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An Assessment of Soil Geochemical Methods for Detecting Copper-Gold Porphyry Mineralization through Quaternary Glaciofluvial Sediments at the Kwanika Central Zone, North-Central British Columbia

by

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EXECUTIVE SUMMARY

As part of a Geoscience BC funded study, a geochemical orientation survey was carried out over the blind Central Zone Cu-Au porphyry deposit at Serengeti's Kwanika project in north-central BC. The objective of this study was to test various widely used partial and selective extractions in a challenging cover environment to determine which performs the best at detecting the mineralization. In addition, the study aims to provide the mining industry with guidance on the optimum combination of soil horizon and extraction method for detecting deeply buried mineralization in areas of thick glacial cover.

In the study area, Cu-Au mineralization is associated with small monzonite intrusions emplaced along the western margin of the Hogem batholith. Mineralization consists of disseminated and fracture controlled pyrite, chalcopyrite and bornite (\pm molybdenite) with intense, texturally destructive albite alteration associated with a multi-phase stockwork of quartz veinlets. Surrounding this albitic core is a broad zone of weak to strong, pervasive and fracture controlled potassic alteration characterized by K-spar and secondary biotite. Potassic assemblages grade laterally into propylitic alteration. Supergene enrichment consisting of an upper oxide zone with native copper and a lower sulphide zone with secondary chalcocite occurs on the upper surface of the hypogene mineralization beneath a package of younger conglomerates and sandstones that bury the mineralization to the west. These sedimentary rocks are interpreted to be part of a post-mineral sedimentary basin formed against the Pinchi Fault, which truncates the intrusions and host rocks to the west.

The study area lies in a wide, flat-bottomed valley underlain by Quaternary-age glacial and glaciofluvial sediments, consisting of sands, gravels and conglomerates. Over the mineralization these reach 40 metres in thickness.

Soil samples were collected from Ah, Upper B, Lower B and C horizons from pits dug along two transects over drill defined mineralization. Transect 1 passes over a part of the mineralized body that subcrops beneath Quaternary sediments. In addition to the Quaternary deposits, Transect 2 crosses mineralization that underlies the post-mineral sedimentary basin. Here sulphides occur at depths of approximately 300 metres below the surface.

Results show that conventional soil sampling (i.e. -80 mesh, B-horizon, aqua regia) is ineffective in this environment. It fails to detect anomalies for the ore elements (Cu, Au, Mo and Ag) or the pathfinder elements (As, Sb, Se, U, W, Cd and Ca). Laboratory specific extractions like MMI-M (SGS) and Ionic Leach (ALS-Chemex), Enzyme Leach and Bioleach (Actlabs) also performed poorly. These methods, which are widely recognized as being capable of detecting deeply buried mineralization in a variety of environments, did not produce convincing responses here. In fact none of the methods that tested the B horizon, the traditional soil sampling medium, did very well. The most robust responses for ore and pathfinder elements were found at the base of the organic layer in the Ah horizon. An aqua regia digestion carried out on samples from this layer identified high to moderate contrast apical or rabbit-ear responses for Cu, Au, Ag, W, As, Sb and Ca on both lines. A sodium pyrophosphate leach performed almost as well, producing convincing responses for Cu, Au, Ag, As and U.

Field soil pH and conductivity measurements were found to be very effective at locating the position of the mineralization down to a depth of 300 metres. Conductivity and Inverse Difference Hydrogen (IDH) anomalies define what is interpreted to be a reduced chimney over the mineralization. The presence of a reduced chimney is supported by soil gas hydrocarbons method (SGH), which defines coincident apical and rabbit-ear responses. The presence of a reduced zone over the mineralization is also supported by high contrast U and W anomalies directly over the mineralization. These elements are highly insoluble under reducing conditions.

Results of this study show that in order to be successful, a soil sampling program over Quaternary glacial sediments in north-central British Columbia should collect the Ah horizon samples and use an aqua regia-low detection limit ICP-MS analyses. In addition, field based soil pH and conductivity measurements should be utilized in order to identify potential reduced chimneys over blind sulphide mineralization.

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INTRODUCTION AND OBJECTIVES

Exploration geochemistry in British Columbia has up to now relied on traditional methods, such as stream sediment and soil geochemistry, to detect metals dispersed mechanically and hydromorphically from outcropping sources. These methods have proven to be highly effective and there has been a long and impressive history of discoveries using them. As exploration maturity increases, however, mining companies are faced with the challenge of exploring more and more in areas of transported cover where traditional geochemical methods are less effective. Much of the central interior of British Columbia is covered by an extensive blanket of glacially derived sediments that completely masks the underlying bedrock. In order to deal with this cover, government, industry and academic institutions have invested heavily in developing airborne and ground geophysical methods to see through the exotic overburden. Unfortunately, geochemical exploration has not evolved as rapidly, despite the availability of a wide range of partial and selective extractions provided by the commercial laboratories. Reasons for this are varied and range from a general lack of understanding by the exploration community of the use and interpretation of these methods to skepticism about their effectiveness. It is only through well documented, nonbiased, comparative field testing of these methods that the exploration community can gain the knowledge and confidence to apply deep-penetrating geochemistry (DPG) to routine exploration programs.

There are relatively few examples of comprehensive comparative studies of DPG methods in BC. Cook and Dunn (2007) evaluated a number of partial leach methods over the 3T's epithermal Au-Ag prospect. They showed that B-horizon soils were more suitable than C-horizon tills for detailed geochemical sampling. Of the methods tested, they concluded that Mobile Metal Ion (MMI[®]) and Enzyme Leach[™] produced superior contrast responses to conventional aqua-regia digestion, although the latter method did detect mineralization in areas of thin cover. Lett and Sandwith (2008) carried out soil orientation surveys to test the effectiveness of a variety of selective and partial extraction methods at the Mouse Mountain, Shilo Lake and Soda Creek properties in the area of Quesnel and Williams Lake. Their study found that the most anomalous Cu and Au values, reflecting blind Cu-Au mineralization, occur in the C and lower B horizons with an aqua-regia digestion. A discussion of the performance of the various partial and selective extraction methods is still in preparation at the time of writing.

Outside BC, there have been a number of important studies of DPG in a variety of climatic and physiographic environments. Perhaps the landmark study has been the Deep Penetrating Geochemistry project, carried out by the Canadian Mining Industry Research Organization (CAMIRO). This study was funded by 26 mining companies, the Ontario Geological Survey and Geological Survey of Canada. Phase I considered movements of elements and ions from buried mineral deposits and nuclear waste facilities in arid and semi-arid environments. It showed that metals and ions can be transported to the surface by advective transport in gases and ground waters (Cameron et al., 2002) and can be effectively detected by partial-extraction methods. In Phase II, a variety of test sites in arid, semi-arid and temperate boreal forest environments were studied. It was found that in all environments partial- and selective-extraction anomalies were detected in soils above buried mineralization (Cameron et al., 2004) and in some cases through appreciable thickness of complex transported cover.

This study builds upon these important contributions by examining the effectiveness of a variety of partial and selective extractions over the Central zone at Serengeti Resources' Kwanika project in north-central BC. The Central Zone is an ideal test case for DPG methods. It comprises a well defined mineralized body with a measured resource of 182.6 Mt grading 0.29 % Cu and 0.28 g/t Au (Rennie and Scott, 2009). The west dipping body lies beneath several tens of metres of Quaternary glaciofluvial sediments. The up-dip part of the zone subcrops beneath the Quaternary cover while the deeper western part is also overlain by at least 250 metres of post-mineral sedimentary rocks deposited in a half graben basin along the nearby Pinchi Fault. As this is quite a recent discovery, the study area is relatively undisturbed and covered by pristine pine and spruce forest.

This report documents the results of a soil pH, conductivity and DPG orientation survey carried out by the senior author at the Kwanika Central Zone in August 2009.

This project is funded by Geoscience BC and carried out in partnership with Activation Laboratories Ltd., Acme Analytical Laboratories Ltd., ALS Chemex and SGS Mineral Services who provided generous support for the Analytical work.

OBJECTIVES

This project set out to address the following questions:

- Is soil pH effective at identifying sulphide mineralization through the Quaternary glacial sediment and post-mineral cover?
- Can soil geochemistry be used to reliably detect blind copper-gold porphyry-style mineralization through the transported cover?
- If so, in which horizon is the signal the strongest?
- Are there any benefits to using laboratory specific methods over generic methods?
- Which of the methods tested performs the best?
- What is the recommended strategy for soil sampling in areas of deep Quaternary sediment cover in central BC?

BENEFITS TO THE MINING INDUSTRY

Independent, nonbiased studies of commercially available partial and selective extractions are few and far between, particularly in BC. These studies are important as they provide the exploration community with valuable insight into the appropriate sampling strategy and combination of analytical methods for a given environment. Without this type of study, the exploration geologist must rely on information provided by the commercial laboratories, who promote their own methods to see through transported cover. Without knowledge of the relative performance of these methods in different cover environments and for different deposit types, the exploration geologist could choose an inappropriate method on the basis of a laboratory's marketing rather than on sound scientific knowledge. This could be an expensive mistake. While all of the methods tested in this study have their merits, it is important to recognize that none of them can be used blindly in all environments. One size does not fit all. This study and others that have preceded it (Cook and Dunn, 2007; Lett and Sandwith, 2008) provide the exploration geologist with the knowledge and tools necessary to make an informed decision and therefore to maximize the benefit of their investment in geochemistry.

Another benefit of this type of study is that it gives mining companies a set of exploration tools and knowledge to help them improve their success rate for exploration projects in covered areas. Deep-penetrating geochemical methods can be used to effectively prioritize drill hole locations to test geophysical targets. Geochemical data can provide an additional layer of information to help discriminate potentially mineralized and barren targets, thus reducing drilling risk and ultimately protecting share holder value.

LOCATION AND ACCESS

The Kwanika project is situated in the Omineca Mining Division of north-central British Columbia, approximately 140 km northwest of Fort St. James and (55°30'N, 125°18'W; Fig. 1). It is accessible by well-maintained Forest

Service roads from Fort St. James via the community of Takla Landing. Serengeti Resources Inc., the owner, holds the title to 28 contiguous mineral claims covering an area of 8,960 ha (Rennie and Scott, 2009).

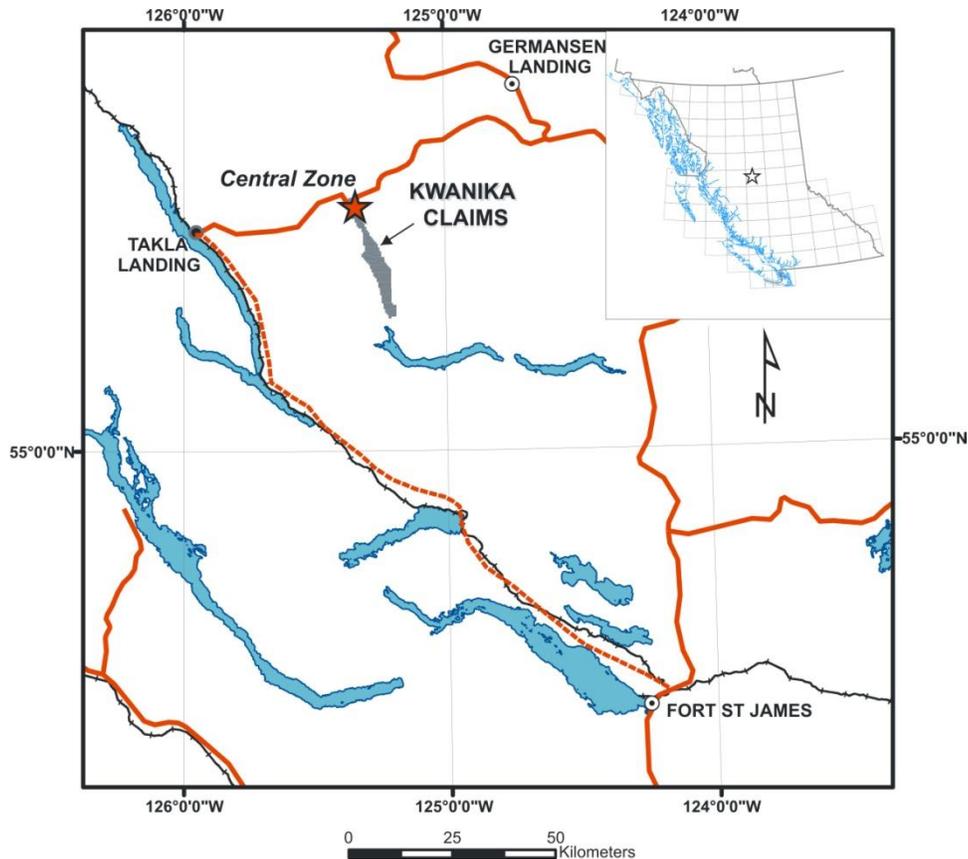


FIGURE 1. LOCATION OF THE STUDY AREA.

SURFICIAL ENVIRONMENT

The Kwanika Central zone lies in a broad, flat-bottomed valley containing an extensive cover of glacial till and outwash sediments. Locally, elevations range from 900 to 1200 metres, but in the study area itself there is only about 40 metres of relief. Drilling has shown that the cover varies in thickness from a few metres to over 40 metres in thickness in the immediate deposit area (D. Moore, pers. comm., 2009). Outcrops are rare and only seen in the bottom of the Kwanika Creek valley, which is deeply incised into the Quaternary sequence (Rennie and Scott, 2009). Away from the river valley, the surface is well-drained and gently sloping and covered by a relatively open lodgepole pine and white spruce woodland (Fig. 2).



FIGURE 2. A TYPICAL SAMPLE LOCATION AT THE KWANIKA CENTRAL ZONE.

Three types of soil profile are present in the Central zone area. These are for the most part developed on a parent material of cobble-rich sand and gravel. Podzols (Orthic Ferro-Humic; soil nomenclature based on the Canadian System of Soil Classification [Canada Soil Survey Committee, Subcommittee on Soil Classification, 1978]) are the most widespread soil type, occurring on well drained, gentle slopes within the pine and spruce forest. A typical profile (Figure 3) includes a thin LFH horizon consisting of partially decomposed wood, twigs, needles and mosses and a thin (<1 cm) black to dark brown, organic-rich Ah horizon. The organic-rich layers overlie a distinct white to grey or pinkish, sandy textured Ae or Aej horizon of variable thickness. Below this, the B horizon is made up of an upper Bf horizon (upper B), enriched with iron oxide, and a lower, medium to chocolate brown, BC horizon (lower B), which grades into medium to dark grey sand or gravel of the C horizon.



FIGURE 3. A TYPICAL PODZOL PROFILE FROM THE CENTRAL ZONE.

Brunisol, the second soil type, is common at the base of slopes adjacent to boggy areas (Fig. 4a). A typical example has a surficial LFH and Ah horizon up to 4cm thick overlying an undifferentiated olive-brown Bm horizon. The third soil type is represented by Organic soils. These occur in depressions and boggy areas (Fig. 4b). Profiles consist of an upper thick, peaty Om horizon that can be tens of centimetres thick, overlying a lower grey or blue-grey C horizon. A mottled Bg horizon was noted at one locality. In all cases, the lower part of the profile is water saturated.

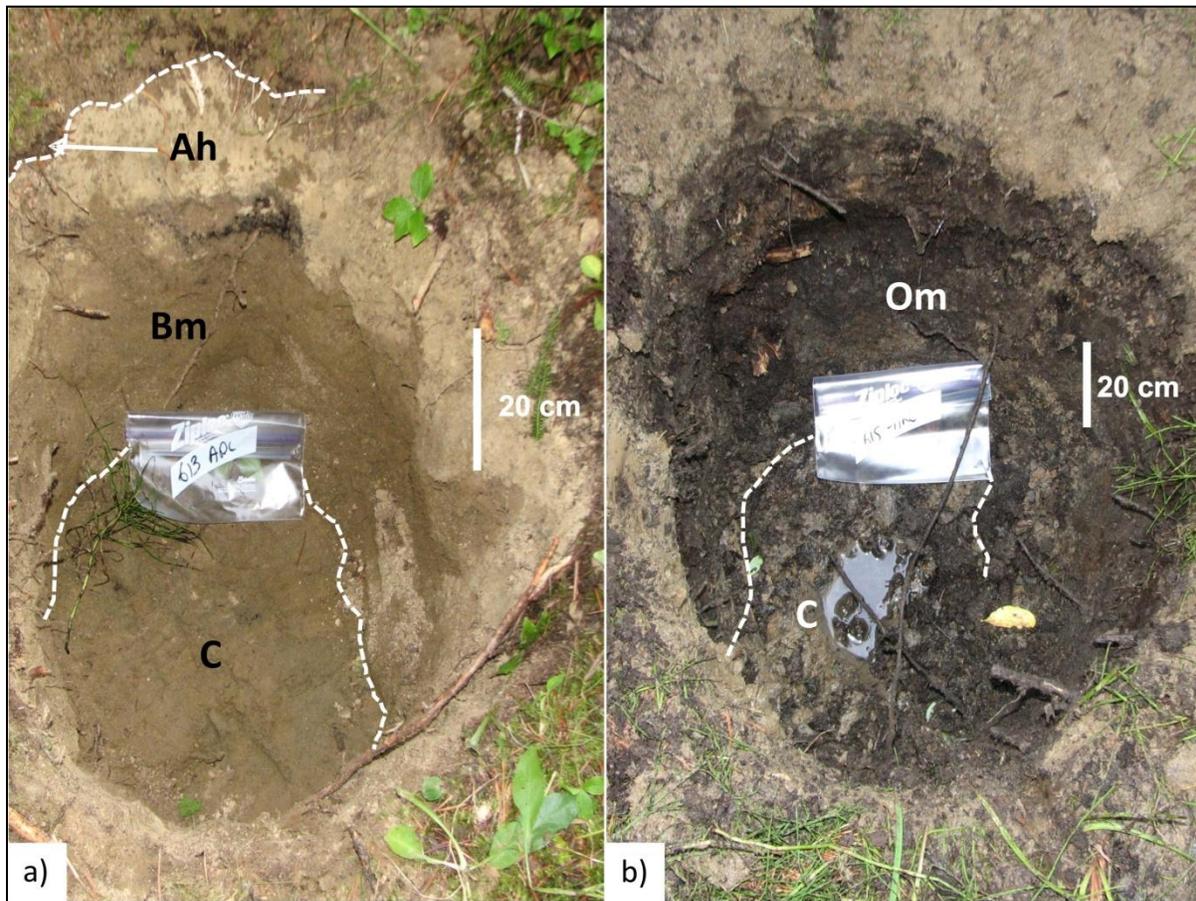


FIGURE 4. SOIL PROFILES FROM THE KWANIKA CENTRAL ZONE AREA. A. BRUNISOL. B. ORGANIC SOIL.

GEOLOGY

REGIONAL SETTING

The Kwanika property lies in the northern part of the Quesnellia Terrane, or Quesnel Trough, which consists of a belt of Early Mesozoic volcanic and intrusive rocks sandwiched between highly deformed Proterozoic and Paleozoic strata of the Slide Mountain Terrane to the east and deformed Upper Paleozoic strata of the Cache Creek Terrane to the west (Garnett, 1978; Fig. 5). The Quesnel Trough hosts numerous alkalic, transitional and calc-alkalic porphyry copper-gold deposits, including Mt. Milligan and Lorraine. Porphyry-style mineralization is associated with island arc-related, Upper Triassic to Lower Jurassic volcanism and plutonism (Nelson and Bellefontaine, 1996).

In the Kwanika area, Quesnellia is bounded by the Pinchi Fault to the west and by the Manson Fault to the east. The Pinchi Fault juxtaposes Permian Cache Creek Terrane rocks to the west against the Upper Triassic Takla Group rocks of the Quesnel Terrane to the east (Fig. 6). Porphyry copper-gold mineralization occurs in the Takla Group rocks and is associated with several irregular-shaped monzonite stocks that intrude along the western margin of the multiphase Hogem batholith (Rennie and Scott, 2009). Host rocks include diorite, quartz monzonite and granite phases of the batholith as well as Takla Group andesitic volcanic rocks.

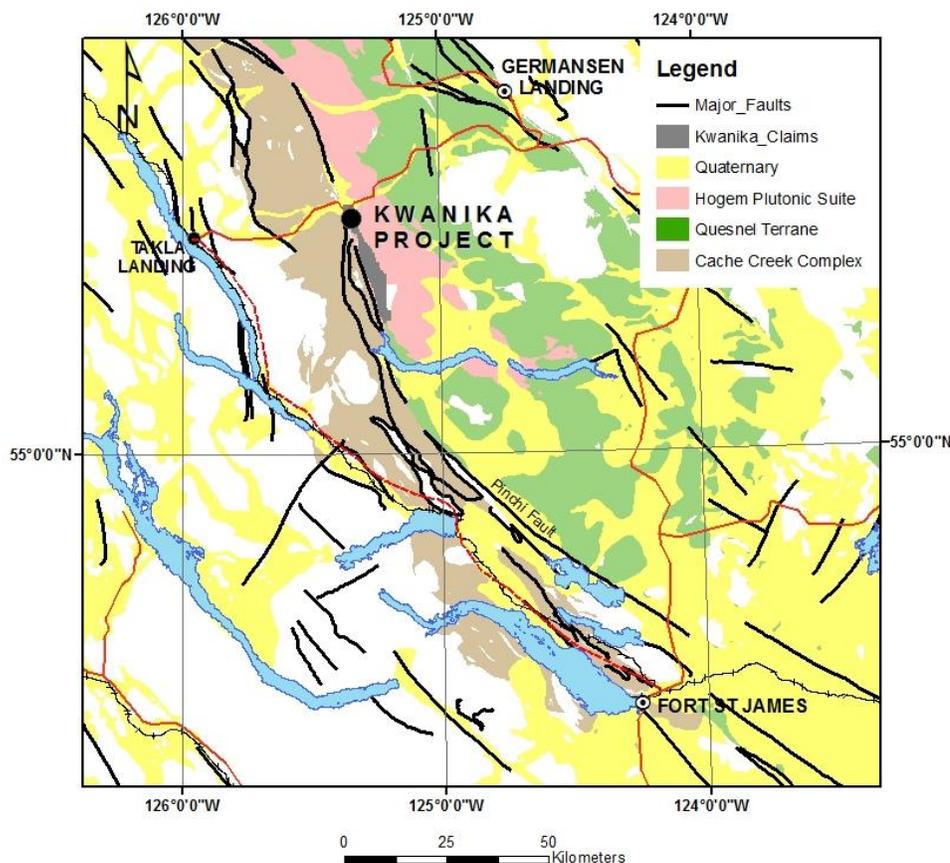


FIGURE 5. REGIONAL GEOLOGICAL SETTING.

LOCAL GEOLOGY

Two zones of porphyry-style mineralization occur at Kwanika. These are: the Central Zone (Cu-Au), which is the focus of this study, and the South Zone (Cu-Mo-Au-Ag). Mineralization at the Central Zone is developed in and around a north-northeast trending monzonite stock that dips shallowly to steeply to the west (Fig. 6). The intrusion consists of a medium-grained, equigranular to feldspar porphyritic rock, made up of plagioclase and K-feldspar, with lesser amounts of amphibole, biotite, quartz, and tourmaline. Highest grade copper-gold mineralization (>0.6% copper equivalent) occurs within, and immediately adjacent the intrusion. The monzonite intrudes into variably copper and gold-mineralized diorites and monzodiorites of the Hogem Batholith Intrusive Suite (Garnett, 1978) as well as Takla Group andesitic volcanic rocks (Fig. 6).

Mineralization is associated with a core zone of intense, texturally destructive albite alteration associated with a multiphase quartz stockwork. Surrounding the albite core is a broad zone of weak to strong, pervasive and fracture-controlled potassic alteration characterized by K-feldspar and secondary biotite (Rennie and Scott, 2009; H. Samson, pers. comm., 2009). This alteration grades laterally into propylitic assemblages. Dominant sulphide minerals include pyrite, which is ubiquitous to the deposit, chalcopyrite and bornite. Molybdenite is also commonly present.

Subsequent to the mineralizing event, the intrusive and volcanic units were locally rotated by listric (?) faulting and overlain to the west by a clastic sediment-filled, half-graben-shaped basin, developed up against the Pinchi Fault. The sedimentary rocks, which consist of conglomerates, sandstones and siltstones, partially cover the Central Zone

(Fig. 4). They thicken to the west and attain a maximum observed thickness (from drill holes) of 435 m along the Pinchi Fault. Outcrop on the property is rare as much of the area is covered by 20-40 metres of Quaternary glaciofluvial sediments.

A zone of supergene enrichment consisting of an upper oxide zone containing native copper and a lower sulphide zone with secondary chalcocite and covellite occurs on the upper surface of the hypogene mineralization at the contact with the post mineral sedimentary rocks.

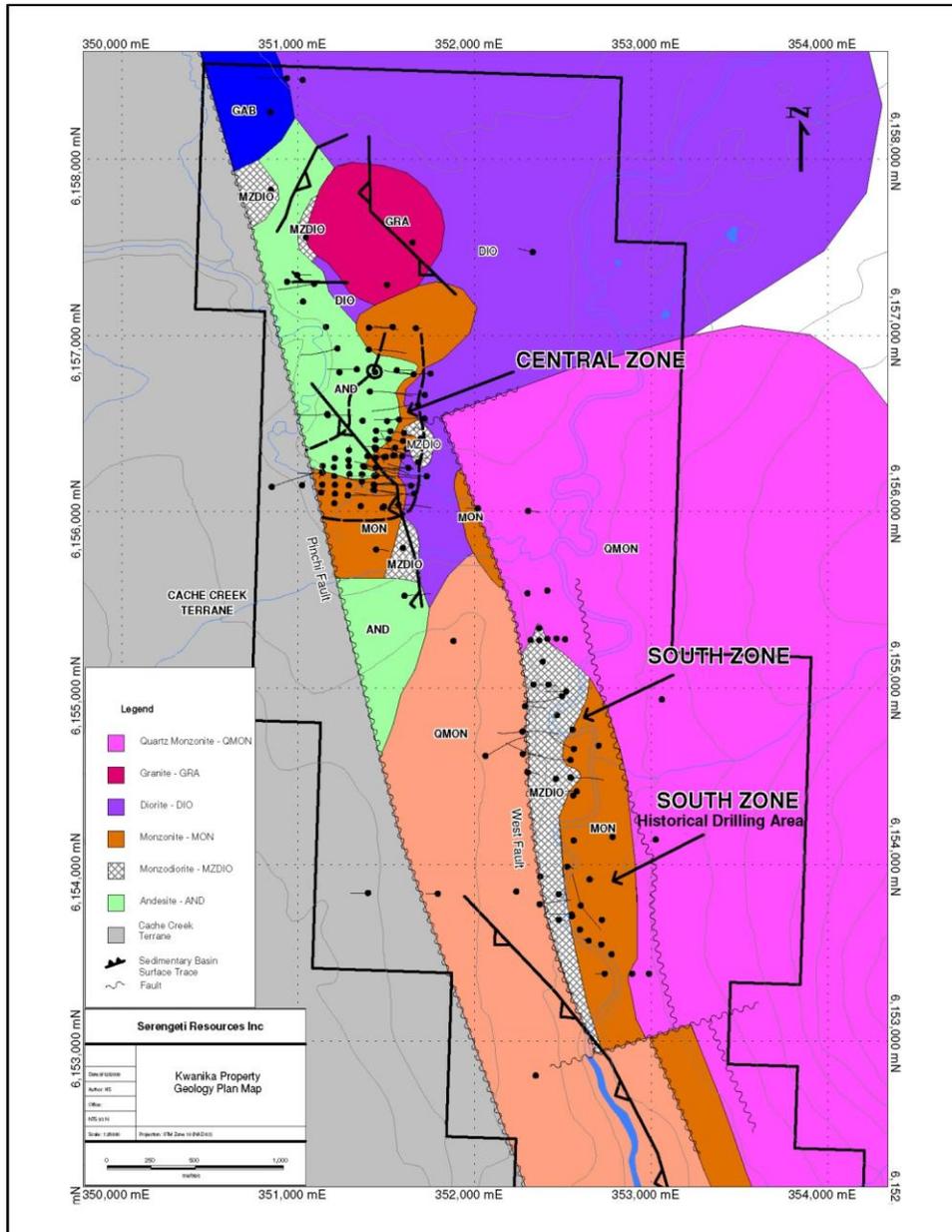


FIGURE 6. LOCAL GEOLOGY OF THE KWANIKA CENTRAL ZONE AREA (COURTESY OF SERENGETI RESOURCES INC.).

EXPLORATION HISTORY

Copper mineralization was first recognized along Kwanika Creek in 1964. Initial exploration carried out by Hogan Mines Ltd. (later Bow River Resources Ltd.) consisted of geochemistry, trenching, prospecting, mapping and two X-Ray drill holes totalling 26.5 metres. The property was subsequently optioned to several companies, including Canex Aerial Explorations Ltd. (1965), and Great Plains Development Company of Canada Ltd. (1969), Bow River Resources Ltd. (1972) and Pechiney Developments Ltd. (1973). From 1966-1974, these companies carried out several geophysical surveys (magnetic and IP), soil geochemistry, bull dozer trenching as well as percussion and diamond drilling programs totalling 2,707 metres. The historical drilling focused on a small area along Kwanika Creek and was successful in defining a poorly constrained, 36 Mt (non 43-101 compliant) body of mineralized material, grading approximately 0.20% Cu with minor Mo. No significant work was carried out on the property again until 1989 when the area was restaked by W. Halleran, who recognized the copper-gold affinity to the mineralization (Buskas et al, 1989). Eastfield Resources Ltd. optioned the property that same year and formed a joint venture with Northair Mines Ltd. The joint venture carried out an aggressive exploration program consisting of line cutting, prospecting, mapping, rock and silt sampling on the Swan 1 to 8 claims. Samples from previous drill holes were also reanalyzed. Four diamond drill holes (549 metres) drilled west of the previously defined mineralization in 1991 detected sporadic copper mineralization along the east side of the Pinchi Fault.

Based on the results of the historical exploration, Serengeti Resources Inc. staked the current claims between 2004 and 2006. In 2005, the company conducted a 530 line kilometre airborne magnetic and radiometric survey, and collected 11 rock samples to assist in porphyry target identification (Osatenko, 2005). The airborne survey identified a small magnetic anomaly on the east side of the known deposit, with similar anomalies trending to the north-northwest and south. Over the course of 2006 and 2007, Walcott Geophysics (Walcott) carried out several ground-based induced polarization (IP) surveys to further investigate the trend of magnetic anomalies.

Results from a 2006 IP survey identified a significant chargeability anomaly over the historical mineralization and defined a north-northwest continuation of the anomaly into an area of glaciofluvial cover (Fig. 7). Drill testing of the chargeability anomaly later that summer confirmed the copper grade of the known mineralization and discovered a new zone with porphyry characteristics, approximately 2 km to the north (hole K-06-04, 0.32% Cu and 0.15 g/t Au over 18.3 m). In November and December 2006, five diamond drill holes (1,215 m) were drilled in the vicinity of hole K-06-04, resulting in the Central Zone discovery hole (K-06-09 - 0.69% Cu and 0.54 g/t Au over 111 m). From 2006-2009, Serengeti drilled 62,280 m of core into the Central and South Zones, defining a measured resource of 182.6 Mt grading 0.29 % Cu and 0.28 g/t Au (Rennie and Scott, 2009) and an additional inferred resource of 28.5 Mt grading 0.19 % Cu and 0.20 g/t Au.

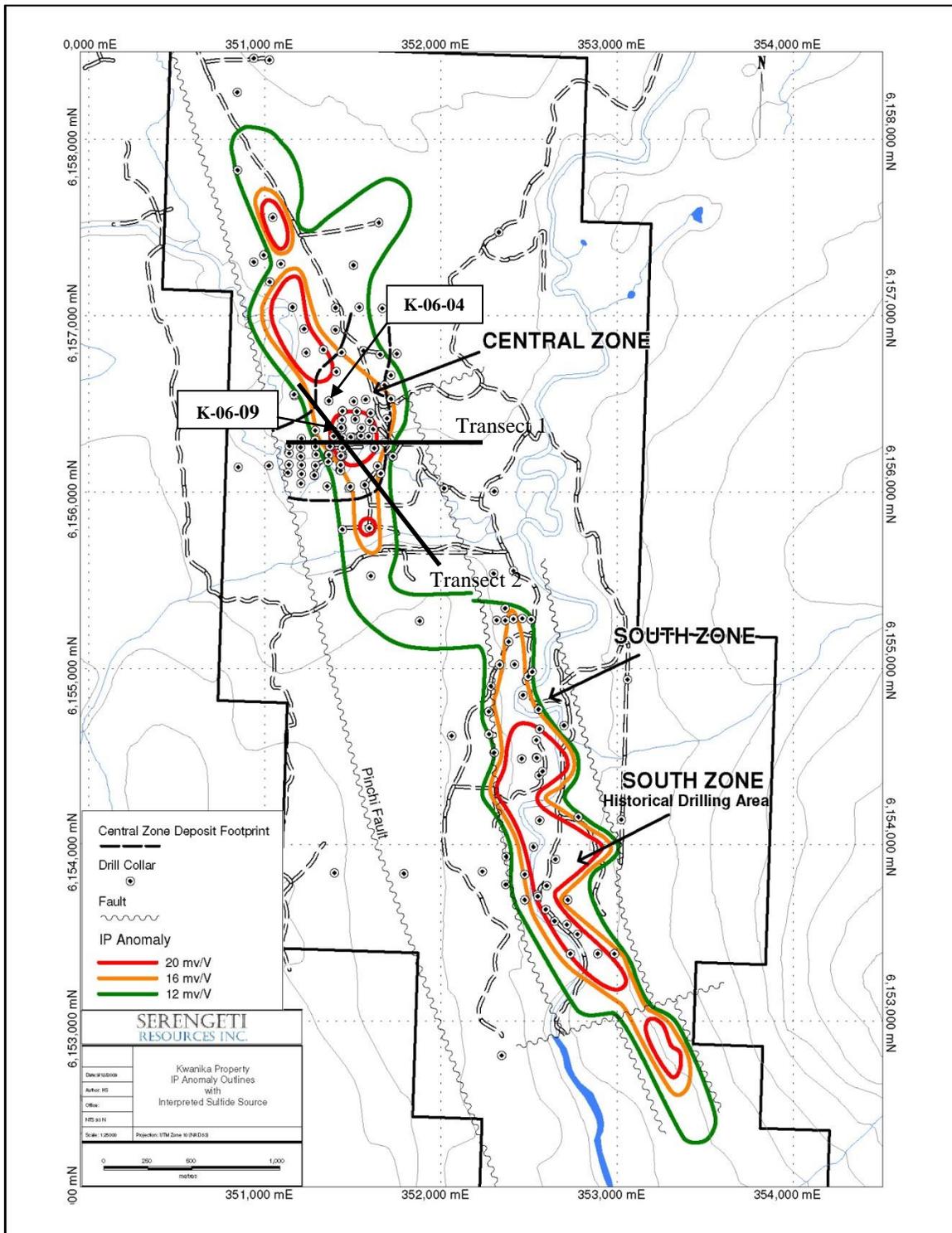


FIGURE 7. KWANIKA PROJECT MAP SHOWING MINERALIZED ZONES AND IP ANOMALIES. THE LOCATION OF THE TWO TRANSECTS SAMPLED IN THIS STUDY ARE SHOWN.

FIELD METHODS

SAMPLING PROCEDURES

Two Transects of soil pits (52 locations) were sampled across the Central zone (Fig. 7 and 8). The east-west transect (Transect 1), which comprises 24 sample sites, passes over the portion of the deposit that subcrops beneath the Quaternary cover (Fig. 9). The Transect extends from the Pinchi fault in the west to approximately 350 metres east of the deposit, where drilling indicates that there is no mineralization. A northwest-southeast line, Transect 2, comprising 29 sample sites crosses the portion of the deposit that underlies a post-mineral sedimentary basin. In this area, the mineralization is present at a depth of approximately 300 metres below surface and is masked by both the post-mineral sedimentary cover and an overlying veneer of Quaternary glacial outwash sediments (Fig. 10). The two transects provide different challenges to the methods being tested. Sample sites are spaced at 50 metre intervals in inferred background areas and at 25 m intervals over the deposit itself.

At each site a 50 by 50 centimetre hole was excavated down to the C horizon to expose the complete soil profile. Each hole was photographed and described using a geochemical coding form and codes proposed by Hoffman (1986), along with the details of the immediate area. Parameters recorded include colour, texture, abundance and shape of coarse fragments, dampness and profile type. A variety of samples were collected from each sample hole as summarized in Table 1. Five samples were taken from the upper B horizon and one each from the Ah, lower B and C. Ah samples were collected from several spots around the sample site but not from the hole itself. This was done to avoid contamination from excavated material and to ensure enough sample material was collected. Sampling was done by hand by peeling back the surface layer of mosses and undecomposed organic matter and sampling the black decomposed material at the mineral soil interface. The sample was placed into a Hubco™ polyweave sample bag to allow it to breath and to prevent decomposition prior to arrival at the laboratory.

Upper B, lower B and C horizon samples were collected in the same way. Material was taken from the sides of the hole using a trowel and screened to -12 mesh onto a plastic sheet to remove rock fragments and organic debris. Approximately 500 grams of this material was placed in breathable Hubco™ polyweave sample bags. Where soil moisture precluded screening, rocks and other coarse debris was removed from the sample by hand. MMI samples were collected using the SGS Minerals Services recommended protocol. Material was taken from a continuous vertical interval from 10 to 25 centimetres below the top of the mineral soil using a plastic scoop. A composite of approximately 350 grams was collected and sealed in heavy duty Ziploc bags. At most localities, this constant depth interval corresponds to a mixture of upper B (Bf or Bm) and lower B (BC) horizons. Finally, samples for pH and conductivity measurements were collected from the top centimetre of the mineral soil, located immediately beneath the organic Ah layer. Approximately 100 grams of this material, usually from the leached Ae horizon, was collected and sealed in Ziploc bags for analysis at the camp the same day.

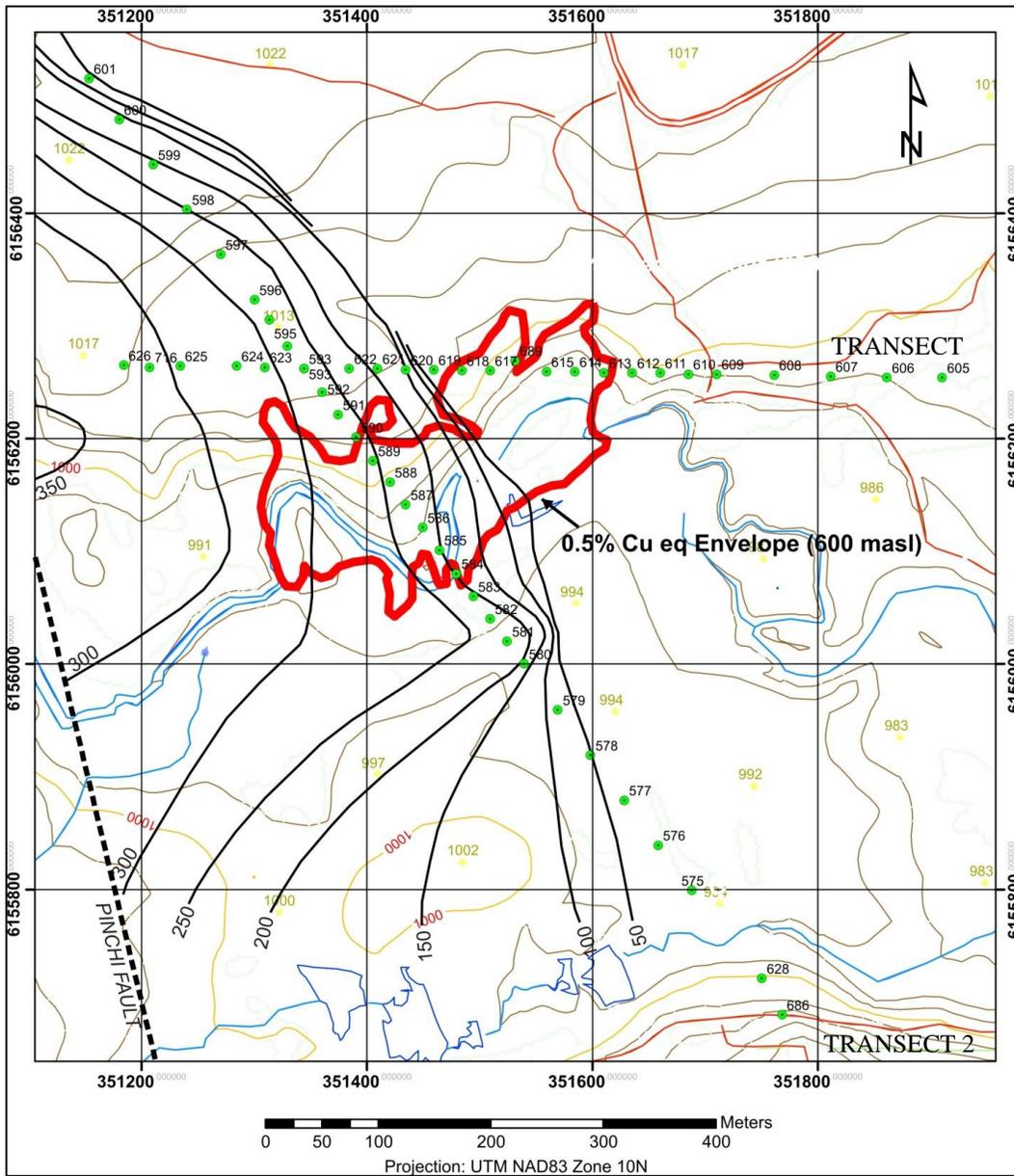


FIGURE 8. LOCATION MAP SHOWING THE SOIL TRANSECTS, SAMPLE STATION NUMBERS AND THICKNESS OF THE POST-MINERAL SEDIMENTARY BASIN AT THE KWANIKA CENTRAL ZONE.

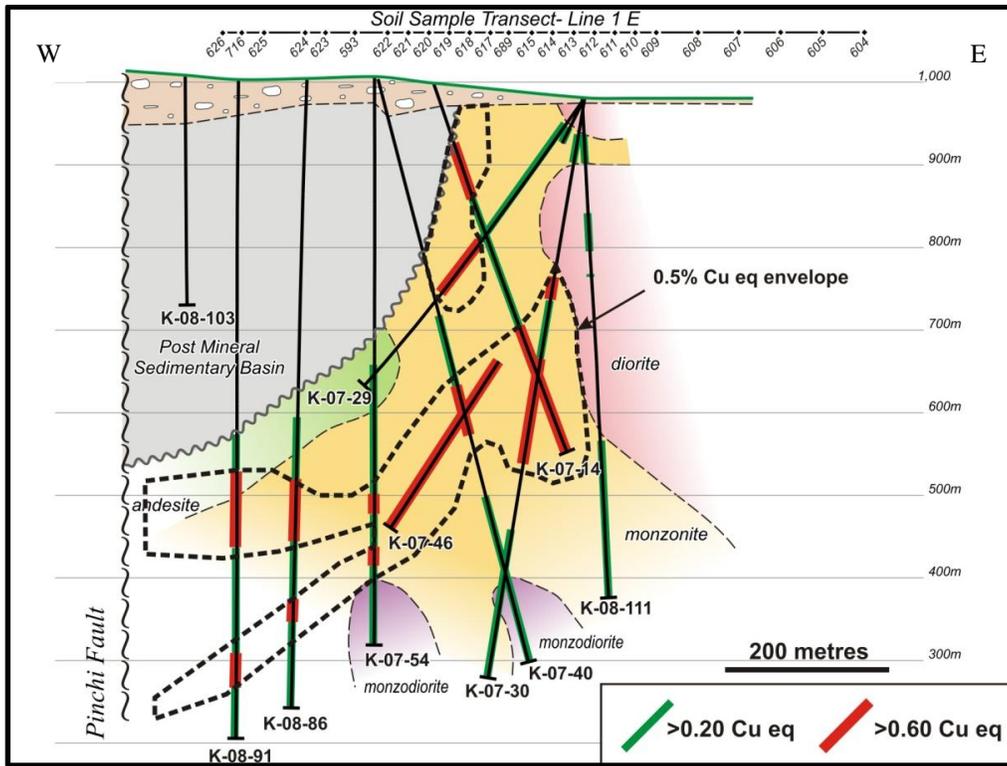


FIGURE 9. GEOLOGICAL CROSS SECTION ALONG TRANSECT 1 (COURTESY OF SERENGETI RESOURCES INC.).

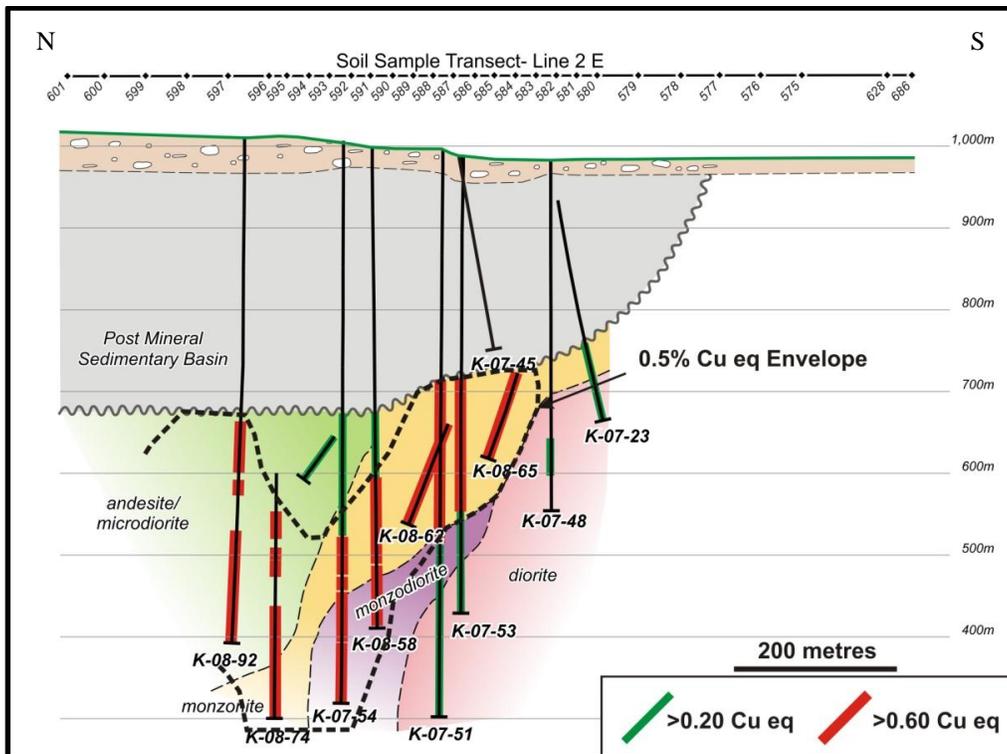


FIGURE 10. GEOLOGICAL CROSS SECTION ALONG TRANSECT 2 (COURTESY OF SERENGETI RESOURCES INC.).

TABLE 1. SUMMARY OF SAMPLE MEDIA AND ANALYTICAL METHODS.

Analytical Method	Ah	Ae	Upper-B	Lower-B	C	Other	Laboratory
Sodium Pyrophosphate	X						Acme
Field pH/Conductivity		X**					Field
Aqua regia	X		X	X	X		Acme/SGS
Cold aqua regia			X				ALS
Hot hydroxylamine HCl			X				ALS
Cold hydroxylamine HCl			X				ALS
De-ionized Water			X				Acme
Ionic Leach			X				ALS
Bioleach			X				Actlab
Enzyme Leach			X				Actlab
SGH			X				Actlab
Supertrace Au			X				ALS
Fire Assay Gold			X	X	X		SGS
LOI	X						Acme
MMI-M						X*	SGS

* Sample collected from 10 to 25cm below top of mineral soil.

** Samples collected from top centimeter of the Ae horizon or below top of mineral soil.

SOIL pH AND CONDUCTIVITY MEASUREMENTS

A description of the soil pH and conductivity survey over the Kwanika Central Zone is included in Heberlein (2010). Conductivity measurements were made on a 1:1 slurry of soil in demineralized water using a VWR International conductivity meter. pH readings were taken on the same slurry using an Oakton® Instruments double junction pHTestr® 30 handheld pH meter. The instrument was calibrated daily using standard pH buffer solutions at pH 4.00, 7.00 and 10.00. Two pH measurements were taken on each sample: one 20 seconds after immersion of the electrode into the slurry and a second measurement 20 seconds after adding one drop of 10% hydrochloric acid and stirring. pH readings were recorded into an Excel spreadsheet and converted to H⁺ concentrations for interpretation.

QUALITY CONTROL MEASURES

Quality control (QC) measures used in this study include the collection of two types of field duplicates. In each survey area, five sites (about 10%) were randomly selected for field duplicate sampling. Two types of duplicates were collected at these sites: within-hole and between-hole duplicates. Within-hole duplicates are a repetition of the original sampling procedure, collecting another soil sample from the cleaned walls of the soil pit. Between-hole duplicates are taken from a second hole dug as close to the original as possible, usually within 2 metres. All duplicate samples were submitted blind to the laboratory.

No standard reference materials were used in this study. The reason for this is the unavailability of suitable matrix-matched materials for the range of sample media collected that are certified for the methods being tested. In order to monitor and mitigate analytical drift, the samples were randomized prior to submission to the laboratory. Randomization has the benefit of distributing the effects of instrumental drift randomly throughout the sample population. It also allows for drift monitoring by plotting the samples in analytical order.

In addition to the field QC procedures, a number of steps were taken at the laboratories to ensure the quality of the analytical results. These include the introduction of analytical standards, blanks and lab duplicates into the sample stream.

LABORATORY METHODS

SAMPLE PREPARATION

Soil samples were shipped to four different commercial laboratories for a variety of analyses as summarized in Table 1.

Ah horizon samples were processed at Acme Analytical Laboratories in Vancouver, where they were air dried at 35 to 40 °C and milled prior to leaching with sodium pyrophosphate and digested with aqua regia. LOI was also carried out on these samples to measure the organic carbon content.

Upper B, lower B and C horizon samples sent to SGS Minerals Services in Toronto for conventional aqua regia digestion and 30g fire assay were prepared by drying at 105 °C, disaggregating and screening to -0.18mm. MMI samples, also analyzed at SGS, were air dried at <60 °C but otherwise received no other preparation prior to leaching. Upper B horizon samples for hot and cold Hydroxylamine Hydrochloride extraction and Supertrace gold analyses were prepared at ALS-Chemex in Vancouver by air drying at <60 °C and screening to -0.18 mm. A second upper B horizon sample was shipped directly to ALS-Chemex in Perth, Australia without preparation. There the sample was split and one half screened to <0.18 mm for cold aqua regia digestion and the other half leached whole by Ionic Leach.

Upper B horizon samples sent to Actlabs in Ancaster, Ontario for Bioleach, Enzyme Leach and Soil Gas Hydrocarbons (SGH). There the samples were air dried and screened to <0.23mm for Enzyme Leach and 0.18mm for Bioleach. Preparation of samples for SGH is a proprietary method of Activation Laboratories Ltd.

DIGESTIONS AND ANALYSES

Analyses carried out at the four laboratories included a variety of generic and laboratory specific¹ partial and selective extractions (Table 1). Laboratory specific extractions included Enzyme leach (EL), Bioleach (BL) Ionic leach (IL) and MMI-M (MMI). In addition, SGH was performed by Activation Laboratories using their proprietary method (Actlabs Brochure; Sutherland, 2009).

Several low detection limit gold methods were employed in this study. These include ALS-Chemex's Supertrace (ST) gold method (0.2 ppb detection limit), MMI (0.1 ppb detection limit), Acme Laboratories' Ultratrace gold (0.2 ppb detection limit), ALS-Chemex's Ionic Leach (0.02 ppb Detection limit) and Cold aqua regia (1 ppb detection limit). In addition to these, conventional fire assay-AAS analyses were carried out on upper B, lower B and C horizon samples (1 ppb detection limit).

The following is a brief description of the analytical methods employed in this study. A list of methods and their corresponding detection limits is included in Appendix 1.

¹ These are proprietary or non proprietary methods specific to individual laboratories.

Aqua regia (AR - SGS Code ICM14B): This method is a traditional aqua regia digestion using a 3:1 combination of HCl: HNO₃ on a 15 gram sample aliquot of the <0.18mm fraction. Analyses for 52 elements are by a combination of ICP-OES and ICP-MS.

Aqua Regia (AR - Acme Code 1F05): This is a modified aqua regia digestion utilizes a 1:1:1 HCl:HNO₃:H₂O combination to achieve ultra low detection limits for many elements. Analysis for 53 elements is carried out on a 15 gram aliquot of the <0.18mm fraction using the Perkin Elmer Elan 6000 or 9000 ICP-MS to resolve very low concentrations.

Cold aqua regia (CAR - ALS-Chemex Code ME-MS41b): This variant of the aqua regia digestion uses a conventional 3:1 combination of HCl:HNO₃ at room temperature (25°C). The digestion is carried out on a 0.5 gram aliquot of the <0.18 mm fraction and analysis for 51 elements is by a combination of ICP-OES and ICP-MS. Cold aqua regia is considered to be a less aggressive leach than conventional aqua regia and is able to extract the most leachable components from the sample, including fine grained gold particles. The extraction is non selective.

Supertrace Gold (ST - ALS-Chemex Code Au-ST43): This method uses a conventional aqua regia digestion on a 25 gram aliquot of the <0.18mm fraction. The dissolved gold is complexed with dibutyl sulphide and extracted into an organic solvent. The gold is determined by Zeeman graphite furnace AAS.

Cold Hydroxylamine Hydrochloride (CHDX - ALS-Chemex Codes ME-MS05): Cold hydroxylamine hydrochloride leach is selective for manganese oxides (also dissolving a small amount of amorphous hydrous iron oxide). It is useful for liberating metal ions adsorbed onto manganese oxide coatings on mineral grains in the soil. The method uses a 1.0 gram aliquot of <0.18mm fraction and mixes it with 20ml of 0.1M hydroxylamine hydrochloride in 0.01M HNO₃. The sample is rolled for two hours at room temperature. The final solution is separated by centrifuging and the supernatant fluid is decanted. Analysis for 51 elements is by ICP-MS. The final solution pH is also measured.

Hot Hydroxylamine Hydrochloride (HHDX - ALS-Chemex Code ME-MS06): This method is more aggressive than the cold leach and is used to decompose amorphous hydrous iron (and manganese) oxides. A 1.0 gram sample of the <0.18mm fraction is mixed with 20ml of 0.25M hydroxylamine hydrochloride (in 0.25M HCl) and digested in a hot water bath at 60°C for two hours. The supernatant fluid is separated and analysed for 51 elements by ICP-MS. Final solution pH is also measured.

Sodium pyrophosphate (SPY - Acme Code 1SLO): This leach is used to extract elements adsorbed by humic and fulvic compounds in organic rich soils. A 1.0 gram sample of milled organic material (Ah horizon) is mixed with 25ml of a neutral (pH 7) 0.1M sodium pyrophosphate solution and rolled for one hour at room temperature. The final solution is centrifuged and the supernatant fluid decanted and analyzed for 58 elements by ICP-MS.

Distilled water (DI - Acme Code 1SLW): Leaching with distilled water was carried out on a 1.0 gram aliquot of <0.18 mm sample. The sample was mixed with 10ml of distilled water and rolled for two hours at room temperature. Analysis of the supernatant fluid for 33 elements was done by ICP-MS.

Ionic Leach (IL - ALS-Chemex Code ME-MS23): This is a new partial leach developed by ALS-Chemex to detect subtle variations in trace element concentrations in soils caused by ionic dispersion from underlying mineralization. The method uses a sodium cyanide leach buffered to pH 8.5 and containing chelating agents ammonium chloride, citric acid and EDTA to liberate weakly bound ions from particle surfaces. The leach is carried out on a 50g aliquot of <0.18mm fraction. Samples are agitated every two hours for six hours at 21°C. The final solution is centrifuged and the fluid decanted for analysis for 58 elements by ICP-MS.

Enzyme Leach (EL - Actlabs Code 7): This is a selective leach method that targets amorphous manganese and iron oxide grain coatings in the soil. A 0.75 gram sample of <0.23mm fraction is leached in a solution containing glucose oxidase and dextrose at 30°C for one hour. The enzyme reacts with the glucose to

produce a weak hydrogen peroxide solution, which reduces and dissolves amorphous iron and manganese oxides. Released metals become complexed with the gluconic acid reaction product. Solutions are analyzed on a Perkin Elmer ELAN 6000, 6100 or 9000 ICP-MS.

Bioleach (BL - Actlabs): A proprietary selective leach designed to liberate metals from bacterial protein remnants in the soil. A 0.75g aliquot of -0.18mm upper B horizon material is leached for 1 hour at 30 °C. Solutions are analyzed on a Perkin Elmer ELAN 6000, 6100 or 9000 ICP-MS.

SGH (SGH - Actlabs): This proprietary method extracts organic compounds adsorbed onto particles in the soil B horizon. It provides highly sensitive analysis of 162 organic compounds in the C5-C17 range using gas chromatography/mass spectrometry (GC/MS). Analysis utilizes a very weak leach to liberate the hydrocarbons from the sample. They are then separated using high capillary column gas chromatography. Together with Bioleach (see above) this method is designed to detect near surface redox variations present above deeply buried sulphide mineralization and hydrocarbons produced directly from the sulphide source as a result of bacterial activity.

MMI-M (MMI - SGS Minerals Services): MMI-M is a proprietary method designed to liberate weakly bound elements from the soil either by desorption or dissolution. The extraction uses strong ligands to bind released metal ions and keep them in solution. Analysis of the leachate is done by low detection limit ICP-MS.

RESULTS

DATA QUALITY

For the purpose of this report, data quality is assessed using average percent relative standard deviation (also known as the % coefficient of variation), or average RSD% as an estimate of precision or reproducibility of the analytical results. Average RSD% is estimated using the results of the field duplicates (for both hole and site duplicates) and can therefore be considered an estimate of the cumulative uncertainty of the sampling and analytical process. Field duplicate results provide important information about the homogeneity of the sample medium and the representativeness of the sampling method employed. Through the use of site duplicates the within-site variability can also be assessed.

Average RSD% is determined from the duplicate results by first calculating the mean and standard deviation of each duplicate pair. An RSD% value is then calculated for each duplicate pair using the formula:

$$\text{RSD\%} = \text{standard deviation/mean} \times 100$$

The average RSD% is then determined by averaging the RSD% values for the duplicate pairs. This has been done for soil pH and conductivity measurements and a selection of elements for each analytical method. A spreadsheet with the calculations is included in Appendix 2. In the following discussions, average RSD% values below 30% are considered to indicate very good data quality; between 30 and 50%, moderate quality and over 50%, poor quality. The higher an average RSD% value is, the less likely it is to be able distinguish a real patterns from noise. Noise is considered as the cumulative effect of geological background variation plus sampling error.

SOIL pH AND CONDUCTIVITY

Table 2 shows the results of the field duplicate samples for soil pH and conductivity measurements. Values for the pH and acidified pH are below 10% indicating that the results are highly reproducible and that the data is of a very high quality. It is interesting to note that the RSD% values for the between-hole duplicates are actually slightly

lower than for the within-hole duplicates. The reason for this is unclear. These results show that there is little variation in the soil pH values over distances of a few metres from a sample site.

TABLE 2. AVERAGE RSD% VALUES FOR SOIL PH AND CONDUCTIVITY MEASUREMENTS.

	pH	pH (Acid)	Conductivity
Hole Duplicate	9.24%	2.97%	32.72%
Site Duplicate	7.10%	2.82%	18.77%

Conductivity measurements have a higher uncertainty than the pH measurements with average RSD% values ranging from 18.77% to 32.72%. This is still within an acceptable range. Once again the between-hole values are marginally lower than those from the same hole; an observation that is not easily explained.

PARTIAL AND SELECTIVE EXTRACTIONS

Average RSD% values for selected elements from the partial and selective extractions are presented in Tables 3 and 4. Values have been classified to reflect data quality, with black signifying good quality (RSD% <30%), green acceptable quality (RSD% >30 and < 50%) and red marginal quality (RSD% >50%).

Table 3 shows the average RSD% values for the hole duplicate samples. The majority of elements show either good or acceptable quality for most methods. Several elements however, exhibit marginal quality for some extractions. The most notable of these is gold, which has RSD% values exceeding 50% for Ah horizon aqua regia, cold aqua regia (CAR) and Supertrace. The fact that these are all aqua regia methods suggests that the digestion is attacking detrital gold particles in the sample and the higher precision values reflect an inhomogeneous distribution of gold grains in the soil. Ionic Leach (IL) and MMI, being much weaker extractions, have significantly lower RSD% values (32.45% and 14.46% respectively). These extractions are most likely not dissolving native gold grains but rather liberating weakly bound ionic gold, which is more evenly distributed in the soil.

Manganese also displays higher precisions for most methods. Higher RSD% values occur in the weaker extractions, particularly the hydroxylamine hydrochloride leaches (CHDX and HHDX), which are selective for amorphous manganese and iron oxides. This result suggests that manganese is not uniformly distributed in the upper B horizon and that duplicate samples from the same hole can produce significantly different results for this element. Iron on the other hand has good precision for more methods than manganese, suggesting a more homogeneous distribution in the upper B horizon.

Of the different methods, Bioleach (BL) and Enzyme Leach (EL) have the poorest overall precisions as shown by the averaged RSD% values for all the elements. This is most likely because of the very low absolute concentrations of elements extracted by these methods. Best overall precisions are produced by the aqua regia methods (AR-UB and AR-C).

Data quality for the site duplicates is shown in Table 4. As one might expect, they have marginally higher average RSD% values, indicating that there is more variation between sample holes than within a hole at the same site. Nevertheless, similar patterns are seen in the results. Gold exhibits acceptable to marginal data quality for most of the methods. A significant difference from the within hole duplicates is that the weaker extractions, MMI and IL have significantly poorer precisions for site duplicates. The aqua regia digestion of the Ah horizon (AR-Ah) has unacceptable data quality for this element. An RSD% value of 98.11% means that the gold data for this method is of dubious value. Data quality for manganese is poorer for most methods in the site duplicates again suggesting that the

distribution of this element in the upper B horizon is highly variable. Again, the weaker extractions have the higher RSD% values and the aqua regia digestions produce the most reproducible results.

The method with the poorest overall data quality is EL, which has an average RSD% value for all the elements of 40.49%. Of the 12 elements reporting values, only three (Br, Cd and Zn) have good data quality. The remaining elements have acceptable to marginal quality with manganese and uranium having the poorest precision.

In summary, the field duplicate results show that for most of the selected elements, the data quality is acceptable for interpretation. Results for gold and manganese are likely to be noisy.

TABLE 3. AVERAGE RSD% VALUES FOR HOLE DUPLICATES.

Method	Ag	As	Au	Bi	Br	Ca	Cd	Co	Cu	Fe	Hg	Mn	Mo	Pb	Sb	Sr	U	W	Zn	Average
CHDX	38.22%					43.59%	39.40%	43.03%	23.19%	9.88%		63.17%		7.07%	18.86%	28.90%	19.09%		21.18%	27.35%
HHDX	51.40%	34.80%		16.45%	16.50%	43.58%	19.91%	17.04%	23.79%	31.36%		53.12%	18.50%	12.08%	40.76%	27.20%	23.46%		13.83%	26.10%
AR-Ah	32.57%	39.38%	58.58%	28.41%		34.36%	34.84%	42.73%	37.46%	33.81%	26.33%	40.09%	19.98%	25.22%	26.87%	31.47%	14.14%		17.39%	31.98%
CAR	28.99%	8.03%	66.52%	2.18%		8.08%	3.91%	31.02%	22.84%	8.87%	58.58%	18.18%	4.46%	9.67%	10.89%	4.87%	12.24%		10.85%	18.25%
SPY	31.14%	21.37%	42.35%	40.69%		20.55%	32.35%	52.30%	47.52%	44.57%	16.71%	31.43%	41.77%	15.42%	39.36%	25.68%	39.81%		30.43%	33.73%
DI		11.60%			5.66%	12.42%		28.83%	17.83%	21.58%		41.51%	20.52%	14.61%	15.08%	16.11%	21.10%		22.90%	19.21%
ST			54.09%																	54.09%
AR-UB	42.86%	18.03%		9.47%		19.88%	7.41%	12.54%	15.43%	12.51%	44.65%	12.31%	12.25%	7.29%	17.17%	7.66%	13.86%	18.86%	11.82%	15.78%
AR-C	22.57%	10.15%		4.90%		2.85%	4.10%	5.41%	6.88%	4.48%	50.50%	8.68%	3.68%	1.02%	5.95%	2.63%	7.14%		3.74%	9.04%
BL	30.02%	14.45%		39.21%	24.14%		57.34%	29.49%	16.04%		11.94%	38.18%	26.30%	28.10%	16.90%	26.68%	7.25%	12.97%	14.95%	24.62%
EL		68.83%		0.00%	40.36%		19.67%	17.61%	17.38%			42.31%	54.68%	11.31%	45.54%	26.51%	73.54%		32.90%	34.66%
IL	25.69%	22.85%	32.45%		8.62%	22.99%	10.26%	19.23%	19.80%	26.74%	43.98%	16.03%	20.53%	14.28%		20.44%	13.00%		15.06%	20.75%
MMI	30.73%	29.87%	14.46%			15.55%	24.37%	36.35%	15.03%	29.85%			12.15%	25.74%	24.04%	16.85%	14.01%		30.10%	22.79%

Blank values represent either below detection limit or not analyzed. Black = Good precision; Green = acceptable precision; Red = unacceptable precision.

Abbreviations: CHDX – Cold hydroxylamine hydrochloride; HHDX – Hot hydroxylamine hydrochloride; AR-Ah – Ah horizon aqua regia; CAR – Cold aqua regia; SPY – Sodium pyrophosphate; DI – Distilled water; ST – Supertrace gold; AR-UB – Upper B horizon aqua regia; AR-C – C horizon aqua regia; BL – Bioleach; EL – Enzyme Leach; IL – Ionic Leach; MMI – MMI-M

TABLE 4. AVERAGE RSD% VALUES FOR SITE DUPLICATES.

Method	Ag	As	Au	Bi	Br	Ca	Cd	Co	Cu	Fe	Hg	Mn	Mo	Pb	Sb	Sr	U	W	Zn	Average
CHDX	29.86%					50.88%	19.13%	40.31%	21.51%	10.03%		49.44%		4.71%	29.24%	19.04%			12.24%	26.03%
HHDX	49.61%	34.26%		13.31%	12.57%	51.90%	16.01%	21.74%	24.25%	31.30%		46.77%	18.28%	2.58%	36.24%	26.67%	23.86%		19.55%	26.81%
AR-Ah	28.66%	33.37%	98.11%			21.34%	20.55%	37.55%	28.30%	41.25%	19.30%	42.97%	19.39%	17.49%	28.54%	24.77%				32.97%
CAR	19.91%	12.44%	49.68%	9.25%		25.93%	10.86%	26.44%	8.64%	15.26%	38.29%	36.69%	18.15%	11.45%	10.58%	20.63%	9.68%		5.50%	19.37%
SPY	22.25%	21.86%	9.43%	23.40%		24.38%	19.90%	28.18%	18.96%	41.95%	18.84%	39.96%	31.00%	10.84%	17.39%	21.00%	17.75%		46.17%	24.31%
DI		32.73%			9.43%	27.00%	35.41%	43.99%	17.37%	47.87%		69.76%	31.98%	26.54%	19.80%	15.56%	24.24%		24.32%	30.43%
ST			29.60%																	29.60%
AR-UB	32.48%	7.59%		7.86%		28.34%	14.21%	13.07%	16.86%	5.85%	32.20%	15.13%	9.52%	9.24%	12.59%	13.86%	18.14%	18.86%	13.01%	15.81%
AR-C	47.26%	26.25%		16.21%		15.09%	18.12%	15.25%	13.11%	9.68%	69.06%	16.96%	11.21%	17.91%	7.99%	15.72%	23.67%	9.43%	5.98%	19.94%
BL	26.31%		37.05%		27.81%		81.01%	35.02%	22.81%		20.28%	57.60%	29.81%	28.52%	29.84%	49.96%	16.09%	14.82%	19.50%	33.09%
EL		68.83%			27.11%		24.05%	46.86%	32.36%			61.88%	54.68%	33.00%	37.53%	43.23%	67.37%		29.55%	40.49%
IL	25.02%	14.55%	40.85%		6.52%	47.89%	36.22%	35.98%	25.68%	21.79%	31.82%	32.10%	26.46%	16.11%	22.17%	33.42%	15.54%		21.13%	25.18%
MMI	30.59%	17.03%	50.31%	9.43%	na	22.31%	31.63%	13.82%	21.85%	34.04%			13.76%	14.49%	14.78%	26.49%	13.65%		27.98%	22.81%

Blank values represent either below detection limit or not analyzed. Black = Good precision; Green = acceptable precision; Red = unacceptable precision.

Abbreviations: CHDX – Cold hydroxylamine hydrochloride; HHDX – Hot hydroxylamine hydrochloride; AR-Ah – Ah horizon aqua regia; CAR – Cold aqua regia; SPY – Sodium pyrophosphate; DI – Distilled water; ST – Supertrace gold; AR-UB – Upper B horizon aqua regia; AR-C – C horizon aqua regia; BL – Bioleach; EL – Enzyme Leach; IL – Ionic Leach; MMI – MMI-M

SOIL GAS HYDROCARBONS (SGH)

Field duplicate results for the SGH method are summarized in Figures 11 and 12. Results for 95 of the 162 compounds reported by Actlabs are discussed here. The remainder, having values at detection limit have been removed from the dataset and will not be considered further.

Average RSD% values for the lighter compounds are presented in Figure 11. The bar chart shows that for most compounds, values for site duplicates fall within the range of 3 to 25% with an average value of 19.94% (blue dashed line), which confirms good reproducibility. Higher RSD% values of 40 to 50% for compounds 002 LA to 006 and over 50% for compound 095 MAR indicates that these compounds have only acceptable to marginal data quality. There is little difference in the precision between the hole and site duplicates. A slightly lower average value of 16.64% (red dashed line) for the hole duplicates confirms that that reproducibility is marginally better within a sample hole than between adjacent holes at the same site.

Results for the heavier compounds are shown in Figure 12. RSD% values are slightly lower than those of the lighter compounds, with the majority falling between 5 and 15%. Heavier compounds generally display higher values, with many of the compounds between 146 HPA and 162 HPH having average RSD% values of over 30% including four compounds with values of over 50%. Three of these (149 HBI, 158 HBA and 159 HBA) exhibit large differences in RSD% between the hole and site duplicate results. The averages of the hole and site duplicates (dashed lines) are almost identical however, suggesting that there is little variation in the distribution of compounds at the sample site scale. The overall reproducibility for the heavier compounds is considered to be good.

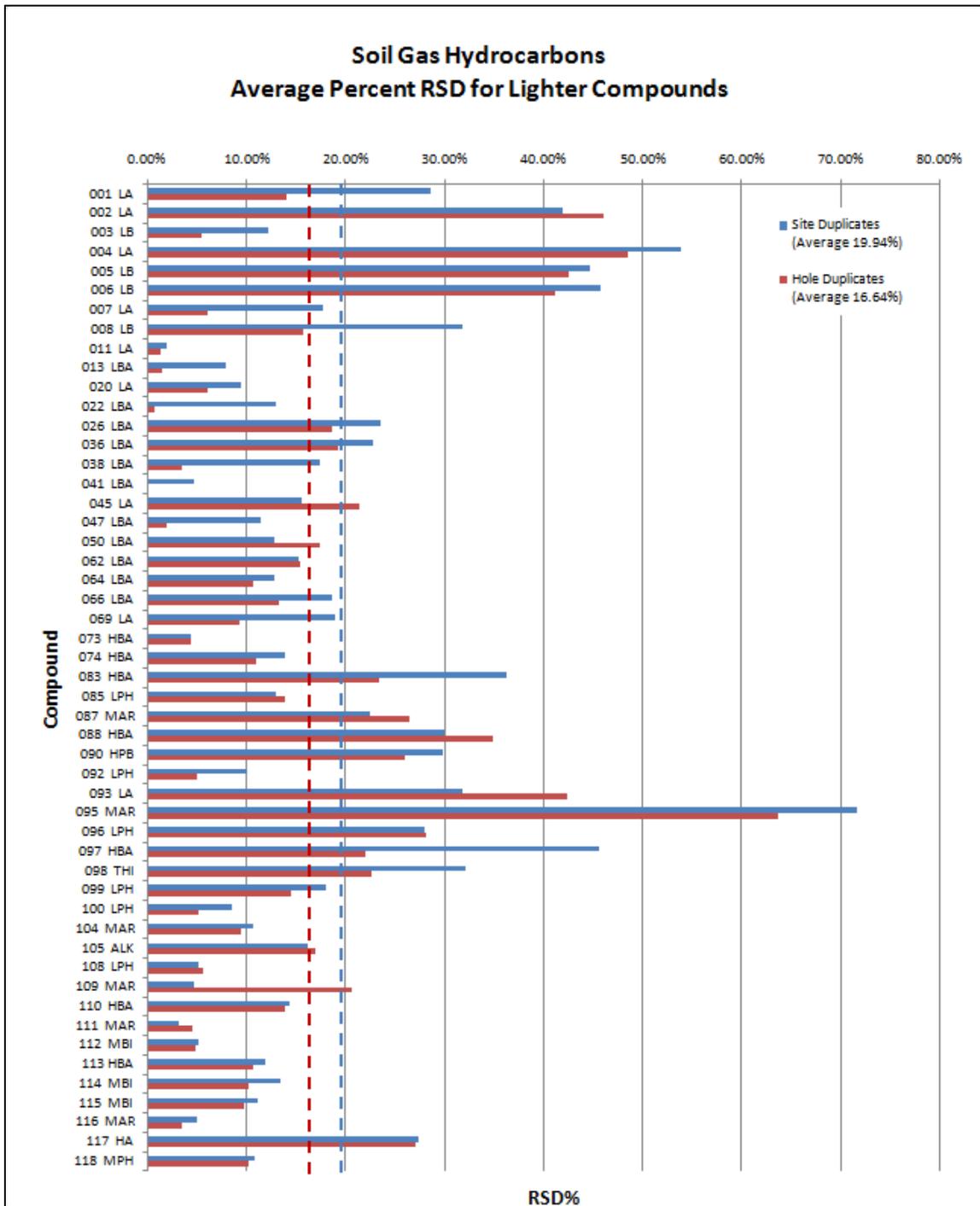


FIGURE 11. AVERAGE PERCENT RSD VALUES FOR LIGHTER COMPOUNDS. RED DASHED LINE INDICATES AVERAGE RSD% VALUE FOR HOLE DUPLICATES. BLUE DASHED LINE INDICATES AVERAGE RSD% VALUE FOR SITE DUPLICATES.

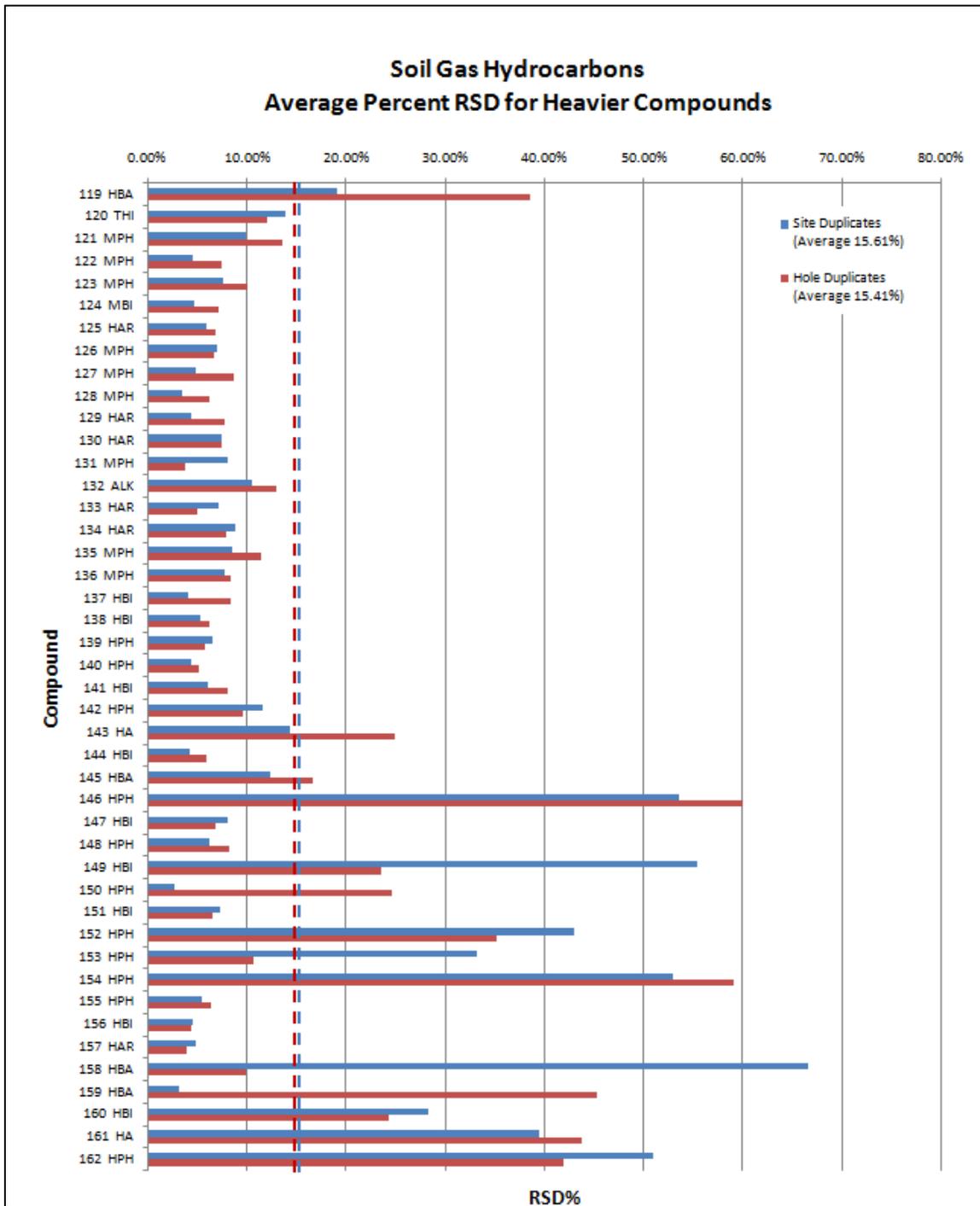


FIGURE 12. AVERAGE PERCENT RSD VALUES FOR HEAVIER COMPOUNDS. RED DASHED LINE INDICATES AVERAGE RSD% VALUE FOR HOLE DUPLICATES. BLUE DASHED LINE INDICATES AVERAGE RSD% VALUE FOR SITE DUPLICATES.

SOIL pH AND CONDUCTIVITY RESULTS

There is a growing body of evidence to indicate that variations in soil pH, or hydrogen ion (H^+) concentration, occur at the surface over buried sulphide mineralization. Smee (1983) proposed a mechanism, based on laboratory experiments and field tests, for the formation of metal anomalies in soils developed on glaciolacustrine clays over massive sulphides in the Abitibi Belt, northern Quebec. His work showed that H^+ released as a byproduct of sulphide oxidation at the water table diffuses to the surface to form detectable acidic anomalies, and that pH sensitive elements like Ca, Sr, Mg, Fe and Mn in a boreal forest environment (i.e., slightly oxidizing to reducing) become redistributed in response to the pH shift.

Smee (1997, 1998) proposed a similar model for ion transport and indirect anomaly formation for arid environments. Results from a multi-company sponsored orientation survey at the Marigold gold deposit in Nevada (Smee, 1998) showed that Ca concentration, in all weak leaches tested, displayed a distinctive rabbit-ear or double-peak response with the peaks occurring over the edges of the mineralization. The ratio of weak leach Ca (e.g., acetic acid or hydroxylamine HCl) to aqua-regia digested Ca showed clear residual anomalies with the same rabbit-ear form and proposed that two forms of Ca exist in the soil; one of which is easily soluble and spatially related to mineralization and a second less soluble form, which represents background carbonate. Smee (1999) concludes that near-surface Ca over oxidizing mineralization is being remobilized in response to the upward movement of H^+ . Reprecipitation of Ca (carbonate) occurs where pH conditions permit, in other words over the edges of the sulphide body.

More recent work by Hamilton et al. (2004 a, b) at the Marsh zone gold prospect and the Cross Lake volcanogenic massive sulphide (VMS) prospect in Ontario shows that similar rabbit-ear patterns occur in H^+ at the surface, above the edges of mineralization. They conclude that pH correlates with oxidation-reduction potential (ORP) and propose that H^+ production is a function of the redox conditions in the overburden column. In an earlier paper, Hamilton (1998) proposed the existence of reduced columns or chimneys in the overburden column above a reduced metal source. Reduction of the overburden column is postulated to occur as a result of upward migration of reduced anionic species between the top of a conductive body and the ground surface. Charge is transferred by the reaction with oxidized cationic species migrating in the other direction. This process results in the formation of an oxidation front that propagates to the surface to form a chimney or column. Within the reduced core of the chimney, oxidation of the underlying mineralization is inhibited thus limiting the amount of H^+ released. At the edges, however, oxidation is enhanced thus promoting H^+ accumulation at the surface over the edges of the underlying mineralization. This process results in a typical rabbit-ear response for H^+ , with a pronounced central low over the reduced chimney, from samples collected at the very top of the mineral soil profile.

Soil pH and conductivity measurements were recorded at the end of each day on material collected from the top centimeter of the mineral soil (usually the top of the Ae or Ae_j horizon). This level was chosen based on results presented by Hamilton et al. (2004b), which indicate that the strongest H^+ patterns occur in the uppermost part of the soil profile. Conductivity measurements were made on a 1:1 slurry of soil in demineralized water using a VWR International conductivity meter. Measurements of the pH were made on the same slurry using an Oakton® Instruments double junction pHTestr® 30. The instrument was calibrated daily using standard pH buffer solutions at pH 4.00, 7.00 and 10.00. Two pH measurements were taken on each sample: one 20 seconds after immersion of the electrode into the slurry and a second measurement 20 seconds after adding one drop of 10% hydrochloric acid and stirring. Measurements of pH were recorded into an Excel spreadsheet and converted to H^+ concentrations. Inverse Difference Hydrogen (IDH) values were also calculated using Smee's (2009) method. Summary statistics for the pH and conductivity measurements are presented in Table 5.

TABLE 5 SUMMARY STATISTICS FOR SOIL PH AND CONDUCTIVITY MEASUREMENTS

	Conductivity ($\mu\text{S}/\text{cm}$)	pH	Acidified pH
N	52	52	52
Min	2.7	3.87	2.91
Max	36.9	6.07	4.76
Range	34.2	2.2	1.85
Mean	7.72	4.67	3.34
Std. Dev.	6.84	0.49	0.46
Variance	46.73	0.24	0.21
Sum	401.50	242.75	173.73
Sum Sq	5483.05	1145.63	591.24
Median	5.25	4.60	3.18
Mode	3.7	4.00	2.97

Figure 13 shows profile plots for Electrical Conductivity (EC), H⁺, acidified H⁺ and IDH along the two transects. Conductivity profiles (Fig. 13a) show a relationship to the eastern and southern surface projection of the mineralization as defined by the 0.5% Cu equivalent envelope (Rennie and Scott, 2009). On the east-west transect (Transect 1); there is a sharp single peak response directly over the mineralization (11 times background) and a second much more subdued feature located 100 metres to the east. It is debatable whether these constitute a rabbit-ear pair or whether they represent two separate features. If the former interpretation is considered, the peaks appear to define a potential source area located to the east of the 0.5% Cu eq. envelope. The latter interpretation suggests that the higher contrast feature is an apical anomaly or perhaps part of a tight rabbit-ear that is not captured by the sample spacing. The correct interpretation cannot be determined from these results. The strongly anomalous value at the east end of the transect, is likely an expression of a wide north-trending fault zone identified by drilling to the south of the transect (D. Moore, pers. comm., 2009; Fig. 13).

Conductivity values on Transect 2 show a different pattern. There is a broad but subtle increase in values (over two times the background levels) from north to south over the projection of the mineralization. This culminates in a moderate contrast peak (9 times the background) situated directly over the southern edge of the zone. There is also an indication of a low-contrast, rabbit-ear anomaly further to the south. This feature is unexplained.

Hydrogen ion (H⁺) profiles are illustrated in Figure 13b. Responses on both transects are relatively noisy but distinct patterns can be seen. On Transect 1, H⁺ values are elevated over the down-dip part of the mineralized body and display a subtle, two-sample low directly over the west edge of the 0.5% Cu eq. envelope. A strong, asymmetrical double-peak or rabbit-ear feature overlies the projected position of the mineralization with the stronger of the two peaks occurring over the eastern edge of the zone. The position of the low between the two peaks coincides with the prominent peak seen in the EC results (Fig. 13a). H⁺ patterns over the deeper mineralization on Transect 2 are quite different. Rather than a prominent H⁺ peak or rabbit-ear, the position of the underlying mineralization is marked by a subtle double low or W-shaped profile with minimum values occurring approximately over the edges of the mineralized body. The contrasting patterns on the two transects may be an expression of the different depths to the mineralization; i.e., less than 40 metres on Transect 1 and approximately 300 metres on Transect 2.

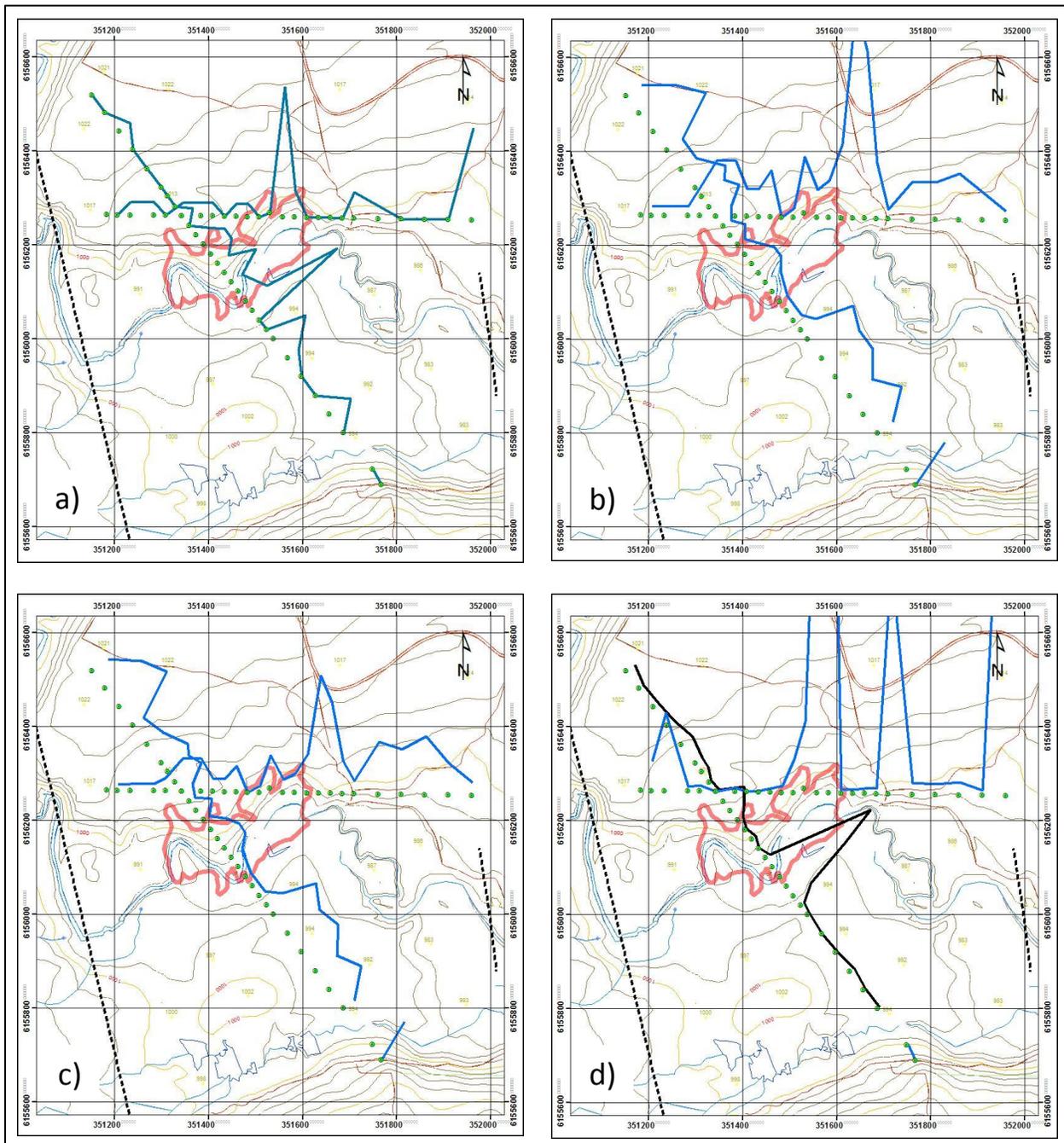


FIGURE 13. PH AND CONDUCTIVITY PROFILES OVER THE CENTRAL ZONE. TRANSECT 1 IS THE EAST-WEST TRANSECT AND TRANSECT 2 IS NORTH-EAST. PINK OUTLINE INDICATES THE SURFACE PROJECTION OF MINERALIZATION AS DEFINED BY THE 0.5% CU EQUIVALENT ENVELOPE AT THE 600 METRE LEVEL. A. CONDUCTIVITY (EC). B. HYDROGEN ION CONCENTRATION. C. ACIDIFIED HYDROGEN ION CONCENTRATION. D. INVERSE DIFFERENCE BETWEEN THE ACIDIFIED AND NON-ACIDIFIED HYDROGEN ION CONCENTRATIONS (IDH).

Similar patterns are evident in the acidified H⁺ results (Fig.13c). On Transect 1, a moderate contrast, asymmetrical rabbit ear feature is present over the sub-cropping part of the mineralization. This feature mimics the response described above for H⁺ but has a slightly lower contrast: the western peak is barely distinguishable from

background values. As with H⁺ results, the low over the mineralization coincides with the position of the EC peak (Fig. 13a). A similar W-shaped profile occurs in the acidified H⁺ readings on Transect 2. The acidified H⁺ lows are coincident with the edges of the mineralization. Again, there is a strong antithetic relationship with conductivity.

IDH, is a good estimator of the presence of remobilized carbonate. As the inverse of the difference between the acidified and non-acidified H⁺ concentrations, high values indicate areas where carbonate has been remobilized and precipitated. Results are shown in Figure 13d. On Transect 1, there are a several peaks present. Strong values at the east end of the line are likely related to the fault zone mentioned earlier. The two prominent peaks located over and just east of the mineralization (66 and 25 times the background levels) are highly suggestive of a rabbit-ear response. This feature is centred slightly east of the projected position of the mineralization and as seen in the H⁺ results could represent either a single rabbit ear centred east of the zone or two separate anomalies; the western one a rabbit ear that is poorly defined by the sample spacing.

The pattern on Transect 2 is much more compelling. The asymmetrical rabbit-ear peaks (13 and 3 times background levels) fall close to the projected edges of the 0.5% Cu eq. envelope of the mineralization. Lower contrast values are likely an expression of the much greater depth to mineralization (>300 metres).

AQUA REGIA ANALYSES

This study is designed to compare the effectiveness of a variety of geochemical methods at detecting mineralization located at different depths from the surface. This is done in two ways: a) by comparing the responses of single elements across a range of extraction methods, and b) by comparing performance of a single extraction at various depths in the soil profile. This section presents the results of aqua regia analyses carried out on Ah, upper B, lower B and C horizons. An aqua regia digestion on upper B horizon soil is considered to be the traditional method for soil geochemistry in British Columbia and as such provides a good baseline for assessing the performance of other extraction methods. Comparative statistics for selected elements in each soil horizon are presented in Tables 6 to 9.

RESPONSES DOWN THE SOIL PROFILE

Figure 14 shows box and whisker plots for a selection of ore and pathfinder elements. It is clear from these plots that each element behaves differently down the soil profile and that there is no zone of preferential enrichment for ore or pathfinder elements. The ore elements copper and molybdenum have quite similar trends. They both display a progressive enrichment from lower values in the Ah horizon to higher values in the C horizon. There is no enrichment in the upper B horizon as one might expect, despite the presence of visibly iron and manganese enriched Bf horizons at most localities.

TABLE 6. SUMMARY STATISTICS FOR AH HORIZON AQUA REGIA ANALYSES.

Element	N	Min	Max	Range	Mean	StdDev	Var	Sum	SumSq	Median	Mode
Ag	47	91	7970	7879	579.45	1154.35	1332530	27234.00	77077212	329.00	421.00
As	47	0.5	14.3	13.8	2.94	2.39	5.706	138.30	669.45	2.60	3.10
Au	47	0.1	89.6	89.5	3.19	12.92	166.8	150.00	8151.38	1.30	1.40
Bi	47	0.03	0.27	0.24	0.11	0.04	0.002	5.31	0.68	0.11	0.11
Cd	47	0.16	3.08	2.92	0.84	0.74	0.541	39.53	58.11	0.58	0.49
Cu	47	4.69	1048.66	1043.97	44.50	150.69	22707	2091.40	1137585	16.34	4.69
Hg	47	91	1280	1189	226.30	211.05	44542	10636.00	4455840	159.00	143.00
Mn	47	33	8046	8013	745.53	1239.57	1536540	35040.00	96804376	373.00	33.00
Mo	47	0.67	8.23	7.56	1.94	1.28	1.634	91.08	251.66	1.57	0.79
Pb	47	5.45	14.7	9.25	8.37	2.11	4.465	393.62	3501.92	8.08	5.91
S	47	0.01	0.37	0.36	0.07	0.06	0.003	3.22	0.38	0.05	0.04
Sb	47	0.22	2.64	2.42	0.62	0.41	0.168	28.92	25.51	0.56	0.26
Sr	47	7.1	119.8	112.7	30.40	23.19	537.669	1429.00	68180.44	23.10	9.20
U	47	0.05	2.8	2.75	0.37	0.46	0.211	17.60	16.31	0.20	0.20
W	47	0.05	70	69.95	1.78	10.21	104.284	83.45	4945.21	0.05	0.05
Zn	47	13.3	179.3	166	57.05	26.85	721.176	2681.20	186128.0	51.70	44.80

TABLE 7. SUMMARY STATISTICS FOR UPPER B HORIZON AQUA REGIA ANALYSES.

Element	N	Min	Max	Range	Mean	StdDev	Var	Sum	SumSq	Median	Mode
Ag	49	0.03	1.23	1.2	0.19	0.20	0.04	9.31	3.68	0.14	0.16
As	49	2	21	19	7.47	4.46	19.92	366.00	3690.00	6	3
Au	49	0.05	0.05	0	0.05	0.00	0.00	2.45	0.12	0.05	0.05
Bi	49	0.08	0.29	0.21	0.13	0.04	0.00	6.60	0.95	0.13	0.13
Cd	49	0.05	0.55	0.5	0.22	0.12	0.01	10.93	3.08	0.18	0.12
Cu	49	9	50.3	41.3	25.42	8.66	74.93	1245.60	35260.50	24.9	17
Fe	49	1.41	5.74	4.33	2.67	1.12	1.26	130.87	409.89	2.29	1.58
Hg	49	0.02	30.1	30.08	1.09	4.38	19.20	53.22	979.34	0.09	0.03
Mn	49	147	1180	1033	344.88	193.64	37496.40	16899.00	7627913.00	290	232
Mo	49	0.89	4.78	3.89	2.18	0.89	0.80	107.00	272.00	1.95	1.52
S	49	0.005	0.03	0.025	0.01	0.01	0.00	0.48	0.01	0.005	0.005
Sb	49	0.28	3.09	2.81	0.83	0.46	0.21	40.55	43.52	0.78	0.66
U	49	0.24	1.3	1.06	0.43	0.19	0.03	20.94	10.61	0.38	0.27
W	49	0.05	1.1	1.05	0.13	0.17	0.03	6.35	2.14	0.1	0.05
Zn	49	36	192	156	69.53	26.69	712.21	3407.00	271077.00	62	62

TABLE 8. SUMMARY STATISTICS FOR LOWER B HORIZON AQUA REGIA ANALYSES.

Element	N	Min	Max	Range	Mean	StdDev	Var	Sum	SumSq	Median	Mode
Ag	49	0.02	0.71	0.69	0.14	0.15	0.02	7.07	2.04	0.09	0.06
As	49	2	20	18	8.49	4.01	16.05	416.00	4302.00	9.00	9.00
Au	49	0.05	0.9	0.85	0.07	0.12	0.01	3.30	0.93	0.05	0.05
Bi	49	0.09	0.26	0.17	0.14	0.04	0.00	6.73	0.99	0.13	0.13
Cd	49	0.06	0.48	0.42	0.24	0.11	0.01	11.71	3.40	0.23	0.19
Cu	49	11.3	78.4	67.1	31.64	13.23	174.92	1550.40	57452.02	29.10	29.10
Fe	49	1.12	5.93	4.81	2.59	0.91	0.83	126.86	368.12	2.43	2.14
Hg	49	0.04	29.1	29.06	1.06	4.29	18.44	51.71	939.64	0.12	0.09
Mn	49	162	579	417	347.00	113.25	12825.70	17003.00	6515675.00	323.00	291.00
Mo	49	0.86	4.19	3.33	2.22	0.75	0.56	109.01	269.62	2.28	1.78
S	49	0.005	0.03	0.025	0.01	0.01	0.00	0.42	0.01	0.01	0.01
Sb	49	0.25	1.32	1.07	0.83	0.29	0.09	40.58	37.72	0.83	0.78
U	49	0.24	0.8	0.56	0.46	0.14	0.02	22.71	11.49	0.45	0.37
W	49	0.05	0.3	0.25	0.09	0.06	0.00	4.50	0.60	0.05	0.05
Zn	49	37	173	136	70.22	23.67	560.22	3441.00	268533.00	68.00	65.00

TABLE 9. SUMMARY STATISTICS FOR C HORIZON AQUA REGIA ANALYSES.

Channel	N	Min	Max	Range	Mean	StdDev	Var	Sum	SumSq	Median	Mode
Ag	51	0.02	0.46	0.44	0.12	0.11	0.01	6.09	1.36	0.07	0.05
As	51	2	34	32	8.53	5.27	27.73	435.00	5097.00	8.00	8.00
Au	51	0.05	0.05	0	0.05	0.00	0.00	2.55	0.13	0.05	0.05
Bi	51	0.07	0.38	0.31	0.13	0.05	0.00	6.82	1.03	0.13	0.13
Cd	51	0.05	3.41	3.36	0.29	0.46	0.21	14.56	14.65	0.21	0.18
Cu	51	11.6	113	101.4	34.52	16.31	265.93	1760.50	74068.21	33.80	33.60
Fe	51	1.3	8.66	7.36	2.61	1.20	1.43	133.29	420.05	2.45	1.61
Hg	51	0.01	6.19	6.18	0.57	1.30	1.69	28.95	100.93	0.10	0.10
Mn	50	144	696	552	359.74	119.84	14362.70	17987.00	7174415.00	344.00	327.00
Mo	51	0.98	47.9	46.92	3.06	6.45	41.64	156.11	2559.66	2.04	1.00
S	51	0.005	0.06	0.055	0.01	0.01	0.00	0.52	0.01	0.01	0.01
Sb	51	0.32	2.51	2.19	0.95	0.38	0.14	48.21	52.62	0.91	1.04
U	51	0.25	2.68	2.43	0.58	0.43	0.19	29.81	26.79	0.47	0.34
W	51	0.05	0.2	0.15	0.07	0.04	0.00	3.50	0.32	0.05	0.05
Zn	51	39	121	82	67.33	18.64	347.39	3434.00	248592.00	66.00	63.00

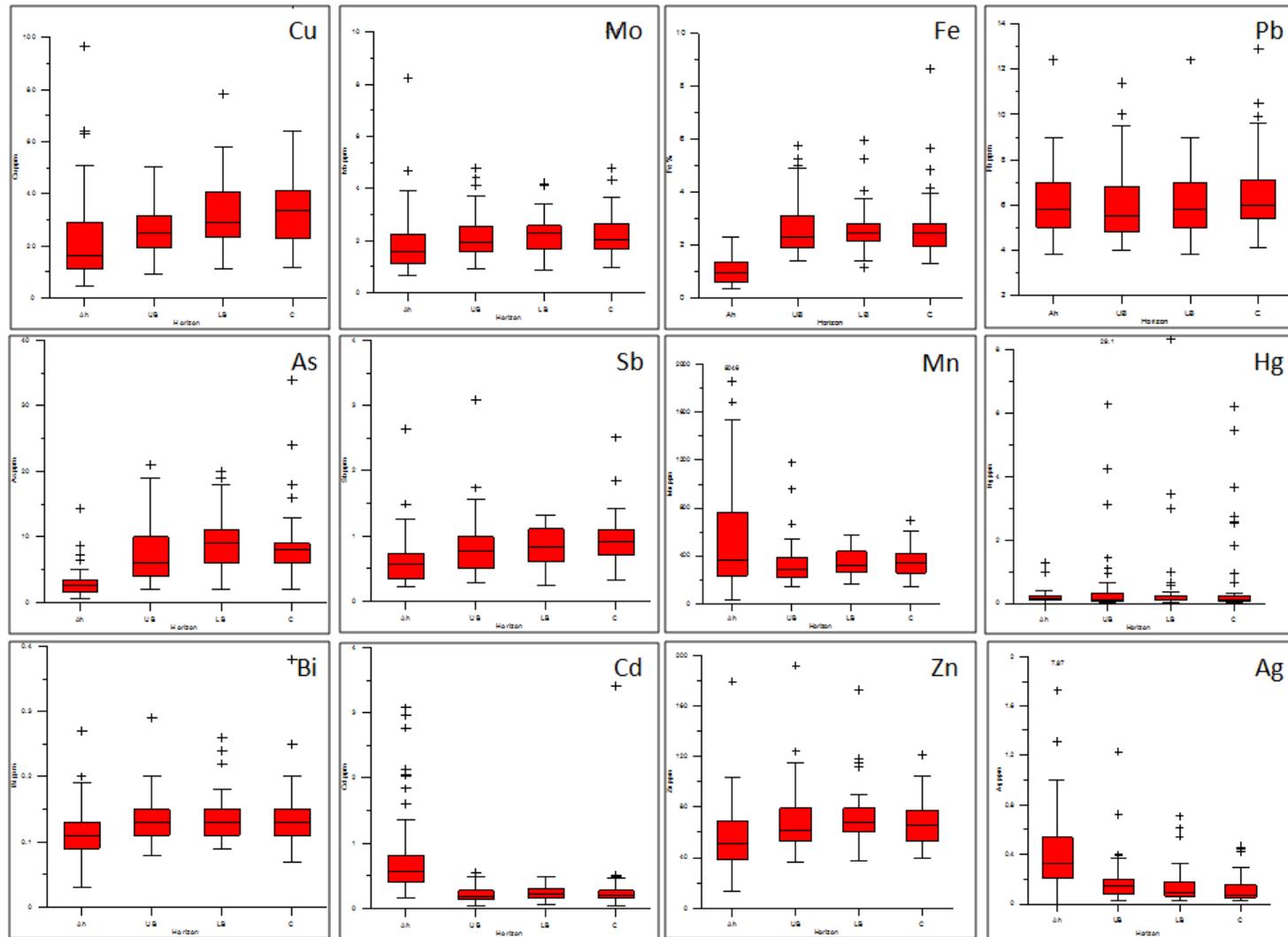


FIGURE 14. BOX AND WHISKER PLOTS FOR SELECTED ELEMENTS, AQUA REGIA ANALYSES. ABBREVIATIONS: UB=UPPER B HORIZON; LB=LOWER B HORIZON.

Arsenic, antimony and bismuth have similar distributions to copper although arsenic displays a more significant depletion in the Ah horizon. This depletion is also seen in iron. Moderate to strong correlations between these elements and iron can be seen in all four horizons (Appendix 3) suggesting that iron concentration is the main control on their distribution. These elements are most likely present as adsorbed ions on hydrous iron oxide.

Zinc shows similar trends to arsenic, antimony and bismuth. Both of these elements have slightly lower values in the Ah horizon and flat profiles through the B and C horizons, suggesting that soil forming processes have not caused significant enrichment or depletion of either metal. Cadmium correlates strongly with calcium ($R=0.84$; Appendix 3) in the Ah and upper B horizons ($R=0.84$ and 0.70) and with calcium and iron in the lower B ($R=0.63$ and 0.57) and C horizons ($R=0.63$ and 0.66). This trend from calcium control higher in the profile to iron control lower in the profile is reflected by the distributions of calcium and iron: calcium being highly enriched and iron being depleted in the Ah horizon.

Lead shows little variation across the soil profile; its concentration range is quite similar in each horizon. In the Ah horizon it has no correlation with iron, calcium or manganese and is likely present as adsorbed ions on organic matter or complexed with humic and fulvic acids. In the upper B, lower B and C horizons it correlates with iron ($R=0.70$, 0.70 and 0.66) suggesting that hydrous iron oxides are the main host.

Mercury is slightly enriched in the upper B horizon and has more or less consistent concentrations in the Ah, lower B and C horizons. The distribution of outliers suggests that highly anomalous values occur in the upper and lower B horizons and to a lesser extent the C horizon. This element does not correlate with any other element in any of the four horizons, therefore it can be surmised that it is present as a mercury compound(s) such as HgS (cinnabar), HgO, HgCl and/or not associated with controlling variables such as amorphous iron and manganese oxides.

RESPONSES ALONG SAMPLE LINES.

The previous section illustrates how element concentrations vary between different soil horizons. Results show that no single horizon is appropriate for all elements and that the geochemical signal from blind mineralization will most likely vary in contrast and element combinations depending on the horizon sampled. This section compares the AR responses from each horizon, along the sample Transects over the Kwanika Central zone. On the following figures, the pink bar on the X-axis represents the surface projection of the mineralized body as defined by drill hole information. References to the mineralized body in the following descriptions refer this surface projection.

TRANSECT 1

Figures 15 to 23 illustrate the results for selected elements on Transect 1. Response ratio (RR) profiles are displayed for Ah (Red), upper B (orange), lower B (green) and C horizons (blue).

Results for copper are shown in Figure 15. Upper B, lower B and C horizons show no significant variations along the sample Transect. There is no contrast between sample sites located over mineralization and those in background areas. Ah horizon however, does show a low contrast response (up to 8 times background) over the eastern or up-dip part of the mineralized body. Molybdenum results (Fig. 16) display no variation at all. Profiles for all four horizons conform to background ranges ($RR < 2.5$).

A more convincing response is shown for silver (Fig. 17). The aqua regia digestion identifies elevated values ($RR > 5$) in all four horizons. Maximum contrast ($RR > 11$) occurs in the C horizon; however, convincing anomalies are also shown by the upper and lower B horizon samples. As with copper, the silver response overlies the eastern or up-dip limit of the mineralization.

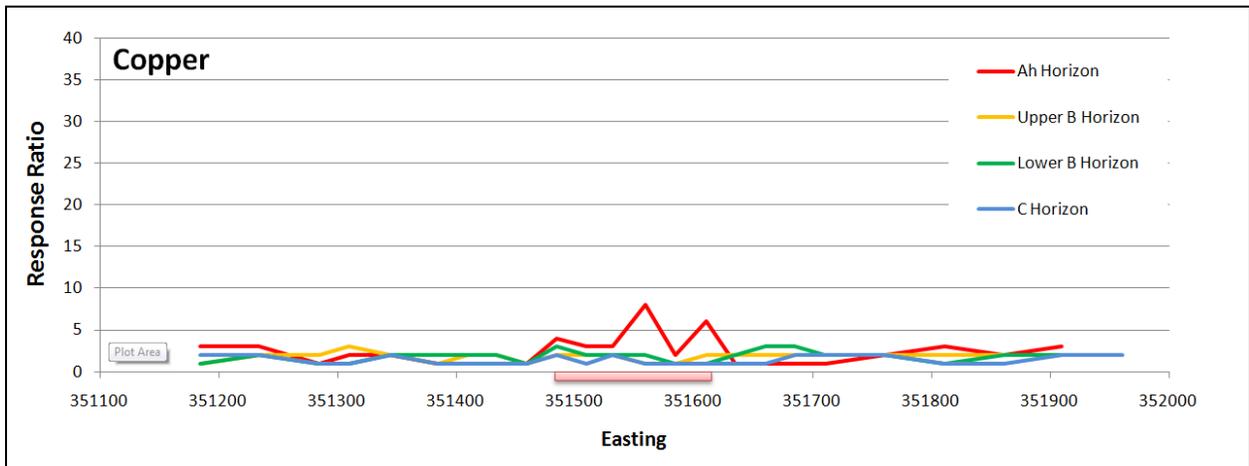


FIGURE 15. TRANSECT 1 - AQUA REGIA RESULTS FOR COPPER IN DIFFERENT SOIL HORIZONS.

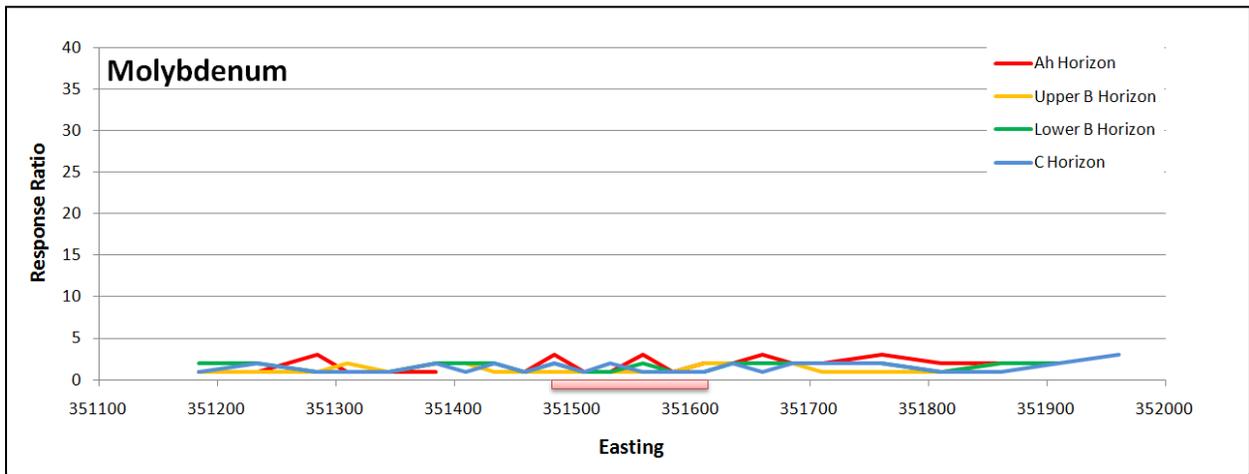


FIGURE 16. TRANSECT 1 - AQUA REGIA RESULTS FOR MOLYBDENUM IN DIFFERENT SOIL HORIZONS.

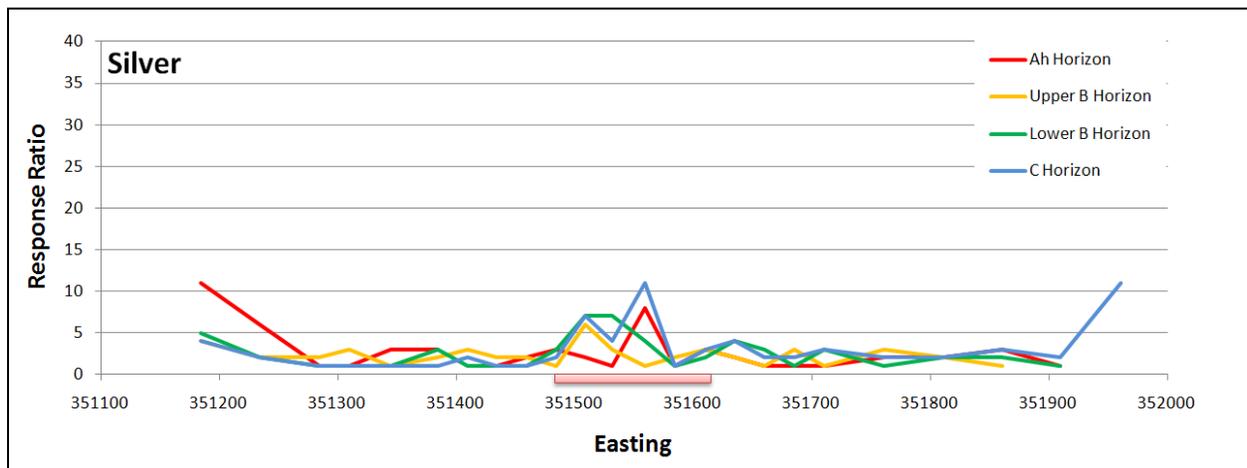


FIGURE 17. TRANSECT 1 – AQUA REGIA RESULTS FOR SILVER IN DIFFERENT SOIL HORIZONS.

Calcium (Fig. 18) has a similar pattern to copper and displays a moderate contrast peak over the eastern third of the mineralization. The maximum contrast response ($RR > 12$) occurs in the Ah horizon. Upper B, lower B and C horizons also display low contrast responses ($RR < 6$) but these are not convincingly different from background variation.

Arsenic and iron, as mentioned previously, have a very high correlation in the upper B, lower B and C horizons (Fig 14). Along the line however, there is no response for either element (Figs. 19 and 20); only background values are observed. There is a response in the Ah horizon where both elements define subtle ($RR < 5$), broad peaks centred over the eastern limit of the mineralized body. A single peak response in the Ah horizon is also observed for antimony (Fig. 21). This low contrast feature ($RR < 7$) is centred directly over the mineralization. There is no corresponding anomaly in the other three horizons.

A different type of response is observed for manganese and tungsten (Figs. 22 and 23). These elements are only anomalous in the Ah horizon, where they define high contrast ($R = 15$ and 26), double peak or rabbit ear-type responses. A rabbit ear anomaly is commonly regarded as an expression of ionic dispersion related to an electrochemical cell or reduced chimney (Hamilton, 1998). There are no recognizable features in the upper B, lower B or C horizons for either element. The manganese rabbit ear anomaly brackets the sub-cropping portion of the mineralized body. For tungsten, the rabbit ears are much broader and encompass the entire down dip extent of the mineralization. They appear to detect the mineralization through both post mineral sedimentary cover and Quaternary glaciofluvial sediments.

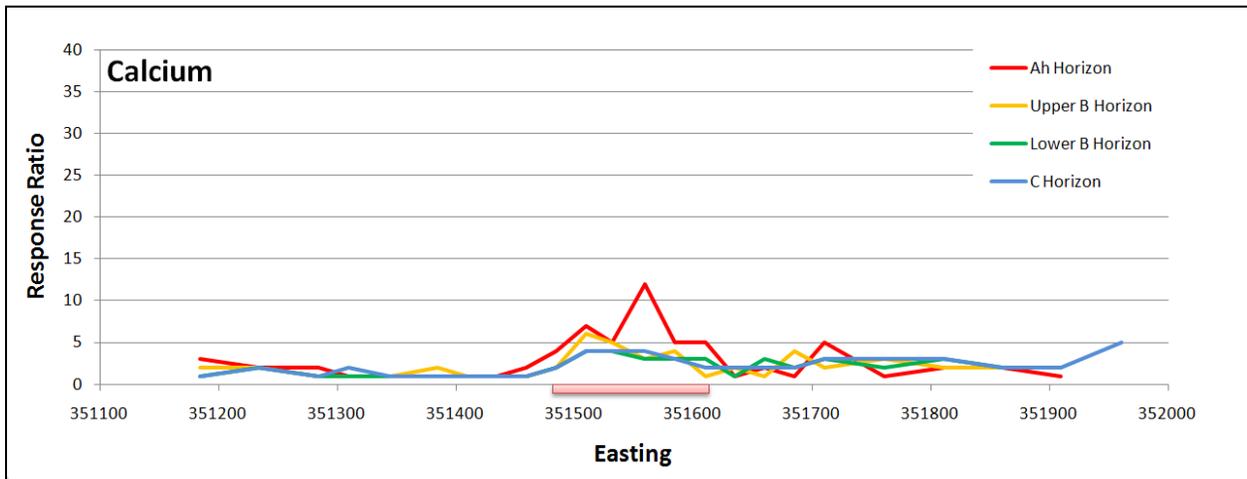


FIGURE 18. TRANSECT 1 – AQUA REGIA RESULTS FOR CALCIUM IN DIFFERENT SOIL HORIZONS.

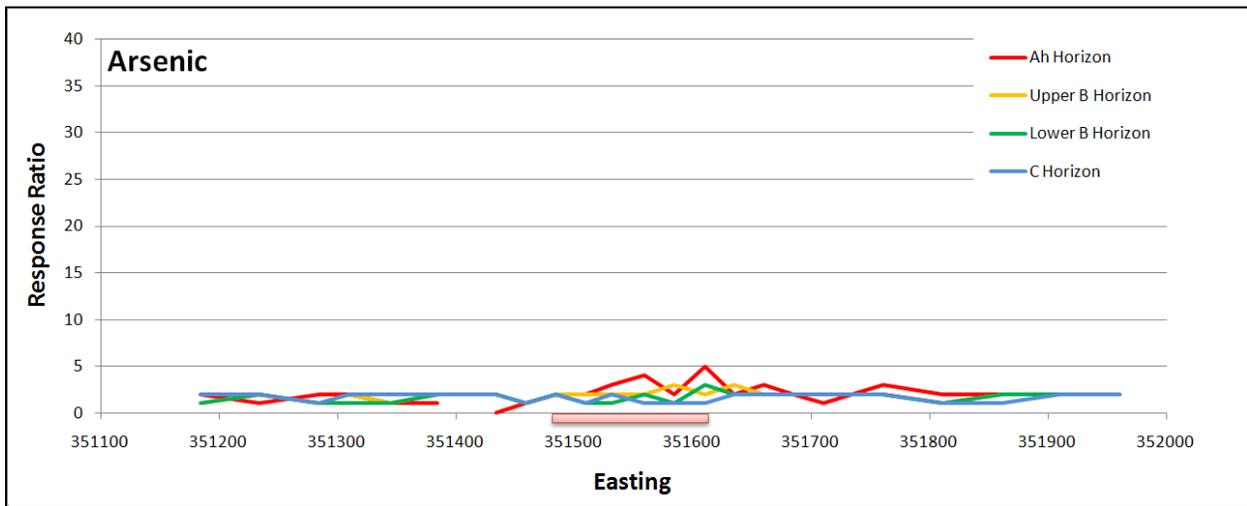


FIGURE 19. TRANSECT 1 – AQUA REGIA RESULTS FOR ARSENIC IN DIFFERENT SOIL HORIZONS.

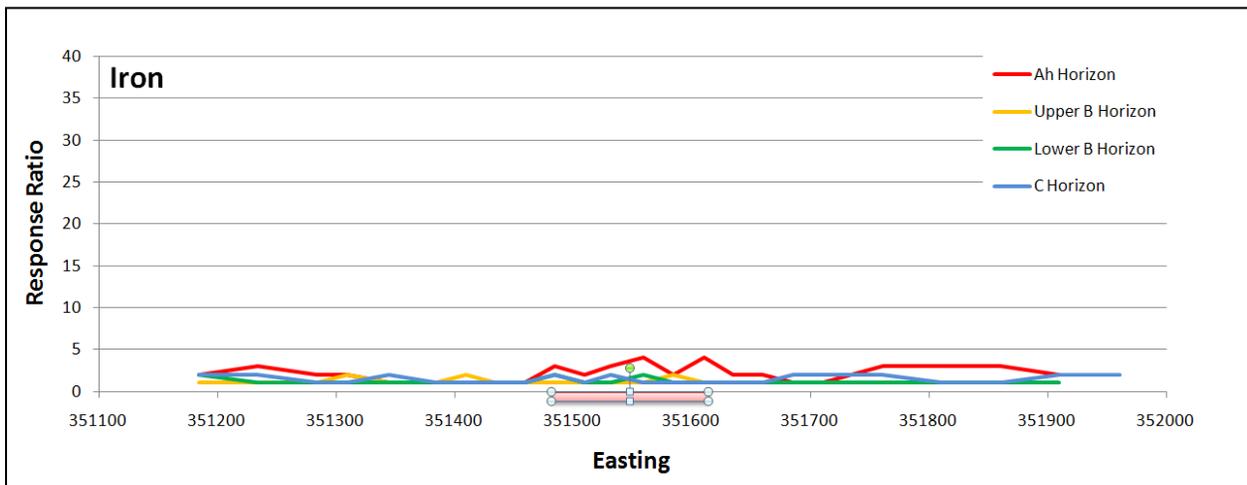


FIGURE 20. TRANSECT 1 - AQUA REGIA RESULTS FOR IRON IN DIFFERENT SOIL HORIZONS.

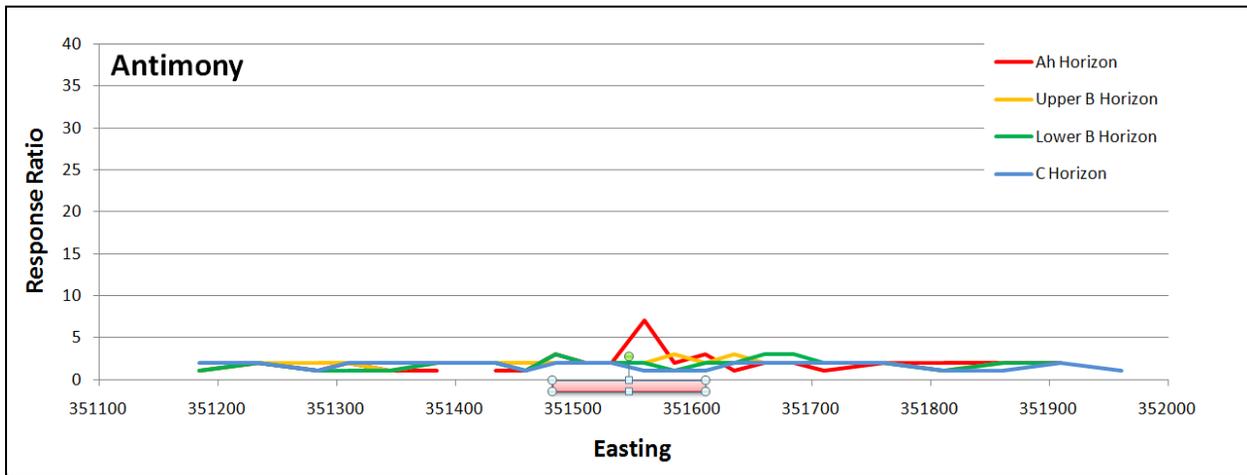


FIGURE 21. TRANSECT 1 – AQUA REGIA RESULTS FOR ANTIMONY IN DIFFERENT SOIL HORIZONS.

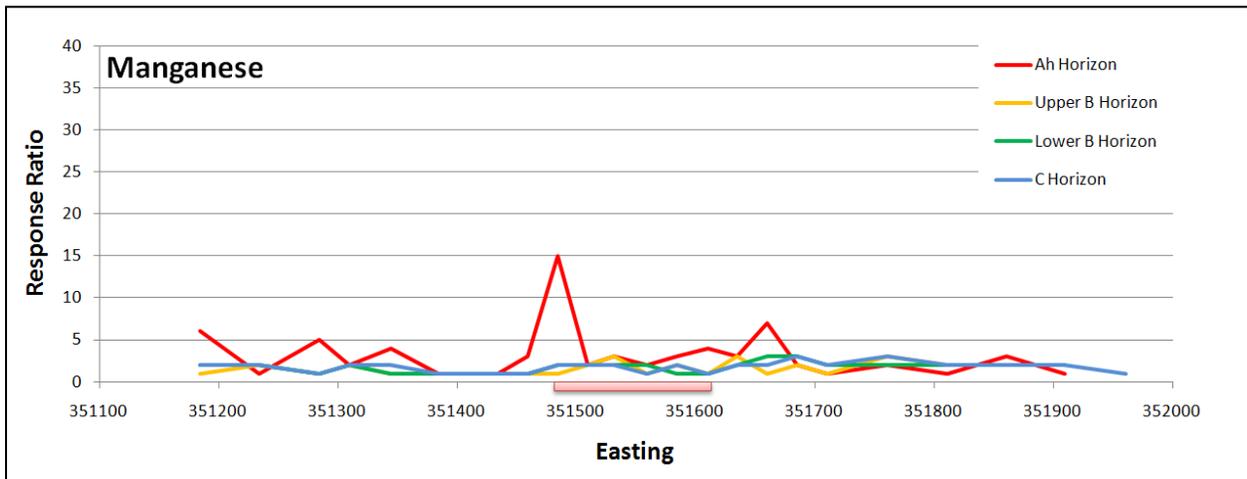


FIGURE 22. TRANSECT 1 – AQUA REGIA RESULTS FOR MANGANESE IN DIFFERENT SOIL HORIZONS.

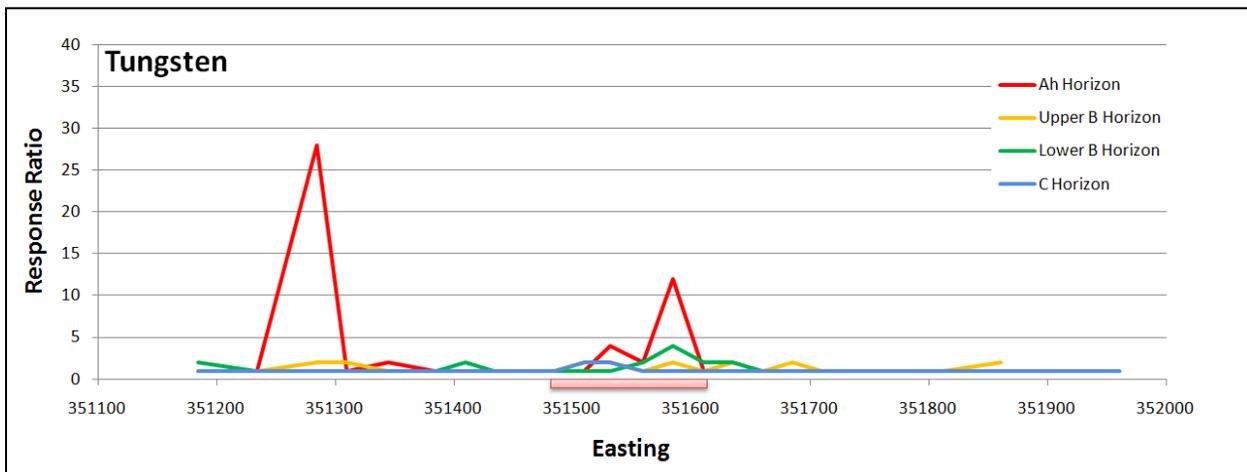


FIGURE 23. TRANSECT 1 – AQUA REGIA RESULTS FOR TUNGSTEN IN DIFFERENT SOIL HORIZONS.

TRANSECT 2

Results of the aqua regia digestions for Transect 2 are presented in Figures 24 to 33. This sample line passes over a part of the Central zone that sits approximately 300 vertical metres below the surface. In the figures, the dashed red line extrapolates the profile over a missing sample location that fell within a creek.

Copper results are illustrated in Figure 24. A very high contrast response ($RR < 137$) with an asymmetrical rabbit-ear form occurs in the Ah horizon. The rabbit-ear peaks lie just inside the edges of the mineralization, with the higher contrast peaks close to the southern margin. There is no response in the upper B, lower B or C horizons. Profiles for these levels are flat and do not deviate from background anywhere on the line.

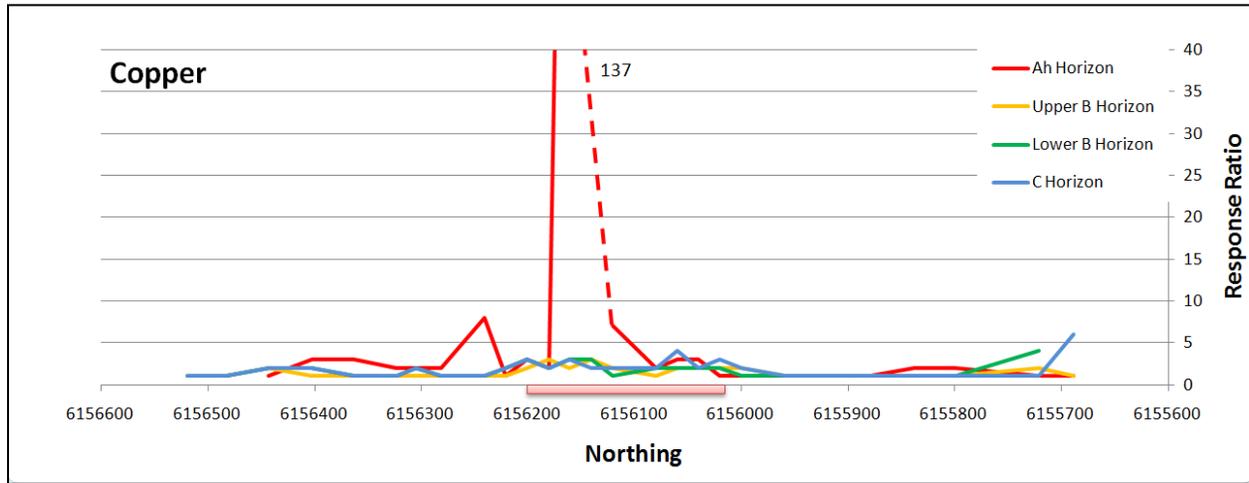


FIGURE 24. TRANSECT 2 – AQUA REGIA RESULTS FOR COPPER IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE WHERE NO SAMPLE COULD BE TAKEN.

Figure 25 shows the results for gold. It is important to note here that only the aqua regia method used on the Ah horizon (Acme) has a sufficiently low detection limit to be able to reveal subtle patterns for this element. The method used for the other horizons (SGS) has a 50 ppb detection limit, which is not sensitive enough to reveal subtle features. The response in the Ah horizon is unequivocal. Gold has a high contrast, multi-sample, apical response ($RR < 273$) located directly over the mineralized body.

The Ah horizon also defines a rabbit ear response for molybdenum (Fig. 26). This low contrast feature is asymmetrical in form with the higher contrast peak ($RR < 10$) overlying the centre of the mineralized body. The lower contrast ($RR < 5$) second peak lies just outside the northern edge. Upper B and lower B horizons have no discernable patterns; their profiles define background values over the entire line. In the C horizon however, there is a single sample peak ($RR < 37$) located just outside the southern edge of the mineralization.

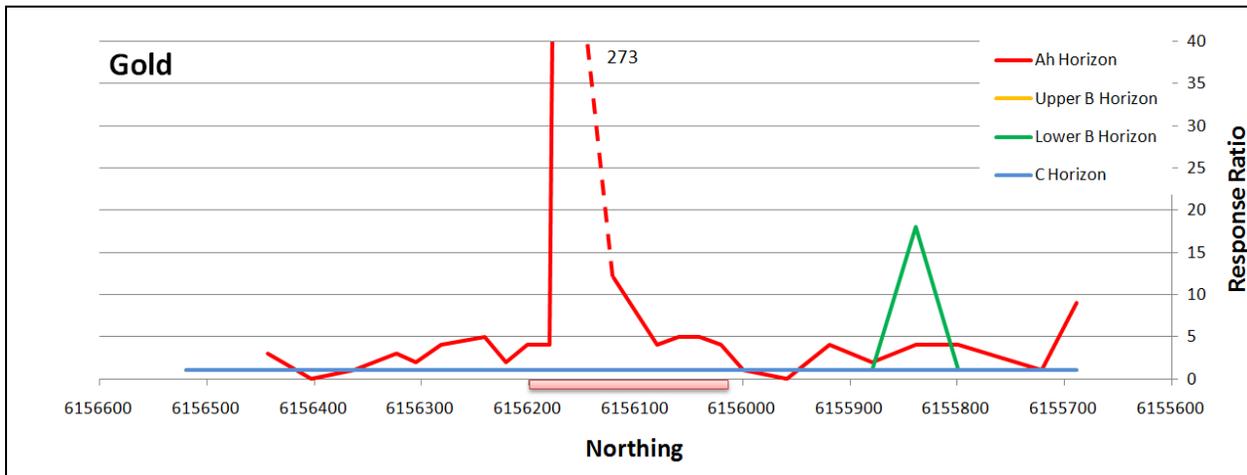


FIGURE 25. TRANSECT 2 – AQUA REGIA RESULTS FOR GOLD IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE WHERE NO SAMPLE COULD BE TAKEN.

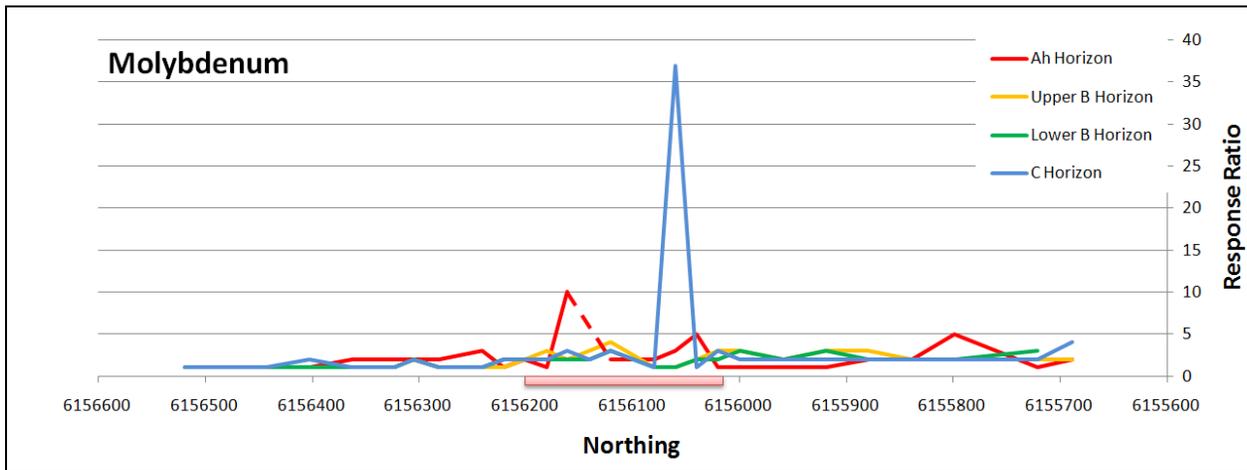


FIGURE 26. TRANSECT 2 – AQUA REGIA RESULTS FOR MOLYBDENUM IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE WHERE NO SAMPLE COULD BE TAKEN.

Silver (Fig. 27) has an almost identical pattern to copper. A strong asymmetrical rabbit-ear anomaly occurs in the Ah horizon results. The higher peak (RR<58) is situated just inside the southern edge of the mineralization. The corresponding north peak is relatively weak (RR<9) and lies just inside the northern edge. Patterns in the upper B, lower B and C horizons are somewhat ambiguous. South of the mineralization they show a significant amount of variation (RR<15). However, the profiles are not consistent with either rabbit-ear or apical type anomalies and therefore are likely to represent noisy background. North of the mineralization, the background is flat with very low contrast values (RR<5).

Flat responses are seen in the upper B, lower B and C horizons for calcium (Fig. 28). Only the Ah horizon defines a recognizable anomaly. This has the form of a broad, triple peak feature centred over the mineralization. The feature has a moderate contrast with the highest peak reaching 17 times background.

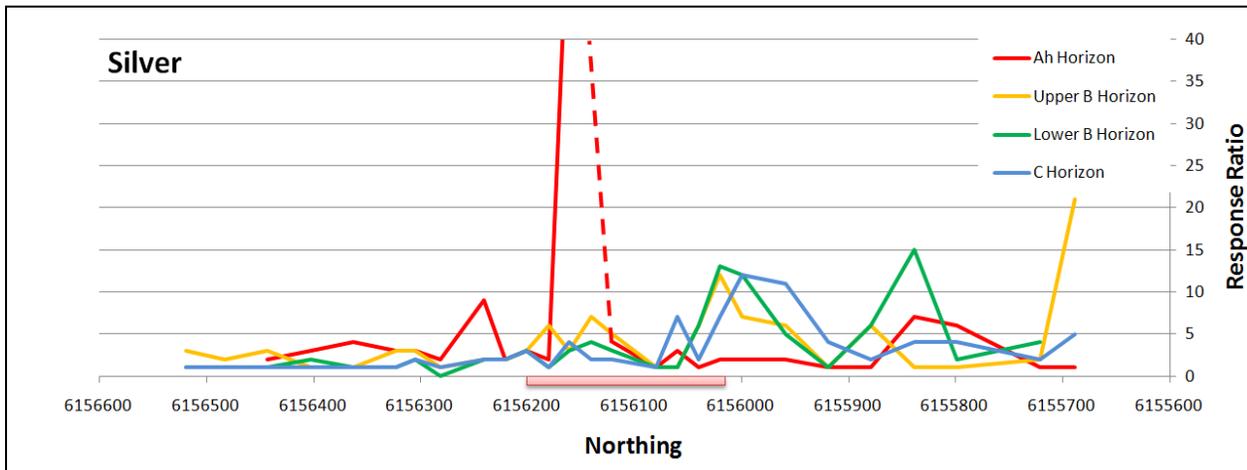


FIGURE 27. TRANSECT 2 – AQUA REGIA RESULTS FOR SILVER IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE DUE WHERE NO SAMPLE COULD BE TAKEN.

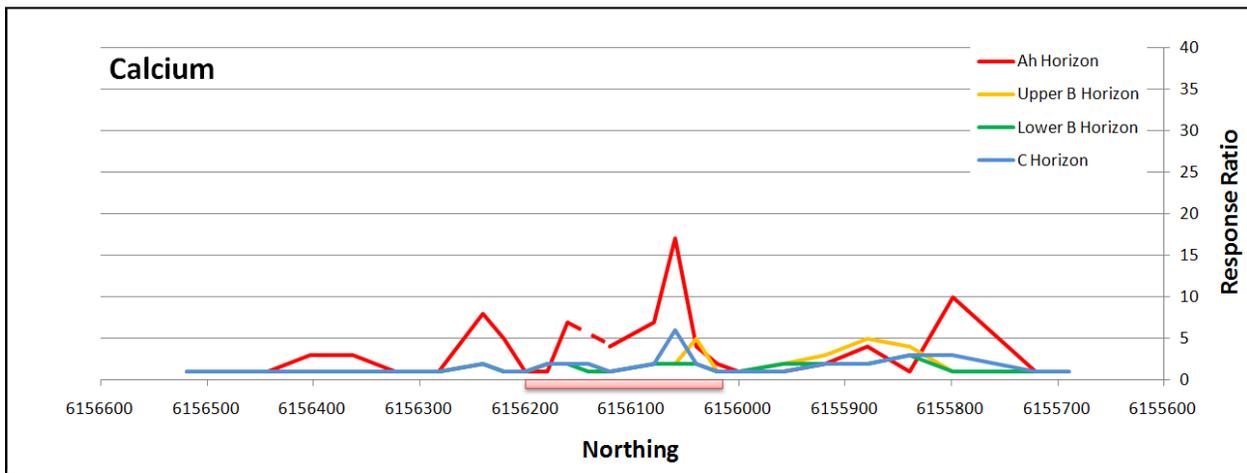


FIGURE 28. TRANSECT 2 - AQUA REGIA RESULTS FOR CALCIUM IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE DUE WHERE NO SAMPLE COULD BE TAKEN.

Arsenic results (Fig. 29) show an anomaly in the Ah horizon and only flat background responses in the upper B, lower B and C horizons. The Ah horizon response is apical in form with the highest contrast value ($RR < 17.5$) falling just inside the southern edge of the mineralized body. Results for iron (Fig. 30) do not reveal any anomalous patterns in the upper B, lower B or C horizons. A very subtle response ($RR < 5$) is visible in the Ah horizon results. This has the form of a broad, rabbit-ear feature with the central low situated over the mineralization.

Manganese has a similar response to calcium and arsenic in the Ah horizon (Fig. 31). It forms a moderate contrast ($RR < 15$) triple peaked anomaly centred directly on top of the mineralization. There is also a curious very high contrast ($RR < 71$) apical-type response located near the south end of the line. It coincides with a lower contrast calcium peak ($RR < 10$). The cause of this feature is unknown. There is nothing obvious about the surficial environment at the sample location to explain this feature. The other three horizons display only background variations along the line, with no discernable response over the mineralization.

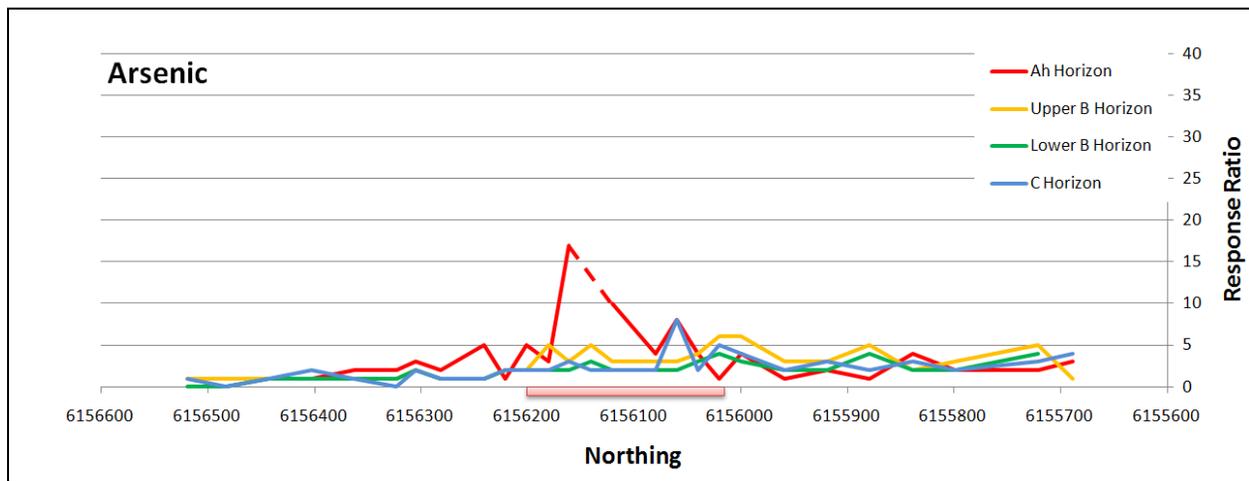


FIGURE 29. TRANSECT 2 – AQUA REGIA RESULTS FOR ARSENIC IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE WHERE NO SAMPLE COULD BE TAKEN.

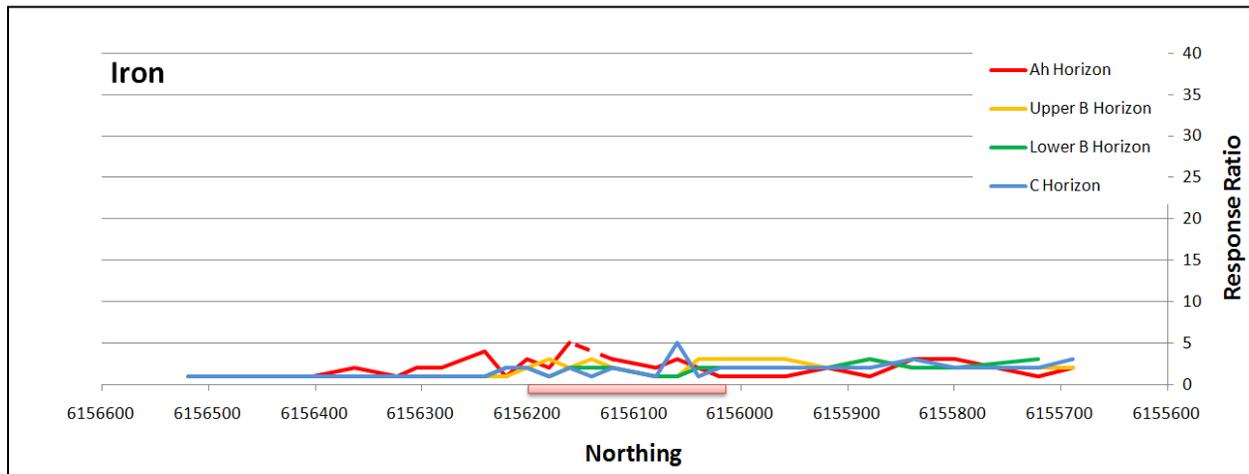


FIGURE 30. TRANSECT 2 - AQUA REGIA RESULTS FOR IRON IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE WHERE NO SAMPLE COULD BE TAKEN.

The most impressive response of any of the ore or pathfinder elements is shown by tungsten (Fig. 32). This element defines a very high contrast ($RR < 1400$), asymmetrical rabbit-ear anomaly in the Ah horizon. The peaks lie directly over the edges of the underlying mineralized body. There is a much more subdued response in the upper B horizon ($RR < 21$). This has the form of an apical anomaly located just off centre to the south of the mineralization. Lower B and C horizons have flat profiles.

Mercury (Fig. 33) is the only element of the ore and pathfinder suite that does not respond well in the Ah horizon. Instead, it has a robust apical response in the upper B ($RR < 843$) and the lower B ($RR < 385$) horizons. The peaks fall directly over the position of the mineralization. In the upper B horizon, there is another high contrast apical anomaly ($RR < 176$) located approximately 200 metres to the south of the mineralized body. This feature correlates with an area of elevated, noisy values in the lower B and C horizons and well correlates with elevated silver values in the lower B horizon. Soil profiles from this area contain a high proportion of rounded cobbles and pebbles, possibly indicating an outwash channel. It is possible that anomalous mercury and silver values are caused by exotic

mineralized clasts or detrital cinnabar grains. C horizon results also show a high contrast (RR<114), single sample anomaly near the north end of the line. This feature is unexplained but could also be caused by mineralized clasts or detrital cinnabar in the glaciofluvial gravels.

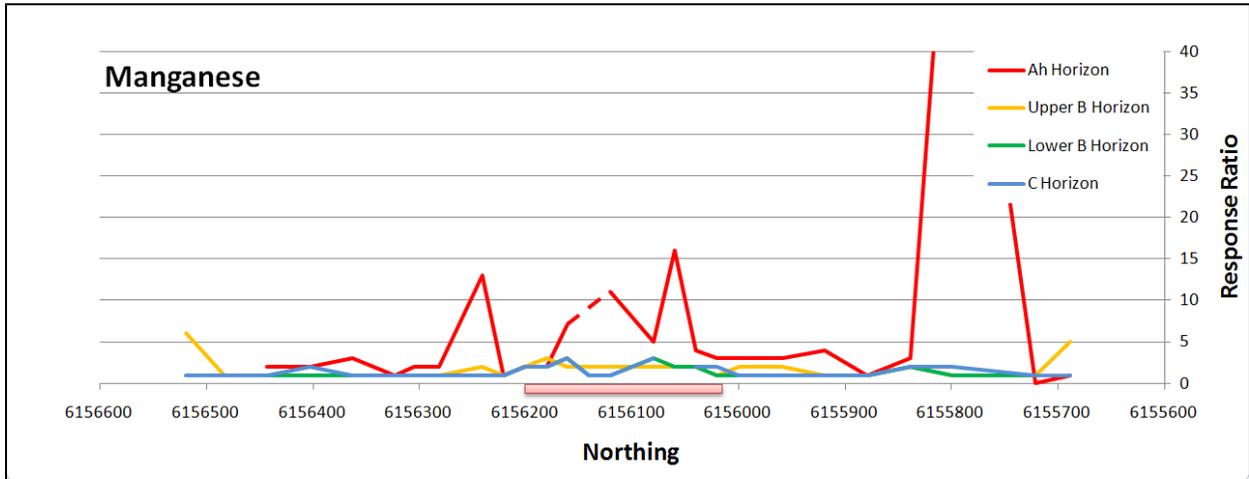


FIGURE 31. TRANSECT 2 – AQUA REGIA RESULTS FOR MANGANESE IN DIFFERENT SOIL HORIZONS. DASHED LINE IS AN EXTRAPOLATION OF THE PROFILE WHERE NO SAMPLE COULD BE TAKEN.

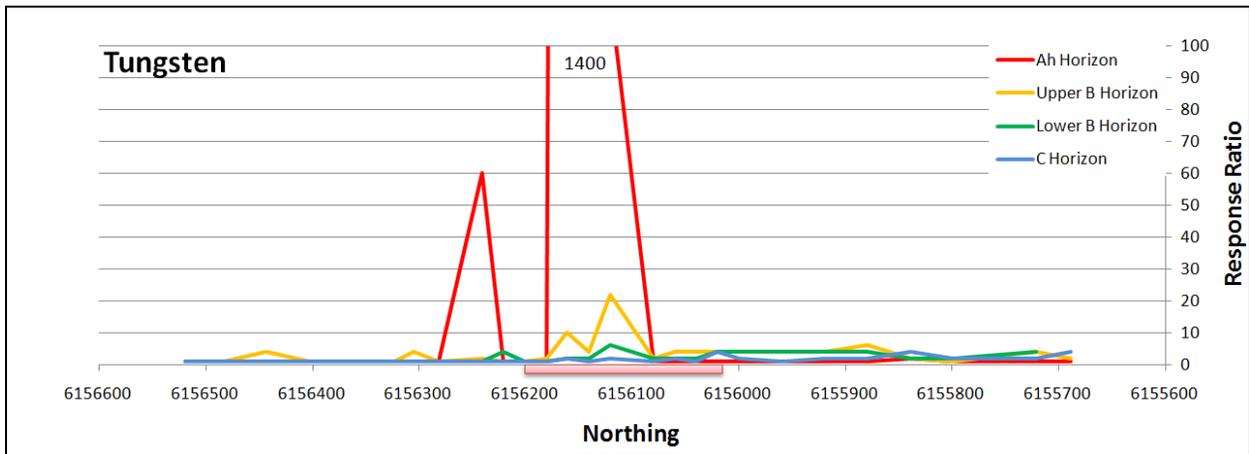


FIGURE 32. TRANSECT 2– AQUA REGIA RESULTS FOR TUNGSTEN IN DIFFERENT SOIL HORIZONS.

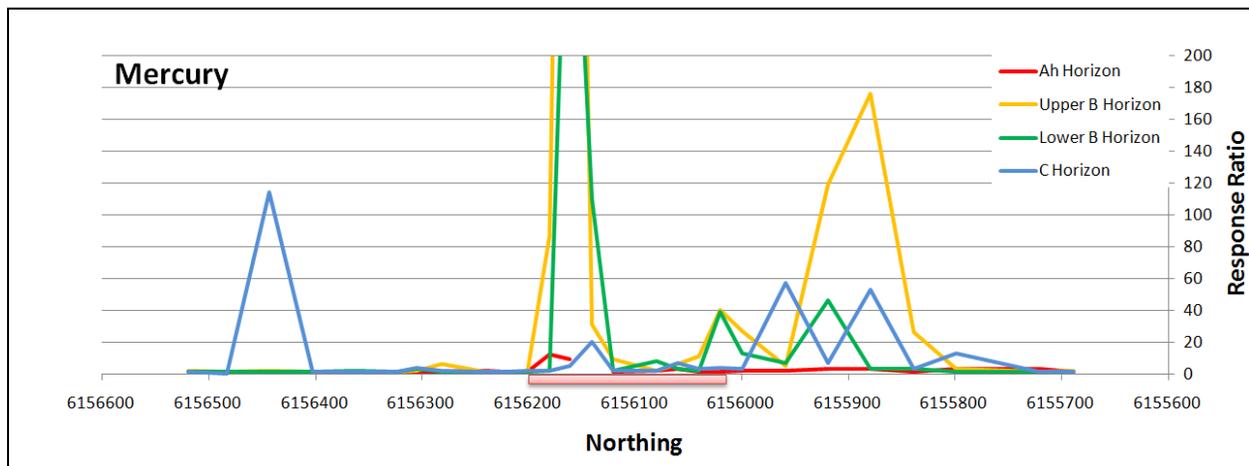


FIGURE 33. TRANSECT 2– AQUA REGIA RESULTS FOR MERCURY IN DIFFERENT SOIL HORIZONS

PARTIAL AND SELECTIVE EXTRACTIONS

Results for the partial and selective extractions are discussed in this section. These methods are designed to detect subtle variations in trace element concentrations caused by the *exogenic* signal. This is the proportion of the total element concentration that is added to the soil in water soluble (ionic) or gaseous form. It typically comprises a very small percentage of the total metal content. The far greater proportion of elements comes from primary and secondary minerals that constitute the soil itself. This is known as the *endogenic* signal.

Cations and anions derived from buried mineralization and other sources are captured by a variety of mechanisms (e.g. adsorption, co-precipitation, ion exchange, chelation etc.) in different trap sites in the soil profile (Cameron et al., 2004). Depending on the Eh and pH conditions of the surficial environment, these may include secondary minerals such as amorphous iron and manganese oxides, clays, carbonates and organic matter. Partial and selective extractions work by liberating these weakly bound ions into solution, either by dissolving target minerals containing a high proportion of the exogenic phase (selective extraction), or by liberating labile metals from all phases in the sample through a weak acid attack or ion exchange (non-selective or partial extraction).

Contrast between the exogenic and endogenic signal is a function of extraction strength. Stronger leaches like aqua regia dissolve a higher proportion of primary and secondary minerals (endogenic component) than weaker extractions. This can overwhelm the exogenic signal and is the reason why aqua regia is often ineffective at defining bedrock derived geochemical signatures in soils developed on transported overburden. Weaker extractions like enzyme leach and deionized water liberate only the most labile components without attacking the soil minerals themselves. Patterns defined by these methods can accurately reflect both ionic signals from underlying bedrock and hydromorphic dispersion along faults and seepages caused by ground water movement. Patterns produced from selective extractions are strongly influenced by the abundance of the target mineral phase. For example results for a cold hydroxylamine hydrochloride extraction are influenced by the abundance of amorphous manganese oxide present in the sample. In order to reveal the true exogenic signal, results must be corrected for the concentration of the target phase or controlling variable (Smee, 1983). This is done by correcting for the aqua regia concentration of the controlling variable (e.g. aqua regia Mn for cold hydroxylamine hydrochloride). Without applying a correction and just plotting raw values or response ratios of raw values, important patterns can be missed.

DATA PROCESSING

In order to prepare the partial and selective extraction results for interpretation a number of steps were taken. Analytical results were first merged with the sample location information using Geosoft's Target™ Geochemistry software. During the loading procedure, the software automatically replaces less than detection limit symbols (< and -) with a value equal to half the detection limit. Next, results for field and analytical duplicates were extracted from the dataset for QAQC evaluation. The completed dataset was then validated to ensure that sample locations were correct and that no merging errors had occurred. For the selective extractions the following corrections were applied to the data:

Sodium pyrophosphate results were corrected for organic carbon content by normalizing to LOI. While not a true organic carbon determination, LOI is a reasonable substitute for organic carbon in organic rich soils.

Cold hydroxylamine hydrochloride results were corrected for aqua regia manganese.

Hot hydroxylamine hydrochloride results were corrected for aqua regia iron and manganese.

The final step in the procedure is to convert the corrected data into response ratios. This is done using Geosoft's Target™ Geochemistry software. Response ratios are calculated by dividing the corrected values by the median of the lower quartile and rounding to the nearest integer. Results for each element are single element profile plots with the responses for each method plotted as coloured lines.

ELEMENT RESPONSES

Diagrams showing the responses for a suite of ore and pathfinder elements are presented in Figures 34 to 44. There are two figures for each element: one presents profiles for generic² partial and selective extractions and the second for laboratory specific³ methods. The pink bars on the following figures indicate the position of the underlying mineralization as defined by drill hole information.

TRANSECT 1

This Transect passes over a portion of the mineralization that subcrops beneath approximately 40 metres of Quaternary glaciofluvial cover.

COPPER

Results for copper are presented in Figure 34. It is apparent from these results that none of the methods tested produce an unequivocal, high contrast response to mineralization. All methods have relatively noisy profiles with contrast values generally below 10 times background. Of the generic methods (Fig. 34a), sodium pyrophosphate (SPY) produces the clearest response. It consists of a triple peaked apical anomaly centred slightly east of centre of the mineralization. The central peak has a maximum response ratio of 12. Background is quite noisy but there is sufficient contrast to suggest that this is a meaningful response.

Quite a different profile can be seen in the cold hydroxylamine hydrochloride results (CHDX). This method defines a distinct, low contrast rabbit-ear feature bracketing the SPY anomaly. Contrast is diminished by strongly elevated values near the ends of the lines. The strong peak (RR<16) at the west end of the line corresponds to boggy ground and therefore likely represents a hydromorphic anomaly. Elevated values at the east end of the line are unexplained. A similar but much lower contrast response is present in the hot hydroxylamine hydrochloride results (HHDX).

² Generic extractions are non-laboratory specific methods.

³ Laboratory specific extractions are proprietary and non-proprietary methods available from specific laboratories.

Rather than a rabbit-ear pattern, the anomaly has the form of a low or depression in the profile. On its own, this would not be considered a significant pattern however in the context of the CHDX rabbit-ear it shows that there is a weak response in the HHDX. Distilled (DI) water also has a weak response. It consists of a single peak located at the eastern edge of the mineralization. This feature has quite a low contrast ($RR < 8$) but it stands out against the relatively flat background. Cold aqua regia (CAR) shows only background variations.

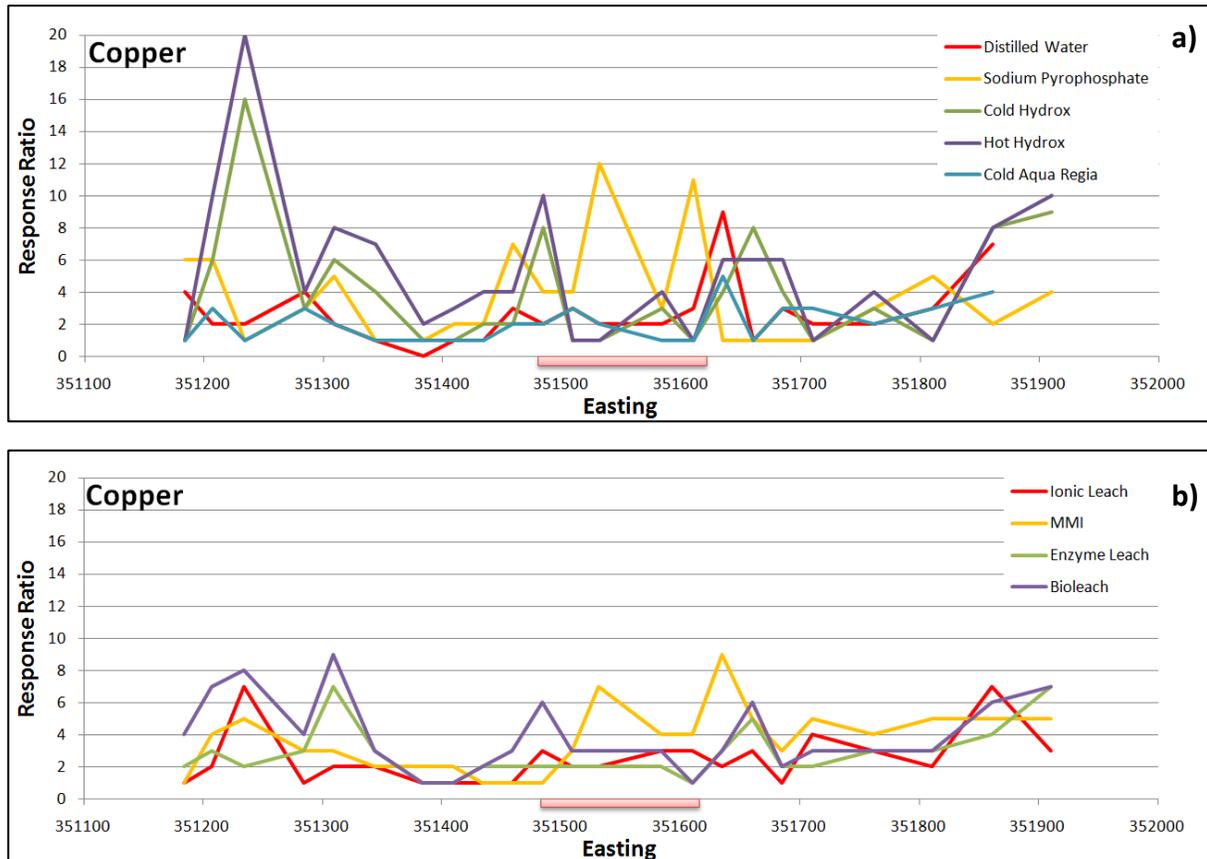


FIGURE 34. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR COPPER. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

Of the laboratory specific methods (Fig. 34b) only MMI has a credible response. It consists of a low contrast ($RR < 7$), rabbit ear feature, again centred over the eastern margin of the mineralization. Ionic Leach (IL), Enzyme Leach (EL) and Bioleach (BL) display only background variations along the Transect.

MOLYBDENUM

Figure 35a shows the molybdenum results for the generic leaches. None of them display a convincing response over the mineralization. The CHDX, HHDX and CAR have flat profiles across the sample Transect. DI is slightly elevated over the eastern portion of the projected mineralization and there is a suggestion of a low contrast ($RR < 6$) rabbit-ear response for this method. This observation is somewhat confirmed by SPY, which appears to have a very subtle apical anomaly centred between the DI rabbit-ear feature.

For the laboratory specific extractions (Fig. 35b), the results are not much better. The most obvious anomaly shows up in MMI. This has the form of a low contrast rabbit-ear anomaly centred over the eastern edge of the

mineralization. There is a subtle wider rabbit-ear feature in BL but the amplitude of this feature is well within that of the overall background and is therefore considered insignificant. There are no responses in either EL or BL.

ARSENIC

Credible patterns for arsenic are present in the SPY and DI extractions (Fig. 36a). SPY produces a low contrast (RR<7) rabbit-ear anomaly centred over the eastern edge of the mineralization. A higher contrast single peak (RR<9) feature is present in the DI results. This feature occurs immediately outside the eastern edge of the mineralization. It also shows a weak elevation above the mineralization with values decreasing to the west. This is a very subtle feature and would more than likely not be picked as anomalous in an exploration survey. CHDX, HHDX and CAR do not detect the mineralization and show only flat background values across the Transect.

None of the laboratory specific extractions detect an arsenic anomaly (Fig. 36b) over the mineralization. MMI has the most contrast of the four methods and shows a double peak feature situated well to the east of the zone. The significance of this feature is unclear; however, soil conditions in this area alternate between boggy and dry and therefore the MMI may be detecting a hydromorphic anomaly related to metal accumulation in the boggy ground. IL, EL and BL show only background values over the mineralization.

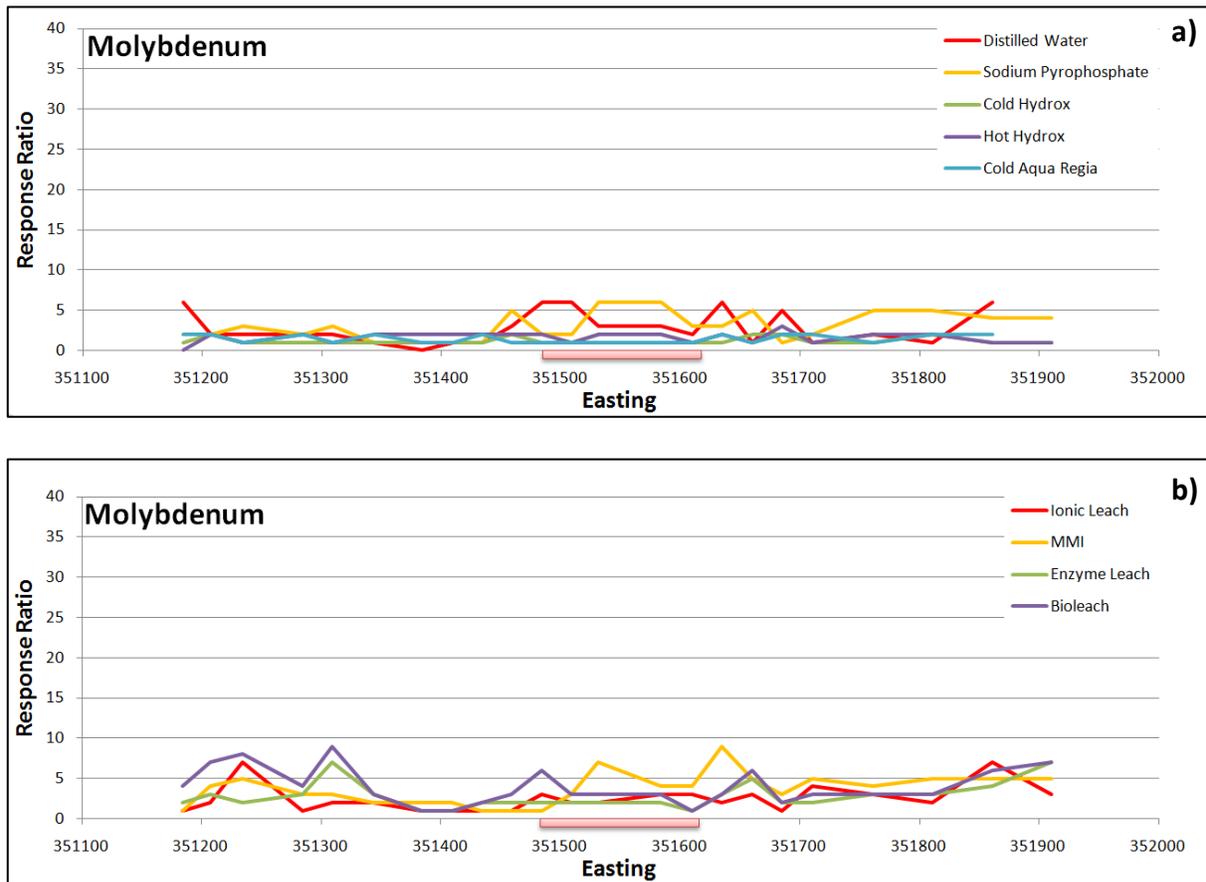


FIGURE 35. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR MOLYBDENUM. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

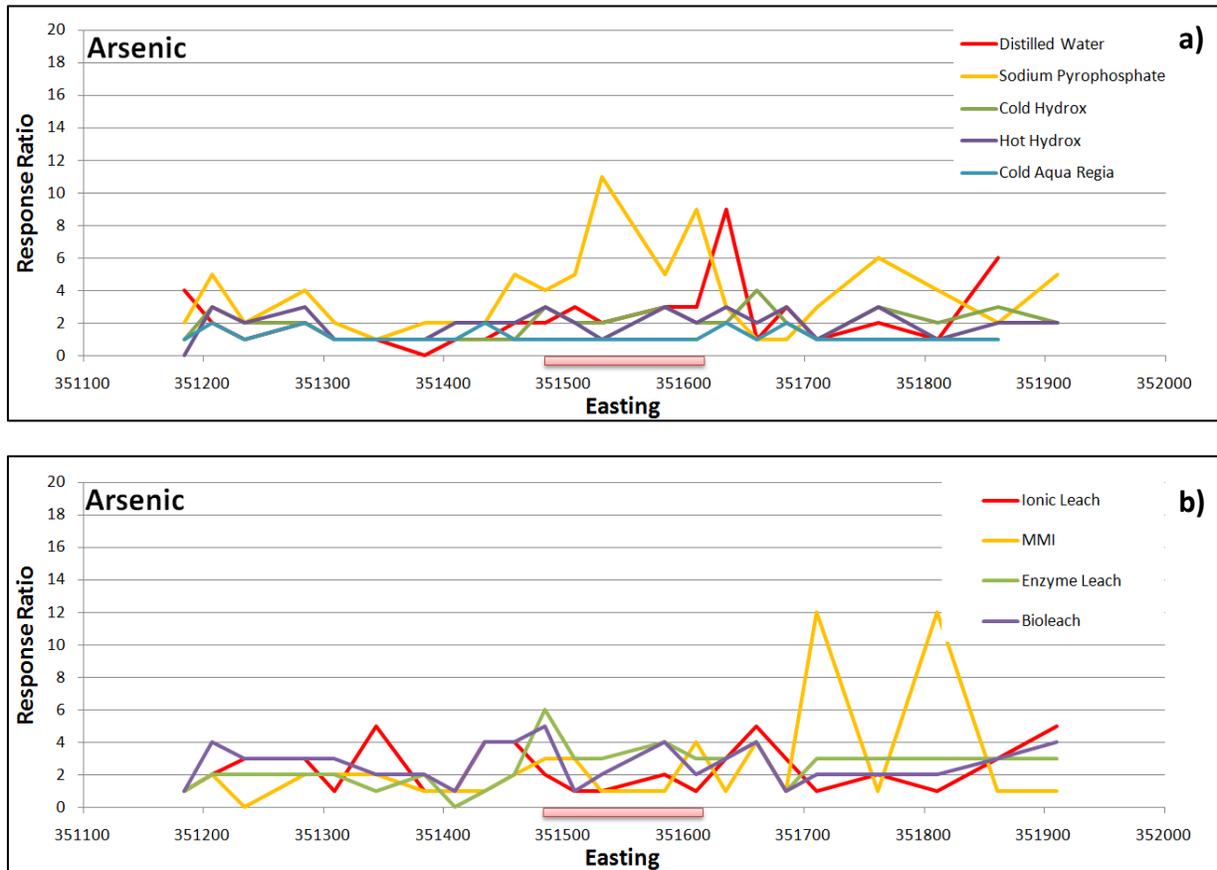


FIGURE 36. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR ARSENIC. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

ANTIMONY

Results for antimony are presented in Figure 37. Responses are slightly stronger than they are for arsenic. SPY defines a weak apical anomaly ($RR < 9$) over the eastern half of the mineralization. This feature is credible because of the flat background over the remainder of the line. A similar response is present in the CHDX although the position of the peak is not coincident with the maximum SPY value. It is slightly offset to the east closer to the edge of the mineralization. DI appears to be broadly elevated over the mineralization with a peak located just outside the eastern edge. Contrast for this feature is so low that it cannot be considered a valid anomaly. HHDX shows a subtle apical anomaly located just inside the eastern edge of the mineralization but as with DI, the contrast is so low ($RR < 4$) that it is difficult to describe this as anomalous. There is no response in the CAR.

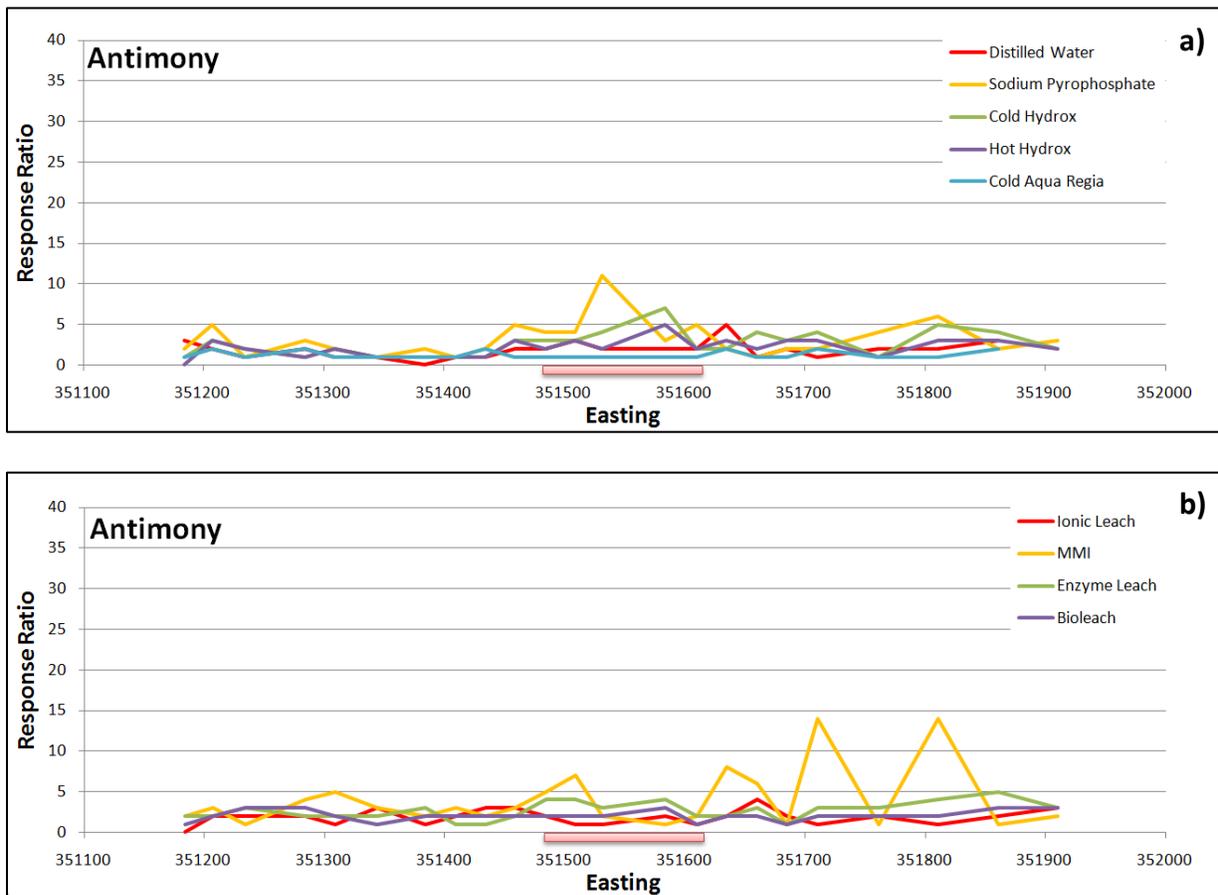


FIGURE 37. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR ANTIMONY. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

MERCURY

Results for the pathfinder element mercury are presented in Figure 38. Only one of the eight methods (MMI does not report this element) produces a recognizable response to the mineralization. CAR defines a moderate contrast ($RR < 11$) triple peak anomaly situated directly over the mineralization (Fig. 38a). There is also a stronger peak located 125 metres east of the mineralization, which is unexplained. Of the laboratory specific methods (Fig. 38b), IL shows a low contrast, single peak anomaly ($RR < 8$) situated 75 metres east of the mineralization. This is not coincident with either the CAR anomaly or the position of the mineralization and is therefore considered to be a spurious feature.

BISMUTH

Figure 39 shows results for bismuth. This element is not convincingly detected by any of the methods. Of the generic extractions, only SPY (Fig. 39a) shows any enrichment above the mineralization but the contrast of the response is so low that it cannot be considered significant. Elevated values over boggy ground east of the mineralization produce a feature of equal amplitude to that over mineralization, making it difficult to distinguish between true and false responses. In the laboratory specific methods (Fig. 39b) only BL has any significant variation

(RR<16) however, this appears to be noise as there is as much variation in background areas as there is over mineralization.

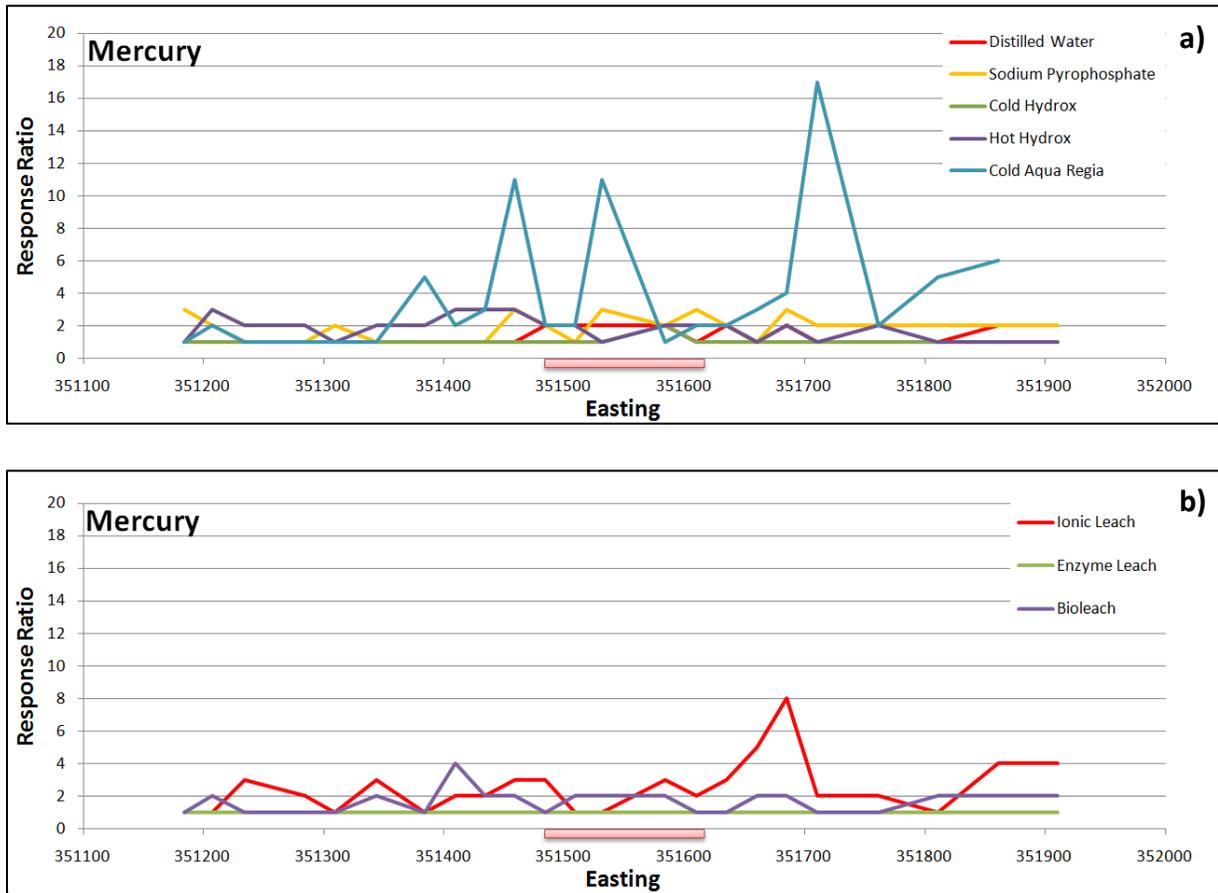


FIGURE 38. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR MERCURY. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

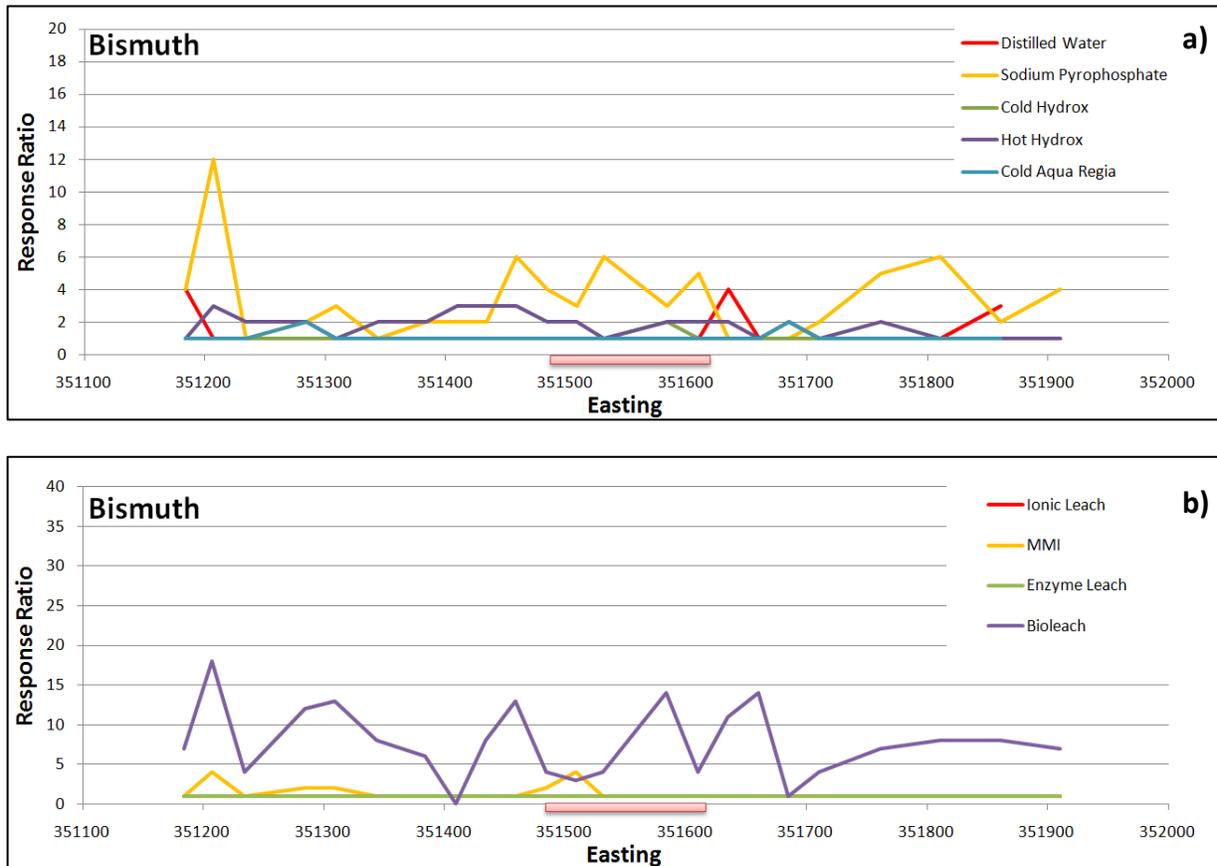


FIGURE 39. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR BISMUTH. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

TUNGSTEN

Tungsten occurs in very low concentrations across the sample Transect. An impressive response to the mineralization can be seen in the SPY results (Fig. 40a). This method defines a high contrast apical anomaly (RR<106) centred over the eastern part of the mineralization. The anomaly is a double peak feature with a small subsidiary peak (RR<14) occurring near the centre of the mineralized zone. The asymmetry between the two peaks is extreme, which makes it unlikely that the profile represents a rabbit-ear response. HHDX appears to define a very low contrast, broad, asymmetrical rabbit-ear feature with the stronger peak (RR<5) located on the western side of the mineralization. The corresponding eastern peak is very subtle and can only be identified because of the flat background. The other generic methods do not yield recognizable responses.

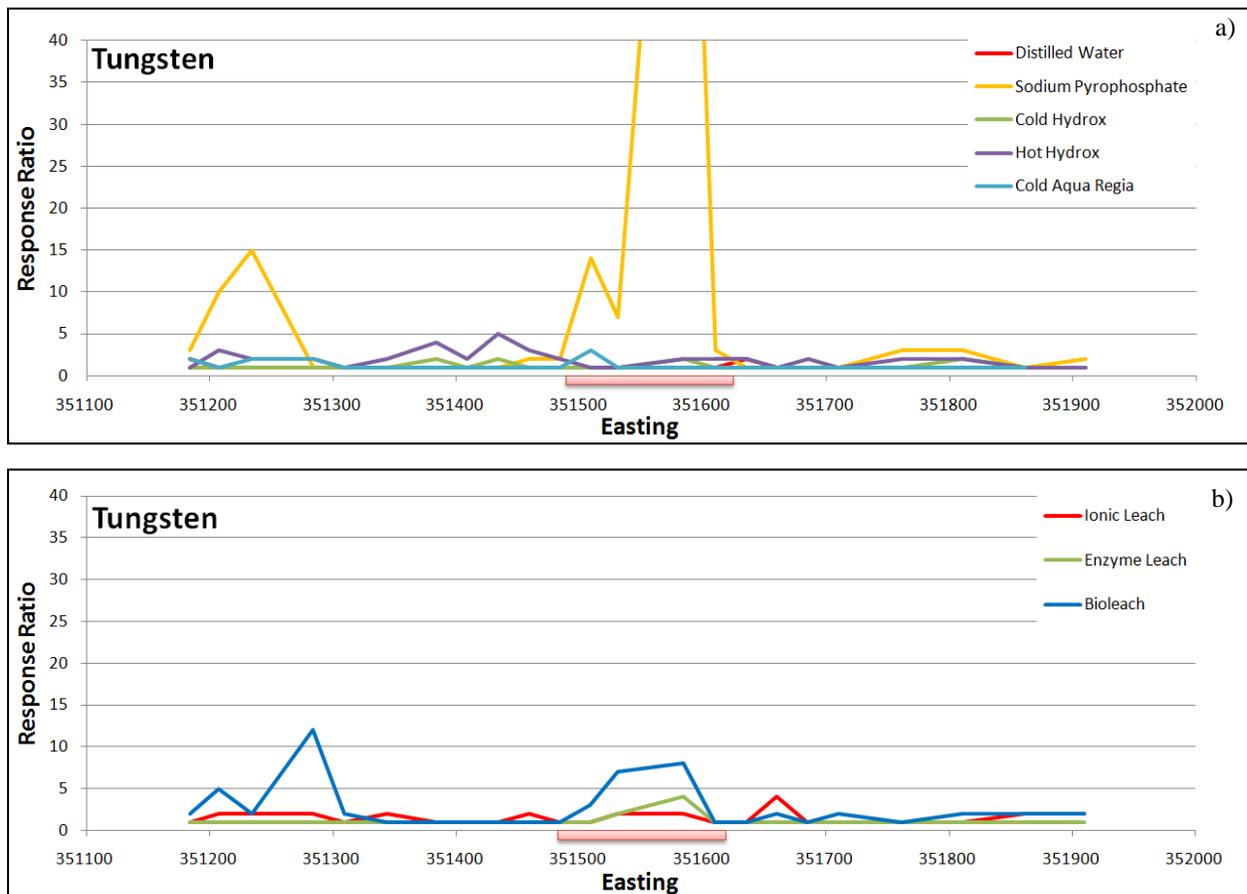


FIGURE 40. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR TUNGSTEN. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

Of the laboratory specific methods (Fig. 40b), BL produces a moderate contrast response near the east edge of the mineralization. There is a second anomaly of greater amplitude ($RR < 12$) near the west end of the Transect. These two features could represent a wide-spaced rabbit-ear anomaly. EL and BL do not show any contrast over the mineralization. MMI does not report tungsten.

URANIUM

Uranium shows a similar pattern to tungsten (Fig. 41). Of the generic extractions (Fig. 41a), only SPY produces a credible response over the mineralization. This feature has the form of a very high contrast ($RR < 68$) apical anomaly centred directly over the zone. There are some spurious peaks (noise) in background areas near the west and east ends of the line. These features are of significantly lower contrast than the response over the zone. Responses for the other generic extractions are essentially flat.

Of the laboratory specific methods (Fig. 41b), only MMI has a recognizable anomaly. It forms a low contrast, single peak response ($RR < 6$) located just outside the east edge of the mineralization.

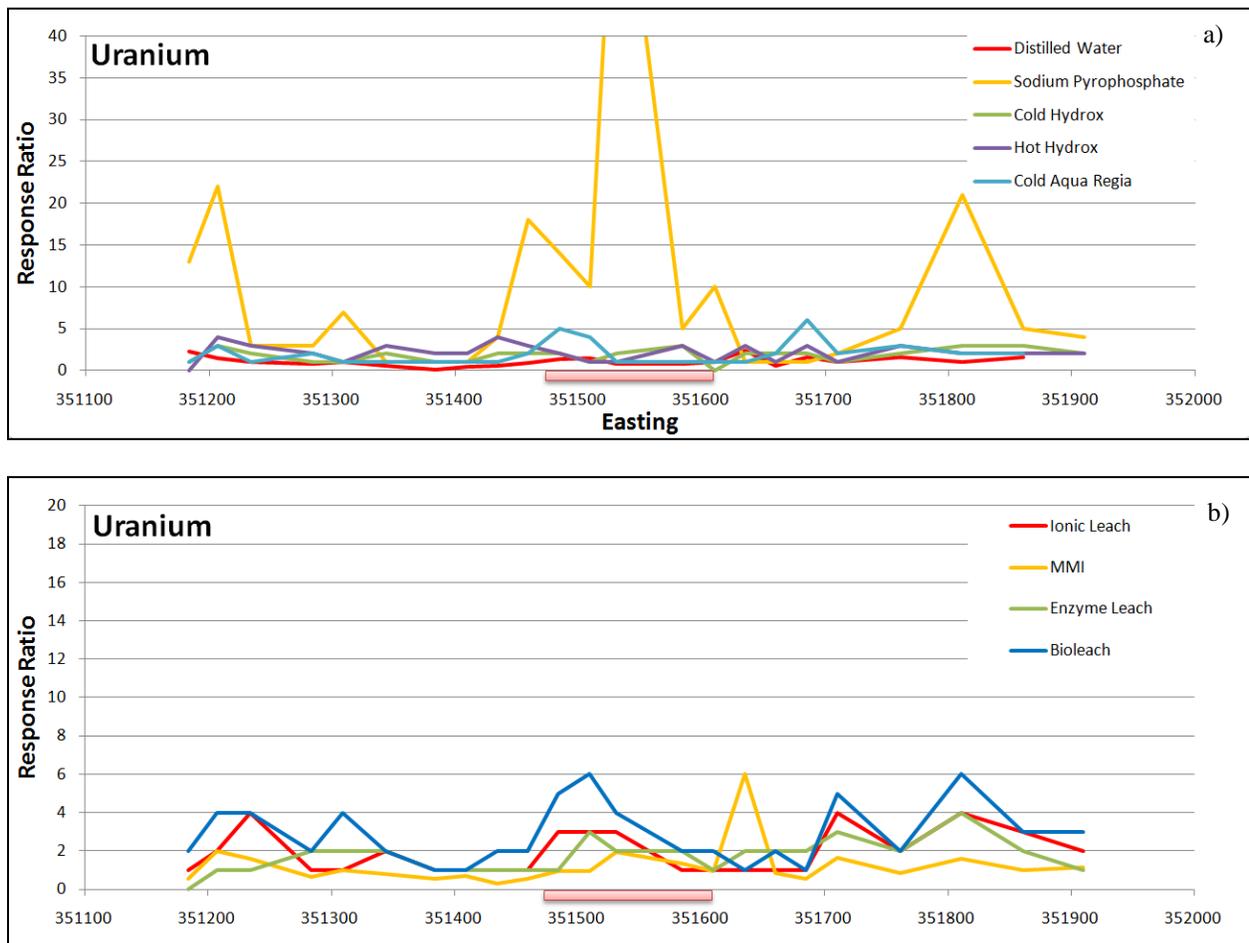


FIGURE 41. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR URANIUM. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

IRON

Iron is sensitive to changes in redox conditions in the soil. The presence of a reduced chimney in the overburden profile should be reflected in the iron distribution. Lows or depletions are predicted in the reduced area over mineralization with possible enrichments as rabbit-ear peaks on the edges of the reduced zone (Hamilton, 1998, 2007). Patterns for the generic methods are shown in Figure 42a. None of the methods detect the predicted pattern. SPY has the most compelling response, albeit a low contrast one. It defines a broad apical anomaly spanning most of the projected width of the mineralized body. Maximum response ratio values only reach 6 but there is enough contrast over background at the west end of the line to be able to distinguish the anomaly. To the east, iron is enriched in the boggy ground creating a false anomaly of equal strength to the one over mineralization.

DI produces a low contrast, single peak anomaly ($R < 9$) on the eastern edge of the mineralization (Fig. 42a). This feature has no corresponding rabbit-ear response on the west side and therefore is considered to be an apical response. SPY shows a broad, low contrast high over the mineralization but also detects iron enrichment over the boggy ground on the east end of the line. The latter has the same amplitude as the anomaly over the mineralizing, making it difficult to distinguish real from false anomalies. There are no significant responses for CHDX, HHDX or CAR, which show only background values.

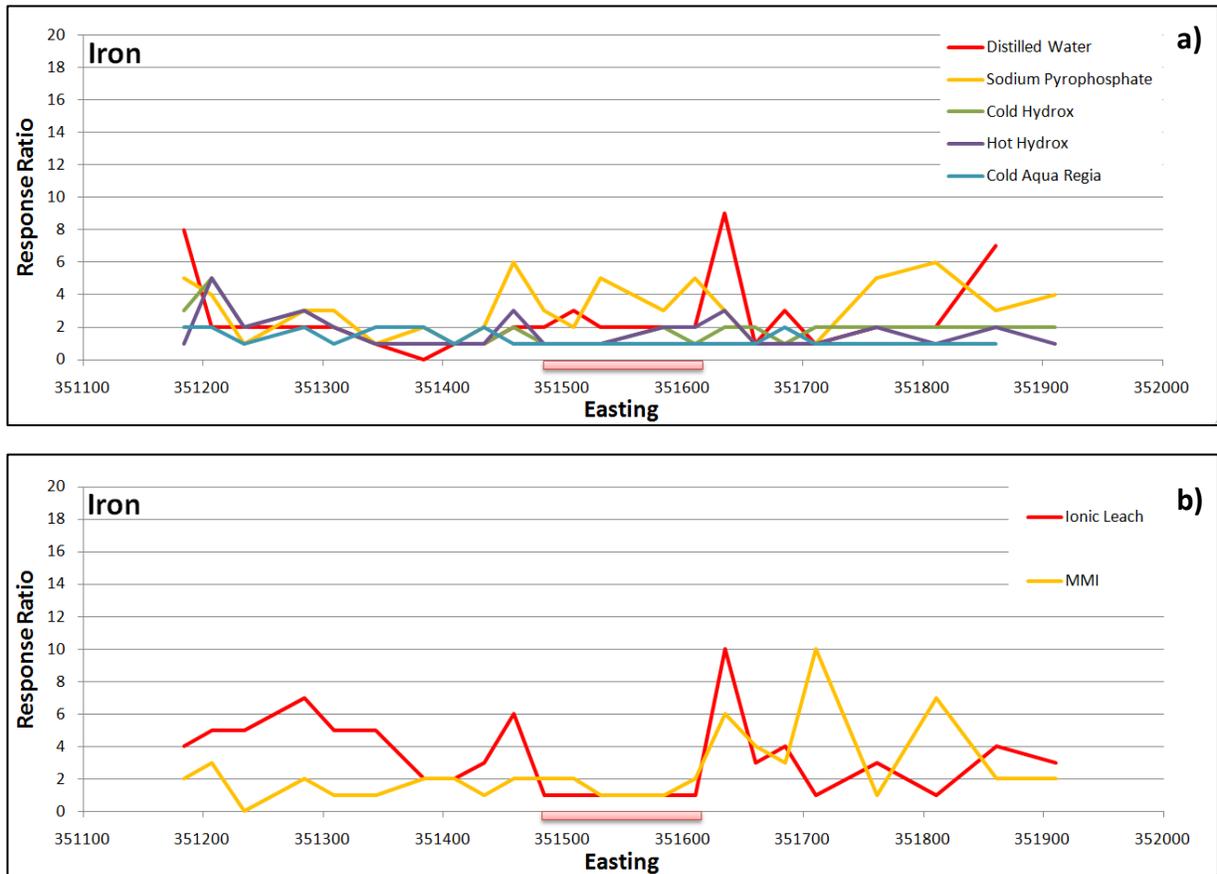


FIGURE 42. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR IRON. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

Only two of the laboratory specific methods report iron (Fig. 42b). IL displays a prominent low directly over the mineralization flanked by weak rabbit-ear features. As mentioned above, this pattern is suggestive of a reduced chimney over a sub-cropping part of the mineralization. IL is the only method to detect this pattern. There is also a suggestion of a corresponding low in the MMI results. Unfortunately the contrast of this feature is very low and it is hard to distinguish it from other lows in the background, particularly to the west of the mineralization. On the east side, MMI iron is more elevated but equally noisy. Higher values in this area are almost certainly reflecting the areas of boggy ground mentioned above.

MANGANESE

Manganese is another element that is sensitive to changes in redox near surface conditions and as such would be expected to display either a depletion anomaly over the mineralization or a rabbit-ear pattern on the edges of a redox cell. SPY shows the latter pattern clearly (Fig. 43a). It defines a moderate contrast ($RR < 20$) rabbit-ear feature centred over the eastern half (up-dip portion) of the mineralized zone. There is no response in the background areas, although background west of the deposit is noisier than it is to the east. A lower contrast ($RR < 10$) rabbit-ear anomaly is also present in the DI results. This feature clearly brackets the sub-cropping part of the mineralization. CHDX has a less clear response, which could be interpreted as a rabbit-ear. This feature is partly compromised by manganese enrichment in the boggy ground east of the mineralization, which forms a peak with higher contrast than the eastern rabbit-ear feature. There are no clear responses for HHDX or CAR.

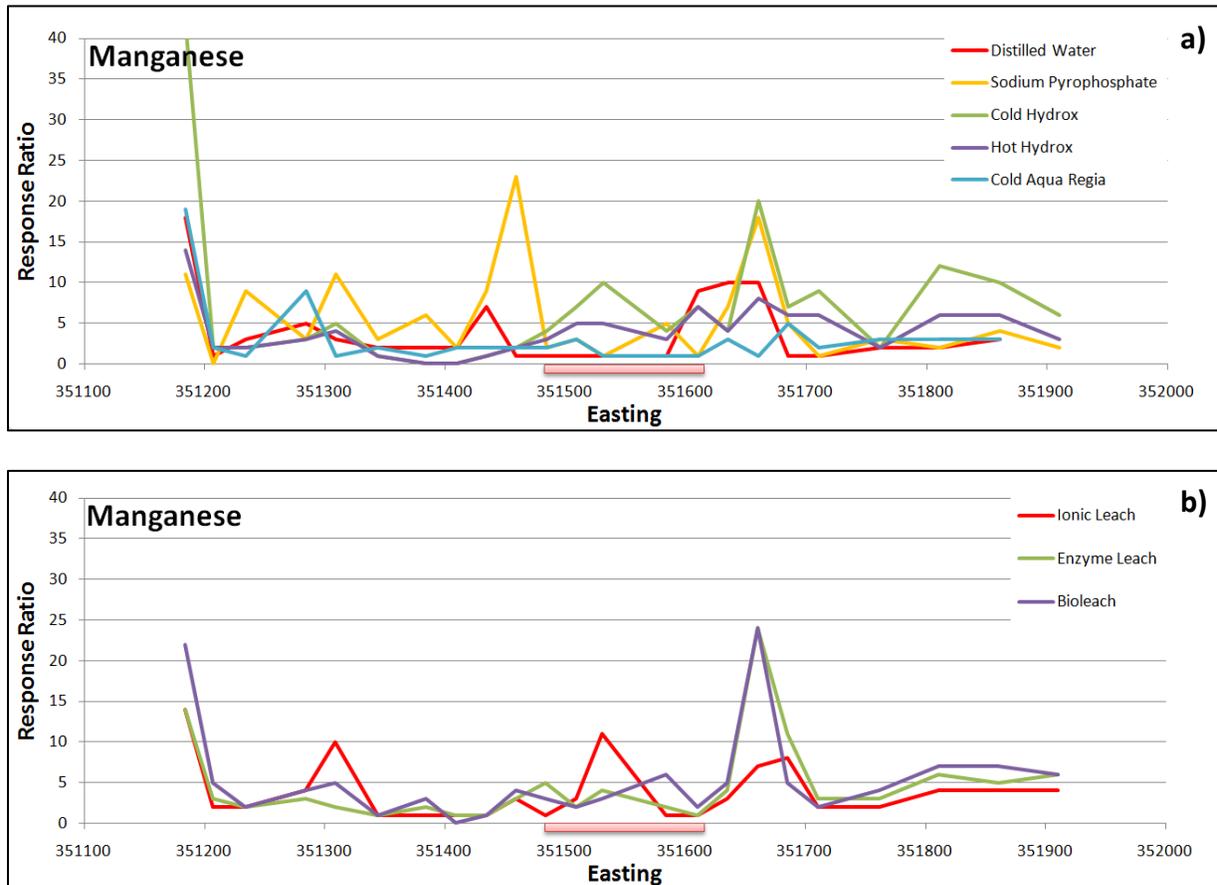


FIGURE 43. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR MANGANESE. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

None of the laboratory specific methods produce convincing patterns for manganese (Fig. 43b). IL shows three separate peaks that are not easily related to the position of the mineralization. EL and BL both define moderate contrast peaks ($RR < 24$) located just outside the eastern edge of the mineralization. There is no obvious expression over the mineralization itself. All methods have a strong response on the western end of the line. This sample location corresponds with a small boggy area. MMI does not report manganese.

CALCIUM

Several of the generic methods display convincing patterns for calcium (Fig. 44a). CHDX, HHDX and CAR all define a broad rabbit-ear response with a central low situated just east of the mineralization. Maximum contrast is shown by CHDX, which has an asymmetrical profile with the stronger peak ($RR < 20$) located on the west side, over the centre of the mineralization. CAR has a similar profile but with slightly lower contrast ($RR < 15$) and DI the same pattern with even lower contrast ($RR < 10$). The only method to not show a credible pattern is SPY, which has a noisy, low contrast response that is not clearly related to the position of the mineralization.

IL has the most convincing pattern of the laboratory specific leaches (Fig. 44b). It defines a pronounced low with broad, moderate contrast shoulders ($RR < 13$), with the centre located east of the mineralization. MMI does not produce a recognizable response. The profile is erratic and shows as much variation in background areas as it does over mineralization. BL and EL do not report this element.

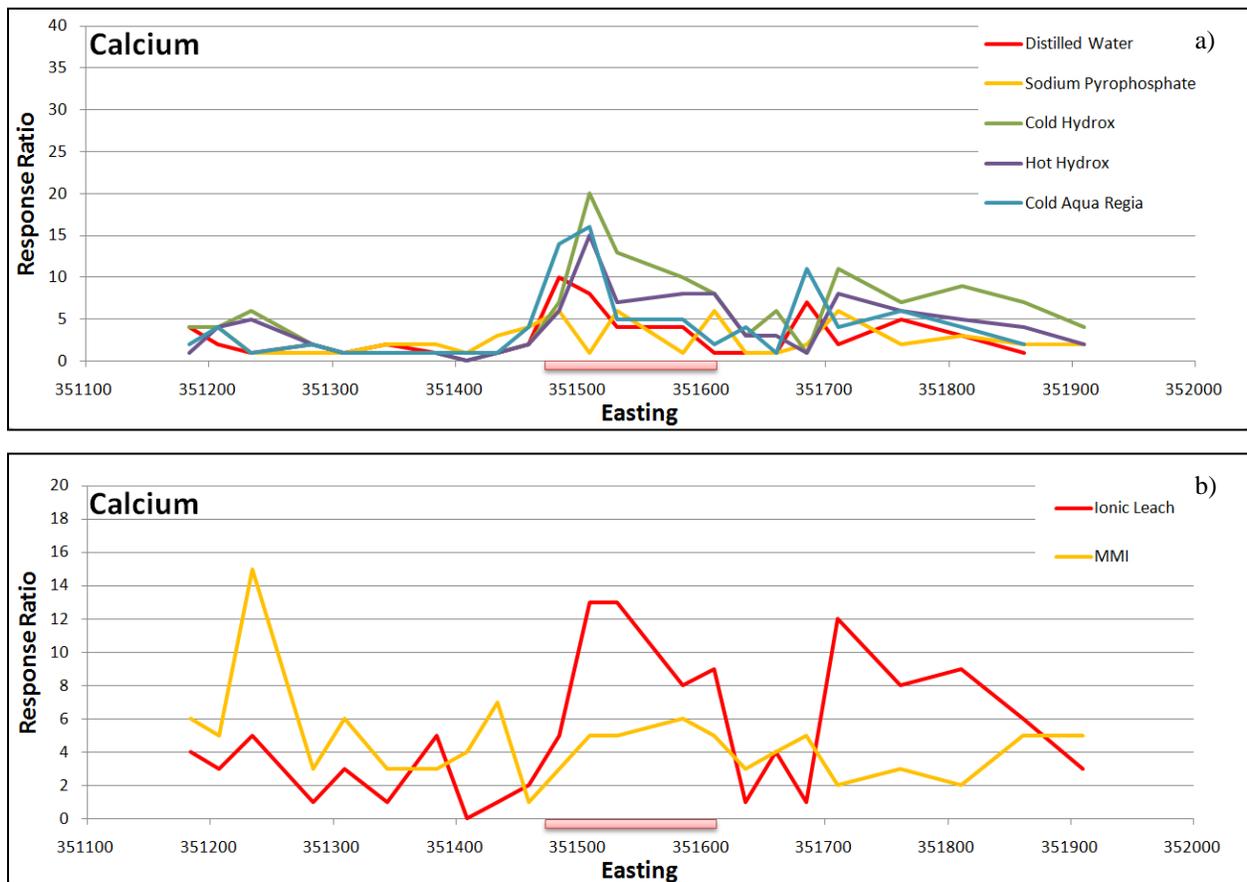


FIGURE 44. TRANSECT 1 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR CALCIUM A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

TRANSECT 2

Results for Transect 2 are presented in Figures 45 to 54. This line passes over mineralization that occurs approximately 300 metres below the surface, beneath post-mineral sedimentary rocks and younger Quaternary glaciofluvial cover (Fig. 10).

COPPER

Results for copper are illustrated in Figure 45. Two different types of response are shown by the generic methods: rabbit-ears and apical anomalies. SPY has the highest contrast response. It defines a triple peak anomaly that appears to be a combination of an apical and rabbit-ear profile. The maximum value ($RR < 40$) occurs directly over the middle of the mineralization and it is bracketed by two lower contrast peaks ($RR < 13$ and $RR < 7$). This profile clearly identifies the position of the mineralization. CHDX and HHDX have quite a different profile. Rather than an apical anomaly over the mineralization, there is a pronounced low, flanked by asymmetrical high shoulders. The larger and sharper shoulder is over the south edge of the mineralization; the one on the north side is broader and grades away into a region of high background values to the north. Of the two hydroxylamine hydrochloride methods, the cold extraction produces the highest contrast anomaly ($RR < 23$). CAR and DI do not produce convincing anomalies. Of the two, DI has the highest contrast ($RR < 7$) and defines an area of elevated, noisy values over the mineralization.

The DI response has a very low contrast. CAR has no credible response; variations over the mineralization are within the background range.

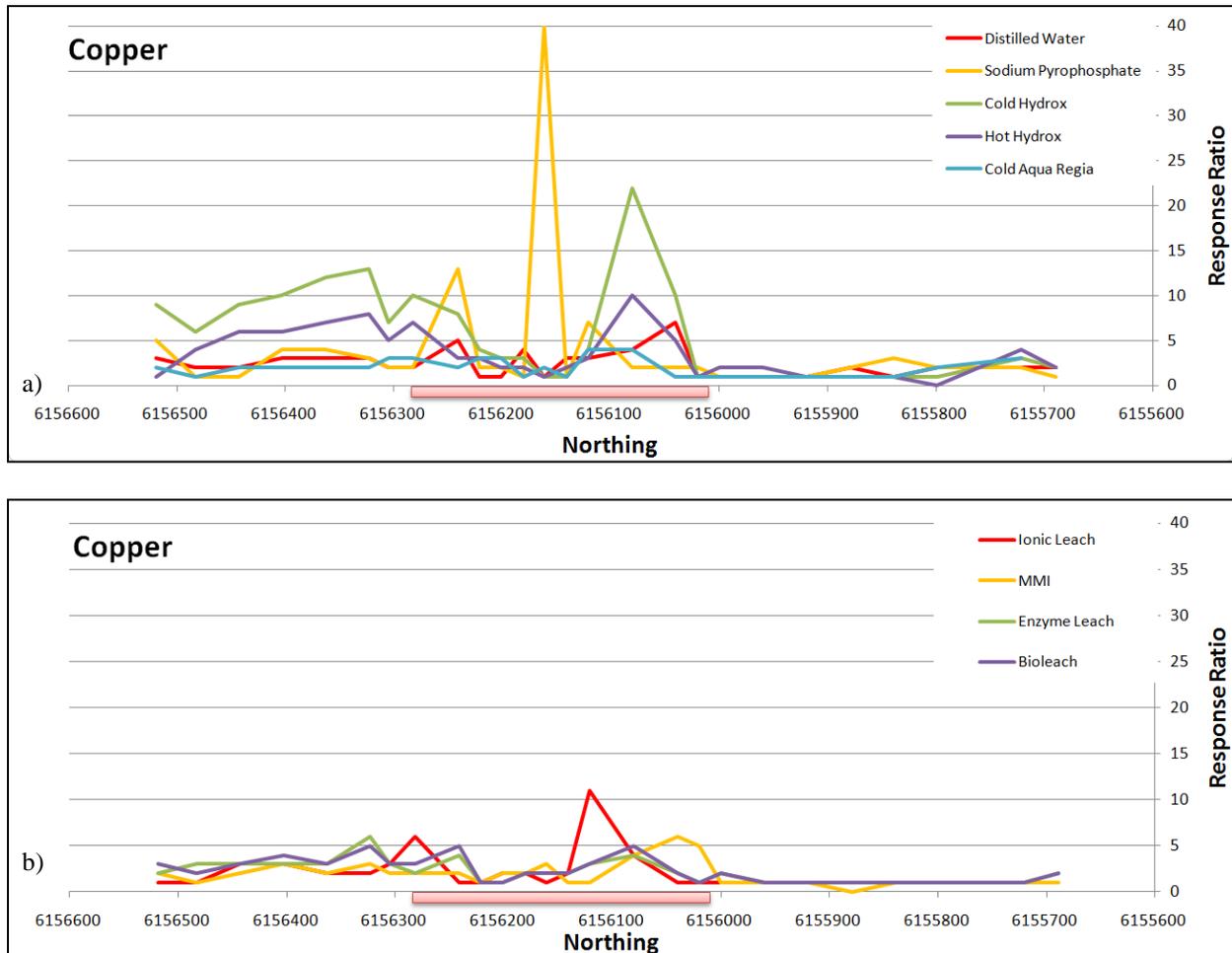


FIGURE 45. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR COPPER. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

Of the laboratory specific methods (Fig. 45b), IL shows the most convincing results for copper. It defines a moderate contrast, ($RR < 11$) asymmetric, rabbit-ear anomaly centred over the middle of the mineralization with the higher peak on the south side. Patterns for MMI, EL and BL are less clear. MMI shows a background shift from lower to higher values just south of the mineralization. There is a subtle peak ($RR < 6$) located just outside the southern edge of the zone but there is no corresponding rabbit-ear peak on the north side. Instead, slightly elevated background values continue to the north end of the line. BL has a similar pattern, with a background shift from lower to higher values just south of the mineralization. There is a suggestion of a rabbit ear response but contrast is within the background range at the north end of the line. EL shows much the same pattern. Background shifts noted for several of the extractions corresponds with a change in bedrock type from post mineral sedimentary rocks in the north (higher background) to intrusions and volcanic to the south (lower background).

MOLYBDENUM

Molybdenum results are shown in Figures 46. Contrast for this element for all extractions is very low ($RR < 10$). The best response is given by SPY (Fig. 46a), which forms a broad zone of elevated and erratic values over the mineralization and extending at least 75 metres beyond the edges. Within this area, the maximum response ratio ($RR < 13$) defines a single sample, apical anomaly over the centre of the mineralization. A stronger peak ($RR < 15$) occurs at the southern end of the line. This feature corresponds with an area of boggy ground and is interpreted to be of hydromorphic origin. The other generic methods do not produce obvious responses to the mineralization.

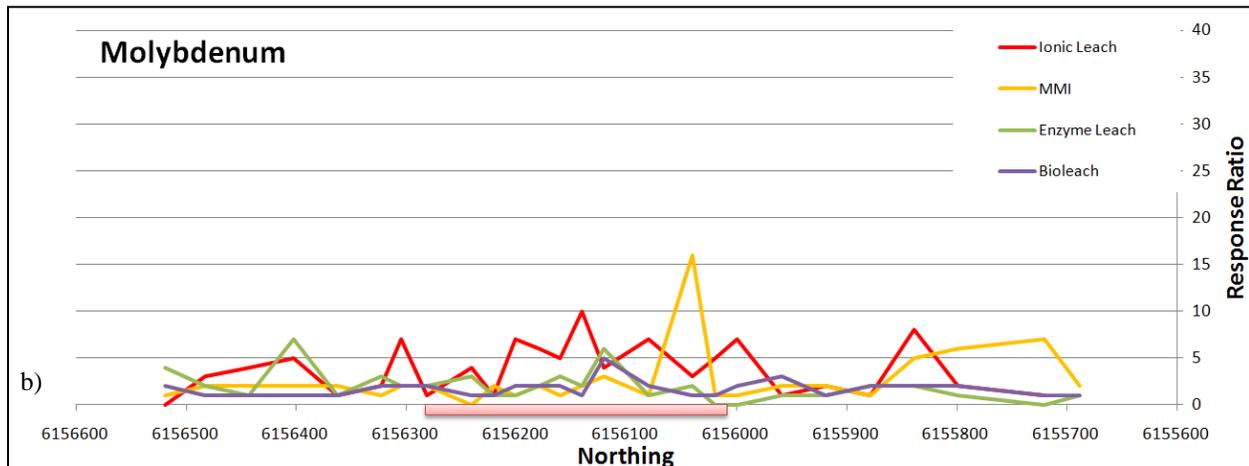
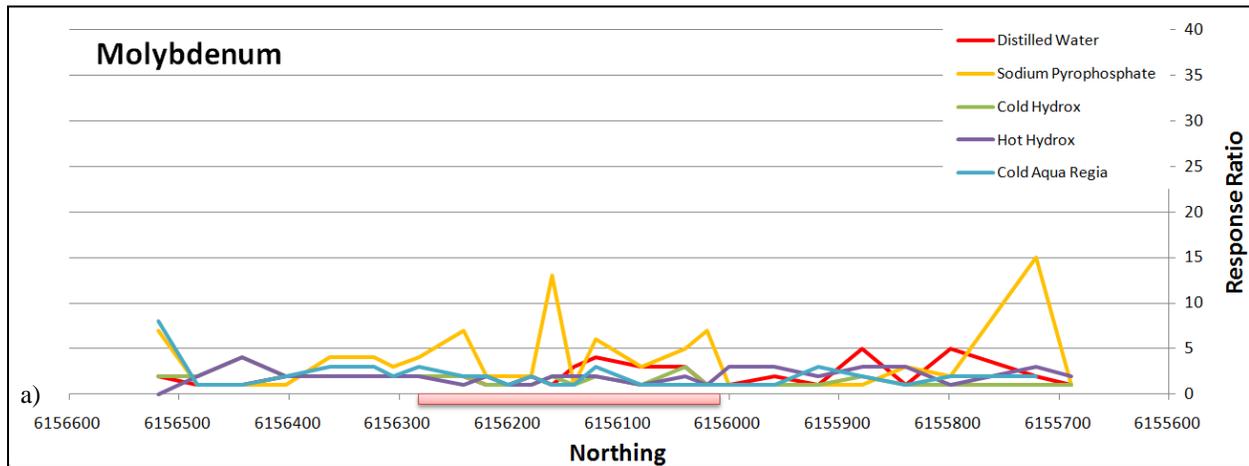


FIGURE 46. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR MOLYBDENUM. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

The most compelling response for the laboratory specific methods is produced by MMI. It defines a single peak anomaly ($RR < 16$) over the southern edge of the mineralization. This is not a rabbit ear response as there is no corresponding peak on the north side. MMI also detects a possible hydromorphic anomaly in the boggy area at the south end of the line.

Subtle apical responses are defined by EL and BL (Fig. 46b). Maximum values for each (5 and 6) occur south of centre of the mineralization. These methods do not appear to detect hydromorphic anomalies related to boggy ground at the south end of the line.

ARSENIC

Convincing arsenic responses are observed in two of the generic methods (Fig. 47a). SPY has the highest contrast response. It defines a double peaked anomaly (RR<16) centred over the southern edge of the mineralization. CAR shows quite a different pattern. It forms an apical anomaly (RR<11) located over the centre of the mineralization. Of the other generic methods, only DI displays a recognizable pattern. It forms a broad, low contrast apical anomaly (RR<5) spanning most of the width of the mineralization.

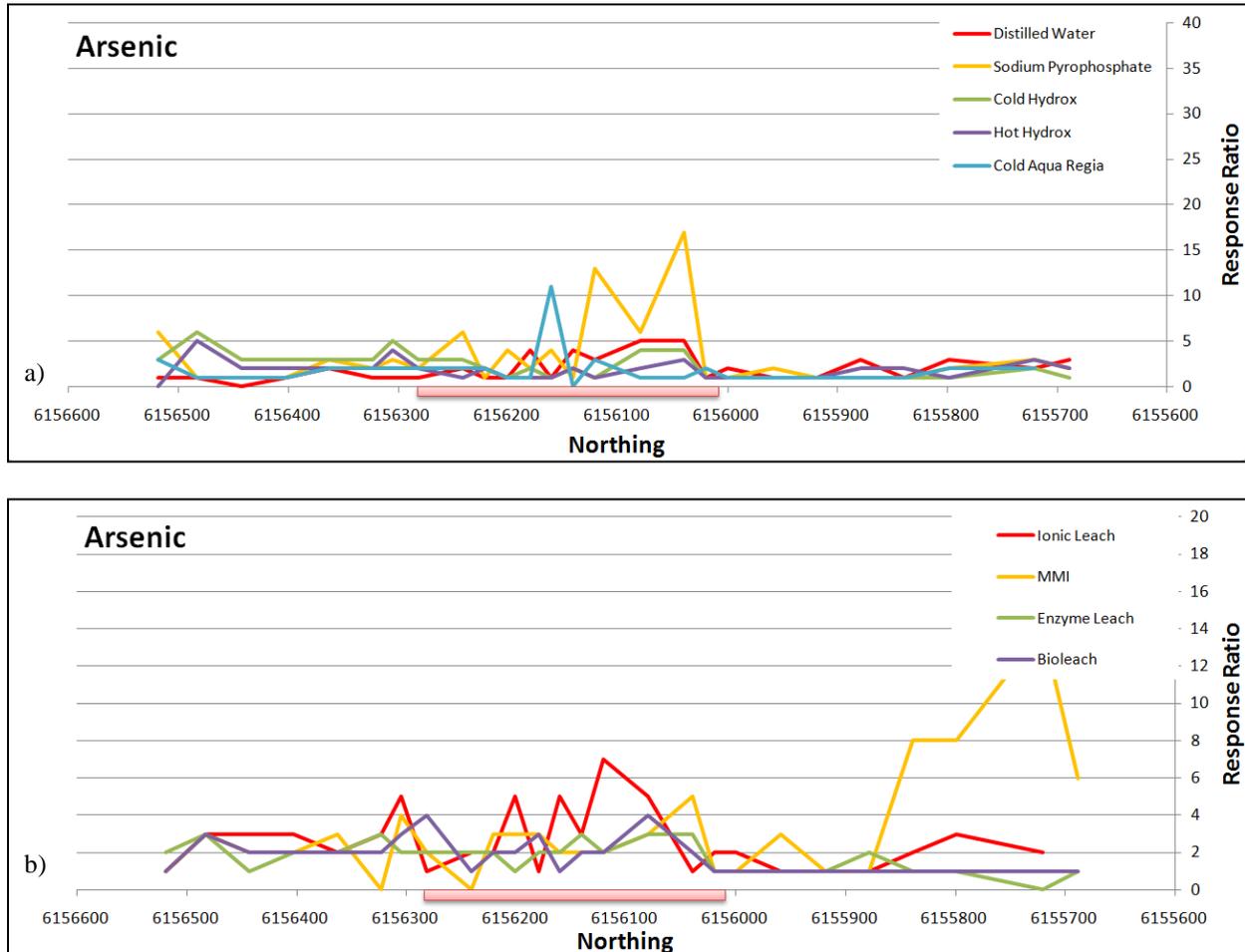


FIGURE 47. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR ARSENIC. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

IL has the most significant response of the laboratory specific methods (Fig. 47b). Elevated values between 5 and 7 comprise a noisy apical anomaly over the mineralization. The contrast of this feature is reduced somewhat by higher background values at the north end of the line. MMI, EI and BL do not have recognizable responses to the mineralization but MMI does produce a moderate contrast anomaly at the south end of the line (RR<14) corresponding to an area of boggy ground.

ANTIMONY

Results for antimony are quite disappointing for all methods tested. CAR (Fig. 48a) is the only one of the generic methods to produce an unequivocal response. It has the form of a low contrast (RR<7) apical anomaly directly over

the centre of the mineralization. The maximum value lies within a broad weakly elevate shoulder on the south side and a slightly higher background on the north. CHDX has a suggestion of a low contrast rabbit-ear anomaly ($RR < 7$) with peaks located over the edges of the mineralization. This feature is not duplicated in the HHDX results. Both hydroxylamine hydrochloride methods define a single sample anomaly located at the north end of the line. These features are unexplained.

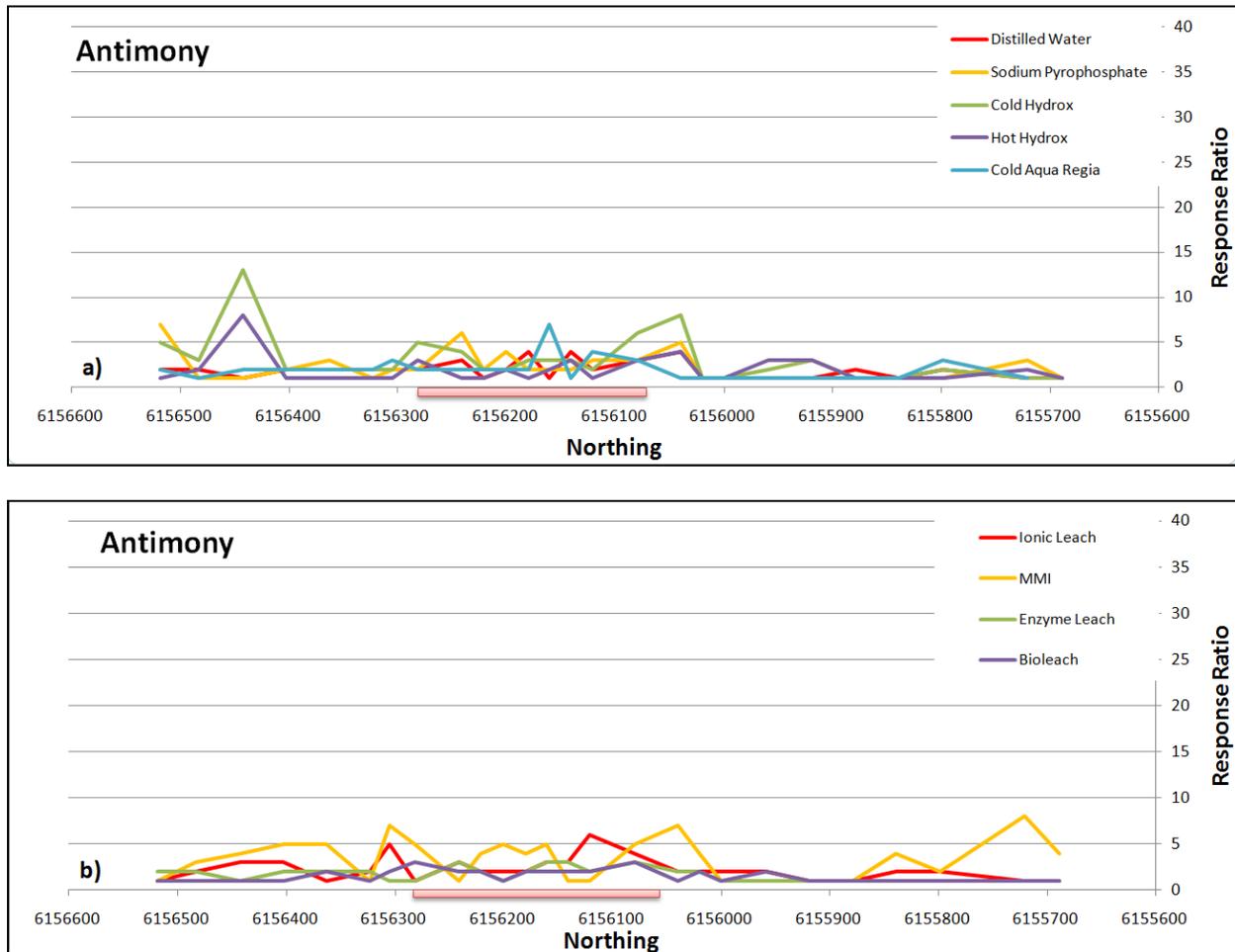


FIGURE 48. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR ANTIMONY A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

IL is the only method of the laboratory specific extractions to produce a clear, albeit very low contrast ($RR < 5$) pattern over mineralization (Fig. 48b). The response consists of a subtle rabbit-ear feature with the southern peak located inside the margin of the mineralization and the northern one just outside. MMI also appears to show a response over the mineralization however, its form is complex and would not be easily identifiable. The profile consists of an elevated background over the mineralization and the northern part of the line with a negative rabbit-ear or “W” shaped feature within the mineralized zone. Patterns for BL are more subtle but identifiable as an anomaly because of the flat background values along the line. The response has the form of a slight elevation of values over the mineralization ($RR < 3$). EL does not have a clear response.

MERCURY

Results for mercury are illustrated in Figure 49. In general, the responses for the generic methods are flat across the Transect with values consistently below 5. CAR is the only method to produce an anomaly over the mineralization, where it forms an apical feature (RR<16) over the middle of the zone (Fig. 49a). Other peaks present south of the mineralization are similar to those detected by conventional aqua regia (Fig. 33) and are interpreted to be caused by detrital cinnabar in outwash channel sediments. These features effectively mask the true response. Of the laboratory specific methods (Fig. 49b), none produce an unequivocal response over the mineralization. BL appears to have an apical feature over the centre of the zone but its amplitude is within that of the background variation for the southern part of the line. EL has no response. MMI and IL do not report mercury.

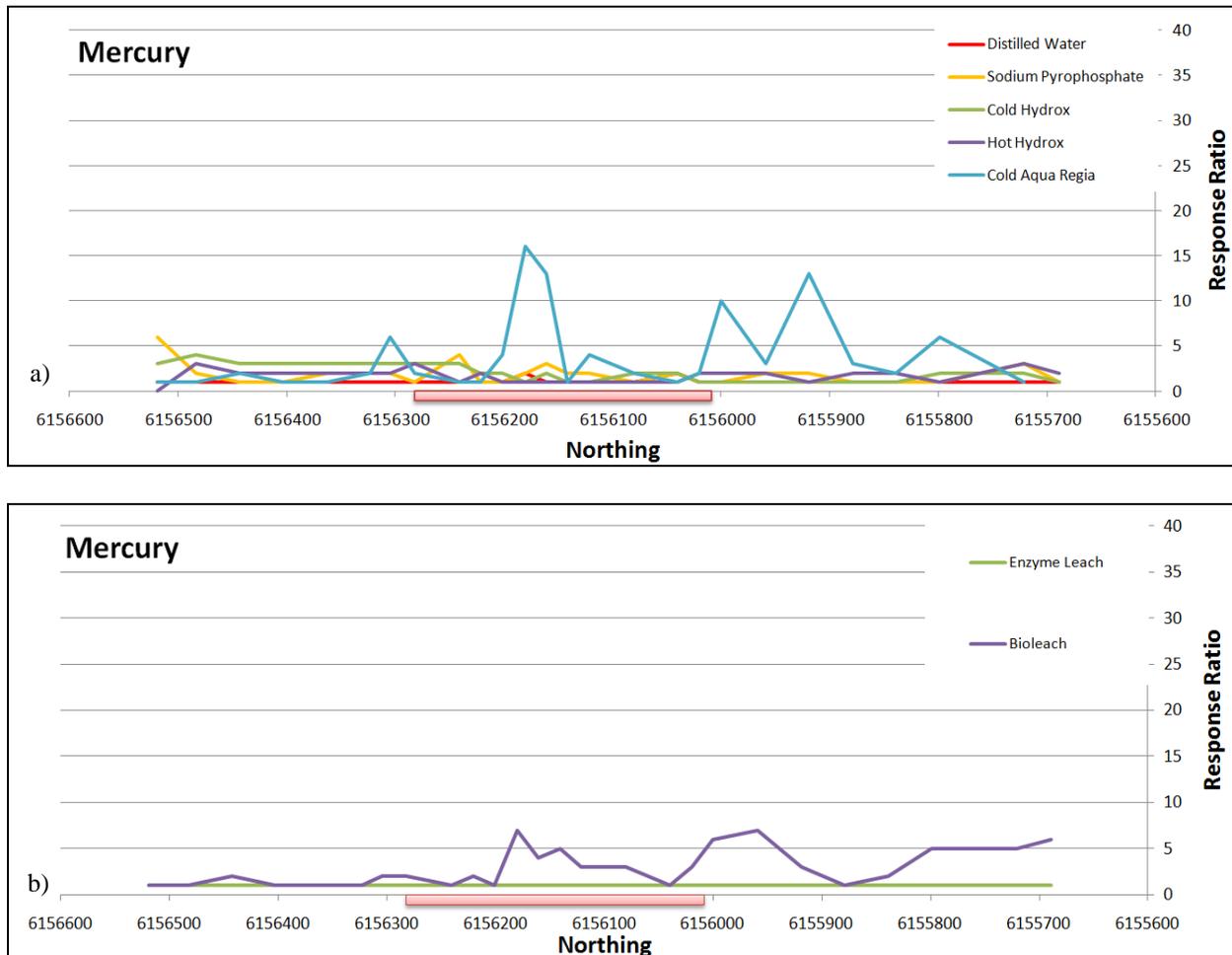


FIGURE 49. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR MERCURY. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

BISMUTH

SPY is the only one of the generic methods with a recognizable response for bismuth (Fig. 50a). It consists of a low contrast (RR<7) single peak feature located over the northern edge of the mineralization. The other methods display only background variations across the Transect. For the laboratory specific methods (Fig. 50b), IL and BL appear to have responses to the mineralization; however they are complicated by a shift in background to higher values north

of the mineralization. This shift coincides with a change in bedrock type from post mineral sedimentary cover north of the mineralization to intrusions and volcanic rocks to the south. Nevertheless, both methods display what appear to be moderate contrast ($RR < 15$ and < 13), rabbit-ear anomalies (Fig. 50b), with a distinct southern peak located over (BL) or just inside (IL) the south edge of the mineralization. The northern rabbit-ear feature is much more pronounced for IL than BL. In the latter it forms a broad shoulder that merges with the elevated background to the north. MMI and EL do not produce any responses.

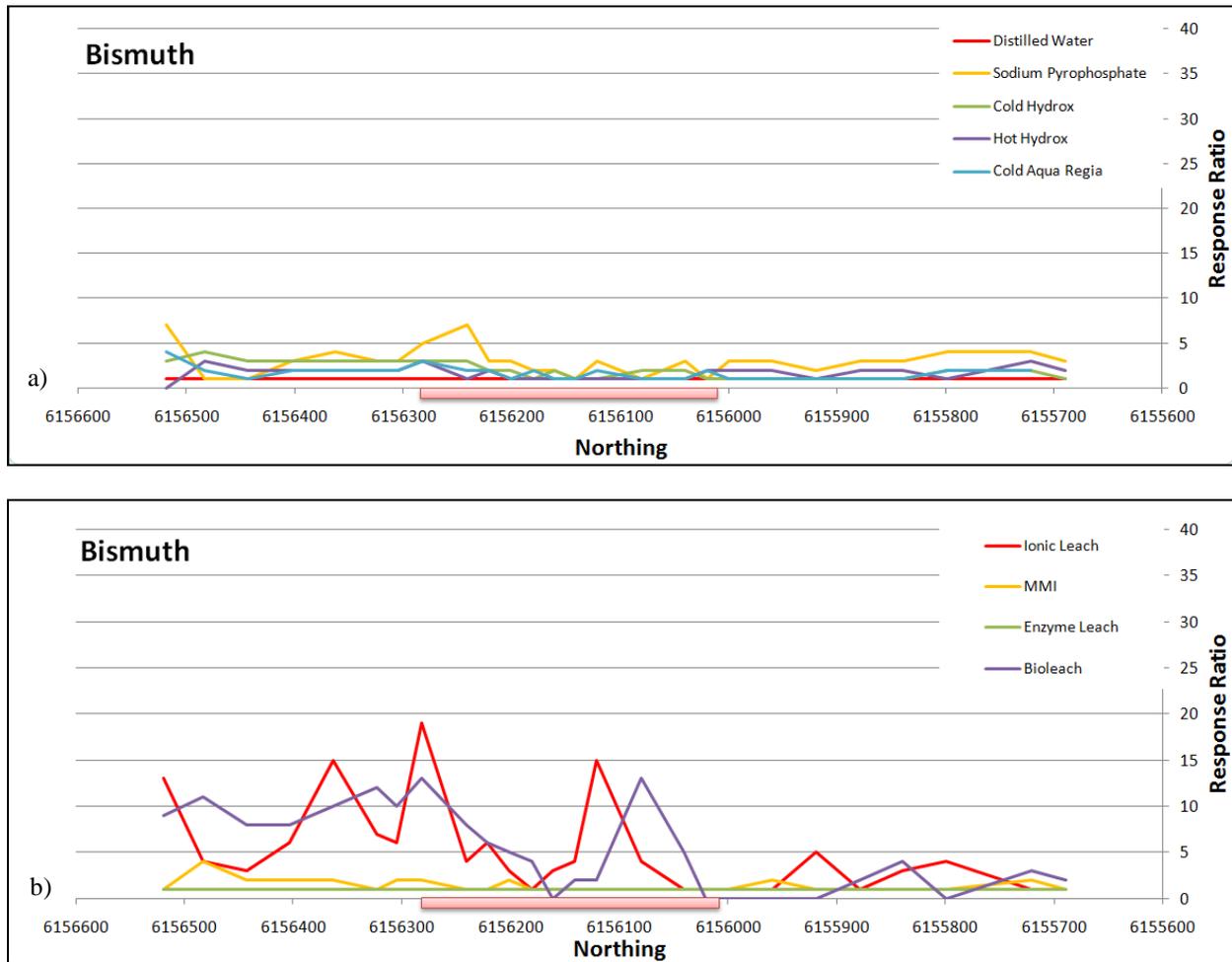


FIGURE 50. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR BISMUTH. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

TUNGSTEN

Results for tungsten are illustrated in Figure 51. As shown for Transect 1, is an excellent indicator of the presence of mineralization at depth, forming very high contrast anomalies in a number of the methods tested. For the generic methods, SPY produces the strongest response (Fig. 50a). It forms a triple peak anomaly ($RR < 232$, < 3344 and < 565) with the outer peaks situated close to the edges of the mineralized zone and the central peak directly over the middle. Background values away from the mineralization are flat with values not exceeding 3. A highly anomalous value at the north end of the line ($RR < 40$) is unexplained. In contrast, CAR defines a very subtle ($RR < 6$) rabbit-ear response for tungsten. This is only visible because of the flat and low level background away from the mineralized zone. DI, CHDX and HHDX do not produce any responses for this element.

For the laboratory specific methods (Fig. 51b), only MMI does not produce a tungsten anomaly over the mineralization. BL has the highest contrast response, forming a triple peak anomaly (RR<11, <118 and <125) directly over the mineralization. EL shows a similar but lower contrast rabbit-ear pattern (RR<34, <26 and <4). IL has quite a different profile. Instead of a triple peak or rabbit-ear form, it defines a single peak, apical response (RR<44). Its maximum value coincides with the low between the higher peaks defined by BL and EL.



FIGURE 51. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR TUNGSTEN. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS. NUMBERS AT THE TOP OF FIGURE 51A INDICATE THE MAXIMUM RESPONSE RATIOS.

URANIUM

For uranium, SPY once again produces the strongest response of all the methods tested (Fig. 52a). It defines a high contrast, triple peak anomaly (RR<22) that has a form somewhere in between an apical and a rabbit-ear anomaly. Background is quite noisy with spurious peaks present to the north and south of the zone. None of the other generic extractions show any credible anomalous patterns.

IL is the only laboratory specific extraction to produce a response over the mineralization (Fig. 52b). It defines a low contrast apical response (RR<6) centred near the southern edge of the mineralization.

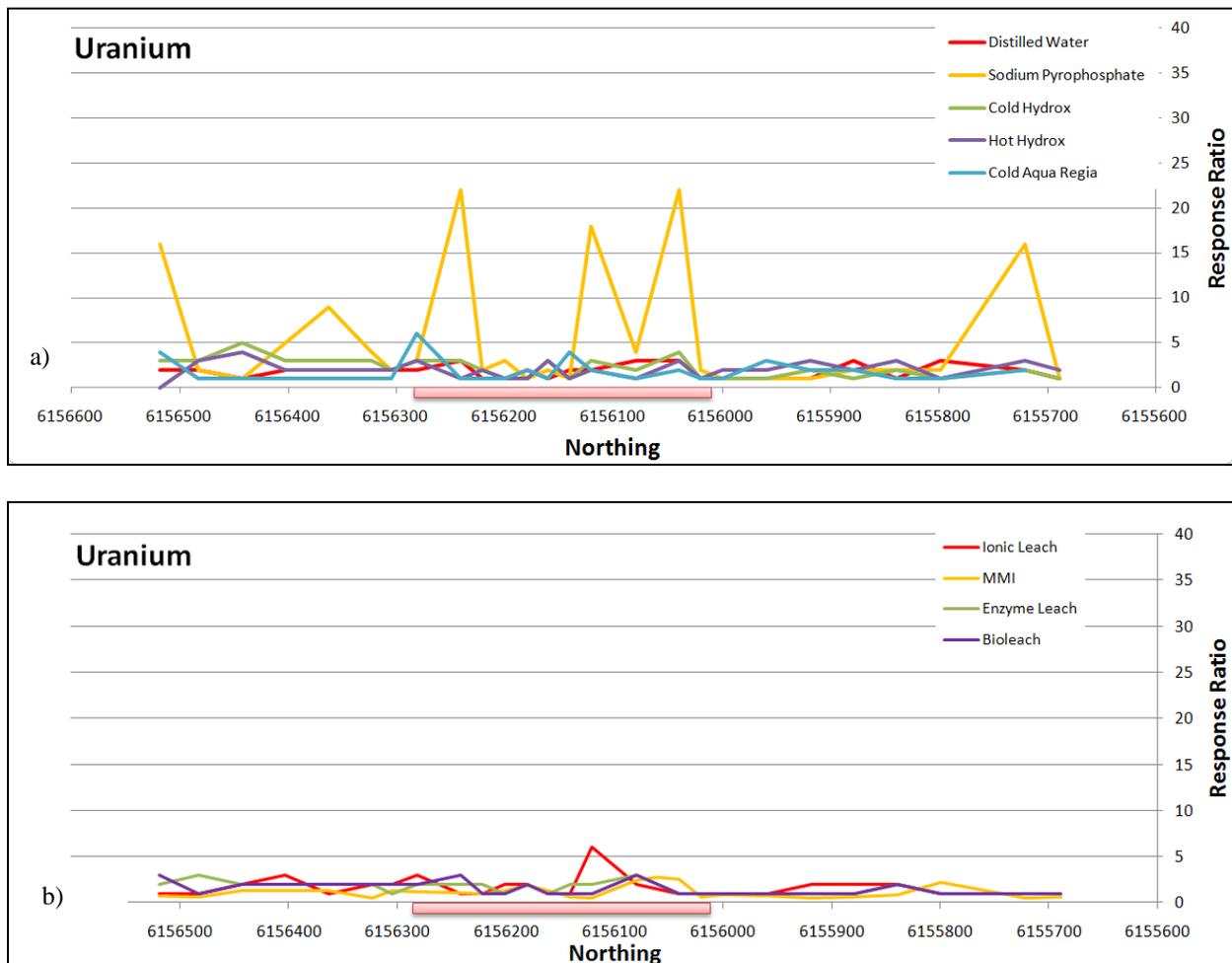


FIGURE 52. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR URANIUM. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

IRON

The weak responses for iron observed over the sub-cropping mineralization on Transect 1 are not seen over deeper mineralization on Transect 2. None of the methods tested detect a response over mineralization. SPY (Fig. 53a), which has the most contrast of any of the methods displays a background shift to higher values to the north of the mineralization. As mentioned earlier, this is an expression of a change in bedrock geology. For all other generic methods, values are consistently low ($RR < 3$) along the Transect. The same is true for the laboratory specific methods. Neither MMI nor IL shows any variation over the mineralization (Fig. 53b). MMI does display a moderate contrast anomaly ($RR < 19$) located at the southern end of the Transect. This feature is unexplained. EL and BL do not report Iron.

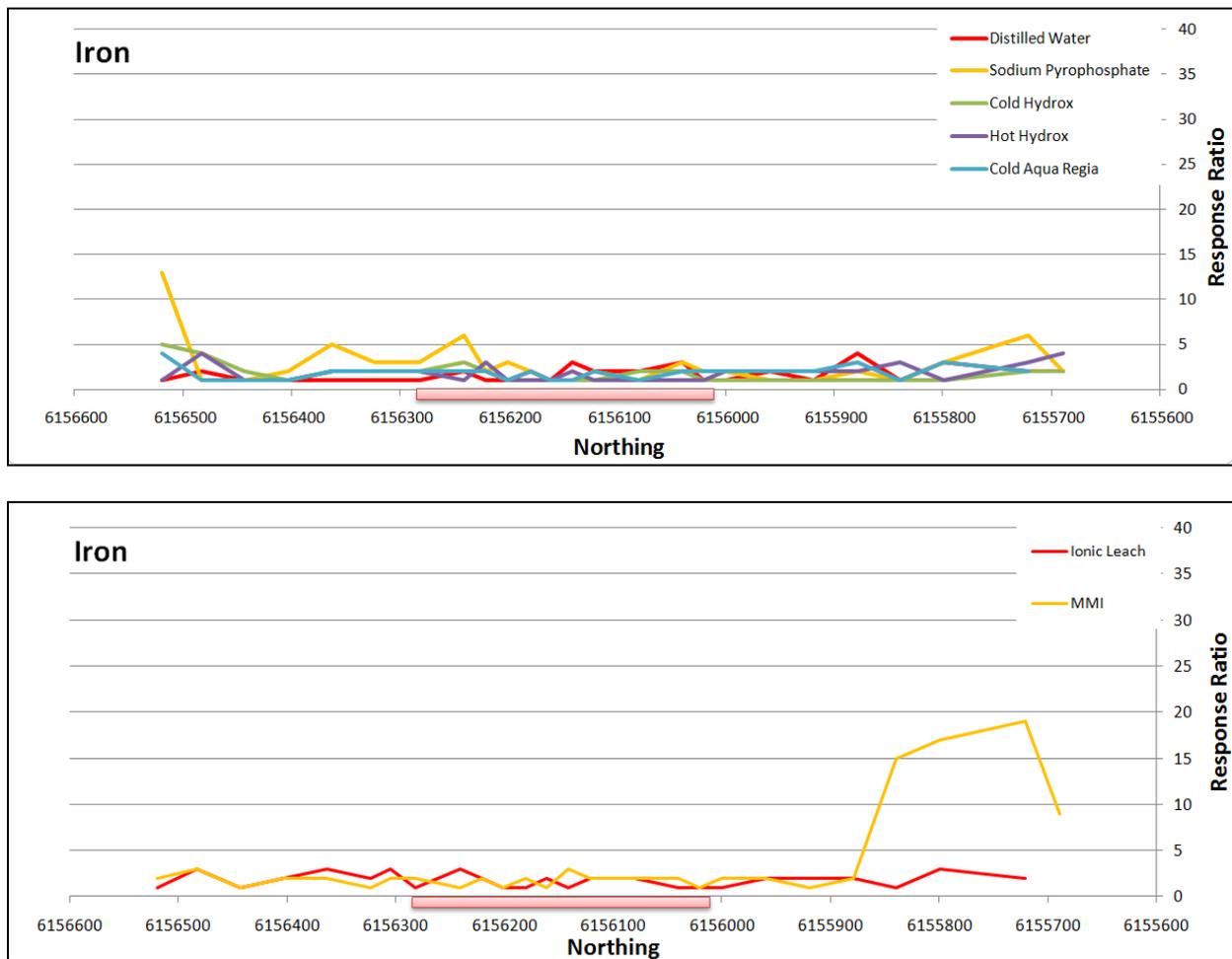


FIGURE 53. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR IRON. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

MANGANESE

In contrast to iron, manganese does produce recognizable responses over mineralization for several of the extractions. Figure 54a shows the profiles for the generic methods. CHDX, HHDX, DI and SP all show multi-peak, apical-type responses over the mineralization. Highest contrast is seen in the CHDX, which has a four peak anomaly and the maximum value (45) occurring over the northern edge of the mineralization. For HHDX, the maximum (21) lies over the middle of the zone. The pattern for DI defines a three peak anomaly with the outer peaks located outside the edges of the mineralization. The central peak, which has the highest value of the three ($RR < 18$) lies slightly north of centre of the mineralized zone. CAR defines a low contrast ($RR < 12$), single peak anomaly coinciding with the north edge of the mineralization. Results for SPY are less clear. This method appears to define a low contrast ($RR < 15$), rabbit-ear feature with the peaks occurring at the edges of the mineralized zone. The region between the peaks corresponding with the middle of the zone is also elevated into a broad low contrast feature. Each of the generic methods is strongly anomalous at the north end of the Transect and near the south end. The high value in the southern part corresponds with an undifferentiated, chocolate brown, organic-rich soil profile, possibly representing an area of periodically saturated ground. The anomalous value at the north end is unexplained.

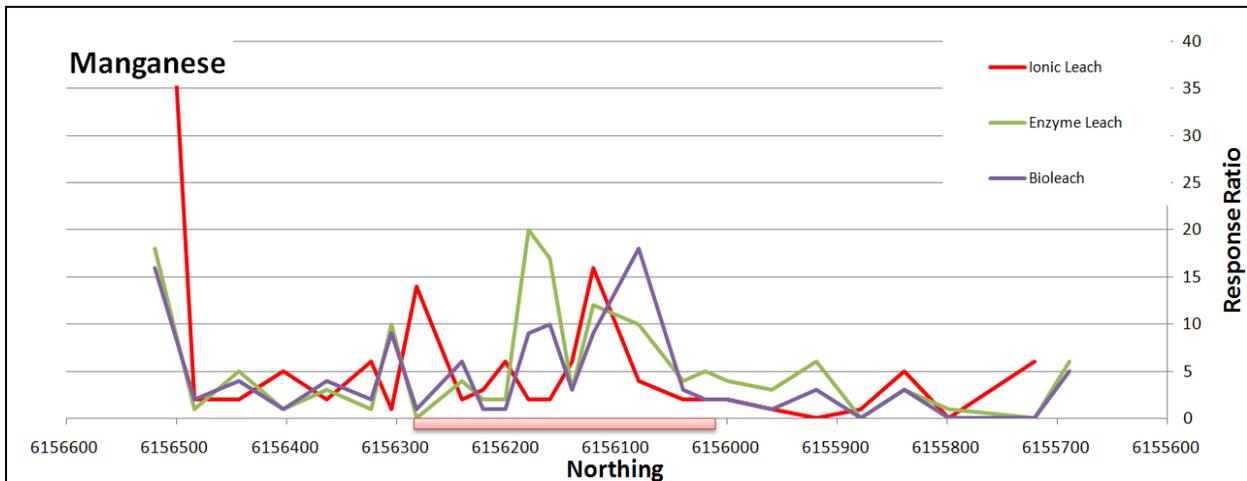
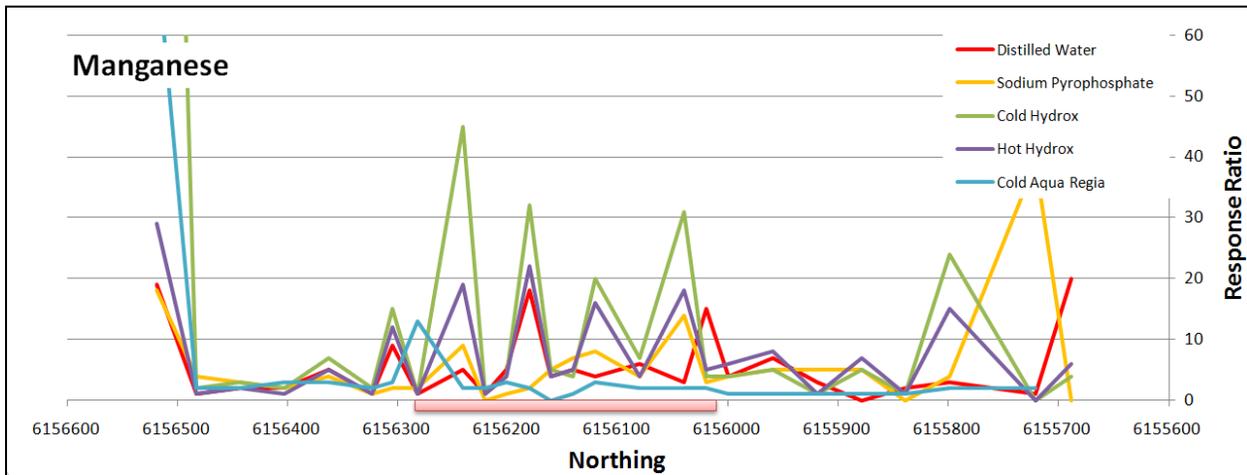


FIGURE 54. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR MANGANESE. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

Laboratory specific methods show much the same patterns as the generic ones, though with lower contrast (Fig. 54b). EL defines an asymmetrical rabbit-ear feature ($RR < 20$) centred over the mineralization. BL shows a similar pattern. A wider rabbit-ear anomaly is defined by IL. This method defines peaks located over the edge of the mineralized zone on the north side and just inside the zone on the south. Its contrast ($RR < 17$) is comparable to that of the other methods. MMI does not report manganese.

CALCIUM

Of the generic extraction methods, CHDX has the most robust response for calcium (Fig. 55a). It produces a classic, high contrast ($RR < 29$) rabbit-ear anomaly, with the peaks located over the edges of the mineralization. This pattern is also visible in the HHDX results, however, the contrast is significantly lower ($RR < 10$) and the peaks broader than in the CHDX response. More subtle responses are present in the DI and SPY. Of the two methods, SPY has the clearest anomaly, forming a low contrast ($RR < 6$), rabbit-ear anomaly with peaks that occur over the edges of the mineralized zone. Only one peak is present in the DI results. This low contrast ($RR < 6$) feature occurs over the north edge of the mineralization and is only distinguishable because of the low flat background.

IL (Fig. 55b) also defines an asymmetrical rabbit-ear anomaly. The higher of the two peaks (RR<45) occurs over the north edge of the mineralization and is a conspicuous feature. The lower peak on the south side is much more subdued and not distinguishable from background variation on the southern part of the Transect. Patterns for MMI are less clear. There is no obvious rabbit ear feature or significant elevation of values over the mineralization, however there does appear to be a negative rabbit-ear response or 'W' shaped profile located over the middle of the mineralized zone. This feature is hard to distinguish from background variation. EL and BL do not report calcium.

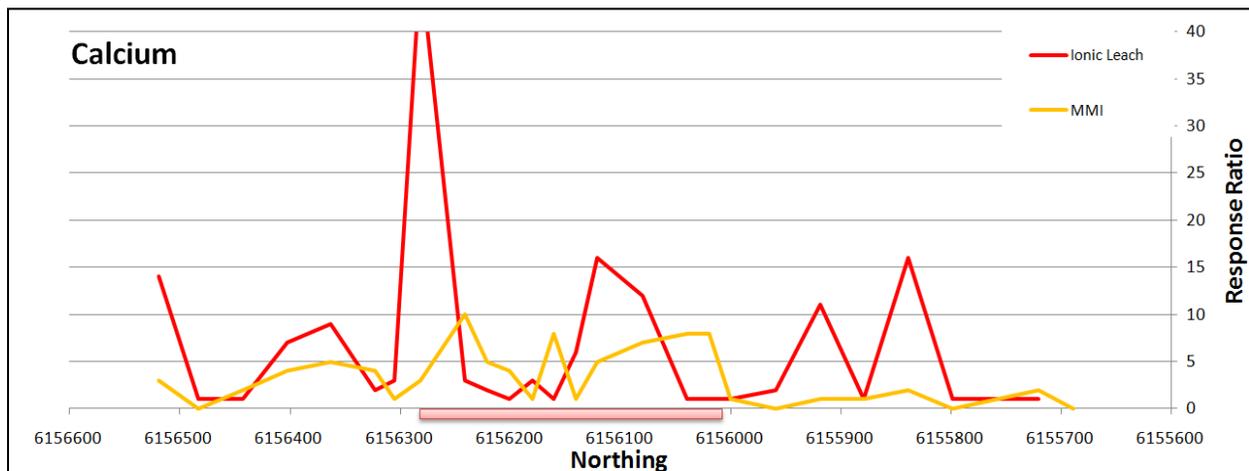
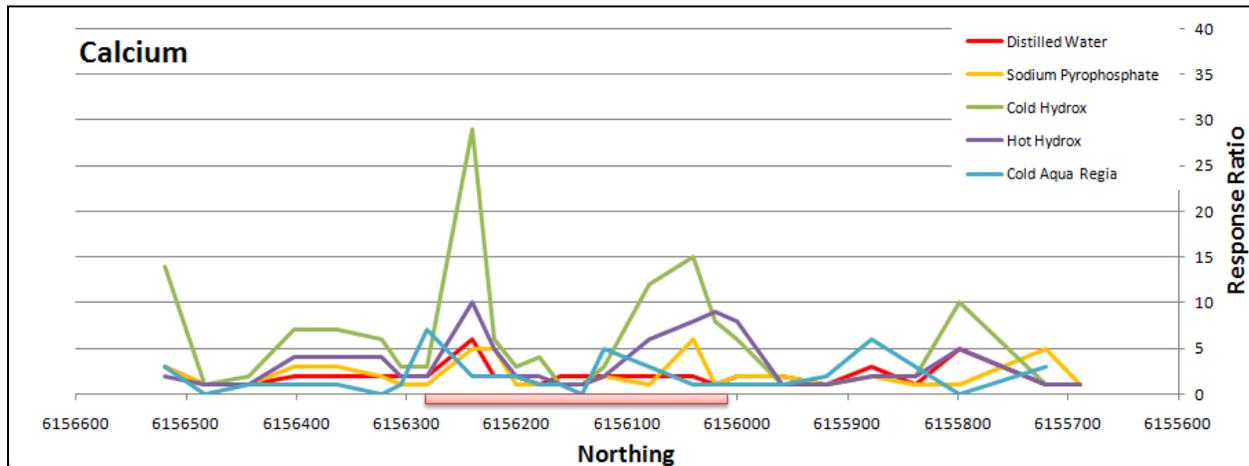


FIGURE 55. TRANSECT 2 - SELECTIVE AND PARTIAL EXTRACTION RESULTS FOR CALCIUM. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

THE RATIO OF WEAK EXTRACTION TO AQUA REGIA CALCIUM

Expressions of buried mineralization can also show up as indirect anomalies caused by redistribution of Eh and pH sensitive elements in the soil in response to oxidation of sulphides at depth or reduction of the overburden column (Hamilton, 1998; Smee, 1997, 1998). This phenomenon, as mentioned earlier in the description of soil pH and conductivity results, is manifested as double-peak anomalies for IDH and H^+ . Smee (1998) in his study at Marigold, Nevada, noted similar patterns in weak extraction results. He observed that in a desert environment, regardless of the weak extraction used, double peak anomalies for calcium and strontium occur over the edges of the mineralization. He proposed a model whereby H^+ released from sulphide oxidation at depth migrates to the surface and causes disequilibrium in pH sensitive compounds such as calcium carbonate. In areas of H^+ accumulation, calcium

carbonate becomes unstable and dissolves and its components (e.g. calcium and strontium) migrate away from the acidified zones and reprecipitate where ambient pH conditions allow, usually over the edges of the mineralization.

Alternate mechanisms for the formation of calcium and strontium rabbit-ear patterns under wet temperate conditions have been proposed by Hamilton (1998, 2000). Hydrogen ions released as a result of (microbially mediated?) oxidation of ferrous iron to ferric iron at the edges of reduced chimneys over sulphide mineralization form localized zones of acidity. These cause dissolution of soil carbonate which remobilizes away from the acid zones and reprecipitates immediately outside the edges of the reduced zone. In the absence of soil carbonate, for example where pH conditions are too acid for the existence of carbonate minerals, carbonate deposition could also occur as the result of anaerobic oxidation of methane to bicarbonate by methanotrophic bacteria at the edges of a reduced chimney.

Weak extractions, particularly unbuffered weak acid leaches like hydroxylamine hydrochloride and enzyme leach, are sensitive to the carbonate content of the soil. Soils with higher (and more reactive) carbonate contents, resulting from this remobilization and reprecipitation process, react with the weak acid solutions and cause a rise in the final solution pH (Smee, 1997). Therefore, final solution pH in a weak acid leach is a reliable measurement of soil carbonate content. Zones of remobilized carbonate can also be identified using the ratio of partial or selective extraction calcium to aqua regia calcium. As pointed out by Smee (1997), residual anomalies from this ratio indicate areas where the more reactive calcium carbonate related to mineralization is present.

Figure 56a shows the results of this ratio for the generic extractions plotted as response ratios for Transect 1. Several methods including CAR, CHDX and HHDX display compelling residual rabbit-ear anomalies indicating the presence of remobilized carbonate. CAR has the maximum contrast with peak values close to 50, or 10 times background. CHDX and HHDX also show clear features but with slightly lower contrast. SPY and DI have the weakest responses. In all methods the peaks appear to be offset approximately 75 metres east of the projected edges of the underlying mineralized body. Smee's model predicts that the rabbit-ear peaks should occur over the edges of the mineralization.

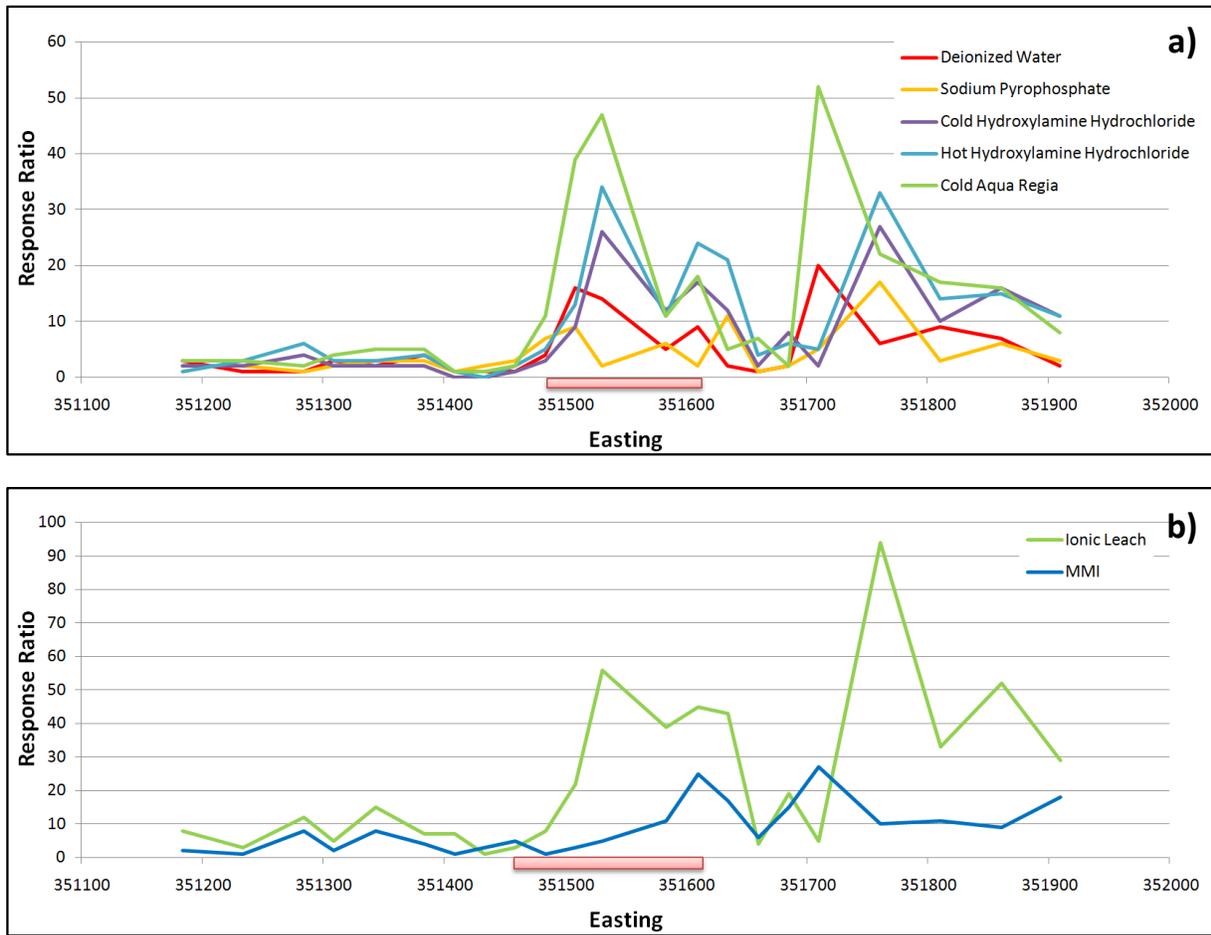


FIGURE 56. TRANSECT 1 - RATIO OF WEAK EXTRACTION CALCIUM TO AQUA REGIA CALCIUM. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

One possible explanation for the observed shift is that the projected position of the mineralization is based on grade (0.5% Cu eq.). As the mineralized body dips steeply west on this section, it is possible that the grade defined position of the mineralization does not coincide with the sub-cropping portion of the body. The presence of lower-grade sulphide mineralization slightly up-dip at the cover-bedrock interface could explain the offset.

The same shift is shown by the laboratory specific methods (Fig. 56b). IL shows a narrow low centred between 125 to 150 metres east of the middle of the mineralization. The low is bracketed by wide shoulders of elevated values reaching up to a response ratio of 94 on the east side. MMI has a much lower contrast and slightly different form to IL. It produces a moderate contrast (RR<27) double-peak anomaly with the central low centred 75 metres east of the eastern edge of the mineralization. Calcium is not reported for the EL or BL methods.

There is a much better coincidence between the position of the mineralization and the rabbit ear anomalies on Transect 2 (Fig. 57). Three of the generic methods; CHDX, HHDX and CAR, define credible rabbit-ear features. CHDX produces the highest contrast response, defining moderate contrast (RR<40), sharp rabbit ear peaks bracketing the mineralization (Fig. 57a). The northern peak sits just inside the projected position of the mineralization and the southern one just outside. The pattern for HHDX is similar to CHDX but the contrast is much lower (RR<14) and the form of the anomaly less well defined. The southern peak is broader and is itself divided into

two sub-peaks and the northern peak is much less pronounced. Peaks for CAR are slightly offset from the hydroxylamine hydrochloride rabbit-ear feature by about 50 metres to the north. They are of moderate contrast (RR<20) and overlie the edges of the mineralization. There is also a single peak located about 200 metres south of the mineralization. This feature is unexplained. Neither the DI nor SPY produces convincing anomalies. While DI does display a low contrast rabbit ear over the mineralization, this feature is easily confused with background variation by the presence of a much stronger single peak feature near the south end of the line.

IL (Fig. 57b) has a similar but higher contrast profile to DI. Well developed moderate contrast (RR<45) rabbit-ear peaks bracket the mineralization with peaks corresponding with the edges of the zone. A much higher contrast peak near the south end of the line (RR<52) puts the rabbit-ear response within background variation, thus making it difficult to identify as an unequivocal anomaly. MMI shows no response over the mineralization.

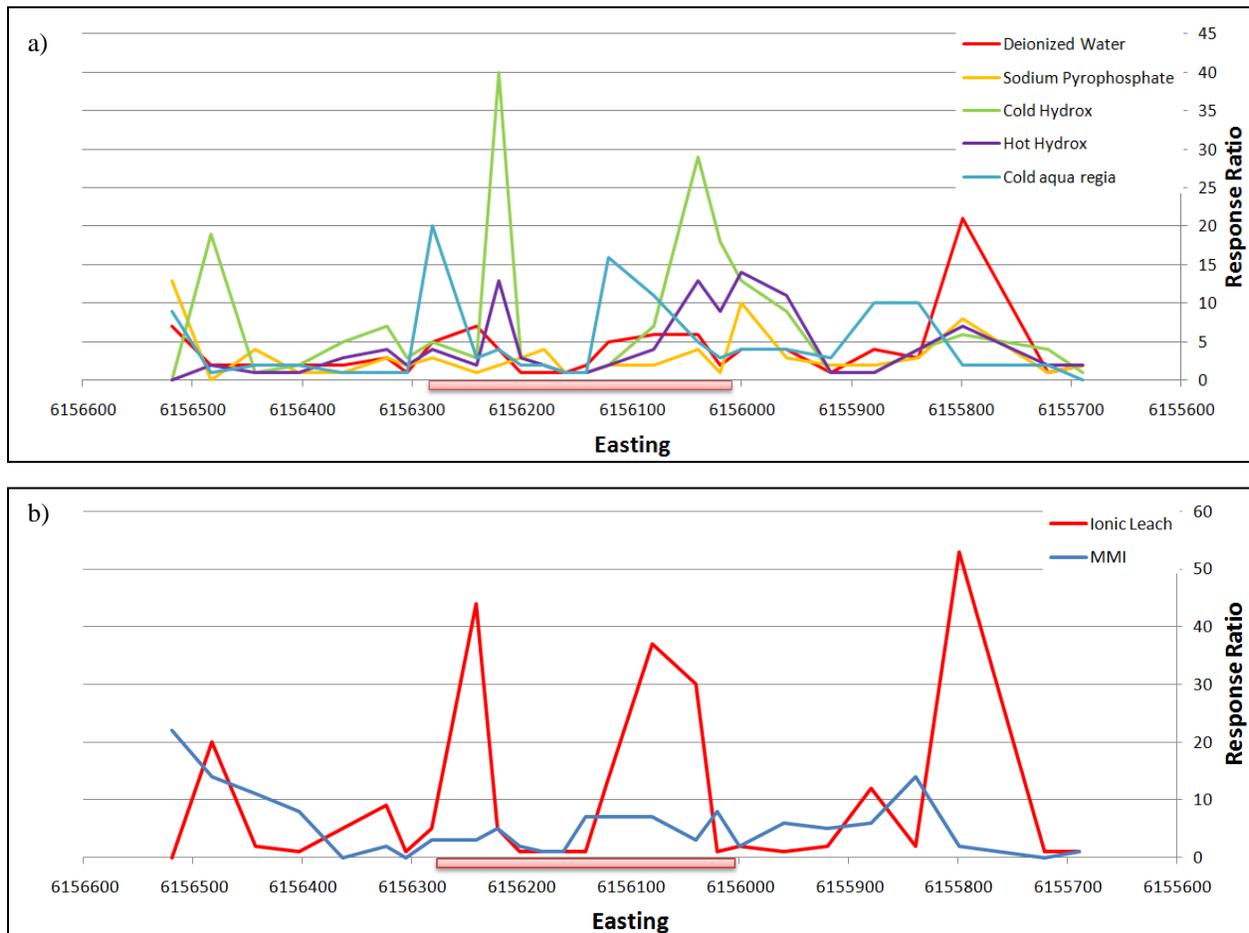


FIGURE 57. TRANSECT 2 - RATIO OF WEAK EXTRACTION CALCIUM TO AQUA REGIA CALCIUM. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS.

GOLD METHODS

This study included several methods for detecting gold. These ranged from traditional fire assay-AAS on Ah, upper B, lower B and C horizons, to low detection limit methods like Supertrace (ALS-Chemex), Ionic Leach and MMI. Summary statistics for these methods are shown in Table 10.

TABLE 10. SUMMARY STATISTICS FOR GOLD METHODS.

Method	Ultratrace	Ionic Leach	Super Trace	Cold Aqua Regia	MMI	Fire Assay	Fire Assay	Fire Assay
Laboratory	Acme	ALS-Chemex	ALS-Chemex	ALS-Chemex	SGS	SGS	SGS	SGS
Horizon	Ah	Upper B	Upper B	Upper B	10-25cm	Upper B	Lower B	C
Units	ppb	ppb	ppm	ppm	ppb	ppb	ppb	ppb
Min	0.1	0.05	0.0007	0.0005	0.05	0.5	2	3
Max	89.6	0.77	0.1	0.025	1.6	346	69	28
Range	89.5	0.72	0.0993	0.0245	1.55	345.5	67	25
Mean	3.191	0.306	0.005	0.002	0.488	15.643	10.458	6.60
StdDev	12.915	0.201	0.014	0.004	0.393	50.132	14.870	5.123
Var	166.797	0.040	0.000	0.000	0.154	2513.170	221.105	26.245
Sum	150.000	14.680	0.268	0.108	26.350	766.500	502	330
SumSq	8151.380	6.383	0.011	0.001	21.043	132622.25	15642	3464
Median	1.300	0.250	0.003	0.001	0.4	4.0	6.0	5.
Mode	1.400	0.140	0.002	0.001	0.2	4.0	6.0	4.0
StdErr	1.884	0.029	0.002	0.001	0.053	7.162	2.146	0.724

Gold results for Transect 1 are presented in Figure 58. For the generic methods (Fig. 58a), responses are for the most part very subdued with response ratios generally under 5. The only method with a recognizable response over the mineralization is SPY, which has a broad apical anomaly centred over the eastern (up-dip) edge of the mineralization. The amplitude of this feature is quite low ($RR < 11$) and the contrast is reduced by noisy background variations away from the deposit. SPY has a high contrast single sample peak near the eastern end of the line: this feature is unexplained. CAR defines two low amplitude peaks ($RR < 7$) in the vicinity of the mineralization. The peaks bracket the SPY anomaly, suggesting that they are real features, perhaps a rabbit-ear anomaly. Confidence in the CAR response is downgraded by the presence of a single sample peak located just east of the mineralization ($RR < 22$). This feature doesn't appear to have any relationship to the position of the mineralization and could be the result of noise caused by detrital gold grains in the soil.

MMI (Fig. 58b) is the only laboratory specific method with a peak over the mineralization. Again the maximum response occurs near the east or up-dip part of the mineralization. Contrast is low and the presence of noisy values of equal amplitude to the east and west of the mineralization means that the mineralization signal is essentially indistinguishable from background values.

For comparison, conventional fire assay results are presented in Figure 58c. Results for the upper B and C horizons fail to detect the mineralization. A robust apical anomaly ($RR < 18$) is present in the lower B horizon results over the eastern margin of the zone.

Results for Transect 2 are shown in Figure 59. Once again, the generic methods respond poorly. The only indication of a response is shown by SPY (Fig. 59a). This method defines three very low contrast ($RR < 6$) peaks over the

mineralization. It is doubtful that these features represent a true anomaly as similar contrast values also occur in background areas, particularly on the southern quarter of the line. There is also a single sample peak feature with higher contrast at the north end. The presence of these background features implies that it would be impossible to distinguish the response over the mineralization from background in an exploration context.

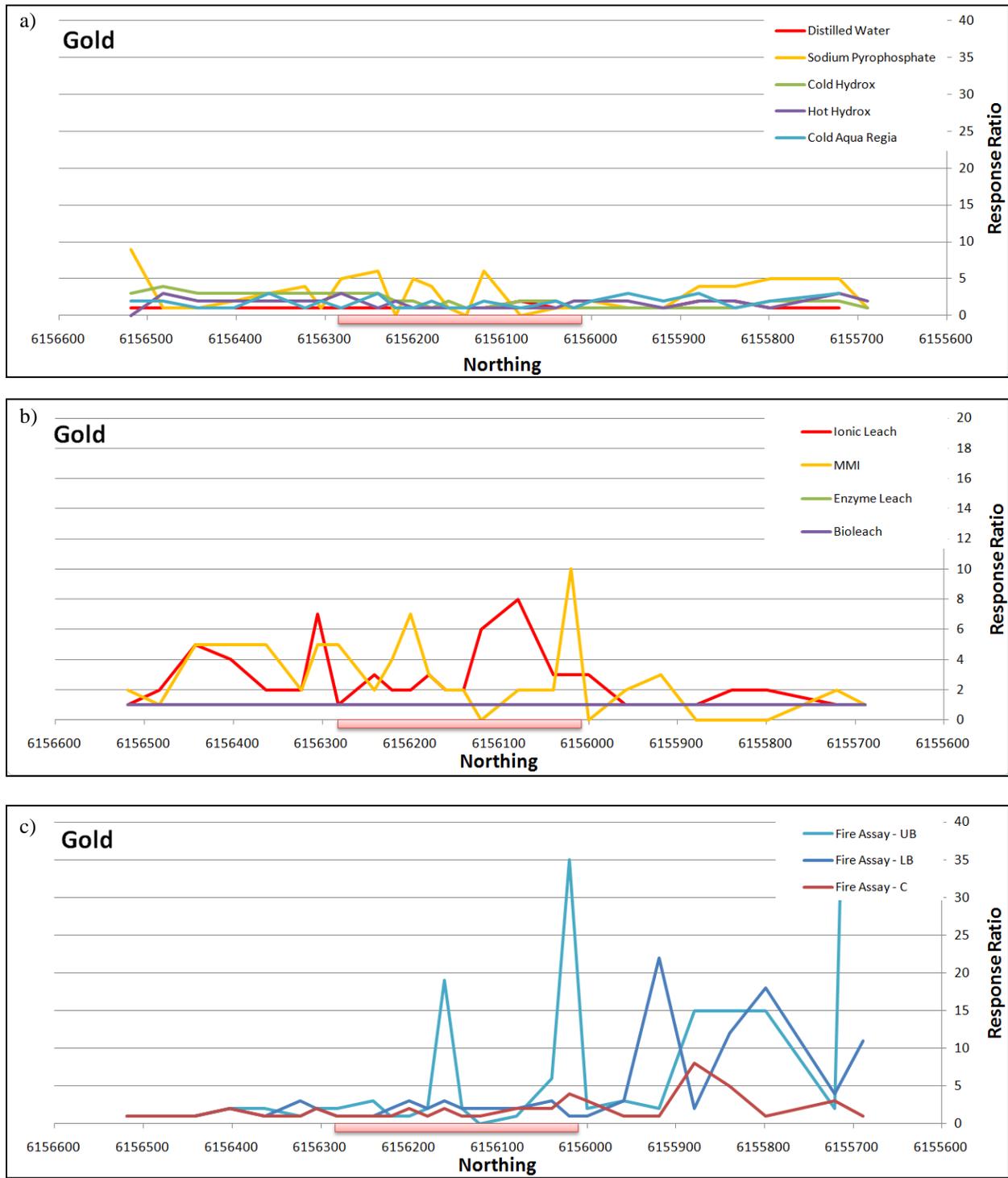


FIGURE 58. GOLD RESULTS FOR TRANSECT 1. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS. C. FIRE ASSAY RESULTS.

MMI (Fig. 59b) also appears to have a response, but as in the case of SPY, confidence in the anomaly is low because of the presence of values of similar contrast in background areas. These are notable along the line to the north of the mineralization. The MMI response is a rabbit-ear anomaly with the peaks located close to the edges of the mineralization. IL results suffer from the same problem. There is an apical response over the southern edge of the zone ($RR < 8$) but contrast over background is so low that without prior knowledge of the position of the mineralization, it is doubtful that this feature would be identified as an anomaly.

Fire assay results (Fig. 59c) are equally ambiguous. Upper B horizon results show two sharp peaks ($RR < 35$ and < 19) located over or close to the mineralization. These could be a genuine rabbit-ear anomaly. High values to the south of the mineralization confuse the issue. Over the southern third of the line, values consistently reach response ratios of over 15, which effectively mask the peaks over the mineralization. In the lower B and C horizons fire assay results there is no response over the mineralization. Highest values occur at the southern third of the line, where detrital gold in outwash channels may be contributing to the anomalous numbers.



FIGURE 59. GOLD RESULTS FOR TRANSECT 2. A. GENERIC EXTRACTION METHODS. B. LABORATORY SPECIFIC EXTRACTION METHODS. C. FIRE ASSAY RESULTS.

SOIL GAS HYDROCARBONS

The SGH method was included in this study because of its ability to detect variations in organic compounds caused by changes in redox conditions in the overburden column above a sulphide body. As proposed by Hamilton (2009), strong redox gradients on the edges of reduced chimneys provide a mechanism for the migration of anionic and cationic species from the sulphide source at depth to the surface, and may explain the presence of apical and rabbit-ear metal anomalies commonly observed in selective and partial extraction results. The presence of a reduced chimney has already been inferred indirectly from the soil pH and various extraction results. As mentioned earlier, the presence of subtle anomalies caused by inferred remobilized carbonate in the soil in an environment that is too acid for carbonate to exist, suggests that microbially mediated oxidation of methane to bicarbonate is likely occurring at the edges of the inferred reduced chimney. SGH should confirm the presence of such a feature.

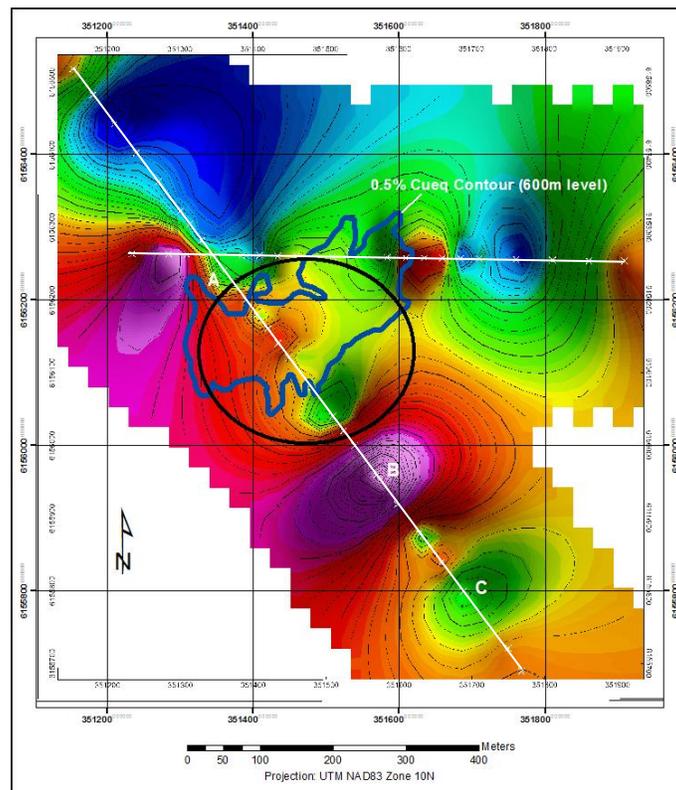


FIGURE 60. SGH RESULTS – GOLD PATHFINDER MAP. THE TWO TRANSECTS ARE SHOW BY THE WHITE LINES. THE BLACK ELLIPSE OUTLINES THE LOCATION OF THE TARGET INFERRED FROM THE GOLD PATHFINDER PEAKS. HIGH GOLD PATHFINDER RESPONSES REFERRED TO IN THE TEXT ARE SHOWN (A, B AND C).

Figure 60 shows the results for the lowest molecular weight class. This class represents a pathfinder for gold and is expected to develop an apical response over the mineralization (i.e. over the reduced chimney). Results show that this is not the case. The prominent peaks define what appears to be a rabbit-ear response bracketing the position of the mineralization on both transects. There is a good correspondence between the position of the inferred target (ellipse) and the 0.5% Cu eq. contour (Rennie and Scott, 2008). With a more uniform sample distribution, it would be easy to imagine this response as an annulus around the deposit. A supporting gold pathfinder class map is shown in Figure 61. The patterns displayed by this compound class are less clear. In the vicinity of the mineralization there is what appears to be an apical anomaly with a distinct arcuate form (A; Fig. 61) centred over the western limit of the 0.5% Cu eq. contour. High values on Transect 2 south of the mineralization (B and C; Fig. 61) are difficult to

explain in the context of the known mineralization; however these features could represent apical responses over unknown gold mineralization.

Results for the copper pathfinder class are shown in Figure 62. There is a strong apical response directly over the mineralization on Transect 2. This feature is not duplicated on Transect 1 where the up-dip sub-cropping parts of the deposit correspond with a deep low. If viewed on a larger scale, this feature could be interpreted as the centre of a wide reduced chimney whose edges are defined by the high value at the east end of Transect 1 and the peak mentioned above, that is interpreted to be an apical anomaly on Transect 2. Responses on the two lines are difficult to reconcile.

While these patterns are by no means conclusive that a reduced chimney exists over the Central Zone, the interpreted rabbit ear (annular) feature for the gold pathfinder class (Fig. 60) together with the apical anomaly for the copper pathfinders appears to suggest that a subtle reduced feature may be present.

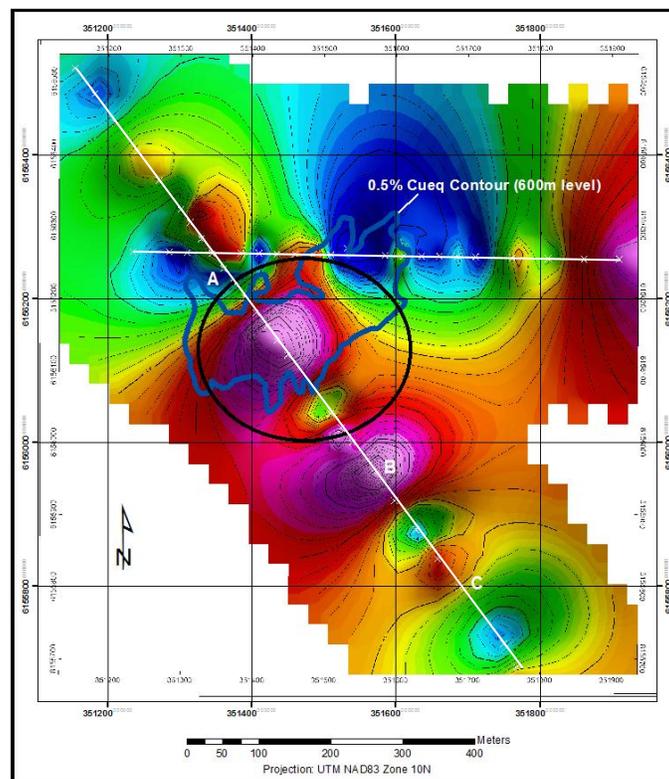


FIGURE 61. SGH RESULTS – SUPPORTING GOLD PATHFINDER MAP. THE TWO TRANSECTS ARE SHOW BY THE WHITE LINES. THE BLACK ELLIPSE OUTLINES THE LOCATION OF THE TARGET INFERRED FROM THE GOLD PATHFINDER PEAKS. HIGH GOLD PATHFINDER RESPONSES REFERRED TO IN THE TEXT ARE SHOWN (A, B AND C).

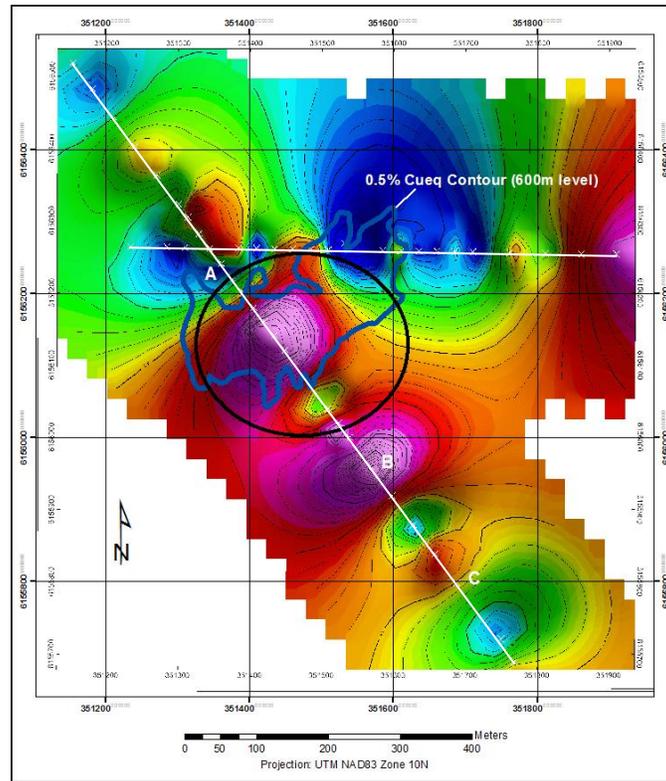


FIGURE 62. SGH RESULTS - COPPER PATHFINDER MAP. THE TWO TRANSECTS ARE SHOW BY THE WHITE LINES. THE BLACK ELLIPSE OUTLINES THE LOCATION OF THE TARGET INFERRED FROM THE GOLD PATHFINDER PEAKS. HIGH GOLD PATHFINDER RESPONSES REFERRED TO IN THE TEXT ARE SHOWN (A, B AND C).

DISCUSSION

EFFECTIVENESS OF SOIL pH, CONDUCTIVITY

This study shows that soil pH and EC measurements can be effective at detecting sulphide mineralization through thick transported overburden in a temperate boreal forest environment. These inexpensive field methods have the advantage over other geochemical techniques in that they provide almost real time results. By doing the measurements in the field camp or even at the sample site, the field geologist can quickly react to the results and change the parameter of the soil survey ‘on the fly’ to provide more reliable results. Such changes might include modification of the sample spacing to detail anomalous features, extension of sample lines to cover end of line anomalies or adding additional infill or step out lines to a survey to fully cover a potential target. Since sulphide mineralization produces predictable patterns, these methods can be used to evaluate multiple geophysical targets or even geochemical anomalies from past surveys, to determine which are caused by possible sulphides and to therefore prioritize them for follow-up work. The ability to do this in the field can significantly speed up targeting and reduce the risk of exploration drill programs by focusing the drill metres into areas with the highest potential for the discovery of sulphides.

The responses for IDH, EC and the ratio of weak extraction (CHDX) to aqua regia calcium suggest the presence of a phenomenon known as a ‘reduced chimney’ in the overburden column above the mineralization. Hamilton (1998) proposed the existence of reduced chimneys above reduced bedrock features and suggested a mechanism for their

formation based on the transfer of charge between the negatively charged bedrock source and the positively charged surface. According to the Hamilton model, overburden reduction occurs through the migration of reduced anionic species between the top of the reduced bedrock feature (i.e. sulphides) and the ground surface. Charge is transferred by the reaction with oxidized cationic species migrating in the opposite direction. This process results in the formation of a redox front that propagates to the surface to form a reduced column or chimney. Strongly reducing conditions inside this chimney inhibit the oxidation of sulphides and thereby limit the amount of hydrogen ions produced. At the edges however, oxidation is enhanced due to the availability of oxygen and oxidizing agents, thus promoting the production of H^+ ions and their migration and accumulation at the soil surface over the edges of the chimney. Generation of hydrogen ions at the edges of the chimney is also promoted by microbial activity. Microbial oxidation of ferrous to ferric iron by iron oxidizing bacteria at the vertical redox boundary at the edge of the chimney also results in the production of H^+ ions. Anomalies formed by these processes would be indistinguishable.

The presence of zones of acidity over the edges of the reduced chimney at the soil surface causes changes in the distribution of certain pH sensitive elements such as calcium and strontium. Smee (1997, 1998) showed that in arid environments, soil carbonate is dissolved and redistributed in response to the presence of acidity generated by oxidation of sulphides at depth. This relationship produces a characteristic pattern of H^+ rabbit-ears over the edges of the underlying sulphide zone with zones of carbonate deposition immediately adjacent to them, where pH conditions allow carbonate to exist. The zones of carbonate deposition are more reactive than background soils and thus have a greater capacity to buffer a weak acid solution. They can therefore be detected using IDH. What happens in environments where the ambient pH is too low to allow for the existence of carbonate in the soil, for instance at Kwanika?

Rabbit ear anomalies for IDH and weak extraction to aqua regia calcium ratio at the Central Zone suggest that subtle changes in soil carbonate content are occurring despite the low average pH values in the survey area (pH 4.67 – Table 5). Carbonate should not exist at these pH values. The presence of a reduced chimney could provide an explanation for these patterns. It is well known that methane gas occurs within and around the edges of reduced chimneys (Hamilton, 2004c and 2005). Methane is produced by a number of possible processes, including: a) anaerobic metabolism of organic matter in the overburden column by methanogenic bacteria; b) reduction of CO_2 by methanogenic bacteria at the edges of the redox zone; c) decomposition of chemotrophic bacterial cell membranes on the sulphide surface; and, d) other bedrock methane sources (i.e. stratigraphic). Where methane and oxygen are in close proximity at the edges of the reduced chimney, methanotrophic bacteria may be converting methane into bicarbonate by anaerobic oxidation. The bicarbonate reacts readily with calcium ions present in the soil to form calcium carbonate.

Anomalous EC values may also indicate the presence of a reduced chimney over the Central Zone. EC is a measure of the total amount of soluble anions and cations in the soil. It has been suggested by various workers that EC variations reflect the release of salts and other ionic species as a result of oxidation of sulphides at depth (Govett, 1974, 1976; Smee, 1998). Hamilton's model (1998) predicts the accumulation of ions at the edges of a reduced chimney as a result of the migration of reduced anions up and away and oxidized cations down and towards the bedrock source.

In summary, the patterns detected by the soil pH and EC measurements are indicative of the presence of a reduced chimney developed in the overburden column above the central zone mineralization. Based on the rabbit-ear anomalies of EC, IDH and weak CHDX to aqua regia calcium ratio, the position of the reduced chimney can be approximated, as illustrated in Figure 63.

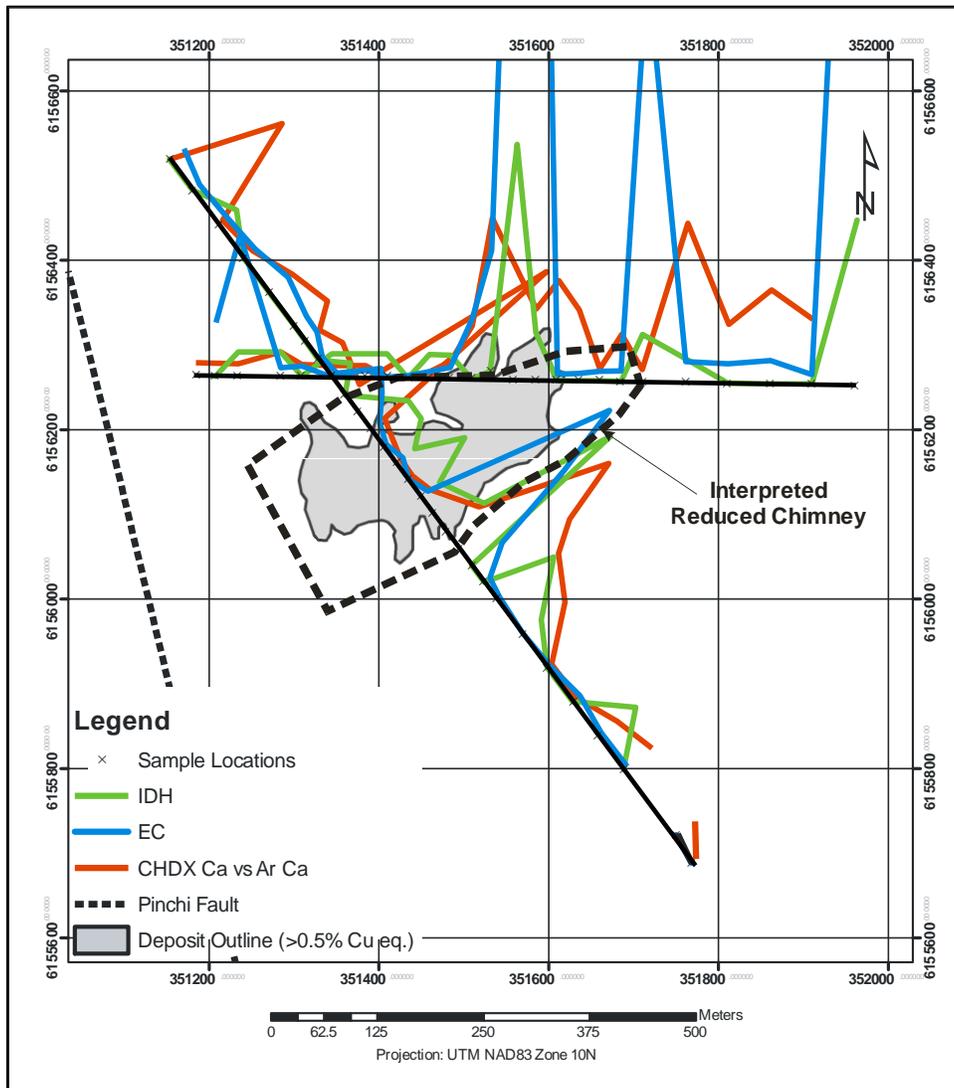


FIGURE 63. INTERPRETED REDUCED CHIMNEY OVER MINERALIZATION.

CORROBORATION OF THE REDUCED CHIMNEY BY SGH

SGH should confirm the location of the interpreted reduced chimney. According to Sutherland (2009), the lowest molecular weight compounds such as those that constitute the gold pathfinder class should form apical anomalies directly over the reduced chimney. As mentioned earlier and as illustrated in Figure 64a, the gold pathfinder class appears to define rabbit ear peaks on both lines that bracket the interpreted reduced zone. The copper pathfinder class, which is made up of heavier molecular weight compounds (Fig. 64b), displays what looks like a prominent apical anomaly in the centre of the inferred reduced zone. A similar feature located immediately to the south on Transect 2 (B; Fig. 64b) is unexplained.

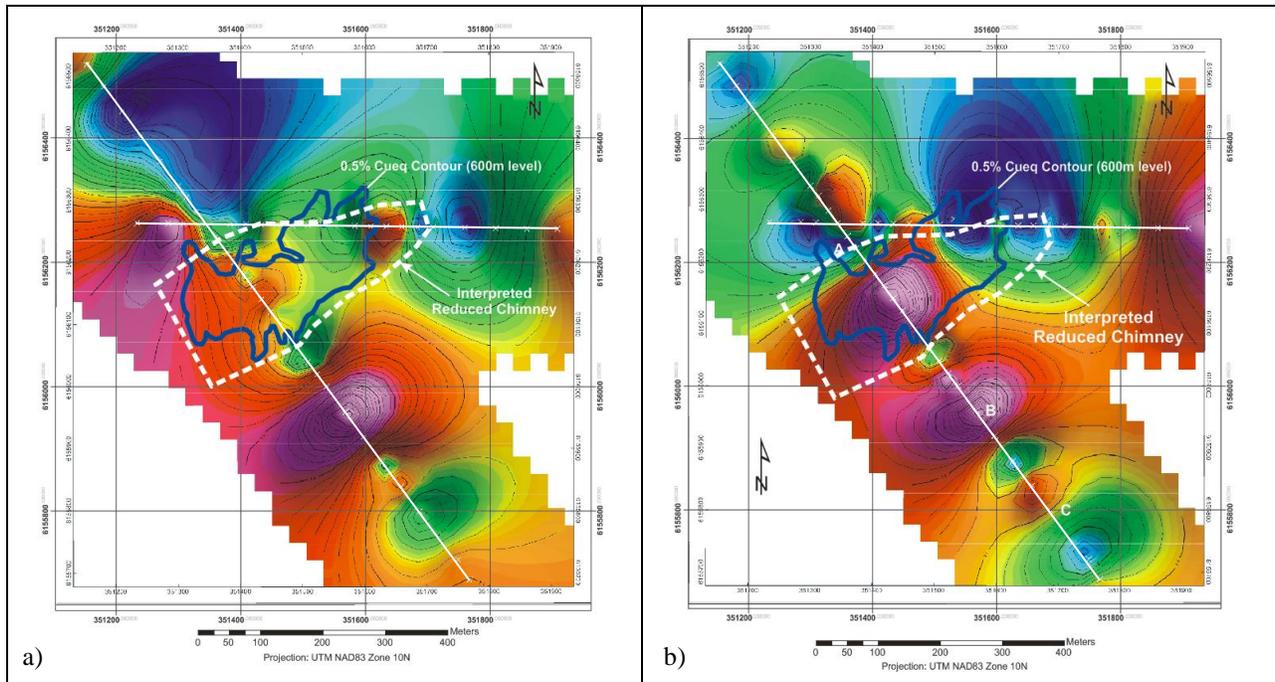


FIGURE 64. A. GOLD PATHFINDER CLASS MAP. B. COPPER PATHFINDER CLASS MAP.

GEOCHEMICAL SUPPORT FOR A REDUCED CHIMNEY

Certain elements such as uranium and tungsten are particularly immobile under reducing conditions. These may show considerable enrichment in a reducing environment, such as that created at the soil surface at the top of a reduced chimney. Results from this study show that both elements form moderate to strong anomalies immediately above mineralization in both aqua regia (Ah horizon) and SPY extraction. Furthermore, redox sensitive elements such as iron and manganese, which would be soluble under the reducing conditions inside the reduced chimney, display prominent central lows and flanking rabbit ear anomalies at the edges of the interpreted reduced zone. These features are clearly visible in the IL extraction for iron (Fig. 42b) and SPY extraction for manganese (Fig. 43a) on Transect 1 and the SPY and IL extractions for manganese on Transect 2 (Fig. 54 a and b).

EFFECTIVENESS OF CONVENTIONAL SOIL GEOCHEMISTRY

Conventional soil sampling (upper B horizon - aqua regia) fails to produce a recognizable response for ore or pathfinder elements on Transect 1 (Fig. 65). Only silver and mercury show any kind of pattern and it is debatable whether these are true responses to the mineralization or artifacts. As discussed earlier, mercury is noisy across both transects, particularly in areas where inferred outwash channels containing detrital cinnabar are present: the nearby Pinchi Fault is a well known source of mercury. The silver response over the zone is very weak and barely distinguishable from background variation; however the strong response at the west end of the line is more impressive and is more likely to be selected as an anomaly for follow-up in an exploration context.

Over the deeper seated mineralization on Transect 2 (Fig. 66), the story is much the same. Mercury shows an erratic response over the mineralization and in background areas to the south. Anomalous values are just as high in the background areas away from the mineralization as they are over it, again suggesting that the pattern may be an artifact caused by detrital cinnabar in glacial outwash channels. Tungsten however, does show a believable anomaly over the zone. It forms a moderate contrast, apical anomaly ($RR < 23$) that is distinct from background variation. A more subtle pattern is displayed by silver, forming what could be interpreted as a low amplitude, rabbit-ear pattern

over the zone. While tungsten and silver appear to be responding to the underlying mineralization, it is unlikely that they would be selected as potential indicators for porphyry copper gold mineralization in an exploration context. The lack of a response in the ore elements in these samples would likely down grade their importance as potential targets.

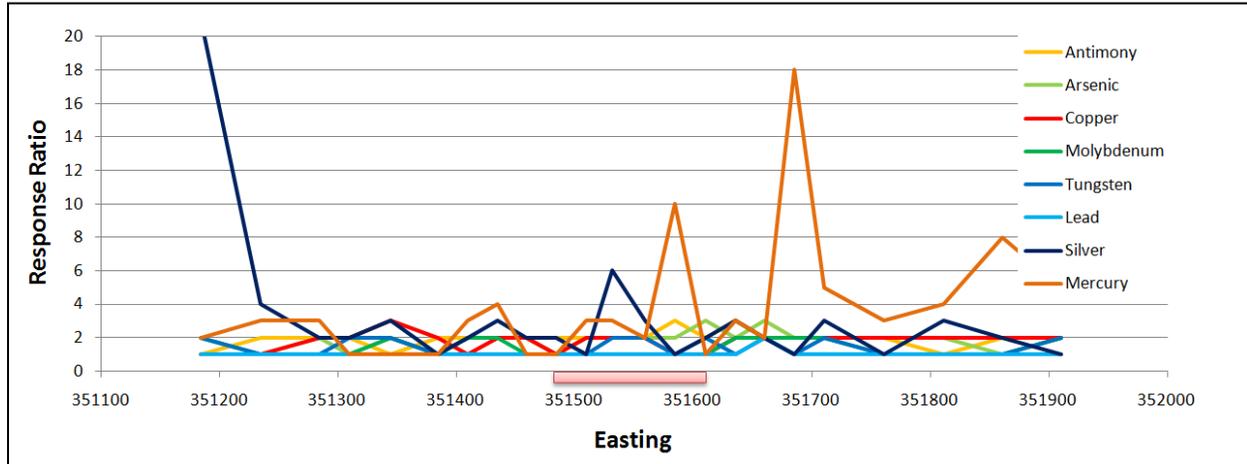


FIGURE 65. TRANSECT 1- B HORIZON AQUA REGIA RESPONSES FOR SELECTED ORE AND PATHFINDER ELEMENTS.

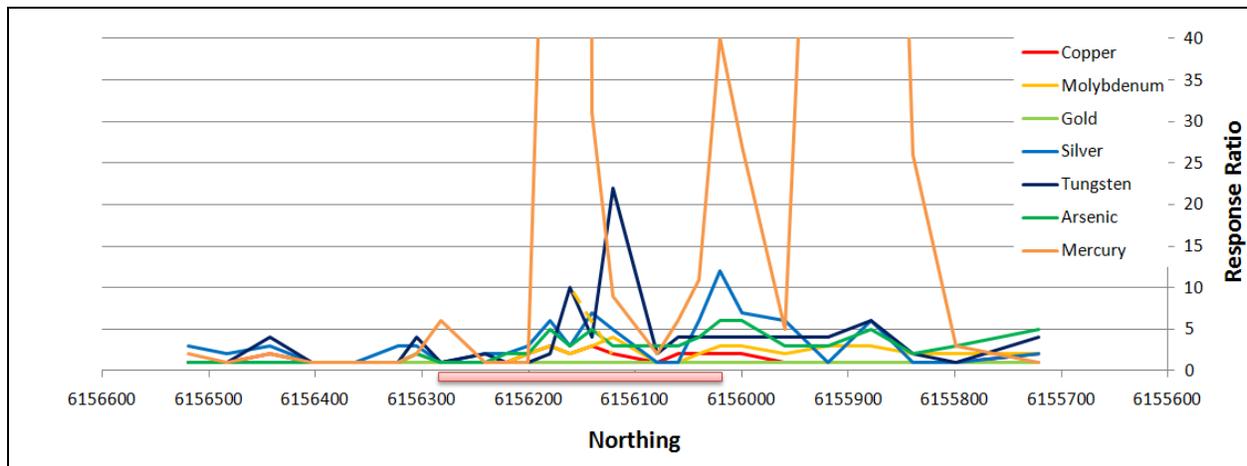


FIGURE 66. TRANSECT 2- B HORIZON AQUA REGIA RESPONSES FOR SELECTED ORE AND PATHFINDER ELEMENTS.

EFFECTIVENESS OF PARTIAL AND SELECTIVE EXTRACTIONS.

In order to compare the large amount of data generated for the partial and selective extractions, the results for each Transect have been compiled into Tables (Tables 12 and 13). Responses for selected ore and pathfinder elements for each extraction are categorized on the basis of: a) the form of the response (i.e. apical, rabbit-ear or single peak); b) contrast; and c) level of confidence in the anomaly. For the level of confidence classification, each field with a recognizable response is assigned a colour ranging from red, indicating very high confidence, to blue, low confidence. The colours aid in visually assessing the relative performance of each extraction. In addition, each cell is assigned a value based on its level of confidence. Very high confidence responses are assigned a 4, high a 3, moderate 2 and low 1. Scores are summed for each extraction to provide an overall measure of effectiveness. These scores reflect both the number of elements responding and the levels of confidence in the response. Finally a relative

score is calculated by subtracting the Upper B horizon aqua regia score from the score for each method. This provides an indication of the relative performance of each leach with respect to the traditional B horizon aqua regia approach. Relative scores with positive values indicate better performance and negative values poorer performance.

Table 12 summarizes the results for Transect 1. The relative scores tell an interesting story. Most extractions in the B and C horizons achieve much the same result as conventional soil sampling regardless of whether they are generic or laboratory specific methods. In other words, they fail to convincingly identify the position of the underlying mineralization. The poorest performer, Enzyme Leach, did not produce a response in any of the elements evaluated. Of the laboratory specific methods only MMI produced a recognizable anomaly for one of the ore elements, copper; however the apical anomaly is of low contrast and as a result assigned a moderate level of confidence. Bioleach and Ionic Leach also perform poorly. Bioleach identified moderate confidence anomalies for arsenic and manganese and Ionic Leach anomalies for mercury, calcium, iron and manganese. Neither of these extractions produces anomalies that would be considered as targets in an exploration setting.

The generic methods fared little better. HHDX, CHDX and CAR score close to the conventional method. Interestingly, both the hydroxylamine hydrochloride methods detected responses for copper and HHDX produces a recognizable response for gold, albeit of low contrast and low confidence.

Most of the generic methods and the Ionic Leach produce anomalies for calcium suggesting that they are sensitive to changes in the carbonate content of the soil. As discussed previously the presence of carbonate likely indicates the edges of a reduced chimney present in the soil and overburden column above the mineralization. These methods therefore may be useful in discriminating changes in the redox conditions and therefore indirectly the position of sulphides at depth.

Three extractions stand out as having significantly better performance than the conventional method. Two of these, aqua regia and sodium pyrophosphate with relative scores of 28 and 29 respectively, were carried out on the organic-rich Ah horizon at the top of the profile. The third method, distilled water (15), was done on upper B horizon material. This is the only B horizon method to detect at least one ore element (copper) and several of the pathfinders, although with moderate confidence. Ah horizon appears to have the most robust signal of the horizons sampled. Both methods produced high to very high confidence responses for the ore elements copper and gold, and robust responses for several of the pathfinder elements. Elements that stand out as useful pathfinders are tungsten and uranium, which display very high contrast apical anomalies in the sodium pyrophosphate results. Significant responses for these elements also occur in the Aqua regia results.

Similar results are seen over much deeper mineralization on Transect 2 (Table 13). Most of the B and C horizon methods fail to produce credible responses over the mineralization. In fact, relative scores for hot hydroxylamine hydrochloride (-3), Enzyme Leach (-4) and Bioleach (-2) indicate slightly poorer performance than the conventional method. MMI (6) does produce anomalies for copper and gold but they are of only moderate confidence because of the amount of background noise. Cold hydroxylamine hydrochloride (5) produces a robust copper response. This is the only generic method for the upper B horizon samples to detect one of the ore elements. Despite this, its relative performance (5) is only slightly better than the conventional method.

With the exception of Ionic Leach, there is no significant difference in the performance between the generic and laboratory specific extractions. Ionic Leach with a relative score of 18 performs significantly better than the other laboratory specific methods. It detects anomalies in most of the studied elements but at low to moderate confidences. Unlike the other laboratory specific methods it does define high confidence anomalies for the ore elements copper and gold, which gives it a distinct advantage over those methods.

Once again it is the Ah horizon methods that produce the most robust responses over mineralization, particularly for the ore elements. Aqua regia defines very high confidence anomalies for copper and gold as well as a number of the pathfinders including: silver, molybdenum, mercury, tungsten and arsenic, which result in it having the highest relative score of 26. Sodium pyrophosphate with a relative score of 14 (similar to Ionic Leach) also detects many of the same elements but with lower levels of confidence.

Tungsten stands out on this transect as well. It appears to be a particularly sensitive indicator of mineralization. Very high confidence anomalies occur in a number of the proprietary and laboratory specific methods in the Ah and upper B horizons. Calcium anomalies are also detected by the non-aqua regia methods again indicating that these weak extractions (when corrected for aqua regia calcium), are sensitive to subtle changes in the soil carbonate content, thereby indirectly indicating the position of the mineralization by identifying the edges of a potentially reduced zone developed above it.

TABLE 11. TRANSECT 1 - SUMMARY OF PARTIAL AND SELECTIVE EXTRACTION RESULTS.

Kwanika Transect 1																		
Horizon	Extraction	Cu	Au	Pb	Zn	Ag	Bi	Mo	Hg	W	U	As	Sb	Ca	Fe	Mn	Score	Relative Score
Ah	Sodium Pyrophosphate	A	R	d	A	R	a	X	X	R	R	A	A	X	a	R	32	28
Ah	Aqua Regia	A	A	X	X	A	X	r	S	A	A	a	a	A	X	R	33	29
Upper B	Distilled Water	S	X	S	r	R	X	a	X	X	X	s	X	A	s	r	19	15
Upper B	Aqua Regia*	a	X	X	X	X	X	X	R	X	X	X	X	a	X	X	4	0
Upper B	Cold Hydroxylamine HCl	r	X	X	X	X	X	X	X	X	X	X	a	R	X	S	7	3
Upper B	Hot Hydroxylamine HCl	r	r	X	X	X	X	X	X	a	X	X	X	R	X	X	4	0
Upper B	Cold Aqua Regia	X	X	X	X	a	X	X	A	a	X	X	X	r	X	X	5	1
Upper B	Enzyme Leach	X	X	X	X	X	X	X	X	X	X	X	X	na	na	X	0	-4
Upper B	BioLeach	X	X	X	X	X	X	X	X	X	X	a	X	na	na	S	4	0
Upper B	Ionic Leach	X	X	X	X	X	X	X	s	X	X	X	X	R	r	r	8	4
Lower B	Aqua Regia	X	X	X	X	a	X	X	S	a	X	X	X	X	X	X	5	1
C	Aqua Regia	X	X	X	X	A	X	A	R	X	a	X	X	X	X	X	9	5
Other	MMI-M	a	X	X	X	X	X	a	X	X	s	X	X	na	na	na	5	1

Score			
4	Very high confidence	a- Apical (2 -10 x background)	r - Rabbit-ear (2 - 10 x background)
3	High confidence	A - Apical (11 -20 x background)	R - Rabbit-ear (11 -20 x background)
2	Moderate confidence	A - Apical (>21 x background)	R - Rabbit-ear (>21 x background)
1	low confidence		

* Conventional soil geochemistry

TABLE 12. TRANSECT 2 - SUMMARY OF PARTIAL AND SELECTIVE EXTRACTION RESULTS.

Kwanika Line 2																			
Horizon	Extraction	Cu	Au	Pb	Zn	Bi	Ag	Mo	Hg	W	U	As	Sb	Ca	Fe	Mn	Score	Relative Score	
Ah	Sodium Pyrophosphate	A	a	X	r	s	R	a	X	R	R	R	X	r	X	R	24	14	
Ah	Aqua Regia	R	R	X	X	r	R	R	A	R	A	A	r	R	X	A	36	26	
Upper B	Distilled Water	a	X	X	a	X	X	X	r	X	X	a	X	s	X	R	7	-3	
Upper B	Aqua Regia*	a	X	X	X	X	X	X	A	A	X	X	r	r	X	X	10	0	
Upper B	Cold Hydroxylamine HCl	R	X	s	X	X	s	X	X	X	X	s	X	R	X	A	15	5	
Upper B	Hot Hydroxylamine HCl	r	X	X	X	X	X	X	X	X	X	X	X	r	X	A	7	-3	
Upper B	Cold Aqua Regia	X	X	X	D	X	a	X	A	X	X	A	a	r	X	S	14	4	
Upper B	Enzyme Leach	X	X	X	X	X	X	X	X	R	X	X	X	na	na	A	6	-4	
Upper B	BioLeach	X	X	X	X	R	X	X	X	R	X	X	X	na	na	A	8	-2	
Upper B	Ionic Leach	R	R	d	r	R	r	X	a	A	s	a	r	R	X	R	28	18	
Lower B	Aqua Regia	X	X	X	X	X	X	X	A	a	X	X	X	X	X	X	4	-6	
C	Aqua Regia	X	X	X	X	r	S	S	R	X	X	S	r	s	s	X	16	6	
Other	MMI-M	s	R	X	X	X	a	S	X	X	X	X	X	na	X	na	10	0	
Score																			
4	Very high confidence	a- Apical (2 -10 x background)					r - Rabbit-ear (2 - 10 x background)					s- Single rabbit ear (2 - 10 x background)							
3	High confidence	A - Apical (11 -20 x background)					R - Rabbit-ear (11 -20 x background)					S - Single rabbit ear (11 - 20 x background)							
2	Moderate confidence	A - Apical (>21 x background)					R - Rabbit-ear (>21 x background)					S - Single rabbit ear (>21x background)							
1	low confidence																		
* Conventional soil geochemistry																			

CONCLUSIONS

This study set out to answer several questions about the effectiveness of soil geochemistry in areas of transported glaciofluvial cover. These are:

- Can soil geochemistry be used to detect blind copper-gold mineralization beneath Quaternary glacial sediment cover?
- Is soil pH effective at identifying sulphide mineralization through the Quaternary cover?
- If so, in which horizon is the signal the strongest?
- Are there any benefits to using laboratory specific methods over generic methods?
- Which of the methods tested performs the best?
- What is the recommended strategy for soil sampling in areas of deep Quaternary sediment cover?

Based on the results presented here, the answers to these questions are as follows:

- Soil geochemistry can be used as an effective exploration method for detecting mineralization through transported glacial overburden if the appropriate combination of sample medium and chemical extraction is used. Not only does it effectively detect sub-cropping sulphide mineralization, it can also detect mineralization located at much greater depths through Quaternary and older post mineral sedimentary basin rocks.
- Soil pH proved to be effective at identifying the position of the underlying mineralization on both transects. Best response occurs in the IDH (Inverse Difference Hydrogen), suggesting that the mineralization is spatially related to subtle variations in the carbonate content of the soil.
- Best results from the selective and partial extractions are obtained from samples taken from the Ah horizon. Both the generic SPY extraction and aqua regia define high contrast apical and rabbit-ear anomalies directly over the mineralized zone. Both of these methods produce high confidence anomalies for the ore elements as well as a suite of pathfinder elements.
- There are no benefits to using laboratory specific methods in this environment. Of the laboratory specific methods tested, only Ionic Leach produced results that were significantly better than traditional B horizon AR but this was only on one of the two transects (transect 2). The other laboratory specific methods provided no advantage over conventional AR. None of them detected ore element anomalies with any degree of confidence.
- On both transects, the most effective combination of sample medium and extraction is aqua regia on the Ah horizon. SPY on the Ah horizon is also robust producing very similar results to aqua regia. This could be used as an alternative to AR if LOI or organic carbon analyses are done as well. These analyses are necessary to correct the SPY analyses for soil organic carbon content.

Other conclusions from this study are:

- Several of the extractions produce stronger responses over the deeper mineralization on Transect 2 than over sub-cropping mineralization on Transect 1. These include CHDX, CAR and IL. The reason why this might be is not clear.
- Rabbit-ear anomalies in the IDH, EC and the ratio of weak extraction to aqua regia calcium suggest the presence of a reduced chimney above the mineralized zone. This interpretation is supported by strong anomalies for tungsten and uranium directly over the mineralization; elements that are highly insoluble under reducing conditions. Rabbit-ear anomalies are seen in the elements iron and manganese in the SPY

and IL extractions. These elements are highly soluble under reducing conditions and form strong enrichments at the edges of the reduced chimney. These results suggest that redox sensitive elements when used together with soil pH and EC are excellent indicators of the presence of a reduced chimney, which is an indirect expression of an underlying sulphide source.

- SGH results support the presence of a reduced chimney but the predicted anomaly patterns for the gold and copper pathfinder classes are reversed.
- A recommended strategy for soil sampling in Quaternary glacial sediment covered areas in central British Columbia should include field soil pH and conductivity measurements in combination with aqua regia and low detection limit ICP-MS analysis of the Ah horizon. Sodium pyrophosphate can also be used as a substitute for aqua regia as long as LOI or organic carbon analyses are done so that appropriate corrections can be made.

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