickness are abundant, moving east, northeast, and north; the most significant dyke is the Ogies dyke (15 m thick, 100 km long and strikes east-west) Transgressive sealing interlayers caused the tilting and displacement of seam mining blocks at various altitudes, resulting in significant mining issues. The volume and intensity of coal combustion caused by intrusions provide a significant challenge to mining and resource assessment (Smith *et al.*, 1994; Smith and Whittaker, 1986).

The Ecca Group conformably rests on the Dwyka tillite or the pre-Karoo basement is the Rooiberg Felsites (Cairncross, 1989). Figure 2-2 depicts stratigraphic sections for several regions of the coalfields illustrating the coal seams and non-coal layers described before. The sandstones and siltstones vary in coarseness, can be dark or light, and range in thickness from a few meters to 70 meters; they are separated by shale layers and coal seams (Graham and Lategan, 1931b).

There are five coal seams, as seen in Figure 2-2. Seam No. 1 is the lowest and is either supported by tillite or Dwyka Group shale and sandstone bands (Graham and Lategan, 1931a). Seam No. 1 is patchily developed across the coalfield with the exception of the northern portion of the coalfield, near to the town of Witbank, and the eastern portion of the Optimum and Arnot collieries (Figure 2-3), where it attains a thickness of 3 m. (Pinheiro, 1999). The majority of seam No.1 is comprised of lustrous to dull coal with shaly sandstone partings, resulting in a localized lower seam No. 1 in the Arnot region. According to Pinheiro (1999), seam No. 1 has an exceptionally low phosphorus level and is frequently exploited as a metallurgical feedstock. Falcon (1989) hypothesized that seam No. 1 originated in a freshwater peat bog that covered a platform of sediment produced from an old braided glacial river system.

2.2 WITBANK COALFIELD

The South African province of Mpumalanga is home to the Witbank coalfield. It is discovered in the Karoo Basin where dolerite dykes and sills from the early Jurassic period of Gondwana fragmentation (about 180 million years ago) were intruded (Du Plessis, 2008). Sandstone, carbonaceous shale, siltstone, minor conglomerate, and a number of coal seams are among the geological units (Graham and Lategan, 1931a; Viljoen and Reimold, 1999; Cairncross, 2001; Vorster, 2003). Figure 2-3 shows an illustration of stratigraphic columns. There are many variations in terms of organic and inorganic content as well as the degree of maturity of the coal seams due to the vast variety of sedimentary and structural environments in which they were formed, as well as a range of ages, climates, and plants (Winter, 1985; Falcon, 1986).

The location and thickness of the sedimentary formations as well as the coal seams were impacted by the distribution and thickness of the Ecca Group of the Karoo Supergroup deposits, which were deposited on an undulating Karoo floor (Pinetown and Boer, 2006). Although significant amounts of coal have been lost to post-Karoo erosion, up to 180 m of Karoo strata have been retained. The region where the Dwyka deposits are the thickest in the deepest palaeo valley has a number of significant glacial valleys.

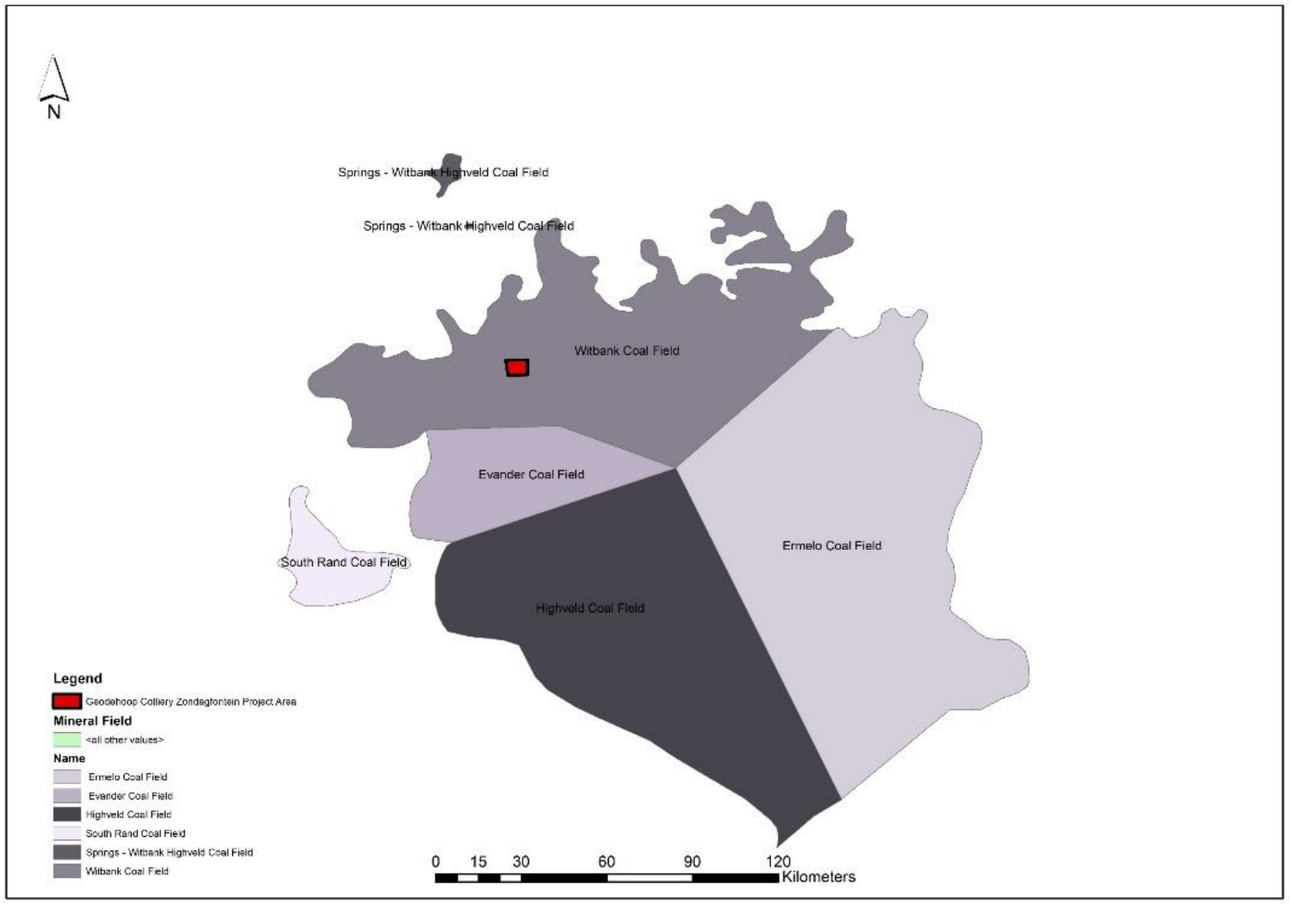
Numerous ridges, mostly made of igneous rocks, constitute the Southern limit of the coalfield, with the felsite ridge being the most lithified (Pinetown and Boer, 2006). The five seams are separated by a sequence of 70 meters, and the parting thickness between them is essentially consistent across the field (Smith and Whittaker, 1986).

The sediments above sills in the Witbank coalfield have been moved and raised, while the sediments under the sills have not been affected. On the Witbank region's dolerite dykes, vertical displacement is barely noticeable. The volatile components of the coal seams were depleted by the heat generated by dolerite dykes and sills, which also promoted metamorphism. Within the Karoo Supergroup's Vryheid formation, Ecca group, and coal reserves are found in the Witbank coalfield. The Witbank Coal Basin's typical seams are numbered 1 to 5. Typically, coal seams get thinner as they approach smaller palaeo-ridges and finally pinch out against the larger palaeo highs (Snyman, 1998). Seams range from flat to moderately sloping; seals interlayers (15–50 m) cross seams; dykes with a thickness of 0–1 m are frequent and tend east, northeast, and north; the Ogies dyke is the most noticeable dyke (15 m thick, 100 km long and strikes east-west) Significant mining issues were created by transgressive seal interlayers, which produced tilting and displacement of seam mining blocks at various altitudes. Resource estimates and mining are severely hampered by the intensity and scale of coal combustion caused by intrusions (Smith *et al.*, 1994; Smith and Whittaker, 1986).

According to Cairncross (1989), the Dwyka tillite or Rooiberg Felsites, which is a pre-Karoo basement, is where the Ecca Group rests. Figure 2-2 shows stratigraphic sections for several coalfield regions that show the above-mentioned coal seams and non-coal layers. Shale beds and coal seams split the sandstone and siltstone layers, which range in coarseness from mild to extreme, can be light or dark, and range in thickness from a few meters to 70 meters (Graham and Lategaan, 1931a).

There are five coal seams, which are depicted in Figure 2-2. The lowest seam, seam No. 1, is either overlain by a tillite or by bands of shale and sandstone from the Dwyka Group (Graham and Lategan, 1931b). Except for the northern portion of the coalfield near Witbank town and in the east in the Optimum and Arnot collieries, where it achieves 3 m in thickness, seam No.

1 is patchily developed across the coalfield (Pinheiro, 1999; Figure 2-3). With shaly sandstone partings that produce a localized lower seam No. 1 near the Arnot region, seam No. 1 is mostly composed of lustrous to dull coal. According to Pinheiro (1999), seam No. 1 is commonly mined as a metallurgical feedstock because of its extremely low phosphorus level. According to Falcon's (1989) theory, the seam No. 1 developed in a freshwater peat bog over a platform of sediment from a long-ago braided glacial river system.



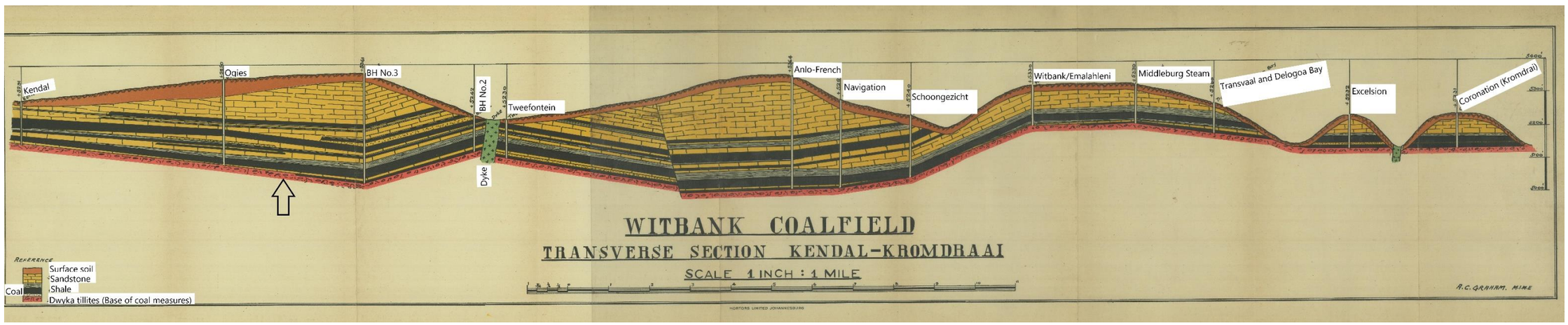


Figure 2-3: A map showing the approximate position (shown by an arrow) of the Geodehoop boreholes ZFN1510 and 1512 project at Zondagfontein farm close to the ROC catchment devide, as well as the Goedehoop Colliery in the Zondagfontein project area and Witbank coalfield cross-section with seams No. 1–5 (after Graham and Lategan, 1931a).

The No. 2 seam has been extensively mined and remains economically vital, while seams No. 1, 4, and 5 include additional economic seams (Uludag *et al.*, 2001). Thin seam No. 3 (usually less than 0.5 m in thickness) is of good grade locally, where it attains a thickness of around 0.8 m, and is a significant opencast resource (Uludag *et al.*, 2001). The No. 2 seam holds approximately 60% of the Witbank coalfield's coal deposits and a fraction of the highest quality coal (Uludag *et al.*, 2001). Seam No. 2 is composed of several sandstone and shale partings, with the deepest splitting occurring locally in the top portion of the seam, so dividing the seam into No. 2 and No. 2 upper seam (Smith and Whittaker 1986; Snyman, 1998; Xaba, 2004). The entire thickness of the No. 2 seam might exceed 10 meters (Pone *et al.*, 2007).

The top seam No. 4 also attains a total thickness of 10 m, but its mining is restricted due to exceedingly poor roof conditions, substantial variation in coal quality, and devolatilization associated with an overlaying dolerite sill (Pone *et al.*, 2007). The No. 4 seam is divided into the No. 4 lower, No. 4 higher, and No. 4A sub seams by the deposition of fine-grained silt inside an embayment and, subsequently, shale and sandstone during the buildup of the coal bed. The No. 4 seam comprises many shale and sandstone fragments (Pone *et al.*, 2007). The primary No. 4 Seam consists of dull to dull lustrous coal with a typical thickness ranging from 2.5 meters in the field's center to 6.5 meters outside (Pinetown and Boer, 2006). This results in mining being restricted to the lowest 3.5 m of the coal seam, which is mostly used as power plant fuel and household steam coal (Smith and Whittaker, 1986; Xaba, 2004).

The contribution of Coal seam No. 5 to the total coal resources of the Witbank coalfield is negligible. This seam is approximately 1.5 to 2.0 m thick and is approximately 25 m above coal seam No. 4. (Pone *et al.*, 2007). The No. 5 seam is generally present in the basement right above palaeo-topographic highs (Cairncross, 1990). The coal seam is overlain by laminated sandstone, creating weak mine-roof conditions that need extensive support if mined underground (Pone *et al.*, 2007). The No. 5 seam consists mostly of brilliant, banded coal with thin shale and mudstone separations (Smith and Whittaker, 1986; Xaba, 2004). According to Smith and Whittaker (1986), seam No. 5 has been mined as a source of blend coking coal and for metallurgical purposes, especially in the central Witbank region, where it is of better grade (Xaba, 2004). The bottom seam (No. 1) is formed as a single seam in the deeper portion of the coal basin, although in certain

sections it is divided into three distinct coal units by interbedded sediment (up to 3.5 m thick) (Pone *et al.*, 2007).

The geological setting of the study area support the overall abjective of the research. The coal seams and associated geological strata, which have been identified as the source of contaminants in the catchment area, will be tested in this study.

3 PETROGRAPHY AND GEOCHEMISTRY OF THE SOURCE ROCK UNITS

3.1 INTRODUCTION

To unravel the fate of metals in the receptor realm, it is necessary to comprehend the geochemical properties of the source rock units. The primary purpose is to geochemical characterize the geological units of the source rock. According to the geological context of the ROC covered in chapter 2, about 80 percent of the geology consists of the Karoo Supergroup's Vryheid Formation. The drillcores donated by Anglo Coal (Pty) Ltd., Zondagsfontein project, Geodehoep Colliery were used in this study. The data of several lithological units were reported in Appendix B-D. Appendix A is the summary focussed more on coal petrology as part of the MSc project, which is vital in understanding the genesis and the depositional environment of coal of the study area. The investigation reveals that the rank of coals ranges from subbituminous to high-volatile bituminous. Maceral groups of vitrinite, inertinite, and liptinite predominate in the coals. Due to the high groundwater table levels in the peat bog, the coal seams developed in anaerobic conditions. However, the presence of fusinite and semi-fusinite macerals suggests that the groundwater level was shifting, reverting to lower groundwater and increasing oxygen ingress, hence activating oxidizing conditions.

3.2 METHODOLOGY

A total of 123 samples were taken from the two boreholes ZFN1512 and ZFN1510 of the Geodehoop coal mine, which represent the Ecca Group lithostratigraphic units (Figures 2-3; 3-1). The two boreholes reveal comparable geological units, which will be discussed together. Sampled rocks of the Bushveld Complex include sandstones/siltstone, siltstone, shale, sandstone, dolerites, coal, shaly coal, tillite, and basement granite (felsites). The representative samples of the stratigraphic units' lithos were gathered. XRF and XRD were used to examine the elemental concentrations and mineralogy of the samples, respectively. Coal analyses for proximate and

ultimate analysis was done to achieve the MSc research objective and is presented in Appendix A, largerly based on ALS Coal Technology (2011).

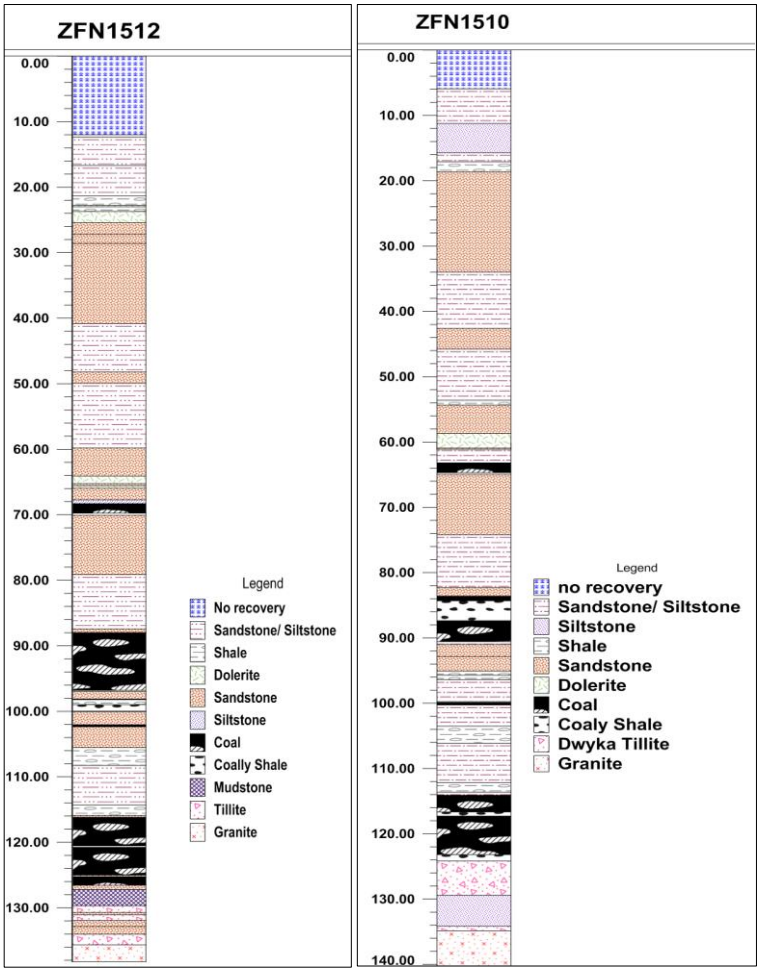


Figure 3-1: The sampled stratigraphic units of the Zondagsfontein project (Geodehoop colliery) from Anglo Coal Pty.Ltd.

3.2.1 Borehole core samples description

Anglo-American Coal (Pty) Ltd constructed a 140 m well and a 138.2 m borehole, labelled ZFN1512 and ZFN1510, for the Zondagsfontein project in the Witbank Goedehoop region. The majority of the stratigraphy of the Witbank coalfield is represented by the boreholes, which include significant coal seams. The unrecovered portion of the boreholes was around 15 to 25 m thick. The two boreholes yielded a total of 65 and 58 samples, respectively. The sample technique was

undertaken at the CGS core shed as part of an internal initiative analyzing the environmental effect of mining using a comprehensive approach. Appendix H has a description of the boreholes.

3.2.2 Analytical Procedure

This research uses a mix of analytical approaches to comprehend the geochemistry of the geological units. X-ray diffraction (XRD) and X-ray fluorescence (XRF) were utilized to determine the elemental composition and mineralogy of each stratigraphic unit using the lithology.

In addition ultimate analysis, the coal seams' analytic approach also incorporates proximate analysis. The proximate analysis was undertaken to determine the concentration of sulphur, moisture, volatile matter, ash, and fixed carbon, while the ultimate analysis quantified the carbon, hydrogen, sulphur, oxygen, and nitrogen content of the coal samples.

3.2.2.1 X-ray diffraction (XRD)

XRD was utilized to determine the composition of the material. In this study, the method of analysis described by Brime (1985) was utilized. On a BRUKER D8 Advance equipment with a 2.2 kW Cu long fine focus tube and LYNXEYE detector, XRD measurements were conducted. The system had a main monochromator and a sample changer with a 90° position. Using CuK radiation at a speed of 0.02° 2 step size/0.5sec and generator settings of 40kV and 40mA, samples were scanned from 2° to 70°. The system is computer-controlled using the software package BRUKER DIFFRACPlus. The solid samples were crushed, processed, and homogenized into a fine powder with a particle size of roughly 10 to 15 m. To guarantee random orientation, a subsample was squeezed into a shallow plastic sample holder against rough filter paper. Using the BRUKER DIFFRACPlus - EVA assessment tool, phase identification was conducted. For search/match, the inorganic/organic database was utilized; the PDF-2, data sets 1-50 were accessible on CD-ROM. Using relative peak height/area ratios, semi-quantitative estimations of phase concentrations were derived (Jenkins, 2000).

3.2.2.2 X-ray fluorescence spectrometry (XRF)

XRF is a method of elemental analysis that assesses the presence and concentration of various elements by measurement of secondary radiation from the sample that has been excited by an X-ray source (Smith, 1990). Major and trace element concentrations in the coal and non-coal samples were also determined using XRF.

The method allows the quantification of a given element by first measuring the emitted characteristic line and then relating this intensity to elemental concentration. X-Ray fluorescence is particularly well-suited for investigations that involve: Bulk chemical analyses of major elements (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P and Cr) in rock and sediment. Bulk chemical analyses of trace elements (in large quantities >1 ppm; As, Ba, Be, Cd, Co, Cr, Cu, Ga, Ge, Mo, Ni, Pb, Rb, Sc, Se, Sm, Sr, Ta, Th, U, W, V, Y, Zr, Zn) in rock and sediment - detection limits for trace elements are typically on the order of a few parts per million.

The glass disks and wax pellets was prepared on milled sample of less than 75 μ fraction and then analyzed by a PANalytical wavelength dispersive Axios X-ray fluorescence spectrometer equipped with a 4 kW Rh tube for a major and traces. The full method is described in Cloete and Truter, (2001). The Lower Limit of Detection (LLD) (minimum (min), maximum (max) and average (av)) is presented in Table 3-1 and Table 3-2. The resulting stability of analyses was monitored on a daily analysis, per batch of 300 samples analysed. XRF data is represented in Appendix D.

Table 3-1: Presents the LLD and the XRF standards in CGS for some majors and largely trace elements.

LLD for application - Traces_2013 Compound	Min. LLD	Standard	Max. LLD	Standard	Av. LLD
	(ppm)		**(ppm)**		**(ppm)**
CaO	3.26	GSR-4_2014	17.67	SARM-40	5.67
Sc	0.95	GSR-4_2014	1.4	GSR-3_2014	1.1
TiO_2	1.65	NBS-99a_2014	17.15	TRMAC-004	2.68
V	0.98	GSR-4_2014	1.8	SARM-40	1.16
Cr	1.6	GSR-4_2014	2.66	SARM-40	1.87
MnO	2.67	CRM-782-1	6.1	SARM-51	3.5
Fe_2O_3	5.96	NBS-99a_2014	73.31	TRMAC-005	10.45
Co	1.15	NBS-99a_2014	1.97	GSR-3_2014	1.44
Ni	1.7	GSS-3_2014	3.14	SARM-51	2.06
Cu	1.29	GSR-4_2014	2.06	SARM-51	1.49
Zn	1.31	GSR-4_2014	2.04	SARM-51	1.5
Ga	0.88	GSR-4_2014	1.39	SARM-51	1.02
Ge	0.66	GSR-4_2014	0.98	SARM-40	0.75
As	3.57	GSR-4_2014	5.16	SARM-40	4.03
Se	1.04	GSR-4_2014	1.47	GSR-3_2014	1.15
Br	0.75	GSS-3_2014	1.03	GSR-3_2014	0.83
Rb	0.44	GSR-4_2014	0.66	SARM-40	0.5
Sr	0.43	GSR-4_2014	0.62	SARM-40	0.48
Y	0.42	GSR-4_2014	0.65	GSD-2	0.52
Zr	0.4	GSR-4_2014	0.8	SARM-40	0.48
Nb	0.35	GSR-4_2014	0.49	SARM-40	0.39
Mo	0.36	GSR-4_2014	0.48	SARM-40	0.39
Cs	3.69	GSR-4_2014	5.11	GSR-3_2014	4.17
Ba	2.88	GSR-4_2014	5.3	GSR-3_2014	3.54
La	5.63	GSR-4_2014	10.55	SARM-40	6.57
Ce	8.3	GSR-4_2014	13.9	SARM-40	9.55
Nd	4.54	GSR-4_2014	7.63	SARM-40	5.24
Sm	3.39	GSR-4_2014	5.46	SARM-40	3.79
Yb	4.16	GSS-3_2014	6.86	GSR-3_2014	4.95
Hf	4.54	GSR-4_2014	6.82	GSR-3_2014	5.17
Ta	2.15	GSR-4_2014	3.42	GSR-3_2014	2.5
W	2.18	GSS-3_2014	3.39	GSR-3_2014	2.53
Tl	2.11	GSR-4_2014	3.06	SARM-40	2.38
Pb	1.14	GSR-4_2014	1.68	SARM-51	1.28
Bi	1.66	NBS-99a_2014	2.47	SARM-40	1.89
Th	1.01	NBS-99a_2014	1.43	SARM-40	1.13
U	0.89	GSR-4_2014	1.23	GSR-3_2014	0.99

Table 3-2: The lower LLD and the standards used by XRF in CGS for the major oxide.

LLD for application - Majors2013_ Compound	Min. LLD	Standard	Max. LLD	Standard	Av. LLD
	(ppm)		**(ppm)**		**(ppm)**
Al_2O_3	10.45	1084	17.06	1065	12.41
CaO	0.69	1074	1.07	1062	0.78
Cr_2O_3	1.15	1072	1.94	1068	1.37
Fe_2O_3	1.64	1072	3.09	1084	2.18
K_2O	1.03	1069	1.2	1084	1.14
MgO	3.76	1069	7.14	1065	4.68
MnO	0.25	1079	2.22	1068	1.235
Na_2O	6.53	1076	11.17	1063	7.76
P_2O_5	1.46	1074	6.18	1079	1.97
SiO_2	2.55	1062	4.81	1075	3.48
TiO_2	1.17	1072	1.75	1062	1.34

3.3 RESULTS

3.3.1 Mineralogy of stratigraphic units

The mineral concentrations generally ranges as follows: dominant mineral is less than 50%, major minerals from 20% to 50%, minor minerals from 10% to 20%, accessory minerals from 2% to 10%, and the rare minerals up to 2%. The mineral concentrations determined by XRD for the two boreholes are presented in Table 3-3, with all results presented in Appendix A. The following minerals were identified in the geological units for both ZFN1510 (samples marked “M”) and ZFN1512 (samples marked “W”): calcite, dolomite, hematite/goethite, potassium feldspar/rutile, plagioclase, quartz, mica, kaolinite/chlorite, kaolinite, anatase, siderite, pyrite, smectite, interstratification, and amorphous material. The most prevalent minerals are potassium feldspar/rutile, plagioclase, quartz, mica, and kaolinite/chlorite, although calcite is prevalent in sandstones and coal. Plagioclase is the most prevalent mineral in dolerites, comprising around 54% of the average percentage. On coal seam no. 5 and the stratigraphic levels below, sulphide minerals are prevalent.

3.3.1.1 Inorganic geological unit

The inorganic geological is represented by the sedimentary and the igneous rocks of the study area. Dywka tillite and the feisc rock form part of the basement rocks in the boreholes ZFN1512 and 1510 (Figure 3-1). The classification schemes of terrigenous shales and sandstones using Fe_2O_3/K_2O vs SiO_2/Al_2O_3 reveals that the majority of the sediments are shales with minor Fe-rich, arkose with minor subarkose, wacke and monor litharenite (Figure 3-2). This is due to intermediate to low SiO_2/ Al_2O_3 values, sediments are regarded as relatively mature, and strongly weathered as shown in their predominantly low Fe_2O_3/K_2O ratios reflecting a feldspar dominance over ferromagnesian minerals as discussed for the Rosh Pinah sedimentary rocks (Gauert, 2005). According to this classification, the majority of the coal seams are plotting on the Fe-shale due to high ratio of Fe_2O_3/K_2O and less SiO_2/Al_2O_3 (Figure 3-2). The shale units is notable below or above coal seam No. 5 (samples W27 and M34) and is confirmed by the logged geological unit for the boreholes. In these shale samples, the XRD results indicate the mineral dorminance of 26% quartz, 38% kaolinite/chlorite, 20% mica, 6% k-felspar and 5% plagioclase for W27 (Table 3-3). The sandstone logged in the boreholes below coal seam No. 5, especially above coal seam No. 4 is in the field of litharenite or sublitharenite. This unit is characterised by the presence of up to 62% quartz, 29% K-feldspar, and 5% plagioclase with minor pyrite up to 2% (Table 3-3). The rest of the siltstones logged on the boreholes is classified as arkosic or subarkiose and is composed commonly of quartz and kaolinite, with tiny amounts of mica, potassium feldspar, plagioclase, and interstratification, as well as anatase, chlorite, siderite, and hematite minerals (Appendix A). Plagioclase and calcite are the predominant minerals in dolerite, with kaolinite, pyroxene, siderite, and mica as minor minerals, and the uncommon minerals smectite, chlorite, and anatase (Table 3-3; Appendix B). The sediments logged as sandstone/ siltstone are dominated by quartz and clay minerals (kaolinite interstratification), with minor carbonates (dolomite, calcite), potassium feldspar, plagioclase, and mica, and minor minerals including siderite, anatase, pyrite, and smectite (Table 3-3; Appendix B). Quartz and kaolinite are the predominant minerals in mudstone, with mica and potassium feldspar serving as accessory phases, which is typical of the Karoo rocks (Baiyegunhi *et al.*, 2017). The tillite (M62) is likewise dominated by quartz and kaolinite, as well as minor minerals including dolomite, plagioclase, and mica, and accessory minerals like anatase, siderite, potassium feldspar, and pyrite (Table 3-3; in Appendix B). Quartz, minor plagioclase,

siderite, potassium feldspar, and the uncommon minerals pyrite and mica dominate the granite M63) at the base of the borehole (Appendix B). Dolerite constitutes sample W23, with clinopyroxene as a minor mineral (Appendix B).

Table 3-3: The results (wt.%) of X-ray diffraction analyses of coal seams with the footwall and the extends above (ZFN1512 and 1510)

BH ID	Sample	Calcite	Dolomite	Hemitite/ Geothite	K-feldspar	Plagioclase	Quartz	Mica	Kaolinite/ Chlorite	Chlorite	Anatase	Pyrite	Siderite	Smectite	I/S Interstratification	Amorphous material	Seam
ZFN1512	W25	-	-	-	11	6	42	10	26	-	-	-	-	-	5	-	
	W26	7	7	-	-	-	34	-	32	-	-	12	-	-	9	-	Seam5
	W27	-	-	1	6	5	26	20	38	2	-	-	-	-	2	-	
	W30	-	-	1	6	-	58	-	23	-	-	-	12	-	-	-	
	W31	3	3	-	-	-	9	-	24	-	-	51	4	5	-	*	Seam4
	W32	-	2	-	1	-	27	4	66	-	1	-	-	-	-	-	
	W40	-	-	-	13	-	71	1	15	-	-	-	-	-	-	-	
	W41	-	1	-	31	-	8	3	48	-	-	5	4	-	-	*	Seam3
	W42	-	-	-	11	-	32	8	45	-	trc	-	4	-	-	-	
	W48	-	-	-	8	-	73	1	18	-	-	-	-	-	-	-	
	W49	-	-	-	1	-	44	2	53	-	1	-	-	-	-	-	Seam2
	W50	-	-	-	6	-	65	3	21	-	-	4	-	-	-	-	
ZFN1510	M34	-			8	13	51	5	10				2		11		
	M35	9	10				9	5				21				*	Seam5
	M36	34	3		10		33	14	trc			1					
	M43				29	5	62					2	1				
	M44				2		47				1	2			2		Seam4
	M45				8		41	4			1						
	M52				8		45	6									
	M53		6				15	3				10	14			*	Seam3
	M54				7		28	12	53				0				
	M60		9		3		62	2				2	2			*	
	M61	3	10				28	5				11					Seam2
	M62		3		6		66	3			1						

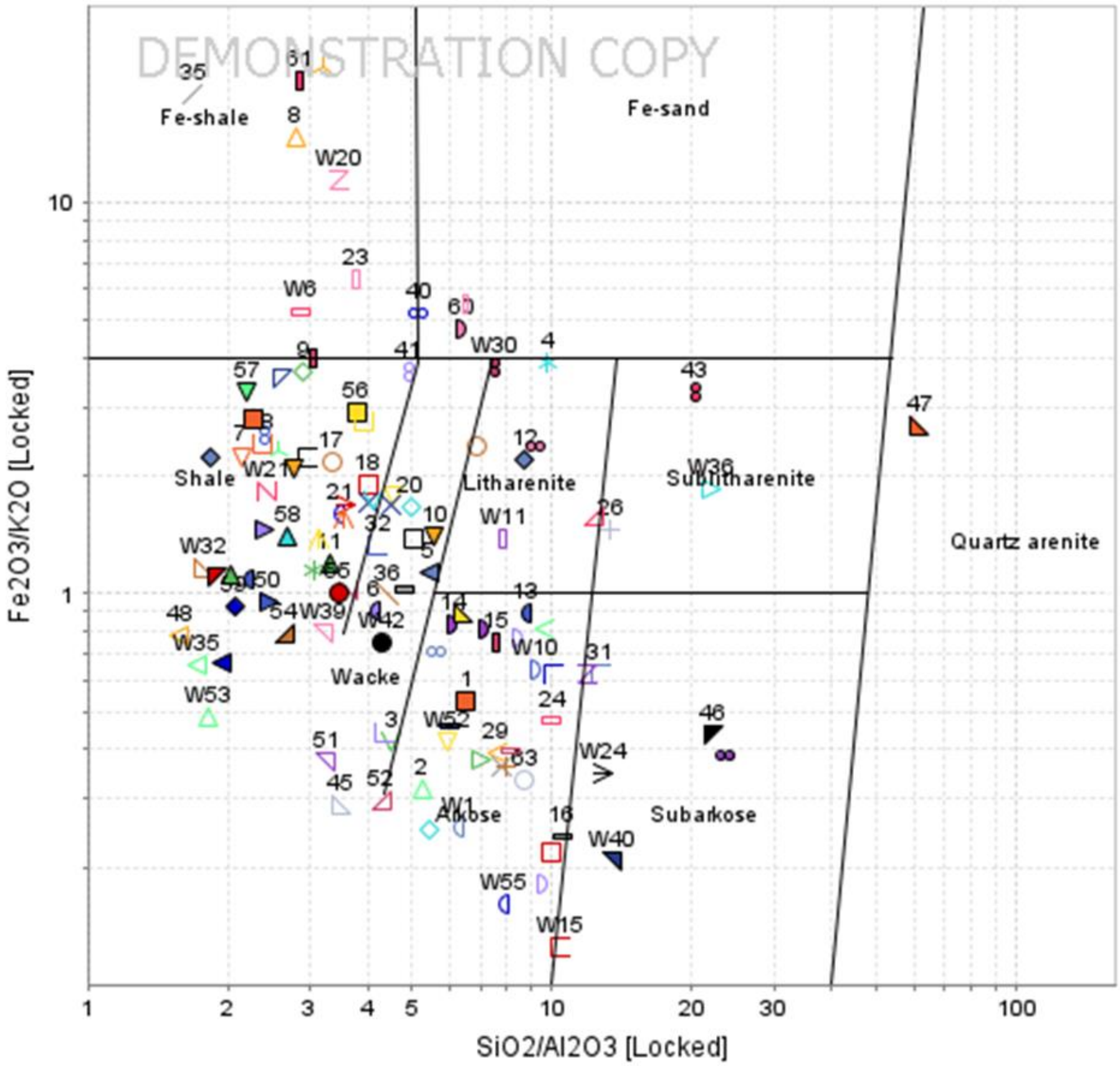


Figure 3-2: Witbank coalfied metasediments compositions for BH1510 and 1512 (valid N = 123) in the classification schemes of terrigenous shales and sandstones using Fe_2O_3/K_2O vs SiO_2/Al_2O_3 by Herron (1988) after Gauert (2005).

3.3.1.2 Organic geological unit

3.3.1.2.1 Coal Seam No. 5

The mineralogical composition of coal deposits around the world is dominated by carbon, quartz, kaolinite, clay minerals, sulphides, carbonates, and phosphates, as well as certain uncommon minerals indicative of the depositional environment or source material (Pinetown, 2003). Seam No. 5 (ZNF1510, sample M35) has two important minerals, kaolinite and pyrite, with carbonate minerals (calcite and dolomite), quartz and mica minerals as accessory minerals (Table 3-3). Seam No. 5 (ZNF1512, sample W26) comprises quartz and kaolinite as the principal minerals, pyrite as a minor mineral, and calcite and dolomite as accessory minerals (Table 3-3). The sandstone-siltstone represented by sample M34 is the rock, which extends above seam No. 5 and is dominated by quartz, with kaolinite, interstratification, and plagioclase as minor clay minerals, and potassium feldspar, mica, and siderite as accessory minerals. The footwall of seam No. 5 is a sandstone (ZNF1510, sample M36) with quartz and calcite as the principal minerals, mica and potassium feldspar as minor minerals, and plagioclase, pyrite, and dolomite as accessory minerals. For borehole ZNF1512, the footwall of coal seam No. 5 is composed of sandstone (sample W27) with quartz, mica, and kaolinite as the major minerals, potassium feldspar and plagioclase as the minor minerals, and hematite and chlorite as the rare minerals.

3.3.1.2.2 Coal Seam No. 4

Seam No. 4 of borehole ZFN1512 is composed of the major minerals pyrite and kaolinite with minor minerals of carbonates (calcite and dolomite), quartz, siderite and smectite (Table 3-3), whereas seam No. 4 of borehole ZFN1510 is composed of quartz and kaolinite as major minerals with potassium feldspar, pyrite and interstratification as minor (Table 3-3). The sandstone-siltstone below seam No. from borehole ZFN1510 represented by M45 has quartz and kaolinite as the major minerals, mica and potassium feldspar as the minor minerals, and anatase as the accessory mineral (Table 3-3). Shale which is the footwall of borehole ZFN1512 (sample W32) is dominated by kaolinite with quartz as the primary material and minor amounts of dolomite, potassium feldspar,

and anatase as accessory minerals (Table 3-3). The sample above represented by M43 of ZNF1510 is composed of sandstone is dominated by quartz and potassium feldspar, with kaolinite and pyrite as minor minerals and siderite as an accessory mineral.

3.3.1.2.3 Coal Seam No. 3

The predominant mineral in seam No. 3 is kaolinite, with quartz, pyrite, siderite, and dolomite as important minerals and mica as a minor mineral (Table 3-3; Appendix A). In seam No. 3 of ZNF1512, kaolinite and potassium feldspar are the predominant minerals, pyrite, siderite, mica, and quartz are the minor minerals, and dolomite is the accessory mineral (Table 3-3). The rocks that extends above represented by sample M52 is composed of sandstone-siltstone with quartz and kaolinite as main minerals and potassium feldspar and mica as minor minerals (Table 3-3), whereas sample W40 is composed of sandstone dominated by quartz with potassium feldspar and kaolinite as minor minerals (Table 3-3). The footwall is composed of sandstone (sample W42) with quartz and kaolinite as the primary minerals, and potassium feldspar, mica, and siderite as minor minerals (Table 3-3). Sample M54 is a sandstone-siltstone that is dominated by kaolinite material, has quartz as its main mineral, mica as its minor mineral, and potassium feldspar as its accessory mineral (Table 3-3).

3.3.1.2.4 Coal Seam No. 2

In the No. 2 seam, kaolinite, calcite, and dolomite are the predominant minerals (Pinetown, 2003). ZNF1510 is dominated by quartz and kaolinite, with dolomite, pyrite, calcite, and mica as accessory minerals (Table 3-3; Appendix B). On sample W49, kaolinite was identified as the main mineral, with quartz, potassium feldspar, mica, and anatase as uncommon minerals (Table 3-3). The rock which extends above is composed of sandstone-siltstone (sample M60), with quartz and kaolinite as the primary minerals and potassium feldspar, mica, pyrite, siderite, and dolomite as the minor minerals. The rocks above represented by sample W48 is composed of sandstone that is dominated by quartz with modest quantities of kaolinite and potassium feldspar as accessory minerals, and microscopic amounts of mica (rare mineral). The below unit of Dwyka tillite represented by sample M62, which is dominated by quartz and kaolinite, with potassium feldspar,

mica, and dolomite serving as accessory minerals (Table 3-3). The ZNF1512 footwall is sandstone (sample W50) and is characterized by quartz with kaolinite as the primary mineral and pyrite, potassium feldspar, and mica as accessory minerals (Table 3-3).

3.3.2 Geological units petrology

For discusion in this section, the minerals has been abbreviated as follows: plagioclase (Plag), clinopyroxene (Cpx), and potassium feldspar (Kfs) phenocryst with Orthoclase twining; quartz (Qtz), and carbonates minerals (Cb), pyrite (Pyrit), mica, chlorite (Chl), inertinite (In) and vitrinite (v).

3.3.2.1 Above Coal Seam no. 5

The upper strata around coal seam No. 5 are enormous reddish-brown to light brown sandstone with medium grains (samples W22-W24, W10-W15 for borehole ZFN1512 and samples M12-M16, M22, M29, and M31 for borehole ZFN1510). In addition, they contain a light greenish-gray porphyritic dolerite dyke (W7, W9, and W23 for ZFN1512 and M30 for borehole ZFN1510) composed primarily of pyroxene, plagioclase, siderite, and interstratification (Tables 3-3; Appendix B), along with minor sandstone clasts and fractures, and fine-grained siltstone. The third kind consists of cross-laminated and minor flat-laminated materials. A very well-sorted and fine-grained black shale (W6 and W8 for borehole ZFN1512 and M4, M11 & M28 for borehole ZFN1510) composed primarily of potassium feldspar, plagioclase, quartz, mica, kaolinite, anatase and interstratification (Tables 3-3; Appendix B) with interlaminated beds and minor cross beds. Fine to medium-grained, light to gray siltstone (W25 for borehole ZFN1512 and M5-M6 for borehole ZFN1510) with minimal cross-lamination is present. It is mostly composed of quartz, plagioclase, potassium feldspar, mica, kaolinite, and interstratified illite/smectite, along with trace amounts of carbonate minerals, anatase, and siderite (Table 3-3; Appendix B).

Pyrite is the sulphide mineral found in coal, sandstone, and shales in the Goedehoop region, according to this study. However, it is connected with early or syngenetic depositional origins as

a minor mineral. As seen through a microscope, sandstone and coal include fragmentoid pyrite grains, but shale rocks are often composed of small, disseminated, euhedral pyrite grains.

The dolerite specimen labeled M30, W7, W9, and W23, consists mostly of pyroxene, plagioclase, siderite, and interstratification (Tables 3-3; Appendix B). Under a microscope, a cross-polarized transmitted light image of dolerite reveals elongated plagioclase with parallel pairs of albite twining, subhedral to anhedral clinopyroxene, potassium feldspar phenocryst, and carbonates minerals with anhedral quartz (Figure 3-3).

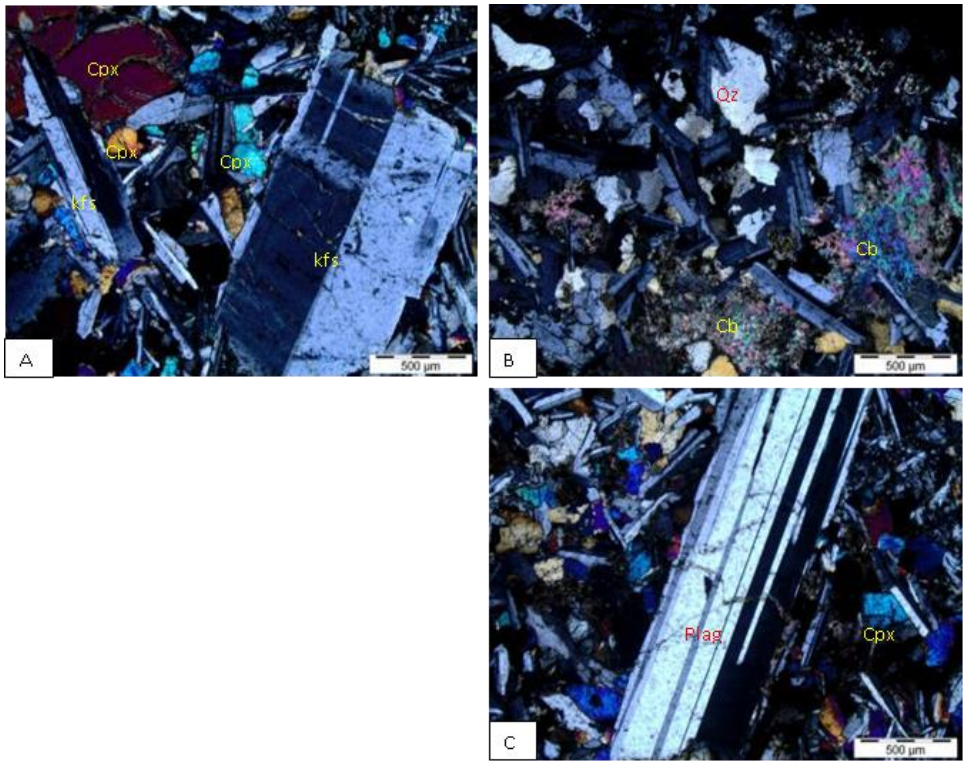


Figure 3-3: A dolerite sample represented by M30 exhibits plagioclase, clinopyroxene, and potassium feldspar phenocryst with orthoclase twining in A; quartz, elongated plagioclase, and carbonates minerals in B; and elongated phenocryst of plagioclase with albite twining in C.

Shale sample M28 consists mostly of plagioclase, quartz, mica, kaolinite, anatase, and interstratification (Appendix B). As seen in Figure 3-4, (A) is a view of reflected plane-polarized light revealing framboidal pyrite grains, the sole identifiable sulphide, and (B) is a view of crossed-polarized transmitted light revealing quartz, mica, plagioclase, and chlorite.

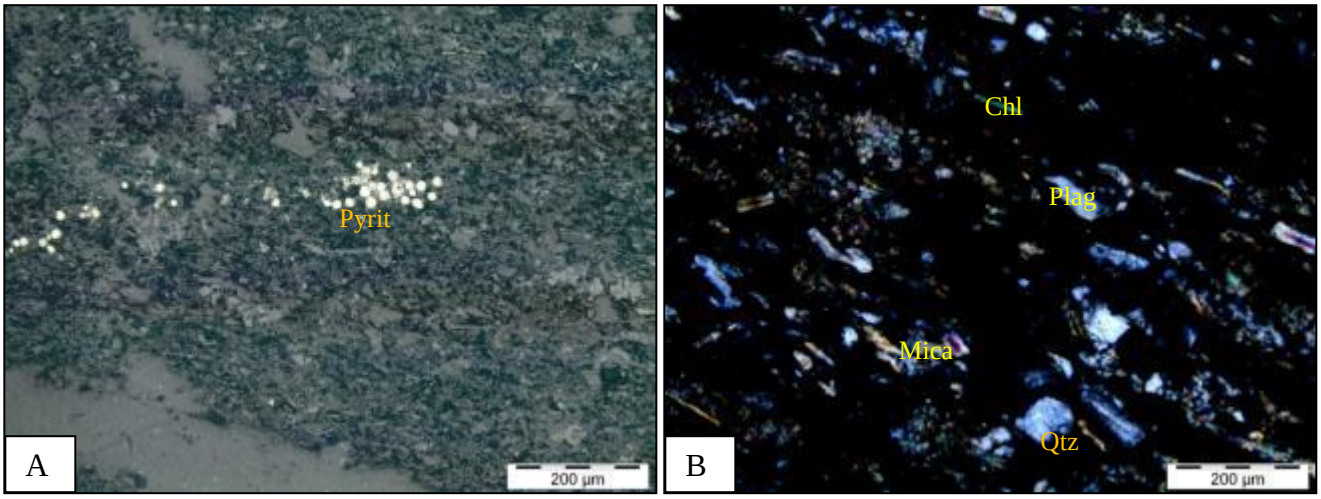


Figure 3-4: Shale represented by sample M28 exhibiting framboidal pyrite grains in A and showing quartz, mica, plagioclase and chlorite in B under crossed-polarised transmitted light.

The sandstone-siltstone above seam No. 5. Sample M33 is predominantly constituted of quartz, plagioclase, potassium feldspar, mica, kaolinite, and interstratified illite/smectite (I/S), with traces of carbonate minerals, anatase, and siderite, as determined by XRD (Appendix B). Under reflected light, the detected minerals are partially decomposed pyrite, however under transmitted light, seen minerals are clasts of quartz and mica altering to chlorite, although plagioclase (albite twining) and clay (kaolinite) constitute the majority of the matrix filling material (Figure 3-5).

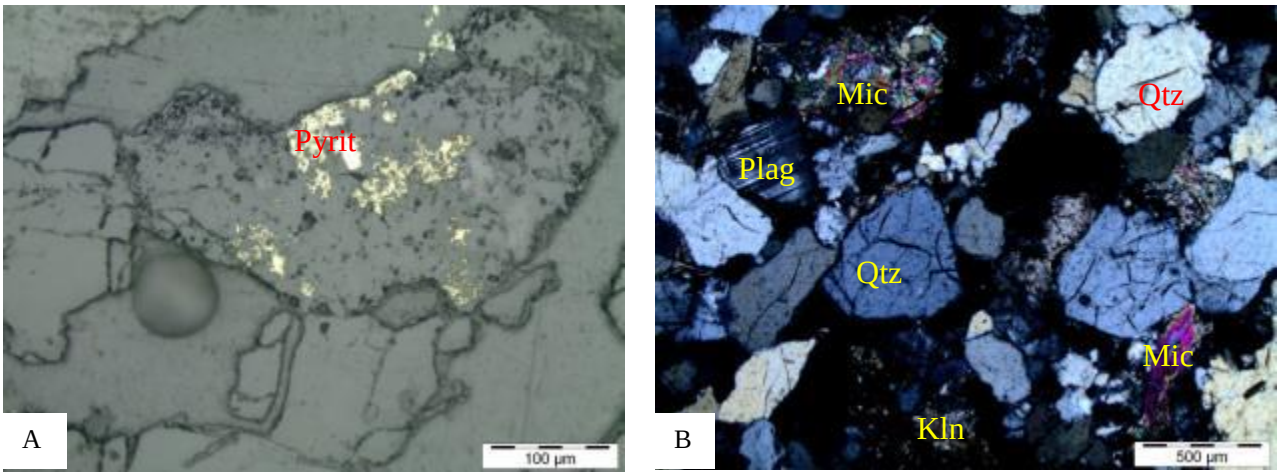


Figure 3-5: Sandstone represented by sample M33 exhibits spongy pyrite in A, and quartz, mica, kaolinite and plagioclase in B under crossed-polirased transmitted light.

3.3.2.2 Coal Seam No. 5

The XRD analysis of this seam (sample M35) revealed that the predominant mineral is kaolinite, followed by pyrite, a minor quantity of mica and quartz, and carbonates (calcite and dolomite) (Table 3-3; Appendix B). This is corroborated by the petrographic findings that the bulk of identified minerals are clays, quartz, mica, and pyrite, and that no carbonates were detected (Figure 3-6).

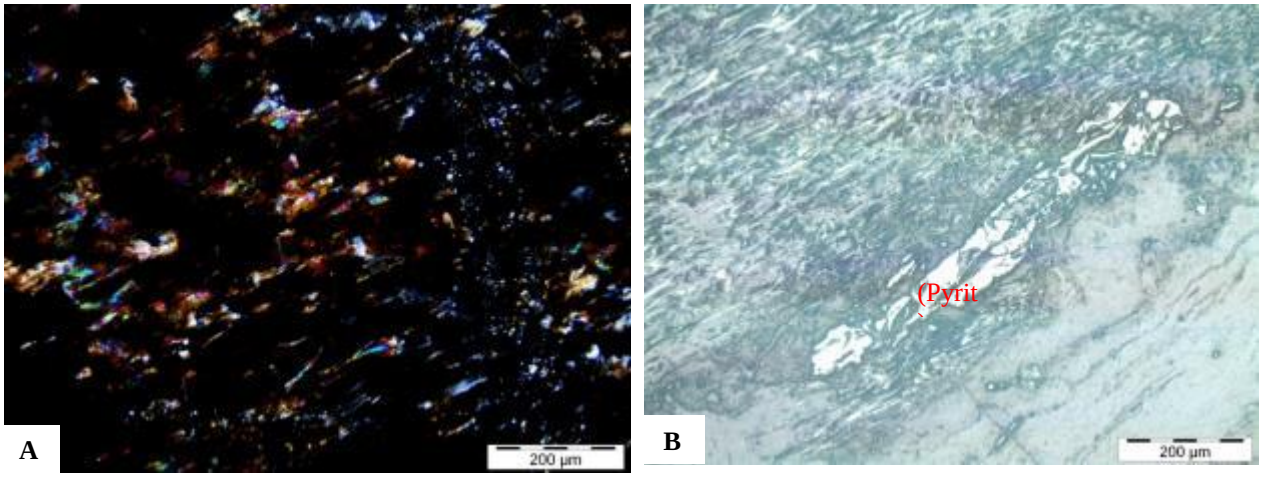


Figure 3-6: The seam No. 5 represented by sample M35 exhibits kaolinite, quartz, and mica in A, and pyrite elongation in B, under reflected light.

3.3.2.3 Within No. 5 and No. 4 Coal Seam

Between seams No. 5 and 4, the sandstone depicts the below and the rocks that extends above (sample M41). XRD revealed that the mineral matter composition of this sandstone consists of potassium feldspar, carbonates (calcite and dolomite), and quartz, with traces of pyrite, minor quantities of muscovite and kaolinite, and siderite (Appendix B). The findings are verified by petrographic mineral group studies, in which the bulk of minerals detected are clastic grains of potassium feldspars and quartz in a matrix of carbonates and mica minerals, with pyrite primarily showing in framboidal form (Figure 3-7).

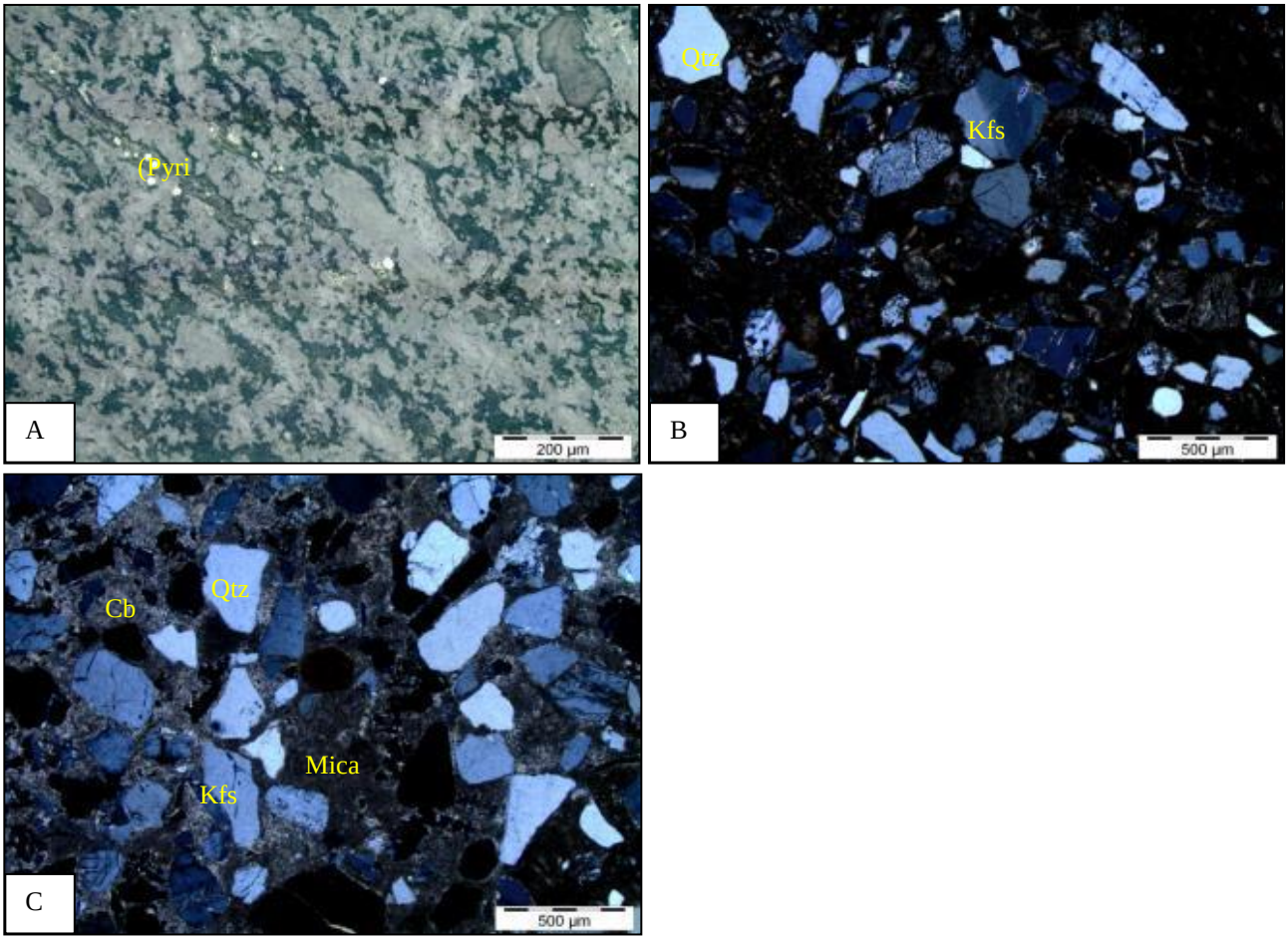


Figure 3-7: A framboidal pyrite in A under reflected light; potassium feldspar and quartz in B, and displaying potassium feldspar and quartz in carbonates and muscovite matrix of sandstone represented by sample M41.

3.3.2.4 Coal Seam No. 4

XRD analysis revealed that seam No. 4 represented by M44 has a preponderance of quartz and kaolinite, with potassium feldspar, anatase, pyrite, and interstratification (I/S) as minor minerals (Table 3-4; Appendix B). Under reflected plane-polarized light, pliable pyrite is shown by petrographic mineral group analysis (Figure 3-8).

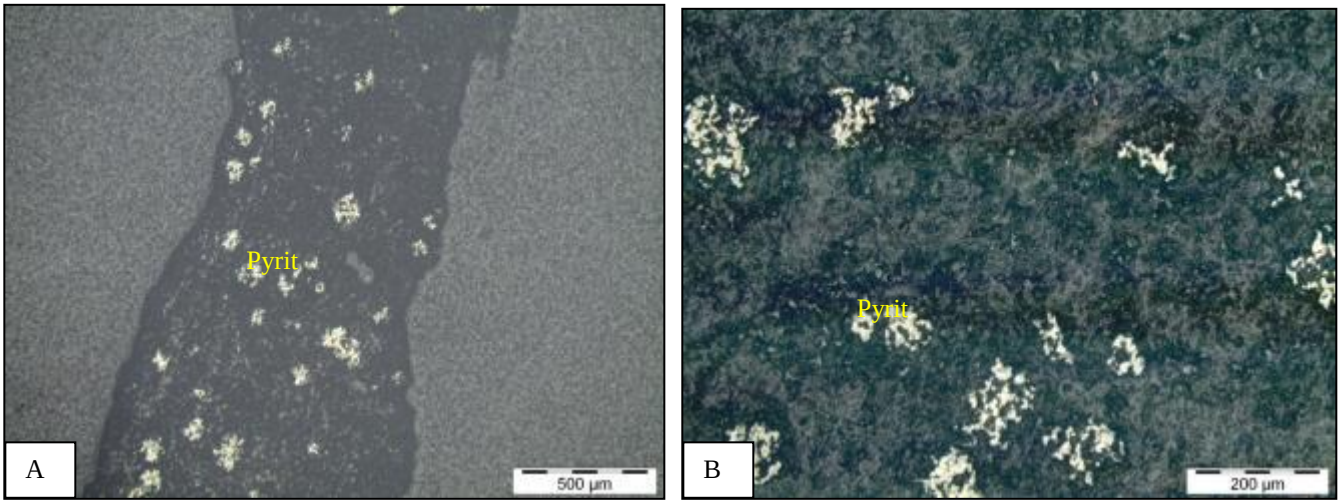


Figure 3-8: Coal seam No. 4 represented by sample M44 display spongy pyrite under a reflected light.

3.3.2.5 Within coal seam No.4 and No.3

The geological unit here is reprented by sample M46, which is composed of a sandstone dominated by quartz and including minor quantities of potassium feldspar, mica, and kaolinite. Under transmitted light, fragments of quartz are visible, but plane-polarized light reveals clusters of dispersed pyrite particles (Figure 3-9).

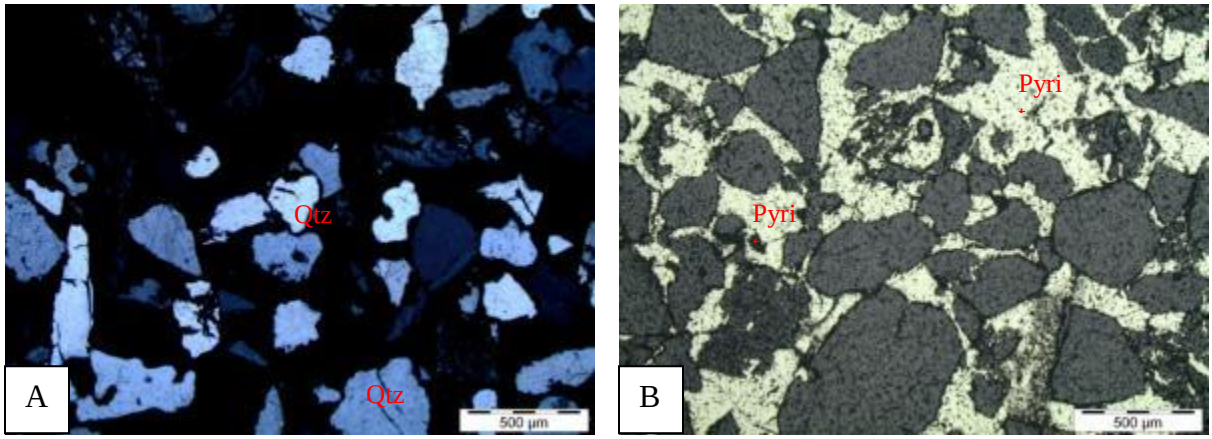


Figure 3-9: Quartz grains showing pyrite matrix under reflected light in B.

3.3.2.6 Coal Seam No. 3

Sample M53 revealed that this seam has large quantity of kaolinite with siderite, quartz, and pyrite as minor minerals and dolomite and mica as trace minerals (Table 3-3; Appendix B). Under reflected light, petrographic mineral group studies reveal pyrite vein filling (Figure 3-10).

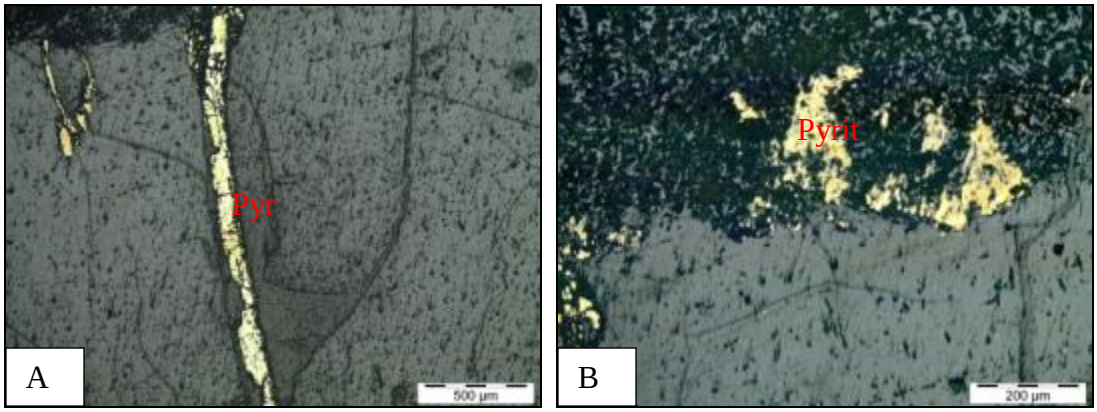


Figure 3-10: Coal seam No. 3 represented by sample M53 exhibiting vein fillings of pyrite in A and spongy pyrite in B under a reflected light.

3.3.2.7 Coal Seam No. 2

The XRD data indicate that seam No. 2 comprises kaolinite and quartz as the principal minerals, dolomite and pyrite as minor minerals, and calcite and mica as accessory minerals (Table 3-3; Appendix B). The mineral visible in the thin slice under reflected light is pyrite embedded in macerals (Figure 3-11).

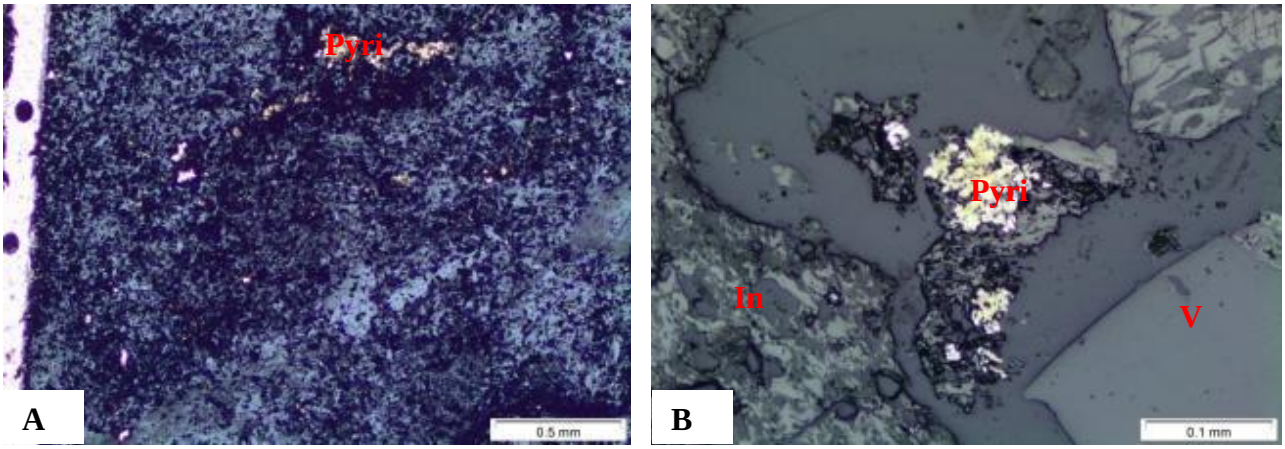


Figure 3-11: The spongy pyrite in A and spongy pyrite with inertinite and vitrinite in B under reflected light.

3.3.2.8 Basement rocks

This geological unit represented by sample M64 is a glacial deposit known as tillite and has a large quantity of kaolinite along with siderite, plagioclase, potassium feldspar, anatase, smectite, and mica as trace minerals (Table 3-3; Appendix A). Quartz is the predominant mineral in the sample, with minor quantities of plagioclase and potassium feldspar and traces of muscovite (Figure 3-12).

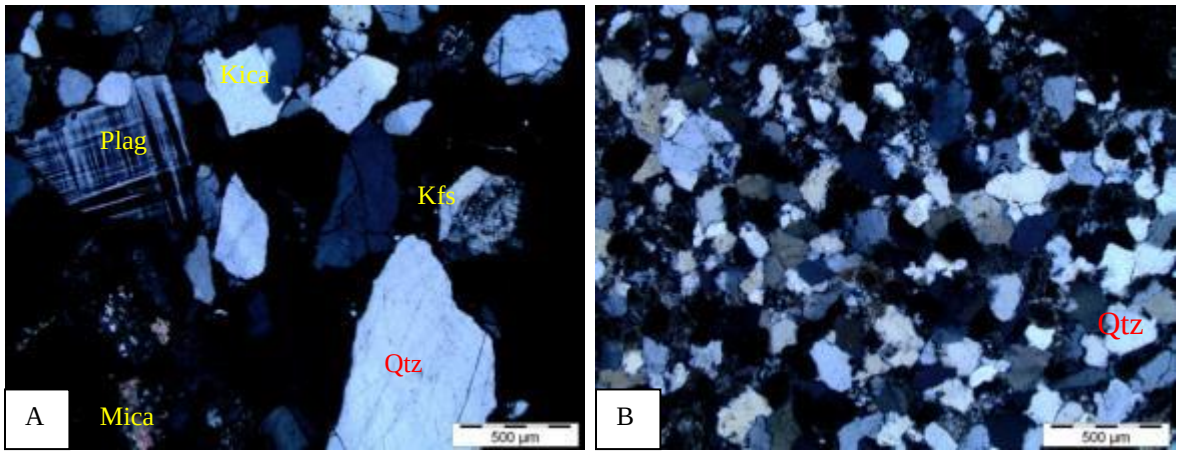


Figure 3-12: Dwyka tillite represented by sample M64 under transmitted light exhibiting plagioclase notably albite twining, potassium feldspar, quartz and muscovite in A; grains of quartz notably clastic in B.

The XRD data indicate that the granite is predominantly made of quartz, plagioclase, potassium feldspar, and siderite, with trace amounts of mica. Granite (M65) seen under transmitted light reveals data supporting the XRD observations, as granite is dominated by quartz with plagioclase (parallel sets of albite twining), potassium feldspar, and minor quantities of muscovite transforming into chlorite (Figure 3-13).

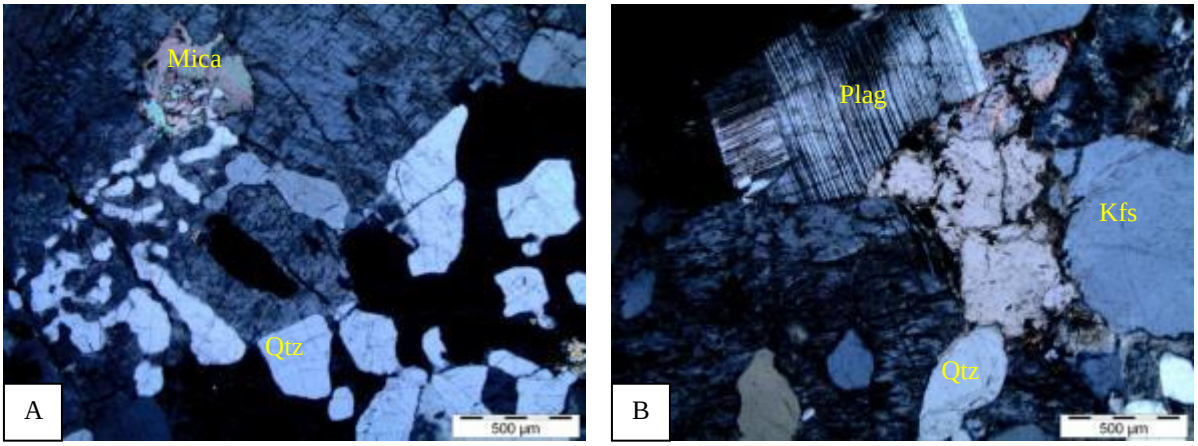


Figure 3-13: Granite reprented by sample M65 presenting muscovite (Ms) altering to chlorite and intersertal or granophyric intergrowth of feldspar and quartz in A; and also showing plagioclase notably albite twining, potassium feldspar and quartz in B.

3.3.3 Geochemical elements distribution

A drill core of the coalbed lithologies reveals that SiO_2, Al_2O_3, Fe_2O_3 and K_2O dominate the samples, with minor levels of TiO_2, CaO, MgO, Na_2O, MnO, P_2O_5 and Cr_2O_3, SiO_2, Al_2O_3 and Fe_2O_3. Correlation matrix reveals the existence of positive and negative linear relations between the main elements or between the major and trace elements, as shown by positive and negative realationships denoted (r) (Table 3-4 and Table 3-5). Feldspar and clay minerals are responsible for the modest correlation between SiO_2 and K_2O. This relationship is supported by K_2O in drill hole ZFN1510, which is strongly connected to SiO_2 and Al_2O_3 and Na_2O. The predominant mineralogy of quartz and clay minerals constitutes this fundamental geochemistry. The increased Fe_2O_3 contents in the samples may be attributable to the presence of hematite in the ferruginous sandstone, pyrite in the coal seams, and dolerite in particular. CaO and MgO concentrations may be caused by the presence of carbonate minerals, and high amounts can lead to alkaline drainage. Corrections between CaO, MgO, Fe_2O_3, and MnO indicate a relationship with carbonate minerals (Tables 3-4 and 3-5; Appendix C). The high positive association between Fe_2O_3 and MnO, r = 0.81, may be attributable for an example to the carbonate mineral siderite (8%) in sample M41 (Appendix B; Figure 3-7). A high LOI suggests a high concentration of volatile materials (i.e. carbonate/hydrous minerals).

Table 3-4: The colour map Pearson correlation matrix of major in wt.% and traces in ppm for the Witbank coalfield geologial units in ZFN 1510, significant at p < .05, classifications after Moore *et al.* (2013).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cr_2O_3	LOI	Total	As	Ba	Bi	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	U	V	Y	Yb	Zn	Zr	S	C
SiO_2	1,0																																												
TiO_2	-0,1	1,0																																											
Al_2O_3	-0,1	0,7	1,0																																										
Fe_2O_3	-0,4	0,3	0,1	1,0																																									
MnO	-0,3	0,2	-0,1	0,8	1,0																																								
MgO	-0,4	0,0	-0,1	0,5	0,4	1,0																																							
CaO	-0,4	-0,1	-0,3	0,5	0,7	0,6	1,0																																						
Na_2O	0,2	0,1	0,1	0,4	0,3	0,1	0,0	1,0																																					
K_2O	0,5	0,1	0,3	-0,2	-0,1	-0,2	-0,2	0,5	1,0																																					
P_2O_5	-0,3	0,0	-0,1	0,6	0,6	0,3	0,7	0,0	-0,2	1,0																																			
Cr_2O_3	-0,1	0,6	0,7	0,2	0,1	0,0	-0,2	0,0	0,0	0,0	1,0																																		
LOI	-0,9	-0,2	-0,2	0,0	-0,1	0,1	0,1	-0,4	-0,6	0,1	-0,1	1,0																																	
Total	0,3	0,0	0,0	0,0	0,1	0,0	0,1	-0,1	0,0	0,1	0,0	-0,3	1,0																																
As	-0,5	0,0	0,0	0,1	0,0	-0,1	0,1	-0,3	-0,5	0,2	0,1	0,6	-0,1	1,0																															
Ba	0,4	0,1	0,3	-0,1	0,0	0,0	-0,1	0,4	0,9	-0,1	-0,1	-0,6	0,1	-0,5	1,0																															
Bi	0,0	0,2	0,0	-0,1	-0,1	0,0	-0,1	0,0	0,0	-0,1	-0,1	0,1	0,1	0,3	0,1	1,0																														
Ce	-0,2	0,5	0,7	0,2	0,0	-0,1	-0,2	-0,1	0,0	0,1	0,5	0,1	0,0	0,1	0,1	0,0	1,0																													
Co	-0,4	0,5	0,4	0,5	0,3	0,2	0,0	0,2	-0,2	0,0	0,6	0,2	-0,2	0,2	-0,2	-0,1	0,3	1,0																												
Cr	-0,1	0,7	0,8	0,1	0,0	-0,1	-0,2	-0,1	0,0	0,0	0,8	-0,1	-0,1	0,2	0,0	0,0	0,6	0,5	1,0																											
Cs	-0,2	0,4	0,7	0,2	0,0	0,0	-0,3	0,0	0,1	-0,1	0,7	0,0	-0,1	0,3	0,0	0,0	0,6	0,4	0,6	1,0																										
Cu	-0,2	0,6	0,3	0,5	0,4	0,2	0,1	0,3	-0,3	0,0	0,5	0,0	0,0	0,0	-0,2	-0,1	0,2	0,6	0,4	0,2	1,0																									
Ga	-0,3	0,6	0,9	0,1	-0,1	-0,1	-0,3	0,1	0,1	-0,1	0,7	0,1	-0,1	0,2	0,2	0,1	0,7	0,6	0,8	0,7	0,3	1,0																								
Ge	-0,4	-0,2	-0,2	0,0	-0,1	-0,1	-0,1	-0,1	-0,3	-0,1	-0,1	0,5	-0,2	0,4	-0,3	0,1	0,0	0,4	0,0	-0,1	0,0	0,2	1,0																							
Hf	0,1	0,6	0,3	-0,1	-0,1	-0,1	-0,2	-0,1	0,3	-0,1	0,2	-0,2	-0,1	-0,1	0,2	0,3	0,4	0,0	0,4	0,1	-0,1	0,3	-0,1	1,0																						
La	-0,2	0,5	0,6	0,2	0,1	-0,1	-0,2	0,0	0,1	0,1	0,5	0,0	0,0	0,1	0,1	0,0	1,0	0,3	0,5	0,6	0,2	0,7	0,0	0,4	1,0																					
Mo	-0,2	0,2	0,2	0,1	-0,1	0,0	-0,1	-0,2	-0,2	-0,1	0,3	0,2	0,0	0,7	-0,2	0,3	0,2	0,2	0,3	0,5	0,1	0,2	0,0	0,0	0,1	1,0																			
Nb	-0,1	0,7	0,7	-0,1	-0,2	-0,2	-0,3	-0,1	0,2	-0,1	0,5	-0,1	-0,1	0,2	0,1	0,3	0,7	0,2	0,7	0,6	0,0	0,7	-0,1	0,7	0,7	0,3	1,0																	
Nd	-0,2	0,6	0,7	0,2	0,0	-0,1	-0,2	0,0	0,1	0,0	0,5	0,0	0,0	0,1	0,2	0,1	1,0	0,3	0,6	0,6	0,2	0,7	0,0	0,4	1,0	0,1	0,7	1,0															
Ni	-0,4	0,5	0,6	0,4	0,1	0,1	-0,1	0,0	-0,2	0,0	0,7	0,1	-0,2	0,3	-0,2	-0,1	0,5	0,9	0,7	0,5	0,5	0,7	0,3	0,1	0,4	0,3	0,4	0,4	1,0													
Pb	0,2	0,2	0,6	-0,2	-0,2	-0,3	-0,4	0,2	0,5	-0,2	0,3	-0,3	0,0	-0,2	0,6	0,1	0,5	0,0	0,3	0,5	-0,1	0,5	-0,1	0,1	0,5	0,1	0,4	0,5	0,1	1,0											
Rb	0,3	0,3	0,5	0,0	-0,1	-0,1	-0,3	0,5	0,9	-0,1	0,2	-0,6	0,0	-0,4	0,8	0,0	0,3	0,0	0,3	0,4	-0,2	0,4	-0,3	0,3	0,4	-0,1	0,4	0,4	0,0	0,6	1,0										
Sc	-0,6	0,4	0,2	0,7	0,7	0,5	0,8	0,1	-0,3	0,7	0,3	0,2	0,0	0,2	-0,1	0,0	0,2	0,5	0,3	0,1	0,5	0,3	0,0	0,0	0,2	0,0	0,1	0,2	0,4	-0,1	-0,1	1,0									
Se	-0,2	0,2	0,2	0,0	-0,1	0,0	-0,1	-0,1	-0,2	-0,1	0,2	0,2	0,0	0,7	-0,2	0,3	0,2	0,1	0,2	0,5	0,1	0,3	0,1	0,0	0,2	0,9	0,3	0,2	0,1	0,1	-0,1	0,1	1,0								
Sm	-0,2	0,3	0,4	0,2	0,1	0,0	-0,2	-0,1	0,0	0,0	0,5	0,0	0,1	0,0	0,1	0,1	0,7	0,2	0,3	0,5	0,2	0,4	0,0	0,1	0,6	0,0	0,3	0,6	0,3	0,4	0,2	0,1	0,1	1,0							
Sr	-0,2	0,0	0,1	0,5	0,6	0,5	0,5	0,3	0,1	0,4	0,0	-0,1	0,1	-0,1	0,3	-0,1	0,1	0,1	-0,1	0,0	0,2	0,0	-0,1	-0,1	0,1	-0,1	-0,3	0,1	0,1	0,2	0,2	0,5	-0,1	0,3	1,0						
Ta	-0,1	0,6	0,1	0,2	0,3	0,1	0,1	0,2	-0,1	0,0	0,3	0,0	0,1	0,2	0,0	0,4	0,2	0,3	0,1	0,2	0,4	0,2	0,0	0,3	0,2	0,3	0,3	0,3	0,2	0,1	0,0	0,3	0,3	0,3	0,1	1,0					
Th	-0,1	0,7	0,6	0,0	0,0	-0,1	-0,2	-0,1	0,0	-0,1	0,5	0,0	0,0	0,2	0,1	0,3	0,9	0,2	0,6	0,5	0,1	0,6	-0,1	0,6	0,8	0,2	0,8	0,9	0,4	0,5	0,2	0,2	0,3	0,6	0,0	0,5	1,0				
U	-0,3	0,5	0,6	0,2	0,0	-0,1	-0,2	-0,2	0,0	0,0	0,6	0,1	-0,1	0,2	0,1	0,1	0,8	0,4	0,6	0,7	0,2	0,7	0,1	0,2	0,8	0,3	0,5	0,8	0,5	0,5	0,3	0,2	0,3	0,8	0,1	0,3	0,8	1,0			
V	-0,2	0,7	0,5	0,5	0,4	0,2	0,0	0,3	-0,1	0,0	0,6	-0,1	-0,1	0,0	-0,1	0,0	0,3	0,8	0,6	0,3	0,9	0,6	0,0	0,1	0,3	0,1	0,2	0,3	0,6	0,0	0,0	0,5	0,1	0,3	0,2	0,5	0,3	0,4	1,0		
Y	-0,3	0,6	0,6	0,2	0,1	0,0	-0,1	0,0	0,0	0,1	0,6	0,1	-0,1	0,1	0,0	0,1	0,9	0,3	0,7	0,5	0,3	0,7	0,1	0,5	0,9	0,1	0,7	0,9	0,5	0,3	0,2	0,4	0,2	0,5	0,0	0,3	0,8	0,7	0,5	1,0	
Yb	-0,2	0,3	0,3	0,1	0,0	-0,1	0,0	-0,1	0,0	0,1	0,3	0,0	0,0	0,1	0,0	-0,1	0,6	0,2	0,3	0,2	0,1	0,4	0,1	0,4	0,6	0,0	0,5	0,6	0,3	0,1	0,2	0,1	0,1	0,5	0,1	0,0	0,5	0,4	0,2	0,7	1,0
Zn	-0,1	0,6	0,8	0,4	0,2	0,0	-0,1	0,2	0,3	0,0	0,6	-0,2	-0,1	-0,1	0,3	-0,1	0,8	0,5	0,6	0,6	0,4	0,8	-0,2	0,3	0,8	0,0	0,6	0,8	0,6	0,4	0,5	0,3	0,0	0,5	0,2	0,2	0,6	0,7	0,6	0,7	0,4
Zr	0,1	0,6	0,3	0,0	0,0	0,0	-0,1	-0,1	0,3	0,0	0,2	-0,2	0,0	-0,1	0,3	0,3	0,4	0,0	0,4	0,1	0,0	0,3	-0,1	1,0	0,4	0,0	0,7	0,5	0,1	0,1	0,3	0,0	0,0	0,2	-0,1	0,3	0,6	0,2	0,1	0,5	0,4
S	-0,5	-0,2	-0,3	-0,1	-0,3	-0,1	-0,1	-0,4	-0,6	-0,1	-0,2	0,8	-0,2	0,7	-0,6	0,2	-0,1	0,0	-0,2	-0,1	-0,1	-0,1	0,3	-0,2	-0,1	0,4	-0,1	-0,2	0,0	-0,3	-0,6	-0,1	0,4	-0,1	-0,3	0,0	-0,1	0,0	-0,2	-0,1	-0,1
C	-0,7	-0,2	-0,3	-0,1	-0,2	-0,1	0,0	-0,3	-0,6	-0,1	-0,2	1,0	-0,3	0,6	-0,6	0,1	0,0	0,1	-0,2	0,0	0,0	0,0	0,5	-0,2	0,0	0,2	-0,1	-0,1	0,1	-0,3	-0,5	0,0	0,2	0,0	-0,2	0,0	-0,1	0,1	-0,1	0,0	0,0

	Very strong (≥8)
	Strong (≥6<8
	Average (≥5<6
	Weak (≥4<5)
	Very weak (>4)

Table 3-5: The colour map Pearson correlation matrix of major in wt.% and traces in ppm for the Witbank coalfield geologial units in ZFN1512, significant at p < .05, classifications after Moore *et al.* (2013).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cr_2O_3	LOI	Total	As	Ba	Bi	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	U	V	W	Y	Yb	Zn	Zr	S	C
SiO_2	1,0																																													
TiO_2	-0,1	1,0																																												
Al_2O_3	0,0	0,7	1,0																																											
Fe_2O_3	-0,4	0,1	-0,1	1,0																																									
MnO	-0,4	0,3	-0,1	0,8	1,0																																								
MgO	-0,3	0,2	0,1	0,7	0,6	1,0																																							
CaO	-0,3	0,3	-0,1	0,5	0,8	0,5	1,0																																						
Na_2O	0,0	0,2	0,0	0,3	0,5	0,4	0,5	1,0																																					
K_2O	0,7	-0,2	0,2	-0,2	-0,3	-0,2	-0,3	0,1	1,0																																				
P_2O_5	-0,3	0,1	0,1	0,8	0,7	0,6	0,5	0,2	-0,1	1,0																																			
Cr_2O_3	-0,1	0,6	0,7	-0,1	-0,1	0,0	-0,1	-0,2	-0,1	0,0	1,0																																		
LOI	-0,8	-0,2	-0,3	0,0	-0,1	-0,1	-0,1	-0,3	-0,6	-0,1	-0,1	1,0																																	
Total	-0,1	-0,2	-0,1	0,2	0,2	0,2	0,2	0,3	-0,1	0,1	-0,1	0,1	1,0																																
As	-0,2	0,2	-0,1	0,0	0,5	-0,1	0,5	0,2	-0,3	0,1	0,0	0,1	0,0	1,0																															
Ba	0,6	-0,1	0,2	-0,1	-0,2	-0,1	-0,2	0,0	0,9	0,0	-0,1	-0,6	-0,1	-0,3	1,0																															
Bi	-0,2	0,3	0,0	0,1	0,6	0,0	0,6	0,3	-0,3	0,1	0,1	0,0	0,1	0,9	-0,2	1,0																														
Ce	0,1	0,1	0,5	-0,1	-0,2	-0,2	-0,3	0,0	0,3	0,0	0,3	-0,1	-0,1	-0,2	0,2	-0,1	1,0																													
Co	-0,3	0,6	0,3	0,3	0,5	0,5	0,5	0,4	-0,3	0,3	0,2	0,0	0,0	0,4	-0,3	0,4	-0,1	1,0																												
Cr	-0,1	0,6	0,7	-0,1	-0,1	-0,1	-0,1	-0,2	0,0	0,0	0,9	0,0	-0,3	0,0	0,0	0,0	0,4	0,3	1,0																											
Cs	0,0	0,3	0,7	0,0	-0,1	0,1	-0,3	-0,1	0,2	0,2	0,4	-0,1	-0,2	-0,2	0,3	-0,1	0,4	0,1	0,5	1,0																									
Cu	-0,2	0,8	0,3	0,3	0,5	0,5	0,6	0,6	-0,3	0,3	0,3	-0,1	0,0	0,4	-0,3	0,4	-0,2	0,8	0,3	0,0	1,0																								
Ga	-0,3	0,6	0,8	-0,1	-0,1	0,0	-0,1	0,0	0,0	0,0	0,6	0,0	-0,3	0,0	0,0	0,0	0,5	0,4	0,6	0,5	0,3	1,0																							
Ge	-0,5	-0,1	-0,2	-0,1	-0,1	-0,2	-0,1	-0,2	-0,4	-0,2	0,0	0,7	-0,2	0,1	-0,4	0,0	-0,2	0,2	0,0	-0,1	-0,1	0,3	1,0																						
Hf	0,1	0,1	0,3	-0,3	-0,3	-0,3	-0,4	-0,2	0,1	-0,2	0,6	0,0	-0,2	-0,1	0,1	-0,1	0,5	-0,2	0,4	0,2	-0,2	0,3	0,1	1,0																					
La	0,1	0,0	0,4	-0,1	-0,2	-0,2	-0,3	0,0	0,4	0,0	0,2	-0,2	-0,1	-0,2	0,4	-0,1	1,0	-0,1	0,3	0,3	-0,2	0,4	-0,2	0,4	1,0																			
Mo	0,1	0,1	0,0	-0,1	-0,2	-0,2	-0,2	-0,2	0,0	-0,1	0,2	0,0	-0,2	0,1	-0,1	0,0	0,0	-0,1	0,2	0,0	0,0	0,0	0,0	0,5	0,0	1,0																		
Nb	0,1	0,2	0,6	-0,3	-0,4	-0,3	-0,5	-0,3	0,2	-0,2	0,5	-0,1	-0,2	-0,2	0,1	-0,2	0,7	-0,2	0,5	0,4	-0,3	0,6	-0,1	0,7	0,6	0,3	1,0																
Nd	0,1	0,0	0,4	-0,1	-0,2	-0,2	-0,3	0,0	0,4	0,0	0,3	-0,2	-0,1	-0,2	0,3	-0,1	1,0	-0,1	0,4	0,3	-0,2	0,4	-0,2	0,4	1,0	0,0	0,6	1,0														
Ni	-0,4	0,6	0,5	0,2	0,3	0,4	0,3	0,2	-0,4	0,3	0,5	0,2	-0,1	0,3	-0,3	0,3	0,2	0,9	0,5	0,4	0,6	0,7	0,2	0,1	0,0	0,1	0,2	0,1	1,0													
Pb	0,2	-0,1	0,3	-0,4	-0,5	-0,4	-0,5	-0,2	0,4	-0,2	0,2	-0,1	-0,1	-0,2	0,4	-0,2	0,5	-0,3	0,3	0,4	-0,4	0,3	-0,1	0,4	0,4	0,4	0,6	0,4	0,0	1,0												
Rb	0,6	-0,1	0,3	-0,1	-0,3	-0,1	-0,4	0,0	0,9	0,0	0,0	-0,6	-0,1	-0,3	0,9	-0,3	0,4	-0,3	0,1	0,5	-0,4	0,2	-0,4	0,1	0,5	0,0	0,4	0,5	-0,2	0,5	1,0										
Sc	-0,4	0,7	0,3	0,3	0,6	0,4	0,7	0,5	-0,4	0,4	0,3	0,1	0,0	0,5	-0,3	0,5	-0,1	0,8	0,3	0,1	0,8	0,4	0,0	-0,2	-0,2	-0,1	-0,2	-0,1	0,7	-0,3	-0,4	1,0									
Se	-0,1	0,3	0,1	0,1	0,5	0,1	0,6	0,3	-0,3	0,2	0,1	0,0	0,1	0,9	-0,2	1,0	-0,1	0,5	0,1	0,0	0,5	0,0	0,0	-0,1	-0,1	0,0	-0,2	-0,1	0,4	-0,2	-0,2	0,6	1,0								
Sm	-0,1	-0,1	-0,1	0,5	0,4	0,2	0,1	0,2	0,1	0,3	-0,1	-0,1	0,1	-0,1	0,0	0,1	0,3	0,0	0,0	-0,1	0,0	0,0	0,0	-0,1	0,4	-0,1	0,0	0,4	0,0	-0,1	0,1	0,0	-0,1	1,0							
Sr	-0,1	0,2	0,1	0,4	0,5	0,4	0,5	0,4	0,0	0,6	0,0	-0,2	0,0	0,3	0,2	0,3	-0,1	0,4	-0,2	0,2	0,4	0,0	-0,2	-0,2	-0,1	-0,3	-0,4	-0,1	0,2	-0,2	0,0	0,5	0,4	-0,1	1,0						
Ta	-0,2	0,8	0,3	0,2	0,4	0,3	0,4	0,5	-0,3	0,2	0,4	-0,1	0,0	0,1	-0,3	0,2	-0,1	0,6	0,3	-0,1	0,9	0,3	0,0	0,0	-0,2	0,0	-0,1	-0,1	0,5	-0,3	-0,4	0,7	0,2	0,0	0,2	1,0					
Th	-0,1	0,1	0,7	-0,2	-0,2	-0,2	-0,3	-0,1	0,0	0,0	0,5	0,0	-0,1	-0,2	0,0	-0,1	0,8	-0,1	0,4	0,6	-0,2	0,6	-0,1	0,5	0,6	0,0	0,8	0,6	0,3	0,6	0,2	0,0	-0,1	0,0	0,0	-0,1	1,0				
U	-0,2	0,2	0,5	-0,1	-0,2	-0,2	-0,3	-0,2	-0,1	0,1	0,4	0,2	-0,1	-0,1	-0,1	-0,1	0,7	0,0	0,4	0,5	-0,1	0,6	0,2	0,4	0,6	0,1	0,6	0,6	0,3	0,5	0,1	0,1	0,0	0,0	0,0	-0,1	0,8	1,0			
V	-0,3	0,9	0,5	0,2	0,4	0,3	0,5	0,4	-0,3	0,2	0,4	-0,1	-0,1	0,3	-0,2	0,4	-0,1	0,7	0,5	0,1	0,9	0,5	-0,1	-0,2	-0,1	0,0	-0,1	0,0	0,7	-0,3	-0,3	0,9	0,4	0,0	0,2	0,8	0,0	0,0	1,0		
W	-0,4	0,2	0,1	-0,1	-0,1	-0,2	-0,1	-0,2	-0,2	-0,2	0,1	0,4	-0,3	0,0	-0,2	0,0	0,0	0,1	0,2	0,1	0,1	0,5	0,6	-0,1	0,0	0,0	0,1	0,0	0,2	0,0	-0,2	0,1	0,0	0,0	-0,2	0,1	0,1	0,3	0,2	1,0	
Y	-0,1	0,2	0,4	-0,1	-0,1	-0,2	-0,2	0,0	0,0	-0,1	0,4	0,0	-0,1	0,0	-0,1	0,1	0,8	0,1	0,5	0,2	0,1	0,5	0,1	0,5	0,8	0,2	0,6	0,8	0,3	0,4	0,1	0,1	0,0	0,4	-0,2	0,1	0,6	0,7	0,2	0,1	1,0
Yb	0,0	0,2	0,2	-0,1	-0,1	-0,2	-0,2	-0,1	-0,1	-0,1	0,3	0,0	-0,2	-0,1	-0,1	-0,1	0,4	0,1	0,4	0,0	0,1	0,3	0,2	0,6	0,4	0,4	0,5	0,4	0,2	0,2	0,0	0,0	-0,1	0,2	-0,2	0,3	0,3	0,4	0,2	0,1	0,6
Zn	0,1	0,3	0,2	0,1	0,1	0,1	0,0	0,1	0,1	0,1	0,2	-0,2	-0,1	0,1	0,0	0,1	0,4	0,3	0,3	0,2	0,2	0,2	-0,2	0,4	0,3	0,7	0,4	0,3	0,4	0,4	0,2	0,2	0,1	0,2	0,0	0,2	0,2	0,3	0,2	-0,1	0,5
Zr	0,2	0,1	0,3	-0,3	-0,4	-0,3	-0,4	-0,2	0,2	-0,2	0,6	-0,1	-0,2	-0,1	0,1	-0,1	0,5	-0,2	0,4	0,2	-0,2	0,3	0,1	1,0	0,5	0,5	0,8	0,5	0,1	0,5	0,2	-0,2	-0,1	0,0	-0,2	0,0	0,5	0,5	-0,1	-0,1	0,6
S	-0,2	0,0	-0,2	-0,1	-0,1	-0,2	-0,1	-0,2	-0,2	-0,2	0,1	0,4	-0,2	0,2	-0,2	0,0	-0,1	0,0	0,0	-0,1	0,0	0,0	0,4	0,5	-0,2	0,7	0,2	-0,2	0,1	0,0	-0,2	-0,1	0,0	-0,1	-0,1	0,1	-0,1	0,0	-0,1	0,1	0,0
C	-0,7	-0,2	-0,3	-0,1	-0,1	-0,2	-0,1	-0,3	-0,6	-0,2	0,0	0,9	0,1	0,1	-0,5	0,0	-0,2	0,0	-0,1	-0,2	-0,1	0,0	0,7	0,2	-0,2	0,0	-0,1	-0,2	0,1	-0,2	-0,6	0,0	0,0	-0,1	-0,2	0,0	0,0	0,1	-0,1	0,4	0,0

	Very strong (≥8)
	Strong (≥6<8
	Average (≥5<6
	Weak (≥4<5)
	Very weak (>4)

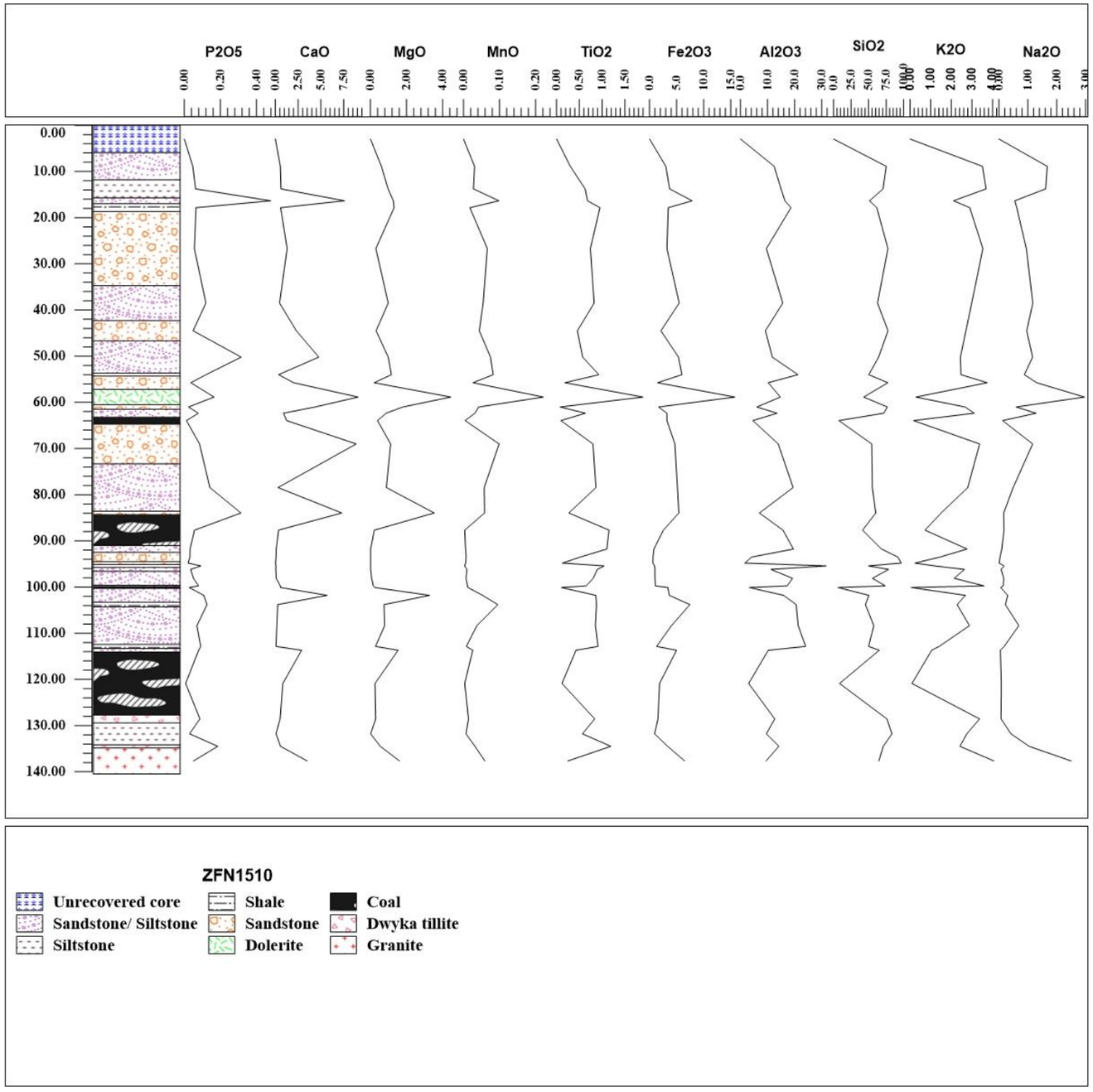


Figure 3-14: Borehole profiles indicate the large quantity of major elements (in weight percent) at the Geodehoop Colliery, Witbank coalfield.

A significant association occurs between TiO_2 and Al_2O_3, suggesting that Ti-bearing minerals are connected with clay minerals.

Sandstones and siltstones contain quartz, feldspar, and clay minerals, together with a significant concentration of main oxides (Figure 3-14). Also, Fe_2O_3 and MnO exhibit a high positive correlation, which may be attributed to the presence of the carbonate mineral siderite (Figure 3-14). The distribution pattern of CaO and P_2O_5 suggests their relationship in phosphate and carbonate minerals in siltstones and shale (Figure 3-14; Tables 3-4 amd 3-5), and their presence in coals has also been observed (Ward *et al.*, 1996). In specific layers of sandstones/siltstones, P_2O_5 is frequently found in high amounts (Figure 3-14). There are lower concentrations of C, S, As, and LOI in the top half of the profile and larger concentrations in the lower half of the profile, with the coal seams containing the majority of the significant concentrations (Figure 3-15).

In this study, Ce, Cs, Ga, Nb, Nd, and Zn are among the elements identified in shales. These elements are associated favorably with Al_2O_3 (Tables 3-4 and 3-5). These trace elements are inversely associated with C and S.

REEs have been detected in coal (Seredin, 1996; Seredin and Finkelman, 2008; Seredin and Dai, 2012). In this study, rare earth elements are connected with carbonates, apatite, and goethite, as demonstrated by the interaction between the main oxides CaO, Fe_2O_3, MnO, and P_2O_5 (Figure 3-14). Significant correlations between K_2O and Rb indicate that Rb is present in potassium feldspar or clay minerals in which potassium is the predominant carrier. These trace elements Cu, Hf, Nb, Th, V, Yb, and Zn exhibit a significant positive connection with TiO_2, indicating that their concentrations are governed by the presence of Fe- and Ti-rich oxides (Tables 3-4 and 3-5). Cr_2O_3 has a strong association with the trace elements Cu, Ga, Ni, U, V, and Zn, indicating that they are mostly housed by the mineral chromite (Tables 3-4 and 3-5).

The existence of trace elements in coal has been recorded (Nicholls, 1968; Swaine (1990); Conaway, 2001; Zhao, 2012), and their origin in the coal matrix has been postulated. The

elements C, S, As, Co, and Ni are related with coal seams in this research. Arsenic has a significant link with Mo, Se, C, and S, and a weak correlation with mafic minerals (Co and Ni). In contrast, Co and Ni have a substantial positive connection with Al_2O_3, indicating that they are present in clay minerals. Their high positive connection with V and Cu suggests that their presence in dolerite mafic minerals (Figure 3-15). S and As correlation of 0.7 confirm the presence of sulphide minerals and the correlation of S and C of 0.8, As and C of 0.6 suggest that sulphides are mainly in the coal seams (Table 3-4). Co and Ni correlation of 0.9 have the same distribution pattern as Cu and V with correlation of 0.9, which may suggest a mafic source (Table 3-4; Figure 3-15). The mafic elements such as Co, Cu, V, Ni are moderately correlated with Fe (Table 3-4; Table 3-5) It has also been noted that the base metals are connected with sulfides and carbonates in Cu sulfides and oxides (Zhao, 2012).

Uranium has a close relationship with Ce, Nd, La, and Y. These elements exhibit parallel distribution with Cs, Th, and U, and distributions that are almost identical to Nb and Pb (Figure 3-16 and 3-17). These elements are predominantly found in sandstones, siltstones, and clay minerals, and they have significant relationships with Ba and Rb (Figure 3-5). Several studies have demonstrated that trace elements Ba, U, Th, V, Rb, Sr, and Cs are linked to aluminosilicates (Dale, 1999; 2003; Swaine, 1990; Palmer, 1985; Tables 3-4 and 3-5).

The trace elements Zn and Ga have a similar distribution pattern to Cr (Figure 3-17), which is corroborated by their positive, moderate correlation with Cr, showing that they are associated with the mineral chromite (Table 3-4; Table 3-5). Zr has the same pattern of distribution as Hf (Figure 3-17). The positive association between Hf and Zr may be owing to its incorporation into zircon.

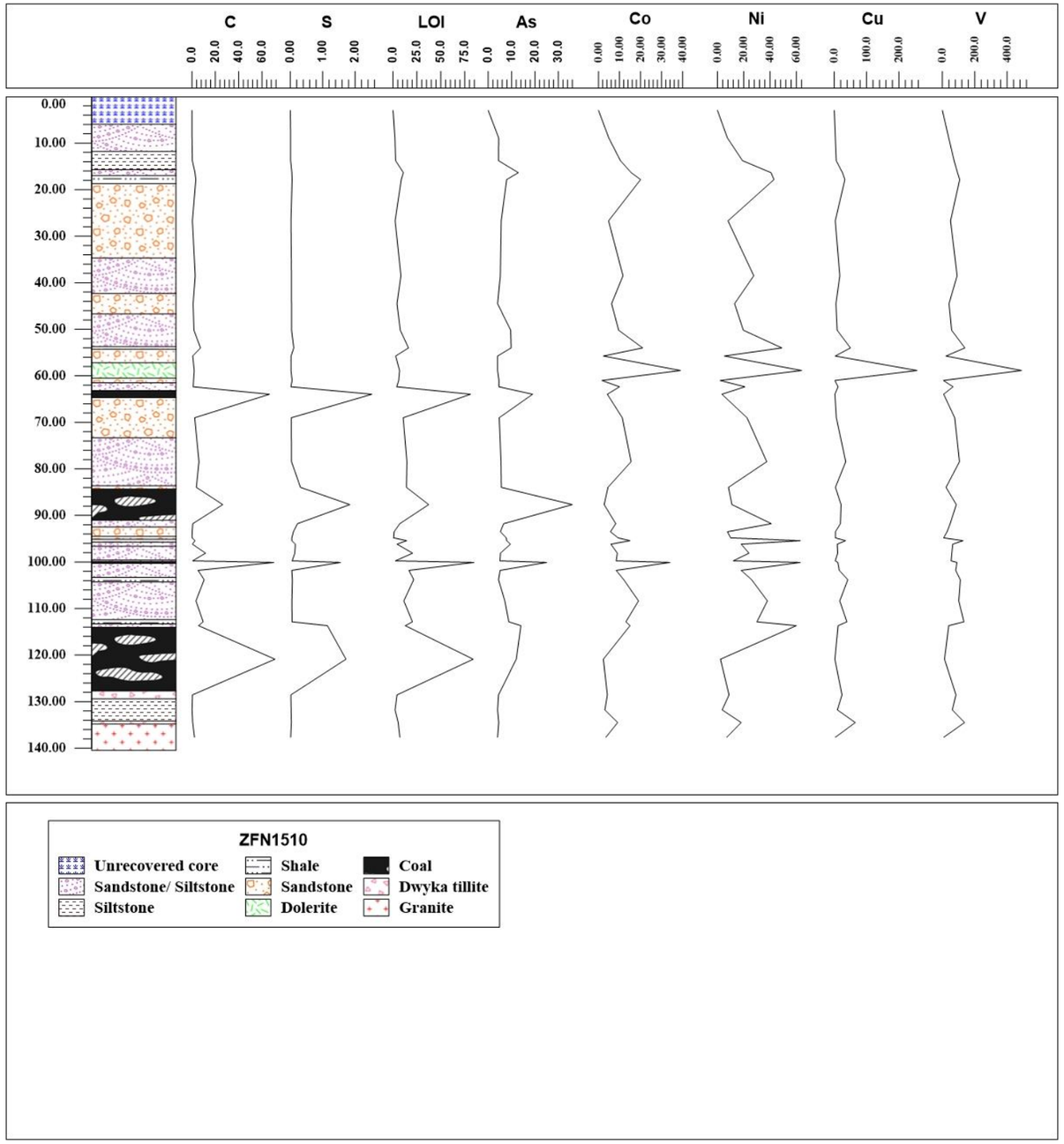


Figure 3-15: Borehole profile showing the large quantity of elements C, S, and LOI (in weight percent) and Co, Ni, Cu, and V (ppm) at the Geodehoop mine, Witbank coalfield.

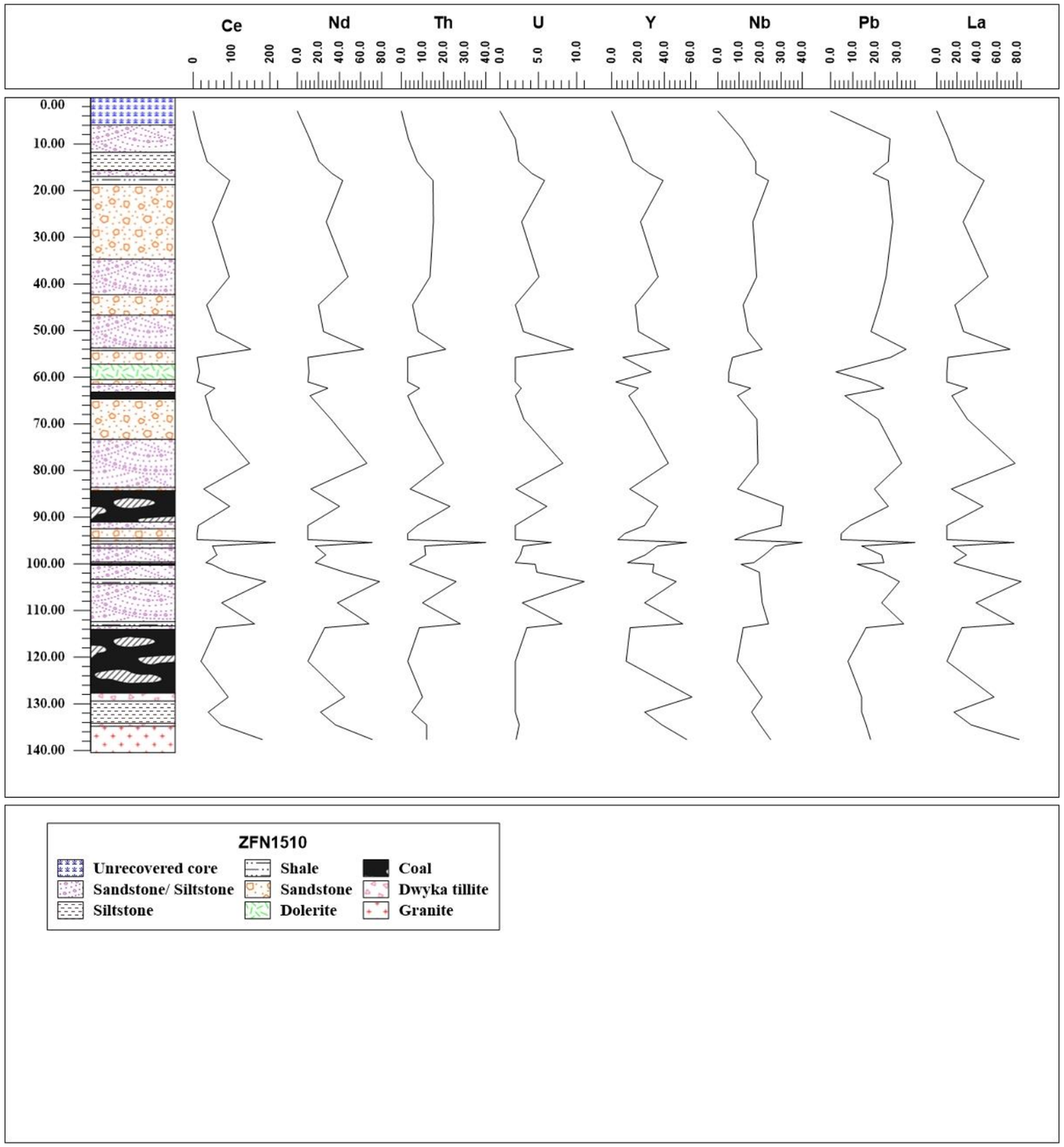


Figure 3-16: Depicts fluctuation profiles of trace element large quantity (ppm) in the Witbank Coalfield..

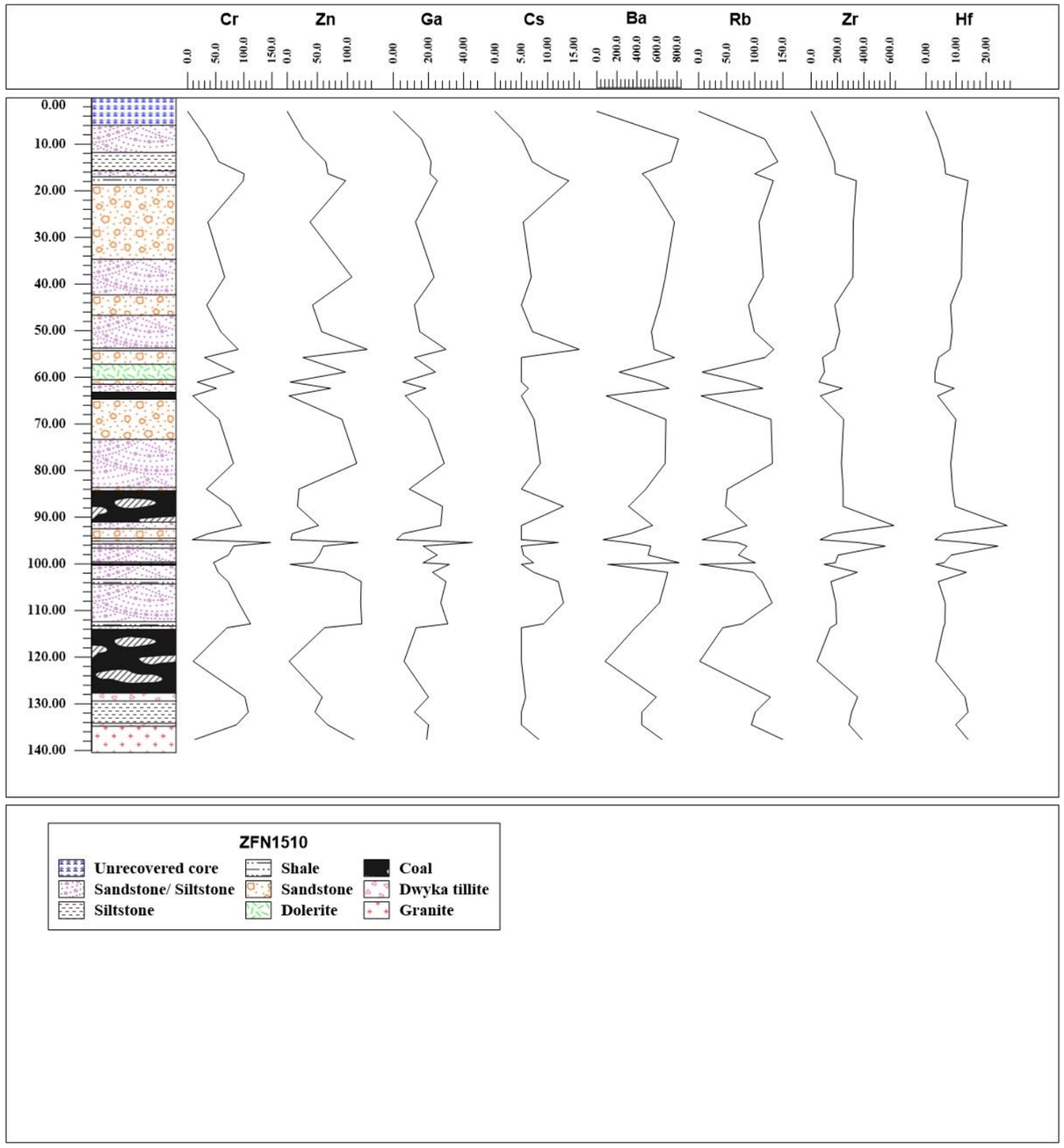


Figure 3-17: Profile variation plots illustrating the large quantity of key minerals (kaolinite, kaolinite/chlorite, mica, anatase, and smectite, in weight percent) in the Witbank coalfield.

3.4 DISCUSSIONS AND CONCLUSSION

3.4.1 Mineralogical profile distribution

The following are the principal minerals found on the vertical section of the Geodehoop mine:

a) Clay elements

Clay minerals are the most common minerals found in coal and shale (Gluskoter, 1975). Figure 3-18 depicts the presence of kaolinite clay in the ZFN1510 borehole. Despite accessory proportions of interstratified smectite, kaolinite is the predominant clay mineral in the Goedehoop coal seams, while kaolinite, chlorite, and interstratified smectite are accessory clay minerals in the non-coal strata (Figure 3-18). The clay minerals in the seams occur as thin bands that may have been transported into the coal by water or wind, indicating that the majority of the clay minerals are the result of neutral-acidic water altering feldspar and mica. Some of the kaolinite in the coals must have originated from the alteration of feldspar from arkoses or granite, or it could have been formed in-situ if the acidic waters of the peat contain sufficient aluminum (Ward, 1989; Speight, 2013). Clay minerals are the most prevalent mineral group in coal and associated lutites. They may be detrital in the form of bands, laminae, and lenticels, authigenic as cell infillings, or late diagenetic veins. The clay minerals may originate from the weathering of feldspars and micas (Mackowsky, 1982). The most prevalent clay minerals in coal are kaolinite, illite, and illite/smectite mixed layer (Zhao, 2012).

b) Chlorite

Figure 3-18 also displays the presence of chrorite. There are two naturally occurring chlorite species, clinochlore (Mg-rich) and chamosite (Fe-rich), with compositional variations within each (Zhao, 2012). Chlorite can be found in coals formed in either freshwater or marine environments, although its proportions are typically higher in marine-influenced coals (Renton, 1982).

c) Carbonate minerals

According to the XRD results, the coal seams and non-coal strata contain trace amounts of carbonate minerals (Figure 3-19). The coals are composed of the most common carbonate minerals, calcite, dolomite, and siderite. According to Taylor *et al.* (1998), the majority of these carbonates are of authigenic origin and have diverse chemical compositions. These carbonate minerals are distributed in minor proportions throughout the majority of coal seams and non-coal strata, with the exception of samples M40, M41, and M56, which contain dolomite as the major mineral, and samples M8 and M36 (Sandstone-siltstone and sandstone), which contain calcite as the major mineral. Calcite occurs in accessory amounts in seams No. 2 and 5, displays rare to significant amounts above seam No. 4, and dolomite is present in accessory to significant amounts below the dolerite (60 km), with seams Nos. 2, 3 and 5 exhibiting peaks (Figure 3-19). Numerous carbonate minerals have been discovered in coal. Common minerals include siderite, calcite, dolomite, and ankerite. The majority of these carbonates are of authigenic origin and have various chemical compositions. They can form in conjunction with deposition, coalification, and post-coalification processes (Taylor *et al.*, 1998).

Siderite is most prevalent in seam No. 2 (sample M53), whereas it is almost nonexistent in the other three seams. Siderite in non-coal strata ranges from minor to major minerals, with the exception of dolerite, where it is a major mineral (sample M30). Syngenetic siderite formation results from the interaction of iron and dissolved CO_2, and it may only be prevalent when the activity of reduced sulphur species is insufficient to produce pyrite (Ward, 1984; Spears, 1987; Spears and Zheng, 1999).

d) Feldspars

Feldspar is the second-most abundant detrital component in non-coal strata, and it occurs in a variety of grain sizes and types. Feldspars are less abundant in coal seams than in non-coal strata, where they are common as minor to major constituents (Figure 3-19). Lamellar twinning

as is typical of plagioclase was observed in the dolerite, granite and sandstone under a plane polarized, transmitted light (Figures 3-3, 3-7 and 3-13). There is a rare amount of feldspar in seam No. 4 (Figure 3-19). Plagioclase appears to be more abundant in the dolerite than in the other rock types (Figure 3-19). Potassium feldspar is the major mineral in the sandstones next to quartz (sample M10, M41 and M43) (Appendix A). Feldspar minerals are frequently present in coal as minor phases, but rarely in concentrations >1 or 2% (Renton, 1982). Albite and orthoclase are mostly of epiclastic origin (e.g. Vassilev and Vassileva, 1996). Feldspar minerals (e.g. sanidine, albite and anorthoclase) in coal may also be relic pyrogenic minerals.

e) Quartz

Quartz is the most dominant mineral within the sandstone, shale, granite, siltstone and Dwyka tillite samples, and is a major mineral in the Goedehoop coal seams (Figure 3-19). Detrital quartz in the non-coal strata commonly occurs as relatively large grains (Figures 3-3, 3-5, 3-7 and 3-9). Quartz usually occurs in the form of sub-angular to sub-rounded and, occasionally, well-rounded grains, indicating the reworked sedimentary origin (Figures 3-3, 3-5 and 3-7). Coal seams No. 2 and 5 have quartz as major mineral, whereas seams No. 3 and 5 have quartz as minor mineral. Quartz is the most common oxide mineral occurring in coal. It largely occurs as discrete grains of detrital origin, as biogenic or authigenic cell or pore infillings, or as veins in the form of crystalline quartz. A high proportion of the quartz commonly occurs in coal plies near the top and the bottom of coal beds (Zhao, 2012).

f) Sulphides

Pyrite is the dominant sulphide mineral in coal while marcasite has also been reported to be present in many coals (Stach *et al.* 1975; Spears, 1994; Spears *et al.* 1999). Pyrite in the coal samples, particularly where it is a major, minor and accessory mineral (Appendix A), typically occurs as spongy crystals (Figure 3-4), euhedral crystal (Figure 3-6) and vein fillings (Figure 3-6). Pyrite occurs as a dorminant mineral in seam No. 5, and as a minor mineral in seams No. 2 and 3, and as accessory mineral in seam No. 4 (Figure 3-19). The sandstones/siltstones and sandstones between seam No. 4 and 5 have trace to rare amounts of pyrite.

According to Zhao (2012), all of these forms of occurrence indicate that the pyrite is, to a great extent, a syngenetic precipitate formed during peat deposition or shortly after peat accumulation. The sandstone and siltstone, also with shale, have pyrite which occurs as cleat-cell fillings, cementing or coating framboids, euhedral minerals (Figures 3-5, 3-7 and 3-9). During the formation of syngenetic pyrite ferrous iron is dissolved, as well as H_2S from the bacterial reduction of sulphate in the peat swamp (Zhao, 2012). Pyrite and, to a lesser extent, marcasite are the most important iron sulphides in coal, and can be especially abundant in coal seams formed under marine influence (Zhao, 2012). Pyrite has been noted as an alteration product of other syngenetic minerals, such as siderite and ferro-dolomite/ankerite, and sometimes occurs as a replacement of cellular or wood structures or bacteria and algae (Smyth, 1966; Wiese and Fyfe, 1986; Kostova *et al.*, 1996; Taylor *et al.*, 1998; Goodarzi, 2002; Dai and Chou, 2007). Marcasite is intimately associated with pyrite in some coals and most of the metals (noble and toxic) are associated with the sulphides (Zhao, 2012). The element sulphur is present in almost all coals, it is usually present in the organic fraction of the coal, but inorganic or mineral sulphur is in the form of pyrite (Thomas, 2012).

g) Other minerals

There are rare amounts of mica minerals in coal seams No. 2, 3 and 5 and with ranges of accessory minerals in the non-coal strata (Figure 3-18). Muscovite is the most common mica mineral identified in the coal, and is found particularly as accessory minerals and in the non-coal strata ranges from accessory to minor minerals (Appendix A). Muscovite and biotite may both be of detrital origin, while muscovite may also result from the diagenetic weathering of feldspars (Vassilev & Vassileva, 1996; Vassilev *et al.* 2010). A rare occurrence of anatase is present in seam No. 4 (M44) and in some coal seams and their immediate footwall, and is persistently present in almost all of the associated non-coal samples (Appendix B).

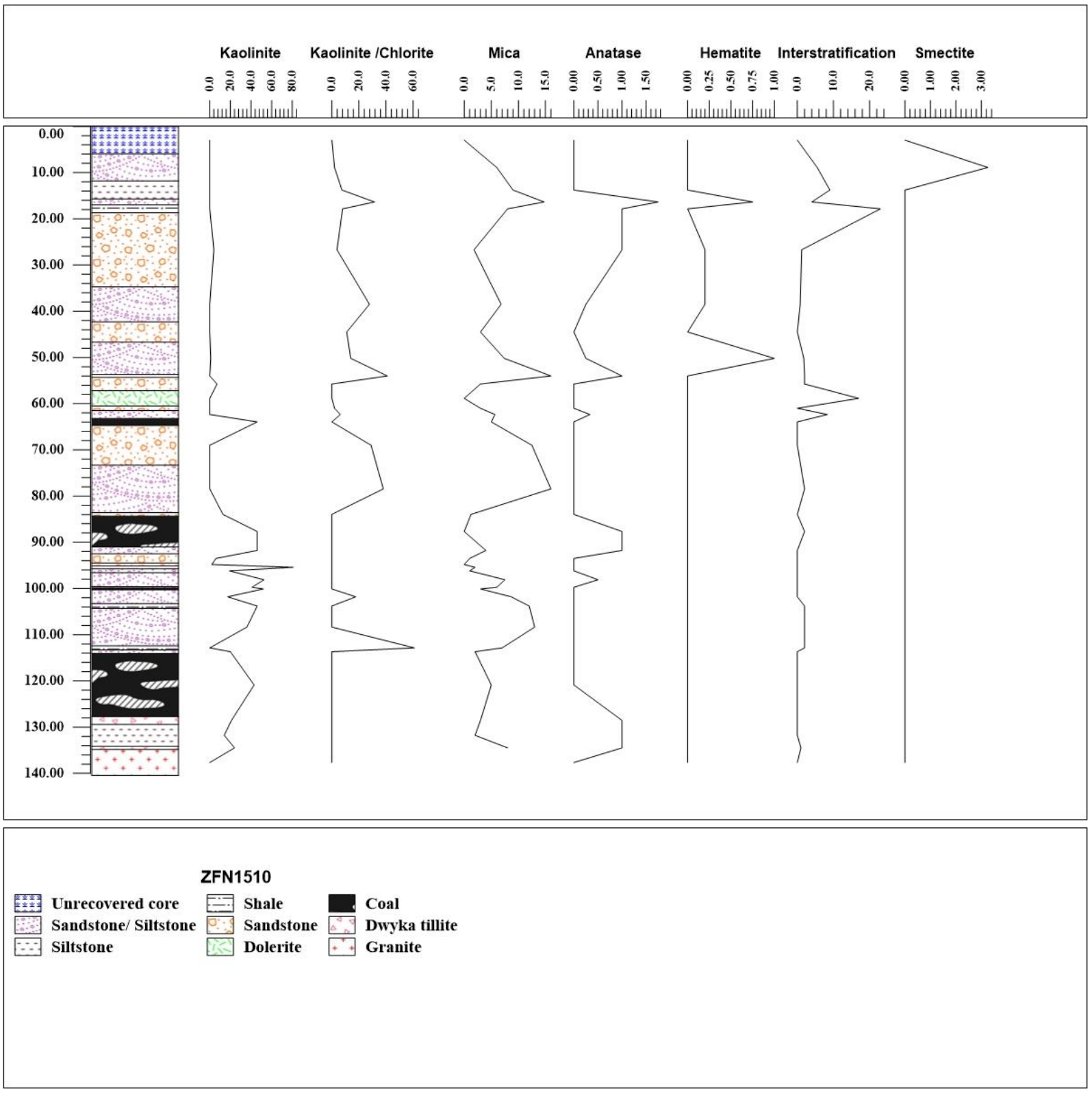


Figure 3-18: Profile variation plots showing an large quantity of major minerals (kaolinite, kaolinite/chlorite, mica, anatase and smectite in wt.%) in the Witbank coalfield.

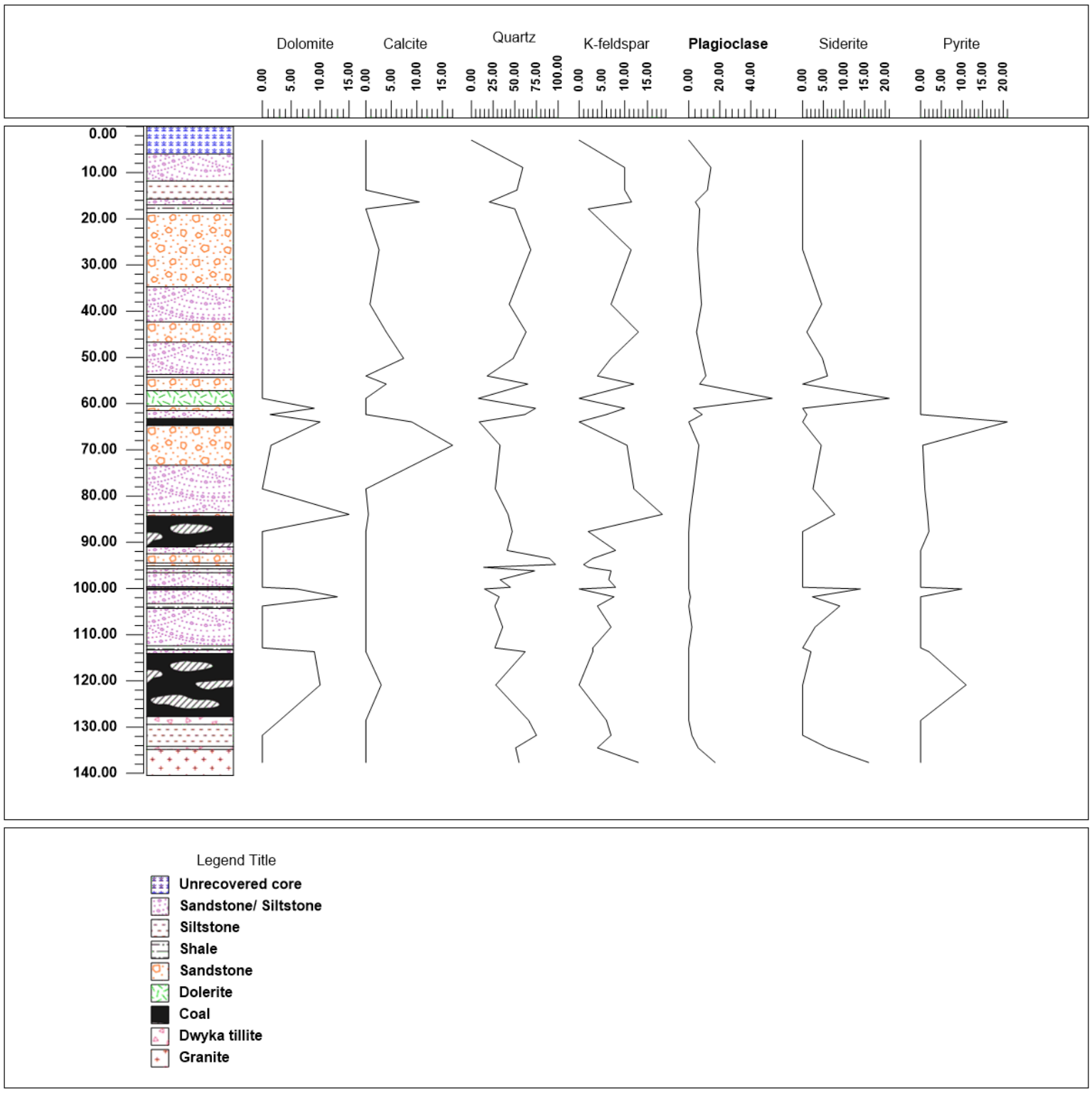


Figure 3-19: Profile variation plots showing major minerals (carbonates, quartz, feldspar and pyrite in wt %) in wt.%, in the Witbank coalfield.

3.4.2 Major elements distribution

The major element associations as displayed in Appendix C symbolizes the presence of the above mineralogy. A moderate, and positive correlation exists between TiO_2 and Al_2O_3 in the Goedehoop coal samples (Tables 3-4 and 3-5). This may indicate that the Ti-bearing minerals are associated with clay minerals. Accordingly, most of clay minerals in the coal are of authigenic origin with some of anatase may be authigentic origin (Zhao, 2012). There is also a rare occurrence of hematite which is observed in the sandstone above the dolerite (Appendix C). The XRF data confirms the interpretation of the XRD analysis as the samples are dominated mostly by SiO_2, Al_2O_3, Fe_2O_3 and K_2O with smaller amounts of TiO_2, CaO, MgO, Na_2O, MnO, P_2O_5 and Cr_2O_3. The major carriers of SiO_2, Al_2O_3 and Fe_2O_3 are quartz, clay minerals, and pyrite. The amount of Fe_2O_3 in the samples appears to present as hematite in the ferruginous sandstone and as pyrite in the coal seams and non-coal strata. The contents of CaO and MgO may indicate carbonate minerals since they are the main constituents of the carbonate (calcite and dolomite) minerals.

Positive and negative linear connections occur among the major elements and even between the major elements and trace elements (Table 3-4 and 3-5). The correlation of K_2O with SiO_2 is moderate on the sandstone and shale, pointing to their association in feldspar and clay minerals (Appendix C). SiO_2 is negatively correlated with TiO_2, Al_2O_3, Fe_2O_3, MnO, MgO, Cr_2O_3 and P_2O_5 (Tables 3-4 and 3-5). A significant correlation exists between TiO_2 and Al_2O_3, indicating that the Ti-bearing minerals are associated with clay minerals. Shales are higher in K_2O, Fe_2O_3 and TiO_2 contents than sandstones, which reflect their association with clay-sized phases (Madhavaraju and Lee, 2010; Cardenas *et al.*, 1996). The correlations that exist between CaO, MgO, Fe_2O_3 and MnO point to their association in carbonate minerals.

In addition, Fe_2O_3 and MnO show a strong, positive correlation of 0.81 which may be due to the carbonate mineral siderite. Relatively higher Na_2O content occurs in the dolerite and granite, which contain high proportions of plagioclase. TiO_2 appears to be more abundant in the non-coal strata samples than in the coal seams. In certain strata of the sandstone-siltstone,

P_2O_5 concentrations are often higher in the non-coal layers than in the coal seams. This can be by presence of apatite or monazite (high density minerals).

The higher concentrations of SiO_2 are mostly caused by the presence of relatively abundant clay minerals and quartz. Al_2O_3 and K_2O generally show a high degree of consistency, due to the presence of relatively abundant clay minerals (mainly biotite, kaolinite) and potassium feldspar (Figure 3-14). The good correlation shown between CaO, MgO and F_2O_3 is respectively associated with pyrite-rich and carbonate-rich rocks. The highest concentration that is observed on MnO, CaO, MgO and Fe_2O_3 is due to the presence of carbonate minerals (Figure 3-14).

The presence of plagioclase and potassium feldspars is also indicated by the higher concentrations shown on Na_2O and K_2O (Figure 3-14; Figure 3-19). The association of CaO, MnO, Fe_2O_3 and P_2O_5 on the sandstone-siltstone is due to the presence of hematite and carbonate mineral (Figures 3-18 and 3-19). P_2O_5 is showing higher concentrations which show an association with carbonates and clay minerals on the sandstone-siltstone (Figure 3-14). The high concentration of TiO_2 in coal seam No. 4 is due to the presence of anatase.

3.4.3 Trace elements distribution

The following are trace elements distribution also in coal as indicated by Swaine (1990) indicates how trace elements were included in the coal matrix by several possible processes. For example, biological and/or chemical processes could have taken up trace elements from the original vegetation that makes up the coal matrix (Lyons *et al.* 1989; Conaway, 2001). During the early stages of coal formation restricted drainage in peat swamps could also have enhanced the uptake of several trace elements into the peat (Conaway, 2001). The binary trace element variation diagrams indicating the correlation of elements are in Appendix B. It is important to note that there is constrained information accessible on the matter of trace elements in South African coals (Bergh *et al.*, 2011). These trace elements Hg, Zr, Zn, Cd, As, Pb, Mn, and Mo were found to be concentrated on the mineral matter in the coal (Bergh *et al.*, 2011). Previous work on a variety of South African coals and particularly on the Highveld

coals gave a better sign of the likely concentrations of the trace elements in South African coal (Cairncross *et al.*, 1990).

a) Sulphur

There are high concentrations of sulphur in the coal seams, which is present in a form of pyritic sulphur due to the present of pyrite minerals. Seam No. 5 has the highest sulphur concentration and seam No. 3 having low concentration of sulphur (Figure 3-15). Carbon and loss of ignition also show higher concentrations on the coal seams (Figure 3-15). There is a positive correlation between sulphur and carbon which indicates that some of the sulphur is present in a form of organic compound (Appendix C).

b) Arsenic

Higher concentrations of As are shown found in sandstone-siltstone and all the four coal seams with coal seam No. 4 having the higher concentration of As (Appendix D). Arsenic has a moderate positive correlation with sulphur (Appendix C) which indicates the association with pyrite in bituminous coals. Wagner and Hlatshwayo (2005) indicated As, as one of the toxic trace elements in five Highveld coals (the coal seam adjacent to the Witbank coalfield). Pyrite is predominantly associated with As, with small amounts that might be organic sulphur and this relationship is illustrated clearly via the similar trends in Figure 3-15. There is immediate evidence and a considerable amount of indirect evidence for the relationship of As with the pyrite in coal (Finkelman, 1994). Arsenic is predominantly associated with the mineral matter, with little amounts that might be organics associated (Swaine, 1990). Finkelman (1994) has stated that in most cases, As is associated with the pyrite for most United States (US) coals (also Palmer and Wandless, 1985).

c) Cobalt

The dolerite has the highest concentrations of cobalt (Figure 3-15). According to the observed concentration on coal seam No. 3 (Figure 3-15), the closest correlation is with the mineral

pyrite and organic sulphur bearing coal matter. Cobalt has a positive correlation with TiO_2, Al_2O_3 and Fe_2O_3 which suggest that cobalt is associated with clay minerals in the coal and plagioclase in the dolerite. Most of the information gathered to date propose that cobalt is associated with the sulphide minerals present in coal (Finkelman, 1994). Nonetheless, cobalt additionally demonstrates some level of association with the organic matter in coal and the clays present in coal (Finkelman, 1994). Swaine, (1990) indicated that cobalt is associated with the mineral matter in coal and cobalt concentration for most coal is in the range of 0.5-30 ppm.

d) Nickel

In literature there is significant uncertainty about the most likely association of Ni in bituminous coals. Nickel has a moderate positive correlation with TiO_2 and Al_2O_3 which suggest association with Ti-bearing minerals, adhesively bound to Fe-Mn-oxyhydroxides, sulphides and clay minerals (Tables 3-4 and 3-5). Nickel has a moderate positive correlation with Cr_2O_3 which has an association with clay minerals (Appendix B). Coal seam No.3 also has a high concentration of nickel and also shows similar trends as cobalt (Figure 3-14).

e) Copper

According to literature this element should be present as chalcopyrite (Rose *et al.* 1979; Levinson, 1974). In this study, copper has a positive correlation with Cr_2O_3 (Appendix C), TiO_2, Fe_2O_3 and MnO (Tables 3-4 and 3-5) which may suggest association with carbonate and possibly with magnetite or hematite or ilmenite, or in pyrite or marcasite. There is high concentration of copper on the dolerite, possibly in the form of sulphides. There are low concentrations of copper in the coal seams which may suggest that it is associated with clays and organic matter in the coal.

f) Vanadium

Vanadium and Copper have similar modes of occurrence in coal (Figure 3-15) and they may occur with both clays and the organic matter. Vanadium has a positive correlation with Cr_2O_3,

TiO_2, Al_2O_3, Fe_2O_3 and MnO (Tables 3-4 and 3-5) which may suggest its association with clay, carbonate and Ti-bearing minerals. As discussed above vanadium and Cr have similar modes of occurrence in coal.

g) Lead

According to literature this element is associated with sulphides (galena) in coal. Lead has a moderate positive correlation with K_2O which suggests association with potassium feldspar. In this research pyrite is the only sulphide found and there might be a relationship between lead and pyrite. Elements such as Ce, Nd, Th, U, Nb and La show similar trends to Pb below the coal seam No. 4 (Figure 3-16).

h) Chromium

The high concentration of chromium is shale below coal seam No. 4 (Figure 3-17). There is a moderate positive correlation between chromium with TiO_2 and Al_2O_3 (Tables 3-4 and 3-5) which suggests association with Ti-bearing and clay minerals. There is no clear mode of occurrence of chromium in coal (Swaine, 1990). Finkelman (1994) expect chromium to either be associated with the organic matter in coal or with the clays in coal. Gluskoter and Lindahl (1973) classify chromium as an intermediate mineral, which implies it is neither strongly associated with the organic or inorganic material. Most coals have concentrations of chromium in the range of 0.5-60 ppm (Swaine, 1990).

i) Zinc

Zinc has a moderate positive correlation with TiO_2, Al_2O_3 and Cr_2O_3 which indicates its association with Ti-bearing and clay minerals (Appendix C). There is a relationship between zinc and chromium illustrated by trends shown on Figure 3-17. The common mineral that is dominated by zinc is sphalerite, which is relatively common in coal (e.g. Swaine, 1990; Hower *et al.*, 2001; Dai *et al.*, 2008). It is also sometimes associated with pyrite (Finkelman, 1995), clay minerals, particularly illite, and carbonate minerals (Spears and Zheng, 1999).

j) Gallium

Gallium is showing similar trends to chromium and zinc which suggest a relationship between these elements (Figure 3-17). Gallium also has a moderate to strong positive correlation with TiO_2, Al_2O_3 and Cr_2O_3 which indicate association with Ti-bearing and clay minerals (Appendix C). Coal seam No. 3 has higher concentration of gallium than coal seam No. 2, 4 and 5. Nicholls (1968) suggested that Ga has to have a mixed organic and an inorganic affinity, or a strong organic affinity (Zubovic, 1966). Gallium is assumed to have a dominant inorganic affinity in many coals, as it has been regularly shown a positive correlation with ash yield (Zubovic, 1966). As concluded by Finkelman, (1980) that the affinity of Ga shows significant variation.

k) Cesium

There is a moderate positive correlation between Cs and Al_2O_3 which indicates the association of Cs with feldspar and clay minerals (Appendix C). Cs has higher concentrations on the sandstone-siltstone, shale and coal seam No. 4 (Figure 3-17).

l) Barium

There is a relationship between Ba and Rb illustrated by similar trends on Figure 3-17. Coal seam No. 4 has higher concentration of Ba than coal seam No. 2, 3 and 5. Ba has a strong positive correlation with K_2O, positive correlation with Na_2O and SiO_2 indicating its association with potassium feldspar minerals (Appendix C).

m) Zirconium

Zirconium and hafnium have a relationship illustrated by similar trends on Figure 3-17 and their correlation coefficient of 0.99 (Tables 3-4 and 3-5). TiO_2 has a moderate positive

correlation with Zr and Hf (Appendix B), which indicates that these elements are associated with Ti-bearing minerals.

n) Scandium

Scandium has a moderate positive correlation with Fe_2O_3, MnO, MgO, CaO and P_2O_5 (Table 3-5) indicating association with carbonate minerals. The high concentration of scandium is which sandstone-siltstone that has carbonate mineral (calcite) as a major mineral (Tables 3-4 and 3-5). Coal seam No. 4 and 3 have a higher concentration of scandium than coal seam No. 2 and 5.

3.5 SUMMARY OUTCOMES

This study validates the association between major and trace elements and the minerals found in coal in Table 3-6, hence validating the relationship between major and trace elements in Tables 3-4 and 3-5. C, S, and As, Co, Ni, Pb, V, Cu, Mo, and Zn, as well as Sc, Ce, and La are discovered to be connected with coal beds in this research. As, Co, Ni, Pb, Cu, and Zn are trace elements related with sulphides (Tables 3-4 and 3-5). The presence of these components downstream of a point source is regarded as harmful. The relationships between these elements with Al_2O_3 indicate that they are present in clay minerals.

Significant concentrations of the trace elements U, Pb, Ce, Y, Nb, and La are also found in sandstones and siltstones above and below coal seams (Figure 3-16). The majority of these trace elements have a significant positive connection with TiO_2, suggesting that their concentration is governed by the presence of Ti-Fe-oxides and anatase.

Ni, V, Co, and Cu are indicative of a mafic source, dolerites in this instance. These elements are present in clays due to their close relationship with Al_2O_3, Fe_2O_3, and TiO_2. The

relationship between these elements suggests their existence in the absorbed components of clay minerals and Fe-Mn hydroxides, as well as the in-situ connection of Ni with sulphides.

The major oxides and trace elements outlined in chapter 3 are the source of some of the mobile major and trace elements that can be carried and are absorbed by stream sediments farther downstream. Carbonates, sulphides, and silicates are the principal mineral families in host rocks that are related with the trace elements Ba, Sc, Sr, V, and Zn; As, Cr, Cu, Mo, Ni, Pb, and Zn; and Rb, U, Cr, Ni, Cu, and Ga (Tables 3-4 and 3-5).

Table 3-6: Trace elements associated with minerals in Australian and South African coals (after Dale, 1999, 2003; Swaine, 1990; Palmer 1985; and present study).

Mineral Group	**Mineral Type**	**Trace elements**				
		Australia (Dale, 1999)	**Australia (Swaine, 1990)**	**US (Palmer and Wandless, 1985)**	**South Africa (Dale 2003)**	**Goedehoop colliery**
Carbonates	Calcite, dolomite, siderite	Ba, Sr, Mn, Co, Ni, V, Cr	Ba, Mn, St	Ca, Mn, Zn		Ba, Sc, Sr, V, Zn
Sulphides	Pyrite, sphalerite	Cu, Zn, Pb, As, Se, Cd, Hg, Mo	As, Cd, Co, Cu, Pb, Hg, Mo, Se, Ag, Th, Sb, Zn	As, Fe, Hg, Se, Co, Mn, Sb Zn	As, Cd, Co, Cu, Hg, Mo, Ni, Pb,	As, Cr, Co, Cu, Ge, Mo, Ni, Pb, Se, Zn
Silicates/ aluminosilicates	Illite, feldspars, quartz, kaolinite, montmorilonite	Be, B, Cr, Co, V, Ni, U, Th, F, refractory elements	V	Al, Cs, K, Na, Rb, Ba, Ca, Sr	Se, Cr	Ba, Cs, Cr, Rb, Zr, Y, V, U, Th, Nb, Ta, Nb, Cu, Ga, Zn, Ni, La
Organic		Sb, Se, Hg, Cl	Be, B, Cr, Se, V			
Aluminophosphate	Apatite, monazite				U, Th, F,Cl	Sc, Sr

4 MINE DRAINAGE: CASE STUDY GEODEHOOP COLLIERY

This chapter seeks to explain the processes involved in metal mobilization and transport. This would be accomplished by conducting static and kinetic tests of the geochemistry of the source rocks, as detailed in chapter 3. This chapter also examines the capacity of lithological units to generate or neutralize acid, as well as the evidence of metals forming complexes throughout time. The boreholes ZFN1510 and 1512 were sampled for static and kinetic tests. Due to not having enough material for the coal seams, ZFN1510 was used for ABA testing, and both boreholes used for kinetic test, for all lithological units' representation. The kinetic prediction of the drilled core strata of source rock from the Goedehoop coalliery's lithological units, achieved by the completing of static tests and a 31-week kinetic test leaching experiment to confirm mechanisms involved in the transport of metals to the recieving environment. As part of the government's reaction to MD, the ABA and conventional kinetic methods may be employed for scientific examination and mining permit applications. Thus, legal disputes between government and industry can be eliminated, since the approach assures a certified process and precision in test result interpretations (Hornberger and Brady, 1998). Its implementation in this study will improve the management of mine waste in the ROC's coalfields.

4.1 INTRODUCTION

Pollution as a result of MD can contaminate groundwater and drinking water and harm aquatic life and habitat. MD happens when sulphide-bearing minerals in a rock are exposed to air and water, oxidizing the sulphide sulphur to sulphuric acid, as is well known (Evangelou, 1995; Evangelou and Zhang, 1995; Hadley and Snow, 1974; Moses *et al.*, 1987; Robertson, 1996). The metals are dissolved in groundwater and surface water by the acid (Hadley and Snow, 1974). The presence of ferric hydroxide precipitates gives water a reddish-brown to brilliant orange type (Evangelou, 1995; Nordstrom and Alpers, 1999). At low pH levels, metal ions

remain soluble, and some naturally occurring bacteria play a role in enhancing the oxidation rate and precipitation.

Metal leaching from the MD process is a global concern (Domvile *et al.*, 1994; Lawrence and Wang, 1997; Schafer Laboratory Testing, 1997; Zhang *et al.*, 2004). The issue impacts the environment of the receptor realm (Lawrence and Day, 1997; Evangelou, 1995).

MD associated with coal and other sulphide-containing mineral in mining operations, which is mostly caused by pyrite oxidation. MD is a significant environmental contamination issue in the studied area. It is estimated that the wet cleaning of coal alone in the United States generates waste slurries containing at least 10 million tons of pyrite every year (Evangelou and Zhang, 1995).

4.2 ACID BASE ACCOUNTING (ABA)

The static test was utilized to measure the acid-generating potential of rock samples from the research area. In order to achieve the goal, the samples were exposed to acid-generating and total acid-neutralizing potential tests, and their potential was determined using Table 4-1. (Zhao, 2012).

According to Zhao (2012), acid-base accounting is a screening technique in which the acid-neutralizing and acid-generating potentials of rock samples are evaluated and the difference in Net Neutralization Potential (NNP) is computed.

Relevant experts (e.g. Miller, 1998; Price and Errington, 1995; Brady *et al.*, 1994; Steffen, Robertson and Kirsten, 1991) have produced rules and recommendations for ABA procedures, which have been provided by Usher *et al.* (2003) and used in this work.

4.2.1 Screening criteria

Price and Errington (1995), Morin and Hutt (1994), and Usher *et al.* (2003) provide exhaustive descriptions of the screening criteria for every type of test. The most crucial factors are as follows:

"For NNP, if NNP =NP-AP is less than zero, the sample has the potential to create acid, whereas if NNP =NP-AP is greater than zero, the sample has the potential to neutralize acid." Specifically, any sample with NNP of -20 may not create acid, but any sample with NNP > -20 may generate acid. There is a clearly defined "grey region" between -20 and 20 kg/t $CaCO_3$ due to the nature of static testing and field variability, which makes it dangerous to ascribe potentially acid-generating or non-acid-generating qualities to such samples. The categorization of samples for NPR is governed by the criteria indicated in Table 4-1.

Table 4-1: Provides parameters for ABA screening (after Price *et al.*, 1997b).

ARD POTENTIAL	**NPR SCREENING CRITERIA**	**COMMENTS**
Likely	<1:1	Likely AMD generating
Possibly	1:1 - 2:1	AMD formation if NP is inadequately reactive or depleted quicker than sulphides.
Low	2:1 - 4:1	Not likely AMD-generating unless considerable preferential exposure of sulphides along fracture planes, or highly reactive sulphides in conjunction with inadequately reactive NP.
None	>4:1	No additional AMD testing necessary unless materials are to be utilized as an alkalinity source.

4.2.2 Results

The likelihood of ZFN1510 drill core was selected as a guide for ABA testing. The samples were tested material producing AMD was evaluated utilizing the NPR vs. Sulphur (Figure 4-1), NNP vs. paste pH (Figure 4-2), and AP vs. NP correlations (Figure 4-3). Table 4-2 demonstrates the ABA's findings.

4.2.2.1 Coal seams

The NPR against S in Figure 4-1 defines coal seams 2, 3, and 4 as having a very high chance of acid production. The following geological units produce acid: coal seam number 4, which contains 2% pyrite and 1.64% sulphur; coal seam number 3, which contains 10% pyrite and 1.07% sulphur; and coal seam number 2, which contains 11% pyrite and 1.03% sulphur. When the acid potential is greater than the neutralising potential, the features of acid-generating coal seams develop. This is demonstrated by the fact that coal seam number 4 has an acid potential of 51.25 and a neutralization potential of 0.15, coal seam number 3 has an acid potential of 33.44 and a neutralization potential of 17.93, and coal seam number 2 has an acid potential of 32.2 and a neutralisation potential of 15.4. As was mentioned in the preceding chapter, coal seams include a high amount of kaolinite, quartz, siderite, and calcite. These minerals possess a strong neutralizing capacity. Utilizing the NPR against S wt.%. The coal seams numbered 4, 3, and 2 have an extremely high possibility of producing acid. The coal seam No. 5 has distinct features. It has a high neutralizing potential of 22.23, a low acidic potential of 0.94, and a NNP of 21.2, indicating a probable surplus of neutralisation materials. NPR vs S wt.% connection indicates coal seam No. 5 as having acid potential under certain conditions (Figure 4-1), however the NNP versus paste pH correlations classify coal seam number 5 as being just beyond the region of uncertainty (Figure 4-2). In Figure 4-1, the NNP vs Paste pH plot classifies coal seams 4, 3, and 2 according to the uncertainty range. The AP vs NP classifies coal seams 4, 3, and 2 as having a high chance of acid production. The NNP of the latter coal seams falls within the negative range, indicating ambiguity over their acid-generating capacity.

In Figure 4-2, the NP versus AP categorize coal seam No. 5 according to the uncertainty range. The mineral composition of coal seam No. 5 is as follows: 21% pyrite, 46% kaolinite, 5% mica, 9% quartz, 10% dolomite, and 9% calcite. The No. 5 coal seam is characterized as a lithological unit that can produce acid under favourable conditions, i.e. when exposed to oxygen and water.

4.2.2.2 Other geological units

The bulk of geological units above coal seam 5 exhibit NNP, with likely excess of neutralising potential units (Figure 4-1 to Figure 4-3). On units above and below the dolerite sill, as well as in the dolerite, the greatest neutralizing potential is seen. The sandstone units above the dolerite include 4% calcite, K-plagioclase, plagioclase, quartz, and mica, while the unit below the dolerite has 9% dolomite, K-plagioclase, plagioclase, quartz, mica, and kaolinite. The dolerite's mineral makeup consists of 54% plagioclase, 8% quartz, 21% siderite, and 17% I/S. On the latter geological units there are no sulphide minerals. The NNP against S weight. The majority of units above coal seam number 5 are classified as having a low risk of producing acid according to the % diagram. By NNP interpretation, these geological units are classed within a range of uncertainty. This consists of all shales above coal seam number 5. Under a microscope, the shales include fromboidal pyrite grains, along with quartz, mica, plagioclase, and mica that has been transformed into chlorite. There are sandstones that are classed similarly to shale; these samples do not have a fizz rating (access to carbonates) and XRD examination reveals no calcite. In the rocks above of seam 5, sample M33 is mostly comprised of quartz, plagioclase, potassium feldspar, mica, kaolinite, and interstratified illite/smectite (I/S), with trace amounts of carbonate minerals, anatase, and siderite, as determined by XRD. Under polarised light, the recognized minerals are partially decomposed pyrite; under crossed polar, the observed minerals include sub-rounded quartz, mica minerals changing to chlorite, plagioclase (albite twining), and clay (kaolinite) is the principal matrix filling material. There are examples of 24, 25, and 26 with robust carbonation characteristics (Table 4-2). These are examples of sandstones and sandstones graded to siltstone that are located above coal seam number 5. The calcite concentration of these samples ranges from 4% to 42%, whereas the siderite content ranges from 1% to 21% and is mostly confined to units from a depth of 32 meters.

Under specific conditions, the lithological layers between coal seam No. 2 and coal seam No. 4 are also classed as having the capacity to generate acid. NPR vs S wt.% categorize the bulk of this lithological unit's samples outside the uncertainty range, with less than four samples falling inside the range (Figure 4-1). The bulk of samples have an extremely low likelihood of

producing acid. The paste pH against NNP classifies coal seams No. 2 to 5 within the uncertainty range (Figure 4-2). Some geological unit samples above coal seam No. 5, above coal seam No. 4, and a couple above coal seam No. 2 and below coal seam No. 2 map beyond the uncertainty range. The bulk of samples are inside the range of uncertainty. The AP versus NP categorization reveals that coal seams 2, 3, and 4 are likely to produce acid while coal seam No. 5 may generate AMD if NP is insufficiently reactive or is depleted at a quicker pace than sulphides (Figure 4-3).

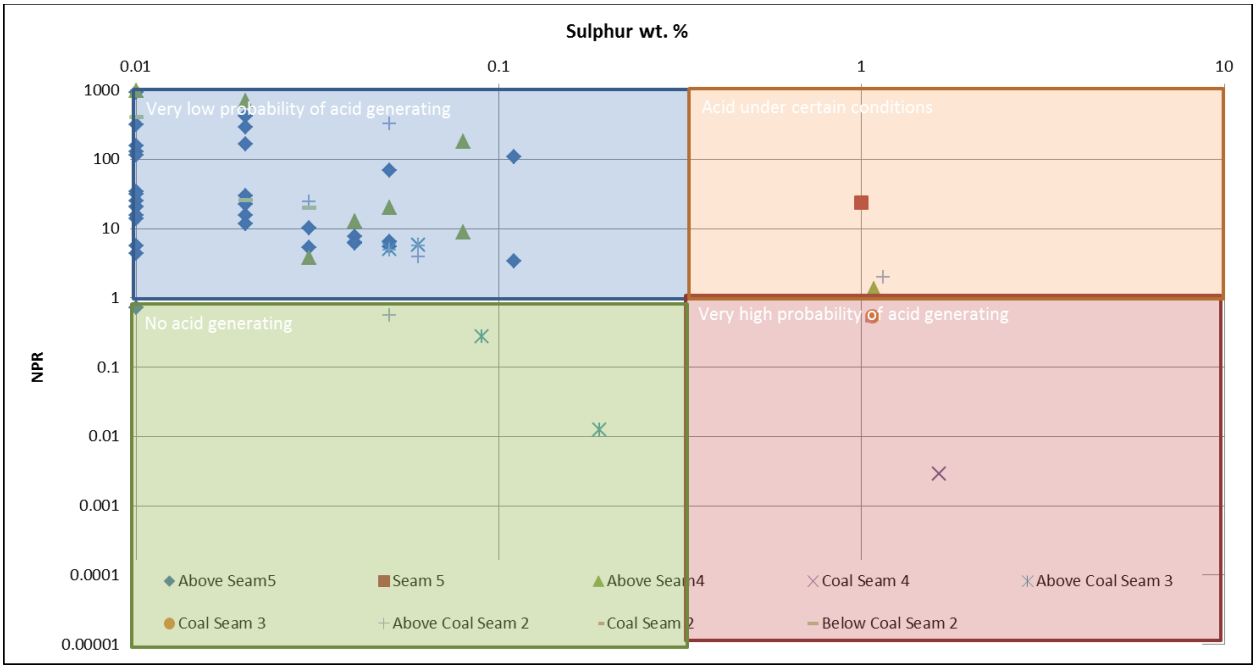


Figure 4-1: Acid base accounting static test pre-assessments using NPR vs Sulphur content in weight %.

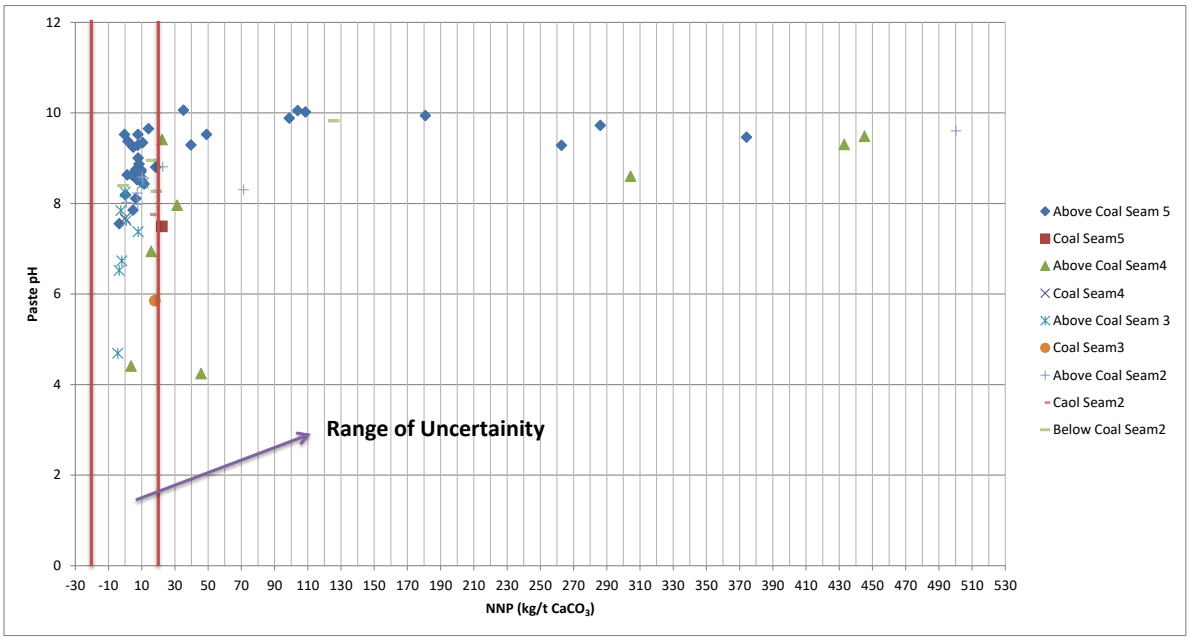


Figure 4-2: Acid base accounting static test pre-assessments using NNP vs Paste pH classification.

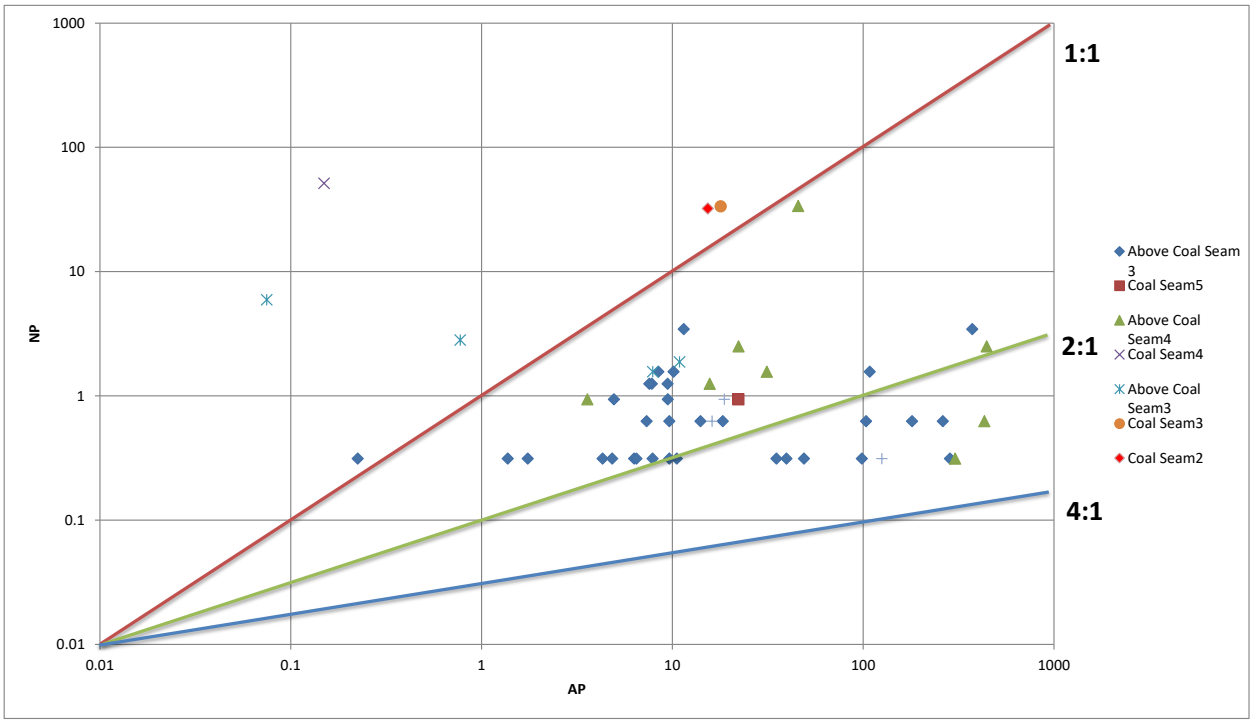


Figure 4-3: Acid base accounting static test pre-assessments using AP vs. NP classification.

It is evident from the preceding explanation that the geochemistry covered in the previous chapter influences the ABA findings. Hydrolysis is exemplified by the interaction between silicate minerals and acid (H^+), which results in the disintegration of the minerals and the release of metal cations and silica. Potassium feldspar hydrolyzes to generate kaolinite or illite plus silicic acid, whereas plagioclase (Na) feldspar hydrolyzes to produce kaolinite or smectite plus silicic acid. The lithological units above coal seam No. 5 include up to 20% kaolinite and up to 3% chlorite, however the lithological unit of coal seam No. 5 and below contain negligible amounts or none of these minerals. The most prevalent alteration type in the layers above coal seam No. 5 is kaolinite, indicating the presence of hydrolysis processes, which would be tested during kinetic modeling.

Table 4-2: The ABA findings for samples from borehole ZFN1510, along with their interpretation.

ACID BASE ACCOUNTING AND INTERPRETATION																BOREHOLE ZFN1510						
Sample ID	**Fizz Rating**	**Total Sulphur %**	**Sample Weight (g)**	**Volume HCl added (ml)**	**HCl Normality (N)**	**Volume NaOH added to pH7 (mL)**	**NaOH Normality (N)**	**Neutralization Potential**	**Acid Potential**	**Net Neutralization Potential**	**Paste pH**	**Paste EC µS/cm**	**NPR**	**NPR Interpretation**	**Net Neutralization Potential**	**NNP Interpretation**	**Lithology (Anglo Coal Mine)**	**Sample no**	**Depth of the sample**		**Length of the sample**	**Depth (m)**	**Lithology**
																			Top (Meter)	**Bottom (Meter)**	**Meter**		
1	None	0.01	2	40	0.1	41.41	0.1	-3.525	0.3125	-3.8375	7.55	72.4	-11.28	No Acid Potential	-3.8375	Uncertain	Sandstone/ Siltstone	1	6.46	6.76	0.3	5.940 - 11.250	Sandstone/ Siltstone
2	None	0.01	2	40	0.1	39.91	0.1	0.225	0.3125	-0.0875	8.19	52.1	0.72	Likely Acid Generator	-0.0875	Uncertain		2	8.37	8.67	0.3		
3	None	0.01	2	40	0.1	39.45	0.1	1.375	0.3125	1.0625	8.63	45.1	4.4	No Acid Potential	1.0625	Uncertain		3	9.7	10	0.3		
4	None	0.01	2	40	0.1	38.27	0.1	4.325	0.3125	4.0125	8.62	34.9	13.84	No Acid Potential	4.0125	Uncertain		4	10.52	10.82	0.3		
5	None	0.01	2	40	0.1	38.06	0.1	4.85	0.3125	4.5375	7.85	41.9	15.52	No Acid Potential	4.5375	Uncertain	Siltstone	5	11.2	11.5	0.3	11.250 - 15.710	Siltstone
6	None	0.01	2	40	0.1	37.47	0.1	6.325	0.3125	6.0125	8.74	80.4	20.24	No Acid Potential	6.0125	Uncertain		6	12.53	12.83	0.3		
7	None	0.04	2	40	0.1	36.87	0.1	7.825	1.25	6.575	9.52	84.9	6.26	No Acid Potential	6.575	Uncertain	Sandstone/ Siltstone	7	15.73	16.03	0.3	15.710 - 17.100	Sandstone/ Siltstone
8	strong	0.11	2	80	0.5	50.06	0.5	374.25	3.4375	370.8125	9.46	135	108.8727	No Acid Potential	370.8125	Probably excess of neutralization material		8	16.45	16.56	0.11		
9	None	0.02	2	40	0.1	36.13	0.1	9.675	0.625	9.05	8.74	129.1	15.48	No Acid Potential	9.05	Uncertain		9	16.56	16.76	0.2		
10	None	0.02	2	40	0.1	32.62	0.1	18.45	0.625	17.825	8.8	252	29.52	No Acid Potential	17.825	Uncertain		10	16.76	16.97	0.21		
11	None	0.05	2	40	0.1	36.61	0.1	8.475	1.5625	6.9125	8.87	241	5.424	No Acid Potential	6.9125	Uncertain	Shale	11	17.7	18	0.3	17.100 - 18.620	Shale
12	strong	0.02	2	80	0.5	58.98	0.5	262.75	0.625	262.125	9.28	140.6	420.4	No Acid Potential	262.125	Probably excess of neutralization material	Sandstone	12	18.65	18.95	0.3	18.620 - 34.000	Sandstone
13	None	0.01	2	40	0.1	35.77	0.1	10.575	0.3125	10.2625	9.34	152.8	33.84	No Acid Potential	10.2625	Uncertain		13	21.3	21.6	0.3		
14	None	0.01	2	40	0.1	39.3	0.1	1.75	0.3125	1.4375	9.37	103.4	5.6	No Acid Potential	1.4375	Uncertain		14	23	23.3	0.3		
15	None	0.03	2	40	0.1	38.02	0.1	4.95	0.9375	4.0125	9.24	146.5	5.28	No Acid Potential	4.0125	Uncertain		15	29	29.3	0.3		
16	None	0.01	2	40	0.1	40.11	0.1	-0.275	0.3125	-0.5875	9.52	104.6	-0.88	Likely Acid Generator	-0.5875	Uncertain		16	33	33.3	0.3		
17	None	0.05	2	40	0.1	35.93	0.1	10.175	1.5625	8.6125	8.47	142	6.512	No Acid Potential	8.6125	Uncertain	Sandstone/ Siltstone	17	37.7	38	0.3	34.000 - 42.620	Sandstone/ Siltstone
18	None	0.03	2	40	0.1	36.2	0.1	9.5	0.9375	8.5625	8.5	154.7	10.13333	No Acid Potential	8.5625	Uncertain		18	39	39.3	0.3		
19	None	0.04	2	40	0.1	36.21	0.1	9.475	1.25	8.225	8.59	171.9	7.58	No Acid Potential	8.225	Uncertain		19	40	40.3	0.3		
20	None	0.02	2	40	0.1	37.06	0.1	7.35	0.625	6.725	8.52	202	11.76	No Acid Potential	6.725	Uncertain		20	41.21	41.51	0.3		
21	None	0.01	2	40	0.1	37.4	0.1	6.5	0.3125	6.1875	8.11	195.6	20.8	No Acid Potential	6.1875	Uncertain		21	42	42.3	0.3		

22	weak	0.01	2	40	0.1	24.11	0.1	39.725	0.3125	39.4125	9.29	161.5	127.12	No Acid Potential	39.4125	Probably excess of neutralization material	Sandstone	22	44.93	45.23	0.3	42.620 - 45.790	Sandstone
23	strong	0.01	2	80	0.5	57.11	0.5	286.125	0.3125	285.8125	9.72	653	915.6	No Acid Potential	285.8125	Probably excess of neutralization material	Sandstone/ Siltstone	23	46.7	47	0.3	45.790 - 53.620	Sandstone/ Siltstone
24	strong	0.01	2	80	0.5	72.09	0.5	98.875	0.3125	98.5625	9.88	306	316.4	No Acid Potential	98.5625	Probably excess of neutralization material		24	47.99	48.23	0.24		
25	None	0.01	2	40	0.1	36.84	0.1	7.9	0.3125	7.5875	9	357	25.28	No Acid Potential	7.5875	Uncertain		25	49	49.3	0.3		
26	strong	0.01	2	80	0.5	76.07	0.5	49.125	0.3125	48.8125	9.52	422	157.2	No Acid Potential	48.8125	Probably excess of neutralization material		26	49.47	49.63	0.16		
27	None	0.04	2	40	0.1	36.96	0.1	7.6	1.25	6.35	9.28	396	6.08	No Acid Potential	6.35	Uncertain		27	51	51.3	0.3		
28	None	0.11	2	40	0.1	35.4	0.1	11.5	3.4375	8.0625	8.43	391	3.345455	No Acid Potential	8.0625	Uncertain	Shale	28	54	54.3	0.3	53.620 - 54.360	Shale
29	strong	0.02	2	80	0.5	71.69	0.5	103.875	0.625	103.25	10.05	362	166.2	No Acid Potential	103.25	Probably excess of neutralization material	Sandstone	29	57	57.3	0.3	54.360 - 58.700	Sandstone
30	strong	0.02	2	80	0.5	65.53	0.5	180.875	0.625	180.25	9.94	563	289.4	No Acid Potential	180.25	Probably excess of neutralization material	Dolerite	30	59.7	60	0.3	58.700 - 60.930	Dolerite
31	strong	0.05	2	80	0.5	71.31	0.5	108.625	1.5625	107.0625	10.02	177.1	69.52	No Acid Potential	107.0625	Probably excess of neutralization material	Sandstone	31	61	61.3	0.3	60.930 - 61.500	Sandstone
32	None	0.02	2	40	0.1	34.36	0.1	14.1	0.625	13.475	9.65	135.3	22.56	No Acid Potential	13.475	Uncertain	Sandstone/ Siltstone	32	61.5	61.8	0.3	61.150 - 63.200	Sandstone/ Siltstone
33	weak	0.01	2	40	0.1	25.91	0.1	35.225	0.3125	34.9125	10.06	338	112.72	No Acid Potential	34.9125	Probably excess of neutralization material		33	61.9	62.2	0.3		
34	None	0.01	2	40	0.1	36.13	0.1	9.675	0.3125	9.3625	8.7	212	30.96	No Acid Potential	9.3625	Uncertain		34	62.9	63.2	0.3		
35	None	0.03	2	40	0.1	31.11	0.1	22.225	0.9375	21.2875	7.49	563	23.70667	No Acid Potential	21.2875	Probably excess of neutralization material	**Coal Seam 5**	35	64.4	64.7	0.3	63.200 - 64.700	Coal
36	strong	0.01	2	80	0.5	55.65	0.5	304.375	0.3125	304.0625	8.6	737	974	No Acid Potential	304.0625	Probably excess of neutralization material	Sandstone	36	66.7	67	0.3	64.980 - 74.220	Sandstone
37	None	0.05	2	40	0.1	27.44	0.1	31.4	1.5625	29.8375	7.96	552	20.096	No Acid Potential	29.8375	Probably excess of		37	73	73.3	0.3		

																neutralization material						
38	None	0.03	2	40	0.1	38.56	0.1	3.6	0.9375	2.6625	4.41	1163	3.84	Acid under Certain Conditions	2.6625	Uncertain	Sandstone/ Siltstone	38	78	78.3	0.3	74.220 - 82.300	Sandstone/ Siltstone
39	None	0.04	2	40	0.1	33.7	0.1	15.75	1.25	14.5	6.94	553	12.6	No Acid Potential	14.5	Uncertain		39	80	80.3	0.3		
40	strong	0.02	2	80	0.5	45.36	0.5	433	0.625	432.375	9.3	248	692.8	No Acid Potential	432.375	Probably excess of neutralization material	Sandstone	40	82.3	82.52	0.22	82.300 - 83.600	Sandstone
41	Strong	0.08	2	80	0.5	44.38	0.5	445.25	2.5	442.75	9.48	181.5	178.1	No Acid Potential	442.75	Probably excess of neutralization material		41	82.52	82.82	0.3		
42	None	0.08	2	40	0.1	31.07	0.1	22.325	2.5	19.825	9.41	133.2	8.93	No Acid Potential	19.825	Uncertain		42	83	83.3	0.3		
43	None	1.08	2	40	0.1	21.69	0.1	45.775	33.75	12.025	4.24	795	1.356296	No Acid Potential	12.025	Uncertain		43	83.52	83.6	0.08		
44	None	1.64	2	40	0.1	39.94	0.1	0.15	51.25	-51.1	7.67	412	0.002927	No Acid Potential	-51.1	Uncertain	**Coal Seam 4**	44	84.32	84.62	0.3	83.600 - 90.560	Coal
45	None	0.22	2	40	0.1	40.98	0.1	-2.45	6.875	-9.325	7.84	95.9	-0.35636	Likely Acid Generator	-9.325	Uncertain	Sandstone/ Siltstone	45	90.7	91	0.3	90.560 - 91.020	Sandstone/ Siltstone
46	None	0.09	2	40	0.1	41.4	0.1	-3.5	2.8125	-6.3125	6.52	161.9	-1.24444	Acid under Certain Conditions	-6.3125	Uncertain	Sandstone	46	92.5	92.8	0.3	91.020 - 92.840	Sandstone
47	None	0.05	2	40	0.1	41.72	0.1	-4.3	1.5625	-5.8625	4.69	208	-2.752	Acid under Certain Conditions	-5.8625	Uncertain	Sandstone	47	94.5	94.8	0.3	92.840 - 95.070	Sandstone
48	None	0.05	2	40	0.1	36.83	0.1	7.925	1.5625	6.3625	7.37	180.4	5.072	No Acid Potential	6.3625	Uncertain	Shale	48	95.1	95.4	0.3	95.070 - 95.730	Shale
49	None	0.16	2	40	0.1	40.78	0.1	-1.95	5	-6.95	6.73	185.3	-0.39	Likely Acid Generator	-6.95	Uncertain	Sandstone/ Siltstone	49	95.74	95.98	0.24	95.730 - 96.410	Sandstone/ Siltstone
50	None	0.19	2	40	0.1	39.97	0.1	0.075	5.9375	-5.8625	8.25	95.9	0.012632	Likely Acid Generator	-5.8625	Uncertain	Coaly shale	50	96.6	96.9	0.3	96.410 - 97.000	Coaly shale
51	None	0.09	2	40	0.1	39.69	0.1	0.775	2.8125	-2.0375	7.62	242	0.275556	Likely Acid Generator	-2.0375	Uncertain	Sandstone/ Siltstone	51	99.3	99.6	0.3	97.000 - 99.760	Sandstone/ Siltstone
52	None	0.06	2	40	0.1	35.63	0.1	10.925	1.875	9.05	8.45	220	5.826667	No Acid Potential	9.05	Uncertain	Sandstone/ Siltstone	52	99.6	99.89	0.29	99.760 - 99.890	Sandstone/ Siltstone
53	None	1.07	2	40	0.1	32.83	0.1	17.925	33.4375	-15.5125	5.85	290	0.536075	Likely Acid Generator	-15.5125	Uncertain	**Coal Seam 3**	53	99.89	100.19	0.3	99.890 - 100.280	Coal
54	None	0.06	2	40	0.1	37.06	0.1	7.35	1.875	5.475	8.23	113.7	3.92	Acid under Certain Conditions	5.475	Uncertain	Sandstone/ Siltstone	54	100.29	100.59	0.3	100.280 - 103.530	Sandstone/ Siltstone
55	None	0.03	2	40	0.1	30.88	0.1	22.8	0.9375	21.8625	8.81	88.2	24.32	No Acid Potential	21.8625	Probably excess of neutralization material		55	101	101.3	0.3		
56	Strong	0.05	2	80	0.5	39.98	0.5	500.25	1.5625	498.6875	9.6	222	320.16	No Acid Potential	498.6875	Probably excess of		56	103	103.3	0.3		

																neutralization material						
57	None	0.06	2	40	0.1	35.83	0.1	10.425	1.875	8.55	8.58	116.6	5.56	No Acid Potential	8.55	Uncertain	Shale	57	104	104.3	0.3	103.530 - 106.120	Shale
58	None	0.05	2	40	0.1	36.93	0.1	7.675	1.5625	6.1125	7.98	259	4.912	No Acid Potential	6.1125	Uncertain	Sandstone/ Siltstone	58	110.4	110.7	0.3	106.120 - 112.140	Sandstone/ Siltstone
59	None	0.05	2	40	0.1	39.65	0.1	0.875	1.5625	-0.6875	8.02	174.2	0.56	Likely Acid Generator	-0.6875	Uncertain	Shale	59	113	113.3	0.3	112.140 - 113.600	Shale
60	Strong	1.15	2	80	0.5	74.29	0.5	71.375	35.9375	35.4375	8.3	451	1.986087	Acid under Certain Conditions	35.4375	Probably excess of neutralization material	Sandstone/ Siltstone	60	113.8	114.06	0.26	113.600 - 114.090	Sandstone/ Siltstone
61	None	1.03	2	40	0.1	33.85	0.1	15.375	32.1875	-16.8125	7.75	258	0.47767	Likely Acid Generator	-16.8125	Uncertain	**Coal Seam 2**	61	116.65	116.95	0.3	114.090 - 124.150	Coal
62	None	0.02	2	40	0.1	33.52	0.1	16.2	0.625	15.575	8.95	143.7	25.92	No Acid Potential	15.575	Uncertain	Dwyka tillite	62	127.7	128	0.3	124.150 - 129.400	Dwyka tillite
63	None	0.01	2	40	0.1	40.48	0.1	-1.2	0.3125	-1.5125	8.39	9.2	-3.84	Acid under Certain Conditions	-1.5125	Uncertain	Siltstone	63	129.3	129.6	0.3	129.400 - 134.150	Siltstone
64	None	0.03	2	40	0.1	32.48	0.1	18.8	0.9375	17.8625	8.27	208	20.05333	No Acid Potential	17.8625	Uncertain	Dwyka tillite	64	134.15	134.45	0.3	134.150 - 134.830	Dwyka tillite
65	Strong	0.01	2	80	0.5	69.95	0.5	125.625	0.3125	125.3125	9.82	284	402	No Acid Potential	125.3125	Probably excess of neutralization material	Granite	65	136.7	137	0.3	134.830 - 140.480	Granite

4.3 HUMIDITY CELL LEACH TESTS

4.3.1 Background

The lithological units samples have been classified as potentially acid-generating, potentially non-acid-generating and uncertain, based on the results of the static ABA tests performed in the previous section. The samples where the potential for acid generation is uncertain were subjected to kinetic tests in an effort of identifying acid generation characteristics by simulating environmental conditions for rock drainage process. A total of 27 samples, labeled BH1 through BH27, were chosen to represent the stratigraphy of the Geodehoop coalfield, which dominates the ROC geology. The samples were tested for 31 consecutive weeks.

Kinetic is used to define a set of test techniques in which the acid generation properties of a sample are quantified in relation to time (Miller, 1998; Chemex Laboratory, 1997). Multiple types of recorded kinetic testing can vary in complexity, time, expense, and sorts of data that can be gathered (Usher *et al.*, 2003).

In this work, the kinetic test is utilized to estimate the relative rates of acid production and neutralization, the time to ARD start, drainage chemistry, and the consequent downstream metal loading for each of the likely geochemical circumstances. The relative rates of acid production and neutralization will help determine if the sample material will produce acid over time.

4.3.2 Methodology

4.3.2.1 Sampling

A total of 27 samples labeled BH1 through BH27 (Table 4-3), representing the stratigraphic units of the ROC, were analyzed for thirty-one consecutive weeks to determine the rate of acid production.

Table 4-3: The table indicating the 27 samples for the kinetic test.

BOREHOLE LAYER SAMPLED	LITHO- TYPE	LAB ID
ZFN1510 (1-7)	Sandstone/Siltstone	BH1
ZFN 1510 (8-12)	Shale	BH2
ZFN 1510 (12-21)	Sandstone	BH3
ZFN 1510 (27 & 28 &29)	Shale	BH4
ZFN 1510 (31-34)	Sandstone/Siltstone	BH5
ZFN 1510 (36, 37, 39)	Sandstone/Siltstone	BH6
ZFN 1510 (49-52)	Sandstone/Shale	BH7
ZFN 1510 (57-60)	Sandstone/Siltstone/Shale	BH8
ZFN 1510 (62-64)	Dwyka tillite	BH9
ZFN 1512 (W26)	Coal seam no. 5	BH10
ZFN 1512 (31)	Coal seam no. 4	BH11
ZFN 1512 (41)	Coal seam no. 3	BH12
ZFN 1512 (49)	Coal seam no. 2	BH13
ZFN 1512 (1-6)	Sandstone/Siltstone	BH14
ZFN 1512 (10-15) [2184]	Sandstone	BH15
ZFN 1512 (16-25)	Sandstone/Siltstone	BH16
ZFN 1512 (27-30) [1158]	Sandstone	BH17
ZFN 1512 (32-34)	Coally Shale	BH18
ZFN 1510 (35)	Coal seam no. 5	BH19
ZFN 1512 (36-40)	Sandstone/Siltstone	BH20
ZFN 1510 (44)	Coal seam no. 4	BH21
ZFN 1512 (42-47) [1166]	Sandstone/Shale	BH22
ZFN 1512 (50-52) [1123]	Sandstone	BH23
ZFN 1510 (53)	Coal seam no. 3	BH24
ZFN 1512 (55-57) [2102]	Dwyka tillite	BH25
ZFN 1510 (54-56)	Shale/Sandstone	BH26
ZFN 1510 (61)	Coal seam no. 2	BH27

4.3.2.2 Humidity cell (IGS)

The humidity cells leach (HCL) test was done at the laboratory of the Institute of Groundwater Studies (IGS) at the University of the Free State (UFS) according to the American Society for Testing and Materials (ASTM) protocol. Usher *et al.* (2003) and Zhao *et al.* (2010) provided a comprehensive description of the HCL analytical process. The purpose of kinetic testing is to simulate the physicochemical processes of weathering, often at a sped-up rate. These tests need additional time and are significantly more costly than static testing (Usher *et al.*, 2003).

The test was conducted to imitate the sample's weathering acceleration by passing transiently wet air followed by dry air through the sample chamber for three days, followed by dry air for three days and distilled water on the seventh day (Figure 4-4). That is three days of dry air and three days of humid air, followed on the seventh day by leaching. Then, the pH, conductivity, sulphate, acidity, and dissolved alkalinity of the leachate are determined. In this study, this cycle was repeated for 31 weeks. According to Lawrence and Day (1997), "it is very uncommon for humidity cell experiments to continue for several months or even years."



Figure 4-4: Generic schematic layout for the arrangement of a humidity cell leach (Mills, 1998), as well as an HCL test at the IGS University of the Free State.

The ASTM procedure stipulates a minimum test time of 20 weeks, although Price *et al.* (1997b) suggest a minimum duration of 40 weeks. The convincing data indicating that in many instances, even 40 weeks is insufficient and that the test should be administered until stable rate results are established (Morin and Hutt, 1997; 1998; 1999; 2000). The duration of the current test was 31 weeks, however it is clear that the the system was stabilized at the fouth week. Other nations, such as Canada, have demonstrated that the experiment may be conducted for longer than two years (104 weeks) (Miller, 1998).

4.3.3 Results

The summary statistics of pH, EC, Malk (total alkalinity), and 25 elements are represented in Figures 4-5, 4-6, 4-7, and 4-8 for pH, EC, Malk, and SO_4^{2-}, respectively, and are briefly discussed here, with the remainder presented in Appendix F. Appendix E depicts the correlation matrix of pH, EC, and 25 elements for all the samples from BH1 to BH27. The remaining metal was calculated (% of orginal) as the [initial metal content (mg/kg)-(cumulative metal leach rate (mg/kg)/initial metal content (mg/kg)]*100% adopted from Morin and Hutt, (1997).

4.3.3.1 Leachate quality

In the assessment of the 31-week experiment, the quality of the leachate reveals a pH distribution that is about normal, with a minimum pH of 5.12 and a high pH of 9.66. (Figure 4-5). The median value of 7.62, which is closer to the mean value of 7.64, indicates that the data are distributed symmetrically, therefore suggesting a no to minimal change of pH during the experimental period. The samples show to have a neutral pH, while pH of less than 6 was recorded 20 times during the experimental period. Additionally, the highest pH values above 8.76 cannot be discounted in the data. Compared to the South African water quality recommendations (DWAF, 1996), the pH range where the abundant of metals are in solution is typically between 4.0 and 6.0. According to South African water quality recommendations (DWAF, 1996), the increased pH has no major impact on human health due to non-toxicity.

Electrical conductivity of all leachates ranges from a minimum of 2.79 mS/m to a mean of 12.8 mS/m (Figure 4-6). The median value is smaller than the mean value of 21.9 mS/m, indicating an asymmetrical (log-normal) data distribution with a rightward skew. The majority of home water quality assessments fall within the range of permitted standards. However, values more than 70 mS/m up to a maximum of 301 mS/m can be detected, which are already harmful for household use (South African water quality recommendations (DWAF, 1996).

The distributions of the earth-alkali elements are favorably skewed, the bivariate elements (Ca, Mg) more so than the monovalent ones (K, Na) (Appendix F). Calcium readings expressed in milligrams per liter range from 0.1 mg/L and 442 mg/L. (see also alkalinity in Figure 4-7). The median value is lower than the mean value, which is 19 mg/L. Calcium concentrations are widely dispersed and positively right-skewed. The minimal Mg concentration is 0.1 mg/L, while the highest concentration is 276 mg/L. The median value of 0.9 mg/L is smaller than the mean value of 5.6 mg/L, indicating that the asymmetrical data distribution is positively right-skewed.

Minimum sodium concentration is 0.35 mg/L and highest sodium concentration is 21.1 mg/L (Appendix F). The median value of 15.5 mg/L is lower than the mean value of 21.1 mg/L, indicating that the data are favorably biased to the right. The values of potassium range from a minimum of 0.2 mg/L to a high of 5.1 mg/L. The tight relationship between the median value of 0.9 mg/L and the mean value of 1.1 mg/L suggests a symmetrical distribution of data. According to South African water quality rules, a maximum concentration of 5.1 mg/L is within the allowed range for household use (DWAF, 1996).

The kinetic geochemistry data suggests common coal seam correlations (Appendix E): Coal seam 5 (BH10 and BH19), Coal seam 4 (BH11 and BH21), Coal seam 3 (BH12 and BH24), and Coal seam 2. (BH 13 and BH27).

There are substantial relationships between SO_4^{2-} and the anions in all coal seams; the cations include Fe, Mn, Ba, B, Se, Sr, and Zn (Appendix E). The coal seam number 5 exhibits SO_4^{2-} leachate values ranging between a minimum of 14.5 mg/L to a high of 842 mg/L for the BH19 sample (Figure 4-8). The coal seam number 4 showed minimum leachate SO_4^{2-} concentrations of 100.4 mg/L and highest values of 1810.6 mg/L for sample BH11, and minimum concentrations of 6 mg/L and maximum concentrations of 298.1 mg/L for sample BH 21. The coal seam number 3 reveals minimum leachate SO_4^{2-} values of 1.5 mg/L and highest concentrations of 42.5 mg/L for sample BH 12, and minimum concentrations of 1.0 mg/L and maximum concentrations of 162.7 mg/L for sample BH 24. The coal seam number 2 exhibits lowest SO_4^{2-} concentrations of 30.3 mg/L and highest concentrations of 721.7 mg/L for sample BH 13, and minimum concentrations of 2.5 mg/L and maximum concentrations of 100.3 mg/L for sample BH 27.

The SO_4^{2-} leachate concentrations of the coal seam for the geological strata below coal seam number 5 (BH4) and below and above coal seam number 4 (BH5), below coal seam number 3 (BH6) and coal seam number 2 (BH7) reveal strong correlations of leachate SO_4^{2-} values with the anions and cations comparable to the coal geological units (Appendix E). The SO_4^{2-} leachate concentrations for sample BH 4 range from a minimum of 2.3 mg/L to a high of 129.3 mg/L. The minimum BH5 sample concentration is 0.6 mg/L and the highest is 31.5 mg/L. Minimum of 5.7 mg/L and maximum of 405 mg/L for the BH6 sample. Sample BH7 has a minimum of 16.8 mg/L and a maximum of 295.9 mg/L.

The SO_4^{2-} leachate of the geological units above coal seam 5 exhibits connections with Mo, Se, and Sr. It is especially intriguing because the latter geological units are composed of sandstones/siltstones and/or shales with low SO_4^{2-} concentrations. The designations for these units are BH1, BH2, BH3, BH14, BH15, BH16, and BH18. The samples exhibit SO_4^{2-} concentrations ranging between 15.9 mg/L and 67.4 mg/L for BH1. In addition, sample BH2 has a range between 1.8 mg/L and 31.4 mg/L. Sample BH3 demonstrates a range between 0.4 mg/L and 35.4 mg/L. Sample BH 14 has a range between 0.8 mg/L and 12.0 mg/L. Minimum concentration of 0.2 mg/L and maximum concentration of 11 mg/L for sample BH15. BH16 sample has a minimum of 0.7 mg/L and a maximum of 24.0 mg/L. Sample BH18 has a minimum of 2.2 mg/L and a maximum of 25.5 mg/L.

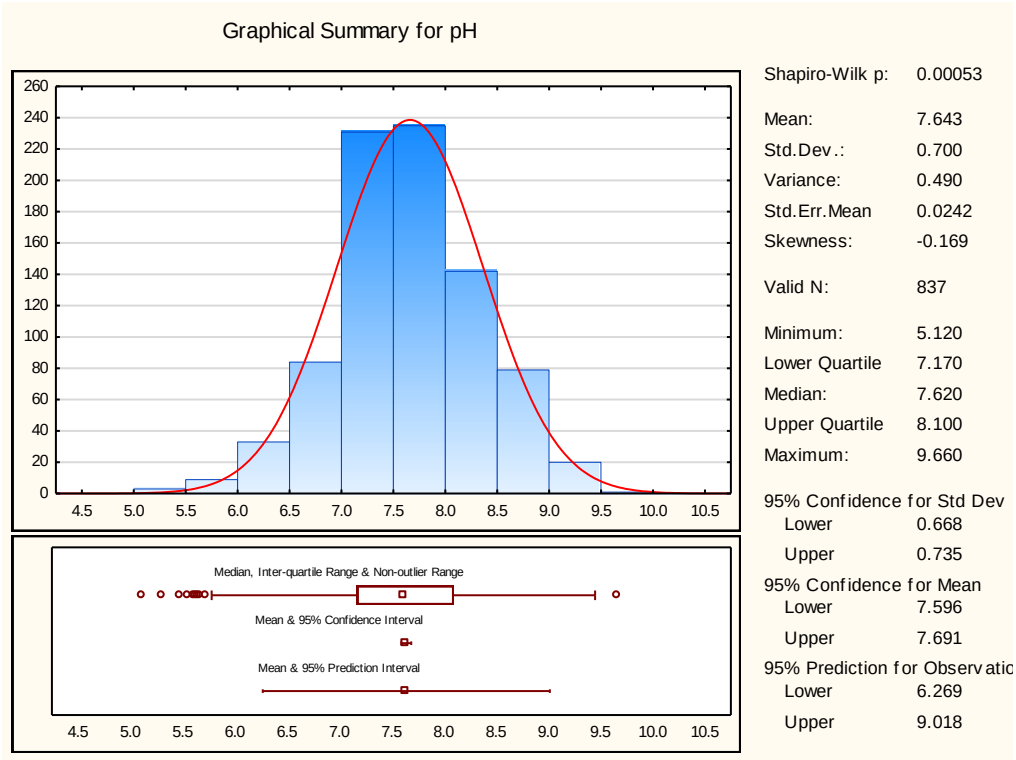


Figure 4-5: Presents a graphical representation of the pH results of the humidity cell leaching 31 week experiments.

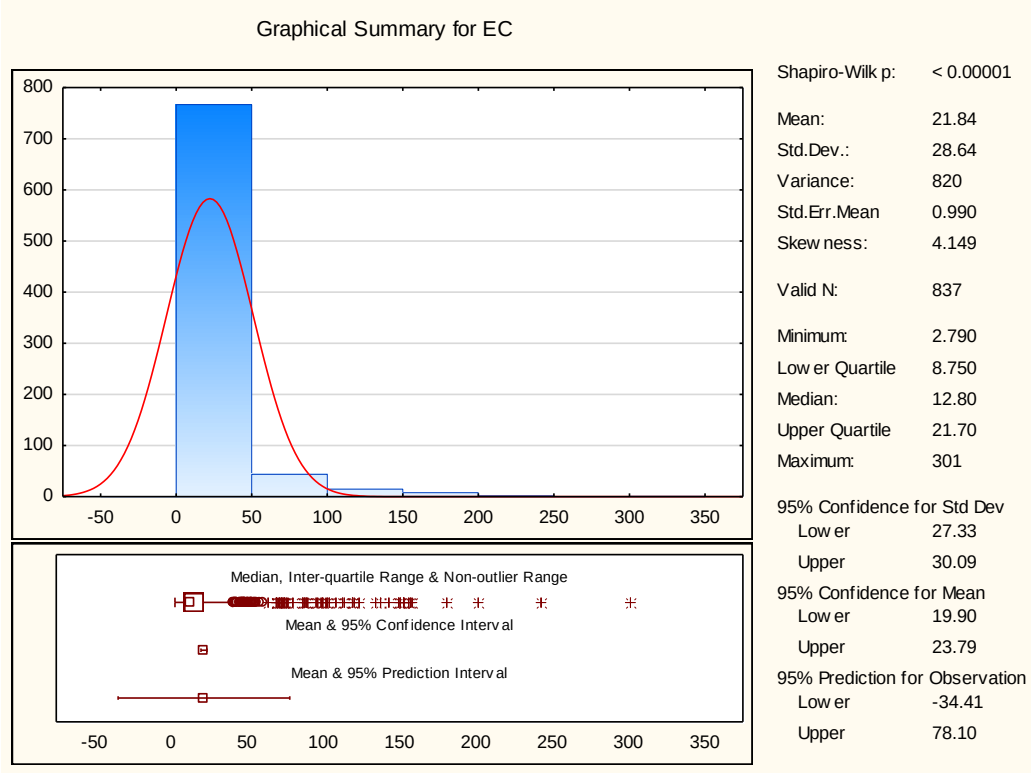


Figure 4-6: Shows a graphical representation of the SO_4^{2-} (mg/L) concentrations in the leachate of the humidity cell leach 31 week tests.

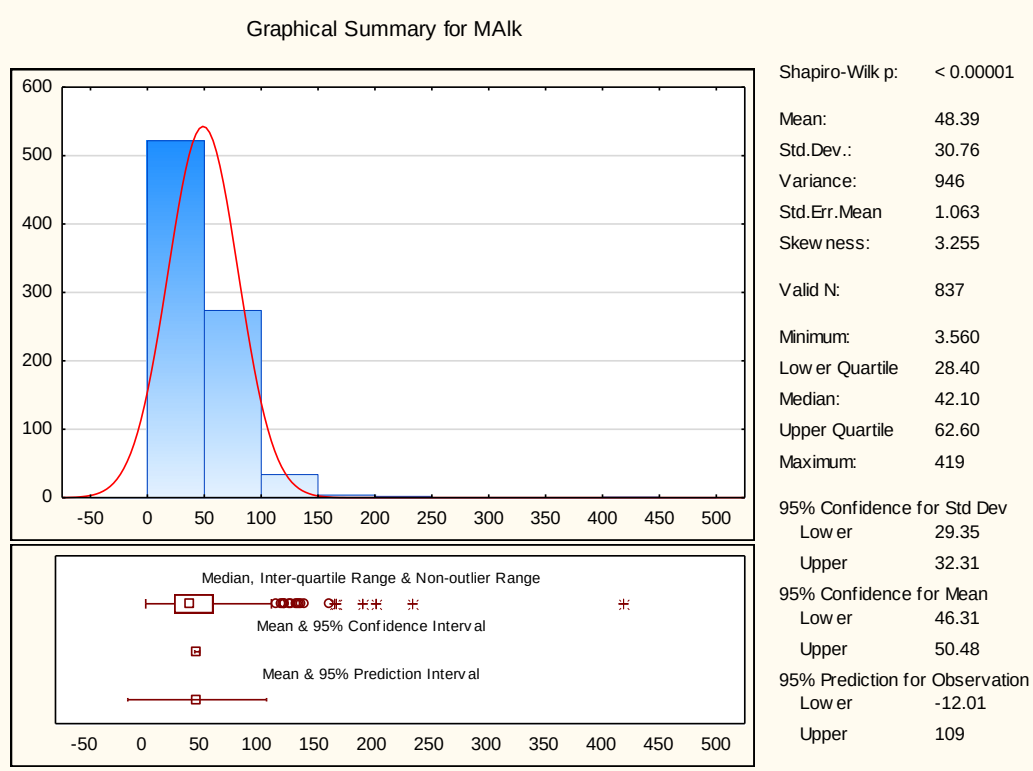


Figure 4-7: Graphical summary statistics of leachate Alkalinity values of the humidity cell leach 31 week tests.

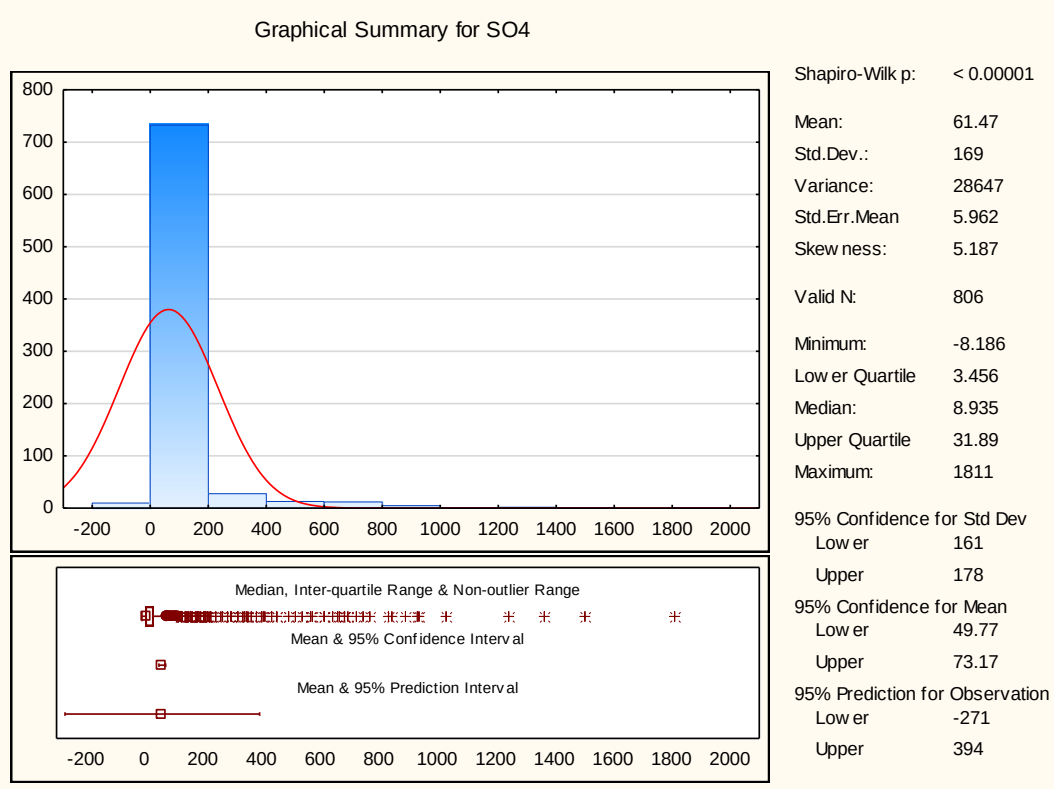


Figure 4-8: Graphical summary statistics of leachate SO_4^{2-} (mg/L) concentrations of the humidity cell leach 31 week tests.

4.3.3.2 Acid production lithological units

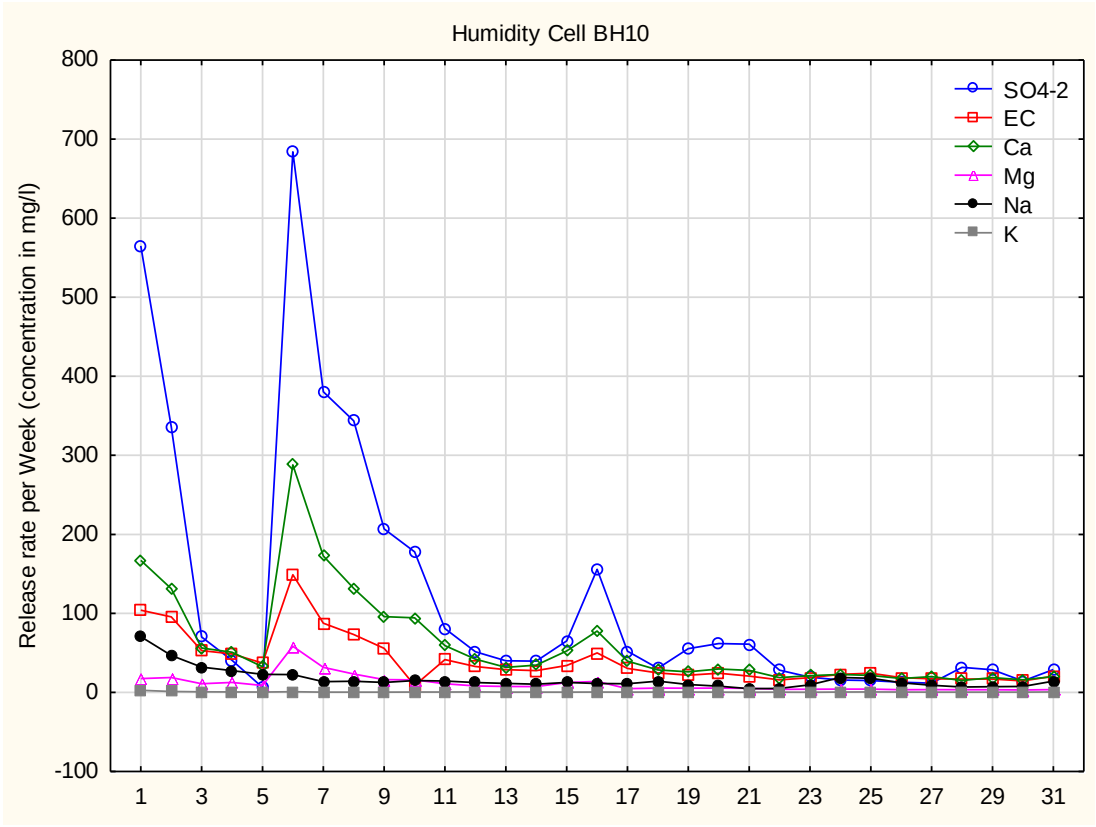
4.3.3.2.1 Coal seam number 5

BH10 and BH19 samples represented coal seam No. 5. Figure 4-9 indicates initial sulphate concentrations in the first 8 weeks that are greater than 600 mg/L. For eight weeks, the sulphate remained in the solution. From week 8 to week 31, the concentration of sulphate falls below 100 mg/L. The presence of oxygen and water accelerates chemical reactions. This is also evidence about the metals Na and Ca, which followed the same pattern as sulphate from week 1 to week 31 and stayed below 50 mg/L at the end of week 31. The precipitation of this species over the 31-week experiment may have reduced the cation and anion concentrations in the leachate (Figure 4-9). Barite, anhydrite, celestite, $CdSO_4$ and gypsum, which are the predominant sulphate minerals in coal seams, have been recorded in the literature (Maty'sek *et al.*, 2014). According to Maty'sek *et al.* (2014), gypsum is typically found on the surface of coal as small, colorless to whitish, rhombic-shaped crystals with a distinct striation that are sometimes elongated or needle-like with a maximum length of 0.2 mm, and the dissolution of gypsum crystals along the cleavage planes is frequently observed. As shown in Figure 4-9, the drop in anions and sulfate concentrations over the first 1-10 weeks can be attributable to the co-precipitation of different sulfate minerals.

4.3.3.2.2 Rock units between C5 and C4 (Sandstone)

Figure 4-10 depicts the geological units as shales and sandstones labeled BH4 and BH20. The experiment indicates that stability developed during the ninth week of the study. BH4's initial sulphate concentrations is greater than 120 mg/L over the first 7 to 10 weeks. It is essential to notice that the sulphate concentration suddenly dropped to less than 50 mg/L in week 8. In week 21, the concentration of sulphate has fallen to less than 10 mg/L. Initial calcium concentrations are above 40 mg/L for the first seven weeks, then decline precipitously in week 8 to below 30 mg/L and remain steady between 10 mg/L and 30 mg/L.

As mentioned in chapter 4, the rock unit in contact with coal seam number 5 contains sulphide minerals. Quartz and pyrite minerals make up the matrix of the main minerals. The decreased percentage of sulphate in the leachate is indicative of the low amounts of sulphide minerals that reacted over the experiment's 17-week duration. In the absence of sulphate, the Na concentration remained quite high 18 weeks after sulphate depletion.



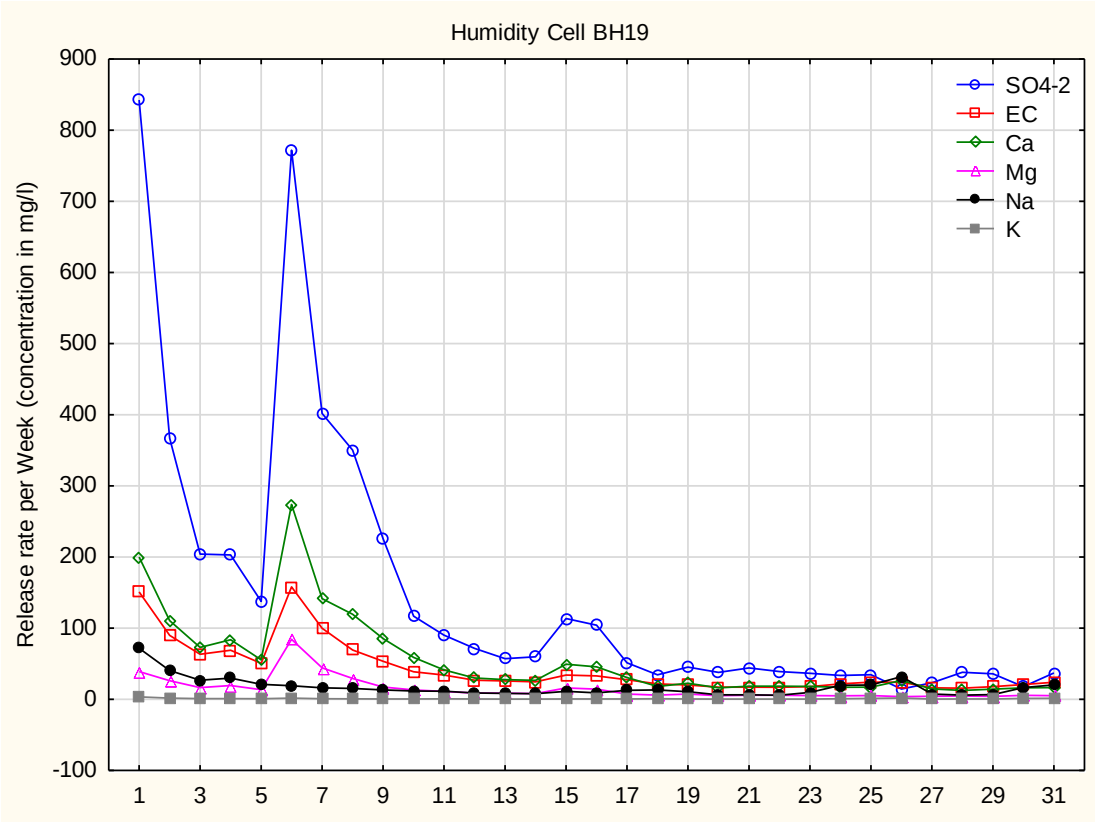


Figure 4-9: The Humidity leach test indicating metal release rate of SO_4^{2-}, EC, Ca, Mg, Na and K per week for BH10 and BH19.

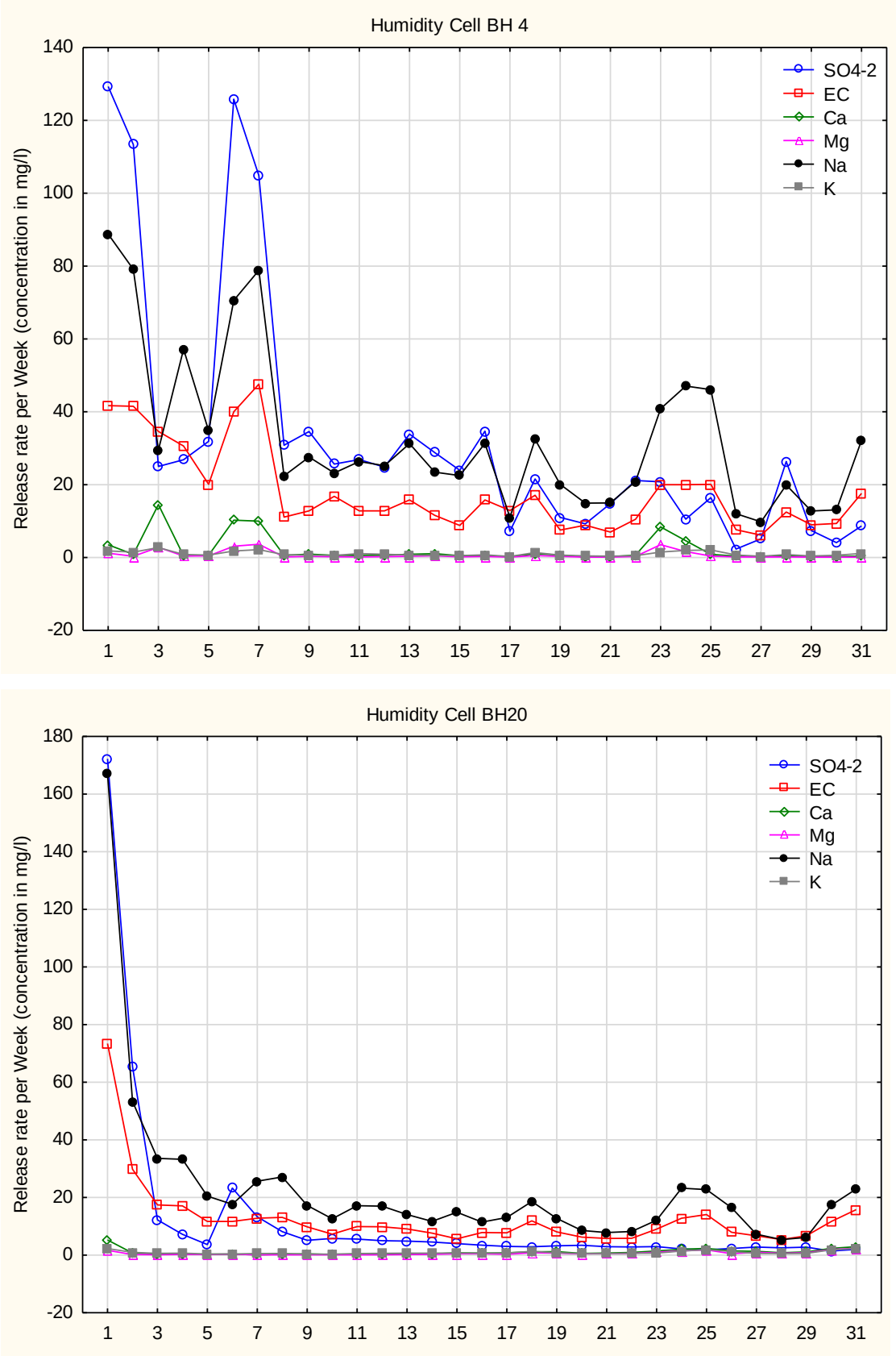


Figure 4-10: The Humidity leach test indicating for SO_4^{2-}, EC, Ca, Mg, Na and K per week of BH4 and BH20.

4.3.3.2.3 Coal seam number 4

Figure 4-11 depicts coal seam number 4 with samples BH11 and BH21. For the first seven weeks of the trial, BH21 had sulphate concentrations exceeding 1000 mg/L. In week 31, the sulphate concentration falls below 200 mg/L. According to Appendix A, this seam No. 4's mineral matter composition included a percentage of sulphide minerals. There is evidence on sample BH11 of sulphate concentrations above 1,400 mg/L in the initial weeks, as well as reactivation in the sixth week of the trial. In week 31, the sulphate levels decreased substantially to less than 200 mg/L. This may reflect the sulphate availability in the leachate for further reactions. Calcium in the leachate was at a low concentration in BH11 but at a high concentration relative to Mg, K, and Na. BH21 indicates sulphate values less than 150 mg/L, with all metals at lower concentrations than BH11, although the trends are comparable.

Other lithological units that have the potential to generate MD under favorable conditions include coal seam No. 3 represented by BH12 and BH24 (Figure 4-12), rock units between C3 and C2 (shale/sandstone) represented by BH17 and 26 (Figure 4-13), below coal seam No. 3 (Figure 4-14), and coal seam No. 2 represented by BH13 (Figure 4-15).

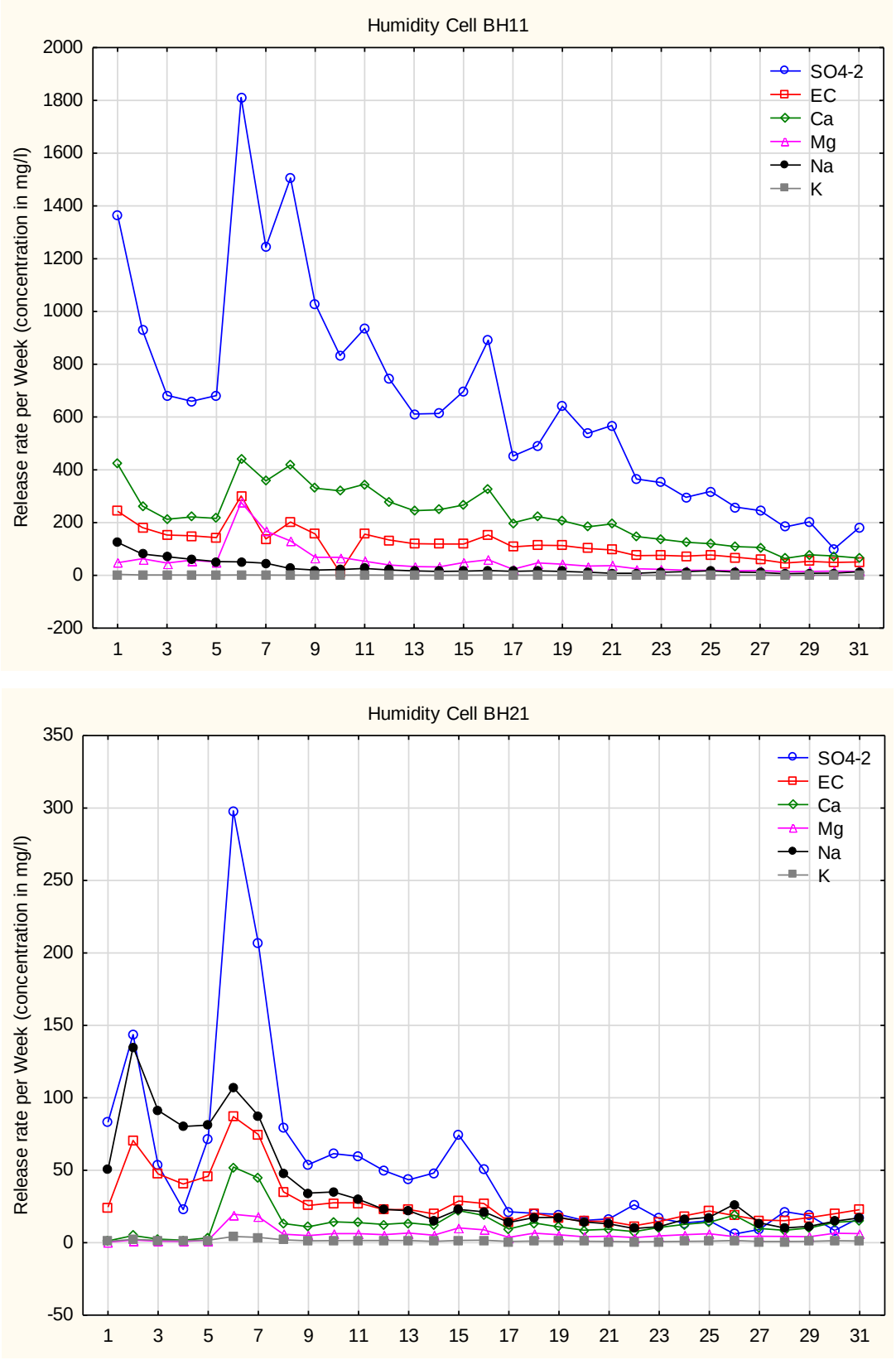


Figure 4-11: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH11 and BH21 for coal seam No 4.

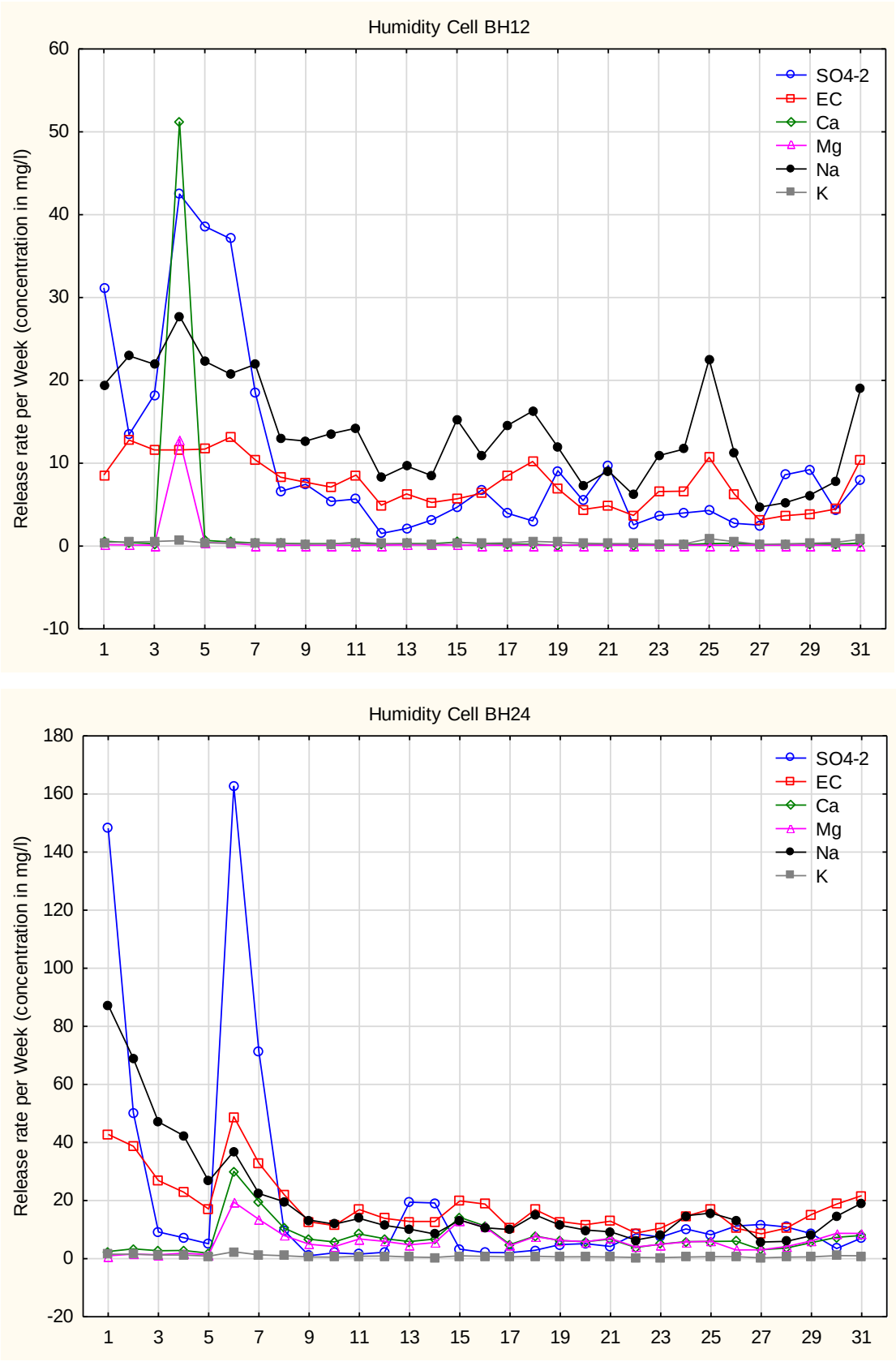


Figure 4-12: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH12 and BH24 for coal seam No. 3.

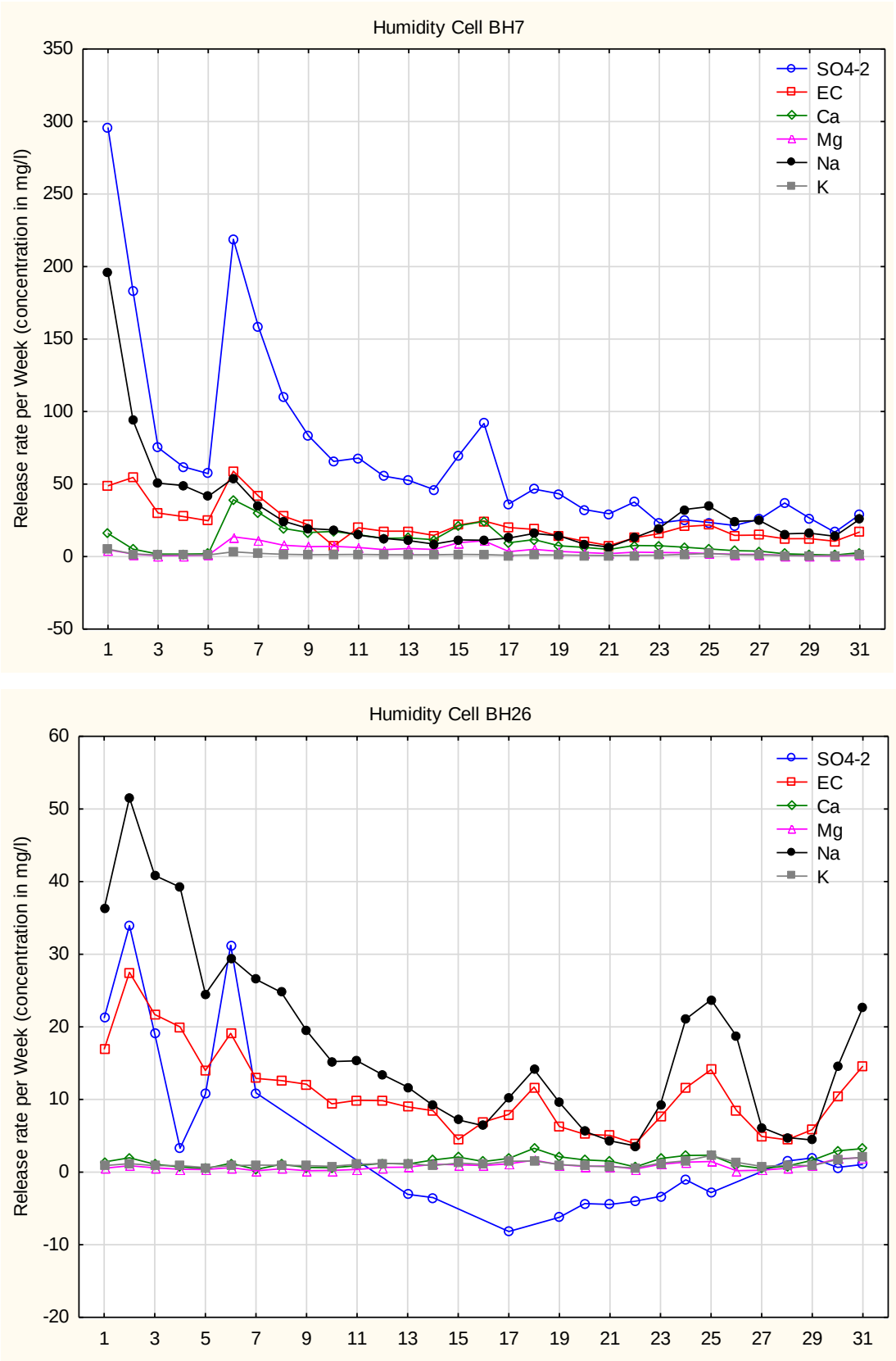


Figure 4-13: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH7 and BH26 rock units between coal seam No. 3 and 2.

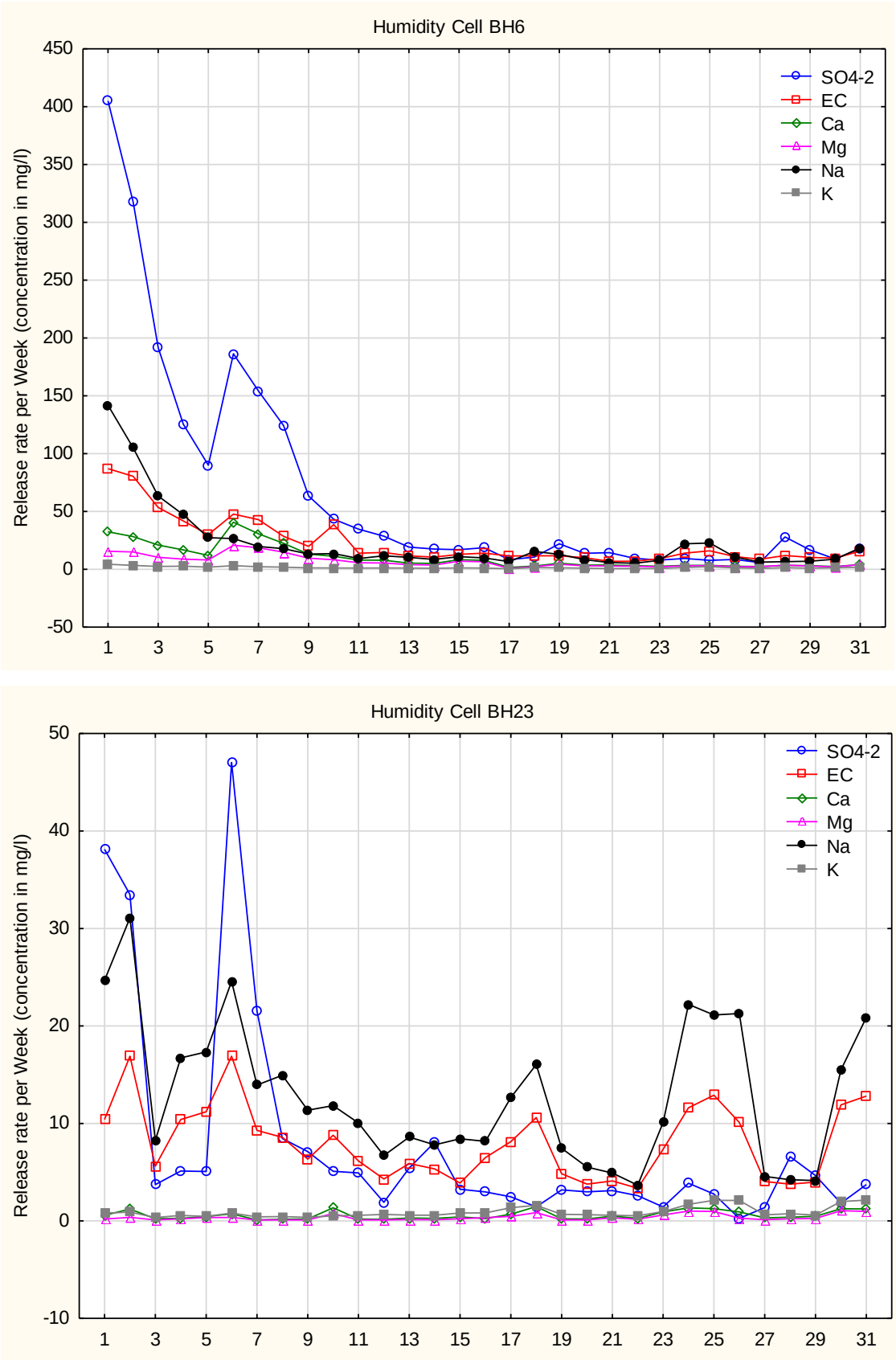


Figure 4-14: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH6 and BH23 for rock units below coal seam No. 3.

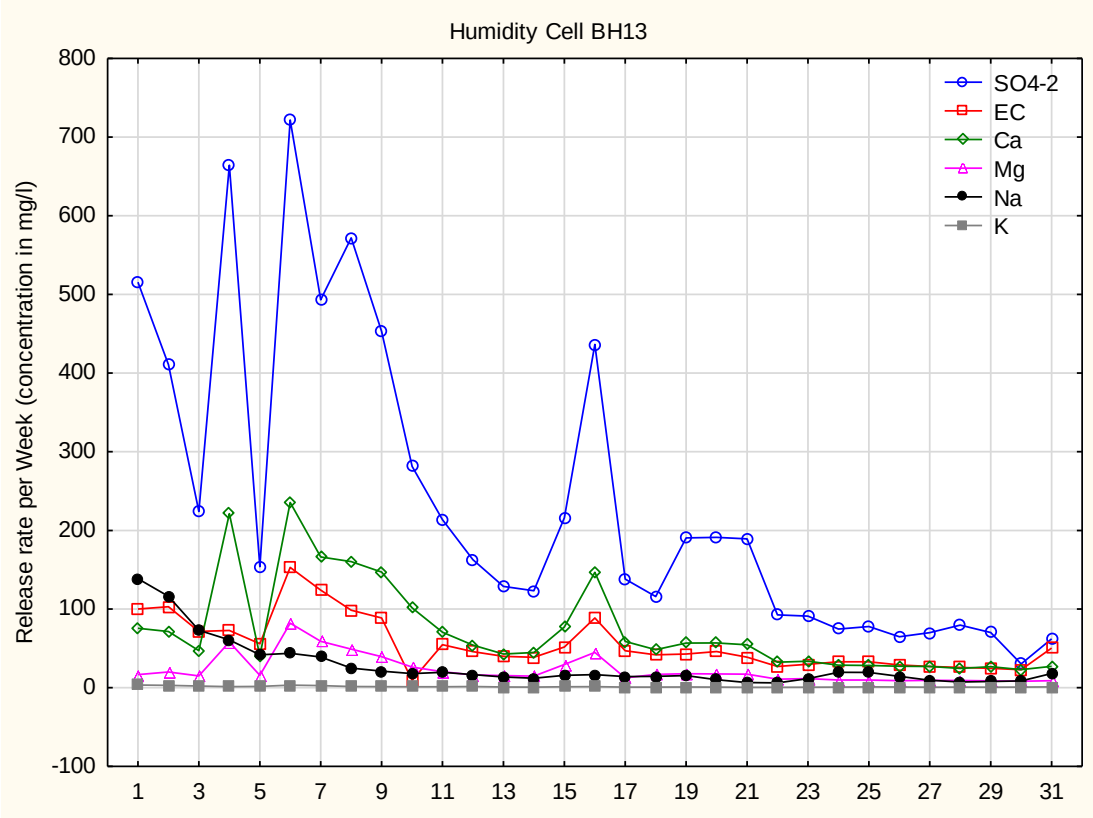


Figure 4-15: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH13 and BH26 for coal seam No. 2.

4.3.3.3 Non-acid generation lithological units

4.3.3.3.1 Rock units above C5 (Sandstone /siltstone, Dolerite)

The overburden rock units above coal seam No. 5 show early sulphate values of around 15 mg/L on BH1, 32 mg/L on BH2, and approximately 35 mg/L on BH3 in week 1 (Figures 4-16 and 4-18). During the first three weeks of the experiment, the metal concentrations in the latter boreholes decreased dramatically since there was little sulphide to react with and the majority of SO_4^{2-} was depleted from the system in week one.

From week 2 to week 31, the Na and electrical conductivity (EC) were stable with negligible fluctuations. The significant occurrences that occurred in weeks 19 and 25 following the growth of these metals must be noted. It appears there was no metal to react with Na, most likely chlorine below the detection limit of the samples. For the Humidity cell leachate data, the presence of BH2 and BH3 suggests that the sulphate content is high enough to react with metals. Between weeks 1 and 2, the sulphate concentration in BH2 and BH3 decreased dramatically from 32 mg/L and 35 mg/L to around 12 mg/L and 17 mg/L, respectively. There is evidence that precipitates or precipitation processes have occurred, eliminating SO_4^{2-} and metals from the system. The basement rocks of the Dwyka tillites, seen in Figure 4-18, likewise have a non-acid-generating potential.

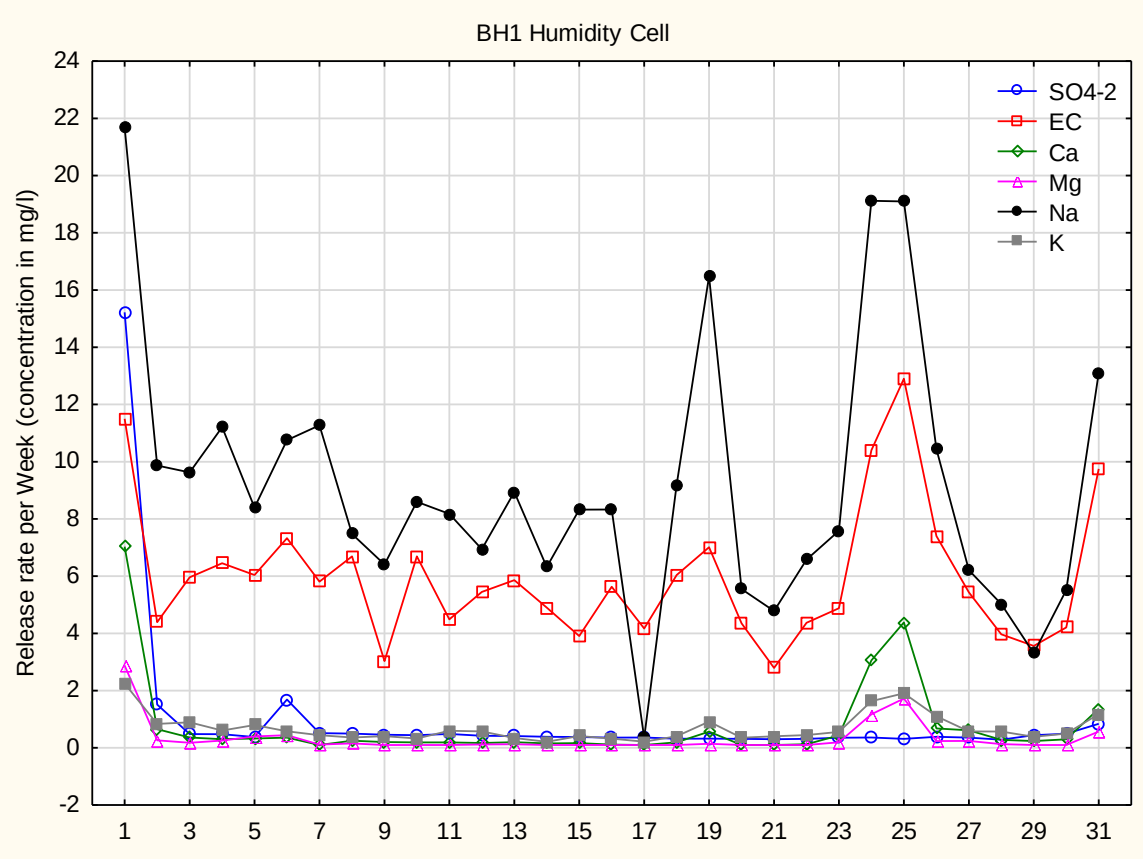


Figure 4-16: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH1.

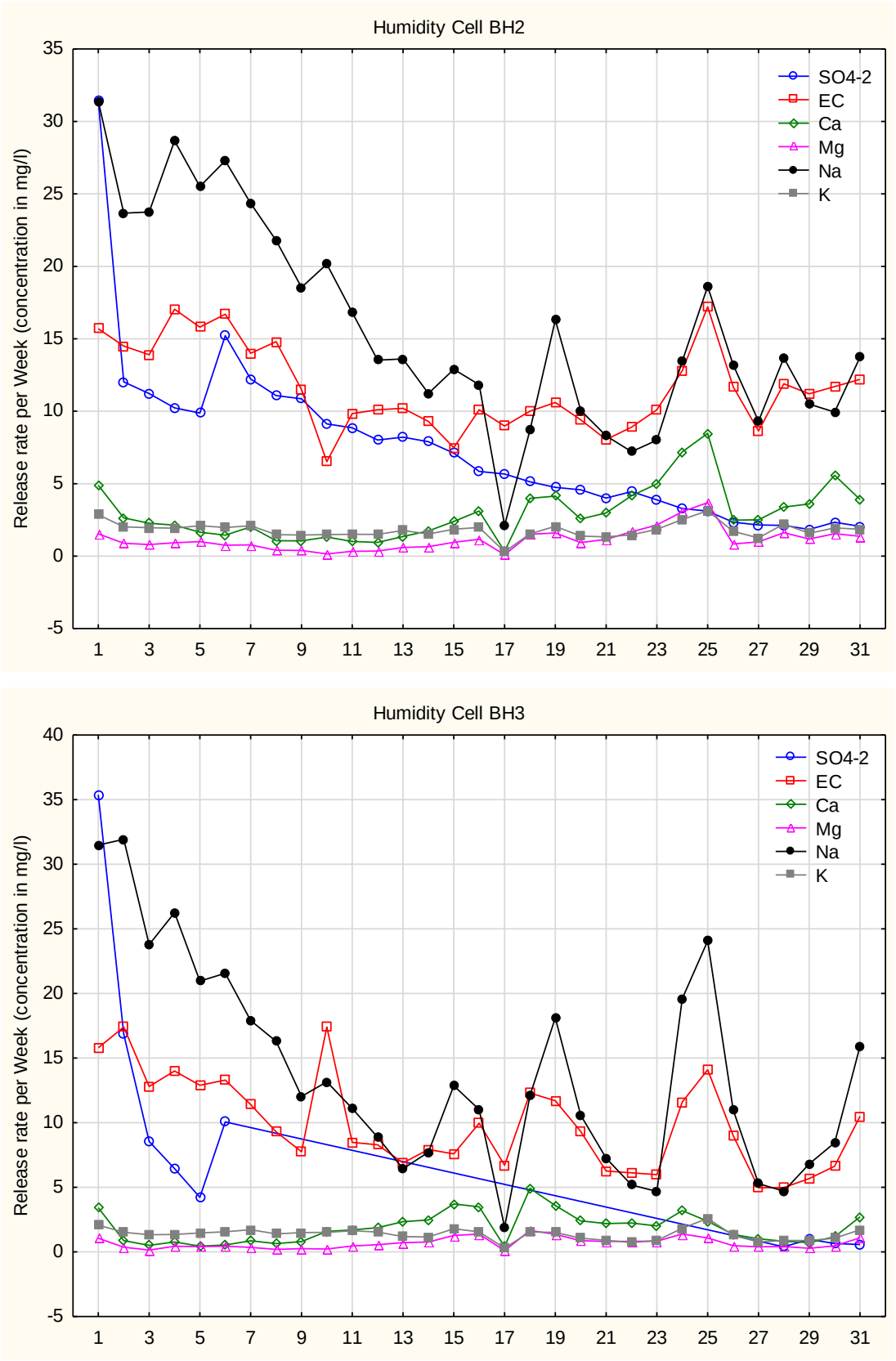


Figure 4-17: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH2 and BH3.

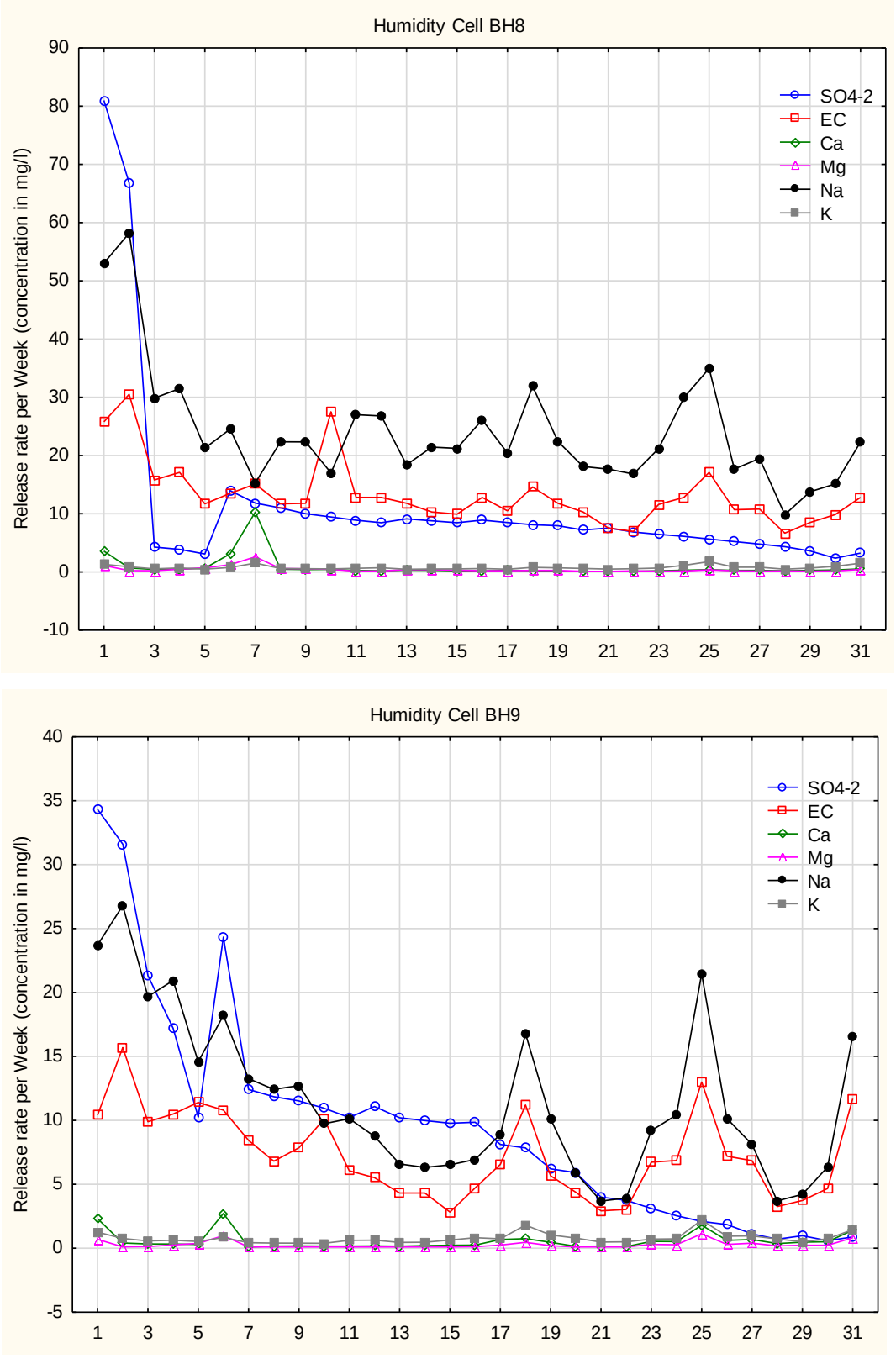


Figure 4-18: The Humidity leach test indicating metal release rate of SO_4^{2-} (mg/L), EC (mS/m), Ca (mg/L), Mg (mg/L), Na (mg/L) and K (mg/L) per week of BH8 and BH9.

4.4 DISCUSSION AND CONCLUSIONS

4.4.1 General observation

Samples of coal seam No. 5, rock units between C5 and C4 (sandstone), coal seam No. 4, rock units between C3 and C2 (shale/sandstone), and coal seam No. 2 produce acid over time (pH values in Appendix E). This is characterized by the presence of high sulphate concentrations, which have been measured as high as 1,810.6 mg/L on the coal seams' single leachate analysis. There are parallels across all coal seams in terms of the significant association between anions and Fe, Cu, Mn, Be, and B in the leachate, and the poor correlation between Na, K, and Mg. As described in chapter 3, the significant association of SO_4^{2-} is supported by the presence of sulphide minerals, particularly pyrite, which is predominant in organics. It is obvious that the geological strata samples from the hanging and footwall of the coal seams produce acid throughout time. By use of ABA analysis, these geological strata were categorized as belonging to the uncertainty range. They contain SO_4^{2-} concentrations comparable to those of coal seams. It is also essential to notice that the latter geological layers exhibit a link with the leachate's Fe, Cu, Mn, Be, and B. These are the geological strata of shales and siltstones. The coal seams, footwall, and hanging geological units show no link between metals and alkalinity. The predominant occurrence of buffer carbonate minerals controls alkalinity.

The overburden geological units, which are represented by sandstones and siltstones, and the basement geological units, which are represented by Bushveld granite and Dwyka tillites, exhibit no traces of acid formation. During ABA analysis, the samples were categorised based on the range of uncertainty. These units demonstrate significant relationships between Mo and Sr and SO_4^{2-}. They have a substantial association with alkalinity as well.

The leachate has a minimum pH of 5.12 and a maximum pH of 9.66; therefore, the water can generally be classified as circumneutral. Alkaline waters, which are produced when acidic mine waters are buffered by carbonate minerals such as calcite and magnesium, have been geologically confirmed as a result of geological assessment (Vermeulen and Usher,

2006; Scholtz, 2013). If AMD passes over dolomite rock, it is somewhat neutralized, and certain metal pollutants precipitate as their respective hydroxides. Sulfates will either precipitate as gypsum or adsorb onto metal hydroxides. The type of water is referred to as "circumneutral mine waters (CMW)" by Banks *et al.* (1997) and Madzivire (2009). It contains less SO_4^{2-} than acid mine water and has a pH of approximately 6.5. The concentration of toxic metals is close to or below the acceptable effluents limit, but the water still contains a significant amount of SO_4^{2-}, Ca, Mg, and Mn. This sort of untreated mine water wreaks havoc on the ecology, hence it is best not to release it into the local receptor zone (Petrik *et al.*, 2003; Banks *et al.*, 1997).

The properties of the leachate reveal that SO_4^{2-} has a high correlation with anions and cations in coal seams (Appendix F). It suggests that the coal leachate in the Witbank coalfields is a major contributor of metals to the receptor realm. The coal mines in the Mpumalanga province generate acidic (pH 3) or circumneutral (pH 6-7) mine fluids (Petrik *et al.*, 2003; Banks *et al.*, 1997). As in the Witbank coalfield, the acidic nature (pH values in Appendix G) of the leachate causes SO_4^{2-} and toxic metals to dissolve in the leachate, contaminating the downstream water or environment (Petrik *et al.*, 2003). Due to buffer material availability in this experiment, the leachate quality remains CMW type, as there was no significant change on the neutral pH leachate quality.

4.4.2 Saturation index of metals

According to the saturation index (SI) calculated by Geochemist's Workbench (GWB), the species found to be supersaturated or under saturated are summarized in Table 4-4 and 4-5. It is important to note that at this initial assessment SI predicts minerals for the lithological unit. The SI also demonstrates a prediction of an interaction mechanisms between water and rock units. For control, the mineral saturation calculated from PhreeqC is also presented in Figures 4-20 to 4-22. The SI was calculated from the total cumulative leachate concentrations for 31 weeks of the HCL test of the samples BH1-27.

The minerals species that are predicted to be supersaturated for coal seams and units above and below are barite, anhydrite, celestine, gypsum and bloedite as indicated by Tables 4-4 and 4-5. Epsom ($MgSO_4 \cdot 7H_2O$) and mirabalite ($Na_2SO_4 \cdot 10H_2O$) salts are also recorded as

supersaturated in BH13 for coal seam no. 2, with bloedite ($Na_2Mg(SO_4)_2 \cdot 4H_2O$) reaching equilibrium with 0.0057 SI. Barite ($BaSO_4$) is the most common species predicted to form in all coal seams (Tables 4-4 and 4-5). Barium mineral is stable up to the pH of 13.5 where it forms $BaOH^+$, however barite is formed on the both oxidising at higher reducing conditions (Figure 4-19). The highest SI of barite of more than 4 is recorded on BH10, 11, 19, 21, 24 and 27, with the highest of 19 on BH11 (Table 4-4 and 4-5). Gypsum and anhydrite ($CaSO_4$) are also formed at oxidising conditions on stability diagrams, with portlandite ($Ca(OH)_2$) forming at higher pH of more than 12 (Figure 4-19). Gypsum and anhydrite recorded in all coal seams with SI of above 2 in BH10, 11, 12, 13, 19 (Table 4-4 and 4-5).

The mineral species that are predicted to be supersaturated in the units above and below the coal seams is represented in Table 4-5. Bassanite ($CaSO_4 \cdot 1/2H_2O$) species these rocks is common in addition to the sulphate species formed in the coal seams. The supersaturation of basanite is recorded in BH6, 7 and 17, and near equilibrium on the other boreholes.

The species that are formed by Al, Mg, Fe, Mn and other metals are mostly under saturation. The species include melanterite ($FeSO_4$), $MnSO_4$ and $Al_2(SO_4)_3$ (Table 4-4 and 4-5). These species can be formed when the conditions progress to reducing and the pH progress acidic (Figure 4-19).

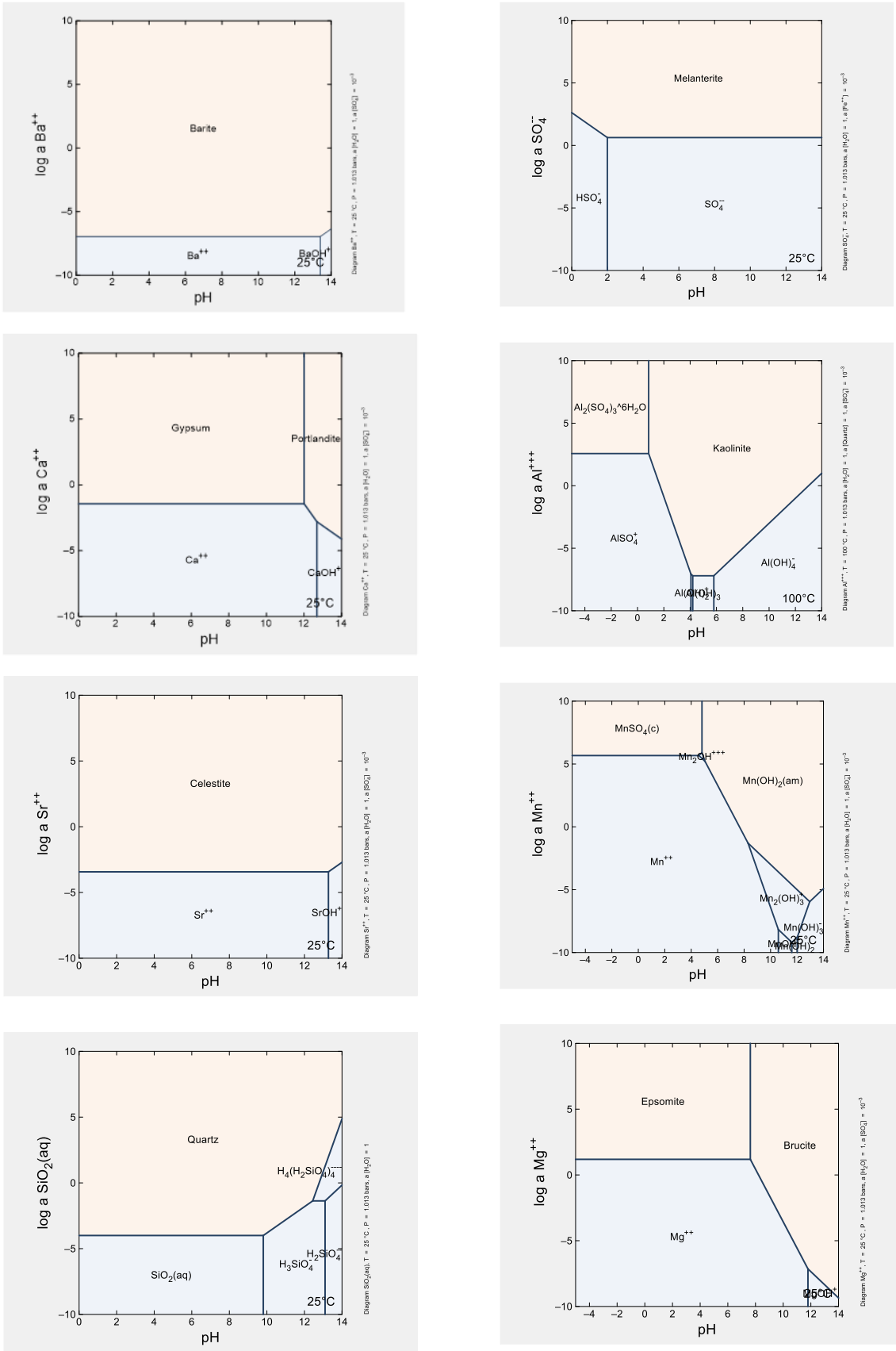


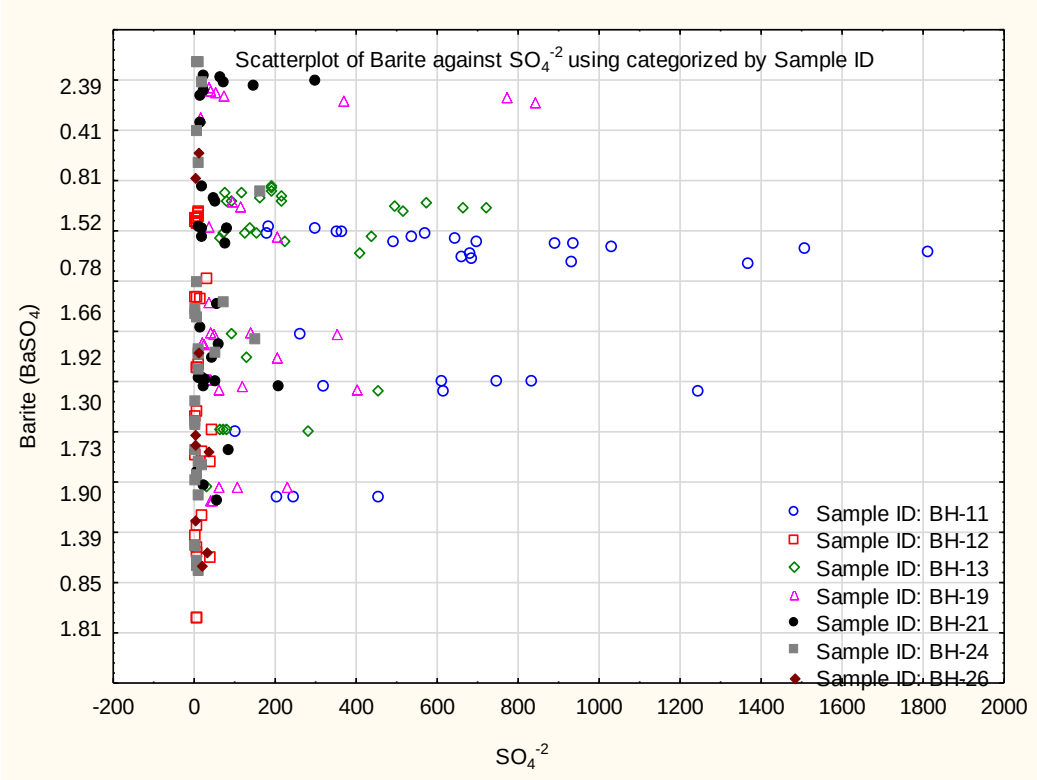
Figure 4-19: General stability diagram from GWB at temperature = 25ºC, pressure = 1.013 bars for elements Ba, Ca, Sr, Si, SO_4^{2-}, Al, Mn and Mg.

Table 4-4: Saturation indices (SI) results for mineral prediction for coal seams using GWB.

Sample ID	BH10		BH11		BH12		BH13		BH19		BH21		BH24		BH27	
Lithology	Coal seam no. 5		Coal seam no. 4		Coal seam no. 3		Coal seam no. 2		Coal seam no. 5		Coal seam no. 4		Coal seam no. 3		Coal seam no. 2	
Geochemical workbench mineral prediction results	***Min.***	***SI***	***Min.***	***SI***	***Min.***	***SI***	***Min.***	***SI***	***Min.***	***SI***	***Min.***	***SI***	***Min.***	***SI***	***Min.***	***SI***
	Barite	4.6621	Bloedite	29.8759	Quartz	3.2727	Quartz	4.1962	Barite	4.6902	Barite	4.4311	Barite	4.0676	Barite	4.6147
	Quartz	3.7363	Barite	19.5979	Tridymite	3.1069	Tridymite	4.0304	Quartz	3.7127	Quartz	3.5860	Quartz	3.3235	Quartz	3.4718
	Tridymite	3.5705	Quartz	18.6566	Chalcedony	3.0015	Chalcedony	3.9250	Tridymite	3.5469	Tridymite	3.4202	Tridymite	3.1577	Tridymite	3.3060
	Chalcedony	3.4651	Tridymite	18.4908	Cristobalite	2.7222	Cristobalite	3.6457	Chalcedony	3.4415	Chalcedony	3.3148	Chalcedony	3.0523	Chalcedony	3.2006
	Cristobalite	3.1858	Chalcedony	18.3854	Amrph^silica	1.9870	Gypsum	3.2747	Cristobalite	3.1622	Cristobalite	3.0355	Cristobalite	2.7730	Cristobalite	2.9213
	Gypsum	2.6314	Gypsum	18.2210	Gypsum	0.7279	Celestite	3.1176	Gypsum	2.6879	Amrph^silica	2.3003	Amrph^silica	2.0378	Amrph^silica	2.1861
	Anhydrite	2.4533	Cristobalite	18.1061	Anhydrite	0.5498	Anhydrite	3.0966	Celestite	2.5984	Gypsum	1.7648	Gypsum	1.3200	Celestite	1.6928
	Amrph^silica	2.4506	Anhydrite	18.0429	Bassanite	-0.0791	Amrph^silica	2.9105	Anhydrite	2.5098	Anhydrite	1.5867	Celestite	1.1872	Gypsum	1.5107
	Celestite	2.3729	Celestite	17.9695	$CaSO_4.1/2H_2O$(beta)	-0.2477	Bassanite	2.4677	Amrph^silica	2.4270	Bassanite	0.9578	Anhydrite	1.1419	Anhydrite	1.3326
	Bassanite	1.8244	Bassanite	17.4140	Mirabilite	-1.5492	$CaSO_4.1/2H_2O$(beta)	2.2991	Bassanite	1.8809	$CaSO_4.1/2H_2O$(beta)	0.7892	Bassanite	0.5130	Bassanite	0.7037
	$CaSO_4.1/2H_2O$(beta)	1.6558	Amrph^silica	17.3709	Boric	-1.6907	Mirabilite	0.4171	$CaSO_4.1/2H_2O$(beta)	1.7123	Mirabilite	-0.2434	$CaSO_4.1/2H_2O$(beta)	0.3444	$CaSO_4.1/2H_2O$(beta)	0.5351
	Mirabilite	-0.5520	$CaSO_4.1/2H_2O$(beta)	17.2454	Epsomite	-2.3618	Epsomite	0.2292	Melanterite	-0.3297	Thenardite	-1.0988	Mirabilite	-1.1814	$MgSeO_3$	-0.3703
	Epsomite	-0.6411	Mirabilite	15.4686	Thenardite	-2.4046	Bloedite	0.0057	Epsomite	-0.4247	Epsomite	-1.1311	Epsomite	-1.2776	Mirabilite	-1.1529
	Boric	-0.7965	Epsomite	15.0479	Hexahydrite	-2.5985	Hexahydrite	-0.0075	Mirabilite	-0.4565	Boric	-1.2631	Boric	-1.4858	Epsomite	-1.2077
	Hexahydrite	-0.8778	Hexahydrite	14.8112	Melanterite	-2.8149	Pentahydrite	-0.3483	Hexahydrite	-0.6614	Hexahydrite	-1.3678	Hexahydrite	-1.5143	Boric	-1.3054
	Pentahydrite	-1.2186	Melanterite	14.8100	Pentahydrite	-2.9393	Thenardite	-0.4383	Boric	-0.9275	Pentahydrite	-1.7086	Pentahydrite	-1.8551	Hexahydrite	-1.4444
	Thenardite	-1.4074	Thenardite	14.6132	Leonhardtite	-3.3278	Boric	-0.5454	Pentahydrite	-1.0022	Bloedite	-2.0151	Thenardite	-2.0368	MgSeO3^6H2O	-1.6963
	Leonhardtite	-1.6071	Pentahydrite	14.4704	Kieserite	-4.0645	Leonhardtite	-0.7368	Thenardite	-1.3119	Leonhardtite	-2.0971	Leonhardtite	-2.2436	Pentahydrite	-1.7852
	Melanterite	-1.7422	Leonhardtite	14.0819	Arcanite	-4.1390	Melanterite	-1.1042	Leonhardtite	-1.3907	Arcanite	-2.6219	Melanterite	-2.9799	Thenardite	-2.0083
	Bloedite	-1.8337	Boric	14.0097	Bloedite	-4.5516	Kieserite	-1.4735	Bloedite	-1.5217	Melanterite	-2.8168	Kieserite	-2.9803	Leonhardtite	-2.1737
	Kieserite	-2.3438	Kieserite	13.3452	FeSO4(c)	-7.8299	Arcanite	-1.9200	Kieserite	-2.1274	Kieserite	-2.8338	Bloedite	-3.0995	$CaSeO_3.2H_2O$	-2.3570
	Arcanite	-3.0723	Arcanite	12.8091	$MgSO_4$(c)	-9.1961	$FeSO_4$(c)	-6.1192	Arcanite	-2.7123	$FeSO_4$(c)	-7.8318	Arcanite	-3.4396	$SrSeO_3$	-2.6741
	$FeSO_4$(c)	-6.7572	$FeSO_4$(c)	9.7950	$Al_2(SO_4)_3.6H_2O$	-15.5456	$MgSO_4$(c)	-6.6051	$FeSO_4$(c)	-5.3447	$MgSO_4$(c)	-7.9654	$FeSO_4$(c)	-7.9949	$BaSeO_3$	-2.8028
	$MnSO_4$(c)	-7.3522	$MnSO_4$(c)	8.2371	$Al_2(SO_4)_3$	-33.0067	$MnSO_4$(c)	-6.9509	$MnSO_4$(c)	-7.0724	$Al_2(SO_4)_3.6H_2O$	-16.3006	$MgSO_4$(c)	-8.1119	Kieserite	-2.9104
	$MgSO_4$(c)	-7.4754	$MgSO_4$(c)	8.2136			$Al_2(SO_4)_3.6H_2O$	-17.3300	$MgSO_4$(c)	-7.2590	$Al_2(SO_4)_3$	-33.7617	$Al_2(SO_4)_3.6H_2O$	-16.1635	Bloedite	-3.0013
							$Al_2(SO_4)_3$	-34.7911							Melanterite	-3.3052
															Arcanite	-3.4808
															$MgSO_4$(c)	-8.0420
															$FeSO_4$(c)	-8.3202
															$Al_2(SO_4)_3.6H_2O$	-16.8314
															$Al_2(SO_4)_3$	-34.2925

Table 4-5: Saturation indices (SI) results for mineral prediction for above and below units of coal seams using GWB.

Sample ID	BH5		BH6		BH7		BH8		BH9		BH16		BH17		BH18		BH22		BH23	
Lithology	Sandstone/Siltstone		Sandstone/Siltstone		Sandstone/Shale		Sandstone/Siltstone/Shale		Dwyka tillite		Sandstone/Siltstone		Sandstone		Coally Shale		Sandstone/Shale		Sandstone	
Geochemical workbench mineral prediction results	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*	*Min.*	*SI*
	Quartz	3.3983	Barite	3.9760	Barite	4.1421	Barite	3.8125	Barite	3.4655	Barite	3.6415	Barite	4.0160	Barite	3.4144	Barite	3.3923	Barite	3.4134
	Tridymite	3.2325	Quartz	3.3898	Quartz	3.7180	Quartz	3.2672	Quartz	3.2543	Quartz	3.3432	Quartz	3.5440	Quartz	3.2186	Quartz	3.2053	Quartz	3.1775
	Chalcedony	3.1271	Tridymite	3.2240	Tridymite	3.5522	Tridymite	3.1014	Tridymite	3.0885	Tridymite	3.1774	Tridymite	3.3782	Tridymite	3.0528	Tridymite	3.0395	Tridymite	3.0117
	Cristobalite	2.8478	Chalcedony	3.1186	Chalcedony	3.4468	Chalcedony	2.9960	Chalcedony	2.9831	Chalcedony	3.0720	Chalcedony	3.2728	Chalcedony	2.9474	Chalcedony	2.9341	Chalcedony	2.9063
	Amrph.silica	2.1126	Cristobalite	2.8393	Cristobalite	3.1675	Cristobalite	2.7167	Cristobalite	2.7038	Cristobalite	2.7927	Cristobalite	2.9935	Cristobalite	2.6681	Cristobalite	2.6548	Cristobalite	2.6270
	Celestite	0.2930	Amrph.silica	2.1041	Amrph.silica	2.4323	Amrph.silica	1.9815	Amrph.silica	1.9686	Amrph.silica	2.0575	Amrph.silica	2.2583	Amrph.silica	1.9329	Amrph.silica	1.9196	Amrph.silica	1.8918
	Gypsum	0.2873	Gypsum	1.6916	Gypsum	1.7218	Gypsum	0.3356	Gypsum	0.2032	Gypsum	0.6900	Celestite	1.7038	Gypsum	0.0053	Gypsum	0.0964	Gypsum	0.1831
	Anhydrite	0.1092	Celestite	1.6497	Celestite	1.5634	Celestite	0.2737	Anhydrite	0.0251	Anhydrite	0.5119	Gypsum	1.6643	Anhydrite	-0.1728	Anhydrite	-0.0817	Anhydrite	0.0050
	Bassanite	-0.5197	Anhydrite	1.5135	Anhydrite	1.5437	Anhydrite	0.1575	Bassanite	-0.6038	Bassanite	-0.1170	Anhydrite	1.4862	Bassanite	-0.8017	Bassanite	-0.7106	Bassanite	-0.6239
	$CaSO_4.1/2H_2O$(beta)	-0.6883	Bassanite	0.8846	Bassanite	0.9148	Bassanite	-0.4714	$CaSO_4.1/2H_2O$(beta)	-0.7724	$CaSO_4.1/2H_2O$(beta)	-0.2856	Bassanite	0.8573	$CaSO_4.1/2H_2O$(beta)	-0.9703	$CaSO_4.1/2H_2O$(beta)	-0.8792	$CaSO_4.1/2H_2O$(beta)	-0.7925
	Mirabilite	-0.9545	$CaSO_4.1/2H_2O$(beta)	0.7160	$CaSO_4.1/2H_2O$(beta)	0.7462	$CaSO_4.1/2H_2O$(beta)	-0.6400	Mirabilite	-1.6877	Mirabilite	-1.0497	$CaSO_4.1/2H_2O$(beta)	0.6887	$MgSeO_3$	-1.0724	Mirabilite	-1.2947	Mirabilite	-1.6638
	$MgSeO_3$	-1.2046	Mirabilite	-0.5718	Mirabilite	-0.2983	Mirabilite	-1.1000	Boric	-1.8033	Boric	-1.6248	Mirabilite	-0.5441	Mirabilite	-1.2711	Boric	-1.7365	Boric	-1.9199
	Boric	-1.5953	Epsomite	-1.0335	Thenardite	-1.1537	$MgSeO_3$	-1.1450	Thenardite	-2.5431	Thenardite	-1.9051	Epsomite	-0.9678	Boric	-1.7211	Thenardite	-2.1501	Thenardite	-2.5192
	Thenardite	-1.8099	Hexahydrite	-1.2702	Boric	-1.1830	Boric	-1.6525	Epsomite	-2.6352	Epsomite	-2.1329	Hexahydrite	-1.2045	Thenardite	-2.1265	Epsomite	-2.5564	Epsomite	-2.5636
	Melanterite	-2.3091	Thenardite	-1.4272	Epsomite	-1.2089	Thenardite	-1.9554	Melanterite	-2.7703	Hexahydrite	-2.3696	Thenardite	-1.3995	$MgSeO_3.6H_2O$	-2.3984	Melanterite	-2.6964	Melanterite	-2.7537
	$MgSeO_3.^6H_2O$	-2.5306	Boric	-1.4296	Hexahydrite	-1.4456	$MnSeO_3$	-1.9565	Hexahydrite	-2.8719	Melanterite	-2.4457	Boric	-1.4331	Epsomite	-2.8435	Hexahydrite	-2.7931	Hexahydrite	-2.8003
	Epsomite	-2.7144	Pentahydrite	-1.6110	Pentahydrite	-1.7864	Melanterite	-2.0288	Pentahydrite	-3.2127	Pentahydrite	-2.7104	Pentahydrite	-1.5453	Melanterite	-2.8820	Pentahydrite	-3.1339	Pentahydrite	-3.1411
	$CaSeO_3.2H_2O$	-2.9080	Leonhardtite	-1.9995	Melanterite	-1.8874	$MgSeO_3.6H_2O$	-2.4710	Arcanite	-3.5308	Leonhardtite	-3.0989	Leonhardtite	-1.9338	$CaSeO_3.2H_2O$	-2.9287	Leonhardtite	-3.5224	Arcanite	-3.4681
	Hexahydrite	-2.9511	Bloedite	-2.2460	MgSeO3	-2.0963	Epsomite	-2.4943	Leonhardtite	-3.6012	Arcanite	-3.1841	Bloedite	-2.1524	BaSeO3	-3.0694	Arcanite	-3.6896	Leonhardtite	-3.5296
	Pentahydrite	-3.2919	Arcanite	-2.5013	Bloedite	-2.1478	Hexahydrite	-2.7310	Kieserite	-4.3379	Bloedite	-3.8231	Arcanite	-2.4339	Hexahydrite	-3.0802	Kieserite	-4.2591	Kieserite	-4.2663
	$SrSeO_3$	-3.4015	Kieserite	-2.7362	Leonhardtite	-2.1749	$MnSeO_3.2H_2O$	-2.8918	Bloedite	-4.9636	Kieserite	-3.8356	Kieserite	-2.6705	Pentahydrite	-3.4210	Bloedite	-4.4917	Bloedite	-4.8680
	Arcanite	-3.5580	Melanterite	-2.8061	Arcanite	-2.5474	$CaSeO_3.2H_2O$	-3.0202	$FeSO_4$(c)	-7.7853	$FeSO_4$(c)	-7.4607	Melanterite	-2.6844	Leonhardtite	-3.8095	$FeSO_4$(c)	-7.7114	$FeSO_4$(c)	-7.7687
	Leonhardtite	-3.6804	$FeSO_4$(c)	-7.8211	Kieserite	-2.9116	Pentahydrite	-3.0718	$MgSO_4$(c)	-9.4695	$MgSO_4$(c)	-8.9672	$FeSO_4$(c)	-7.6994	Arcanite	-3.8471	$MgSO_4$(c)	-9.3907	$MgSO_4$(c)	-9.3979
	Bloedite	-4.3095	$MnSO_4$(c)	-7.8280	$MgSeO_3.6H_2O$	-3.4223	$BaSeO_3$	-3.0931	$Al_2(SO_4)^3.6H_2O$	-15.4971	$Al_2(SO_4)^3.6H_2O$	-15.4275	$MgSO_4$(c)	-7.8021	Kieserite	-4.5462	$Al_2(SO_4)^3.6H_2O$	-15.6391	$Al_2(SO_4)^3.6H_2O$	-15.4123
	Kieserite	-4.4171	$MgSO_4$(c)	-7.8678	$MnSeO_3$	-3.4606	Leonhardtite	-3.4603	$Al_2(SO_4)^3$	-32.9582	$Al_2(SO_4)^3$	-32.8886	$MnSO_4$(c)	-7.9042	Bloedite	-4.7552	$Al_2(SO_4)^3$	-33.1002	$Al_2(SO_4)^3$	-32.8734
	$FeSO_4$(c)	-7.3241			$CaSeO_3.2H_2O$	-3.8708	$SrSeO_3$	-3.5814					$Al_2(SO_4)^3.6H_2O$	-16.5634	$FeSO_4$(c)	-7.8970				
	$MgSO_4$(c)	-9.5487			$ZnSeO_3.H_2O$	-4.1816	Arcanite	-3.6007					$Al_2(SO_4)^3$	-34.0245	$MgSO_4$(c)	-9.6778				
	$Al_2(SO_4)^3.6H_2O$	-14.9379			$MnSeO_3.2H_2O$	-4.3959	Kieserite	-4.1970							$Al_2(SO_4)^3.6H_2O$	-15.1389				
	$Al_2(SO_4)^3$	-32.3990			$SrSeO_3$	-4.5283	Bloedite	-4.2349							$Al_2(SO_4)^3$	-32.6000				
					$BaSeO_3$	-5.0002	$FeSO_4$(c)	-7.0438												
					$FeSO^4$(c)	-6.9024	$MnSO_4$(c)	-8.3773												
					$MnSO^4$(c)	-7.6446	$MgSO_4$(c)	-9.3286												
					$MgSO^4$(c)	-8.0432	$Al_2(SO_4)^3.6H_2O$	-14.4302												
					$Al_2(SO_4)^3.6H_2O$	-15.8640	$Al_2(SO_4)^3$	-31.8913												
					$Al_2(SO_4)^3$	-33.3251														



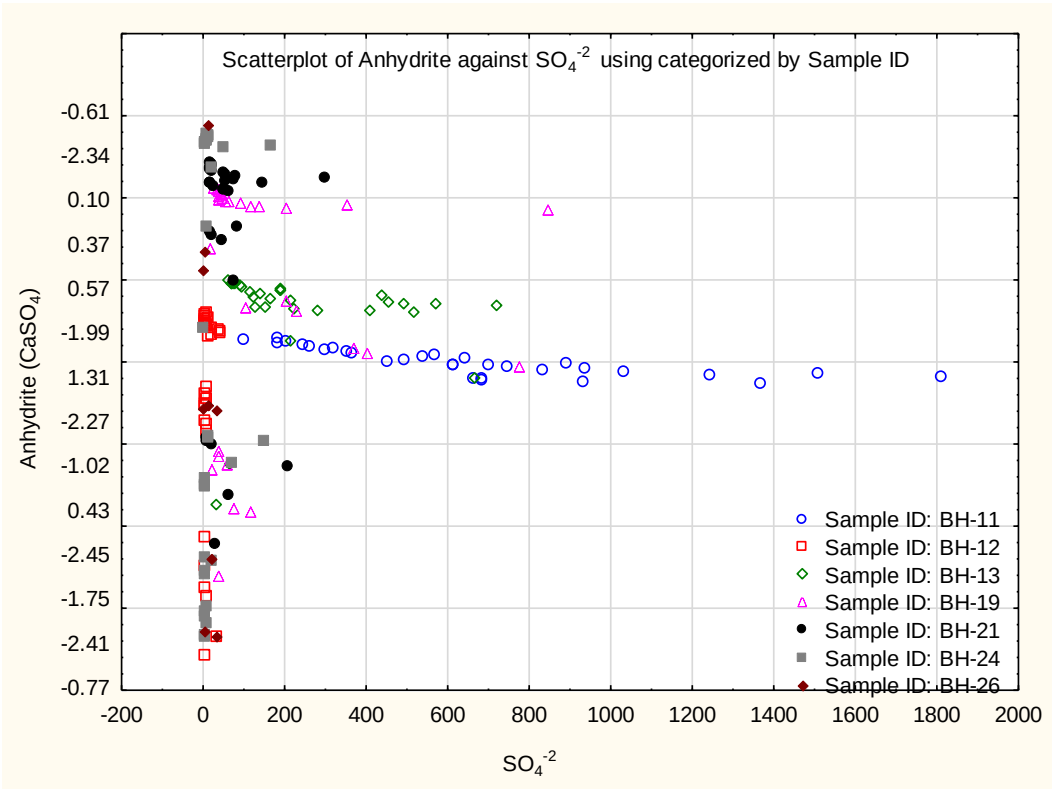
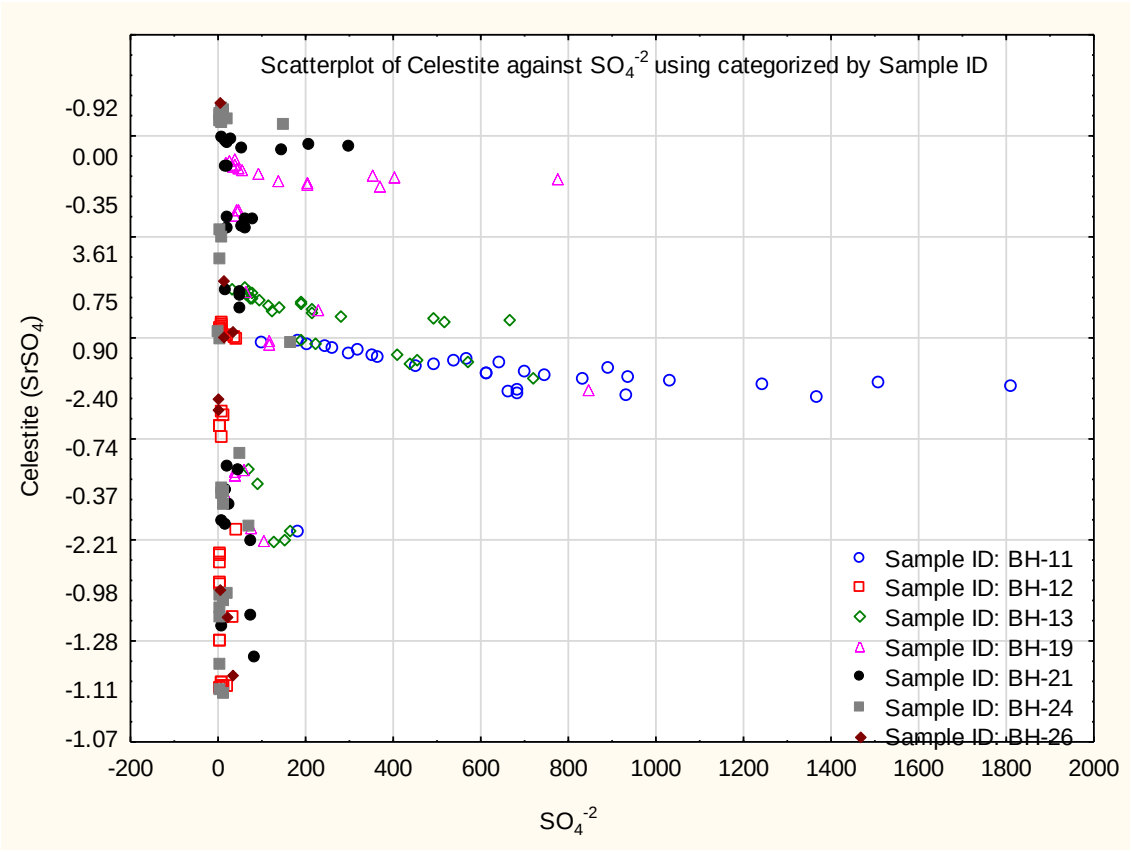


Figure 4-20: Saturation index of species of barite and anhydrite versus the SO_4^{2-} contrations in mg/L in the leachate.



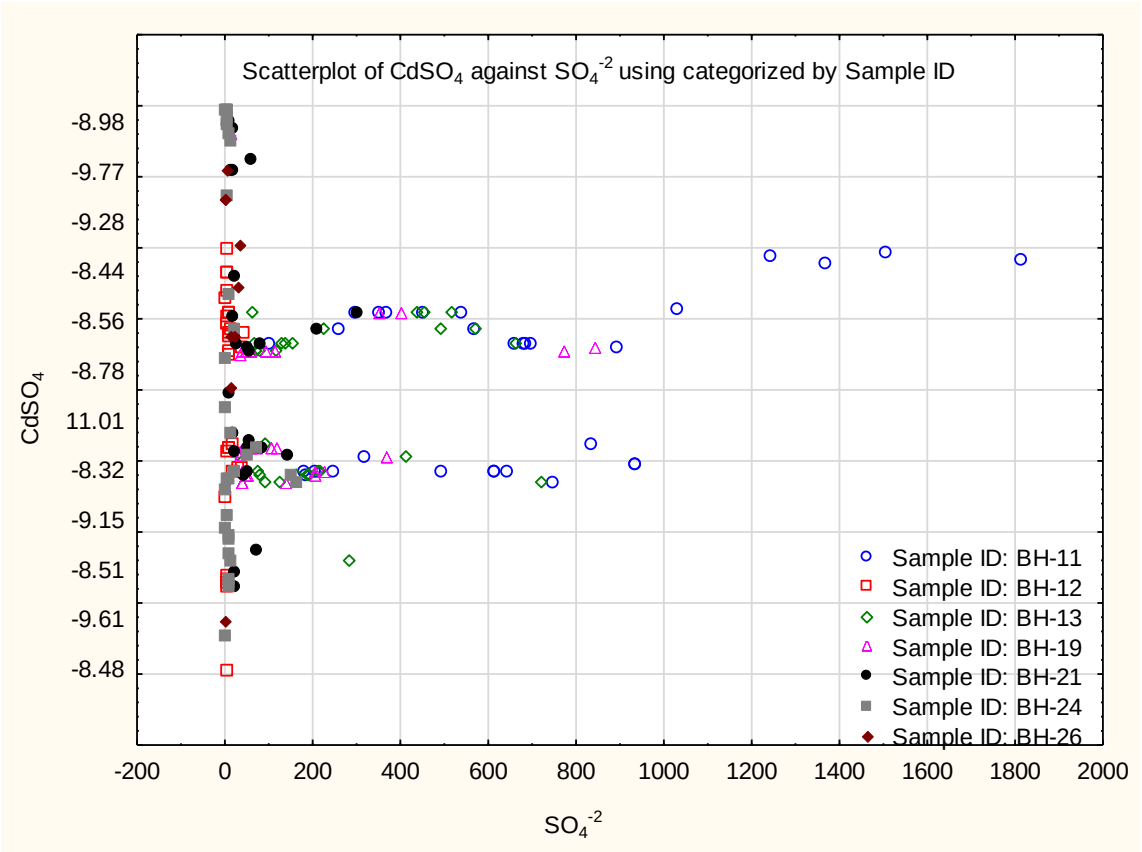


Figure 4-21: Saturation index of species of celestine and $CdSO_4$ (hawleyite, greenockite) versus the SO_4^{2-} contrations in mg/L in the leachate.

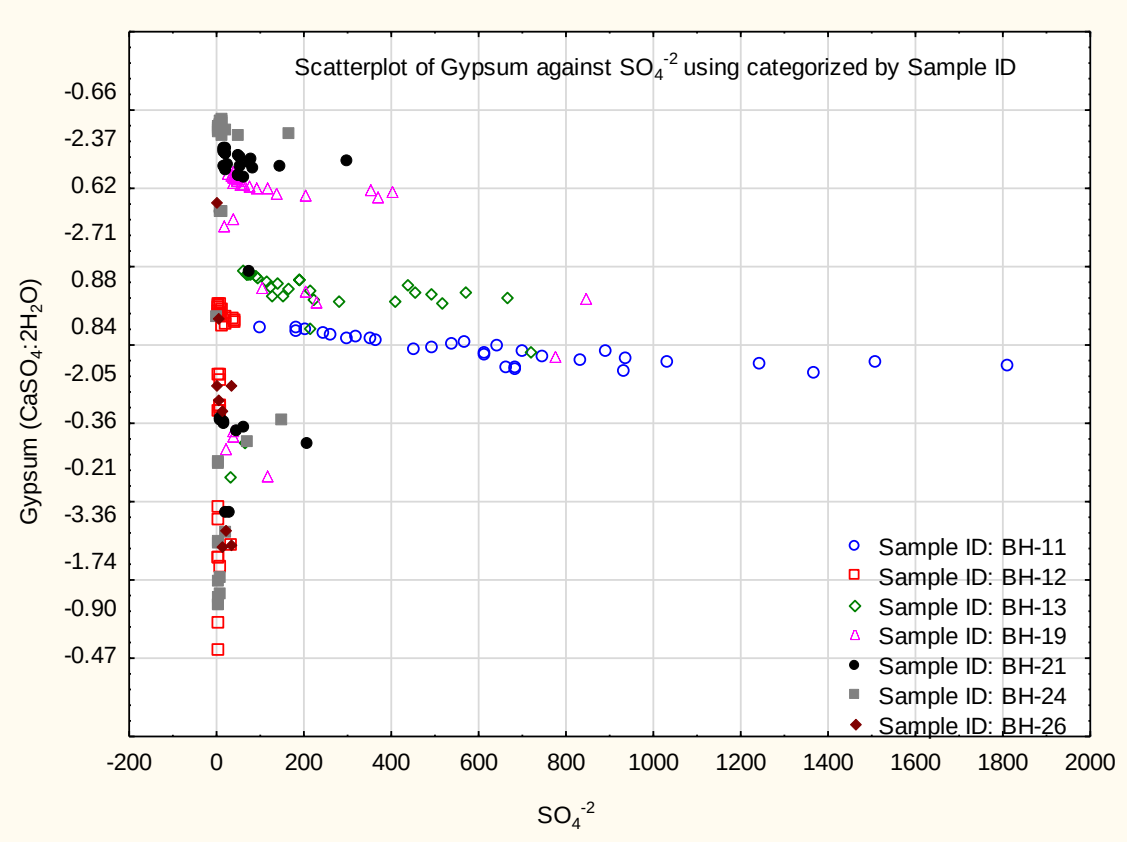


Figure 4-22: Saturation index of species of gypsum versus the SO_4^{2-} contrations in mg/L in the leachate.

4.4.3 Kinetic models

The kinetic models were created on the composite samples as follows: coal seams for ZFN1512 (BH10, 11, 12 and 13); coal seams for ZFN1510 (BH19, 21, 24 and 27); units above and below coal seams for ZFN1512 (BH16, 17, 18, 22 and 23); units above and below coal seams for ZFN1510 (BH4, 5, 6, 7, 8 and 9); and other units for ZFN1512 (BH14, 15, 20 and 25) and ZFN1510 (BH1, 2, 3 and 26). The model was based on initial and total cumulative of metals concentrations as shown in Appendix K. The input data was represented in Table 4-6. The reactective model was simulated for more 100 years as the history of coal mining in this region spans for more than 100 years (Falconer, 1990).

4.4.3.1 Coal seams

The assessment of cumulative sulphate release for coal seams is discussed herein briefly. BH13 had the intial concentrations of 515,6 mg/L and final cumulative load concentrations

of 7309,0 mg/L. After 31 week experiment the total cumulative sulphate concentration of 573,1 mg/L was recorded compared to the week 1 of 72 mg/L. Coal seams show the concentration of pyrite of 11% and S% of 1.72 with 71% C in BH27, and only 573,1 mg/L has been leached. There were no traces of pyrite in BH13 and the analyses show the C and S concentration of 57,6% and 0.02% respectively. The sandstone below coal seam No. 2 is marked by the S% of 3.73%. During the leach test for BH13, the sulphate release rate was much higher than in BH27. This could be as a result of sample mixing with the lower unit. The cumulative sulphate release is represented in this section by BH10 for ZFN1510 and BH19 for ZFN1512, representing coal seam No. 5 (Figure 4-25). The total cumulative SO_4^{2-} for week 31 is 3711.5 mg/L. The increase of of SO_4^{2-} is noticeable at week 6 of the experiment at the cumulative concentrations of 1702.1 mg/L (Figure 4-25). Another increase of sulphate concentrations of 3243.5 mg/L is in week 16 of the experiment. The increase in concentrations is similarly to the other coal seams (Figures 4-23, 4-24, and 4-26). The total cumulative sulphate concentrations of 4640.8 mg/L in BH19 for 31 weeks is slightly higher than in BH10. The initial sulphate concentrations for both samples were 564.9 mg/L for BH10 and 842.4 mg/L for BH19.

The sulphate cumulative is also assessed in BH12 and BH24 representing coal seam No. 3 (Figure 4-26). There is a total SO_4^{2-} cumulative concentrations of 324.2 mg/L in BH12. Whereas BH24 has total SO_4^{2-} cumulative concentrations of 621.3 mg/L. Coal seam No. 3 show relatively low concentrations of SO_4^{2-} compared to the seams that are mined.

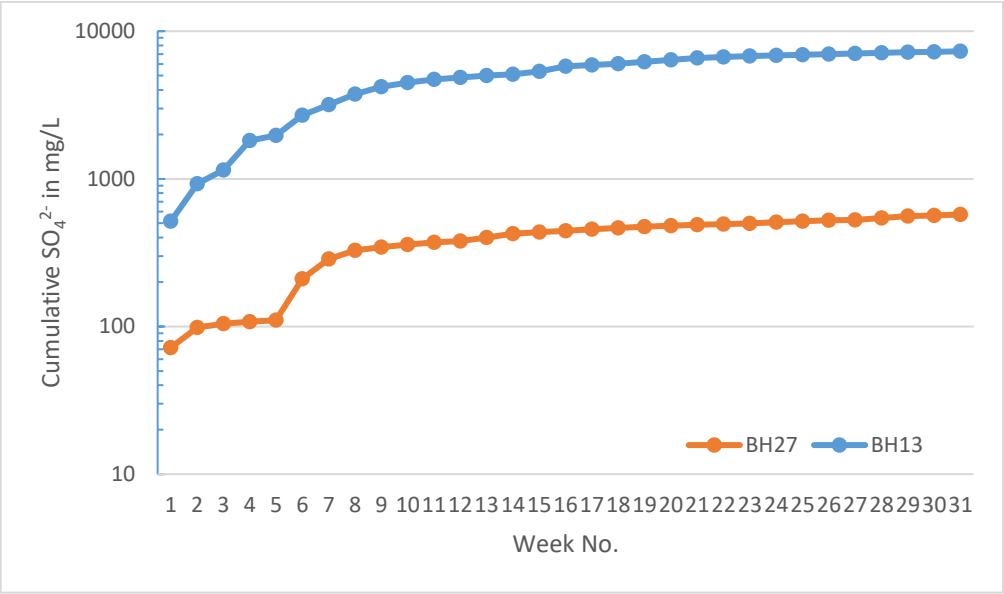


Figure 4-23: Sulphate cumulative representation over 31 week HCL experiment for coal seam No. 2.

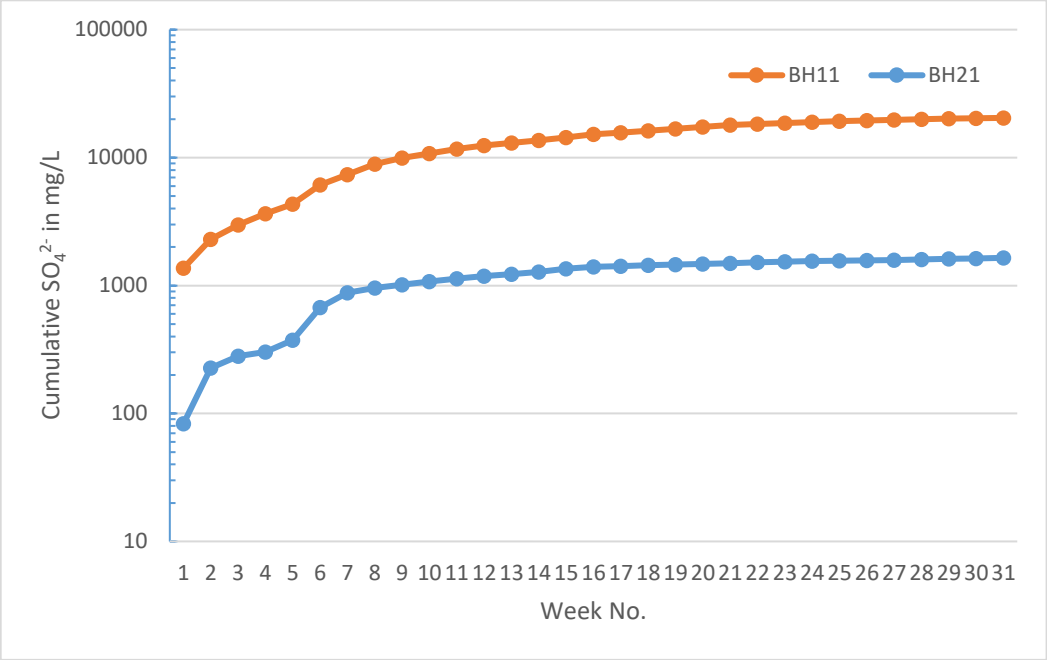


Figure 4-24: Sulphate cumulative representation over 31 week HCL experiment for coal seam No. 4.

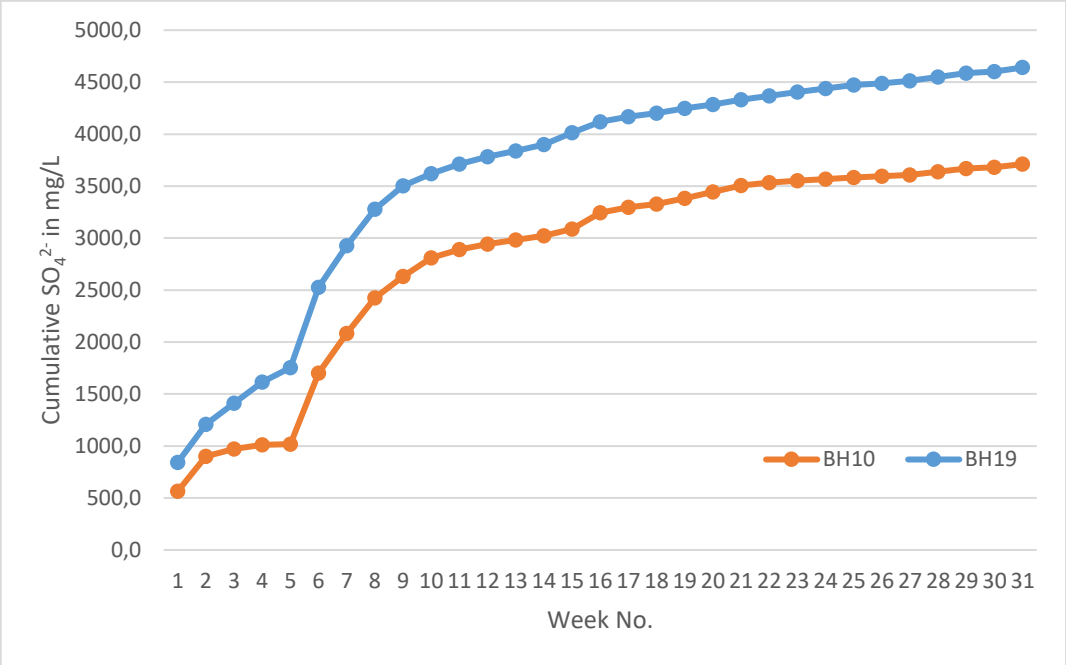


Figure 4-25: Sulphate cumulative representation over 31 week HCL experiment for coal seam No. 5

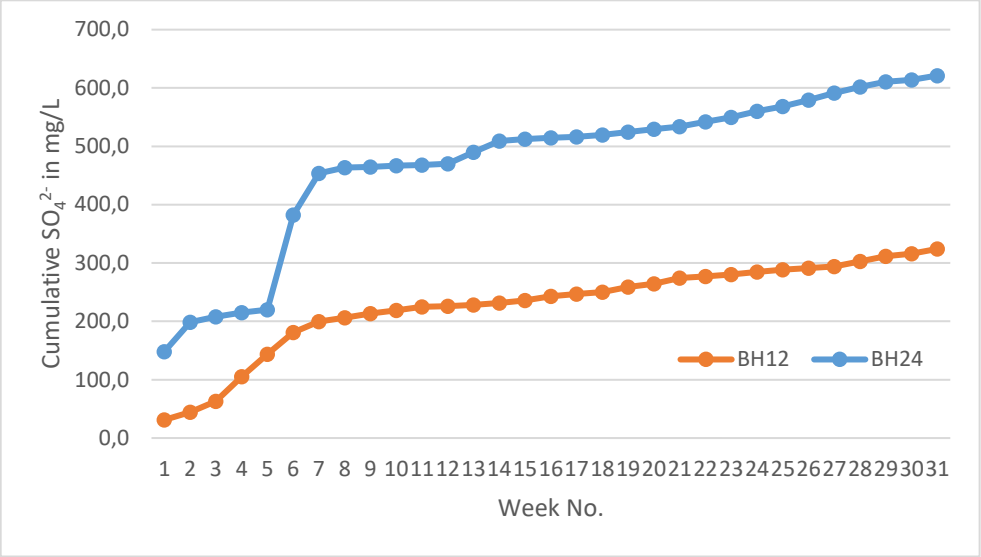


Figure 4-26: Sulphate cumulative representation over 31 week HCL experiment for coal seam No. 5.

The kinetic reactive model composite for coal seams was calculated for 100 years (Figure 4-27). Kinetic reactive model in Figure 4-27 ZFN1512 and 1510 coal indicate most the species are formed in the first 10 years. For ZFN1512 coal seams, the minerals that were found most supersaturated during the reaction path are alunite, barite, gibbsite, cuprite, daphnite and muscovite of the initial conditions. At the beginning of the reactive transport simulation, the minerals of kaolinite, quartz, gypsum, daphnite and cuprite were also most supersaturated at the end of interval 10 years. At the begining of the time interval of more than 10 years, kaolinite, and gibbisite were supersaturated. Some of the XRD results in BH11 and 27 indicate the presence of quartz, kaolinite, siderite, smectite, and dolomite and calcite minerals. At the interval more than 10 years, there is a continuous reaction of saponite, gibbsite and muscovite continues.

With exception of Ba, the reaction reaches the equilibrium phase for most metals in the 20th month of the experiment. The nature of the leachate shows two types, which is Ca-SO_4 and Mg-SO_4. The changes are noticiable in node 3 of the modelling for the coal seams in ZFN1512 (Figure 4-27). The coal seams also indicate the leachate classification of Na-SO_4 in ZFN1510 unchanged for 100 years. The pH changes from 6.473 to 5.952 in ZFN 1512 for 100 year, whereas the pH in ZFN1512 changes from 6.646 to 6.075 in 100 years.

Table 4-6: Composite leachate cumulative for lithological units input data for kinetic reactive model, A-B are units above and below coal seams.

Humidity Cells		ZFN1512 coal units	ZFN1510 coal units	ZFN1512 A-B units	ZFN1510 A-B units	ZFN1512 other units	ZFN1510 other units
EC	Initial	113,89	67,95	21,54	40,41667	27,63	14,98
	Final	1707,45	903,79	447,68	523,09	317,52	297,58
Ca	Initial	166,49	52,13	1,63	10,00	3,12	4,18
	Final	2782,69	704,44	85,08	130,86	52,41	54,38
Mg	Initial	20,56	10,49	0,82	4,02	0,99	1,50
	Final	667,20	278,30	61,53	64,67	23,54	22,88
Na	Initial	88,41	81,88	43,86	95,04	57,42	30,20
	Final	659,62	758,13	696,67	803,61	485,04	436,47
K	Initial	2,63	2,03	1,13	2,64	1,92	2,02
	Final	25,20	32,13	34,23	33,86	39,19	38,44
Alkalinity	Initial	30,48	72,80	46,16	58,92	67,20	56,00
	Final	1461,38	2167,40	1517,07	1310,41	1312,64	1323,04
SO_4^{2-}	Initial	619,53	286,43	63,15	160,12	60,33	25,80
	Final	7943,65	1870,22	575,03	1014,47	222,24	109,86
Al	Initial	0,08	0,11	0,30	0,43	0,10	0,15
	Final	2,38	2,18	7,16	11,86	7,05	8,71
As	Initial	0,02	0,02	0,02	0,02	0,02	0,02
	Final	0,61	0,60	0,60	0,63	0,60	0,64
B	Initial	0,90	0,90	0,21	0,29	0,35	0,17
	Final	26,45	23,67	13,57	16,27	13,66	15,78
Ba	Initial	0,11	0,10	0,01	0,03	0,01	0,01
	Final	1,04	1,63	0,28	0,43	0,24	0,22
Cd	Initial	0,00	0,00	0,00	0,00	0,00	0,00
	Final	0,09	0,09	0,09	0,09	0,09	0,09
Co	Initial	0,03	0,02	0,02	0,02	0,02	0,02
	Final	0,63	0,62	0,62	0,62	0,62	0,62
Cr	Initial	0,02	0,02	0,02	0,02	0,02	0,02
	Final	0,62	0,62	0,62	0,62	0,62	0,62
Cu	Initial	0,03	0,02	0,01	0,02	0,01	0,01
	Final	0,78	0,56	0,37	0,47	0,33	0,33
Fe	Initial	51,30	29,73	0,12	0,20	0,05	0,11
	Final	64,52	37,64	2,70	7,05	4,10	6,13
Mn	Initial	0,51	0,24	0,02	0,05	0,02	0,02
	Final	3,33	1,38	0,72	0,91	0,62	0,62
Mo	Initial	0,02	0,02	0,05	0,07	0,06	0,17
	Final	0,62	0,63	0,78	0,78	0,80	1,03
Ni	Initial	0,16	0,02	0,02	0,02	0,02	0,02
	Final	0,80	0,62	0,62	0,62	0,62	0,62
Pb	Initial	0,02	0,02	0,02	0,02	0,02	0,02
	Final	0,47	0,47	0,47	0,47	0,47	0,47
Sb	Initial	0,02	0,02	0,02	0,02	0,02	0,02
	Final	0,62	0,62	0,62	0,62	0,62	0,62

Humidity Cells		ZFN1512 coal units	ZFN1510 coal units	ZFN1512 A-B units	ZFN1510 A-B units	ZFN1512 other units	ZFN1510 other units
Se	Initial	0,02	0,02	0,02	0,03	0,04	0,04
	Final	0,61	0,65	0,61	0,64	0,62	0,63
Si	Initial	0,68	0,99	1,32	2,08	1,35	2,11
	Final	139,91	149,44	138,71	147,72	165,83	192,65
Sr	Initial	1,17	0,47	0,02	0,06	0,02	0,01
	Final	16,18	7,64	1,13	1,11	0,40	0,50
U	Initial	0,03	0,03	0,03	0,03	0,03	0,03
	Final	0,93	0,93	0,93	0,93	0,93	0,93
V	Initial	0,01	0,01	0,01	0,01	0,01	0,01
	Final	0,36	0,36	0,38	0,38	0,36	0,34
Zn	Initial	0,05	0,03	0,02	0,02	0,02	0,02
	Final	0,85	0,71	0,64	1,06	0,64	0,63
pH	Initial	6,48	7,04	8,26	8,24	8,04	8,62
	Final	7,28	7,66	7,83	7,80	8,09	8,00

The model shows an increase of metals for the period of 100 years. The metals reach their maximum concentrations in the period of the first 10 years for both ZFN1512 and 1510 and then become stabilized (Figure 4-27). The major metal ions that show the increasing trend include Na, Ca, Mg and SO_4^{2-}. K, B, Ba, and Al show decreasing trends in the first 10 years (Figure 4-27). The leachate composition show the increase of cations of Na^{+}+K^{+}, Mg^{++} and Ca^{++}, and anions of SO_4^{2-}, Cl^{-} and HCO_3^{-}+CO_3^{-} (Figure 4-28 and 4-29). The other classification plots that support this trend are presented in Appendix L. The mineral saturated states in year 100, include kaolinite, V_2O_3, dolomite, uraninite, quartz, $ZnCr_2O_4$, siderite, cuprite, gypsum, strontianite, Co_2SiO_4 and barite for ZFN1512 coal and ZFN1510 coal shows additions of cuprite and Co_2SiO_4. This is indicative of continuous reactions for more than 100 years of inputs of this metals into the receiving environment, the cumulative influxes are presented in Appendix M. These units are probably the source of cations and anions metals in the receceptor realm. The high concentrations of SO_4^{2-} also indicate the transport of chalcophile elements such as Fe, Cu, Zn, As and Pb. SO_4^{2-} shows a clear distinction between coal- (highest), A-B- (intermediate) and other units (lowest). This also applies to Mg, B, Ba, (Cu), Fe, Mn, Sr, which are positively correlated with SO_4^{2-} in coal (e.g. BH10, BH11, BH12 etc.) in Appendix E. But not for Co, Ni, Cr, Pb, Sb, V, U, which may suggest a different source other than coal seams.

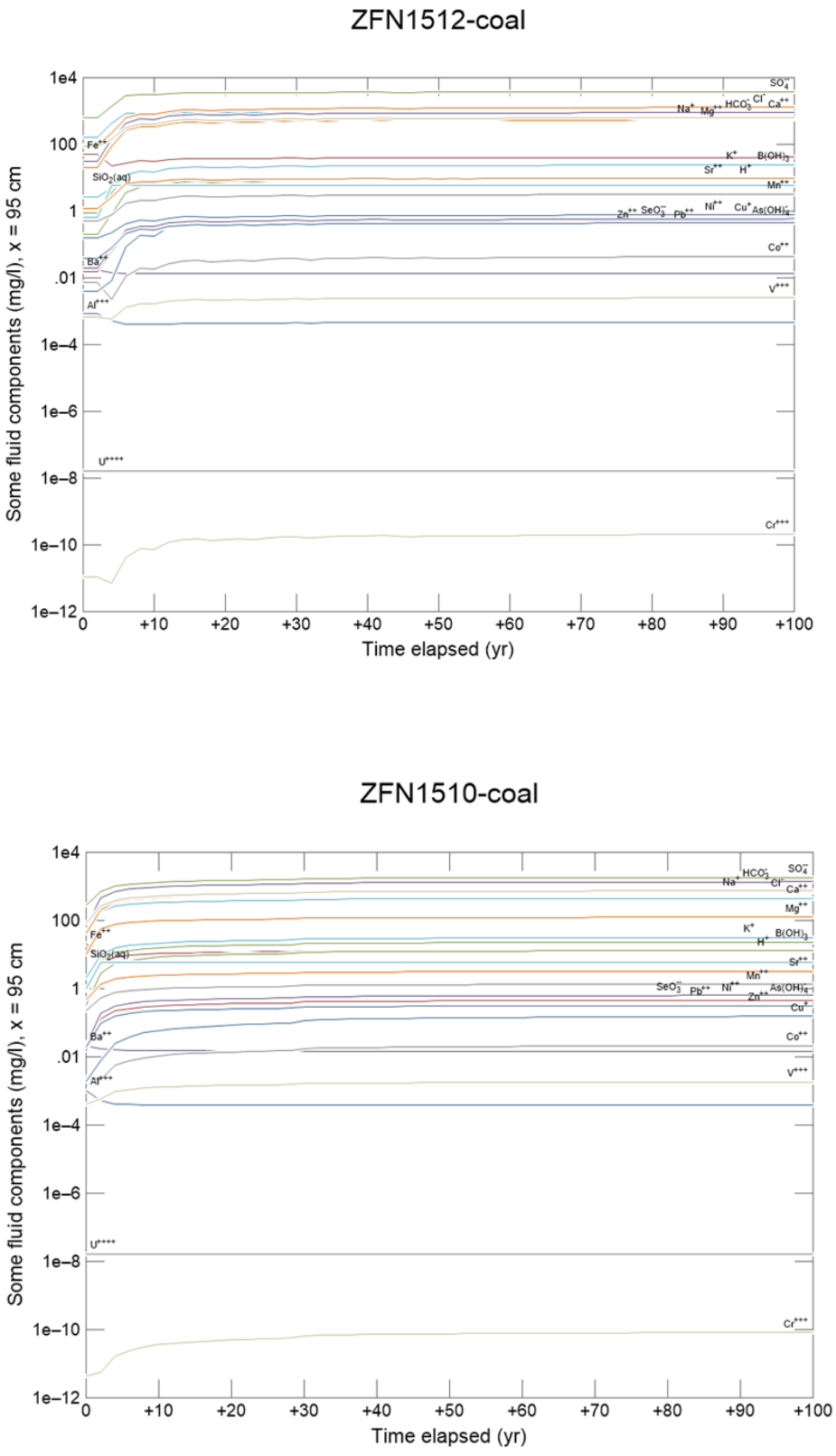


Figure 4-27: Kinetic reative model for 100 years the ZFN1512 and ZFN1510 coal units.

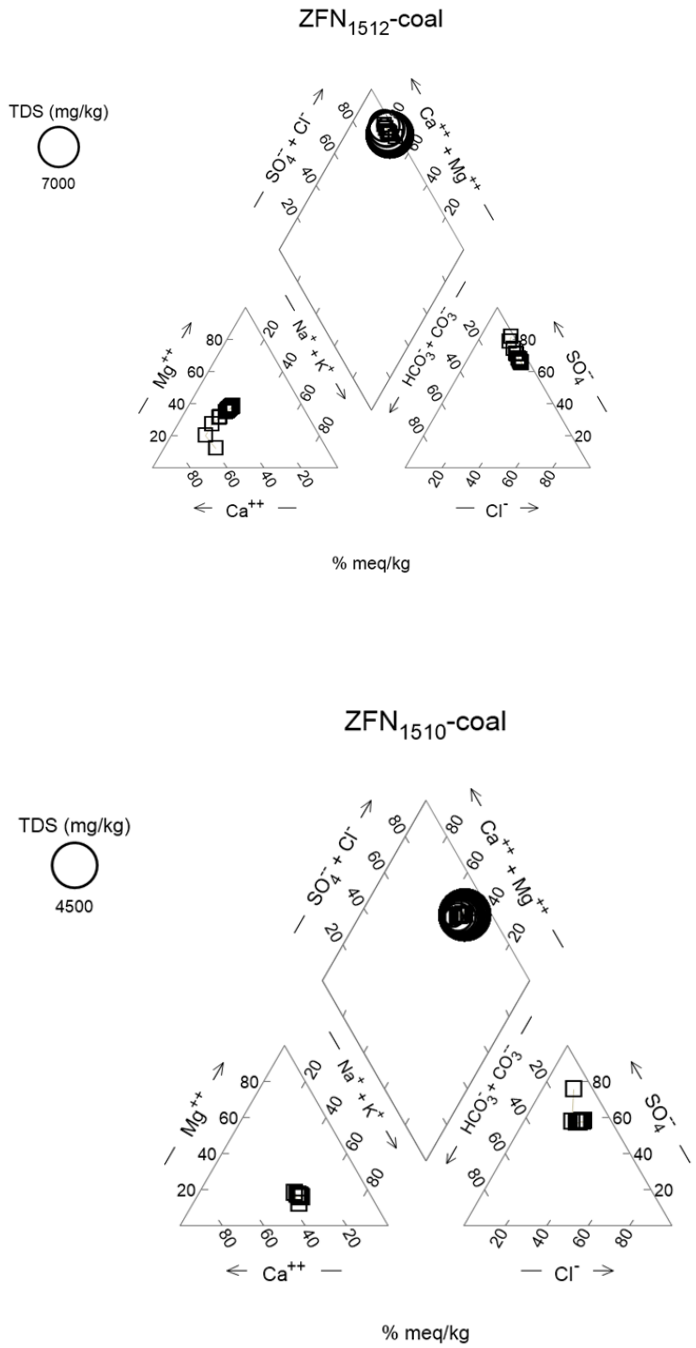


Figure 4-28: Piper diagram for the cumulative leachate for the ZFN1512 and ZFN1510 coal units, symbols indicates changes in composition at different nodes.

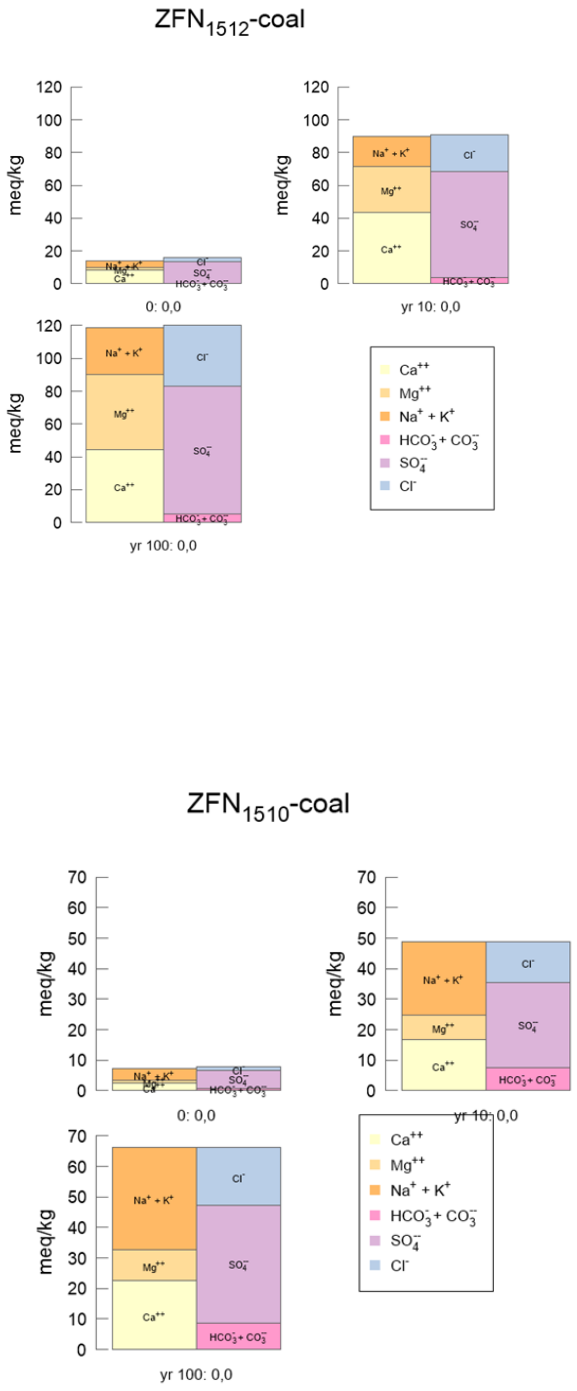
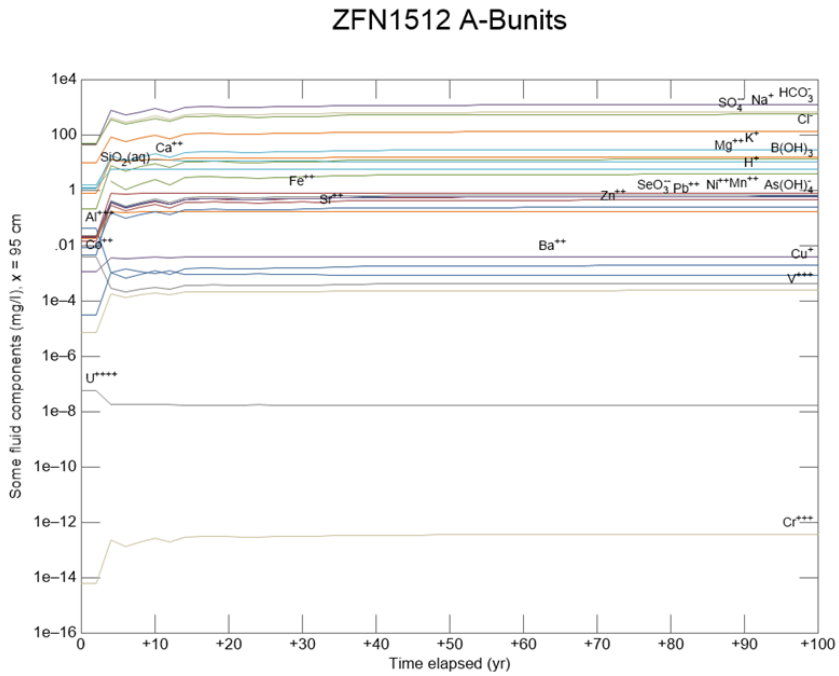


Figure 4-29: Bar chart for cumulative representation for cations and anions modelled for 100 years in coal seams.

4.4.3.2 Profile above/below coal seams

The above and below units is represented by composite samples ZFN1512 and ZFN1510 A-B units. The models indicate that most of the reactions occur within the first 10 to 20 years. The pH for ZFN1512 decreases from 8.258 to 6.914 in year 100. The mineral saturation states in node 9 include quartz, witherite, muscovite, $ZnCr_2O_4$, dolomite, Co_2SiO_4, strontianite, uraninite, siderite, V_2O_3, dolomite and cuprite. The pH for ZFN1510 also decreases from 8.237 to 6.765 in year 100. The mineral saturation in year 100 are similar to ZFN1512. The leachate type for both the samples is Na-HCO_3^- which changes to Na-SO_4 towards node 9. The other classification that support the leachate type is presented in Appendix L. The cation and anion trends are similar to that of the coal seams, but with less concentrations. The other units have the leachate classified as Na-HCO_3^-. These units are probably the source of Zn, Co, V, and U. The influxes or effluxes are represented in Appendix M.

In comparison of all the geological units subjected to kinetic modelling, the following can be summarized: a) the coal seams shows high concentrations of SO_4^{2-}, which remains high in a system even after 100 years. The other elements of high concentrations such as Ca, Mg, K, Fe, and H^+ also remain in a sytem for more than 100 years. On the cumulative mass influxes and effluxes over simulation (Appendix M), the metals remains top in metals entering and leaving the domain. For coal beds in ZFN1512, H^+ and SO_4^{2-} remains top in leaving the domain, followed by Ca, Na, Mg. Al and Ba reacts in less than 10 years and reach equilibrium; b) The lithologigical units above and below the coal seams also show concentrations of SO_4^{2-}, which is lower than the coal seams but remains in a system for more than 100 years. Alkalinity (HCO_{3-}), Na and SO_4^{2-} remains top in entering and leaving a domain (Appendix M). Al also remains in a system for more than 100 years. Al and Ba remains in system at low concentrations for more than 100 years; c)The other units show low concentrations of SO_4^{2-}, which react early and reach equilibrium (Appendix L). The alkalinity remains in a system for more than 100 years. All the lithological units indicate that H^+ leaves the domain, which support the process of hydrolysis. The elements such as Fe, Mn and Al undergo hydrolysis, thereby consuming the released OH^- ions from the buffer elements and in turn releasing H^+. The elements such as U, Co and V reacts in less than 100 years and reach equilibrium.



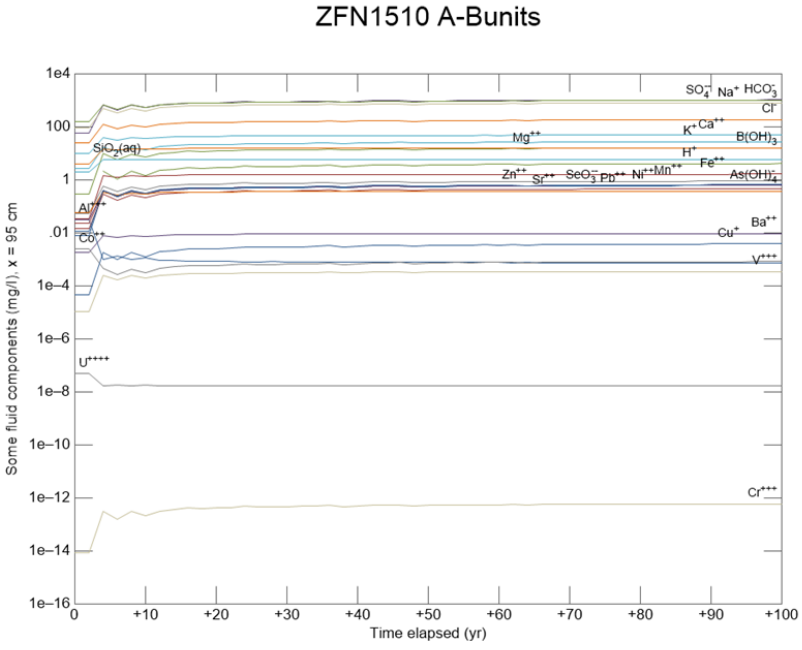
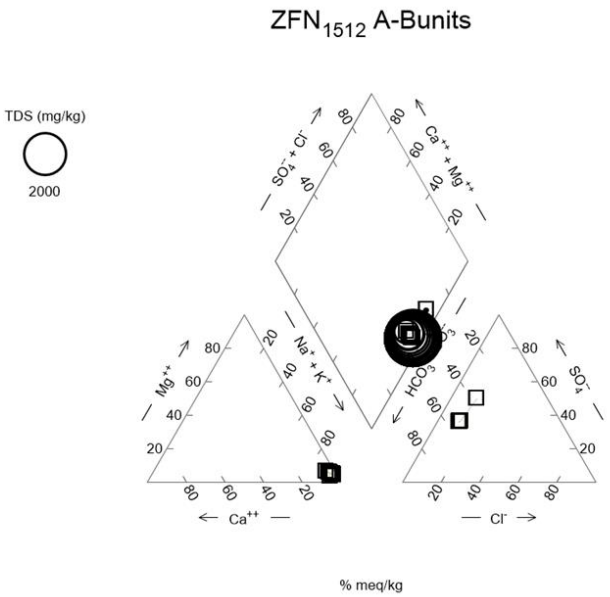


Figure 4-30: Kinetic reative model for 100 years the ZFN1512 and ZFN1510 A-B (above and below) units.



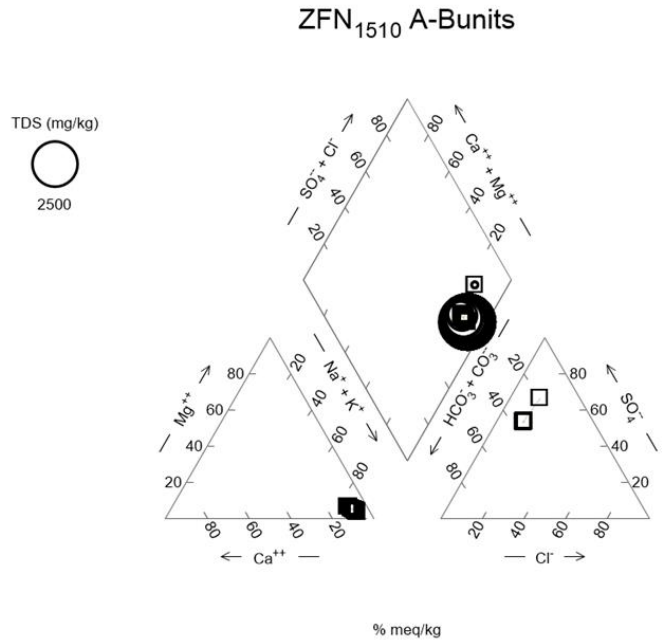


Figure 4-31: Piper diagram for the cumulative leachate for the ZFN1512 and ZFN1510 for above and below units, symbols indicates changes in composition at different nodes.

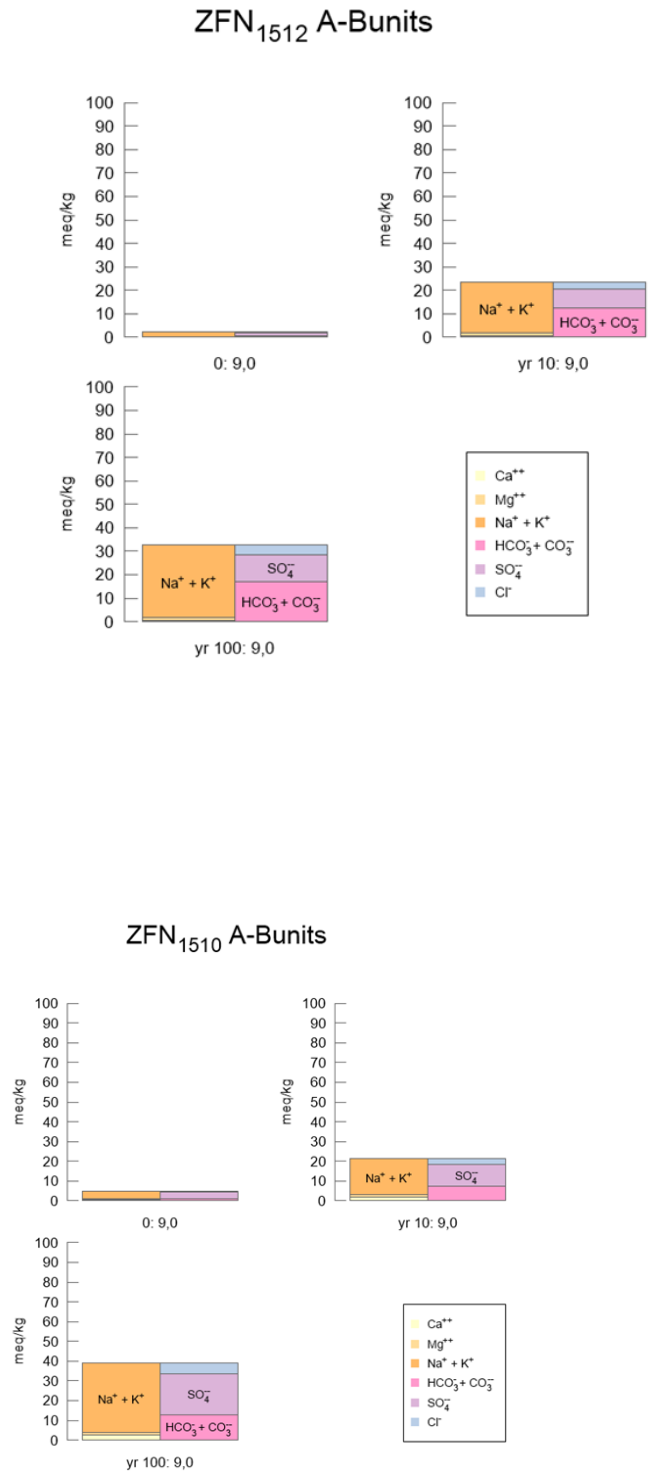


Figure 4-32: Bar chart for cumulative representation for cation and anion modelled for 100 years in above and below coal seams units.

4.4.3.3 Reaction processes

4.4.3.3.1 Sulphide-oxidation

The coal strata in the study area is dominated by pyrite as discussed in chapter 3. The sulphide oxidation process happened when the iron sulfide minerals oxidate by the reaction with water and the atmospheric oxygen. The oxidation of sulfides is characterized by low pH and high concentrations of SO_4^{2-}, Fe, metalloids, and many metals (Larsen and Mann, 2005). In the humidity cell the sulphur is reported in the form of sulphate. The coal seams shows strong correlations of Fe and SO_4^{2-} as shown in the Appendix E (e.g. BH10, 11, 12, 13). The humidity cell experiment was undertaken under oxidation conditions enhancing the reaction rate, and the abrupt peaks show the time when the reactions happening and stabilizes (Figure 4-33). The effect on ferrous/ferric species in the leachate is evident from the high values for free SO_4^{2-} and sulphate compounds. The relationship of Fe and SO_4^{2-} in this study is found to be linear, once the leaching reaction started, and the pyrite oxidation process forms SO_4^{2-} and Fe species (Figure 4-33). The pyrite has been the main sulphide mineral identified in the study. When exposed to water and oxygen, it can react to form sulphuric acid (H_2SO_4). The following oxidation and reduction reactions the pyrite oxidation that leads to AMD (after Stumm and Morgan, 1970; Evangelou, 1995; Usher *et al.*, 2003).

$FeS_2 + 7/2\ O_2 + H_2O \Rightarrow Fe^{2+} + 2SO_4^{2-} + 2H$ ..... (1)

$Fe^{2+} + 1/4O_2 + H^+ \Rightarrow Fe^{3+} + 1/2\ H_2O$ ..... (2)

$Fe^{3+} + 3H_2O \Rightarrow Fe(OH)_3 + 3H^+$ ..... (3)

$FeS_2 + 14Fe^{3+} + 8H_2O \Rightarrow 15Fe^{2+} + 2SO_4^{2-} + 16H^+$ ..... (4)

4.4.3.3.2 Acid neutralization and alkalinity generation (carbonation)

The lithological units discussed in chapter 3 also indicated the excess of carbonates minerals. The typical minerals identified include dolomites, calcite and siderite. Figure 4-34 indicates the cumulative total alkalinity on the coalbed unit. The acid generation in these units will start once the available buffer reacted. These carbonates are expected to dissolve

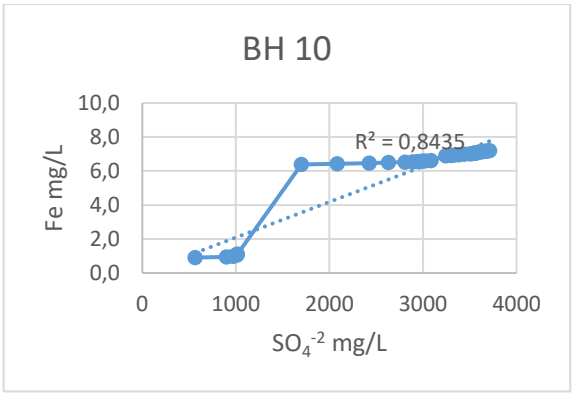
first and form alkalinity as the carbonates minerals are readily available slowing the drop of pH, by buffering the acids given enough resident time. Depending on the pH of the solution, the carbonic acid will tend to dissociate to hydrogen, bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) ions, the dominant species in solution being H_2CO_3 (pH<6, 3); HCO_3^- (6.3<pH<10.3); and CO_3^{2-} (pH>10.3) (Sherlock *et al.*, 1995). This is evident in the humidity cell concentrations as illustrated in Figure 4-34. On the positive side of the scale, the pH upon oxidation (final pH) did not turn acidic and these samples contain a neutralisation potential with a lower likelihood of producing AMD. Calcite is assumed to consume 2 moles H^+ per mole C, according to the following reaction:

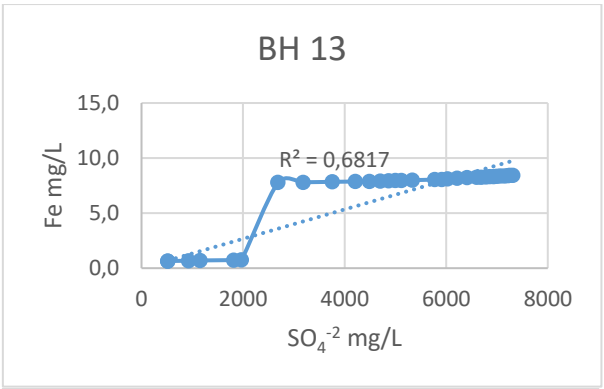
$CaCO_3 + 2H^+ => Ca^{2+} + H_2O + CO_{2(g)}$ (Kempton *et al.*, 1997).

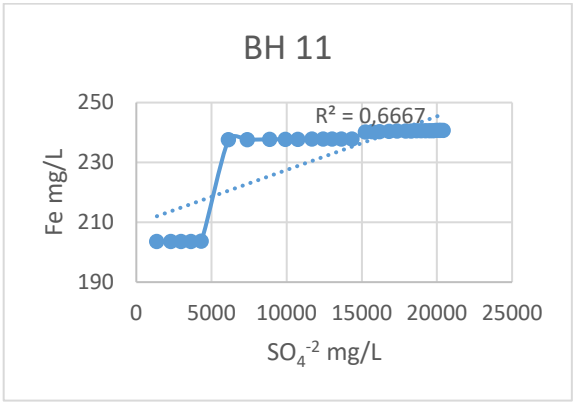
In a closed system:
$FeS_2 + 2CaCO_3 + 3{,}75O_2 + 3{,}5H_2O => Fe(OH)_3 + 2SO_4^{2-} + 2Ca^{2+} + 2H_2CO_3$ (carbon dioxide dissolve in water)
H_2CO_3 reacts with carbonate in the following reaction:
$H_2CO_3 + CaCO_3 => Ca^{2+} + 2HCO_3$- (Lloyd and Heathcote, 1985; Cravotta *et al.*, 1990).

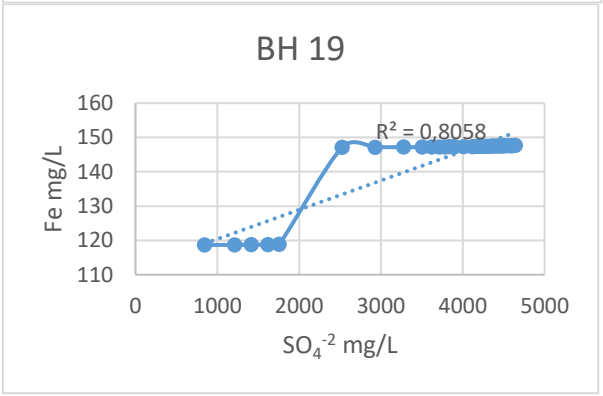
4.4.3.3.3 Ion exchange or adsorption

The Ca and Mg dominated concentrations results in the increase of sodium, which maybe due to the exchange of Ca, Mg or Fe^{2+} for adsorbed sodium as examined. The adjacent coalfields of Vryheid and Highveld were identified as affected by high concentrations of Na, which the mine water is deemed not usable in agriculture and other purposes (Malaza and Zhao, 2009). In this study, there is a strong correlation (R^2>0.9) of the cummulative concentrations of Mg and Ca for the coalbed (Figures 4-35). The evidence of Na-bearing mineral of plagioclase was discussed in this study, and confirmed also in Malaza and Zhao (2009), specifically the coal seams and arkosic sandstone are likely the most probable source of sodium in the study area based on XRD studies. The increase of Na concentrations with rising Na concentrations is shown in Figure 4-36.









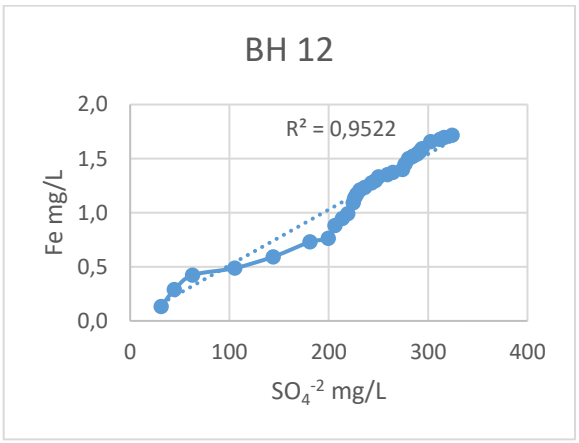


Figure 4-33: A total of 31 weeks cumulative concentrations of Fe and SO_4^{2-} of the coal seams marked by BH 10, 11, 12, 13 and 19.

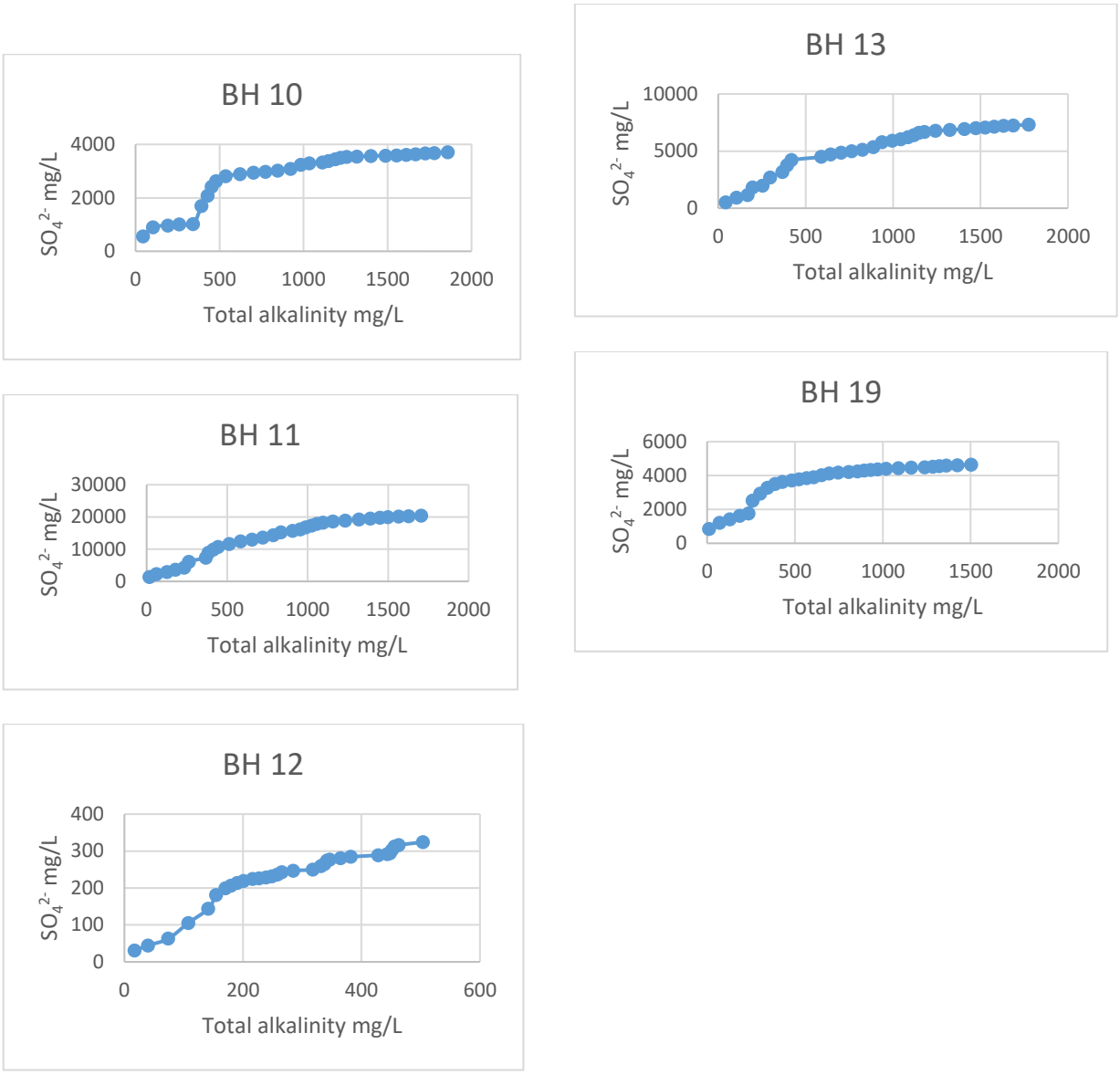
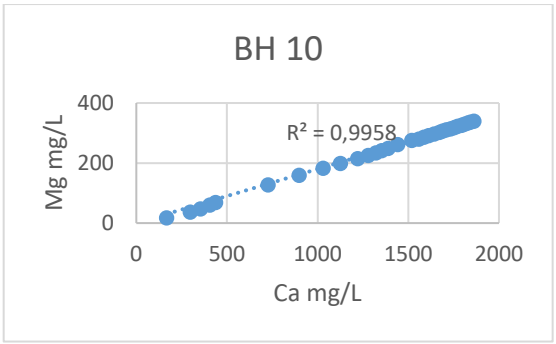
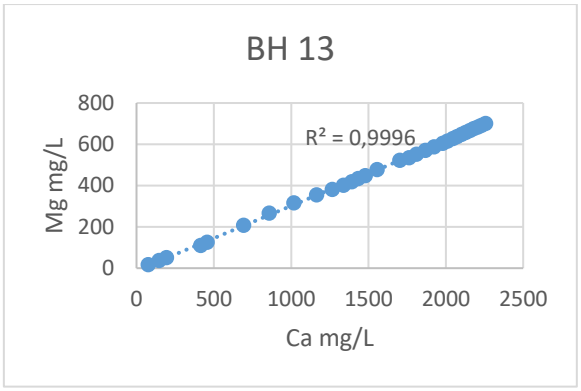
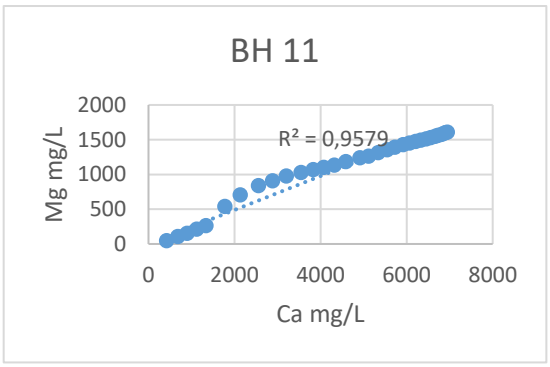
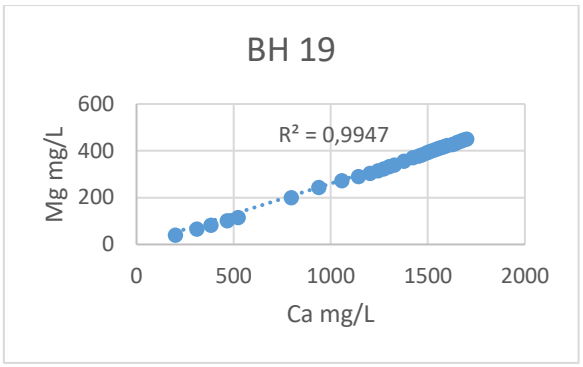


Figure 4-34: A total of 31 weeks cumulative concentrations of SO_4^{2-} and Total alkalinity of the coal seams marked by BH 10, 11, 12, 13 and 19.









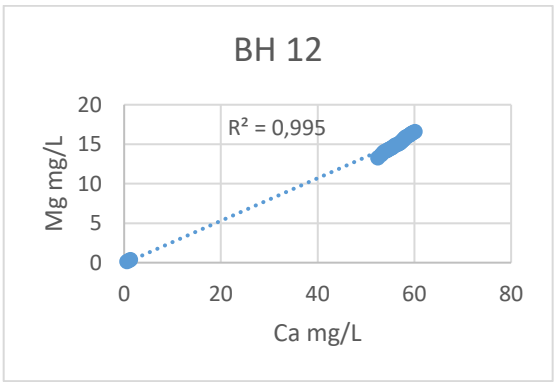
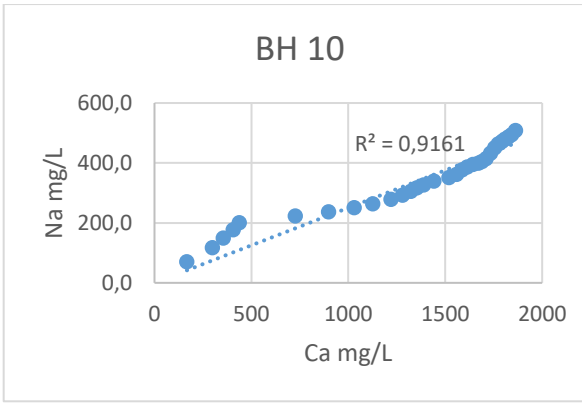
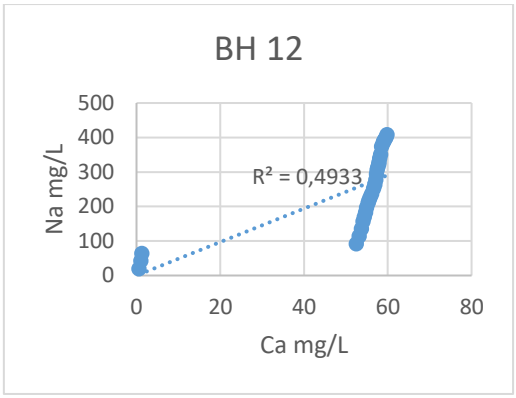


Figure 4-35: A total of 31 weeks cumulative concentrations of Mg and Ca of the coal seams marked by BH 10, 11, 12, 13 and 19.





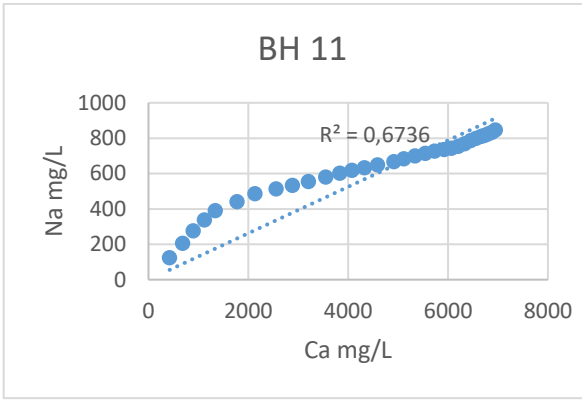


Figure 4-36: A total of 31 weeks cumulative concentrations of Ca and Na of the coal seams marked by BH 10, 11, 12.

4.5 SUMMARY CONCLUSION

The coal seams and associated geological units are capable of generating MD, as supported by ABA assessment. Reaction processes show that there is metal transportation, complexing and deposition as discussed in the latter sections. The evident processes that are involved in the metal deportment of the sediments are oxidation-reduction, adsorption or ion exchange, precipitation and carbonation. The continuous hydrolysis process was demonstrated by means of a the reactive geochemical model over 100 years created in GWB, indicating a pH decrease from high to low during that period. This model also proves a continuous influx of metals from the sources for the same period (Appendix M). Metal leach throughout the lithological strata is evident in the study area. According to the kinetic model, the coal seams are the main source of metals of Mn, Na, K, Mg, Ca and chalcophile elements (Fe, As, Pb, and Zn) to the receptor realm. The above and below lithogical units are the main source of metals of Zn, Co, V, and U to the receiving environment, which will be discussed in the subsequent chapter.

The proximity to the receptor realm (streams) is also estimated to the source, which is active and inactive coal mines. Figures 4-37 through 4-39 depict the locations of coal mines according to the South Africa mineral database (SAMINDABA). In this conclusion, the source is in close proximity to the receptor realm (Figure 4-37). This demonstrates that the majority of coal mines are drained by some type of stream, and there is likely a strong imprint of mine waters on the first and higher order stream water chemistry as a result (Figure 4-38). The majority of the region's southern streams follow former palaeochannels, which determine their course. Depending on the erosion of the bedrock, the dissolution of minerals may also affect the stream water chemistry (Figure 4-39).

The mines are evenly distributed throughout the catchment, with the exception of the northern most downstream section. The water and sediment chemistry is therefore affected by the geochemistry of the source rock. In the subsequent chapter 5, the dominant element contents of stream sediments and thresholds that could be influenced by the sources of MD release refered to "geogenic" erosion of bed rock strata to the streams are investigated.

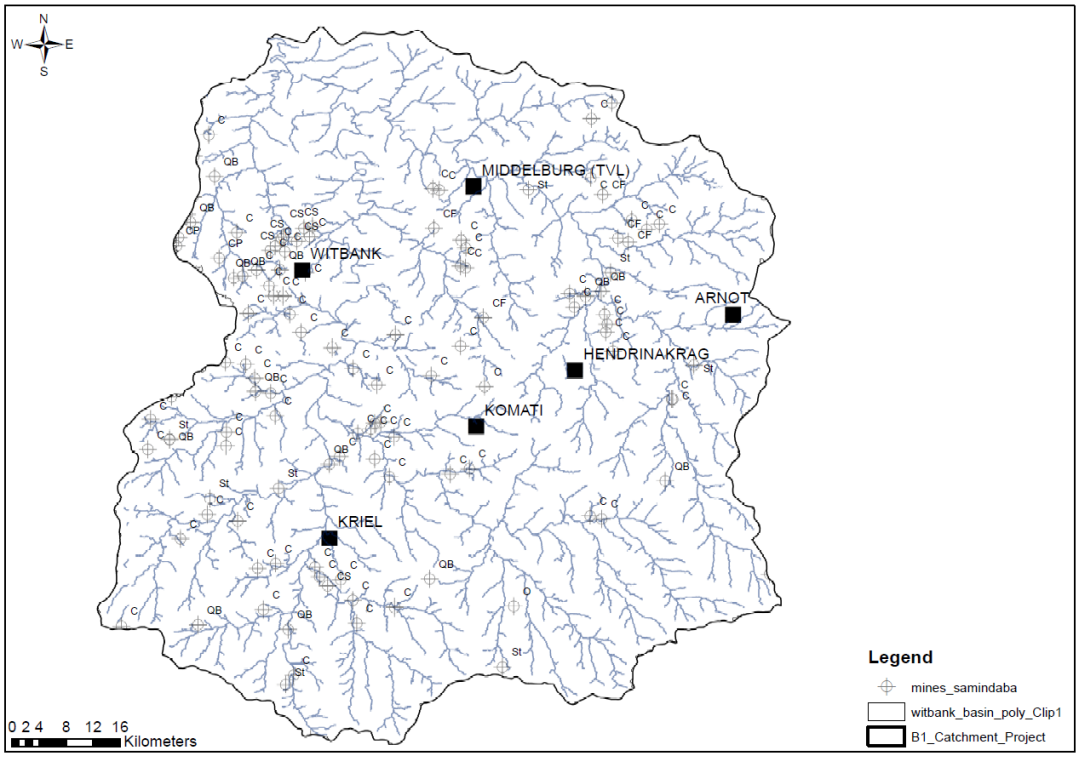


Figure 4-37: ROC indicating the locations of the mines.

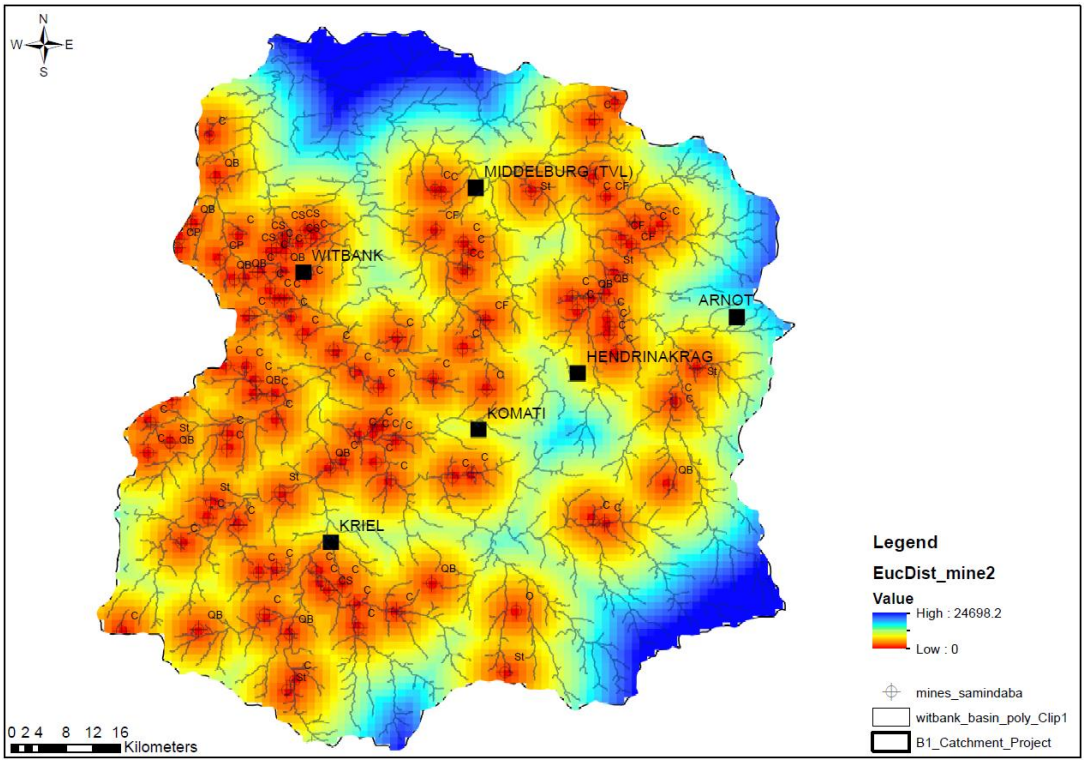


Figure 4-38: Mines occurences proximity to the ROC.

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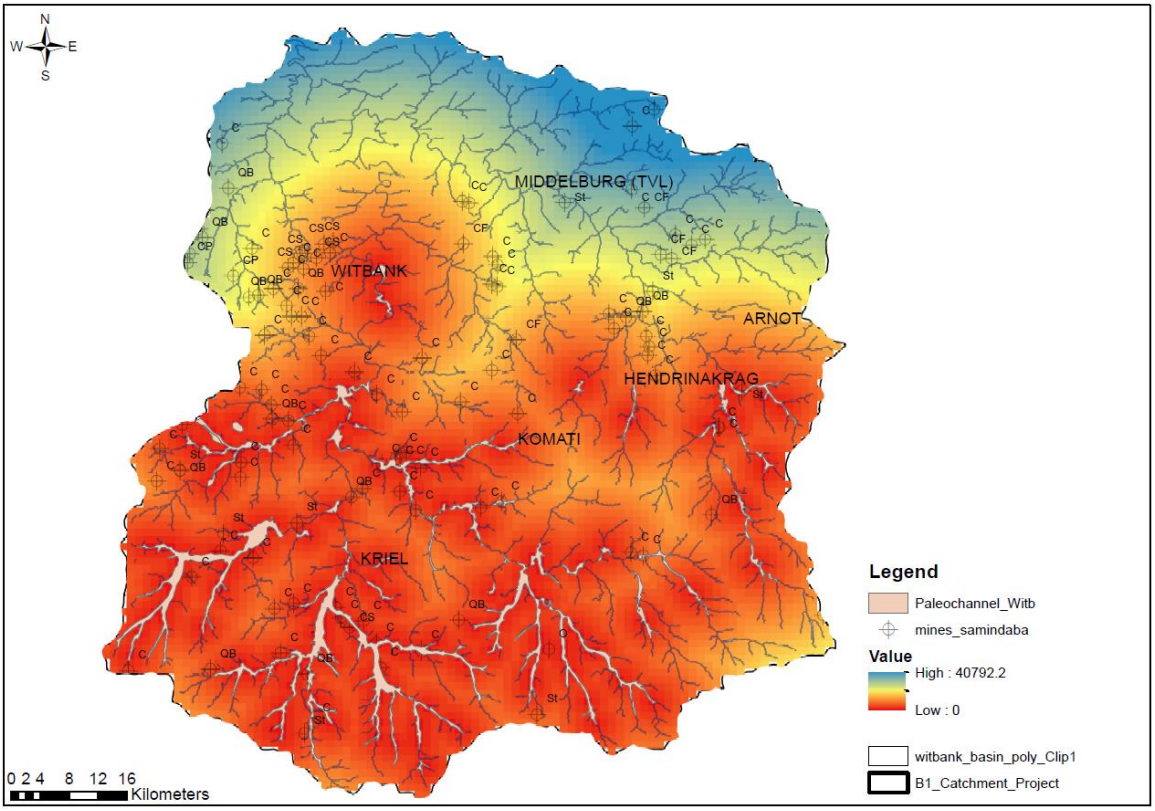


Figure 4-39: Figure indicating paleochannel as traps showing the a larger part of the southern streams of the area are running in former palaeochannels in the ROC.

5 STREAM SEDIMENTS GEOCHEMISTRY

This chapter's primary objective is to calculate the elemental concentrations of 246 stream sediment samples in order to differentiate between an element's background concentration and anomalous enrichment utilizing established techniques of stream sediment chemistry evaluation for geochemical exploration. This data will aid in the comprehension of metal accumulation in concentrations downstream of their origins, i.e. in the receptor domain. During the process of metal deportment downstream, the metals become adsorbed or precipitated in the finer proportion of sediments, according to the hypothetical statement.

5.1 INTRODUCTION

Stream sediments are the most significant sample medium for geochemical surveys. Since the early 1900s, sediments have played a part in geological studies (Dewey *et al.*, 1925; Labuschagne *et al.*, 1993; Xie *et al.*, 1997; Salminen *et al.*, 2005; Carranza, 2009; Lapworth *et al.*, 2012; Netshitungulwana *et al.*, 2012; Netshitungulwana *et al.*, 2013; Ahrens and McLennan, 2013; Kirkwood *et al.*, 2016; Zuluaga *et al.*, 2017). Understanding the significance of sediments in discovering major mineral deposits and geological settings was the focus of earlier studies (e.g., Birke *et al.*, 2015). Later, the desire to investigate mineral occurrences using stream sediments emerged. The geochemical information in sediments leads to the discovery of major deposits. The sediments are homogenized materials that reflect the catchment, which is obtained from the weathering and erosion of in-situ upstream sources. Depending on advantageous

environmental circumstances, sediments may potentially serve as a source of metals (Segura-Munoz *et al.*, 2006). Forstner (2004) noted that "stream sediment analysis can be used to estimate point sources of pollution that, upon being released to surface waters, are rapidly absorbed by particle matter and hence escape detection by water monitoring."

Rose *et al.* (1979) revealed that certain chemical concentrations of stream sediments had a positive correlation with the specific lithological units in a catchment basin and a negative correlation with the total concentrations of the catchment basin due to dilution factor. Hawkes (1976) examined such connections owing to the downstream dilution of chemical solute concentrations in stream sediments. Using 246 samples of stream sediment, this study determined the regional geochemical background values of the lithologies of the ROC, which is a sub-catchment of the OPC. Using the threshold determination approach based on probability plots, the geochemical data will be analyzed to differentiate between background concentrations of an element and anomalies (enrichment). This is to comprehend the transmission of elements from several potential sources to the receiving environment.

Prior work in the study area included stream water and sediment sampling for metal loads and ecotoxicological impact analysis, hydrological and hydrogeological investigations, and other tasks to assess metal loading and losses; they were also conducted to comprehend the interactions between metals in stream water and bed sediment and to compare leachate water with national water quality standards (DWAF, 1996). All of this information will be utilized to establish a management plan for direct point sources in order to reduce future contamination. During the regional study at the catchment scale, approximately 118 stream sediments were sampled, and 19 potentially anomalous sample areas

were identified with various element concentrations exceeding thresholds of the host rocks to the streams (Netshitungulwana *et al.*, 2012; 2013; 2015). The specifics will be discussed in the following chapters. The problem areas were submitted to a more thorough investigation (Netshitungulwana *et al.*, 2015).

5.2 SAMPLING AND METHODOLOGY

5.2.1 Sampling and Preparations

At the ROC, a total of 246 stream sediment samples (0-20 cm depth in stream bed) were collected (Figure 5-1). The samples were gathered at a rate of three samples per 10 km^2 in streams of the first through fourth order. Salminen *et al.* (2005) and Alexakis (2008) provided examples of the evaluation of regional geochemical sampling of stream sediments in terms of contamination thresholds (2008). Stream sediment samples are commonly utilized for mineral prospecting and environmental risk assessment (e.g. Salminen *et al.*, 2005). The sample at each location is a blend of source rock information representing the upstream geology and point and non-point sources.

The catchment area of ROC include both permanent and seasonal streams. In the ROC, bulk sediment samples were collected at five to ten locations throughout a stretch of more than 50 meters. The sediment samples were wet-sieved to a fraction of >2 mm mesh, dried, and then milled to a fraction of -75 microns. The sample was then averaged to reflect the drainage region upstream. The averaging was performed by homogenizing a bulk sample obtained from many locations, and a 5 kilogram sample was kept in the polyethene bag. In this investigation, the fine to clay silt samples were favored since they presumably contain the

majority of the metals adsorbed (Salminen *et al.*, 2005; Alexakis, 2008; Bogen *et al.*, 2004). The samples were dried at a temperature of 27^{o}C to prevent the clay component from forming a crust after drying. The crusted sample was next crushed with a 3x4 inch carbon steel jaw crusher, divided in a rotary splitter, and milled to 75 m. Using an X-ray Fluorescence Spectrometer, the material was tested for chemical analysis.

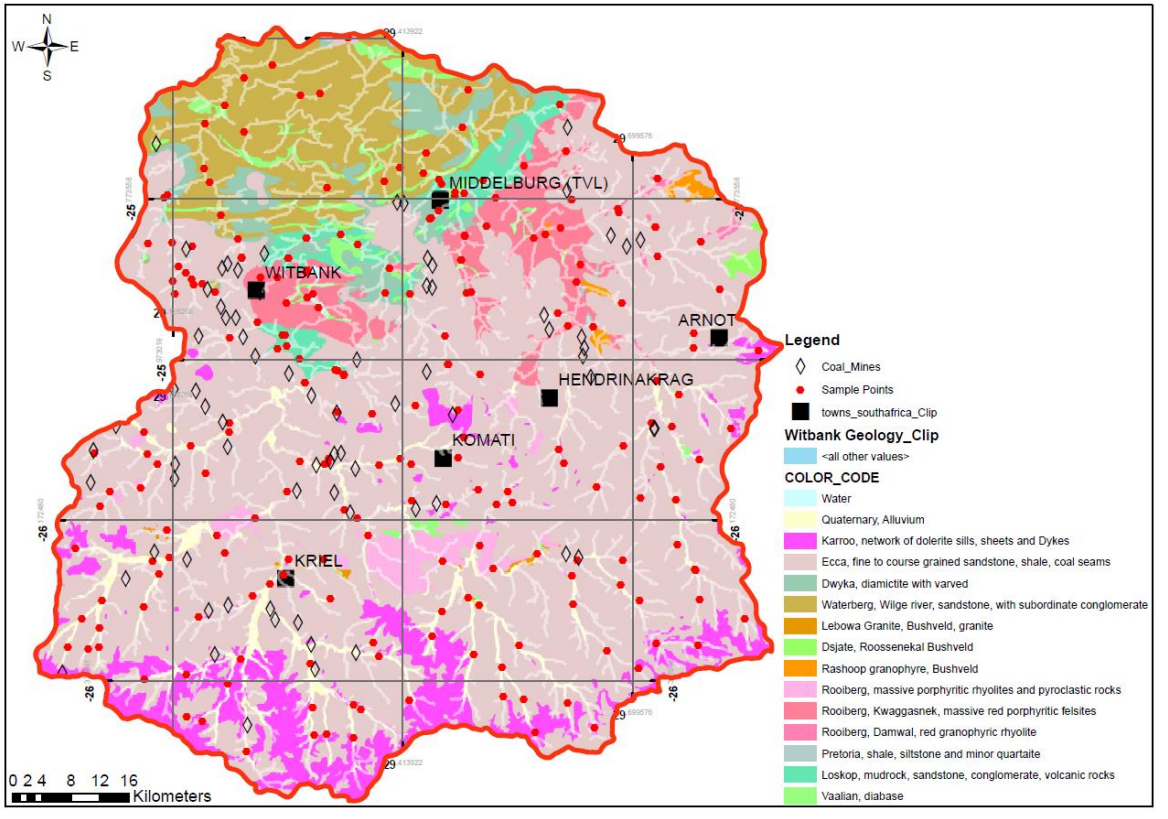


Figure 5-1: The ROC simplified geological map, distribution of sample locations, and placement of coal mines (the study area).

5.2.2 Fluorescence X-Ray Spectrometer (XRF)

The minus 75 m fraction was tested of the milled bulk sample for major and trace elements. On a Philips PW 1606 Simultaneous XRF, samples were evaluated specifically for the following elements: SiO_2, Al_2O_3, TiO_2, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, Cr_2O_3, and Fe_2O_3 in weight. Sc, V, Cr, Co, Ni, Cu, Zn, As, Rb, Sr, Y, Zr, Nb, Sn, Sb, Ba, W, Pb, Th, and U are expressed in parts per million. Elsenbroek (1996) explained the processes to calibrate an instrument for accuracy and precision, as well as the reference materials employed.

5.2.3 Limit of Detection

Similar to baselines or data outliers, threshold values are a range of numbers that define the bottom and upper limits of populations and, at best, separate the background from abnormal values. These are the values found in the datasets' tails. It contains both the minimum and maximum values. They are in the tails of a separate population because they come from a different origin and for environmental reasons (Reimann *et al.*, 2005; Mimba *et al.*, 2018; Nogueira, 2018). The mean plus 2 std.-dev (std.-dev: Standard deviation) to find approximately 2.5% of the maximum (or minimum) values for quality assurance and control (QAQC) (Reimann *et al.*, 2005). In South Africa, the approach of employing mean plus 2 std.-dev is prevalent. CGS has maintained the usage of the threshold for identifying or producing exploration targets on a regional basis (Elsenbroek *et al.*, 2000a; Elsenbroek *et al.*, 2000b and Mapukule, 2009). In environmental geochemistry, threshold determination has been a difficulty; consequently, it is crucial that regulators acknowledge that background concentrations depend on size and location (Salminen and Gregorauskiene,

2000). Background values are determined by the scale of inquiry (district to local). At a continental scale, the background level rises, which may result in missing the targeted point sources (Reimann and Garrett, 2005; Ander *et al.*, 2013). In this study, the majority of element data is favorably skewed, indicating that the data contains many populations. Due to the presence of several populations within the data, probability plots were employed to analyze this collection of information.

This study's probability plots were generated using PROBPLOT version 1.00 DJ software (Stanley, 1987). Sinclair (1974), Sinclair (1976), and Sinclair (1991) have all described the procedure. Probability plots are utilized to divide data sets into component populations, yielding background and anomalous values, the latter indicating the probable existence of mineralization of ores or an anthropogenic effect. This approach has been widely employed for both exploration and environmental application (Lepeltier, 1969; Parslow, 1974; Davies, 1983; Davies and Wixson, 1985; Fleischhauer and Korte, 1990; McGrath, 1986; Tobias *et al.*, 1997; Sinclair, 1974; Sinclair, 1976 and Sinclair, 1991; Nogueira *et al.*, 2018). On a probabilistic scale, the cumulative frequencies of the log-transformed data were shown. According to Davies (1983), McGrath (1986), and Fleischhauer and Korsmeyer (1990), the resultant plots revealed a straight bottom line representing a lognormal population consisting of background values. The inflexion points that separate the background populations from the contaminated ones were determined using the standard threshold method (Fleischhauer and Korte, 1990), with the threshold objectively determined as the value that produced the background population with the closest skewness to zero. The antilogs of mean and std.-dev are the geometric mean and geometric deviation of the arithmetic values, respectively. The bottom and upper boundaries of the background ranges were calculated as antilog (mean

minus std.-dev) and antilog (mean plus std.-dev). Sinclair (1974) details the phases of the probability plot process. For geochemical exploration, determining the background or threshold level to identify outliers has been standard procedure (Hawkes and Webb, 1962; Tennant and White, 1959).

Hawkes and Webb (1962) and Sinclair (1974) presented in detail a method for selecting threshold values between anomalous and background geochemical data based on a probability plot of the data, with a focus on defining the background using the mean 2 std.-dev. Some exploration and environmental geochemists have utilized the approach employed by the latter to define backgrounds to date. In addition to box plot, median 2 MAD (median absolute deviation), and probability plots, there are more methods for establishing the threshold. The usage of merely mean plus 2 std.-dev is insufficient and has been widely utilized without consideration that it is only applicable to a specific demographic. The latter is appropriate to an actual population and defines around 5 percent of the extreme values. Extreme values or outliers can have a significant impact on data while processing datasets. Therefore, outliers are eliminated so that the data may be treated uniformly, resulting in subjectivity. The data can still be log converted to obtain a statistically tractable normal log distribution.

5.2.4 Calculating the Enrichment Factor

According to Bourennane *et al.* (2010), "the notion of enrichment factor (EF) was created in the early 1970s to determine the origin of elements in the atmosphere, precipitation, and saltwater." Other environmental resources, such as soils, lake sediments, and peat, were also treated (Reimann *et al.*, 2005). In several instances, it was utilized to detect the effect of human-caused emissions

on trace element variations (Bourennane *et al.*, 2010). The following formula was used to compute EF:

$$EF = \frac{[El]\ sample/\ [Al]\ sample}{[El]\ crust/\ [Al]\ crust}$$

Where EF is the enrichment factor, (El/Al) sample is the ratio of element and aluminum concentration in a sample, and (El/Al) crust is the ratio of element and aluminum concentration derived from crustal values (Taylor, 1964).

For a more accurate estimate of anthropogenic input, enrichment factors were determined by dividing each metal's ratio to the normalizing element. Using the enrichment factor (EF) method, the EF was determined using the Aluminum concentration as a normalization factor to distinguish the anthropogenic source from the geogenic.

In the majority of instances, a significant part of the variance in stream sediment uni-element concentrations is attributable to the lithologic units underlying regions upstream of sampling locations. Hawkes (1976) and Rose *et al.* (1979) noted the downstream dilution of chemical solute concentrations in stream sediments. Stream sediments were employed to define the regional geochemical baselines of the ROC in this investigation. Using conventional geochemical exploration techniques, estimate the elemental concentrations of 246 stream sediment geochemical data in order to differentiate between an element's background concentration and anomalies (enrichment).

Some exploration and environmental geochemists continue to employ the latter's technique for identifying the backdrops. In South Africa, the mean plus two std.-dev has been utilized by CGS for defining or creating regional geochemical mapping objectives (Elsenbroek *et al.*, 2000a; 2000b). In addition to box plot,

median 2MAD and probability plots, there are more methods for establishing the threshold values. The usage of merely mean plus 2 std.-dev is insufficient and has been widely utilized without consideration for the fact that it is suitable for a specific demographic. The latter is appropriate to an actual population and defines around 5 percent of the extreme values. What about ten percent, ten percent, or none of the extreme values? During the processing of datasets, the data may be totally altered by extreme values or outliers; hence, outliers are deleted so that the data may be processed with uniformity; this has resulted in subjectivity. The data may still be log-transformed to reduce the impact of extreme numbers. These efforts do not take into account more than one population. Geochemical exploration has used the calculation of the background or threshold level to find outliers as early as 1950s (Hawkes and Webb, 1962; Tennant and White, 1959). According to Reimann *et al.* (2005), the first approach was to conduct an orientation survey to define a local threshold against which anomalies can be judged; the second approach was to order the data and select the top 2.5% of the data for further inspection, and this was a practice if no orientation survey results were available; and the third approach was for large data sets, which cannot be easily ordered (at the time, with current technology, this is no longer the case). In reality, threshold determination methods cannot be used to datasets including numerous populations. In environmental geochemistry, determining the threshold has been a difficulty; hence, it is crucial that regulators acknowledge that background differs on size and location. The backdrop varies from region to region and with the researched area's size. When mapping at the continental scale, natural element concentrations might be as high as or even higher than any obvious anthropogenic pollution, causing the point sources or issues to be overlooked (Reimann and Garrett, 2005). Reimann and Garrett (2005) and Négrel *et al.* (2015) state that it is crucial for regulators to note that background concentrations vary on location and size when determining

thresholds. Moreover, the natural fluctuations in element concentrations in various environmental sample materials are sometimes so great that it is difficult to recognize anthropogenic additions, contamination in cases other than the most obvious. These will typically be limited to the local scale.

Similar to baselines or data outliers, the threshold value is a range of numbers that separates the background from abnormal values. These numbers may be $2^{1/2}$, 5%, or any other percentage of the datasets. These are the values found in the datasets' tails. It contains both the minimum and maximum values. They are found in the tails of a distinct population because they originate from a different source, and they may be ascribed to the contaminated sources for environmental reasons. On the basis of partitioning a cumulative probability plot of the data, Sinclair (1974) and Hawkes and Webb (1962), who focused on defining the background by employing the mean plus 2 std.-dev, describe a method for determining the threshold values between anomalous and background geochemical data. Until now, certain exploration and environmental geochemists have utilized this strategy for characterizing the backdrops. In South Africa, the approach of employing mean plus 2 std.-dev is prevalent. Has been used by the CGS to define or generate geochemical mapping goals on a regional basis. The latter is appropriate to an actual population and defines around 5 percent of the extreme values. During the processing of datasets, the data might be totally altered by extreme values or outliers; thus, outliers are eliminated so that the data can be processed with uniformity; this has led to subjectivity. The data may still be log-transformed to reduce the impact of extreme numbers. All of these efforts disregard the existence of more than one population.

Typically, geochemists utilize probability plots to divide data sets into component populations, so getting background and anomalous values, the latter indicating the potential presence of economically significant ores. Lepeltier (1969), Parslow (1974), and Sinclair (1974), among others, described this method. This method was used by Davies (1983) to determine the normal Pb content in British soils and the background concentrations of Co, Cu, Mn, Ni, Pb, and Zn in Missouri soils (Davies and Wixson, 1985). Through this method, McGrath (1986) also identified the typical range of Lead in soils from England and Wales. Fleischhauer and Korte (1990) formulated cleaning requirements and established background values for several trace elements in the Kansas City, Missouri metropolitan area using the approach. Tobias *et al.* (1997) employed probability plots to determine the reference values of several trace elements in the soils of an agro-industrial region near Barcelona. The approach proved beneficial for establishing reference levels of soil trace elements, however authors' estimates of the inflexion point that separates the background population from the anomalous population can vary substantially. Erroneous positioning of this point can result in significant inaccuracies in determining the reference levels. Fleischhauer and Korte (1990) examined this issue, culminating in the creation of a standard threshold that provides an objective and repeatable selection of the inflexion point.

This study's probability plots were generated using PROBPLOT version 1.00 DJ (Stanley, 1987). On a probabilistic scale, the cumulative frequencies of the log-transformed data were shown. According to Davies (1983), McGrath (1986), and Fleischhauer and Korsmeyer (1990), the resultant plots revealed a straight bottom line representing a lognormal population consisting of background values. The inflexion points that separate the background populations from the contaminated ones were determined using the standard threshold method

(Fleischhauer and Korte, 1990), with the threshold objectively determined as the value that produced the background population with the closest skewness to zero. The mean and std.-dev of the log-transformed values of the generated background populations were determined. The antilogs of mean and std.-dev are the geometric mean and geometric deviation of the arithmetic values, respectively. The lower and upper boundaries of the background ranges were calculated as the antilog of the mean minus 2 std.-dev and the mean plus 2 std.-dev.

5.3 RESULTS ANALYSIS

Table 5-1 provides an overview of the geochemical data for the samples of stream sediment. The LLD is discussed in section 5.2.3. The whole set of data is supplied in Appendix J.

5.3.1 Major Oxides

Figures 5-2 through 5-8 exhibit the statistical overview of the main oxides. The Figures 5-9, 5-11, 5-13; 5-15, 5-17, 5-19, 5-21, 5-23, and 5-25 depict probability plots for the major elements CaO, Na_2O, MgO, Cr_2O_3, Al_2O_3, SiO_2, K_2O, P_2O_5, and Fe_2O_3, while the Figures 5-10, 5-12, 5-14, 5-16, 5-18, 5-20, 5-24, 5-26, and 5-28 depict distribution maps for the major elements listed above.

Table 5-1: Summary data for the major elements (wt%) and trace metals in stream sediments (ppm).

Element	Valid N	Min	Max	Std.-dev.	Mean	Median	CV	Mean+Std.-dve.	Mean+2Std.-dve.
SiO_2	246	15,37	98,08	14,56	75,63	77,66	19,25	90,19	104,75
TiO_2	246	0,06	6,52	0,47	0,54	0,48	86,13	1,01	1,48
Al_2O_3	246	0,81	24,03	3,87	7,16	6,65	54,07	11,04	14,91
Fe_2O_3	246	0,59	33,60	4,65	5,74	4,65	81,00	10,39	15,04
MnO	246	0,01	0,55	0,10	0,11	0,08	92,79	0,21	0,31
MgO	246	0,01	16,97	1,45	0,62	0,24	234,53	2,07	3,52
CaO	246	0,01	12,69	1,89	1,07	0,32	177,46	2,96	4,86
Na_2O	246	-0,02	2,73	0,39	0,26	0,13	153,20	0,65	1,05
K_2O	246	0,05	4,20	0,63	1,05	0,96	59,76	1,68	2,31
P_2O_5	246	0,01	1,44	0,13	0,11	0,07	123,31	0,24	0,37
Cr_2O_3	246	0,00	11,53	0,74	0,10	0,02	765,24	0,84	1,58
LOI	246	0,41	69,99	8,68	7,30	4,50	118,97	15,98	24,66
As	246	4	680	102	36	4	286	138	240
Ba	246	3	1128	209	363	378	57	572	780
Bi	246	2	36	3	4	3	92	7	10
Br	246	2	670	58	16	2	354	74	131
Ce	246	5	335	50	70	59	72	120	171
Co	246	2	1273	120	50	20	242	169	289
Cr	246	5	3207	347	230	143	151	577	924
Cs	246	5	93	10	8	5	127	17	27
Cu	246	2	89	17	23	17	73	40	56

Element	Valid N	Min	Max	Std.-dev.	Mean	Median	CV	Mean+Std.-dve.	Mean+2Std.-dve.
Ga	246	1	34	6	9	8	66	15	21
Ge	246	1	12	2	2	1	125	4	6
Hf	246	3	223	19	12	8	158	32	51
La	246	2	105	17	24	21	70	41	58
Mo	246	2	16	2	3	2	85	5	8
Nb	246	2	358	30	14	9	213	44	75
Nd	246	6	379	31	28	23	110	59	90
Ni	246	5	197	23	31	24	74	53	76
Pb	246	3	98	17	24	19	69	40	57
Rb	246	3	181	31	47	43	66	79	110
Sc	246	1	31	6	9	8	69	15	21
Se	246	1	72	7	3	1	245	9	16
Sm	246	7	194	20	15	10	135	35	55
Sr	246	2	458	57	54	44	104	111	168
Ta	246	2	19	2	3	2	80	5	7
Th	246	3	42	5	7	6	66	11	16
Tl	246	2	37	2	3	3	72	5	8
U	246	2	1898	178	40	2	447	217	395
V	246	3	1028	108	94	76	115	202	310
W	246	3	352	30	11	3	264	41	71
Y	246	3	211	18	17	15	102	35	53
Yb	246	3	4131	318	50	3	632	368	686
Zn	246	3	724	132	108	50	122	240	372
Zr	246	56	893	113	275	276	41	388	502

The sediments exhibit a variety of SiO_2 values, the lowest of which is 15.4 wt.% up to a maximum of 98.1 wt.% (Table 5-1). The concentration falls within the concentration range of sediments in the Karoo Supergroup, as reported by Coney *et al.* (2007), but is somewhat higher, most likely due to sedimentary processes on the Basin enriching the sediments. The SiO_2 concentration of sediments has a negative correlation (Tables 5-2 and 5-3), is homogeneously distributed, and occasionally has no association with other major and trace elements (Figures 5-3 to 5-8). The average SiO_2 concentration is 75.6 wt.% exceeds the maximum figure provided for the Karoo Supergroup by a little margin (Table 5-1). The negative skewness of the SiO_2 concentration (Figure 5-2) is likely attributable to the low SiO_2 concentration in the coal seams. According to reports, the Karoo Supergroup coal seams have a low SiO_2 content. The samples inside the outlier range constitute fewer than 5% of the whole data set. The majority of samples fall within the higher SiO_2 concentration range. Quartz is a mineral that is resistant to erosion and rich in debris.

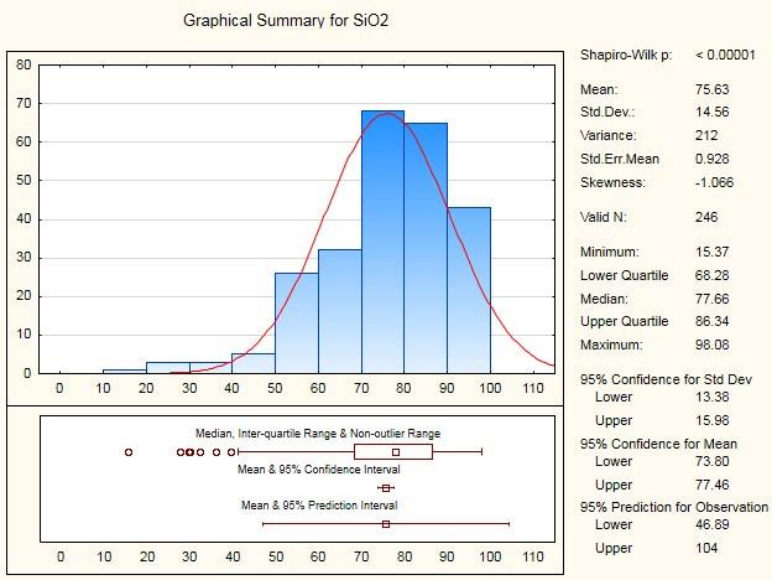


Figure 5-2: Presents a statistical overview of Al_2O_3 concentrations.

In contrast, the concentration of Al_2O_3 in the Witbank coalfield is uniformly distributed and positively skewed, with a minimum value of 0.8 wt.% and 24 wt as the maximum value. % (Table 5-2). The bulk of samples had Al_2O_3 concentrations within the range of the mean value plus 1 std.-dev, however less than 5% of the samples fall within the outlier range (Figure 5-3). Al_2O_3 concentrations are greatest in shale- and feldspar-bearing strata's detritus. The ratio of aluminum to titanium varies from 16 wt.% to 20 wt.%, are the average values for shale and upper crust (Nakai *et al.*, 1993; Weeber, 1996), while Al enrichments in sediments are negligible (Murray and Leinen, 1996).

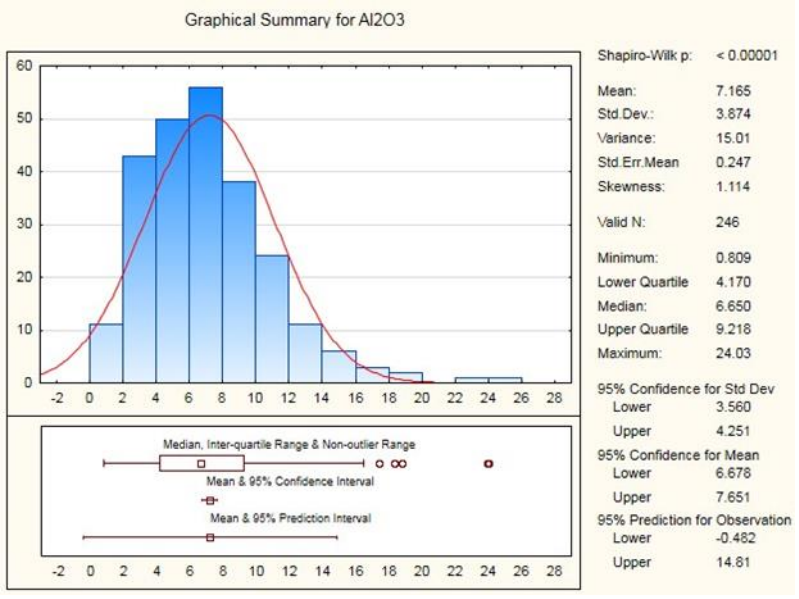


Figure 5-3: Summary statistics of Al_2O_3 concentrations.

K_2O is uniformly distributed across the Witbank basin and has a minimum of 0.1 wt.% up to a maximum of 4.2 weight % (Table 5-1). K is a highly mobile element that is liberated by the deterioration of feldspars and mica. It has a

positive skew (Figure 5-4). 5% of the findings may represent samples containing potassium minerals and mica with low potassium concentrations. The minerals are present in coal in smaller quantities. The majority (95%) of Witbank coalfield samples had K_2O concentrations within the non-outlier range, whereas just 5% have outlier and extreme values.

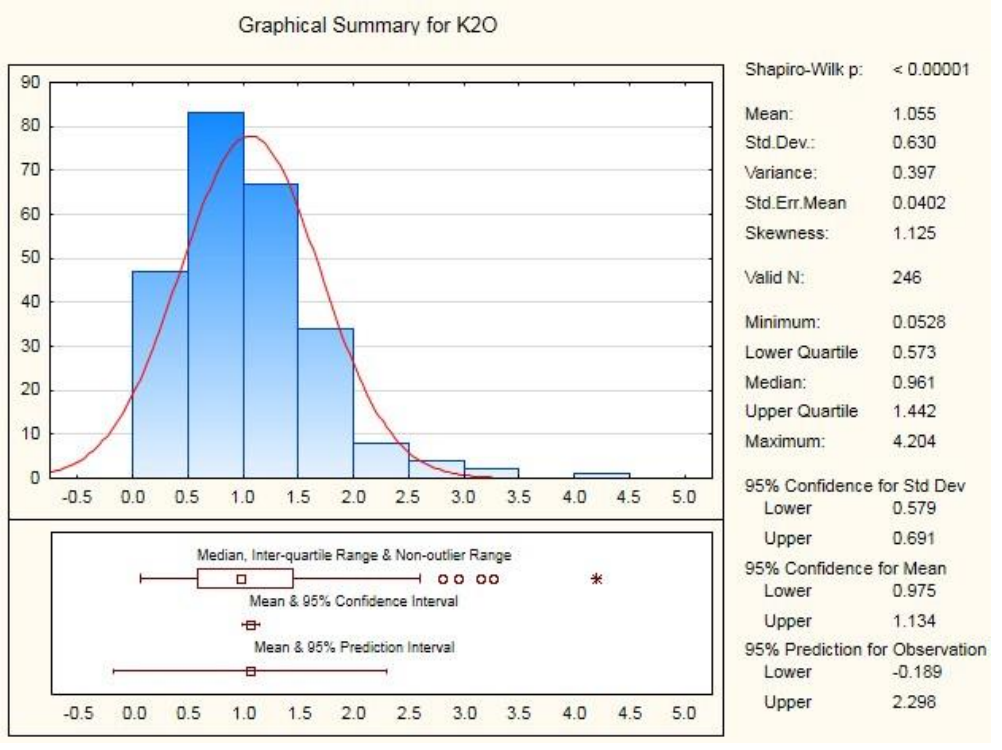


Figure 5-4: Summary statistics of K_2O values.

The Fe_2O_3 content has a minimum heterogeneous distribution of 0.6 wt.%, with a limit of 33.6 wt.%. The average value of 246 investigated sediment samples is 5.7 wt.% (Table 5-1). Positively skewed long tails may indicate the presence of iron minerals in the samples. Iron is a siderophile element predominantly found in mafic and ultramafic rocks. It is present in hematite, pyrite, and magnetite minerals. It is found in soils as limonite, magnetite, or clay (Hawkes and Webb,

1962). As described in chapter 3, the dolerites, coal, and lithological layers above and below the coal seams contain more iron. In the latter case, it may be due to sulphides, as chapter 3 indicates that the coal and strata above and below are rich in sulphides. The majority of stream sediment samples have a low iron oxide content, and roughly 5% are long-tailed (Figure 5-5). Approximately two populations are displayed on the outlier range, while another population is provided on the extreme values. As seen by their somewhat strong correlation coefficients, Fe_2O_3 and MnO co-occur due to their comparable chemical characteristics and shared mineral parageneses (Table 5-3).

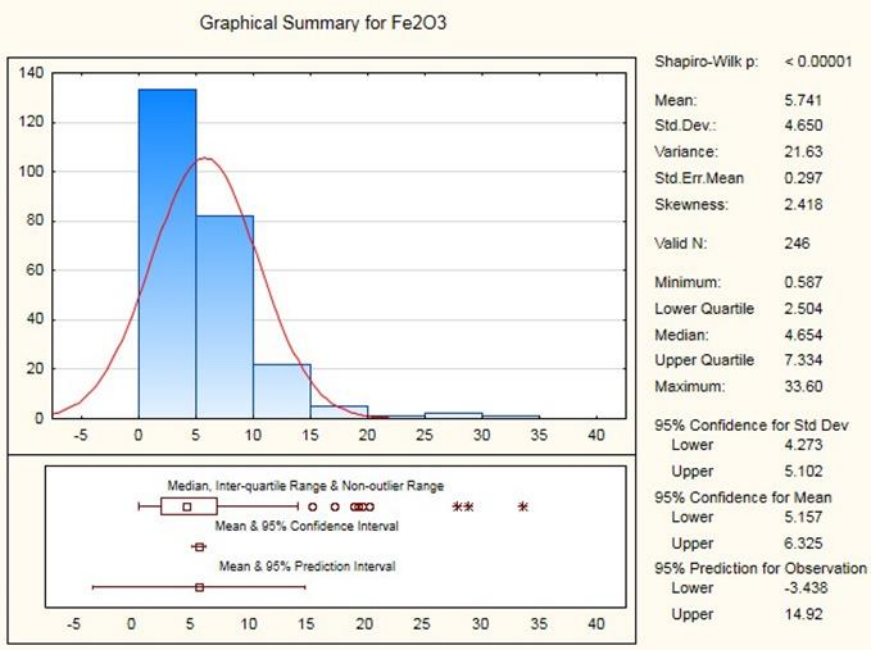


Figure 5-5: Summary Fe_2O_3 statistics.

The distribution of MnO is likewise diverse, with a coefficient variation of 92.2%. The sediments have low manganese content. Minimum MnO concentration is 0.0058 wt.% or not identified, with a maximum of 0.6 wt.%

(Table 5-1). Manganese is related to lithophile elements and magnesium and iron silicates. It is most prevalent among mafic minerals. Manganite, pyrolusite, alabandite, rhodochrosite, and rhodonite are ores, whereas columbite and other silicates are replacements. It is found as Mn-Fe oxides in soils and clays (Hawkes and Webb, 1962). There are about two populations that fall within the outlier range and another that falls within the extreme value range (Figure 5-6). On the stratigraphy of the Witbank coalfield, the greatest MnO concentrations are recorded in dolerites and some shales. MnO concentrations in coal seams and the lithological layers above and below are quite low.

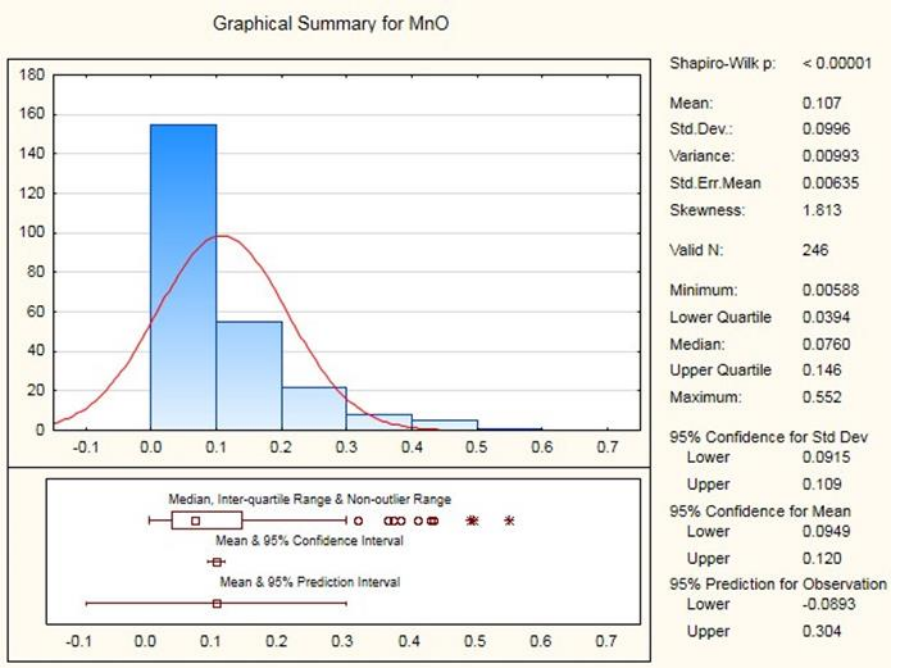


Figure 5-6 Summary statistics of MnO.

CaO and MgO, the predominant oxides in Figures 5-7 and 5-8, illustrate the diverse distribution of sediments. The later oxides exhibit the phenomena of positive skewness. The reason might be because Ca^{2+} is a very mobile cation.

The smallest CaO concentration is 0.008 wt.% and the maximum is 12.69 wt.%, while the lowest concentration of MgO is 0.007 wt.% with a cap of 16,97 wt.% (Table 5-1). Magnesium exists in sediments either as a solute in pore water or as a key component in the production of late-stage diagenetic chlorite and dolomite (Wedepohl, 1978; 1995). The average Mg content in loess is 0.68 wt.% (McLennan and Murray, 1999). High Mg readings imply mafic or ultramafic igneous rocks (in conjunction with Cr, Ni, V, etc.) or calcareous igneous rocks (with Ba, Ca and Sr). Due to the high solubility of several Mg compounds, Mg is extremely mobile following its release through weathering in all environmental situations (Salminen *et al.*, 2005). Under the normal pH, redox, and conductivity conditions of streams, Mg is expected to exist virtually completely as Mg^{2+}. In some locations, this ion is more abundant than Na^{+} and Ca^{2+} in stream water. $MgSO_4$ is more soluble than $CaSO_4$, hence Mg^{2+} may be more frequent in streams supplied by sulphate-rich mine drainage resulting from sulphide mineral oxidation. Considering that the majority of limestone is rich in magnesium, streams draining limestone and other carbonate-rich rocks are likely to have elevated Mg^{2+} concentrations. The average Mg concentration in river particles is 1.2 wt.% (Murray and Leinen, 1996). CaO, MnO, and MgO coexist because to their comparable chemical characteristics and shared mineral parageneses, as seen by their strong correlation coefficients (Table 5-3).

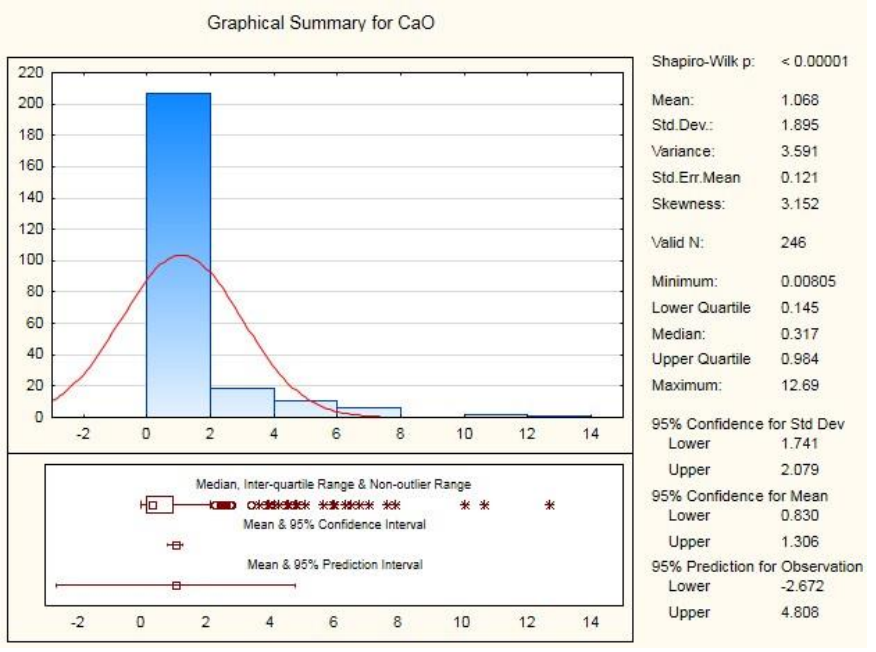


Figure 5-7 Summary statistics of CaO.

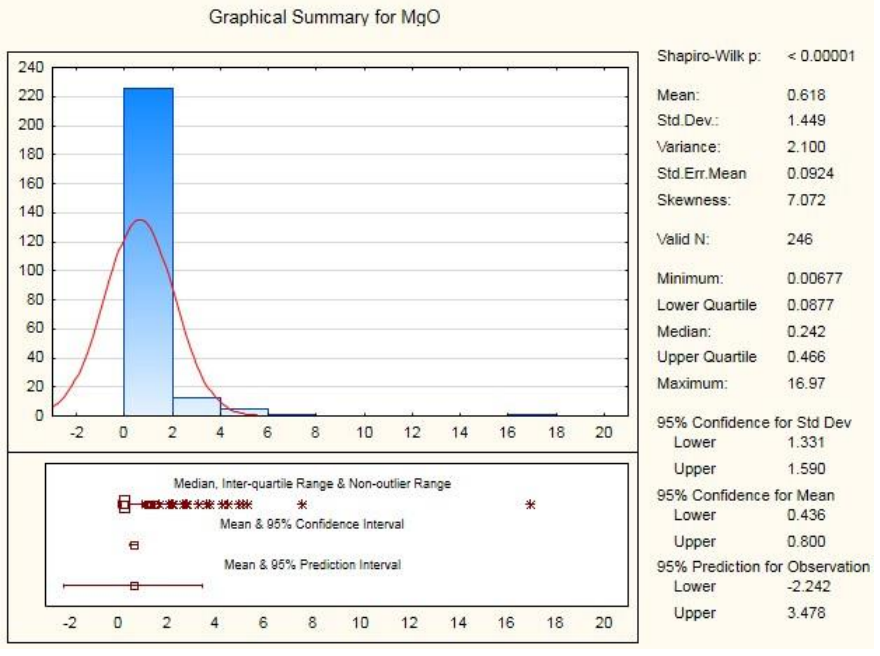


Figure 5-8 Summary statistics of MgO.

Minimum chromium (Cr_2O_3) content is 0.1 wt.% and no more than 11.5 wt.%. Figure 5-16 demonstrates that the distribution of chromium in stream sediments is positively skewed, indicating a heterogeneous distribution. As a siderophile element, chromium is concentrated in ultramafic rocks. Chromium's ore mineral is chromite, however Cr is also present in micas, garnets, pyroxene, and magnetite. It is found in chromite, limonite, magnetite, and clays in soils. It serves as a compass for chromite, platinum, and other ultramafic minerals (Levinson, 1974). Exposed to air, the metal interacts with oxygen to generate a thin oxide coating that resists corrosion. Chromium exists in oxidation states ranging from 0 to VI (Irwin *et al.*, 1997; Kuyek, 2011). The higher population is located in close proximity to the processing factories in the large cities of Witbank and Middleburg (Figure 5-15 and 5-16).

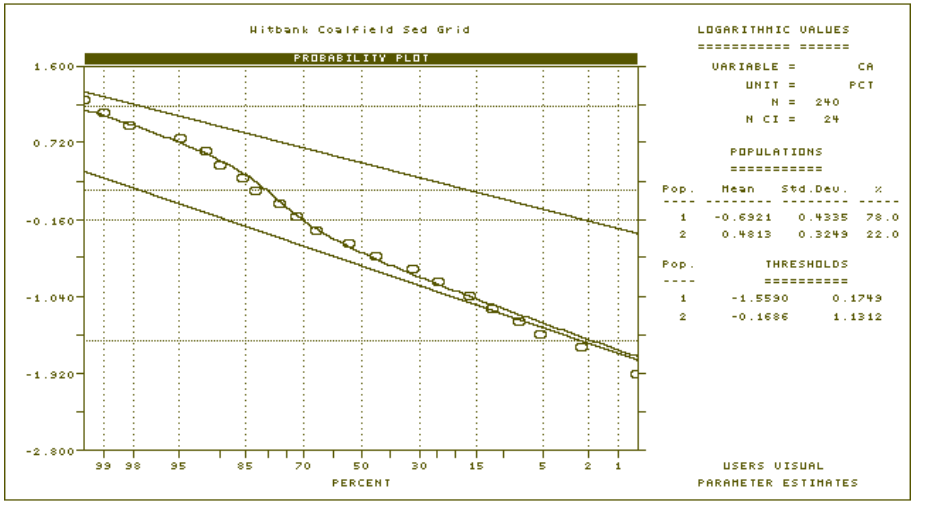


Figure 5-9: Figure indicating the probability plot of CaO log concentrations indicating bimodal distribution of three populations which is represented by 78 and 22% respectively. Population 1 indicates the mean of 0.203 (-0.075 and +0.551 std.-dev), population 2 indicate the mean of 3.029 (-1.433 and +6.401 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.028 wt.% and maximum of 1.496 wt. %, population 2 minimum of 0.678 wt.% and maximum of 13.526 wt.%.

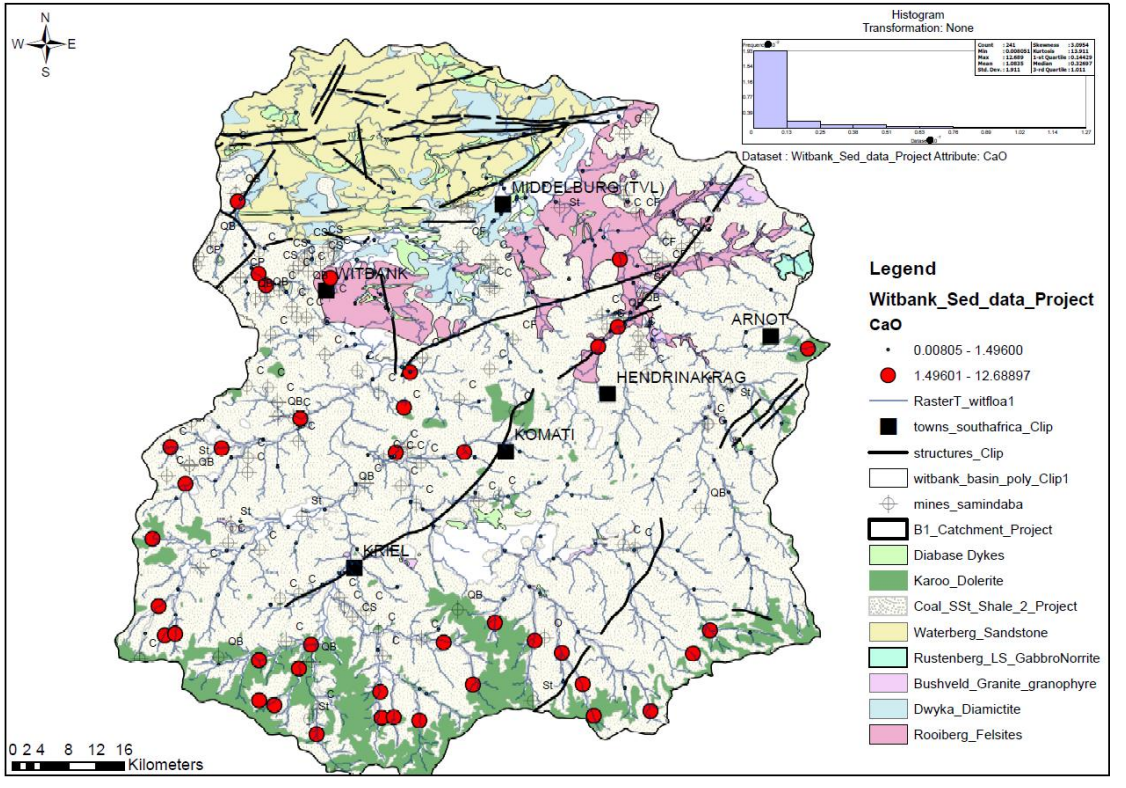


Figure 5-10: Figure indicating the uni-element distribution of CaO on the ROC, the red is higher than the threshold value.

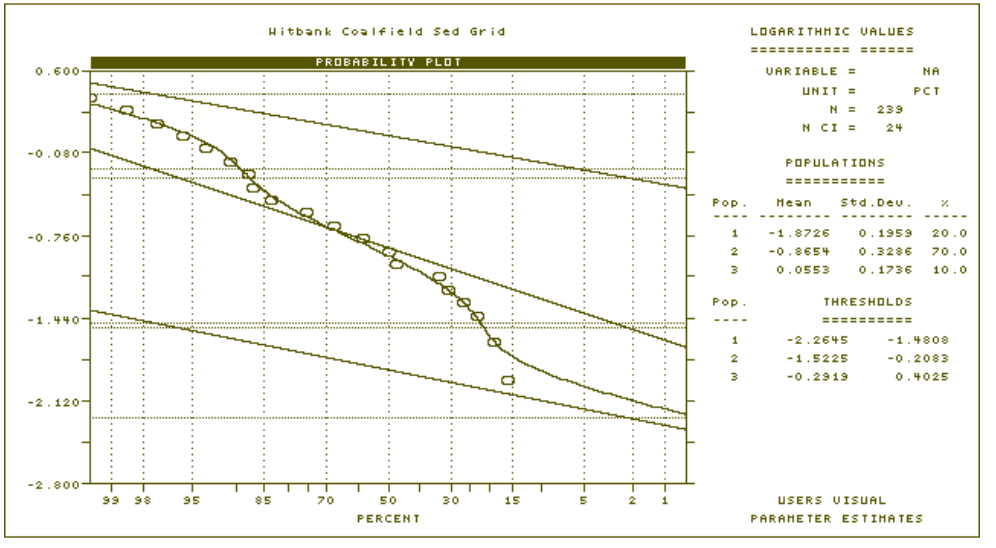


Figure 5-11: Figure indicating the probability plot of sodium log concentrations indicating bimodal distribution of three populations which is represented by 20, 70 and 10% respectively. Population 1 indicates the mean of 0.013 (-0.009 and +0.021 std.-dev), population 2 indicate the mean of 0.136 (-0.064 and +0.290 std.-dev) and population 3 indicate the mean of 1.136 (-0.762 and +1.694). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.005 wt.% and maximum of 0.033 wt.%, population 2 minimum of 0.030 wt.% and maximum of 0.619 wt.% and population 3 minimum of 0.511 wt.% and the maximum of 2.526 wt.%.

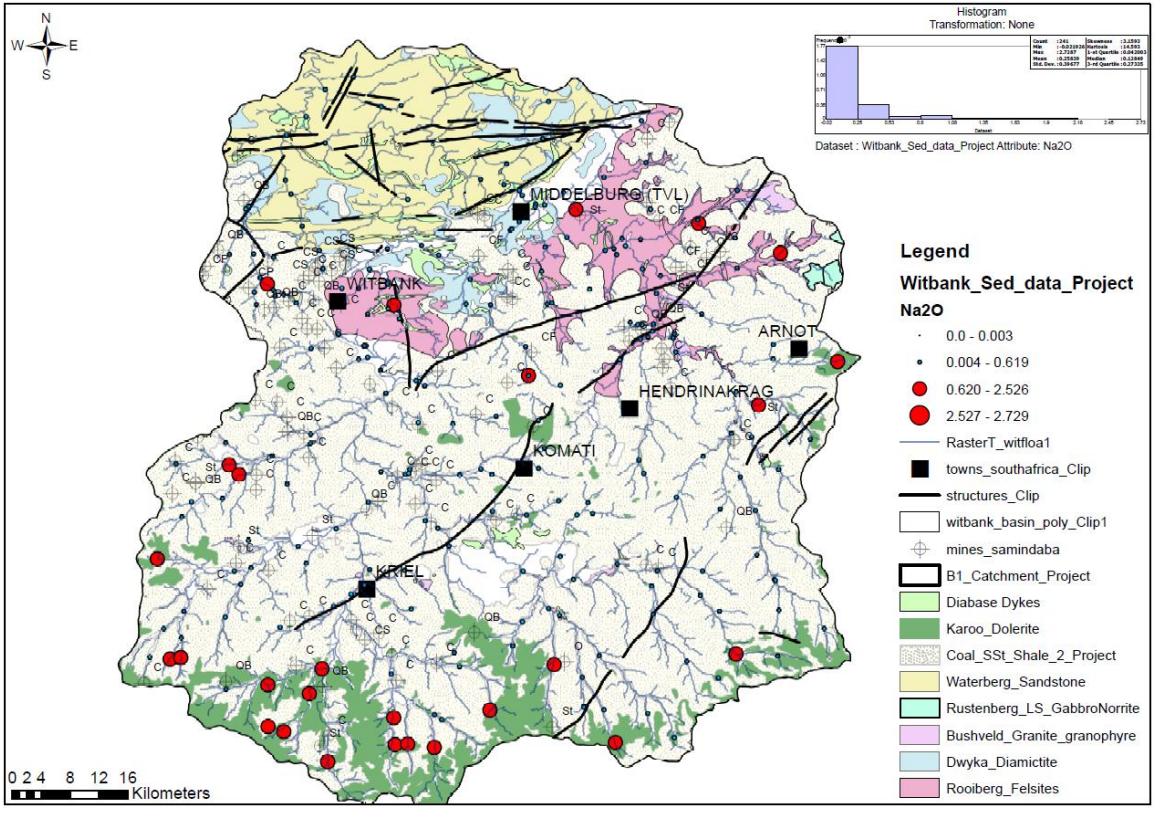


Figure 5-12: Figure indicating the uni-element distribution of sodium on the ROC, the red are higher than the threshold value.

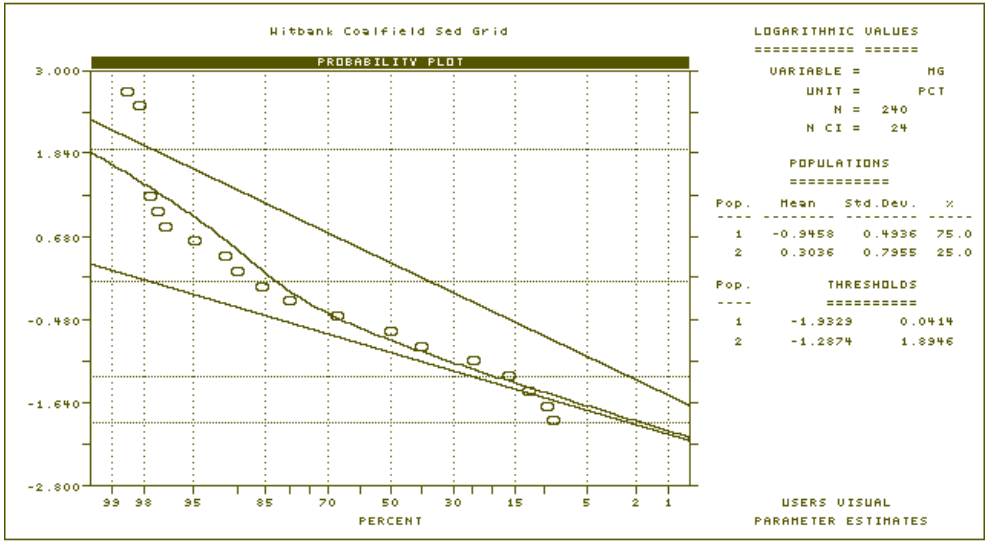


Figure 5-13: Figure indicating the probability plot of magnesium log concentrations indicating bimodal distribution of three populations which is represented by 75 and 25% respectively. Population 1 indicates the mean of 0.113 (-0.036 and +0.353 std.-dev), population 2 indicate the mean of 0.052 (-0.322 and +12.564 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.012 wt.% and maximum of 1.100 wt.%, population 2 minimum of 0.052 wt.% and maximum of 78.453 wt.%.

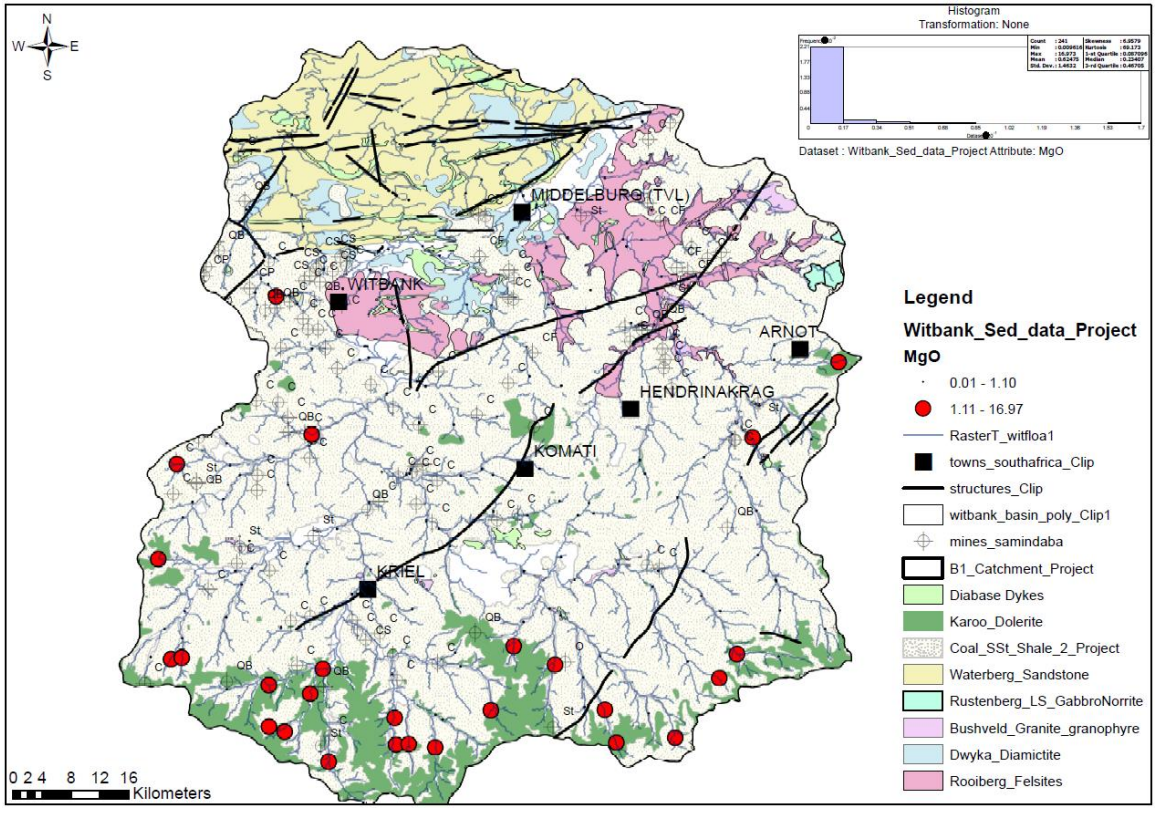


Figure 5-14: Figure indicating the uni-element distribution of magnesium on the ROC.

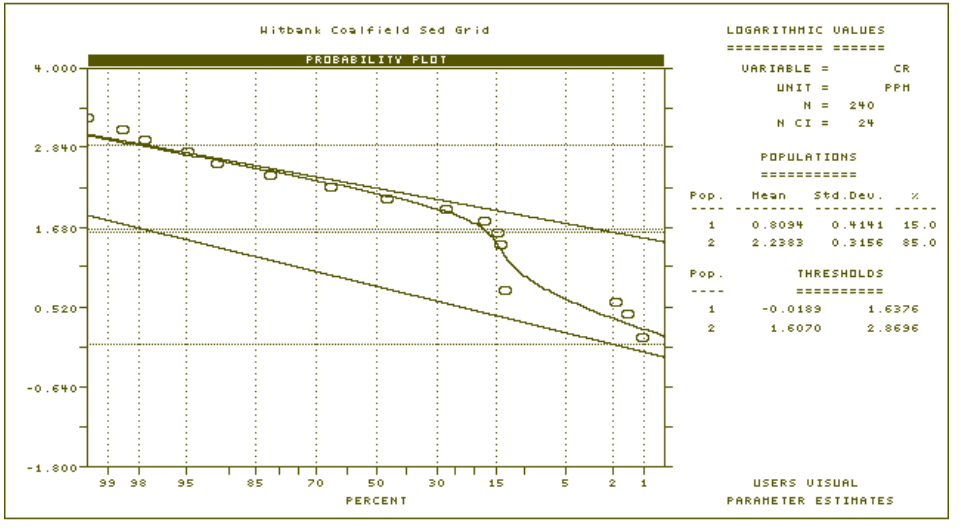


Figure 5-15: Figure indicating the probability plot of chromium log concentrations indicating bimodal distribution of two populations, which is represented by 15 and 85% respectively. Population 1 indicates the mean of 6.447 (-2.484 and +16.730 std.-dev), population 2 indicate the mean of 173.093 (-83.683 and +358.032 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.957 ppm and maximum of 43.415 ppm, population 2 minimum of 40.457 ppm and maximum of 740.569 ppm.

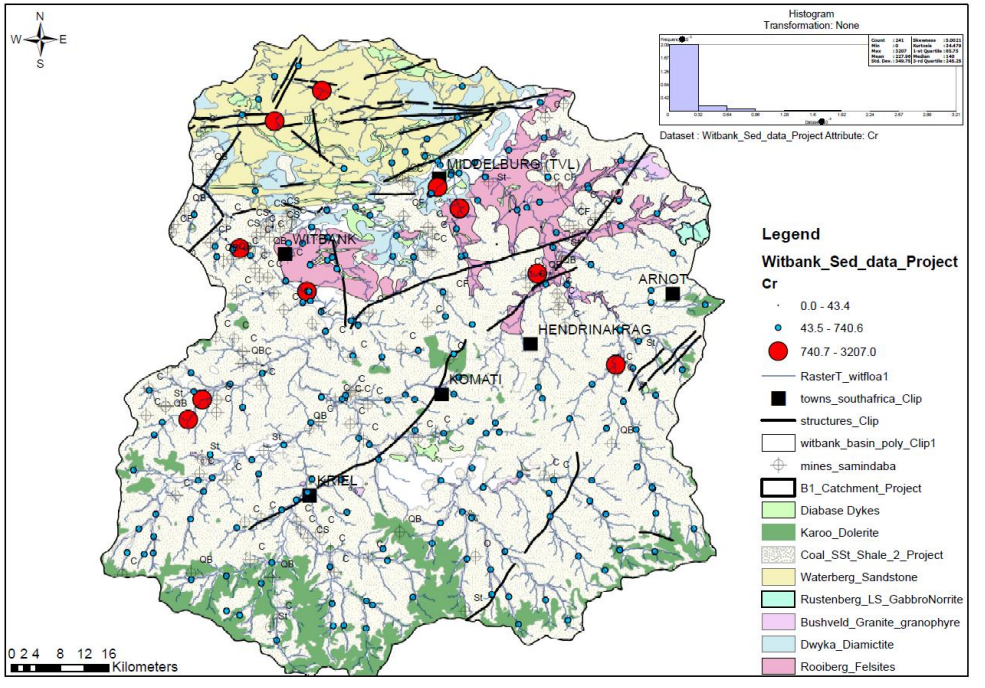


Figure 5-16: Figure indicating the uni-element distribution of chromium (ppm) on the ROC, the red are above the threshold value.

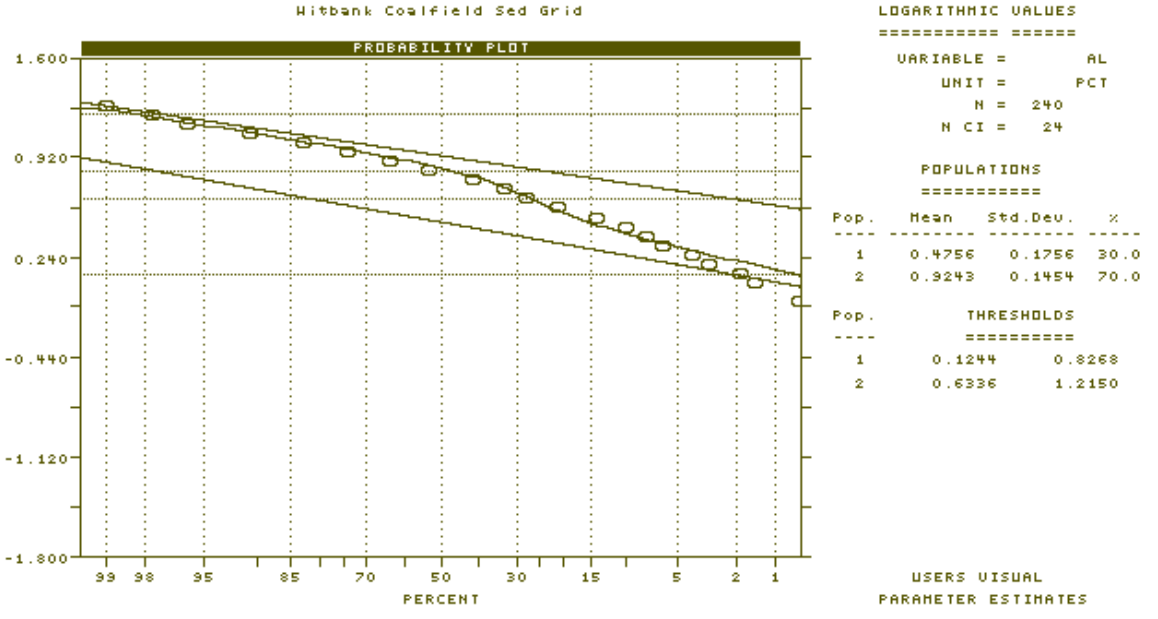


Figure 5-17: Figure indicating the probability plot of aluminium log concentrations indicating bimodal distribution of two populations which is represented by 30 and 70% respectively. Population 1 indicates the mean of 2.990 (-1.995 and +4.479 std.-dev), population 2 indicate the mean of 8.401 (-6.011 and +11.740 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 1.332 wt.% and maximum of 6.711 wt.%, population 2 minimum of 4.301 wt.% and maximum of 16.407 wt.%.

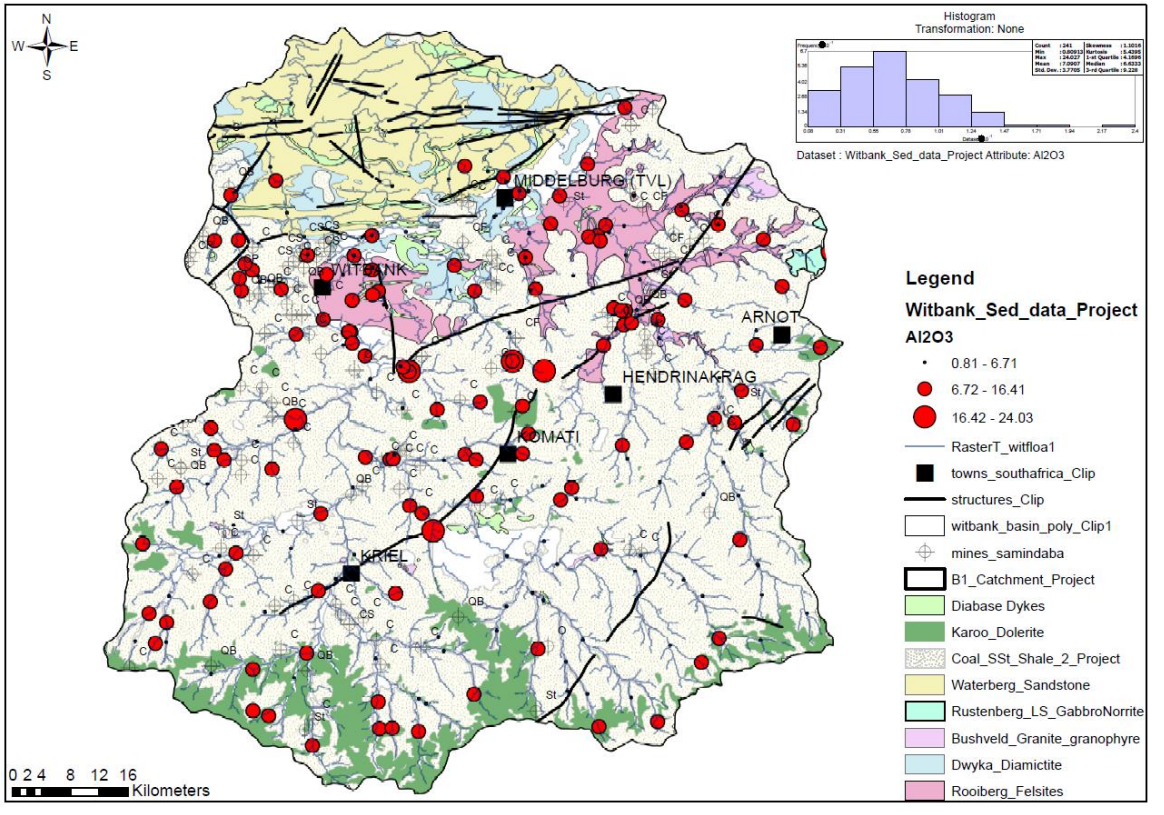


Figure 5-18: Figure indicating the uni-element distribution of aluminium on the ROC, the red are above thethreshold value.

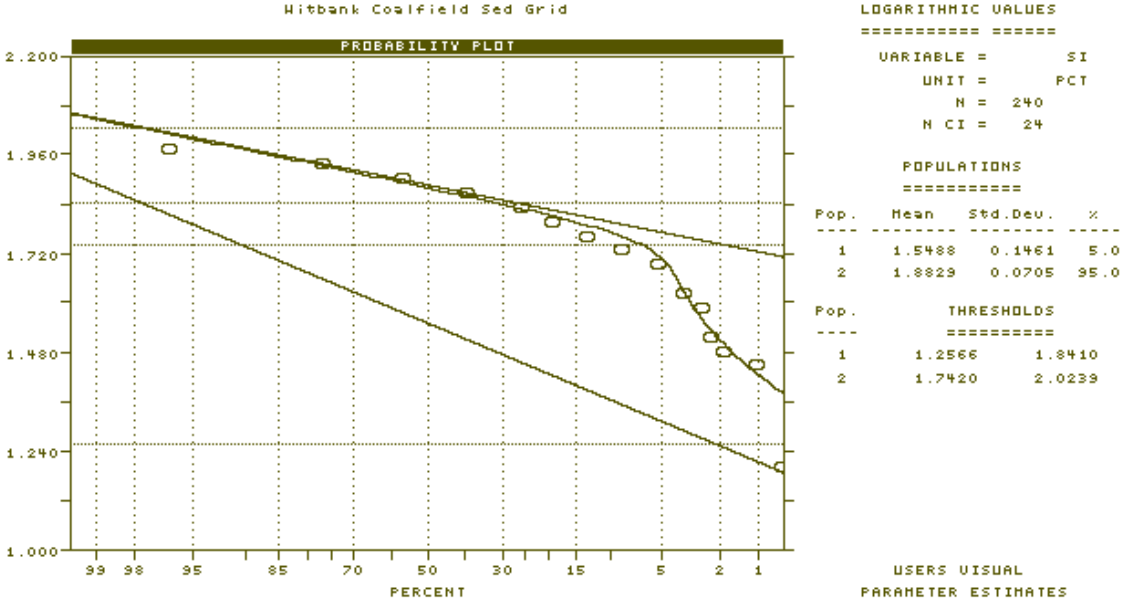


Figure 5-19: Figure indicating the probability plot of silica log concentrations indicating bimodal distribution of two populations which is represented by 5 and 95% respectively. Population 1 indicates the mean of 35.385 (-25.227 and +49.534 std.-dev), population 2 indicate the mean of 76.372 (-64.934 and +89.825 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 18.057 ppm and maximum of 69.341 ppm, population 2 minimum of 55.208 ppm and maximum of 105.649 ppm.

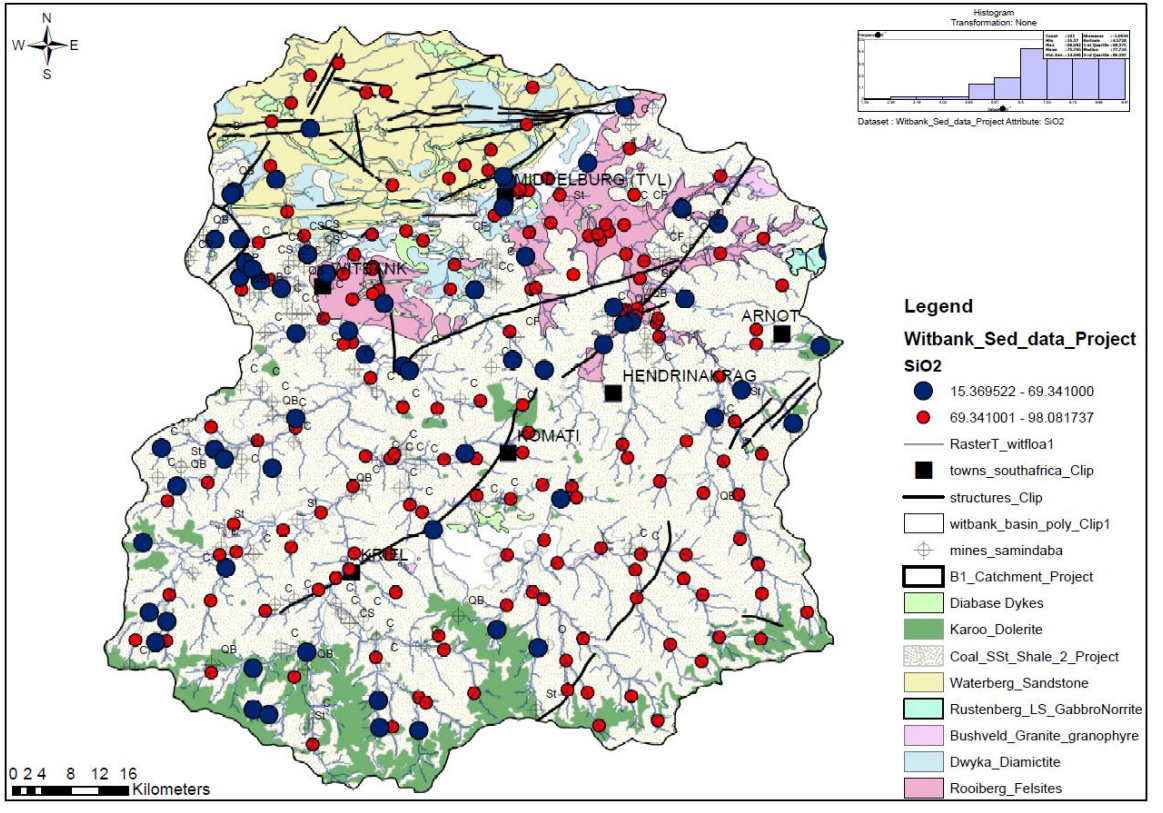


Figure 5-20: Figure indicating the uni-element distribution of As on the ROC, the red are above thethreshold value.

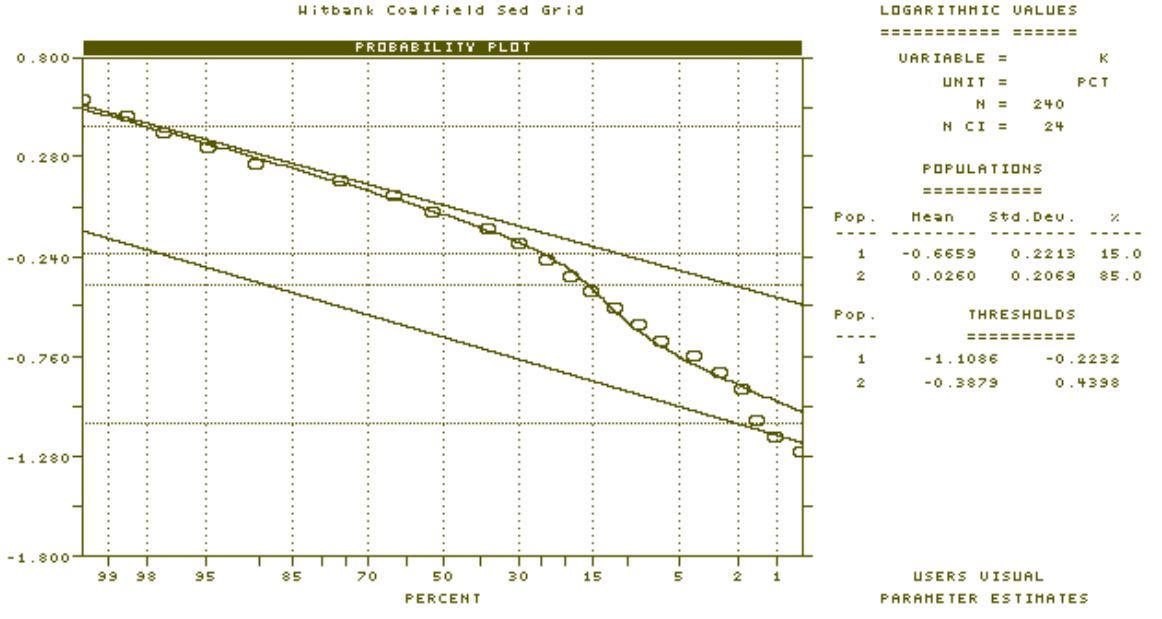


Figure 5-21: Figure indicating the probability plot of potassium log concentrations indicating bimodal distribution of two populations which is represented by 15 and 85% respectively. Population 1 indicates the mean of 0.216 (-0.130 and +0.359 std.-dev), population 2 indicate the mean of 1.062 (-0.659 and +1.710 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.078 wt.% and maximum of 0.598 wt.%, population 2 minimum of 0.409 wt.% and maximum of 2.753 wt.%.

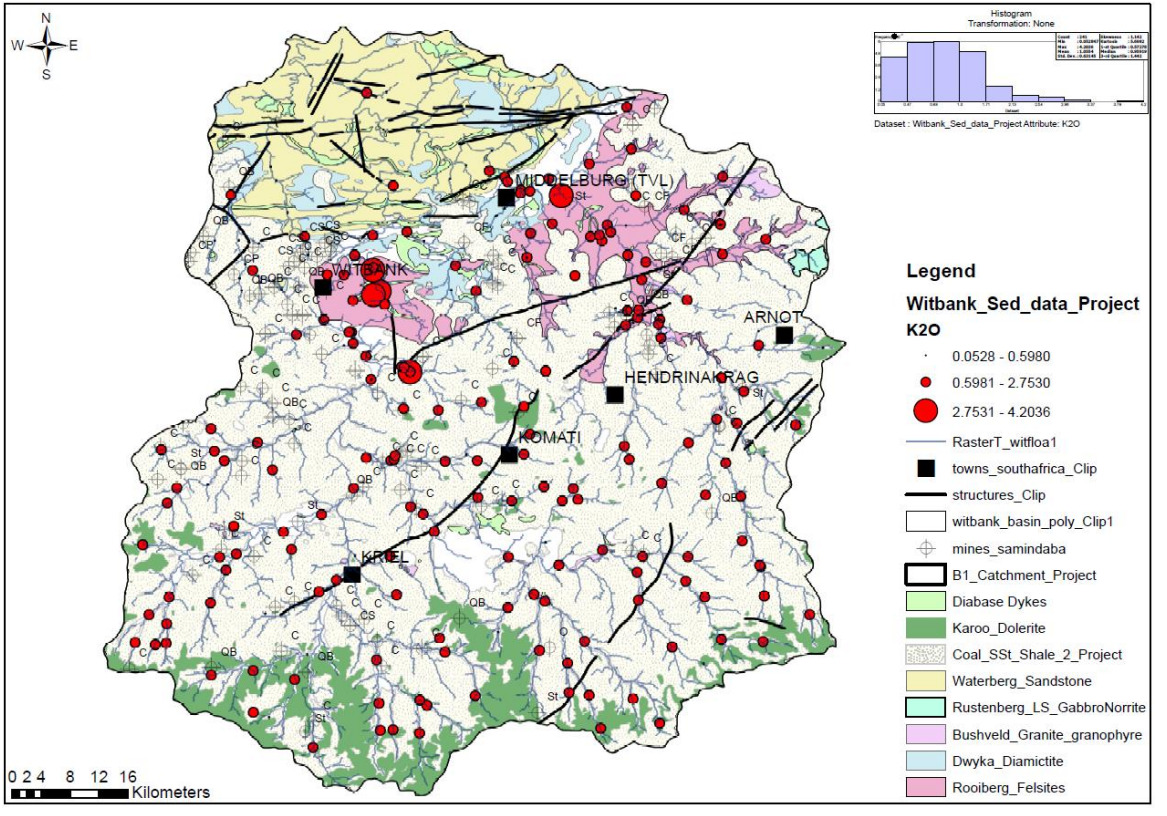


Figure 5-22: Figure indicating the uni-element distribution of potassium on the ROC, the red are above the threshold values.

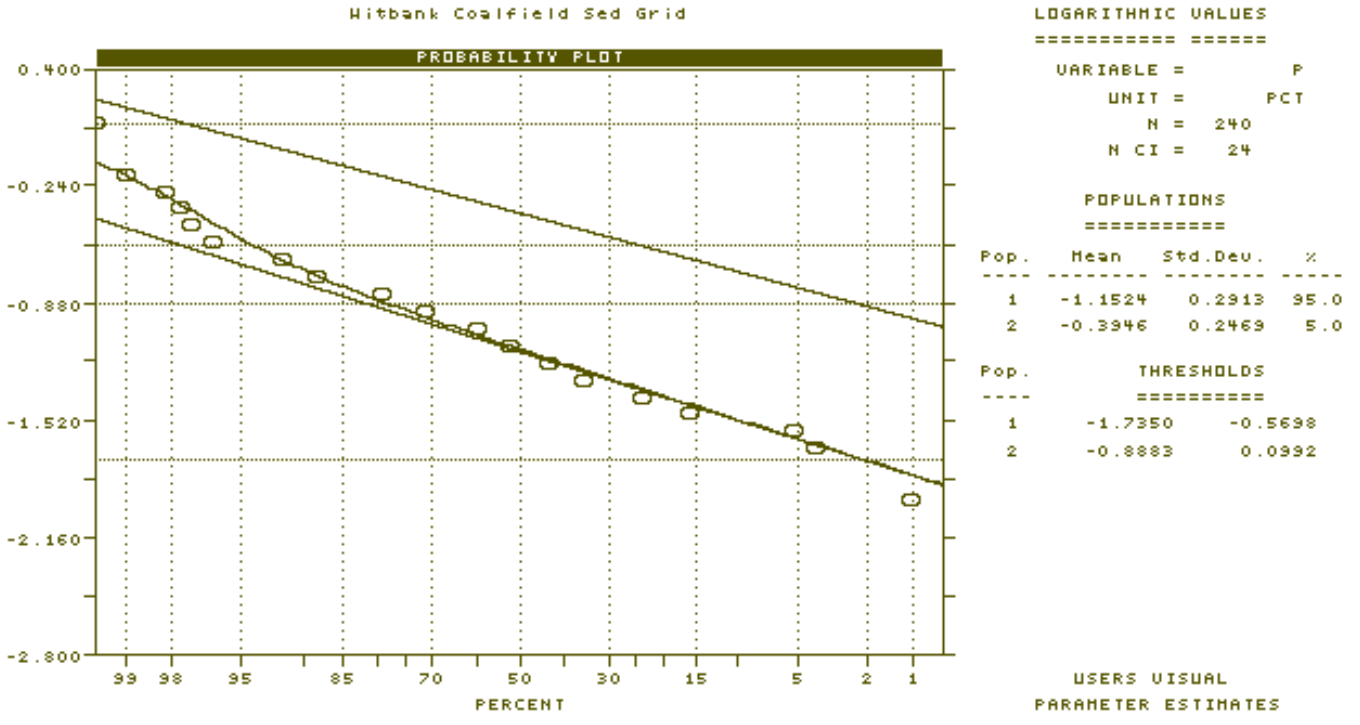


Figure 5-23: Figure indicating the probability plot of phosphate log concentrations indicating bimodal distribution of two populations which is represented by 95 and 5% respectively. Population 1 indicates the mean of 0.070 (-0.036 and +0.138 std.-dev), population 2 indicate the mean of 0.403 (-0.228 and +0.712 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.018 wt.% and maximum of 0.269 wt.%, population 2 minimum of 0.129 wt.% and maximum of 1.256 wt.%.

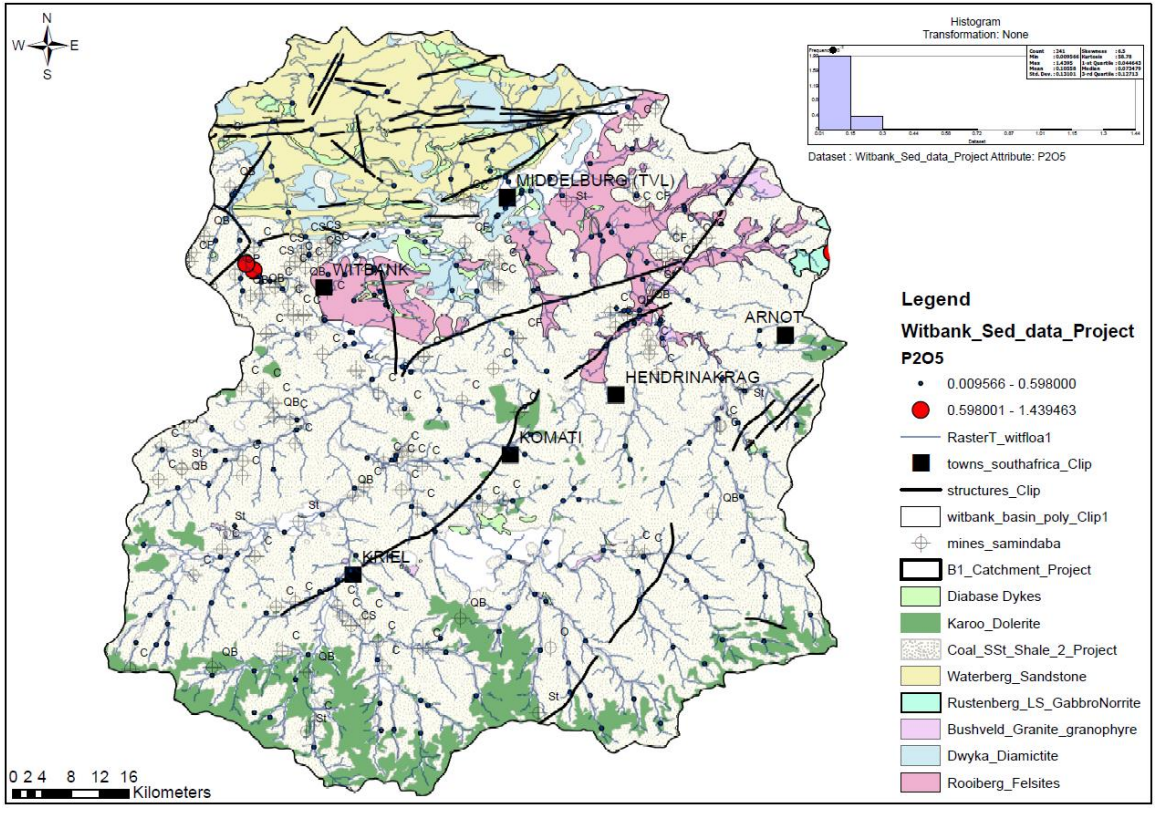


Figure 5-24: Figure indicating the uni-element distribution of phosphorus on the ROC.

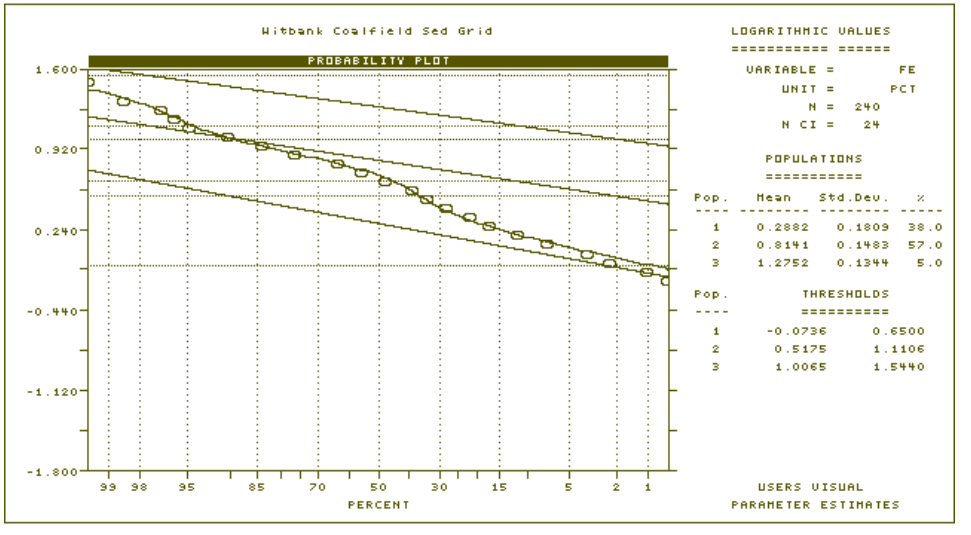


Figure 5-25: Figure indicating the probability plot of iron log concentrations indicating bimodal distribution of three populations which is represented by 38, 57 and 5% respectively. Population 1 indicates the mean of 1.942 (-1.280 and +2.945 std.-dev), population 2 indicate the mean of 6.517 (-4.632 and +9.169 std.-dev) and population 3 indicate the mean of 18.846 (-13.830 and +25.680). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.844 wt.% and maximum of 4.467 wt.%, population 2 minimum of 3.293 wt.% and maximum of 12.900 wt.% and population 3 minimum of 10.150 wt.% and the maximum of 34.993 wt.%.

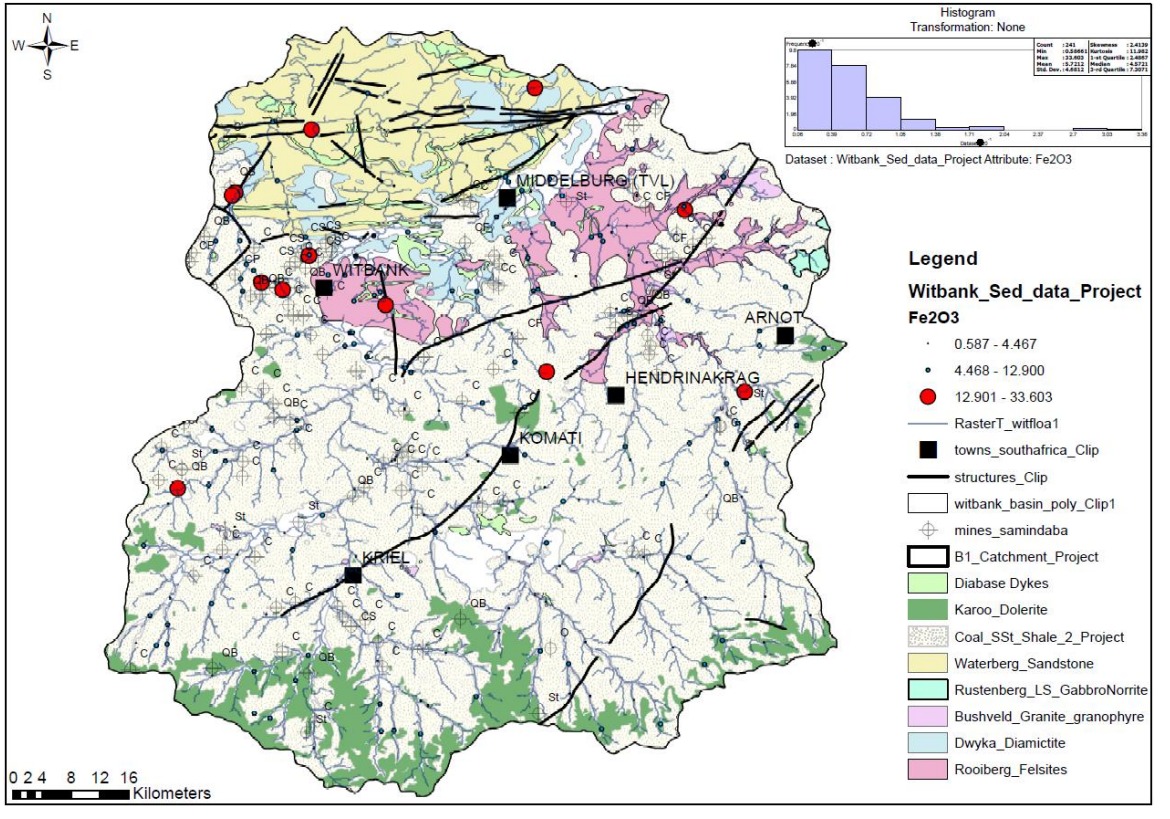


Figure 5-26: Figure indicating the uni-element distribution of total iron on the ROC, the red symbol is above the threshold.

5.3.2 Trace elements

5.3.2.1 Arsenic

Figures 5-28 and 5-29 show that the sediments of the ROC, where the majority of the Ecca coal seams were deposited on the Vryheid Formation, have a lower As content than the lithological units of the Rooiberg felsites. The high anomalous values recorded in the northern region of Witbank or Emalahleni imply the existence of a diverse source, most likely processing factories. Normalized to Si, As indicates an enrichment factor of around 31.5%, whereas selenium indicates an enrichment factor of approximately 71%. The processed materials may originate from the Bushveld Complex. Arsenic is a chalcophile element that forms supra-ore halos in late differentiates and veins. The ore minerals consist of arsenopyrite, realgar, and orpiment, while it substitutes for pyrite, galena, sphalerite, and other sulphides, as well as apatite. It is found in clays, limonite, and pyrite in soils. Arsenic is used to locate resources of Au, Ag, Cu, and Pb-Zn (Levinson, 1974; Sorensen, 1991; Manahan, 1992; Irwin *et al.*, 1997 and references therein). The abnormal distribution of As is mostly concentrated northeast of Witbank and south-southwest of Middelburg, and the samples represent the metals' downstream transport.

Interestingly, Rooiberg felsites include As concentrations that defy expectations. Rooiberg felsites are distinguished for their base metal mineralization (Schweitzer *et al.*, 1995). The Rooiberg felsites are the third mineralization event in reaction to contact metamorphism during the last phases of the Rustenburg Layered Suite, particularly because Pb and Zn were introduced into the felsite

roof rocks. This kind of mineralization impacted the whole of the Rooiberg Group, although it was most prevalent around the contact with the Rustenburg Layered Suite. According to Brookins (1988), the natural As in sediments precipitates under alkaline and mostly reducing conditions. Arsenic is significantly related with the metals Br, Co, Cs, Ge, Hf, Mo, Nb, Se, Sm, Ta, U, W, Zn, and Zr in the Witbank coalfield (Table 5-2). However, it has a limited correlation with the main oxide. As and Co are moderately correlated in the ROC, and this might cause As to precipitate as cobaltite (CoAsS) or safforlite (CoAs). It is essential to remember that the Witbank coalfield has levels as low as 12 ppm. The 12 ppm threshold established by the likelihood plot in Figure 5-27 for As in the Witbank coalfield is more than the element large quantities of volcanic rocks (1-2.1 ppm), limestone (1.1 ppm), and sandstone (1.2 ppm), but equal to shale, which is also 12 ppm (Rose *et al.*, 1979).

Table 5-2: Colour map of Pearson correlations matrix for the 246 stream sediments trace element data, the correlations are significant at $p < .05$, classifications after Moore *et al.* (2013).

	Nd	Pb	Nb	W	Hf	Br	U	Se	Yb	Tl	Bi	Cs	Zn	Co	Sm	Ta	Mo	As	Ge	Cr	Ba	Sr	Sc	V	Ga	Rb	La	Cu	Th	Y	Ni	Zr	Ce
Nd	1.00																																
Pb	0.11	1.00																															
Nb	0.76	0.11	1.00																														
W	0.75	0.09	0.93	1.00																													
Hf	0.73	0.19	0.95	0.90	1.00																												
Br	0.73	0.14	0.97	0.93	0.95	1.00																											
U	0.60	0.02	0.67	0.75	0.71	0.70	1.00																										
Se	0.68	0.12	0.95	0.90	0.93	0.97	0.66	1.00																									
Yb	0.38	0.07	0.44	0.51	0.50	0.46	0.78	0.45	1.00																								
Tl	0.19	0.07	0.22	0.22	0.24	0.23	0.15	0.24	0.14	1.00																							
Bi	0.37	0.17	0.59	0.52	0.60	0.60	0.22	0.62	0.32	0.26	1.00																						
Cs	0.34	0.19	0.41	0.44	0.50	0.49	0.55	0.51	0.59	0.66	0.46	1.00																					
Zn	0.09	0.47	0.14	0.27	0.20	0.19	0.22	0.22	0.14	0.09	0.16	0.28	1.00																				
Co	0.24	0.14	0.29	0.34	0.39	0.40	0.58	0.43	0.52	0.14	0.26	0.70	0.28	1.00																			
Sm	0.27	0.33	0.24	0.28	0.42	0.33	0.38	0.34	0.51	0.14	0.56	0.53	0.32	0.43	1.00																		
Ta	0.19	0.46	0.27	0.31	0.42	0.39	0.27	0.41	0.30	0.57	0.43	0.77	0.42	0.56	0.59	1.00																	
Mo	0.15	0.53	0.27	0.33	0.45	0.39	0.35	0.42	0.37	0.29	0.39	0.63	0.54	0.54	0.66	0.87	1.00																
As	0.10	0.58	0.24	0.28	0.41	0.38	0.27	0.40	0.28	0.13	0.37	0.50	0.50	0.47	0.67	0.78	0.88	1.00															
Ge	0.08	0.45	0.25	0.29	0.40	0.37	0.26	0.46	0.18	0.19	0.34	0.49	0.56	0.55	0.56	0.77	0.84	0.86	1.00														
Cr	-0.07	0.02	-0.08	-0.12	-0.11	-0.13	-0.09	-0.15	-0.09	-0.06	-0.11	-0.15	-0.07	-0.14	-0.15	-0.18	-0.12	-0.19	-0.20	1.00													
Ba	-0.07	-0.07	-0.27	-0.26	-0.37	-0.36	-0.26	-0.41	-0.23	-0.13	-0.30	-0.39	-0.20	-0.34	-0.40	-0.46	-0.51	-0.50	-0.55	0.00	1.00												
Sr	-0.03	-0.10	-0.16	-0.16	-0.23	-0.18	-0.14	-0.21	-0.12	-0.07	-0.16	-0.19	-0.07	-0.16	-0.21	-0.23	-0.27	-0.27	-0.29	0.01	0.49	1.00											
Sc	0.07	-0.07	-0.17	-0.22	-0.25	-0.23	-0.19	-0.28	-0.17	-0.11	-0.22	-0.27	-0.16	-0.20	-0.29	-0.31	-0.37	-0.37	-0.38	0.13	0.49	0.47	1.00										
V	-0.01	0.08	-0.09	-0.20	-0.10	-0.16	-0.17	-0.18	-0.12	-0.06	-0.14	-0.19	-0.26	-0.14	-0.20	-0.18	-0.21	-0.24	-0.26	0.26	0.19	0.19	0.55	1.00									
Ga	0.09	0.19	-0.12	-0.20	-0.25	-0.25	-0.22	-0.31	-0.18	-0.08	-0.23	-0.27	-0.04	-0.26	-0.31	-0.33	-0.37	-0.38	-0.40	0.16	0.50	0.45	0.72	0.42	1.00								
Rb	0.10	0.22	-0.07	-0.09	-0.18	-0.20	-0.14	-0.25	-0.13	0.04	-0.18	-0.18	0.06	-0.23	-0.26	-0.27	-0.33	-0.33	-0.36	-0.04	0.60	0.19	0.28	0.00	0.70	1.00							
La	0.28	0.13	-0.14	-0.17	-0.25	-0.25	-0.19	-0.30	-0.16	-0.08	-0.22	-0.28	0.00	-0.23	-0.25	-0.35	-0.36	-0.37	-0.40	0.12	0.48	0.27	0.52	0.19	0.70	0.63	1.00						
Cu	0.06	0.16	-0.09	-0.15	-0.14	-0.14	-0.12	-0.19	-0.08	-0.04	-0.13	-0.13	-0.05	-0.08	-0.15	-0.13	-0.17	-0.20	-0.23	0.21	0.40	0.40	0.75	0.56	0.68	0.22	0.38	1.00					
Th	0.09	0.27	0.01	-0.07	-0.03	-0.17	-0.12	-0.19	-0.11	-0.02	-0.15	-0.17	0.09	-0.19	-0.20	-0.20	-0.20	-0.24	-0.26	0.13	0.31	0.14	0.31	0.34	0.70	0.67	0.56	0.35	1.00				
Y	0.41	0.13	0.01	-0.11	-0.05	-0.07	-0.10	-0.10	-0.07	-0.04	-0.09	-0.14	-0.18	-0.11	-0.10	-0.19	-0.22	-0.21	-0.24	0.07	0.18	0.09	0.34	0.23	0.46	0.34	0.69	0.29	0.35	1.00			
Ni	0.12	0.13	-0.06	-0.09	-0.09	-0.06	-0.03	-0.10	0.01	-0.02	-0.05	0.00	0.00	0.07	-0.03	-0.02	-0.04	-0.06	-0.09	0.10	0.27	0.55	0.61	0.39	0.49	0.10	0.34	0.62	0.12	0.25	1.00		
Zr	-0.01	0.33	-0.05	-0.06	0.04	-0.10	-0.06	-0.11	-0.05	0.00	-0.08	-0.03	0.27	-0.02	0.06	0.05	0.12	0.11	0.10	-0.01	0.00	-0.22	-0.12	-0.12	0.16	0.36	0.21	-0.07	0.34	0.19	-0.15	1.00	
Ce	0.59	0.34	0.29	0.23	0.20	0.20	0.15	0.14	0.04	0.03	0.01	-0.05	-0.08	-0.06	-0.10	-0.16	-0.17	-0.21	-0.26	0.14	0.36	0.14	0.39	0.36	0.49	0.38	0.60	0.41	0.44	0.56	0.34	0.10	1.00

	Very strong (≥8)
	Strong (≥6<8
	Average (≥5<6
	Weak (≥4<5)
	Very weak (>4)

Table 5-3: Color map of Pearson correlations matrix for the 246 stream sediments major oxide data, the correlations are significant at $p < .05$, classifications after Moore *et al.* (2013).

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cr_2O_3	LOI
SiO_2	1.0											
TiO_2	-0.4	1.0										
Al_2O_3	-0.8	0.4	1.0									
Fe_2O_3	-0.6	0.5	0.4	1.0								
MnO	-0.4	0.1	0.3	0.3	1.0							
MgO	-0.4	0.2	0.4	0.2	0.5	1.0						
CaO	-0.4	0.1	0.3	0.2	0.6	0.7	1.0					
Na_2O	-0.2	0.2	0.3	0.2	0.3	0.5	0.6	1.0				
K_2O	0.0	0.0	0.3	-0.1	0.1	-0.1	-0.1	0.3	1.0			
P_2O_5	-0.5	0.2	0.4	0.3	0.1	0.0	0.1	0.1	-0.1	1.0		
Cr_2O_3	-0.2	0.0	0.3	0.1	0.3	0.7	0.1	0.0	-0.1	0.0	1.0	
LOI	-0.8	0.1	0.4	0.2	0.1	-0.1	0.0	-0.1	-0.2	0.5	0.0	1.0

	Very strong (≥8)
	Strong (≥6<8
	Average (≥5<6
	Weak (≥4<5)
	Very weak (>4)

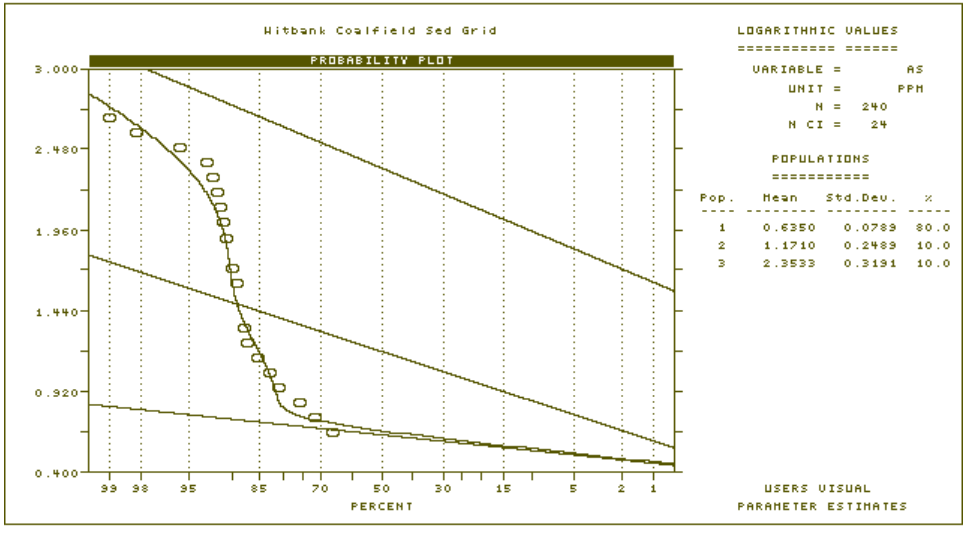


Figure 5-27: Figure indicating the probability plot of As log concentrations indicating bimodal distribution of three populations divided at 80% and 90% percentile, population 1 indicate the mean of 4.963 (-3.1 and +7.946 std.-dev), population 2 indicate the mean of 225.685 (-100.215 and +470.337 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 1.936 ppm and maximum of 12.721 ppm, population 2 minimum of 51.907 ppm and maximum of 908.552 ppm.

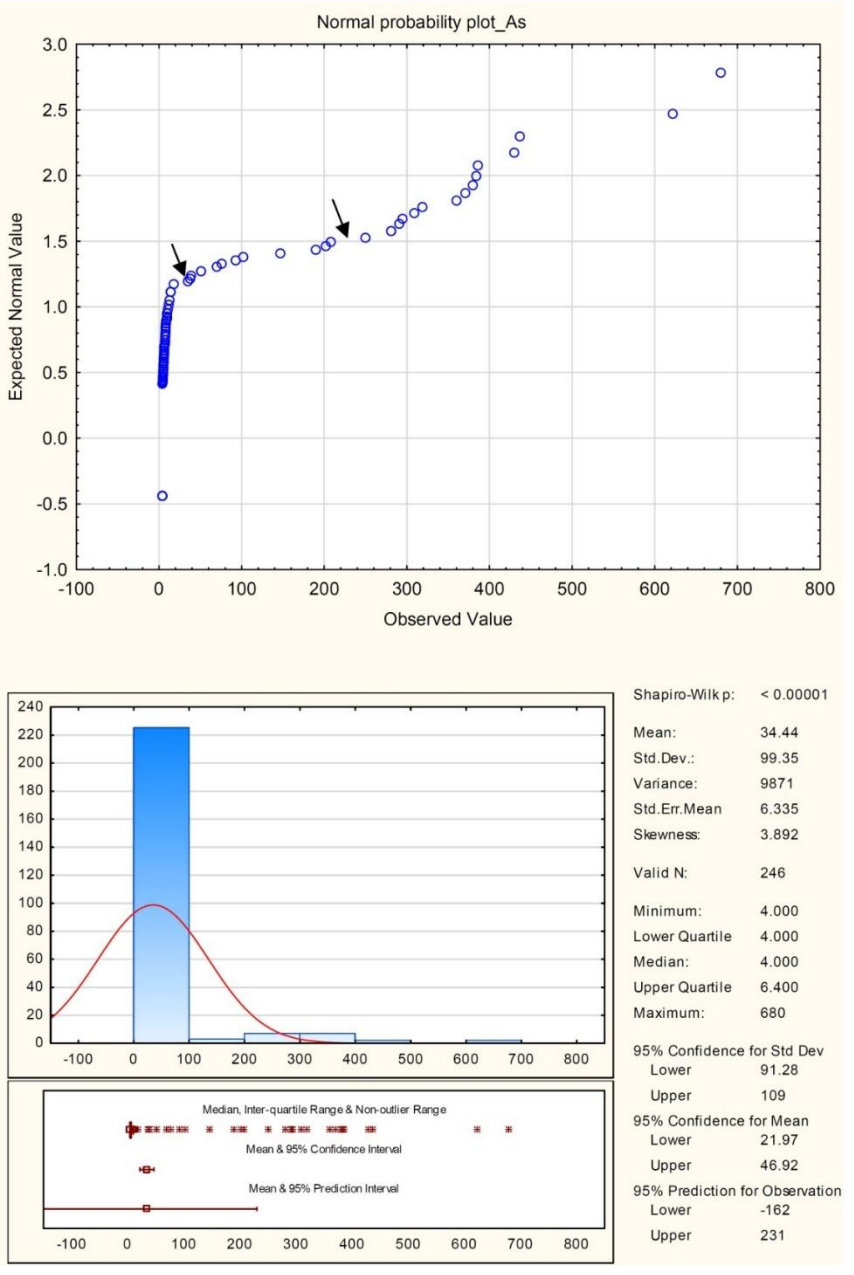


Figure 5-28: The normal probability plot, histogram and box and whisker plots with the summary statistics of As in the ROC. The inflexion points are the borders between different populations

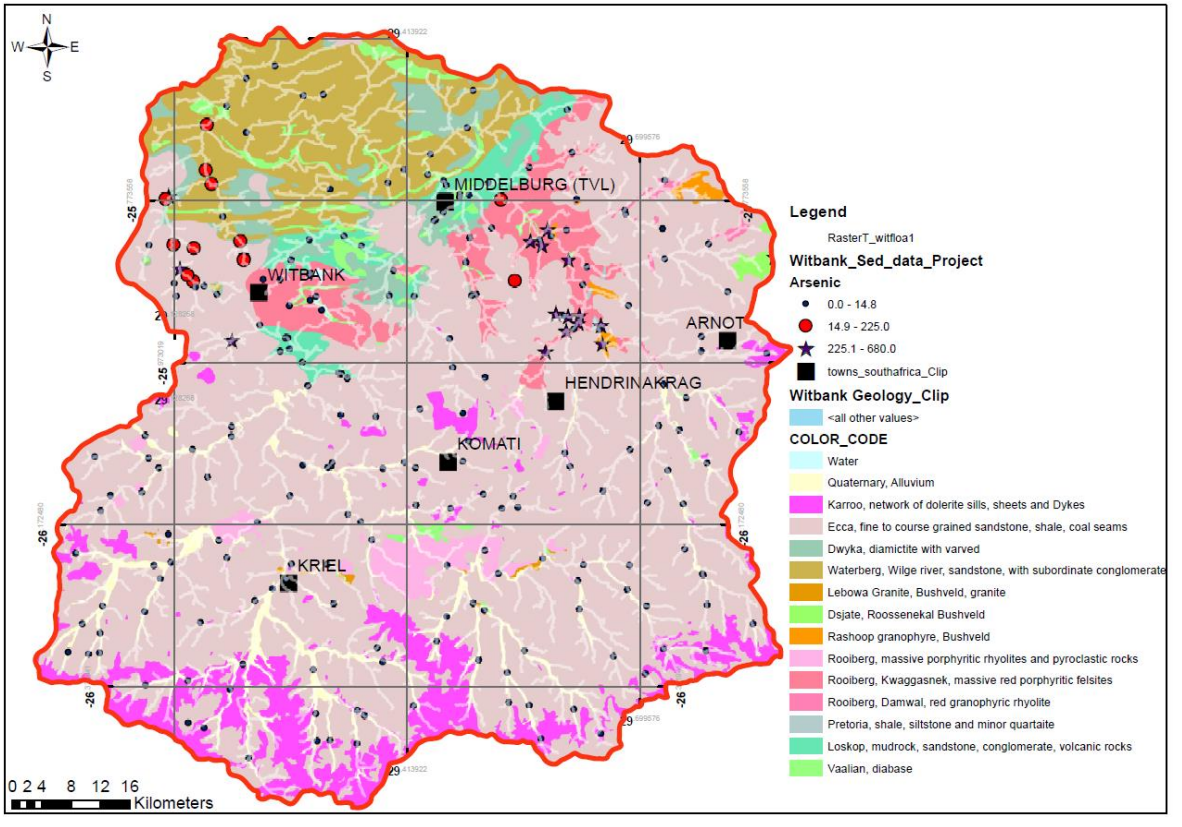


Figure 5-29: Figure indicating the uni-element distribution of As on the ROC. The anomalous distribution of As is mainly located north-east of Witbank and SSW of Middelburg area.

5.3.2.2 Uranium

Uranium concentrations in the stream sediments of the ROC range from a minimum of 2 ppm to a maximum of 1898 ppm and are positively skewed (Figure 5-31). There are three recognized populations (Figure 5-30). The anomalous upper population threshold of 265 ppm is situated in the western section of the city of Witbank (Figure 5-32). The second population threshold of 4 ppm is predominantly located in granitic and Waterberg Group rocks (Figure 5-32). The third population is the backdrop on the Witbank coalfield deposits. The U has moderate associations with Cs and Co and significant associations with Nd, Nb, W, Hf, Se, and Yb (Table 5-2).

Uranium is lithophile and abundant in the igneous rocks pegmatite and carbonatite (Levinson, 1974). It is rich in sandstone and placers in sediments. In the bedrock geochemistry of this study, uranium is highly related with rare-earth elements. Uranium also substitutes in zircon, apatite, allanite, niobate-tantalates, and monazite, and it acts as a guide for locating U deposits, Au-U placers, Ag-Au veins, and carbonatites (Levinson, 1974). Commonly, soil has varying levels, but the average is around 2 ppm (Levinson, 1974). Other sources, such as fertilizers derived from phosphate rocks, may contain greater concentrations of U than natural soils. In the mining environments of underground and open pit, uranium concentrations may be greater (Irwin *et al.*, 1997 and references therein).

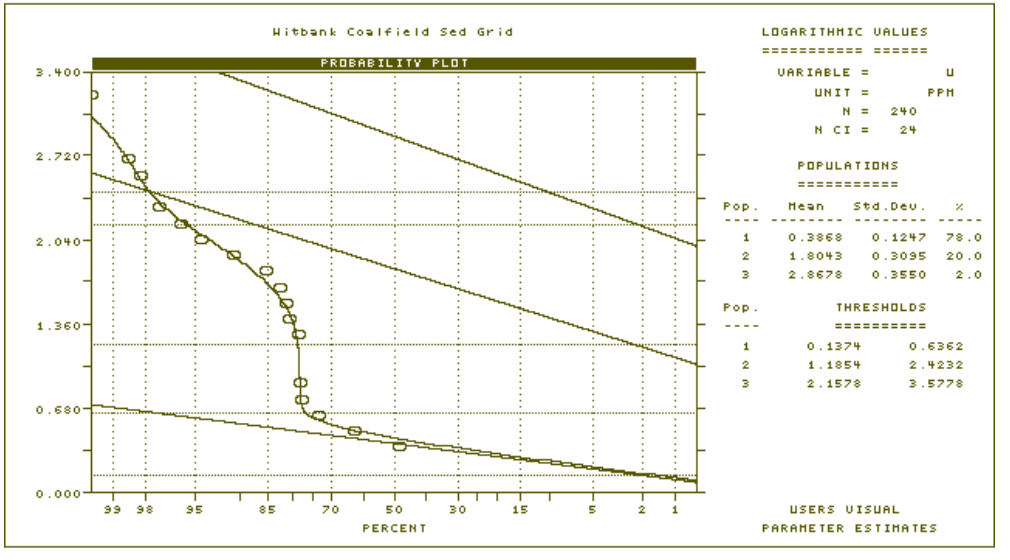
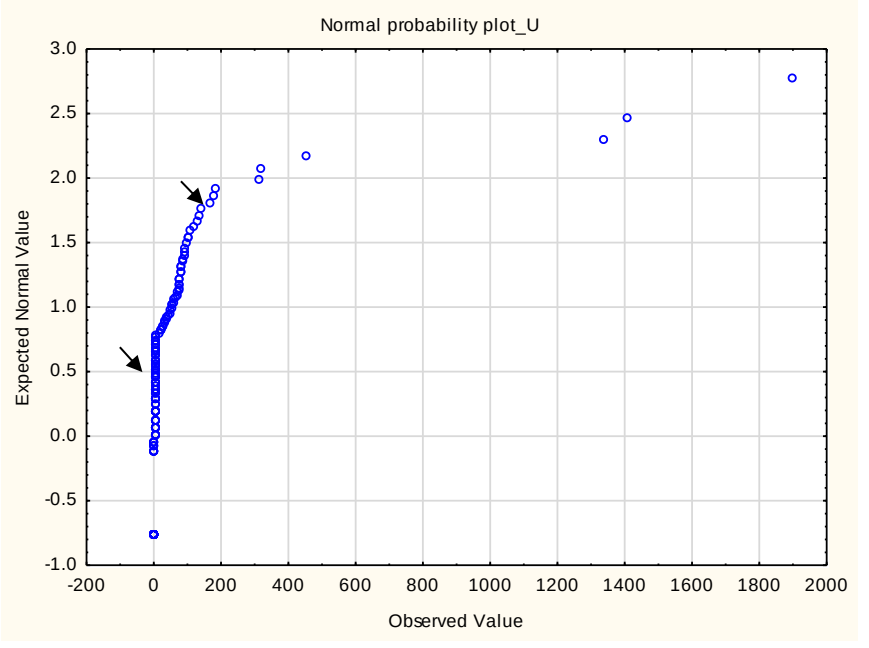


Figure 5-30: Figure indicating the probability plot of indicating bimodal distribution of three populations of U at 78, 20 and 2%. Population 1 indicates the mean of 2.437 (-1.829 and +3.247 std.-dev), population 2 indicate the mean of 63.725 (-31.250 and +129.947 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 1.372 ppm and maximum of 4.327 ppm, population 2 minimum of 15.325 ppm and maximum of 264.989 ppm and population 3 minimum of 143.829 ppm and the maximum of 1898 ppm.



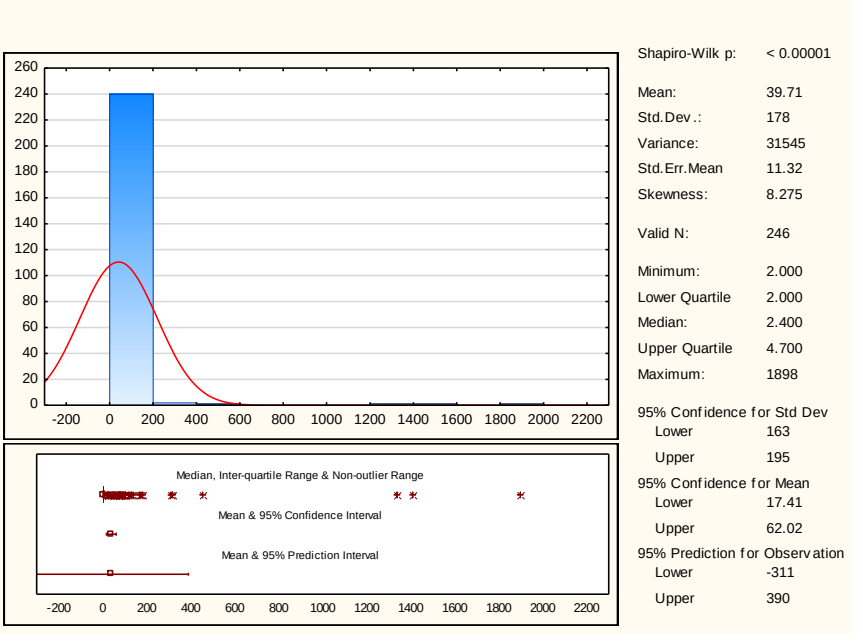


Figure 5-31: Depicts the normal probability plot, the histogram, and the box and whisker plots for U in the ROC.

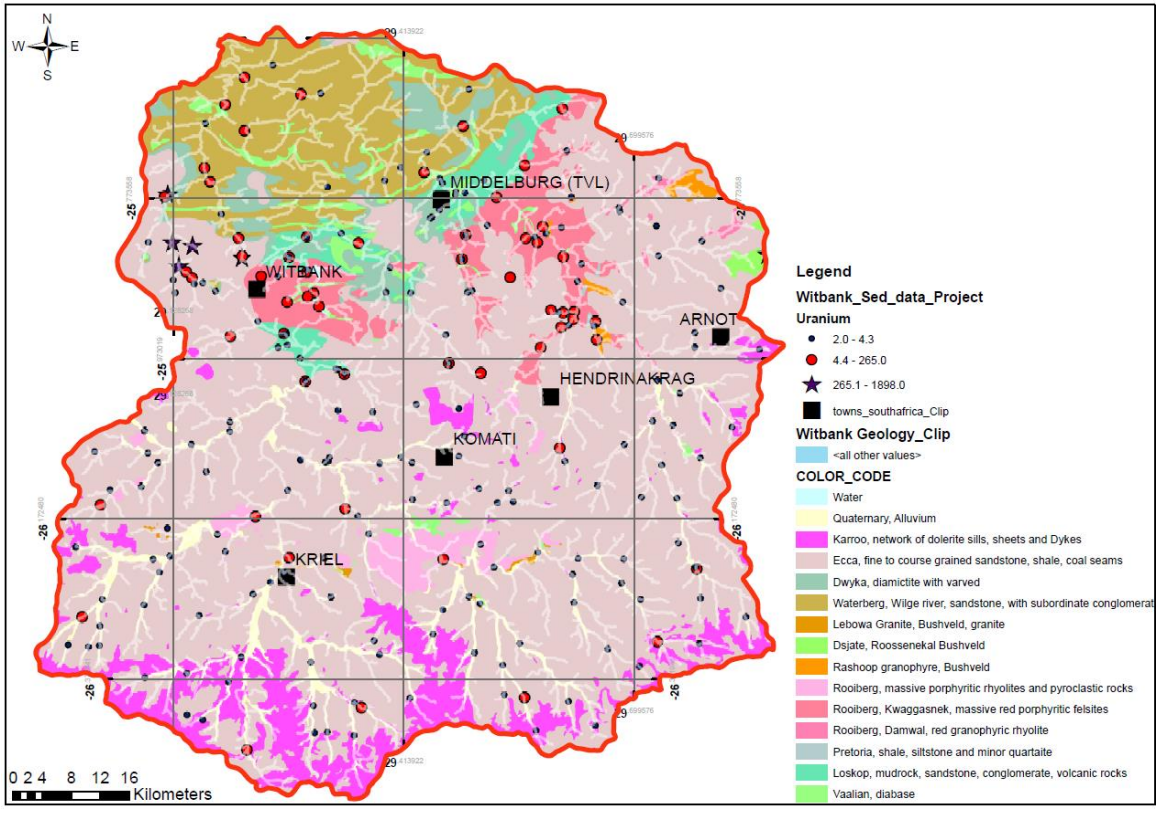


Figure 5-32: Figure indicating the element distribution of U on the ROC.

5.3.2.3 Zinc

Two Zn populations were discovered (Figure 5-33). Minimum Zn concentration is 3 ppm and maximum concentration is 724 ppm (Figure 5-34 and Table 5-1). The median value is less than the mean value, suggesting a heterogeneous distribution and positively skewed data (Figure 5-34). The upper limit criterion of the first population was at the mean plus 2 std.-dev from the mean at 112.7 ppm (Figure 5-33). The 112.74 ppm threshold determined by the probability map separates the background and abnormal populations (Figure 5-33). The abnormal Zn content is found in the felsites rocks of Rooiberg.

Sphalerite (ZnS) is the principal Zn mineral. It is contained in sulphide ores ranging from those of magmatic origin to those produced at the surface under reducing circumstances. Zinc is a chalcophile that is mostly found in intermediate igneous rocks, shales, and black shales (Levinson, 1974). In minerals such as biotite, amphibole, and magnetite, zinc also substitutes. Zinc is adsorbed or co-precipitated on Fe-Mn oxides and organic materials and clays in soils (Levinson, 1974). Zinc acts as a guide for the discovery of Pb deposits, Zn-Pb-Ag deposits, fluorite deposits, polymetallic sulphide deposits, skarn deposits, porphyry Copper deposits, and countless other deposits (Levinson, 1974). It has a high degree of mobility in both primary and secondary contexts.

The Vryheid Formation, comprised of sandstones, shales, and coal, is home to the background population. A large concentration of Zn is situated in the northwest portion of Witbank, which is downstream of the Transvaal and Delagoa Bay colliery (abandoned and unclaimed mines) and the processing plants. In addition, there are isolated abnormalities in the Vryheid Formation. The anomalous Zn readings on the

Rooiberg felsites might be indicative of the base metal mineralization documented by Schweitzer *et al.*, (1995). Zinc has a significant correlation with As, Br, Co, Ge, Mo, Nb, U, and W. The average Zn content of 45 ppm is lower than that of the crust of the earth (70 ppm) and ultra-mafic rocks (50 ppm) (Levinson, 1974). The abnormal Zn levels range from 112.74 ppm to 558 ppm, which is above the average for the earth's crust.

Similar to the As anomalies, the Zn concentration is mostly seen in the vicinity of Middleburg and Witbank (Figure 5-35). The samples demonstrate the flow downstream. The Vryheid formation rocks have a lower Zn content than the Bushveld Rooiberg felsites rocks. To the east of the Witbank, where Transvaal and Delagoa Bay colliery abandoned and unclaimed mines are situated, as well as the Witbank Steel and Vanadium processing plants, the Vryheid Formation contains a significant concentration of Zn (Figure 5-35).

On the Rooiberg felsites, abnormal As concentrations may indicate the presence of base metal mineralization. This might be corroborated by the study conducted by Schweitzer *et al.* (1995). This mineralization was defined as the third mineralizing event that occurred as a result of contact metamorphism during the last phases of the Rustenburg Layered Suite, when Pb and Zn were particularly introduced into the felsite roof rocks. This kind of mineralization affects the entirety of the Rooiberg Group, however it is most prevalent around the contact with the Rustenburg Layered Suite. As, Br, Co, Ge, Mo, Nb, U, and W are strongly correlated with Zn. The std.-dev value of 60 ppm in Figure 5-30 and Table 5-1 is more than the mean value of 45 ppm and the median value of 33 ppm. Statistical findings imply that Zn is distributed heterogeneously in sediments. The average Zn content of 45 ppm is lower than that of the crust of the earth (70 ppm) and ultra-mafic rocks (50 ppm) (Levinson, 1974). The abnormal Zn levels vary from 167 ppm to a high of 558 ppm,

which is above the average for the earth's crust. Using the probability plots in Figure 5-33, the threshold was established, and two populations were observed. The upper threshold's background population is 112.73 ppm, which is where the majority of the Vryheid Formation is found. The second population is found on the felsites of Rooiberg, where concentrations vary from 112.73 to 692.26 ppm. The second Zn population is dispersed across the strata of the Witbank coalfield. In contrast, the third population is concentrated in the northeastern region of the town of Witbank. The anomaly is positioned on the structure's east-west trend and likely suggests a Zn hydrothermal enrichment event.

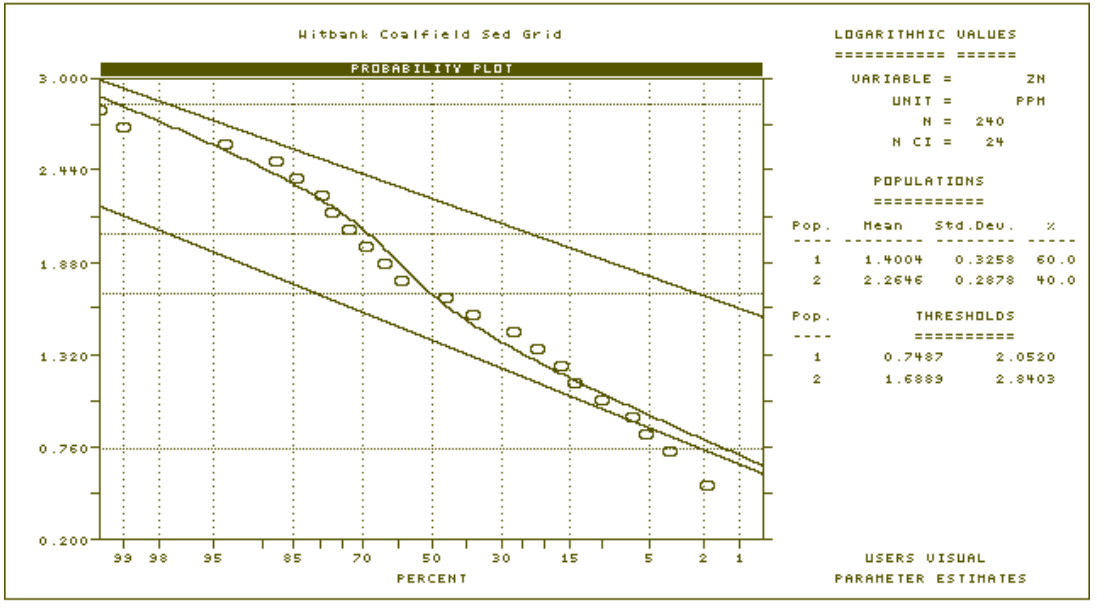
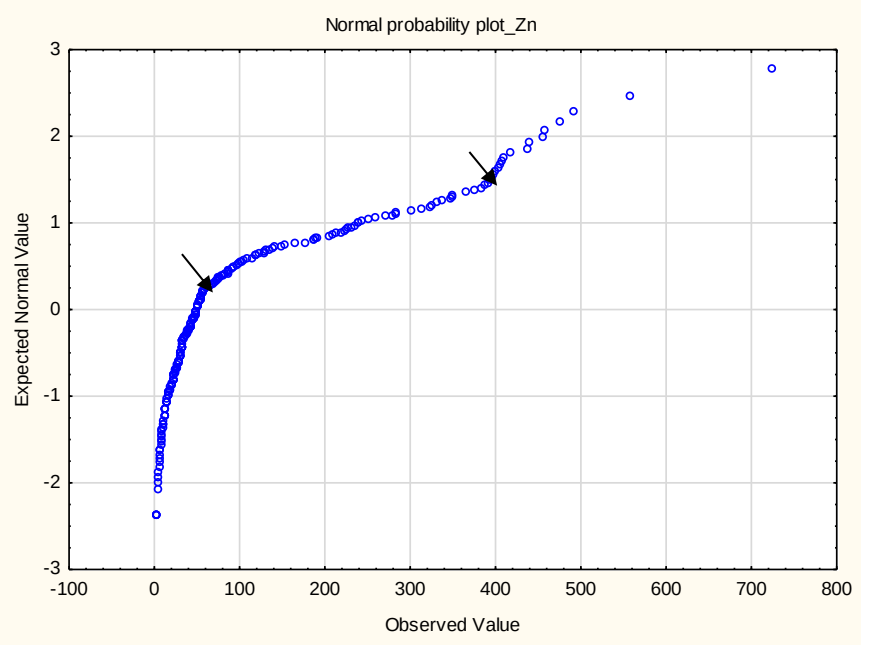


Figure 5-33: Figure indicating the probability plot of indicating bimodal distribution of two populations of Zn divided at 60% percentile, population 1 indicate the mean of 25.140 (-11.872 and +53.235 std.-dev), population 2 indicate the mean of 183.987 (-94.790 and +356.808 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 5.607 ppm and maximum of 112.728 ppm, population 2 minimum of 48.857 ppm and maximum of 692.261 ppm.



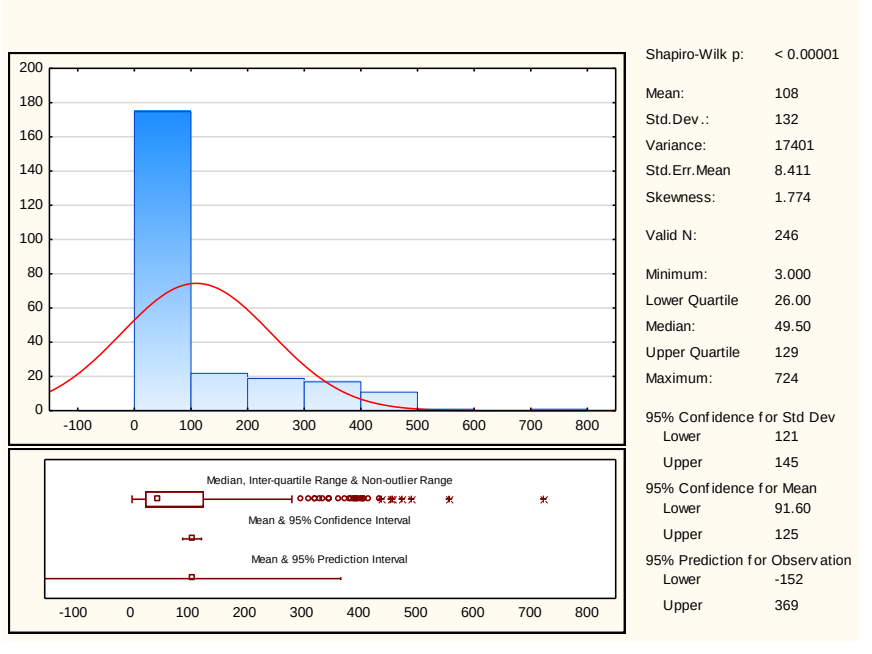


Figure 5-34: The normal probability plot, histogram and box and whisker plots with the summary statistics of Zn in the ROC.

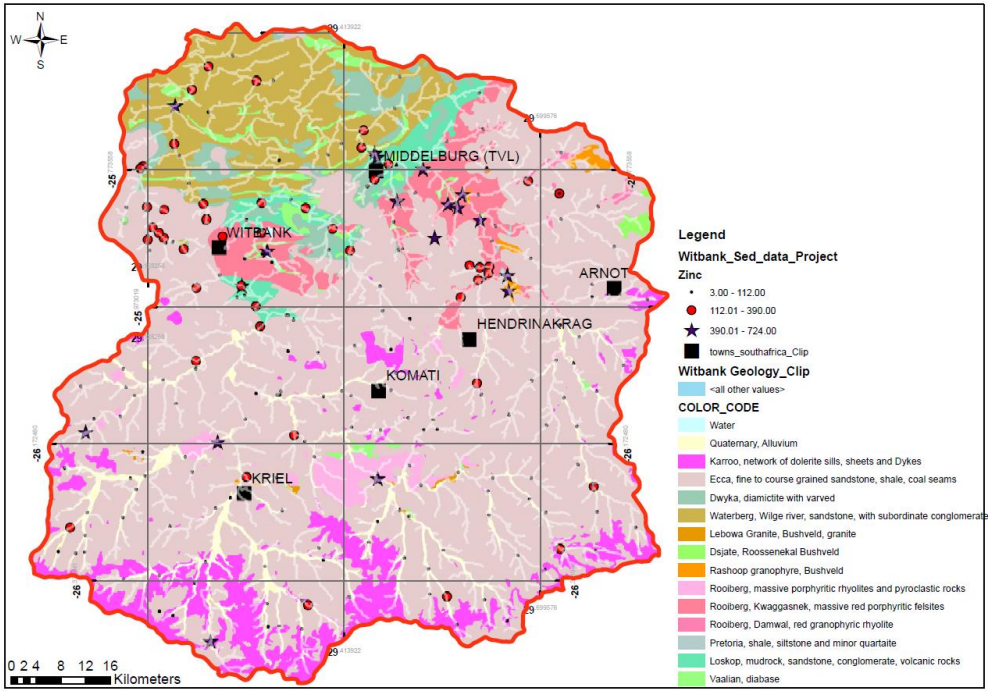


Figure 5-35: Figure indicating the uni-element distribution of Zinc on the ROC. The anomalous distribution of Zn is mainly located north-east of Witbank and SSW of Middelburg area, the samples the downstream deportment of metals.

5.3.2.4 Lead

The minimal quantity of Pb is 2.9 ppm and the maximum concentration is 98 ppm (Figure 5-37 and Table 5-1). The median value of 19 ppm is slightly lower but closer to the mean of 23.9 ppm, which may indicate the presence of a heterogeneous data distribution (Figure 5-37). The upper limit criterion of the first population was at the mean plus 2 std.-dev from the mean of 11.66 ppm (Figure 5-36). Using the probability map, a threshold of 11.7 ppm separates the background population from the abnormal population (Figure 5-36). The samples of the background population are found in the Waterberg rocks (Figure 5-38). With a threshold of 51.08 ppm, the medium population reflects the background population of the Vryheid Formation, which consists of sandstones, shales, and coal. The statistics indicate that the abnormal population ranges from 51.09 ppm to a high of 98 ppm (Table 5-1). The unusual concentration is situated on the felsites rocks of Rooiberg (Figure 5-38).

Lead is a chalcophile that accumulates in felsic igneous rocks and in sedimentary black shales. Galena is the primary ore mineral, however Pb may also be found in potassium feldspar, plagioclase, mica, zircon, and magnetite. It exists as galena, anglesite, and sericite in soil and is absorbed by clays and organic materials. Lead is an indicator of the presence of Pb deposits, Uranium deposits, and multimetallic vein deposits (Levinson, 1974).

Lead is concentrated in sediments above coal seam no. 5 as reported in chapter 3. Some naturally occurring and synthetic compounds include Pb, yet do not seem metallic (Irwin *et al.*, 1997 and references therein). Some of these materials can burn (Irwin *et al.*, 1997 and references therein). Lead resembles several alkaline earth metals (Ca, Sr, and Ba) in terms of absorption, internal distribution, and secretion (Sorensen, 1991; Irwin *et al.*, 1997 and references therein).

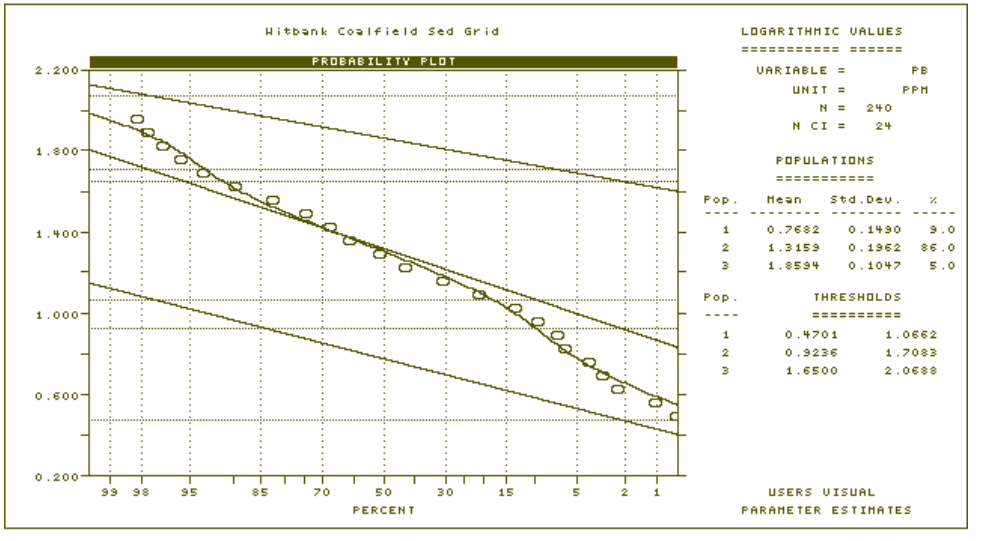


Figure 5-36: Figure indicating the probability plot of indicating bimodal distribution of three populations of Pb at 9, 86 and 5%. Population 1 indicates the mean of 5.864 (-4.161 and +8.265 std.-dev), population 2 indicate the mean of 20.698 (-13.175 and +32.516 std.-dev). The thresholds calculated at 2 std.-dev for population 1 is minimum 2.952 ppm and maximum of 11.648 ppm, population 2 minimum of 8.387 ppm and maximum of 51.080 ppm and population 3 minimum of 44.671 ppm and the maximum of 117.154 ppm.

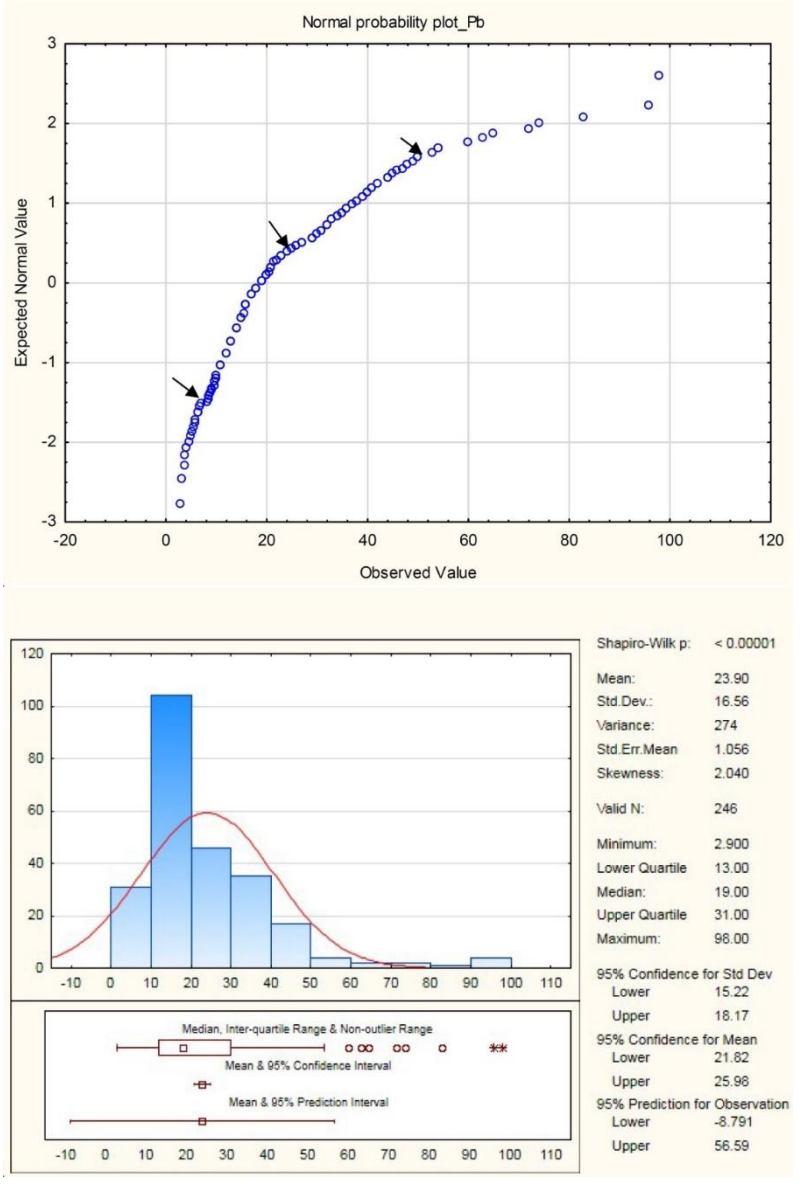


Figure 5-37: The normal probability plot, histogram and box and whisker plots with the summary statistics of Pb in the ROC.

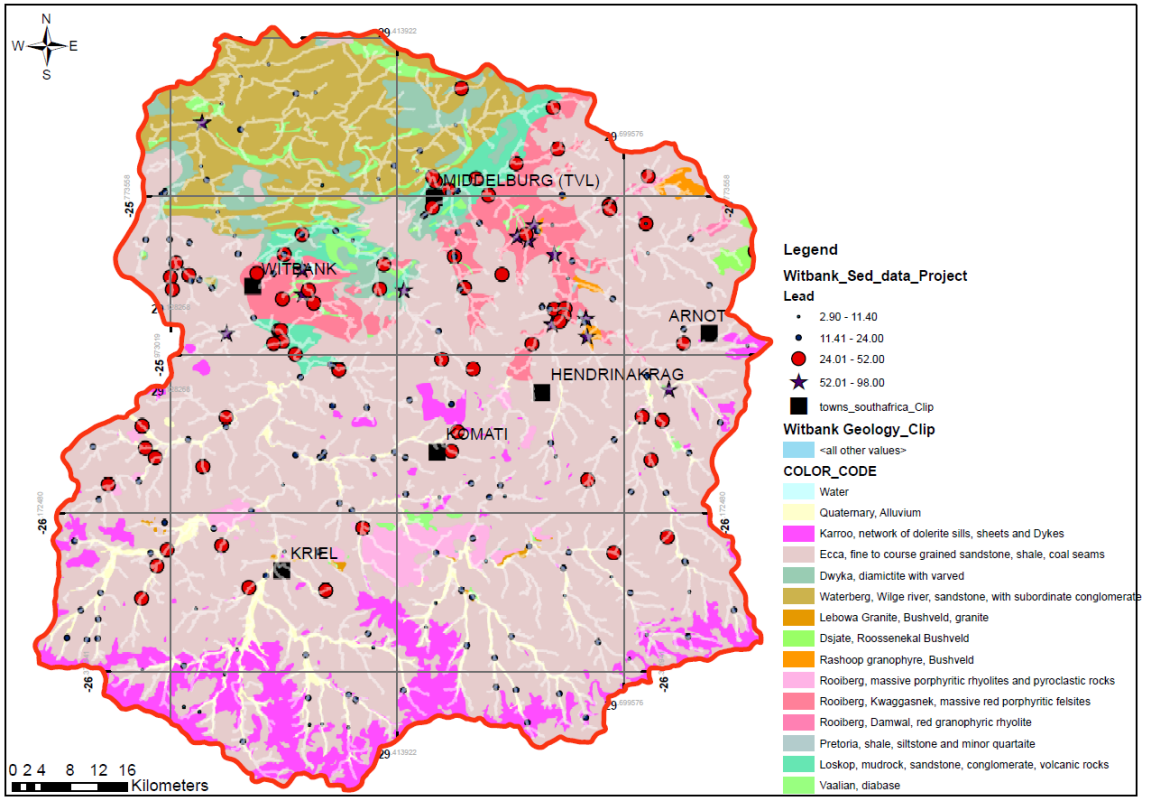


Figure 5-38: Figure indicating the uni-element distribution of Pb on the ROC.

5.3.2.5 Vanadium

Figures 5-40 and 5-41 depict vanadium with a minimum concentration of 3 ppm and a maximum concentration of 1028b ppm. Figure 5-40 depicts three populations, with the top population threshold set at 972 ppm. In the western section of Witbank city, close to the steel processing plant, the upper threshold is unusual. The second population with a 250 ppm threshold is found close to the dolerite dykes in the upper ROC (Figure 5-41). The sedimentary units of the research region are related with the third population, which has a threshold of 38 ppm. The alleged source (Figure 5-41) consists of the Karro dolerite sills and the V smelting area to the west of Witbank. Mobilization of V from magnetite is conceivable, as is precipitation/adhesion to caly minerals and Fe-Mn-oxihadoxites (Rose *et al.*, 1979).

Vanadium is predominantly lithophile but can be siderophile at favorable pressure conditions. Vanadium is related to Ti, Fe, and P in V-rich magnetites and Cu, Pb, Zn, Mo, Ag, Au, and As in polymetallic sulphide deposits (Levinson, 1974). In addition, sandstone-type U ores and P, U, F, Se, As in phosphorites and black shales are connected with it (Levinson, 1974).

Vanadium is a directional indicator for sandstone, classical vein, and unconformity vein-U deposits. Vanadium is an excellent indication of vanadiferous magnetite deposits and V deposits (Levinson, 1974). In this study, a substantial correlation exists between V and Cu and Ni (Table 5-2).

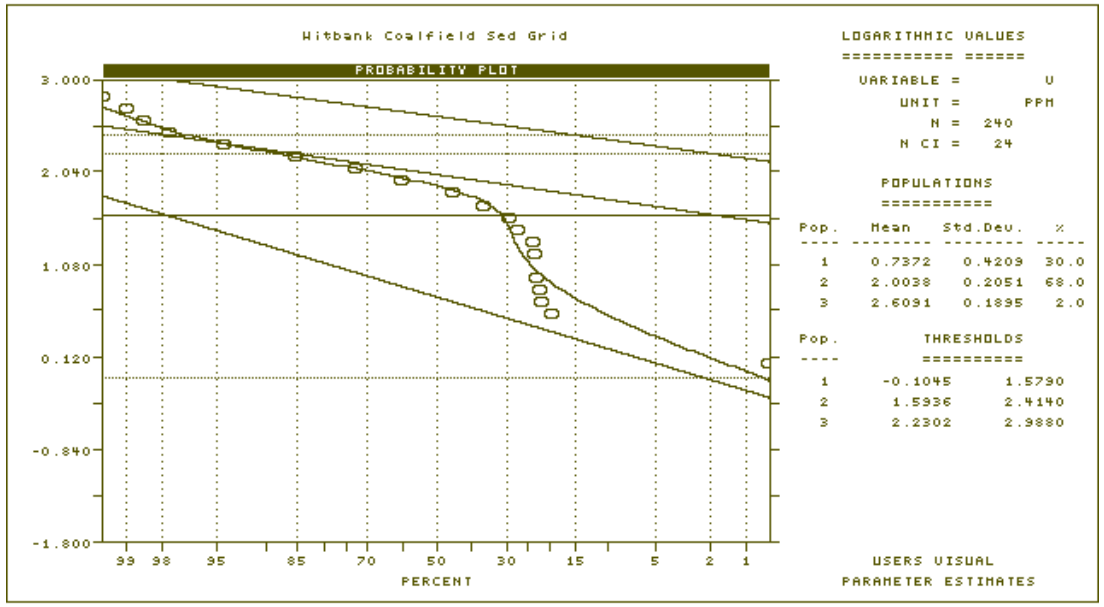


Figure 5-39: Figure indicating the probability plot of V indicating bimodal distribution of three populations which is represented by 30, 68 and 2% respectively. Population 1 indicates the mean of 5.460 (-2.072 and +14.391 std.-dev), population 2 indicate the mean of 100.877 (-62.906 and +161.761 std.-dev) and population 3 indicate the mean of 406.550 (-262.818 and +628.885). The thresholds calculated at 2 std.-dev for population 1 is minimum 0.786 and maximum of 37.928, population 2 minimum of 39.231 and maximum of 259.392 and population 3 minimum of 169.902 and the maximum of 972.812.

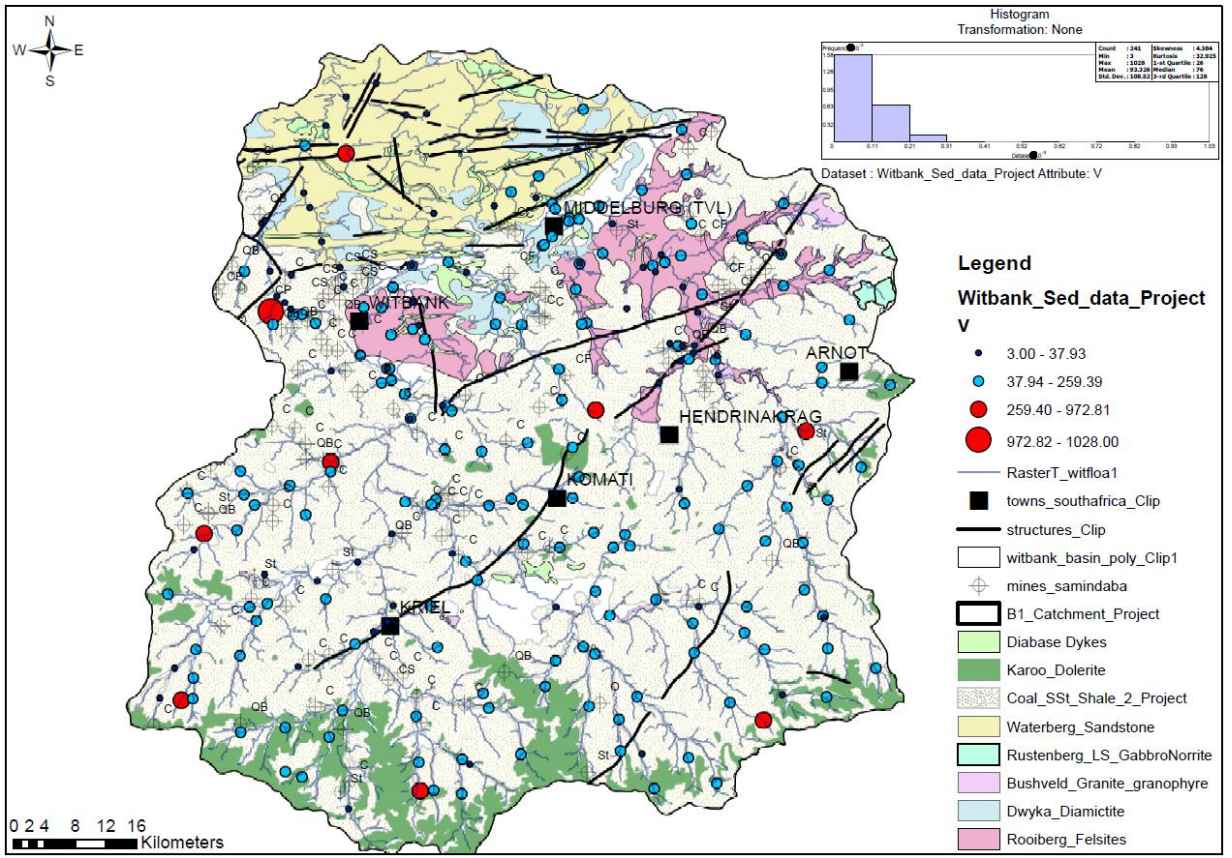


Figure 5-40: Figure indicating the uni-element distribution of V on the ROC.

5.4 DISCUSSION AND CONCLUSIONS

This study's primary objective is to compare the geogenic vs mining-related deportment of mobile elements, particularly metals, in the ROC region, which is located in the uppermost reaches of the OPC. The objective of the research as a whole is to create geochemical thresholds for these elements using conventional geochemical exploration techniques and, in a second phase, to attribute populations of elements to geogenic and/or anthropogenic sources, respectively. This section evaluates the repercussions of metal exportation from the source. The evaluation was conducted by comparing the geochemistry of the stream sediments and the source. Figure 5-42 depicts probable surface water and streambed sediment processes. Metals are transported by water from both point and nonpoint sources. Sedimentation occurs by precipitation, dissolution, dispersion, deposition, and adsorption or desorption (Caruso *et al.*, 2008; Ji *et al.*, 2002). It is crucial to highlight that there is a link between the downstream chemistry of stream sediments and the point source rock in a catchment (Rose *et al.*, 1979), and this is true for the research region.

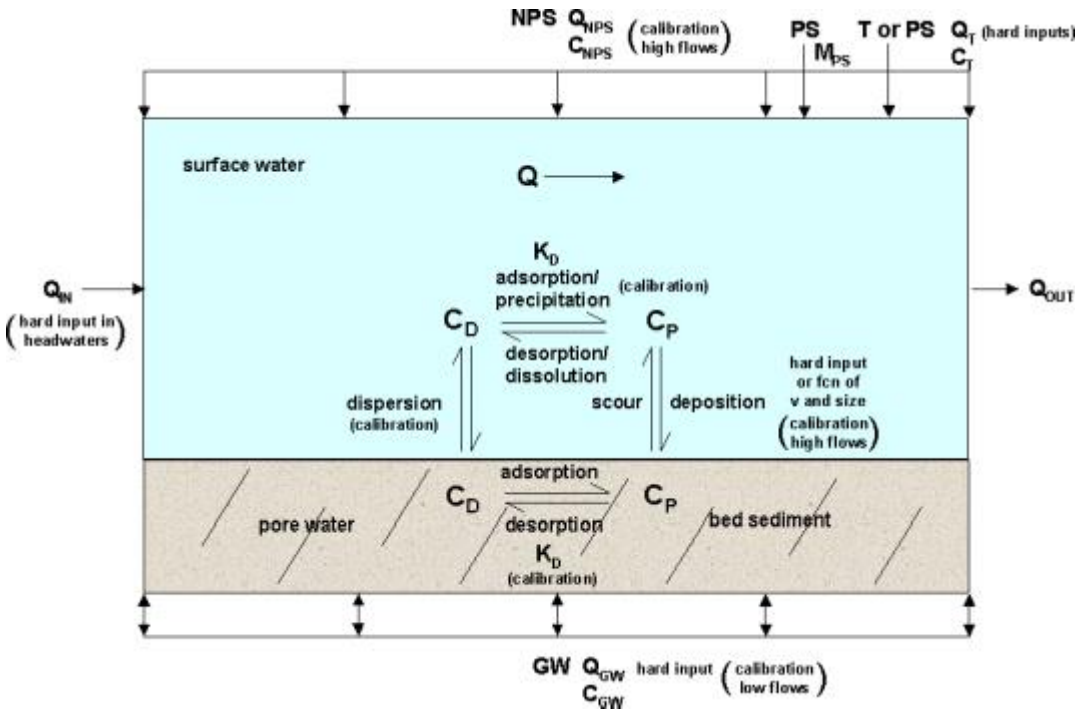


Figure 5-41: Illustrations of the processes of fate and transport of metals (after Caruso *et al.*, 2008).

Q is streamflow in the stream-(modeled) segment, and the inputs are coalmines, processing plants and agricultural activities in the ROC (Caruso *et al.,* 2008). The processes are aligned with the reaction processes discussed in chapter 4.

5.4.1 Major oxides

The geochemistry of sediments reveals an enrichment of the principal oxides with a maximum SiO_2 content of 98.10 wt.%; TiO_2 (maximum 6.50 wt.%); MgO (maximum 17.00 wt.%); Fe_2O_3 (maximum 33.60 wt.%); MnO (maximum 0.60 wt.%); Cr_2O_3 (maximum 11.50 wt.%); low contents of Al_2O_3 (maximum 24.00 wt.%); Na_2O (maximum 2.70 wt.%); K_2O (maximum 4.20 wt.%); CaO (maximum 12.70 wt.%); and P_2O_5 (maximum 1.40 wt.%). The study reveals that the geology and geochemistry of the bedrock primarily govern the elemental distribution in stream sediments. With the exception of CaO, the increased levels of SiO_2, TiO_2, Fe_2O_3, MnO, MgO, and Cr_2O_3 match the region's bedrock surprisingly well. According to Sikakwe *et al.* (2015), the comparative large quantity of inorganic ions/salts (Ca, Mg, Na, K) and metals in water, sediments, and mine dumps revealed that these components are significantly more concentrated in sediments and mine dumps than in water. Even though these major elements were found in lower concentrations than SiO_2 in the sediments, their concentrations are higher than the average point source rock of silica in the Witbank coalfield. The sediments and mine dumps serve as a pool that can release toxic metals into the water column through various remobilization or desorption processes. Calcium and magnesium leaching patterns were comparable due to the dissolution of carbonates and the similarity of their surface exchange (or sorption/ desorption) properties. In addition, the non-coal strata contain minerals such as clay (kaolinite/chlorite, smectite), quartz, potassium feldspar, and plagioclase, along with minor amounts of pyrite, carbonates (calcite, dolomite, and siderite), mica minerals, hematite, and anatase as accessory minerals. Only K_2O exhibits a moderately positive correlation with SiO_2 in coal and non-coal strata, possibly due to the presence of potassium feldspars and clay minerals (Table 5-3). Significant correlation exists between TiO_2 and Al_2O_3, indicating a shared origin. CaO, MgO, Fe_2O_3, and MnO correlations indicate the presence of carbonate minerals.

Table 5-3 displays the correlative behavior of the major oxides. The increase of SiO_2 in stream sediments is attributable to the presence of quartz grains, which are the most resistant, stable, and insoluble mineral. The amount of detrital oxides and silicates, such as chlorite and clay minerals, influences the enrichment of TiO_2 in sediments derived from bedrock. Due to the presence of pyrite, siderite, and hematite, stream sediments are enriched with Fe_2O_3. This indicates that the minerals containing this oxide have undergone dissolution processes, which are heavily influenced by pH and Eh values. It's possible that MnO's association with carbonates and clay minerals is the primary cause of its increase in stream sediments. The elevated Cr_2O_3 levels are attributable to the ferrochrome processing facility, not the bedrock.

Al_2O_3, CaO, Na_2O, K_2O, and P_2O_5 concentrations in stream sediments indicate the dissolution of feldspar and phosphate minerals in the system. The decrease of these elements and the enrichment of SiO_2 may be the result of sedimentary sorting and the loss of clays with fine particle sizes. Feldspars regulate CaO, K_2O, and Na_2O concentrations, and their depletion is caused by physical weathering and dissolution, resulting in clastic particles with finer grain size. It also proposes the transformation of plagioclase into clay minerals as a result of chemical weathering. Low CaO values also indicate carbonate mineral depletion in the stream.

5.4.2 Trace elements

Stream sediments have higher concentrations of trace elements than the average point source rocks. As, Ba, Bi, Br, Ce, Co, Cs, Hf, La, Mo, Nb, Nd, Ni, Pb, Rb, Se, Sm, Sr, Ta, Tl, Y, Yb, U, V, W, Zn, and Zr are enriched in the stream sediments, while Cu, Ga, Ge, Sc, and Th are depleted. The sediments have high contents of As (maximum 680 ppm), Co (maximum 1273 ppm), Mo (maximum 16 ppm), Ni (maximum 197 ppm), Pb (maximum 98 ppm), U (maximum 1898 ppm) and Zn (maximum 724 ppm), low contents of Cu (maximum 89 ppm), Ga (maximum 34 ppm), Ge (maximum 12ppm), Sc (maximum 31 ppm), and Th (maximum 42 ppm) (Table 5-1). The deposition and adsorption of minerals on the organic matter present in the clay fraction may be the primary reason for the high concentrations of As and other elements found in stream sediments. It is evident that the point source rock exhibits a strong positive correlation between the As element and S and

C, confirming that the As element is predominantly concentrated in pyrite and organic matter (chapter 3). It is important to consider the possibility of anthropogenic sources, particularly the rich sulphide mineral content of the Bushveld Complex ores for the smelter.

From Figure 5-43 to Figure 5-47, the issue of metal enrichment in sediments is addressed. The weathering of average bedrocks causes the enrichment of trace elements Co, Ce, Cs, Hf, La, Nb Nd, Ni, Pb, U, Zn, and V in sediments, which are then absorbed by clay in streambed sediments. Co, Ce, Cs, Hf, La, Nb, Nd, Ni, Pb, U, Zn, and V are positively correlated with Al_2O_3, indicating a relationship with clay minerals and Ti-bearing minerals.

Elements that indicate anthropogenic or geogenic sources exhibit enrichment, such as an EF greater than 1.5. 0.5 EF 1.5, according to Zhange and Liu (2002), trace metals may be entirely derived from crustal materials or natural weathering processes. As (11.2), Bi (12.9), Br (3.1), Hf (1.9), Se (25.6), Tl (3.3), U (6.9), W (3.5), and Yb are enriched in the stream sediments data of this investigation (7.9). As shown in Figure 5-47, the elements have a high mobility, as indicated by EF 1.5, which suggests an anthropogenic origin (Khalil *et al.*, 2013). Except for Bi and Tl, the remaining elements exhibit a heterogeneous distribution and have coefficients of variation as follows: As (288.5%), Br (354.4%), Hf (156.6%), Se (244.6%), U (447.2%), W (263.7) and Yb (631.8%). According to the metal association revealed by the correspondence analysis, the enriched elements fall within the high mobility field (Figure 5-46). In Figures 5-43 and 5-44, the trace elements of the stream sediment samples were also normalized to the upper continental crust and upper crust (Taylor and McLennan, 1985). As a result, U, Cs, Nb, Hf, Sm, and Yb are enriched relative to upper continental crust, whereas Ba, K, La, Sr, P, Ti, Tb, and Y are generally depleted. In figure 4-48, samples are again normalized against the upper continental crust according to Taylor and McLennan (1985), but in comparison with samples from Karoo dykes and sills, Bushveld felsites (granite, granophyre, felsites, and rhyolites), Karoo mudstones, sandstones, and diamictite, as well as Karoo (Vryheid Formation) sandstone In general, the sediments have the most extreme minimum and maximum values for trace elements among all rock types. Stream sediment trace element data normalized to the Average Crust (Weaver and Tarney, 1984) display a nearly identical pattern when normalized to the Average Crust. In subsequent sections of this study, U, As, Pb, and Zn will be discussed for populations derived from anthropogenic and geogenic sources.

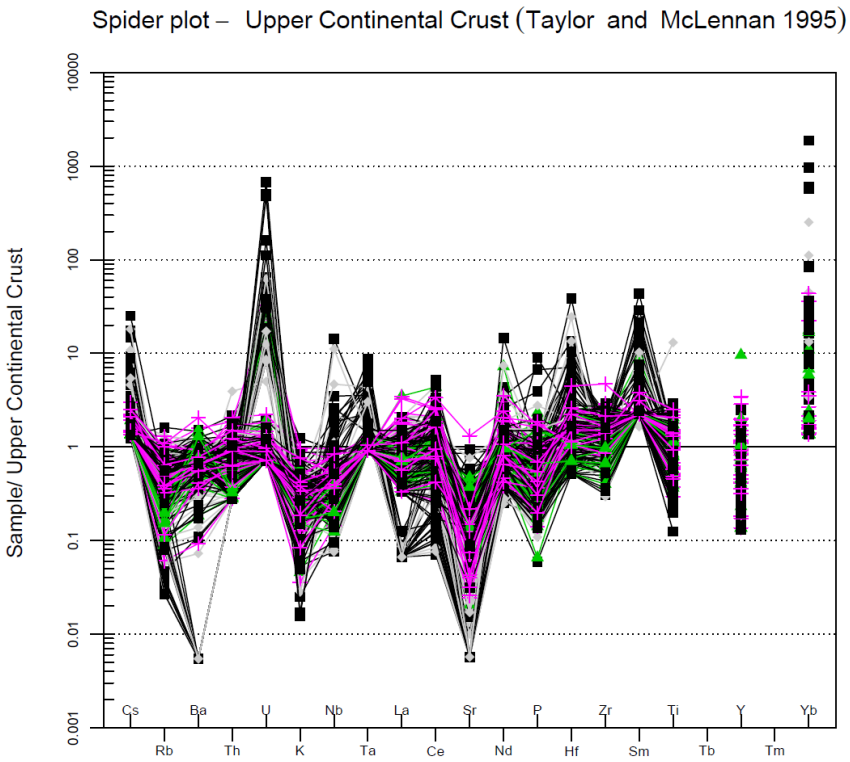


Figure 5-42: Sediment geochemical trace element data normalized to the upper continental crust (Taylor and McLennon, 1985), for the enrichment of the trace metals.

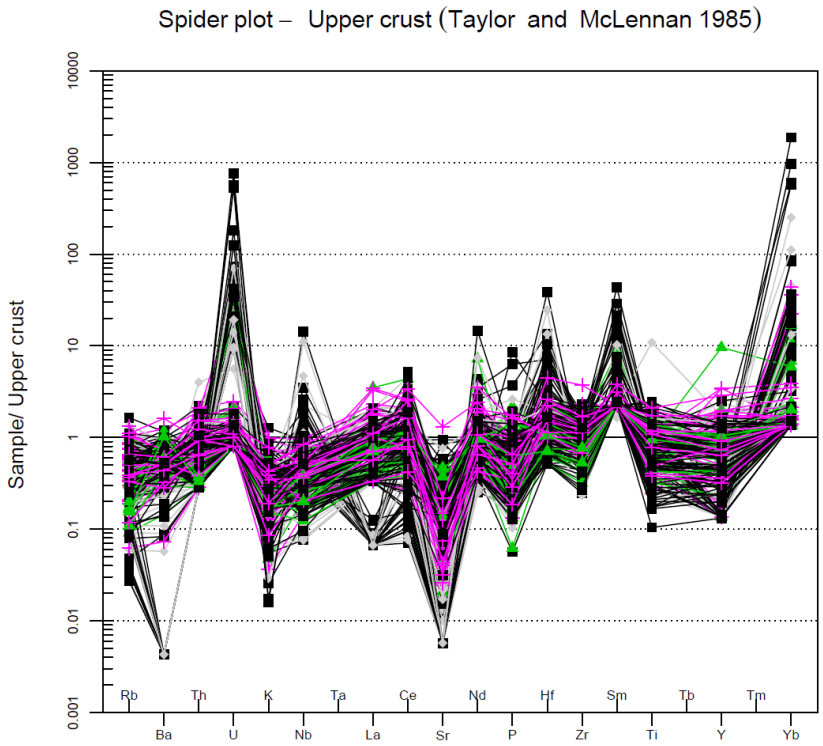


Figure 5-43: Sediment geochemical trace element data normalized to the upper crust (Taylor and McLennon, 1985), for the enrichment of the trace metals.

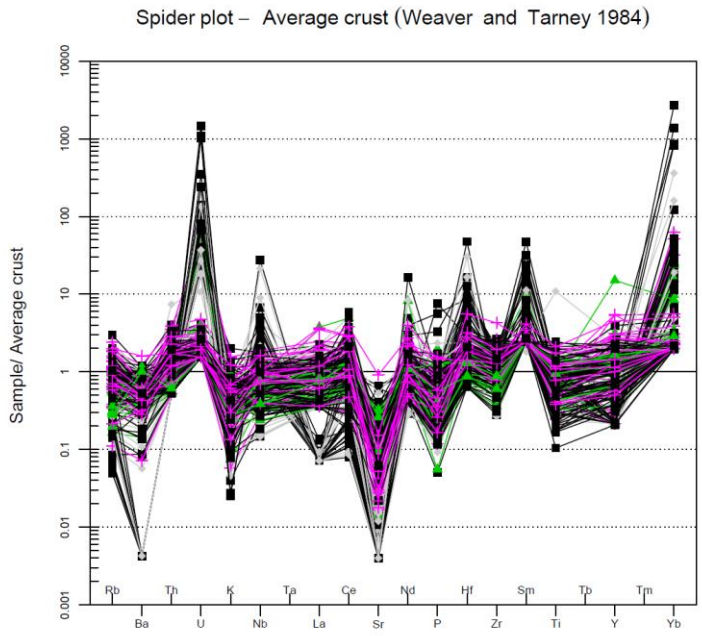


Figure 5-44: Sediment geochemical trace element data normalized to the average rrust (Weaver and Tarney, 1984), for the enrichment of the trace metals.

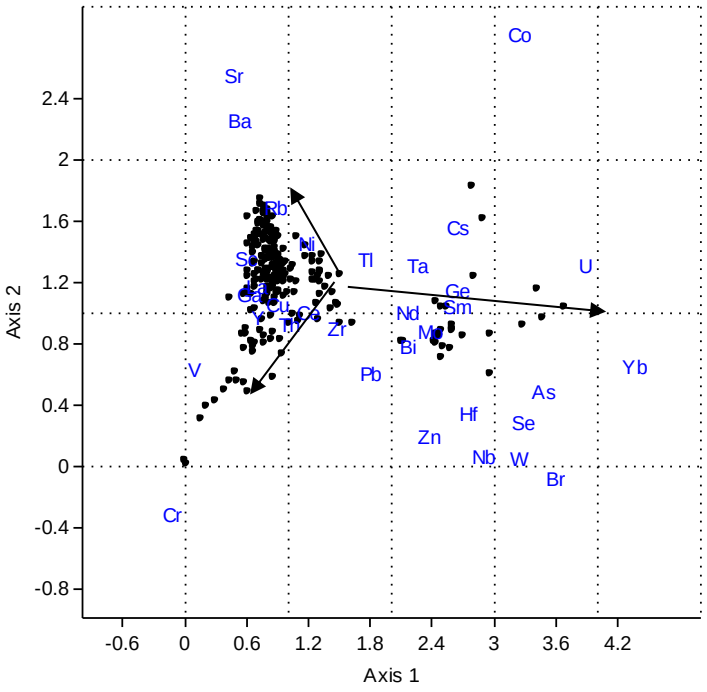


Figure 5-45: Metal association using the correspondence analysis, displaying different axes directions for various trace elements roughly showing different fractionation/mobilization behaviour; the black dots are the sample points.

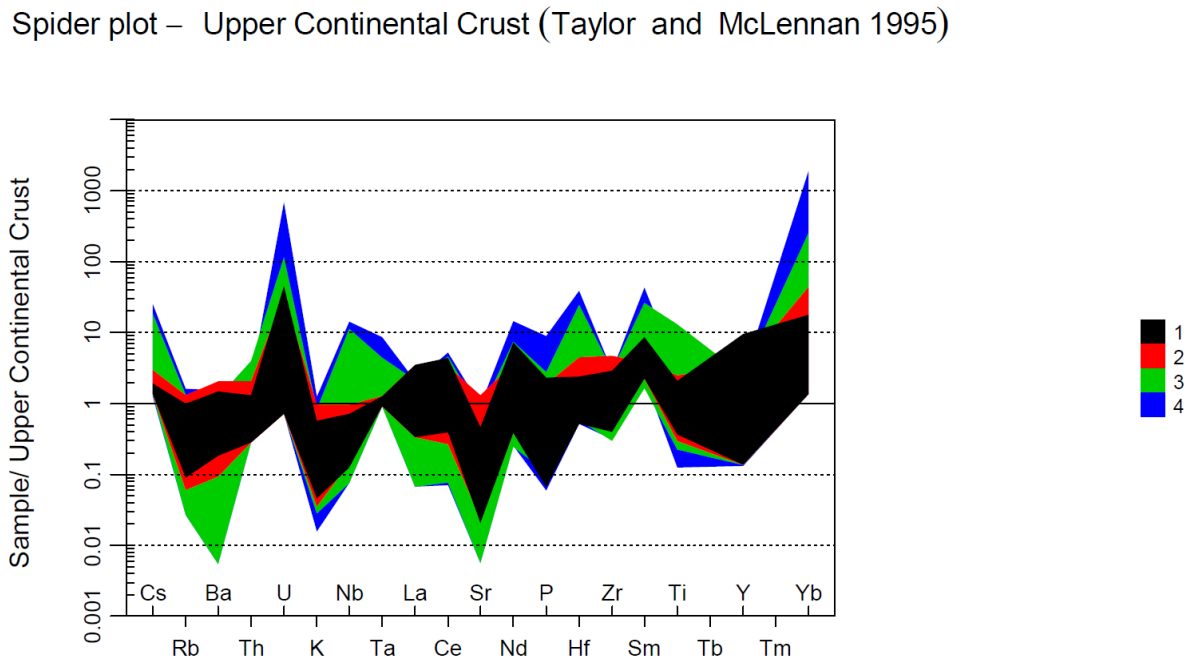


Figure 5-46: Sediment geochemical trace element data normalized to the upper continental crust (Taylor and McLennon, 1985), for the enrichment of the trace metals on samples located in 1: dykes and sills; 2: granite (granophyre, felsites and rhyolites); 3: mudstones, sandstones and diamictite; 4: Vryheid (sandstones, shale and coal).

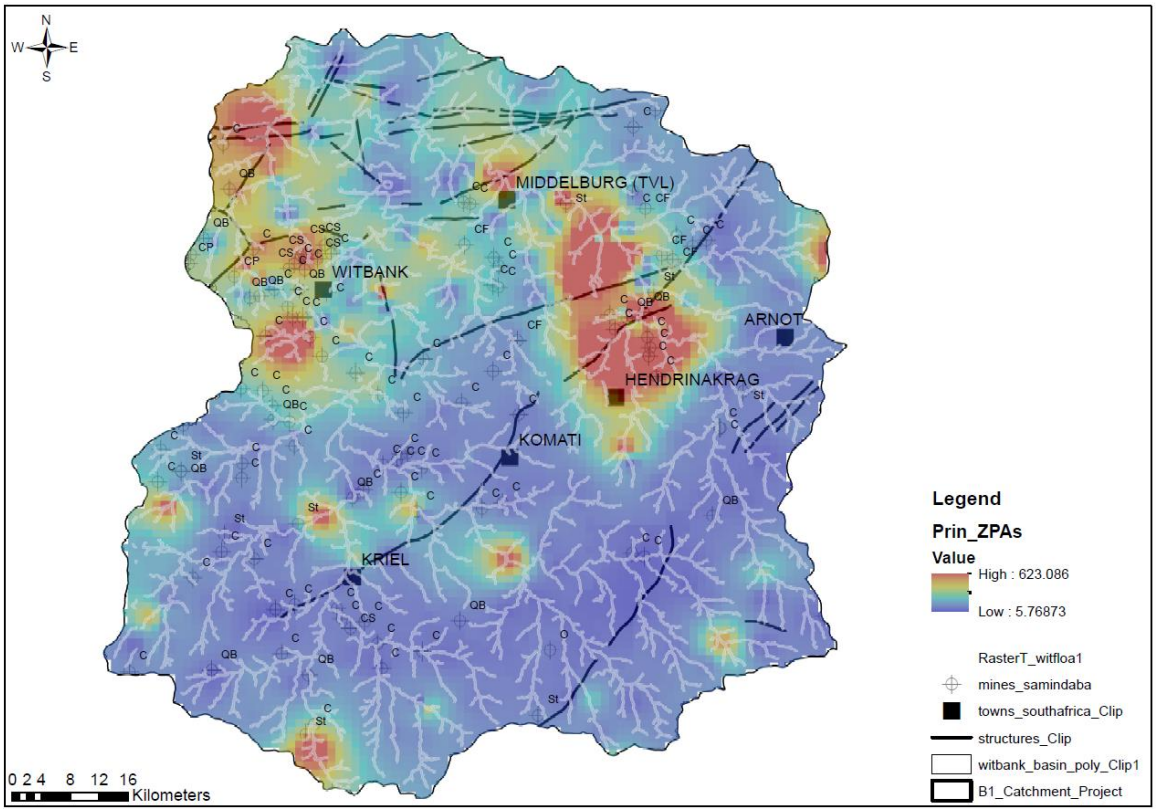


Figure 5-47 A weighted sum map (ppm) dustribution of Zn, Pb and As from the stream sediment.

The upper populations of Pb, Zn, and As anomalies represent similar areas within ROC, and these areas likely have a geogenic origin (Figure 5-48). The majority of the anomalies to the north of Hendrinakrag are located on Rooiberg felsites rocks. Because elements are strongly associated with Ge, they may also be linked to the base metal deposit. Frondel and Ito (1957) report that the primary sulphide ores of the Pb-Cu-Zn deposit at Tsumeb are significantly enriched in Ge. In the case of the Witbank coalfield, Ge could have been mobile in the reducing environment of the coal, but complexed with the sulphides under oxidizing conditions (Table 5-1). Ge is released during oxidation from the primary minerals and is found in two valence states in the secondary minerals. It occurs very infrequently as divalent Ge in substitution for Pb in anglesite and cerussite (50-500 ppm) and in a new basic Lead sulphate containing 8.18 percent GeO by weight (Frondel and Ito, 1957). Schweitzer *et al.* (1995) have documented the presence of Pb-Zn mineralization within the Rooiberg felsites. Therefore, the Rooiberg felsites may be the source of the elevated Pb, Zn, and As concentrations. In Tsumeb Pb-Cu-Zn deposits, 6 ppm of Ge was detected in the mineral Bayldonite $(Cu, Pb)_2(AsO)(OH)$ (Frondel and Ito, 1957). Ge in solid solution is relatively abundant in enargite, tennantite, renierite, and germanite in the primary ores of the Cu-Pb-Zn deposit at Tsumeb. A vast array of secondary carbonates, sulfates, arsenates, phosphates, vanadates, and oxides have been produced by the oxidation of ores in a limestone environment. Cu, Pb, and Zn are the predominant cations, with minor amounts of Ca, Mg, Fe, Ba, Cd, Mo, and Co. In accordance with the known chemical and Eh-pH relations of this ion, the Ge^{2+} ion appears to have formed under weakly acidic and reducing conditions, as reported by Frondel and Itu (1957).

Ge^{2+} is converted to Ge^{4+} and stored in early-formed arsenates stable under moderately acidic and oxidizing conditions as the environment's Eh and pH increase (Frondel and Ito, 1957). In the upper portion of the oxidation zone, under alkaline and oxidizing conditions, Ge is leached as alkali germinates in the absence of hemimorphite and other secondary silicates stable under such conditions and able to accommodate Ge^{4+} in solid solution. Ge is strongly associated with Mo, Ta, Mo, Sm, and Co in Witbank sediments (correlates well in Table 5-2). Schweitzer *et al.* (1995) confirms that the sub-economic localized base metal mineralization of the Rooiberg felsites is responsible for the anomalies of these metals to the southwest of Middleburg. In response to contact metamorphism during the final stages of the Rustenburg Layered Suite, a third mineralization event occurred in which Pb and Zn were introduced into the felsite roof rocks (Schweitzer *et al.*, 1995).

According to Brookins (1988), the natural arsenic in sediments precipitates under alkaline and mostly reducing conditions. These anomalies are significant for future research on the mineralization of the Rooiberg felsites, despite the significant coal mining in the region. Using the probability plot, the 14.8 ppm threshold of As separates the background from subsequent populations. The background concentrations of As in the sediments of the Vryheid Formation are significantly dispersed. The increased As population may be attributable to the coal source. In Witbank and Emalahleni, the presence of processing plants and coal mining denotes areas of anthropogenic activity.

It is interpreted that the Rooiberg felsites contain the middle population of Uranium anomalies. U is mobilized by fluids and precipitated as pitchblende or adherently bound to carbon under a reducing environment in the geogenic source, causing anomalies downstream.

The upper population of U and the middle populations of As, Pb, and Zn illustrate the anthropogenic source regions. The anthropogenic source areas are located to the northwest, west, and southwest of the town of Emalahleni (Figure 5-31). Upper U concentrations range from 265 ppm to a maximum of 1898 ppm and are primarily attributable to sedimentary rocks above coal seam No. 5. This is because the granitic source is absent from the upper reaches of the catchment. Strong correlations exist between U and Nd, Nb, W, Hf, Br, Se, Yb, Cs, and Co. (Table 5-3). The spatial distribution of these elements is nearly identical and reveals background concentrations in the sediments of the Vryheid Formation and the felsic rocks of the Bushveld region.

Strong correlations between U and Yb may also indicate a geologic origin. The Bushveld rocks have been identified as the REE element carriers. According to Maier and Barnes (1998), the initial Sr isotopic ratio of the magma that formed the Lower and Lower Critical Zones of the Bushveld Complex was relatively low. However, its REE and Th concentrations are elevated, and its LREE content is notably enriched. But these are relatively small absolute concentrations because the highly differentiated A-type granites have higher U contents; the coal, however, has an unusually low U content (10-50 ppm) compared to the U in coal lying directly on the Bushveld granite (the Springbok Flats), which calls for additional research in the future (Nxumalo, 2020).

In contrast, a significant portion of the Main Zone crystallized from magma with a high initial Sr isotopic ratio, relatively low REE and Th contents, and moderate LREE enrichment. Graupner *et al.* (2015) state that the Vergenoeg fluorite mine contains xenotime, which is an essential transporter of MREE, HREE, and Y throughout the Vergenoeg pipe. The distribution of its two compositional varieties, Yb-rich and Y-rich xenotime, governs the REE-Y distribution patterns to a great extent. The Yb-rich xenotime is confined to fayalite-bearing lithological units, whereas the Y-rich variety dominates the remaining lithological units. The Sm-Nd isotope systematics of fluorite separates strongly indicate that the Vergenoeg pipe's REE budget originated from a Lebowa-type granitic magma (Maier and Barnes, 1998). It is possible that the sediments of the Witbank region contain fragments of Vergenoeg-type Fe-oxide-rich fluorite-pipes and thus contain trace concentrations of rare earth elements such as La, Hf, Nd, Yb, and Y in garnets.

The enrichment of Yb and Sm on the western side of Witbank is due to the Bushveld rocks. The enrichment of Yb and Sm could be a result of the continuous processing of Bushveld materials in the Witbank region. In the current study area, Yb and Sm are the only two strongly correlated REEs (Maier and Barnes, 1998). The Yb strongly correlates with U, whereas Sm strongly correlates with As (Table 5-2). When normalized to upper continental crust (Taylor and McLennon, 1985), the sediments show enrichment of these two metals (Figures 5-44 and 5-45). These relationships are essential in understanding the metal mobility influenced by the sedimentary processes. These include the initial conditions of the REE. The presence of clay minerals in the sediments also indicates that sediments are highly altered. The clay fraction noted in the sediments illustrates the environmental condition that allows the elemental adsorption process, and under oxidizing/reducing conditions, most of the metals are adsorbed the favorable conditions.

Investigating the geochemical threshold of selected metals from the regional stream sediments to evaluate populations of geogenic and anthropogenic sources has been meaningful. The influence of contamination on the receiving environment is drawn after the element background is determined to distinguish the input as either geogenic or anthropogenic or mixed source.

6 SUMMARY AND RECOMMENDATIONS

6.1 DISCUSSION AND INTEGRATION FINDINGS

The study's discussion and conclusion are based on the integration of data from chapters 3, 4, and 5. The study has effectively described the mineralogy and geochemistry of the geological units of the ROC, predicting mine drainage through ABA and kinetic predicting through HCL and assigned metal sources to lithological units in the source environment. To understand the nature of the receiving environment, the controls through the leaching process and the metal deportment to the stream sediments of the drainage region have been defined in response to the geochemical properties of the source rocks.

As described in the geological sections, it is vital to emphasize in the conclusion that the ROC is defined by the well-known geology of the Vryheid Formation of the Ecca Group, Karoo Supergroup. Pre-Karoo Supergroup basement rocks provide the foundation of these rocks. By dissecting the petrography and geochemistry of the geological layers in the Goedehoep colliery drill core, chapter 3 provides a thorough examination of the geochemical properties of all these rocks. The acid-base accounting and kinetic studies detailed in chapter 4 demonstrated that, under favorable conditions, coal seams above and below strata might release metals. The remobilization of these metals into surrounding streams or leaching ponds has an effect on the receiving environment. Conducting static testing has enabled the prediction of rock drainage, which aids in the comprehension of metal leaching from the source rock. The experiment with leaching was also covered in chapter 4.

The geochemistry of stream sediments has been investigated in detail in chapter 5. The elements concentrations of 246 stream sediment geochemical data to differentiate between the background concentration of an element and anomalies (enrichment), using the traditional methods for geochemical exploration and the details are discussed in chapter 5 to fathom the metal concentrations in the receiving environment. Either an anthropogenic or a geogenic entrance may be traced back to the enrichment of components in the receiving environment.

From the observations, the following inferences may be made: tillite, granite, and dolerite in the ROC are categorized as non-acid-generating rocks due to the absence of acid-generating minerals. Similar amounts of Na_2O_2, Zr, Hf, Ba, Rb, K_2O, and SiO_2 are present in Dywka tillite, granite, and sandstone grading to siltstone and sandstone. Minor minerals such as dolomite, plagioclase, and mica, as well as accessory minerals such as anatase, siderite, potassium feldspar, and pyrite, are also present in the tillite. Quartz, minor plagioclase, siderite, and potassium feldspar, and the uncommon minerals pyrite and mica dominate the granite near the base of the series.

It has been discovered that the mineralogical composition of the Witbank coalfield geological units influences the acid producing potential as determined by the static test of ABA. Due to the predominance of quartz and clay minerals (kaolinite, smectite), with minor minerals carbonates (dolomite, calcite), potassium feldspar, plagioclase, and mica, and rare siderite, anatase, and pyrite minerals, sandstones and siltstones most of the samples are classified as uncertain of acid generating potential. Shale units are also classed as having an unknown potential for acid generation. Although the shale exhibits an enrichment of trace metals including Yb, Sm, U, Cr, TiO_2, Cs, Ce, La, Th, Nd, Zn, Al_2O_3, and Nb, this is not the case for all trace elements. Due to the presence of buffer minerals, particularly feldspar and mica, the acid production capability of the shale is uncertain. Framboidal pyrite grains, which are the sole identifiable sulphides, are visible under crossed polarized light, whereas quartz, mica, plagioclase, and chlorite are visible in a plain polarized light.

Clearly, geological units on the hanging and footwall of coal seams produce acid and release metals into the receiving environment over time (chapter 4). The reaction processes which aid in the transportation of elements include but not limited to: sulphide oxidation, acid neutralization and alkalinity, ion exchange or adsorption and the precipitation metal hydroxides and salts. This is evidenced by the high sulphate content in the coal seam leachate, which has been measured as high as 1810.6 mg/L. All coal seams have commonalities, the most notable of which is their significant association with SO_4^{2-} and with Fe, Cu, Mn, Be, and B, and their modest correlation with Na, K, and Mg (Appendix E). The presence of SO_4^{2-} in sulphide minerals, primarily pyrite, and organics explains the significant link between SO_4^{2-} and metals. During ABA analysis, these geological strata were identified as uncertainty clusters. They contain SO_4^{2-} concentrations comparable to those of coal seams.

It is also important to note that the subsequent geological layers correspond to the Fe, Cu, Mn, Be, and B. Shales and siltstones are rich in these elements. The coal seams, hanging, and footwall geological strata reveal no relationship between metals and alkalinity (Appendix E). Mineral distributions in the Witbank coalfield are comparable to the mineralogy of the coal and sediments in the Witbank coalfield. Alkalinity corresponds strongly with carbonate buffer minerals (Appendix E). The overburden geological units comprised of sandstones and siltstones, as well as the basement geological units comprised of Bushveld granite and Dwyka tillites, exhibit no traces of acid production. In the profile, there are trace levels of hematite in the sandstone-siltstone above coal seam No. 5 (Figure 3-18). According to Pinetown and Boer (2006), coal-bearing units have the potential to generate acid rock drainage. In addition, with the exception of the unit between the No. 1 and No. 2 coal seams, they may produce acid. The average Net Neutralizing Potential (NNP) results indicate that the No. 5 coal seam, the No. 4 Upper coal seam, and the unit between the No. 4 and No. 2 coal seams may produce acid. Pyrite exhibits a similar distribution pattern to that of carbon and sulphur, both of which are abundant in coals. Significant levels of calcite are present in coal seams No. 2 and 5 (Tables 3-2), whereas dolomite is present in trace amounts in coal seams No. 2, 3 and 4. (Tables 3-2).

The following minerals are related with trace elements in host rocks:

a) Carbonates are associated with Ba, Sc, Sr, V, and Zn;

b) Sulphides with As, Cr, Cu, Mo, Ni, Pb, and Zn; and silicates with Rb, U, Cr, Ni, Cu, and Ga.

The elements associated with carbonates, sulphides, and silicates had an enrichment factor (EF) of greater than 1.5 in sediment samples.

There have been reports of rare earth elements in coal (Seredin, 2008; Seredin and Finkelman, 2008; Seredin and Dai, 2012), however their concentrations in this research were minor. Co, Cu, Ni, and V have a positive connection with Al_2O_3, FeO_3, and TiO_3, indicating that they are associated with clay minerals, sulphides, and other mafic minerals. The favorable link between the rare earth element Sc and the major oxides CaO, Fe_2O_3, MnO, and P_2O_5 may be attributable to their existence in carbonates, apatite, and goethite. Significant association between K_2O and Rb suggests that Rb is present in rich potassium feldspar or clay minerals.

According to the information presented in chapter 2, there are five coal seams numbered 1 to 5 in the Witbank coalfield area. The present study confirms report on boreholes ZFN1510 and 1512 for the four coal seams numbered 2 to 5. In certain regions, particularly to the south of the city of Witbank, coal seam number 1 is reportedly underdeveloped. The commercially feasible seam is coal seam no. 2, which consists of dull to dull-lustrous coal and coaly shale and has a thickness of about 10 meters, with 0.22 meters of carbonaceous shale and 0.23 meters of sandstone. The physical appearance of the coals is characterized by approximately 90% brilliant and dull-lustrous coal with sulphide lenses, comprised of high-quality coal, and hence vulnerable to metal release during AMD.

6.2 CONCLUSION REMARKS

This study demonstrates that the source rock composition of the Witbank coalfield geological strata strongly influences the geochemistry of the stream sediments in the receiving environment, causing anomalous elements on downstream sediments. The elements comprise Si, Fe, Mn, Mg, Na, K and traces such as Cr, As, U, V, Zn, Pb, Co, Ce, Br, Ni, Sr, Hf, Nb, Nd, Yb, and Zr above average of the source rock (Table 3-6). The source lithology contains the following mineral groups: carbon, carbonates (calcite, dolomite, and siderite), sulphides (mostly pyrite), silicates (kaolinite, chlorite, quartz), and aluminosilicates. These minerals include the following trace elements: Ba, Sc, Sr, V, Zn, As, Cr, Co, Cu, Mo, Ni, Pb, Se, Cs, Rb, Zr, Y, V, U, Th, Nb, Ta, Ga, and La. (Table 3-6). The ABA and HCL experiments suggest that these elements may be leached from the source coal rock units as well as the lithological units between, above, and below each coal bed unit. Since coal and similar strata are enriched in the aforementioned elements through sedimentary to supergene genetic processes, but are only exposed to air and water, followed by weathering and leaching process, a combined geogenic and anthropogenic source of the mobile elements may be hypothesized. The metal-rich fluids represented by the leachate from coal seams and adjacent lithological units are not only the transport medium, but their lower pH also enhances element dissolution. It is obvious that sulphides in the form of sulphate (SO_4^{2-}) and related trace elements are leached under favorable acidic conditions, transported, and then adsorbed, absorbed, or precipitated in the sediments of the river catchment under near-neutral conditions. As stated in chapter 4, mineral species of barite, anhydrite, celestine, gypsum precipitates during the process, as anticipated by GWB and PHREEQC modeling. Table 6-1 highlights the enrichment or depletion of

elements in the source system and the receiving environment for typical bedrock. Additional comparisons are extracted from Appendix I. Table 6-2 translate the cumulative metal leachate into comparable loads for source element input. The metal loads ($mg.kg^{-2}.yr$) were calculated as follows:

$$[(\rho\ (kg.m^{-3}).t\ (m)\ x\ (E_{critical}\ concentrations\ (mg.kg^{-3})- E_{initial}\ concentrations\ (mg/kg))/ T]$$

Where, ρ is density in $kg.m^{-3}$;

t is thickness (m);

$E_{critical}$ is remaining leachate cumulative;

$E_{initial}$ is total leachate cumulative; and

T is a permissible time estimated at 100 years.

A source input is determined when results of receptor sediments indicate elemental concentrations exceeding that of a source. A source can also be determined by a negative value, meaning an initial element input exceeds an element critical input. The following sources were classified to determine the element input: coal seams for ZFN1512 (BH10, 11, 12 and 13); coal seams for ZFN1510 (BH19, 21, 24 and 27); units above and below coal seams for ZFN1512 (BH16, 17, 18, 22 and 23); units above and below coal seams for ZFN1510 (BH4, 5, 6, 7, 8 and 9); and other units for ZFN1512 (BH14, 15, 20 and 25) and ZFN1510 (BH1, 2, 3 and 26). It is important to note that units above and below coal seams and other units are mainly sandstones, siltstones and shales, and the bulk density was kept constant at 2000 kg/m^{-3} and the average thickness at 1 m. The calculated bulk density of the coal seams were kept at minimum of 700 kg/m^{-3} and average thickness of 3,72 m for ZFN1512 and 2,36 m for ZFN1510. The results were calculated from the composite samples.

The following stream sediments were assessed of the source input: composite sediments around 10 km radius downstream of ZFN1512 and ZFN1510 borehole drainage basin and the average sediments of the ROC. The composite samples used include B1S24, WB004, WB006, WB061, WB062, WB063, WB064, WB066, WB069, WB071, WB67, and WB68.

Table 6-1: Descriptive data (minimum, maximum, mean, std.-dev, and median) of major (wt. %) and trace (ppm) elements in the bedrock and stream sediments of the Witbank coalfield.

Elements	Witbank bedrock average						Stream sediments average					
	Valid N	Min	Max	Std.-dev.	Mean	Median	Valid N	Min	Max	Std.-dev.	Mean	Median
SiO2	123	2,58	96,63	20,83	61,04	65,23	246	15,37	98,08	14,56	75,63	77,66
TiO2	123	0,00	2,81	0,49	0,69	0,69	246	0,06	6,52	0,47	0,54	0,48
Al2O3	123	1,31	31,65	6,46	13,27	12,75	246	0,81	24,03	3,87	7,16	6,65
Fe2O3 (t)	123	0,36	39,29	4,75	4,13	2,92	246	0,59	33,60	4,65	5,74	4,66
MnO	123	0,00	0,55	0,08	0,05	0,03	246	0,01	0,55	0,10	0,11	0,08
MgO	123	0,01	8,61	1,36	0,95	0,68	246	0,01	16,97	1,45	0,62	0,24
CaO	123	0,02	27,95	4,79	2,26	0,53	246	0,01	12,69	1,89	1,07	0,32
Na2O	123	0,01	3,31	0,73	0,76	0,60	246	0,02	2,73	0,39	0,26	0,13
K2O	123	0,02	5,45	1,24	2,45	2,70	246	0,05	4,20	0,63	1,05	0,96
P2O5	123	0,01	1,69	0,21	0,11	0,06	246	0,01	1,44	0,13	0,11	0,07
Cr2O3	123	0,00	0,06	0,01	0,01	0,01	246	0,00	11,53	0,74	0,10	0,02
LOI	123	0,21	91,56	20,04	13,75	6,74	246	0,41	69,99	8,68	7,30	4,50
Total	123	98,52	100,06	0,39	99,35	99,50	246	98,50	101,25	0,60	99,68	99,62
As	123	4,00	92,00	9,46	7,46	4,60	246	4,00	680,00	100,49	35,17	4,00
Ba	123	62,00	1228,00	230,27	562,90	605,00	246	3,00	1128,00	208,53	363,11	378,00
Bi	123	3,00	15,00	1,18	3,25	3,00	246	2,00	36,00	3,28	3,56	3,00
Br	123	2,00	2,00	0,00	2,00	2,00	246	2,00	670,00	57,59	16,25	2,05
Ce	123	10,00	214,00	52,91	65,57	49,00	246	4,50	335,00	50,19	70,15	59,00
Co	123	1,00	42,00	8,57	10,12	7,80	246	1,60	1273,00	119,83	49,51	20,00
Cr	123	4,30	189,00	36,18	62,93	61,00	246	5,00	3207,00	347,19	229,86	143,00
Cs	123	5,00	16,00	3,03	7,06	5,00	246	4,60	93,00	9,60	7,53	5,00
Cu	123	2,00	296,00	47,21	22,30	9,50	246	1,60	89,00	16,74	22,94	17,00
Ga	123	1,80	46,00	9,44	19,32	19,00	246	1,00	34,00	5,96	8,98	8,45
Ge	123	1,00	33,00	4,01	1,78	1,00	246	1,00	12,00	2,27	1,81	1,00
Hf	123	3,00	104,00	10,23	9,57	7,40	246	3,00	223,00	19,42	12,33	8,25
La	123	10,00	117,00	26,14	33,82	24,00	246	2,00	105,00	16,84	23,92	21,00
Mo	123	2,00	16,00	1,40	2,34	2,00	246	2,00	16,00	2,41	2,83	2,00
Nb	123	2,80	57,00	9,05	17,33	17,00	246	1,90	358,00	30,27	14,23	9,05
Nd	123	10,00	96,00	21,83	31,46	25,00	246	6,40	379,00	31,01	28,29	22,50
Ni	123	2,00	71,00	18,05	22,39	18,00	246	4,50	197,00	22,76	30,57	24,00
Pb	123	2,40	64,00	9,44	21,93	23,00	246	2,90	98,00	16,56	23,91	19,00
Rb	123	2,00	179,00	44,85	91,10	101,00	246	3,00	181,00	31,42	47,30	43,00
Sc	123	3,00	64,00	10,72	13,27	12,00	246	1,00	31,00	6,10	8,87	8,30
Se	123	1,00	6,60	0,63	1,17	1,00	246	1,00	72,00	6,65	2,72	1,00
Sm	123	10,00	23,00	1,79	10,62	10,00	246	7,40	194,00	20,09	14,90	10,00
Sr	123	8,50	415,00	70,88	122,75	123,00	246	2,00	458,00	56,67	54,25	44,00
Ta	123	2,00	5,60	0,51	2,17	2,00	246	2,00	19,00	2,15	2,69	2,00
Th	123	3,00	47,00	8,55	10,26	7,80	246	3,00	42,00	4,56	6,92	5,65
Tl	123	3,00	3,00	0,00	3,00	3,00	246	2,00	37,00	2,28	3,18	3,00
U	123	2,00	11,00	2,11	3,61	2,50	246	2,00	1898,00	177,61	39,71	2,40
V	123	3,00	492,00	84,11	81,57	63,00	246	3,00	1028,00	107,91	94,02	76,00
W	123	3,00	5,00	0,20	3,03	3,00	246	3,00	352,00	29,69	11,26	3,00
Y	123	3,10	74,00	17,06	27,92	27,00	246	2,90	211,00	17,78	17,45	15,00
Yb	123	3,00	12,00	1,40	3,90	3,00	246	3,00	4131,00	318,05	50,33	3,00
Zn	123	3,00	711,00	72,73	69,81	60,00	246	3,00	724,00	131,91	108,18	49,50
Zr	123	18,00	2364,00	238,48	247,53	196,00	246	56,00	893,00	113,34	275,04	276,00

Table 6-2: Loading of elements of the source rocks compared to the stream sediment data.

Elements	Sediments proximity - ZFN (mg/kg)	Stream Sediments average - ROC (mg/kg)	ZFN1512 coal (mg.kg-2.yr)	ZFN1510 coal (mg.kg-2.yr)	ZFN1512 A-B units (mg.kg-2.yr)	ZFN1510 A-B units (mg.kg-2.yr)	ZFN1512 other units (mg.kg-2.yr)	ZFN1510 other units (mg.kg-2.yr)	ZFN1512 proximity water Q (mg.kg-2.yr)	ZFN1510 proximity water Q (mg.kg-2.yr)	A-B and other units water Q - (mg/L)
Si	341700	353514	1131139	495550	1131139	1213465	1167535	289548	-	-	-
Ti	3206	3236	10045	14712	21910	17778	17259	4274	-	-	-
Al	42873	37894	159132	233619	328467	331444	306533	75929	-52082	-13811	-20109
Fe_{total}	40811	40147	132014	127829	125705	92884	130189	32251	-2577	-2006	-995
Mn	1039	852	237	281	1571	1196	1884	468	-30385	-7907	-11732
Mg	4322	3739	-4874	8143	16499	16674	35330	8808	-1022937	-834186	-394956
Ca	9428	7648	-15286	28791	37568	40873	98191	24447	800	512	-6
Na	2671	1929	-19046	-12965	3756	12674	19586	6052	-1244873	-1403713	-481641
K	10820	8716	4049	13531	75813	91601	97781	24312	-247863	-348173	-96195
P	502	480	522	739	1724	1471	2852	706	-	-	-
Cr	496	684	488	280	583	454	337	85	-	-	-
As	5	36	125	139	20	17	18	6	-259	-166	-195
Ba	468	363	551	574	2029	2220	2510	655	-	-	-
Bi	3	4	35	23	14	12	13	3	-	-	-
Br	6	16	21	13	8	8	8	2	-	-	--
Ce	80	70	197	324	327	310	267	66	-	-	-
Co	22	50	80	58	32	34	30	9	-162	-184	-58
Cr	308	230	461	224	310	285	237	60	-	-	-
Cs	6	8	53	47	31	31	30	8	-	-	-
Cu	27	23	23	49	81	76	52	14	26	-314	-
Ga	11	9	170	122	91	85	79	20	-	-	-
Ge	1	2	130	60	5	4	5	1	-	-	-
Hf	9	12	58	34	71	37	40	10	-	-	-
La	27	24	110	154	169	157	143	36	-	-	-
Mo	2	3	13	4	2	-5	-3	1	-	-	-
Nb	10	14	5	101	98	73	71	18	-	-	-
Nd	25	28	124	140	156	147	135	33	-	-	-
Ni	30	31	207	119	99	89	78	21	-1295	-843	-495
Pb	23	24	161	76	94	87	91	24	-518	-355	-295
Rb	56	47	24	94	364	438	440	109	-	-	-
Sc	11	9	108	66	53	50	67	17	-	-	-
Se	1	3	-12	-2	-4	-4	-4	0	-4	-38	-197
Sm	10	15	105	67	44	44	42	10	-	-	-
Sr	83	54	861	360	459	494	497	124	-	-	-
Ta	2	3	21	15	9	9	8	2	-	-	-
Th	8	7	58	55	52	47	47	12	-	-	-
Tl	3	3	32	20	12	12	12	3	-	-	-
U	6	40	2	3	5	4	2	3	-39	-58	-15
V	117	94	649	320	319	318	297	74	3	-47	
W	4	11	33	20	12	12	12	3	-	-	-
Y	17	17	237	152	154	119	105	26	-	-	-
Yb	5	50	43	22	20	15	14	4	-	-	-
Zn	78	108	216	37	480	309	280	70	-7692	-4912	-2995
Zr	256	275	1241	761	1739	931	1064	264	-	-	-
C	-	-	719	391	24	15	10	2	-	-	-
EC (mS/m)	-	-	-29611	-11640	-12687	-5088	-4377	-298	-25227	-22702	-10435
$HC0_3$-	-	-	-39504	-31802	-30426	-18522	-18469	-1323	-	-	-
SO_4^{2-}	-	-	197416	352874	32898	6412	889	771	-1985	-1096	-2761

Table 6-3: Metal comparison to the world sediment quality guidelines of the ROC stream sediments averages.

	Threshold effect SQG (mg/kg)							Midrange effect (mg/kg)				Extreme effect (mg/kg)				ROC SA
SQG	TEL1	ERL	LEL2	MET3	CB TEC	EC-TEL4	Min - Max	PEL1	ERM	EC-PEL2	Min - Max	TET	SEL1	CB PEC	Min - Max	
As	5,9	33	6	7	9,79	7,24	5,9 - 33	17	85	41,6	17 - 85	17	33	33	17 - 33	4-680
Cd	0,6	5	0,6	0,9	0,99	0,68	0,6 - 5	3,53	9	4,21	3,53 - 9	3	10	4,98	3,53 - 5	-
Cr	37,3	80	26	55	43,4	52,3	26 - 55	90	145	160	90 - 145	100	110	111	90 - 80	5-3200
Cu	35,7	70	16	28	31,6	18,7	16-35,7	197	390	108	197 - 390	86	110	149	197 - 70	2-89
Pb	35	35	31	42	35,8	30,2	30,2 - 42	91,3	110	112	91,3 - 110	170	250	128	91,3 - 35	3-98
Hg	0,17	0,15	0,2	0,2	0,18	0,13	0,13 - 0,2	0,486	1,3	0,7	0,486 - 1,3	1	2	1,06	0,486 - 0,15	-
Ni	18	30	16	35	22,7	15,9	16 - 35	36	50	42,8	36 - 50	61	75	48,6	36 - 30	5-197
Zn	123	120	120	150	121	124	120 - 124	315	270	271	315 - 270	540	820	459	315 - 120	3-724
Reference	a	a	a	a	a	b		a	a	b		a	a	a		

SQG, Sediment quality guideline; TEL, threshold effect level; ERL, effects range low; LEL, lowest effect level; MET, minimal effect threshold; CB, Consensus Based; TEC, threshold effect concentration; EC, Environment Canada

a MacDonald et al. 2000; b Smith et al 1996

The large quantity of major elements in stream sediments shows that some mobile components of the parent rocks were lost during weathering and transit. The potential absence of fine-grained material in the stream sediments indicates that physical weathering and depletion of highly mobile elements such as Na, K, P, U, and Cr have also happened. Phosphate (together with U, Zr, REE, and Nd from fertilizers), base metals, and steel-refining metals can be predicted to receive anthropogenic input (Ti, V, Cr, Mo, and W). Certainly, As, Pb, Cd, Tl, and other metals are derived from the biological content of the coal seams when they are leached by mining. Table 6-2 indicate the high loads of the major elements in the stream associated with the coal seams. The contributions of Mg, Ca, Na, Fe, Mn and K concentrations are associated with coal seams. The analysis reveals that the geochemistry of bedrock is the primary determinant of elements inputs in the stream sediments of the receptor region (Table 6-2). Compared to the water quality downstream, the elements of Mn, Fe, Mg, Ca, Na and K exceeds the required guidelines (DWAF, 1996).

With the exception of Ca, the increased levels of Si, Ti, Fe, Mn, Mg, and Cr match the bedrock remarkably well. The reason for the increase of Si in stream sediments is because Si is present as quartz grains, which are the most durable, stable, and insoluble mineral and are less abundant in the coal seams than in other stratigraphic units. The amount of detrital oxides and silicates, such as chlorite and clay minerals, influences the enrichment of Ti in sediments derived from bedrock. The concentration of Fe in stream sediments is the result of MD and the presence of pyrite, siderite, and hematite can be expected downstream. Mn is associated with carbonates and clay minerals, particularly from coal seams, may be the primary cause of its accumulation in stream sediments (Table 6-2). The higher Cr concentrations may be attributable to the geological units above and below coal seams (Table 6-2).

The elements of Al, Ca, Na, K, and P concentrations are lower in the stream sediments than in the source rocks, indicating the dissolution of associated minerals. The decrease of these elements and the enrichment of Si may be attributed to sedimentary sorting and the loss of clays with fine particle sizes. Feldspars are composed of Ca, K, and Na concentrations, and their depletion is linked to physical weathering and dissolution, resulting in clastic particles with smaller grain sizes as discussed in the leaching experiment. It also proposes the alteration of plagioclase into clay minerals as a result of chemical weathering. Low Ca values also indicate carbonate mineral depletion in the stream.

In conclusion, the combination of these assessments suggests the potential sources of metals in the lithological units, as explained in chapters 3 to 5, Netshitungulwana *et al.* (2023) and summarized in Tables 6-1 and 6-2. In chapter 4, the acid-base analysis and kinetic testing demonstrated that coal seams, above and below strata release metals under favorable conditions, it was also validated by the 100 years kinetic models. The following is a logical conclusion:

- Possible coal seam contributions to the downstream geochemistry include high concentrations of Ca, Mg, Mn Na, K and SO_4^{2-}. The chalcophile elements like Fe, Cu, As, and Zn are also included in the contributions. As, indicate the highest value of 36 ppm on average bedrock to the maximum value of 680 ppm on average stream sediment (Tables 6-2 and 6-3). The range of As and Zn is above the SQG in Table 6-3.

- Possible of above and below lithological units contributions to the downstream geochemistry include moderate SO_4^{2-} and associated chalcophile elements (As, Pb and Zn). The lithological units above and below coal seams have As concentrations ranging from 4 to 40 ppm in sandstone and siltstone, and from 4 to 9 ppm in shale (Appendix I). The second U population, primarily derived from sandstones/siltstones or granite, has the highest concentration of the second population of 265 ppm, although the source of the first population is different (Figure 5-32). Pb concentrations also increase significantly, from a maximum value of 38 ppm in the bedrock to a maximum concentration of 98 ppm in the stream sediments.

- The likely source of Cr is the above and the below units and the steel processing plants in the main cities of Emalahleni and Middleburg, as evidenced by the upper populations in Figures 5-15 and 5-16. The Cr content has average minimum 40 ppm in coal to a maximum of 92, ppm in tillites of the ROC (Appendix I). However, the range of the Cr is above the SQG in Table 6-3. The downstream sediments were enriched to a maximum concentration of 3207 ppm. Figures 5-32 and 5-40, respectively, illustrate that the anomaly is supported by the U and V upper populations, which supports Cr upper population. U concentrations ranging from a maximum of 11 ppm on average bedrock to an average of 1898 ppm in average stream sediments. This putative source may be anthropogenic because the enrichment metals are minor to the geology of the

Witbank coalfield. The other plausible mafic source is the considerable increase in V concentrations from a high of 492 ppm in average bedrock to a maximum of 1028 ppm in average stream sediments. Typical stream sediments have Co concentrations ranging from 42 ppm to 1273 ppm.

The leach test revealed a modest but constant release of metals; it is probable that downstream contributions will persist for a lengthy period of time if no cleanup measures are taken. This study lacks the mineralogy of the receptor realm (stream sediments) and comparison with the predicted SI of the leachate was not made. It is recommended that this can be investigated in future.

As a conclusion of this study. It has achieved its objective, highlighting that characterization of the lithogical units, the deportment processes and the assessment of a potential source of metals can be achieved at pre-feasibility stage prior to the exploitation of resource, and can be modelled for future years. During the planning and monitoring phases of waste management, it is advised that attention be paid to mobile metals to guarantee that there are no pollutants that may impact the surrounding environment. In order to minimize or zero impact to the receptor realm, the subsequent final section focuses on an example of the guidelines for waste management in the research region.

7 WASTE MANAGEMENT FRAMEWORK GUIDELINE PROPOSAL

As part of the management requirements for environmental impacts are stipulated in the NEMA of 1998 and section 36 of the MPRDA Act of 2008 as discussed in the introduction chapter. This highlights will assist in the amendment of section 24 (1) of the NEMA Act of 1998, mining licenses in South Africa must be issued prior to the submission of an MD report, which includes detailing all potential consequences and the management thereof, as a forced requirement.

This proposal is intended to serve as a summary of feasible guidelines for waste disposal management in the coalfield of the research region. The ROC is mostly related with the Witbank (Emalahleni) coalfield, where coal is the primary resource. It is one of the most abundant resources in the planet. There are two major types of coal: hard coal (coking coal, bituminous coal, and anthracite) and brown coal (subbituminous and lignite) (Appenix A). It is crucial to highlight that the primary effects of mining in the Emalahleni area are the vast disturbance of broad areas of land, the interruption of surface and subsurface water, and the production of AMD. As previously noted, it is obvious that the coal seam waste and the lithological units above and below the coal seams are capable of producing AMD.

This section shows the high-level management framework plan for mitigating environmental consequences. Early planning and meticulous operation design are essential for minimizing the environmental impact of mining activities. Before mining begins, throughout mine planning, during mine closure, and after restoration, the authorized plans must be drafted.

Initial mining stage

Initial evaluation of the material generated in each phase of a proposed new mine might include, but is not limited to, the following:

- Geochemical characterisation of the geological units,
- Compilation of static test findings,
- Characterization of AP/NP waste,
- Kinetic tests,
- Prediction of ground or surface water chemistry and remediation proposal.

Developmental mining stage

This research aided in the identification of geological units susceptible to MD, which is necessary for the control of AMD generation. This comprises coal seams and geological units that are above or below coal seams. The waste created by these geological units must be separated to prevent it from coming into contact with surface water drainage streams and groundwater. The following are also crucial throughout the development phase of a mine in order to minimize its environmental impact:

- Formulation of a plan for mine residues,
- Classification of waste (AP/NP) for minimal contamination,
- Operational water management plan,
- Formulation of dust control strategy,
- Restoration and revegetation strategy development.

Plan for mine closure

The mine closure and restoration or reclamation plan must incorporate the repair of disturbed land (open pit and underground mining designs), waste heaps, and tailings facilities, as well as any infrastructure (mill, campsites etc.). The strategy should emphasize the following, among others:

- Strategy for post-closure water management,
- Revegetation and contouring,
- Reclamation of land to address socioeconomic or other ecologically appropriate land use.

The most important task is to establish and implement the above-described plan to mitigate the severe impact on the receiving environment. Continuous monitoring and reporting are required. Produced nations like as Canada and Australia have already developed these criteria, which must be authorized prior to the start of any mining operations. It is crucial that our Environmental Management Plans in South Africa incorporate the scientific output of waste management from the initiation, development, and closure phases.

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APPENDIX A: COAL PETROGRAPHY

A1. Methodology

A1-1. Proximate analysis

The proximate analysis of coal is an assay of the moisture, ash, volatile matter, and fixed carbon as determined by series of prescribed or standard test methods (Speight, 2005). It was developed as a simple means of determining the distribution of products obtained when the coal sample is heated under specified conditions (Speight, 2005). Coal analysis that was conducted on the coal seam samples was proximate analysis and parameters include inherent moisture, ash yield and volatile matter content. This is partly to investigate the forms of sulphur in the coals, and partly to cross check the mineralogical data, especially pyrite and sulphate minerals.

Ash is defined as the substance remaining after coal or coke has been burnt. The must at least 212 µm, and a 1 g of sample is put in furnace of a temperature of 500 °C, and let the temperature stay for 30 minutes. Then the temperature will rise automatically up to 815 °C after the 30 minutes are completed. The samples must stay in the furnace for approximately 3 ½ hrs. At the latter temperature water and other volatile materials are vaporized and organic substances are burnt. Most minerals are converted to oxides, sulfates, phosphates, chlorides or silicates. Although most minerals have fairly low volatility at these high temperatures, some are volatile and may be partially lost (Lead and Mercury).

The final mass will be used to calculate the percentage mass of the ash using the following equations:

$$m_3 - m_1 / m_2 - m_1 \text{ X } 100\% = \text{Ash}$$

Where m_1 is the mass, in grams, of the dish plus lid, m_2 is the mass, in grams, of the dish plus lid plus sample, m_3 is the mass, in grams, of the dish plus lid plus ash.

Moisture is defined as an important parameter in respect of coal quality. The sample must crush to at least 212 µm, weigh the crucible mass with a lid and record the mass, 1 g of a sample is weighed and put into a furnace of a temperature of 105 °C to 110 °C. The samples must stay in an oven for at least 2 ½ hrs, crucibles are re-weighed to obtain the final percentage mass, and the percentage moisture content is calculated using the following equations:

$$m_2 – m_3 / m_2 – m_1 \times 100\% = \text{Moisture}$$

Where m_1 is the mass, in grams, of the empty vessel plus cover, m_2 is the mass, in grams, of the empty vessel plus sample, m_3 is the mass, in grams, of the vessel plus cover plus test sample after heating.

Volatile Matter is regarded as the loss in mass, less than due to the moisture, when coal or coke is heated without contact with air under standardized conditions. Samples must be crushed up to at least 212 µm, the crucible mass be weighed with a lid, the mass recorded and 1 g of the sample be weighed, and put into a furnace of a temperature of 900±5 °C. The samples stay in an oven for at least 7 minutes, the crucibles are re-weighed to obtain the final percentage mass, the percentage moisture content is calculated using the following equation:

$$[100 (m_2 – m_3) / m_2 – m_1] - M = \text{Volatile Matter on a dry basis}$$

$$V \times 100/100 – (M+A) = \text{Volatile matter on a dry ash-free basis}$$

Where m_1 is the mass, in grams, of the crucible plus lid, m_2 is the mass, in grams, of the crucible and lid plus sample before heating, m_3 is the mass, in grams, of the crucible plus lid plus sample after heating, M is the moisture, as a percentage by mass, in the sample as analyzed, A is the ash, as a percentage by mass, of the sample analyzed, V is the volatile matter, as percentage by mass, in the sample as analyzed.

A1-2. Ultimate analysis

The ultimate analysis of coal provides a valuable information about element composition, these involves determination of the weight percent carbon as well as sulphur, nitrogen, hydrogen and oxygen (usually estimated by difference) (Speight, 2005). Coal analysis that was conducted on the 7 coal seam samples ultimate analysis; parameters include nitrogen, carbon, hydrogen and sulphur content. The weight percentage of carbon as well as hydrogen and nitrogen are determined by using LECO CHN628 instrument, while that of sulphur is determined by the use of LECO 628S instrument. The oxygen was determined by the first equation and the calorific value was determined by the 2nd equation:

Oxygen = 100 – (% nitrogen + % carbon + % hydrogen + % moisture)

Calorific value = (37 - % moisture – (0.408 x % ash) (after Smith and Whittaker, 1986)

In the analytical procedure, a weighed amount 0.15 - 0.25 g of coal is placed in a foil inserted into the combustion tube under the first furnace, where the sample is burned in oxygen (Speight, 2005).

A1-3. Carbon and Sulphur determination

Samples must be milled to less than 75 microns. A sample size of 0.2 g is normally used. The sample is placed into a ceramic crucible with half a scoop of iron chips (Catalog no: 501-077) and one scoop of tungsten chips (Catalog no. 763-263). The crucible is then slowly rotated at a slight angle to mix the sample and metal chips. Samples are placed directly into the ELTRA Analyzer without any further preparation. Samples are usually run without any dilution. If the sample tends to evaporate rather than combust, quartz powder or Vanadium pentoxide powder may be added to the sample. This is usually done after the samples have been weighed out.

A1-4. Petrographic analysis

Microscopic studies of coal samples are used to understand coal composition and how they are arranged and to provide knowledge of the maceral composition and distribution (Schweinfurth, 2003). Macerals are the various organic components that make up coal, and sulphur can occur as

an organic component in a coal. Coal petrographers may assess the rank of a coal by measuring the intensity of light reflected from the vitrinite macerals in a polished surface of a coal sample; the higher the reflectivity, the higher the rank (Schweinfurth, 2003).

Analyses used for determination of maceral group composition and vitrinite reflectance in coal samples are conducted using a white light of Leica CTR 6000 Microscope that has Carl Hilgers system software to allow quantification of maceral groups and vitrinite reflectance on polished particulate blocks. The analyses serve as a coal quality assessment that is conducted to obtain the coal chemical properties and the degree of burial for coal.

Samples must be prepared to -1 mm with the -20-micron fraction removed, and approximately 100 – 200 g of the crushed coal is required. Samples should be polished with some, but not excessive relief. Examination of samples is done in oil of 1.518 refractive index, using a low glare optical system with the objectives in a range of normal magnification of 25 to 50 times.

Vitrinite reflectance is a direct measure of the rank of coal and is known to be a major factor affecting coke quality (ALS Coal Technology, 2011). Coal reflectance (ASTM D-2798) is very useful because it indicates several important properties of coal, including determination of the maceral composition of coal (Speight, 2005). Maceral analysis is usually considered the primary tool for determining coal type and to classify the various organically derived constituents, that is, vitrinite, liptinite and inertinite (ALS Coal Technology, 2011). A maceral is the smallest recognizable individual constituent of a coal grain.

A1-5. Optical microscopy

Optical microscopy is another method that has been used to determine the distribution of minerals (Speight, 2005). This method is based on the detailed microscopic examination of polished or thin sections in transmitting and/or reflected light. In principle, observing several of its optical properties, such as morphology, reflectance, refractive index, and anisotropy, makes identification of a mineral type possible (Speight, 2005).

A2. RESULTS

A2-1. Coal Quality

A2-1-1. Proximate and Ultimate analysis

The results obtained from the proximate and ultimate analyses and the calorific values of the pulverised coal samples of the Geodehoop coal seams is given in Table 1. The moisture has a minimum concentration of 4.40% in seam No. 3 and 5 and a maximum concentration of 4.6% in seam No. 2 of borehole ZFN1510, while borehole ZFN1512 samples show a minimum moisture of 3.40% in seam No. 2 and the maximum moisture of 4.20% in seam No. 3 (Table A1). Borehole ZFN1512 has the highest std.-dev of moisture, but a low average on moisture. The volatile matter ranges from 13.20% to 36.50% on both boreholes. The minimum and maximum concentrations of volatile matter are in samples of seam No. 5 and 3 in borehole ZFN1510, and of seam No. 2 and 3 in borehole ZFN1512 (Table A1). The concentrations of ash of the borehole ZFN1510 range from 11.40% in seam No. 2 and 3 to 15.60% in seam No. 5, and in ZNF1512 ranges from 8.80% in seam No. 3 to 29.20% in seam No. 2 (Table A1).

Nitrogen shows a minimum concentration of 1.8% in seam No. 5 and a maximum concentration of 2.1% in seam No. 3 for borehole ZFN1510 samples. While in borehole ZFN1512 nitrogen shows a minimum concentration of 1.34% in seam No. 2 and a maximum concentration of 2.06% in seam No. 3. Carbon shows a minimum concentration of 66.40% in seam No. 5 and a maximum concentration of 71.10% in seam No. 2 for the borehole ZFN1510 (Table A1). In borehole ZFN1512, carbon shows a minimum concentration of 57.60% in seam No. 3 and a maximum concentration of 72.90% in seam No. 5. In seam No. 5, there is a minimum concentration of 4.54% for hydrogen and a maximum concentration of 4.70% in seam No. 3 of ZFN1510 (Table A1). Hydrogen shows a minimum concentration of 2.87% in seam No. 2 and a maximum concentration of 4.81% of seam No. 3 of borehole ZFN1512 (Table 3-8). Sulphur shows a minimum concentration of 1.55% in seam No. 3 and a maximum concentration of 2.52% in seam No. 5 of the borehole ZFN1510. Borehole ZFN1512 shows a minimum concentration of sulphur of 0.20% in seam No. 2 and a maximum concentration of 1.41% in seam No. 5 (Table A1). Oxygen shows

a minimum concentration of 20.72% in seam No. 2 and a maximum concentration of 24.74% in seam No. 5 for the borehole ZFN1510, borehole ZFN1512 shows a minimum concentration of 18.88% for oxygen in seam No. 5 and a maximum concentration of 37.99% in the same seam No. 2 (Table A1). The std.-dev of nitrogen, carbon, hydrogen, sulphur and oxygen are 0.32, 2.49, 0.09, 0.52 and 2.21 respectively for borehole ZFN1510, while those for borehole ZFN1512 are 03.4, 7.27, 0.92, 0.56 and 8.98 respectively. The high oxygen std.-dev may be due to high ash content in coal seam No. 2. The calorific value ranges from 26.24-27.95 kJ/kg for borehole ZFN1510, and that for borehole ZFN1512 ranges from 21.69-29.21 kJ/kg.

Table A-1: Results of the proximate and ultimate analyses of the Geodehoop coal seams in percentages with average, std.-dev., minimum and maximum; calorific value (kJ/kg).

BORE HOLE ZFN1510										
		Ultimate analysis				**Proximate Analysis**				
Lab No.	**Coal Seam**	**Nitrogen**	**Carbon**	**Hydrogen**	**Sulphur**	**Volatile matter**	**Ash**	**Moisture**	**Oxygen**	**Calorific Value**
M35	Seam No. 5	1.80	66.40	4.54	2.52	13.20	15.6	4.4	24.74	26.24
M53	Seam No. 3	2.40	70.20	4.70	1.55	36.50	11.4	4.4	21.15	27.95
M61	Seam No. 2	1.90	71.10	4.56	1.72	33.80	11.4	4.6	20.72	27.75
Average		2.03	69.23	4.60	1.93	27.83	12.80	4.47	22.20	27.31
Std.dev		0.32	2.49	0.09	0.52	12.74	2.42	0.12	2.21	0.94
Min		1.80	66.40	4.54	1.55	13.20	11.40	4.40	20.72	26.24
Max		2.40	71.10	4.70	2.52	36.50	15.60	4.60	24.74	27.95
BORE HOLE ZFN1512										
W26	Seam No. 5	2.01	72.90	4.80	1.41	35.20	9.6	4	18.88	29.08
W31	Seam No. 4	1.60	70.90	3.91	1.32	28.60	11.0	4.1	22.27	28.41
W41	Seam No. 3	2.06	72.30	4.81	1.16	36.00	8.8	4.2	19.67	29.21
W49	Seam No. 2	1.34	57.60	2.87	0.20	19.60	29.2	3.4	37.99	21.69
Average		1.75	68.43	4.10	1.02	29.85	14.65	3.93	24.70	27.10
Std.dev		0.34	7.27	0.92	0.56	7.60	9.74	0.36	8.98	3.62
Min		1.34	57.60	2.87	0.20	19.60	8.80	3.40	18.88	21.69
Max		2.06	72.90	4.81	1.41	36.00	29.20	4.20	37.99	29.21

A2-1-2. Coal petrography

The physical appearance of the coals in the study area is dominated by banded 90% bright and dull lustrous macerals with pyrite lenses. Coal maturation is characterized by a progressive loss of volatile matter and an increase in carbon content, an increase in latent heat value and a decrease in porosity and inherent moisture content (Smith *et al.*, 1994). Coal rank is determined by the increase in coal maturation, which ranges from lignite through sub-bituminous, high volatile, medium

volatile, low volatile bituminous rank to anthracite and meta-anthracite (Stopes, 1919; Smith *et al.*, 1994; Stach *et al.*, 1982).

Table A-2 illustrates the maceral analysis results for the individual coal seam No. 2 to 5 from the Goedehoop colliery. According to Table A-2, the random mean vitrinite reflectance of borehole ZFN1510 through seam No. 2 to 5 ranges from 0.5 to 0.85%, while it ranges from 0.45 to 0.85% for borehole ZFN1512 (Table A2). The sulphur concentration in the coals of the Permian Vryheid Formation has been reported to have a positive correlation with the content of the vitrinite maceral group, and a negative correlation with the inertinite maceral family (Roberts, 1988) and this may results in metal leach more on the vitrinite-rich coal. Inertinite is associated with organic sulphur (Roberts, 1988). In borehole ZFN1510, seam No. 2 shows a minimum vitrinite concentration of 19% and while a maximum concentration is in seam No. 3 of 85.6%, an average vitrinite of 58.20% and a std.-dev of 34.83. Borehole ZFN1512, shows a minimum concentration of vitrinite in seam No. 2 of 30.3% and a maximum concentration in seam No. 5 of 71.2%, with an average of 52.58% and a std.-dev of 19.81 (Table A-2). The minimum concentration of liptinite is 0.3% found in seam No. 2 and maximum concentration is 2.4% in seam No. 3 with an average of 1.23 and a std.-dev of 1.07 in borehole ZFN1510. While the std.-dev for liptinite in borehole ZFN1512 is 1.34 and average of 2% with minimum concentration found in seam No. 4 (0.8%), and maximum concentrations of 3.6% in seam No. 5 (Table A-2).

Inertinite is the second maceral that also shows higher concentrations in boreholes, where ZFN1510 shows that seam No. 5 has the minimum concentration of 6.6% and seam No. 2 have the maximum concentration of 43.4%. In ZFN1512 seam No. 5 has the minimum concentration of 23.2% and seam No. 4 has the maximum concentration of 55.8% for inertinite. The average concentrations found in inertinite are 19.07% and 33.28% with std.-dev of 21.08 and 15.7 respectively (Table A-2). The mineral content in borehole ZFN1510 is 4.8% in seam No. 3 and the maximum value of 37.3% in seam No. 2. Seam No. 2 have a maximum value of 43% and seam No. 3 & 4 have the minimum value of 1.8% of mineral content in borehole ZFN1512 (Table A-2). The average values are 21.50% and 12.15%, respectively for minerals. While the std.-dev for ZFN1510 is 16.27, which for ZFN1512 are 20.57.

Table A-2: Three major groups of macerals, mineral and reflectance of vitrinite in (wt %).

ZNF1510								
Sample No	**Coal Seam**	**Vitrinite%**	**Liptinite%**	**Inertinite%**	**Minerals %**	**Vitrinite reflectance %**		
						0.45-0.50	0.50-0.75	0.75-0.85
M35	Seam No. 5	70	1	6.6	22.4		95	5
M53	Seam No. 3	85.6	2.4	7.2	4.8		91	9
M61	Seam No. 2	19	0.3	43.4	37.3		97	3
Average		58.20	1.23	19.07	21.50			
Std.v		34.83	1.07	21.08	16.27			
Min		19	0.3	6.6	4.8			
Max		85.6	2.4	43.4	37.3			
ZNF1512								
W26	Seam No. 5	71.2	3.6	23.2	2		99	1
W31	Seam No. 4	41.6	0.8	55.8	1.8	1	97	2
W41	Seam No. 3	67.2	2.6	28.4	1.8		84	16
W49	Seam No. 2	30.3	1	25.7	43		93	7
Average		52.58	2.00	33.28	12.15			
Std.v		19.81	1.34	15.17	20.57			
Min		30.3	0.8	23.2	1.8			
Max		71.2	3.6	55.8	43			

The coal samples from Goedehoep are rich in telovitrinite, which is the dominant component of the vitrinite group. The main constituents of the liptinite group are sporinite, cutinite and resinite, while fusinite, semifusinite, micrinite and inertodetrinite are common macerals in the inertinite group. The abbreviations for macerals in the photomicrographs of the research are: (T) telovitrinite, (F) fusinite, (Sf) semifusinite, (Id) inertodetrinite, (Mi) micrinite, (C) cutinite and (Sp) sporinite with mineral matter (MM). Figure A-17 is coal seam No. 5 (W26) which is dominated by a parallel bedding of vitrinite which is mainly telinite maceral with inertinite (fusinite, semifusinite, micrinite and inertodetrinite) as major maceral and a lower content of liptinite (cutinite & sporinite) and mineral matter. Early peat accumulation at coal seam No. 5 (W26) occurred under anaerobic conditions due to high groundwater table levels in the peat mire (Thomas, 2012), indicated by a high proportion of vitrinite and oxidation as indicated by the low proportion of inertinite.

The analysed coal seam No. 4 (W31) is dominated in inertinite group macerals followed by vitrinite and lower amounts of liptinite group, where fusinite and semifusinite are the constituents of the inertinite group. Telovitrinite is the common maceral of vitrinite while liptinite's common macerals are cutinite and sporinite in coal seam No. 4 (Figure A-2). Coal seam No. 2 (W49) has a major proportion of mineral matter, inertinite and vitrinite group macerals, followed by liptinite group. Telovitrinite is the most abundant vitrinite maceral, while the inertinite macerals in seam No. 2 (W49) are mainly fusinite, semifusinite and inertodetrinite (Figure A-3). Sporinite and cutinite are common macerals of the liptinite group (Figure A-3).

Coal seam No. 3 (W41) is dominated by vitrinite, with telovitrinite being the most abundant maceral followed by major maceral of inertinite (fusinite, semifusinite and micrinite) and lower proportions of liptinite (cutinite and sporinite) (Figure A-22). Coal seam No. 3 (Figure A-22) occurred under anaerobic conditions due to high groundwater table levels in the peat mire (Thomas, 2012) indicated by high proportion of vitrinite and environmental conditions returned to a lower ground-water table and oxidising conditions as seen by the presence of fusinite and semi-fusinite (Weeber, 1996). Sporinite typically occurs as discrete bodies (Figure A-22).

Coal seam No. 5 (M35) & M53) is dominated by vitrinite group maceral followed by inertinite and liptinite group with the exception that it has a major content of mineral matter (Figure A-17 and 21). Coal seam No. 3 (M53) is dominated by vitrinite group maceral followed by inertinite and liptinite group and it has less mineral matter (Figure A-22). The liptinite group macerals occurring in the seam No. 5 (M35) & 3 (M53) are mainly sporinite and cutinite, even the vitrinite maceral group is mainly telovitrinite. Coal seam No. 5 (M35) & 3 (M53) have the same inertinite macerals group mainly being fusinite, semifusinite and micritinte, the only difference being that coal seam No. 3 (M53) also has inertodetrinite which shows a white to yellowish-white colour in reflected white light. The macerals of the liptinite group are distinguished by their slightly darker colour in reflected white light (Farhaduzzaman, 2013). Thomas (2012) states that vitrinite occurred under anaerobic conditions due to high groundwater table levels in the peat mire indicated by a higher proportion of vitrinite, and environmental conditions returned to a lower ground-water table and oxidising conditions as seen by the presence of fusinite, semifusinite, micrinite and inertodetrinite in both seams (Figures A-21 and A-22).

Coal seam No. 2 (M61) consists of mineral matter and the major maceral is inertinite group macerals followed by the vitrinite and liptinite groups (Figures A-19 and 23). The most common constituents of the inertinite maceral group are fusinite, semifusinite and inertodetrinite, while telovitrinite is a vitrinite maceral that mainly occurs in coal seam No. 2 (M61). Sporinite and cutinite are the dominant component macerals of the liptinite group (Figure A-19). The environmental formation were anaerobic conditions due to high groundwater table levels in the peat mire (Thomas, 2012), indicated by minor vitrinite. Then the environmental conditions returned to a lower ground-water table and oxidizing conditions as seen by the presence of fusinite and semi-fusinite (Weeber, 1996).

The microscopic study of coal has enabled a better understanding of its organic and mineral components and its industrial utilization (Thomas, 2012). Carboniferous coals have a typically bright lustrous appearance and consist of predominantly vitrite and clarite, a combination of vitrinite and exinite. Permian coals were principally formed in the Gondwana super continent with the exception of early Permian in the north of China (Thomas, 2012). Late Mesozoic and Paleogene-Neogene coals are variable and can be more complex in their make-up. They are usually rich in huminite and vitrinite with variable amounts of liptinite and are low inertinite. The majority of these coals are low rank and do not exhibit the fine banding that characterizes the older coals (Taylor *et al.*, 1998).

Francis (1961) classified the minerals in coal into inherent and adventitious mineral matter on a genetic basis, referring to inorganic constituents that were derived from coal-forming plants and added after peat deposition, respectively. However, distinction is not always possible, especially when mineral matter was precipitated from solutions, which may have been derived from either the plants or ions transported to the peat (Diessel, 1992). According to another genetic classification of minerals in coal by Mackowsky (1982), discrete minerals in coal may be of detrital, syngenetic, or epigenetic origin.

Coal is the end product of sequence of biological, geochemical and geologic processes and coals are divided into three main groups (Table A-3), the humic coals, the sapropelic and the liptobiolith.

Humic coals are composed of a diversified mixture of macroscopic plant debris and they typically have a banded appearance. Sapropelic coals are composed of a restricted variety of microscopic plant debris and have a homogeneous appearance (Thomas, 2012). The mineral content of coal is the non-combustible inorganic fraction, which is made up of minerals that are either detrital or authigenic in origin, and which are introduced into coal in the first or second phases of coalification (Thomas, 2012).

A variety of minerals can be found in coal, commonly these are dominated by quartz, carbonate, iron and clay minerals with a diverse suite of accessory minerals such as pyrite, marcasite, sphalerite, galena, pyrrhotite and stibnite (Table A-4) that may be perculiar to the local source rock (Thomas, 2012). Waterborne mineral matter is transported into coal swamps along channels that cut through the accumulating organic debris. Windborne mineral matter is important, as this can be a significant contributor to the mineral contents of coals because of the slow accumulation rates in peat swamps (Thomas, 2012).

Table A-3. Table indicating the types of coal.

Class	Type
Humic coal	Brown coal
	Bituminuos coal
	Antracite
Sapropelic	Cannel coal
	Boghead coal
	Saprocollite
Liptobiolith	Cutinitic
	Bark
	Resinitic
	Sporinitic

In this study, the most common minerals in coal are silicates, sulphides and carbonates. Sulphates and phosphates are less common, but may occur as secondary enrichment as proposed by Zhao

(2012) in significant proportions in some cases. Other accessory minerals are not always abundant enough to be identified from XRD analysis of whole coal or low temperature ashes. Table A-4 lists the minerals that can be identified in coal and its complexing will be highlighted in the subsequent chapter.

The main constituents of quartz, kaolinite, calcite, dolomite and minor montmorillonite, occur in the coal in varying proportions, while illite, siderite and potassium-feldspar are more common in the roof and floor rocks (Pinetown and Boer, 2006). A similar distribution pattern is displayed in the Witbank coalfield, however, chlorite dominance in certain sections of the sequence is commonly associated with the carbonate minerals, and the illite/smectite interstratification contains up to 80% illite in some cases (Pinetown and Boer, 2006).

Table A-4 Major minerals identified in coal (modified from Ward, 2002).

Mineral	Formula	Mineral	Formula
Silicates		Oxides and hydroxides	
Clay minerals		Quartz	SiO_2
Kaolinite	$Al_2Si_2O_5(OH)_4$	Chalcedony	SiO_2
Illite	$K_{1.5}Al_4(Si_{6.5}Al_{1.5})O_{20}(OH)_4$	Anatase	TiO_2
Smectite	$Na_{0.33}(Al_{1.67}Mg_{0.33})Si_4O_{10}(OH)_2$	Rutile	TiO_2
Chlorite	$(MgFeAl)_6(AlSi)_4O_{10}(OH)_8$	Diaspore	$Al_2O_3.H_2O$
Feldspars		Hematite	Fe_2O_3
Plagioclase	$(Na,Ca)Al(Al,Si)Si_2O_8$	Magnetite	Fe_3O_4
Albite	$NaAlSi_3O_8$	Goethite	$Fe_2O_3.H_2O$
Anorthite	$CaAlSi_3O_8$	Ilmenite	$FeTiO_3$
Orthoclase	$KAlSi_3O_8$	Boehmite	AlOOH
Sanidine	$KAlSi_3O_8$	Gibbsite	$Al(OH)_3$
Tourmaline	Na(MgFeMn)3Al6B3Si6O27(OH)4	Carbonates	
Zircon	$ZrSiO_4$	Calcite	$CaCO_3$
Sulphides		Dolomite	$CaMg(CO_3)_2$
Pyrite	FeS_2	Ankerite	$(Fe,Ca,Mg)CO_3$
Marcasite	FeS_2	Siderite	$FeCO_3$
Sphalerite	(Zn,Fe)S	Witherite	$BaCO_3$
Galena	PbS	Aragonite	$CaCO_3$
Pyrrhotite	$Fe_{(1-x)}S$	Sulphates	

Stibnite	SbS	Anhydrite	$CaSO_4.2H_2O$
Millerite	NiS	Bassanite	$CaSO_4$
Phosphates		Barite	$BaSO_4$
Apatite	$Ca_5F(PO_4)_3$	Jarosite	$KFe_3(SO_4)2(OH)_6$

The optical nature of coal can be classified as dominantly (90%) banded bright coal and dull-lustrous coal with pyrite lenses as determined by XRD and coal petrography above. The present sulphides minerals such as pyrite are exposed to air and water, their oxidation leads to sulfuric acid production and the results is rock drainage. The environment of deposition of the Witbank coalfield is known, and the coals are classified sub-bituminous to high-volatile bituminous rank with vitrinite being the most dominant maceral group followed by the inertinite and liptinite groups. The most common constituents of the inertinite maceral group are fusinite, semifusinite, micritinte and inertodetrinite, while telovitrinite is a vitrinite maceral that occurs mainly in the coals. Sporinite and cutinite are the dominant component macerals of the liptinite group.

The seams have higher vitrinite percentages than other coals, which indicates anaerobic conditions due to high groundwater table levels in the peat swamp, environmental conditions returned to a lower ground-water table and oxidizing conditions, as seen by the presence of fusinite and semi-fusinite (Weeber, 1996). Therefore, Tankard *et al.* (1982) propose that the southern hemisphere Permian coals originated during a cool-temperate post-glacial palaeoclimatic regime.

The oxidation of the coal seams causes the acid producing, but includes buffering minerals such as carbonates (calcite, dolomite, and siderite). The details of this hypothesis will be discussed in the subsequent chapters. These latter minerals plays a vital role in the buffering capacity of the release of metals, thereby reducing mobility of toxic elements. The strong correlation between carbon and sulphur suggests that some of the sulphur is of organic origin whereas the rest of the sulphur maybe from an inorganic source such as hydrothermally formed pyrite.

The progressive loss of volatile matter and an increase in carbon content, latent heat value and a decrease in porosity and inherent moisture content characterizes coal maturation (Smith *et al.*, 1994). The coal ranks are as follows lignite through sub-bituminous, high volatile, medium

volatile, low volatile bituminous rank to anthracite and meta-anthracite (Figure A-1) (Smith *et al.*, 1994). The effect of the vitrinite reflectance and calorific value in a coal of its rank is illustrated in Figure A-1.

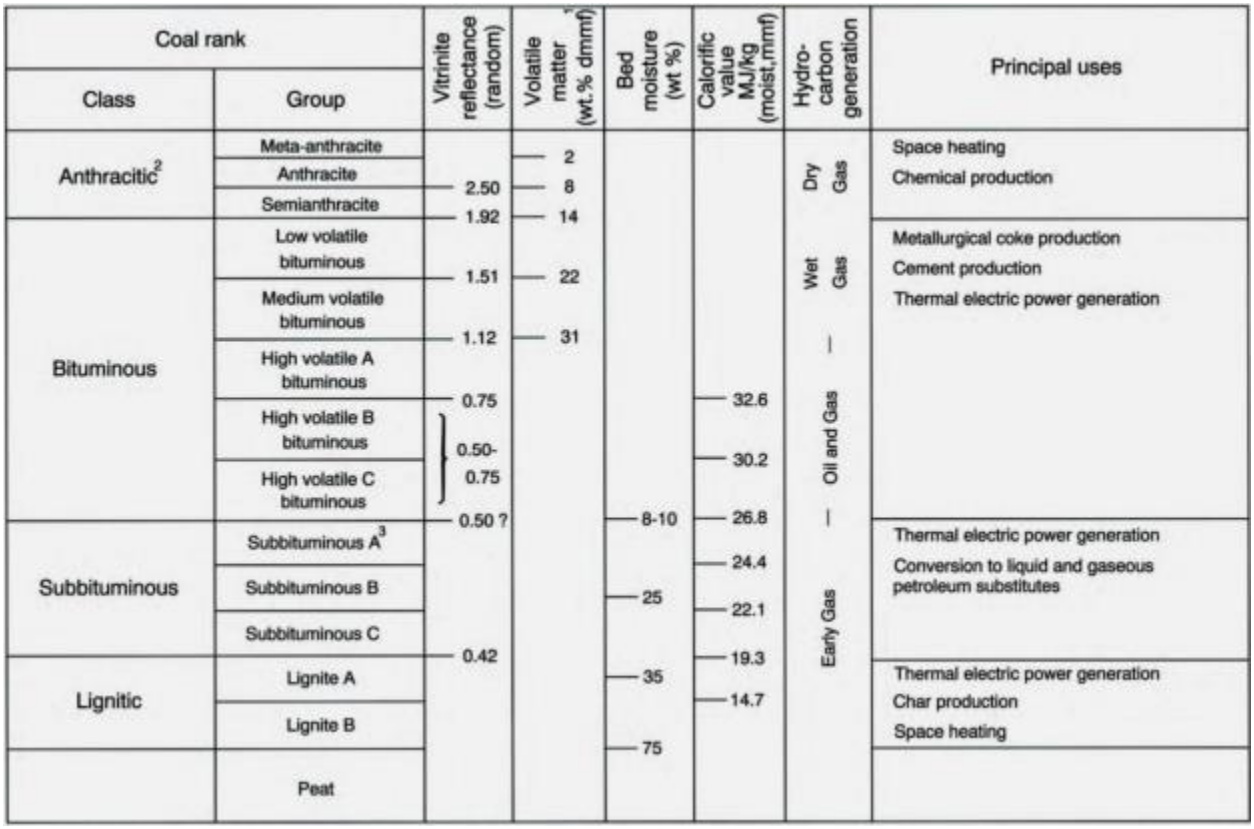


Figure A-1: Classification of coals by rank and indices of organic maturity. The chart is a composite modified from (ASTM, 1981; Teichmuller & Teichmuller (in Stach *et al.*, 1975); Dow 1977; Cameron (1989)

The proximate and ultimate analysis data, total sulphur, oxygen and calorific value of the Witbank coals are given in Figure A-2. The moisture content seems to be relatively constant within the seams except on seam No. 2, which shows 3.4% moisture (Table A-5). The high proportions of clay minerals may be associated with high moisture content (Table A-5), which they contain moisture attached to their crystal structures (Zhao, 2012). The moisture content of the coal samples appears to be relatively constant within seam sections (Figure A-25) and the moisture content is

lower in the Witbank coals (Smith & Whittaker, 1986) and Highveld (Jordan, 1986) coals except Seam No. 5 of Witbank, in which it shows higher moisture content (Table A-5).

Volatile matter in coal refers to the components of coal (except for moisture) which are liberated at high temperatures in the absence of air (Farhaduzzaman, 2013). Volatile matter content is highest in liptinite, lowest in inertinite and that for vitrinite lying in between (Sanyal, 1997). High volatile values occur in the Goedehoop samples (W26, W31, W41, M53 and M61) compared to the Witbank and Highveld coals (Smith & Whittaker, 1986; Jordan, 1986). The highest volatile matter values occur on seam W26, W31, W41, M53 and M61 samples. The high volatile yield may therefore be associated with the loss on ignition where carbon and sulphur escape during the analytical process.

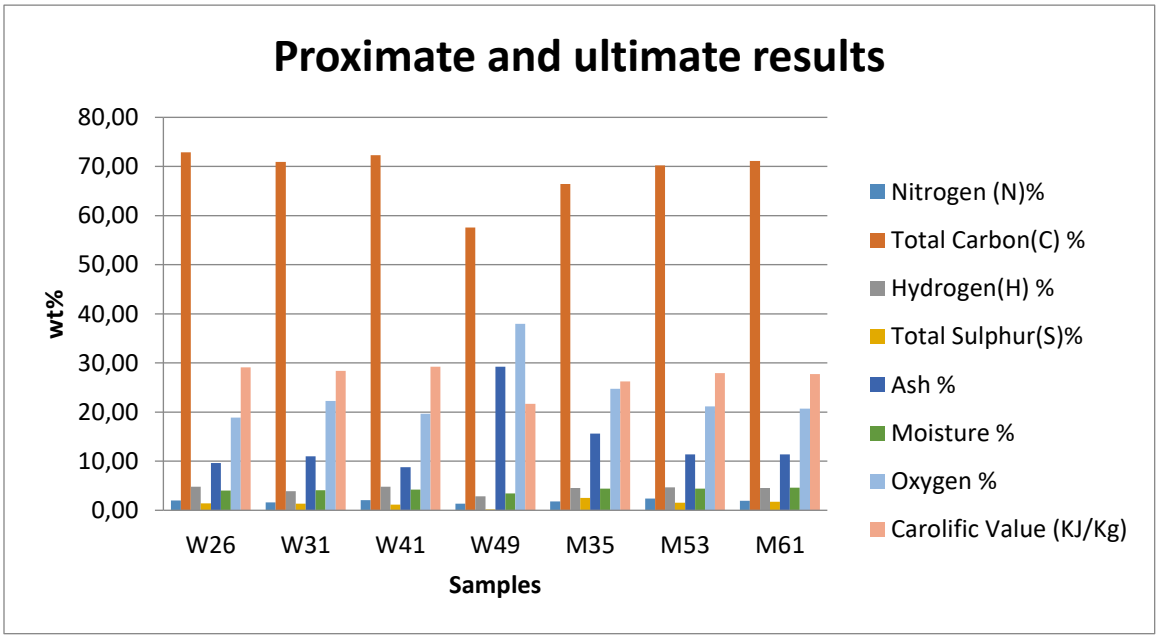


Figure A2. Bar chart showing proximate and ultimate results from the Geodehoop colliery.

The ash content of coal is the non-combustible residue left after coal is burnt and it represents the bulk mineral matter after carbon, oxygen, sulphur and water are driven off during combustion (Farhaduzzaman, 2013). Seam No. 2 (sample W49) forms an exception in that it has higher ash

content which indicates that the coal is generally high in mineral matter and displays a highly variable type (Falcon, 1986).

The carbon content was far higher than the hydrogen, nitrogen and sulphur concentrations in the coal samples as expected (Figure A-2), and the coals, therefore, commonly range from sub-bituminous to high volatile bituminous. Higher concentrations of sulphur were found in the samples with the exception of sample W49 which gave the lowest value of 0.2% (Figure A-2).

The hydrogen determination includes hydrogen present in the organic materials and hydrogen in the free moisture accompanying the sample as well as hydrogen as water of hydration of silicates (Zhu, 2014). For a maceral group of the same rank, vitrinite contains more carbon content, liptinite contains more hydrogen content, and inertinite more carbon (Sanyal, 1997). The hydrogen content of the coal samples ranges from 2.87 to 4.81%, while the low hydrogen samples also have high oxygen content in the lower seam (sample W49). This may be associated with the presence of higher amounts of mineral matter content and vitrinite (Table A-5). The data of the investigation indicate that the vitrinite contains relatively more oxygen, the liptinite more hydrogen, and inertinite more carbon.

Table A-5: Typical analyses of raw coal for the Witbank and Highveld coalfields (Cairncross, 2001).

Coalfield	Seam	Moisture %	Ash %	Volatile matter %	CV(KJ/Kg)	references
Witbank	1	1.7	25.4	21	24	Smith and Whittaker (1986)
	2	5.2	23.3	21.5	21.2	
	4	2.6	22.6	20.7	22.2	
	5	2.5	13.1	32	28.2	
Highveld	2	3.8	29	19.9	20.5	Jordan (1986)
	4	2.5	27.9	20.2	21.9	
	5	3.2	17.1	32.7	25.9	

As mentioned and defined in section 3.3.4, the vitrinite group maceral in the Goedehoop coals are mainly telovitrinite. Telovitrinite consists of phytoclasts comprised of intact plant tissues (International Committee for Coal Petrology, 2011). Both cell wall and cell contents are present but either or both may be impregnated with humic matter of colloidal origin and most telovitrinite appears grey in polished sections (International Committee for Coal Petrology, 2011). Telovitrinite

is mostly characterized by a groundmass of a clear cell structure, with color that varies from light to moderately dark grey in a reflected white light, and occurs as parallel thick and thin bands in the seams (Figures A-3 to A-9).

Liptinite macerals identified in the Goedehoop Permian coals are sporinite and cutinite (Figure A-8). Sporinite is the most common liptinite maceral derived from spore and pollen coats (International Committee for Coal Petrology, 2011). Sporinite occurs as elongated, flattened or disc-shaped, thread-like bodies that are parallel to the stratification (Farhaduzzaman, 2013). As shown in Figures A-3 to A-9, sporinite is identified as cleats that are parallel to the bedding plane of the coal and also occur as discrete bodies; under reflected white light, they appear darker (dark grey to brownish-black) than the surrounding telovitrinite. It is widely believed that cutinite is derived from the outer coating of leaves, needles, shoots, and some roots and thin stem, and has long chain structures that are waxy in nature (International Committee for Coal Petrology, 2011). Under reflected white light, cutinite is dark grey to black in color and is recognized as sheet-like fragments (Figure A-8).

Speight (2013) mentions that the inertinite macerals are derived from plant material that has been strongly altered and degraded in the peat stage of coal formation. As mentioned in coal quality section, fusinite, semifusinite, inertodetrinite and micrinite are the main constituents of the inertinite maceral group that occur in the Goedehoop coals. Cell structures in both fusinite and semifusinite are commonly well preserved (Farhaduzzaman, 2013; under reflected white light, fusinite and semifusinite are recognized by a white to yellowish-white color (Figure A-8).

The highly-reflective particles are often shown by the original morphology of micrinite, where the cell substance has been converted to small (Scott, 2002). Micrinite occurs as very fine granular particles which are white to yellowish-grey in color in reflected white light (Figures A-4a, A-3a, A-8d and A-9d). Inertodetrinite represents small fragments derived from the physical degradation of other types of Inertinite (International Committee for Coal Petrology, 2011). Inertodetrinite is identified by a white to yellowish-white color under a reflected white light (Figures A-5a, A-8a-c and A-9a).

Semi-quantitative X-Ray Diffraction analysis data on the mineral assemblage in the coal and non-coal samples of the Witbank coalfield are given in Appendix B.

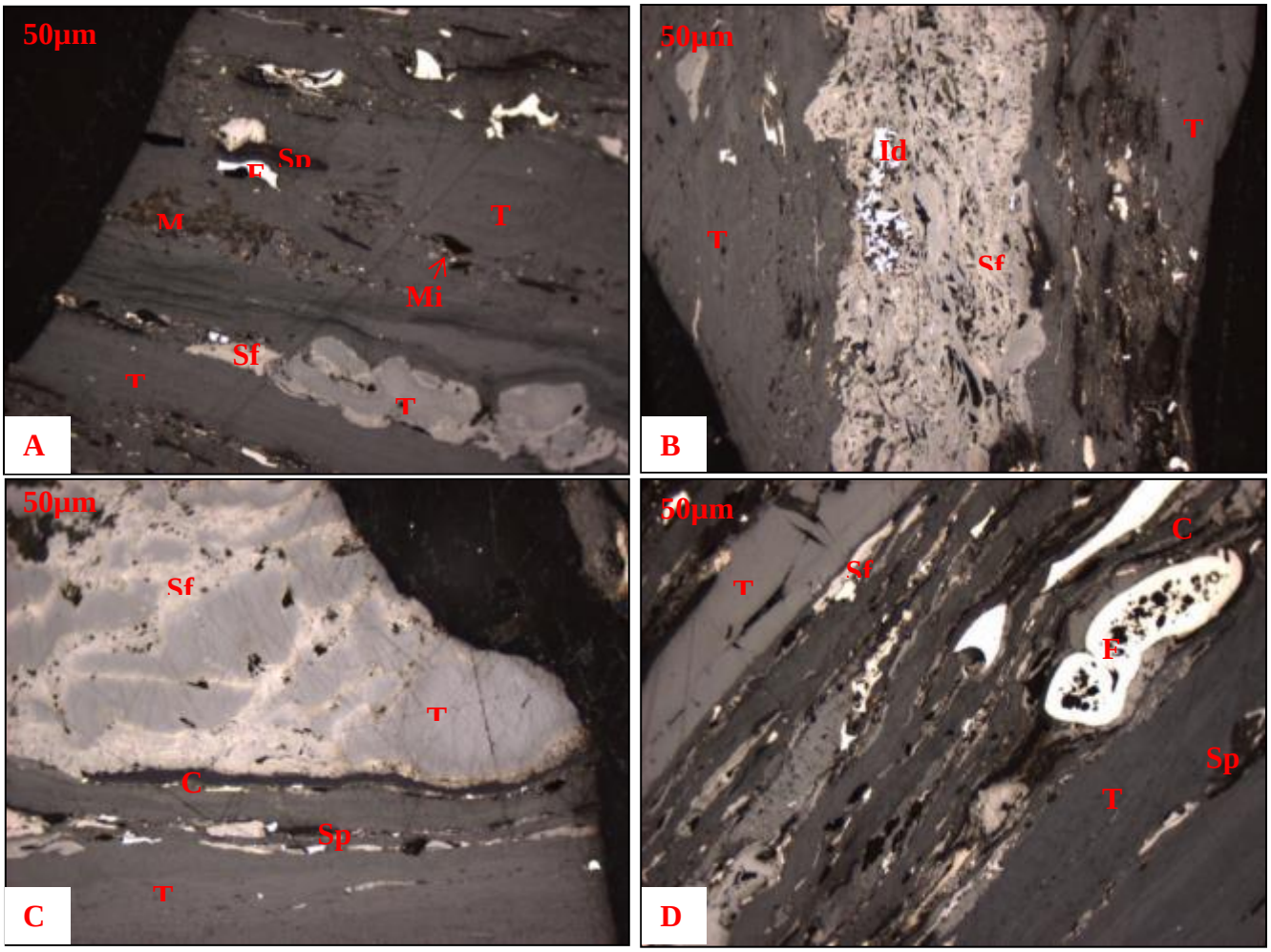


Figure A-3: Photomicrographs of coal seam No. 5 (W26) showing typical macerals under reflected white light. (a) Ground mass of vitrinite (T) with liptinite (Sp) and inertinite (F, Sf & Mi) with less mineral matter; (b) vitrinite (T) and inertinite (Sf & Id); (c) vitrinite (T) with liptinite (C & Sp) and inertinite (Sf); (d) vitrinite (T) with liptinite (Sp & C) and inertinite (F & Sf).

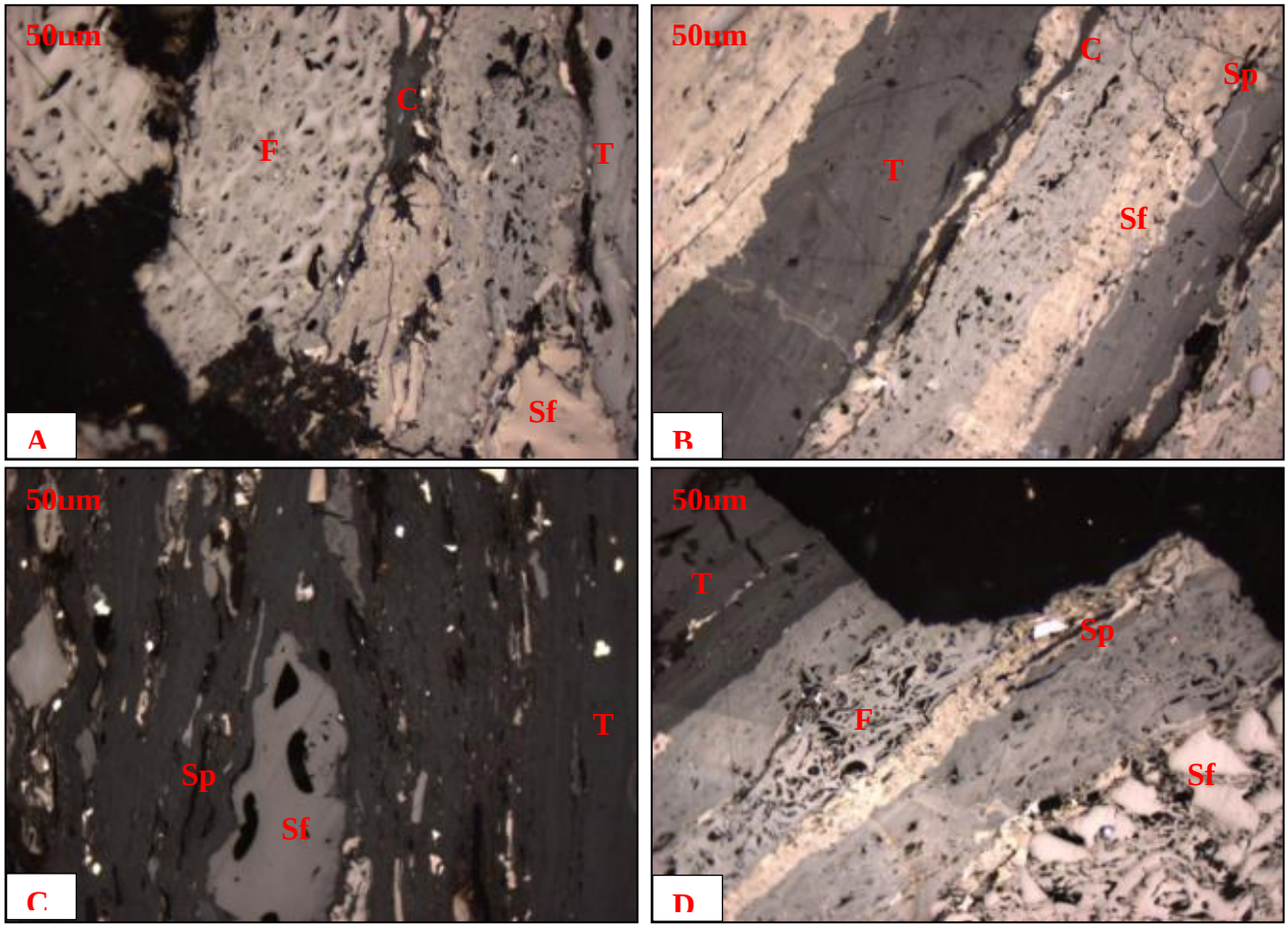


Figure A-4: Photomicrographs of macerals from Witbank coalfield bituminous coal seam No. 4 (W31): (a) liptinite (C) in an inertinite (F & Sf) with vitrinite (T); (b) parallel lamination on vitrinite (T) with inertinite and liptinite (C & Sp); (c) lamination of vitrinite (T) with inertinite (Sf) inside and liptinite (Sp); (d) parallel bedding between vitrinite (T), inertinite (F & Sf) and liptinite (Sp).

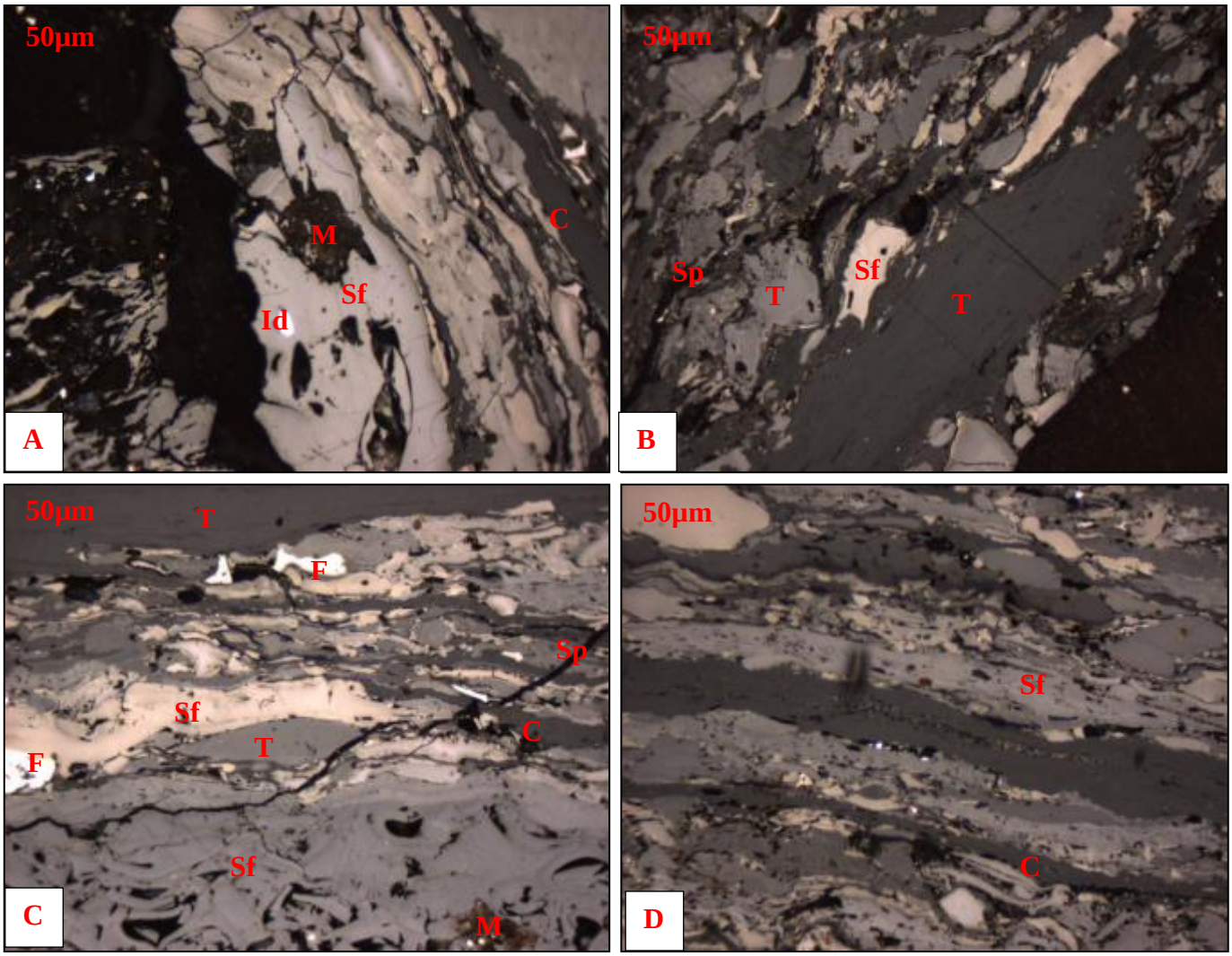


Figure A-5: Photomicrographs of macerals from Witbank coalfield high volatile bituminous coal seam No. 2 (W49): (a) inertinite (Id & Sf) with mineral matter (MM) and liptinite (C); (b) Vitrinite (T), liptinite (Sp) and inertinite (Sf); (c) vitrinite (T), inertinite (F & Sf) with mineral matter (MM) and liptinite (C & Sp); (d) parallel lamentation of inertinite (Sf) and liptinite (C).

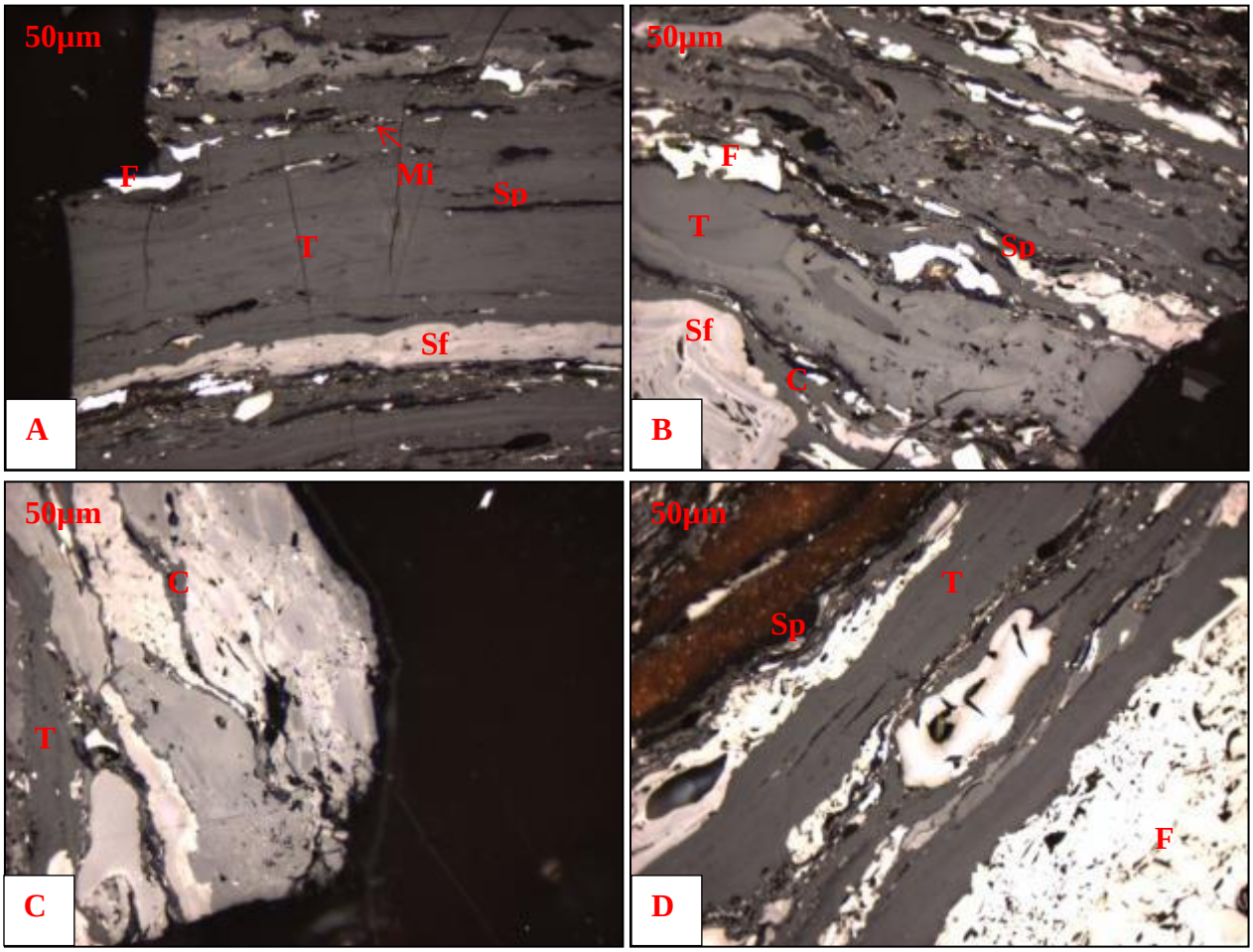


Figure A-6: Photomicrographs of macerals from Witbank coalfield high-volatile bituminous coal seam No. 4 (W41): (a) liptinite (Sp) and inertinite (F, Sf & Mi) in a ground mass of vitrinite (T); (b) liptinite (C & Sp) with vitrinite (T) and inertinite (F & Sf); (c) vitrinite (T) with liptinite (C) in inertinite (F); (d) elongated, flattened liptinite (Sp) along inertinite (F) and vitrinite (T).

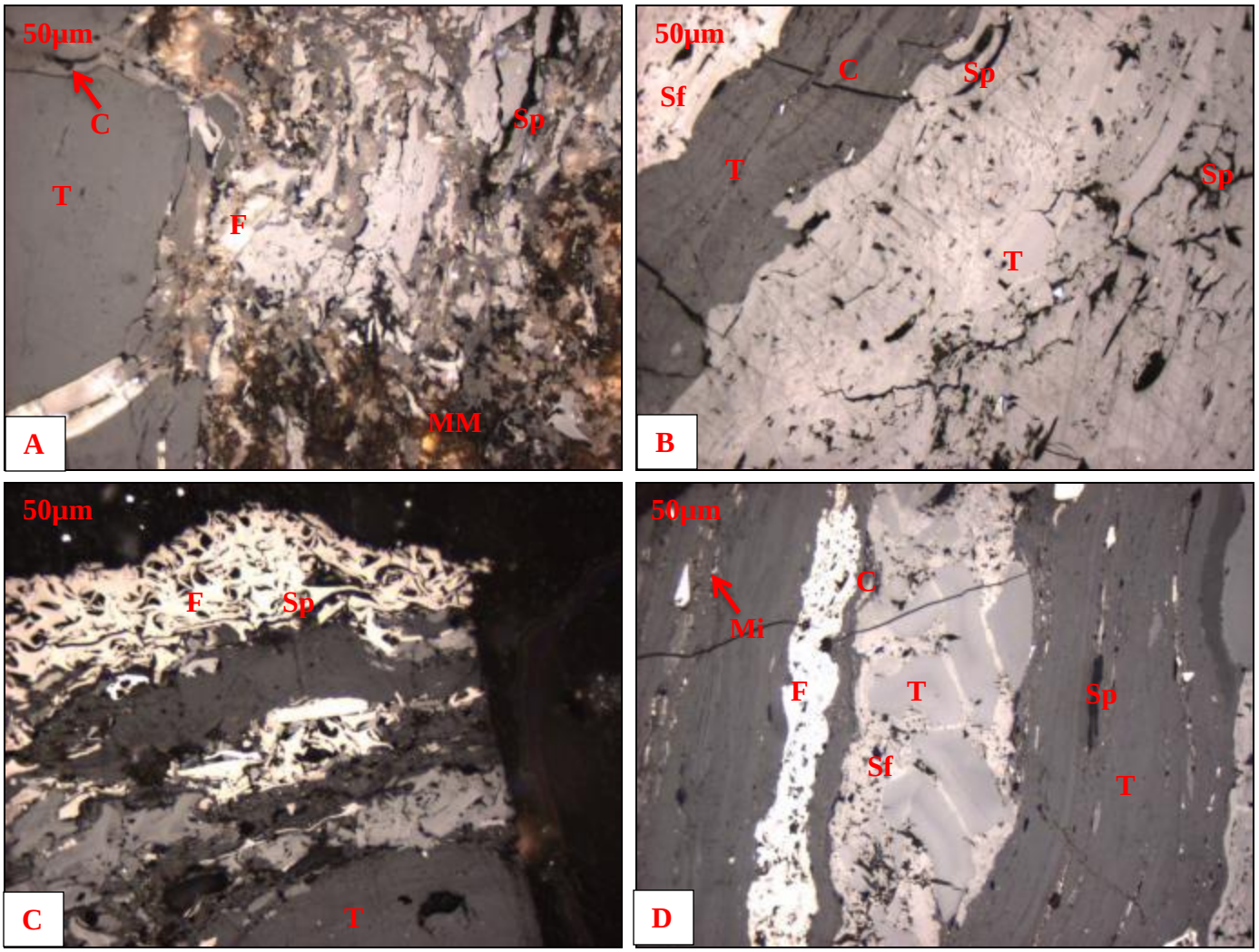


Figure A-7: Photomicrographs of macerals from Witbank coalfield high volatile bituminous coal seam No. 5 (M35): (a) mineral matter (MM) with vitrinite (T), inertinite (F) and liptinite (C &Sp); (b) shows of vitrinite (T) with inertinite (F) and liptinite (C &); (c) shows vitrinite (T) and liptinite (Sp) in inertinite (F); (d) liptinite (C & Sp) incorporated with vitrinite (T) and inertinite (F, Sf & Mi).

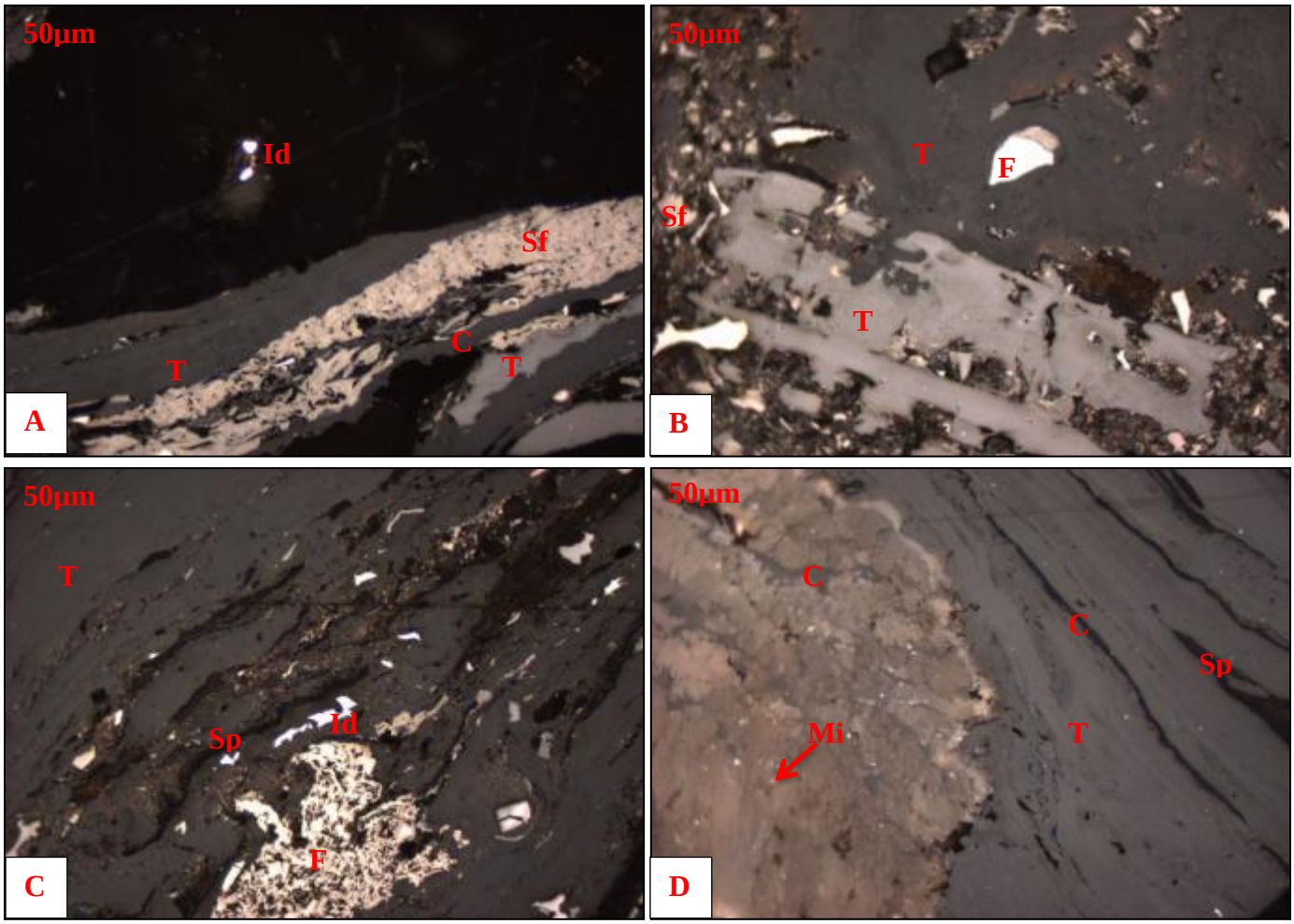


Figure A-8. Photomicrographs of macerals from Witbank coalfield high volatile bituminous coal seam No. 3 (M53): (a) elongated shaped liptinite (C) parallel with inertinite (Sf & Id) and vitrinite (T); (b) vitrinite (T) with inertinite (F & Sf); (c) liptinite (Sp) in vitrinite (T) and inertinite (F & Id); (d) a enlongated shaped liptinite (C & Sp) in a vitrinite (T) and inertinite (Mi).

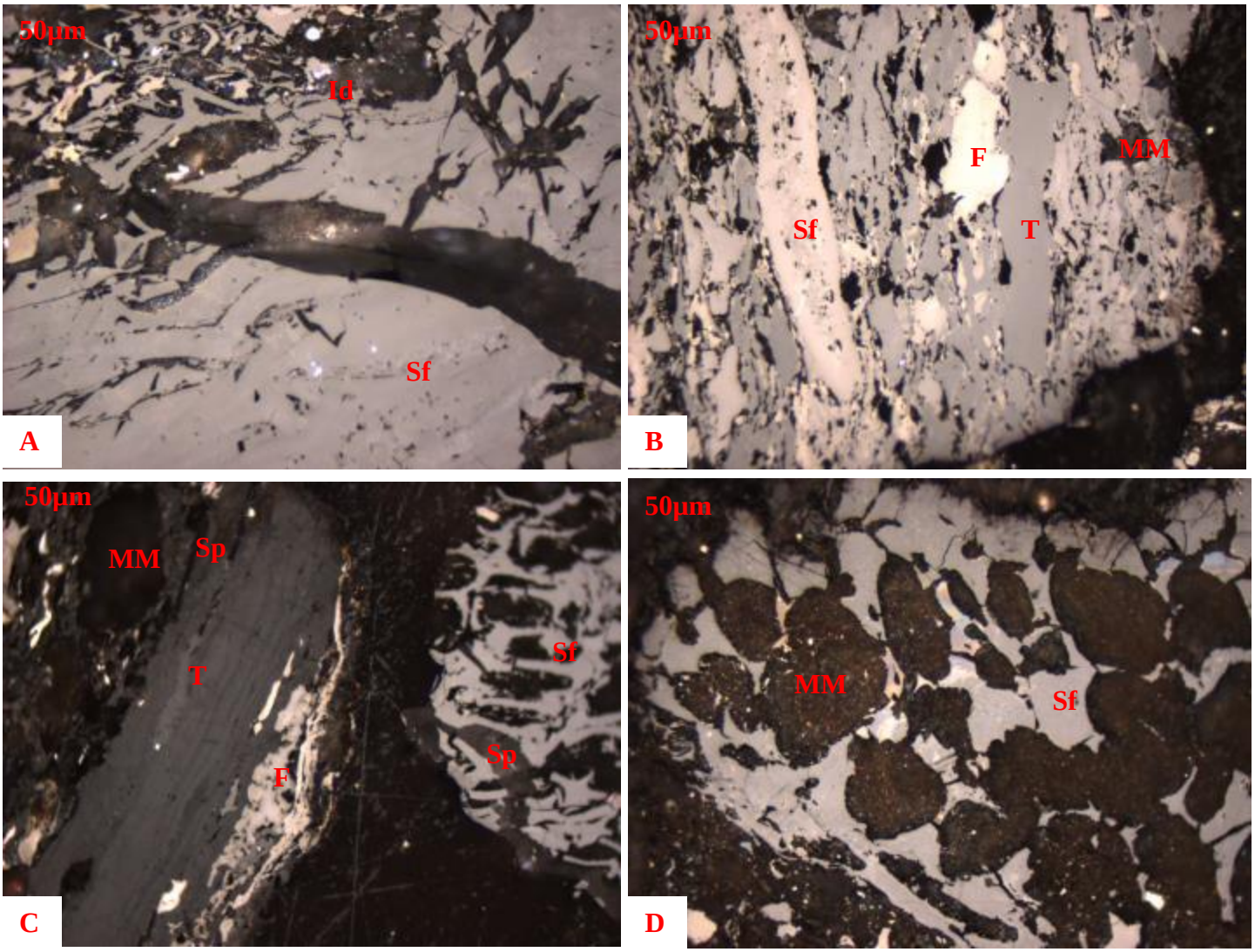


Figure A-9: Photomicrographs of macerals from Witbank coalfield high volatile bituminous coal seam No. 2 (M61): (a) inertinite (Id & Sf); (b) inertinite (F & Sf) with vitrinite (T) and mineral matter (MM); (c) mineral matter (MM) with vitrinite (T) and liptinite (Sp) in inertinite (F & Sf); (d) mineral matter (MM) in a ground mass of inertinite (Sf).

APPENDIX B: X-RAY DIFFRACTION (XRD) RESULTS

B.1. Borehole ZFN 1510

Sample	Rock Name	Calcite	Dolomite	Hematite/ Goethite	Potassium feldspar /Rutile	Plagioclase	Quartz	Mica	Kaolinite /Chlorite	Kaolinite	Anatase	Siderite	Pyrite	Smectite	I/S Interstratification	Amorphous material	Seams
M1	Sandstone/ Siltstone	-	-	-	14	13	66	1	1	-	-	-	-	5	-		
M2		-	-	-	13	18	49	9	1	-	-	-	-	-	10		
M3		-	-	-	8	14	49	8	1	-	-	-	-	8	12		
M4		-	-	-	5	12	73	6	5	-	-	-	-	-	-	-	
M5	Siltstone	-	-	-	10	7	60	8	8	-	-	-	-	-	7	-	
M6		-	-	-	10	17	45	10	7	-	-	-	-	-	11	-	
M7	Sandstone/ Siltstone	-	-	-	-	1	20	25	44	-	2	-	-	-	7	-	
M8		42	-	2	3	4	10	9	29	-	-	-	-	-	-	-	
M9		-	-	1	6	9	35	10	27	-	3	-	-	-	9	-	
M10		-	-	-	37	3	17	15	26	-	2	-	-	-	-	-	
M11	Shale	-	-	-	2	7	50	8	8	-	1	-	-	-	23	-	
M12	Sandstone	11	-	1	10	4	59	1	-	11	2	-	-	-	1	-	
M13		2	-	-	8	7	73	1	6	-	1	-	-	-	2	-	
M14		-	-	-	12	8	66	3	6	-	2	-	-	-	3	-	
M15		-	-	-	14	4	73	2	7	-	-	-	-	-	-	-	
M16		-	-	-	13	5	71	2	-	9	-	-	-	-	-	-	
M17	Sandstone/ Siltstone	-	-	1	-	9	38	10	34	-	1	7	-	-	2	-	

Sample	Rock Name	Calcite	Dolomite	Hematite/ Goethite	Potassium feldspar /Rutile	Plagioclase	Quartz	Mica	Kaolinite /Chlorite	Kaolinite	Anatase	Siderite	Pyrite	Smectite	I/S Interstratification	Amorphous material	Seams
M18		-	-	-	11	5	39	10	29	-	-	4	-	-	2	-	
M19		-	-	-	9	11	50	5	21	-	-	4	-	-	-	-	
M20		4	-	-	7	10	48	4	22	-	-	4	-	-	-	-	
M21		-	-	-	8	6	43	5	33	-	trc	4	-	-	-	-	
M22	Sandstone	4	-	-	13	5	63	3	11	-	-	1	-	-	-	-	
M23	Sandstone/ Siltstone	17	-	2	5	5	30	9	13	-	-	18	-	-	2	-	
M24		14	-	-	11	5	64	2	-	5	-	-	-	-	-	-	
M25		-	-	1	8	13	42	11	21	-	trc	3	-	-	2	-	
M26		6	-	1	6	3	78	2	6	-	-	-	-	-	-	-	
M27		-	-	1	5	16	27	13	30	-	1	3	-	-	5	-	
M28	Shale	-	-	-	4	11	18	16	41	-	1	6	-	-	2	-	
M29	Sandstone	4	-	-	12	7	65	3	-	7	-	-	-	-	2	-	
M30	Dolerite	-	-	-	-	54	8	-	-	-	-	21	-	-	17	-	
M31	Sandstone	-	9	-	10	3	74	3	2	-	-	-	-	-	-	-	
M32	Sandstone/ Siltstone	-	-	-	4	9	57	9	8	-	1	1	-	-	10	-	
M33		0	4	-	6	4	77	3	1	-	-	-	-	-	4	-	
M34		-	-	-	8	13	51	5	10	-	-	2	-	-	11	-	
M35	Coal	9	10	-	-	-	9	5	-	46	-	-	21	-	-	*	SEAM 5
M36	Sandstone	34	3	-	10	5	33	14	trc	-	-	-	1	-	-	-	
M37		-	-	-	11	8	33	11	29	-	-	9	-	-	-	-	
M38	Sandstone/ Siltstone	-	-	-	16	3	35	13	30	-	-	-	1	-	2	-	
M39		-	-	-	8	trc	20	19	46	-	-	5	1	-	2	-	
M40	Sandstone	1	35	-	5	2	29	2	-	11	-	14	1	-	-	-	
M41		1	23	-	32	1	23	2	-	7	-	8	2	-	-	-	

Sample	Rock Name	Calcite	Dolomite	Hematite/ Goethite	Potassium feldspar /Rutile	Plagioclase	Quartz	Mica	Kaolinite /Chlorite	Kaolinite	Anatase	Siderite	Pyrite	Smectite	I/S Interstratification	Amorphous material	Seams
M42		-	2	-	7	-	55	1	-	26	-	8	trc	-	-	-	
M43		-	-	-	29	-	62	-	-	7	-	1	2	-	-	-	
M44	Coal	-	-	-	2	-	47	-	-	46	1	-	2	-	2	-	SEAM 4
M45	Sandstone/ Siltstone	-	-	-	8	-	41	4	-	46	1	-	-	-	-	-	
M46	Sandstone	-	-	-	3	-	90	1	-	6	-	-	-	-	-	-	
M47	Sandstone	-	-	-	1	-	97	-	-	2	-	-	-	-	-	-	
M48	Shale	-	-	-	2	-	14	2	-	81	trc	-	-	-	-	-	
M49	Sandstone/ Siltstone	-	-	-	7	-	73	1	-	19	-	-	-	-	-	-	
M50	Coally shale	-	-	-	2	-	32	4	-	62	1	-	-	-	-	-	
M51	Sandstone/ Siltstone	-	-	-	11	-	34	11	-	43	-	-	-	-	-	-	
M52	Sandstone/ Siltstone	-	-	-	8	-	45	6	-	41	-	-	-	-	-		
M53	Coal	-	6	-	-	-	15	3	-	52	-	14	10	-	-	*	SEAM 3
M54	Sandstone/ Siltstone	-	-	-	7	-	28	12	53	-	-	0	-	-	-	-	
M55		-	-	-	9	-	42	7	-	37	trc	4	-	-	-	-	
M56		-	39	-	7	3	26	7	-	15	-	3	-	-	-	-	
M57	Shale	-	-	-	4	-	27	12	-	46	-	9	-	-	2	-	
M58	Sandstone/ Siltstone	-	-	-	7	2	36	13	-	36	trc	3	-	-	2	-	
M59	Shale	-	-	-	3	-	27	7	61	-	trc	-	-	-	2		
M60	Sandstone/ Siltstone	-	9	-	3	-	62	2	-	20	-	2	2	-	-	*	
M61	Coal	3	10	-	-	-	28	5	-	43	-	-	11	-	-	-	SEAM 2
M62	Dwyka tillite	-	3	-	6	-	66	3	-	21	1	-	-	-	-	-	
M63	Siltstone	-	-	-	7	2	75	2	-	14	trc	-	-	-	-	-	
M64	Dwyka tillite	-	-	-	4	6	51	8	-	24	1	6	-	-	1	-	
M65	Granite	-	-	-	13	17	55	trc	-	-	-	16	-	-	-	-	

B.2. Borehole ZFN1512

Sample	Rock Name	Calcite	Dolomite	Clinopyroxene	Hemitite/ Geothite	Potassium feldspar	Plagioclase	Quartz	Mica	Kaolinite	Kaolinite/ Chlorite	Chlorite	Anatase	Pyrite	Siderite	Smectite	I/S Interstratification	Amorphous material	Seams
W1	Sandstone/ Siltstone	-	-	-	-	14	10	66	1	-	1	-	-	-	-	-	8	-	
W2		-	-	-	-	10	17	38	15	-	5	2	-	-	-	-	14	-	
W3		-	-	-	-	6	3	87	1	-	-	-	-	-	-	-	2	-	
W4		-	-	-	-	7	5	75	4	5	-	-	trc	-	-	-	4	-	
W5	Sandstone/ Siltstone	-	-	-	-	17	8	47	9	7	-	1	1	-	-	-	11	-	
W6	Shale	-	-	-	2	3	6	48	16	6	-	3	8	-	-	-	9	-	
W7	Dolerite	32	-	-	-	-	34	18	3	-	4	-	2	-	4	3	-	-	
W8	Shale	-	-	-	-	2	6	56	11	6	-	2	-	-	-	-	17	-	
W9	Dolerite	17	-	-	-	-	32	8	2	21	-	3	4	-	10	3	-	-	
W10	Sandstone	8	-	-	-	13	7	65	2	3	-	-	-	-	-	-	2	-	
W11		30	-	-	-	18	4	42	1	-	3	-	1	-	-	1	-	-	
W12	Sandstone	-	-	-	-	15	8	58	6	7	-	1	1	-	-	-	5	-	
W13		-	-	-	-	15	6	69	2	8	-	-	-	-	-	-	-	-	
W14		-	-	-	-	11	5	73	2	10	-	-	-	-	-	-	-	-	
W15		-	-	-	-	15	4	73	2	5	-	-	-	-	-	-	-	-	
W16	Sandstone/ Siltstone	-	-	-	-	2	2	88	2	5	-	1	trc	-	1	trc	-	-	

Sample	Rock Name	Calcite	Dolomite	Clinopyroxene	Hemitite/ Geothite	Potassium feldspar	Plagioclase	Quartz	Mica	Kaolinite	Kaolinite/ Chlorite	Chlorite	Anatase	Pyrite	Siderite	Smectite	I/S Interstratification	Amorphous material	Seams
W17		-	-	-	-	9	5	75	3	8	-	1	-	-	-	-	-	-	
W18		-	-	-	-	10	11	32	10	30	-	2	-	1	2	2	-	-	
W19	Sandstone/ Siltstone	-	-	-	-	8	5	75	2	9	-	1	-	-	-	-	-	-	
W20		38	-	-	-	2	3	15	11	17	-	2	-	1	10	-	-	-	
W21		-	-	-	-	5	6	22	17	43	-	2	trc	-	2	-	2	-	
W22	Sandstone	15	3	-	-	3	7	5	14	9	-	-	-	-	43	-	-	*	
W23		-	-	18	-	-	79	2	-	-	-	-	-	-	-	-	-	-	
W24	Sandstone	-	-	-	-	20	7	62	2	-	5	-	-	-	-	-	5	-	
W25	Siltstone	-	-	-	-	11	6	42	10	-	26	-	-	-	-	-	5	-	
W26	Coal	7	7	-	-	-	-	34	-	-	32	-	-	12	-	-	9	-	SEAM 5
W27	Sandstone	-	-	-	1	6	5	26	20	-	38	2	-	-	-	-	2	-	
W28		-	9	-	-	12	6	49	4	-	19	-	-	-	-	-	-	-	
W29	Sandstone/ Siltstone	-	-	-	-	6	-	26	14	-	50	-	-	-	5	-	-	-	
W30		-	-	-	1	6	-	58	-	-	23	-	-	-	12	-	-	-	
W31	Coal	3	3	-	-	-	-	9	-	-	24	-	-	51	4	5	-	*	SEAM 4
W32	Coally Shale	-	2	-	-	1	-	27	4	-	66	-	1	-	-	-	-	-	
W33	Coal	-	-	-	-	2	-	19	2	-	76	-	trc	-	1	-	-	-	
W34		-	-	-	-	7	-	62	1	-	28	-	1	-	1	-	-	-	
W35	Shale	-	-	-	-	2	-	19	3	-	76	-	1	-	-	-	-	-	

Sample	Rock Name	Calcite	Dolomite	Clinopyroxene	Hemitite/ Geothite	Potassium feldspar	Plagioclase	Quartz	Mica	Kaolinite	Kaolinite/ Chlorite	Chlorite	Anatase	Pyrite	Siderite	Smectite	I/S Interstratification	Amorphous material	Seams
W36	Sandstone	-	-	-	-	1	-	92	-	-	7	-	-	-	-	-	-	-	
W37	Shale	-	-	-	-	4	-	23	2	-	70	-	1	-	-	-	-	-	
W38	Coally Shale	-	-	-	-	2	-	31	4	-	63	-	-	-	1	-	-	-	
W39	shale	-	-	-	-	10	-	20	12	-	57	-	-	-	-	-	-	-	
W40	Sandstone	-	-	-	-	13	-	71	1	-	15	-	-	-	-	-	-	-	
W41	Coal	-	1	-	-	31	-	8	3	-	48	-	-	5	4	-	-	*	SEAM 3
W42	Sandstone	-	-	-	-	11	-	32	8	-	45	-	trc	-	4	-	-	-	
W43	Shale	-	-	-	-	12	-	42	31	-	7	-	-	-	8	-	-	-	
W44	Sandstone/ Siltstone	-	-	-	-	7	-	22	16	-	51	-	-	-	4	-	-	-	
W45		-	-	-	-	3	-	23	3	-	69	1	-	-	1	-	-	-	
W46	Shale	-	9	-	-	-	-	16	4	-	72	-	-	-	-	-	-	-	
W47		-	-	-	-	1	-	36	1	-	61	-	1	-	-	-	-	-	
W48	Sandstone	-	-	-	-	8	-	73	1	-	18	-	-	-	-	-	-	-	
W49	Coal	-	-	-	-	1	-	44	2	-	53	-	1	-	-	-	-	-	SEAM 2
W50	sandstone	-	-	-	-	6	-	65	3	-	21	-	-	4	-	-	-	-	
W51		-	-	-	-	6	-	81	2	-	10	-	trc	-	-	-	-	-	
W52	Mudstone	-	-	-	-	8	-	62	3	-	27	-	-	-	-	-	-	-	
W53	Tillite	-	-	-	-	1	-	11	25	-	60	-	2	-	-	-	-	-	
W54	Sandstone	-	-	-	-	13	-	58	2	-	27	-	-	-	-	-	-	-	
W55	Tillite	-	-	-	-	9	-	69	3	-	18	-	-	-	-	-	-	-	
W56	sandstone	-	-	-	-	5	-	80	2	-	14	-	trc	-	-	-	-	-	

Sample	Rock Name	Calcite	Dolomite	Clinopyroxene	Hemitite/ Geothite	Potassium feldspar	Plagioclase	Quartz	Mica	Kaolinite	Kaolinite/ Chlorite	Chlorite	Anatase	Pyrite	Siderite	Smectite	I/S Interstratification	Amorphous material	Seams
W57	Tillite	-	-	-	-	17	16	38	2	-	8	-	-	20	-	-	-	-	
W58	Granite	-	-	-	-	17	21	57	1	-	2	-	-	3	-	-	-	-	

APPENDIX C: MAJOR AND TRACE ELEMENTS SCATTERPLOTS

C.1. Major Elements

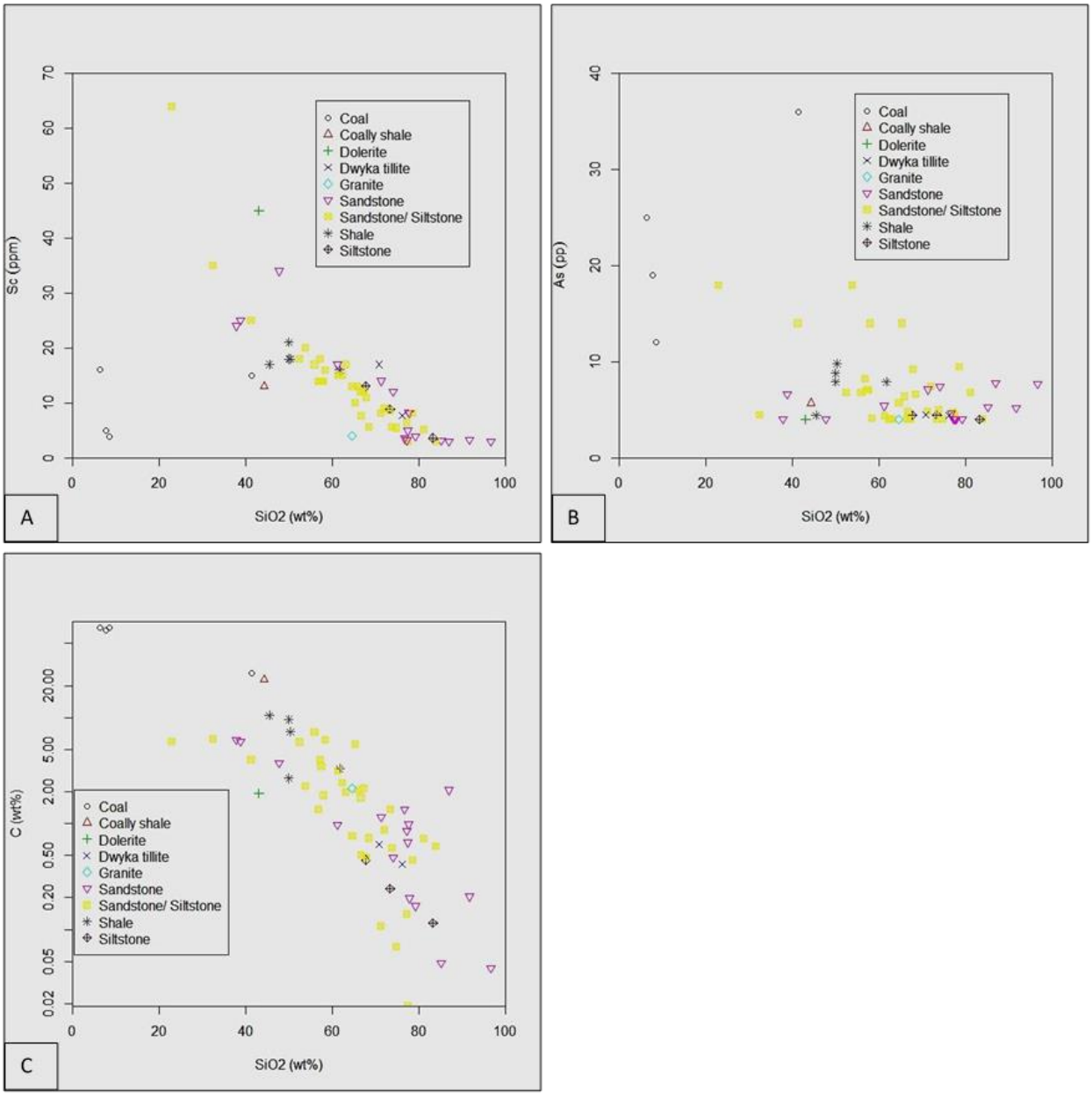


Figure C-1: SiO_2 (wt%) versus carbon (c) (wt%) also trace elements Arsenic (b), and scandium (a) in ppm.

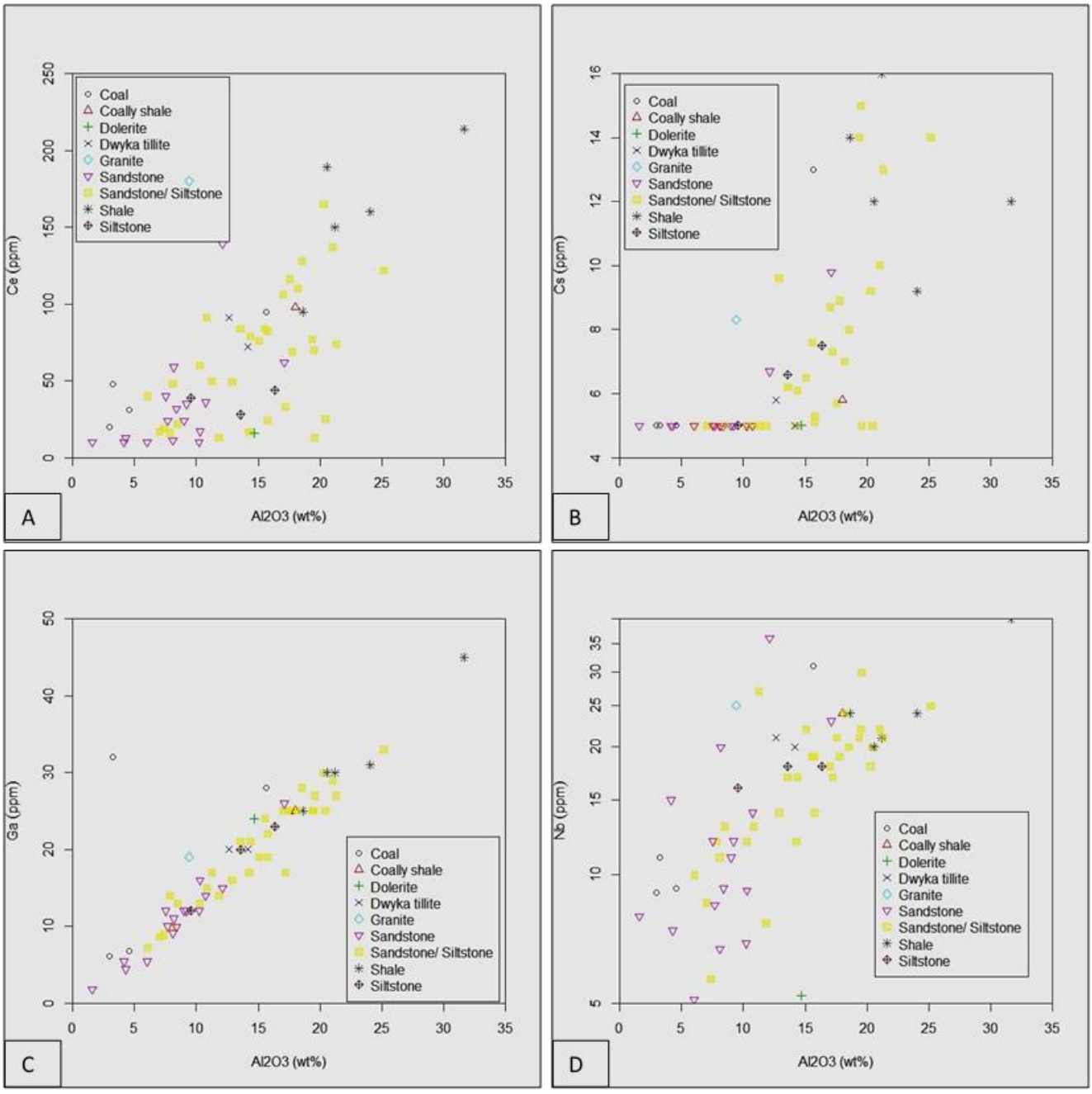


Figure C-2: Al_2O_3 (wt%) versus trace elements (a) cerium, (b) caesium, (c) gallium and (d) niobium in ppm.

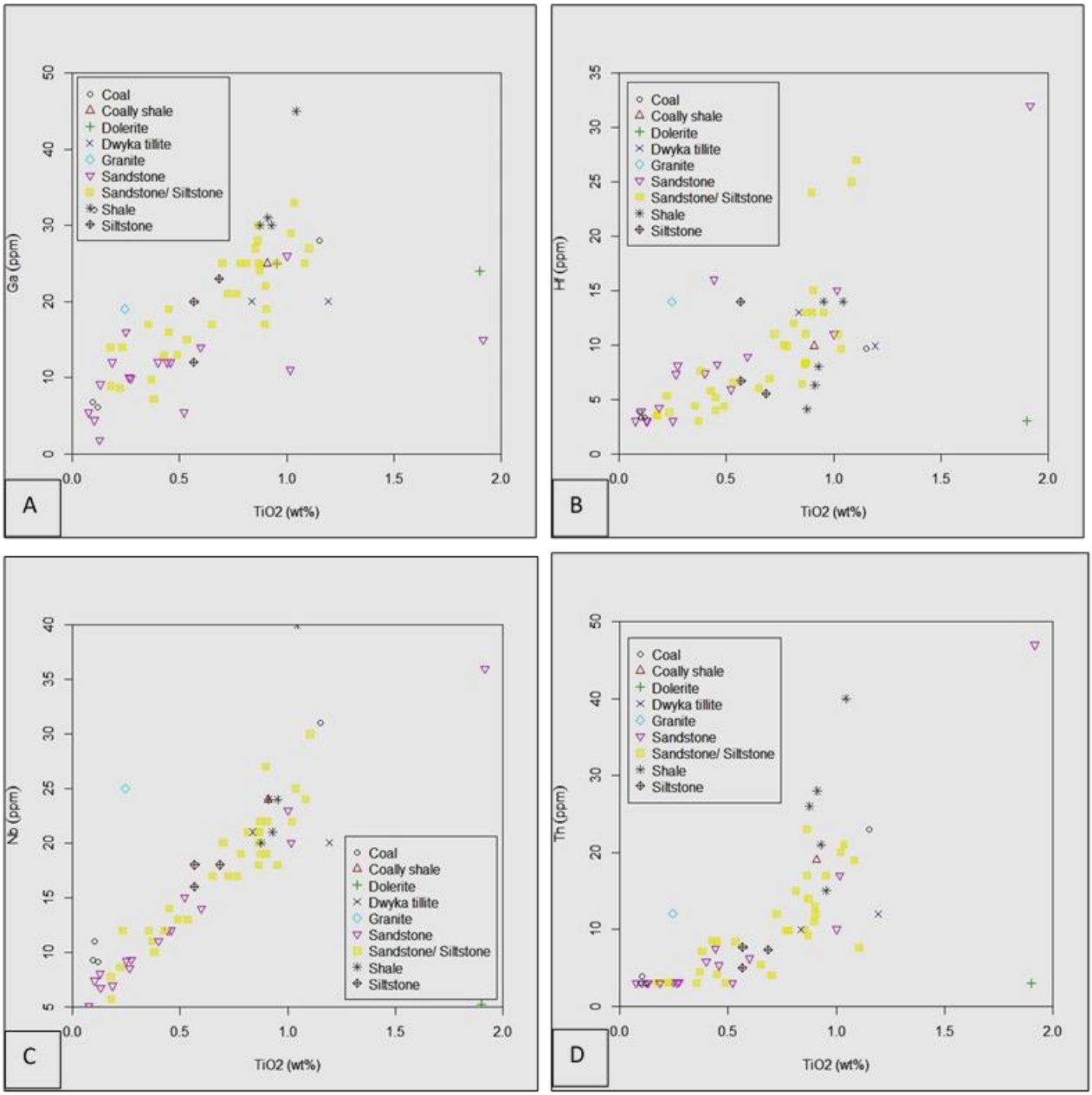


Figure C-3: (a) TiO_2 (in wt%) versus Ga (ppm); (b) TiO_2 (in wt%) versus Hf (ppm); (c) TiO_2 (in wt%) versus Nb (ppm) and (d) TiO_2 (in wt%) versus Th (ppm).

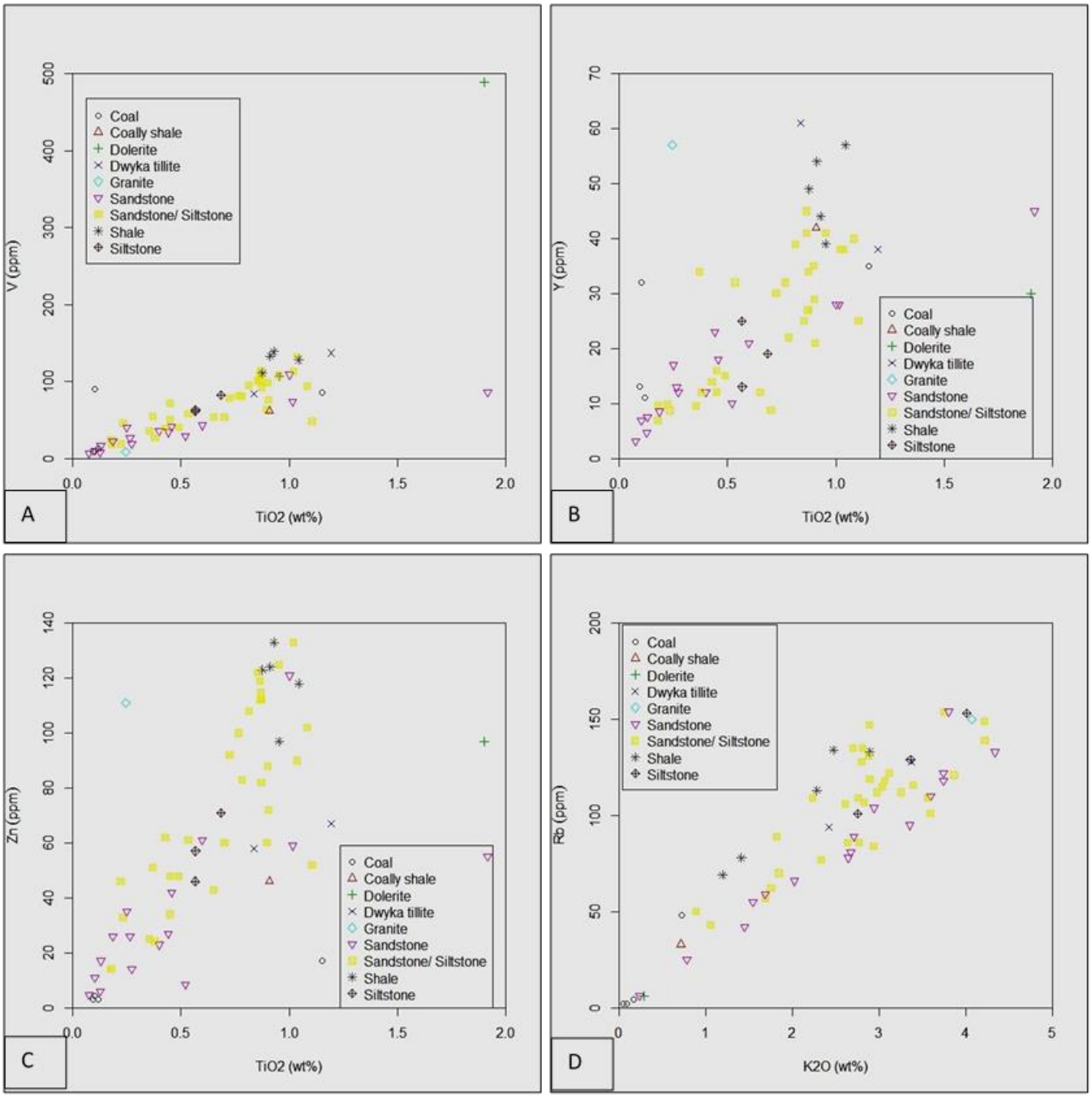


Figure C-4: (a) TiO_2 (in wt%) versus V (ppm); (b) TiO_2 (in wt%) versus Y (ppm); (c) TiO_2 (in wt%) versus Zn (ppm) and (d) K_2O (in wt%) versus Rb (ppm).

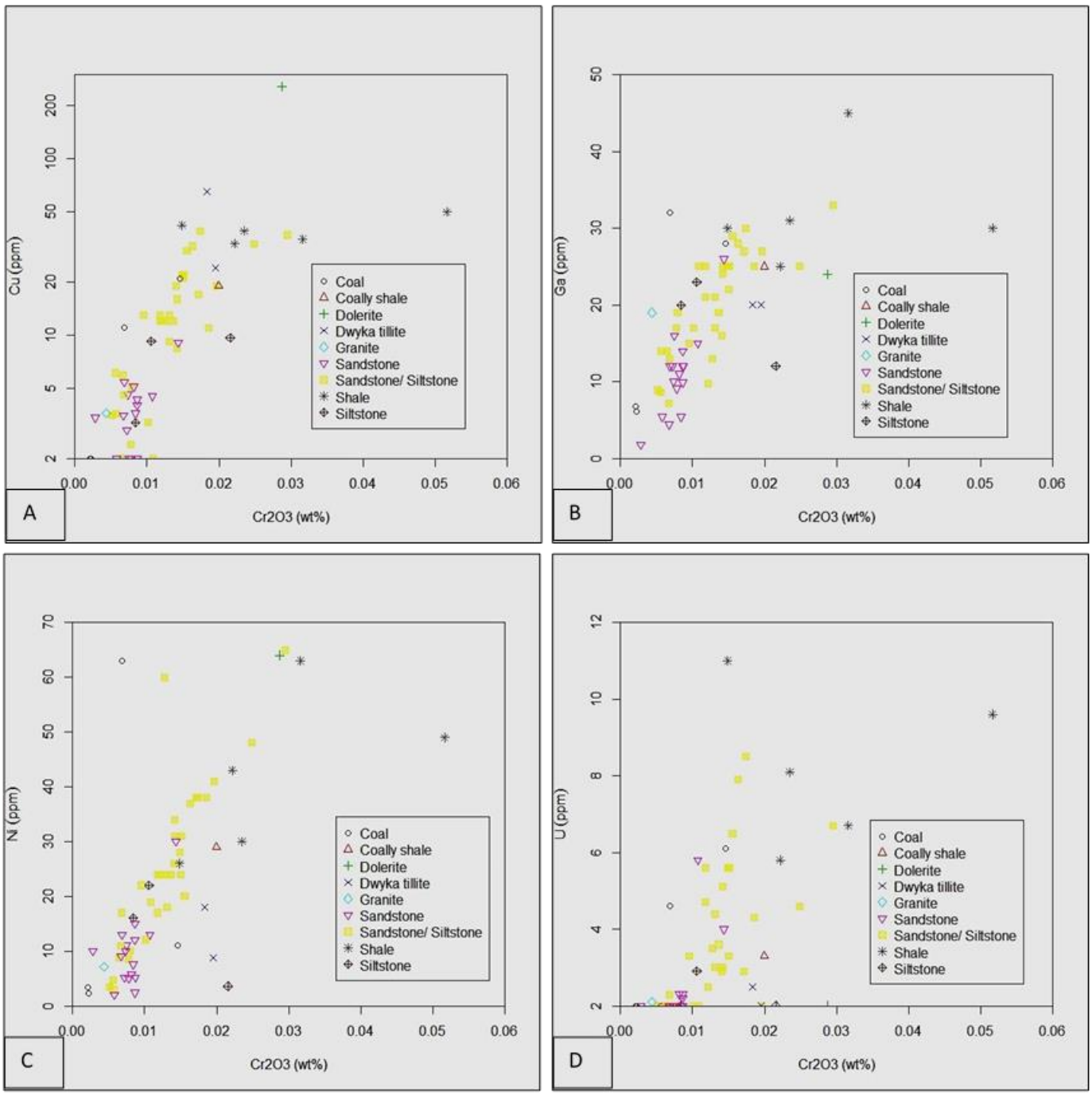


Figure C-5: (a) Cr_2O_3 (in wt%) versus Cu (ppm); (b) Cr_2O_3 (in wt%) versus Ga (ppm); (c) Cr_2O_3 (in wt%) versus Ni (ppm) and (d) Cr_2O_3 (in wt%) versus U (ppm).

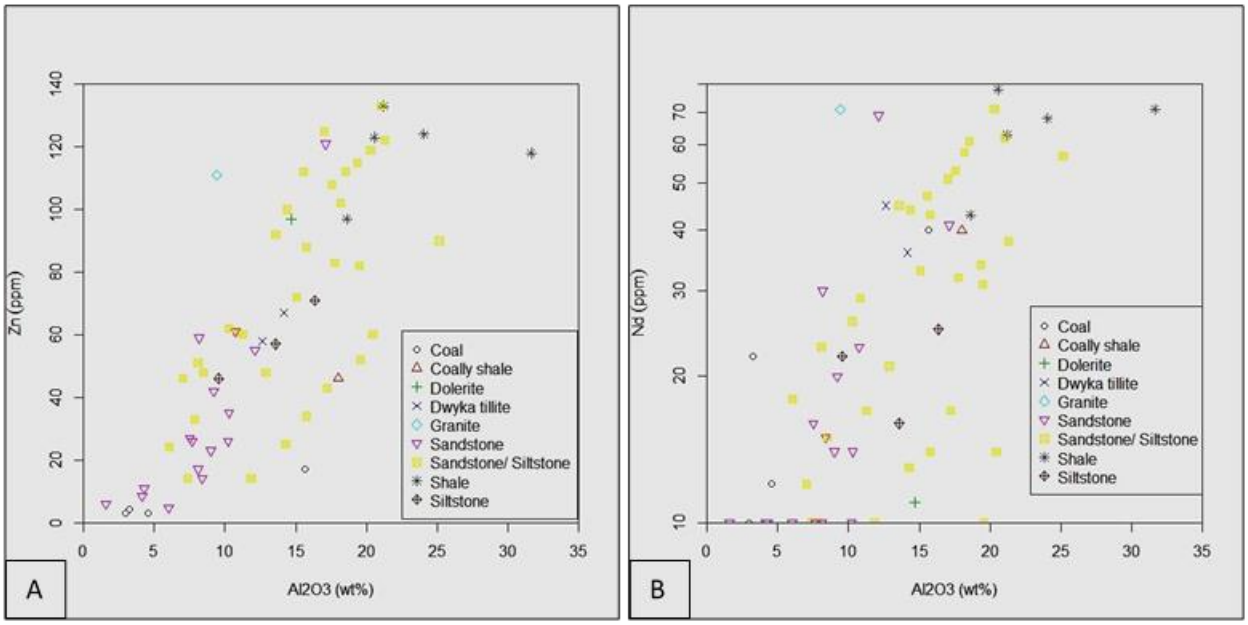


Figure C-6: Al_2O_3 (wt%) versus trace elements (a) Zinc and (b) neodymium in ppm.

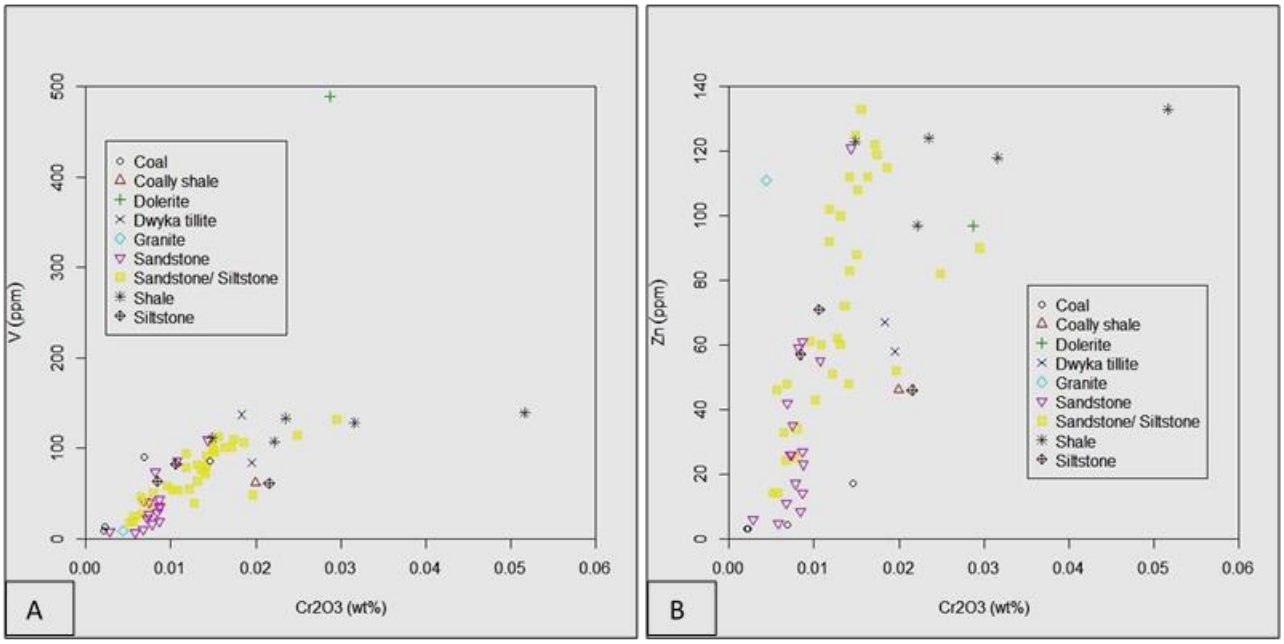


Figure C-7: (a) Cr_2O_3 (in wt%) versus V (ppm) and (b) Cr_2O_3 (in wt%) versus Zn (ppm).

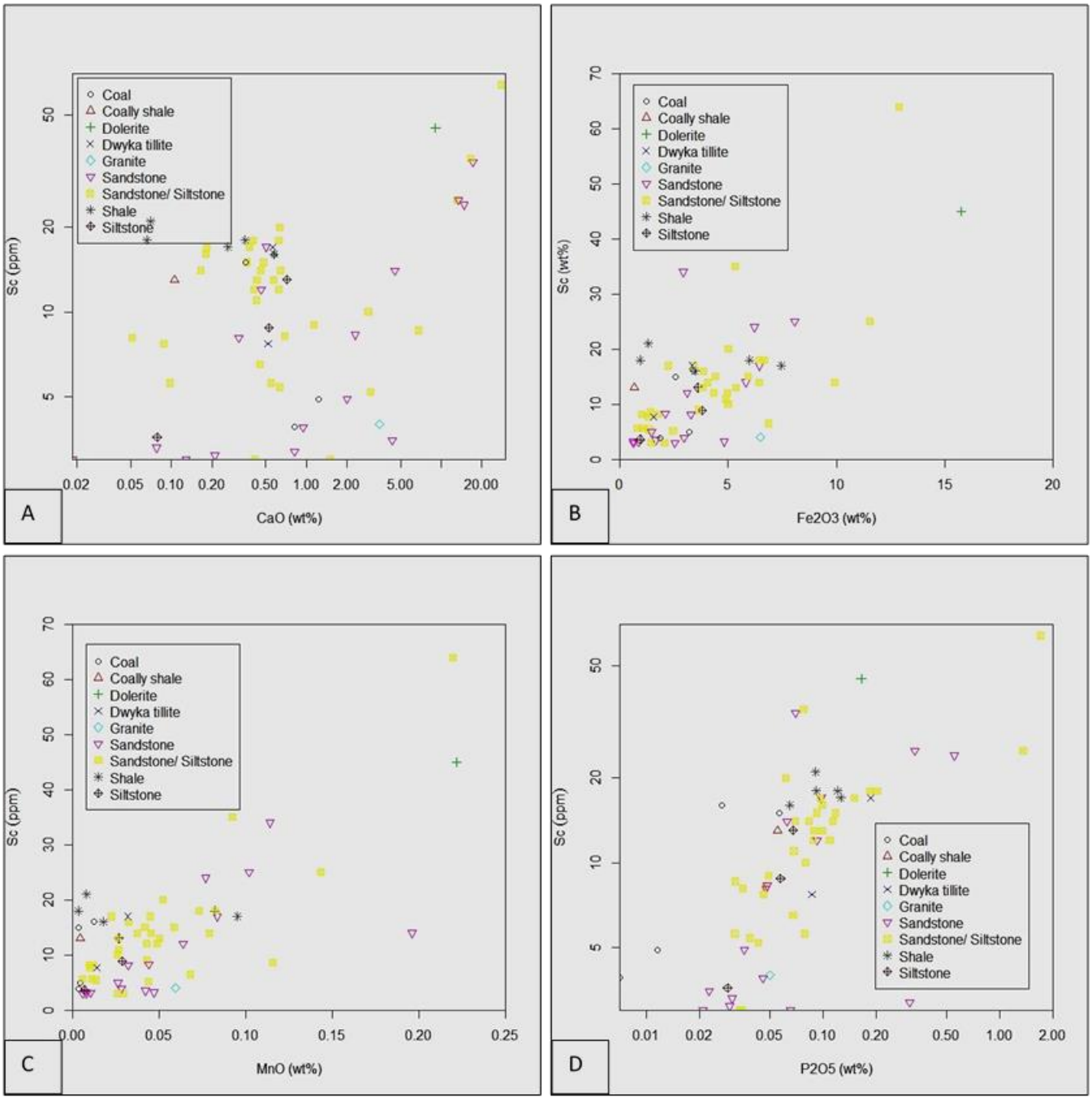


Figure C-8: (a) CaO (in wt%) versus Sc (ppm); (b) F_2O_3 (in wt%) versus Ga (ppm); (c) MnO (in wt%) versus Ni (ppm) and (d) P_2O_5 (in wt%) versus U (ppm).

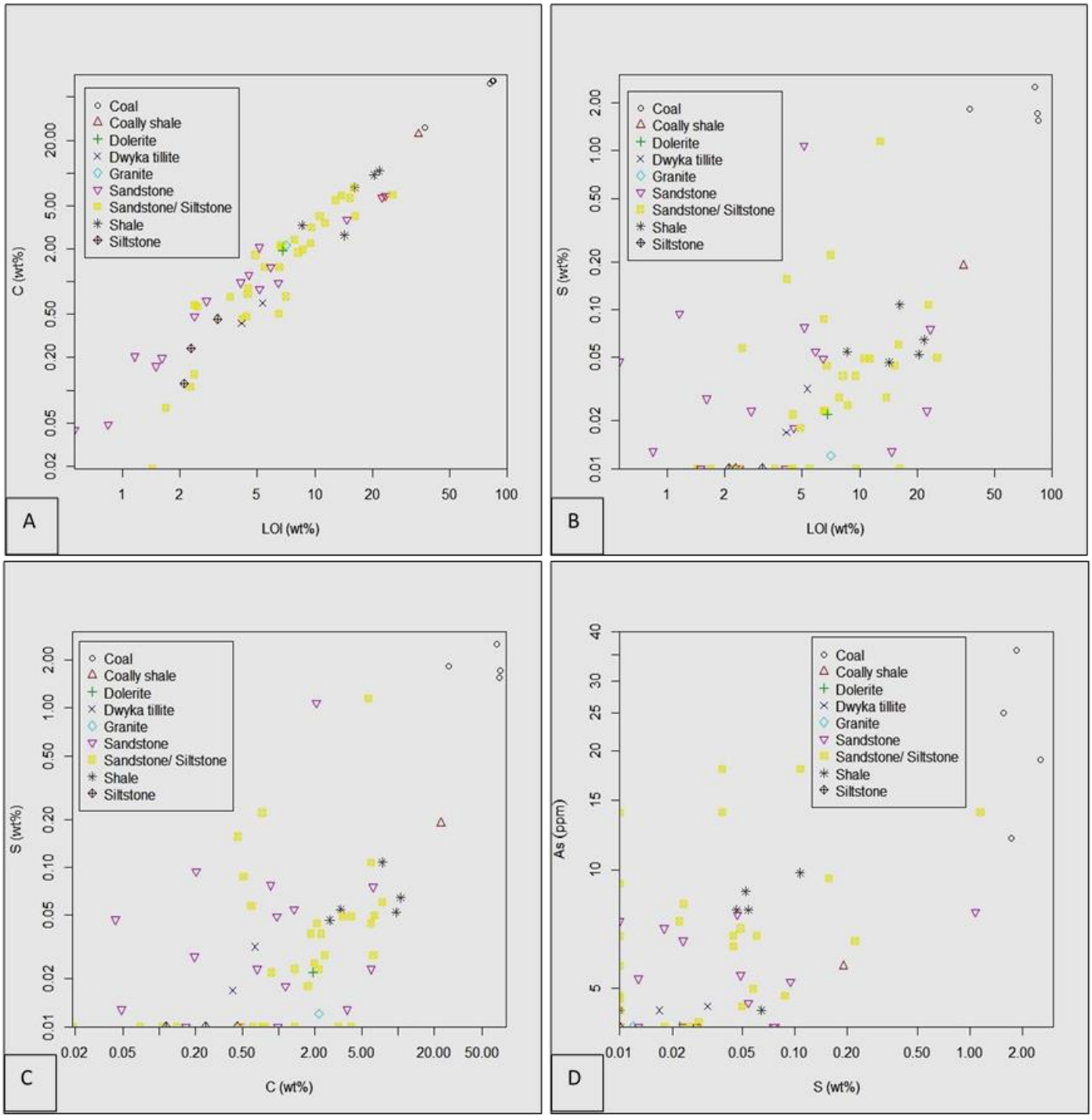


Figure C-9: (a) LOI versus C (in wt%); (b) LOI versus S (in wt%); (c) S versus C (in wt%) and (d) S versus As (ppm).

C.2. Trace elements

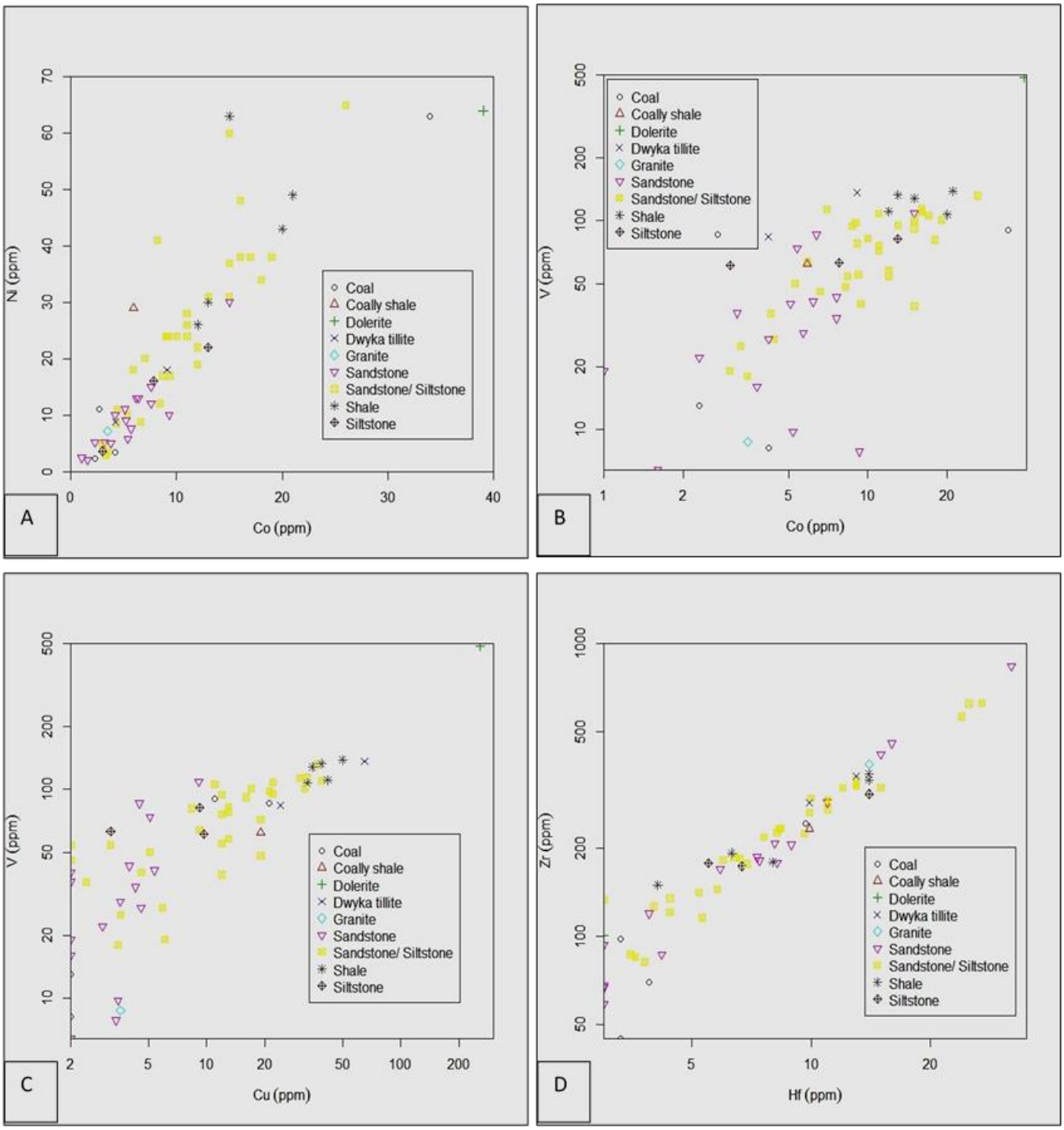


Figure C-10: (a) Co versus Ni (ppm); (b) Co versus V (ppm); (c) Cu versus V (ppm) and (d) Hf versus Zr (ppm).

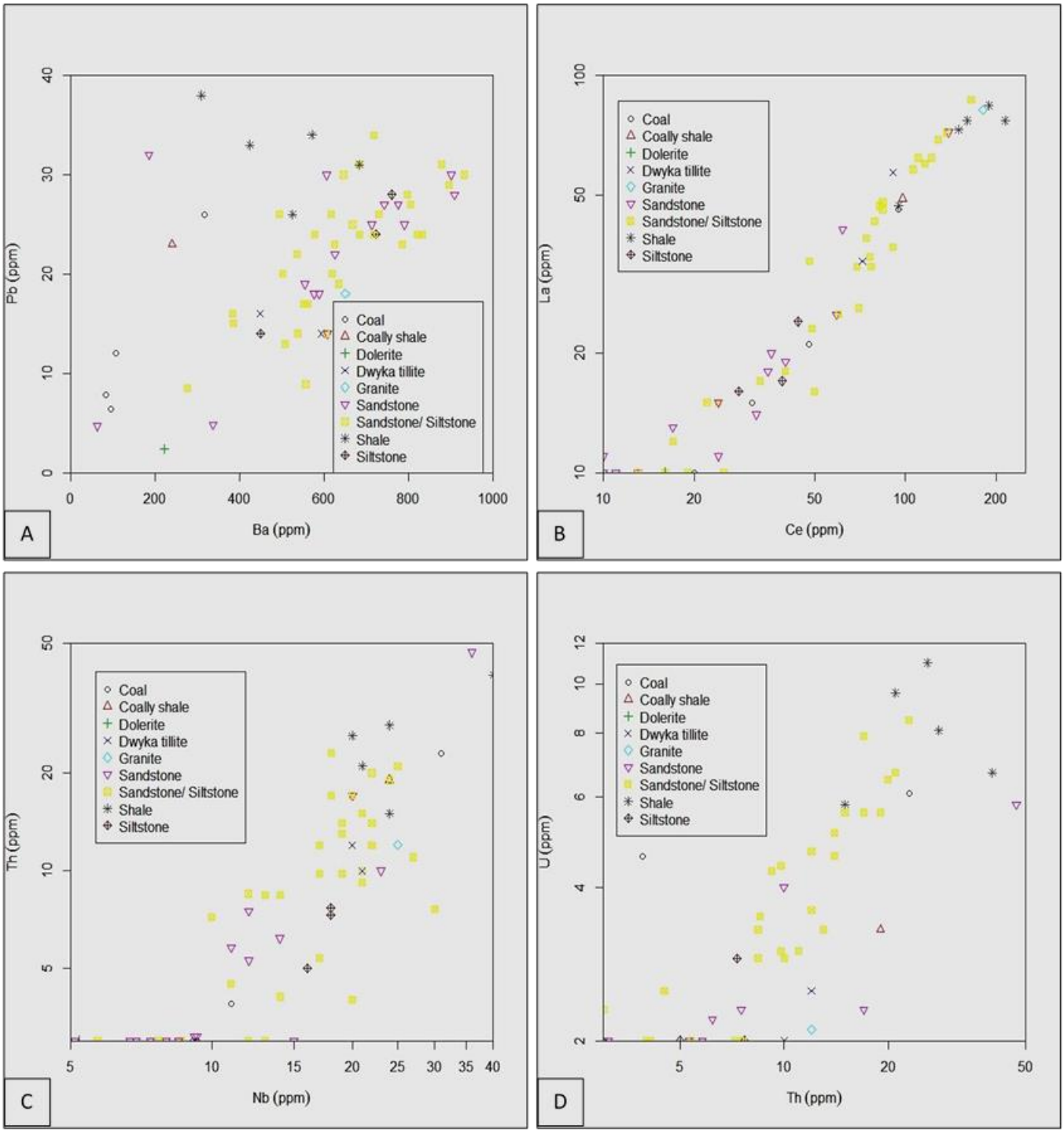


Figure C-11: (a) Ba versus Rb (ppm); (b) Ce versus La (ppm); (c) Nb versus Ni (ppm) and (d) Th versus U (ppm).

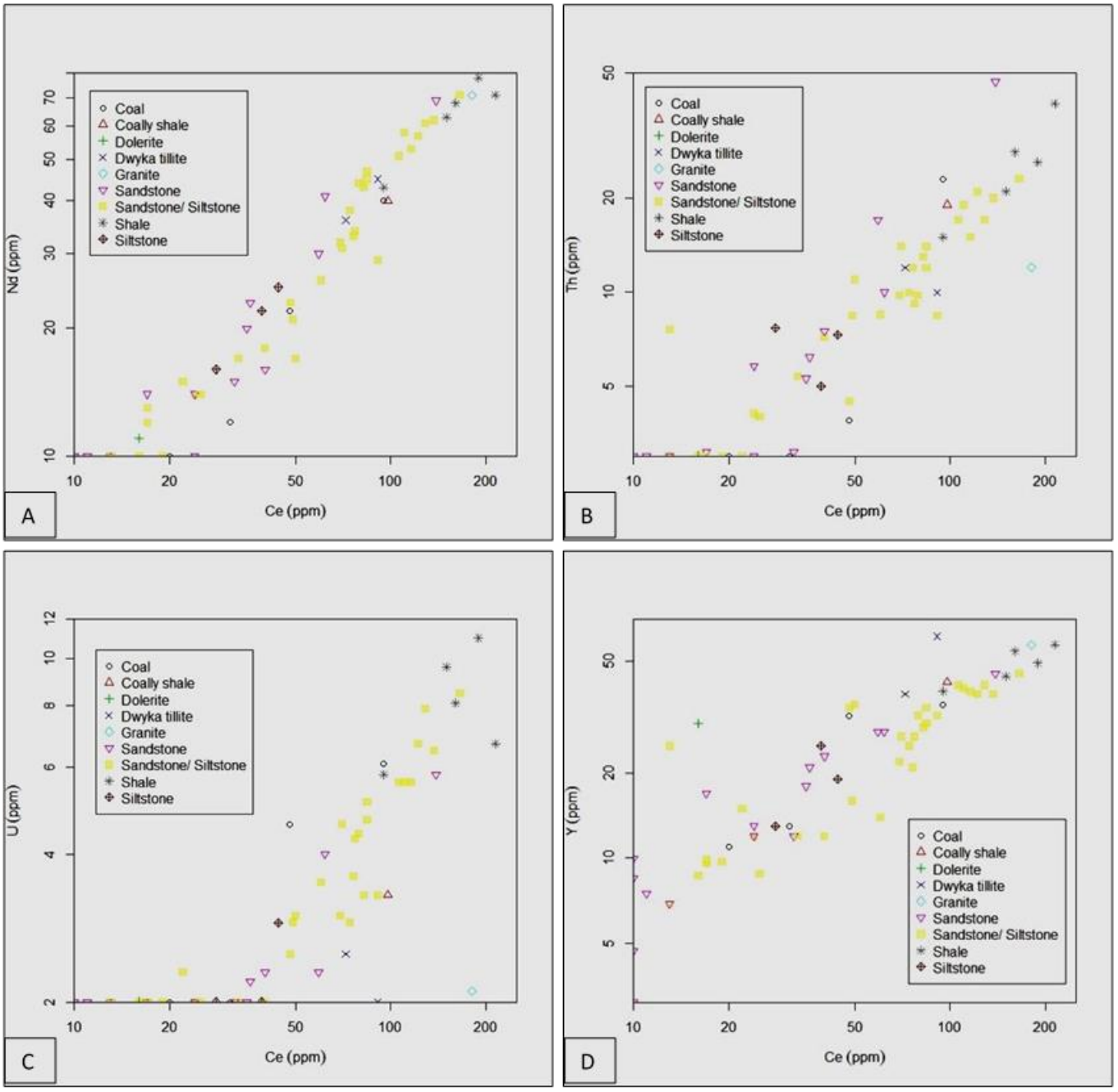


Figure C-12: (a) Ce versus Nd (ppm); (b) Ce versus Th (ppm); (c) Ce versus U (ppm) and (d) Ce versus Y (ppm).

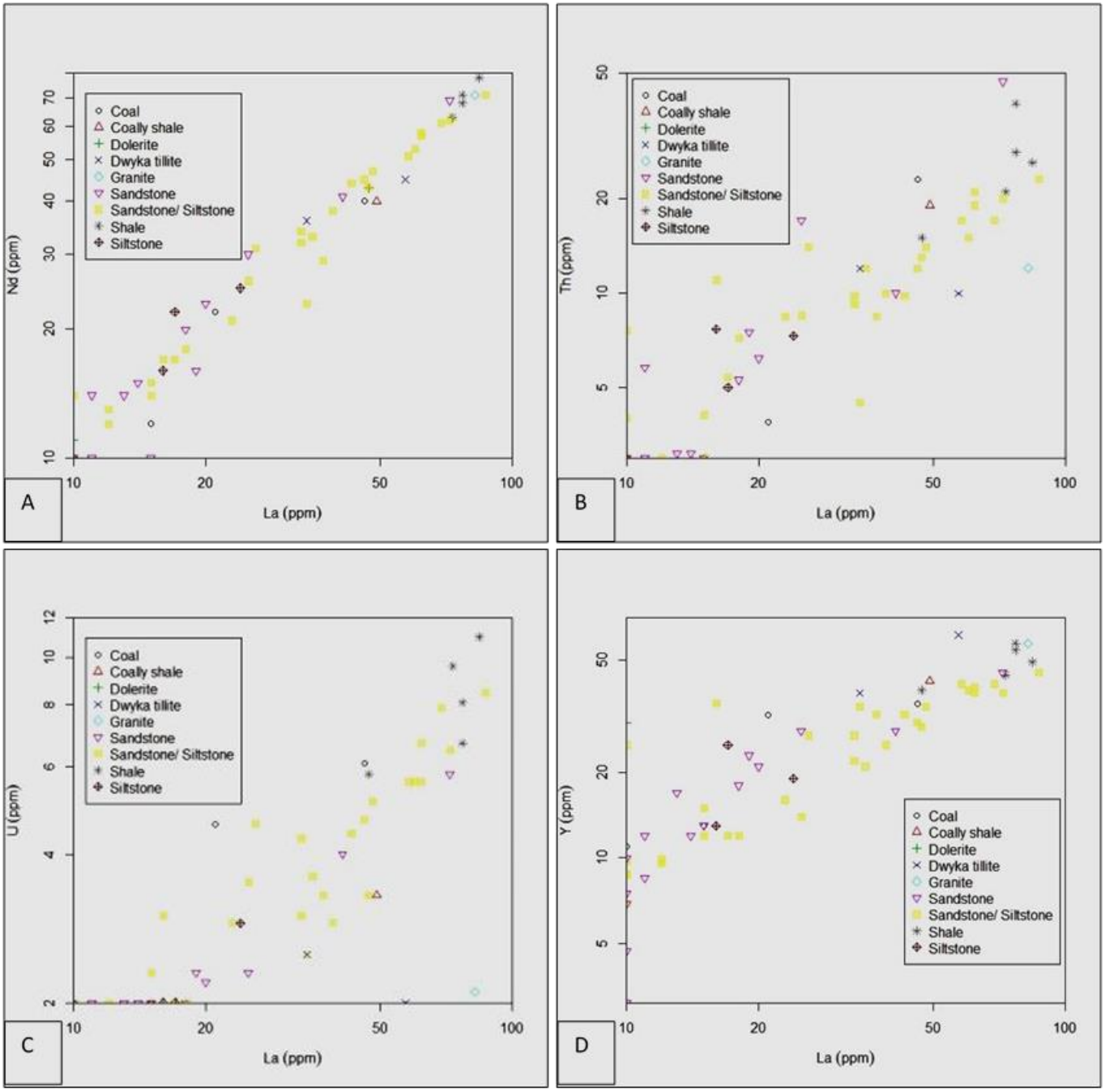


Figure C-13: (a) La versus Nd (ppm); (b) La versus Th (ppm); (c) La versus U (ppm) and (d) La versus Y (ppm).

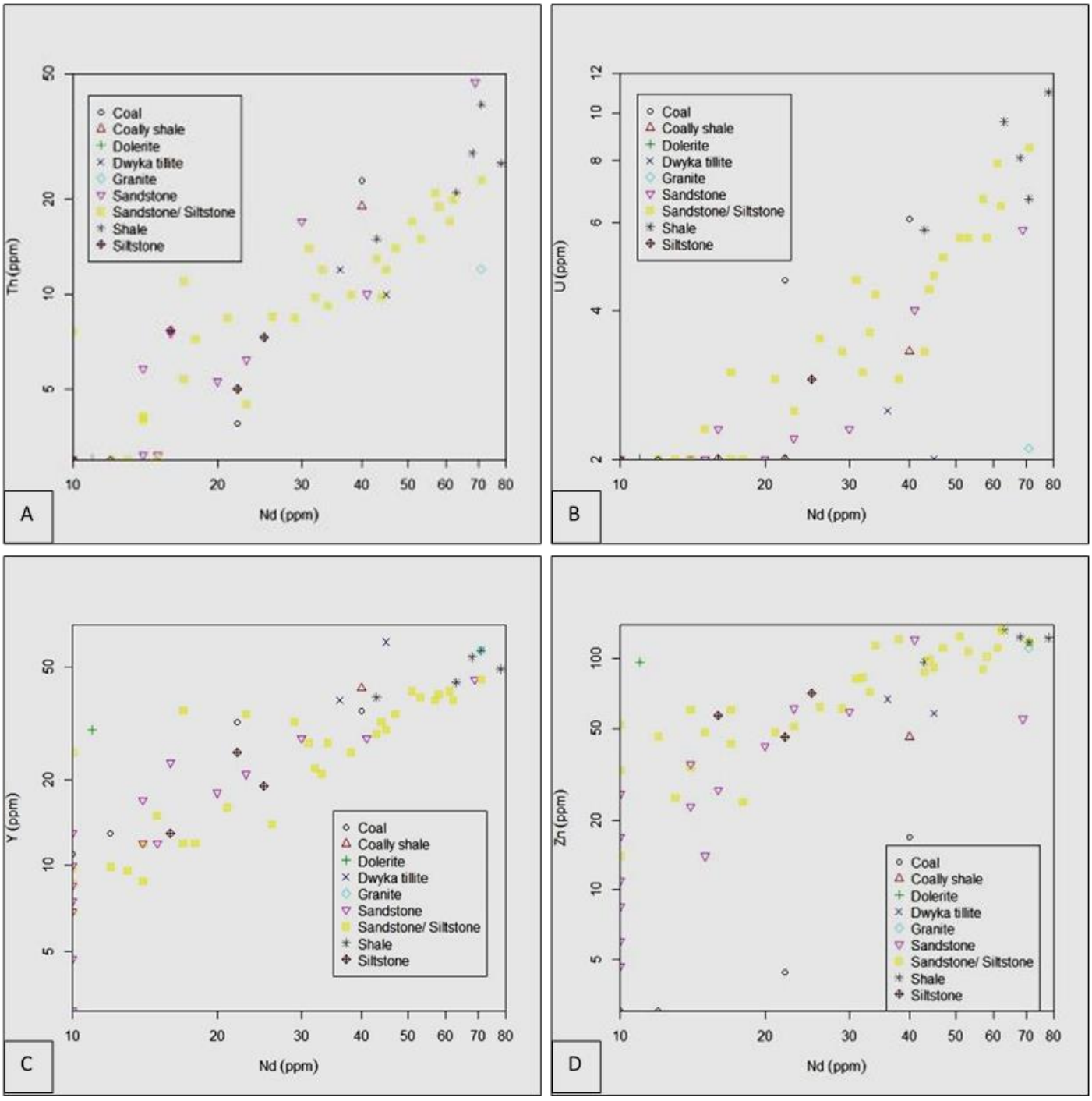


Figure C-14: (a) Nd versus Th (ppm); (b) Ndversus U (ppm); (c) Nd versus Y (ppm) and (d) Nd versus Zn (ppm).

APPENDIX D: X-RAY FLUORESCENCE SPECTROMETRY (XRF) MAJOR (wt.%) AND TRACES (PPM)

Table D-1: Borehole ZFN1510.

Sample	Rock Name	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cr_2O_3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr	S	C
M1	Sandstone/ Siltstone	77,37	0,18	11,84	2,05	0,029	0,41	0,41	1,90	3,86	0,035	0,006	1,42	99,51	4,4	878	3	2	13	3,3	22	5	3,6	14	1	3,6	10	2	7,7	10	2,9	31	121	3	1	10	130	2	3	3	2	25	3	6,9	3	14	85	0,01	0,02
M2	Sandstone/ Siltstone	74,71	0,35	14,26	1,34	0,014	0,50	0,64	2,00	4,22	0,038	0,008	1,68	99,77	4	931	3	2	17	4,3	39	5	2,4	17	1	4,4	12	2	12	13	8,5	30	139	5,4	1	10	151	2	3	3	2	36	3	9,6	3	25	121	0,01	0,07
M3	Sandstone/ Siltstone	71,12	0,45	15,73	1,76	0,012	0,67	0,69	1,74	4,21	0,047	0,008	2,25	98,68	4,8	896	3	2	24	5,3	38	5,3	5,1	19	1	4	15	2	14	14	10	29	149	8,2	1	10	143	2	4,1	3	2	50	3	12	3	34	127	0,01	0,11
M4	Sandstone/ Siltstone	77,09	0,23	7,88	6,85	0,068	0,86	0,45	1,05	1,75	0,067	0,006	2,35	98,65	4,7	551	3,3	2	16	6,6	38	5	2	14	3	3,8	10	2	12	10	8,8	17	62	6,5	1	10	78	2	3	3	2	46	3	8,7	3	33	82	0,01	0,14
M5	Siltstone	73,33	0,57	13,55	3,80	0,028	0,85	0,53	1,42	3,36	0,057	0,008	2,27	99,77	4,4	722	5,2	2	28	7,8	50	6,6	3,2	20	1,1	6,7	16	2	18	16	16	24	129	8,8	1	10	119	2	7,7	3	2	63	3	13	3	57	174	0,01	0,24
M6	Siltstone	67,70	0,69	16,37	3,61	0,027	1,11	0,72	1,81	4,01	0,068	0,011	3,13	99,25	4,4	760	3	2	44	13	61	7,5	9,2	23	1	5,5	24	2	18	25	22	28	153	13	1	10	147	2	7,3	3	2,9	82	3	19	3	71	178	0,01	0,45
M7	Sandstone/ Siltstone	53,78	1,03	25,15	5,00	0,052	1,21	0,63	0,45	2,23	0,061	0,030	9,51	99,14	18	494	3	2	122	26	147	14	37	33	1	9,6	62	3,3	25	57	65	26	109	20	1,8	11	90	2,1	21	3	6,7	132	3	38	5,6	90	225	0,04	2,27
M8	Sandstone/ Siltstone	22,75	0,37	8,10	12,89	0,220	1,56	27,95	0,56	0,88	1,69	0,012	22,63	99,61	18	276	3	2	48	9,2	59	5	12	9,7	1	3	34	2	11	23	24	8,5	50	64	1	10	184	2	4,5	3	2,5	55	3	34	3	51	134	0,11	5,91
M9	Sandstone/ Siltstone	56,76	0,87	19,48	9,91	0,079	1,55	0,64	0,61	2,70	0,114	0,025	6,53	99,26	8,2	535	3	2	70	16	124	15	33	25	1	8,4	26	3,4	22	31	48	22	135	14	1,1	11	77	2	14	3	4,6	114	3	27	3,1	82	234	0,02	1,37
M10	Sandstone/ Siltstone	71,95	0,45	12,87	3,63	0,043	0,74	1,14	0,58	2,60	0,049	0,014	4,49	98,56	7,4	501	3	2	49	11	72	9,6	19	16	1	5,2	23	2	14	21	26	20	106	9	1	10	93	2	8,4	3	2,9	72	3	16	3	48	141	0,02	0,87
M11	Shale	61,65	0,95	18,62	3,46	0,018	1,31	0,58	0,61	2,89	0,065	0,022	8,60	98,79	7,9	525	3	2	95	20	99	14	33	25	1	14	47	3,7	24	43	43	26	133	16	1,6	10	78	2,3	15	3	5,8	107	3	39	3,6	97	343	0,05	3,30
M12	Sandstone	71,29	1,02	8,17	5,82	0,196	0,37	4,55	0,75	2,64	0,062	0,008	4,54	99,41	7,1	606	3	2	59	5,4	59	5	5,1	11	1,1	15	25	2	20	30	5,8	30	78	14	1	10	138	2	17	3	2,3	74	3	28	3	59	420	0,02	1,14
M13	Sandstone	79,19	0,40	9,01	2,97	0,028	0,23	0,95	1,04	3,35	0,046	0,009	1,50	98,72	4	713	3	2	24	3,2	23	5	2	12	1	7,4	11	2	11	14	5,2	25	95	3,9	1	10	120	2	5,8	3	2	36	3	12	3	23	182	0,01	0,17
M14	Sandstone	73,97	1,92	12,10	3,11	0,064	0,54	0,46	1,03	3,74	0,093	0,011	2,36	99,40	7,4	909	4,7	2	139	6,4	52	6,7	4,5	15	1	32	72	2	36	69	13	28	122	12	1	13	123	3,8	47	3	5,8	86	3	45	3,8	55	838	0,01	0,48
M15	Sandstone	77,85	0,25	10,28	3,27	0,032	0,36	0,32	1,02	4,34	0,047	0,008	1,60	99,37	4	900	3,4	2	17	5,1	30	5	2	16	1	3	13	2	9,2	14	11	30	133	8,1	1	10	142	2	3,1	3	2	40	3	17	3	35	94	0,03	0,20
M16	Sandstone	85,16	0,13	8,10	0,86	0,010	0,01	0,21	0,91	3,59	0,029	0,008	0,85	99,86	5,3	742	3	2	11	3,8	16	5	2	9,1	1	3	10	2	6,7	10	5	27	110	3,1	1	10	117	2	3	3	2	16	3	7,5	3	17	67	0,01	0,05
M17	Sandstone/ Siltstone	57,12	0,95	17,02	6,66	0,073	1,17	0,63	1,29	3,06	0,202	0,015	10,58	98,76	7,1	730	3	2	106	11	70	8,7	22	25	1,4	13	58	2	18	51	28	26	118	18	1,6	15	250	2	17	3	5,6	108	3	41	6,1	125	345	0,05	4,02
M18	Sandstone/ Siltstone	62,21	0,87	15,55	5,91	0,058	1,12	0,48	1,28	3,11	0,117	0,014	7,79	98,52	4	718	3	2	84	15	63	7,6	16	24	1	13	48	2	19	47	31	24	122	15	1	10	151	2	14	3	5,1	92	3	34	4,2	112	331	0,03	2,43
M19	Sandstone/ Siltstone	65,74	0,77	14,39	5,37	0,050	0,97	0,43	1,20	3,03	0,100	0,013	6,74	98,80	6,4	684	3	2	79	10	59	6,1	13	21	1	10	43	2	17	44	24	24	115	13	1	10	130	2	9,8	3	4,4	82	3	32	3	100	297	0,04	2,09
M20	Sandstone/ Siltstone	67,15	0,72	13,57	4,97	0,049	0,87	0,41	1,11	2,97	0,088	0,012	6,64	98,55	4	667	3	2	84	9,1	58	6,2	13	21	1,3	11	46	2	17	45	24	25	112	12	1	10	123	2	12	3	4,7	78	3	30	3	92	288	0,02	2,15
M21	Sandstone/ Siltstone	61,28	0,81	17,56	4,42	0,042	0,80	0,36	0,99	2,76	0,091	0,015	9,56	98,69	4,4	617	3	2	116	13	80	5,7	22	25	1,1	12	60	2	21	53	31	26	109	15	1	10	124	2	15	3	5,6	95	3	39	3	108	323	0,01	3,15
M22	Sandstone	77,57	0,46	9,18	2,09	0,044	0,31	2,30	0,96	2,71	0,048	0,007	4,11	99,79	4	625	3	2	35	6,2	34	5	5,4	12	1	8,2	18	2	12	20	13	22	89	8,3	1	10	159	2	5,3	3	2	41	3	18	3,6	42	179	0,01	0,98
M23	Sandstone/ Siltstone	41,13	0,53	10,84	11,52	0,143	1,81	13,18	1,05	1,81	1,35	0,010	16,17	99,56	14	507	3	2	91	12	49	5	13	15	1	6,6	37	2	13	29	22	13	89	25	1	10	234	2	8,4	3	3,3	58	3	32	5,6	61	185	0,01	4,02
M24	Sandstone/ Siltstone	73,35	0,18	7,35	1,39	0,116	0,18	6,76	1,16	2,93	0,032	0,005	5,49	98,95	4	619	3	2	19	3,5	59	5	3,5	8,9	1	3,5	10	2	5,7	10	3,4	20	84	8,6	1	10	239	2	3	3	2	18	3	9,7	3	14	87	0,01	1,37
M25	Sandstone/ Siltstone	67,80	0,90	15,08	4,88	0,026	1,16	0,43	1,66	2,89	0,068	0,014	4,41	99,33	9,2	634	3	2	76	11	62	6,5	12	19	1	15	35	2	22	33	24	19	119	11	1	10	138	2	12	3	3,6	76	3	21	3	72	322	0,01	0,48
M26	Sandstone/ Siltstone	81,05	0,38	6,08	2,45	0,044	0,34	3,00	0,56	1,69	0,043	0,007	3,63	99,26	6,8	385	3	2	40	4,4	28	5	5,9	7,2	1	7,6	18	2	10	18	11	15	57	5,2	1	10	131	2	7,2	3	2	27	3	12	3	24	219	0,01	0,72
M27	Sandstone/ Siltstone	57,81	0,87	19,36	6,44	0,045	1,43	0,46	1,39	2,89	0,083	0,019	8,18	98,97	14	577	3	2	77	17	96	14	11	25	1	11	33	2,9	21	34	38	24	147	14	1,3	10	156	2,3	9,2	3	4,3	106	3	27	3,2	115	272	0,04	1,85
M28	Shale	50,24	0,93	21,19	5,98	0,082	1,16	0,35	0,88	2,47	0,121	0,052	16,14	99,61	9,8	571	3	2	150	21	90	16	50	30	1,9	8	73	2,7	21	63	49	34	134	18	1,7	15	167	2,8	21	3	9,6	139	3	44	4,2	133	180	0,11	7,34
M29	Sandstone	77,45	0,18	10,21	1,47	0,026	0,21	2,01	1,31	3,74	0,036	0,007	2,74	99,38	4	775	3	2	10	2,3	30	5	2,9	12	1	4,2	11	2	6,9	10	5,2	27	118	4,9	1	10	181	2	3	3	2	22	3	8,5	3	26	87	0,02	0,66
M30	Dolerite	43,02	1,90	14,70	15,77	0,222	4,46	9,08	2,96	0,28	0,164	0,029	6,81	99,39	4	222	3	2	16	39	83	5	256	24	1	3	10	2	5,2	11	64	2,4	6,1	45	1	10	247	3,2	3	3	2	489	3	30	3,2	97	101	0,02	1,94
M31	Sandstone	76,68	0,08	6,03	1,66	0,042	1,79	4,35	0,59	2,67	0,023	0,006	5,88	99,80	4,6	576	3	2	10	1,6	17	5	2	5,4	1	3	10	2	5,1	10	2	18	81	3,5	1	10	152	2	3	3	2	6,4	3	3,1	3	4,7	59	0,05	1,35
M32	Sandstone/ Siltstone	66,49	0,90	15,74	4,34	0,043	1,11	0,62	1,46	3,25	0,109	0,015	4,91	98,99	4	805	3,2	2	82	9	72	5,1	21	22	1	13	47	2	19	43	24	27	112	12	1	10	124	2	13	3	3,3	98	3	29	3	88	327	0,02	1,75
M33	Sandstone/ Siltstone	83,81	0,22	7,04	1,46	0,026	0,47	1,51	0,67	2,33	0,034	0,006	2,35	99,92	4	561	3	2	17	3	18	5	6,1	8,6	1	5,3	12	2	8,6	12	4,7	17	77	3	1	10	105	2	3	3	2	19	3	9,9	3	46	116	0,01	0,61
M34	Sandstone/ Siltstone	64,52	0,78	17,74	3,82	0,026	1,04	0,57	1,73	3,74	0,089	0,014	4,47	98,55	5,7	796	3	2	69	18	64	8,9	8,4	25	1	9,9	33	2	19	32	34	28	154	13	1	10	154	2	9,8	3	3	81	3	22	3	83	266	0,01	0,77
M35	Coal	7,69	0,10	4,56	3,20	0,004	0,39	1,23	0,13	0,17	0,012	0,002	81,05	98,53	19	94	3	2	31	4,2	9,2	5	2	6,8	1	3,9	15	2	9,3	12	3,4	6,4	4,4	4,9	1	10	54	2	3	3	2	8,1	3	13	3	3	70	2,52	66,4
M36	Sandstone	47,66	0,60	10,76	2,92	0,114	1,01	17,24	1,06	2,94	0,070	0,009	14,73	99,11	4	588	3	2	36	7,6	30	5	4	14	1	8,9	20	2	14	23	15	18	104	34	1	10	199	2,7	6,2	3	2,2	43	3	21	4,7	61	206	0,01	3,72
M37	Sandstone	61,18	1,00	17,10	6,43	0,083	1,23	0,50	1,27	3,80	0,098	0,014	6,47	99,17	5,4	790	3	2	62	15	82	9,8	9,1	26	1	11	41	2	23	41	30	25	154	17	1,7	10	123	2	10	3	4	109	3	28	3	121	287	0,05	0,97
M38	Sandstone/ Siltstone	58,22	0,86	18,55	3,85	0,032	0,77	0,18	0,63	2,79	0,099	0,016	13,70	99,70	4,1	645	3	2	128	15	80	8	32	28	1	8,3	69	2	20	61	37	30	128	16	1	11	117	2,7	17	3	7,9	101	3	41	3,3	112	233	0,03	6,15
M39	Sandstone/ Siltstone	52,38	0,87	20,30	6,45	0,082	0,99	0,40	0,35	2,80	0,183	0,017	15,23	100,06	6,8	718	3	2	165	16	83	9,2	39	30	1	8,2	87	2	18	71	38	34	135	18	1	15	302	2,1	23	3	8,5	110	3	45	5,8	119	226	0,04	5,90
M40	Sandstone	38,72	0,44	7,51	8,06	0,102	6,74	13,46	0,27	1,54	0,330	0,009	22,33	99,51	6,6	607	3,4	2	40	7,6	31	5	4,3	12	1	16	19	2	12	16	12	14	55	25	1	10	291	2	7,5	3	2,3	34	3	23	3,3	27	457	0,02	5,91

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Table D-2: Borehole ZFN1512.

Sample	Rock Name	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cr_2O_3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr	C	S
W1	Sandstone/ Siltstone	77,80	0,23	12,37	1,04	0,009	0,38	0,42	1,88	4,14	0,029	0,008	1,35	99,66	4	839	3	2	15	3,4	21	5	3,9	14	1	3,6	10	2	8,9	11	6,3	31	134	4	1	10	131	2	4	3	2	27	3	7,8	3	16	105	0,03	0,01
W2	Sandstone/ Siltstone	70,61	0,46	16,28	1,97	0,017	0,82	0,71	1,85	4,49	0,037	0,010	2,37	99,62	4	782	3	2	27	7,5	48	5	2,6	22	1	4,3	19	2	14	18	13	28	165	8,3	1	10	155	2	5,6	3	2	59	3	12	3	38	132	0,22	0,01
W3	Sandstone/ Siltstone	92,32	0,10	3,90	0,63	0,008	0,04	0,13	0,49	1,64	0,022	0,007	0,21	99,50	4,1	371	3	2	10	2,7	17	5	2	3,4	1	4,3	10	2	7	10	3,2	13	52	3	1	10	53	2	3	3	2	12	3	4,4	3	7,1	82	0,03	0,00
W4	Sandstone/ Siltstone	84,69	0,19	6,90	3,21	0,032	0,47	0,26	0,66	2,03	0,043	0,009	1,18	99,67	4,7	521	3	2	13	3,3	34	5	2,1	9	1	3	10	2	10	10	7,5	16	73	5	1,2	10	68	2	3	3	2	32	3	9	3	31	85	0,13	0,00
W5	Sandstone/ Siltstone	70,15	0,71	14,57	3,71	0,029	1,06	0,63	1,45	3,62	0,083	0,012	3,08	99,10	4	761	3	2	41	9,6	63	13	6,9	20	1	5,2	25	2	19	26	21	25	144	13	1	10	117	2	9,1	3	3,2	76	3	20	3	69	184	0,48	0,02
W6	Shale	54,21	0,83	18,87	12,71	0,105	1,83	0,79	0,54	2,42	0,265	0,023	6,96	99,55	9,5	541	3	2	74	16	126	14	33	26	1	5,7	36	3,3	22	35	45	23	128	16	1,6	14	76	2	14	3	5	119	3	33	3	92	221	1,47	0,06
W7	Dolerite	43,26	1,77	14,56	7,76	0,503	0,80	15,92	2,53	0,47	0,163	0,015	11,82	99,59	92	240	15	2	18	39	72	5	232	21	1	3,4	10	2	4,6	16	57	4,7	13	50	6,6	10	293	3	3	3	2,3	384	3	32	3	98	107	3,08	0,13
W8	Shale	67,08	0,88	16,69	4,15	0,018	1,28	0,59	0,71	2,43	0,059	0,021	5,65	99,57	4	593	3,3	2	80	16	100	13	28	22	1,1	12	43	2,9	21	39	35	22	129	14	1,7	10	113	2	14	3	4	99	3	33	5,1	81	316	1,30	0,02
W9	Dolerite	41,00	2,20	15,86	15,30	0,320	1,73	8,20	3,28	0,39	0,207	0,019	11,17	99,68	4	220	3	2	21	42	93	5	296	25	1,3	3	10	2	6,4	14	61	4,3	9,9	49	1	13	224	5,6	3	3	2	492	3	37	6,8	170	121	2,50	0,15
W10	Sandstone	76,83	0,41	8,37	1,99	0,054	0,21	3,79	1,00	3,10	0,040	0,009	3,34	99,13	4	772	3	2	21	2,2	47	5	2	11	1	7,4	10	2	10	15	3,7	21	89	9,3	1	10	147	2	3	3	2	40	3	11	3	16	187	0,66	0,00
W11	Sandstone	54,24	0,34	6,91	3,35	0,128	0,50	17,00	1,00	2,44	0,047	0,006	13,67	99,64	4	652	3	2	15	4,3	26	5	2	9	1	6,1	10	2	7,6	11	6	16	69	30	1	10	192	2	3	3	2	25	3	16	3	19	155	3,41	0,01
W12	Sandstone	80,34	0,48	9,87	1,42	0,024	0,24	1,06	0,89	3,58	0,040	0,008	1,61	99,57	4	805	3,1	2	16	4,7	68	5	2	12	1	6,5	10	2	12	13	5,7	24	110	8,7	1	10	132	2	3	3	2	46	3	13	3	29	136	0,23	0,01
W13	Sandstone	78,52	0,24	10,07	1,56	0,034	0,17	1,45	1,03	4,33	0,038	0,009	2,28	99,73	4	971	3	2	15	4,2	25	5	2,3	13	1	3,2	12	2	7,8	15	5,3	31	134	6,5	1	10	179	2	3	3	2	31	3	11	3	40	86	0,47	0,04
W14	Sandstone	80,38	0,32	10,08	1,38	0,017	0,10	0,72	1,07	3,82	0,036	0,007	1,66	99,59	4	842	3	2	16	3,2	22	5	2	12	1	4,6	11	2	10	14	5,6	26	112	5,5	1	10	139	2	3	3	2	29	3	11	3,7	24	125	0,17	0,01
W15	Sandstone	83,70	0,07	8,06	0,54	0,012	0,01	0,91	0,84	4,34	0,044	0,006	1,10	99,57	6	947	3	2	10	5	13	5	2	9,3	1	3	10	2	4,5	10	6	31	130	3,1	1	10	164	2	3	3	2	12	3	7,7	3	10	50	0,20	0,01
W16	Sandstone/ Siltstone	60,80	0,91	15,46	8,67	0,099	1,47	0,72	1,30	3,15	0,112	0,014	6,68	99,38	4	744	3	2	59	12	65	10	8,3	23	1	11	37	2	20	37	28	22	129	22	1	10	141	2	7,9	3	3,5	104	3	31	3	113	330	1,31	0,01
W17	Sandstone/ Siltstone	80,52	0,40	8,35	2,10	0,038	0,27	1,36	0,91	2,59	0,055	0,008	2,83	99,45	4	607	3	2	27	7	31	5,3	4	11	1	8,1	15	2	11	16	12	19	83	6	1	10	134	2	3,9	3	2	33	3	18	3	34	182	0,61	0,01
W18	Sandstone/ Siltstone	63,82	0,88	15,60	5,24	0,054	0,97	0,50	1,20	3,04	0,119	0,012	7,78	99,22	4	690	3	2	96	12	72	8,8	16	22	1	14	58	2	18	53	26	24	117	15	1	11	147	2,3	13	3	5,5	92	3	37	3,8	105	385	2,50	0,04
W19	Sandstone/ Siltstone	83,91	0,55	8,34	1,61	0,019	0,18	0,27	0,94	2,58	0,050	0,007	1,27	99,72	4	623	3	2	51	6,3	39	5	2	10	1	12	23	2	14	26	6,2	20	78	5,8	1	10	100	2	11	3	2	35	3	18	3	28	332	0,10	0,01
W20	Sandstone/ Siltstone	27,17	0,40	7,81	13,86	0,165	1,91	20,79	0,70	1,21	0,690	0,007	24,56	99,26	4	394	3	2	92	8,7	37	5	12	13	1	4	42	2	11	33	18	9,4	66	51	1	10	180	2	3,3	3	3,4	47	3	35	3	52	136	6,32	0,02
W21	Sandstone/ Siltstone	51,02	0,94	20,97	4,42	0,048	1,10	0,34	1,01	2,42	0,099	0,019	17,02	99,39	4	585	3	2	154	21	88	12	54	30	1,5	5,4	74	2,5	21	65	48	35	130	18	1,5	14	143	2,2	24	3	9	143	3	47	5,2	137	162	7,59	0,07
W22	Sandstone	12,25	0,21	4,11	39,29	0,548	3,35	8,76	0,44	0,70	0,444	0,006	29,55	99,66	4	346	3	2	16	2,1	31	5	2	9,3	1	3	10	2	8,5	10	11	4,5	47	16	1	15	174	2	3	3	2	46	3	9,1	3	50	32	9,24	0,01
W23	Sandstone	47,93	1,68	14,48	14,59	0,203	5,25	10,56	2,57	0,30	0,146	0,020	1,65	99,38	4	195	3	2	20	40	67	5	243	24	1,4	3	10	2	5,5	12	60	2,4	6,1	31	1,4	10	183	3,4	3	3	2	368	3	28	3,7	92	94	0,57	0,03
W24	Sandstone	85,78	0,30	6,66	0,95	0,020	0,21	0,74	0,81	2,72	0,032	0,006	1,27	99,51	4	619	3	2	18	1,2	29	5	2	7	1	5,2	10	2	9,3	11	2,4	22	87	3	1	10	105	2	4,5	3	2	13	3	11	3	8,3	152	0,29	0,00
W25	Siltstone	62,49	0,79	17,65	5,34	0,048	1,13	0,61	1,54	3,44	0,102	0,015	6,26	99,44	4	729	3	2	75	14	77	12	10	26	1	11	32	2	20	35	28	28	160	15	1	10	154	2	10	3	3,4	90	3	24	4	84	262	0,98	0,01
W26	Coal	4,77	0,10	1,49	1,10	0,005	0,30	0,65	0,12	0,05	0,011	0,001	91,41	100,00	12	100	3,2	2	13	1,8	7,5	5	2	2,8	1	3	10	2	6,7	10	2	6,5	2	3	1	10	73	2	3	3	2	10	3	6	3	3	21	72,90	1,41
W27	Sandstone	58,39	1,01	19,06	4,03	0,032	1,12	0,37	1,43	3,50	0,088	0,018	10,46	99,50	4	754	3	2	121	18	108	12	22	30	1,3	14	73	2	23	65	37	29	161	19	1	13	125	2	16	3	4,9	132	3	47	3	133	342	3,69	0,49
W28	Sandstone	68,53	0,62	12,21	2,64	0,047	1,12	2,98	1,14	3,71	0,067	0,009	5,74	98,80	4	770	3	2	41	4,9	31	5	3	15	1	8,9	21	2	15	24	8,7	24	111	8,3	1	10	149	2	7,8	3	2	39	3	18	3	42	228	0,98	0,06
W29	Sandstone/ Siltstone	49,49	0,94	20,49	7,53	0,101	0,90	0,43	0,22	2,95	0,255	0,018	15,29	98,61	4	736	3	2	162	14	78	14	37	29	1	9,5	77	2	16	67	37	32	119	17	1	10	415	2	23	3	8	111	3	46	4,5	115	254	5,27	0,18
W30	Sandstone/ Siltstone	70,37	0,32	9,31	8,57	0,084	0,68	0,33	0,15	2,27	0,169	0,007	7,29	99,54	6	699	3	2	33	5,1	22	5	2,9	12	1	11	15	2	10	10	4,9	19	73	5,1	1	10	227	2	3	3	2	24	3	9,3	6,2	17	277	1,57	0,30
W31	Coal	2,58	0,07	1,31	4,22	0,000	0,24	0,81	0,13	0,01	0,011	0,001	90,04	99,41	14	285	3	2	13	2,4	8,4	5	2	11	28	3	10	5,6	2,8	10	4	6,4	2	3	1	10	344	2	3	3	2	11	3	6,2	3	5,3	18	70,90	1,41
W32	Coally Shale	33,62	0,89	18,92	0,65	0,007	0,31	0,76	0,20	0,56	0,066	0,028	43,48	99,48	5,7	396	3,7	2	99	2,1	60	7,6	18	27	1	7,5	49	2	25	43	12	18	38	15	2,5	10	155	2	23	3	4,7	66	3	40	3,7	18	196	27,20	0,18
W33	Coal	53,18	0,91	27,85	1,11	0,007	0,01	0,06	0,15	1,01	0,029	0,062	15,33	99,59	4	247	3	2	20	8,5	94	5,1	36	34	1	18	10	2	30	10	60	14	42	7,9	1	10	24	2,3	13	3	3,4	43	3	25	4,6	76	411	3,82	0,05
W34	Coal	76,14	2,40	11,81	1,85	0,030	0,08	0,14	0,08	2,08	0,047	0,060	4,92	99,64	4,2	685	7	2	59	7,6	189	6,1	12	18	1	104	12	4,3	57	24	21	17	70	15	1	10	60	4,6	15	3	7,2	67	3	69	12	100	2364	3,56	0,04
W35	Coal	51,16	1,08	29,68	0,86	0,006	0,01	0,06	0,15	1,31	0,076	0,042	15,17	99,50	4	318	3,8	2	194	12	152	11	30	42	1	19	69	2	39	67	49	31	71	14	1	10	88	3,1	32	3	6,8	133	3,1	54	4,8	88	446	3,71	0,03
W36	Shale	90,12	0,81	4,08	0,94	0,013	0,01	0,05	0,01	0,51	0,030	0,008	1,98	98,53	4,6	218	3	2	33	4,3	51	5	4	6,4	1	6,8	10	2	15	13	7,2	6,6	18	4,7	1	10	37	2	4,3	3	2	52	3	14	3	26	153	0,38	0,05
W37	Sandstone	52,54	1,09	27,13	1,11	0,008	0,01	0,06	0,18	1,67	0,071	0,017	15,34	99,15	5,5	360	3,1	2	163	12	79	9,5	29	42	1	18	69	2	41	58	41	27	81	16	1	10	61	2	35	3	7	134	3	66	8	124	448	4,41	0,06
W38	Coally Shale	36,82	0,72	15,34	0,79	0,006	0,04	0,10	0,15	0,54	0,052	0,018	44,98	99,55	5	218	3,7	2	108	9	84	5	21	22	1	7	50	2	21	43	38	23	25	18	1	10	40	2	16	3	3,5	149	3	54	3,6	33	205	30,28	0,10
W39	Sandstone	62,32	0,77	19,32	2,37	0,033	0,94	1,63	0,15	2,99	0,095	0,017	8,96	99,58	9,4	655	3	2	36	23	64	5,4	4,9	24	1	8	21	2,4	20	18	32	22	98	8,6	1	10	99	2	4,3	3	2	71	3	13	3	66	199	1,12	0,06
W40	Sandstone	87,87	0,23	6,56	0,46	0,007	0,01	0,34	0,08	2,21	0,027	0,007	1,84	99,63	4	541	3	2	10	2,5	34	5	2,5	7	1	5	10	2	8,8	10	3,8	20	66	3	1	10	73	2	3,3	3	2	30	3	5,5	3,6	14	124	0,28	0,06
W41	Coal	3,56	0,00	2,10	1,31	0,006	0,01	0,15	0,07	0,02	0,009	0,005	91,56	98,81	21	79	3,4	2	13	28	36	5	8	37	16	3	10	2	9,2	10	53	9,7	2	14	1	10	39	2	3	3	4,7	60	3,7	27	4,5	3	41	72,30	1,16

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APPENDIX E: KINETIC TEST RESULTS CORRELATIONS MATRIX BH1-27

Table E-1: BH1 with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.0	-0.1	-0.1	0.1	-0.1	0.0	0.0	0.3	0.2	0.5	0.4				-0.2	0.4		-0.1				0.0	0.2	0.1		0.5	0.1
EC	0.0	1.0	0.8	0.8	0.9	0.9	0.9	0.4	0.2	0.0	-0.1	0.2				-0.1	0.2		0.4				0.4	-0.1	0.5		-0.1	0.0
Ca	-0.1	0.8	1.0	1.0	0.8	0.9	0.8	0.8	0.1	-0.1	-0.3	0.2				-0.1	0.0		0.7				0.8	-0.2	0.7		-0.2	-0.1
Mg	-0.1	0.8	1.0	1.0	0.8	0.9	0.8	0.8	0.1	-0.1	-0.2	0.2				-0.2	0.0		0.8				0.8	-0.2	0.7		-0.1	0.0
Na	0.1	0.9	0.8	0.8	1.0	0.9	0.9	0.5	0.1	0.1	0.0	0.2				-0.1	0.1		0.5				0.5	0.0	0.5		0.0	0.1
K	-0.1	0.9	0.9	0.9	0.9	1.0	0.9	0.6	0.2	-0.1	-0.3	0.2				-0.1	0.0		0.6				0.6	-0.2	0.6		-0.1	0.0
MAlk	0.0	0.9	0.8	0.8	0.9	0.9	1.0	0.3	0.2	0.0	-0.2	0.1				0.0	0.0		0.3				0.3	0.0	0.5		-0.1	0.0
SO4	0.0	0.4	0.8	0.8	0.5	0.6	0.3	1.0	-0.1	0.0	-0.1	0.3				-0.2	0.0		0.9				1.0	-0.3	0.5		-0.1	0.0
Al	0.3	0.2	0.1	0.1	0.1	0.2	0.2	-0.1	1.0	0.0	0.1	0.7				-0.1	0.6		-0.1				-0.1	0.3	0.1		0.5	0.0
As	0.2	0.0	-0.1	-0.1	0.1	-0.1	0.0	0.0	0.0	1.0	0.2	0.0				-0.2	0.1		-0.1				0.0	-0.1	-0.1		0.1	0.0
B	0.5	-0.1	-0.3	-0.2	0.0	-0.3	-0.2	-0.1	0.1	0.2	1.0	0.5				-0.1	0.5		0.0				-0.1	0.3	0.0		0.5	0.5
Ba	0.4	0.2	0.2	0.2	0.2	0.2	0.1	0.3	0.7	0.0	0.5	1.0				-0.2	0.7		0.3				0.3	0.0	0.1		0.5	0.2
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	-0.1	-0.1	-0.2	-0.1	-0.1	0.0	-0.2	-0.1	-0.2	-0.1	-0.2				1.0	-0.1		-0.3				-0.2	0.3	0.0		-0.1	-0.2
Fe	0.4	0.2	0.0	0.0	0.1	0.0	0.0	0.0	0.6	0.1	0.5	0.7				-0.1	1.0		-0.1				-0.1	0.1	0.1		0.5	0.1
mn																		1.0										
Mo	-0.1	0.4	0.7	0.8	0.5	0.6	0.3	0.9	-0.1	-0.1	0.0	0.3				-0.3	-0.1		1.0				0.9	-0.3	0.5		-0.1	0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.0	0.4	0.8	0.8	0.5	0.6	0.3	1.0	-0.1	0.0	-0.1	0.3				-0.2	-0.1		0.9				1.0	-0.2	0.5		-0.1	0.0
Si	0.2	-0.1	-0.2	-0.2	0.0	-0.2	0.0	-0.3	0.3	-0.1	0.3	0.0				0.3	0.1		-0.3				-0.2	1.0	0.2		0.3	0.0
Sr	0.1	0.5	0.7	0.7	0.5	0.6	0.5	0.5	0.1	-0.1	0.0	0.1				0.0	0.1		0.5				0.5	0.2	1.0		-0.1	-0.1
U																										1.0		
V	0.5	-0.1	-0.2	-0.1	0.0	-0.1	-0.1	-0.1	0.5	0.1	0.5	0.5				-0.1	0.5		-0.1				-0.1	0.3	-0.1		1.0	0.3
Zn	0.1	0.0	-0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.5	0.2				-0.2	0.1		0.1				0.0	0.0	-0.1		0.3	1.0

Table E-2: BH2, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.3	-0.2	-0.2	0.6	0.1	-0.2	0.6	0.1	0.1	0.4	0.1				-0.3	0.2		0.4				0.4	-0.3	-0.3			0.0
EC	0.3	1.0	0.3	0.3	0.7	0.7	0.5	0.4	0.4	-0.2	0.3	0.8				-0.2	0.5		0.5				0.4	-0.1	0.2			-0.1
Ca	-0.2	0.3	1.0	1.0	-0.1	0.7	0.8	-0.2	0.1	-0.3	-0.5	0.7				0.1	-0.2		0.1				0.2	0.3	0.9			0.1
Mg	-0.2	0.3	1.0	1.0	-0.1	0.7	0.7	-0.3	0.1	-0.3	-0.5	0.7				0.1	-0.1		0.0				0.1	0.3	1.0			0.1
Na	0.6	0.7	-0.1	-0.1	1.0	0.5	0.2	0.8	0.4	0.3	0.6	0.4				-0.2	0.6		0.7				0.5	-0.3	-0.2			0.0
K	0.1	0.7	0.7	0.7	0.5	1.0	0.7	0.3	0.3	-0.1	0.0	0.7				0.0	0.2		0.4				0.4	0.2	0.7			0.1
MAlk	-0.2	0.5	0.8	0.7	0.2	0.7	1.0	-0.1	0.3	-0.1	-0.3	0.7				0.1	0.0		0.0				0.1	0.3	0.7			0.1
SO4	0.6	0.4	-0.2	-0.3	0.8	0.3	-0.1	1.0	0.1	0.1	0.3	0.2				-0.3	0.3		0.8				0.8	-0.5	-0.3			-0.1
Al	0.1	0.4	0.1	0.1	0.4	0.3	0.3	0.1	1.0	0.3	0.3	0.5				-0.2	0.7		0.2				0.0	0.2	0.0			-0.1
As	0.1	-0.2	-0.3	-0.3	0.3	-0.1	-0.1	0.1	0.3	1.0	0.4	-0.1				0.1	0.3		0.1				-0.1	0.1	-0.3			-0.2
B	0.4	0.3	-0.5	-0.5	0.6	0.0	-0.3	0.3	0.3	0.4	1.0	0.0				-0.1	0.6		0.0				-0.2	0.0	-0.5			-0.1
Ba	0.1	0.8	0.7	0.7	0.4	0.7	0.7	0.2	0.5	-0.1	0.0	1.0				-0.2	0.4		0.3				0.2	0.1	0.6			-0.2
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.3	-0.2	0.1	0.1	-0.2	0.0	0.1	-0.3	-0.2	0.1	-0.1	-0.2				1.0	-0.3		-0.2				-0.2	0.3	0.1			0.4
Fe	0.2	0.5	-0.2	-0.1	0.6	0.2	0.0	0.3	0.7	0.3	0.6	0.4				-0.3	1.0		0.4				0.1	-0.1	-0.2			-0.2
Mn																		1.0										
Mo	0.4	0.5	0.1	0.0	0.7	0.4	0.0	0.8	0.2	0.1	0.0	0.3				-0.2	0.4		1.0				0.9	-0.4	-0.1			-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.4	0.4	0.2	0.1	0.5	0.4	0.1	0.8	0.0	-0.1	-0.2	0.2				-0.2	0.1		0.9				1.0	-0.4	0.0			-0.1
Si	-0.3	-0.1	0.3	0.3	-0.3	0.2	0.3	-0.5	0.2	0.1	0.0	0.1				0.3	-0.1		-0.4				-0.4	1.0	0.4			0.1
Sr	-0.3	0.2	0.9	1.0	-0.2	0.7	0.7	-0.3	0.0	-0.3	-0.5	0.6				0.1	-0.2		-0.1				0.0	0.4	1.0			0.1
U																										1.0		
V																											1.0	
Zn	0.0	-0.1	0.1	0.1	0.0	0.1	0.1	-0.1	-0.1	-0.2	-0.1	-0.2				0.4	-0.2		-0.1				-0.1	0.1	0.1			1.0

Table E-3: BH3, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.4	0.3	0.3	0.5	0.5	0.5	0.5	0.2	0.2	0.3	0.5				-0.3	0.0		0.0					-0.4	-0.1		0.5	0.5
EC	0.4	1.0	0.2	0.2	1.0	0.8	0.8	0.7	0.2	0.1	0.4	0.4				-0.5	0.4		0.8					-0.6	-0.1		0.3	0.2
Ca	0.3	0.2	1.0	0.9	0.3	0.7	0.2	0.5	-0.6	-0.3	-0.7	-0.3				0.0	-0.6		0.1					-0.5	0.5		-0.3	-0.2
Mg	0.3	0.2	0.9	1.0	0.2	0.7	0.2	0.4	-0.5	-0.4	-0.6	-0.1				0.0	-0.4		0.0					-0.4	0.7		-0.3	-0.1
Na	0.5	1.0	0.3	0.2	1.0	0.8	0.8	0.8	0.2	0.2	0.3	0.3				-0.5	0.3		0.8					-0.6	-0.1		0.3	0.3
K	0.5	0.8	0.7	0.7	0.8	1.0	0.7	0.8	-0.2	0.0	-0.1	0.2				-0.4	0.0		0.5					-0.7	0.4		0.0	0.0
MAlk	0.5	0.8	0.2	0.2	0.8	0.7	1.0	0.4	0.2	0.3	0.5	0.5				-0.7	0.2		0.5					-0.2	0.2		0.6	0.5
SO4	0.5	0.7	0.5	0.4	0.8	0.8	0.4	1.0	-0.1	0.0	-0.2	-0.1				-0.2	0.0		0.7					-0.9	-0.2		-0.1	-0.1
Al	0.2	0.2	-0.6	-0.5	0.2	-0.2	0.2	-0.1	1.0	-0.1	0.6	0.7				-0.1	0.9		0.2					0.1	-0.4		0.5	0.6
As	0.2	0.1	-0.3	-0.4	0.2	0.0	0.3	0.0	-0.1	1.0	0.3	-0.2				-0.4	-0.3		0.1					0.1	-0.2		0.3	-0.1
B	0.3	0.4	-0.7	-0.6	0.3	-0.1	0.5	-0.2	0.6	0.3	1.0	0.8				-0.4	0.7		0.1					0.3	-0.3		0.6	0.6
Ba	0.5	0.4	-0.3	-0.1	0.3	0.2	0.5	-0.1	0.7	-0.2	0.8	1.0				-0.2	0.7		-0.1					0.1	-0.1		0.7	0.8
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.3	-0.5	0.0	0.0	-0.5	-0.4	-0.7	-0.2	-0.1	-0.4	-0.4	-0.2				1.0	0.0		-0.4					0.0	0.0		-0.4	-0.3
Fe	0.0	0.4	-0.6	-0.4	0.3	0.0	0.2	0.0	0.9	-0.3	0.7	0.7				0.0	1.0		0.3					0.0	-0.3		0.3	0.4
Mn																		1.0										
Mo	0.0	0.8	0.1	0.0	0.8	0.5	0.5	0.7	0.2	0.1	0.1	-0.1				-0.4	0.3		1.0					-0.5	-0.3		0.0	0.0
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	-0.4	-0.6	-0.5	-0.4	-0.6	-0.7	-0.2	-0.9	0.1	0.1	0.3	0.1				0.0	0.0		-0.5					1.0	0.1		0.4	0.4
Sr	-0.1	-0.1	0.5	0.7	-0.1	0.4	0.2	-0.2	-0.4	-0.2	-0.3	-0.1				0.0	-0.3		-0.3					0.1	1.0		-0.3	-0.2
U																										1.0		
V	0.5	0.3	-0.3	-0.3	0.3	0.0	0.6	-0.1	0.5	0.3	0.6	0.7				-0.4	0.3		0.0					0.4	-0.3		1.0	0.9
Zn	0.5	0.2	-0.2	-0.1	0.3	0.0	0.5	-0.1	0.6	-0.1	0.6	0.8				-0.3	0.4		0.0					0.4	-0.2		0.9	1.0

Table E-4: BH4, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.7	0.5	0.4	0.6	0.5	0.1	0.6	0.3		0.6	0.3				-0.2	0.2	0.3	0.3	0.3			0.4	0.5	0.4		0.5	0.3
EC	0.7	1.0	0.7	0.7	0.9	0.8	0.4	0.8	0.4		0.6	0.6				0.1	0.5	0.5	0.6	0.5			0.7	0.7	0.7		0.6	0.5
Ca	0.5	0.7	1.0	0.9	0.5	0.8	0.3	0.4	0.5		0.3	0.8				-0.1	0.4	0.5	0.0	0.4			0.2	0.6	0.9		0.2	0.4
Mg	0.4	0.7	0.9	1.0	0.6	0.7	0.4	0.5	0.5		0.4	0.9				-0.1	0.6	0.6	0.0	0.5			0.2	0.6	0.9		0.2	0.5
Na	0.6	0.9	0.5	0.6	1.0	0.7	0.5	0.9	0.4		0.5	0.6				0.1	0.5	0.4	0.6	0.4			0.7	0.5	0.5		0.5	0.4
K	0.5	0.8	0.8	0.7	0.7	1.0	0.6	0.5	0.6		0.3	0.7				-0.2	0.4	0.4	0.3	0.3			0.4	0.6	0.7		0.2	0.4
MAlk	0.1	0.4	0.3	0.4	0.5	0.6	1.0	0.1	0.1		0.2	0.5				-0.3	0.2	0.2	0.3	0.1			0.3	0.3	0.4		0.3	0.1
SO4	0.6	0.8	0.4	0.5	0.9	0.5	0.1	1.0	0.3		0.4	0.5				0.3	0.4	0.3	0.6	0.4			0.7	0.4	0.4		0.3	0.4
Al	0.3	0.4	0.5	0.5	0.4	0.6	0.1	0.3	1.0		0.2	0.4				0.1	0.5	0.5	0.1	0.4			0.2	0.6	0.6		0.2	0.4
As										1.0																		
B	0.6	0.6	0.3	0.4	0.5	0.3	0.2	0.4	0.2		1.0	0.3				0.0	0.3	0.4	0.3	0.4			0.2	0.7	0.4		0.9	0.4
Ba	0.3	0.6	0.8	0.9	0.6	0.7	0.5	0.5	0.4		0.3	1.0				0.0	0.4	0.4	0.3	0.3			0.3	0.6	0.8		0.2	0.3
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	0.1	-0.1	-0.1	0.1	-0.2	-0.3	0.3	0.1		0.0	0.0				1.0	0.3	0.2	0.1	0.2			0.2	0.1	0.0		-0.1	0.2
Fe	0.2	0.5	0.4	0.6	0.5	0.4	0.2	0.4	0.5		0.3	0.4				0.3	1.0	1.0	0.0	1.0			0.2	0.6	0.7		0.3	1.0
Mn	0.3	0.5	0.5	0.6	0.4	0.4	0.2	0.3	0.5		0.4	0.4				0.2	1.0	1.0	-0.1	1.0			0.1	0.6	0.8		0.3	1.0
Mo	0.3	0.6	0.0	0.0	0.6	0.3	0.3	0.6	0.1		0.3	0.3				0.1	0.0	-0.1	1.0	-0.1			0.9	0.2	0.0		0.6	-0.1
Ni	0.3	0.5	0.4	0.5	0.4	0.3	0.1	0.4	0.4		0.4	0.3				0.2	1.0	1.0	-0.1	1.0			0.2	0.5	0.7		0.3	1.0
Pb																					1.0							
Sb																						1.0						
Se	0.4	0.7	0.2	0.2	0.7	0.4	0.3	0.7	0.2		0.2	0.3				0.2	0.2	0.1	0.9	0.2			1.0	0.2	0.2		0.5	0.2
Si	0.5	0.7	0.6	0.6	0.5	0.6	0.3	0.4	0.6		0.7	0.6				0.1	0.6	0.6	0.2	0.5			0.2	1.0	0.7		0.6	0.6
Sr	0.4	0.7	0.9	0.9	0.5	0.7	0.4	0.4	0.6		0.4	0.8				0.0	0.7	0.8	0.0	0.7			0.2	0.7	1.0		0.2	0.7
U																										1.0		
V	0.5	0.6	0.2	0.2	0.5	0.2	0.3	0.3	0.2		0.9	0.2				-0.1	0.3	0.3	0.6	0.3			0.5	0.6	0.2		1.0	0.3
Zn	0.3	0.5	0.4	0.5	0.4	0.4	0.1	0.4	0.4		0.4	0.3				0.2	1.0	1.0	-0.1	1.0			0.2	0.6	0.7		0.3	1.0

Table E-5: BH5, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.6	0.1	0.2	0.7	0.2	0.7	0.5	0.3	0.4	0.5	0.4				-0.2	0.1		0.3				0.2	0.5	0.2		0.6	0.1
EC	0.6	1.0	0.3	0.4	0.8	0.6	0.9	0.5	0.3	0.6	0.7	0.7				0.1	0.4		0.6				0.5	0.4	0.4		0.7	0.3
Ca	0.1	0.3	1.0	1.0	-0.1	0.6	0.3	0.5	0.1	-0.1	-0.1	0.7				0.0	0.5		0.0				0.0	-0.1	0.9		0.0	1.0
Mg	0.2	0.4	1.0	1.0	0.0	0.6	0.4	0.6	0.1	0.0	0.0	0.8				0.0	0.6		0.0				0.0	-0.1	1.0		0.0	1.0
Na	0.7	0.8	-0.1	0.0	1.0	0.5	0.9	0.4	0.3	0.7	0.8	0.4				0.0	0.2		0.6				0.5	0.6	0.1		0.8	-0.1
K	0.2	0.6	0.6	0.6	0.5	1.0	0.6	0.5	0.5	0.1	0.2	0.8				0.3	0.8		0.3				0.1	0.1	0.7		0.3	0.6
MAlk	0.7	0.9	0.3	0.4	0.9	0.6	1.0	0.7	0.3	0.5	0.7	0.7				0.2	0.5		0.4				0.3	0.5	0.5		0.7	0.3
SO4	0.5	0.5	0.5	0.6	0.4	0.5	0.7	1.0	0.2	0.0	0.4	0.7				0.2	0.5		0.0				-0.2	0.3	0.7		0.3	0.5
Al	0.3	0.3	0.1	0.1	0.3	0.5	0.3	0.2	1.0	0.0	0.1	0.3				0.3	0.6		0.1				0.0	0.4	0.1		0.2	0.1
As	0.4	0.6	-0.1	0.0	0.7	0.1	0.5	0.0	0.0	1.0	0.7	0.1				-0.4	-0.1		0.8				0.8	0.4	0.0		0.8	-0.1
B	0.5	0.7	-0.1	0.0	0.8	0.2	0.7	0.4	0.1	0.7	1.0	0.3				0.0	0.1		0.2				0.3	0.6	0.1		0.7	0.0
Ba	0.4	0.7	0.7	0.8	0.4	0.8	0.7	0.7	0.3	0.1	0.3	1.0				0.3	0.7		0.2				0.0	0.0	0.9		0.3	0.7
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	0.1	0.0	0.0	0.0	0.3	0.2	0.2	0.3	-0.4	0.0	0.3				1.0	0.6		-0.4				-0.3	-0.1	0.1		-0.2	0.0
Fe	0.1	0.4	0.5	0.6	0.2	0.8	0.5	0.5	0.6	-0.1	0.1	0.7				0.6	1.0		-0.1				-0.2	0.1	0.6		0.1	0.5
Mn																		1.0										
Mo	0.3	0.6	0.0	0.0	0.6	0.3	0.4	0.0	0.1	0.8	0.2	0.2				-0.4	-0.1		1.0				0.8	0.0	0.0		0.6	-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.2	0.5	0.0	0.0	0.5	0.1	0.3	-0.2	0.0	0.8	0.3	0.0				-0.3	-0.2		0.8				1.0	0.1	0.0		0.5	-0.1
Si	0.5	0.4	-0.1	-0.1	0.6	0.1	0.5	0.3	0.4	0.4	0.6	0.0				-0.1	0.1		0.0				0.1	1.0	-0.1		0.6	0.0
Sr	0.2	0.4	0.9	1.0	0.1	0.7	0.5	0.7	0.1	0.0	0.1	0.9				0.1	0.6		0.0				0.0	-0.1	1.0		0.0	0.9
U																										1.0		
V	0.6	0.7	0.0	0.0	0.8	0.3	0.7	0.3	0.2	0.8	0.7	0.3				-0.2	0.1		0.6				0.5	0.6	0.0		1.0	-0.1
Zn	0.1	0.3	1.0	1.0	-0.1	0.6	0.3	0.5	0.1	-0.1	0.0	0.7				0.0	0.5		-0.1				-0.1	0.0	0.9		-0.1	1.0

Table E-6: BH6, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.2	0.3	0.4	0.2	0.4	0.1	0.3	0.1		0.0	0.4				0.2	0.4	0.4					-0.1	-0.2	0.3			0.3
EC	0.2	1.0	0.9	0.8	0.9	0.9	-0.1	1.0	-0.1		0.3	0.8				0.4	0.4	0.8					0.5	-0.5	0.9			0.1
Ca	0.3	0.9	1.0	1.0	0.7	0.8	-0.3	0.9	-0.1		0.5	0.9				0.7	0.7	0.9					0.4	-0.5	1.0			0.3
Mg	0.4	0.8	1.0	1.0	0.6	0.8	-0.3	0.8	-0.1		0.5	0.9				0.7	0.6	0.8					0.4	-0.4	1.0			0.4
Na	0.2	0.9	0.7	0.6	1.0	0.9	0.2	0.9	-0.1		0.0	0.7				0.2	0.3	0.7					0.4	-0.5	0.7			0.0
K	0.4	0.9	0.8	0.8	0.9	1.0	0.2	0.9	0.0		0.1	0.8				0.4	0.5	0.8					0.3	-0.5	0.8			0.1
MAlk	0.1	-0.1	-0.3	-0.3	0.2	0.2	1.0	-0.1	0.0		-0.6	-0.3				-0.4	-0.3	-0.1					-0.1	0.0	-0.3			-0.5
SO4	0.3	1.0	0.9	0.8	0.9	0.9	-0.1	1.0	-0.1		0.2	0.8				0.4	0.4	0.8					0.5	-0.6	0.9			0.1
Al	0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.0	-0.1	1.0		0.0	0.0				-0.1	0.2	-0.1					-0.3	0.2	-0.1			0.4
As										1.0																		
B	0.0	0.3	0.5	0.5	0.0	0.1	-0.6	0.2	0.0		1.0	0.5				0.6	0.4	0.1					0.1	0.2	0.5			0.4
Ba	0.4	0.8	0.9	0.9	0.7	0.8	-0.3	0.8	0.0		0.5	1.0				0.7	0.7	0.9					0.2	-0.3	0.9			0.3
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.2	0.4	0.7	0.7	0.2	0.4	-0.4	0.4	-0.1		0.6	0.7				1.0	0.5	0.5					0.1	0.1	0.7			0.5
Fe	0.4	0.4	0.7	0.6	0.3	0.5	-0.3	0.4	0.2		0.4	0.7				0.5	1.0	0.6					0.1	-0.1	0.7			0.5
Mn	0.4	0.8	0.9	0.8	0.7	0.8	-0.1	0.8	-0.1		0.1	0.9				0.5	0.6	1.0					0.2	-0.6	0.8			0.2
Mo																			1.0									
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	-0.1	0.5	0.4	0.4	0.4	0.3	-0.1	0.5	-0.3		0.1	0.2				0.1	0.1	0.2					1.0	-0.3	0.4			0.0
Si	-0.2	-0.5	-0.5	-0.4	-0.5	-0.5	0.0	-0.6	0.2		0.2	-0.3				0.1	-0.1	-0.6					-0.3	1.0	-0.4			-0.2
Sr	0.3	0.9	1.0	1.0	0.7	0.8	-0.3	0.9	-0.1		0.5	0.9				0.7	0.7	0.8					0.4	-0.4	1.0			0.3
U																										1.0		
V																											1.0	
Zn	0.3	0.1	0.3	0.4	0.0	0.1	-0.5	0.1	0.4		0.4	0.3				0.5	0.5	0.2					0.0	-0.2	0.3			1.0

Table E-7: BH7, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	-0.4	-0.5	-0.6	0.0	-0.2	0.5	-0.4	0.3	-0.1	0.7	-0.6				-0.5	-0.4	-0.5	0.0				0.0	0.5	-0.6			-0.5
EC	-0.4	1.0	0.5	0.5	0.7	0.7	-0.1	0.9	0.0	0.4	0.0	0.5				0.2	0.5	0.6	0.5				0.5	-0.6	0.5			0.5
Ca	-0.5	0.5	1.0	1.0	0.1	0.5	-0.4	0.6	-0.3	0.1	-0.3	0.8				0.6	0.6	0.8	-0.1				-0.1	-0.4	1.0			0.7
Mg	-0.6	0.5	1.0	1.0	0.0	0.4	-0.5	0.5	-0.4	0.0	-0.3	0.8				0.6	0.5	0.8	-0.1				-0.1	-0.4	1.0			0.7
Na	0.0	0.7	0.1	0.0	1.0	0.9	0.2	0.8	0.1	0.9	0.0	0.2				0.1	0.1	0.1	0.3				0.3	-0.5	0.0			0.1
K	-0.2	0.7	0.5	0.4	0.9	1.0	0.1	0.9	-0.1	0.8	0.0	0.6				0.3	0.4	0.5	0.1				0.1	-0.5	0.4			0.4
MAlk	0.5	-0.1	-0.4	-0.5	0.2	0.1	1.0	-0.2	0.1	0.1	0.5	-0.4				-0.5	-0.2	-0.4	0.0				0.0	0.4	-0.5			-0.3
SO4	-0.4	0.9	0.6	0.5	0.8	0.9	-0.2	1.0	-0.1	0.7	-0.2	0.6				0.4	0.4	0.5	0.3				0.3	-0.7	0.5			0.5
Al	0.3	0.0	-0.3	-0.4	0.1	-0.1	0.1	-0.1	1.0	-0.1	0.4	-0.3				-0.5	-0.1	-0.2	-0.1				-0.1	0.2	-0.3			-0.1
As	-0.1	0.4	0.1	0.0	0.9	0.8	0.1	0.7	-0.1	1.0	-0.1	0.2				0.3	0.0	0.0	0.0				0.0	-0.4	-0.1			0.0
B	0.7	0.0	-0.3	-0.3	0.0	0.0	0.5	-0.2	0.4	-0.1	1.0	-0.2				-0.4	0.1	0.0	-0.1				-0.1	0.6	-0.3			0.0
Ba	-0.6	0.5	0.8	0.8	0.2	0.6	-0.4	0.6	-0.3	0.2	-0.2	1.0				0.6	0.8	0.9	-0.1				-0.1	-0.4	0.9			0.9
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.5	0.2	0.6	0.6	0.1	0.3	-0.5	0.4	-0.5	0.3	-0.4	0.6				1.0	0.3	0.5	-0.1				-0.1	-0.3	0.6			0.5
Fe	-0.4	0.5	0.6	0.5	0.1	0.4	-0.2	0.4	-0.1	0.0	0.1	0.8				0.3	1.0	0.9	0.0				0.0	-0.3	0.7			0.9
Mn	-0.5	0.6	0.8	0.8	0.1	0.5	-0.4	0.5	-0.2	0.0	0.0	0.9				0.5	0.9	1.0	-0.1				-0.1	-0.3	0.8			1.0
Mo	0.0	0.5	-0.1	-0.1	0.3	0.1	0.0	0.3	-0.1	0.0	-0.1	-0.1				-0.1	0.0	-0.1	1.0				1.0	-0.3	-0.1			-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.0	0.5	-0.1	-0.1	0.3	0.1	0.0	0.3	-0.1	0.0	-0.1	-0.1				-0.1	0.0	-0.1	1.0				1.0	-0.3	-0.1			-0.1
Si	0.5	-0.6	-0.4	-0.4	-0.5	-0.5	0.4	-0.7	0.2	-0.4	0.6	-0.4				-0.3	-0.3	-0.3	-0.3				-0.3	1.0	-0.3			-0.3
Sr	-0.6	0.5	1.0	1.0	0.0	0.4	-0.5	0.5	-0.3	-0.1	-0.3	0.9				0.6	0.7	0.8	-0.1				-0.1	-0.3	1.0			0.8
U																										1.0		
V																											1.0	
Zn	-0.5	0.5	0.7	0.7	0.1	0.4	-0.3	0.5	-0.1	0.0	0.0	0.9				0.5	0.9	1.0	-0.1				-0.1	-0.3	0.8			1.0

Table E-8: BH8, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.0	0.3	0.4	-0.1	-0.1	-0.1	-0.2	0.4	0.0	0.6	0.6				-0.3	0.5		-0.1				-0.3	0.5	0.3		0.7	0.5
EC	0.0	1.0	0.2	0.2	0.8	0.3	0.1	0.7	0.1	0.0	0.3	0.2				0.0	0.1		0.7				0.7	0.0	0.1		0.2	0.3
Ca	0.3	0.2	1.0	1.0	0.0	0.5	-0.2	0.3	0.0	-0.1	0.1	0.5				-0.2	0.1		0.0				0.1	-0.1	0.9		0.0	0.3
Mg	0.4	0.2	1.0	1.0	0.0	0.5	-0.2	0.3	0.0	-0.1	0.2	0.6				-0.2	0.2		0.0				0.1	0.0	0.9		0.1	0.4
Na	-0.1	0.8	0.0	0.0	1.0	0.3	0.3	0.8	0.1	0.0	0.2	-0.1				0.0	-0.2		0.8				0.8	-0.2	-0.2		0.2	-0.1
K	-0.1	0.3	0.5	0.5	0.3	1.0	0.5	0.2	0.1	-0.1	-0.3	-0.1				0.0	-0.3		0.1				0.2	-0.2	0.4		-0.3	-0.1
MAlk	-0.1	0.1	-0.2	-0.2	0.3	0.5	1.0	-0.2	0.2	0.2	-0.2	-0.3				0.1	-0.1		-0.1				-0.1	0.2	-0.1		-0.2	-0.2
SO4	-0.2	0.7	0.3	0.3	0.8	0.2	-0.2	1.0	-0.2	0.0	0.0	0.0				0.0	-0.2		0.7				0.9	-0.4	0.0		0.0	-0.1
Al	0.4	0.1	0.0	0.0	0.1	0.1	0.2	-0.2	1.0	-0.1	0.3	0.3				-0.1	0.3		-0.2				-0.2	0.7	0.0		0.4	0.3
As	0.0	0.0	-0.1	-0.1	0.0	-0.1	0.2	0.0	-0.1	1.0	0.1	-0.1				0.1	0.0		-0.1				-0.1	0.3	0.0		0.0	-0.1
B	0.6	0.3	0.1	0.2	0.2	-0.3	-0.2	0.0	0.3	0.1	1.0	0.7				-0.3	0.4		0.3				0.0	0.5	0.0		0.9	0.6
Ba	0.6	0.2	0.5	0.6	-0.1	-0.1	-0.3	0.0	0.3	-0.1	0.7	1.0				-0.1	0.8		0.0				-0.1	0.5	0.5		0.7	0.9
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.3	0.0	-0.2	-0.2	0.0	0.0	0.1	0.0	-0.1	0.1	-0.3	-0.1				1.0	0.2		-0.3				-0.1	-0.1	-0.3		-0.4	0.0
Fe	0.5	0.1	0.1	0.2	-0.2	-0.3	-0.1	-0.2	0.3	0.0	0.4	0.8				0.2	1.0		-0.3				-0.3	0.6	0.1		0.4	0.8
Mn																		1.0										
Mo	-0.1	0.7	0.0	0.0	0.8	0.1	-0.1	0.7	-0.2	-0.1	0.3	0.0				-0.3	-0.3		1.0				0.9	-0.2	-0.1		0.2	0.0
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	-0.3	0.7	0.1	0.1	0.8	0.2	-0.1	0.9	-0.2	-0.1	0.0	-0.1				-0.1	-0.3		0.9				1.0	-0.4	0.0		0.0	-0.2
Si	0.5	0.0	-0.1	0.0	-0.2	-0.2	0.2	-0.4	0.7	0.3	0.5	0.5				-0.1	0.6		-0.2				-0.4	1.0	0.0		0.5	0.5
Sr	0.3	0.1	0.9	0.9	-0.2	0.4	-0.1	0.0	0.0	0.0	0.0	0.5				-0.3	0.1		-0.1				0.0	0.0	1.0		0.0	0.3
U																										1.0		
V	0.7	0.2	0.0	0.1	0.2	-0.3	-0.2	0.0	0.4	0.0	0.9	0.7				-0.4	0.4		0.2				0.0	0.5	0.0		1.0	0.6
Zn	0.5	0.3	0.3	0.4	-0.1	-0.1	-0.2	-0.1	0.3	-0.1	0.6	0.9				0.0	0.8		0.0				-0.2	0.5	0.3		0.6	1.0

Table E-9: BH9, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.5	0.2	0.2	0.5	0.0	0.3	0.4	0.1		0.6	0.5				-0.1	0.8		0.2				-0.1	0.0	0.2		0.3	0.4
EC	0.5	1.0	0.5	0.5	0.9	0.5	0.7	0.5	0.3		0.3	0.4				-0.2	0.5		0.5				0.5	-0.1	0.5		0.1	0.2
Ca	0.2	0.5	1.0	0.9	0.5	0.6	0.4	0.3	0.3		-0.2	0.4				0.1	0.1		0.3				-0.1	-0.1	0.7		-0.1	-0.1
Mg	0.2	0.5	0.9	1.0	0.5	0.8	0.7	0.1	0.5		-0.2	0.4				0.0	0.1		0.1				-0.1	0.0	0.9		-0.1	0.0
Na	0.5	0.9	0.5	0.5	1.0	0.4	0.6	0.7	0.3		0.4	0.5				-0.2	0.5		0.7				0.5	-0.1	0.4		0.2	0.3
K	0.0	0.5	0.6	0.8	0.4	1.0	0.8	-0.1	0.6		-0.3	0.1				0.0	-0.1		0.1				0.0	0.1	0.7		-0.1	-0.1
MAlk	0.3	0.7	0.4	0.7	0.6	0.8	1.0	-0.1	0.6		0.1	0.3				-0.2	0.2		0.1				0.0	0.1	0.6		0.1	0.2
SO4	0.4	0.5	0.3	0.1	0.7	-0.1	-0.1	1.0	-0.2		0.4	0.4				-0.1	0.5		0.8				0.5	-0.2	-0.1		0.1	0.2
Al	0.1	0.3	0.3	0.5	0.3	0.6	0.6	-0.2	1.0		0.0	0.2				-0.1	0.2		-0.1				-0.1	0.1	0.6		0.3	0.1
As										1.0																		
B	0.6	0.3	-0.2	-0.2	0.4	-0.3	0.1	0.4	0.0		1.0	0.7				-0.1	0.8		0.1				0.0	0.1	0.0		0.6	0.7
Ba	0.5	0.4	0.4	0.4	0.5	0.1	0.3	0.4	0.2		0.7	1.0				0.0	0.8		0.1				-0.1	0.0	0.3		0.5	0.8
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.1	-0.2	0.1	0.0	-0.2	0.0	-0.2	-0.1	-0.1		-0.1	0.0				1.0	0.1		-0.1				-0.2	0.5	0.0		-0.2	0.1
Fe	0.8	0.5	0.1	0.1	0.5	-0.1	0.2	0.5	0.2		0.8	0.8				0.1	1.0		0.2				0.0	0.1	0.1		0.5	0.7
Mn																		1.0										
Mo	0.2	0.5	0.3	0.1	0.7	0.1	0.1	0.8	-0.1		0.1	0.1				-0.1	0.2		1.0				0.6	-0.2	-0.1		0.0	0.0
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	-0.1	0.5	-0.1	-0.1	0.5	0.0	0.0	0.5	-0.1		0.0	-0.1				-0.2	0.0		0.6				1.0	-0.1	-0.1		-0.1	0.0
Si	0.0	-0.1	-0.1	0.0	-0.1	0.1	0.1	-0.2	0.1		0.1	0.0				0.5	0.1		-0.2				-0.1	1.0	0.1		0.1	0.1
Sr	0.2	0.5	0.7	0.9	0.4	0.7	0.6	-0.1	0.6		0.0	0.3				0.0	0.1		-0.1				-0.1	0.1	1.0		-0.1	-0.1
U																										1.0		
V	0.3	0.1	-0.1	-0.1	0.2	-0.1	0.1	0.1	0.3		0.6	0.5				-0.2	0.5		0.0				-0.1	0.1	-0.1		1.0	0.7
Zn	0.4	0.2	-0.1	0.0	0.3	-0.1	0.2	0.2	0.1		0.7	0.8				0.1	0.7		0.0				0.0	0.1	-0.1		0.7	1.0

Table E-10: BH10, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	-0.4	-0.3	-0.2	-0.4	-0.5	-0.2	-0.3	0.4		0.1	-0.6				0.0	-0.5	-0.6						0.1	-0.3			0.2
EC	-0.4	1.0	0.9	0.9	0.6	0.6	-0.3	0.9	0.0		0.6	0.4				0.5	0.7	0.8						-0.3	1.0			0.4
Ca	-0.3	0.9	1.0	1.0	0.5	0.5	-0.4	1.0	0.2		0.5	0.3				0.7	0.7	0.8						-0.3	1.0			0.4
Mg	-0.2	0.9	1.0	1.0	0.3	0.3	-0.3	0.9	0.2		0.5	0.2				0.6	0.8	0.8						-0.2	0.9			0.4
Na	-0.4	0.6	0.5	0.3	1.0	0.9	0.1	0.6	-0.1		0.5	0.6				0.2	0.2	0.4						-0.3	0.7			0.1
K	-0.5	0.6	0.5	0.3	0.9	1.0	0.0	0.6	-0.2		0.3	0.7				0.2	0.3	0.5						-0.3	0.6			0.0
MAlk	-0.2	-0.3	-0.4	-0.3	0.1	0.0	1.0	-0.4	-0.3		0.0	0.1				-0.4	-0.1	-0.2						0.3	-0.3			-0.3
SO4	-0.3	0.9	1.0	0.9	0.6	0.6	-0.4	1.0	0.1		0.5	0.4				0.7	0.7	0.8						-0.4	0.9			0.4
Al	0.4	0.0	0.2	0.2	-0.1	-0.2	-0.3	0.1	1.0		0.2	-0.1				0.5	-0.1	-0.1						0.3	0.1			0.5
As										1.0																		
B	0.1	0.6	0.5	0.5	0.5	0.3	0.0	0.5	0.2		1.0	0.1				0.3	0.2	0.2						0.0	0.7			0.5
Ba	-0.6	0.4	0.3	0.2	0.6	0.7	0.1	0.4	-0.1		0.1	1.0				0.3	0.3	0.5						0.2	0.4			0.0
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.0	0.5	0.7	0.6	0.2	0.2	-0.4	0.7	0.5		0.3	0.3				1.0	0.5	0.6						0.1	0.6			0.6
Fe	-0.5	0.7	0.7	0.8	0.2	0.3	-0.1	0.7	-0.1		0.2	0.3				0.5	1.0	1.0						-0.3	0.6			0.3
Mn	-0.6	0.8	0.8	0.8	0.4	0.5	-0.2	0.8	-0.1		0.2	0.5				0.6	1.0	1.0						-0.3	0.8			0.2
Mo																			1.0									
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	0.1	-0.3	-0.3	-0.2	-0.3	-0.3	0.3	-0.4	0.3		0.0	0.2				0.1	-0.3	-0.3						1.0	-0.2			-0.1
Sr	-0.3	1.0	1.0	0.9	0.7	0.6	-0.3	0.9	0.1		0.7	0.4				0.6	0.6	0.8						-0.2	1.0			0.4
U																										1.0		
V																											1.0	
Zn	0.2	0.4	0.4	0.4	0.1	0.0	-0.3	0.4	0.5		0.5	0.0				0.6	0.3	0.2						-0.1	0.4			1.0

Table E-11: BH11, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	-0.6	-0.4	-0.4	-0.3	-0.6	0.3	-0.4	-0.4		-0.1	-0.5				0.1	-0.7	-0.7		-0.7			0.4	0.3	-0.3			-0.8
EC	-0.6	1.0	0.8	0.7	0.7	0.7	-0.4	0.9	0.4		0.7	0.6				0.0	0.5	0.8		0.5			0.2	-0.1	0.9			0.6
Ca	-0.4	0.8	1.0	0.7	0.5	0.5	-0.4	1.0	0.4		0.7	0.5				0.1	0.4	0.6		0.4			0.1	0.0	0.8			0.5
Mg	-0.4	0.7	0.7	1.0	0.3	0.3	-0.3	0.8	0.1		0.6	0.2				0.0	0.1	0.8		0.2			0.0	-0.2	0.7			0.3
Na	-0.3	0.7	0.5	0.3	1.0	0.9	-0.3	0.6	0.5		0.8	0.9				-0.4	0.7	0.5		0.7			0.4	-0.4	0.8			0.6
K	-0.6	0.7	0.5	0.3	0.9	1.0	-0.3	0.6	0.6		0.6	1.0				-0.3	0.9	0.6		0.9			0.2	-0.4	0.7			0.8
MAlk	0.3	-0.4	-0.4	-0.3	-0.3	-0.3	1.0	-0.5	-0.2		-0.2	-0.4				-0.4	-0.4	-0.4		-0.4			-0.1	0.0	-0.4			-0.4
SO4	-0.4	0.9	1.0	0.8	0.6	0.6	-0.5	1.0	0.4		0.7	0.5				0.1	0.4	0.8		0.4			0.1	-0.1	0.9			0.5
Al	-0.4	0.4	0.4	0.1	0.5	0.6	-0.2	0.4	1.0		0.2	0.6				-0.1	0.7	0.4		0.7			-0.1	-0.4	0.4			0.6
As										1.0																		
B	-0.1	0.7	0.7	0.6	0.8	0.6	-0.2	0.7	0.2		1.0	0.5				-0.2	0.2	0.5		0.3			0.3	-0.1	0.9			0.2
Ba	-0.5	0.6	0.5	0.2	0.9	1.0	-0.4	0.5	0.6		0.5	1.0				-0.3	0.9	0.6		0.9			0.2	-0.4	0.7			0.8
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.1	0.0	0.1	0.0	-0.4	-0.3	-0.4	0.1	-0.1		-0.2	-0.3				1.0	-0.3	0.0		-0.2			0.0	0.4	-0.1			0.0
Fe	-0.7	0.5	0.4	0.1	0.7	0.9	-0.4	0.4	0.7		0.2	0.9				-0.3	1.0	0.5		1.0			0.0	-0.5	0.5			0.9
Mn	-0.7	0.8	0.6	0.8	0.5	0.6	-0.4	0.8	0.4		0.5	0.6				0.0	0.5	1.0		0.6			0.0	-0.3	0.7			0.7
Mo																			1.0									
Ni	-0.7	0.5	0.4	0.2	0.7	0.9	-0.4	0.4	0.7		0.3	0.9				-0.2	1.0	0.6		1.0			0.0	-0.5	0.5			0.9
Pb																					1.0							
Sb																						1.0						
Se	0.4	0.2	0.1	0.0	0.4	0.2	-0.1	0.1	-0.1		0.3	0.2				0.0	0.0	0.0		0.0			1.0	0.0	0.3			-0.1
Si	0.3	-0.1	0.0	-0.2	-0.4	-0.4	0.0	-0.1	-0.4		-0.1	-0.4				0.4	-0.5	-0.3		-0.5			0.0	1.0	-0.2			-0.4
Sr	-0.3	0.9	0.8	0.7	0.8	0.7	-0.4	0.9	0.4		0.9	0.7				-0.1	0.5	0.7		0.5			0.3	-0.2	1.0			0.5
U																										1.0		
V																											1.0	
Zn	-0.8	0.6	0.5	0.3	0.6	0.8	-0.4	0.5	0.6		0.2	0.8				0.0	0.9	0.7		0.9			-0.1	-0.4	0.5			1.0

Table E-12: BH12, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.6	0.3	0.3	0.6	0.1	0.2	0.5	0.0		0.5	0.3				0.0	0.6	0.3	0.1					0.0	0.3		0.4	0.3
EC	0.6	1.0	0.3	0.3	0.9	0.6	0.7	0.6	0.1		0.5	0.3				0.0	0.6	0.3	0.4					0.0	0.3		0.4	0.4
Ca	0.3	0.3	1.0	1.0	0.5	0.3	0.3	0.6	-0.2		0.9	1.0				0.2	0.1	1.0	0.0					0.1	1.0		-0.3	0.9
Mg	0.3	0.3	1.0	1.0	0.5	0.3	0.3	0.6	-0.2		0.9	1.0				0.2	0.1	1.0	0.0					0.1	1.0		-0.3	0.9
Na	0.6	0.9	0.5	0.5	1.0	0.7	0.8	0.7	0.0		0.6	0.5				-0.1	0.5	0.4	0.3					-0.1	0.4		0.3	0.6
K	0.1	0.6	0.3	0.3	0.7	1.0	0.9	0.2	0.1		0.3	0.3				0.1	0.0	0.3	0.1					-0.2	0.3		0.0	0.3
MAlk	0.2	0.7	0.3	0.3	0.8	0.9	1.0	0.2	0.1		0.3	0.3				-0.1	0.1	0.3	0.1					0.0	0.3		0.1	0.3
SO4	0.5	0.6	0.6	0.6	0.7	0.2	0.2	1.0	-0.1		0.7	0.6				0.2	0.5	0.6	0.1					-0.2	0.6		0.0	0.6
Al	0.0	0.1	-0.2	-0.2	0.0	0.1	0.1	-0.1	1.0		0.0	-0.2				-0.3	0.4	-0.2	0.0					0.2	-0.2		0.6	-0.1
As										1.0																		
B	0.5	0.5	0.9	0.9	0.6	0.3	0.3	0.7	0.0		1.0	0.9				0.1	0.3	0.9	0.1					0.2	0.9		0.0	0.8
Ba	0.3	0.3	1.0	1.0	0.5	0.3	0.3	0.6	-0.2		0.9	1.0				0.2	0.1	1.0	0.0					0.0	1.0		-0.3	0.9
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.0	0.0	0.2	0.2	-0.1	0.1	-0.1	0.2	-0.3		0.1	0.2				1.0	-0.1	0.2	-0.3					0.0	0.2		-0.3	0.1
Fe	0.6	0.6	0.1	0.1	0.5	0.0	0.1	0.5	0.4		0.3	0.1				-0.1	1.0	0.0	0.5					0.0	0.0		0.7	0.4
Mn	0.3	0.3	1.0	1.0	0.4	0.3	0.3	0.6	-0.2		0.9	1.0				0.2	0.0	1.0	0.0					0.1	1.0		-0.3	0.9
Mo	0.1	0.4	0.0	0.0	0.3	0.1	0.1	0.1	0.0		0.1	0.0				-0.3	0.5	0.0	1.0					0.0	0.0		0.4	0.4
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	0.0	0.0	0.1	0.1	-0.1	-0.2	0.0	-0.2	0.2		0.2	0.0				0.0	0.0	0.1	0.0					1.0	0.1		0.3	0.0
Sr	0.3	0.3	1.0	1.0	0.4	0.3	0.3	0.6	-0.2		0.9	1.0				0.2	0.0	1.0	0.0					0.1	1.0		-0.3	0.9
U																										1.0		
V	0.4	0.4	-0.3	-0.3	0.3	0.0	0.1	0.0	0.6		0.0	-0.3				-0.3	0.7	-0.3	0.4					0.3	-0.3		1.0	0.0
Zn	0.3	0.4	0.9	0.9	0.6	0.3	0.3	0.6	-0.1		0.8	0.9				0.1	0.4	0.9	0.4					0.0	0.9		0.0	1.0

Table E-13: BH13, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	-0.2	0.2	0.1	0.0	-0.2	0.5	0.1	0.3		0.4	-0.3		-0.5		0.1	-0.4	-0.2		-0.4			-0.1	0.3	0.2			0.0
EC	-0.2	1.0	0.8	0.8	0.6	0.9	-0.4	0.9	0.0		0.6	0.4		0.4		0.4	0.6	0.7		0.5			0.4	-0.2	0.6			0.4
Ca	0.2	0.8	1.0	1.0	0.3	0.5	-0.2	0.9	0.2		0.8	0.1		0.2		0.5	0.5	0.8		0.5			0.2	0.1	0.9			0.5
Mg	0.1	0.8	1.0	1.0	0.2	0.6	-0.2	0.9	0.1		0.7	0.1		0.1		0.4	0.6	0.8		0.6			0.2	0.0	0.9			0.4
Na	0.0	0.6	0.3	0.2	1.0	0.8	-0.1	0.6	-0.2		0.5	0.7		0.7		0.2	0.2	0.3		0.1			0.2	-0.4	0.3			0.1
K	-0.2	0.9	0.5	0.6	0.8	1.0	-0.1	0.7	-0.1		0.5	0.6		0.6		0.3	0.5	0.6		0.5			0.3	-0.4	0.4			0.3
MAlk	0.5	-0.4	-0.2	-0.2	-0.1	-0.1	1.0	-0.3	0.2		-0.1	-0.2		-0.1		-0.2	-0.1	-0.2		-0.1			0.1	-0.1	-0.3			-0.1
SO4	0.1	0.9	0.9	0.9	0.6	0.7	-0.3	1.0	0.1		0.8	0.4		0.4		0.5	0.5	0.7		0.5			0.2	-0.1	0.9			0.4
Al	0.3	0.0	0.2	0.1	-0.2	-0.1	0.2	0.1	1.0		0.1	-0.3		-0.1		0.4	-0.1	-0.2		-0.1			-0.1	0.1	0.0			0.3
As										1.0																		
B	0.4	0.6	0.8	0.7	0.5	0.5	-0.1	0.8	0.1		1.0	0.2		0.1		0.2	0.2	0.6		0.2			0.2	0.1	0.9			0.3
Ba	-0.3	0.4	0.1	0.1	0.7	0.6	-0.2	0.4	-0.3		0.2	1.0		0.9		0.2	0.2	0.4		0.2			-0.2	-0.4	0.2			0.2
Cd													1.0															
Co	-0.5	0.4	0.2	0.1	0.7	0.6	-0.1	0.4	-0.1		0.1	0.9		1.0		0.4	0.4	0.4		0.3			-0.1	-0.5	0.2			0.2
Cr															1.0													
Cu	0.1	0.4	0.5	0.4	0.2	0.3	-0.2	0.5	0.4		0.2	0.2		0.4		1.0	0.2	0.2		0.2			-0.3	0.1	0.3			0.5
Fe	-0.4	0.6	0.5	0.6	0.2	0.5	-0.1	0.5	-0.1		0.2	0.2		0.4		0.2	1.0	0.8		1.0			-0.1	-0.3	0.4			0.4
Mn	-0.2	0.7	0.8	0.8	0.3	0.6	-0.2	0.7	-0.2		0.6	0.4		0.4		0.2	0.8	1.0		0.8			0.0	-0.3	0.8			0.4
Mo																			1.0									
Ni	-0.4	0.5	0.5	0.6	0.1	0.5	-0.1	0.5	-0.1		0.2	0.2		0.3		0.2	1.0	0.8		1.0			-0.1	-0.3	0.4			0.4
Pb																					1.0							
Sb																						1.0						
Se	-0.1	0.4	0.2	0.2	0.2	0.3	0.1	0.2	-0.1		0.2	-0.2		-0.1		-0.3	-0.1	0.0		-0.1			1.0	-0.1	0.0			-0.2
Si	0.3	-0.2	0.1	0.0	-0.4	-0.4	-0.1	-0.1	0.1		0.1	-0.4		-0.5		0.1	-0.3	-0.3		-0.3			-0.1	1.0	0.1			0.0
Sr	0.2	0.6	0.9	0.9	0.3	0.4	-0.3	0.9	0.0		0.9	0.2		0.2		0.3	0.4	0.8		0.4			0.0	0.1	1.0			0.4
U																										1.0		
V																											1.0	
Zn	0.0	0.4	0.5	0.4	0.1	0.3	-0.1	0.4	0.3		0.3	0.2		0.2		0.5	0.4	0.4		0.4			-0.2	0.0	0.4			1.0

Table E-14: BH14, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.0	-0.2	-0.2	0.3	-0.2	0.0	-0.2	0.3	0.2	0.5	0.2				0.1	0.3		-0.3					0.0	-0.1		0.3	0.1
EC	0.0	1.0	0.7	0.7	0.7	0.8	0.7	0.3	0.0	0.0	0.0	0.6				-0.4	0.1		0.4					-0.4	0.6		-0.3	0.2
Ca	-0.2	0.7	1.0	1.0	0.1	0.7	0.8	0.2	-0.3	-0.2	-0.5	0.5				-0.2	-0.4		0.1					-0.3	0.9		-0.2	0.1
Mg	-0.2	0.7	1.0	1.0	0.2	0.8	0.8	0.2	-0.2	-0.2	-0.5	0.6				-0.2	-0.3		0.2					-0.3	0.9		-0.2	0.2
Na	0.3	0.7	0.1	0.2	1.0	0.5	0.4	0.1	0.5	0.2	0.5	0.6				-0.3	0.7		0.5					-0.2	0.1		0.0	0.4
K	-0.2	0.8	0.7	0.8	0.5	1.0	0.7	0.3	0.1	0.0	-0.2	0.6				-0.2	0.1		0.5					-0.3	0.6		-0.1	0.2
MAlk	0.0	0.7	0.8	0.8	0.4	0.7	1.0	-0.1	0.0	-0.1	-0.3	0.5				0.0	-0.1		-0.1					-0.1	0.8		-0.1	0.1
SO4	-0.2	0.3	0.2	0.2	0.1	0.3	-0.1	1.0	-0.1	-0.1	-0.2	-0.1				-0.3	-0.1		0.8					-0.6	-0.1		0.0	0.0
Al	0.3	0.0	-0.3	-0.2	0.5	0.1	0.0	-0.1	1.0	0.3	0.4	0.4				0.0	0.7		0.3					0.2	-0.3		0.4	0.3
As	0.2	0.0	-0.2	-0.2	0.2	0.0	-0.1	-0.1	0.3	1.0	0.5	0.1				0.3	0.4		0.1					0.4	-0.2		0.0	0.3
B	0.5	0.0	-0.5	-0.5	0.5	-0.2	-0.3	-0.2	0.4	0.5	1.0	0.2				-0.1	0.6		0.1					0.4	-0.4		0.1	0.4
Ba	0.2	0.6	0.5	0.6	0.6	0.6	0.5	-0.1	0.4	0.1	0.2	1.0				-0.3	0.4		0.3					-0.1	0.6		0.0	0.6
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.1	-0.4	-0.2	-0.2	-0.3	-0.2	0.0	-0.3	0.0	0.3	-0.1	-0.3				1.0	0.0		-0.5					0.3	-0.1		0.2	0.0
Fe	0.3	0.1	-0.4	-0.3	0.7	0.1	-0.1	-0.1	0.7	0.4	0.6	0.4				0.0	1.0		0.3					0.2	-0.3		0.1	0.6
Mn																		1.0										
Mo	-0.3	0.4	0.1	0.2	0.5	0.5	-0.1	0.8	0.3	0.1	0.1	0.3				-0.5	0.3		1.0					-0.4	-0.1		0.0	0.2
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	0.0	-0.4	-0.3	-0.3	-0.2	-0.3	-0.1	-0.6	0.2	0.4	0.4	-0.1				0.3	0.2		-0.4					1.0	-0.2		0.1	0.0
Sr	-0.1	0.6	0.9	0.9	0.1	0.6	0.8	-0.1	-0.3	-0.2	-0.4	0.6				-0.1	-0.3		-0.1					-0.2	1.0		-0.1	0.1
U																										1.0		
V	0.3	-0.3	-0.2	-0.2	0.0	-0.1	-0.1	0.0	0.4	0.0	0.1	0.0				0.2	0.1		0.0					0.1	-0.1		1.0	0.1
Zn	0.1	0.2	0.1	0.2	0.4	0.2	0.1	0.0	0.3	0.3	0.4	0.6				0.0	0.6		0.2					0.0	0.1		0.1	1.0

Table E-15: BH15, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	-0.2	-0.3	-0.1	-0.1	0.2	-0.2	0.5	0.4		0.4	0.4				-0.2	0.5	0.2	-0.1					-0.2	-0.3			-0.1
EC	-0.2	1.0	0.6	0.7	0.9	0.8	0.9	-0.1	-0.1		0.0	0.1				-0.1	-0.1	0.1	0.3					-0.2	0.7			0.3
Ca	-0.3	0.6	1.0	0.8	0.5	0.4	0.7	-0.2	-0.3		-0.4	-0.1				-0.1	-0.3	0.0	-0.1					-0.2	0.9			0.0
Mg	-0.1	0.7	0.8	1.0	0.6	0.6	0.6	0.1	0.1		0.1	0.4				-0.3	0.2	0.5	0.2					-0.1	0.8			0.4
Na	-0.1	0.9	0.5	0.6	1.0	0.8	0.9	0.0	0.0		0.0	0.1				-0.1	0.0	0.2	0.4					-0.3	0.5			0.3
K	0.2	0.8	0.4	0.6	0.8	1.0	0.6	0.3	0.1		0.1	0.3				-0.2	0.1	0.2	0.6					-0.3	0.4			0.5
MAlk	-0.2	0.9	0.7	0.6	0.9	0.6	1.0	-0.3	0.0		-0.1	0.1				-0.1	-0.1	0.1	0.1					-0.2	0.7			0.1
SO4	0.5	-0.1	-0.2	0.1	0.0	0.3	-0.3	1.0	0.1		0.3	0.2				-0.4	0.2	0.1	0.3					-0.2	-0.2			0.2
Al	0.4	-0.1	-0.3	0.1	0.0	0.1	0.0	0.1	1.0		0.5	0.8				-0.1	0.7	0.4	-0.1					0.3	-0.2			0.2
As										1.0																		
B	0.4	0.0	-0.4	0.1	0.0	0.1	-0.1	0.3	0.5		1.0	0.6				-0.4	0.7	0.5	0.2					0.6	-0.2			0.4
Ba	0.4	0.1	-0.1	0.4	0.1	0.3	0.1	0.2	0.8		0.6	1.0				-0.1	0.8	0.7	0.1					0.2	0.0			0.4
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	-0.1	-0.1	-0.3	-0.1	-0.2	-0.1	-0.4	-0.1		-0.4	-0.1				1.0	-0.2	-0.2	-0.3					0.0	-0.2			-0.3
Fe	0.5	-0.1	-0.3	0.2	0.0	0.1	-0.1	0.2	0.7		0.7	0.8				-0.2	1.0	0.6	0.0					0.3	-0.2			0.3
Mn	0.2	0.1	0.0	0.5	0.2	0.2	0.1	0.1	0.4		0.5	0.7				-0.2	0.6	1.0	0.2					0.2	0.1			0.7
Mo	-0.1	0.3	-0.1	0.2	0.4	0.6	0.1	0.3	-0.1		0.2	0.1				-0.3	0.0	0.2	1.0					-0.1	0.0			0.8
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	-0.2	-0.2	-0.2	-0.1	-0.3	-0.3	-0.2	-0.2	0.3		0.6	0.2				0.0	0.3	0.2	-0.1					1.0	-0.1			0.0
Sr	-0.3	0.7	0.9	0.8	0.5	0.4	0.7	-0.2	-0.2		-0.2	0.0				-0.2	-0.2	0.1	0.0					-0.1	1.0			0.1
U																										1.0		
V																											1.0	
Zn	-0.1	0.3	0.0	0.4	0.3	0.5	0.1	0.2	0.2		0.4	0.4				-0.3	0.3	0.7	0.8					0.0	0.1			1.0

Table E-16: BH16, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.7	-0.7	-0.7	0.8	-0.7	0.6	0.8	0.6	0.2	0.7	-0.1				-0.2	0.7		0.3				0.2	0.3	-0.6		0.5	-0.2
EC	0.7	1.0	-0.4	-0.4	0.9	-0.3	0.9	0.8	0.4	0.5	0.8	0.0				-0.4	0.4		0.7				0.5	0.3	-0.3		0.7	-0.3
Ca	-0.7	-0.4	1.0	1.0	-0.6	0.9	-0.2	-0.7	-0.5	-0.1	-0.6	0.7				0.2	-0.6		-0.2				-0.1	-0.5	1.0		-0.3	0.1
Mg	-0.7	-0.4	1.0	1.0	-0.6	0.9	-0.3	-0.7	-0.5	-0.1	-0.6	0.8				0.2	-0.5		-0.3				-0.1	-0.5	1.0		-0.3	0.1
Na	0.8	0.9	-0.6	-0.6	1.0	-0.5	0.9	0.9	0.5	0.4	0.9	-0.2				-0.4	0.4		0.7				0.4	0.4	-0.6		0.7	-0.3
K	-0.7	-0.3	0.9	0.9	-0.5	1.0	-0.1	-0.7	-0.4	-0.1	-0.6	0.6				0.2	-0.7		-0.2				-0.1	-0.5	0.9		-0.4	-0.1
MAlk	0.6	0.9	-0.2	-0.3	0.9	-0.1	1.0	0.7	0.4	0.4	0.7	0.0				-0.4	0.2		0.5				0.4	0.3	-0.2		0.6	-0.4
SO4	0.8	0.8	-0.7	-0.7	0.9	-0.7	0.7	1.0	0.4	0.3	0.7	-0.3				-0.4	0.5		0.7				0.3	0.3	-0.7		0.6	-0.3
Al	0.6	0.4	-0.5	-0.5	0.5	-0.4	0.4	0.4	1.0	0.0	0.5	-0.1				-0.2	0.6		0.0				0.0	0.4	-0.5		0.4	-0.1
As	0.2	0.5	-0.1	-0.1	0.4	-0.1	0.4	0.3	0.0	1.0	0.3	-0.2				-0.1	-0.1		0.5				1.0	0.1	-0.1		0.4	0.0
B	0.7	0.8	-0.6	-0.6	0.9	-0.6	0.7	0.7	0.5	0.3	1.0	-0.2				-0.3	0.5		0.4				0.3	0.6	-0.6		0.9	-0.2
Ba	-0.1	0.0	0.7	0.8	-0.2	0.6	0.0	-0.3	-0.1	-0.2	-0.2	1.0				0.2	0.0		-0.3				-0.2	-0.3	0.7		-0.1	0.0
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	-0.4	0.2	0.2	-0.4	0.2	-0.4	-0.4	-0.2	-0.1	-0.3	0.2				1.0	0.1		-0.3				-0.1	-0.1	0.1		-0.2	0.2
Fe	0.7	0.4	-0.6	-0.5	0.4	-0.7	0.2	0.5	0.6	-0.1	0.5	0.0				0.1	1.0		-0.1				-0.1	0.4	-0.5		0.3	-0.1
Mn																		1.0										
Mo	0.3	0.7	-0.2	-0.3	0.7	-0.2	0.5	0.7	0.0	0.5	0.4	-0.3				-0.3	-0.1		1.0				0.5	0.0	-0.3		0.5	-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.2	0.5	-0.1	-0.1	0.4	-0.1	0.4	0.3	0.0	1.0	0.3	-0.2				-0.1	-0.1		0.5				1.0	0.1	-0.1		0.4	0.0
Si	0.3	0.3	-0.5	-0.5	0.4	-0.5	0.3	0.3	0.4	0.1	0.6	-0.3				-0.1	0.4		0.0				0.1	1.0	-0.4		0.5	-0.1
Sr	-0.6	-0.3	1.0	1.0	-0.6	0.9	-0.2	-0.7	-0.5	-0.1	-0.6	0.7				0.1	-0.5		-0.3				-0.1	-0.4	1.0		-0.3	0.1
U																										1.0		
V	0.5	0.7	-0.3	-0.3	0.7	-0.4	0.6	0.6	0.4	0.4	0.9	-0.1				-0.2	0.3		0.5				0.4	0.5	-0.3		1.0	-0.1
Zn	-0.2	-0.3	0.1	0.1	-0.3	-0.1	-0.4	-0.3	-0.1	0.0	-0.2	0.0				0.2	-0.1		-0.1				0.0	-0.1	0.1		-0.1	1.0

Table E-17: BH17, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.4	0.4	0.3	0.3	0.5	0.0	0.3	0.2		0.2	0.6				0.3	0.4	0.3					0.1	-0.2	0.4			0.5
EC	0.4	1.0	0.7	0.6	0.9	0.8	-0.3	1.0	0.0		0.5	0.6				0.0	0.3	0.7					0.6	-0.4	0.7			0.3
Ca	0.4	0.7	1.0	1.0	0.2	0.6	-0.5	0.7	-0.1		0.5	0.7				0.4	0.4	0.9					0.1	-0.3	1.0			0.4
Mg	0.3	0.6	1.0	1.0	0.2	0.6	-0.4	0.7	-0.2		0.5	0.6				0.4	0.3	0.8					0.1	-0.3	1.0			0.3
Na	0.3	0.9	0.2	0.2	1.0	0.7	-0.1	0.8	0.0		0.3	0.5				-0.3	0.3	0.3					0.6	-0.4	0.3			0.1
K	0.5	0.8	0.6	0.6	0.7	1.0	0.1	0.7	0.1		0.3	0.7				0.1	0.4	0.7					0.3	-0.5	0.7			0.3
MAlk	0.0	-0.3	-0.5	-0.4	-0.1	0.1	1.0	-0.5	0.2		-0.6	-0.2				-0.5	-0.3	-0.3					0.0	-0.1	-0.5			-0.2
SO4	0.3	1.0	0.7	0.7	0.8	0.7	-0.5	1.0	-0.1		0.5	0.6				0.1	0.4	0.7					0.5	-0.4	0.8			0.3
Al	0.2	0.0	-0.1	-0.2	0.0	0.1	0.2	-0.1	1.0		0.0	0.0				0.1	0.5	-0.2					-0.2	-0.1	-0.1			0.1
As										1.0																		
B	0.2	0.5	0.5	0.5	0.3	0.3	-0.6	0.5	0.0		1.0	0.3				0.3	0.2	0.3					0.1	0.2	0.5			0.3
Ba	0.6	0.6	0.7	0.6	0.5	0.7	-0.2	0.6	0.0		0.3	1.0				0.3	0.4	0.8					0.1	-0.3	0.7			0.4
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.3	0.0	0.4	0.4	-0.3	0.1	-0.5	0.1	0.1		0.3	0.3				1.0	0.3	0.3					-0.4	-0.1	0.4			0.3
Fe	0.4	0.3	0.4	0.3	0.3	0.4	-0.3	0.4	0.5		0.2	0.4				0.3	1.0	0.3					-0.2	-0.3	0.3			0.5
Mn	0.3	0.7	0.9	0.8	0.3	0.7	-0.3	0.7	-0.2		0.3	0.8				0.3	0.3	1.0					0.2	-0.3	0.9			0.2
Mo																			1.0									
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.1	0.6	0.1	0.1	0.6	0.3	0.0	0.5	-0.2		0.1	0.1				-0.4	-0.2	0.2					1.0	-0.1	0.2			-0.1
Si	-0.2	-0.4	-0.3	-0.3	-0.4	-0.5	-0.1	-0.4	-0.1		0.2	-0.3				-0.1	-0.3	-0.3					-0.1	1.0	-0.3			-0.1
Sr	0.4	0.7	1.0	1.0	0.3	0.7	-0.5	0.8	-0.1		0.5	0.7				0.4	0.3	0.9					0.2	-0.3	1.0			0.4
U																										1.0		
V																											1.0	
Zn	0.5	0.3	0.4	0.3	0.1	0.3	-0.2	0.3	0.1		0.3	0.4				0.3	0.5	0.2					-0.1	-0.1	0.4			1.0

Table E-18: BH18, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.5	-0.2	-0.1	0.6	-0.3	0.0	0.5	0.2		0.7	0.3				0.0	0.7	0.2	0.1				0.2	-0.1	-0.1		0.6	0.2
EC	0.5	1.0	0.2	0.2	0.9	0.2	0.3	0.3	0.0		0.7	0.4				0.1	0.4	0.2	0.6				0.6	-0.1	0.2		0.3	0.2
Ca	-0.2	0.2	1.0	1.0	0.1	0.9	0.2	-0.2	-0.2		-0.4	0.5				0.2	-0.3	-0.1	-0.1				-0.1	-0.3	0.9		-0.3	-0.1
Mg	-0.1	0.2	1.0	1.0	0.1	0.9	0.2	-0.1	-0.2		-0.3	0.6				0.1	-0.3	0.0	-0.1				-0.1	-0.3	0.9		-0.3	0.0
Na	0.6	0.9	0.1	0.1	1.0	0.2	0.3	0.3	0.2		0.7	0.3				0.1	0.5	0.2	0.6				0.6	-0.1	0.1		0.4	0.2
K	-0.3	0.2	0.9	0.9	0.2	1.0	0.4	-0.3	-0.1		-0.4	0.4				0.1	-0.4	-0.1	0.0				-0.1	-0.3	0.8		-0.4	-0.1
MAlk	0.0	0.3	0.2	0.2	0.3	0.4	1.0	-0.1	0.8		0.2	0.2				0.1	0.4	0.1	0.2				0.1	0.3	0.2		0.1	0.1
SO4	0.5	0.3	-0.2	-0.1	0.3	-0.3	-0.1	1.0	0.1		0.2	0.2				0.2	0.5	-0.1	-0.1				0.0	-0.2	-0.2		0.1	-0.1
Al	0.2	0.0	-0.2	-0.2	0.2	-0.1	0.8	0.1	1.0		0.3	0.1				0.2	0.6	0.1	0.1				0.1	0.3	-0.2		0.4	0.1
As										1.0																		
B	0.7	0.7	-0.4	-0.3	0.7	-0.4	0.2	0.2	0.3		1.0	0.2				0.1	0.7	0.4	0.5				0.5	0.3	-0.3		0.8	0.4
Ba	0.3	0.4	0.5	0.6	0.3	0.4	0.2	0.2	0.1		0.2	1.0				0.1	0.4	0.5	0.1				0.1	-0.1	0.6		0.1	0.5
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.0	0.1	0.2	0.1	0.1	0.1	0.1	0.2	0.2		0.1	0.1				1.0	0.1	-0.1	0.1				0.0	0.1	0.2		0.3	-0.1
Fe	0.7	0.4	-0.3	-0.3	0.5	-0.4	0.4	0.5	0.6		0.7	0.4				0.1	1.0	0.3	0.4				0.4	0.2	-0.3		0.6	0.3
Mn	0.2	0.2	-0.1	0.0	0.2	-0.1	0.1	-0.1	0.1		0.4	0.5				-0.1	0.3	1.0	0.0				-0.1	0.1	-0.1		0.4	1.0
Mo	0.1	0.6	-0.1	-0.1	0.6	0.0	0.2	-0.1	0.1		0.5	0.1				0.1	0.4	0.0	1.0				1.0	0.1	-0.1		0.2	0.0
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.2	0.6	-0.1	-0.1	0.6	-0.1	0.1	0.0	0.1		0.5	0.1				0.0	0.4	-0.1	1.0				1.0	0.0	-0.1		0.2	-0.1
Si	-0.1	-0.1	-0.3	-0.3	-0.1	-0.3	0.3	-0.2	0.3		0.3	-0.1				0.1	0.2	0.1	0.1				0.0	1.0	-0.2		0.4	0.1
Sr	-0.1	0.2	0.9	0.9	0.1	0.8	0.2	-0.2	-0.2		-0.3	0.6				0.2	-0.3	-0.1	-0.1				-0.1	-0.2	1.0		-0.2	-0.1
U																										1.0		
V	0.6	0.3	-0.3	-0.3	0.4	-0.4	0.1	0.1	0.4		0.8	0.1				0.3	0.6	0.4	0.2				0.2	0.4	-0.2		1.0	0.4
Zn	0.2	0.2	-0.1	0.0	0.2	-0.1	0.1	-0.1	0.1		0.4	0.5				-0.1	0.3	1.0	0.0				-0.1	0.1	-0.1		0.4	1.0

Table E-19: BH19, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	-0.6	-0.6	-0.5	-0.5	-0.6	0.7	-0.7	0.2		0.0	-0.7				-0.2	-0.9	-0.7					0.0	0.4	-0.6			-0.3
EC	-0.6	1.0	1.0	0.9	0.7	0.7	-0.5	1.0	0.0		0.7	0.7				0.4	0.7	0.8					0.3	-0.6	1.0			0.5
Ca	-0.6	1.0	1.0	1.0	0.5	0.6	-0.5	1.0	0.1		0.6	0.6				0.5	0.6	0.9					0.3	-0.5	1.0			0.5
Mg	-0.5	0.9	1.0	1.0	0.4	0.4	-0.5	0.9	0.0		0.6	0.5				0.4	0.5	0.9					0.3	-0.5	1.0			0.3
Na	-0.5	0.7	0.5	0.4	1.0	0.9	-0.1	0.7	-0.2		0.3	0.9				0.0	0.8	0.5					0.0	-0.6	0.6			0.5
K	-0.6	0.7	0.6	0.4	0.9	1.0	-0.1	0.7	-0.2		0.1	0.8				0.0	0.8	0.6					0.0	-0.6	0.6			0.3
MAlk	0.7	-0.5	-0.5	-0.5	-0.1	-0.1	1.0	-0.6	-0.1		-0.3	-0.4				-0.4	-0.6	-0.5					-0.1	0.1	-0.5			-0.4
SO4	-0.7	1.0	1.0	0.9	0.7	0.7	-0.6	1.0	0.0		0.6	0.8				0.4	0.7	0.9					0.2	-0.6	1.0			0.5
Al	0.2	0.0	0.1	0.0	-0.2	-0.2	-0.1	0.0	1.0		0.3	-0.2				0.3	-0.1	-0.1					-0.1	0.2	0.0			0.4
As										1.0																		
B	0.0	0.7	0.6	0.6	0.3	0.1	-0.3	0.6	0.3		1.0	0.3				0.3	0.2	0.3					0.3	-0.2	0.7			0.6
Ba	-0.7	0.7	0.6	0.5	0.9	0.8	-0.4	0.8	-0.2		0.3	1.0				0.2	0.9	0.7					-0.1	-0.5	0.7			0.6
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	0.4	0.5	0.4	0.0	0.0	-0.4	0.4	0.3		0.3	0.2				1.0	0.1	0.4					-0.1	-0.1	0.4			0.5
Fe	-0.9	0.7	0.6	0.5	0.8	0.8	-0.6	0.7	-0.1		0.2	0.9				0.1	1.0	0.7					0.0	-0.4	0.6			0.5
Mn	-0.7	0.8	0.9	0.9	0.5	0.6	-0.5	0.9	-0.1		0.3	0.7				0.4	0.7	1.0					0.0	-0.5	0.9			0.3
Mo																			1.0									
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.0	0.3	0.3	0.3	0.0	0.0	-0.1	0.2	-0.1		0.3	-0.1				-0.1	0.0	0.0					1.0	-0.2	0.3			-0.2
Si	0.4	-0.6	-0.5	-0.5	-0.6	-0.6	0.1	-0.6	0.2		-0.2	-0.5				-0.1	-0.4	-0.5					-0.2	1.0	-0.6			-0.2
Sr	-0.6	1.0	1.0	1.0	0.6	0.6	-0.5	1.0	0.0		0.7	0.7				0.4	0.6	0.9					0.3	-0.6	1.0			0.5
U																										1.0		
V																											1.0	
Zn	-0.3	0.5	0.5	0.3	0.5	0.3	-0.4	0.5	0.4		0.6	0.6				0.5	0.5	0.3					-0.2	-0.2	0.5			1.0

Table E-20: BH20, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.3	-0.2	-0.3	0.3	-0.1	0.2	0.2	0.4		0.6	0.2				-0.3	0.7		0.2				0.1	-0.1	0.1		0.7	0.1
EC	0.3	1.0	0.7	0.3	1.0	0.6	0.9	1.0	0.0		0.7	0.9				0.3	0.2		0.3				0.9	-0.2	0.9		0.1	1.0
Ca	-0.2	0.7	1.0	0.8	0.7	0.9	0.9	0.6	-0.3		0.1	0.9				0.4	-0.2		-0.1				0.7	-0.4	0.9		-0.4	0.7
Mg	-0.3	0.3	0.8	1.0	0.3	0.9	0.6	0.2	-0.4		-0.3	0.5				0.2	-0.4		-0.2				0.3	-0.3	0.7		-0.5	0.2
Na	0.3	1.0	0.7	0.3	1.0	0.5	0.9	1.0	0.0		0.7	0.9				0.3	0.2		0.2				1.0	-0.2	0.8		0.1	1.0
K	-0.1	0.6	0.9	0.9	0.5	1.0	0.8	0.4	-0.2		0.0	0.7				0.2	-0.2		0.0				0.5	-0.3	0.8		-0.3	0.5
MAlk	0.2	0.9	0.9	0.6	0.9	0.8	1.0	0.8	-0.1		0.5	0.9				0.2	0.0		0.0				0.9	-0.2	0.9		-0.1	0.8
SO4	0.2	1.0	0.6	0.2	1.0	0.4	0.8	1.0	0.0		0.7	0.9				0.4	0.3		0.3				1.0	-0.2	0.8		0.0	1.0
Al	0.4	0.0	-0.3	-0.4	0.0	-0.2	-0.1	0.0	1.0		0.3	-0.1				-0.3	0.4		0.2				-0.1	0.2	-0.2		0.5	-0.1
As										1.0																		
B	0.6	0.7	0.1	-0.3	0.7	0.0	0.5	0.7	0.3		1.0	0.5				-0.1	0.4		0.5				0.6	0.1	0.4		0.7	0.6
Ba	0.2	0.9	0.9	0.5	0.9	0.7	0.9	0.9	-0.1		0.5	1.0				0.4	0.1		0.0				0.9	-0.3	1.0		-0.1	0.9
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.3	0.3	0.4	0.2	0.3	0.2	0.2	0.4	-0.3		-0.1	0.4				1.0	-0.2		-0.1				0.4	-0.3	0.3		-0.3	0.4
Fe	0.7	0.2	-0.2	-0.4	0.2	-0.2	0.0	0.3	0.4		0.4	0.1				-0.2	1.0		0.4				0.1	-0.1	0.0		0.4	0.2
Mn																		1.0										
Mo	0.2	0.3	-0.1	-0.2	0.2	0.0	0.0	0.3	0.2		0.5	0.0				-0.1	0.4		1.0				0.0	0.1	-0.1		0.5	0.2
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.1	0.9	0.7	0.3	1.0	0.5	0.9	1.0	-0.1		0.6	0.9				0.4	0.1		0.0				1.0	-0.2	0.9		-0.1	1.0
Si	-0.1	-0.2	-0.4	-0.3	-0.2	-0.3	-0.2	-0.2	0.2		0.1	-0.3				-0.3	-0.1		0.1				-0.2	1.0	-0.3		0.2	-0.2
Sr	0.1	0.9	0.9	0.7	0.8	0.8	0.9	0.8	-0.2		0.4	1.0				0.3	0.0		-0.1				0.9	-0.3	1.0		-0.2	0.8
U																										1.0		
V	0.7	0.1	-0.4	-0.5	0.1	-0.3	-0.1	0.0	0.5		0.7	-0.1				-0.3	0.4		0.5				-0.1	0.2	-0.2		1.0	0.0
Zn	0.1	1.0	0.7	0.2	1.0	0.5	0.8	1.0	-0.1		0.6	0.9				0.4	0.2		0.2				1.0	-0.2	0.8		0.0	1.0

Table E-21: BH21, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.3	-0.3	-0.3	0.6	0.1	-0.3	0.1	0.6		0.7	-0.4				-0.2	0.5	-0.1	0.6				0.5	0.2	-0.3		0.4	0.1
EC	0.3	1.0	0.6	0.6	0.9	0.9	0.1	0.9	0.2		0.7	-0.3				0.4	0.7	0.7	0.5				0.8	0.0	0.6		0.3	-0.1
Ca	-0.3	0.6	1.0	1.0	0.3	0.8	0.0	0.8	-0.3		0.0	0.3				0.5	0.2	0.9	-0.3				0.1	-0.2	1.0		-0.3	0.0
Mg	-0.3	0.6	1.0	1.0	0.2	0.8	0.0	0.7	-0.4		0.0	0.3				0.5	0.2	0.8	-0.3				0.1	-0.2	1.0		-0.3	0.0
Na	0.6	0.9	0.3	0.2	1.0	0.8	0.1	0.8	0.4		0.8	-0.5				0.2	0.7	0.5	0.7				0.9	0.1	0.2		0.5	-0.1
K	0.1	0.9	0.8	0.8	0.8	1.0	0.0	0.9	0.0		0.5	-0.1				0.5	0.6	0.8	0.2				0.6	-0.1	0.8		0.1	0.0
MAlk	-0.3	0.1	0.0	0.0	0.1	0.0	1.0	0.0	0.1		0.2	0.0				0.3	0.0	-0.1	0.2				0.1	0.1	-0.1		0.6	0.1
SO4	0.1	0.9	0.8	0.7	0.8	0.9	0.0	1.0	0.0		0.5	-0.2				0.5	0.6	0.9	0.2				0.6	-0.2	0.7		0.0	0.0
Al	0.6	0.2	-0.3	-0.4	0.4	0.0	0.1	0.0	1.0		0.7	-0.4				-0.3	0.7	-0.1	0.6				0.3	0.5	-0.4		0.8	-0.2
As										1.0																		
B	0.7	0.7	0.0	0.0	0.8	0.5	0.2	0.5	0.7		1.0	-0.5				0.2	0.7	0.2	0.7				0.7	0.5	0.0		0.7	0.1
Ba	-0.4	-0.3	0.3	0.3	-0.5	-0.1	0.0	-0.2	-0.4		-0.5	1.0				0.1	-0.3	0.1	-0.4				-0.4	-0.2	0.3		-0.4	0.1
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	0.4	0.5	0.5	0.2	0.5	0.3	0.5	-0.3		0.2	0.1				1.0	0.1	0.5	-0.1				0.1	0.0	0.6		0.0	0.5
Fe	0.5	0.7	0.2	0.2	0.7	0.6	0.0	0.6	0.7		0.7	-0.3				0.1	1.0	0.6	0.5				0.6	0.2	0.2		0.5	-0.2
Mn	-0.1	0.7	0.9	0.8	0.5	0.8	-0.1	0.9	-0.1		0.2	0.1				0.5	0.6	1.0	-0.1				0.3	-0.3	0.8		-0.1	-0.1
Mo	0.6	0.5	-0.3	-0.3	0.7	0.2	0.2	0.2	0.6		0.7	-0.4				-0.1	0.5	-0.1	1.0				0.9	0.3	-0.3		0.6	-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.5	0.8	0.1	0.1	0.9	0.6	0.1	0.6	0.3		0.7	-0.4				0.1	0.6	0.3	0.9				1.0	0.1	0.1		0.4	-0.1
Si	0.2	0.0	-0.2	-0.2	0.1	-0.1	0.1	-0.2	0.5		0.5	-0.2				0.0	0.2	-0.3	0.3				0.1	1.0	-0.1		0.5	0.0
Sr	-0.3	0.6	1.0	1.0	0.2	0.8	-0.1	0.7	-0.4		0.0	0.3				0.6	0.2	0.8	-0.3				0.1	-0.1	1.0		-0.3	0.0
U																										1.0		
V	0.4	0.3	-0.3	-0.3	0.5	0.1	0.6	0.0	0.8		0.7	-0.4				0.0	0.5	-0.1	0.6				0.4	0.5	-0.3		1.0	0.0
Zn	0.1	-0.1	0.0	0.0	-0.1	0.0	0.1	0.0	-0.2		0.1	0.1				0.5	-0.2	-0.1	-0.1				-0.1	0.0	0.0		0.0	1.0

Table E-22: BH22, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.5	-0.3	-0.2	0.6	-0.3	0.2	0.5	0.5		0.6	0.1				-0.4	0.5		0.2				0.0	-0.2	-0.1		0.3	0.1
EC	0.5	1.0	0.2	0.2	0.9	0.2	0.7	0.5	0.3		0.5	0.4				-0.1	0.4		0.6				0.5	-0.2	0.3		0.4	0.0
Ca	-0.3	0.2	1.0	1.0	0.1	0.9	0.6	-0.2	-0.3		-0.5	0.6				0.3	-0.4		-0.2				-0.1	-0.4	0.7		-0.2	-0.1
Mg	-0.2	0.2	1.0	1.0	0.1	0.9	0.6	-0.3	-0.3		-0.4	0.7				0.2	-0.4		-0.2				-0.2	-0.3	0.8		-0.2	-0.1
Na	0.6	0.9	0.1	0.1	1.0	0.1	0.7	0.6	0.4		0.6	0.2				-0.3	0.4		0.6				0.4	-0.2	0.1		0.5	-0.1
K	-0.3	0.2	0.9	0.9	0.1	1.0	0.7	-0.3	-0.2		-0.5	0.6				0.2	-0.4		-0.2				-0.1	-0.3	0.7		-0.2	-0.1
MAlk	0.2	0.7	0.6	0.6	0.7	0.7	1.0	0.0	0.2		0.2	0.5				-0.3	0.0		0.2				0.0	-0.1	0.6		0.3	-0.1
SO4	0.5	0.5	-0.2	-0.3	0.6	-0.3	0.0	1.0	0.2		0.3	-0.1				-0.2	0.2		0.5				0.3	-0.2	-0.2		0.1	0.0
Al	0.5	0.3	-0.3	-0.3	0.4	-0.2	0.2	0.2	1.0		0.6	-0.1				-0.3	0.5		0.5				0.2	0.2	-0.2		0.7	0.4
As										1.0																		
B	0.6	0.5	-0.5	-0.4	0.6	-0.5	0.2	0.3	0.6		1.0	0.0				-0.3	0.7		0.6				0.4	0.3	-0.2		0.7	0.1
Ba	0.1	0.4	0.6	0.7	0.2	0.6	0.5	-0.1	-0.1		0.0	1.0				0.1	0.0		0.0				0.0	-0.1	0.9		0.1	-0.1
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.4	-0.1	0.3	0.2	-0.3	0.2	-0.3	-0.2	-0.3		-0.3	0.1				1.0	0.0		-0.1				0.3	-0.2	0.0		-0.4	-0.1
Fe	0.5	0.4	-0.4	-0.4	0.4	-0.4	0.0	0.2	0.5		0.7	0.0				0.0	1.0		0.3				0.4	0.3	-0.2		0.4	0.0
Mn																		1.0										
Mo	0.2	0.6	-0.2	-0.2	0.6	-0.2	0.2	0.5	0.5		0.6	0.0				-0.1	0.3		1.0				0.7	0.1	-0.1		0.6	-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.0	0.5	-0.1	-0.2	0.4	-0.1	0.0	0.3	0.2		0.4	0.0				0.3	0.4		0.7				1.0	0.0	-0.1		0.1	-0.1
Si	-0.2	-0.2	-0.4	-0.3	-0.2	-0.3	-0.1	-0.2	0.2		0.3	-0.1				-0.2	0.3		0.1				0.0	1.0	-0.1		0.3	0.0
Sr	-0.1	0.3	0.7	0.8	0.1	0.7	0.6	-0.2	-0.2		-0.2	0.9				0.0	-0.2		-0.1				-0.1	-0.1	1.0		-0.1	-0.1
U																										1.0		
V	0.3	0.4	-0.2	-0.2	0.5	-0.2	0.3	0.1	0.7		0.7	0.1				-0.4	0.4		0.6				0.1	0.3	-0.1		1.0	-0.1
Zn	0.1	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.4		0.1	-0.1				-0.1	0.0		-0.1				-0.1	0.0	-0.1		-0.1	1.0

Table E-23: BH23, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.4	0.1	0.1	0.5	0.0	0.3	0.1	0.1		0.6	0.3				0.0	0.1	0.3	0.2					-0.3	0.3		0.4	0.3
EC	0.4	1.0	0.7	0.6	0.9	0.5	0.6	0.6	-0.2		0.3	0.4				0.2	0.3	0.0	0.4					-0.3	0.5		0.1	0.2
Ca	0.1	0.7	1.0	0.9	0.6	0.8	0.8	0.0	-0.2		-0.3	0.0				0.2	-0.1	0.3	0.1					-0.2	0.6		-0.2	-0.1
Mg	0.1	0.6	0.9	1.0	0.4	0.8	0.9	-0.2	-0.2		-0.3	-0.1				0.1	-0.2	0.2	-0.1					-0.2	0.6		-0.1	-0.2
Na	0.5	0.9	0.6	0.4	1.0	0.5	0.5	0.6	-0.2		0.2	0.3				0.2	0.2	0.0	0.6					-0.4	0.4		0.1	0.3
K	0.0	0.5	0.8	0.8	0.5	1.0	0.9	-0.2	-0.1		-0.4	-0.1				0.1	-0.3	-0.1	-0.1					-0.2	0.4		-0.1	-0.2
MAlk	0.3	0.6	0.8	0.9	0.5	0.9	1.0	-0.3	-0.2		-0.2	0.0				0.0	-0.3	0.0	-0.1					-0.2	0.5		0.0	-0.2
SO4	0.1	0.6	0.0	-0.2	0.6	-0.2	-0.3	1.0	-0.1		0.3	0.4				0.1	0.6	-0.1	0.6					-0.3	0.2		-0.1	0.4
Al	0.1	-0.2	-0.2	-0.2	-0.2	-0.1	-0.2	-0.1	1.0		0.0	0.3				0.2	0.2	0.0	0.0					0.2	-0.1		0.1	0.1
As										1.0																		
B	0.6	0.3	-0.3	-0.3	0.2	-0.4	-0.2	0.3	0.0		1.0	0.6				-0.1	0.4	0.1	0.5					0.2	-0.1		0.7	0.3
Ba	0.3	0.4	0.0	-0.1	0.3	-0.1	0.0	0.4	0.3		0.6	1.0				0.0	0.5	0.0	0.5					0.0	0.2		0.6	0.2
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	0.0	0.2	0.2	0.1	0.2	0.1	0.0	0.1	0.2		-0.1	0.0				1.0	0.5	0.3	-0.1					0.0	0.3		-0.2	-0.1
Fe	0.1	0.3	-0.1	-0.2	0.2	-0.3	-0.3	0.6	0.2		0.4	0.5				0.5	1.0	0.1	0.1					0.1	0.3		0.1	0.0
Mn	0.3	0.0	0.3	0.2	0.0	-0.1	0.0	-0.1	0.0		0.1	0.0				0.3	0.1	1.0	-0.1					0.0	0.5		0.0	-0.1
Mo	0.2	0.4	0.1	-0.1	0.6	-0.1	-0.1	0.6	0.0		0.5	0.5				-0.1	0.1	-0.1	1.0					-0.1	-0.2		0.4	0.7
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	-0.3	-0.3	-0.2	-0.2	-0.4	-0.2	-0.2	-0.3	0.2		0.2	0.0				0.0	0.1	0.0	-0.1					1.0	-0.2		0.1	-0.1
Sr	0.3	0.5	0.6	0.6	0.4	0.4	0.5	0.2	-0.1		-0.1	0.2				0.3	0.3	0.5	-0.2					-0.2	1.0		-0.1	-0.2
U																										1.0		
V	0.4	0.1	-0.2	-0.1	0.1	-0.1	0.0	-0.1	0.1		0.7	0.6				-0.2	0.1	0.0	0.4					0.1	-0.1		1.0	0.4
Zn	0.3	0.2	-0.1	-0.2	0.3	-0.2	-0.2	0.4	0.1		0.3	0.2				-0.1	0.0	-0.1	0.7					-0.1	-0.2		0.4	1.0

Table E-24: BH24, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	-0.2	-0.6	-0.6	0.1	-0.2	0.3	-0.4	0.3		0.2	-0.5				-0.5	-0.1	-0.5	0.1				-0.2	0.0	-0.6		0.3	-0.3
EC	-0.2	1.0	0.5	0.3	0.8	0.9	0.1	0.9	0.0		0.5	0.2				0.5	0.7	0.6	0.2				0.3	-0.5	0.4		0.1	0.5
Ca	-0.6	0.5	1.0	0.9	0.0	0.6	-0.3	0.6	-0.3		0.1	0.6				0.6	0.1	0.8	-0.2				0.4	-0.2	1.0		-0.2	0.1
Mg	-0.6	0.3	0.9	1.0	-0.2	0.4	-0.1	0.4	-0.4		-0.1	0.7				0.5	-0.1	0.7	-0.2				0.4	-0.1	0.9		-0.3	0.0
Na	0.1	0.8	0.0	-0.2	1.0	0.7	0.2	0.7	0.3		0.6	-0.2				0.2	0.8	0.2	0.3				0.0	-0.4	-0.1		0.3	0.6
K	-0.2	0.9	0.6	0.4	0.7	1.0	0.1	0.8	0.1		0.5	0.3				0.5	0.6	0.7	0.2				0.2	-0.5	0.5		0.2	0.4
MAlk	0.3	0.1	-0.3	-0.1	0.2	0.1	1.0	-0.3	0.1		0.0	0.3				-0.4	-0.2	-0.4	0.2				-0.2	-0.1	-0.2		0.1	-0.3
SO4	-0.4	0.9	0.6	0.4	0.7	0.8	-0.3	1.0	-0.1		0.3	0.1				0.6	0.7	0.7	-0.1				0.2	-0.5	0.4		-0.1	0.8
Al	0.3	0.0	-0.3	-0.4	0.3	0.1	0.1	-0.1	1.0		0.4	-0.4				-0.1	0.3	-0.1	0.9				-0.1	0.3	-0.4		0.5	0.0
As										1.0																		
B	0.2	0.5	0.1	-0.1	0.6	0.5	0.0	0.3	0.4		1.0	-0.1				0.1	0.5	0.2	0.4				0.2	0.2	0.1		0.7	0.1
Ba	-0.5	0.2	0.6	0.7	-0.2	0.3	0.3	0.1	-0.4		-0.1	1.0				0.3	-0.2	0.4	-0.2				-0.1	0.1	0.7		-0.2	0.0
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.5	0.5	0.6	0.5	0.2	0.5	-0.4	0.6	-0.1		0.1	0.3				1.0	0.3	0.7	0.0				-0.1	-0.2	0.5		-0.2	0.4
Fe	-0.1	0.7	0.1	-0.1	0.8	0.6	-0.2	0.7	0.3		0.5	-0.2				0.3	1.0	0.3	0.3				0.1	-0.3	0.0		0.3	0.7
Mn	-0.5	0.6	0.8	0.7	0.2	0.7	-0.4	0.7	-0.1		0.2	0.4				0.7	0.3	1.0	0.0				0.1	-0.3	0.7		-0.1	0.3
Mo	0.1	0.2	-0.2	-0.2	0.3	0.2	0.2	-0.1	0.9		0.4	-0.2				0.0	0.3	0.0	1.0				0.0	0.2	-0.2		0.2	-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	-0.2	0.3	0.4	0.4	0.0	0.2	-0.2	0.2	-0.1		0.2	-0.1				-0.1	0.1	0.1	0.0				1.0	-0.2	0.4		0.0	-0.1
Si	0.0	-0.5	-0.2	-0.1	-0.4	-0.5	-0.1	-0.5	0.3		0.2	0.1				-0.2	-0.3	-0.3	0.2				-0.2	1.0	0.0		0.3	-0.4
Sr	-0.6	0.4	1.0	0.9	-0.1	0.5	-0.2	0.4	-0.4		0.1	0.7				0.5	0.0	0.7	-0.2				0.4	0.0	1.0		-0.2	0.0
U																										1.0		
V	0.3	0.1	-0.2	-0.3	0.3	0.2	0.1	-0.1	0.5		0.7	-0.2				-0.2	0.3	-0.1	0.2				0.0	0.3	-0.2		1.0	-0.1
Zn	-0.3	0.5	0.1	0.0	0.6	0.4	-0.3	0.8	0.0		0.1	0.0				0.4	0.7	0.3	-0.1				-0.1	-0.4	0.0		-0.1	1.0

Table E-25: BH25, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.1	-0.4	-0.4	0.2	-0.1	-0.1	0.1	0.2		0.5	-0.2				-0.2	0.0		0.1					-0.3	-0.3		0.3	0.1
EC	0.1	1.0	0.3	0.1	1.0	0.5	0.5	0.7	-0.1		0.2	0.4				0.1	0.1		0.7					-0.3	0.1		0.1	0.2
Ca	-0.4	0.3	1.0	0.9	0.1	0.7	0.9	-0.3	-0.3		-0.5	0.8				-0.1	-0.4		-0.2					-0.1	0.9		-0.2	-0.2
Mg	-0.4	0.1	0.9	1.0	-0.1	0.5	0.8	-0.4	-0.4		-0.5	0.8				-0.1	-0.4		-0.3					-0.1	0.9		-0.3	-0.2
Na	0.2	1.0	0.1	-0.1	1.0	0.5	0.4	0.7	0.0		0.2	0.2				0.0	0.1		0.7					-0.3	0.0		0.2	0.2
K	-0.1	0.5	0.7	0.5	0.5	1.0	0.8	0.0	0.0		-0.3	0.7				0.0	-0.2		0.1					-0.2	0.5		-0.1	-0.1
MAlk	-0.1	0.5	0.9	0.8	0.4	0.8	1.0	-0.2	-0.2		-0.3	0.8				-0.2	-0.3		0.1					-0.3	0.7		0.0	-0.2
SO4	0.1	0.7	-0.3	-0.4	0.7	0.0	-0.2	1.0	0.1		0.2	-0.1				0.3	0.5		0.7					-0.1	-0.3		0.0	0.5
Al	0.2	-0.1	-0.3	-0.4	0.0	0.0	-0.2	0.1	1.0		0.3	-0.2				-0.1	0.3		0.1					0.3	-0.3		0.3	0.1
As										1.0																		
B	0.5	0.2	-0.5	-0.5	0.2	-0.3	-0.3	0.2	0.3		1.0	-0.3				-0.2	0.2		0.5					0.4	-0.3		0.7	0.1
Ba	-0.2	0.4	0.8	0.8	0.2	0.7	0.8	-0.1	-0.2		-0.3	1.0				-0.1	-0.1		-0.1					0.0	0.9		-0.3	0.0
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.2	0.1	-0.1	-0.1	0.0	0.0	-0.2	0.3	-0.1		-0.2	-0.1				1.0	0.5		0.1					0.0	-0.2		-0.2	0.6
Fe	0.0	0.1	-0.4	-0.4	0.1	-0.2	-0.3	0.5	0.3		0.2	-0.1				0.5	1.0		0.3					0.2	-0.3		0.0	0.5
Mn																		1.0										
Mo	0.1	0.7	-0.2	-0.3	0.7	0.1	0.1	0.7	0.1		0.5	-0.1				0.1	0.3		1.0					0.0	-0.2		0.4	0.3
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	-0.3	-0.3	-0.1	-0.1	-0.3	-0.2	-0.3	-0.1	0.3		0.4	0.0				0.0	0.2		0.0					1.0	0.1		0.1	0.1
Sr	-0.3	0.1	0.9	0.9	0.0	0.5	0.7	-0.3	-0.3		-0.3	0.9				-0.2	-0.3		-0.2					0.1	1.0		-0.2	-0.1
U																										1.0		
V	0.3	0.1	-0.2	-0.3	0.2	-0.1	0.0	0.0	0.3		0.7	-0.3				-0.2	0.0		0.4					0.1	-0.2		1.0	0.0
Zn	0.1	0.2	-0.2	-0.2	0.2	-0.1	-0.2	0.5	0.1		0.1	0.0				0.6	0.5		0.3					0.1	-0.1		0.0	1.0

Table E-26: BH26, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.6	-0.2	-0.2	0.6	0.1	0.2	0.7	0.0		0.2	0.1				-0.5	0.1		0.2					-0.5	-0.2		0.1	-0.2
EC	0.6	1.0	-0.1	-0.1	1.0	0.1	0.7	0.8	0.1		0.6	0.2				-0.4	0.2		0.8					-0.2	-0.2		0.6	-0.4
Ca	-0.2	-0.1	1.0	1.0	-0.1	0.7	-0.1	-0.3	0.2		-0.6	0.6				0.2	-0.2		-0.1					0.0	0.8		-0.4	-0.2
Mg	-0.2	-0.1	1.0	1.0	-0.2	0.8	-0.1	-0.4	0.2		-0.5	0.6				0.2	-0.2		-0.2					0.1	0.9		-0.4	-0.1
Na	0.6	1.0	-0.1	-0.2	1.0	0.0	0.7	0.8	0.0		0.6	0.1				-0.5	0.1		0.8					-0.3	-0.3		0.7	-0.4
K	0.1	0.1	0.7	0.8	0.0	1.0	0.2	-0.3	0.5		-0.4	0.6				0.0	-0.1		-0.1					0.1	0.8		-0.2	-0.1
MAlk	0.2	0.7	-0.1	-0.1	0.7	0.2	1.0	0.3	0.2		0.6	0.2				-0.5	-0.1		0.5					-0.1	-0.1		0.8	-0.3
SO4	0.7	0.8	-0.3	-0.4	0.8	-0.3	0.3	1.0	-0.1		0.5	0.1				-0.2	0.4		0.7					-0.4	-0.5		0.3	-0.2
Al	0.0	0.1	0.2	0.2	0.0	0.5	0.2	-0.1	1.0		-0.2	0.4				0.2	0.2		-0.1					0.4	0.3		-0.1	0.0
As										1.0																		
B	0.2	0.6	-0.6	-0.5	0.6	-0.4	0.6	0.5	-0.2		1.0	-0.1				-0.4	0.2		0.6					0.1	-0.5		0.9	-0.3
Ba	0.1	0.2	0.6	0.6	0.1	0.6	0.2	0.1	0.4		-0.1	1.0				0.3	0.4		-0.1					0.2	0.7		-0.2	0.0
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.5	-0.4	0.2	0.2	-0.5	0.0	-0.5	-0.2	0.2		-0.4	0.3				1.0	0.6		-0.2					0.3	0.2		-0.4	0.7
Fe	0.1	0.2	-0.2	-0.2	0.1	-0.1	-0.1	0.4	0.2		0.2	0.4				0.6	1.0		0.2					0.3	-0.1		-0.1	0.3
Mn																		1.0										
Mo	0.2	0.8	-0.1	-0.2	0.8	-0.1	0.5	0.7	-0.1		0.6	-0.1				-0.2	0.2		1.0					-0.1	-0.4		0.6	-0.2
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se																							1.0					
Si	-0.5	-0.2	0.0	0.1	-0.3	0.1	-0.1	-0.4	0.4		0.1	0.2				0.3	0.3		-0.1					1.0	0.2		0.0	0.1
Sr	-0.2	-0.2	0.8	0.9	-0.3	0.8	-0.1	-0.5	0.3		-0.5	0.7				0.2	-0.1		-0.4					0.2	1.0		-0.4	-0.1
U																										1.0		
V	0.1	0.6	-0.4	-0.4	0.7	-0.2	0.8	0.3	-0.1		0.9	-0.2				-0.4	-0.1		0.6					0.0	-0.4		1.0	-0.2
Zn	-0.2	-0.4	-0.2	-0.1	-0.4	-0.1	-0.3	-0.2	0.0		-0.3	0.0				0.7	0.3		-0.2					0.1	-0.1		-0.2	1.0

Table E-27: BH27, with marked correlations significant at p < .05000 and N=30 (missing data are below detection limit).

	pH	EC	Ca	Mg	Na	K	MAlk	SO4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn
pH	1.0	0.4	-0.7	-0.6	0.7	0.5	0.4	0.1	0.7		0.7	0.0				-0.4	0.1	-0.2	0.4				0.6	-0.1	-0.5		0.4	-0.1
EC	0.4	1.0	0.0	0.0	0.8	0.9	0.4	0.8	0.4		0.7	0.2				0.0	0.7	0.4	0.4				0.8	-0.5	0.1		0.1	-0.1
Ca	-0.7	0.0	1.0	0.9	-0.5	-0.1	-0.6	0.4	-0.6		-0.3	-0.1				0.5	0.2	0.5	-0.3				-0.4	0.0	0.9		-0.3	0.2
Mg	-0.6	0.0	0.9	1.0	-0.5	-0.2	-0.6	0.4	-0.5		-0.1	-0.3				0.3	0.1	0.4	-0.3				-0.4	0.2	0.9		-0.3	0.2
Na	0.7	0.8	-0.5	-0.5	1.0	0.9	0.7	0.5	0.7		0.7	0.3				-0.2	0.6	0.1	0.5				0.9	-0.5	-0.4		0.2	-0.1
K	0.5	0.9	-0.1	-0.2	0.9	1.0	0.5	0.7	0.5		0.7	0.2				0.0	0.7	0.4	0.4				0.7	-0.5	0.0		0.2	0.0
MAlk	0.4	0.4	-0.6	-0.6	0.7	0.5	1.0	0.0	0.6		0.2	0.4				-0.3	0.1	-0.3	0.3				0.7	-0.2	-0.4		0.1	0.1
SO4	0.1	0.8	0.4	0.4	0.5	0.7	0.0	1.0	0.2		0.4	0.2				0.2	0.8	0.7	0.1				0.5	-0.5	0.5		-0.1	-0.1
Al	0.7	0.4	-0.6	-0.5	0.7	0.5	0.6	0.2	1.0		0.3	0.3				-0.3	0.3	-0.1	-0.1				0.6	-0.3	-0.4		0.1	-0.1
As										1.0																		
B	0.7	0.7	-0.3	-0.1	0.7	0.7	0.2	0.4	0.3		1.0	-0.2				-0.2	0.4	0.3	0.4				0.4	-0.1	-0.1		0.5	0.0
Ba	0.0	0.2	-0.1	-0.3	0.3	0.2	0.4	0.2	0.3		-0.2	1.0				-0.1	0.5	0.3	-0.2				0.2	-0.1	0.0		0.1	-0.1
Cd													1.0															
Co														1.0														
Cr															1.0													
Cu	-0.4	0.0	0.5	0.3	-0.2	0.0	-0.3	0.2	-0.3		-0.2	-0.1				1.0	0.1	0.2	0.0				-0.2	0.0	0.4		-0.3	0.1
Fe	0.1	0.7	0.2	0.1	0.6	0.7	0.1	0.8	0.3		0.4	0.5				0.1	1.0	0.9	0.0				0.4	-0.5	0.3		0.0	-0.1
Mn	-0.2	0.4	0.5	0.4	0.1	0.4	-0.3	0.7	-0.1		0.3	0.3				0.2	0.9	1.0	0.0				-0.1	-0.2	0.6		0.0	-0.1
Mo	0.4	0.4	-0.3	-0.3	0.5	0.4	0.3	0.1	-0.1		0.4	-0.2				0.0	0.0	0.0	1.0				0.5	-0.1	-0.4		0.0	-0.1
Ni																				1.0								
Pb																					1.0							
Sb																						1.0						
Se	0.6	0.8	-0.4	-0.4	0.9	0.7	0.7	0.5	0.6		0.4	0.2				-0.2	0.4	-0.1	0.5				1.0	-0.6	-0.3		-0.1	-0.1
Si	-0.1	-0.5	0.0	0.2	-0.5	-0.5	-0.2	-0.5	-0.3		-0.1	-0.1				0.0	-0.5	-0.2	-0.1				-0.6	1.0	0.2		0.2	0.3
Sr	-0.5	0.1	0.9	0.9	-0.4	0.0	-0.4	0.5	-0.4		-0.1	0.0				0.4	0.3	0.6	-0.4				-0.3	0.2	1.0		-0.3	0.3
U																										1.0		
V	0.4	0.1	-0.3	-0.3	0.2	0.2	0.1	-0.1	0.1		0.5	0.1				-0.3	0.0	0.0	0.0				-0.1	0.2	-0.3		1.0	-0.1
Zn	-0.1	-0.1	0.2	0.2	-0.1	0.0	0.1	-0.1	-0.1		0.0	-0.1				0.1	-0.1	-0.1	-0.1				-0.1	0.3	0.3		-0.1	1.0

APPENDIX F: KINETIC TEST GRAPHICAL SUMMARY

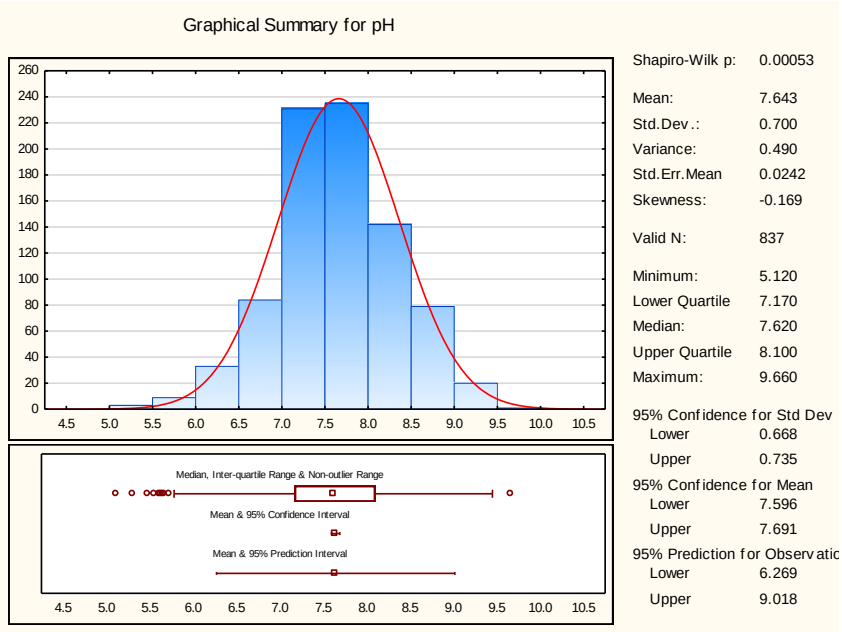


Figure F-1: Graphical summary statistics of pH of the humidity cell leach tests.

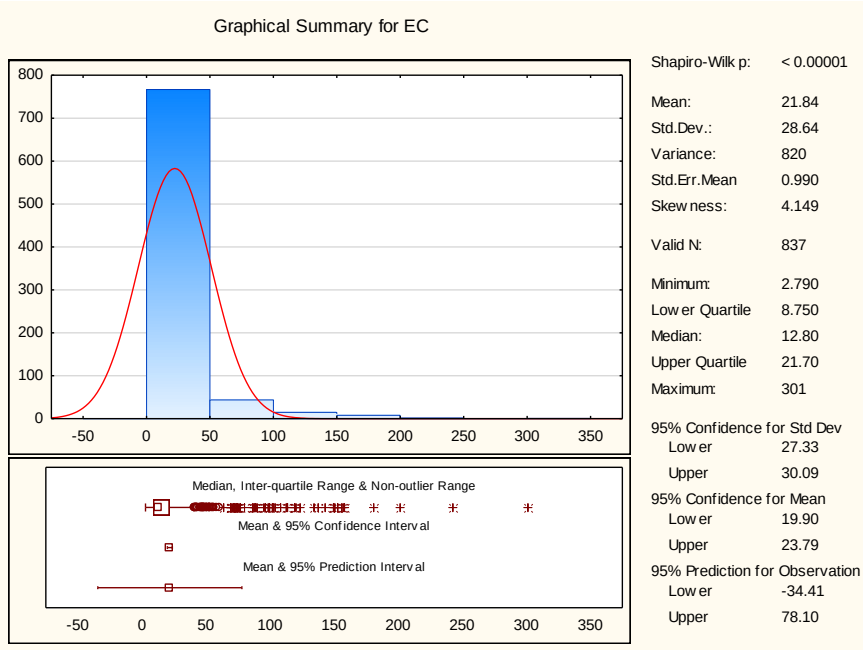


Figure F-2: Graphical summary statistics of EC (mS/m) of the humidity cell leach tests.

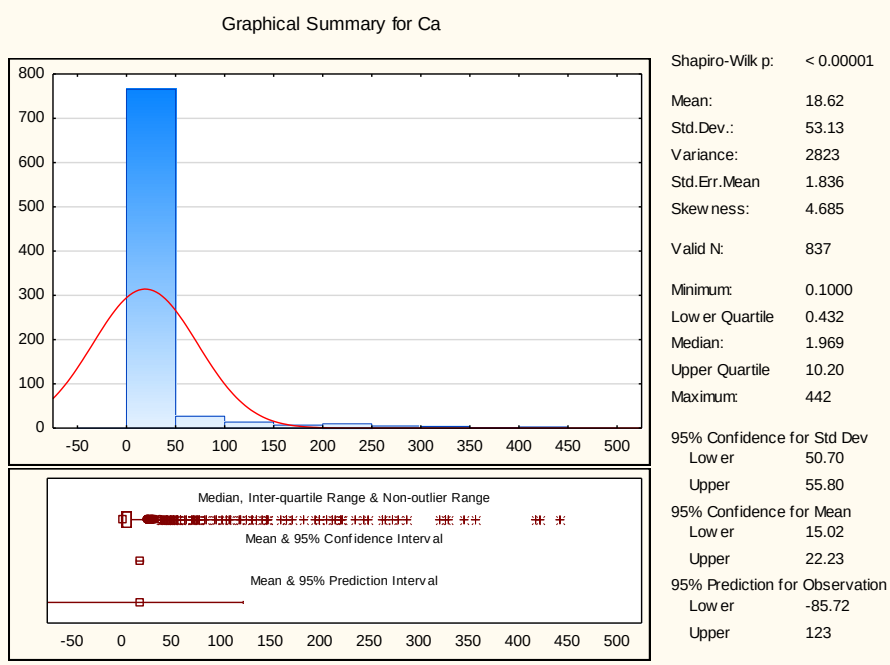


Figure F-3: Graphical summary statistics of leachate Ca (mg/L) concentrations of the humidity cell leach tests.

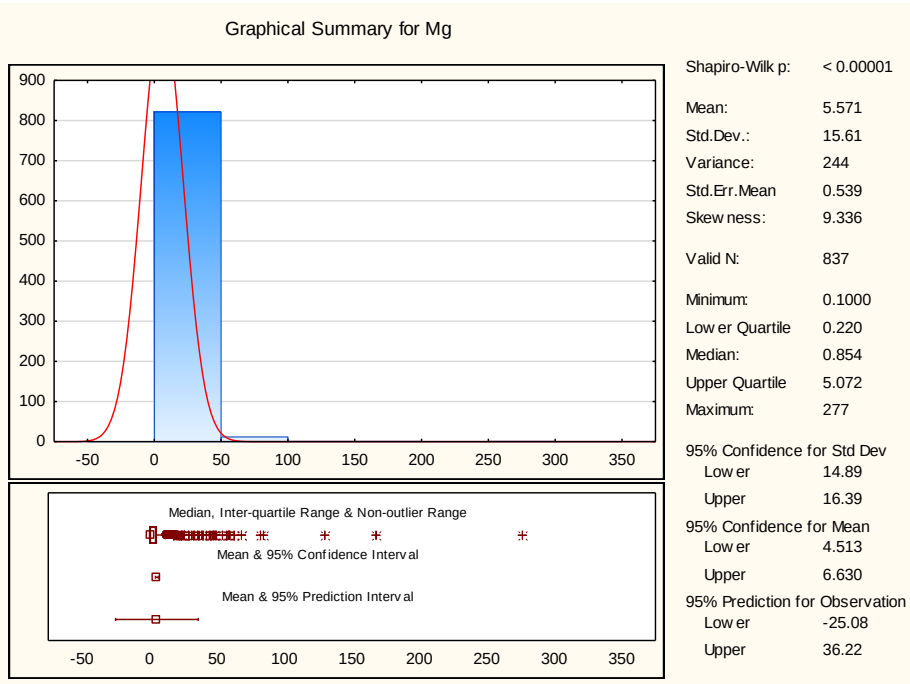


Figure F-4: Graphical summary statistics leachate Mg (mg/L) concentrations of the humidity cell leach tests.

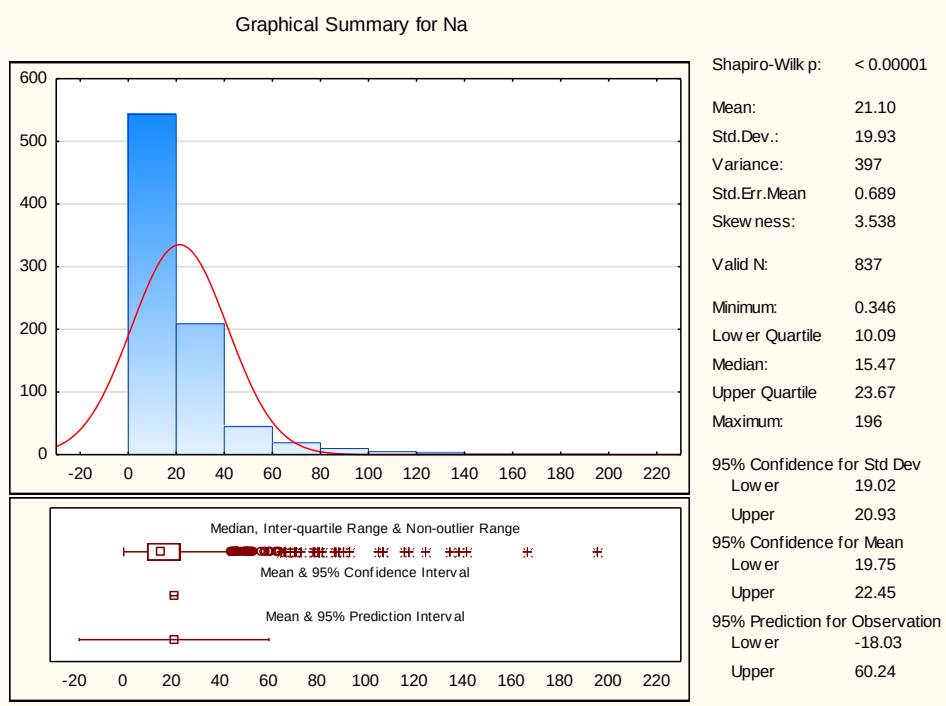


Figure F-5: Graphical summary statistics leachate Na (mg/L) concentrations of the humidity cell leach tests.

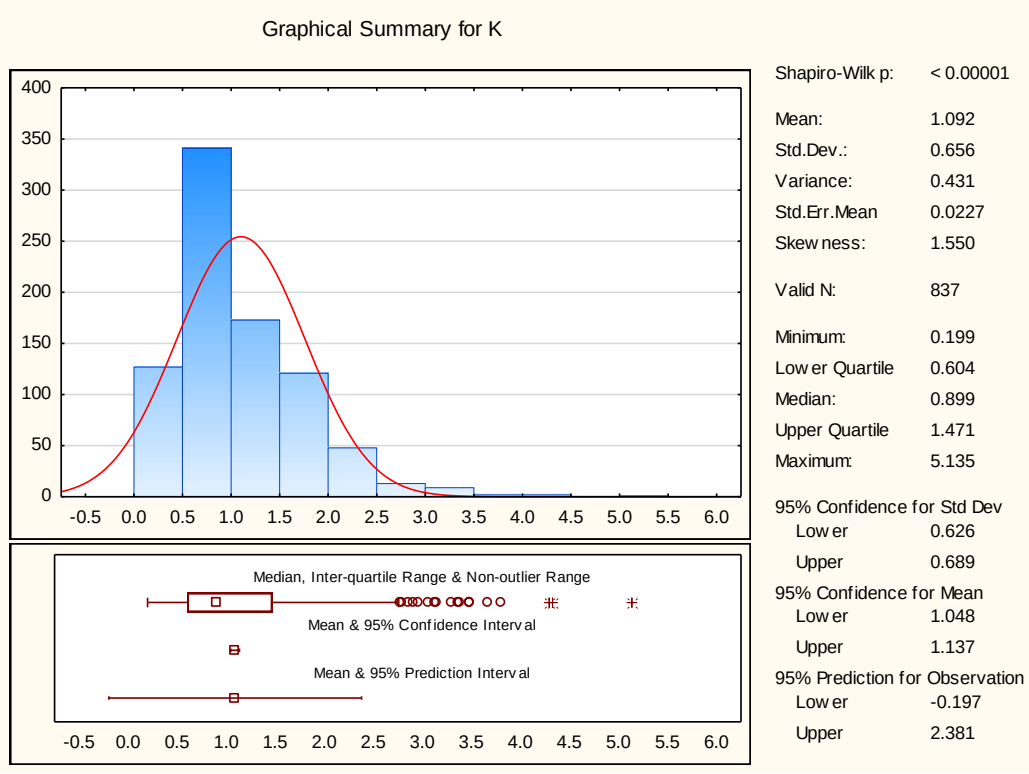


Figure F-6: Graphical summary statistics of leachate K (mg/L) concentrations of the humidity cell leach tests.

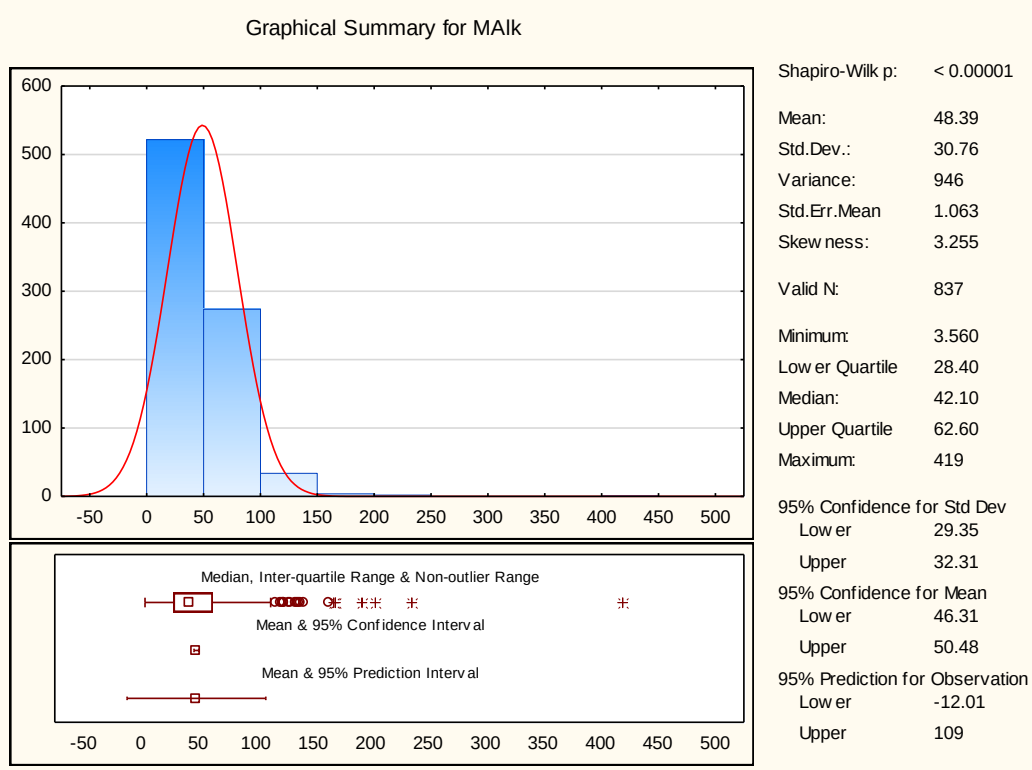


Figure F-7: Graphical summary statistics of leachate Alkalinity values of the humidity cell leach tests.

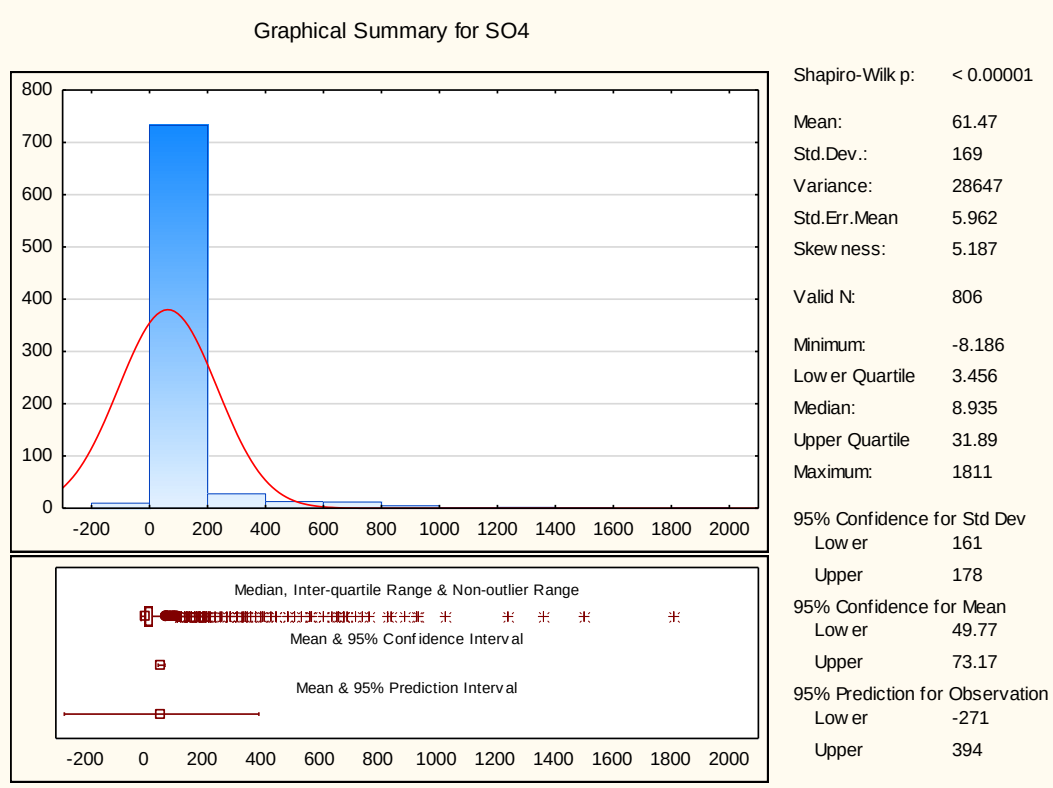


Figure F-8: Graphical summary statistics of leachate SO_4^{2-} (mg/L) concentrations of the humidity cell leach tests.

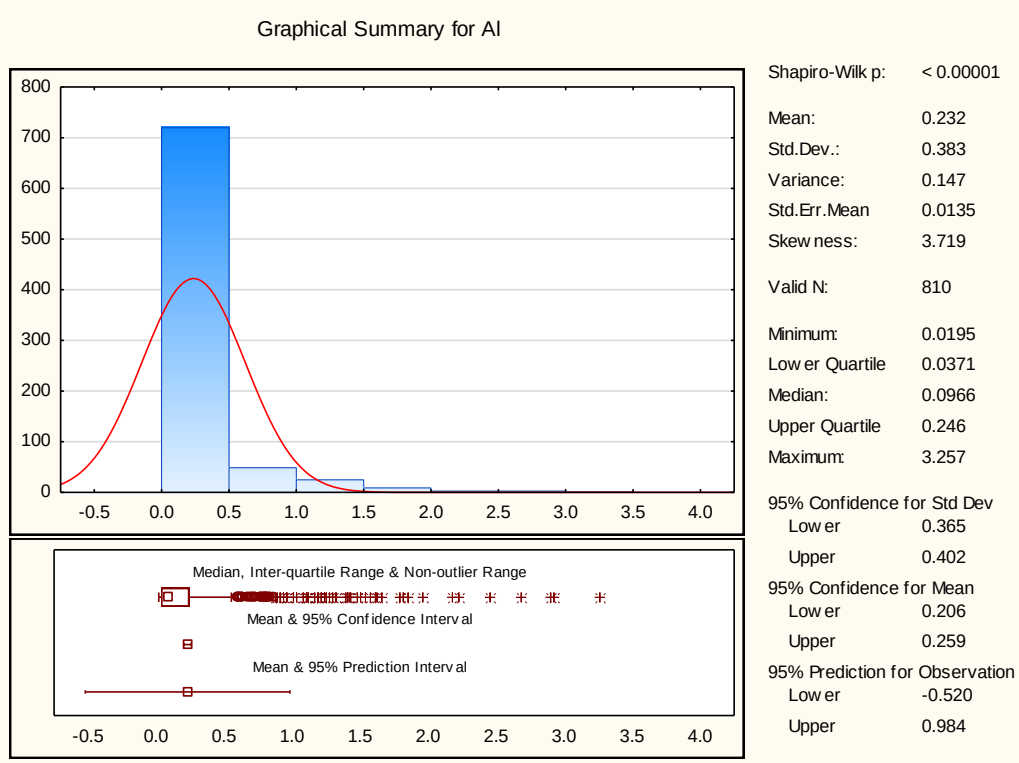


Figure F-9: Graphical summary statistics of leachate Al (mg/L) concentrations of the humidity cell leach tests.

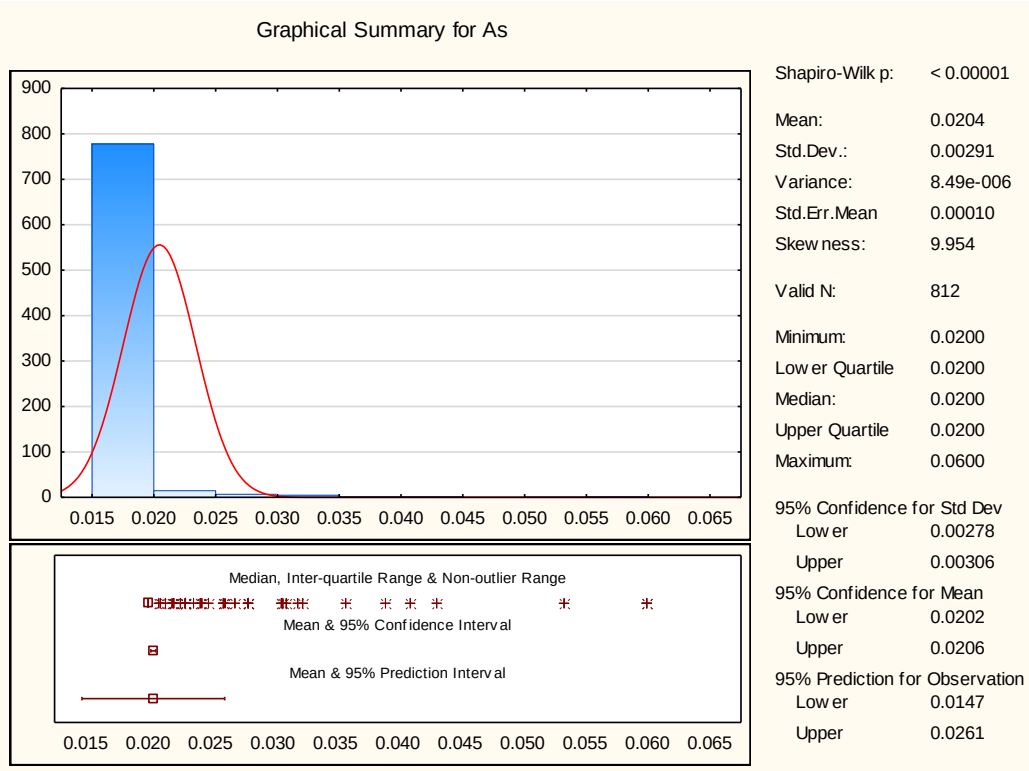


Figure F-10: Graphical summary statistics of leachate As (mg/L) concentrations of the humidity cell leach tests.

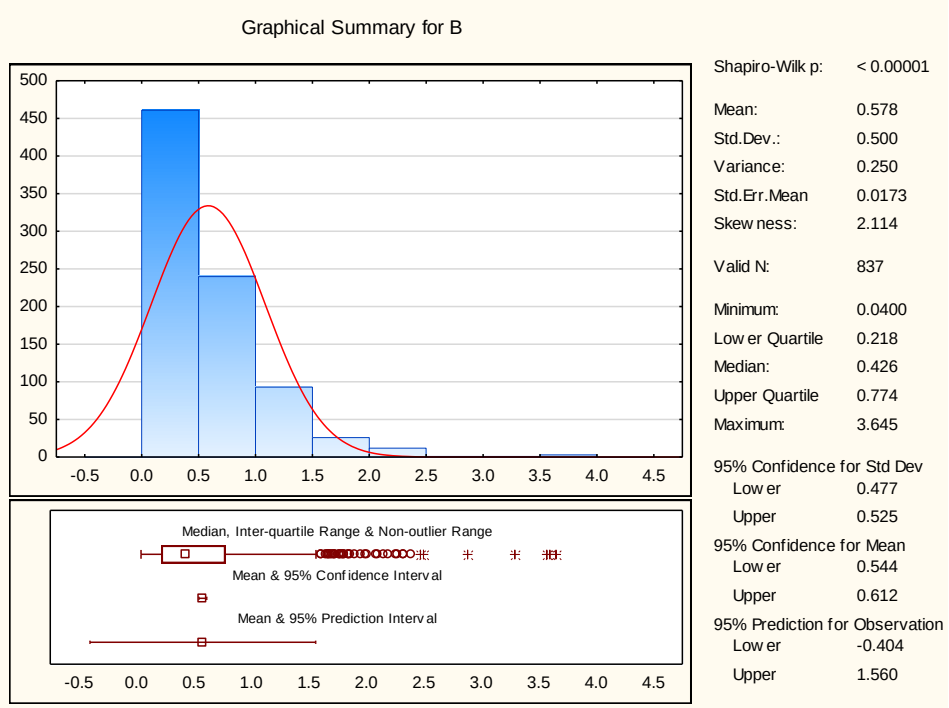


Figure F-11: Graphical summary statistics of leachate B (mg/L) concentrations of the humidity cell leach tests.

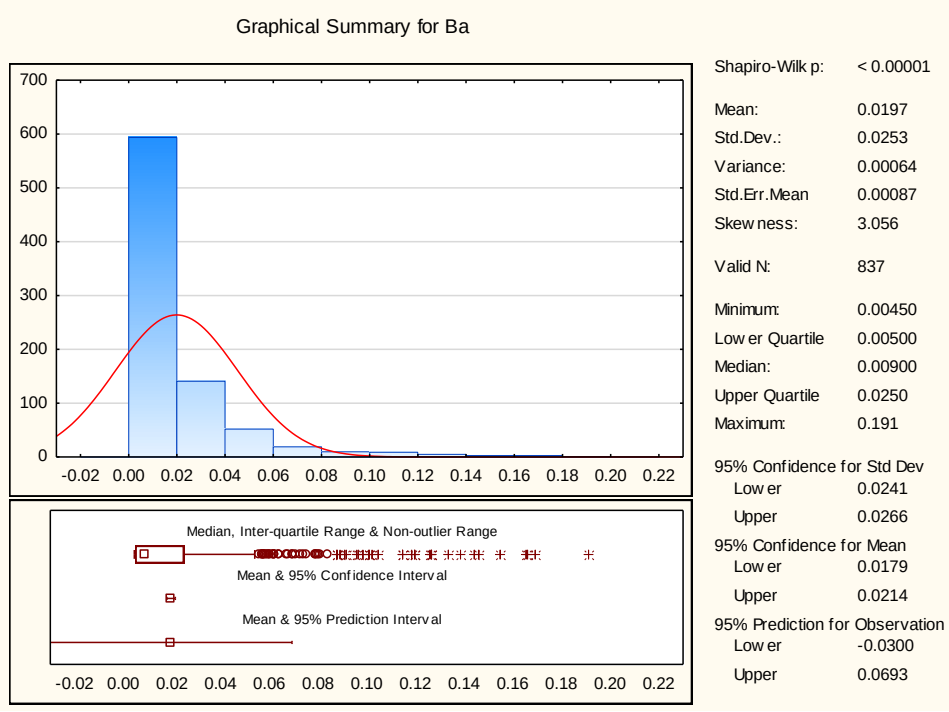


Figure F-12: Graphical summary statistics of leachate Ba (mg/L) concentrations of the humidity cell leach tests.

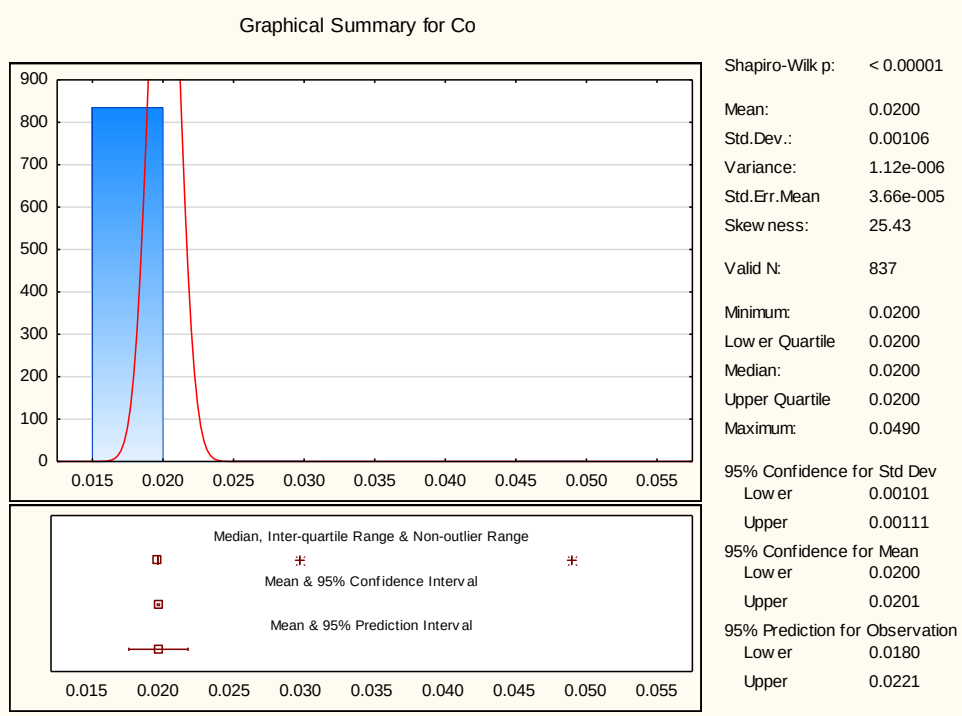


Figure F-13: Graphical summary statistics of leachate Co (mg/L) concentrations of the humidity cell leach tests.

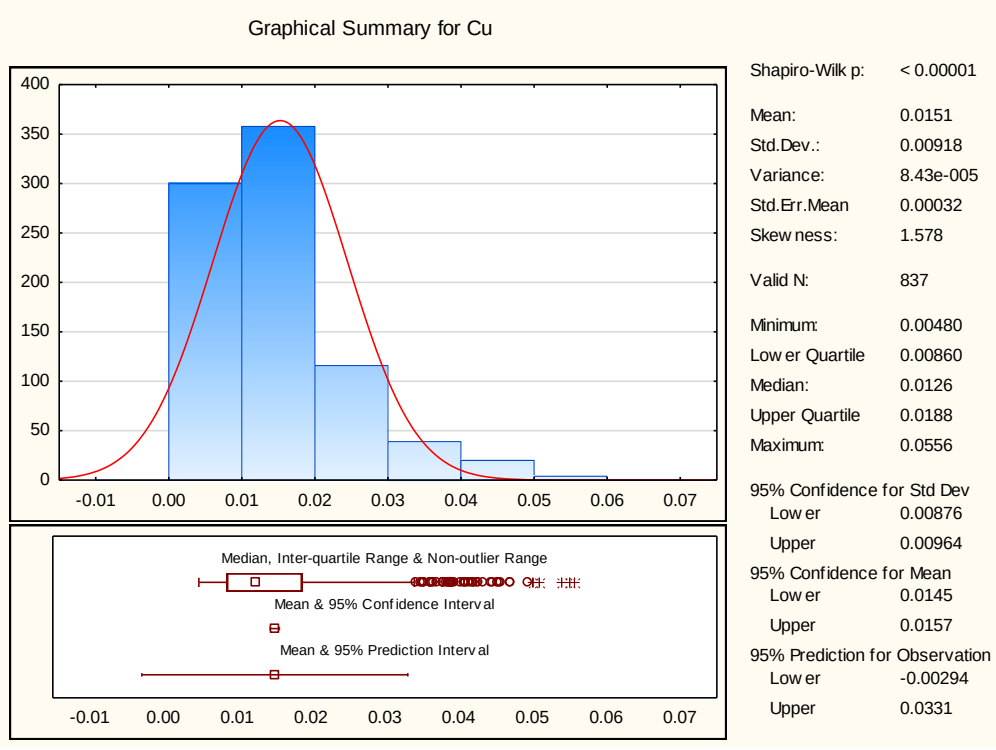


Figure F-14: Graphical summary statistics of leachate Cu (mg/L) concentrations of the humidity cell leach tests.

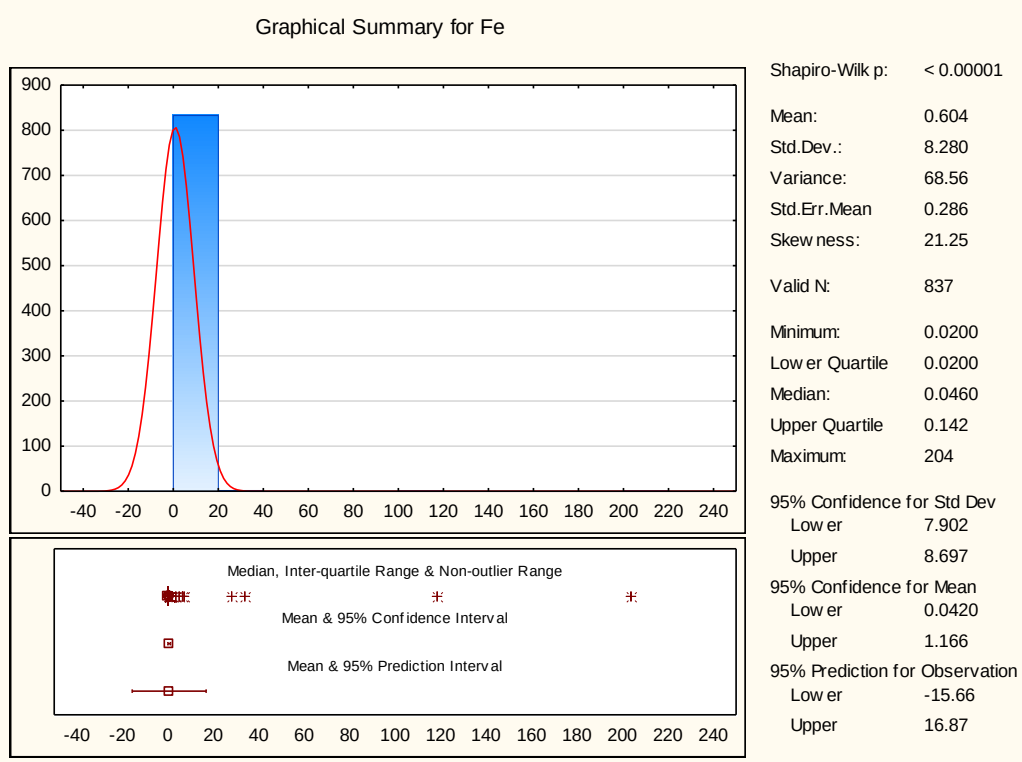


Figure F-15: Graphical summary statistics of leachate Fe (mg/L) concentrations of the humidity cell leach tests.

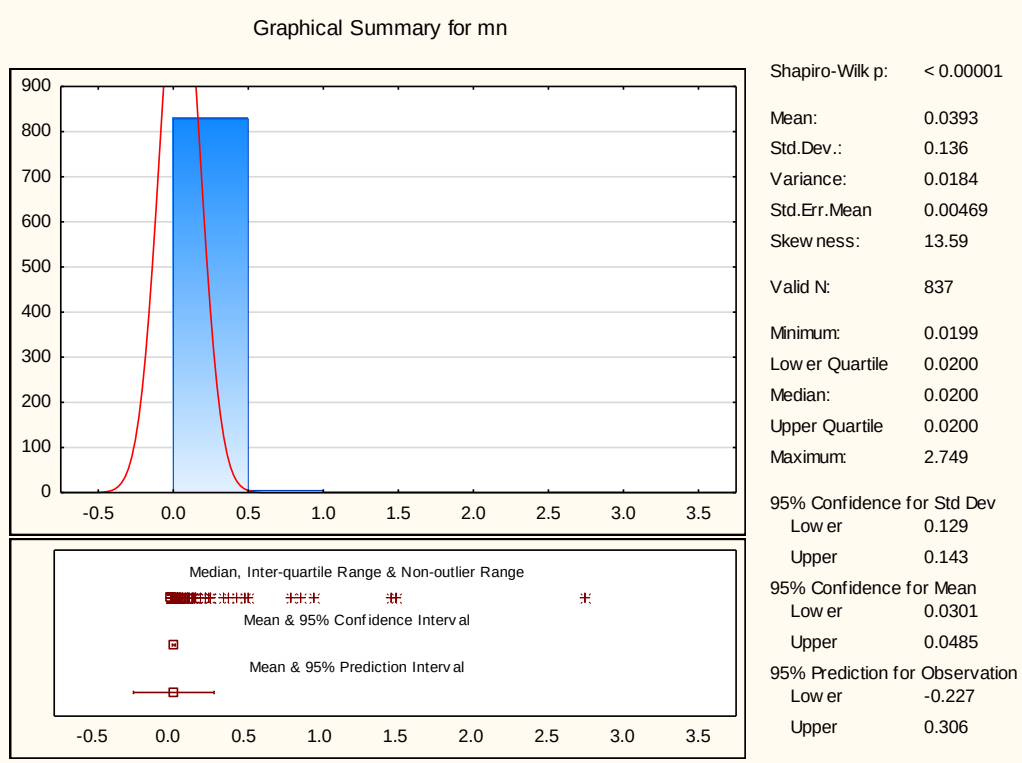


Figure F-16: Graphical summary statistics of leachate Mn (mg/L) concentrations of the humidity cell leach tests.

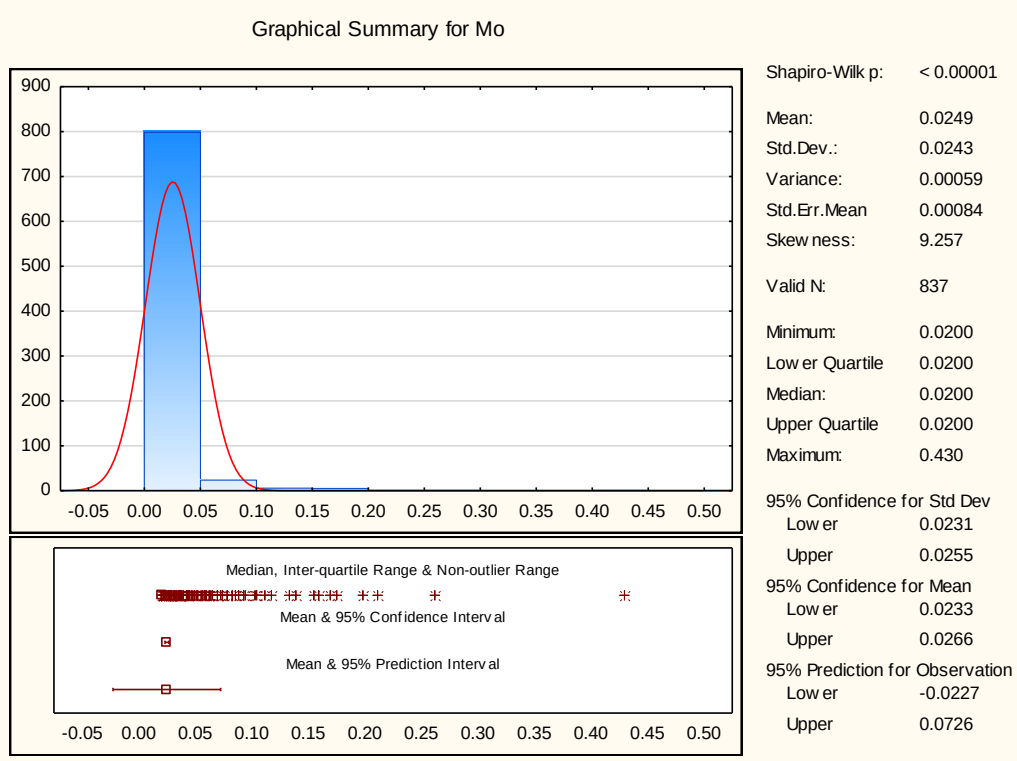


Figure F:17: Graphical summary statistics of leachate Mo (mg/L) concentrations of the humidity cell leach tests.

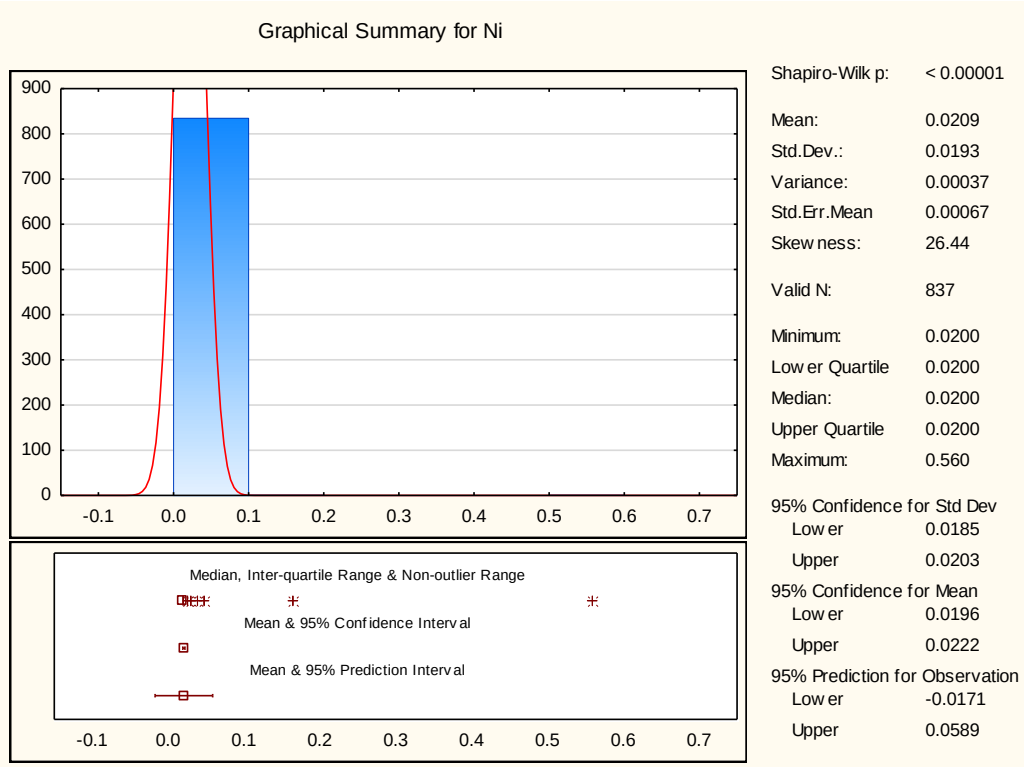


Figure F-18: Graphical summary statistics of leachate Ni (mg/L) concentrations of the humidity cell leach tests.

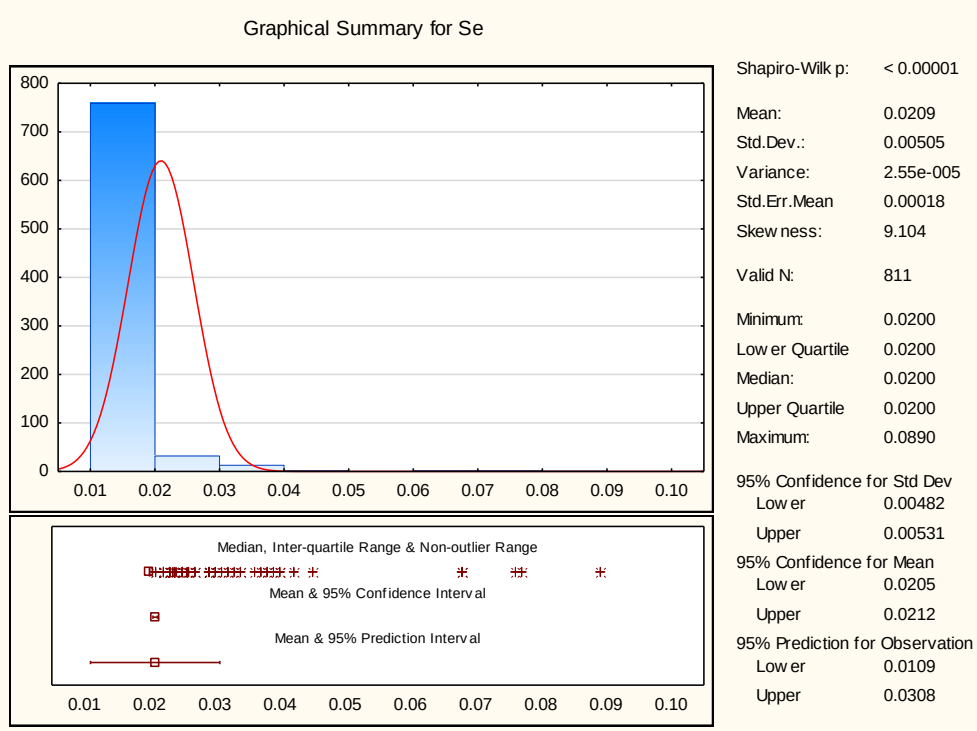


Figure F-19: Graphical summary statistics of leachate Se (mg/L) concentrations of the humidity cell leach tests.

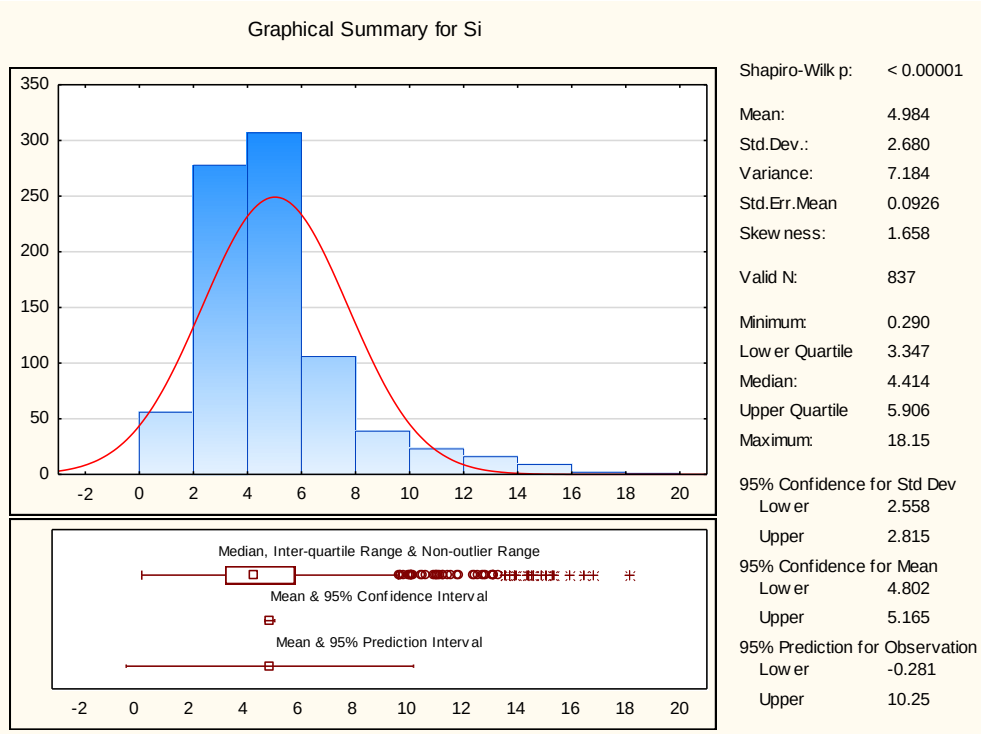


Figure F-20: Graphical summary statistics of leachate Si (mg/L) concentrations of the humidity cell leach tests.

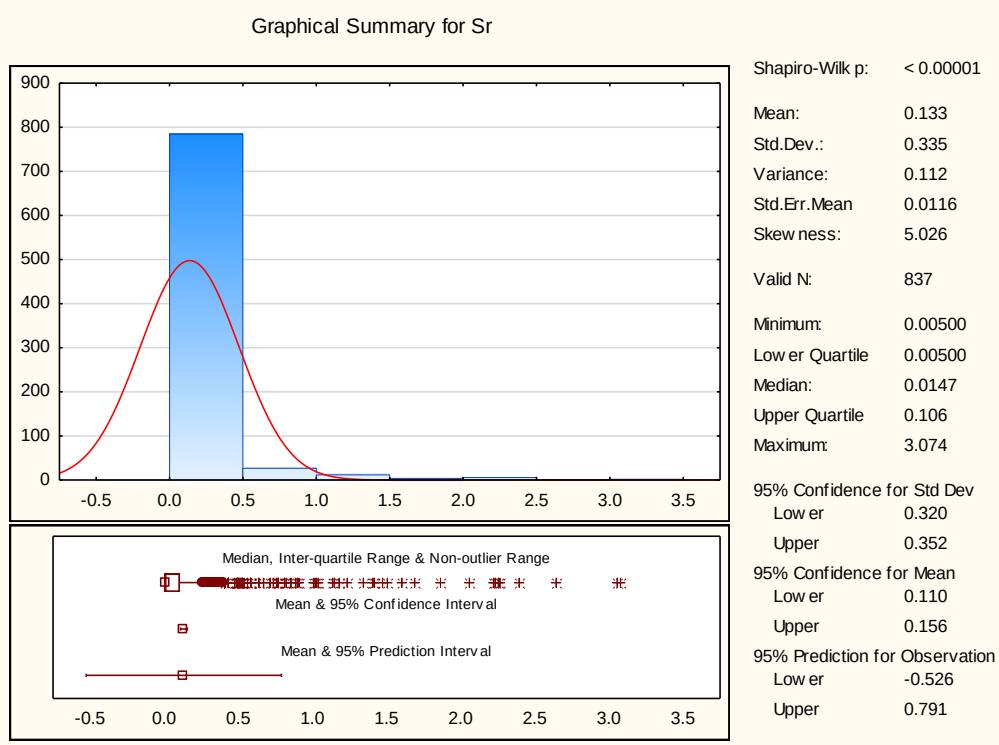


Figure F-21: Graphical summary statistics of leachate Sr (mg/L) concentrations of the humidity cell leach tests.

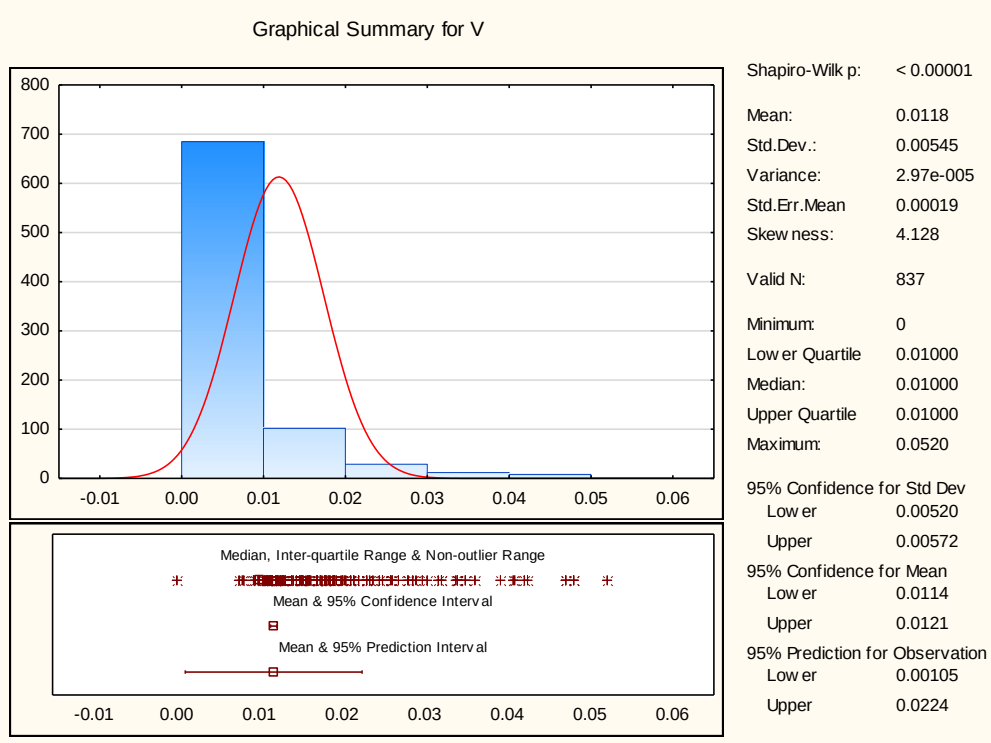


Figure F-22: Graphical summary statistics of leachate V (mg/L) concentrations of the humidity cell leach tests.

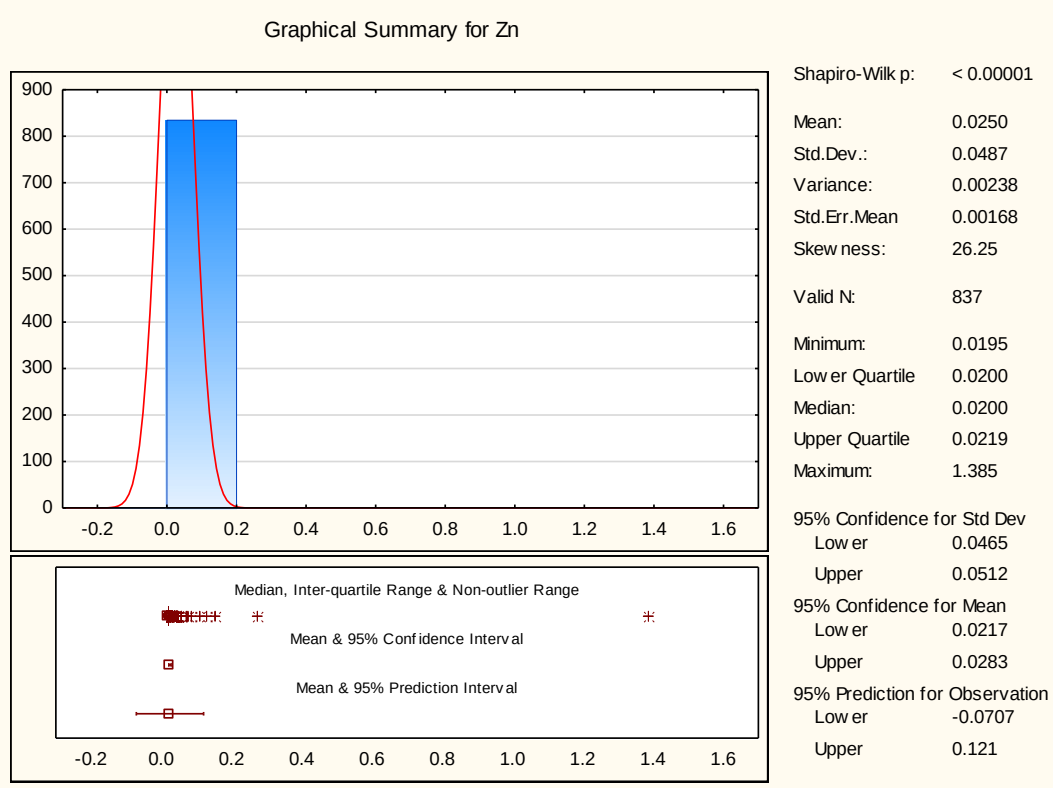


Figure F-23: Graphical summary statistics of leachate Zn (mg/L) concentrations of the humidity cell leach tests.

APPENDIX G: HUMIDITY CELL LEACH TEST FOR 31 WEEKS RESULTS

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH1	7,71	11,5	7,03	2,87	21,68	2,25	52,0	15,22	0,192	<0.020	0,266	0,010	<0.003	<0.020	<0.020	<0.005	0,250	<0.020	0,169	<0.020	<0.015	<0.020	0,029	4,826	0,015	<0.030	<0.010	<0.020	1
BH10	6,37	104	167,14	17,49	70,64	2,78	44,3	564,90	<0.020	<0.020	1,220	0,144	<0.003	<0.020	<0.020	0,031	0,909	0,397	<0.020	<0.020	<0.015	<0.020	<0.020	0,578	1,002	<0.030	<0.010	0,023	1
BH11	5,56	243	422,65	47,92	125,01	3,81	18,5	1366,48	0,170	<0.020	1,471	0,155	<0.003	<0.020	<0.020	0,020	203,530	1,477	<0.020	0,560	<0.015	<0.020	<0.020	0,353	3,074	<0.030	<0.010	0,128	1
BH12	7,54	8,57	0,58	0,15	19,44	0,44	17,2	31,16	0,091	<0.020	0,198	<0.005	<0.003	<0.020	<0.020	0,012	0,132	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,161	<0.005	<0.030	0,014	0,022	1
BH13	6,43	100	75,57	16,68	138,55	3,49	41,9	515,59	<0.020	<0.020	0,703	0,126	<0.003	0,049	<0.020	0,047	0,648	0,134	<0.020	<0.020	<0.015	<0.020	<0.020	0,609	0,588	<0.030	<0.010	0,030	1
BH14	7,50	11,6	3,85	1,37	14,39	2,29	36,0	11,96	0,075	<0.020	0,102	0,005	<0.003	<0.020	<0.020	0,006	0,047	<0.020	0,155	<0.020	<0.015	<0.020	<0.020	1,467	0,006	<0.030	<0.010	<0.020	1
BH15	9,01	6,82	2,20	0,57	10,92	1,71	31,4	10,97	0,111	<0.020	0,047	<0.005	<0.003	<0.020	<0.020	0,006	0,052	<0.020	0,022	<0.020	<0.015	<0.020	<0.020	1,158	0,008	<0.030	<0.010	<0.020	1
BH16	9,45	19,9	0,76	0,24	36,69	0,99	84,7	24,01	0,456	<0.020	0,133	0,006	<0.003	<0.020	<0.020	0,007	0,254	<0.020	0,072	<0.020	<0.015	<0.020	<0.020	1,907	<0.005	<0.030	0,010	<0.020	1
BH17	7,31	47,7	5,76	3,27	90,81	2,63	34,8	193,30	0,149	<0.020	0,181	0,025	<0.003	<0.020	<0.020	0,009	0,093	0,039	<0.020	<0.020	<0.015	<0.020	<0.020	1,048	0,069	<0.030	<0.010	0,021	1
BH18	8,55	12,8	0,45	0,18	30,18	0,53	47,1	20,94	0,595	<0.020	0,329	0,012	<0.003	<0.020	<0.020	0,005	0,151	<0.020	<0.020	<0.020	<0.015	<0.020	0,023	1,639	<0.005	<0.030	<0.010	<0.020	1
BH19	5,12	151	200,02	38,96	71,81	3,49	10,3	842,40	<0.020	<0.020	1,099	0,169	<0.003	<0.020	<0.020	0,027	118,668	0,882	<0.020	<0.020	<0.015	<0.020	<0.020	0,290	1,694	<0.030	<0.010	0,049	1
BH2	8,81	15,7	4,89	1,54	31,39	2,86	59,1	31,40	0,118	<0.020	0,163	0,011	<0.003	<0.020	<0.020	0,008	0,072	<0.020	0,430	<0.020	<0.015	<0.020	0,076	1,380	0,022	<0.030	<0.010	<0.020	1
BH20	7,94	73,4	5,26	1,67	166,95	2,27	168	172,20	0,095	<0.020	1,143	0,041	<0.003	<0.020	<0.020	0,018	0,070	<0.020	<0.020	<0.020	<0.015	<0.020	0,089	1,741	0,066	<0.030	<0.010	0,028	1
BH21	7,69	24,6	1,25	0,46	50,31	0,97	35,3	83,10	0,090	<0.020	0,172	0,005	<0.003	<0.020	<0.020	0,005	0,035	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	0,942	<0.005	<0.030	<0.010	<0.020	1
BH22	8,66	16,9	0,60	0,23	36,94	0,69	49,4	39,38	0,146	<0.020	0,303	<0.005	<0.003	<0.020	<0.020	0,007	0,076	<0.020	0,035	<0.020	<0.015	<0.020	<0.020	1,054	<0.005	<0.030	<0.010	<0.020	1
BH23	7,32	10,4	0,58	0,19	24,69	0,79	14,8	38,12	0,157	<0.020	0,102	0,005	<0.003	<0.020	<0.020	0,008	0,046	<0.020	0,083	<0.020	<0.015	<0.020	<0.020	0,970	<0.005	<0.030	<0.010	0,025	1
BH24	7,14	42,8	2,47	0,99	87,30	1,53	53,6	148,20	0,084	<0.020	0,839	0,019	<0.003	<0.020	<0.020	0,019	0,133	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,394	0,015	<0.030	<0.010	0,039	1
BH25	7,72	18,7	1,19	0,35	37,40	1,39	33,4	46,20	0,128	<0.020	0,103	0,007	<0.003	<0.020	<0.020	0,012	0,036	<0.020	0,032	<0.020	<0.015	<0.020	<0.020	1,053	<0.005	<0.030	<0.010	0,024	1
BH26	8,94	16,9	1,39	0,52	36,24	0,89	62,9	21,22	0,147	<0.020	0,120	0,006	<0.003	<0.020	<0.020	<0.005	0,032	<0.020	0,026	<0.020	<0.015	<0.020	<0.020	0,867	<0.005	<0.030	<0.010	<0.020	1
BH27	8,22	53,4	4,78	1,53	118,11	2,14	192	72,00	0,247	<0.020	1,501	0,191	<0.003	<0.020	<0.020	0,011	0,064	<0.020	<0.020	<0.020	<0.015	<0.020	0,027	1,334	0,180	<0.030	<0.010	<0.020	1
BH3	9,03	15,8	3,42	1,06	31,48	2,08	50,0	35,38	0,154	<0.020	0,113	<0.005	<0.003	<0.020	<0.020	0,009	0,100	<0.020	0,060	<0.020	<0.015	<0.020	<0.020	1,361	0,008	<0.030	<0.010	<0.020	1
BH4	8,77	41,7	3,52	1,20	88,79	1,81	73,2	129,30	0,808	<0.020	0,246	0,024	<0.003	<0.020	<0.020	0,016	0,478	<0.020	0,094	<0.020	<0.015	<0.020	0,068	2,723	0,025	<0.030	0,017	<0.020	1
BH5	9,66	28,8	2,13	0,78	67,08	1,96	134	15,22	0,959	0,041	0,397	0,047	<0.003	<0.020	<0.020	<0.005	0,343	<0.020	0,198	<0.020	<0.015	<0.020	0,022	3,252	0,023	<0.030	0,026	<0.020	1
BH6	7,99	87,0	32,45	15,67	141,91	4,34	48,4	405,00	<0.020	<0.020	0,152	0,038	<0.003	<0.020	<0.020	0,022	0,031	0,187	<0.020	<0.020	<0.015	<0.020	<0.020	0,813	0,247	<0.030	<0.010	0,020	1
BH7	6,89	48,8	15,95	4,67	195,73	5,14	31,3	295,90	0,082	0,022	0,550	0,036	<0.003	<0.020	<0.020	0,034	0,122	0,054	0,020	<0.020	<0.015	<0.020	0,020	2,602	0,050	<0.030	<0.010	0,048	1
BH8	7,93	25,8	3,60	1,12	53,03	1,32	40,1	80,99	0,424	<0.020	0,279	0,012	<0.003	<0.020	<0.020	0,019	0,124	<0.020	0,037	<0.020	<0.015	<0.020	0,033	1,619	0,006	<0.030	<0.010	<0.020	1
BH9	8,18	10,4	2,32	0,70	23,71	1,26	26,5	34,33	0,257	<0.020	0,114	0,007	<0.003	<0.020	<0.020	0,012	0,072	<0.020	0,038	<0.020	<0.015	<0.020	<0.020	1,479	<0.005	<0.030	<0.010	<0.020	1
BH1	7,28	4,39	0,653	0,263	9,865	0,8355	27,6	1,51	0,058	<0.020	0,483	<0.005	<0.003	<0.020	<0.020	0,006	0,066	<0.020	0,063	<0.020	<0.015	<0.020	<0.020	4,750	<0.005	<0.030	<0.010	<0.020	2
BH10	7,43	95,7	131,365	18,844	46,838	1,2605	60,2	336,26	<0.020	<0.020	3,601	0,039	<0.003	<0.020	<0.020	0,042	0,036	0,098	<0.020	<0.020	<0.015	<0.020	<0.020	4,677	1,019	<0.030	<0.010	0,028	2
BH11	7,76	181	263,079	63,173	80,721	1,5295	42,7	931,50	<0.020	<0.020	1,991	0,062	<0.003	<0.020	<0.020	0,034	0,027	0,278	<0.020	<0.020	<0.015	<0.020	0,022	3,909	2,645	<0.030	<0.010	0,025	2
BH12	7,38	12,8	0,419	0,139	22,958	0,475	22,7	13,45	0,259	<0.020	0,731	0,008	<0.003	<0.020	<0.020	0,006	0,158	<0.020	0,025	<0.020	<0.015	<0.020	<0.020	4,287	<0.005	<0.030	0,034	0,024	2
BH13	7,72	103	71,466	20,102	116,188	3,066	61,8	410,73	<0.020	<0.020	1,229	0,047	<0.003	<0.020	<0.020	0,021	0,028	0,029	<0.020	<0.020	<0.015	<0.020	0,027	2,381	0,483	<0.030	<0.010	0,025	2
BH14	7,41	11,6	2,101	1,052	17,175	2,2325	44,7	2,66	0,260	0,020	0,547	0,010	<0.003	<0.020	<0.020	0,006	0,374	<0.020	0,133	<0.020	<0.015	<0.020	<0.020	4,552	0,011	<0.030	<0.010	<0.020	2
BH15	7,56	12,8	1,964	0,601	19,98	2,156	46,0	4,75	0,052	<0.020	0,525	0,005	<0.003	<0.020	<0.020	<0.005	0,037	<0.020	0,058	<0.020	<0.015	<0.020	<0.020	4,820	0,011	<0.030	<0.010	0,030	2
BH16	8,20	30,5	0,567	0,147	60,162	1,1455	109	21,91	0,164	<0.020	0,765	<0.005	<0.003	<0.020	<0.020	<0.005	0,079	<0.020	0,159	<0.020	<0.015	<0.020	<0.020	4,023	<0.005	<0.030	0,015	<0.020	2
BH17	7,40	71,6	16,466	10,746	106,99	2,966	32,5	266,12	<0.020	<0.020	0,554	0,018	<0.003	<0.020	<0.020	0,005	<0.020	0,065	<0.020	<0.020	<0.015	<0.020	0,025	2,982	0,209	<0.030	<0.010	<0.020	2
BH18	7,92	24,0	0,357	<0.1	44,432	0,7145	80,6	3,92	0,371	<0.020	1,040	0,007	<0.003	<0.020	<0.020	0,012	0,118	<0.020	0,062	<0.020	<0.015	<0.020	0,039	4,126	<0.005	<0.030	0,021	<0.020	2
BH19	7,70	89,9	110,665	26,184	40,478	1,5715	59,8	367,03	<0.020	<0.020	1,372	0,084	<0.003	<0.020	<0.020	0,029	0,033	0,217	<0.020	<0.020	<0.015	<0.020	<0.020	1,192	1,147	<0.030	<0.010	0,035	2
BH2	7,60	14,5	2,644	0,887	23,67	2,022	47,5	12,02	0,331	0,031	0,505	0,010	<0.003	<0.020	<0.020	0,009	0,573	<0.020	0,262	<0.020	<0.015	<0.020	0,037	3,796	0,014	<0.030	<0.010	<0.020	2
BH20	7,76	29,8	0,723	0,212	53,323	0,963	44,2	65,37	0,247	<0.020	0,676	0,007	<0.003	<0.020	<0.020	0,010	0,111	<0.020	0,043	<0.020	<0.015	<0.020	0,025	3,063	<0.005	<0.030	0,025	0,023	2
BH21	8,18	70,6	4,963	1,858	135,101	2,327	125	143,64	0,070	<0.020	1,723	0,013	<0.003	<0.020	<0.020	0,018	0,044	<0.020	0,039	<0.020	<0.015	<0.020	0,077	4,962	0,059	<0.030	0,023	0,021	2

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH22	7,57	18,8	0,359	0,105	31,639	0,6525	46,3	18,10	0,203	<0.020	0,776	0,005	<0.003	<0.020	<0.020	0,015	0,133	<0.020	0,058	<0.020	<0.015	<0.020	0,031	3,183	<0.005	<0.030	<0.010	<0.020	2
BH23	6,96	16,9	1,211	0,367	31,093	0,9085	21,8	33,48	0,262	<0.020	0,623	0,007	<0.003	<0.020	<0.020	0,015	0,087	<0.020	0,103	<0.020	<0.015	<0.020	<0.020	3,669	<0.005	<0.030	<0.010	0,022	2
BH24	7,99	38,7	3,407	1,578	68,913	1,554	97,8	50,25	0,053	<0.020	1,200	0,012	<0.003	<0.020	<0.020	0,014	0,043	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,326	0,022	<0.030	<0.010	<0.020	2
BH25	7,62	28,6	1,477	0,403	49,937	1,6205	49,1	61,25	0,364	<0.020	0,532	0,012	<0.003	<0.020	<0.020	0,023	0,189	<0.020	0,079	<0.020	<0.015	<0.020	<0.020	4,797	0,010	<0.030	0,010	0,034	2
BH26	7,91	27,5	1,969	0,885	51,534	1,1635	82,7	33,94	0,231	<0.020	0,639	0,009	<0.003	<0.020	<0.020	0,015	0,209	<0.020	0,070	<0.020	<0.015	<0.020	<0.020	3,755	0,007	<0.030	0,016	<0.020	2
BH27	8,18	46,9	5,788	2,731	82,241	1,7505	136	26,59	0,037	<0.020	2,013	0,075	<0.003	<0.020	<0.020	0,015	0,028	<0.020	0,023	<0.020	<0.015	<0.020	0,025	4,626	0,113	<0.030	0,010	<0.020	2
BH3	7,67	17,4	0,88	0,363	31,936	1,523	53,8	16,85	0,398	<0.020	0,580	0,006	<0.003	<0.020	<0.020	0,007	0,695	<0.020	0,093	<0.020	<0.015	<0.020	<0.020	4,180	0,008	<0.030	<0.010	<0.020	2
BH4	7,69	41,5	0,88	0,358	79,092	1,489	46,3	113,35	0,641	<0.020	0,720	0,031	<0.003	<0.020	<0.020	0,018	0,470	<0.020	0,139	<0.020	<0.015	<0.020	0,068	4,093	0,015	<0.030	0,023	0,025	2
BH5	8,54	31,6	0,369	0,139	63,75	1,0355	137	3,09	0,296	0,060	0,864	0,012	<0.003	<0.020	<0.020	<0.005	0,101	<0.020	0,211	<0.020	<0.015	<0.020	0,029	5,982	0,006	<0.030	0,019	<0.020	2
BH6	7,35	80,4	28,352	14,977	105,135	3,3595	29,3	317,62	<0.020	<0.020	0,396	0,025	<0.003	<0.020	<0.020	0,025	0,037	0,084	<0.020	<0.020	<0.015	<0.020	0,034	1,783	0,272	<0.030	<0.010	0,023	2
BH7	7,10	54,6	5,141	1,786	93,748	1,834	19,8	182,67	0,030	<0.020	0,612	0,009	<0.003	<0.020	<0.020	0,018	0,034	<0.020	0,021	<0.020	<0.015	<0.020	0,030	3,198	0,042	<0.030	<0.010	<0.020	2
BH8	7,72	30,5	0,694	0,237	58,208	0,885	44,7	66,82	0,112	<0.020	0,709	0,005	<0.003	<0.020	<0.020	0,005	0,041	<0.020	0,085	<0.020	<0.015	<0.020	0,040	2,707	<0.005	<0.030	0,019	<0.020	2
BH9	7,24	15,7	0,412	0,105	26,803	0,769	28,2	31,61	0,088	<0.020	0,352	<0.005	<0.003	<0.020	<0.020	0,007	0,060	<0.020	0,036	<0.020	<0.015	<0.020	0,021	2,745	<0.005	<0.030	<0.010	<0.020	2
BH1	7,89	5,96	0,361	0,177	9,627	0,893	27,3	0,48	0,963	<0.020	0,853	0,011	<0.003	<0.020	<0.020	0,006	0,369	<0.020	0,050	<0.020	<0.015	<0.020	<0.020	6,772	<0.005	<0.030	0,012	<0.020	3
BH10	7,30	52,9	56,2	10,987	32,052	0,874	87,8	70,11	<0.020	<0.020	3,291	0,041	<0.003	<0.020	<0.020	0,013	0,032	0,039	<0.020	<0.020	<0.015	<0.020	<0.020	5,548	0,527	<0.030	<0.010	0,022	3
BH11	7,20	153	212,571	46,717	70,685	1,499	64,6	682,21	<0.020	<0.020	2,093	0,056	<0.003	<0.020	<0.020	0,023	0,023	0,249	<0.020	<0.020	<0.015	<0.020	<0.020	4,292	2,054	<0.030	<0.010	0,024	3
BH12	7,47	11,6	0,285	<0.1	21,947	0,546	34,1	18,26	0,837	<0.020	1,144	<0.005	<0.003	<0.020	<0.020	0,007	0,133	<0.020	0,020	<0.020	<0.015	<0.020	<0.020	6,293	<0.005	<0.030	0,048	<0.020	3
BH13	7,33	71,7	47,202	14,963	73,09	2,217	65,0	224,09	<0.020	<0.020	1,451	0,045	<0.003	<0.020	<0.020	0,020	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,714	0,361	<0.030	<0.010	0,025	3
BH14	8,12	10,4	1,911	0,857	16,709	2,1215	46,0	1,98	0,797	0,023	0,932	0,014	<0.003	<0.020	<0.020	0,006	0,300	<0.020	0,088	<0.020	<0.015	<0.020	<0.020	7,328	0,009	<0.030	<0.010	<0.020	3
BH15	8,46	9,72	1,51	0,421	15,652	1,837	47,7	3,94	0,171	<0.020	0,668	0,005	<0.003	<0.020	<0.020	0,006	0,048	<0.020	0,043	<0.020	<0.015	<0.020	<0.020	6,476	0,008	<0.030	<0.010	<0.020	3
BH16	8,82	32,8	0,951	0,266	66,404	1,055	130	19,25	0,297	0,021	1,210	0,005	<0.003	<0.020	<0.020	0,007	0,085	<0.020	0,117	<0.020	<0.015	<0.020	0,023	5,723	0,005	<0.030	0,023	<0.020	3
BH17	7,03	48,8	9,288	7,06	66,241	2,1995	24,6	150,94	0,121	<0.020	0,747	0,015	<0.003	<0.020	<0.020	0,020	0,041	0,022	<0.020	<0.020	<0.015	<0.020	<0.020	3,862	0,132	<0.030	<0.010	0,026	3
BH18	8,60	15,7	0,458	0,15	31,215	0,4735	59,2	4,52	1,108	<0.020	1,015	0,008	<0.003	<0.020	<0.020	0,009	0,144	<0.020	0,036	<0.020	<0.015	<0.020	0,025	4,899	<0.005	<0.030	0,028	<0.020	3
BH19	7,15	63,4	72,997	16,426	26,766	1,0275	58,6	204,05	<0.020	<0.020	1,345	0,045	<0.003	<0.020	<0.020	0,027	0,032	0,091	<0.020	<0.020	<0.015	<0.020	<0.020	1,622	0,671	<0.030	<0.010	0,037	3
BH2	8,23	13,9	2,273	0,806	23,75	1,9655	52,5	11,22	0,890	0,032	0,959	0,012	<0.003	<0.020	<0.020	0,007	0,486	<0.020	0,175	<0.020	<0.015	<0.020	0,025	5,987	0,010	<0.030	<0.010	<0.020	3
BH20	8,21	17,4	0,439	0,121	33,568	0,6395	47,4	12,24	0,825	<0.020	0,743	0,006	<0.003	<0.020	<0.020	0,007	0,114	<0.020	0,033	<0.020	<0.015	<0.020	<0.020	4,254	<0.005	<0.030	0,035	<0.020	3
BH21	8,37	47,5	2,543	1,065	91,238	1,6315	105	53,59	1,077	<0.020	1,773	0,015	<0.003	<0.020	<0.020	0,008	0,093	<0.020	0,034	<0.020	<0.015	<0.020	0,042	7,353	0,036	<0.030	0,036	<0.020	3
BH22	8,41	17,5	0,234	<0.1	35,394	0,5975	62,4	12,25	1,039	<0.020	0,998	0,007	<0.003	<0.020	<0.020	<0.005	0,189	<0.020	0,056	<0.020	<0.015	<0.020	0,023	5,186	<0.005	<0.030	0,022	<0.020	3
BH23	7,20	5,62	0,231	<0.1	8,257	0,3455	11,5	3,73	0,376	<0.020	0,238	0,007	<0.003	<0.020	<0.020	0,008	0,078	<0.020	0,029	<0.020	<0.015	<0.020	<0.020	3,136	<0.005	<0.030	<0.010	<0.020	3
BH24	7,50	26,9	2,734	1,353	47,104	1,237	78,1	9,20	0,767	<0.020	1,385	0,013	<0.003	<0.020	<0.020	0,017	0,076	<0.020	0,022	<0.020	<0.015	<0.020	<0.020	5,403	0,019	<0.030	0,013	<0.020	3
BH25	8,05	15,6	1,005	0,233	29,485	0,933	40,1	15,83	0,312	<0.020	0,684	0,005	<0.003	<0.020	<0.020	0,005	0,038	<0.020	0,059	<0.020	<0.015	<0.020	<0.020	3,582	0,007	<0.030	0,012	<0.020	3
BH26	8,54	21,7	1,076	0,594	40,842	0,8915	66,0	19,02	0,239	<0.020	0,699	0,005	<0.003	<0.020	<0.020	<0.005	0,034	<0.020	0,043	<0.020	<0.015	<0.020	<0.020	3,633	0,005	<0.030	0,018	<0.020	3
BH27	8,12	29,9	5,631	2,744	52,303	1,3235	109	5,88	0,103	<0.020	1,710	0,105	<0.003	<0.020	<0.020	0,007	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,435	0,136	<0.030	0,010	<0.020	3
BH3	8,66	12,8	0,511	0,142	23,778	1,329	55,7	8,56	0,267	0,028	0,670	<0.005	<0.003	<0.020	<0.020	0,005	0,110	<0.020	0,047	<0.020	<0.015	<0.020	<0.020	5,144	<0.005	<0.030	0,012	<0.020	3
BH4	8,83	34,6	14,538	2,798	29,494	2,7405	47,0	24,99	1,394	<0.020	0,691	0,034	<0.003	<0.020	<0.020	0,006	0,223	0,026	0,037	<0.020	<0.015	<0.020	0,029	6,409	0,071	<0.030	0,017	0,076	3
BH5	9,07	31,6	0,353	0,131	65,212	0,95	139	1,09	0,383	0,060	1,669	0,011	<0.003	<0.020	<0.020	0,007	0,097	<0.020	0,111	<0.020	<0.015	<0.020	0,026	10,548	<0.005	<0.030	0,023	<0.020	3
BH6	7,18	53,5	21,027	10,406	63,407	2,463	18,4	191,79	0,123	<0.020	0,624	0,023	<0.003	<0.020	<0.020	0,019	0,037	0,037	<0.020	<0.020	<0.015	<0.020	<0.020	2,399	0,223	<0.030	<0.010	0,022	3
BH7	7,57	30,0	1,746	0,585	50,63	1,09	16,7	75,15	1,102	<0.020	0,828	0,008	<0.003	<0.020	<0.020	0,008	0,103	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,955	0,010	<0.030	<0.010	<0.020	3
BH8	8,60	15,8	0,423	0,207	29,868	0,5385	41,7	4,28	0,682	<0.020	1,030	0,020	<0.003	<0.020	<0.020	0,009	0,208	<0.020	0,039	<0.020	<0.015	<0.020	<0.020	4,412	<0.005	<0.030	0,029	0,029	3
BH9	8,59	9,90	0,334	0,127	19,686	0,5705	38,4	21,32	0,239	<0.020	0,829	0,006	<0.003	<0.020	<0.020	0,008	0,077	<0.020	0,030	<0.020	<0.015	<0.020	<0.020	4,808	<0.005	<0.030	0,010	<0.020	3
BH1	8,41	6,45	0,302	0,253	11,208	0,604	31,5	0,48	0,345	<0.020	1,701	0,009	<0.003	<0.020	<0.020	<0.005	0,394	<0.020	0,044	<0.020	<0.015	<0.020	<0.020	8,103	<0.005	<0.030	0,019	0,021	4
BH10	7,28	48,8	50,931	12,661	27,673	0,674	67,5	40,61	0,027	<0.020	3,575	0,057	<0.003	<0.020	<0.020	0,015	0,080	0,036	<0.020	<0.020	<0.015	<0.020	<0.020	4,746	0,496	<0.030	<0.010	0,040	4
BH11	7,00	150	221,526	57,7	60,9	1,18	53,4	660,06	<0.020	<0.020	2,471	0,058	<0.003	<0.020	<0.020	0,024	0,053	0,275	<0.020	<0.020	<0.015	<0.020	<0.020	4,606	2,225	<0.030	<0.010	0,031	4
BH12	8,21	11,6	51,205	12,894	27,754	0,657	33,9	42,50	<0.020	<0.020	3,645	0,054	<0.003	<0.020	<0.020	0,015	0,065	0,036	<0.020	<0.020	<0.015	<0.020	<0.020	4,817	0,502	<0.030	0,000	0,028	4
BH13	8,06	72,8	221,325	58,158	60,864	1,346	28,2	664,24	<0.020	<0.020	2,495	0,059	<0.003	<0.020	<0.020	0,025	0,033	0,277	<0.020	<0.020	<0.015	<0.020	<0.020	4,622	2,229	<0.030	<0.010	0,034	4

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH14	8,05	10,6	1,433	0,793	19,264	1,805	41,3	1,49	0,499	0,023	1,523	0,015	<0.003	<0.020	<0.020	0,010	0,695	<0.020	0,079	<0.020	<0.015	<0.020	<0.020	6,379	0,008	<0.030	0,012	0,021	4
BH15	8,54	10,0	2,196	0,89	16,428	1,802	51,9	3,55	0,724	<0.020	1,162	0,020	<0.003	<0.020	<0.020	0,005	1,151	0,021	0,032	<0.020	<0.015	<0.020	<0.020	8,305	0,013	<0.030	<0.010	0,029	4
BH16	9,09	31,8	0,745	0,374	64,386	0,976	117	18,87	0,469	<0.020	1,901	0,011	<0.003	<0.020	<0.020	0,005	0,289	<0.020	0,074	<0.020	<0.015	<0.020	<0.020	8,520	0,006	<0.030	0,032	<0.020	4
BH17	7,59	37,1	7,705	6,061	51,609	2,11	24,5	105,34	0,130	<0.020	1,107	0,018	<0.003	<0.020	<0.020	0,015	0,050	0,021	<0.020	<0.020	<0.015	<0.020	<0.020	6,008	0,108	<0.030	<0.010	0,026	4
BH18	8,58	15,8	0,35	0,24	32,444	0,509	64,0	4,87	0,615	<0.020	1,141	0,014	<0.003	<0.020	<0.020	0,009	0,122	0,050	0,023	<0.020	<0.015	<0.020	<0.020	4,956	<0.005	<0.030	0,035	0,031	4
BH19	7,28	68,9	83,759	19,477	29,741	1,003	56,2	202,93	<0.020	<0.020	2,263	0,040	<0.003	<0.020	<0.020	0,018	0,056	0,062	<0.020	<0.020	<0.015	<0.020	<0.020	4,072	0,754	<0.030	<0.010	0,038	4
BH2	8,69	17,04	2,14	0,922	28,665	1,93	47,6	10,23	0,409	0,026	1,215	0,013	<0.003	<0.020	<0.020	0,005	0,567	<0.020	0,105	<0.020	<0.015	<0.020	<0.020	5,823	0,014	<0.030	<0.010	0,020	4
BH20	8,28	17,1	0,316	0,22	33,245	0,675	45,9	7,22	0,603	<0.020	1,075	0,006	<0.003	<0.020	<0.020	<0.005	0,052	<0.020	0,027	<0.020	<0.015	<0.020	<0.020	5,324	<0.005	<0.030	0,047	<0.020	4
BH21	8,42	40,5	1,719	0,962	80,207	1,482	87,2	22,88	0,817	<0.020	2,194	0,015	<0.003	<0.020	<0.020	0,008	0,085	<0.020	0,026	<0.020	<0.015	<0.020	0,032	8,407	0,030	<0.030	0,047	<0.020	4
BH22	8,45	17,6	0,266	0,223	36,965	0,627	69,0	8,12	0,503	<0.020	1,476	0,007	<0.003	<0.020	<0.020	0,005	0,192	<0.020	0,045	<0.020	<0.015	<0.020	<0.020	5,432	<0.005	<0.030	0,028	<0.020	4
BH23	8,20	10,4	0,255	0,213	16,72	0,564	27,4	5,12	0,450	<0.020	1,095	0,009	<0.003	<0.020	<0.020	0,006	0,099	<0.020	0,069	<0.020	<0.015	<0.020	<0.020	4,646	<0.005	<0.030	0,015	0,023	4
BH24	7,69	22,9	2,832	1,884	42,36	1,254	66,3	7,21	0,339	<0.020	1,842	0,018	<0.003	<0.020	<0.020	0,007	0,061	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,233	0,028	<0.030	0,021	<0.020	4
BH25	8,39	14,0	0,651	0,276	27,1	1,037	43,0	11,25	0,697	<0.020	1,142	<0.005	<0.003	<0.020	<0.020	0,006	0,064	<0.020	0,052	<0.020	<0.015	<0.020	<0.020	5,522	0,005	<0.030	0,018	<0.020	4
BH26	7,24	20,0	0,727	0,398	39,243	0,889	163	3,29	0,368	<0.020	1,080	0,008	<0.003	<0.020	<0.020	<0.005	0,057	<0.020	0,036	<0.020	<0.015	<0.020	<0.020	5,161	<0.005	<0.030	0,025	<0.020	4
BH27	8,16	30,0	6,268	3,538	53,126	1,339	108	3,20	0,076	<0.020	2,324	0,120	<0.003	<0.020	<0.020	0,006	0,023	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,445	0,154	<0.030	0,013	<0.020	4
BH3	9,02	14,0	0,772	0,439	26,252	1,355	64,7	6,45	0,545	<0.020	0,838	0,012	<0.003	<0.020	<0.020	0,006	0,682	<0.020	0,036	<0.020	<0.015	<0.020	<0.020	6,539	0,006	<0.030	0,015	0,025	4
BH4	9,00	30,6	0,469	0,429	57,22	0,85	62,6	26,85	0,419	<0.020	2,324	0,011	<0.003	<0.020	<0.020	0,006	0,228	<0.020	0,070	<0.020	<0.015	<0.020	0,030	6,723	0,006	<0.030	0,048	0,024	4
BH5	9,29	25,8	0,35	0,268	52,37	0,813	110	1,25	0,360	0,039	1,956	0,014	<0.003	<0.020	<0.020	<0.005	0,151	<0.020	0,051	<0.020	<0.015	<0.020	<0.020	8,569	0,005	<0.030	0,017	<0.020	4
BH6	8,02	41,8	16,762	8,813	47,22	2,745	20,8	125,54	0,088	<0.020	0,902	0,029	<0.003	<0.020	<0.020	0,017	0,043	0,031	<0.020	<0.020	<0.015	<0.020	<0.020	3,287	0,187	<0.030	<0.010	0,025	4
BH7	8,03	27,6	1,729	0,726	48,993	1,238	16,8	61,98	0,292	<0.020	1,165	0,010	<0.003	<0.020	<0.020	0,012	0,067	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,036	0,010	<0.030	<0.010	0,030	4
BH8	9,03	17,1	0,499	0,472	31,488	0,693	50,0	3,89	1,193	0,020	1,615	0,032	<0.003	<0.020	<0.020	0,008	0,587	<0.020	0,034	<0.020	<0.015	<0.020	<0.020	5,988	0,005	<0.030	0,041	0,048	4
BH9	8,93	10,5	0,333	0,26	20,943	0,625	42,0	17,21	0,357	<0.020	1,191	0,016	<0.003	<0.020	<0.020	0,011	0,189	<0.020	0,023	<0.020	<0.015	<0.020	<0.020	5,968	<0.005	<0.030	0,012	0,032	4
BH1	8,77	6,04	0,326	0,397	8,398	0,7985	26,5	0,38		0,023	1,232	0,022	<0.003	<0.020	<0.020	<0.005	0,803	<0.020	0,028	<0.020	<0.015	<0.020	0,022	10,734	<0.005	<0.030	0,018	<0.020	5
BH10	7,14	37,1	32,547	8,783	22,951	0,5515	82,9	6,23		<0.020	2,877	0,046	<0.003	<0.020	<0.020	0,026	0,057	0,021	<0.020	<0.020	<0.015	<0.020	<0.020	5,038	0,303	<0.030	<0.010	0,026	5
BH11	7,01	143	215,829	50,141	52,375	1,147	54,3	681,19		<0.020	2,267	0,042	<0.003	<0.020	<0.020	0,039	0,028	0,243	<0.020	<0.020	<0.015	<0.020	<0.020	5,442	1,868	<0.030	<0.010	0,027	5
BH12	7,69	11,7	0,681	0,418	22,308	0,3905	33,7	38,59		<0.020	1,314	0,006	<0.003	<0.020	<0.020	0,007	0,105	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,894	<0.005	<0.030	0,052	0,020	5
BH13	7,4	55,9	40,442	15,749	41,812	1,6625	55,7	154,00		<0.020	1,676	0,040	<0.003	<0.020	<0.020	0,023	0,030	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,410	0,351	<0.030	<0.010	0,035	5
BH14	8,26	10,4	1,386	0,831	17,139	1,9415	41,2	1,29		<0.020	1,406	0,016	<0.003	<0.020	<0.020	0,006	0,316	<0.020	0,042	<0.020	<0.015	<0.020	<0.020	7,859	0,007	<0.030	<0.010	0,020	5
BH15	8,64	10,8	1,483	0,66	14,153	1,9685	46,9	3,85		<0.020	1,302	0,032	<0.003	<0.020	<0.020	0,005	0,740	<0.020	0,022	<0.020	<0.015	<0.020	<0.020	13,961	0,008	<0.030	<0.010	<0.020	5
BH16	9,2	25,8	0,446	0,341	46,528	0,8	104	17,55		<0.020	1,563	0,009	<0.003	<0.020	<0.020	0,010	0,215	<0.020	0,038	<0.020	<0.015	<0.020	<0.020	7,818	<0.005	<0.030	0,025	<0.020	5
BH17	7,95	25,8	5,255	4,137	32,771	1,5915	19,3	74,74		<0.020	0,874	0,014	<0.003	<0.020	<0.020	0,013	0,048	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,638	0,067	<0.030	<0.010	0,025	5
BH18	8,82	17,1	0,39	0,312	31,813	0,455	62,8	5,20		<0.020	1,154	0,010	<0.003	<0.020	<0.020	0,011	0,174	<0.020	0,023	<0.020	<0.015	<0.020	0,034	6,088	<0.005	<0.030	0,034	0,024	5
BH19	7,08	50,6	55,416	13,552	20,999	0,747	51	137,64		<0.020	1,813	0,029	<0.003	<0.020	<0.020	0,020	0,037	0,042	<0.020	<0.020	<0.015	<0.020	<0.020	3,769	0,498	<0.030	<0.010	0,035	5
BH2	8,72	15,8	1,653	1,003	25,507	2,0995	44,2	9,88		0,020	1,193	0,022	<0.003	<0.020	<0.020	0,007	0,811	<0.020	0,066	<0.020	<0.015	<0.020	<0.020	8,776	0,009	<0.030	<0.010	<0.020	5
BH20	8,59	11,7	0,289	0,269	20,465	0,402	36,5	3,67		<0.020	0,755	0,006	<0.003	<0.020	<0.020	0,010	0,069	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,182	<0.005	<0.030	0,032	<0.020	5
BH21	8,84	45,9	3,333	1,693	81,191	1,7145	69,4	71,95		<0.020	1,855	0,018	<0.003	<0.020	<0.020	0,021	0,136	<0.020	<0.020	<0.020	<0.015	<0.020	0,045	8,856	0,055	<0.030	0,042	0,023	5
BH22	8,63	10,5	0,295	0,288	19,735	0,384	46,5	6,95		<0.020	0,772	0,008	<0.003	<0.020	<0.020	0,005	0,177	<0.020	0,022	<0.020	<0.015	<0.020	<0.020	4,616	<0.005	<0.030	0,016	<0.020	5
BH23	8,79	11,2	0,443	0,35	17,331	0,4655	31,2	5,07		<0.020	1,127	0,014	<0.003	<0.020	<0.020	0,012	0,138	<0.020	0,064	<0.020	<0.015	<0.020	<0.020	5,313	<0.005	<0.030	0,015	0,027	5
BH24	8,19	17,1	1,875	1,395	26,708	0,86	48,5	5,12		<0.020	1,436	0,014	<0.003	<0.020	<0.020	0,013	0,077	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,999	0,018	<0.030	0,018	0,020	5
BH25	8,56	10,5	0,283	0,26	18,489	0,6995	38,2	4,86		<0.020	1,030	0,006	<0.003	<0.020	<0.020	0,012	0,086	<0.020	0,037	<0.020	<0.015	<0.020	<0.020	5,227	<0.005	<0.030	0,015	<0.020	5
BH26	8,6	14	0,456	0,355	24,52	0,6325	54,3	10,73		<0.020	0,685	0,005	<0.003	<0.020	<0.020	0,008	0,052	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,879	<0.005	<0.030	0,016	<0.020	5
BH27	8,34	27,1	5,104	3,475	40,164	1,1145	89,6	2,56		<0.020	1,783	0,081	<0.003	<0.020	<0.020	0,010	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	0,025	5,857	0,124	<0.030	0,010	0,023	5
BH3	8,99	12,9	0,45	0,414	20,962	1,4725	60	4,23		<0.020	1,095	0,016	<0.003	<0.020	<0.020	<0.005	0,335	<0.020	0,038	<0.020	<0.015	<0.020	<0.020	8,696	<0.005	<0.030	0,016	<0.020	5
BH4	9,01	20,1	0,642	0,455	34,798	0,6675	31,8	31,89		<0.020	1,136	0,015	<0.003	<0.020	<0.020	0,015	0,247	<0.020	0,023	<0.020	<0.015	<0.020	0,023	4,912	0,006	<0.030	0,023	0,023	5
BH5	9,4	24,2	0,378	0,394	42,83	0,7645	105	5,45		0,028	1,809	0,018	<0.003	<0.020	<0.020	<0.005	0,198	<0.020	0,033	<0.020	<0.015	<0.020	<0.020	9,909	<0.005	<0.030	0,014	0,020	5

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH6	7,93	30	11,99	8,028	27,322	1,9155	21,1	90,01		<0.020	0,987	0,019	<0.003	<0.020	<0.020	0,030	0,067	0,032	<0.020	<0.020	<0.015	<0.020	<0.020	3,004	0,126	<0.030	<0.010	0,042	5
BH7	8,1	24,7	1,949	0,99	41,528	1,146	17,9	57,21		<0.020	1,265	0,009	<0.003	<0.020	<0.020	0,018	0,055	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,615	0,013	<0.030	<0.010	0,027	5
BH8	9,07	11,7	0,647	0,708	21,271	0,4945	39,6	3,10		<0.020	1,270	0,045	<0.003	<0.020	<0.020	0,013	0,635	<0.020	0,025	<0.020	<0.015	<0.020	<0.020	5,547	0,006	<0.030	0,034	0,058	5
BH9	8,88	11,4	0,298	0,384	14,584	0,532	43	10,25		<0.020	1,450	0,012	<0.003	<0.020	<0.020	0,012	0,162	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,736	<0.005	<0.030	0,013	0,027	5
BH1	8,69	7	0,356	0,44	10,751	0,58	25,4	1,69	0,779	<0.020	1,282	0,014	<0.003	<0.020	<0.020	0,012	1,023	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,741	0,007	<0.030	0,014	<0.020	6
BH10	6,52	149	287,933	58,382	22,61	0,9945	50,4	683,94	<0.020	<0.020	2,104	0,071	<0.003	<0.020	<0.020	0,055	5,278	0,969	<0.020	<0.020	<0.015	<0.020	<0.020	1,398	1,343	<0.030	<0.010	0,034	6
BH11	5,96	301	442,057	276,635	51,288	1,6335	29,7	1810,64	0,056	<0.020	1,766	0,057	<0.003	<0.020	<0.020	0,041	33,896	2,749	<0.020	0,164	<0.015	<0.020	<0.020	1,889	3,057	<0.030	<0.010	0,088	6
BH12	8,59	13	0,498	0,328	20,785	0,3455	13,3	37,12	0,137	<0.020	0,581	0,007	<0.003	<0.020	<0.020	0,015	0,137	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,389	0,007	<0.030	0,017	<0.020	6
BH13	6,41	153	235,504	82,214	43,787	3,3875	44,5	721,70	<0.020	<0.020	1,191	0,058	<0.003	0,030	<0.020	0,039	7,006	0,456	<0.020	0,047	<0.015	<0.020	<0.020	1,810	1,505	<0.030	<0.010	0,040	6
BH14	8,38	12	1,021	0,638	18,575	1,7515	40,4	1,86	0,300	<0.020	0,992	0,011	<0.003	<0.020	<0.020	0,008	0,348	<0.020	0,036	<0.020	<0.015	<0.020	<0.020	4,424	0,010	<0.030	<0.010	<0.020	6
BH15	8,53	11	1,28	0,575	14,439	1,652	43,2	4,01	0,422	<0.020	0,868	0,012	<0.003	<0.020	<0.020	0,013	0,645	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,665	0,011	<0.030	<0.010	<0.020	6
BH16	9,16	23	0,927	0,548	39,571	0,893	75,7	16,00	0,737	<0.020	0,739	0,026	<0.003	<0.020	<0.020	0,010	0,609	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,188	0,012	<0.030	0,011	<0.020	6
BH17	7,93	55	33,216	22,011	46,227	3,4825	14,7	207,33	0,081	<0.020	0,635	0,050	<0.003	<0.020	<0.020	0,038	0,068	0,170	<0.020	<0.020	<0.015	<0.020	<0.020	2,305	0,372	<0.030	<0.010	0,028	6
BH18	8,66	19	0,414	0,289	32,962	0,511	39,9	25,50	0,300	<0.020	0,803	0,008	<0.003	<0.020	<0.020	0,019	0,114	<0.020	<0.020	<0.020	<0.015	<0.020	0,021	2,243	0,007	<0.030	0,017	<0.020	6
BH19	6,13	158	273,949	84,334	19,122	1,586	22,7	771,92	<0.020	<0.020	1,285	0,074	<0.003	<0.020	<0.020	0,042	28,300	1,502	<0.020	<0.020	<0.015	<0.020	<0.020	1,097	2,264	<0.030	<0.010	0,028	6
BH2	8,57	17	1,449	0,758	27,286	1,9755	49,4	15,21	0,216	0,022	1,208	0,011	<0.003	<0.020	<0.020	0,012	0,300	<0.020	0,055	<0.020	<0.015	<0.020	<0.020	3,472	0,013	<0.030	<0.010	<0.020	6
BH20	8,5	12	0,344	0,316	17,656	0,391	25,2	23,27	0,220	<0.020	0,443	0,010	<0.003	<0.020	<0.020	0,009	0,136	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,996	0,007	<0.030	0,018	<0.020	6
BH21	7,50	87	52,239	19,627	107,151	4,3	41,4	298,08	0,023	<0.020	1,122	0,060	<0.003	<0.020	<0.020	0,038	0,111	0,039	<0.020	<0.020	<0.015	<0.020	0,040	2,919	0,739	<0.030	<0.010	0,021	6
BH22	8,71	16	0,311	0,287	24,816	0,4475	38,7	20,54	0,191	<0.020	0,652	0,009	<0.003	<0.020	<0.020	0,009	0,135	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,526	0,007	<0.030	<0.010	<0.020	6
BH23	7,09	17	0,727	0,36	24,575	0,799	12,4	47,03	0,143	<0.020	0,460	0,008	<0.003	<0.020	<0.020	0,018	0,333	<0.020	0,022	<0.020	<0.015	<0.020	<0.020	2,013	0,008	<0.030	<0.010	<0.020	6
BH24	6,71	49	30,079	19,499	36,954	2,358	15,2	162,68	<0.020	<0.020	0,919	0,042	<0.003	<0.020	<0.020	0,047	0,076	0,072	<0.020	<0.020	<0.015	<0.020	<0.020	2,077	0,194	<0.030	<0.010	0,029	6
BH25	8,37	13	0,387	0,353	20,718	0,967	24,4	32,16	0,257	<0.020	0,489	0,012	<0.003	<0.020	<0.020	0,014	0,143	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,647	0,008	<0.030	<0.010	0,023	6
BH26	8,62	19	1,225	0,614	29,484	0,8815	42,1	31,25	0,314	<0.020	0,594	0,012	<0.003	<0.020	<0.020	0,015	0,339	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,550	0,009	<0.030	0,010	<0.020	6
BH27	7,68	48	29,122	18,059	43,598	1,757	61,2	100,30	0,022	<0.020	1,654	0,166	<0.003	<0.020	<0.020	0,022	0,098	0,023	<0.020	<0.020	<0.015	<0.020	<0.020	3,586	0,518	<0.030	<0.010	<0.020	6
BH3	8,79	13	0,538	0,447	21,566	1,5585	46,0	10,06	0,473	<0.020	0,751	0,010	<0.003	<0.020	<0.020	0,010	0,806	<0.020	0,029	<0.020	<0.015	<0.020	<0.020	3,290	0,009	<0.030	<0.010	<0.020	6
BH4	8,89	40	10,248	3,122	70,599	1,793	24,7	125,82	0,468	<0.020	0,955	0,036	<0.003	<0.020	<0.020	0,011	0,290	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,649	0,039	<0.030	0,011	<0.020	6
BH5	9,25	37	2,844	1,144	78,614	2,098	236	31,52	0,772	0,026	1,852	0,080	<0.003	<0.020	<0.020	0,030	0,755	<0.020	0,028	<0.020	<0.015	<0.020	<0.020	5,694	0,050	<0.030	0,017	0,049	6
BH6	8,12	48	40,742	20,839	26,595	3,144	19,2	186,36	0,084	<0.020	0,624	0,047	<0.003	<0.020	<0.020	0,039	0,071	0,178	<0.020	<0.020	<0.015	<0.020	<0.020	2,003	0,336	<0.030	<0.010	0,026	6
BH7	5,62	59	39,265	13,67	53,991	3,2935	5,58	218,78	0,064	<0.020	0,889	0,089	<0.003	<0.020	<0.020	0,037	6,204	0,510	<0.020	<0.020	<0.015	<0.020	<0.020	3,477	0,318	<0.030	<0.010	0,274	6
BH8	8,90	14	3,118	1,25	24,532	0,77	34,1	13,97	0,839	<0.020	0,849	0,019	<0.003	<0.020	<0.020	0,009	0,343	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,123	0,011	<0.030	0,020	<0.020	6
BH9	8,67	11	2,72	0,989	18,209	0,841	22,5	24,34	0,181	<0.020	0,538	0,012	<0.003	<0.020	<0.020	0,011	0,103	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,694	0,010	<0.030	<0.010	<0.020	6
BH1	8,45	**5,81**	<0.1	0,111	11,276	0,44	25,85	0,51	0,312	0,023	0,988	0,006	<0.003	<0.020	<0.020	<0.005	0,399	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,695	<0.005	<0.030	0,014	<0.020	7
BH10	7,28	**87,6**	172,667	31,787	13,692	0,401	35,5	380,34	<0.020	<0.020	2,393	0,020	<0.003	<0.020	<0.020	0,012	0,034	0,073	<0.020	<0.020	<0.015	<0.020	0,020	2,976	0,768	<0.030	<0.010	<0.020	7
BH11	6,81	**138**	357,931	167,944	45,908	1,176	104,00	1243,76	<0.020	<0.020	1,671	0,028	<0.003	<0.020	<0.020	0,015	0,029	0,533	<0.020	0,025	<0.015	<0.020	0,020	2,506	2,398	<0.030	<0.010	<0.020	7
BH12	7,17	**10,4**	0,38	0,106	21,924	0,352	15,40	18,51	0,043	<0.020	0,889	<0.005	<0.003	<0.020	<0.020	0,006	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,362	<0.005	<0.030	0,018	<0.020	7
BH13	7,06	**124**	166,284	58,995	39	2,79	69,00	493,31	<0.020	<0.020	1,209	0,035	<0.003	<0.020	<0.020	0,023	0,033	0,095	<0.020	<0.020	<0.015	<0.020	0,038	3,097	0,825	<0.030	<0.010	0,026	7
BH14	7,99	**10,4**	1,213	0,475	13,975	1,41	38,50	1,20	0,107	<0.020	0,964	0,006	<0.003	<0.020	<0.020	<0.005	0,125	<0.020	0,028	<0.020	<0.015	<0.020	<0.020	4,315	0,008	<0.030	<0.010	<0.020	7
BH15	8,33	**8,22**	1,655	0,392	9,732	1,336	37,10	3,85	0,266	<0.020	0,739	0,007	<0.003	<0.020	<0.020	<0.005	0,386	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,660	0,011	<0.030	<0.010	<0.020	7
BH16	8,58	**21,8**	0,309	0,175	43,229	0,915	97,33	15,98	0,289	<0.020	0,798	0,010	<0.003	<0.020	<0.020	<0.005	0,294	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,265	0,007	<0.030	0,012	<0.020	7
BH17	6,89	**50,6**	32,6	25,645	23,948	2,909	24,26	174,44	<0.020	<0.020	0,710	0,020	<0.003	<0.020	<0.020	0,016	0,054	0,138	<0.020	<0.020	<0.015	<0.020	<0.020	2,804	0,317	<0.030	<0.010	<0.020	7
BH18	8,16	**17,6**	0,143	<0.1	33,984	0,526	53,10	7,85	0,111	<0.020	0,834	<0.005	<0.003	<0.020	<0.020	<0.005	0,056	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,576	<0.005	<0.030	0,018	<0.020	7
BH19	6,94	**99,9**	141,566	44,348	16,103	0,845	43,10	401,76	<0.020	<0.020	1,460	0,025	<0.003	<0.020	<0.020	0,020	0,034	0,113	<0.020	<0.020	<0.015	<0.020	0,022	1,688	1,141	<0.030	<0.010	<0.020	7
BH2	8,23	**14**	2,016	0,776	24,351	2,101	46,8	12,22	0,224	<0.020	1,128	0,009	<0.003	<0.020	<0.020	<0.005	0,385	<0.020	0,049	<0.020	<0.015	<0.020	0,026	4,081	0,016	<0.030	<0.010	<0.020	7
BH20	7,98	**12,8**	0,113	<0.1	25,641	0,566	45,50	13,32	0,134	<0.020	0,483	0,005	<0.003	<0.020	<0.020	<0.005	0,065	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,274	<0.005	<0.030	0,018	<0.020	7
BH21	7,5	**74,7**	44,695	17,993	87,697	3,665	71,20	206,72	0,025	<0.020	1,095	0,024	<0.003	<0.020	<0.020	0,017	0,029	0,027	<0.020	<0.020	<0.015	<0.020	0,038	4,022	0,640	<0.030	<0.010	<0.020	7

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH22	8,14	**15,8**	0,112	0,135	33,143	0,627	55,00	7,01	0,168	<0.020	0,671	0,005	<0.003	<0.020	<0.020	0,005	0,157	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,567	<0.005	<0.030	<0.010	<0.020	7
BH23	7,5	**9,28**	<0.1	<0.1	13,933	0,416	13,95	21,54	0,101	<0.020	0,446	<0.005	<0.003	<0.020	<0.020	0,006	0,075	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,298	<0.005	<0.030	<0.010	<0.020	7
BH24	7,14	**32,9**	19,755	13,546	22,419	1,327	41,78	71,25	0,045	<0.020	1,013	0,021	<0.003	<0.020	<0.020	0,011	0,050	0,025	<0.020	<0.020	<0.015	<0.020	0,029	3,078	0,125	<0.030	<0.010	<0.020	7
BH25	7,87	**11,1**	0,188	<0.1	16,912	0,882	30,20	13,23	0,119	<0.020	0,551	0,006	<0.003	<0.020	<0.020	0,012	0,095	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,205	0,005	<0.030	<0.010	<0.020	7
BH26	8,4	**12,9**	0,367	0,186	26,546	0,971	57,20	10,91	0,064	<0.020	0,515	<0.005	<0.003	<0.020	<0.020	<0.005	0,040	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,806	0,005	<0.030	0,013	<0.020	7
BH27	7,81	**40,6**	25,663	17,338	26,374	1,186	64,40	76,45	<0.020	<0.020	1,242	0,050	<0.003	<0.020	<0.020	0,012	0,023	<0.020	<0.020	<0.020	<0.015	<0.020	0,022	3,429	0,399	<0.030	<0.010	<0.020	7
BH3	8,18	**11,4**	0,864	0,354	17,911	1,722	47,9		0,115	<0.020	0,921	0,005	<0.003	<0.020	<0.020	0,007	0,200	<0.020	0,026	<0.020	<0.015	<0.020	<0.020	5,598	0,013	<0.030	<0.010	<0.020	7
BH4	8,67	**47,6**	9,98	3,628	78,835	2,167	53,2	104,83	1,474	<0.020	1,287	0,033	<0.003	<0.020	<0.020	0,020	3,653	0,089	<0.020	0,038	<0.015	<0.020	0,036	7,941	0,115	<0.030	0,026	1,385	7
BH5	8,66	**24,7**	15,968	3,754	11,687	2,184	124,99	25,67	0,619	<0.020	0,156	0,064	<0.003	<0.020	<0.020	0,008	0,628	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,947	0,094	<0.030	<0.010	0,152	7
BH6	7,68	**43**	30,732	18,601	19,74	2,245	12,57	154,18	0,027	<0.020	0,711	0,020	<0.003	<0.020	<0.020	0,021	0,033	0,072	<0.020	<0.020	<0.015	<0.020	0,029	1,972	0,241	<0.030	<0.010	0,021	7
BH7	6,63	**41,8**	30,477	11,464	35,453	2,267	12,12	158,65	<0.020	<0.020	0,665	0,019	<0.003	<0.020	<0.020	0,016	0,033	0,122	<0.020	0,020	<0.015	<0.020	<0.020	3,451	0,186	<0.030	<0.010	0,028	7
BH8	8,81	**15,1**	10,279	2,595	15,306	1,523	44	11,83	0,710	<0.020	0,496	0,041	<0.003	<0.020	<0.020	0,005	0,485	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,549	0,053	<0.030	0,016	0,045	7
BH9	8,1	**8,44**	<0.1	<0.1	13,266	0,436	23,5	12,42	0,123	<0.020	0,491	0,008	<0.003	<0.020	<0.020	0,006	0,100	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,904	<0.005	<0.030	<0.010	<0.020	7
BH1	8,32	6,69	0,2486	0,1559	7,4738	0,3619	19,2	0,50	0,525	<0.020	0,618	0,008	<0.003	<0.020	<0.020	<0.005	0,791	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,289	<0.005	<0.030	0,015	<0.020	8
BH10	7,66	73,3	131,686	23,3012	14,1519	0,3865	24,7	343,49	0,040	<0.020	2,159	0,027	<0.003	<0.020	<0.020	0,041	0,041	0,048	<0.020	<0.020	<0.015	<0.020	<0.020	4,143	0,642	<0.030	<0.010	0,039	8
BH11	6,79	202	418,5206	130,5172	25,8535	0,7316	18,0	1505,91	0,028	<0.020	1,378	0,037	<0.003	<0.020	<0.020	0,043	0,127	0,364	<0.020	<0.020	<0.015	<0.020	<0.020	4,720	2,255	<0.030	<0.010	0,027	8
BH12	8,49	8,31	0,331	<0.1	12,9626	0,291	9,40	6,60	0,189	<0.020	0,513	<0.005	<0.003	<0.020	<0.020	0,016	0,118	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,989	<0.005	<0.030	0,020	<0.020	8
BH13	7,78	98,6	160,3304	49,1052	24,9148	1,5591	27,2	571,88	0,044	<0.020	1,043	0,040	<0.003	<0.020	<0.020	0,043	0,036	0,030	<0.020	<0.020	<0.015	<0.020	<0.020	5,145	0,889	<0.030	<0.010	0,029	8
BH14	8,35	9,51	0,592	0,2269	15,5999	1,2106	38,7	1,16	0,158	<0.020	1,166	<0.005	<0.003	<0.020	<0.020	0,007	0,231	<0.020	0,027	<0.020	<0.015	<0.020	<0.020	6,611	<0.005	<0.030	<0.010	<0.020	8
BH15	8,78	7,91	1,3256	0,381	12,8216	1,2826	40,3	3,54	0,640	<0.020	0,915	0,012	<0.003	<0.020	<0.020	0,010	1,049	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,350	<0.005	<0.030	<0.010	<0.020	8
BH16	9,01	19,4	0,5045	0,1601	37,2922	0,694	85,1	15,60	0,300	<0.020	1,143	0,009	<0.003	<0.020	<0.020	0,009	0,277	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,722	<0.005	<0.030	0,018	<0.020	8
BH17	7,55	43,0	32,0736	24,4284	22,978	2,3221	11,1	200,88	0,056	<0.020	0,619	0,019	<0.003	<0.020	<0.020	0,024	0,036	0,062	<0.020	<0.020	<0.015	<0.020	<0.020	2,813	0,330	<0.030	<0.010	0,024	8
BH18	8,90	13,1	0,2502	<0.1	27,217	0,3995	37,7	8,21	0,411	<0.020	0,782	<0.005	<0.003	<0.020	<0.020	0,009	0,086	<0.020	<0.020	<0.020	<0.015	<0.020	0,024	4,081	<0.005	<0.030	0,029	<0.020	8
BH19	6,96	69,3	119,4499	29,27	15,3383	0,6924	41,2	350,33	0,038	<0.020	1,382	0,023	<0.003	<0.020	<0.020	0,035	<0.020	0,066	<0.020	<0.020	<0.015	<0.020	<0.020	2,848	0,816	<0.030	<0.010	0,031	8
BH2	8,12	14,8	1,0701	0,412	21,7788	1,4831	45,9	11,08	0,094	0,031	1,058	<0.005	<0.003	<0.020	<0.020	0,013	0,166	<0.020	0,048	<0.020	<0.015	<0.020	<0.020	5,393	0,006	<0.030	<0.010	<0.020	8
BH20	8,20	13,1	0,3034	<0.1	27,1256	0,5898	49,4	8,12	0,066	<0.020	0,529	<0.005	<0.003	<0.020	<0.020	<0.005	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,401	<0.005	<0.030	0,022	<0.020	8
BH21	7,61	35,1	13,2141	5,8868	47,9171	1,9772	68,7	79,10	0,041	<0.020	1,016	0,027	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,959	0,227	<0.030	<0.010	0,022	8
BH22	8,45	15,3	0,2139	0,1343	31,485	0,5873	53,3	7,12	0,291	<0.020	0,796	0,007	<0.003	<0.020	<0.020	0,016	0,361	<0.020	<0.020	<0.020	<0.015	<0.020	0,026	3,931	<0.005	<0.030	0,011	<0.020	8
BH23	7,87	8,57	0,1685	<0.1	14,9449	0,4418	22,8	8,46	0,145	<0.020	0,551	<0.005	<0.003	<0.020	<0.020	0,017	0,076	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,596	<0.005	<0.030	<0.010	<0.020	8
BH24	7,24	22,1	10,5454	7,9602	19,6193	1,0251	69,4	9,70	0,048	<0.020	0,998	0,026	<0.003	<0.020	<0.020	0,020	0,026	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,211	0,089	<0.030	<0.010	<0.020	8
BH25	8,31	8,13	0,2609	<0.1	14,6532	0,7363	28,4	12,86	0,061	<0.020	0,571	<0.005	<0.003	<0.020	<0.020	0,013	0,034	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,313	<0.005	<0.030	<0.010	0,021	8
BH26	8,30	12,6	1,0708	0,4563	24,757	0,9341	47,1		0,268	<0.020	0,828	0,009	<0.003	<0.020	<0.020	0,008	0,504	<0.020	<0.020	<0.020	<0.015	<0.020	0,024	4,903	<0.005	<0.030	0,011	<0.020	8
BH27	7,82	31,1	20,6097	14,6725	27,5387	1,1433	87,7	41,10	0,053	<0.020	1,375	0,058	<0.003	<0.020	<0.020	0,023	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,197	0,338	<0.030	<0.010	0,030	8
BH3	8,10	9,30	0,65	0,197	16,2982	1,3975	42,7		0,096	<0.020	0,855	<0.005	<0.003	<0.020	<0.020	0,010	0,193	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,397	<0.005	<0.030	<0.010	<0.020	8
BH4	8,04	11,1	0,6	0,1678	22,4246	0,7658	14,1	30,83	0,284	<0.020	0,372	0,010	<0.003	<0.020	<0.020	0,008	0,219	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,040	0,008	<0.030	<0.010	<0.020	8
BH5	8,44	12,1	0,2599	<0.1	22,8688	0,5508	61,2	18,56	0,186	0,021	0,784	0,011	<0.003	<0.020	<0.020	0,009	0,156	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,348	<0.005	<0.030	<0.010	<0.020	8
BH6	8,00	28,5	22,448	14,7886	17,8767	1,8676	13,9	124,27	0,050	<0.020	0,710	0,022	<0.003	<0.020	<0.020	0,036	0,022	0,050	<0.020	<0.020	<0.015	<0.020	<0.020	2,867	0,198	<0.030	<0.010	0,030	8
BH7	6,84	27,9	19,4044	7,8531	24,4507	1,5644	9,76	109,56	0,044	<0.020	0,655	0,017	<0.003	<0.020	<0.020	0,038	0,044	0,068	<0.020	<0.020	<0.015	<0.020	<0.020	4,874	0,135	<0.030	<0.010	0,037	8
BH8	8,96	11,7	0,4821	0,5997	22,3615	0,603	37,5	11,00	1,578	<0.020	1,003	0,037	<0.003	<0.020	<0.020	0,020	0,823	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,863	<0.005	<0.030	0,030	0,049	8
BH9	8,07	6,81	0,1637	<0.1	12,4246	0,4057	22,8	11,86	0,079	<0.020	0,509	<0.005	<0.003	<0.020	<0.020	0,006	0,056	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,598	<0.005	<0.030	<0.010	<0.020	8
BH1	8,06	3,03	0,2011	<0.1	6,4064	0,4061	17,6	0,46	0,290	<0.020	0,416	<0.005	<0.003	<0.020	<0.020	0,005	0,439	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,607	<0.005	<0.030	0,015	<0.020	9
BH10	7,72	55,8	95,9089	16,173	12,6864	0,4163	26,7	206,85	0,051	<0.020	1,800	0,026	<0.003	<0.020	<0.020	0,042	0,033	0,032	<0.020	<0.020	<0.015	<0.020	<0.020	4,033	0,494	<0.030	<0.010	0,038	9
BH11	6,97	157	330,5091	68,6574	19,8392	0,6904	30,9	1029,35	0,036	<0.020	1,021	0,035	<0.003	<0.020	<0.020	0,051	0,023	0,166	<0.020	<0.020	<0.015	<0.020	<0.020	3,981	1,601	<0.030	<0.010	0,040	9
BH12	8,37	7,7	0,2783	<0.1	12,6711	0,233	10,53	7,45	0,128	<0.020	0,490	<0.005	<0.003	<0.020	<0.020	0,011	0,067	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,005	<0.005	<0.030	0,017	<0.020	9
BH13	7,56	88,7	147,0075	39,5461	21,0714	1,4492	25,96	453,03	0,055	<0.020	0,980	0,038	<0.003	<0.020	<0.020	0,056	0,032	0,032	<0.020	<0.020	<0.015	<0.020	<0.020	4,560	0,816	<0.030	<0.010	0,040	9

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH14	8,45	9,47	0,6068	0,2696	14,6482	1,2275	41,6	1,55	0,190	0,024	1,007	<0.005	<0.003	<0.020	<0.020	0,015	0,283	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,027	<0.005	<0.030	<0.010	<0.020	9
BH15	8,72	8,19	1,2854	0,247	12,1193	1,3707	40,88	3,12	0,194	<0.020	0,697	0,006	<0.003	<0.020	<0.020	0,005	0,254	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,771	<0.005	<0.030	<0.010	<0.020	9
BH16	9,21	19,8	0,4898	0,2345	36,971	0,8074	93,94	13,22	0,546	<0.020	0,944	0,015	<0.003	<0.020	<0.020	0,020	0,638	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,139	<0.005	<0.030	0,017	<0.020	9
BH17	7,81	26,9	18,4499	13,5912	15,6648	1,6456	11,55	102,44	0,105	<0.020	0,555	0,013	<0.003	<0.020	<0.020	0,029	0,101	0,027	<0.020	<0.020	<0.015	<0.020	<0.020	2,841	0,183	<0.030	<0.010	0,032	9
BH18	8,81	10,3	0,2399	<0.1	24,7239	0,4013	40,8	8,01	0,294	<0.020	0,622	<0.005	<0.003	<0.020	<0.020	0,009	0,079	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,561	<0.005	<0.030	0,024	<0.020	9
BH19	7,14	53,5	85,4908	17,3346	13,2401	0,5681	44,59	225,90	0,047	<0.020	1,215	0,030	<0.003	<0.020	<0.020	0,038	<0.020	0,043	<0.020	<0.020	<0.015	<0.020	<0.020	3,522	0,562	<0.030	<0.010	0,043	9
BH2	8,16	11,5	1,0574	0,3971	18,552	1,4566	46,55	10,86	0,126	0,026	0,906	<0.005	<0.003	<0.020	<0.020	0,009	0,206	<0.020	0,035	<0.020	<0.015	<0.020	<0.020	4,944	0,006	<0.030	<0.010	<0.020	9
BH20	8,59	9,81	0,423	<0.1	17,2425	0,356	35,3	5,13	0,071	<0.020	0,413	<0.005	<0.003	<0.020	<0.020	0,009	0,026	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,773	<0.005	<0.030	0,022	<0.020	9
BH21	8,06	25,7	10,9981	4,948	34,2525	1,3273	42,28	53,93	0,045	<0.020	1,022	0,027	<0.003	<0.020	<0.020	0,029	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,624	0,185	<0.030	0,013	0,030	9
BH22	8,72	10,3	0,2762	<0.1	22,2959	0,4009	44,71	6,88	0,074	<0.020	0,656	<0.005	<0.003	<0.020	<0.020	0,006	0,028	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,594	<0.005	<0.030	0,010	<0.020	9
BH23	8,28	6,33	0,1982	<0.1	11,3575	0,3608	19,94	7,11	0,049	<0.020	0,475	<0.005	<0.003	<0.020	<0.020	0,006	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,303	<0.005	<0.030	<0.010	<0.020	9
BH24	7,6	12,7	6,7112	4,9835	13,2993	0,6056	43,84	1,01	0,049	<0.020	0,877	0,019	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,373	0,056	<0.030	<0.010	<0.020	9
BH25	8,35	7,51	0,263	<0.1	12,5044	0,681	27,5	13,14	0,047	<0.020	0,512	<0.005	<0.003	<0.020	<0.020	0,005	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,888	<0.005	<0.030	<0.010	<0.020	9
BH26	8,51	12,1	0,6411	0,1998	19,472	0,8891	44,96		0,050	<0.020	0,639	<0.005	<0.003	<0.020	<0.020	0,005	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,251	<0.005	<0.030	<0.010	<0.020	9
BH27	7,96	25,6	15,5378	10,5955	22,1001	0,9706	85,58	16,45	0,056	<0.020	1,144	0,051	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,283	0,252	<0.030	<0.010	0,022	9
BH3	8,09	7,75	0,8043	0,2527	12,037	1,4985	35,14		0,098	<0.020	0,622	<0.005	<0.003	<0.020	<0.020	0,006	0,160	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,076	0,006	<0.030	<0.010	<0.020	9
BH4	8,18	12,8	0,9174	0,3208	27,5857	0,6406	14,14	34,58	0,345	<0.020	0,491	0,012	<0.003	<0.020	<0.020	0,014	0,310	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,157	0,013	<0.030	<0.010	<0.020	9
BH5	8,84	22,8	0,3323	<0.1	47,0959	0,7914	121	17,22	0,272	0,043	1,727	0,012	<0.003	<0.020	<0.020	0,012	0,297	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,338	<0.005	<0.030	0,026	<0.020	9
BH6	8	19,8	13,1221	9,5933	13,133	1,2665	15,6	63,36	0,073	<0.020	0,644	0,016	<0.003	<0.020	<0.020	0,025	0,058	0,039	<0.020	<0.020	<0.015	<0.020	<0.020	2,547	0,115	<0.030	<0.010	0,031	9
BH7	7,4	21,9	16,5715	6,8519	19,3401	1,3369	12,69	83,39	0,049	<0.020	0,605	0,020	<0.003	<0.020	<0.020	0,028	<0.020	0,048	<0.020	<0.020	<0.015	<0.020	<0.020	5,543	0,121	<0.030	<0.010	0,026	9
BH8	8,84	11,8	0,4151	0,5624	22,3429	0,561	40,3	10,00	1,218	<0.020	0,758	0,032	<0.003	<0.020	<0.020	0,009	0,856	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,569	<0.005	<0.030	0,027	0,047	9
BH9	8,95	7,86	0,18	<0.1	12,7254	0,3956	24,3	11,53	0,147	<0.020	0,585	0,006	<0.003	<0.020	<0.020	0,008	0,103	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,338	<0.005	<0.030	<0.010	<0.020	9
BH1	8,24	6,69	0,1905	<0.1	8,599	0,3263	24,07	0,44	0,297	<0.020	0,866	<0.005	<0.003	<0.020	<0.020	0,014	0,327	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,517	<0.005	<0.030	0,012	<0.020	10
BH10	7,87	8,79	94,4661	15,9226	14,9708	0,5171	56,50	177,83	0,042	<0.020	1,684	0,029	<0.003	<0.020	<0.020	0,045	<0.020	0,041	<0.020	<0.020	<0.015	<0.020	<0.020	4,368	0,434	<0.030	<0.010	0,031	10
BH11	7,77	11,4	320,7184	68,5732	22,2419	0,6587	27,80	832,85	0,030	<0.020	0,998	0,035	<0.003	<0.020	<0.020	0,043	<0.020	0,134	<0.020	<0.020	<0.015	<0.020	<0.020	3,866	1,421	<0.030	<0.010	0,027	10
BH12	8,5	7,12	0,2789	<0.1	13,5635	0,2593	10,70	5,39	0,179	<0.020	0,529	<0.005	<0.003	<0.020	<0.020	0,008	0,043	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,149	<0.005	<0.030	0,015	<0.020	10
BH13	8,63	9,4	101,5298	26,33	18,0544	1,1893	170,00	281,41	0,045	<0.020	0,854	0,029	<0.003	<0.020	<0.020	0,039	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,451	0,532	<0.030	<0.010	0,028	10
BH14	8,24	6,69	0,1515	0,1579	10,4435	1,0936	32,00	1,40	0,166	<0.020	0,552	<0.005	<0.003	<0.020	<0.020	0,013	0,114	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,872	<0.005	<0.030	<0.010	<0.020	10
BH15	8,39	6,52	1,6016	0,2175	8,1066	1,1231	33,30	3,42	0,261	<0.020	0,513	0,006	<0.003	<0.020	<0.020	0,005	0,330	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,019	0,009	<0.030	<0.010	<0.020	10
BH16	9,02	17,4	0,3212	0,1287	39,2597	0,7196	93,70	12,06	0,357	<0.020	0,754	0,008	<0.003	<0.020	<0.020	<0.005	0,323	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,355	<0.005	<0.030	0,011	<0.020	10
BH17	7,43	16,8	11,2028	7,5727	12,477	1,2585	14,70	45,13	0,116	<0.020	0,581	0,010	<0.003	<0.020	<0.020	0,024	0,040	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,503	0,101	<0.030	<0.010	0,023	10
BH18	8,8	11,1	0,1877	<0.1	21,6758	0,3299	37,00	7,90	0,381	<0.020	0,547	<0.005	<0.003	<0.020	<0.020	0,007	0,113	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,678	<0.005	<0.030	0,021	<0.020	10
BH19	7,15	38,7	58,9088	13,2231	11,7287	0,4571	41,70	116,84	0,034	<0.020	1,070	0,026	<0.003	<0.020	<0.020	0,024	<0.020	0,028	<0.020	<0.020	<0.015	<0.020	<0.020	3,518	0,398	<0.030	<0.010	0,026	10
BH2	8,39	6,52	1,3161	0,1496	20,1555	1,4881	48,3	9,13	0,229	0,053	0,894	<0.005	<0.003	<0.020	<0.020	0,011	0,181	<0.020	0,032	<0.020	<0.015	<0.020	<0.020	5,888	0,006	<0.030	<0.010	<0.020	10
BH20	8,8	7,28	0,1888	<0.1	12,5926	0,3349	28,80	5,78	0,419	<0.020	0,261	0,007	<0.003	<0.020	<0.020	0,005	0,208	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,740	<0.005	<0.030	0,018	<0.020	10
BH21	8,08	27,5	14,4127	6,2935	35,0561	1,4606	37,00	61,47	0,135	<0.020	0,882	0,029	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,248	0,230	<0.030	0,011	0,021	10
BH22	8,79	10,1	0,1907	<0.1	21,4743	0,3932	41,10	6,75	0,201	<0.020	0,572	<0.005	<0.003	<0.020	<0.020	0,005	0,153	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,585	<0.005	<0.030	0,010	<0.020	10
BH23	7,87	8,79	1,3423	0,751	11,8262	0,517	27,20	5,08	0,171	<0.020	0,354	0,005	<0.003	<0.020	<0.020	0,017	0,089	0,092	<0.020	<0.020	<0.015	<0.020	<0.020	3,451	0,008	<0.030	<0.010	<0.020	10
BH24	7,77	11,4	5,7501	4,15	11,8916	0,5257	41,20	2,02	0,074	<0.020	0,808	0,016	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,657	0,047	<0.030	<0.010	<0.020	10
BH25	8,5	7,12	0,274	<0.1	11,2422	0,7793	24,80	12,80	0,255	<0.020	0,436	0,007	<0.003	<0.020	<0.020	0,018	0,152	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,248	<0.005	<0.030	<0.010	0,029	10
BH26	8,63	9,4	0,5967	0,2314	15,2234	0,8031	33,90		0,189	<0.020	0,393	<0.005	<0.003	<0.020	<0.020	0,012	0,058	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,385	<0.005	<0.030	<0.010	<0.020	10
BH27	8	21,6	15,236	10,0865	16,7527	0,7251	66,50	14,96	0,072	<0.020	0,890	0,060	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,438	0,257	<0.030	<0.010	<0.020	10
BH3	9,02	17,4	1,5897	0,2259	13,1647	1,5112	39,90		0,122	<0.020	0,724	<0.005	<0.003	<0.020	<0.020	0,012	0,061	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,597	0,019	<0.030	<0.010	<0.020	10
BH4	7,43	16,8	0,6071	0,2148	23,1961	0,5794	17,20	25,65	0,411	<0.020	0,332	0,008	<0.003	<0.020	<0.020	0,023	0,378	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,894	<0.005	<0.030	<0.010	<0.020	10
BH5	8,8	11,1	0,2513	<0.1	59,1267	0,8691	142,30	16,88	0,246	0,036	1,115	0,006	<0.003	<0.020	<0.020	0,006	0,190	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	13,178	<0.005	<0.030	0,020	<0.020	10

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH6	7,15	38,7	11,3128	8,2443	13,6151	1,1847	21,20	43,27	0,070	<0.020	0,712	0,014	<0.003	<0.020	<0.020	0,024	0,020	0,029	<0.020	<0.020	<0.015	<0.020	<0.020	3,041	0,091	<0.030	<0.010	0,024	10
BH7	8,8	7,28	17,3076	7,0804	18,3611	1,406	19,50	65,64	0,074	<0.020	0,614	0,023	<0.003	<0.020	<0.020	0,029	<0.020	0,044	<0.020	<0.020	<0.015	<0.020	<0.020	6,418	0,118	<0.030	<0.010	0,029	10
BH8	8,08	27,5	0,446	0,4531	17,0174	0,5246	47,10	9,45	1,294	<0.020	0,606	0,034	<0.003	<0.020	<0.020	0,018	1,026	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,416	<0.005	<0.030	0,019	0,056	10
BH9	8,79	10,1	0,1689	<0.1	9,7343	0,3918	22,74	10,96	0,206	<0.020	0,461	0,006	<0.003	<0.020	<0.020	0,017	0,135	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,019	<0.005	<0.030	<0.010	0,022	10
BH1	8,81	4,49	0,1881	<0.1	8,175	0,5942	27,11	0,49	1,233	<0.020	0,871	0,010	<0.003	<0.020	<0.020	0,011	0,511	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,630	<0.005	<0.030	0,030	<0.020	11
BH10	7,14	41,6	59,3193	10,9756	14,5174	0,5202	85,90	80,84	0,039	<0.020	1,615	0,035	<0.003	<0.020	<0.020	0,023	<0.020	0,042	<0.020	<0.020	<0.015	<0.020	<0.020	4,982	0,321	<0.030	<0.010	0,024	11
BH11	6,89	156	345,5829	53,8523	26,0778	1,0066	70,30	935,50	0,031	<0.020	1,020	0,043	<0.003	<0.020	<0.020	0,046	<0.020	0,174	<0.020	<0.020	<0.015	<0.020	<0.020	4,387	1,469	<0.030	<0.010	0,042	11
BH12	7,65	8,57	0,359	<0.1	14,231	0,4572	15,50	5,68	1,119	<0.020	0,555	<0.005	<0.003	<0.020	<0.020	0,011	0,100	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,375	<0.005	<0.030	0,041	0,021	11
BH13	7,08	54,7	70,565	20,335	19,5681	1,2206	53,80	213,69	0,058	<0.020	0,831	0,031	<0.003	<0.020	<0.020	0,030	<0.020	0,033	<0.020	<0.020	<0.015	<0.020	<0.020	3,703	0,431	<0.030	<0.010	0,037	11
BH14	8,34	6,83	0,7038	0,2477	11,9554	1,3665	39,10	1,36	0,492	<0.020	0,693	0,005	<0.003	<0.020	<0.020	0,013	0,150	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,875	<0.005	<0.030	0,023	<0.020	11
BH15	8,42	7,44	1,6721	0,4124	8,6932	1,5745	34,70	2,85	0,865	<0.020	0,526	0,014	<0.003	<0.020	<0.020	0,012	0,353	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,227	0,010	<0.030	<0.010	<0.020	11
BH16	8,68	20,4	0,3577	0,2013	45,4337	1,2733	111,00	11,59	1,499	<0.020	0,804	0,010	<0.003	<0.020	<0.020	0,006	0,310	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,825	<0.005	<0.030	0,017	<0.020	11
BH17	7,3	15,7	8,9911	7,1124	10,5724	1,2854	23,90	40,39	0,315	<0.020	0,511	0,013	<0.003	<0.020	<0.020	0,026	0,057	0,020	<0.020	<0.020	<0.015	<0.020	<0.020	4,069	0,096	<0.030	<0.010	0,021	11
BH18	8,32	11,4	0,2657	<0.1	23,6974	0,5823	45,70	7,12	1,188	<0.020	0,536	<0.005	<0.003	<0.020	<0.020	0,018	0,060	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,369	<0.005	<0.030	0,043	<0.020	11
BH19	7,26	34	41,2673	11,1111	11,4247	0,5915	52,50	90,13	0,046	<0.020	1,073	0,036	<0.003	<0.020	<0.020	0,029	<0.020	0,035	<0.020	<0.020	<0.015	<0.020	<0.020	4,569	0,322	<0.030	<0.010	0,034	11
BH2	8,01	9,84	1,0153	0,3334	16,8156	1,509	45,70	8,85	0,526	0,024	0,824	0,005	<0.003	<0.020	<0.020	0,008	0,224	<0.020	0,031	<0.020	<0.015	<0.020	<0.020	6,395	<0.005	<0.030	<0.010	<0.020	11
BH20	8,03	9,91	0,2445	<0.1	17,1583	0,5474	39,50	5,57	1,212	<0.020	0,266	<0.005	<0.003	<0.020	<0.020	0,010	0,050	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,576	<0.005	<0.030	0,032	<0.020	11
BH21	6,81	27,5	13,8682	6,2435	29,968	1,5012	419,00	59,57	0,094	<0.020	0,831	0,035	<0.003	<0.020	<0.020	0,031	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,298	0,231	<0.030	0,039	0,024	11
BH22	8,27	10,3	0,2203	<0.1	21,4359	0,5477	49,60	6,11	0,816	<0.020	0,505	<0.005	<0.003	<0.020	<0.020	0,006	0,153	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,118	<0.005	<0.030	0,018	<0.020	11
BH23	7,65	6,15	0,1912	<0.1	10,0463	0,5724	18,20	4,92	0,910	<0.020	0,347	<0.005	<0.003	<0.020	<0.020	0,013	0,070	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,895	<0.005	<0.030	<0.010	0,024	11
BH24	7,44	16,9	8,4947	6,7684	13,8606	0,8153	71,59	1,58	0,098	<0.020	0,729	0,031	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,262	0,078	<0.030	<0.010	<0.020	11
BH25	7,86	6,33	0,4213	0,1471	8,9344	0,9823	24,61	11,54	0,911	<0.020	0,389	0,005	<0.003	<0.020	<0.020	0,016	0,099	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,466	<0.005	<0.030	0,013	0,032	11
BH26	8,22	9,88	0,8752	0,3659	15,3227	1,0733	43,70		0,189	<0.020	0,476	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,891	<0.005	<0.030	0,016	<0.020	11
BH27	7,8	21,6	13,8345	9,2342	15,1991	0,8506	92,00	12,00	0,043	<0.020	0,779	0,067	<0.003	<0.020	<0.020	0,026	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,019	0,238	<0.030	<0.010	<0.020	11
BH3	8,18	8,48	1,7041	0,4663	11,1073	1,6374	40,37		0,247	<0.020	0,657	<0.005	<0.003	<0.020	<0.020	0,005	0,077	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,452	0,021	<0.030	<0.010	<0.020	11
BH4	8,11	12,8	0,6101	0,1644	26,359	1,0827	16,30	26,89	1,323	<0.020	0,407	0,005	<0.003	<0.020	<0.020	0,007	0,211	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,665	<0.005	<0.030	0,010	0,023	11
BH5	9,06	24,5	0,2396	<0.1	50,5949	1,2565	128,33	14,23	1,403	<0.020	0,749	0,016	<0.003	<0.020	<0.020	0,016	0,361	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	13,394	<0.005	<0.030	0,019	<0.020	11
BH6	7,39	13,9	7,9698	5,6484	9,3328	1,0651	22,98	34,65	0,233	<0.020	0,501	0,014	<0.003	<0.020	<0.020	0,021	0,040	0,033	<0.020	<0.020	<0.015	<0.020	<0.020	2,673	0,066	<0.030	<0.010	0,031	11
BH7	7,1	19,9	15,0648	6,2905	14,7438	1,5302	17,30	67,87	0,105	<0.020	0,526	0,024	<0.003	<0.020	<0.020	0,023	0,023	0,055	<0.020	<0.020	<0.015	<0.020	<0.020	6,607	0,113	<0.030	<0.010	0,036	11
BH8	8,64	12,8	0,2536	0,1345	27,0136	0,6224	54,50	8,89	1,437	<0.020	0,698	0,013	<0.003	<0.020	<0.020	<0.005	0,233	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,045	<0.005	<0.030	0,034	0,025	11
BH9	8,21	6,06	0,1687	<0.1	10,1371	0,6195	24,80	10,23	0,795	<0.020	0,408	<0.005	<0.003	<0.020	<0.020	<0.005	0,060	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,231	<0.005	<0.030	0,012	<0.020	11
BH1	8,61	5,45	0,167	0,117	6,941	0,574	23,40	0,42	1,110	<0.020	0,799	0,010	<0.003	<0.020	<0.020	0,009	0,457	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,207	<0.005	<0.030	0,015	<0.020	12
BH10	7,17	32,8	42,088	8,211	12,557	0,620	79,40	51,43	<0.020	<0.020	1,336	0,042	<0.003	<0.020	<0.020	0,021	<0.020	0,026	<0.020	<0.020	<0.015	<0.020	<0.020	4,408	0,248	<0.030	<0.010	0,037	12
BH11	7,09	134	278,552	39,103	20,470	0,859	70,30	744,65	0,173	<0.020	0,853	0,036	<0.003	<0.020	<0.020	0,039	<0.020	0,104	<0.020	<0.020	<0.015	<0.020	<0.020	4,029	1,230	<0.030	<0.010	0,031	12
BH12	6,97	4,93	0,204	<0.1	8,251	0,291	10,60	1,52	0,339	<0.020	0,349	<0.005	<0.003	<0.020	<0.020	0,008	0,048	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,256	<0.005	<0.030	0,015	<0.020	12
BH13	7,06	45,8	54,177	16,184	16,721	1,483	58,90	162,75	<0.020	<0.020	0,769	0,035	<0.003	<0.020	<0.020	0,026	<0.020	0,023	<0.020	<0.020	<0.015	<0.020	<0.020	4,003	0,377	<0.030	<0.010	0,042	12
BH14	8,25	8,83	0,953	0,348	11,082	1,534	37,40	1,86	0,081	<0.020	0,786	<0.005	<0.003	<0.020	<0.020	0,015	0,080	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,074	<0.005	<0.030	<0.010	<0.020	12
BH15	8,42	7,13	1,176	0,292	7,776	1,495	34,40	2,51	0,551	<0.020	0,535	0,010	<0.003	<0.020	<0.020	0,009	0,231	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,420	0,007	<0.030	<0.010	<0.020	12
BH16	8,55	20,5	0,379	0,146	45,556	1,308	110,50	11,01	0,735	<0.020	0,759	0,006	<0.003	<0.020	<0.020	0,007	0,163	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,069	<0.005	<0.030	<0.010	<0.020	12
BH17	7,07	14,6	7,362	6,166	10,719	1,305	27,60	28,05	<0.020	<0.020	0,635	0,014	<0.003	<0.020	<0.020	0,027	0,032	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,041	0,084	<0.030	<0.010	<0.020	12
BH18	7,45	10,3	0,260	<0.1	22,817	0,813	204,00	7,45	3,257	<0.020	0,583	0,007	<0.003	<0.020	<0.020	0,012	0,149	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,741	<0.005	<0.030	0,022	<0.020	12
BH19	6,88	26,8	29,998	8,671	8,837	0,507	42,20	71,61	<0.020	<0.020	0,864	0,038	<0.003	<0.020	<0.020	0,031	<0.020	0,026	<0.020	<0.020	<0.015	<0.020	<0.020	3,369	0,254	<0.030	<0.010	0,030	12
BH2	7,9	10,1	0,946	0,349	13,526	1,503	43,00	8,01	0,073	<0.020	0,794	<0.005	<0.003	<0.020	<0.020	0,012	0,112	<0.020	0,028	<0.020	<0.015	<0.020	<0.020	5,201	0,005	<0.030	<0.010	<0.020	12
BH20	7,69	9,84	0,236	<0.1	16,993	0,627	41,30	5,01	1,538	<0.020	0,329	0,005	<0.003	<0.020	<0.020	0,005	0,073	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,388	<0.005	<0.030	0,015	<0.020	12
BH21	7,54	22,8	12,654	5,536	23,043	1,491	41,80	49,84	<0.020	<0.020	0,734	0,038	<0.003	<0.020	<0.020	0,025	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,521	0,222	<0.030	0,012	0,028	12

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH22	8,27	11,3	0,172	<0.1	18,933	0,570	45,30	5,49	0,714	<0.020	0,545	<0.005	<0.003	<0.020	<0.020	0,008	0,078	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,048	<0.005	<0.030	<0.010	0,024	12
BH23	6,9	4,3	0,155	<0.1	6,709	0,663	13,50	1,91	2,452	<0.020	0,194	0,007	<0.003	<0.020	<0.020	0,017	0,120	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,204	<0.005	<0.030	<0.010	<0.020	12
BH24	7,35	13,9	6,881	5,952	11,469	0,918	62,70	2,22	<0.020	<0.020	0,670	0,031	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,530	0,071	<0.030	<0.010	<0.020	12
BH25	7,95	5,91	0,419	0,193	8,281	1,209	23,60	10,52	2,177	<0.020	0,429	0,007	<0.003	<0.020	<0.020	0,010	0,111	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,351	<0.005	<0.030	<0.010	<0.020	12
BH26	8,05	9,84	1,204	0,638	13,429	1,163	39,10		1,327	<0.020	0,526	0,011	<0.003	<0.020	<0.020	0,010	0,168	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,290	0,009	<0.030	<0.010	<0.020	12
BH27	7,85	23,9	14,908	10,420	18,152	1,123	95,95	8,05	<0.020	<0.020	1,074	0,079	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,017	0,276	<0.030	<0.010	0,026	12
BH3	8,25	8,29	1,879	0,558	8,879	1,539	38,00		<0.020	<0.020	0,528	0,005	<0.003	<0.020	<0.020	0,015	0,043	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,992	0,026	<0.030	<0.010	<0.020	12
BH4	7,34	12,8	0,632	0,243	25,196	0,896	14,00	24,80	1,616	<0.020	0,417	0,006	<0.003	<0.020	<0.020	0,017	0,273	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,081	<0.005	<0.030	<0.010	0,024	12
BH5	9,2	24	0,211	0,116	47,890	1,370	123,70	11,90	1,418	<0.020	0,604	0,016	<0.003	<0.020	<0.020	0,016	0,392	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,168	<0.005	<0.030	0,013	<0.020	12
BH6	7,34	14,6	7,792	5,409	11,700	1,188	28,30	28,62	<0.020	<0.020	0,716	0,013	<0.003	<0.020	<0.020	0,020	<0.020	0,021	<0.020	<0.020	<0.015	<0.020	<0.020	2,918	0,074	<0.030	<0.010	<0.020	12
BH7	6,99	17,5	12,601	4,809	12,563	1,337	17,60	55,53	<0.020	<0.020	0,539	0,022	<0.003	<0.020	<0.020	0,032	<0.020	0,032	<0.020	<0.020	<0.015	<0.020	<0.020	6,066	0,097	<0.030	<0.010	0,036	12
BH8	8,56	12,8	0,198	0,168	26,806	0,717	54,60	8,46	2,902	<0.020	0,685	0,010	<0.003	<0.020	<0.020	0,005	0,233	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,328	<0.005	<0.030	0,019	<0.020	12
BH9	8	5,52	0,183	<0.1	8,762	0,634	22,80	11,09	0,179	<0.020	0,391	<0.005	<0.003	<0.020	<0.020	0,012	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,688	<0.005	<0.030	<0.010	<0.020	12
BH1	8,45	5,86	0,1978	0,1238	8,9396	0,3438	27,52	0,41	0,165	<0.020	0,874	<0.005	<0.003	<0.020	<0.020	0,008	0,217	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,520	<0.005	<0.030	0,011	<0.020	13
BH10	7,2	28,8	31,8175	7,6768	11,4164	0,3819	71,7	40,02	<0.020	<0.020	1,346	0,052	<0.003	<0.020	<0.020	0,020	<0.020	0,023	<0.020	<0.020	<0.015	<0.020	<0.020	5,433	0,209	<0.030	<0.010	0,020	13
BH11	7,01	120	245,2658	33,4555	17,0933	0,7403	70,52	611,48	<0.020	<0.020	0,895	0,038	<0.003	<0.020	<0.020	0,045	<0.020	0,078	<0.020	<0.020	<0.015	<0.020	<0.020	4,912	1,040	<0.030	<0.010	0,033	13
BH12	6,91	6,29	0,3156	0,1343	9,659	0,3081	12,15	2,12	0,063	<0.020	0,496	<0.005	<0.003	<0.020	<0.020	0,014	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,067	<0.005	<0.030	0,016	<0.020	13
BH13	7,04	39,9	42,9256	15,5037	13,7561	0,985	61,63	128,77	<0.020	<0.020	0,741	0,042	<0.003	<0.020	<0.020	0,020	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,274	0,358	<0.030	<0.010	0,022	13
BH14	8,17	8,86	0,8511	0,3451	11,7876	1,4865	38,06	1,10	0,052	<0.020	1,010	<0.005	<0.003	<0.020	<0.020	0,008	0,063	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,333	<0.005	<0.030	<0.010	<0.020	13
BH15	8,45	7,85	1,4347	0,347	7,99	1,0909	34,8	2,43	0,161	<0.020	0,715	0,005	<0.003	<0.020	<0.020	0,008	0,201	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,037	0,007	<0.030	<0.010	<0.020	13
BH16	8,28	17,5	0,4091	0,1958	37,3908	1,2626	99,81	10,25	0,241	<0.020	0,727	0,005	<0.003	<0.020	<0.020	0,014	0,344	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,448	<0.005	<0.030	<0.010	<0.020	13
BH17	7,13	11,6	5,1691	4,7476	9,3935	1,0846	27	19,70	<0.020	<0.020	0,586	0,011	<0.003	<0.020	<0.020	0,014	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,688	0,068	<0.030	<0.010	<0.020	13
BH18	7,98	12,6	0,218	<0.1	20,2057	0,45	45,35	5,64	0,101	<0.020	0,563	<0.005	<0.003	<0.020	<0.020	0,011	0,040	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,456	<0.005	<0.030	0,016	<0.020	13
BH19	6,99	25,8	27,5987	8,5463	8,452	0,3869	43,32	57,19	<0.020	<0.020	0,892	0,038	<0.003	<0.020	<0.020	0,029	<0.020	0,027	<0.020	<0.020	<0.015	<0.020	<0.020	3,743	0,246	<0.030	<0.010	0,027	13
BH2	8,21	10,2	1,3544	0,6029	13,6098	1,7753	43,63	8,21	0,139	0,028	0,871	<0.005	<0.003	<0.020	<0.020	0,009	0,233	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,457	0,008	<0.030	<0.010	<0.020	13
BH20	7,39	9,07	0,3753	0,2139	14,0873	0,7062	37,22	4,86	0,026	<0.020	0,325	<0.005	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,716	<0.005	<0.030	0,009	<0.020	13
BH21	7,52	22,9	13,6729	6,6449	22,0387	1,5273	53,8	43,39	<0.020	<0.020	0,773	0,051	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,030	0,273	<0.030	0,012	<0.020	13
BH22	8,37	11,5	0,2731	0,1879	17,6426	0,5172	35,31	5,85	0,251	<0.020	0,496	0,006	<0.003	<0.020	<0.020	0,015	0,232	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,478	<0.005	<0.030	<0.010	<0.020	13
BH23	7,15	5,89	0,3001	0,1374	8,5978	0,5938	12,99	5,43	0,089	<0.020	0,313	<0.005	<0.003	<0.020	<0.020	0,015	0,124	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,304	<0.005	<0.030	<0.010	<0.020	13
BH24	7,47	12,8	5,8823	4,7588	10,167	0,547	24,82	19,44	0,040	<0.020	0,704	0,018	<0.003	<0.020	<0.020	0,029	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,060	0,056	<0.030	<0.010	<0.020	13
BH25	7,66	5,45	0,6063	0,336	6,4444	1,0054	20,31	11,02	0,115	<0.020	0,358	0,005	<0.003	<0.020	<0.020	0,012	0,087	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,372	<0.005	<0.030	<0.010	<0.020	13
BH26	8	8,98	1,0992	0,6765	11,6995	1,183	33,21	-3,06	0,037	<0.020	0,471	0,005	<0.003	<0.020	<0.020	0,007	0,034	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,869	0,007	<0.030	<0.010	<0.020	13
BH27	7,84	28,7	18,1029	12,8806	17,0204	1,117	94,83	21,20	<0.020	<0.020	1,117	0,101	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,318	0,355	<0.030	<0.010	0,021	13
BH3	8,18	6,89	2,3434	0,7227	6,4381	1,1882	32,17		<0.020	<0.020	0,269	<0.005	<0.003	<0.020	<0.020	0,006	0,030	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,784	0,033	<0.030	<0.010	<0.020	13
BH4	7,52	15,8	0,9015	0,3525	31,2608	0,6837	11,62	33,87	0,271	<0.020	0,609	0,007	<0.003	<0.020	<0.020	0,013	0,207	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,135	0,007	<0.030	<0.010	<0.020	13
BH5	8,98	12,8	0,1638	<0.1	21,8867	0,4514	66,68	11,22	0,107	<0.020	0,291	<0.005	<0.003	<0.020	<0.020	0,006	0,096	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,444	<0.005	<0.030	<0.010	<0.020	13
BH6	7,47	11,6	5,3354	4,0351	10,255	1,0992	25,25	19,18	<0.020	<0.020	0,657	0,010	<0.003	<0.020	<0.020	0,023	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,162	0,051	<0.030	<0.010	0,021	13
BH7	7,29	17,5	12,8565	5,5537	10,9993	1,2608	17,97	52,58	<0.020	<0.020	0,603	0,029	<0.003	<0.020	<0.020	0,026	<0.020	0,032	<0.020	<0.020	<0.015	<0.020	<0.020	7,330	0,106	<0.030	<0.010	0,024	13
BH8	8,7	11,8	0,3168	0,3906	18,3982	0,4592	44,38	9,12	0,784	<0.020	0,640	0,019	<0.003	<0.020	<0.020	0,010	0,481	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,126	<0.005	<0.030	0,019	0,027	13
BH9	7,83	4,32	0,1561	<0.1	6,5938	0,4587	17,42	10,21	0,022	<0.020	0,356	<0.005	<0.003	<0.020	<0.020	0,006	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,305	<0.005	<0.030	<0.010	<0.020	13
BH1	7,08	4,9	0,1531	<0.1	6,3179	0,2122	21,46	0,39	0,148	<0.020	0,713	<0.005	<0.003	<0.020	<0.020	0,006	0,209	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,937	<0.005	<0.030	0,008	<0.020	14
BH10	7,51	27,6	34,6019	7,5311	10,3881	0,3199	73,88	39,58	<0.020	<0.020	1,148	0,059	<0.003	<0.020	<0.020	0,018	<0.020	0,026	<0.020	<0.020	<0.015	<0.020	<0.020	4,724	0,210	<0.030	<0.010	<0.020	14
BH11	7,55	119	248,5886	32,0244	14,8534	0,5567	66,31	613,39	<0.020	<0.020	0,764	0,036	<0.003	<0.020	<0.020	0,039	<0.020	0,068	<0.020	<0.020	<0.015	<0.020	<0.020	4,614	1,033	<0.030	<0.010	0,027	14
BH12	6,21	5,26	0,289	0,123	8,4972	0,1986	9,92	3,15	0,039	<0.020	0,407	<0.005	<0.003	<0.020	<0.020	0,011	0,039	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,085	<0.005	<0.030	0,012	<0.020	14
BH13	7,45	38,8	44,8548	14,8064	12,1473	0,8551	61,4	123,27	<0.020	<0.020	0,644	0,042	<0.003	<0.020	<0.020	0,029	<0.020	0,021	<0.020	<0.020	<0.015	<0.020	<0.020	8,677	0,345	<0.030	<0.010	0,024	14

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH14	7,29	7,44	0,9676	0,3826	9,361	1,1695	31,51	0,95	0,065	<0.020	0,846	<0.005	<0.003	<0.020	<0.020	0,011	0,088	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,227	<0.005	<0.030	<0.010	<0.020	14
BH15	7,59	7,61	2,5236	0,53	7,7746	1,0767	35,69	2,31	0,127	<0.020	0,687	0,005	<0.003	<0.020	<0.020	0,010	0,185	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	13,610	0,015	<0.030	<0.010	<0.020	14
BH16	7,66	13,9	0,4321	0,1909	29,5103	0,9836	73,96	9,12	0,124	<0.020	0,489	<0.005	<0.003	<0.020	<0.020	0,007	0,208	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,081	<0.005	<0.030	<0.010	<0.020	14
BH17	7,12	11,6	5,6008	5,0453	8,071	0,9543	27,49	19,90	0,027	<0.020	0,544	0,013	<0.003	<0.020	<0.020	0,015	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,978	0,071	<0.030	<0.010	<0.020	14
BH18	7,11	11	0,1951	0,1126	18,8563	0,386	38,71	5,85	0,069	<0.020	0,489	<0.005	<0.003	<0.020	<0.020	0,008	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,752	<0.005	<0.030	0,019	<0.020	14
BH19	7,25	24,6	26,6034	8,1374	7,8795	0,3871	39,93	59,78	<0.020	<0.020	0,782	0,034	<0.003	<0.020	<0.020	0,021	<0.020	0,025	<0.020	<0.020	<0.015	<0.020	<0.020	8,374	0,217	<0.030	<0.010	<0.020	14
BH2	7,26	9,3	1,7414	0,6509	11,23	1,5287	38,62	7,89	0,034	0,032	0,704	<0.005	<0.003	<0.020	<0.020	0,013	0,055	<0.020	0,023	<0.020	<0.015	<0.020	<0.020	5,529	0,013	<0.030	<0.010	<0.020	14
BH20	6,84	7,63	0,4105	0,2478	11,717	0,6876	30,92	4,55	0,026	<0.020	0,280	<0.005	<0.003	<0.020	<0.020	0,006	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,649	<0.005	<0.030	0,008	<0.020	14
BH21	7,11	19,9	12,0413	5,2345	15,6608	0,9609	29,66	48,06	<0.020	<0.020	0,571	0,040	<0.003	<0.020	<0.020	0,014	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,684	0,206	<0.030	0,010	<0.020	14
BH22	7,2	9,7	0,267	0,1489	15,0928	0,4419	31,66	5,22	0,120	<0.020	0,420	<0.005	<0.003	<0.020	<0.020	0,010	0,162	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,198	<0.005	<0.030	<0.010	<0.020	14
BH23	6,03	5,33	0,2577	0,1227	7,8072	0,5827	9,79	8,07	0,059	<0.020	0,230	<0.005	<0.003	<0.020	<0.020	0,014	0,135	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,114	<0.005	<0.030	<0.010	<0.020	14
BH24	6,83	12,8	6,7407	5,5204	8,5007	0,4298	24,13	19,15	0,048	<0.020	0,662	0,022	<0.003	<0.020	<0.020	0,020	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,226	0,060	<0.030	<0.010	<0.020	14
BH25	6,74	5,31	0,7982	0,4119	5,1367	0,9661	19,43	10,54	0,100	<0.020	0,286	0,007	<0.003	<0.020	<0.020	0,015	0,111	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,760	<0.005	<0.030	<0.010	<0.020	14
BH26	7,18	8,47	1,6751	1,0808	9,2001	0,8921	30,31	-3,50	0,135	<0.020	0,453	0,011	<0.003	<0.020	<0.020	0,016	0,217	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,145	0,012	<0.030	<0.010	<0.020	14
BH27	7,73	28,7	20,8768	13,8616	14,5555	0,9873	95,4	24,90	0,021	<0.020	0,911	0,115	<0.003	<0.020	<0.020	0,024	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,720	0,359	<0.030	<0.010	<0.020	14
BH3	7,27	7,93	2,4667	0,7645	7,7187	1,1594	36,8		0,034	<0.020	0,647	0,005	<0.003	<0.020	<0.020	0,007	0,054	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,356	0,038	<0.030	<0.010	<0.020	14
BH4	6,21	11,6	1,068	0,4812	23,4362	0,6175	9,97	28,81	0,607	<0.020	0,406	0,018	<0.003	<0.020	<0.020	0,022	0,636	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,612	0,016	<0.030	<0.010	0,026	14
BH5	8,12	14,6	0,2365	0,1042	30,3159	0,6547	78,47	10,45	0,183	<0.020	0,353	0,007	<0.003	<0.020	<0.020	0,009	0,221	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,368	<0.005	<0.030	<0.010	<0.020	14
BH6	6,51	10,5	5,0703	3,7155	8,5625	0,8555	21,42	17,56	<0.020	<0.020	0,574	0,011	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,311	0,055	<0.030	<0.010	<0.020	14
BH7	6,4	14,6	11,6407	4,9765	8,62	1,2371	13,31	46,23	<0.020	<0.020	0,502	0,032	<0.003	<0.020	<0.020	0,023	<0.020	0,059	<0.020	<0.020	<0.015	<0.020	<0.020	6,150	0,104	<0.030	<0.010	0,035	14
BH8	7,46	10,3	0,3032	0,3891	21,4524	0,5084	49,39	8,78	0,554	<0.020	0,520	0,017	<0.003	<0.020	<0.020	0,011	0,551	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,029	<0.005	<0.030	0,011	0,025	14
BH9	6,06	4,32	0,2024	<0.1	6,3214	0,4671	16,03	9,99	<0.020	<0.020	0,376	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,383	<0.005	<0.030	<0.010	<0.020	14
BH1	8,46	3,91	0,164	<0.1	8,324	0,410	26,3	0,38	0,215	<0.020	1,020	<0.005	<0.003	<0.020	<0.020	0,016	0,260	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	13,761	0,016	<0.030	0,012	<0.020	15
BH2	8,19	7,49	2,388	0,955	12,894	1,857	42,5	7,11	0,034		0,880	0,005	<0.003	<0.020	<0.020	0,010	0,045	<0.020	0,027	<0.020	<0.015	<0.020	<0.020	10,211	0,048	<0.030	<0.010	<0.020	15
BH3	8,15	7,59	3,714	1,278	12,859	1,799	44,9		0,052		1,045	0,007	<0.003	<0.020	<0.020	0,014	0,070	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	13,611	0,078	<0.030	<0.010	<0.020	15
BH4	7,11	8,79	0,509	0,199	22,495	0,543	12,1	23,95	0,265		0,335	0,007	<0.003	<0.020	<0.020	0,027	0,280	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,323	0,046	<0.030	<0.010	<0.020	15
BH5	8,87	20,0	0,223	<0.1	45,267	0,948	102	9,88	0,171		0,588	0,007	<0.003	<0.020	<0.020	0,012	0,195	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,087	0,022	<0.030	<0.010	<0.020	15
BH6	7,54	12,9	8,278	7,007	10,924	1,237	28,7	16,93	0,044		0,752	0,019	<0.003	<0.020	<0.020	0,024	0,045	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,870	0,137	<0.030	<0.010	<0.020	15
BH7	7,18	21,8	21,243	9,641	11,506	1,507	15,4	69,81	0,040		0,731	0,053	<0.003	<0.020	<0.020	0,034	0,024	0,075	<0.020	<0.020	<0.015	<0.020	<0.020	14,569	0,201	<0.030	<0.010	0,044	15
BH8	8,34	9,92	0,191	0,289	21,239	0,519	45,8	8,45	0,469		0,638	0,011	<0.003	<0.020	<0.020	0,017	0,454	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	11,950	0,036	<0.030	0,017	<0.020	15
BH9	7,29	2,83	0,236	<0.1	6,522	0,640	17,3	9,78	0,021		0,439	<0.005	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	14,419	0,025	<0.030	<0.010	<0.020	15
BH10	7,02	34,1	52,479	12,461	12,732	0,438	76,7	65,19	0,029	<0.020	1,428	0,091	<0.003	<0.020	<0.020	0,029	<0.020	0,037	<0.020	<0.020	<0.015	<0.020	<0.020	13,160	0,323	<0.030	<0.010	0,022	15
BH11	6,67	119	266,637	48,717	15,998	0,769	65,7	697,45	0,022		0,777	0,036	<0.003	<0.020	<0.020	0,049	0,023	0,082	<0.020	<0.020	<0.015	<0.020	<0.020	9,140	1,185	<0.030	<0.010	0,036	15
BH12	6,58	5,70	0,477	0,118	15,278	0,411	8,93	4,68	0,030		0,558	<0.005	<0.003	<0.020	<0.020	0,014	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	16,835	0,013	<0.030	0,015	<0.020	15
BH13	6,85	51,8	77,256	29,566	15,749	1,229	61,3	216,07	0,036		0,761	0,038	<0.003	<0.020	<0.020	0,035	0,021	0,031	<0.020	<0.020	<0.015	<0.020	<0.020	12,495	0,581	<0.030	<0.010	0,029	15
BH14	7,96	6,88	1,324	0,506	11,687	1,519	37,5	0,98	0,072		1,114	<0.005	<0.003	<0.020	<0.020	0,017	0,075	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	12,766	0,048	<0.030	<0.010	<0.020	15
BH15	8,34	6,82	3,403	0,762	10,071	1,452	42,8	2,41	0,233		1,045	0,008	<0.003	<0.020	<0.020	0,011	0,298	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	18,153	0,067	<0.030	<0.010	<0.020	15
BH16	7,97	13,9	0,653	0,262	37,506	1,623	82,2	7,45	0,189		0,719	0,006	<0.003	<0.020	<0.020	0,012	0,279	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	15,312	0,029	<0.030	<0.010	<0.020	15
BH17	7,20	14,6	9,542	9,176	11,342	1,506	31	24,20	0,051		0,774	0,021	<0.003	<0.020	<0.020	0,021	0,058	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	15,408	0,158	<0.030	<0.010	<0.020	15
BH18	7,77	9,90	0,234	<0.1	25,543	0,620	42,2	6,01	0,169		0,640	<0.005	<0.003	<0.020	<0.020	0,013	0,061	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	14,954	0,035	<0.030	0,025	<0.020	15
BH19	7,03	34,1	49,463	15,921	11,254	0,560	44,5	113,59	0,030		1,100	0,046	<0.003	<0.020	<0.020	0,034	0,034	0,047	<0.020	<0.020	<0.015	<0.020	<0.020	12,891	0,430	<0.030	<0.010	0,030	15
BH20	7,19	5,67	0,791	0,502	14,888	0,771	32,7	3,98	0,030		0,378	0,005	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	14,624	0,029	<0.030	0,014	<0.020	15
BH21	7,65	28,8	22,139	10,212	22,943	1,579	43,7	74,21	0,033		0,752	0,070	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,810	0,413	<0.030	0,012	<0.020	15
BH22	7,77	10,4	0,360	0,210	27,772	0,838	51,2	5,01	0,136		0,695	0,005	<0.003	<0.020	<0.020	0,011	0,159	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	15,101	0,023	<0.030	0,011	<0.020	15
BH23	6,81	3,88	0,408	0,217	8,427	0,813	11,1	3,25	0,111		0,407	<0.005	<0.003	<0.020	<0.020	0,012	0,070	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	12,821	0,021	<0.030	<0.010	<0.020	15

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH24	7,42	19,9	14,225	13,157	13,297	0,974	70,5	3,27	0,037		1,019	0,061	<0.003	<0.020	<0.020	0,023	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	12,433	0,154	<0.030	0,011	<0.020	15
BH25	7,80	7,46	2,954	2,068	11,100	1,251	41,3	10,81	0,098		0,623	0,016	<0.003	<0.020	<0.020	0,011	0,150	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	13,184	0,061	<0.030	<0.010	<0.020	15
BH26	7,62	4,49	2,075	1,010	7,181	1,247	25,1		0,059		0,543	0,009	<0.003	<0.020	<0.020	0,013	0,043	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	13,984	0,045	<0.030	<0.010	<0.020	15
BH27	7,67	24,1	18,960	12,717	15,444	0,891	83,1	9,07	0,051		1,036	0,088	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,067	0,351	<0.030	<0.010	<0.020	15
BH1	8,37	5,63	0,11	<0.1	8,33	0,32	28,2	0,35	0,172	<0.020	0,924	<0.005	<0.003	<0.020	<0.020	0,011	0,228	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	16,497	<0.005	<0.030	0,013	<0.020	16
BH2	8,19	10,1	3,12	1,16	11,83	1,98	42,3	5,85	0,043	0,025	0,735	0,007	<0.003	<0.020	<0.020	0,009	0,049	<0.020	0,024	<0.020	<0.015	<0.020	<0.020	12,632	0,031	<0.030	<0.010	<0.020	16
BH3	7,92	9,97	3,49	1,38	11,02	1,55	49,6		0,051	0,021	1,021	0,007	<0.003	<0.020	<0.020	0,009	0,064	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	14,471	0,071	<0.030	<0.010	<0.020	16
BH4	8,01	15,8	0,52	0,28	31,31	0,73	16,8	34,70	0,332	<0.020	0,507	0,009	<0.003	<0.020	<0.020	0,017	0,291	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,264	0,013	<0.030	<0.010	0,020	16
BH5	8,66	14,6	0,16	<0.1	30,43	0,64	73,5	8,11	0,091	<0.020	0,435	<0.005	<0.003	<0.020	<0.020	0,008	0,125	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,636	<0.005	<0.030	<0.010	<0.020	16
BH6	7,49	14,0	7,71	6,48	9,91	1,09	29,1	18,68	0,045	<0.020	0,685	0,015	<0.003	<0.020	<0.020	0,031	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,488	0,092	<0.030	<0.010	0,020	16
BH7	6,19	24,6	24,28	10,89	11,26	1,41	8,67	91,81	0,079	<0.020	0,659	0,043	<0.003	<0.020	<0.020	0,040	0,084	0,182	<0.020	<0.020	<0.015	<0.020	<0.020	8,156	0,208	<0.030	<0.010	0,112	16
BH8	8,30	12,8	0,18	0,21	26,13	0,58	61,9	8,90	0,261	0,023	0,635	0,007	<0.003	<0.020	<0.020	0,015	0,387	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,938	<0.005	<0.030	0,016	<0.020	16
BH9	7,55	4,72	0,25	0,12	6,95	0,83	16,7	9,86	0,056	<0.020	0,346	<0.005	<0.003	<0.020	<0.020	0,020	0,053	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	15,953	<0.005	<0.030	<0.010	<0.020	16
BH10	7,06	50,0	77,70	14,00	11,41	0,53	59,3	155,84	0,037	<0.020	1,181	0,079	<0.003	<0.020	<0.020	0,042	0,269	0,131	<0.020	<0.020	<0.015	<0.020	<0.020	13,190	0,427	<0.030	<0.010	0,029	16
BH11	6,55	153	326,98	59,22	18,10	1,21	47,7	891,38	<0.020	<0.020	0,931	0,044	<0.003	<0.020	<0.020	0,046	2,347	0,811	<0.020	0,029	<0.015	<0.020	<0.020	9,693	1,409	<0.030	<0.010	0,043	16
BH12	6,35	6,38	0,29	<0.1	10,87	0,33	7,54	6,79	0,054	<0.020	0,301	<0.005	<0.003	<0.020	<0.020	0,019	0,041	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,721	<0.005	<0.030	0,013	<0.020	16
BH13	7,05	88,7	146,67	44,96	16,61	1,42	49,6	436,35	0,029	<0.020	0,915	0,039	<0.003	<0.020	<0.020	0,035	0,051	0,044	<0.020	<0.020	<0.015	<0.020	<0.020	6,710	0,896	<0.030	<0.010	0,033	16
BH14	7,92	8,56	0,66	0,43	12,04	1,72	38,8	0,75	0,199	0,027	1,017	0,005	<0.003	<0.020	<0.020	0,016	0,263	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,289	<0.005	<0.030	<0.010	<0.020	16
BH15	8,08	7,48	1,61	0,40	8,66	1,05	39,2	2,34	0,076	<0.020	0,779	<0.005	<0.003	<0.020	<0.020	0,008	0,066	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,034	0,011	<0.030	<0.010	<0.020	16
BH16	8,33	11,7	0,24	<0.1	24,00	1,15	67,7	7,22	0,107	<0.020	0,523	<0.005	<0.003	<0.020	<0.020	0,014	0,094	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,776	<0.005	<0.030	<0.010	<0.020	16
BH17	7,48	15,7	9,84	7,39	9,82	1,55	18,0	43,81	0,039	<0.020	0,445	0,016	<0.003	<0.020	<0.020	0,022	0,040	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,004	0,125	<0.030	<0.010	<0.020	16
BH18	7,92	11,3	0,18	<0.1	20,74	0,66	41,3	5,77	0,152	<0.020	0,447	<0.005	<0.003	<0.020	<0.020	0,017	0,099	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,422	<0.005	<0.030	0,020	<0.020	16
BH19	7,10	32,9	45,66	14,30	9,09	0,47	42,2	104,18	0,031	<0.020	0,978	0,034	<0.003	<0.020	<0.020	0,040	<0.020	0,046	<0.020	<0.020	<0.015	<0.020	<0.020	6,890	0,393	<0.030	<0.010	0,043	16
BH20	7,06	7,84	0,70	0,50	11,46	0,68	32,1	3,46	0,052	<0.020	0,305	<0.005	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,459	0,006	<0.030	0,012	<0.020	16
BH21	7,49	27,1	18,82	8,93	21,35	1,70	60,5	50,28	0,034	<0.020	0,719	0,062	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,267	0,371	<0.030	0,013	<0.020	16
BH22	7,63	10,5	<0.1	0,22	20,78	0,69	55,4	5,00	0,065	<0.020	0,514	<0.005	<0.003	<0.020	<0.020	0,009	0,087	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,660	<0.005	<0.030	<0.010	<0.020	16
BH23	6,51	6,50	0,24	0,34	8,16	0,82	18,3	2,97	0,057	<0.020	0,410	<0.005	<0.003	<0.020	<0.020	0,009	0,031	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,595	<0.005	<0.030	<0.010	<0.020	16
BH24	7,12	18,8	11,25	10,92	10,64	0,79	85,8	2,12	0,034	<0.020	0,729	0,051	<0.003	<0.020	<0.020	0,012	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,047	0,119	<0.030	<0.010	<0.020	16
BH25	7,61	10,2	2,83	2,24	10,05	1,29	46,0	10,74	0,035	<0.020	0,575	0,015	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,772	0,037	<0.030	<0.010	<0.020	16
BH26	7,21	6,90	1,45	0,91	6,39	1,07	28,7		0,043	<0.020	0,480	0,007	<0.003	<0.020	<0.020	0,011	0,037	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,449	0,019	<0.030	<0.010	<0.020	16
BH27	7,63	27,0	19,61	13,86	16,68	1,06	113	10,17	0,039	<0.020	0,981	0,088	<0.003	<0.020	<0.020	0,018	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,931	0,376	<0.030	<0.010	0,040	16
BH1	8,33	4,17	<0.1	<0.1	0,346	0,214	20,7	0,36	<0.020	<0.020	0,060	<0.005	<0.003	<0.020	<0.020	<0.005	0,065	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,552	<0.005	<0.030	<0.010	<0.020	17
BH10	7,22	30,5	39,689	4,835	11,010	0,405	51,9	52,20	0,026	<0.020	0,692	0,034	<0.003	<0.020	<0.020	0,011	<0.020	0,028	<0.020	<0.020	<0.015	<0.020	<0.020	4,731	0,129	<0.030	<0.010	<0.020	17
BH11	6,65	108	199,342	23,218	15,366	0,642	71,7	451,97	<0.020	<0.020	0,375	0,026	<0.003	<0.020	<0.020	0,015	<0.020	0,130	<0.020	<0.020	<0.015	<0.020	<0.020	3,483	0,536	<0.030	<0.010	<0.020	17
BH12	6,08	8,46	0,255	<0.1	14,552	0,383	19,3	3,96	0,082	<0.020	0,230	<0.005	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,851	<0.005	<0.030	0,010	<0.020	17
BH13	6,90	47,0	58,890	12,518	14,107	0,763	60,1	138,18	0,030	<0.020	0,411	0,025	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	0,032	3,884	0,265	<0.030	<0.010	<0.020	17
BH14	7,80	8,70	2,045	0,668	11,420	1,325	42,0	0,99	0,133	<0.020	0,396	0,006	<0.003	<0.020	<0.020	0,008	0,067	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,609	0,010	<0.030	<0.010	<0.020	17
BH15	7,89	7,85	2,043	0,387	9,445	0,933	39,7	2,26	0,199	<0.020	0,224	0,006	<0.003	<0.020	<0.020	0,007	0,234	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,921	0,010	<0.030	<0.010	<0.020	17
BH16	7,82	14,0	1,660	0,571	28,950	1,479	79,0	6,89	0,160	<0.020	0,286	0,006	<0.003	<0.020	<0.020	0,007	0,104	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,092	0,019	<0.030	<0.010	<0.020	17
BH17	7,13	20,5	13,049	8,429	14,079	1,796	39,2	41,63	0,104	<0.020	0,382	0,021	<0.003	<0.020	<0.020	0,015	0,053	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,912	0,113	<0.030	<0.010	0,034	17
BH18	7,55	12,0	0,281	<0.1	23,183	0,631	46,1	4,83	0,210	<0.020	0,267	<0.005	<0.003	<0.020	<0.020	0,008	0,029	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,548	<0.005	<0.030	0,011	<0.020	17
BH19	7,12	27,5	30,537	7,453	12,719	0,514	52,4	51,39	0,039	<0.020	0,664	0,030	<0.003	<0.020	<0.020	0,009	0,020	0,029	<0.020	<0.020	<0.015	<0.020	<0.020	5,151	0,189	<0.030	<0.010	<0.020	17
BH2	8,07	8,98	0,332	<0.1	2,122	0,301	38,8	5,67	<0.020	<0.020	0,104	<0.005	<0.003	<0.020	<0.020	<0.005	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,574	<0.005	<0.030	<0.010	<0.020	17
BH20	7,5	7,73	0,799	0,308	13,060	0,737	32,6	3,04	0,168	<0.020	0,171	<0.005	<0.003	<0.020	<0.020	0,007	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,055	<0.005	<0.030	0,012	<0.020	17
BH21	7,77	14,5	9,497	3,719	14,047	0,839	42,7	21,36	0,089	<0.020	0,326	0,028	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,525	0,126	<0.030	0,011	<0.020	17

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH22	7,85	9,90	0,481	0,184	19,184	0,708	42,0	4,55	0,158	<0.020	0,319	<0.005	<0.003	<0.020	<0.020	0,008	0,038	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,672	<0.005	<0.030	<0.010	<0.020	17
BH23	7,00	8,13	0,68	0,47	12,66	1,35	25,2	2,47	0,218	<0.020	0,288	<0.005	<0.003	<0.020	<0.020	0,015	0,125	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,181	<0.005	<0.030	<0.010	<0.020	17
BH24	7,71	10,4	4,88	4,54	10,02	0,62	36,8	2,09	0,130	<0.020	0,510	0,017	<0.003	<0.020	<0.020	0,012	0,082	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,341	0,044	<0.030	0,011	<0.020	17
BH25	7,76	9,40	2,23	1,59	11,82	1,36	41,8	9,91	0,099	<0.020	0,313	0,010	<0.003	<0.020	<0.020	0,010	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,319	0,023	<0.030	<0.010	<0.020	17
BH26	7,61	7,95	1,89	1,14	10,22	1,50	35,2	-8,19	0,108	<0.020	0,253	0,009	<0.003	<0.020	<0.020	0,010	0,035	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,839	0,021	<0.030	<0.010	<0.020	17
BH27	7,81	25,8	19,63	13,24	18,32	1,20	103	11,25	0,087	<0.020	0,804	0,101	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,440	0,361	<0.030	<0.010	<0.020	17
BH3	8,00	6,71	0,401	<0.1	1,925	0,297	35,0		<0.020	<0.020	0,108	<0.005	<0.003	<0.020	<0.020	0,005	0,028	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,961	<0.005	<0.030	<0.010	<0.020	17
BH4	7,76	12,9	0,210	<0.1	11,006	0,299	19,5	7,22	0,078	<0.020	0,131	<0.005	<0.003	<0.020	<0.020	0,007	0,123	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,539	<0.005	<0.030	<0.010	<0.020	17
BH5	8,71	17,0	0,122	<0.1	17,589	0,399	85,7	6,55	0,057	<0.020	0,124	<0.005	<0.003	<0.020	<0.020	0,007	0,053	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,498	<0.005	<0.030	<0.010	<0.020	17
BH6	7,29	11,5	1,668	0,833	6,584	0,471	35,6	8,44	<0.020	<0.020	0,152	<0.005	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	0,024	2,088	0,014	<0.030	<0.010	<0.020	17
BH7	6,41	20,0	9,570	3,443	12,802	0,867	20,4	36,33	0,033	<0.020	0,333	0,020	<0.003	<0.020	<0.020	0,010	<0.020	0,032	<0.020	<0.020	<0.015	<0.020	<0.020	5,414	0,066	<0.030	<0.010	0,026	17
BH8	8,57	10,5	0,280	0,220	20,440	0,482	54,2	8,50	0,370	<0.020	0,309	0,011	<0.003	<0.020	<0.020	0,008	0,382	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,470	<0.005	<0.030	0,013	<0.020	17
BH9	7,11	6,56	0,688	0,248	8,918	0,736	28,4	8,12	0,128	<0.020	0,179	<0.005	<0.003	<0.020	<0.020	0,009	0,026	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,161	<0.005	<0.030	<0.010	<0.020	17
BH1	7,96	6,04	0,191	<0.1	9,201	0,404	31,3	0,32	0,212	<0.020	0,439	<0.005	<0.003	<0.020	<0.020	0,009	0,197	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,464	<0.005	<0.030	<0.010	<0.020	18
BH10	7,05	24,7	28,515	5,614	14,308	0,573	77,5	30,67	<0.020	<0.020	0,760	0,034	<0.003	<0.020	<0.020	0,016	<0.020	0,021	<0.020	<0.020	<0.015	<0.020	<0.020	4,106	0,137	<0.030	<0.010	<0.020	18
BH11	6,79	114	222,383	47,162	17,167	0,867	47,9	492,24	<0.020	<0.020	0,555	0,040	<0.003	<0.020	<0.020	0,045	0,059	0,160	<0.020	<0.020	<0.015	<0.020	<0.020	4,114	0,905	<0.030	<0.010	0,032	18
BH12	6,29	10,2	0,202	<0.1	16,290	0,563	32,9	3,04	0,229	<0.020	0,181	<0.005	<0.003	<0.020	<0.020	0,013	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,754	<0.005	<0.030	<0.010	<0.020	18
BH13	7,16	41,8	48,311	17,009	14,371	0,797	47,9	115,89	<0.020	<0.020	0,439	0,035	<0.003	<0.020	<0.020	0,039	0,044	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,615	0,330	<0.030	<0.010	0,027	18
BH14	7,68	10,5	2,594	1,095	15,906	2,085	59,3	0,85	0,229	<0.020	0,419	0,008	<0.003	<0.020	<0.020	0,014	0,169	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,602	0,016	<0.030	<0.010	<0.020	18
BH15	7,69	11,0	2,709	0,594	13,420	1,443	52,6	2,85	0,163	<0.020	0,230	<0.005	<0.003	<0.020	<0.020	0,006	0,107	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,217	0,016	<0.030	<0.010	<0.020	18
BH16	7,46	15,8	2,136	1,049	25,976	1,964	88,8	7,18	0,083	<0.020	0,276	0,006	<0.003	<0.020	<0.020	0,005	0,029	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,524	0,045	<0.030	<0.010	<0.020	18
BH17	7,14	17,5	7,261	6,863	15,657	1,752	56,9	22,81	0,064	<0.020	0,251	0,011	<0.003	<0.020	<0.020	0,011	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,569	0,083	<0.030	<0.010	<0.020	18
BH18	7,47	12,8	0,260	0,107	23,760	0,799	62,7	5,84	0,285	<0.020	0,254	<0.005	<0.003	<0.020	<0.020	0,007	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,396	<0.005	<0.030	0,008	<0.020	18
BH19	7,07	21,7	18,109	5,956	13,248	0,772	60,5	34,47	<0.020	<0.020	0,492	0,026	<0.003	<0.020	<0.020	0,022	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,584	0,150	<0.030	<0.010	0,020	18
BH2	7,81	10,0	3,991	1,509	8,708	1,539	42,3	5,13	0,040	<0.020	0,412	0,006	<0.003	<0.020	<0.020	0,007	0,030	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,414	0,032	<0.030	<0.010	<0.020	18
BH20	7,08	11,9	1,149	0,815	18,590	1,308	56,0	2,90	0,090	<0.020	0,155	<0.005	<0.003	<0.020	<0.020	0,005	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,125	0,008	<0.030	<0.010	<0.020	18
BH21	7,44	20,5	13,631	6,594	17,315	1,116	76,2	20,31	0,022	<0.020	0,399	0,044	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,195	0,241	<0.030	<0.010	<0.020	18
BH22	7,48	12,8	0,662	0,475	24,812	1,038	67,1	4,85	0,067	<0.020	0,300	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,702	<0.005	<0.030	<0.010	<0.020	18
BH23	6,78	10,6	1,471	0,854	16,036	1,599	44,7	1,45	0,175	<0.020	0,194	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,680	0,007	<0.030	<0.010	<0.020	18
BH24	7,30	16,9	7,810	7,604	15,080	0,810	87,0	2,91	0,091	<0.020	0,432	0,029	<0.003	<0.020	<0.020	0,005	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,984	0,067	<0.030	<0.010	<0.020	18
BH25	7,39	11,6	3,450	2,426	15,509	1,467	63,7	9,22	0,166	<0.020	0,285	0,017	<0.003	<0.020	<0.020	0,007	0,074	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,921	0,032	<0.030	<0.010	<0.020	18
BH26	7,15	11,7	3,277	1,642	14,131	1,544	54,2		0,149	<0.020	0,203	0,010	<0.003	<0.020	<0.020	0,010	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,837	0,025	<0.030	<0.010	<0.020	18
BH27	7,54	22,8	16,357	10,812	13,474	0,737	101	9,35	<0.020	<0.020	0,478	0,079	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,016	0,261	<0.030	<0.010	<0.020	18
BH3	7,69	12,3	4,926	1,666	12,111	1,544	60,7		0,037	<0.020	0,408	0,008	<0.003	<0.020	<0.020	0,013	0,023	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,648	0,081	<0.030	<0.010	<0.020	18
BH4	7,46	17,1	1,029	0,568	32,421	1,361	47,0	21,58	0,814	<0.020	0,360	0,018	<0.003	<0.020	<0.020	0,026	0,889	0,025	<0.020	<0.020	<0.015	<0.020	<0.020	4,217	0,014	<0.030	<0.010	0,038	18
BH5	8,30	14,6	0,161	<0.1	30,675	0,629	82,4	5,49	0,176	<0.020	0,214	<0.005	<0.003	<0.020	<0.020	0,015	0,154	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,367	<0.005	<0.030	<0.010	<0.020	18
BH6	7,35	11,7	2,789	2,207	15,506	1,599	48,4	10,51	0,075	<0.020	0,218	0,005	<0.003	<0.020	<0.020	0,018	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,041	0,025	<0.030	<0.010	<0.020	18
BH7	6,29	18,8	11,705	5,038	15,927	1,210	26,4	46,53	<0.020	<0.020	0,343	0,020	<0.003	<0.020	<0.020	0,022	<0.020	0,024	<0.020	<0.020	<0.015	<0.020	<0.020	4,934	0,083	<0.030	<0.010	0,030	18
BH8	8,00	14,6	0,236	0,255	31,865	0,798	81,9	8,12	0,321	<0.020	0,299	0,006	<0.003	<0.020	<0.020	0,017	0,300	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,519	<0.005	<0.030	<0.010	<0.020	18
BH9	7,45	11,2	0,754	0,461	16,784	1,812	47,8	7,85	0,221	<0.020	0,209	<0.005	<0.003	<0.020	<0.020	0,009	0,044	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,175	<0.005	<0.030	<0.010	<0.020	18
BH1	8,30	7,01	0,565	0,142	16,476	0,915	43,0	0,32	0,146	<0.020	0,336	<0.005	<0.003	<0.020	<0.020	0,013	0,141	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,783	<0.005	<0.030	<0.010	<0.020	19
BH10	7,79	21,8	26,160	5,396	10,057	0,475	37,1	55,44	0,023	<0.020	0,699	0,030	<0.003	<0.020	<0.020	0,020	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,882	0,124	<0.030	<0.010	<0.020	19
BH11	6,94	113	206,968	42,574	14,859	0,802	35,3	641,13	<0.020	<0.020	0,516	0,038	<0.003	<0.020	<0.020	0,030	0,102	0,158	<0.020	<0.020	<0.015	<0.020	<0.020	5,021	0,855	<0.030	<0.010	<0.020	19
BH12	6,23	6,92	<0.1	<0.1	11,938	0,463	13,9	9,10	0,039	<0.020	0,185	<0.005	<0.003	<0.020	<0.020	0,016	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,840	<0.005	<0.030	<0.010	<0.020	19
BH13	7,17	42,9	56,831	17,834	15,466	1,008	40,7	190,47	0,020	<0.020	0,441	0,042	<0.003	<0.020	<0.020	0,021	0,064	0,034	<0.020	<0.020	<0.015	<0.020	<0.020	4,529	0,379	<0.030	<0.010	<0.020	19

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH14	7,95	8,91	1,526	0,696	15,715	1,806	43,7	1,13	0,474	<0.020	0,377	0,007	<0.003	<0.020	<0.020	0,012	0,486	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,555	0,007	<0.030	<0.010	<0.020	19
BH15	7,99	7,16	1,408	0,277	12,232	1,271	37,4	2,15	0,213	<0.020	0,241	<0.005	<0.003	<0.020	<0.020	0,011	0,208	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,916	0,005	<0.030	<0.010	<0.020	19
BH16	7,60	11,7	2,001	0,960	24,296	1,862	69,8	6,85	0,052	<0.020	0,259	<0.005	<0.003	<0.020	<0.020	0,014	0,031	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,729	0,036	<0.030	<0.010	<0.020	19
BH17	7,18	12,9	5,940	5,435	14,415	1,524	42,1	22,25	0,041	<0.020	0,351	0,008	<0.003	<0.020	<0.020	0,016	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,243	0,060	<0.030	<0.010	0,025	19
BH18	7,68	10,5	0,128	<0.1	21,106	0,734	45,3	5,43	0,058	<0.020	0,266	<0.005	<0.003	<0.020	<0.020	0,009	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,210	<0.005	<0.030	0,011	<0.020	19
BH19	7,21	20,0	22,554	7,408	10,685	0,560	48,9	45,35	<0.020	<0.020	0,563	0,033	<0.003	<0.020	<0.020	0,016	<0.020	0,023	<0.020	<0.020	<0.015	<0.020	<0.020	4,461	0,177	<0.030	<0.010	<0.020	19
BH2	8,10	10,6	4,145	1,602	16,297	2,059	53,9	4,75	0,056	<0.020	0,477	0,005	<0.003	<0.020	<0.020	0,019	0,045	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,501	0,029	<0.030	<0.010	0,025	19
BH20	7,12	8,06	1,213	0,691	12,753	0,805	35,7	3,21	0,043	<0.020	0,129	<0.005	<0.003	<0.020	<0.020	0,009	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,411	0,005	<0.030	<0.010	<0.020	19
BH21	7,43	17,1	10,856	5,458	17,454	1,102	62,8	19,59	0,026	<0.020	0,403	0,038	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,161	0,186	<0.030	<0.010	<0.020	19
BH22	7,59	8,19	0,435	0,225	16,810	0,636	36,4	4,21	0,032	<0.020	0,270	<0.005	<0.003	<0.020	<0.020	0,010	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,793	<0.005	<0.030	<0.010	<0.020	19
BH23	6,51	4,84	0,206	<0.1	7,446	0,667	16,9	3,18	0,068	<0.020	0,176	<0.005	<0.003	<0.020	<0.020	0,009	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,758	<0.005	<0.030	<0.010	<0.020	19
BH24	7,24	12,8	6,209	6,294	11,476	0,640	67,0	4,87	0,047	<0.020	0,426	0,024	<0.003	<0.020	<0.020	0,008	0,044	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,739	0,052	<0.030	<0.010	<0.020	19
BH25	7,39	7,18	1,734	1,437	7,218	0,748	34,3	8,55	0,068	<0.020	0,282	0,007	<0.003	<0.020	<0.020	0,016	0,100	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,125	0,016	<0.030	<0.010	<0.020	19
BH26	7,12	6,28	2,107	1,018	9,592	1,031	28,7	-6,22	0,056	<0.020	0,240	<0.005	<0.003	<0.020	<0.020	0,011	0,038	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,809	0,013	<0.030	<0.010	<0.020	19
BH27	7,75	24,1	18,581	12,413	14,039	0,785	110	8,80	<0.020	<0.020	0,625	0,102	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,366	0,300	<0.030	<0.010	<0.020	19
BH3	7,94	11,7	3,597	1,364	18,116	1,517	64,6		0,023	<0.020	0,396	<0.005	<0.003	<0.020	<0.020	0,022	0,027	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,623	0,056	<0.030	<0.010	<0.020	19
BH4	7,29	7,53	0,684	0,329	20,089	0,650	27,5	11,02	0,535	<0.020	0,204	0,010	<0.003	<0.020	<0.020	0,013	0,544	0,025	<0.020	<0.020	<0.015	<0.020	<0.020	2,401	<0.005	<0.030	<0.010	0,022	19
BH5	8,63	11,8	<0.1	<0.1	27,995	0,632	62,8	4,96	0,119	<0.020	0,217	<0.005	<0.003	<0.020	<0.020	0,012	0,112	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,570	<0.005	<0.030	<0.010	<0.020	19
BH6	7,32	11,7	5,265	4,391	12,883	1,304	33,9	22,06	0,032	<0.020	0,278	0,007	<0.003	<0.020	<0.020	0,016	0,029	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,728	0,048	<0.030	<0.010	<0.020	19
BH7	6,37	14,1	7,446	3,539	14,312	1,132	16,4	43,26	<0.020	<0.020	0,445	0,011	<0.003	<0.020	<0.020	0,031	<0.020	0,025	<0.020	<0.020	<0.015	<0.020	<0.020	6,022	0,053	<0.030	<0.010	0,045	19
BH8	8,51	11,8	<0.1	0,265	22,439	0,701	53,7	7,96	0,669	<0.020	0,243	0,010	<0.003	<0.020	<0.020	0,014	0,566	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,064	<0.005	<0.030	<0.010	0,027	19
BH9	7,71	5,67	0,465	0,197	10,121	1,038	25,6	6,21	0,110	<0.020	0,182	<0.005	<0.003	<0.020	<0.020	0,012	0,080	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,797	<0.005	<0.030	<0.010	<0.020	19
BH1	8,32	4,35	<0.1	<0.1	5,546	0,350	19,0	0,31	0,120	<0.020	0,316	<0.005	<0.003	<0.020	<0.020	0,010	0,127	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,075	<0.005	<0.030	<0.010	<0.020	20
BH10	7,47	24,3	29,748	5,589	7,880	0,436	39,6	61,81	<0.020	<0.020	0,656	0,039	<0.003	<0.020	<0.020	0,030	0,032	0,021	<0.020	<0.020	<0.015	<0.020	<0.020	4,472	0,147	<0.030	<0.010	0,024	20
BH11	6,76	102	183,540	35,347	12,149	0,716	35,7	537,25	<0.020	<0.020	0,427	0,037	<0.003	<0.020	<0.020	0,050	0,102	0,135	<0.020	<0.020	<0.015	<0.020	<0.020	4,362	0,774	<0.030	<0.010	0,041	20
BH12	5,78	4,41	0,173	<0.1	7,342	0,347	6,21	5,48	0,041	<0.020	0,134	<0.005	<0.003	<0.020	<0.020	0,012	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,057	<0.005	<0.030	<0.010	<0.020	20
BH13	7,07	46,0	57,026	17,560	10,169	0,810	33,5	191,24	<0.020	<0.020	0,359	0,036	<0.003	<0.020	<0.020	0,036	0,054	0,043	<0.020	<0.020	<0.015	<0.020	<0.020	3,840	0,380	<0.030	<0.010	0,026	20
BH14	7,87	8,81	1,224	0,524	11,141	1,626	41,6	1,58	0,311	<0.020	0,265	<0.005	<0.003	<0.020	<0.020	0,015	0,295	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,666	0,005	<0.030	<0.010	<0.020	20
BH15	8,13	5,92	1,140	0,142	6,442	0,902	29,4	1,85	0,180	<0.020	0,220	<0.005	<0.003	<0.020	<0.020	0,019	0,189	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,079	<0.005	<0.030	<0.010	<0.020	20
BH16	7,53	11,4	1,846	0,915	15,743	1,492	57,7	6,52	0,037	<0.020	0,219	<0.005	<0.003	<0.020	<0.020	0,013	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,059	0,041	<0.030	<0.010	<0.020	20
BH17	6,91	10,6	4,810	4,651	7,436	0,971	34,5	16,42	0,022	<0.020	0,284	0,006	<0.003	<0.020	<0.020	0,025	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,058	0,054	<0.030	<0.010	<0.020	20
BH18	7,60	8,0	<0.1	<0.1	15,722	0,599	33,0	5,12	0,080	<0.020	0,240	<0.005	<0.003	<0.020	<0.020	0,006	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,582	<0.005	<0.030	0,012	<0.020	20
BH19	6,90	17,2	16,211	5,120	6,309	0,379	38,2	37,86	<0.020	<0.020	0,428	0,024	<0.003	<0.020	<0.020	0,037	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,168	0,127	<0.030	<0.010	0,020	20
BH2	8,19	9,41	2,559	0,934	10,057	1,385	37,4	4,58	0,026	<0.020	0,435	<0.005	<0.003	<0.020	<0.020	0,010	0,027	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,841	0,019	<0.030	<0.010	<0.020	20
BH20	7,09	6,26	0,605	0,414	8,575	0,563	27,6	3,41	0,025	<0.020	0,137	<0.005	<0.003	<0.020	<0.020	0,014	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,114	<0.005	<0.030	<0.010	<0.020	20
BH21	7,43	14,8	8,615	4,108	14,356	1,015	55,1	15,36	<0.020	<0.020	0,313	0,031	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,204	0,141	<0.030	<0.010	<0.020	20
BH22	7,57	8,17	0,166	<0.1	15,148	0,852	37,5	4,34	0,053	<0.020	0,243	<0.005	<0.003	<0.020	<0.020	0,009	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,560	<0.005	<0.030	<0.010	<0.020	20
BH23	6,29	3,77	0,201	<0.1	5,524	0,643	13,2	2,98	0,057	<0.020	0,149	<0.005	<0.003	<0.020	<0.020	0,008	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,434	<0.005	<0.030	<0.010	<0.020	20
BH24	7,07	11,7	5,849	5,815	9,882	0,665	64,7	5,17	0,035	<0.020	0,374	0,021	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,651	0,047	<0.030	<0.010	<0.020	20
BH25	7,67	7,75	2,252	1,638	7,522	0,855	36,2	7,20	0,067	<0.020	0,230	0,007	<0.003	<0.020	<0.020	0,010	0,073	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,255	0,018	<0.030	<0.010	<0.020	20
BH26	7,18	5,21	1,689	0,781	5,612	0,850	23,9	-4,34	0,041	<0.020	0,170	<0.005	<0.003	<0.020	<0.020	0,010	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,951	0,009	<0.030	<0.010	<0.020	20
BH27	7,68	23,0	15,520	9,863	14,552	0,813	109	6,22	0,034	<0.020	0,565	0,096	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,377	0,257	<0.030	<0.010	<0.020	20
BH3	7,99	9,32	2,401	0,871	10,581	1,065	45,8		0,022	<0.020	0,330	<0.005	<0.003	<0.020	<0.020	0,015	0,023	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,667	0,038	<0.030	<0.010	<0.020	20
BH4	7,19	8,87	0,169	<0.1	14,942	0,458	21,3	9,26	0,248	<0.020	0,221	<0.005	<0.003	<0.020	<0.020	0,018	0,238	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,495	<0.005	<0.030	<0.010	<0.020	20
BH5	8,53	10,0	<0.1	<0.1	20,453	0,483	53,7	5,76	0,051	<0.020	0,189	<0.005	<0.003	<0.020	<0.020	0,013	0,056	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,865	<0.005	<0.030	<0.010	<0.020	20

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH6	7,25	10,0	3,581	3,082	8,384	0,961	28,5	13,85	0,021	<0.020	0,281	<0.005	<0.003	<0.020	<0.020	0,020	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,334	0,034	<0.030	<0.010	0,022	20
BH7	6,59	10,6	6,340	2,788	8,633	0,873	12,9	32,49	<0.020	<0.020	0,236	0,010	<0.003	<0.020	<0.020	0,023	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,009	0,046	<0.030	<0.010	0,032	20
BH8	8,18	10,3	<0.1	0,123	18,099	0,602	44,8	7,21	0,355	<0.020	0,233	<0.005	<0.003	<0.020	<0.020	0,015	0,344	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,838	<0.005	<0.030	<0.010	<0.020	20
BH9	6,99	4,38	0,155	<0.1	5,883	0,798	18,6	5,91	0,043	<0.020	0,217	<0.005	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,034	<0.005	<0.030	<0.010	<0.020	20
BH1	7,89	2,79	<0.1	<0.1	4,781	0,402	15,9	0,30	0,093	<0.020	0,214	<0.005	<0.003	<0.020	<0.020	0,010	0,087	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,351	<0.005	<0.030	<0.010	<0.020	21
BH10	7,18	20,6	27,864	5,283	4,780	0,270	31,6	61,06	<0.020	<0.020	0,592	0,035	<0.003	<0.020	<0.020	0,029	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,581	0,129	<0.030	<0.010	0,031	21
BH11	6,95	96,4	194,970	36,695	8,187	0,438	31,9	567,81	<0.020	<0.020	0,398	0,031	<0.003	<0.020	<0.020	0,039	<0.020	0,068	<0.020	<0.020	<0.015	<0.020	<0.020	4,485	0,715	<0.030	<0.010	0,030	21
BH12	5,61	4,85	0,197	<0.1	9,059	0,297	4,11	9,71	0,236	<0.020	0,208	<0.005	<0.003	<0.020	<0.020	0,014	0,026	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,019	<0.005	<0.030	<0.010	0,021	21
BH13	7,12	38,9	54,601	17,258	6,607	0,578	28,9	189,19	<0.020	<0.020	0,225	0,028	<0.003	<0.020	<0.020	0,032	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,168	0,327	<0.030	<0.010	0,028	21
BH14	7,52	7,32	1,759	0,681	9,124	1,540	37,4	1,43	0,104	<0.020	0,247	<0.005	<0.003	<0.020	<0.020	0,013	0,089	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,255	0,008	<0.030	<0.010	<0.020	21
BH15	7,92	5,66	2,128	0,335	5,828	0,953	30,8	1,85	0,120	<0.020	0,193	<0.005	<0.003	<0.020	<0.020	0,013	0,133	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,753	0,012	<0.030	<0.010	<0.020	21
BH16	7,32	9,99	3,780	1,891	13,805	1,708	62,6	4,12	0,042	<0.020	0,194	0,009	<0.003	<0.020	<0.020	0,010	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,162	0,088	<0.030	<0.010	<0.020	21
BH17	6,99	9,91	5,289	4,842	5,927	0,907	33,7	15,95	0,028	<0.020	0,272	0,009	<0.003	<0.020	<0.020	0,022	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,721	0,058	<0.030	<0.010	<0.020	21
BH18	7,39	7,51	<0.1	<0.1	13,818	0,464	31,4	4,86	0,101	<0.020	0,233	<0.005	<0.003	<0.020	<0.020	0,010	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,338	<0.005	<0.030	0,013	<0.020	21
BH19	6,96	17,1	18,487	5,711	6,312	0,343	37,6	44,07	<0.020	<0.020	0,426	0,028	<0.003	<0.020	<0.020	0,027	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,255	0,139	<0.030	<0.010	0,029	21
BH2	7,84	8,05	2,980	1,161	8,305	1,332	37,4	4,01	0,050	<0.020	0,412	<0.005	<0.003	<0.020	<0.020	0,016	0,043	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,189	0,024	<0.030	<0.010	<0.020	21
BH20	6,88	5,78	0,735	0,546	7,831	0,530	26,3	2,92	0,053	<0.020	0,110	<0.005	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,794	<0.005	<0.030	<0.010	<0.020	21
BH21	7,33	14,7	9,325	4,487	12,984	0,862	61,4	16,49	0,020	<0.020	0,311	0,040	<0.003	<0.020	<0.020	0,025	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,442	0,157	<0.030	<0.010	0,023	21
BH22	7,41	5,76	0,152	0,103	12,554	0,522	34,1	3,99	0,041	<0.020	0,226	<0.005	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,316	<0.005	<0.030	<0.010	<0.020	21
BH23	6,30	4,10	0,494	0,318	4,907	0,572	15,8	3,11	0,047	<0.020	0,145	<0.005	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,391	<0.005	<0.030	<0.010	<0.020	21
BH24	7,05	12,9	6,701	6,975	9,247	0,599	65,0	4,23	0,055	<0.020	0,382	0,029	<0.003	<0.020	<0.020	0,022	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,809	0,056	<0.030	<0.010	<0.020	21
BH25	7,59	6,97	2,766	2,162	6,766	0,848	40,3	7,55	0,067	<0.020	0,253	0,011	<0.003	<0.020	<0.020	0,019	0,068	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,921	0,026	<0.030	<0.010	0,033	21
BH26	6,92	5,05	1,522	0,841	4,302	0,728	24,4	-4,45	0,065	<0.020	0,170	0,005	<0.003	<0.020	<0.020	0,019	0,058	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,804	0,010	<0.030	<0.010	0,030	21
BH27	7,68	23,0	18,331	11,602	12,726	0,764	111	7,42	<0.020	<0.020	0,528	0,139	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,834	0,317	<0.030	<0.010	<0.020	21
BH3	7,80	6,26	2,198	0,813	7,256	0,899	35,2		0,037	<0.020	0,304	<0.005	<0.003	<0.020	<0.020	0,015	0,026	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,513	0,033	<0.030	<0.010	<0.020	21
BH4	6,91	6,99	0,225	<0.1	14,983	0,377	13,3	14,80	0,188	<0.020	0,251	<0.005	<0.003	<0.020	<0.020	0,020	0,187	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,516	<0.005	<0.030	<0.010	<0.020	21
BH5	8,43	8,87	<0.1	<0.1	19,670	0,479	52,0	4,86	0,073	<0.020	0,191	<0.005	<0.003	<0.020	<0.020	0,008	0,070	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,943	<0.005	<0.030	<0.010	<0.020	21
BH6	7,37	6,95	3,681	2,914	5,847	0,696	20,2	14,37	0,043	<0.020	0,248	<0.005	<0.003	<0.020	<0.020	0,019	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,369	0,033	<0.030	<0.010	0,025	21
BH7	6,08	7,59	4,961	2,045	6,506	0,744	6,07	29,51	0,062	<0.020	0,192	0,013	<0.003	<0.020	<0.020	0,032	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,548	0,032	<0.030	<0.010	0,045	21
BH8	7,99	7,55	<0.1	<0.1	17,655	0,497	43,7	7,55	0,162	<0.020	0,194	<0.005	<0.003	<0.020	<0.020	0,014	0,180	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,146	<0.005	<0.030	<0.010	<0.020	21
BH9	6,46	2,93	0,170	<0.1	3,696	0,484	13,4	4,00	0,148	<0.020	0,162	<0.005	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,933	<0.005	<0.030	<0.010	<0.020	21
BH1	7,89	4,37	0,123	<0.1	6,580	0,446	21,3	0,31	0,800	<0.020	0,229	<0.005	<0.003	<0.020	<0.020	0,016	0,341	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,728	<0.005	<0.030	<0.010	<0.020	22
BH10	7,37	15,9	18,767	3,964	5,117	0,313	36,4	28,19	0,025	<0.020	0,626	0,024	<0.003	<0.020	<0.020	0,027	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		5,251	0,097	<0.030	<0.010	<0.020	22
BH11	6,91	74,8	147,102	24,986	7,939	0,500	38,6	365,06	<0.020	<0.020	0,355	0,022	<0.003	<0.020	<0.020	0,039	<0.020	0,042	<0.020	<0.020	<0.015	<0.020		4,265	0,585	<0.030	<0.010	0,033	22
BH12	5,64	3,70	<0.1	<0.1	6,168	0,298	4,78	2,57	0,232	<0.020	0,186	<0.005	<0.003	<0.020	<0.020	0,020	0,050	<0.020	<0.020	<0.020	<0.015	<0.020		5,724	<0.005	<0.030	<0.010	<0.020	22
BH13	7,14	27,0	32,545	10,909	6,204	0,518	31,7	92,73	0,040	<0.020	0,304	0,028	<0.003	<0.020	<0.020	0,034	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		4,527	0,237	<0.030	<0.010	0,028	22
BH14	7,58	6,92	1,950	0,756	7,562	1,504	35,7	1,25	0,272	<0.020	0,252	<0.005	<0.003	<0.020	<0.020	0,008	0,102	<0.020	<0.020	<0.020	<0.015	<0.020		6,836	0,011	<0.030	<0.010	<0.020	22
BH15	7,85	5,57	2,830	0,478	4,408	0,888	30,2	1,55	0,200	<0.020	0,211	<0.005	<0.003	<0.020	<0.020	0,010	0,104	<0.020	<0.020	<0.020	<0.015	<0.020		6,943	0,017	<0.030	<0.010	<0.020	22
BH16	7,42	10,5	5,367	2,792	12,451	2,061	64,4	2,78	0,060	<0.020	0,202	0,014	<0.003	<0.020	<0.020	0,013	0,020	<0.020	<0.020	<0.020	<0.015	<0.020		5,126	0,137	<0.030	<0.010	<0.020	22
BH17	6,92	11,7	6,652	6,348	5,949	0,988	39,8	18,25	0,091	<0.020	0,262	0,012	<0.003	<0.020	<0.020	0,017	0,029	<0.020	<0.020	<0.020	<0.015	<0.020		5,346	0,080	<0.030	<0.010	<0.020	22
BH18	7,31	6,90	<0.1	<0.1	13,719	0,482	31,2	5,75	0,272	<0.020	0,207	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		5,006	<0.005	<0.030	0,012	<0.020	22
BH19	6,88	16,9	18,503	5,727	5,716	0,368	39,0	39,08	<0.020	<0.020	0,380	0,029	<0.003	<0.020	<0.020	0,023	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		4,853	0,146	<0.030	<0.010	0,025	22
BH2	7,68	8,90	4,166	1,684	7,210	1,471	41,8	4,45	0,232	<0.020	0,250	0,006	<0.003	<0.020	<0.020	0,019	0,080	<0.020	<0.020	<0.020	<0.015	<0.020		6,629	0,033	<0.030	<0.010	<0.020	22
BH20	6,82	5,82	0,929	0,609	8,195	0,649	26,8	2,82	0,107	<0.020	0,102	<0.005	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		4,362	<0.005	<0.030	<0.010	<0.020	22
BH21	7,63	11,7	7,636	3,537	9,831	0,674	32,6	26,21	0,086	<0.020	0,257	0,027	<0.003	<0.020	<0.020	0,019	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		5,024	0,127	<0.030	<0.010	<0.020	22

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH22	7,55	6,55	<0.1	<0.1	11,477	0,491	31,2	4,51	0,102	<0.020	0,247	<0.005	<0.003	<0.020	<0.020	0,006	0,021	<0.020	<0.020	<0.020	<0.015	<0.020		5,319	<0.005	<0.030	<0.010	<0.020	22
BH23	6,07	3,35	0,254	0,169	3,667	0,523	11,4	2,59	0,232	<0.020	0,148	<0.005	<0.003	<0.020	<0.020	0,018	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		5,125	<0.005	<0.030	<0.010	<0.020	22
BH24	7,09	8,78	3,849	4,003	6,412	0,436	39,5	8,57	0,185	<0.020	0,358	0,013	<0.003	<0.020	<0.020	0,020	0,025	<0.020	<0.020	<0.020	<0.015	<0.020		5,303	0,031	<0.030	<0.010	<0.020	22
BH25	7,57	6,94	2,350	1,855	5,543	0,725	32,3	6,89	0,209	<0.020	0,214	0,009	<0.003	<0.020	<0.020	0,019	0,093	<0.020	<0.020	<0.020	<0.015	<0.020		5,238	0,022	<0.030	<0.010	<0.020	22
BH26	7,02	3,91	0,713	0,418	3,610	0,592	18,5	-4,01	0,191	<0.020	0,142	<0.005	<0.003	<0.020	<0.020	0,018	0,157	<0.020	<0.020	<0.020	<0.015	<0.020		4,880	<0.005	<0.030	<0.010	0,024	22
BH27	7,75	14,6	10,567	6,917	8,266	0,470	64,9	5,59	0,061	<0.020	0,322	0,091	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020		5,397	0,199	<0.030	<0.010	<0.020	22
BH3	7,87	6,12	2,240	0,815	5,174	0,732	33,4		0,151	<0.020	0,239	<0.005	<0.003	<0.020	<0.020	0,020	0,041	<0.020	<0.020	<0.020	<0.015	<0.020		6,120	0,031	<0.030	<0.010	<0.020	22
BH4	8,00	10,5	0,656	0,288	20,855	0,515	19,9	21,14	0,494	<0.020	0,352	0,010	<0.003	<0.020	<0.020	0,023	0,245	<0.020	<0.020	<0.020	<0.015	<0.020		5,358	0,011	<0.030	<0.010	0,022	22
BH5	8,39	7,52	<0.1	<0.1	17,437	0,623	46,7	4,11	1,165	<0.020	0,176	0,006	<0.003	<0.020	<0.020	0,017	0,185	<0.020	<0.020	<0.020	<0.015	<0.020		5,883	<0.005	<0.030	<0.010	<0.020	22
BH6	7,46	6,96	3,147	2,636	5,275	0,642	24,2	9,45	0,114	<0.020	0,233	<0.005	<0.003	<0.020	<0.020	0,019	0,021	<0.020	<0.020	<0.020	<0.015	<0.020		4,531	0,029	<0.030	<0.010	<0.020	22
BH7	6,33	12,9	7,619	3,063	12,990	0,848	13,6	37,58	1,816	<0.020	0,489	0,024	<0.003	<0.020	<0.020	0,021	0,103	0,061	<0.020	<0.020	<0.015	<0.020		7,815	0,049	<0.030	<0.010	0,029	22
BH8	8,36	6,97	<0.1	0,185	16,815	0,562	38,9	6,86	2,221	<0.020	0,220	0,011	<0.003	<0.020	<0.020	0,012	0,355	<0.020	<0.020	<0.020	<0.015	<0.020		7,168	<0.005	<0.030	<0.010	<0.020	22
BH9	7,21	3,04	0,127	<0.1	3,932	0,502	12,6	3,75	0,276	<0.020	0,212	<0.005	<0.003	<0.020	<0.020	0,018	0,089	<0.020	<0.020	<0.020	<0.015	<0.020		5,211	<0.005	<0.030	<0.010	<0.020	22
BH1	8,07	4,88	0,434	0,192	7,586	0,558	24,1	0,35	1,113	<0.020	0,198	0,010	<0.003	<0.020	<0.020	0,008	0,471	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,603	<0.005	<0.030	<0.010	<0.020	23
BH10	7,16	18,8	21,306	4,123	9,647	0,247	59,8	19,33	0,025	<0.020	0,590	0,032	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,655	0,101	<0.030	<0.010	0,024	23
BH11	6,89	75,9	136,584	22,772	11,690	0,437	61,3	351,64	<0.020	<0.020	0,329	0,022	<0.003	<0.020	<0.020	0,036	<0.020	0,035	<0.020	<0.020	<0.015	<0.020	<0.020	3,932	0,527	<0.030	<0.010	0,028	23
BH12	5,98	6,57	0,192	<0.1	10,915	0,243	17,9	3,69	0,808	<0.020	0,161	<0.005	<0.003	<0.020	<0.020	0,009	0,051	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,547	<0.005	<0.030	<0.010	<0.020	23
BH13	7,09	29,9	33,766	11,681	11,651	0,662	64,6	91,07	0,032	<0.020	0,303	0,036	<0.003	<0.020	<0.020	0,025	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,003	0,247	<0.030	<0.010	0,023	23
BH14	7,46	8,88	3,193	1,245	7,844	1,674	41,7	1,75	0,137	<0.020	0,235	0,006	<0.003	<0.020	<0.020	0,012	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,818	0,021	<0.030	<0.010	<0.020	23
BH15	7,88	7,84	2,801	0,531	8,465	0,956	37,9	1,25	0,297	<0.020	0,187	0,005	<0.003	<0.020	<0.020	0,012	0,091	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,889	0,015	<0.030	<0.010	<0.020	23
BH16	7,26	12,8	6,846	3,543	12,358	2,014	78,3	2,65	0,025	<0.020	0,189	0,022	<0.003	<0.020	<0.020	0,008	0,034	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,859	0,181	<0.030	<0.010	<0.020	23
BH17	7,22	14,6	7,144	6,686	10,338	1,116	60,9	12,70	0,133	<0.020	0,262	0,016	<0.003	<0.020	<0.020	0,011	0,029	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,530	0,088	<0.030	<0.010	<0.020	23
BH18	7,32	10,4	0,424	0,159	17,465	0,540	44,5	5,33	0,204	<0.020	0,193	<0.005	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,603	<0.005	<0.030	<0.010	<0.020	23
BH19	7,04	17,7	18,086	5,300	9,636	0,288	49,1	36,49	<0.020	<0.020	0,345	0,029	<0.003	<0.020	<0.020	0,020	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,768	0,136	<0.030	<0.010	0,023	23
BH2	7,73	10,1	4,988	2,149	8,000	1,850	50,5	3,89	0,260	<0.020	0,258	0,009	<0.003	<0.020	<0.020	0,009	0,089	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,301	0,042	<0.030	<0.010	<0.020	23
BH20	7,08	9,02	1,438	1,051	12,119	0,681	40,8	2,98	0,121	<0.020	0,111	0,005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,103	0,012	<0.030	<0.010	<0.020	23
BH21	7,46	14,6	10,515	4,667	11,073	0,740	58,2	16,76	0,044	<0.020	0,227	0,042	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,021	0,174	<0.030	<0.010	<0.020	23
BH22	7,62	10,2	0,507	0,312	16,621	0,993	45,7	4,01	0,059	<0.020	0,193	<0.005	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,468	<0.005	<0.030	<0.010	<0.020	23
BH23	6,74	7,35	0,916	0,609	10,090	0,956	26,7	1,44	0,358	<0.020	0,124	<0.005	<0.003	<0.020	<0.020	0,010	0,043	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,935	<0.005	<0.030	<0.010	<0.020	23
BH24	7,34	10,5	4,997	4,925	7,933	0,352	51,3	7,45	0,216	<0.020	0,307	0,019	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,597	0,041	<0.030	<0.010	<0.020	23
BH25	7,59	6,91	1,223	0,764	8,347	0,740	32,9	5,85	0,345	<0.020	0,055	0,005	<0.003	<0.020	<0.020	0,009	0,055	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,851	0,007	<0.030	<0.010	0,023	23
BH26	7,62	7,61	1,865	1,072	9,334	1,238	36,2	-3,34	1,624	<0.020	0,135	0,009	<0.003	<0.020	<0.020	0,015	0,114	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,789	0,016	<0.030	<0.010	0,023	23
BH27	7,89	17,5	13,341	8,350	11,400	0,571	78,1	6,24	0,068	<0.020	0,410	0,119	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,473	0,242	<0.030	<0.010	<0.020	23
BH3	8,09	5,98	2,008	0,834	4,689	0,884	29,7		1,273	<0.020	0,160	0,011	<0.003	<0.020	<0.020	0,007	0,262	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,540	0,028	<0.030	<0.010	0,021	23
BH4	7,34	20,0	8,411	3,533	40,865	1,505	89,3	20,78	0,878	<0.020	0,596	0,064	<0.003	<0.020	<0.020	0,009	0,675	0,036	<0.020	<0.020	<0.015	<0.020	<0.020	5,386	0,080	<0.030	<0.010	0,072	23
BH5	8,28	10,0	0,192	0,105	16,426	0,715	45,8	3,99	1,961	<0.020	0,168	0,013	<0.003	<0.020	<0.020	0,015	0,235	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,270	<0.005	<0.030	<0.010	<0.020	23
BH6	7,39	9,11	2,643	2,174	7,716	0,701	27,2	7,98	0,118	<0.020	0,194	<0.005	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,871	0,024	<0.030	<0.010	<0.020	23
BH7	7,13	15,9	7,478	2,830	19,595	0,925	24,0	23,19	0,637	<0.020	0,874	0,010	<0.003	<0.020	<0.020	0,016	0,054	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,378	0,038	<0.030	<0.010	0,029	23
BH8	8,18	11,6	0,205	0,129	21,224	0,683	51,8	6,45	1,850	<0.020	0,177	0,005	<0.003	<0.020	<0.020	0,016	0,220	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,457	<0.005	<0.030	<0.010	<0.020	23
BH9	7,16	6,73	0,536	0,299	9,204	0,714	30,9	3,11	0,609	<0.020	0,228	<0.005	<0.003	<0.020	<0.020	0,012	0,037	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,622	<0.005	<0.030	<0.010	<0.020	23
BH1	7,73	10,4	3,055	1,175	19,118	1,631	59,8	0,36	0,299	<0.020	0,118	<0.005	<0.003	<0.020	<0.020	0,015	0,377	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,592	0,007	<0.030	<0.010	<0.020	24
BH10	7,26	22,9	22,670	4,223	18,825	0,584	83,6	15,72	<0.020	<0.020	0,579	0,038	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,558	0,106	<0.030	<0.010	<0.020	24
BH11	6,96	72,9	125,530	19,439	14,213	0,526	76,8	295,83	<0.020	<0.020	0,321	0,022	<0.003	<0.020	<0.020	0,030	0,027	0,030	<0.020	<0.020	<0.015	<0.020	<0.020	3,721	0,511	<0.030	<0.010	0,031	24
BH12	6,20	6,62	0,167	<0.1	11,700	0,250	17,4	3,99	0,092	<0.020	0,152	<0.005	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,492	<0.005	<0.030	<0.010	<0.020	24
BH13	7,21	32,9	28,711	9,924	19,640	0,874	81,8	74,57	<0.020	<0.020	0,270	0,039	<0.003	<0.020	<0.020	0,029	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,392	0,234	<0.030	<0.010	<0.020	24

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH14	7,81	11,5	6,093	2,257	12,661	2,320	63,2	1,85	0,039	<0.020	0,230	0,011	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,161	0,041	<0.030	<0.010	<0.020	24
BH15	7,94	10,3	3,619	0,621	18,357	1,253	61,9	1,03	0,080	<0.020	0,151	<0.005	<0.003	<0.020	<0.020	0,008	0,059	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,372	0,018	<0.030	<0.010	<0.020	24
BH16	7,46	16,9	7,916	3,959	19,611	2,496	92,6	2,54	<0.020	<0.020	0,144	0,028	<0.003	<0.020	<0.020	0,006	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,248	0,214	<0.030	<0.010	<0.020	24
BH17	7,34	17,0	5,502	5,073	21,699	1,661	76,6	8,42	0,045	<0.020	0,200	0,013	<0.003	<0.020	<0.020	0,009	0,022	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,518	0,066	<0.030	<0.010	<0.020	24
BH18	7,56	13,9	1,076	0,493	29,643	1,105	71,1	5,00	0,078	<0.020	0,158	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,712	0,011	<0.030	<0.010	<0.020	24
BH19	7,20	21,7	17,026	4,880	19,725	0,826	68,6	33,63	<0.020	<0.020	0,309	0,029	<0.003	<0.020	<0.020	0,020	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,212	0,126	<0.030	<0.010	<0.020	24
BH2	7,97	12,8	7,197	3,068	13,460	2,527	71,6	3,29	0,141	0,024	0,288	0,013	<0.003	<0.020	<0.020	0,012	0,204	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,964	0,063	<0.030	<0.010	<0.020	24
BH20	7,36	12,8	1,992	1,479	23,257	1,416	69,2	2,15	0,044	<0.020	0,077	0,007	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,255	0,016	<0.030	<0.010	<0.020	24
BH21	7,56	18,6	12,675	5,529	15,991	0,932	81,8	13,61	<0.020	<0.020	0,241	0,059	<0.003	<0.020	<0.020	0,023	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,421	0,213	<0.030	<0.010	<0.020	24
BH22	7,67	14,6	1,449	1,351	29,322	1,329	79,3	3,95	0,022	<0.020	0,178	0,006	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,939	0,011	<0.030	<0.010	<0.020	24
BH23	7,22	11,6	1,332	1,004	22,208	1,700	55,8	3,86	0,077	<0.020	0,101	<0.005	<0.003	<0.020	<0.020	0,019	0,051	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,429	0,007	<0.030	<0.010	<0.020	24
BH24	7,58	14,6	5,869	5,807	14,776	0,545	71,3	10,23	0,035	<0.020	0,298	0,022	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,784	0,045	<0.030	<0.010	<0.020	24
BH25	7,70	12,8	3,005	2,282	20,385	1,328	67,5	6,21	0,092	<0.020	0,174	0,013	<0.003	<0.020	<0.020	0,006	0,089	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,909	0,026	<0.030	<0.010	<0.020	24
BH26	7,75	11,6	2,291	1,368	21,065	1,551	64,4	-1,05	0,086	<0.020	0,107	0,008	<0.003	<0.020	<0.020	0,016	0,067	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,868	0,019	<0.030	<0.010	<0.020	24
BH27	7,88	20,5	13,462	7,617	14,917	0,572	87,2	8,13	0,069	<0.020	0,287	0,120	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,082	0,246	<0.030	<0.010	0,020	24
BH3	7,92	11,6	3,193	1,392	19,607	1,830	65,8		0,094	<0.020	0,186	<0.005	<0.003	<0.020	<0.020	0,010	0,093	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,573	0,046	<0.030	<0.010	<0.020	24
BH4	7,11	20,0	4,607	1,649	47,063	1,951	100	10,53	0,408	<0.020	0,240	0,017	<0.003	<0.020	<0.020	<0.005	0,431	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,638	0,036	<0.030	<0.010	0,020	24
BH5	8,34	14,6	0,503	0,167	37,629	1,135	79,8	3,58	0,153	<0.020	0,133	<0.005	<0.003	<0.020	<0.020	0,013	0,142	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,052	<0.005	<0.030	<0.010	<0.020	24
BH6	7,65	14,0	3,335	2,926	22,025	1,609	61,1	9,42	0,068	<0.020	0,162	0,005	<0.003	<0.020	<0.020	0,010	0,030	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,337	0,032	<0.030	<0.010	<0.020	24
BH7	7,29	20,7	6,455	2,669	32,447	1,601	49,6	25,34	0,073	<0.020	0,722	0,008	<0.003	<0.020	<0.020	0,015	0,083	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,195	0,033	<0.030	<0.010	0,027	24
BH8	8,19	12,8	0,298	0,168	29,933	1,143	70,4	6,12	0,202	<0.020	0,104	<0.005	<0.003	<0.020	<0.020	0,014	0,221	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,147	<0.005	<0.030	<0.010	<0.020	24
BH9	7,37	6,86	0,525	0,275	10,427	0,736	32,5	2,55	0,189	<0.020	0,211	<0.005	<0.003	<0.020	<0.020	0,011	0,030	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,998	<0.005	<0.030	<0.010	<0.020	24
BH1	7,61	12,9	4,384	1,722	19,096	1,906	67,4	0,31	1,255	<0.020	0,137	0,006	<0.003	<0.020	<0.020	0,006	0,360	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,258	0,014	<0.030	<0.010	<0.020	25
BH10	7,29	24,3	21,578	4,184	17,995	0,688	87,0	15,04	<0.020	<0.020	0,587	0,039	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,947	0,105	<0.030	<0.010	<0.020	25
BH11	6,98	77,2	119,820	18,981	17,639	0,837	85,6	317,92	<0.020	<0.020	0,368	0,022	<0.003	<0.020	<0.020	0,035	<0.020	0,026	<0.020	<0.020	<0.015	<0.020	<0.020	4,505	0,515	<0.030	<0.010	0,036	25
BH12	6,41	10,7	0,294	<0.1	22,538	0,895	46,4	4,30	0,299	<0.020	0,169	<0.005	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,621	<0.005	<0.030	<0.010	<0.020	25
BH13	7,24	33,0	28,372	9,917	19,414	1,073	82,0	77,81	0,039	<0.020	0,268	0,041	<0.003	<0.020	<0.020	0,020	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,504	0,230	<0.030	<0.010	0,030	25
BH14	7,76	13,0	5,273	2,020	16,377	2,350	71	1,23	0,059	<0.020	0,230	0,007	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,741	0,033	<0.030	<0.010	<0.020	25
BH15	7,75	13,0	3,151	0,622	20,871	1,672	69,1	0,85	0,416	<0.020	0,209	<0.005	<0.003	<0.020	<0.020	0,007	0,107	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,976	0,015	<0.030	<0.010	<0.020	25
BH16	7,54	17,7	7,893	4,153	21,216	2,760	101	2,35	0,022	<0.020	0,162	0,028	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,551	0,209	<0.030	<0.010	<0.020	25
BH17	7,44	18,9	5,506	5,124	23,261	2,267	83,5	8,15	0,304	<0.020	0,261	0,013	<0.003	<0.020	<0.020	0,017	0,057	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,771	0,065	<0.030	<0.010	<0.020	25
BH18	7,58	14,7	1,375	0,691	29,054	1,546	78,2	5,31	0,128	<0.020	0,196	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,560	0,015	<0.030	<0.010	<0.020	25
BH19	7,24	24,2	17,145	5,237	20,001	1,286	74,3	34,58	<0.020	<0.020	0,334	0,031	<0.003	<0.020	<0.020	0,016	<0.020	0,029	<0.020	<0.020	<0.015	<0.020	<0.020	3,726	0,131	<0.030	<0.010	<0.020	25
BH2	7,73	17,2	8,475	3,695	18,617	3,137	90,8	3,11	0,477	<0.020	0,346	0,017	<0.003	<0.020	<0.020	0,009	0,129	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,422	0,076	<0.030	<0.010	<0.020	25
BH20	7,44	14,1	2,338	1,805	22,757	1,890	74,2	1,85	0,306	<0.020	0,106	0,008	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,035	0,019	<0.030	<0.010	<0.020	25
BH21	7,59	21,9	14,191	6,184	17,573	1,089	90,1	15,18	0,028	<0.020	0,278	0,073	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,095	0,237	<0.030	<0.010	<0.020	25
BH22	7,90	14,7	1,252	1,135	28,682	1,719	77,5	3,32	0,362	<0.020	0,190	<0.005	<0.003	<0.020	<0.020	0,008	0,038	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,419	0,007	<0.030	<0.010	<0.020	25
BH23	7,29	12,9	1,252	0,963	21,128	2,115	60,3	2,76	0,225	<0.020	0,112	<0.005	<0.003	<0.020	<0.020	0,007	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,421	0,006	<0.030	<0.010	<0.020	25
BH24	7,57	17,1	5,910	6,004	15,702	0,690	79,3	8,25	0,180	<0.020	0,294	0,023	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,270	0,046	<0.030	<0.010	<0.020	25
BH25	7,76	14,7	3,366	2,618	21,618	1,785	73,7	5,25	0,240	<0.020	0,204	0,014	<0.003	<0.020	<0.020	0,008	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,370	0,031	<0.030	<0.010	<0.020	25
BH26	7,82	14,1	2,322	1,454	23,727	2,292	74,4	-2,82	2,919	<0.020	0,134	0,012	<0.003	<0.020	<0.020	0,015	0,133	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,257	0,021	<0.030	<0.010	<0.020	25
BH27	7,84	24,7	15,628	9,628	16,839	0,826	107	9,29	0,069	<0.020	0,353	0,146	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,839	0,290	<0.030	<0.010	<0.020	25
BH3	7,94	14,1	2,371	1,083	24,071	2,594	73,1		0,941	<0.020	0,248	<0.005	<0.003	<0.020	<0.020	0,007	0,186	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,939	0,028	<0.030	<0.010	<0.020	25
BH4	7,58	20,1	0,883	0,406	46,096	2,082	76,1	16,43	1,015	<0.020	0,245	0,018	<0.003	<0.020	<0.020	<0.005	0,380	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,740	0,019	<0.030	<0.010	<0.020	25
BH5	7,97	20,0	0,537	0,243	40,259	1,970	100	2,86	1,656	<0.020	0,240	0,015	<0.003	<0.020	<0.020	0,017	0,668	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,448	<0.005	<0.030	<0.010	0,027	25

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH6	7,64	16,0	3,377	3,196	22,678	2,299	68,3	7,70	0,132	<0.020	0,213	<0.005	<0.003	<0.020	<0.020	0,013	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,015	0,033	<0.030	<0.010	<0.020	25
BH7	7,73	21,8	5,250	2,100	34,524	2,113	60,9	23,55	0,360	<0.020	1,311	0,007	<0.003	<0.020	<0.020	0,016	0,038	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,774	0,027	<0.030	<0.010	0,024	25
BH8	8,15	17,1	0,392	0,364	34,958	1,773	87,7	5,67	2,690	<0.020	0,159	<0.005	<0.003	<0.020	<0.020	0,013	0,277	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,931	<0.005	<0.030	<0.010	<0.020	25
BH9	7,66	13,0	1,807	1,133	21,469	2,208	68,6	2,10	1,790	<0.020	0,255	0,008	<0.003	<0.020	<0.020	0,011	0,083	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,430	0,014	<0.030	<0.010	<0.020	25
BH1	7,67	7,40	0,6754	0,2342	10,4402	1,1029	35,3	0,39	0,263	<0.020	0,113	<0.005	<0.003	<0.020	<0.020	<0.005	0,192	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,185	<0.005	<0.030	<0.010	<0.020	26
BH10	6,99	18,8	17,7363	3,5516	12,2624	0,5789	67,2	12,89	<0.020	<0.020	0,498	0,031	<0.003	<0.020	<0.020	0,019	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,152	0,087	<0.030	<0.010	0,025	26
BH11	6,97	68,9	109,0363	17,5761	12,284	0,6377	69,6	259,09	<0.020	<0.020	0,296	0,025	<0.003	<0.020	<0.020	0,041	<0.020	0,027	<0.020	<0.020	<0.015	<0.020	<0.020	3,673	0,497	<0.030	<0.010	0,045	26
BH12	6,06	6,28	0,3288	<0.1	11,215	0,5308	15,1	2,74	0,230	<0.020	0,131	<0.005	<0.003	<0.020	<0.020	0,012	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,649	<0.005	<0.030	<0.010	<0.020	26
BH13	7,11	28,9	27,2992	8,9787	14,5095	1,0051	65,2	64,80	0,033	<0.020	0,211	0,042	<0.003	<0.020	<0.020	0,022	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,775	0,221	<0.030	<0.010	0,031	26
BH14	7,75	10,8	1,9776	0,7421	13,5138	1,6111	50,2	1,32	0,163	<0.020	0,195	<0.005	<0.003	<0.020	<0.020	0,015	0,051	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,202	0,009	<0.030	<0.010	<0.020	26
BH15	7,99	12,9	2,223	0,4424	23,0744	1,8122	69,8	0,64	0,187	<0.020	0,194	<0.005	<0.003	<0.020	<0.020	0,025	0,088	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,356	0,010	<0.030	<0.010	<0.020	26
BH16	7,48	10,5	2,9839	1,365	11,4388	1,577	50,5	2,12	0,376	<0.020	0,102	0,009	<0.003	<0.020	<0.020	0,020	0,283	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,186	0,055	<0.030	<0.010	0,022	26
BH17	7,32	18,8	6,0858	5,2666	25,1955	2,6113	84,6	7,84	0,111	<0.020	0,179	0,015	<0.003	<0.020	<0.020	0,019	0,033	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,569	0,069	<0.030	<0.010	<0.020	26
BH18	7,30	9,33	0,8741	0,1657	25,2734	0,9786	40,2	4,88	0,152	<0.020	0,085	<0.005	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,583	<0.005	<0.030	<0.010	<0.020	26
BH19	7,12	24,1	26,4534	3,8653	31,8755	1,7831	76,7	14,47	<0.020	<0.020	0,176	0,033	<0.003	<0.020	<0.020	0,025	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,284	0,108	<0.030	<0.010	<0.020	26
BH2	7,92	11,7	2,4843	0,8402	13,2131	1,7128	71,3	2,34	0,217	<0.020	0,252	<0.005	<0.003	<0.020	<0.020	0,012	0,075	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,074	0,013	<0.030	<0.010	0,021	26
BH20	7,16	7,94	1,4399	0,4817	16,4768	1,2534	32,9	2,32	0,156	<0.020	0,056	<0.005	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,523	<0.005	<0.030	<0.010	<0.020	26
BH21	7,55	18,8	18,9629	4,2016	26,572	1,5133	81,1	5,98	0,021	<0.020	0,130	0,068	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,908	0,177	<0.030	<0.010	<0.020	26
BH22	7,66	9,40	1,0794	0,4281	21,8014	1,1111	38,6	3,11	0,133	<0.020	0,094	<0.005	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,826	<0.005	<0.030	<0.010	<0.020	26
BH23	7,01	10,1	0,9142	0,2771	21,2766	2,0921	43,2	0,26	0,144	<0.020	<0.040	<0.005	<0.003	<0.020	<0.020	0,019	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,553	<0.005	<0.030	<0.010	<0.020	26
BH24	7,34	10,5	6,0094	3,0022	13,2091	0,7006	52,5	11,24	0,115	<0.020	0,135	0,015	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,298	0,025	<0.030	<0.010	<0.020	26
BH25	7,74	14,4	3,7657	1,3973	32,0193	2,7133	72,4	4,88	0,140	<0.020	0,066	0,012	<0.003	<0.020	<0.020	0,013	0,021	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,276	0,016	<0.030	<0.010	<0.020	26
BH26	7,62	8,53	0,9458	0,1929	18,7531	1,3522	37,2		0,145	<0.020	0,066	<0.005	<0.003	<0.020	<0.020	0,022	0,035	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,831	<0.005	<0.030	<0.010	<0.020	26
BH27	7,68	20,5	21,4695	4,9595	27,2502	1,1831	93,7	7,01	0,024	<0.020	0,111	0,127	<0.003	<0.020	<0.020	0,025	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,942	0,187	<0.030	<0.010	<0.020	26
BH3	7,85	9,02	1,349	0,4845	11,0094	1,295	43,8		0,185	<0.020	0,217	<0.005	<0.003	<0.020	<0.020	0,011	0,047	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,308	0,010	<0.030	<0.010	<0.020	26
BH4	6,96	7,65	0,3824	0,1608	12,0475	0,6799	31,1	2,33	0,391	<0.020	0,061	0,005	<0.003	<0.020	<0.020	0,007	0,319	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,647	<0.005	<0.030	<0.010	<0.020	26
BH5	7,50	12,2	0,3999	0,143	13,7992	0,8129	59,1	2,15	0,348	<0.020	0,084	0,009	<0.003	<0.020	<0.020	0,016	0,469	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,984	<0.005	<0.030	<0.010	<0.020	26
BH6	7,71	11,0	2,6165	2,1852	10,5862	1,2539	34,2	8,60	0,038	<0.020	0,155	<0.005	<0.003	<0.020	<0.020	0,014	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,199	0,023	<0.030	<0.010	0,026	26
BH7	7,65	14,6	4,1047	1,595	24,3137	1,2305	26,4	21,45	0,122	<0.020	1,187	0,006	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,220	0,021	<0.030	<0.010	0,040	26
BH8	7,98	10,7	0,2578	0,1956	17,6841	0,8266	46,5	5,22	0,296	<0.020	0,137	<0.005	<0.003	<0.020	<0.020	0,010	0,276	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,507	<0.005	<0.030	<0.010	<0.020	26
BH9	7,50	7,20	0,6174	0,3	10,1542	0,9474	33,4	1,85	0,092	<0.020	0,209	<0.005	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,401	<0.005	<0.030	<0.010	0,020	26
BH1	6,31	5,43	0,6109	0,2398	6,2082	0,5752	25,5	0,35	0,258	<0.020	0,206	<0.005	<0.003	<0.020	<0.020	0,013	0,147	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,967	<0.005	<0.030	<0.010	<0.020	27
BH10	7,11	17,2	20,0568	3,6832	9,1491	0,3804	57,7	11,80	0,020	<0.020	0,485	0,038	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,852	0,095	<0.030	<0.010	<0.020	27
BH11	7,10	60,1	105,9907	18,0533	11,0933	0,6297	60,2	245,45	<0.020	<0.020	0,285	0,029	<0.003	<0.020	<0.020	0,023	<0.020	0,033	<0.020	<0.020	<0.015	<0.020	<0.020	3,626	0,471	<0.030	<0.010	<0.020	27
BH12	5,72	3,13	0,1863	<0.1	4,6921	0,2068	4,56	2,53	0,292	<0.020	0,085	<0.005	<0.003	<0.020	<0.020	0,007	0,028	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,624	<0.005	<0.030	<0.010	<0.020	27
BH13	7,10	27,1	27,0883	9,4522	9,6105	0,6492	55,0	69,96	<0.020	<0.020	0,236	0,041	<0.003	<0.020	<0.020	0,019	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,970	0,233	<0.030	<0.010	0,026	27
BH14	7,84	7,97	1,7217	0,6375	9,6479	1,1945	37,6	1,75	0,162	<0.020	0,182	0,005	<0.003	<0.020	<0.020	0,007	0,048	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,303	0,009	<0.030	<0.010	<0.020	27
BH15	8,08	7,14	1,0215	0,1974	9,9	0,9417	34,7	0,51	0,189	<0.020	0,165	<0.005	<0.003	<0.020	<0.020	0,009	0,119	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,456	<0.005	<0.030	<0.010	<0.020	27
BH16	7,57	8,38	2,8612	1,4195	6,8914	1,2057	39,3	1,19	0,202	<0.020	0,110	0,010	<0.003	<0.020	<0.020	0,010	0,133	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,231	0,061	<0.030	<0.010	<0.020	27
BH17	6,96	10,2	3,4617	3,0961	7,9896	0,917	35,1	5,15	0,087	<0.020	0,218	0,010	<0.003	<0.020	<0.020	0,011	0,043	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,841	0,040	<0.030	<0.010	<0.020	27
BH18	7,12	7,13	0,3762	0,1374	11,6217	0,4723	28,1	5,12	0,106	<0.020	0,166	<0.005	<0.003	<0.020	<0.020	0,006	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,333	<0.005	<0.030	<0.010	<0.020	27
BH19	6,84	16,1	14,6966	4,3437	7,3836	0,374	45,1	23,21	<0.020	<0.020	0,284	0,030	<0.003	<0.020	<0.020	0,022	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,710	0,113	<0.030	<0.010	0,025	27
BH2	7,85	8,64	2,512	0,9903	9,3118	1,2616	40,5	2,15	0,264	<0.020	0,234	0,006	<0.003	<0.020	<0.020	0,009	0,257	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,014	0,018	<0.030	<0.010	<0.020	27
BH20	6,83	6,73	1,3236	0,979	7,2423	0,5864	30,0	2,78	0,100	<0.020	0,091	0,007	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,909	0,010	<0.030	<0.010	<0.020	27
BH21	7,35	15,7	9,7991	4,4509	13,6715	0,8947	60,6	9,14	0,059	<0.020	0,212	0,053	<0.003	<0.020	<0.020	0,017	0,024	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,794	0,170	<0.030	0,012	0,023	27

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH22	7,36	7,48	0,7047	0,588	11,2778	0,6285	33,5	2,55	0,063	<0.020	0,156	<0.005	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,631	<0.005	<0.030	<0.010	<0.020	27
BH23	6,27	4,04	0,3151	0,13	4,5604	0,6224	11,2	1,36	0,234	<0.020	0,076	<0.005	<0.003	<0.020	<0.020	0,009	0,046	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,304	<0.005	<0.030	<0.010	<0.020	27
BH24	7,43	8,56	3,0667	3,0688	5,7286	0,3032	30,0	11,78	0,180	<0.020	0,238	0,013	<0.003	<0.020	<0.020	0,010	0,029	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,347	0,023	<0.030	<0.010	<0.020	27
BH25	7,59	7,88	1,4465	1,1189	8,3811	0,8328	32,4	4,12	0,175	<0.020	0,152	0,008	<0.003	<0.020	<0.020	0,013	0,052	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,974	0,011	<0.030	<0.010	<0.020	27
BH26	7,34	4,91	0,5088	0,2605	6,1512	0,7881	21,9		0,203	<0.020	0,116	0,006	<0.003	<0.020	<0.020	0,015	0,098	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,812	<0.005	<0.030	<0.010	0,022	27
BH27	7,80	18,8	12,6209	7,3927	12,3978	0,6	78,0	2,47	0,067	<0.020	0,329	0,115	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,906	0,239	<0.030	<0.010	<0.020	27
BH3	7,88	4,97	1,0197	0,3983	5,2875	0,7724	24,5		0,253	<0.020	0,166	<0.005	<0.003	<0.020	<0.020	0,013	0,226	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,673	0,008	<0.030	<0.010	<0.020	27
BH4	8,03	6,13	0,3439	0,1438	9,798	0,3485	16,4	5,14	0,352	<0.020	0,118	0,007	<0.003	<0.020	<0.020	0,006	0,280	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,589	<0.005	<0.030	<0.010	<0.020	27
BH5	6,59	10,4	0,3629	0,1269	15,5468	0,7773	41,8	1,88	0,191	<0.020	0,151	0,007	<0.003	<0.020	<0.020	0,020	0,201	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,322	<0.005	<0.030	<0.010	<0.020	27
BH6	7,93	8,75	2,3729	2,2472	6,258	0,827	22,8	5,74	0,091	<0.020	0,223	0,006	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,227	0,025	<0.030	<0.010	<0.020	27
BH7	8,02	14,8	3,7942	1,4927	24,8383	1,1403	29,9	25,81	0,271	<0.020	1,300	0,008	<0.003	<0.020	<0.020	0,012	0,032	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,590	0,020	<0.030	<0.010	<0.020	27
BH8	7,88	10,8	0,2566	0,1459	19,4972	0,8298	46,7	4,78	0,378	<0.020	0,205	<0.005	<0.003	<0.020	<0.020	0,015	0,111	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,773	<0.005	<0.030	<0.010	<0.020	27
BH9	7,59	6,85	0,6878	0,3956	8,1157	0,9632	29,2	1,12	0,339	<0.020	0,214	<0.005	<0.003	<0.020	<0.020	0,009	0,035	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,949	<0.005	<0.030	<0.010	<0.020	27
BH1	7,86	3,97	0,277	0,127	5,025	0,572	19,0	0,29	0,309	<0.020	0,225	<0.005	<0.003	<0.020	<0.020	0,012	0,161	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,732	<0.005	<0.030	<0.010	<0.020	28
BH10	7,14	16,9	15,146	3,506	6,898	0,439	54,7	31,75	<0.020	<0.020	0,530	0,028	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,291	0,092	<0.030	<0.010	<0.020	28
BH11	7,00	46,7	64,348	14,095	6,356	0,485	50,1	183,27	<0.020	<0.020	0,236	0,021	<0.003	<0.020	<0.020	0,054	<0.020	0,024	<0.020	<0.020	<0.015	<0.020	<0.020	3,148	0,366	<0.030	<0.010	0,039	28
BH12	5,31	3,66	0,219	<0.1	5,211	0,258	3,56	8,60	0,503	<0.020	0,188	<0.005	<0.003	<0.020	<0.020	0,011	0,064	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,296	<0.005	<0.030	<0.010	<0.020	28
BH13	7,04	25,9	24,519	9,287	7,266	0,741	50,4	79,61	<0.020	<0.020	0,262	0,036	<0.003	<0.020	<0.020	0,025	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,576	0,235	<0.030	<0.010	0,031	28
BH14	7,84	6,97	1,458	0,612	7,702	1,249	32,8	1,27	0,153	<0.020	0,216	<0.005	<0.003	<0.020	<0.020	0,008	0,055	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,736	0,009	<0.030	<0.010	<0.020	28
BH15	8,03	5,64	1,024	0,245	6,154	0,991	28,6	0,21	0,190	<0.020	0,213	<0.005	<0.003	<0.020	<0.020	0,015	0,076	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,670	<0.005	<0.030	<0.010	<0.020	28
BH16	7,49	7,87	2,812	1,694	5,879	1,423	38,7	1,13	0,185	<0.020	0,141	0,008	<0.003	<0.020	<0.020	0,008	0,077	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,334	0,072	<0.030	<0.010	<0.020	28
BH17	6,91	9,69	2,780	2,916	5,868	0,912	28,9	14,96	0,162	<0.020	0,223	0,007	<0.003	<0.020	<0.020	0,011	0,039	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,572	0,036	<0.030	<0.010	0,020	28
BH18	7,09	6,25	0,391	0,166	9,322	0,535	25,5	4,49	0,119	<0.020	0,177	<0.005	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,724	<0.005	<0.030	<0.010	<0.020	28
BH19	6,77	15,6	12,565	4,544	5,917	0,451	37,3	38,06	<0.020	<0.020	0,282	0,025	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,634	0,118	<0.030	<0.010	0,024	28
BH2	7,75	11,9	3,384	1,623	13,685	2,223	63,3	2,12	0,485	0,031	0,503	0,008	<0.003	<0.020	<0.020	0,014	0,211	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	10,211	0,031	<0.030	<0.010	<0.020	28
BH20	6,71	5,41	0,837	0,672	5,398	0,576	22,4	2,55	0,105	<0.020	0,100	<0.005	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,088	0,006	<0.030	<0.010	<0.020	28
BH21	7,31	15,2	8,554	4,335	10,161	0,893	53,7	21,47	0,058	<0.020	0,224	0,042	<0.003	<0.020	<0.020	0,011	0,031	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,463	0,166	<0.030	0,011	0,022	28
BH22	7,38	6,66	0,519	0,422	9,114	0,716	29,5	1,74	0,088	<0.020	0,169	<0.005	<0.003	<0.020	<0.020	0,009	0,032	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,706	<0.005	<0.030	<0.010	<0.020	28
BH23	6,10	3,77	0,373	0,217	4,227	0,741	9,29	6,59	0,385	<0.020	0,111	<0.005	<0.003	<0.020	<0.020	0,010	0,047	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,160	<0.005	<0.030	<0.010	<0.020	28
BH24	7,48	10,5	3,662	4,172	5,951	0,511	40,5	10,89	0,193	<0.020	0,326	0,013	<0.003	<0.020	<0.020	0,016	0,039	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,670	0,032	<0.030	<0.010	0,030	28
BH25	7,78	5,87	1,118	0,925	5,518	0,883	26,4	2,47	0,228	<0.020	0,179	0,005	<0.003	<0.020	<0.020	0,021	0,063	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,919	0,009	<0.030	<0.010	<0.020	28
BH26	7,52	4,45	0,822	0,528	4,760	0,962	19,9	1,52	0,358	<0.020	0,158	0,009	<0.003	<0.020	<0.020	0,026	0,258	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,237	0,006	<0.030	<0.010	0,042	28
BH27	7,79	19,7	12,224	7,664	10,710	0,772	78,2	17,40	0,041	<0.020	0,319	0,098	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,134	0,259	<0.030	<0.010	0,023	28
BH3	7,97	4,98	0,823	0,416	4,708	0,884	24,0	0,40	0,440	<0.020	0,227	<0.005	<0.003	<0.020	<0.020	0,011	0,341	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,302	0,009	<0.030	<0.010	<0.020	28
BH4	7,62	12,5	0,390	0,173	19,923	0,814	38,8	26,38	0,320	<0.020	0,299	0,006	<0.003	<0.020	<0.020	0,007	0,214	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,436	0,006	<0.030	<0.010	<0.020	28
BH5	7,57	11,3	0,403	0,183	19,474	0,884	51,8	1,61	0,260	<0.020	0,195	0,012	<0.003	<0.020	<0.020	0,014	0,426	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,718	<0.005	<0.030	<0.010	0,022	28
BH6	8,07	11,9	3,347	3,606	6,605	1,361	24,8	28,00	0,070	<0.020	0,249	0,007	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,915	0,043	<0.030	<0.010	<0.020	28
BH7	8,09	12,3	1,895	0,816	15,655	0,847	18,5	36,92	0,348	<0.020	1,374	<0.005	<0.003	<0.020	<0.020	0,018	0,045	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,423	0,010	<0.030	<0.010	0,022	28
BH8	8,14	6,66	0,191	0,157	9,843	0,469	26,8	4,34	0,450	<0.020	0,238	0,005	<0.003	<0.020	<0.020	0,010	0,254	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,001	<0.005	<0.030	<0.010	<0.020	28
BH9	6,76	3,26	0,368	0,188	3,704	0,733	15,5	0,71	0,448	<0.020	0,191	<0.005	<0.003	<0.020	<0.020	0,010	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,828	<0.005	<0.030	<0.010	<0.020	28
BH1	6,13	3,56	0,236	<0.1	3,306	0,384	17,1	0,44	0,224	<0.020	0,228	<0.005	<0.003	<0.020	<0.020	0,022	0,239	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,270	<0.005	<0.030	<0.010	<0.020	29
BH10	7,10	16,9	18,795	3,496	7,377	0,380	58,1	28,64	<0.020	<0.020	0,509	0,036	<0.003	<0.020	<0.020	0,025	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,333	0,089	<0.030	<0.010	<0.020	29
BH11	6,92	53,0	77,818	15,028	8,198	0,687	67,4	202,89	<0.020	<0.020	0,266	0,030	<0.003	<0.020	<0.020	0,031	<0.020	0,022	<0.020	<0.020	<0.015	<0.020	<0.020	3,878	0,377	<0.030	<0.010	0,034	29
BH12	5,48	3,90	0,276	<0.1	6,164	0,325	4,12	9,23	0,116	<0.020	0,157	<0.005	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,118	<0.005	<0.030	<0.010	<0.020	29
BH13	6,98	24,6	26,805	8,602	7,938	0,626	54,0	70,15	0,020	<0.020	0,228	0,046	<0.003	<0.020	<0.020	0,019	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,735	0,213	<0.030	<0.010	0,026	29

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH14	7,71	7,17	1,123	0,403	7,934	1,176	32,4	1,79	0,076	<0.020	0,200	<0.005	<0.003	<0.020	<0.020	0,013	0,026	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,793	<0.005	<0.030	<0.010	<0.020	29
BH15	8,06	6,01	1,570	0,271	5,280	1,044	27,7	0,52	0,109	<0.020	0,181	<0.005	<0.003	<0.020	<0.020	0,021	0,088	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,499	0,005	<0.030	<0.010	<0.020	29
BH16	7,44	8,37	3,208	1,672	5,712	1,251	38,6	1,17	0,069	<0.020	0,120	0,010	<0.003	<0.020	<0.020	0,014	0,030	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,299	0,069	<0.030	<0.010	0,028	29
BH17	6,89	10,6	3,680	3,416	6,225	0,882	32,1	16,17	0,052	<0.020	0,217	0,010	<0.003	<0.020	<0.020	0,020	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,049	0,040	<0.030	<0.010	<0.020	29
BH18	6,86	6,89	0,408	0,138	9,629	0,494	26,8	3,90	0,077	<0.020	0,145	<0.005	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,660	<0.005	<0.030	<0.010	<0.020	29
BH19	6,84	17,7	14,314	4,176	6,635	0,498	39,9	35,91	<0.020	<0.020	0,279	0,027	<0.003	<0.020	<0.020	0,027	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,031	0,108	<0.030	<0.010	0,023	29
BH2	7,64	11,2	3,603	1,177	10,489	1,573	54,9	1,84	0,148	0,022	0,431	0,008	<0.003	<0.020	<0.020	0,021	0,123	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,559	0,022	<0.030	<0.010	<0.020	29
BH20	6,67	6,70	1,125	0,807	6,115	0,578	28,3	2,78	0,046	<0.020	0,084	0,005	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,329	0,007	<0.030	<0.010	<0.020	29
BH21	7,28	17,3	10,198	4,180	11,304	0,934	60,9	18,69	0,038	<0.020	0,215	0,049	<0.003	<0.020	<0.020	0,014	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,719	0,160	<0.030	<0.010	<0.020	29
BH22	7,15	7,92	0,564	0,375	9,904	0,643	34,5	2,36	0,036	<0.020	0,174	<0.005	<0.003	<0.020	<0.020	0,017	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,210	<0.005	<0.030	<0.010	<0.020	29
BH23	6,04	3,98	0,477	0,247	4,134	0,593	11,6	4,65	0,073	<0.020	0,108	<0.005	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,945	<0.005	<0.030	<0.010	0,021	29
BH24	7,31	15,2	5,528	6,130	7,931	0,619	65,3	8,58	0,092	<0.020	0,268	0,025	<0.003	<0.020	<0.020	0,022	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,623	0,045	<0.030	<0.010	<0.020	29
BH25	7,49	8,37	2,170	1,743	6,351	0,872	35,5	3,72	0,073	<0.020	0,175	0,011	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,048	0,019	<0.030	<0.010	<0.020	29
BH26	7,08	5,85	1,629	0,943	4,423	0,874	25,6	1,95	0,088	<0.020	0,145	0,008	<0.003	<0.020	<0.020	0,020	0,053	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,145	0,012	<0.030	<0.010	<0.020	29
BH27	7,66	22,9	15,424	8,103	10,793	0,643	93,5	14,27	0,030	<0.020	0,376	0,133	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,241	0,276	<0.030	<0.010	0,020	29
BH3	8,02	5,68	0,720	0,286	6,812	0,885	25,5	0,97	0,220	<0.020	0,387	<0.005	<0.003	<0.020	<0.020	0,017	0,299	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,221	<0.005	<0.030	<0.010	<0.020	29
BH4	7,09	8,98	0,277	<0.1	12,766	0,423	33,1	7,41	0,238	<0.020	0,182	0,005	<0.003	<0.020	<0.020	0,019	0,234	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,221	<0.005	<0.030	<0.010	<0.020	29
BH5	6,90	9,57	0,278	<0.1	13,884	0,645	40,6	1,43	0,111	<0.020	0,166	0,005	<0.003	<0.020	<0.020	0,018	0,136	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,393	<0.005	<0.030	<0.010	<0.020	29
BH6	7,25	10,3	3,158	2,786	7,021	0,953	27,5	16,74	0,076	<0.020	0,266	0,007	<0.003	<0.020	<0.020	0,022	0,031	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,020	0,028	<0.030	<0.010	<0.020	29
BH7	8,08	12,4	1,432	0,488	16,159	0,655	22,5	26,50	0,114	<0.020	1,263	<0.005	<0.003	<0.020	<0.020	0,021	0,050	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	9,478	<0.005	<0.030	<0.010	<0.020	29
BH8	7,44	8,50	0,269	0,128	13,771	0,682	35,4	3,60	0,153	<0.020	0,267	<0.005	<0.003	<0.020	<0.020	0,017	0,085	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,830	<0.005	<0.030	<0.010	<0.020	29
BH9	6,57	3,74	0,475	0,236	4,222	0,497	16,0	0,98	0,151	<0.020	0,209	<0.005	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,665	<0.005	<0.030	<0.010	<0.020	29
BH1	6,15	4,21	0,294	<0.1	5,512	0,4957	19,1	0,49	0,168	<0.020	0,218	<0.005	<0.003	<0.020	<0.020	0,008	0,161	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,573	<0.005	<0.030	<0.010	<0.020	30
BH10	6,95	14,6	16,019	3,239	7,614	0,4249	53,7	14,48	<0.020	<0.020	0,312	0,036	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,205	0,061	<0.030	<0.010	<0.020	30
BH11	6,84	48,9	73,593	15,970	8,360	0,6666	61,5	100,44	<0.020	<0.020	0,174	0,035	<0.003	<0.020	<0.020	0,027	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,430	0,276	<0.030	<0.010	<0.020	30
BH12	5,66	4,46	0,213	<0.1	7,759	0,4301	6,92	4,35	0,090	<0.020	0,100	<0.005	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,321	<0.005	<0.030	<0.010	<0.020	30
BH13	6,89	22,9	22,965	8,217	8,731	0,8473	54,5	30,33	<0.020	<0.020	0,139	0,048	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,236	0,149	<0.030	<0.010	<0.020	30
BH14	7,68	8,78	2,562	0,996	8,926	1,9762	38,3	0,88	0,057	<0.020	0,168	0,007	<0.003	<0.020	<0.020	0,010	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,288	0,011	<0.030	<0.010	<0.020	30
BH15	8,10	12,0	4,603	0,913	15,532	1,8568	52,0	0,36	0,080	<0.020	0,097	0,007	<0.003	<0.020	<0.020	0,011	0,027	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,918	0,020	<0.030	<0.010	<0.020	30
BH16	7,52	12,9	5,280	2,830	16,763	2,4605	67,1	0,69	0,059	<0.020	0,091	0,019	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,658	0,091	<0.030	<0.010	<0.020	30
BH17	7,28	14,7	4,377	4,214	17,152	1,9489	61,1	7,67	0,055	<0.020	0,116	0,013	<0.003	<0.020	<0.020	0,019	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,243	0,036	<0.030	<0.010	<0.020	30
BH18	7,36	11,7	1,574	0,840	20,523	1,4597	58,2	2,18	0,030	<0.020	0,098	0,009	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,915	0,015	<0.030	<0.010	<0.020	30
BH19	6,92	20,7	16,195	5,519	16,542	1,3671	62,5	17,82	<0.020	<0.020	0,173	0,032	<0.003	<0.020	<0.020	0,014	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,969	0,084	<0.030	<0.010	<0.020	30
BH2	7,42	11,7	5,582	1,548	9,946	1,9508	73,0	2,34	0,145	<0.020	0,423	0,012	<0.003	<0.020	<0.020	0,009	0,175	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,558	0,028	<0.030	<0.010	<0.020	30
BH20	7,15	11,7	2,326	1,989	17,305	1,8395	60,6	1,42	0,026	<0.020	0,057	0,011	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,463	0,013	<0.030	<0.010	<0.020	30
BH21	7,3	20,0	14,043	6,512	14,799	1,3928	81,4	8,45	<0.020	<0.020	0,134	0,070	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,584	0,156	<0.030	<0.010	<0.020	30
BH22	7,49	12,8	2,545	2,046	21,299	1,8829	63,5	0,86	<0.020	<0.020	0,094	0,009	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,706	0,010	<0.030	<0.010	<0.020	30
BH23	7,00	11,9	1,240	1,043	15,473	1,9851	46,3	1,82	0,059	<0.020	0,060	0,005	<0.003	<0.020	<0.020	0,011	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,642	<0.005	<0.030	<0.010	<0.020	30
BH24	7,11	18,8	7,338	8,722	14,625	1,0419	90,2	3,50	0,022	<0.020	0,142	0,030	<0.003	<0.020	<0.020	0,014	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,272	0,038	<0.030	<0.010	<0.020	30
BH25	7,55	12,9	2,794	2,285	16,564	1,8817	62,6	1,31	0,035	<0.020	0,095	0,011	<0.003	<0.020	<0.020	0,018	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,766	0,014	<0.030	<0.010	<0.020	30
BH26	7,54	10,5	2,937	1,853	14,482	1,7357	55,2	0,64	0,042	<0.020	0,083	0,010	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	1,858	0,015	<0.030	<0.010	<0.020	30
BH27	7,54	22,9	16,377	9,499	14,307	0,9854	104,9	5,56	<0.020	<0.020	0,225	0,127	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,525	0,197	<0.030	<0.010	<0.020	30
BH3	8,00	6,63	1,176	0,472	8,451	1,0636	31,0	0,66	0,143	<0.020	0,391	<0.005	<0.003	<0.020	<0.020	0,007	0,163	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,244	0,009	<0.030	<0.010	<0.020	30
BH4	6,85	9,34	0,275	<0.1	13,089	0,6485	37,5	4,08	0,106	<0.020	0,140	<0.005	<0.003	<0.020	<0.020	0,008	0,063	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,067	<0.005	<0.030	<0.010	<0.020	30
BH5	6,45	9,31	0,238	<0.1	13,047	0,8652	40,9	0,63	0,110	<0.020	0,109	<0.005	<0.003	<0.020	<0.020	0,008	0,091	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,659	<0.005	<0.030	<0.010	<0.020	30

Humidity Cells	pH	EC	Ca	Mg	Na	K	MAlk	SO_4	Al	As	B	Ba	Cd	Co	Cr	Cu	Fe	Mn	Mo	Ni	Pb	Sb	Se	Si	Sr	U	V	Zn	Week No.
BH6	7,77	9,61	2,426	2,082	8,796	1,309	25,3	8,97	0,059	<0.020	0,211	0,006	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,823	0,015	<0.030	<0.010	<0.020	30
BH7	8,13	10,6	1,080	0,414	14,047	0,8859	24,6	16,83	0,064	<0.020	0,892	<0.005	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	6,951	<0.005	<0.030	<0.010	<0.020	30
BH8	7,54	9,86	0,343	0,163	15,116	0,9649	41,4	2,36	0,099	<0.020	0,245	<0.005	<0.003	<0.020	<0.020	0,010	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,872	<0.005	<0.030	<0.010	<0.020	30
BH9	7,25	4,67	0,505	0,230	6,349	0,7362	18,5	0,59	0,083	<0.020	0,170	<0.005	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,183	<0.005	<0.030	<0.010	<0.020	30
BH1	7,44	9,75	1,364	0,571	13,108	1,180	43,2	0,84	0,211	<0.020	0,192	<0.005	<0.003	<0.020	<0.020	0,016	0,188	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	7,051	<0.005	<0.030	<0.010	<0.020	31
BH10	7,50	20,5	20,059	3,694	14,355	0,600	80,4	29,01	<0.020	<0.020	0,483	0,047	<0.003	<0.020	<0.020	0,024	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,848	0,097	<0.030	<0.010	0,022	31
BH11	7,33	50,7	65,703	14,997	13,610	0,622	77,3	180,09	<0.020	<0.020	0,268	0,040	<0.003	<0.020	<0.020	0,029	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,727	0,365	<0.030	<0.010	0,035	31
BH12	6,82	10,4	0,337	<0.1	18,983	0,811	41,2	7,93	0,156	<0.020	0,142	<0.005	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,233	<0.005	<0.030	<0.010	<0.020	31
BH13	7,48	50,4	27,128	9,028	18,205	1,089	90,1	62,16	<0.020	<0.020	0,207	0,062	<0.003	<0.020	<0.020	0,021	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,414	0,231	<0.030	<0.010	0,036	31
BH14	8,24	12,8	7,200	2,641	13,318	2,270	65,8	1,10	0,043	<0.020	0,192	0,016	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,025	0,049	<0.030	<0.010	0,020	31
BH15	8,42	13,9	3,890	0,629	20,698	1,846	69,3	0,27	0,057	<0.020	0,183	0,007	<0.003	<0.020	<0.020	0,008	0,034	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,976	0,025	<0.030	<0.010	<0.020	31
BH16	7,97	15,7	5,315	2,842	20,702	2,427	81,6	0,88	0,049	<0.020	0,143	0,021	<0.003	<0.020	<0.020	0,022	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,091	0,128	<0.030	<0.010	<0.020	31
BH17	7,81	18,7	5,207	4,750	22,307	2,137	78,4	14,00	0,056	<0.020	0,187	0,017	<0.003	<0.020	<0.020	0,013	0,025	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,567	0,061	<0.030	<0.010	0,026	31
BH18	7,86	15,7	2,386	1,256	24,680	1,706	74,1	3,54	0,032	<0.020	0,155	0,016	<0.003	<0.020	<0.020	0,015	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,261	0,040	<0.030	<0.010	<0.020	31
BH19	7,54	24,0	16,502	5,155	20,259	1,442	79,6	37,12	<0.020	<0.020	0,276	0,039	<0.003	<0.020	<0.020	0,024	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,598	0,132	<0.030	<0.010	0,020	31
BH2	8,29	12,2	3,910	1,371	13,739	1,858	54,2	2,06	0,029	<0.020	0,267	0,008	<0.003	<0.020	<0.020	0,008	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,756	0,027	<0.030	<0.010	<0.020	31
BH20	7,76	15,8	2,918	2,386	22,933	2,283	74,7	2,02	0,038	<0.020	0,088	0,017	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,874	0,029	<0.030	<0.010	<0.020	31
BH21	7,74	22,8	15,166	6,296	17,207	1,194	95,1	17,33	<0.020	<0.020	0,203	0,097	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	4,296	0,241	<0.030	<0.010	0,026	31
BH22	7,87	16,9	2,276	2,423	25,277	2,033	81,5	1,87	<0.020	<0.020	0,164	0,017	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,392	0,026	<0.030	<0.010	<0.020	31
BH23	7,66	12,8	1,222	0,980	20,878	2,134	64,2	3,72	0,095	<0.020	0,113	0,007	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,558	0,008	<0.030	<0.010	<0.020	31
BH24	7,50	21,7	8,008	8,684	19,122	0,981	102	7,14	0,027	<0.020	0,232	0,046	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,934	0,065	<0.030	<0.010	0,020	31
BH25	7,92	14,5	3,742	3,072	21,429	2,066	79,3	2,46	0,077	<0.020	0,180	0,024	<0.003	<0.020	<0.020	0,010	0,032	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,865	0,038	<0.030	<0.010	<0.020	31
BH26	7,98	14,6	3,235	1,955	22,702	2,053	73,8	1,05	0,078	<0.020	0,144	0,016	<0.003	<0.020	<0.020	0,012	0,036	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,445	0,029	<0.030	<0.010	0,024	31
BH27	7,87	24,0	16,472	9,168	16,903	0,884	110	9,16	<0.020	<0.020	0,368	0,166	<0.003	<0.020	<0.020	0,012	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,962	0,308	<0.030	<0.010	0,034	31
BH3	8,27	10,5	2,716	1,089	15,929	1,715	56,6	0,57	0,116	<0.020	0,337	0,006	<0.003	<0.020	<0.020	0,009	0,076	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	5,802	0,033	<0.030	<0.010	<0.020	31
BH4	7,22	17,6	0,384	<0.1	32,172	1,119	86,7	8,67	0,076	<0.020	0,270	<0.005	<0.003	<0.020	<0.020	0,008	0,050	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	2,594	<0.005	<0.030	<0.010	<0.020	31
BH5	7,04	12,8	0,597	0,238	23,645	1,371	68,7	1,06	0,172	<0.020	0,131	0,007	<0.003	<0.020	<0.020	0,011	0,258	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,506	0,005	<0.030	<0.010	<0.020	31
BH6	7,91	15,8	4,134	4,112	18,537	1,874	59,7	17,77	0,064	<0.020	0,309	0,012	<0.003	<0.020	<0.020	0,016	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,483	0,046	<0.030	<0.010	0,020	31
BH7	8,49	17,0	2,696	0,979	25,834	1,419	52,2	28,99	0,072	<0.020	1,142	0,006	<0.003	<0.020	<0.020	0,013	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	8,747	0,013	<0.030	<0.010	0,020	31
BH8	8,10	12,8	0,529	0,420	22,321	1,507	65,5	3,25	0,177	<0.020	0,287	<0.005	<0.003	<0.020	<0.020	0,011	0,118	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,327	<0.005	<0.030	<0.010	<0.020	31
BH9	8,05	11,7	1,421	0,821	16,608	1,454	51,2	0,88	0,050	<0.020	0,218	0,006	<0.003	<0.020	<0.020	0,009	<0.020	<0.020	<0.020	<0.020	<0.015	<0.020	<0.020	3,914	0,010	<0.030	<0.010	<0.020	31

APPENDIX H: BOREHOLE LOG ZFN 1510 AND 1512

Table H-1: ZFN 1510

TOP(m)	BASE (m)	THICKNESS	LITHOLOGY	CONTACT	DESCRIPTION
0,000	5,940	5,940	no recovery		Unrecovered core
5,940	11,250	5,310	Sandstone/ Siltstone	Horizontal	Orangy khaki fine to medium grained micaceous
11,250	15,710	4,460	Siltstone	Horizontal	Grey fine to medium grained micaceous and wavely with sulphides
15,710	17,100	1,390	Sandstone/ Siltstone	Horizontal	Grey fine to medium grained micaceous, shaly banded
17,100	18,620	1,520	Shale	Horizontal	Dark grey fine grained micaceous, interlaminated and minor cross beds
18,620	34,000	15,380	Sandstone	Horizontal	Whitish grey coarse to medium grained rock laminae, carbonaceous with sulphides
34,000	42,620	8,620	Sandstone/ Siltstone		light grey fine to medium grained shaly gritty, cross bedded
42,620	45,790	3,170	Sandstone		Whitish grey medium grained core, cross bedded
45,790	53,620	7,830	Sandstone/ Siltstone		Grey fine to medium grained gritty banded sand, micaceous, wavy bedded with sulphides
53,620	54,360	0,740	Shale	Horizontal	Carbonaceous shale, greyish black fine to very fine grained rock
54,360	58,700	4,340	Sandstone		Whitish grey medium grained core, rock laminae
58,700	60,930	2,230	Dolerite		Light greenish grey porphyritic feldspathic rock, interbedded
60,930	61,150	0,220	Sandstone		Whitish grey fine to medium grained sandy/ silty micaceous, rock laminae with fractures
60,150	63,200	3,050	Sandstone/ Siltstone		fine to medium grained light to grey siltstone, wavely and cross lamination
63,200	64,700	1,500	Coal		Seam 5, 90% bright black carbonaceous matrix core, horizontal bedded
64,700	64,980	0,280	Shale	Horizontal	black > 90% bright bands carbonaceous matrix
64,980	74,220	9,240	Sandstone		Whitish grey medium grained rock laminae with fractures and sulphides
74,220	82,300	8,080	Sandstone/ Siltstone		light grey fine to medium grained shaly gritty, rock laminae
82,300	83,610	1,310	Sandstone		Whitish grey coarse to medium grained rock with bioturbation and sulphides
83,610	84,320	0,710	Coal		Seam 4, 90% bright black rock, horizontal bedded with occassional pyrite lenses
84,320	87,380	3,060	Coaly Shale	Horizontal	Coaly shale black
87,380	90,560	3,180	Coal	Horizontal	Seam 4, 60-90% bright black to dull lustrous black with rare pyrite lenses
90,560	91,020	0,460	Sandstone/ Siltstone	Horizontal	light brownish grey fine grained and cross lamination

TOP(m)	BASE (m)	THICKNESS	LITHOLOGY	CONTACT	DESCRIPTION
91,020	92,840	1,820	Sandstone		Whitish grey medium grained rock laminae with rare pyrite nodules
92,840	95,070	2,230	Sandstone	Horizontal	Whitish grey coarse grained massive rock
95,070	95,730	0,660	Shale	Horizontal	Grey fine grained coally banded rock with bands of sulphides
95,730	96,410	0,680	Sandstone	Horizontal	
96,410	96,410	0,000	Shale	Horizontal	Carbonaceous shale greyish black coaly shale > 90% bright
96,410	99,760	3,350	Sandstone/ Siltstone	Horizontal	Light grey fine grained micaceous well sorted rock
99,760	99,890	0,130	Sandstone/ Siltstone	Horizontal	Light grey fine to medium grained gritty rock with occasional siderite nudules
99,890	100,280	0,390	Coal	Horizontal	Seam 3, 90 % bright black carbonaceous matrix
100,280	103,530	3,250	Sandstone/ Siltstone	Horizontal	Light grey fine to medium grained shaly banded micaceous rock
103,530	106,120	2,590	Shale	Horizontal	Greyish black fine to very fine grained carbonaceous
106,120	112,140	6,020	Sandstone/ Siltstone		Grey fine to medium grained micaceous rock laminae
112,140	113,600	1,460	Shale	Horizontal	Carbonaceous shale black with sulphides
113,600	114,090	0,490	Sandstone/ Siltstone	Horizontal	Grey fine to medium grained gritty
114,090	116,650	2,560	Coal	Horizontal	Seam 2, 40-60% bright black
116,650	117,290	0,640	Coaly Shale	Horizontal	Black
117,290	123,190	5,900	Coal	Horizontal	60-90% bright black > 90% bright
123,190	124,150	0,960	Coaly Shale	Horizontal	black
124,150	129,400	5,250	Dwyka Tillite	Horizontal	grey fine to coarse grained
129,400	134,150	4,750	Silstone		pinkish grey fine grained rock laminae
134,150	134,830	0,680	Dwyka Tillite		Very coarse to coarse grained pebbly rock
134,830	140,480	5,650	Granite		Reddist pink coarsely crystalline rock, purely structural holes

Table H-2: ZFN 1512

TOP(m)	BASE (m)	THICKNESS	LITHOLOGY	CONTACT	DESCRIPTION
0,000	12,000	12,000			No recovery
12,000	12,370	0,370	Sandstone-siltstone	Horizontal	Orangey grey fine to medium grained solids, Core weak rock moderately, Weathered horizontal contact at the base
12,370	16,700	4,330	Sandstone-siltstone	Horizontal	Light grey fine to medium grained micaceous, Solid core moderately weak rock, Slightly weathered horizontal at the base
16,700	21,320	4,620	Sandstone-siltstone		grey fine to medium grained micaceous, solid core strong rock, fresh rock wavy bedded
21,320	22,760	1,440	Shale	sharp	grey fine to muddy broken core due to jointing, moderately strong rock, fresh rock sharp contact at 5 degree with joints, at 60 dgrees extremely closed slicknesided
22,760	23,000	0,240	Dolerite	sharp	Greenish grey porphyritic feldspathic, Solid core strong rock, fresh rock sharp contact at 45 degrees with fractures closely spaced
23,000	23,700	0,700	Shale	sharp	Carbonaceous shale, black fine to very grained core dure to jointing moderately strong rock, fresh rock sharp contact at 5degree with jointing at 65 degree extremely closeley spaced slicknesided
23,700	25,430	1,730	Dolerite	sharp	Greenish grey porphyritic feldspathic, Solid core strong rock, fresh rock sharp contact at 60 degrees with fractures closely spaced
25,430	27,200	1,770	Sandstone	Horizontal	Whitish grey fine to medium grained massive solid core, stron rock, Fresh rock horizontal contact at the base
27,200	28,590	1,390	Sandstone	Horizontal	light grey fine grained massive solid core strong rock, fresh rock horizontal contact at the base
28,590	40,830	12,240	Sandstone	Horizontal	greyish white medium grained massive solid core, strong fresh rock, horizontal contact
40,830	48,210	7,380	Sandstone-siltstone		light grey fine to medium grained micaceous gritty, solid core strong fresh rock trough cross bedded
48,210	49,950	1,740	Sandstone	Horizontal	greyish white medium grained massive solid core, strong fresh rock, horizontal contact
49,950	59,800	9,850	Sandstone-siltstone		Light grey fine grained micaceous solid core strong rock fresh rock wavy bedded
59,800	64,100	4,300	Sandstone		Greyish white to medium grained sandy/ silty solid core strong rock fresh rock laminae, visible sulphides noddles
64,100	65,260	1,160	Dolerite	sharp	Greenish grey porphyritic sill, with fine ground mass of mafic minerals around the grains of plagioclase feldspar
65,260	65,580	0,320	sandstone	Horizontal	grey fine to medium grained sandstone with carboneous material and sulphides
65,580	65,960	0,380	Dolerite	sharp	light greyish khaki porphyritic fedspathic
65,960	67,730	1,770	Sandstone		light grey fine to medium grained with sulphites
67,730	68,310	0,580	Siltstone		grey fine grained micaceous interlaminated bioturbated siltstone

TOP(m)	BASE (m)	THICKNESS	LITHOLOGY	CONTACT	DESCRIPTION
68,310	69,760	1,450	Coal	Horizontal	Coal seam 5, 90% bright black interbedded with pyrite lenses
69,760	70,100	0,340	Shale	Horizontal	carbonaceous shale, black > 90% bright
70,100	79,150	9,050	Sandstone		greyish white medium grained sandstone, cross bedded with nearly horizontal beds, laminated, bioturbated with noddle of sulphites
79,150	87,420	8,270	Sandstone-siltstone		grey fine to medium grained gritty micaceous, interbedded and interlaminated with nearly horizontal beds and sulphites
87,420	87,960	0,540	Sandstone	Horizontal	greyish white medium grained massive solid core with lenses of carbonaceous
87,960	88,070	0,110	Sandstone	Horizontal	grey to light brown fine to coarse grained
88,070	96,810	8,740	Coal	Horizontal	Seam 4 60-90% bright black core with occasional pyrite lenses
96,810	97,000	0,190	Shale		grey to black, interbedded silt to mud
97,000	98,120	1,120	Sandstone	Horizontal	greyish white medium grained sandstone
98,120	98,180	0,060	Shale	Horizontal	grey fine to very fine grained
98,180	98,240	0,060	Coal	Horizontal	90% bright black banded solid core
98,240	98,980	0,740	Shale	Horizontal	grey fine to very fine grained and interlaminated silts
98,980	99,970	0,990	Coally Shale	Horizontal	broken core due to jointing
99,970	100,100	0,130	Shale	Horizontal	fine grey to very fine grained with micaceous silts
100,100	102,040	1,940	Sandstone	Horizontal	light grey fine to medium grained sandy/ silty core with carbonaceous material
102,040	102,360	0,320	Coal	Horizontal	Seam 3, 90% bright black carbonaceous matrix with rare siderite nodules
102,360	105,540	3,180	Sandstone	Horizontal	grey fine to medium grained with carbonaceous material
105,540	108,270	2,730	Shale	Horizontal	greyish black fine to very fine grained, highly carbonaceous with sulphites
108,270	114,300	6,030	sandstone/ Siltstone		grey fine to medium grained carbonaceous siltstone, wavy bedded
114,300	115,890	1,590	Shale	Horizontal	grey fine to very fine grained
115,890	116,180	0,290	Sandstone	Horizontal	grey fine to medium grained , wavely interlaminated, carbonaceous with sulphides
116,180	120,550	4,370	Coal	Horizontal	Seam 2, 40-60, 60-90% bright to dull black coal with rare pyrite lenses

TOP(m)	BASE (m)	THICKNESS	LITHOLOGY	CONTACT	DESCRIPTION
120,550	120,770	0,220	Shale	Horizontal	blackish grey carboneous shale with sulphides nodules
120,770	125,020	4,250	Coal	Horizontal	60-90% bright to dull black coal with occasional pyrite lenses
125,020	125,250	0,230	Sandstone	Horizontal	blackish grey gritty carbonaceous with sulphides nodules
125,250	126,570	1,320	Coal	Horizontal	dull black lustorus coal
126,570	127,205	0,635	sandstone	Horizontal	massive coarse grained sandstone of th dwyka formation
127,205	129,675	2,470	Mudstone		light grey mudstone of the dwyka formation
129,675	130,685	1,010	Tillite		conglomerate or diacmitite of dwyka formation
130,685	131,055	0,370	Sandstone		medium sandstone of the dwyka formation
131,055	131,925	0,870	Tillite		conglomerate or diamictite of dwyka formation
131,925	132,845	0,920	sandstone		massive coarse grained sandstone of th dwyka formation
132,845	134,025	1,180	Sandstone		medium to fine grained light brown sandstone of dwyka formation
134,025	135,650	1,625	Tillite		conglomerate or diamictite of dwyka formation
135,650	138,240	2,590	Granite		Reddish pink coarse crystalline, pre-karoo basement composed of alkali granite

APPENDIX I: LITHOLOGICAL MAJOR AND TRACES AVERAGES OF BHZFN1510 AND ZFN1512

BH No	Lithology	Sample ID/Seam No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Cr_2O_3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr	S
1512	**Coal**	5	4,8	0,1	1,5	1,1	0,0	0,3	0,7	0,1	0,0	0,0	0,0	91,4	100,0	12,0	100,0	3,2	2,0	13,0	1,8	7,5	5,0	2,0	2,8	1,0	3,0	10,0	2,0	6,7	10,0	2,0	6,5	2,0	3,0	1,0	10,0	73,0	2,0	3,0	3,0	2,0	10,0	3,0	6,0	3,0	3,0	21,0	0,8
1512	**Coal**	4	2,6	0,1	1,3	4,2	0,0	0,2	0,8	0,1	0,0	0,0	0,0	90,0	99,4	14,0	285,0	3,0	2,0	13,0	2,4	8,4	5,0	2,0	11,0	28,0	3,0	10,0	5,6	2,8	10,0	4,0	6,4	2,0	3,0	1,0	10,0	344,0	2,0	3,0	3,0	2,0	11,0	3,0	6,2	3,0	5,3	18,0	5,4
1512	**Coal**	3	3,6	0,0	2,1	1,3	0,0	0,0	0,2	0,1	0,0	0,0	0,0	91,6	98,8	21,0	79,0	3,4	2,0	13,0	28,0	36,0	5,0	8,0	37,0	16,0	3,0	10,0	2,0	9,2	10,0	53,0	9,7	2,0	14,0	1,0	10,0	39,0	2,0	3,0	3,0	4,7	60,0	3,7	27,0	4,5	3,0	41,0	0,8
1512	**Coal**	2	20,0	0,5	6,5	0,6	0,0	0,0	0,1	0,1	0,2	0,0	0,0	71,1	99,2	9,0	86,0	3,6	2,0	36,0	6,8	132,0	5,0	5,3	14,0	4,4	13,0	12,0	4,0	13,0	17,0	29,0	45,0	3,2	21,0	1,2	10,0	12,0	2,0	13,0	3,0	4,9	171,0	3,0	51,0	5,9	76,0	392,0	0,1
1510	**Coal**	5	7,7	0,1	4,6	3,2	0,0	0,4	1,2	0,1	0,2	0,0	0,0	81,0	98,5	19,0	94,0	3,0	2,0	31,0	4,2	9,2	5,0	2,0	6,8	1,0	3,9	15,0	2,0	9,3	12,0	3,4	6,4	4,4	4,9	1,0	10,0	54,0	2,0	3,0	3,0	2,0	8,1	3,0	13,0	3,0	3,0	70,0	0,0
1510	**Coal**	4	41,4	1,2	15,7	2,6	0,0	0,2	0,4	0,2	0,7	0,1	0,0	37,3	99,6	36,0	317,0	4,3	2,0	95,0	2,7	76,0	13,0	21,0	28,0	1,0	9,7	46,0	6,3	31,0	40,0	11,0	26,0	48,0	15,0	4,4	10,0	88,0	2,8	23,0	3,0	6,1	86,0	3,0	35,0	3,2	17,0	243,0	1,6
1510	**Coal**	3	6,3	0,1	3,2	3,4	0,0	0,2	0,6	0,1	0,1	0,0	0,0	84,7	98,7	25,0	107,0	3,5	2,0	48,0	34,0	48,0	5,0	11,0	32,0	33,0	3,3	21,0	2,4	11,0	22,0	63,0	12,0	2,0	16,0	1,4	10,0	59,0	2,0	3,9	3,0	4,6	90,0	3,0	32,0	4,0	4,4	98,0	1,1
1510	**Coal**	2	8,5	0,1	3,0	1,8	0,0	0,3	0,8	0,1	0,1	0,0	0,0	83,8	98,6	12,0	82,0	3,0	2,0	20,0	2,3	9,8	5,0	2,0	6,1	1,0	3,3	10,0	2,0	9,1	10,0	2,3	7,8	2,0	3,9	1,0	10,0	56,0	2,0	3,0	3,0	2,0	13,0	3,0	11,0	3,0	3,0	45,0	1,0
Coal Descriptive Statistics		Average	**11,9**	**0,3**	**4,7**	**2,3**	**0,0**	**0,2**	**0,6**	**0,1**	**0,2**	**0,02**	**0,007**	**78,9**	**99,1**	**18,5**	**143,8**	**3,4**	**2,0**	**33,6**	**10,3**	**40,9**	**6,0**	**6,7**	**17,2**	**10,7**	**5,3**	**16,8**	**3,3**	**11,5**	**16,4**	**21,0**	**15,0**	**8,2**	**10,1**	**1,5**	**10,0**	**90,6**	**2,1**	**6,9**	**3,0**	**3,5**	**56,1**	**3,1**	**22,7**	**3,7**	**14,3**	**116,0**	**1,4**
		Min	2,6	0,0	1,3	0,6	0,0	0,0	0,1	0,1	0,0	0,0	0,0	37,3	98,5	9,0	79,0	3,0	2,0	13,0	1,8	7,5	5,0	2,0	2,8	1,0	3,0	10,0	2,0	2,8	10,0	2,0	6,4	2,0	3,0	1,0	10,0	12,0	2,0	3,0	3,0	2,0	8,1	3,0	6,0	3,0	3,0	18,0	0,0
		Max	41,4	1,2	15,7	4,2	0,0	0,4	1,2	0,2	0,7	0,1	0,0	91,6	100,0	36,0	317,0	4,3	2,0	95,0	34,0	132,0	13,0	21,0	37,0	33,0	13,0	46,0	6,3	31,0	40,0	63,0	45,0	48,0	21,0	4,4	10,0	344,0	2,8	23,0	3,0	6,1	171,0	3,7	51,0	5,9	76,0	392,0	5,4
		Stdev	14,6	0,4	5,3	1,3	0,0	0,1	0,4	0,0	0,3	0,0	0,0	20,3	0,6	9,7	100,1	0,5	0,0	30,8	13,4	47,8	3,2	7,3	13,5	13,5	4,1	13,9	1,8	9,7	11,6	25,2	15,0	18,3	7,3	1,3	0,0	120,2	0,3	8,0	0,0	1,7	62,2	0,3	17,1	1,1	28,6	143,9	1,9
		C of V	123,0	164,0	112,3	58,2	84,4	64,3	69,3	41,7	168,6	100,1	119,4	25,7	0,6	52,4	69,6	14,3	0,0	91,6	130,4	117,0	53,4	109,7	78,2	126,3	77,4	83,1	55,1	84,3	70,8	120,1	100,5	222,7	71,9	89,2	0,0	132,6	15,3	116,9	0,0	48,3	110,8	9,1	75,3	30,7	199,8	124,0	142,7
		Sum	94,9	2,1	37,9	18,2	0,0	1,7	4,7	0,8	1,3	0,1	0,1	631,0	792,8	148,0	1150,0	27,0	16,0	269,0	82,2	326,9	48,0	53,3	137,7	85,4	42,2	134,0	26,3	92,1	131,0	167,7	119,8	65,6	80,8	12,0	80,0	725,0	16,8	54,9	24,0	28,3	449,1	24,7	181,2	29,6	114,7	928,0	10,9
1512	**Sandstone-siltstone**	W1	77,8	0,2	12,4	1,0	0,0	0,4	0,4	1,9	4,1	0,0	0,0	1,3	99,7	4,0	839,0	3,0	2,0	15,0	3,4	21,0	5,0	3,9	14,0	1,0	3,6	10,0	2,0	8,9	11,0	6,3	31,0	134,0	4,0	1,0	10,0	131,0	2,0	4,0	3,0	2,0	27,0	3,0	7,8	3,0	16,0	105,0	0,0
1512	**Sandstone-siltstone**	W2	70,6	0,5	16,3	2,0	0,0	0,8	0,7	1,8	4,5	0,0	0,0	2,4	99,6	4,0	782,0	3,0	2,0	27,0	7,5	48,0	5,0	2,6	22,0	1,0	4,3	19,0	2,0	14,0	18,0	13,0	28,0	165,0	8,3	1,0	10,0	155,0	2,0	5,6	3,0	2,0	59,0	3,0	12,0	3,0	38,0	132,0	0,0
1512	**Sandstone-siltstone**	W3	92,3	0,1	3,9	0,6	0,0	0,0	0,1	0,5	1,6	0,0	0,0	0,2	99,5	4,1	371,0	3,0	2,0	10,0	2,7	17,0	5,0	2,0	3,4	1,0	4,3	10,0	2,0	7,0	10,0	3,2	13,0	52,0	3,0	1,0	10,0	53,0	2,0	3,0	3,0	2,0	12,0	3,0	4,4	3,0	7,1	82,0	0,0
1512	**Sandstone-siltstone**	W4	84,7	0,2	6,9	3,2	0,0	0,5	0,3	0,7	2,0	0,0	0,0	1,2	99,7	4,7	521,0	3,0	2,0	13,0	3,3	34,0	5,0	2,1	9,0	1,0	3,0	10,0	2,0	10,0	10,0	7,5	16,0	73,0	5,0	1,2	10,0	68,0	2,0	3,0	3,0	2,0	32,0	3,0	9,0	3,0	31,0	85,0	0,0
1512	**Sandstone-siltstone**	W5	70,1	0,7	14,6	3,7	0,0	1,1	0,6	1,4	3,6	0,1	0,0	3,1	99,1	4,0	761,0	3,0	2,0	41,0	9,6	63,0	13,0	6,9	20,0	1,0	5,2	25,0	2,0	19,0	26,0	21,0	25,0	144,0	13,0	1,0	10,0	117,0	2,0	9,1	3,0	3,2	76,0	3,0	20,0	3,0	69,0	184,0	0,0
1512	**Sandstone-siltstone**	W10	76,8	0,4	8,4	2,0	0,1	0,2	3,8	1,0	3,1	0,0	0,0	3,3	99,1	4,0	772,0	3,0	2,0	21,0	2,2	47,0	5,0	2,0	11,0	1,0	7,4	10,0	2,0	10,0	15,0	3,7	21,0	89,0	9,3	1,0	10,0	147,0	2,0	3,0	3,0	2,0	40,0	3,0	11,0	3,0	16,0	187,0	0,0
1512	**Sandstone-siltstone**	W11	54,2	0,3	6,9	3,3	0,1	0,5	17,0	1,0	2,4	0,0	0,0	13,7	99,6	4,0	652,0	3,0	2,0	15,0	4,3	26,0	5,0	2,0	9,0	1,0	6,1	10,0	2,0	7,6	11,0	6,0	16,0	69,0	30,0	1,0	10,0	192,0	2,0	3,0	3,0	2,0	25,0	3,0	16,0	3,0	19,0	155,0	0,0
1512	**Sandstone-siltstone**	W12	80,3	0,5	9,9	1,4	0,0	0,2	1,1	0,9	3,6	0,0	0,0	1,6	99,6	4,0	805,0	3,1	2,0	16,0	4,7	68,0	5,0	2,0	12,0	1,0	6,5	10,0	2,0	12,0	13,0	5,7	24,0	110,0	8,7	1,0	10,0	132,0	2,0	3,0	3,0	2,0	46,0	3,0	13,0	3,0	29,0	136,0	0,0
1512	**Sandstone-siltstone**	W13	78,5	0,2	10,1	1,6	0,0	0,2	1,4	1,0	4,3	0,0	0,0	2,3	99,7	4,0	971,0	3,0	2,0	15,0	4,2	25,0	5,0	2,3	13,0	1,0	3,2	12,0	2,0	7,8	15,0	5,3	31,0	134,0	6,5	1,0	10,0	179,0	2,0	3,0	3,0	2,0	31,0	3,0	11,0	3,0	40,0	86,0	0,0
1512	**Sandstone-siltstone**	W14	80,4	0,3	10,1	1,4	0,0	0,1	0,7	1,1	3,8	0,0	0,0	1,7	99,6	4,0	842,0	3,0	2,0	16,0	3,2	22,0	5,0	2,0	12,0	1,0	4,6	11,0	2,0	10,0	14,0	5,6	26,0	112,0	5,5	1,0	10,0	139,0	2,0	3,0	3,0	2,0	29,0	3,0	11,0	3,7	24,0	125,0	0,0
1512	**Sandstone-siltstone**	W15	83,7	0,1	8,1	0,5	0,0	0,0	0,9	0,8	4,3	0,0	0,0	1,1	99,6	6,0	947,0	3,0	2,0	10,0	5,0	13,0	5,0	2,0	9,3	1,0	3,0	10,0	2,0	4,5	10,0	6,0	31,0	130,0	3,1	1,0	10,0	164,0	2,0	3,0	3,0	2,0	12,0	3,0	7,7	3,0	10,0	50,0	0,0
1512	**Sandstone-siltstone**	W16	60,8	0,9	15,5	8,7	0,1	1,5	0,7	1,3	3,2	0,1	0,0	6,7	99,4	4,0	744,0	3,0	2,0	59,0	12,0	65,0	10,0	8,3	23,0	1,0	11,0	37,0	2,0	20,0	37,0	28,0	22,0	129,0	22,0	1,0	10,0	141,0	2,0	7,9	3,0	3,5	104,0	3,0	31,0	3,0	113,0	330,0	0,0
1512	**Sandstone-siltstone**	W17	80,5	0,4	8,4	2,1	0,0	0,3	1,4	0,9	2,6	0,1	0,0	2,8	99,4	4,0	607,0	3,0	2,0	27,0	7,0	31,0	5,3	4,0	11,0	1,0	8,1	15,0	2,0	11,0	16,0	12,0	19,0	83,0	6,0	1,0	10,0	134,0	2,0	3,9	3,0	2,0	33,0	3,0	18,0	3,0	34,0	182,0	0,0
1512	**Sandstone-siltstone**	W18	63,8	0,9	15,6	5,2	0,1	1,0	0,5	1,2	3,0	0,1	0,0	7,8	99,2	4,0	690,0	3,0	2,0	96,0	12,0	72,0	8,8	16,0	22,0	1,0	14,0	58,0	2,0	18,0	53,0	26,0	24,0	117,0	15,0	1,0	11,0	147,0	2,3	13,0	3,0	5,5	92,0	3,0	37,0	3,8	105,0	385,0	0,0
1512	**Sandstone-siltstone**	W19	83,9	0,6	8,3	1,6	0,0	0,2	0,3	0,9	2,6	0,0	0,0	1,3	99,7	4,0	623,0	3,0	2,0	51,0	6,3	39,0	5,0	2,0	10,0	1,0	12,0	23,0	2,0	14,0	26,0	6,2	20,0	78,0	5,8	1,0	10,0	100,0	2,0	11,0	3,0	2,0	35,0	3,0	18,0	3,0	28,0	332,0	0,0
1512	**Sandstone-siltstone**	W20	27,2	0,4	7,8	13,9	0,2	1,9	20,8	0,7	1,2	0,7	0,0	24,6	99,3	4,0	394,0	3,0	2,0	92,0	8,7	37,0	5,0	12,0	13,0	1,0	4,0	42,0	2,0	11,0	33,0	18,0	9,4	66,0	51,0	1,0	10,0	180,0	2,0	3,3	3,0	3,4	47,0	3,0	35,0	3,0	52,0	136,0	0,0
1512	**Sandstone-siltstone**	W21	51,0	0,9	21,0	4,4	0,0	1,1	0,3	1,0	2,4	0,1	0,0	17,0	99,4	4,0	585,0	3,0	2,0	154,0	21,0	88,0	12,0	54,0	30,0	1,5	5,4	74,0	2,5	21,0	65,0	48,0	35,0	130,0	18,0	1,5	14,0	143,0	2,2	24,0	3,0	9,0	143,0	3,0	47,0	5,2	137,0	162,0	0,1
1512	**Sandstone-siltstone**	W22	12,2	0,2	4,1	39,3	0,5	3,4	8,8	0,4	0,7	0,4	0,0	29,5	99,7	4,0	346,0	3,0	2,0	16,0	2,1	31,0	5,0	2,0	9,3	1,0	3,0	10,0	2,0	8,5	10,0	11,0	4,5	47,0	16,0	1,0	15,0	174,0	2,0	3,0	3,0	2,0	46,0	3,0	9,1	3,0	50,0	32,0	0,0

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APPENDIX I: ROC stream sediment XRF data

SAMPLE	LONGITUDE	LATITUDE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr
B1B10	29,51377	-25,75043	78,56	0,78	6,20	8,73	0,05	0,26	0,23	0,10	0,70	0,06	0,02	4,30	100,00	4,0	317,0	3,0	2,2	106,0	33,0	171,0	5,0	34,0	9,2	1,0	7,3	29,0	2,0	9,1	21,0	26,0	32,0	44,0	9,2	1,0	10,0	21,0	2,0	6,8	3,0	2,3	144,0	3,0	18,0	3,0	30,0	324
B1B14	29,56422	-25,73152	57,62	0,71	13,46	4,03	0,03	0,17	0,08	0,06	1,44	0,15	0,02	21,85	99,61	14,0	413,0	3,0	12,0	115,0	13,0	143,0	5,0	33,0	20,0	1,0	9,0	59,0	2,0	17,0	47,0	34,0	39,0	96,0	11,0	1,0	10,0	17,0	2,0	14,0	3,0	4,8	82,0	3,8	44,0	4,2	87,0	188
B1B16	29,60904	-25,65544	59,56	0,83	13,12	8,46	0,07	0,37	0,27	0,09	1,24	0,20	0,02	15,28	99,51	8,1	388,0	3,0	6,4	113,0	31,0	148,0	5,0	30,0	18,0	1,0	10,0	57,0	2,0	16,0	49,0	39,0	31,0	110,0	13,0	1,1	11,0	24,0	2,0	15,0	3,0	5,1	102,0	3,0	38,0	5,1	64,0	281
B1B18	29,62387	-25,77399	81,99	0,73	5,09	2,52	0,03	0,29	0,21	0,37	1,60	0,08	0,02	7,47	100,39	4,0	545,0	3,0	15,0	49,0	9,7	123,0	5,0	9,7	6,8	1,0	6,4	28,0	2,0	8,0	21,0	14,0	15,0	62,0	7,0	1,0	10,0	39,0	2,0	4,8	3,0	2,0	44,0	3,0	24,0	3,0	32,0	325
B1B2	29,39057	-25,75100	95,42	0,18	1,46	1,31	0,02	0,03	0,04	-0,02	0,18	0,03	0,00	0,92	99,56	4,0	58,0	3,0	2,0	15,0	4,9	74,0	5,0	9,6	2,7	1,0	5,5	10,0	2,0	1,9	10,0	8,0	6,5	8,7	3,0	1,0	10,0	4,3	2,0	3,0	3,0	2,0	27,0	3,0	5,1	3,0	9,4	293
B1B21	29,35282	-25,4849	74,98	0,63	8,06	3,66	0,08	0,34	0,97	0,10	1,32	0,14	0,02	9,17	99,48	384,0	3,0	14,0	64,0	14,0	133,0	5,0	19,0	12,0	1,0	10,0	37,0	2,0	9,3	28,0	25,0	21,0	65,0	12,0	1,0	10,0	88,0	2,0	6,3	3,0	2,7	70,0	3,0	22,0	3,0	44,0	392,0	382
B1B22	29,3645	-25,5045	87,20	0,29	3,67	2,88	0,03	0,11	2,15	0,23	1,42	0,04	0,01	2,15	100,17	430,0	3,0	2,0	40,0	9,4	182,0	5,0	7,0	5,3	1,0	11,0	18,0	2,0	7,0	18,0	9,3	14,0	54,0	3,0	1,0	10,0	57,0	2,0	6,7	3,0	2,1	50,0	3,0	19,0	3,1	17,0	398,0	392
B1B25	29,32484	-25,54459	39,41	0,51	8,79	4,14	0,01	0,11	0,08	0,01	0,34	0,12	0,03	46,22	99,77	250,0	3,0	2,3	53,0	7,6	167,0	5,0	17,0	13,0	1,1	5,7	31,0	2,2	9,0	20,0	18,0	22,0	21,0	10,0	1,0	10,0	107,0	2,0	7,4	3,0	2,7	75,0	3,0	19,0	3,0	19,0	152,0	313
B1B26	29,36421	-25,54569	82,59	0,55	7,48	3,37	0,01	0,14	0,12	0,01	0,69	0,07	0,01	5,37	100,42	295,0	3,0	2,0	69,0	13,0	115,0	5,0	13,0	11,0	1,0	8,2	38,0	2,0	11,0	29,0	27,0	19,0	50,0	11,0	1,0	10,0	28,0	2,0	6,6	3,0	2,9	79,0	3,0	27,0	3,3	47,0	348,0	421
B1B27	29,37324	-25,54531	92,21	0,25	2,93	1,13	0,02	0,07	0,11	0,02	0,95	0,03	0,01	2,60	100,33	437,0	3,0	2,0	42,0	6,1	95,0	5,0	5,2	5,4	1,0	11,0	21,0	2,0	7,9	18,0	6,6	12,0	49,0	3,8	1,0	10,0	15,0	2,0	6,9	3,0	2,0	42,0	3,0	29,0	3,1	20,0	350,0	345
B1B28	29,37279	-25,55255	91,55	0,23	3,68	1,78	0,04	0,03	0,04	0,01	1,22	0,04	0,01	1,68	100,30	281,0	3,0	2,0	23,0	6,2	67,0	5,0	4,6	3,8	1,0	5,7	13,0	2,0	3,9	10,0	7,7	13,0	38,0	4,3	1,0	10,0	34,0	2,0	3,0	3,0	2,0	23,0	3,0	9,2	3,0	11,0	230,0	256
B1B29	29,3634	-25,56012	49,07	0,68	11,11	6,03	0,18	0,74	6,37	0,03	0,85	0,21	0,02	23,89	99,18	319,0	3,0	19,0	99,0	53,0	132,0	5,0	25,0	13,0	1,0	6,6	59,0	2,5	10,0	42,0	113,0	21,0	63,0	10,0	1,0	10,0	194,0	2,0	9,6	3,0	4,2	72,0	3,0	39,0	3,0	188,0	251,0	332
B1B3	29,41017	-25,73463	82,86	0,80	9,20	1,51	0,02	0,20	0,07	0,02	0,57	0,03	0,02	5,24	100,53	4,0	259,0	3,0	2,0	55,0	8,5	137,0	5,0	23,0	14,0	1,0	7,8	30,0	2,0	10,0	21,0	36,0	17,0	41,0	13,0	1,0	10,0	11,0	2,0	6,3	3,0	2,4	100,0	3,0	19,0	3,0	23,0	296
B1B31	29,38564	-25,55426	69,68	0,82	11,44	4,78	0,12	0,46	0,47	0,09	1,23	0,16	0,02	11,00	100,20	386,0	3,0	8,1	78,0	23,0	148,0	5,0	27,0	15,0	1,0	10,0	42,0	2,0	11,0	34,0	37,0	60,0	74,0	17,0	1,0	10,0	78,0	2,0	9,3	3,0	4,0	103,0	3,0	26,0	3,0	56,0	458,0	439
B1B33	29,39173	-25,56597	85,71	0,48	5,93	1,57	0,01	0,16	0,29	0,14	1,35	0,04	0,01	4,66	100,35	371,0	3,0	2,0	56,0	8,0	110,0	5,0	11,0	8,9	1,0	11,0	40,0	2,0	9,2	30,0	16,0	17,0	60,0	8,8	1,0	10,0	50,0	2,0	5,6	3,0	2,7	51,0	3,0	22,0	3,0	27,0	406,0	392
B1B34	29,3457	-25,57314	63,59	0,60	7,13	3,79	0,07	0,34	1,53	0,01	0,56	0,21	0,03	22,54	100,39	380,0	3,0	24,0	73,0	31,0	185,0	5,0	17,0	9,5	1,0	9,6	37,0	2,0	9,8	28,0	35,0	20,0	44,0	10,0	1,0	10,0	118,0	2,0	6,7	3,0	2,8	67,0	3,0	23,0	3,0	99,0	384,0	289
B1B35	29,33539	-25,4923	72,90	0,28	7,91	12,06	0,04	0,10	0,02	0,10	1,92	0,10	0,03	4,06	99,50	360,0	3,0	2,0	85,0	13,0	211,0	5,0	25,0	16,0	1,0	11,0	27,0	2,5	15,0	23,0	11,0	35,0	98,0	4,5	1,0	10,0	11,0	2,0	15,0	3,0	4,8	116,0	3,4	45,0	4,4	58,0	396,0	265
B1B36	29,34446	-25,49326	77,47	0,36	7,19	4,81	0,12	0,11	0,15	0,07	1,87	0,25	0,02	7,78	100,20	622,0	3,0	8,6	67,0	12,0	120,0	5,0	11,0	12,0	1,0	11,0	34,0	2,0	16,0	36,0	15,0	20,0	96,0	4,2	1,0	10,0	20,0	2,0	12,0	3,0	3,8	57,0	3,0	45,0	5,8	59,0	409,0	373
B1B37	29,32487	-25,52224	91,90	0,43	3,40	1,30	0,01	0,12	0,02	0,01	0,76	0,05	0,01	1,98	99,98	208,0	3,0	2,0	29,0	4,5	69,0	5,0	6,0	5,4	1,0	11,0	10,0	2,0	5,8	11,0	8,8	13,0	34,0	3,7	1,0	10,0	23,0	2,0	3,0	3,0	2,0	36,0	3,0	10,0	3,0	8,3	439,0	106
B1B4	29,44257	-25,71569	85,69	0,61	4,03	2,83	0,04	0,12	0,25	0,07	0,52	0,17	0,02	5,04	99,40	4,0	208,0	3,0	2,0	40,0	9,8	156,0	5,0	28,0	5,6	1,0	7,7	18,0	2,0	5,3	15,0	19,0	16,0	24,0	8,4	1,0	10,0	21,0	2,0	3,0	3,0	2,0	66,0	3,0	12,0	3,0	212,0	162
B1B6	29,45852	-25,74879	52,29	0,63	8,41	9,38	0,37	0,53	1,44	0,22	0,96	0,37	0,10	24,98	99,70	4,0	408,0	3,0	31,0	84,0	32,0	605,0	5,0	49,0	12,0	1,0	7,0	25,0	3,1	7,0	19,0	50,0	42,0	45,0	10,0	1,0	10,0	55,0	2,0	4,7	3,0	2,9	154,0	3,0	17,0	3,0	476,0	294
B1B7	29,46208	-25,75470	68,28	0,87	6,67	5,67	0,16	0,44	1,18	0,26	0,96	0,18	0,13	14,31	99,12	4,0	330,0	3,0	12,0	68,0	26,0	729,0	5,0	42,0	10,0	1,0	8,0	30,0	4,6	9,1	22,0	37,0	48,0	46,0	8,9	1,0	10,0	63,0	2,0	7,8	3,0	2,7	101,0	3,0	19,0	3,0	558,0	412
B1B9	29,45838	-25,78741	66,12	0,53	4,72	3,96	0,03	0,29	0,57	0,09	0,44	0,17	0,17	22,69	99,79	4,0	211,0	3,0	7,3	50,0	11,0	950,0	5,0	58,0	7,9	1,0	7,4	22,0	2,0	7,0	18,0	32,0	48,0	26,0	5,9	1,0	10,0	33,0	2,0	3,0	3,0	2,0	78,0	3,0	15,0	3,0	187,0	248
B1C13	29,16792	-25,68008	79,85	0,41	4,08	7,53	0,04	0,10	0,06	0,01	0,40	0,07	0,01	7,24	99,81	35,0	610,0	3,0	2,0	68,0	15,0	61,0	7,1	20,0	19,0	1,0	6,0	30,0	2,0	15,0	23,0	22,0	96,0	147,0	10,0	1,0	10,0	164,0	3,5	14,0	3,0	2,9	87,0	6,2	24,0	3,0	724,0	360
B1C14	29,21636	-25,68929	50,58	6,52	4,41	33,60	0,09	0,11	0,03	0,01	0,45	0,14	0,11	2,92	98,97	14,0	156,0	3,0	2,0	80,0	28,0	812,0	5,0	72,0	14,0	1,0	67,0	29,0	3,9	56,0	27,0	41,0	19,0	23,0	19,0	1,9	10,0	4,5	3,4	42,0	3,0	14,0	790,0	4,3	38,0	3,0	38,0	203
B1C23	29,31096	-25,64246	96,09	0,11	1,10	0,59	0,01	0,01	0,03	0,01	0,13	0,02	0,00	0,86	98,95	4,0	40,0	3,0	2,0	16,0	2,1	25,0	5,0	4,9	1,6	1,0	4,8	10,0	2,0	2,4	10,0	4,5	2,9	6,5	3,0	1,0	10,0	7,4	2,0	3,0	3,0	2,0	14,0	3,0	5,2	3,0	3,0	301
B1C5	29,25157	-25,60711	96,42	0,15	1,48	0,97	0,01	0,01	0,03	0,01	0,24	0,02	0,00	1,16	100,50	4,0	63,0	3,0	2,0	18,0	3,3	117,0	5,0	4,5	1,7	1,0	4,7	10,0	2,0	2,0	11,0	5,0	3,9	10,0	3,0	1,0	10,0	11,0	2,0	3,0	3,0	2,0	28,0	3,0	5,6	3,0	3,0	551
B1S01	29,30201	-25,89141	76,99	0,26	11,12	4,91	0,05	0,13	0,17	1,45	4,20	0,03	0,01	1,75	101,08	4,0	805,0	3,0	2,0	139,0	8,6	76,0	5,0	24,0	20,0	1,5	14,0	61,0	2,0	23,0	50,0	7,6	32,0	181,0	3,0	1,0	14,0	31,0	2,0	23,0	5,8	24,0	3,3	69,0	6,4	80,0	491,0	491
B1S02	29,35777	-25,82925	89,58	0,45	3,78	2,49	0,10	0,22	0,19	0,16	0,39	0,03	0,01	3,42	100,83	4,0	229,0	3,0	2,0	46,0	21,0	109,0	5,0	14,0	5,3	1,3	6,8	27,0	2,0	8,4	20,0	28,0	11,0	32,0	8,6	1,0	10,0	20,0	2,0	5,2	2,0	60,0	3,0	18,0	3,0	40,0	283,0	283
B1S03	29,49097	-25,81883	84,27	0,56	5,05	4,41	0,19	0,45	0,43	0,05	0,74	0,05	0,34	3,94	100,48	8,4	349,0	3,0	2,4	72,0	19,0	1257,0	5,4	17,0	8,1	1,1	10,0	38,0	12,0	15,0	26,0	28,0	18,0	54,0	6,1	1,0	10,0	21,0	2,0	8,9	2,6	92,0	3,0	30,0	3,8	49,0	404,0	404
B1S04	29,52902	-25,77197	75,64	0,25	8,98	8,85	0,20	0,12	0,16	0,98	3,15	0,08	0,01	2,48	100,89	18,0	867,0	3,0	2,0	86,0	15,0	112,0	5,0	13,0	15,0	1,0	10,0	40,0	2,0	18,0	34,0	11,0	26,0	114,0	3,3	1,0	10,0	28,0	2,0	20,0	4,8	75,0	4,9	56,0	3,0	79,0	408,0	408
B1S05	29,43938	-25,74118	91,67	0,56	2,76	2,38	0,03	0,07	0,13	0,28	0,92	0,05	0,01	1,89	100,74	4,0	294,0	3,0	2,0	30,0	7,6	95,0	5,0	10,0	3,8	1,1	5,8	16,0	2,0	7,7	10,0	8,9	10,0	34,0	3,5	1,0	10,0	26,0	2,0	7,1	2,0	52,0	3,0	16,0	3,0	39,0	365,0	365
B1S06	29,48777	-25,68375	98,08	0,17	0,81	0,92	0,02	0,04	0,05	0,01	0,08	0,01	0,00	0,50	100,70	4,0	61,0	3,0	2,0	10,0	4,2	49,0	5,0	2,6	1,3	1,2	3,0	10,0	2,0	3,0	10,0	6,1	3,7	5,2	3,0	1,0	10,0	3,7	2,0	3,0	2,0	23,0	3,0	5,5	3,0	3,0	105,0	105
B1S07	29,19238	-25,65672	94,85	0,52	1,62	1,55	0,02	0,04	0,06	0,01	0,15	0,01	0,00	1,60	100,45	4,0	101,0	3,0	2,0	27,0	7,7	86,0	5,0	10,0	3,5	1,0	5,1	12,0	2,0	5,3	16,0	11,0	4,1	10,0	5,8	1,0	10,0	7,2	2,0	3,1	2,0	81,0	3,0	11,0	3,0	15,0	187,0	187
B1S08	29,21625	-25,62293	95,73	0,14	1,36	1,41	0,02	0,06	0,08	0,01	0,29	0,04	0,00	0,97	100,12	4,0	127,0	3,0	2,0	15,0	5,2	123,0	5,0	5,0	2,6	1,0	3,4	12,0	2,0	4,0	10,0	7,7	5,4	14,0	3,0	1,0	10,0	8,4	2,0	3,0	2,0	33,0	3,0	6,5	3,0	16,0	118,0	118
B1S09	29,28643	-25,64402	80,35	0,31	5,47	7,07	0,11	0,62	1,09	0,14	0,85	0,07	0,46	3,72	100,25	4,0	363,0	3,0	2,0	78,0	21,0	1718,0	5,0	22,0	8,4	1,5	9,0	31,0	2,0	8,8	17,0	21,0	20,0	35,0	9,7	1,0	10,0	44,0	2,0	7,6	2,3	169,0	3,0	17,0	3,1	31,0	224,0	224

SAMPLE	LONGITUDE	LATITUDE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr
B1S10	29,46316	-26,22276	86,08	0,47	6,26	2,30	0,04	0,29	0,31	0,27	1,55	0,04	0,01	3,37	100,98	4,0	439,0	3,0	2,0	46,0	12,0	185,0	5,0	15,0	9,1	1,4	13,0	30,0	2,0	9,8	25,0	20,0	16,0	68,0	11,0	1,0	10,0	64,0	2,0	7,2	2,0	73,0	3,0	18,0	3,0	26,0	417,0	417
B1S12	29,27168	-26,22073	95,04	0,18	2,09	1,11	0,07	0,13	0,23	0,01	0,52	0,03	0,01	1,70	101,11	4,0	271,0	3,0	2,0	37,0	11,0	62,0	5,0	3,5	2,8	1,1	3,9	12,0	2,0	4,9	11,0	12,0	8,9	25,0	3,0	1,0	10,0	22,0	2,0	3,0	2,0	30,0	7,9	8,5	3,0	8,7	188,0	188
B1S13	29,22983	-26,16978	69,95	0,64	10,38	5,47	0,12	0,33	0,72	0,20	2,41	0,16	0,01	9,92	100,31	4,0	573,0	3,0	9,7	96,0	16,0	117,0	5,0	24,0	16,0	1,0	10,0	54,0	2,0	18,0	51,0	27,0	22,0	114,0	11,0	1,0	10,0	76,0	2,0	13,0	3,5	81,0	3,0	38,0	4,0	96,0	399,0	399
B1S14	29,29373	-25,82134	93,01	0,29	3,27	1,18	0,02	0,13	0,14	0,09	1,14	0,03	0,01	1,19	100,50	4,0	364,0	3,0	2,0	24,0	7,8	96,0	5,0	6,0	3,8	1,0	5,8	16,0	2,0	6,8	12,0	10,0	13,0	45,0	4,5	1,0	10,0	39,0	2,0	5,9	2,0	35,0	3,0	12,0	3,0	17,0	270,0	270
B1S16	29,26515	-25,94176	76,13	0,44	9,02	7,25	0,05	0,17	0,18	0,01	1,59	0,13	0,04	5,58	100,60	10,0	384,0	3,0	2,0	118,0	17,0	212,0	8,7	21,0	15,0	1,5	12,0	46,0	2,0	18,0	32,0	23,0	37,0	98,0	8,3	1,0	10,0	26,0	2,0	16,0	5,2	77,0	6,5	39,0	3,2	66,0	438,0	438
B1S17	29,29175	-26,00121	81,82	0,53	6,31	1,98	0,02	0,26	0,33	0,14	1,13	0,05	0,01	7,55	100,13	4,0	322,0	3,0	3,2	43,0	19,0	120,0	5,0	17,0	8,5	1,1	9,2	25,0	2,0	10,0	21,0	25,0	17,0	50,0	9,3	1,0	10,0	56,0	2,0	6,7	2,6	74,0	3,0	21,0	3,0	40,0	337,0	337
B1S18	29,34118	-26,15996	75,72	0,83	10,38	4,12	0,09	0,61	1,03	0,08	1,33	0,13	0,02	6,92	101,25	4,0	703,0	3,0	2,5	68,0	22,0	146,0	5,0	37,0	13,0	1,2	6,4	46,0	2,0	15,0	38,0	35,0	20,0	89,0	16,0	1,0	10,0	87,0	2,0	11,0	2,7	94,0	3,0	30,0	3,0	62,0	300,0	300
B1S19	29,56395	-26,39535	83,57	0,28	4,22	3,48	0,38	1,15	3,42	0,37	0,85	0,05	0,02	2,88	100,67	4,0	723,0	3,0	2,0	79,0	47,0	216,0	5,0	18,0	4,1	1,0	3,0	29,0	2,0	4,9	24,0	51,0	13,0	30,0	5,5	1,0	10,0	73,0	2,0	3,0	2,0	140,0	3,0	18,0	3,0	19,0	131,0	131
B1S20	29,59454	-26,4828	66,73	0,91	11,30	4,29	0,08	1,33	1,62	0,43	1,53	0,11	0,01	12,00	100,36	4,0	411,0	3,0	11,0	77,0	18,0	78,0	5,1	28,0	13,0	1,2	3,0	41,0	2,0	15,0	38,0	23,0	22,0	95,0	13,0	1,0	10,0	158,0	2,0	12,0	6,5	77,0	3,0	32,0	3,2	60,0	223,0	223
B1S21	29,36162	-26,40767	84,08	0,40	6,34	2,83	0,10	0,43	1,10	0,24	1,64	0,02	0,01	3,26	100,44	4,0	557,0	3,0	2,0	46,0	20,0	115,0	5,0	16,0	7,7	1,0	5,1	23,0	2,0	6,7	17,0	24,0	16,0	62,0	9,5	1,0	10,0	79,0	2,0	6,4	2,0	79,0	3,0	16,0	3,0	24,0	208,0	208
B1S22	29,21935	-26,4601	80,87	0,75	7,60	3,86	0,06	1,20	2,02	0,86	1,36	0,07	0,02	1,76	100,43	4,0	468,0	3,0	2,0	41,0	19,0	170,0	5,0	16,0	10,0	1,6	14,0	20,0	2,0	7,7	17,0	29,0	14,0	51,0	11,0	1,0	10,0	109,0	2,0	7,3	2,0	99,0	3,0	16,0	3,0	36,0	455,0	455
B1S23	29,01474	-26,29467	67,10	1,04	9,66	7,04	0,17	0,99	2,79	0,18	0,81	0,05	0,02	10,39	100,23	4,0	431,0	3,0	17,0	52,0	33,0	127,0	5,0	75,0	12,0	1,1	3,7	26,0	2,0	9,7	23,0	44,0	14,0	41,0	19,0	1,0	10,0	63,0	2,0	6,6	2,0	182,0	3,0	27,0	3,0	55,0	279,0	279
B1S24	29,03746	-26,15533	83,74	0,48	6,71	2,14	0,04	0,24	0,50	0,17	2,60	0,10	0,01	3,38	100,12	4,0	621,0	3,0	7,1	49,0	11,0	78,0	5,0	5,8	8,1	1,0	9,4	29,0	2,0	10,0	18,0	12,0	21,0	91,0	7,1	1,0	10,0	90,0	2,0	11,0	2,0	52,0	3,0	18,0	3,0	21,0	394,0	394
B1S25	29,60777	-26,08435	80,88	0,56	8,11	4,68	0,09	0,39	0,37	0,01	1,48	0,06	0,02	3,91	100,55	4,0	618,0	3,0	2,0	90,0	19,0	146,0	5,0	15,0	11,0	1,0	5,8	36,0	2,0	12,0	28,0	24,0	23,0	69,0	11,0	1,0	10,0	55,0	2,0	12,0	2,9	103,0	3,0	22,0	3,0	43,0	388,0	388
B1S26	29,72886	-26,3258	75,12	0,60	7,90	4,57	0,13	2,26	3,91	0,80	0,92	0,05	0,02	3,65	99,92	4,0	425,0	3,0	7,2	36,0	32,0	219,0	5,0	36,0	9,9	1,4	11,0	22,0	2,0	7,3	16,0	56,0	11,0	39,0	15,0	1,0	10,0	102,0	2,0	6,1	2,0	127,0	3,0	16,0	3,0	37,0	313,0	313
B1S27	29,7779	-26,23488	89,80	0,31	4,57	1,83	0,10	0,18	0,43	0,15	1,48	0,02	0,01	2,25	101,13	4,0	595,0	3,0	2,0	53,0	23,0	148,0	5,0	11,0	6,3	1,0	7,9	21,0	2,0	5,7	21,0	21,0	17,0	60,0	8,5	1,0	10,0	64,0	2,0	4,1	2,0	89,0	3,0	12,0	3,0	17,0	259,0	259
MD01	29,48248	-26,09460	70,21	0,70	11,25	6,20	0,19	0,45	0,42	0,13	1,00	0,11	0,03	9,84	100,52	4,0	436,0	3,0	15,0	87,0	30,0	182,0	5,0	31,0	14,0	1,0	7,9	37,0	2,0	11,0	30,0	51,0	30,0	73,0	14,0	1,0	10,0	54,0	2,0	8,5	3,0	2,5	128,0	3,8	22,0	3,0	46,0	324
MD02	29,48985	-26,06960	77,35	0,40	7,92	4,07	0,09	0,41	0,42	0,20	1,56	0,05	0,01	7,85	100,33	4,0	528,0	3,0	2,5	76,0	26,0	114,0	5,0	13,0	11,0	1,0	6,1	32,0	2,0	7,1	27,0	32,0	26,0	77,0	10,0	1,0	10,0	68,0	2,0	4,8	3,0	2,0	89,0	3,0	15,0	3,0	38,0	188
MD03	29,42952	-26,02990	70,24	0,70	11,47	5,01	0,12	0,84	0,98	0,16	0,81	0,09	0,02	10,53	100,97	4,0	396,0	3,0	18,0	65,0	22,0	157,0	5,0	24,0	15,0	1,0	7,6	37,0	2,0	12,0	32,0	41,0	21,0	70,0	17,0	1,0	10,0	63,0	2,0	8,7	3,0	2,4	112,0	81,0	25,0	3,0	55,0	281
MD04	29,37560	-26,03970	82,79	0,63	7,12	2,24	0,03	0,09	0,08	0,02	0,70	0,08	0,01	5,51	99,31	4,0	212,0	3,0	6,2	60,0	15,0	105,0	5,0	12,0	9,9	1,0	7,5	24,0	2,0	10,0	25,0	19,0	16,0	41,0	7,2	1,0	10,0	35,0	2,0	6,0	3,0	2,1	76,0	3,0	18,0	3,0	29,0	325
MD05	29,33245	-26,03770	72,41	0,44	5,95	2,88	0,18	0,39	4,15	0,10	1,17	0,09	0,01	11,44	99,20	4,0	403,0	3,0	5,1	42,0	21,0	105,0	5,0	11,0	8,0	1,0	8,1	19,0	2,0	7,1	15,0	27,0	18,0	53,0	5,1	1,0	10,0	193,0	2,0	4,6	3,0	2,2	51,0	19,0	14,0	3,0	77,0	293
MD06(1)	29,47005	-25,97900	74,22	0,42	8,61	7,58	0,08	0,21	0,21	0,71	1,66	0,07	0,03	6,28	100,09	4,0	483,0	3,0	2,0	172,0	24,0	272,0	5,0	33,0	13,0	1,0	9,1	32,0	2,0	11,0	33,0	32,0	47,0	73,0	8,1	1,0	10,0	39,0	2,0	11,0	3,0	3,9	125,0	3,0	31,0	3,0	55,0	382
MD06(2)	29,47005	-25,97900	74,23	0,45	8,16	6,72	0,08	0,24	0,75	0,63	1,56	0,07	0,06	6,53	99,49	4,0	409,0	3,0	2,1	110,0	24,0	283,0	5,0	31,0	12,0	1,0	8,1	37,0	2,0	9,5	32,0	31,0	37,0	69,0	8,7	1,0	10,0	38,0	2,0	9,1	3,0	4,1	118,0	3,0	28,0	3,0	49,0	392
MD06(3)	29,47005	-25,97900	55,51	1,01	18,29	6,72	0,22	0,61	0,64	0,19	1,34	0,20	0,04	15,34	100,10	4,0	412,0	3,0	7,5	104,0	47,0	214,0	5,0	33,0	24,0	1,0	9,1	52,0	2,0	17,0	41,0	60,0	32,0	112,0	18,0	1,0	10,0	80,0	2,0	14,0	3,0	5,1	131,0	3,0	31,0	3,0	93,0	313
MD07	29,46630	-25,94300	78,77	0,50	5,69	4,27	0,02	0,08	0,17	0,01	0,37	0,07	0,02	9,60	99,57	4,0	201,0	3,0	2,4	70,0	26,0	154,0	5,0	12,0	7,8	1,0	9,9	35,0	2,0	7,1	32,0	43,0	16,0	23,0	7,3	1,0	10,0	47,0	2,0	5,5	3,0	2,2	82,0	4,3	25,0	3,0	50,0	421
MD08	29,49329	-25,89018	82,56	0,53	4,16	6,86	0,02	0,05	0,05	0,01	0,23	0,09	0,04	5,27	99,88	5.0	173,0	3,0	2,0	48,0	11,0	319,0	5,0	22,0	6,7	1,0	6,5	29,0	2,0	7,9	15,0	23,0	21,0	17,0	9,8	1,0	10,0	29,0	2,0	4,8	3,0	2,6	150,0	3,6	15,0	3,0	36,0	345
MD09	29,49895	-25,88868	72,06	0,52	6,77	10,44	0,04	0,08	0,13	0,01	0,44	0,25	0,05	9,04	99,85	11	177,0	3,0	2,7	87,0	15,0	408,0	5,0	26,0	11,0	1,0	7,0	25,0	2,1	9,7	18,0	24,0	32,0	33,0	11,0	1,0	10,0	22,0	2,0	7,2	3,0	4,1	176,0	51,0	20,0	3,0	55,0	256
MD1	30,8865	-23,00998	57,83	0,88	15,68	7,99	0,12	2,82	3,67	2,73	1,53	0,08	0,05	6,99	100,36	4,0	377,0	3,0	2,0	10,0	23,0	303,0	5,0	32,0	11,0	1,0	3,9	10,0	2,0	4,0	10,0	197,0	15,0	23,0	6,6	1,0	10,0	307,0	2,0	3,2	3,0	2,0	84,0	3,0	5,9	3,0	39,0	216
MD10(1)	29,48621	-25,84921	78,61	0,56	6,54	6,42	0,04	0,24	0,18	0,05	0,38	0,06	0,02	6,55	99,67	4,0	223,0	3,0	2,0	279,0	42,0	158,0	5,0	17,0	7,0	1,0	7,3	105,0	2,0	6,8	188,0	31,0	15,0	33,0	11,0	1,0	39,0	16,0	2,0	3,8	3,0	2,9	89,0	3,0	211,0	13,0	44,0	332
MD10(3)	29,48621	-25,84921	53,94	1,04	15,07	5,76	0,04	0,31	0,24	0,07	1,27	0,28	0,07	21,85	99,93	4.2	390,0	3,0	14,0	96,0	22,0	365,0	5,0	32,0	22,0	1,0	8,6	45,0	2,0	15,0	35,0	44,0	29,0	111,0	12,0	1,0	10,0	39,0	2,0	13,0	3,0	4,6	177,0	10,0	31,0	3,0	92,0	296
MD10(4)	29,48621	-25,84921	72,72	1,03	9,98	6,98	0,09	0,33	0,12	0,03	0,72	0,06	0,06	7,42	99,54	4,0	241,0	3,0	2,0	86,0	37,0	360,0	5,0	44,0	14,0	1,0	14,0	32,0	2,0	14,0	31,0	46,0	20,0	61,0	15,0	1,0	10,0	13,0	2,0	7,0	3,0	3,2	137,0	3,0	31,0	3,2	51,0	439
MD11	29,39712	-25,85909	75,06	0,61	7,72	3,80	0,55	0,48	0,48	0,11	0,82	0,08	0,06	10,73	100,52	4,0	380,0	3,0	6,9	159,0	120,0	254,0	5,0	22,0	10,0	1,0	7,2	98,0	2,0	10,0	78,0	138,0	25,0	66,0	12,0	1,0	14,0	47,0	2,0	7,5	3,0	3,5	77,0	7,1	76,0	3,0	218,0	392
MD12	29,39184	-25,89011	78,15	0,33	4,47	12,70	0,07	0,05	0,03	0,01	0,30	0,07	0,05	3,57	99,80	12	182,0	3,0	2,0	81,0	24,0	426,0	5,0	36,0	6,8	1,0	4,4	15,0	2,4	5,7	12,0	28,0	29,0	19,0	8,2	1,4	10,0	13,0	2,0	3,5	3,0	2,6	209,0	3,0	15,0	3,0	28,0	289
MD13	29,42265	-25,89107	65,57	0,60	10,97	10,74	0,29	0,34	0,29	0,14	0,86	0,12	0,04	9,83	99,80	7.5	626,0	3,0	2,7	289,0	91,0	308,0	5,0	44,0	15,0	1,0	5,7	62,0	2,4	9,8	51,0	84,0	83,0	63,0	15,0	1,0	10,0	80,0	2,0	9,0	3,0	4,0	162,0	9,1	39,0	3,0	139,0	265
MD14(1)	29,42422	-26,10250	80,34	0,43	7,18	1,97	0,26	0,28	0,29	0,33	2,18	0,05	0,01	5,86	99,19	4,0	539,0	3,0	3,0	52,0	52,0	120,0	5,0	12,0	7,8	1,0	9,3	22,0	2,0	6,4	20,0	23,0	21,0	77,0	9,6	1,0	10,0	76,0	2,0	5,0	3,0	2,5	59,0	9,2	15,0	3,0	30,0	373
MD14(2)	29,41061	-26,09563	15,37	0,35	7,43	2,14	0,08	0,54	2,07	0,05	0,32	0,17	0,01	69,99	98,51	4,0	507,0	3,0	4,8	60,0	22,0	110,0	5,0	31,0	16,0	1,0	3,5	33,0	2,0	9,2	24,0	42,0	17,0	31,0	11,0	1,0	10,0	331,0	2,0	7,9	3,0	3,2	67,0	3,0	21,0	3,0	69,0	106
MD15	29,38419	-26,10336	88,29	0,21	3,84	1,65	0,04	0,23	0,54	0,09	0,88	0,03	0,00	4,79	100,60	4,0	393,0	3,0	2,0	62,0	17,0	71,0	5,0	9,5	5,4	1,0	4,3	23,0	2,0	3,3	17,0	18,0	16,0	37,0	6,3	1,0	10,0	55,0	2,0	3,0	3,0	2,0	52,0	4,0	11,0	3,0	17,0	162
MD16	29,32030	-26,10119	82,45	0,43	6,73	2,94	0,19	0,36	0,83	0,28	1,36	0,05	0,01	4,76	100,40	4,0	456,0	3,0	2,0	57,0	18,0	163,0	5,0	15,0	8,4	1,0	7,3	24,0	2,0	6,5	25,0	23,0	18,0	58,0	11,0	1,0	10,0	71,0	2,0	5,5	3,0	2,0	77,0	3,0	15,0	3,0	28,0	294
MD17	29,31643	-26,10220	81,42	0,42	6,89	1,94	0,21	0,26	0,26	0,32	2,16	0,05	0,01	5,45	99,39	4,0	555,0	3,0	2,3	49,0	44,0	104,0	5,0	11,0	7,9	1,0	8,7	23,0	2,0	6,1	19,0	21,0	21,0	77,0	7,0	1,0	10,0	76,0	2,0	5,5	3,0	2,0	50,0	3,0	16,0	3,0	27,0	412
MD18	29,32188	-26,09629	80,31	0,43	6,45	2,80	0,09	0,40	1,87	0,08	0,93	0,04	0,01	5,19	98,58	4,0	420,0	3,0	2,0	90,0	22,0	88,0	5,0	14,0	8,1	1,0	7,1	31,0	2,0	6,8	32,0	19,0	15,0	43,0	9,2	1,0	10,0	66,0	2,0	4,1	3,0	2,0	63,0	3,0	20,0	3,0	29,0	248
MD19	29,28583	-26,09911	76,31	0,53	7,75	3,31	0,07	0,35	0,46	0,20	1,34	0,09	0,01	9,29	99,70	4,0	398,0	3,0	2,0	57,0	20,0	130,0	5,0	18,0	9,5	1,0	10,0	30,0	2,0	7,8	27,0	26,0	19,0	58,0	12,0	1,0	10,0	86,0	2,0	5,6	3,0	2,0	75,0	3,0	19,0	3,0	33,0	360
MD2	30,3935	-23,27732	59,65	0,84	16,49	7,30	0,13	1,23	2,44	2,04	1,72	0,10	0,03	8,97	100,96	4,0	692,0	3,0	4,9	55,0	23,0	216,0	5,0	65,0	20,0	1,0	3,0	31,0	2,0	7,7	25,0	117,0	14,0	73,0	16,0	1,0	10,0	298,0	2,0	8,6	3,0	2,0	131,0	3,0	17,0	3,0	57,0	59
MD21	29,34039	-25,99218	52,98	0,70	14,30	7,15	0,44	0,85	6,52	0,12	2,80	0,13	0,02	13,22	99,24	4,0	639,0	3,0	7,7	89,0	43,0	156,0	5,0	28,0	19,0	1,0	5,9	46,0	2,0	11,0	36,0	82,0	32,0	148,0	13,0	1,0	10,0	266,0	2,0	12,0	3,0	5,3	84,0	4,5	27,0	3,0	103,0	203
MD22	29,33297	-25,98627	68,83	0,74	10,27	5,20	0,05	0,52	0,50	0,12	0,94	0,14	0,02	12,72	100,04	4,0	358,0	3,0	9,7	76,0	29,0	125,0	5,0	26,0	13,0	1,0	9,5	40,0	2,0	11,0	34,0	52,0	21,0	67,0	13,0	1,0	10,0	65,0	2,0	7,0	3,0	3,1	89,0	3,0	25,0	3,0	86,0	301
MD23	29,32983	-25,98551	93,14	0,34	2,75	1,03	0,02	0,03	0,07	0,09	1,08	0,03	0,00	1,36	99,93	4,0	320,0	3,0	2,0	35,0	9,3	72,0	5,0	7,0	3,9	1,0	14,0	16,0	2,0	4,0	17,0	8,7	13,0	39,0	3,0	1,0	10,0	35,0	2,0	4,8	3,0	2,0	24,0	3,0	10,0	3,0	38,0	551

SAMPLE	LONGITUDE	LATITUDE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr
MD24	29,28538	-25,97237	59,92	0,76	11,88	5,79	0,09	0,42	1,15	0,09	0,90	0,16	0,04	18,76	99,95	4,0	314,0	3,0	10,0	84,0	35,0	259,0	5,0	40,0	16,0	1,0	8,1	47,0	2,0	12,0	39,0	65,0	36,0	66,0	13,0	1,0	10,0	71,0	2,0	8,8	3,0	3,5	116,0	3,0	33,0	3,0	115,0	347
MD25	29,26929	-25,95633	78,15	0,49	7,50	5,17	0,04	0,13	0,18	0,03	0,73	0,12	0,03	7,01	99,58	4,0	283,0	3,0	2,2	72,0	11,0	246,0	5,0	21,0	12,0	1,0	9,3	34,0	2,0	10,0	28,0	19,0	34,0	49,0	8,8	1,0	10,0	19,0	2,0	7,9	3,0	2,9	84,0	3,0	26,0	3,3	66,0	370
MD26	29,23285	-25,92677	79,92	0,77	8,66	2,50	0,04	0,23	0,24	0,39	2,14	0,04	0,01	3,93	98,88	4,0	443,0	3,0	2,0	55,0	16,0	124,0	5,0	19,0	9,8	1,0	13,0	30,0	2,0	9,1	26,0	22,0	22,0	76,0	12,0	1,0	10,0	72,0	2,0	5,7	3,0	3,1	75,0	3,0	22,0	3,0	26,0	520
MD27	29,29203	-26,00095	86,34	0,50	5,48	0,84	0,05	0,06	0,10	0,01	0,31	0,05	0,01	7,07	100,81	4,0	169,0	3,0	4,2	74,0	135,0	129,0	5,0	42,0	9,3	1,0	11,0	38,0	2,0	9,0	55,0	48,0	14,0	28,0	8,8	1,0	12,0	33,0	2,0	3,0	3,0	3,4	45,0	3,0	56,0	5,3	57,0	404
MD28	29,25799	-25,95904	75,89	0,48	5,46	5,03	0,20	0,26	0,19	0,04	0,39	0,07	0,11	10,57	98,68	4,0	232,0	3,0	5,2	59,0	25,0	594,0	5,0	19,0	8,0	1,0	6,9	22,0	2,0	8,2	20,0	29,0	31,0	24,0	6,7	1,0	10,0	44,0	2,0	3,6	3,0	2,0	68,0	3,0	18,0	3,0	74,0	330
MD29	29,26435	-25,94231	57,06	0,75	12,45	7,34	0,06	0,44	0,53	0,09	1,07	0,44	0,14	20,06	100,43	4.6	391,0	3,0	13,0	141,0	36,0	791,0	5,0	43,0	17,0	1,0	11,0	60,0	2,0	14,0	49,0	61,0	46,0	84,0	12,0	1,1	10,0	52,0	2,0	12,0	3,0	3,8	108,0	4,3	53,0	3,0	226,0	428
MD30	29,26747	-25,94218	73,79	0,69	11,05	4,64	0,03	0,25	0,16	0,04	1,67	0,11	0,01	7,15	99,59	13	439,0	3,0	2,0	134,0	14,0	116,0	5,0	21,0	18,0	1,0	9,0	64,0	2,0	17,0	51,0	27,0	36,0	145,0	11,0	1,0	10,0	28,0	2,0	13,0	3,0	3,4	65,0	5,2	40,0	4,9	50,0	431
MD31	29,29476	-25,89595	74,46	0,69	8,65	8,84	0,10	0,16	0,25	0,07	2,94	0,05	0,02	3,83	100,06	4,0	690,0	3,0	2,0	165,0	14,0	136,0	5,0	23,0	15,0	1,0	12,0	19,0	2,0	22,0	21,0	16,0	53,0	122,0	5,1	1,0	10,0	18,0	2,0	18,0	3,0	5,4	86,0	3,0	55,0	7,0	50,0	551
MD32	29,26925	-25,90277	77,19	0,54	9,65	6,21	0,05	0,13	0,13	0,31	1,47	0,05	0,03	4,82	100,59	4,0	344,0	3,0	2,1	104,0	16,0	249,0	5,0	20,0	16,0	1,0	10,0	38,0	2,0	18,0	32,0	25,0	40,0	101,0	8,3	1,0	10,0	16,0	2,0	14,0	3,0	4,7	82,0	3,0	44,0	4,6	49,0	491
MD34	29,30879	-25,90806	65,60	0,26	6,59	20,36	0,05	0,12	0,18	0,02	0,94	0,11	0,07	5,02	99,31	14	197,0	3,0	2,0	76,0	15,0	499,0	5,0	32,0	15,0	1,0	12,0	10,0	3,9	13,0	17,0	17,0	41,0	66,0	4,5	2,0	10,0	11,0	2,0	13,0	3,0	5,3	199,0	4,0	37,0	3,0	32,0	384
MD35	29,25776	-25,87072	83,12	0,26	6,20	4,67	0,08	0,12	0,12	0,27	1,86	0,05	0,02	2,50	99,27	4.0	391,0	3,0	2,0	51,0	6,9	146,0	5,0	11,0	12,0	1,0	9,7	19,0	2,0	14,0	18,0	8,8	19,0	82,0	3,1	1,0	10,0	16,0	2,0	11,0	3,0	3,8	58,0	3,0	43,0	4,7	61,0	389
MD37	29,29491	-25,86190	91,54	0,15	4,10	1,89	0,02	0,11	0,08	0,20	1,35	0,02	0,00	1,22	100,68	4,0	327,0	3,0	2,0	37,0	6,8	60,0	5,0	5,2	7,7	1,0	5,8	21,0	2,0	6,9	18,0	8,6	23,0	59,0	3,0	1,0	10,0	21,0	2,0	4,4	3,0	2,0	22,0	3,0	21,0	3,6	64,0	197
MD38	29,29409	-25,86484	76,26	0,30	11,68	4,20	0,03	0,14	0,08	0,06	3,26	0,03	0,00	3,76	99,80	14	376,0	3,0	2,0	134,0	6,7	26,0	5,0	8,8	21,0	1,0	13,0	69,0	2,0	24,0	54,0	8,2	72,0	146,0	3,0	1,0	10,0	12,0	2,0	22,0	3,0	6,2	7,1	3,0	75,0	8,5	243,0	552
MD39	29,27130	-25,84689	81,55	0,31	6,54	6,28	0,05	0,23	0,18	0,34	1,63	0,06	0,03	3,13	100,34	7.9	425,0	3,0	2,0	93,0	13,0	174,0	5,0	14,0	11,0	1,0	5,2	38,0	2,0	12,0	27,0	20,0	44,0	84,0	6,6	1,0	10,0	20,0	2,0	11,0	3,0	4,1	69,0	3,1	37,0	3,6	81,0	343
MD40	29,27158	-25,84672	80,46	0,29	6,99	7,22	0,07	0,30	0,12	0,23	1,82	0,06	0,03	2,61	100,20	13	443,0	3,0	2,0	80,0	14,0	185,0	5,0	14,0	13,0	1,0	9,1	30,0	2,0	13,0	26,0	23,0	38,0	90,0	6,2	1,0	10,0	20,0	2,0	11,0	3,0	4,6	74,0	3,2	38,0	3,0	79,0	310
MD41	29,27119	-25,84641	89,29	0,30	3,89	2,91	0,04	0,14	0,15	0,15	1,04	0,04	0,02	1,92	99,88	4,0	294,0	3,0	2,0	54,0	8,1	135,0	5,0	8,3	6,5	1,0	5,6	21,0	2,0	9,0	20,0	13,0	23,0	52,0	3,1	1,0	10,0	20,0	2,0	5,8	3,0	2,1	42,0	3,0	23,0	3,0	43,0	321
MD44	29,49079	-25,81924	80,39	0,48	5,38	3,37	0,13	0,28	0,25	0,04	0,88	0,06	0,36	6,96	98,59	4,0	295,0	3,0	4,6	59,0	17,0	1473,0	5,0	16,0	9,2	1,0	10,0	31,0	2,0	14,0	27,0	39,0	19,0	55,0	6,4	1,0	10,0	24,0	2,0	7,1	3,0	2,6	68,0	3,0	33,0	3,4	54,0	399
MD45	29,44897	-25,79656	93,44	0,15	1,59	3,71	0,03	0,06	0,04	0,01	0,21	0,02	0,06	1,16	100,47	4,0	76,0	3,0	2,0	28,0	6,9	361,0	5,0	10,0	2,8	1,0	4,3	10,0	2,0	1,9	10,0	7,9	13,0	12,0	3,1	1,0	10,0	3,5	2,0	3,0	3,0	2,0	115,0	3,0	4,9	3,0	6,8	82
MD46	29,44720	-25,79795	82,17	0,53	4,97	6,73	0,06	0,14	0,11	0,03	0,36	0,06	0,15	4,27	99,60	4,0	124,0	3,0	2,0	60,0	14,0	713,0	5,0	23,0	7,9	1,0	9,2	14,0	2,0	6,7	14,0	25,0	24,0	25,0	8,2	1,0	10,0	11,0	2,0	3,5	3,0	2,0	140,0	3,0	13,0	3,0	33,0	274
MD47 (2)	29,47886	-25,76534	76,73	0,42	5,85	7,12	0,09	0,32	0,64	0,39	1,49	0,10	0,04	5,68	98,87	4,0	379,0	3,0	2,0	52,0	19,0	283,0	5,0	28,0	8,8	1,0	5,7	24,0	2,0	7,9	21,0	25,0	26,0	57,0	7,3	1,0	10,0	40,0	2,0	6,2	3,0	2,7	109,0	3,0	23,0	3,0	128,0	230
MD47 (3)	29,48995	-25,76648	87,69	0,55	3,99	2,59	0,06	0,16	0,21	0,17	0,89	0,05	0,01	4,21	100,58	4,0	291,0	3,0	3,6	41,0	11,0	97,0	5,0	13,0	5,5	1,0	8,0	21,0	2,0	5,7	17,0	15,0	14,0	41,0	5,4	1,0	10,0	34,0	2,0	3,1	3,0	2,0	62,0	3,0	15,0	3,0	20,0	345
MD47(1)	29,47823	-25,76907	79,72	0,68	6,74	4,41	0,07	0,30	0,33	0,23	1,18	0,06	0,02	5,22	98,96	4,0	370,0	3,0	2,1	60,0	18,0	129,0	5,0	22,0	9,4	1,0	8,2	31,0	2,0	8,7	26,0	23,0	24,0	57,0	10,0	1,0	10,0	40,0	2,0	4,8	3,0	2,7	76,0	3,0	20,0	3,0	49,0	319
MD48	29,29400	-25,82168	70,20	0,58	13,11	7,99	0,11	0,83	0,29	0,36	1,85	0,13	0,17	4,98	100,6	51	674,0	3,0	2,0	101,	37,0	334,0	5,0	89,	18,	1,0	7,6	51,0	2,0	10,0	42,0	58,0	42,	115,	16,	1,0	10,0	63,0	2,0	12,	3,0	4,2	132,0	3,0	33,0	3,0	129,	22
MD49	29,33645	-25,81701	79,44	0,51	6,55	6,94	0,08	0,42	0,31	0,22	0,78	0,04	0,05	5,16	100,49	4,0	353,0	3,0	2,0	77,0	33,0	209,0	5,0	26,0	9,8	1,0	7,8	32,0	2,0	6,8	25,0	39,0	24,0	50,0	12,0	1,0	10,0	27,0	2,0	4,0	3,0	2,0	101,0	3,0	20,0	3,0	47,0	257
MD50	29,31939	-25,75965	93,96	0,23	2,02	1,82	0,06	0,09	0,13	0,09	0,61	0,03	0,01	1,23	100,27	4,0	239,0	3,0	2,0	20,0	10,0	89,0	5,0	6,8	2,6	1,0	5,3	10,0	2,0	2,7	10,0	12,0	9,6	23,0	3,0	1,0	10,0	16,0	2,0	3,0	3,0	2,0	32,0	3,0	8,8	3,0	10,0	169
WB01	29,72780	-25,80780	52,77	1,18	16,11	10,73	0,18	0,29	0,24	0,03	0,80	0,18	0,08	17,95	100,53	4,0	315,0	3,0	14,0	98,0	30,0	453,0	5,0	56,0	22,0	1,0	6,2	47,0	2,0	15,0	38,0	52,0	27,0	65,0	18,0	1,0	10,0	37,0	2,0	11,0	3,0	2,6	208,0	3,0	30,0	3,0	122,0	314
WB02	29,72780	-25,80780	92,49	0,34	2,41	2,62	0,02	0,01	0,03	0,02	0,12	0,03	0,01	2,82	100,91	4,0	51,0	3,0	2,0	17,0	4,6	97,0	5,0	7,1	2,9	1,0	5,1	10,0	2,0	3,6	10,0	7,8	8,2	6,8	3,3	1,0	10,0	14,0	2,0	3,0	3,0	2,0	29,0	3,0	7,0	3,0	14,0	177
WB03	29,16649	-25,73563	94,08	0,35	1,07	1,17	0,01	0,03	0,02	0,01	0,10	0,02	0,01	2,73	99,59	38,0	3,0	2,0	24,0	5,4	72,0	5,0	5,4	1,8	1,0	7,6	10,0	2,0	4,5	13,0	7,4	7,2	6,5	3,0	1,0	10,0	7,6	2,0	3,0	3,0	2,0	24,0	3,0	14,0	3,1	7,5	349,0	349
WB04	29,20895	-25,82317	83,35	0,55	5,71	5,62	0,03	0,23	0,10	0,01	0,70	0,10	0,06	3,87	100,34	39,0	3,0	2,0	28,0	4,9	68,0	5,0	5,3	1,6	1,0	7,3	10,0	2,0	4,5	15,0	6,4	6,2	6,5	3,0	1,0	10,0	7,4	2,0	3,0	3,0	2,0	23,0	3,0	13,0	3,0	7,7	325,0	325
WB05	29,15119	-25,87251	93,61	0,18	1,90	1,12	0,01	0,03	0,04	0,01	0,06	0,10	0,01	3,82	100,88	202,0	3,0	2,0	100,0	15,0	312,0	5,0	22,0	6,9	1,0	7,9	45,0	2,0	8,1	46,0	22,0	20,0	37,0	9,4	1,0	10,0	20,0	2,0	5,0	3,0	3,0	85,0	3,0	35,0	3,0	62,0	375,0	375
WB06A	29,14403	-25,86504	36,10	0,70	11,91	12,19	0,07	0,39	2,28	0,62	0,72	1,44	0,12	32,42	98,96	70,0	3,0	2,0	23,0	6,7	175,0	5,0	8,6	3,6	1,0	4,4	13,0	2,0	3,5	13,0	9,3	8,7	5,7	3,0	1,0	10,0	30,0	2,0	3,0	3,0	2,0	133,0	3,0	11,0	3,0	80,0	118,0	118
WB06B	29,86558	-25,14273	47,69	0,73	12,69	4,21	0,02	0,29	0,69	0,48	0,37	0,63	0,05	31,65	99,48	291,0	3,0	13,0	169,0	42,0	768,0	5,0	64,0	16,0	1,0	4,8	78,0	3,7	10,0	87,0	67,0	42,0	36,0	12,0	1,5	19,0	130,0	5,4	7,9	3,0	5,2	1408,0	3,0	108,0	7,6	4131,0	238,0	238
WB07	29,13492	-25,85710	67,33	0,48	7,03	7,00	0,04	0,19	0,38	0,25	0,23	1,07	0,08	15,58	99,66	281,0	3,0	7,7	88,0	54,0	361,0	5,0	55,0	18,0	1,3	3,5	41,0	2,7	13,0	54,0	90,0	35,0	35,0	15,0	1,0	15,0	96,0	2,0	10,0	3,0	5,8	452,0	3,0	55,0	7,1	2119,0	234,0	234
WB08	29,15185	-25,83186	90,43	0,30	2,89	2,57	0,02	0,11	0,05	0,01	0,05	0,05	0,09	3,86	100,44	190,0	3,0	7,0	118,0	44,0	529,0	5,0	33,0	8,3	1,0	6,1	57,0	2,3	7,8	65,0	63,0	28,0	18,0	10,0	1,0	14,0	70,0	2,0	3,1	3,0	2,2	1335,0	3,0	85,0	6,7	1267,0	238,0	238
WB09	29,12679	-25,82767	53,98	0,34	8,87	11,68	0,30	0,73	1,07	0,09	0,17	0,17	0,09	22,00	99,48	76,0	3,0	5,7	670,0	335,0	316,0	5,0	34,0	6,7	1,0	3,7	223,0	2,1	4,8	358,0	379,0	13,0	16,0	29,0	1,9	72,0	18,0	2,0	4,3	3,0	8,2	1898,0	4,8	352,0	23,0	1308,0	149,0	149
WB11A	29,11721	-25,77138	29,93	0,45	13,72	13,90	0,20	0,45	2,55	0,01	1,33	0,15	0,03	36,25	98,98	93,0	3,0	25,0	212,0	134,0	159,0	5,0	40,0	10,0	1,0	4,9	78,0	2,0	6,5	117,0	192,0	23,0	19,0	17,0	1,0	26,0	46,0	2,0	9,6	3,0	6,0	175,0	4,6	138,0	6,4	554,0	135,0	135
WB11B	29,12103	-25,76805	67,55	0,59	6,03	19,75	0,09	0,12	0,02	0,01	0,36	0,14	0,10	4,98	99,72	309,0	3,0	2,0	87,0	20,0	835,0	5,0	67,0	10,0	1,0	4,3	13,0	2,6	5,1	10,0	30,0	40,0	19,0	18,0	1,6	10,0	11,0	2,0	6,7	3,0	3,0	319,0	3,0	12,0	3,0	29,0	191,0	191
WB27A	29,21314	-25,84645	53,65	0,56	8,29	27,93	0,03	0,12	0,01	0,01	0,17	0,10	0,16	8,90	99,93	102,0	3,0	4,6	37,0	10,0	1273,0	5,0	33,0	15,0	1,0	12,0	20,0	3,8	9,2	10,0	23,0	28,0	16,0	15,0	3,0	10,0	26,0	2,0	11,0	3,0	3,3	313,0	3,8	12,0	3,0	39,0	323,0	323
WB27B	29,21338	-25,84557	70,85	0,53	6,25	7,62	0,01	0,08	0,04	0,01	0,31	0,10	0,03	13,63	99,46	147,0	3,0	11,0	52,0	9,1	186,0	5,0	93,0	12,0	1,0	7,7	27,0	2,0	11,0	26,0	27,0	22,0	24,0	55,0	1,1	10,0	34,0	2,0	19,0	3,0	37,0	86,0	3,0	22,0	3,0	74,0	282,0	282
WB28	29,19869	-25,9453	62,06	0,47	10,35	7,09	0,21	0,28	0,39	0,30	2,03	0,18	0,04	16,38	99,78	680,0	3,0	9,7	173,0	115,0	216,0	5,0	23,0	16,0	1,0	8,1	60,0	2,0	14,0	49,0	53,0	36,0	98,0	10,0	1,0	10,0	81,0	2,0	13,0	3,0	5,4	105,0	3,0	46,0	3,1	185,0	332,0	332
WB29	29,17364	-25,75293	27,66	0,19	7,63	10,10	0,03	0,22	0,27	0,09	0,20	0,19	0,02	53,14	99,75	51,0	3,0	36,0	467,0	88,0	128,0	5,0	20,0	3,4	1,0	3,0	142,0	2,0	2,2	278,0	95,0	14,0	15,0	9,4	1,0	60,0	14,0	2,0	3,0	3,0	5,4	48,0	3,7	193,0	17,0	245,0	56,0	56
WB200	29,0367	-26,3060	66,75	1,04	10,19	6,25	0,11	0,69	0,86	0,30	1,30	0,14	0,02	10,86	98,50	4	326	3	8	67	19	127	5	39	13	1	9,4	29	2	14	32	35	17	72	15	2	10	62	2	9,8	3	2	113	3	28	3	53	263
W301	29,0399	-26,2726	85,39	0,55	5,57	2,83	0,06	0,30	0,37	0,26	1,05	0,04	0,01	3,31	99,74	4	351	3	3,2	48	19	106	5	19	7,6	1	12	18	2	8,4	19	22	14	44	9,9	1	10	49	2	6,1	3	2	77	3	13	3,5	32	375
WB02	29,0915	-26,2798	73,07	0,47	7,23	10,46	0,12	0,34	0,72	0,17	1,09	0,15	0,04	5,82	99,68	7,7	494	3	3,7	109	30	301	5	46	10	1	10	21	2	8,7	23	36	30	46	9,3	1,3	10	47	2	8	3	2,1	204	3	16	3	31	292
WB10	29,0362	-26,3304	71,11	0,73	6,19	6,89	0,39	2,18	5,97	0,83	0,63	0,11	0,02	4,72	99,77	5,8	811	3	2	112	64	130	5	38	9	2	6	35	2	5	37	52	12	21	15	1	10	104	3	3	3	2	214	3	25	3	43	175

SAMPLE	LONGITUDE	LATITUDE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr
WB11	29,0226	-26,3322	62,66	1,17	10,35	10,48	0,27	3,64	5,98	1,43	0,95	0,21	0,03	2,62	99,79	4	720	3	2,2	71	51	232	5	70	16	1	5,8	20	2	6,9	29	64	12	32	21	1,9	10	155	2,3	4,6	3	2	278	3	26	3	82	193
WB12	28,9974	-26,3296	93,53	0,10	2,70	1,43	0,05	0,01	0,05	0,08	1,14	0,03	0,01	0,57	99,69	4	352	3	2	30	13	76	5	7,1	3,1	1	3	10	2	4,4	10	8,7	13	38	3	1	10	34	2	4	3	2	37	3	4,4	3	4,3	82
WB26	29,3840	-26,3413	85,26	0,29	4,23	2,72	0,11	0,69	2,14	0,32	1,09	0,04	0,01	2,18	99,09	4	389	3	2	41	17	121	5	14	5,4	1	10	15	2	5,1	16	23	11	35	6,1	1,3	10	59	2	5,6	3	2	71	3	12	3	14	302
WB29	29,4217	-26,3960	70,70	0,51	7,95	8,30	0,13	2,81	4,29	0,86	1,08	0,11	0,12	1,94	98,80	4	417	3	2	103	41	422	7	43	9	2	6	12	2	6	14	46	21	34	12	2	10	84	2	4	3	2	180	3	14	3	33	177
WB30	29,5370	-26,3549	79,63	0,31	4,94	4,93	0,32	0,35	2,77	0,25	1,44	0,07	0,02	4,09	99,11	7,1	523	3	2	77	27	164	5	24	5	1	3,5	30	2	5,5	26	27	20	48	8,3	1,6	10	68	2	4,5	3	2	127	3	18	3	18	159
WB33	29,5582	-26,3279	88,19	0,34	5,01	2,00	0,06	0,09	0,29	0,30	1,90	0,03	0,00	1,33	99,54	4	609	3	2	52	11	111	5	10	6,3	1	14	19	2	6,8	23	15	16	62	5,5	1	10	70	2	5,9	3	2	59	3	13	3	14	368
WB35	29,5783	-26,4363	71,92	0,68	8,07	5,66	0,30	2,08	3,66	0,88	1,13	0,11	0,03	4,64	99,18	4	658	3	7	59	47	195	5	34	9,8	1	5,7	21	2	6,5	23	62	13	36	14	1	10	97	2,2	3	3	2	149	3	17	3	42	179
WB46	29,6237	-26,2418	89,10	0,10	2,37	4,26	0,16	0,01	0,52	0,04	0,83	0,04	0,02	1,33	98,79	6,1	404	3	2	76	21	155	5	20	2,5	1,1	3	15	2	3,9	21	21	18	26	3,9	1	10	30	2	3,2	3	2	118	3	10	3	4,4	94
WB53	29,3773	-26,3242	82,74	0,33	5,86	3,84	0,06	0,74	1,20	0,30	1,48	0,08	0,02	2,80	99,46	4	483	3	3,5	52	16	140	5	15	7,5	1	7,2	12	2	6,7	15	23	18	55	6,6	1,4	10	66	2	5,2	3	2	69	3	10	3	22	243
WB55	29,2652	-26,2402	93,84	0,23	2,01	0,90	0,01	0,01	0,05	0,02	0,50	0,06	0,00	2,15	99,79	4	190	3	2	23	1,6	50	5	5,8	2,1	1	9,5	10	2	6,1	10	7,6	7	19	3	1	10	18	2	3,5	3	2	23	3	7,2	3	12	296
WB56	29,3237	-26,2697	73,42	0,48	7,48	10,44	0,17	0,99	0,47	0,09	1,12	0,09	0,06	4,78	99,58	5,9	664	3	5,6	177	48	398	7,7	38	11	1	6,9	18	2	10	20	62	40	57	11	2,1	10	40	2	8,5	3	2,3	180	3	14	3	30	273
WB57	29,2486	-26,2516	89,93	0,29	4,05	1,52	0,03	0,08	0,32	0,29	1,52	0,05	0,01	1,24	99,32	4	443	3	2	27	8,1	75	5	9,3	4,4	1	9	10	2	5,6	13	12	13	47	3,4	1	10	58	2	5,4	3	2	34	3	7	3	20	250
WB59	29,2269	-26,2661	81,43	0,45	7,33	4,30	0,09	0,19	0,35	0,17	2,09	0,06	0,02	3,15	99,63	4	608	3	2	91	18	115	5	13	11	1	12	31	2	11	28	19	25	81	6,3	1	10	59	2	9,2	3	2	62	3	19	3,2	32	404
WB67	29,0922	-26,0628	72,56	0,42	6,79	5,63	0,06	0,04	0,24	0,03	0,72	0,13	0,03	12,95	99,61	5,9	382	3	4,6	102	18	205	5,7	25	9,1	1	11	19	2	9,2	22	26	27	35	9,6	1	10	71	2	8,7	3	2,4	113	3	15	3	35	289
WB68	29,0963	-26,0906	68,87	0,75	9,72	8,09	0,11	0,80	2,50	1,88	2,39	0,12	0,03	4,53	99,81	6,5	575	3	2	95	17	191	7	41	18	1,2	11	42	2	16	42	24	29	88	8	1,1	10	141	2,1	12	3	4	106	3,2	36	3,4	86	322
WB70	29,1087	-26,1026	67,64	0,45	7,54	9,86	0,11	1,00	1,01	0,69	1,48	0,11	1,43	7,77	99,08	7,7	438	3	2	101	20	2 518	6	30	12	1,3	8,5	30	2	11	33	27	25	51	7,9	1,2	10	74	2,2	7,3	3	2,7	158	3	23	4,3	53	271
WB73	29,2699	-26,1369	93,59	0,12	2,74	0,75	0,01	0,01	0,11	0,21	1,43	0,03	0,00	0,47	99,46	4	366	3	2	11	5	49	5	3,7	2,3	1	3,8	10	2	4	10	6,5	10	40	3	1,1	10	47	2	3	3	2	16	3	4,3	3	3	122
WB75	29,1980	-26,0634	80,82	0,99	5,20	4,88	0,07	0,28	0,49	0,18	0,55	0,06	0,07	5,80	99,40	4	277	3	2	39	13	340	5	32	7,7	1	9,4	12	2	8,4	13	22	14	27	8,7	1	10	53	2	5,7	3	2	133	3	12	3	32	257
WB76	29,1826	-26,1918	91,17	0,19	3,44	1,98	0,03	0,01	0,12	0,15	1,44	0,03	0,02	1,14	99,73	4	417	3	2	38	8,5	118	5	6,9	3,5	1	7	13	2	5,7	14	8	15	47	3,1	1,1	10	47	2	4,6	3	2	34	3	9,3	3	8,8	224
WB77	29,1926	-26,2130	77,72	0,43	6,22	6,28	0,09	0,12	0,26	0,06	0,91	0,12	0,06	7,56	99,85	6,3	404	3	7,8	92	32	216	5	21	8,9	1	9,2	18	2,2	9,8	24	27	29	48	8,9	1,6	10	51	2	7,2	3	2	122	3	15	3	32	282
WB78	29,3154	-26,2214	92,29	0,14	2,66	2,07	0,08	0,07	0,34	0,04	0,63	0,03	0,01	1,35	99,73	5,4	309	3	2	62	16	87	5	5,9	2,4	1	4,3	16	2	5,5	16	16	13	25	3	1	10	26	2	4,2	3	2	42	3	7,8	3	12	99
WB91	29,7531	-26,1471	88,00	0,30	5,16	1,82	0,05	0,11	0,24	0,28	1,85	0,04	0,01	1,83	99,67	4	504	3	2	30	10	93	5	8,5	5,4	1	8,6	10	2	6,4	14	13	17	61	5,3	1,1	10	62	2	5,5	3	2	48	3	10	3	13	220
WB92	29,7822	-26,0965	91,95	0,12	2,32	3,66	0,04	0,01	0,03	0,03	0,40	0,02	0,02	1,15	99,95	4,7	204	3	2	53	15	136	5	17	3,4	1	6,5	10	2	5,1	10	13	14	18	3,6	1,2	10	15	2	3	3	2	89	3	5,1	3	5,1	23
WB93	29,7343	-26,1055	77,59	0,48	6,47	8,77	0,18	0,10	0,20	0,18	1,76	0,15	0,03	3,54	99,46	8,3	668	3	2	192	40	206	5,6	35	6,9	1,2	16	24	2	9,8	24	32	41	62	8	1,2	10	54	2	14	3	2,5	178	3,2	16	3	23	515
WB94	29,6878	-26,0801	74,73	0,53	7,99	5,95	0,19	0,15	0,27	0,16	1,61	0,16	0,05	7,28	99,07	5,5	507	3	8,9	62	22	196	5	14	11	1,7	12	24	2	11	23	25	22	74	9,2	1	10	55	2	9,5	3	2	82	3	16	3	36	352
WB97	29,7569	-26,0160	62,91	0,46	7,99	19,06	0,20	0,78	1,21	0,71	1,08	0,19	0,06	4,52	99,17	12	496	3	2	283	47	420	7,3	65	12	1,5	6,8	28	2,9	8,5	25	48	54	41	12	1	10	67	2,9	10	3,6	3,2	384	3	18	3	33	225
WB100	29,7484	-26,0558	70,72	0,62	9,30	8,97	0,21	1,15	0,93	0,19	0,90	0,10	0,04	5,90	99,03	4	524	3	2,4	137	49	286	6,9	42	10	1	11	23	2	9,4	23	49	36	44	18	1,7	10	42	2	6,8	3	2,7	159	3	17	3	42	296
WB105	29,6296	-25,8769	91,33	0,25	3,51	1,45	0,02	0,01	0,27	0,10	1,00	0,06	0,00	1,77	99,76	5,4	302	3	2	31	5,4	82	5	6,5	4	1	7,9	11	2	5,9	13	9,5	9,6	36	3,7	1	10	37	2	3,8	3	2	28	3	9	3	13	216
WB106	29,6191	-25,9310	52,72	0,54	8,61	9,30	0,15	0,23	0,51	0,04	0,35	0,15	0,13	26,92	99,66	6	304	3	6,1	94	20	658	5	33	14	1,1	9,9	40	2,4	11	27	36	33	21	11	1,1	10	106	2	11	3	3,8	159	3	21	3	75	280
WB112	29,1982	-26,0519	32,15	0,72	24,03	7,72	0,50	16,97	4,59	0,19	0,20	0,03	11,53	1,20	99,83	4	220	3	2	215	78	See oxide value	5	12	11	1	6,5	23	2	2,4	68	99	34	9	28	1,1	10	97	2	5,2	3	2	609	3	12	3	177	100
WB120	29,7753	-25,9588	70,62	0,64	11,39	8,57	0,10	0,49	0,23	0,07	1,14	0,07	0,03	5,28	98,63	4,8	573	3	2	108	20	188	9	35	16	1,4	10	26	2,1	13	23	44	44	85	13	1	10	53	2	12	3	2,4	177	3	21	3	42	346
WB121	29,7754	-25,9406	84,60	0,34	4,86	5,47	0,04	0,01	0,19	0,03	0,32	0,13	0,03	2,83	98,84	4,5	274	3	2	47	10	272	5	17	5,5	1	7,8	15	2	5,7	14	17	14	13	6,2	1,3	10	110	2,1	5,5	3	2	134	3	8,5	3	19	177
WB127	29,7843	-25,8265	73,19	1,08	9,52	7,33	0,11	0,40	1,17	1,76	1,87	0,16	0,01	2,86	99,46	4	525	3	3,1	91	23	83	7,9	46	14	1,2	8,9	42	2	10	40	24	20	68	15	1	10	117	2	10	3	2	102	3	26	3,1	56	248
WB130	29,6346	-25,8548	86,01	0,70	5,11	4,01	0,05	0,01	0,11	0,09	1,01	0,07	0,01	2,62	99,81	4	406	3	2	79	8,4	104	5	15	7,8	1	12	20	2	13	24	12	14	49	4,9	1	10	21	2	9,6	3	2	59	3	25	3,6	34	381
WB131	29,5908	-25,8176	86,55	0,89	4,02	2,30	0,05	0,01	0,31	0,16	1,24	0,07	0,02	3,17	98,80	4	387	3	3,5	47	6,9	145	5	8,8	4,4	1	26	15	2	13	20	12	12	48	5	1,6	10	44	2	7,6	3	2	43	3	19	3	22	893
WB132	29,5766	-25,8213	71,23	0,47	8,18	7,01	0,05	0,10	0,19	0,09	1,64	0,14	0,04	10,51	99,67	6,4	327	3	7,8	111	12	227	8,2	19	15	1	13	26	2,1	20	26	18	35	92	4,4	1,5	10	20	2,8	16	3	4,1	64	3,4	43	5,9	74	461
WB133	29,6098	-25,8095	92,08	0,49	2,50	2,62	0,02	0,01	0,05	0,13	0,56	0,04	0,01	1,07	99,58	4	188	3	2	24	2,9	72	5	6,3	2,7	1	7,9	10	2	8,5	10	6,8	8,9	23	3	1	10	8,5	2	5,2	3	2	44	3	10	3	11	244
WB134	29,6064	-25,9156	71,02	0,39	6,84	7,51	0,05	0,67	0,61	0,04	0,55	0,09	0,46	11,44	99,68	8,4	251	3	2,6	87	11	1 584	5	19	10	1,2	9,5	29	2	12	24	26	21	24	9,3	1,1	10	47	2	10	3	2,5	139	3	22	3	45	287
WB135	29,5178	-25,8069	69,95	0,75	11,21	5,79	0,03	0,21	0,17	0,04	0,87	0,26	0,23	9,05	98,58	10	326	3	3,8	108	13	217	7,1	31	16	1,3	11	55	2	18	49	40	22	70	12	1,1	10	28	2	15	3	2,9	101	3	37	3,5	71	354
WB138	29,1803	-25,8891	59,31	0,47	9,15	14,30	0,04	0,08	0,98	0,01	0,31	0,12	0,11	14,44	99,32	5,3	179	3	5,5	84	18	554	5	20	11	1,1	3,9	32	2,4	10	37	53	24	25	9	1	13	52	2	7,8	3	2,8	131	3	21	3	118	164
WB139	29,1646	-25,8783	88,24	0,34	3,72	3,10	0,08	0,95	0,44	0,10	0,25	0,05	0,65	1,33	99,25	4	101	3	2	44	10	3 207	5	12	3,2	1	5,7	11	2	7,7	13	17	12	12	4,8	1	10	18	2	3	3	2	119	3	10	3	40	183
WB140	29,1279	-25,8752	68,76	0,89	9,68	4,47	0,27	0,28	0,60	0,05	0,48	0,14	0,12	13,79	99,54	9,7	227	3	20	73	13	528	5	34	15	1	12	34	3,1	17	30	32	38	32	11	1,6	10	55	2,3	11	3	2,9	1 028	3,5	28	3	164	382
WB141	29,1304	-25,8908	73,98	0,59	9,95	5,38	0,06	0,01	0,16	0,01	0,20	0,32	0,03	8,42	99,12	8	370	3	4,9	109	13	267	5	24	16	1,2	8	63	2	12	42	26	29	15	9,3	1,6	10	190	2	12	3	3,5	128	3	15	3,8	50	210
WB143	29,1875	-25,7929	91,76	0,22	3,07	2,60	0,02	0,02	0,04	0,01	0,46	0,05	0,02	1,57	99,83	4	163	3	2	36	5,4	85	5	9,4	2,5	1	5	17	2	5,6	17	12	4,9	21	3,9	1,4	10	6	2	3,7	3	2	33	3	12	3	15	139
WB145	29,0968	-25,8280	65,09	0,76	8,79	9,89	0,05	0,04	0,12	0,01	0,20	0,15	0,04	14,39	99,53	7,4	131	3	6,9	67	14	285	5	28	12	1,1	13	28	2	15	25	24	18	19	11	1,8	10	34	2	9,1	3	2,7	157	3	17	3	59	366

SAMPLE	LONGITUDE	LATITUDE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr
WB152	29,4950	-25,6374	70,67	0,42	5,84	17,35	0,25	0,05	0,03	0,01	0,26	0,10	0,07	4,54	99,58	8,8	363	3	2	137	24	534	5	46	11	1,1	7,6	14	3,5	8,2	14	53	39	16	15	1,5	10	7,6	2	6,5	3	2,6	206	3	16	3	53	201
WB157	29,6813	-25,7849	81,30	0,53	3,79	10,71	0,13	0,08	0,15	0,06	0,43	0,07	0,04	2,46	99,74	4	353	3	2	118	16	338	5	33	6,5	1	8,3	12	2	8,2	14	18	45	22	8,5	1	10	9	2,3	5,5	3	2	173	3	11	3	30	250
WB161	29,7091	-26,1453	75,67	0,26	3,74	2,59	0,04	0,03	0,19	0,07	0,88	0,05	0,03	16,27	99,82	4	380	3	2	51	13	214	5	11	5,5	1	10	14	2	7,5	16	15	21	41	5,3	1	10	37	2	5,2	3	2	71	3	9,4	3	21	296
WB166	29,1539	-25,8799	46,78	0,34	6,06	28,94	0,24	4,98	7,65	0,08	0,24	0,08	0,05	3,39	98,84	4	96	3	2	90	8,1	274	5	16	6,9	1,7	4	24	2	8	30	24	12	13	14	1,8	17	41	2	5,9	3,8	3,2	114	3	33	3	97	193
WB003	29,1600	-26,2929	96,43	0,06	1,23	0,88	0,01	0,01	0,05	0,05	0,35	0,02	0,00	0,41	99,51	4	117	3	2	16	3,9	49	5	3,2	1	1	3	10	2	3,6	10	5,9	4,8	11	3	1	10	11	2	3	3	2	26	3	2,9	3	3	64
WB004	29,1107	-26,2390	64,88	0,76	12,02	6,85	0,10	0,44	0,51	0,16	1,27	0,13	0,03	12,57	99,71	6,4	467	3	17	122	22	179	8,4	38	17	1,6	9,3	31	2	13	31	42	32	76	15	1	10	62	2,2	9,3	3	2,4	135	3	23	3	64	276
WB007	29,0924	-26,3701	92,14	0,19	2,86	1,48	0,07	0,06	0,28	0,23	1,01	0,03	0,00	0,80	99,14	5,1	357	3	2	31	18	49	5	9,5	3,1	1	5	11	2	4,5	10	16	11	32	3	1,4	10	39	2	3	3	2	56	3	6,4	3	9,3	118
WB009	29,1446	-26,3645	59,83	0,97	11,24	8,77	0,21	2,68	3,97	0,86	0,83	0,20	0,03	9,38	98,98	4	419	3	27	61	41	200	5	59	15	2,3	8,6	19	2	8	24	54	13	40	21	1,3	10	96	2	4,6	3	2	225	3	21	3,3	72	214
WB013	29,1449	-26,4164	65,80	1,12	9,32	8,67	0,12	3,76	4,81	1,11	1,17	0,12	0,04	2,83	98,86	4	384	3	3,8	45	24	228	5	37	14	1,3	8	13	2	9,1	23	49	11	49	17	1	10	108	2	6,1	3	2	175	3	19	3,9	56	224
WB014	29,1646	-26,4225	53,30	0,87	11,95	11,13	0,20	7,54	10,67	1,76	0,50	0,12	0,05	1,18	99,28	4	303	3	2	25	39	275	5	46	15	1	3	10	2	3,1	12	67	3,2	12	29	1,1	10	161	2	3	3	2	229	3	17	4,8	72	76
WB018	29,1965	-26,3755	73,58	0,39	5,78	4,88	0,22	3,27	6,78	0,67	0,65	0,05	0,04	2,74	99,05	4	297	3	2	29	32	193	5	18	6	1	5	13	2	4	14	40	6	19	15	1	10	87	2	4	3	2	122	3	16	3	25	97
WB019	29,2122	-26,3444	62,12	0,79	10,53	8,82	0,19	5,13	7,08	1,06	0,57	0,08	0,05	2,47	98,88	4	408	3	3,5	36	38	295	5	51	12	1	3,6	10	2	4,6	15	72	6,8	19	25	1	10	114	2	3,9	3	2	192	3	14	3	48	124
WB020	29,3524	-26,4425	68,26	0,76	9,28	7,28	0,14	4,29	5,64	1,10	0,97	0,10	0,04	1,95	99,82	4	417	3	2	30	29	245	5	40	12	1	4,1	12	2	5	14	63	9,2	33	16	1	10	109	2	3,2	3	2	159	3	18	3	50	153
WB021	29,3193	-26,4381	73,04	0,75	7,00	5,99	0,43	2,18	4,84	0,81	0,71	0,08	0,03	3,80	99,66	6	776	3	4	73	68	172	5	39	9	1	6	27	2	6	30	68	10	25	14	1	10	107	3	4	3	2	200	3	24	5	38	173
WB022	29,3034	-26,4389	54,22	1,47	12,34	12,65	0,19	5,30	7,93	2,13	0,89	0,20	0,04	2,15	99,51	4	541	3	2,8	37	40	178	5	81	22	1,1	5,6	12	2	5	22	67	5,9	24	22	2	10	206	3,9	3,3	3	2	281	3	25	3,4	87	159
WB023	29,3018	-26,4053	69,26	1,09	9,63	6,82	0,18	2,74	4,29	1,39	1,45	0,10	0,03	1,55	98,54	4	691	3	2	45	38	179	5	39	15	1	9	19	2	6,9	20	51	12	46	15	1	10	149	2	5,2	3	2	160	3	19	3,3	49	276
WB024	29,2986	-26,3509	88,76	0,26	3,61	2,19	0,15	0,12	0,60	0,29	1,47	0,04	0,01	1,35	98,84	4	466	3	2	41	19	92	5	9,9	3,7	1	6,2	13	2	4,5	15	18	15	44	3,8	1	10	51	2	5,3	3	2	65	3	11	3,5	12	192
WB025	29,3527	-26,4014	90,69	0,18	2,96	1,70	0,09	0,09	0,42	0,21	1,29	0,04	0,00	0,96	98,64	4	441	3	2	41	15	50	5	9,4	3,2	1	6,1	13	2	4,8	15	14	13	42	3	1,2	10	49	2	4,9	3	2	44	3	9,1	3	6,8	174
WB039	29,7809	-26,3283	89,07	0,20	3,55	1,92	0,17	0,31	1,30	0,37	1,10	0,03	0,01	1,65	99,67	4	450	3	2	41	29	105	5	13	3,3	1	3,5	13	2	4,7	15	25	12	36	4,3	1	10	57	2	4,1	3	2	81	3	10	3	10	104
WB040	29,7825	-26,2713	92,26	0,14	1,94	1,78	0,09	0,03	0,44	0,08	0,64	0,03	0,00	1,22	98,66	4	312	3	2	42	15	60	5	9,8	2,3	1	7,1	12	2	4,2	16	17	9,9	22	3	1	10	28	2	4,6	3	2	63	3	9,1	3	5,4	204
WB041	29,7767	-26,2330	90,51	0,13	3,06	1,79	0,15	0,15	0,50	0,23	1,43	0,03	0,00	0,83	98,82	4	558	3	2	40	26	63	5	9	3	1	4	12	2	4	13	18	14	44	3	1	10	49	2	3	3	2	56	3	7	3	5	119
WB042	29,8390	-26,2945	84,15	0,61	5,83	2,47	0,02	0,08	0,16	0,14	1,69	0,06	0,01	4,46	99,67	4	449	3	5,2	50	7,4	112	5	11	7,4	1	15	19	2	9,4	20	16	16	70	7	1	10	51	2	10	3	2,7	65	3	14	3	16	467
WB048	29,4624	-26,2857	93,16	0,12	2,39	1,15	0,02	0,06	0,22	0,13	0,80	0,03	0,00	0,73	98,84	4	306	3	2	19	10	118	5	6,9	2,3	1	4	10	2	4,4	10	14	8,5	27	3	1,5	10	31	2	3,4	3	2	41	3	5,4	3	8,1	99
WB049	29,4950	-26,2692	90,33	0,19	3,79	1,69	0,10	0,08	0,34	0,21	1,63	0,03	0,00	1,07	99,46	4	506	3	2	45	18	71	5	8,7	3,6	1	6,1	13	2	4,7	15	16	16	53	3	1,2	10	55	2,7	4,4	3	2	47	3	9,1	3	7,9	170
WB050	29,5087	-26,2778	88,38	0,24	4,31	1,43	0,08	0,17	1,14	0,24	1,94	0,03	0,00	1,96	99,91	4	589	3	2	35	10	53	5	9	4,5	1	9,6	15	2	5,2	15	13	16	63	3,6	1	10	77	2	5,4	3	2	42	3	10	3	9	290
WB052	29,4503	-26,3162	65,33	0,34	4,50	3,26	0,41	1,57	12,69	0,32	0,56	0,06	0,02	10,15	99,19	4	594	3	3,1	76	57	137	5	26	5,6	1	4,8	41	2	4,6	35	61	11	22	29	1	10	120	2,2	3,1	3	2	128	3	34	3	22	134
WB061	29,1237	-26,2188	79,79	0,49	7,31	4,22	0,25	0,42	1,40	0,24	1,56	0,05	0,01	3,91	99,65	4	662	3	2	140	46	107	5,5	27	9,2	1	7,5	43	2	7,9	42	38	31	60	11	1,4	10	75	2	5,9	3	2	128	3	23	3	42	207
WB062	29,1205	-26,1845	92,15	0,16	3,13	1,19	0,01	0,01	0,08	0,09	1,46	0,03	0,00	0,81	99,13	4	376	3	2	23	5,1	59	5	4,1	2,8	1	4	10	2	5	10	8,9	12	43	3	1	10	45	2	3	3	2	26	3	5,1	3	8,2	125
WB063	29,1029	-26,2227	84,49	0,47	5,73	3,02	0,16	0,25	0,53	0,27	1,38	0,04	0,01	2,47	98,81	4	604	3	2	87	32	90	5	18	7,1	1	12	30	2	7,7	27	28	20	50	8,4	1,6	10	64	2	5,4	3	2	94	3	16	3,3	25	328
WB083	29,4674	-26,1526	88,64	0,26	4,26	1,69	0,04	0,20	0,48	0,09	0,89	0,04	0,02	3,24	99,85	4	326	3	2,4	32	7,7	111	5	8,5	5,7	1	8,7	13	2	6,4	16	15	11	40	5,8	1,2	10	46	2	5,6	3	2	40	3	8,7	3	16	188
WB086	29,5499	-26,1508	72,22	0,29	4,17	3,51	0,03	0,07	0,26	0,06	0,66	0,16	0,01	18,17	99,61	4	219	3	22	28	6,9	82	5	13	5,2	1	6,3	11	2	7,1	13	14	9,1	34	5,9	1	10	31	2	3,5	3	2	48	3	8,5	3	31	178
WB087	29,6306	-26,2220	91,13	0,17	3,71	1,17	0,02	0,01	0,25	0,29	1,76	0,03	0,00	0,81	99,35	4	449	3	2	16	6,6	69	5	5,2	3,8	1	7,1	10	2	4,5	10	9,5	14	54	3,3	1	10	59	2	4,2	3	2	26	3	6,4	3	6,3	179
WB090	29,7548	-26,2025	76,59	0,52	8,70	5,34	0,15	0,27	0,57	0,22	2,34	0,09	0,02	4,48	99,28	4	840	3	2,4	105	35	143	7,7	35	11	1	10	25	2	10	23	29	34	86	9,1	1	10	83	2	7,4	3	2,2	112	3	16	3	31	268
WB104	29,2370	-25,8704	29,69	0,76	14,244	6,67	0,13	0,70	2,58	0,15	0,79	0,16	0,04	43,57	99,49	14	484	3	3,4	215	47	203	11	37	19	1,3	5,2	60	3,9	8,9	63	75	32	38	15	2,6	14	458	2,5	18	3	5,1	100	3,2	43	3,6	204	153
WB108	29,6140	-26,1011	90,46	0,29	3,66	1,78	0,03	0,10	0,24	0,10	0,68	0,03	0,01	2,40	99,77	4	271	3	2	33	7,4	62	5	8,7	4,7	1,1	12	14	2	7,1	17	14	8,6	29	6,1	1	10	29	2	4,9	3	2	49	3	9,9	3	12	364
WB109	29,5075	-26,1349	84,57	0,32	4,39	4,33	0,04	0,01	0,10	0,03	1,00	0,11	0,03	4,71	99,65	4	343	3	2	59	14	201	5	16	6,6	1	13	14	2	8,5	15	14	22	41	4,6	1,1	10	36	2	7	3	2	74	3	14	3	31	415
WB116	29,3406	-25,9917	53,33	0,97	18,77	9,05	0,17	0,41	0,57	0,09	1,46	0,24	0,05	14,53	99,65	11	457	3	9,7	131	33	255	9,3	45	26	2	12	49	2,2	19	41	52	44	96	17	2,2	10	91	2	15	3	3,7	141	3,4	32	3	109	317
WB117	29,5097	-25,9910	41,22	1,27	23,93	15,52	0,09	0,32	0,20	0,03	0,98	0,24	0,05	14,77	98,61	4	293	3	14	150	32	288	9,9	58	34	3	7,7	38	2,7	21	38	85	39	100	24	1,3	10	32	2,5	19	3	4,5	279	3	31	3,2	100	238
WB118	29,4824	-26,0351	79,50	0,63	7,10	4,49	0,11	0,56	0,73	0,22	0,86	0,06	0,04	4,91	99,21	4	414	3	6,9	70	21	238	5	24	8,8	1	13	27	2	11	25	32	16	42	12	1,5	10	42	2,7	8,1	3	2,5	113	3	19	3	35	350
WB159	29,5442	-26,1373	76,90	0,61	10,85	4,40	0,06	0,31	0,78	0,09	1,19	0,03	0,01	4,34	99,57	4	415	3	2	62	13	102	5	11	13	1,6	11	31	2	12	38	31	16	78	14	1,4	10	43	3,7	11	3	2	91	3	24	3	26	300
WB160	29,5303	-26,1525	60,72	0,92	14,25	4,76	0,04	0,49	0,50	0,12	1,48	0,15	0,02	16,15	99,60	4,9	429	3	18	72	14	121	6,1	29	18	1,3	8,5	36	2	17	38	43	21	106	16	1,5	10	60	2,5	14	3	3,4	97	3	28	4,8	59	261
WB162	29,6545	-26,1308	77,19	0,39	6,35	10,20	0,06	0,07	0,10	0,08	1,33	0,09	0,04	3,68	99,58	7,5	469	3	2	102	20	329	5	33	9,2	1	10	19	2	9,3	22	25	31	57	9,9	1,7	10	44	2,6	10	3	2,8	191	3,6	13	3	18	322
WB006	29,0069	-26,2074	49,41	0,87	13,61	8,21	0,14	2,84	4,54	0,82	0,85	0,25	0,04	18,02	99,59	4	392	3	15	50	31	221	5	67	18	1,6	6,5	21	2	9,2	21	56	16	45	19	1	10	163	2,7	5,7	3	2	164	3	20	3	91	152
WB031	29,5018	-26,3392	68,41	0,59	9,00	7,65	0,25	2,81	5,09	0,75	1,07	0,08	0,05	3,80	99,55	4	768	3	2	152	50	248	5,3	44	12	1	5	36	2	6,6	32	66	23	48	15	1,2	10	107	2	5,3	3	2	164	3	20	3	42	171
WB032	29,5388	-26,3919	90,49	0,21	3,54	1,97	0,09	0,11	0,30	0,17	1,16	0,03	0,01	1,42	99,49	4	501	3	2	61	18	122	5	13	4,7	1	4,5	18	2	4,6	18	18	16	41	5,5	1,1	10	41	2	3	3	2	82	3	8,1	3	13	132

SAMPLE	LONGITUDE	LATITUDE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr
WB034	29,6187	-26,3999	86,31	0,33	4,17	3,06	0,29	0,36	1,35	0,34	1,32	0,05	0,01	1,87	99,46	4	738	3	2	59	35	125	5	15	5,5	1	5,1	22	2	5	20	25	16	44	4,4	1,1	10	68	2	3	3	2	104	3	11	3	16	165
WB036	29,6519	-26,4301	72,40	0,82	8,74	5,82	0,14	1,26	2,62	0,60	0,89	0,08	0,02	5,91	99,31	4	459	3	7,1	76	24	136	5	35	12	1	6,8	28	2	8,6	34	31	13	44	17	1	10	100	2,8	6,4	3	2	137	3	22	3,4	48	226
WB037	29,6674	-26,3349	83,65	0,34	5,51	3,93	0,26	0,45	1,18	0,21	0,95	0,03	0,02	3,07	99,60	4	796	3	2	119	48	215	5	29	7,2	1	5,2	35	2	6,3	36	55	21	42	10	1	10	46	2	3,5	3	2	164	3	17	3	25	164
WB038	29,7068	-26,3560	74,45	0,68	8,94	6,43	0,49	1,52	2,08	0,49	0,54	0,04	0,03	4,15	99,85	4	815	3	2	105	80	225	5	56	11	1	4,4	34	2	7,3	36	81	11	22	25	1	10	71	2,7	3,9	3	2	288	3	26	3	44	176
WB043	29,6844	-26,2530	89,50	0,10	2,99	1,62	0,09	0,54	1,47	0,32	1,23	0,04	0,01	0,85	98,76	4	356	3	2	18	14	387	5	6,7	3,1	1,1	3	10	2	3,5	10	18	9,8	34	4,9	1	10	46	2	3	3	2	72	3	6,2	3	5,6	69
WB044	29,7081	-26,2726	84,70	0,31	5,91	2,32	0,03	0,07	0,16	0,12	1,19	0,07	0,01	4,34	99,23	4	374	3	4	36	7,5	117	5	12	8,6	1	5,4	16	2	7,2	20	18	13	55	7,6	1	10	36	3,3	5,9	3	2	64	3	11	3	23	186
WB047	29,6254	-26,2764	93,62	0,10	2,22	1,53	0,10	0,01	0,25	0,14	0,95	0,03	0,00	0,69	99,65	4	421	3	2	36	16	146	5	7,9	2,5	1	3,8	10	2	4	13	14	11	29	3	1	10	32	2	3	3	2	66	3	5,3	3	4,8	100
WB064	29,0494	-26,1364	58,12	0,44	7,58	13,79	0,39	0,74	2,44	0,08	0,71	0,26	0,11	14,95	99,61	6,5	509	3	9,1	92	44	495	5	46	12	1	4,6	21	2,2	7,6	18	49	41	35	13	1,8	10	105	2,8	6,5	3	2,3	302	3	13	3	46	178
WB066	29,0301	-26,0890	62,48	0,79	13,28	7,04	0,08	1,65	1,77	0,36	1,26	0,11	0,07	10,42	99,32	4	424	3	2,5	84	17	290	7,6	29	18	1	7,6	36	2	14	33	39	20	75	17	1	10	89	2,9	11	3	2,1	119	3	22	3	98	198
WB069	29,0881	-26,1322	82,07	0,24	4,70	6,89	0,21	0,99	1,01	0,10	0,28	0,06	0,51	2,41	99,47	5	226	3	2	63	13	1 662	5,3	15	6,4	1	6,1	17	2	7	11	16	16	13	7,5	1,4	10	27	2	5,9	3	2	136	3	7,9	3,8	17	163
WB071	29,1502	-26,0797	78,67	0,55	6,63	2,95	0,06	0,18	0,31	0,12	1,16	0,10	0,02	8,80	99,56	4	379	3	11	51	11	114	5	13	9,5	1	15	21	2	11	22	19	16	56	10	1,4	10	60	2	9	3	2	76	3	17	4,4	30	438
WB079	29,3706	-26,1913	52,11	1,03	17,41	10,68	0,16	0,55	0,41	0,19	1,66	0,30	0,02	15,07	99,58	5,1	515	3	10	104	25	130	9,2	25	24	1,3	5,9	53	2	21	53	41	27	112	15	1,1	10	78	2	16	3	3,6	117	3	38	3,8	87	234
WB081	29,4249	-26,1482	76,63	0,48	9,06	3,92	0,06	0,23	0,34	0,25	1,75	0,10	0,02	6,69	99,54	4	486	3	6,7	49	15	162	5	17	13	1	11	19	2	10	22	31	19	82	11	1,6	10	63	2	8,7	3	2	90	3	15	3	41	343
WB082	29,3569	-26,1692	82,69	0,41	6,82	2,74	0,08	0,27	0,42	0,23	1,70	0,06	0,01	3,89	99,31	4	541	3	2	59	16	148	5	16	9,2	1	8,6	25	2	8,3	23	24	18	63	9,5	1,6	10	90	2	8,2	3	2	68	3	15	3,2	26	238
WB084	29,5094	-26,2042	86,80	0,29	4,17	4,88	0,01	0,01	0,05	0,01	0,53	0,06	0,04	2,88	99,73	4	198	3	2	50	4,6	148	5	9,7	7,8	1	9,7	30	2	10	32	12	13	36	7,7	1	10	11	2	7	3	2	85	3	18	3	22	268
WB085	29,5260	-26,2328	90,68	0,23	3,34	1,43	0,02	0,25	0,50	0,20	1,28	0,03	0,01	1,32	99,30	4	372	3	2	27	6,8	273	5	7	3,6	1	9,6	10	2	5,1	12	12	11	40	4	1	10	48	2	4	3	2	47	3	7	3	9,1	268
WB088	29,5806	-26,2139	82,68	0,52	7,16	2,97	0,07	0,35	0,47	0,31	1,65	0,05	0,01	3,32	99,56	4	479	3	2,2	43	18	199	5	19	9,3	1	9,4	19	2	8,9	21	31	16	64	13	1,2	10	64	2	6,4	3	2	91	3	14	3	29	271
WB089	29,6871	-26,2225	78,80	0,29	5,56	9,86	0,15	0,02	0,08	0,09	1,60	0,11	0,02	3,02	99,60	4	701	3	2	166	53	303	5	41	7,8	1	9,6	12	3,3	7	16	29	40	59	7,6	1,1	10	47	2	8	3	2,5	238	3	9,7	3	14	312
WB095	29,7230	-26,0510	62,55	0,76	12,73	12,29	0,12	0,46	0,27	0,21	1,43	0,18	0,68	7,34	99,01	8	428	3	3,8	161	40	852	7,8	46	19	1	8,2	30	2,4	14	29	47	50	72	17	1,3	10	44	2	13	3	2,7	245	3	20	3	49	324
WB096	29,8217	-26,0581	57,60	0,57	8,94	6,79	0,28	0,47	0,92	0,06	0,64	0,24	0,02	22,09	98,62	4	418	3	22	54	37	125	5	26	11	1	6,1	23	2	9,7	25	37	16	50	13	1,4	10	49	2	6,6	3	2	110	3	17	4,4	55	185
WB101	29,7292	-25,9994	90,11	0,33	3,23	3,15	0,01	0,01	0,05	0,04	0,73	0,05	0,02	1,93	99,66	4	272	3	2	55	8	239	5	11	5,1	1	14	12	2	7,4	15	13	15	28	5,6	1	10	25	2	6,8	3	2	89	3	9,5	3	13	351
WB107	29,6504	-25,9321	85,35	0,47	5,36	2,31	0,06	0,10	0,38	0,14	1,14	0,07	0,03	4,18	99,57	4	424	3	2	48	12	163	5	15	7,4	1	13	22	2	9,1	21	19	14	48	9,8	1	10	52	2	6,7	3	2	67	3	14	3	24	310
WB119	29,8557	-25,9617	58,79	0,69	9,76	9,41	0,36	4,50	10,06	1,22	0,56	0,11	0,04	3,14	98,60	4	713	3	2	74	55	269	5	55	11	1	4,1	21	2	5	26	56	9,8	17	28	2,1	10	131	2	3,5	3	2	245	3	23	3	50	127
WB122	29,8077	-25,8853	75,59	0,67	9,72	4,52	0,03	0,04	0,12	0,00	0,51	0,11	0,02	8,27	99,59	4	268	3	8,1	67	13	177	6,5	18	13	1	9	30	2	13	30	33	15	50	15	1	10	29	2	8,3	3	2	89	3	18	3	33	264
WB123	29,6861	-25,9024	55,49	1,41	14,10	8,95	0,11	0,47	0,72	0,13	0,65	0,24	0,02	16,34	98,61	4	352	3	21	77	33	149	5,6	82	20	1	8,6	33	2	14	39	71	19	63	22	2,2	10	89	2,9	8,6	3	2	196	3	31	3	99	311
WB128	29,7303	-25,8450	86,31	0,65	4,45	3,59	0,07	0,12	0,22	0,25	0,97	0,05	0,01	2,48	99,17	4	305	3	2	51	13	92	5	14	6,6	1	8,8	21	2	9,9	21	15	11	43	6,5	1,3	10	26	2	6,8	3	2	63	3	16	3	22	286
WB129	29,6823	-25,7894	56,38	1,25	11,11	19,39	0,27	0,56	0,43	0,92	2,57	0,28	0,01	5,87	99,04	4	1 128	3	2	166	38	70	5,5	55	22	1	6,6	103	2	13	92	21	29	121	31	1	17	76	2	10	3	3,3	94	3	63	7,7	140	270
WB155	29,6165	-25,7139	80,68	0,69	5,68	5,84	0,06	0,04	0,14	0,01	0,86	0,09	0,02	5,39	99,50	4	352	3	2,9	61	11	130	5	16	9,2	1	15	17	2	14	17	15	29	43	6	1,3	10	15	2	10	3	2	64	3	26	3	44	403
WB156	29,7306	-25,7484	73,99	0,71	6,60	12,42	0,10	0,06	0,08	0,01	0,63	0,11	0,04	4,58	99,32	4	348	3	3	106	18	279	5	39	14	1	10	33	2	12	28	25	32	55	15	1,5	10	14	2,3	9,7	3	2,5	131	3,2	20	3	54	310
WB072	29,1688	-26,1142	65,31	0,84	9,22	12,38	0,06	0,18	0,19	0,15	0,91	0,17	0,04	9,26	98,71	9,8	370	3	5,6	121	18	250	5	34	15	1	9,7	45	2,1	13	39	32	30	63	16	1,5	11	31	3,3	11	3	3,4	179	3,2	28	3,3	53	306

APPENDIX J: ROC STREAM SEDIMENT GEOCHEMICAL MAJOR (wt.%) AND TRACES (PPM) XRF DATA

SAMPLE	LONGITUDE	LATITUDE	SiO2	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5	Cr2O3	LOI	Total	As	Ba	Bi	Br	Ce	Co	Cr	Cs	Cu	Ga	Ge	Hf	La	Mo	Nb	Nd	Ni	Pb	Rb	Sc	Se	Sm	Sr	Ta	Th	Tl	U	V	W	Y	Yb	Zn	Zr
B1B10	29,51377	-25,75043	78,56	0,78	6,2	8,73	0,05	0,26	0,23	0,1	0,7	0,06	0,02	4,3	100	4	317	3	2,2	106	33	171	5	34	9,2	1	7,3	29	2	9,1	21	26	32	44	9,2	1	10	21	2	6,8	3	2,3	144	3	18	3	30	324
B1B14	29,56422	-25,73152	57,62	0,71	13,46	4,03	0,03	0,17	0,08	0,06	1,44	0,15	0,02	21,85	99,61	14	413	3	12	115	13	143	5	33	20	1	9	59	2	17	47	34	39	96	11	1	10	17	2	14	3	4,8	82	3,8	44	4,2	87	188
B1B16	29,60904	-25,65544	59,56	0,83	13,12	8,46	0,07	0,37	0,27	0,09	1,24	0,2	0,02	15,28	99,51	8,1	388	3	6,4	113	31	148	5	30	18	1	10	57	2	16	49	39	31	110	13	1,1	11	24	2	15	3	5,1	102	3	38	5,1	64	281
B1B18	29,62387	-25,77399	81,99	0,73	5,09	2,52	0,03	0,29	0,21	0,37	1,6	0,08	0,02	7,47	100,39	4	545	3	15	49	9,7	123	5	9,7	6,8	1	6,4	28	2	8	21	14	15	62	7	1	10	39	2	4,8	3	2	44	3	24	3	32	325
B1B2	29,39057	-25,751	95,42	0,18	1,46	1,31	0,02	0,03	0,04	-0,02	0,18	0,03	0	0,92	99,56	4	58	3	2	15	4,9	74	5	9,6	2,7	1	5,5	10	2	1,9	10	8	6,5	8,7	3	1	10	4,3	2	3	3	2	27	3	5,1	3	9,4	293
B1B21	29,35282	-25,4849	74,98	0,63	8,06	3,66	0,08	0,34	0,97	0,1	1,32	0,14	0,02	9,17	99,48	384	3,000	14	64	14	133	5	19	12	1	10	37	2	9,3	28	25	21	65	12	1	10	88	2	6,3	3	2,7	70	3	22	3	44	392	382
B1B22	29,3645	-25,5045	87,2	0,29	3,67	2,88	0,03	0,11	2,15	0,23	1,42	0,04	0,01	2,15	100,17	430	3	2	40	9,4	182	5	7	5,3	1	11	18	2	7	18	9,3	14	54	3	1	10	57	2	6,7	3	2,1	50	3	19	3,1	17	398	392
B1B25	29,32484	-25,54459	39,41	0,51	8,79	4,14	0,01	0,11	0,08	0,01	0,34	0,12	0,03	46,22	99,77	250	3	2,3	53	7,6	167	5	17	13	1,1	5,7	31	2,2	9	20	18	22	21	10	1	10	107	2	7,4	3	2,7	75	3	19	3	19	152	313
B1B26	29,36421	-25,54569	82,59	0,55	7,48	3,37	0,01	0,14	0,12	0,01	0,69	0,07	0,01	5,37	100,42	295	3	2	69	13	115	5	13	11	1	8,2	38	2	11	29	27	19	50	11	1	10	28	2	6,6	3	2,9	79	3	27	3,3	47	348	421
B1B27	29,37324	-25,54531	92,21	0,25	2,93	1,13	0,02	0,07	0,11	0,02	0,95	0,03	0,01	2,6	100,33	437	3	2	42	6,1	95	5	5,2	5,4	1	11	21	2	7,9	18	6,6	12	49	3,8	1	10	15	2	6,9	3	2	42	3	29	3,1	20	350	345
B1B28	29,37279	-25,55255	91,55	0,23	3,68	1,78	0,04	0,03	0,04	0,01	1,22	0,04	0,01	1,68	100,3	281	3	2	23	6,2	67	5	4,6	3,8	1	5,7	13	2	3,9	10	7,7	13	38	4,3	1	10	34	2	3	3	2	23	3	9,2	3	11	230	256
B1B29	29,3634	-25,56012	49,07	0,68	11,11	6,03	0,18	0,74	6,37	0,03	0,85	0,21	0,02	23,89	99,18	319	3	19	99	53	132	5	25	13	1	6,6	59	2,5	10	42	113	21	63	10	1	10	194	2	9,6	3	4,2	72	3	39	3	188	251	332
B1B3	29,41017	-25,73463	82,86	0,8	9,2	1,51	0,02	0,2	0,07	0,02	0,57	0,03	0,02	5,24	100,53	4	259	3	2	55	8,5	137	5	23	14	1	7,8	30	2	10	21	36	17	41	13	1	10	11	2	6,3	3	2,4	100	3	19	3	23	296
B1B31	29,38564	-25,55426	69,68	0,82	11,44	4,78	0,12	0,46	0,47	0,09	1,23	0,16	0,02	11	100,25	386	3	8,1	78	23	148	5	27	15	1	10	42	2	11	34	37	60	74	17	1	10	78	2	9,3	3	4	103	3	26	3	56	458	439
B1B33	29,39173	-25,56597	85,71	0,48	5,93	1,57	0,01	0,16	0,29	0,14	1,35	0,04	0,01	4,66	100,35	371	3	2	56	8	110	5	11	8,9	1	11	40	2	9,2	30	16	17	60	8,8	1	10	50	2	5,6	3	2,7	51	3	22	3	27	406	392
B1B34	29,3457	-25,57314	63,59	0,6	7,13	3,79	0,07	0,34	1,53	0,01	0,56	0,21	0,03	22,54	100,39	380	3	24	73	31	185	5	17	9,5	1	9,6	37	2	9,8	28	35	20	44	10	1	10	118	2	6,7	3	2,8	67	3	23	3	99	384	289
B1B35	29,33539	-25,4923	72,9	0,28	7,91	12,06	0,04	0,1	0,02	0,1	1,92	0,1	0,03	4,06	99,5	360	3	2	85	13	211	5	25	16	1	11	27	2,5	15	23	11	35	98	4,5	1	10	11	2	15	3	4,8	116	3,4	45	4,4	58	396	265
B1B36	29,34446	-25,49326	77,47	0,36	7,19	4,81	0,12	0,11	0,15	0,07	1,87	0,25	0,02	7,78	100,2	622	3	8,6	67	12	120	5	11	12	1	11	34	2	16	36	15	20	96	4,2	1	10	20	2	12	3	3,8	57	3	45	5,8	59	409	373
B1B37	29,32487	-25,52224	91,9	0,43	3,4	1,3	0,01	0,12	0,02	0,01	0,76	0,05	0,01	1,98	99,98	208	3	2	29	4,5	69	5	6	5,4	1	11	10	2	5,8	11	8,8	13	34	3,7	1	10	23	2	3	3	2	36	3	10	3	8,3	439	106
B1B4	29,44257	-25,71569	85,69	0,61	4,03	2,83	0,04	0,12	0,25	0,07	0,52	0,17	0,02	5,04	99,4	4	208	3	2	40	9,8	156	5	28	5,6	1	7,7	18	2	5,3	15	19	16	24	8,4	1	10	21	2	3	3	2	66	3	12	3	212	162
B1B6	29,45852	-25,74879	52,29	0,63	8,41	9,38	0,37	0,53	1,44	0,22	0,96	0,37	0,1	24,98	99,7	4	408	3	31	84	32	605	5	49	12	1	7	25	3,1	7	19	50	42	45	10	1	10	55	2	4,7	3	2,9	154	3	17	3	476	294
B1B7	29,46208	-25,7547	68,28	0,87	6,67	5,67	0,16	0,44	1,18	0,26	0,96	0,18	0,13	14,31	99,12	4	330	3	12	68	26	729	5	42	10	1	8	30	4,6	9,1	22	37	48	46	8,9	1	10	63	2	7,8	3	2,7	101	3	19	3	558	412
B1B9	29,45838	-25,78741	66,12	0,53	4,72	3,96	0,03	0,29	0,57	0,09	0,44	0,17	0,17	22,69	99,79	4	211	3	7,3	50	11	950	5	58	7,9	1	7,4	22	2	7	18	32	48	26	5,9	1	10	33	2	3	3	2	78	3	15	3	187	248
B1C13	29,16792	-25,68008	79,85	0,41	4,08	7,53	0,04	0,1	0,06	0,01	0,4	0,07	0,01	7,24	99,81	35	610	3	2	68	15	61	7,1	20	19	1	6	30	2	15	23	22	96	147	10	1	10	164	3,5	14	3	2,9	87	6,2	24	3	724	360
B1C14	29,21636	-25,68929	50,58	6,52	4,41	33,6	0,09	0,11	0,03	0,01	0,45	0,14	0,11	2,92	98,97	14	156	3	2	80	28	812	5	72	14	1	67	29	3,9	56	27	41	19	23	19	1,9	10	4,5	3,4	42	3	14	790	4,3	38	3	38	203
B1C23	29,31096	-25,64246	96,09	0,11	1,1	0,59	0,01	0,01	0,03	0,01	0,13	0,02	0	0,86	98,95	4	40	3	2	16	2,1	25	5	4,9	1,6	1	4,8	10	2	2,4	10	4,5	2,9	6,5	3	1	10	7,4	2	3	3	2	14	3	5,2	3	3	301
B1C5	29,25157	-25,60711	96,42	0,15	1,48	0,97	0,01	0,01	0,03	0,01	0,24	0,02	0	1,16	100,5	4	63	3	2	18	3,3	117	5	4,5	1,7	1	4,7	10	2	2	11	5	3,9	10	3	1	10	11	2	3	3	2	28	3	5,6	3	3	551
B1S01	29,30201	-25,89141	76,99	0,26	11,12	4,91	0,05	0,13	0,17	1,45	4,2	0,03	0,01	1,75	101,08	4	805	3	2	139	8,6	76	5	24	20	1,5	14	61	2	23	50	7,6	32	181	3	1	14	31	2	23	5,8	24	3,3	69	6,4	80	491	491
B1S02	29,35777	-25,82925	89,58	0,45	3,78	2,49	0,1	0,22	0,19	0,16	0,39	0,03	0,01	3,42	100,83	4	229	3	2	46	21	109	5	14	5,3	1,3	6,8	27	2	8,4	20	28	11	32	8,6	1	10	20	2	5,2	2	60	3	18	3	40	283	283
B1S03	29,49097	-25,81883	84,27	0,56	5,05	4,41	0,19	0,45	0,43	0,05	0,74	0,05	0,34	3,94	100,48	8,4	349	3	2,4	72	19	1257	5,4	17	8,1	1,1	10	38	12	15	26	28	18	54	6,1	1	10	21	2	8,9	2,6	92	3	30	3,8	49	404	404
B1S04	29,52902	-25,77197	75,64	0,25	8,98	8,85	0,2	0,12	0,16	0,98	3,15	0,08	0,01	2,48	100,89	18	867	3	2	86	15	112	5	13	15	1	10	40	2	18	34	11	26	114	3,3	1	10	28	2	20	4,8	75	4,9	56	3	79	408	408
B1S05	29,43938	-25,74118	91,67	0,56	2,76	2,38	0,03	0,07	0,13	0,28	0,92	0,05	0,01	1,89	100,74	4	294	3	2	30	7,6	95	5	10	3,8	1,1	5,8	16	2	7,7	10	8,9	10	34	3,5	1	10	26	2	7,1	2	52	3	16	3	39	365	365
B1S06	29,48777	-25,68375	98,08	0,17	0,81	0,92	0,02	0,04	0,05	0,01	0,08	0,01	0	0,5	100,7	4	61	3	2	10	4,2	49	5	2,6	1,3	1,2	3	10	2	3	10	6,1	3,7	5,2	3	1	10	3,7	2	3	2	23	3	5,5	3	3	105	105
B1S07	29,19238	-25,65672	94,85	0,52	1,62	1,55	0,02	0,04	0,06	0,01	0,15	0,01	0	1,6	100,45	4	101	3	2	27	7,7	86	5	10	3,5	1	5,1	12	2	5,3	16	11	4,1	10	5,8	1	10	7,2	2	3,1	2	81	3	11	3	15	187	187
B1S08	29,21625	-25,62293	95,73	0,14	1,36	1,41	0,02	0,06	0,08	0,01	0,29	0,04	0	0,97	100,12	4	127	3	2	15	5,2	123	5	5	2,6	1	3,4	12	2	4	10	7,7	5,4	14	3	1	10	8,4	2	3	2	33	3	6,5	3	16	118	118

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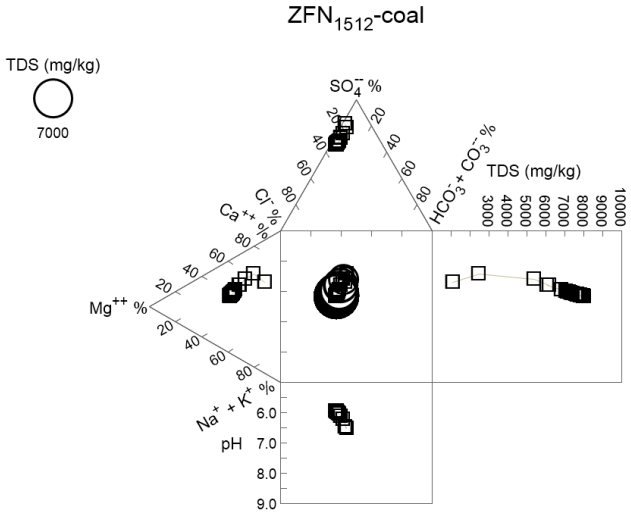
APPENDIX K: CUMMULATIVE INITIAL AND FINAL (mg/L)

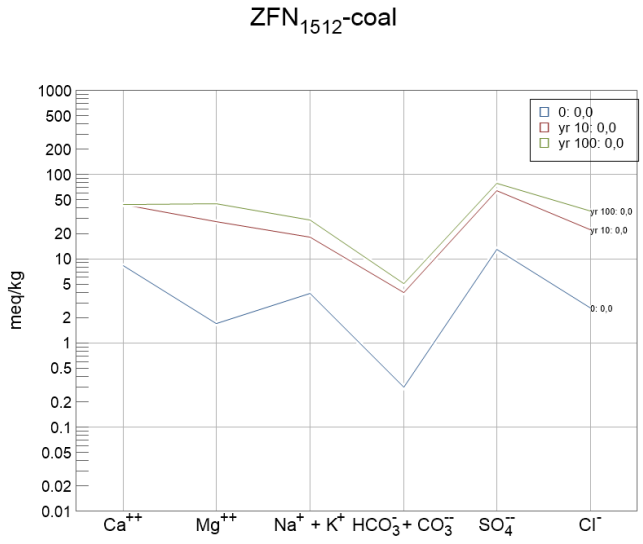
Humidity Cells		BH1	BH10	BH11	BH12	BH13	BH14	BH15	BH16	BH17	BH18	BH19	BH2	BH20	BH21	BH22	BH23	BH24	BH25	BH26	BH27	BH3	BH4	BH5	BH6	BH7	BH8	BH9
EC	***Initial***	11,5	104,0	243,0	8,6	100,0	11,6	6,8	19,9	47,7	12,8	151,0	15,7	73,4	24,6	16,9	10,4	42,8	18,7	16,9	53,4	15,8	41,7	28,8	87,0	48,8	25,8	10,4
	Final	185,4	1236,6	3642,9	234,3	1716,0	289,3	267,7	524,5	723,1	376,3	1323,6	360,9	389,8	886,4	364,8	249,7	572,4	323,3	337,0	832,7	307,1	560,6	540,4	713,2	683,5	413,5	227,5
Ca	***Initial***	7,0	167,1	422,7	0,6	75,6	3,8	2,2	0,8	5,8	0,4	200,0	4,9	5,3	1,3	0,6	0,6	2,5	1,2	1,4	4,8	3,4	3,5	2,1	32,4	16,0	3,6	2,3
	Final	23,3	1863,0	6949,7	60,1	2258,0	61,4	64,5	70,4	305,3	14,4	1700,2	91,4	32,3	416,2	17,1	18,2	225,3	51,4	45,6	476,0	57,2	65,6	28,7	318,6	329,1	25,7	17,5
Mg	***Initial***	2,9	17,5	47,9	0,2	16,7	1,4	0,6	0,2	3,3	0,2	39,0	1,5	1,7	0,5	0,2	0,2	1,0	0,3	0,5	1,5	1,1	1,2	0,8	15,7	4,7	1,1	0,7
	Final	10,6	339,6	1611,2	16,6	701,4	24,9	14,4	35,4	241,3	6,9	450,2	35,2	19,9	177,8	12,9	11,1	190,2	35,0	24,6	295,0	21,2	22,3	9,5	203,6	131,1	12,8	8,7
Na	***Initial***	21,7	70,6	125,0	19,4	138,5	14,4	10,9	36,7	90,8	30,2	71,8	31,4	166,9	50,3	36,9	24,7	87,3	37,4	36,2	118,1	31,5	88,8	67,1	141,9	195,7	53,0	23,7
	Final	284,6	508,6	846,5	427,6	855,8	394,6	365,4	931,7	733,1	731,0	515,2	488,2	696,7	1109,5	688,8	398,7	611,6	483,4	543,9	796,3	429,1	1020,2	1064,5	701,3	930,5	748,1	356,9
K	***Initial***	2,2	2,8	3,8	0,4	3,5	2,3	1,7	1,0	2,6	0,5	3,5	2,9	2,3	1,0	0,7	0,8	1,5	1,4	0,9	2,1	2,1	1,8	2,0	4,3	5,1	1,3	1,3
	Final	21,1	18,5	28,7	12,3	41,4	51,6	42,7	44,8	53,2	20,9	26,1	55,7	26,9	44,8	24,3	27,9	26,3	35,5	34,7	31,3	42,3	31,3	29,8	48,9	45,1	23,8	24,2
Alkalinity	***Initial***	52,0	44,3	18,5	17,2	41,9	36,0	31,4	84,7	34,8	47,1	10,3	59,1	168,0	35,3	49,4	14,8	53,6	33,4	62,9	192,0	50,0	73,2	134,0	48,4	31,3	40,1	26,5
	Final	892,7	1859,7	1705,6	503,9	1776,3	1315,5	1311,4	2545,6	1154,4	1635,9	1503,5	1565,3	1378,0	2324,6	1506,8	742,7	1837,7	1245,7	1447,8	3003,8	1386,4	1122,5	2795,0	917,9	656,8	1519,1	851,2
SO_4^{2-}	***Initial***	15,2	564,9	1366,5	31,2	515,6	12,0	11,0	24,0	193,3	20,9	842,4	31,4	172,2	83,1	39,4	38,1	148,2	46,2	21,2	72,0	35,4	129,3	15,2	405,0	295,9	81,0	34,3
	Final	29,8	3711,5	20429,9	324,2	7309,0	53,7	78,0	280,2	1929,1	206,4	4640,8	230,9	382,9	1645,7	216,0	243,5	621,3	374,4	94,5	573,1	84,1	1007,9	252,7	2026,6	2147,0	355,9	296,7
Al	***Initial***	0,2	0,0	0,2	0,1	0,0	0,1	0,1	0,5	0,1	0,6	0,0	0,1	0,1	0,1	0,1	0,2	0,1	0,1	0,1	0,2	0,2	0,8	1,0	0,0	0,1	0,4	0,3
	Final	12,3	0,7	1,0	7,0	0,8	5,9	7,5	7,9	2,6	11,1	0,7	6,1	7,0	3,1	6,2	8,0	3,4	7,8	9,8	1,5	6,6	16,8	14,1	2,0	6,1	24,8	7,4
As	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,7	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,8	0,6	0,6	0,6	0,6
B	***Initial***	0,3	1,2	1,5	0,2	0,7	0,1	0,0	0,1	0,2	0,3	1,1	0,2	1,1	0,2	0,3	0,1	0,8	0,1	0,1	1,5	0,1	0,2	0,4	0,2	0,6	0,3	0,1
	Final	17,1	41,4	27,5	15,1	21,8	18,5	14,6	16,6	13,7	14,4	25,4	19,1	10,0	21,1	13,9	9,3	20,6	11,6	11,4	27,6	15,4	14,9	17,8	13,7	23,5	15,7	11,9
Ba	***Initial***	0,0	0,1	0,2	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,2	1,4	1,2	0,2	1,3	0,2	0,2	0,3	0,5	0,2	1,2	0,3	0,2	1,3	0,2	0,2	0,7	0,3	0,2	3,3	0,2	0,5	0,4	0,4	0,6	0,4	0,2
	DF	21,6	9,6	8,0	42,0	10,5	44,7	47,2	56,8	18,8	16,7	7,2	23,0	5,5	257,4	37,2	35,7	39,4	41,2	39,5	17,0	38,5	18,9	9,4	11,1	16,6	37,1	27,4
Cd	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
	DF	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0
Co	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,6	0,6	0,6	0,6	0,7	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
	DF	31,0	31,0	31,0	31,0	13,4	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0
Cr	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
	DF	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0
Cu	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,3	0,8	1,1	0,4	0,9	0,3	0,3	0,3	0,6	0,3	0,8	0,3	0,3	0,5	0,3	0,4	0,5	0,4	0,4	0,5	0,3	0,4	0,4	0,6	0,7	0,4	0,3
	DF	59,4	24,8	56,0	30,2	18,8	54,1	50,9	44,5	61,5	62,8	29,0	40,3	16,5	104,1	41,4	45,5	25,1	31,7	74,7	42,8	34,9	26,2	72,7	28,3	20,5	19,6	27,3
Fe	***Initial***	0,3	0,9	203,5	0,1	0,6	0,0	0,1	0,3	0,1	0,2	118,7	0,1	0,1	0,0	0,1	0,0	0,1	0,0	0,0	0,1	0,1	0,5	0,3	0,0	0,1	0,1	0,1
	Final	10,0	7,2	240,7	1,7	8,4	5,1	7,7	5,3	1,3	1,9	147,7	6,0	1,4	1,0	2,8	2,1	1,1	2,3	3,0	0,8	5,5	13,3	7,6	0,9	7,5	11,2	1,8
	DF	40,0	7,9	1,2	13,0	13,0	107,5	147,9	21,0	13,6	12,8	1,2	83,2	19,8	29,4	37,4	45,9	8,5	62,5	94,1	11,9	55,4	27,8	22,0	30,2	61,2	90,3	25,6
Mn	***Initial***	0,0	0,4	1,5	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,1	0,0	0,0
	Final	0,6	2,3	8,7	0,6	1,6	0,6	0,6	0,6	1,0	0,7	3,6	0,6	0,6	0,6	0,6	0,7	0,7	0,6	0,6	0,6	0,6	0,7	0,6	1,2	1,7	0,6	0,6

	DF	31,0	5,9	5,9	31,8	12,1	31,0	31,1	31,0	25,8	32,5	4,1	31,0	31,0	32,3	31,0	34,6	33,9	31,0	31,0	31,2	31,0	36,1	31,0	6,3	31,9	31,0	31,0
Mo	***Initial***	0,2	0,0	0,0	0,0	0,0	0,2	0,0	0,1	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,1	0,1	0,2	0,0	0,0	0,0	0,0
	Final	0,9	0,6	0,6	0,6	0,6	1,0	0,7	1,0	0,6	0,7	0,6	1,7	0,7	0,7	0,7	0,9	0,6	0,8	0,7	0,6	0,8	0,9	1,1	0,6	0,6	0,7	0,7
	DF	5,2	31,0	31,0	31,3	31,0	6,8	31,7	13,6	31,0	34,2	31,0	4,0	33,2	33,0	21,0	10,5	31,1	24,3	27,5	31,2	13,5	9,4	5,7	31,0	31,1	20,0	17,6
Ni	***Initial***	0,0	0,0	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,6	0,6	1,3	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
	DF	31,0	31,0	2,4	31,0	32,4	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,9	31,0	31,0	31,0	31,0	31,0
Pb	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
	DF	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0
Sb	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
	DF	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0
Se	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0
	Final	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,7	0,7	0,8	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,7	0,6	0,6	0,6	0,6	0,6
	DF	21,8	30,0	30,1	30,0	31,9	30,0	30,0	30,2	30,3	28,1	30,1	9,0	7,6	37,7	31,0	30,0	30,5	30,0	30,2	22,9	30,0	10,8	28,0	31,3	30,5	19,2	30,1
Si	***Initial***	4,8	0,6	0,4	1,2	0,6	1,5	1,2	1,9	1,0	1,6	0,3	1,4	1,7	0,9	1,1	1,0	1,4	1,1	0,9	1,3	1,4	2,7	3,3	0,8	2,6	1,6	1,5
	Final	255,8	151,3	130,7	148,8	128,8	196,0	212,6	165,3	139,5	134,0	118,9	192,0	115,6	159,8	129,9	124,8	141,9	139,1	141,2	177,2	181,7	114,5	188,3	97,1	200,5	140,3	145,6
	DF	53,0	261,7	370,3	128,2	211,5	133,6	183,6	86,7	133,1	81,7	409,9	139,1	66,4	169,6	123,3	128,7	101,8	132,1	162,8	132,9	133,5	42,0	57,9	119,5	77,1	86,6	98,4
Sr	***Initial***	0,0	1,0	3,1	0,0	0,6	0,0	0,0	0,0	0,1	0,0	1,7	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,2	0,1	0,0	0,0
	Final	0,2	10,4	38,2	0,7	15,5	0,4	0,4	1,6	3,4	0,2	13,8	0,7	0,3	6,6	0,2	0,2	1,8	0,5	0,4	8,4	0,8	0,6	0,3	3,0	2,3	0,2	0,2
	DF	12,6	10,3	12,4	132,3	26,3	65,3	48,5	312,1	49,8	49,7	8,1	31,2	4,8	1318,7	41,6	37,1	120,4	96,8	72,6	46,5	96,1	24,2	14,1	12,0	46,7	40,3	38,7
U	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9	0,9
	DF	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0	31,0
V	***Initial***	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,4	0,3	0,3	0,5	0,3	0,3	0,3	0,4	0,3	0,5	0,3	0,3	0,5	0,5	0,4	0,3	0,3	0,3	0,4	0,3	0,3	0,4	0,4	0,3	0,3	0,5	0,3
	DF	37,5	31,0	31,0	35,5	31,0	32,5	31,0	39,2	31,0	53,6	31,0	31,0	48,8	46,4	35,5	32,0	33,4	32,8	35,5	31,3	32,3	23,8	15,6	31,0	31,0	51,3	31,7
Zn	***Initial***	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
	Final	0,6	0,8	1,1	0,6	0,9	0,6	0,6	0,6	0,7	0,6	0,9	0,6	0,6	0,7	0,6	0,6	0,7	0,7	0,7	0,7	0,6	2,1	0,8	0,7	1,3	0,8	0,6
	DF	31,1	33,8	8,7	28,9	29,6	31,1	32,0	31,5	32,9	31,8	17,5	31,3	22,5	33,2	31,2	25,7	16,9	28,3	33,2	33,9	31,3	106,8	39,5	35,5	26,1	41,7	32,0
pH	***Initial***	7,71	6,37	5,56	7,54	6,43	7,50	9,01	9,45	7,31	8,55	5,12	8,81	7,94	7,69	8,66	7,32	7,14	7,72	8,94	8,22	9,03	8,77	9,66	7,99	6,89	7,93	8,18
	Final	7,44	7,50	7,33	6,82	7,48	8,24	8,42	7,97	7,81	7,86	7,54	8,29	7,76	7,74	7,87	7,66	7,50	7,92	7,98	7,87	8,27	7,22	7,04	7,91	8,49	8,10	8,05

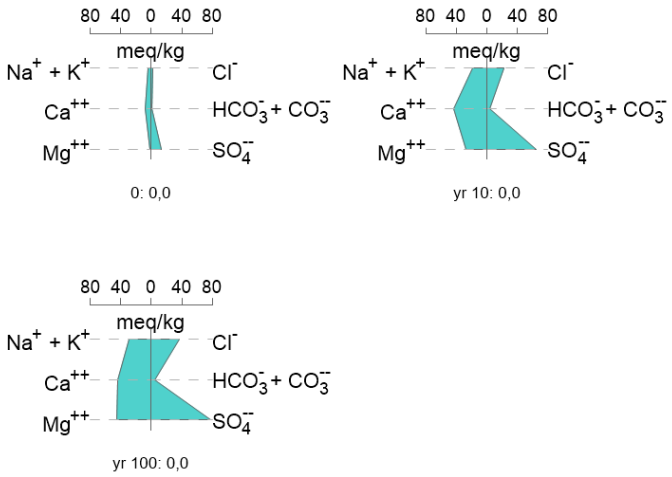
APPENDIX L: OTHER KINETIC MODEL PLOTS

A) ZFN1512 - coal

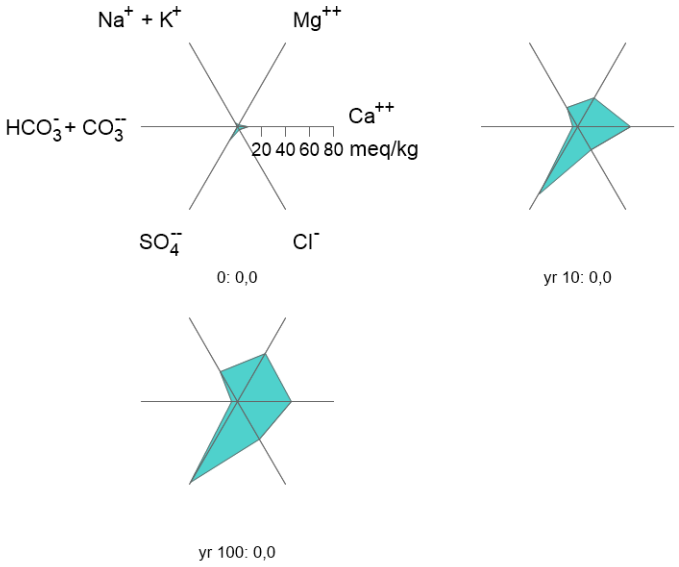




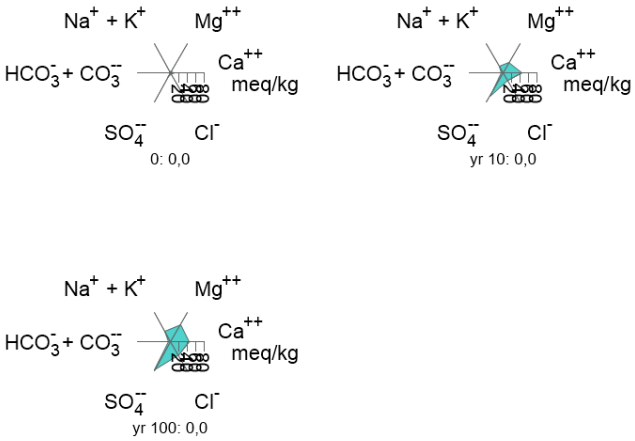
ZFN_{1512}-coal



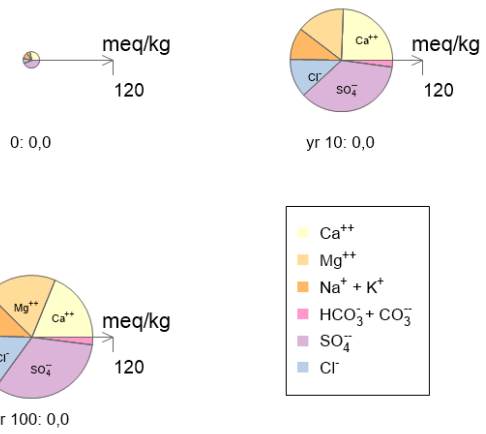
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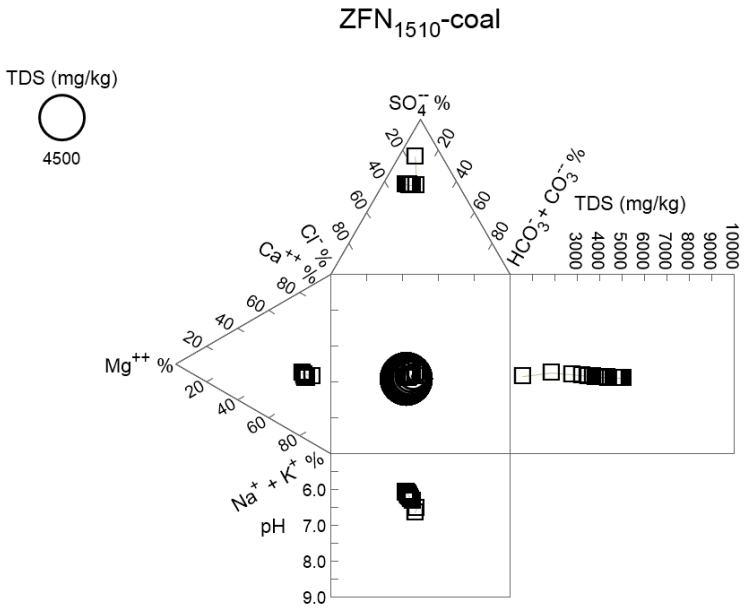
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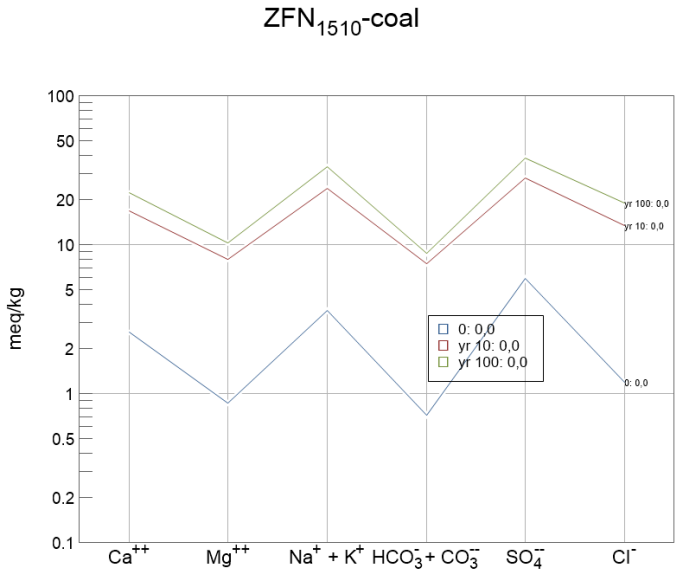


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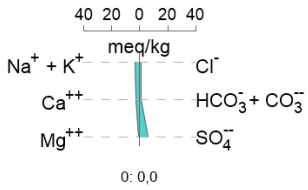


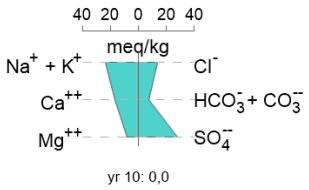
B) ZFN1510 - coal

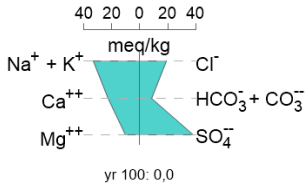




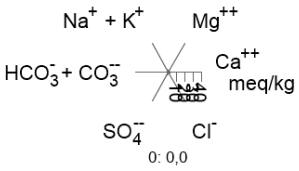
ZFN_{1510}-coal

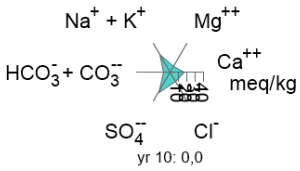


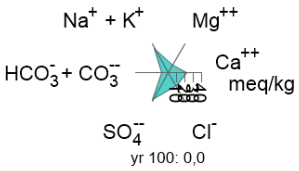


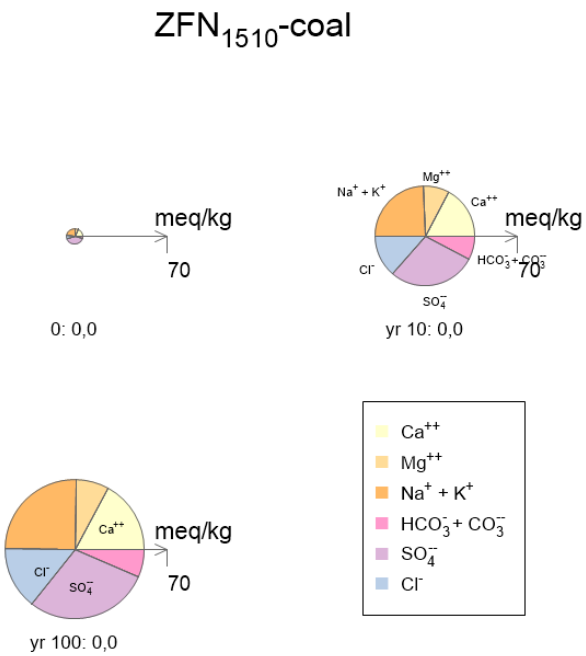


ZFN_{1510}-coal

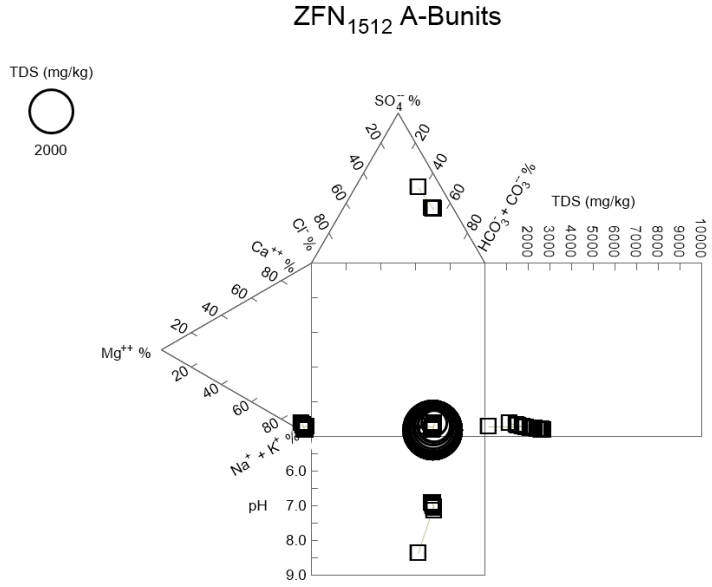




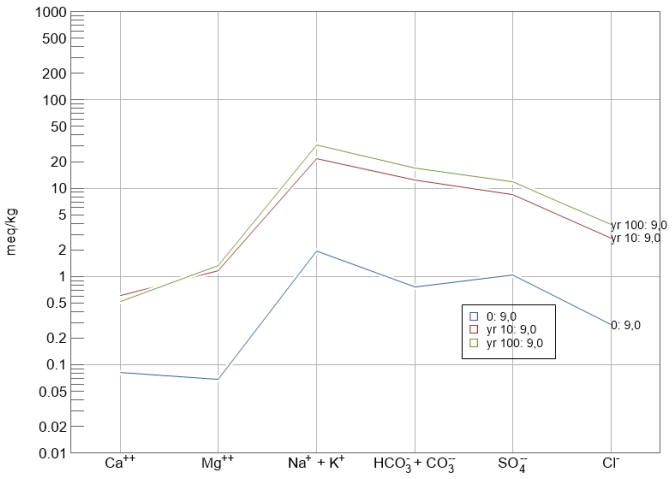




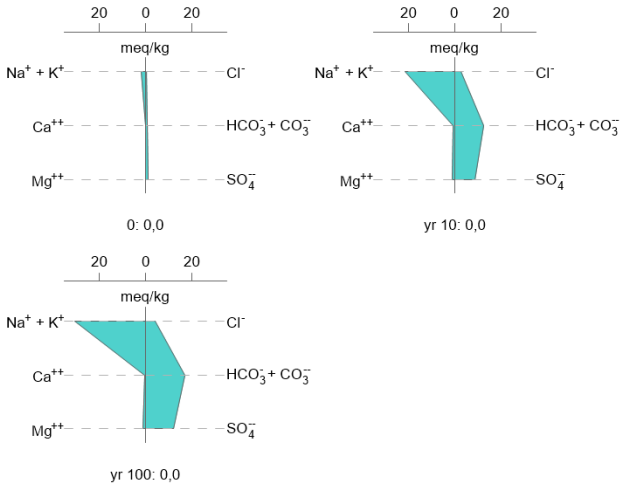
C) ZFN1512 A-B units



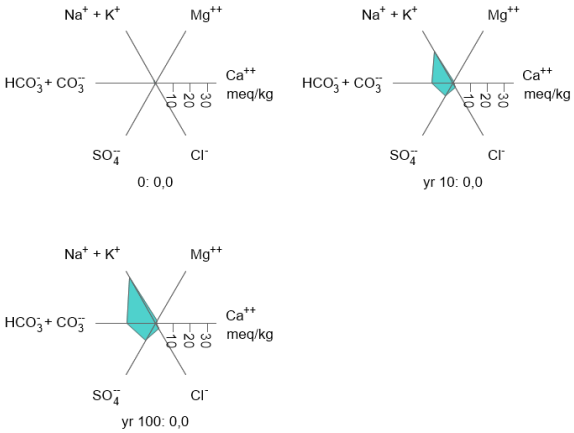
ZFN_{1512} A-Bunits



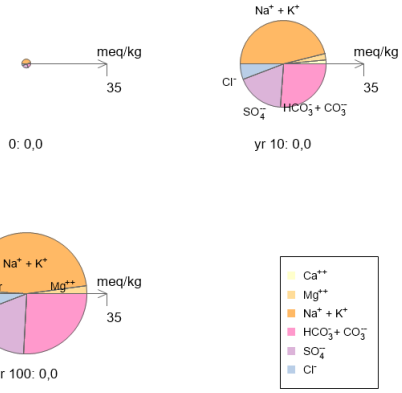
ZFN_{1512} A-Bunits



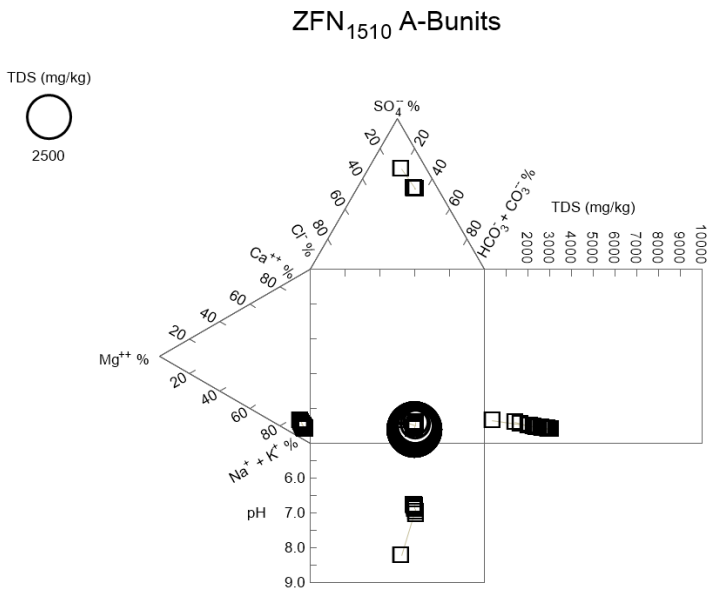
ZFN_{1512} A-Bunits

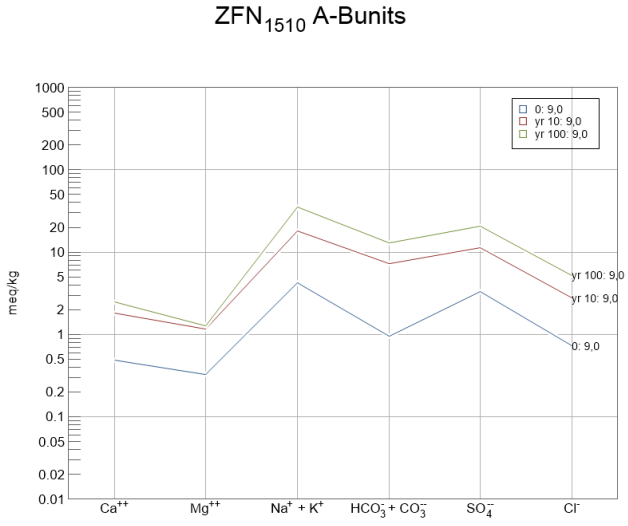


ZFN_{1512} A-Bunits

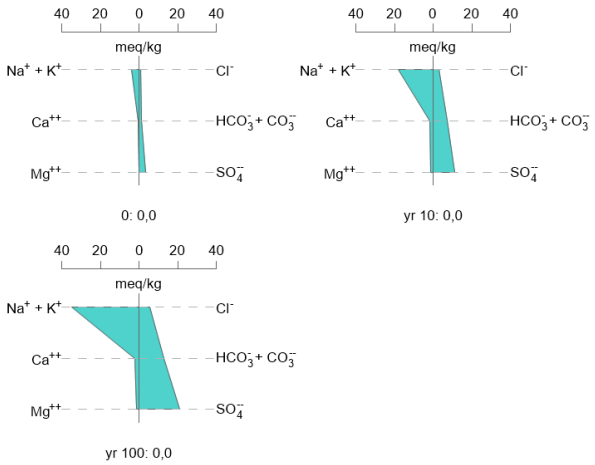


D) ZFN1510 A-B units

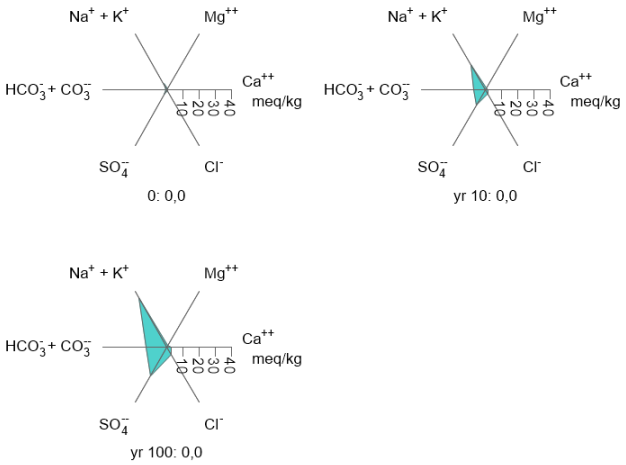




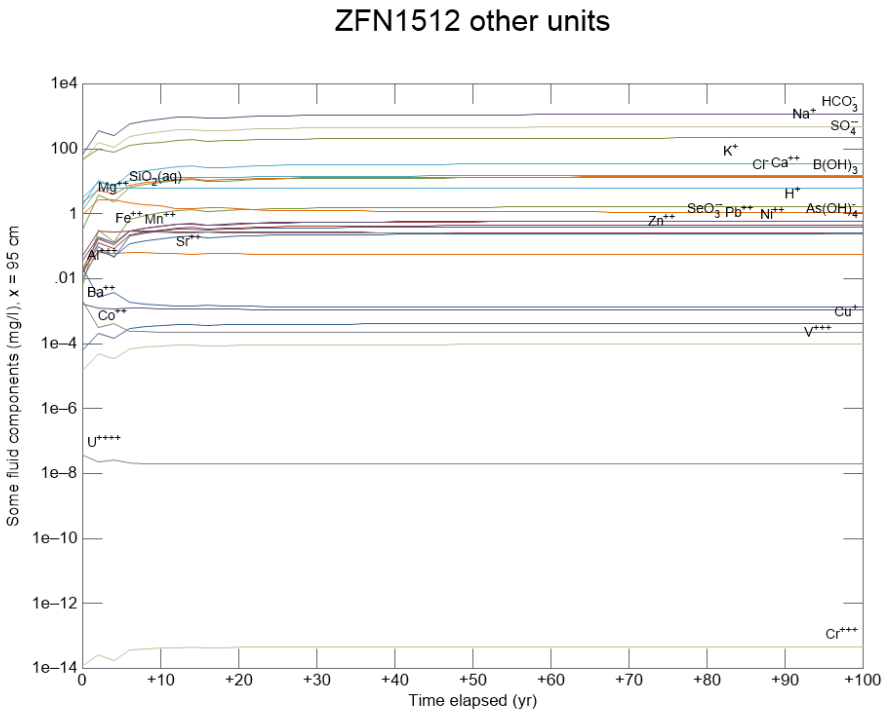
ZFN_{1510} A-Bunits

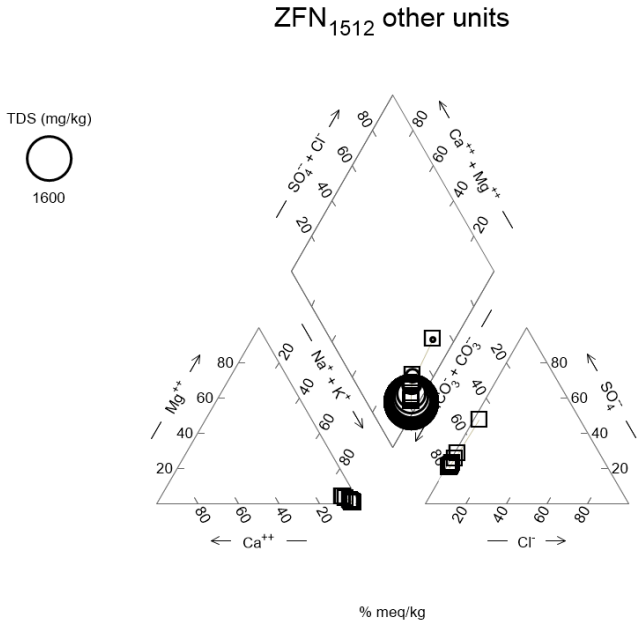


ZFN_{1510} A-Bunits

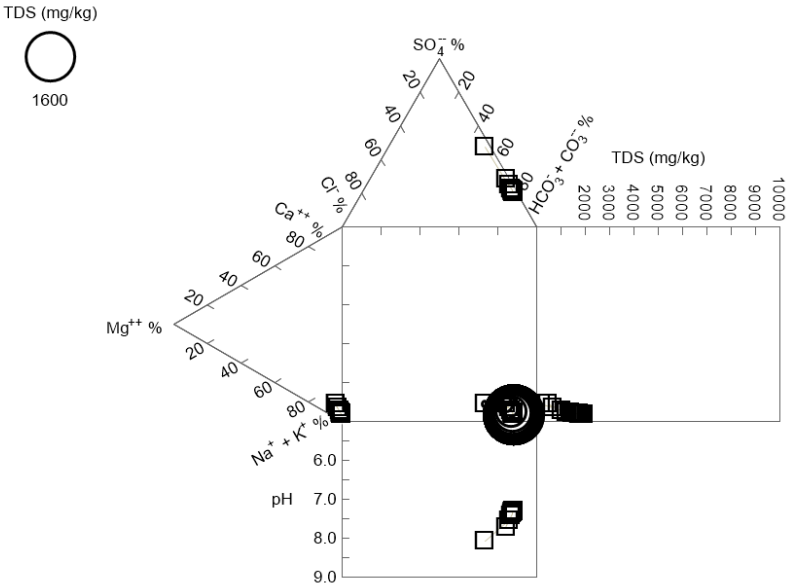


E) ZFN1512 other units





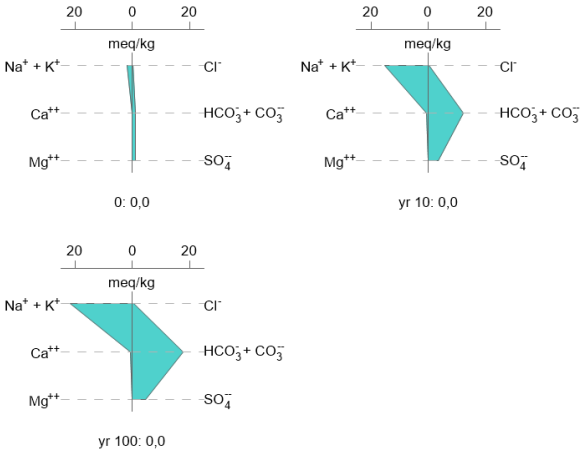
ZFN_{1512} other units



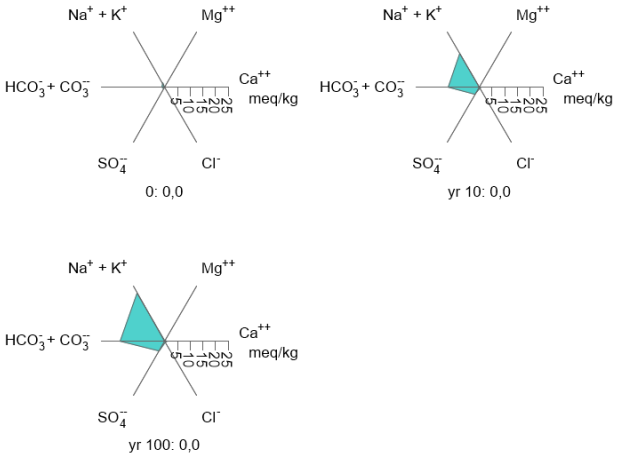
ZFN_{1512} other units



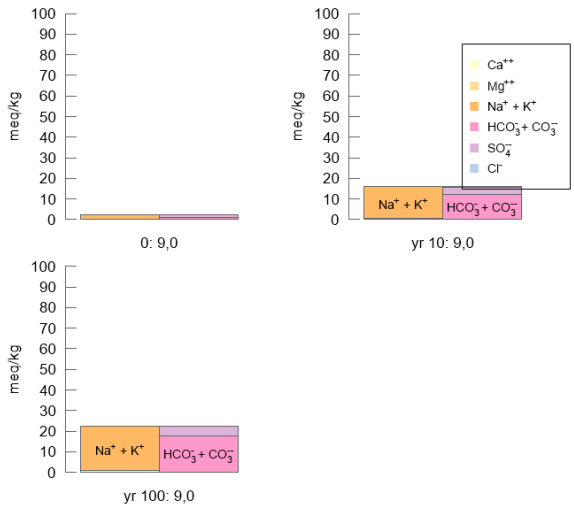
ZFN_{1512} other units



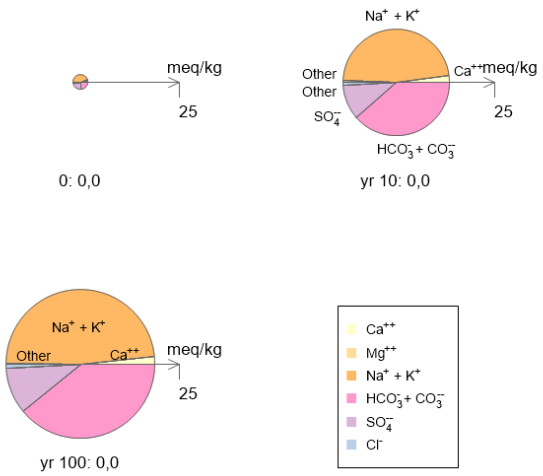
ZFN_{1512} other units



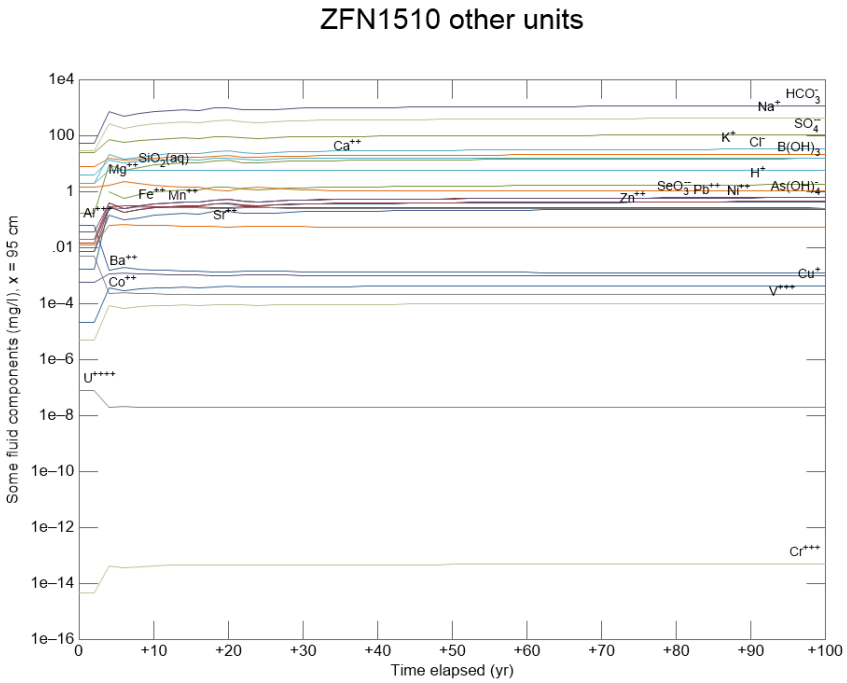
ZFN_{1512} other units

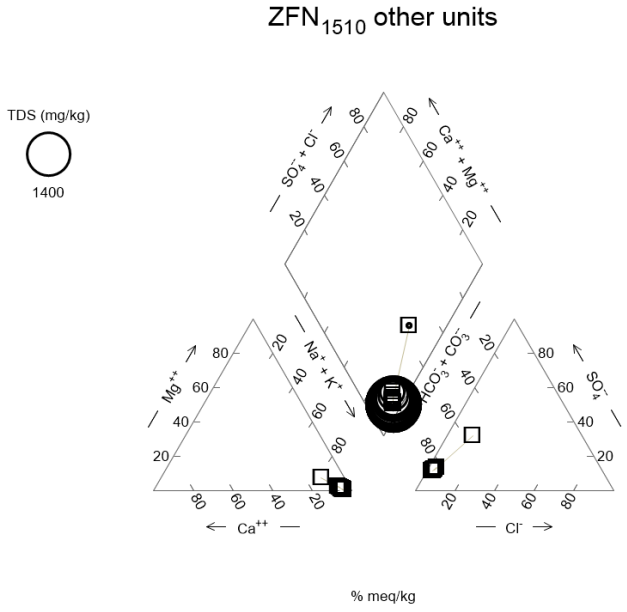


ZFN_{1512} other units

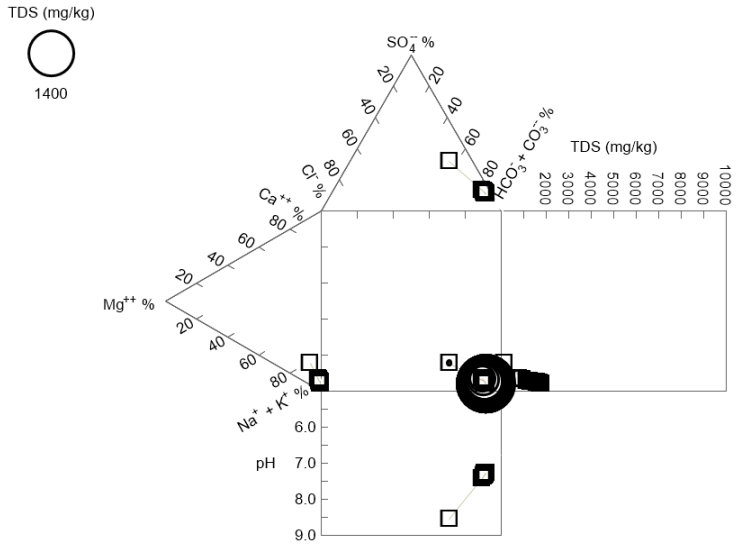


F) ZFN1510 other units

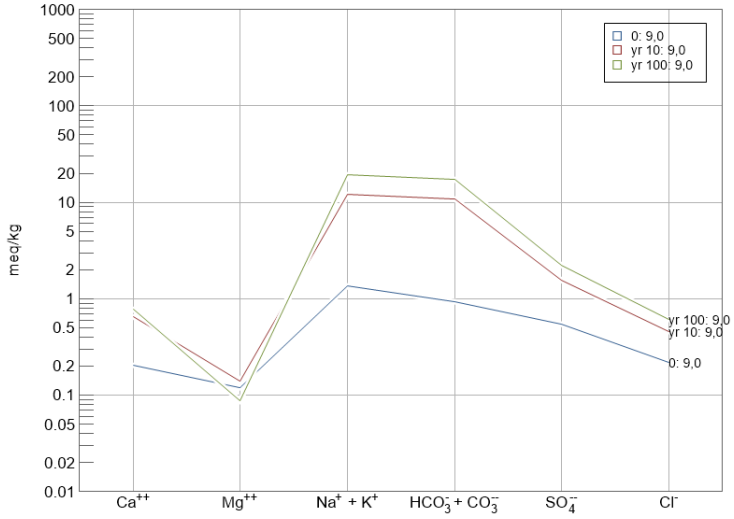




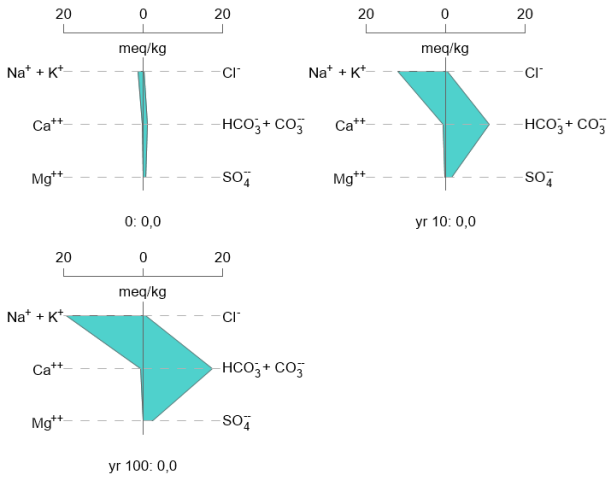
ZFN_{1510} other units



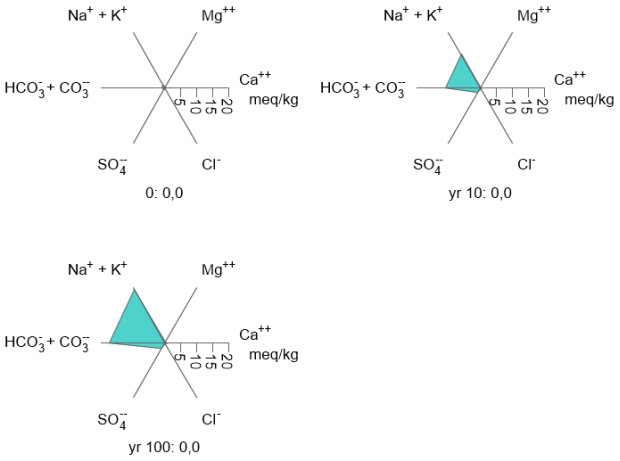
ZFN_{1510} other units



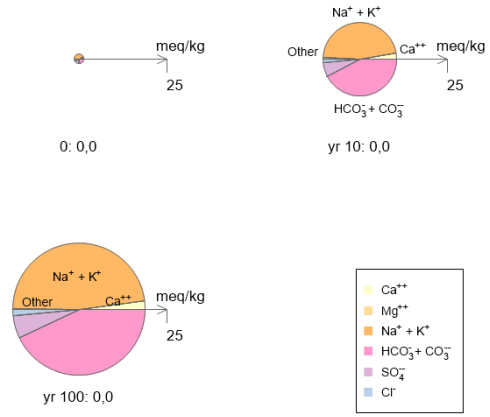
ZFN_{1510} other units



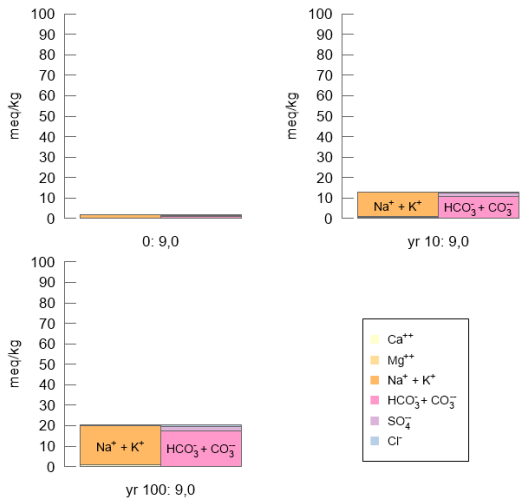
ZFN_{1510} other units



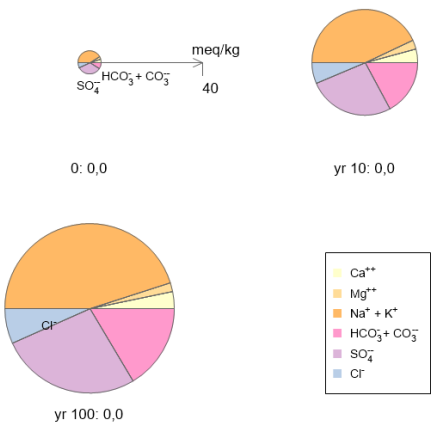
ZFN_{1510} other units



ZFN_{1510} other units



ZFN_{1510} A-Bunits



APPENDIX M: CUMULATIVE MASS INFLUXES AND EFFLUXES OVER SIMULATION

ZFN1512 - coal						ZFN1510 - coal					
Entering domain			**Leaving domain**			**Entering domain**			**Leaving domain**		
Basis entry	moles	grams	Basis entry	moles	grams	Basis entry	moles	grams	Basis entry	moles	grams
H_2O	0.00869371	0.156619	H_2O	0.0309920	0.558328	HCO_3^-	0.00296816	0.181109	H_2O	0.00787567	0.141882
Ca^{++}	0.00814276	0.326362	H^+	0.00124040	0.00125020	Ca^{++}	0.00141543	0.0567302	H^+	0.00205493	0.00207116
SO_4^{--}	0.00789372	0.758252	SO_4^{--}	2.01615e-05	0.00193667	Mg^{++}	0.00126618	0.0307746	Na^+	3.56313e-06	8.19155e-05
HCO_3^-	0.00185506	0.113190	Cl^-	1.82912e-05	0.000648477	Na^+	0.000835101	0.0191988	SO_4^{--}	2.11101e-06	0.000202778
Mg^{++}	0.00130269	0.0316619	Na^+	1.39965e-05	0.000321776	Cl^-	0.000517133	0.0183339	Cl^-	2.08789e-06	7.40219e-05
Cl^-	0.000984528	0.0349045	Ca^{++}	1.17601e-05	0.000471343	H_2O	0.000482968	0.00870076	Ca^{++}	1.23850e-06	4.96389e-05
Na^+	0.000696030	0.0160016	Mg^{++}	1.13416e-05	0.000275658	SO_4^{--}	0.000470004	0.0451474	HCO_3^-	2.44796e-06	0.000149368
$SiO_2(aq)$	0.000381971	0.0229503	HCO_3^-	7.47560e-06	0.000456140	$SiO_2(aq)$	0.000445315	0.0267562	Mg^{++}	5.74585e-07	1.39653e-05
Fe^{++}	8.05689e-05	0.00449953	Fe^{++}	3.76669e-07	2.10359e-05	Fe^{++}	8.32028e-05	0.00464663	K^+	8.84204e-08	3.45709e-06
K^+	1.61724e-05	0.000632315	K^+	3.13508e-07	1.22576e-05	K^+	2.18487e-05	0.000854246	$B(OH)_3$	4.11049e-08	2.54163e-06
Al^{+++}	1.50838e-05	0.000406984	$B(OH)_3$	2.06493e-07	1.27680e-05	Al^{+++}	1.50546e-05	0.000406197	Fe^{++}	2.77866e-08	1.55180e-06
Sr^{++}	1.40855e-05	0.00123417	Sr^{++}	5.69387e-08	4.98897e-06	Sr^{++}	1.00739e-05	0.000882677	$SiO_2(aq)$	1.14044e-08	6.85220e-07
$B(OH)_3$	1.15732e-05	0.000715602	$SiO_2(aq)$	5.09510e-08	3.06133e-06	$B(OH)_3$	1.04533e-05	0.000646356	Sr^{++}	4.10093e-09	3.59323e-07
Cr^{+++}	2.03984e-06	0.000106063	Mn^{++}	2.96196e-08	1.62724e-06	Cr^{+++}	2.22158e-06	0.000115513	Mn^{++}	2.72922e-09	1.49938e-07
Co^{++}	1.72464e-06	0.000101639	Ni^{++}	6.69916e-09	3.93308e-07	Ba^{++}	2.18590e-06	0.000300189	Ni^{++}	1.13324e-09	6.65323e-08
Mn^{++}	1.43926e-06	7.90703e-05	Cu^+	5.03468e-09	3.19933e-07	Co^{++}	1.90685e-06	0.000112377	$SeO3^{--}$	5.46095e-10	6.93313e-08
Ba^{++}	1.27655e-06	0.000175309	Zn^{++}	3.43286e-09	2.24440e-07	Cu^+	1.31738e-06	8.37142e-05	Zn^{++}	5.33342e-10	3.48699e-08
Zn^{++}	1.20173e-06	7.85694e-05	$SeO3^{--}$	2.31842e-09	2.94342e-07	V^{+++}	1.29363e-06	6.58993e-05	$As(OH)_4^-$	4.50451e-10	6.43924e-08
V^{+++}	1.19066e-06	6.06540e-05	$As(OH)_4^-$	2.04298e-09	2.92045e-07	Zn^{++}	1.24309e-06	8.12734e-05	Cu^+	2.41513e-10	1.53472e-08
Cu^+	7.22509e-07	4.59126e-05	Pb^{++}	1.08323e-09	2.24446e-07	U^{++++}	7.28719e-07	0.000173456	Pb^{++}	2.40826e-10	4.98992e-08
U^{++++}	6.69104e-07	0.000159266	Co^{++}	3.58757e-10	2.11427e-08	Mn^{++}	5.91444e-07	3.24927e-05	Co^{++}	3.74655e-11	2.20796e-09
Pb^{++}	6.08284e-08	1.26036e-05	Ba^{++}	5.21703e-11	7.16455e-09	Ni^{++}	2.90104e-07	1.70320e-05	Ba^{++}	1.24700e-11	1.71251e-09
H^+	3.92559e-07	3.95660e-07	V^{+++}	2.52265e-11	1.28507e-09	SeO_3^{--}	1.39577e-07	1.77204e-05	V^{+++}	3.91352e-12	1.99360e-10
Ni^{++}	3.08439e-07	1.81084e-05	Al^{+++}	8.99750e-12	2.42766e-10	$As(OH)_4^-$	1.15174e-07	1.64643e-05	Al^{+++}	1.69907e-12	4.58434e-11
$As(OH)_4^-$	1.14618e-07	1.63848e-05	U^{++++}	3.59502e-17	8.55720e-15	Pb^{++}	6.16505e-08	1.27740e-05	U^{++++}	7.95014e-18	1.89236e-15
SeO_3^{--}	1.30110e-07	1.65185e-05	Cr^{+++}	1.91560e-18	9.96038e-17	H^+	0.000000	0.000000	Cr^{+++}	1.61418e-19	8.39309e-18

ZFN1512 A-B Units						ZFN1510 A-B Units					
Entering domain:			**Leaving domain**			**Entering domain**			**Leaving domain**		
Basis entry	moles	grams	Basis entry	moles	grams	Basis entry	moles	grams	Basis entry	moles	grams
HCO_{3}^{-}	0.00121327	0.0740302	H^{+}	0.000703519	0.000709077	HCO_{3}^{-}	0.00112468	0.0686245	H^{+}	0.000809538	0.000815934
Na+	0.000798905	0.0183667	Na^{+}	1.04817e-06	2.40972e-05	Na^{+}	0.000864414	0.0198727	Na^{+}	1.18539e-06	2.72519e-05
SiO_2(aq)	0.000385765	0.0231782	SO_4^{--}	2.07466e-07	1.99287e-05	SiO_2(aq)	0.000390812	0.0234815	SO_4^{--}	3.59456e-07	3.45285e-05
Mg^{++}	0.000334518	0.00813046	HCO_3^{-}	7.29873e-07	4.45347e-05	Ca^{++}	0.000352126	0.0141132	Cl^{-}	1.80521e-07	6.40002e-06
Ca^{++}	0.000322830	0.0129390	Cl^{-}	1.35765e-07	4.81329e-06	Mg^{++}	0.000337536	0.00820382	HCO_{3}^{-}	5.86949e-07	3.58140e-05
SO_4^{--}	0.000153772	0.0147709	K^{+}	2.71479e-08	1.06144e-06	SO_4^{--}	0.000249451	0.0239616	Ca^{++}	4.38609e-08	1.75794e-06
Cl-	0.000102410	0.00363073	Mg^{++}	2.40978e-08	5.85697e-07	Cl^{-}	0.000128739	0.00456420	K^{+}	2.43213e-08	9.50920e-07
Al^{+++}	4.62539e-05	0.00124800	Ca^{++}	1.00572e-08	4.03092e-07	Al^{+++}	7.27712e-05	0.00196348	Mg^{++}	2.33381e-08	5.67234e-07
K^{+}	3.68491e-05	0.00144074	$B(OH)_3$	7.56286e-09	4.67633e-07	K^{+}	4.26695e-05	0.00166830	$B(OH)_3$	8.84176e-09	5.46712e-07
$B(OH)_3$	6.08073e-06	0.000375989	SiO_2(aq)	3.69111e-09	2.21776e-07	Fe^{++}	1.62729e-05	0.000908792	SiO_2(aq)	3.61769e-09	2.17364e-07
Fe^{++}	6.00582e-06	0.000335407	Fe^{++}	5.32471e-10	2.97369e-08	$B(OH)_3$	7.24928e-06	0.000448244	Fe^{++}	1.06566e-09	5.95137e-08
Cr^{+++}	2.08010e-06	0.000108157	Mn^{++}	4.50462e-10	2.47475e-08	Cr^{+++}	1.97353e-06	0.000102616	Mn^{++}	5.60284e-10	3.07809e-08
Sr^{++}	1.90357e-06	0.000166791	Ni^{++}	3.64448e-10	2.13967e-08	Co^{++}	1.73915e-06	0.000102493	Ni^{++}	3.57086e-10	2.09645e-08
Co^{++}	1.83384e-06	0.000108074	SeO_3^{--}	1.67075e-10	2.12115e-08	Sr^{++}	1.42784e-06	0.000125108	Zn^{++}	3.44889e-10	2.25488e-08
V^{+++}	1.30916e-06	6.66907e-05	$As(OH)_4^{-}$	1.44867e-10	2.07088e-08	Zn^{++}	1.26947e-06	8.29978e-05	SeO_3^{--}	1.69030e-10	2.14598e-08
Zn^{++}	1.14582e-06	7.49139e-05	Zn^{++}	1.34275e-10	8.77890e-09	V^{+++}	1.22257e-06	6.22794e-05	Sr^{++}	1.54370e-10	1.35259e-08
Cu^{+}	1.00166e-06	6.36513e-05	Pb^{++}	7.74255e-11	1.60426e-08	Cu^{+}	1.20844e-06	7.67918e-05	$As(OH)_4^{-}$	1.48277e-10	2.11963e-08
U^{++++}	6.82311e-07	0.000162410	Sr^{++}	7.47074e-11	6.54587e-09	U^{++++}	6.47353e-07	0.000154089	Pb^{++}	7.55008e-11	1.56438e-08
Mn^{++}	3.55130e-07	1.95101e-05	Al^{+++}	1.21180e-12	3.26960e-11	Ba^{++}	5.01534e-07	6.88757e-05	Ba^{++}	2.47974e-12	3.40542e-10
Ba^{++}	3.44586e-07	4.73220e-05	Cu^{+}	1.07309e-12	6.81906e-11	Mn^{++}	4.38619e-07	2.40969e-05	Cu^{+}	2.00069e-12	1.27136e-10
Ni^{++}	2.87590e-07	1.68844e-05	Ba^{++}	1.06977e-12	1.46912e-10	Ni^{++}	2.88106e-07	1.69147e-05	Al^{+++}	1.06370e-12	2.87001e-11
SeO_3^{--}	1.31668e-07	1.67164e-05	Co^{++}	2.65586e-13	1.56518e-11	SeO_3^{-}-	1.33967e-07	1.70082e-05	Co^{++}	4.72975e-13	2.78739e-11
$As(OH)_4^{-}$	1.14190e-07	1.63236e-05	V^{+++}	1.72968e-13	8.81122e-12	$As(OH)_4^{-}$	1.18868e-07	1.69923e-05	V^{+++}	2.40330e-13	1.22428e-11
Pb^{++}	6.11028e-08	1.26605e-05	Cr^{+++}	2.52672e-22	1.31379e-20	Pb^{++}	6.09095e-08	1.26204e-05	U^{++++}	2.64675e-18	6.30003e-16
H^{+}	4.35223e-14	4.38661e-14	U^{++++}	2.76434e-18	6.57993e-16	H^{+}	6.18384e-14	6.23269e-14	Cr^{+++}	3.86457e-22	2.00942e-20

ZFN1512 Other units						ZFN1510 Other units					
Entering domain			**Leaving domain**			**Entering domain**			**Leaving domain**		
Basis entry	moles	grams	Basis entry	moles	grams	Basis entry	moles	grams	Basis entry	moles	grams
HCO_3^-	0.000864345	0.0527398	H_2O	0.00219673	0.0395745	HCO_3^-	0.000852267	0.0520029	H^+	0.000473839	0.000477582
Na^+	0.000541553	0.0124502	H^+	0.000473067	0.000476804	SiO_2(aq)	0.000521607	0.0313402	H_2O	0.00221471	0.0398984
SiO_2(aq)	0.000478824	0.0287695	Na^+	5.45208e-07	1.25342e-05	Na^+	0.000494794	0.0113752	HCO_3^-	4.98936e-07	3.04436e-05
Ca^{++}	0.000172855	0.00692803	HCO_3^-	5.04749e-07	3.07983e-05	Ca^{++}	0.000164401	0.00658921	Na^+	4.81248e-07	1.10638e-05
Mg^{++}	0.000164336	0.00399419	SO_4^{--}	6.04434e-08	5.80605e-06	Mg^{++}	0.000149762	0.00363997	SO_4^{--}	2.93985e-08	2.82395e-06
H_2O	7.18994e-05	0.00129528	K^+	2.35630e-08	9.21275e-07	H_2O	8.81745e-05	0.00158848	K^+	2.21656e-08	8.66637e-07
SO_4^{--}	5.04484e-05	0.00484595	Cl^-	1.04100e-08	3.69065e-07	Al^{+++}	5.41379e-05	0.00146072	Cl^-	1.62427e-08	5.75852e-07
Al^{+++}	4.70037e-05	0.00126823	Ca^{++}	1.02101e-08	4.09220e-07	K^+	4.11674e-05	0.00160957	Ca^{++}	1.07500e-08	4.30860e-07
K^+	4.01488e-05	0.00156975	$B(OH)_3$	5.67071e-09	3.50637e-07	SO_4^{--}	2.44225e-05	0.00234597	$B(OH)_3$	6.42962e-09	3.97562e-07
Fe^{++}	1.23286e-05	0.000688516	SiO_2(aq)	2.80442e-09	1.68500e-07	Fe^{++}	1.76427e-05	0.000985290	SiO_2(aq)	2.75889e-09	1.65764e-07
Cl^-	9.47317e-06	0.000335852	Mg^{++}	1.42814e-09	3.47109e-08	Cl^-	1.13791e-05	0.000403424	Mg^{++}	1.26924e-09	3.08490e-08
$B(OH)_3$	6.07348e-06	0.000375541	Ni^{++}	1.81101e-10	1.06324e-08	$B(OH)_3$	7.06882e-06	0.000437086	Ni^{++}	1.89875e-10	1.11475e-08
Cr^{+++}	2.14550e-06	0.000111557	Fe^{++}	1.34291e-10	7.49973e-09	Cr^{+++}	2.00103e-06	0.000104045	Fe^{++}	1.31466e-10	7.34198e-09
Co^{++}	1.89220e-06	0.000111513	Mn^{++}	1.28099e-10	7.03751e-09	Co^{++}	1.76454e-06	0.000103990	$SeO3^{--}$	1.25568e-10	1.59419e-08
V^{+++}	1.28184e-06	6.52989e-05	SeO_3^{--}	1.25516e-10	1.59353e-08	Mn^{++}	1.14619e-06	6.29696e-05	Mn^{++}	1.24437e-10	6.83632e-09
Mn^{++}	1.21239e-06	6.66065e-05	$As(OH)_4^-$	1.08621e-10	1.55274e-08	V^{+++}	1.12238e-06	5.71756e-05	$As(OH)_4^-$	1.13157e-10	1.61758e-08
Zn^{++}	1.17731e-06	7.69728e-05	Zn^{++}	9.93862e-11	6.49787e-09	Zn^{++}	1.10201e-06	7.20493e-05	Zn^{++}	9.43993e-11	6.17182e-09
Cu^+	9.23815e-07	5.87048e-05	Pb^{++}	5.76600e-11	1.19471e-08	Cu^+	8.61813e-07	5.47648e-05	Pb^{++}	5.66767e-11	1.17434e-08
Ni^{++}	8.13214e-07	4.77438e-05	Sr^{++}	1.80448e-11	1.58109e-09	Sr^{++}	8.55848e-07	7.49894e-05	Sr^{++}	1.74362e-11	1.52776e-09
U^{++++}	7.03764e-07	0.000167516	Al^{+++}	1.42893e-12	3.85548e-11	Ni^{++}	7.09042e-07	4.16279e-05	Al^{+++}	1.35862e-12	3.66575e-11
Sr^{++}	6.95128e-07	6.09071e-05	Ba^{++}	2.24862e-13	3.08802e-11	U^{++++}	6.56373e-07	0.000156236	Ba^{++}	2.01481e-13	2.76694e-11
Ba^{++}	3.17959e-07	4.36653e-05	Cu^+	1.78351e-13	1.13335e-11	Ba^{++}	2.73040e-07	3.74965e-05	Cu^+	1.87937e-13	1.19427e-11
SeO_3^{--}	1.29200e-07	1.64030e-05	Co^{++}	1.09184e-13	6.43458e-12	SeO_3^{--}	1.30866e-07	1.66145e-05	Co^{++}	1.04356e-13	6.15003e-12
$As(OH)_4^-$	1.15347e-07	1.64889e-05	V^{+++}	5.16411e-14	2.63067e-12	$As(OH)_4^-$	1.21547e-07	1.73752e-05	V^{+++}	5.37452e-14	2.73786e-12
Pb^{++}	6.12885e-08	1.26990e-05	U^{++++}	2.37301e-18	5.64846e-16	Pb^{++}	6.08078e-08	1.25994e-05	U^{++++}	2.30053e-18	5.47594e-16
H^+	0.000000	0.000000	Cr^{+++}	2.44667e-23	1.27217e-21	H^+	7.52159e-14	7.58101e-14	Cr^{+++}	2.61591e-23	1.36017e-21