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**Ministry of Energy, Mines & Petroleum Resources**
Mining & Minerals Division
BC Geological Survey

**Assessment Report**
**Title Page and Summary**

**TYPE OF REPORT [type of survey(s)]:** Geophysical

**TOTAL COST:** $235,062.85

**AUTHOR(S):** Christopher Hicks

**SIGNATURE(S):** Christopher Hicks

**NOTICE OF WORK PERMIT NUMBER(S)/DATE(S):** MX-1-926 July 10, 2014

**YEAR OF WORK:** 2016

**STATEMENT OF WORK - CASH PAYMENTS EVENT NUMBER(S)/DATE(S):** 5658993, August 2, 2017

**PROPERTY NAME:** S2

**CLAIM NAME(S) (on which the work was done):** S2-9, S2-10, S2-11

**COMMODITIES SOUGHT:** Copper, Molybdenum, Gold

**MINERAL INVENTORY MINFILE NUMBER(S), IF KNOWN:**

**MINING DIVISION:** Omineca

**NTS/BCGS:** 93M

**LATITUDE:** 55 ° 54 ' 56.37 " **LONGITUDE:** 127 ° 29 ' 53.30 " (at centre of work)

**OWNER(S):**
1) Vale Canada Limited
2)

**MAILING ADDRESS:**
Highway 17 West
Copper Cliff, ON, P0M 1N0

**OPERATOR(S) [who paid for the work]:**
1) Vale Canada Limited
2)

**MAILING ADDRESS:**
Highway 17 West
Copper Cliff, ON, P0M 1N0

**PROPERTY GEOLOGY KEYWORDS (lithology, age, stratigraphy, structure, alteration, mineralization, size and attitude):**
Porphyry, Induced Polarization, Magnetotellurics

**REFERENCES TO PREVIOUS ASSESSMENT WORK AND ASSESSMENT REPORT NUMBERS:** 35139

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| TYPE OF WORK IN THIS REPORT | EXTENT OF WORK (IN METRIC UNITS) | ON WHICH CLAIMS | PROJECT COSTS APPORTIONED (incl. support) |
|---|---|---|---|
| **GEOLOGICAL (scale, area)** | | | |
| Ground, mapping | | | |
| Photo interpretation | | | |
| **GEOPHYSICAL (line-kilometres)** | | | |
| Ground | | | |
| Magnetic | | | |
| Electromagnetic | | | |
| Induced Polarization | 48 Stations | S2-9, S2-10, S2-11 | 235,062.85 |
| Radiometric | | | |
| Seismic | | | |
| Other | Magnetotellurics - 42 Stations | S2-9, S2-10, S2-11 | |
| Airborne | | | |
| **GEOCHEMICAL (number of samples analysed for...)** | | | |
| Soil | | | |
| Silt | | | |
| Rock | | | |
| Other | | | |
| **DRILLING (total metres; number of holes, size)** | | | |
| Core | | | |
| Non-core | | | |
| **RELATED TECHNICAL** | | | |
| Sampling/assaying | | | |
| Petrographic | | | |
| Mineralographic | | | |
| Metallurgic | | | |
| **PROSPECTING (scale, area)** | | | |
| **PREPARATORY / PHYSICAL** | | | |
| Line/grid (kilometres) | | | |
| Topographic/Photogrammetric (scale, area) | | | |
| Legal surveys (scale, area) | | | |
| Road, local access (kilometres)/trail | | | |
| Trench (metres) | | | |
| Underground dev. (metres) | | | |
| Other | | | |
| | | TOTAL COST: | 235,062.85 |

# ASSESSMENT REPORT

**of**

# 3D-IP and MT Geophysical Survey

**on the**

# S2 Property

**Event Number 5658993**

**OM INECA MINING DIVISION,**
**British Columbia**
**NTS: 93M**
**Latitude 55° 54' 56.37" N, Longitude 127° 29' 53.30" W**
**(NAD 83, Zone 9N)**

**Prepared By:**
**Christopher Hicks**

**Vale Canada Limited**
**Highway 17 West Copper Cliff,**
**Ontario, Canada**
**P0M 1N0**

**October 20th, 2017**

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# 1 Introduction

Results from previous exploration programs at S2 indicated the potential for a copper-molybdenum porphyry system within the property. The Fog Target area, located in the center of the S2 property contained multi-generation vein sets which contained various amounts of pyrite-chalcopyrite-molybdenite mineralization. Due to the rugged terrain and lack of available surface exposure it was determined that continued surface exploration would no longer be beneficial and that drilling was required to further test the target. The purpose of a drill program would be to first, determine if a porphyry system existed at depth and second, if a system did exist provide a rough estimate of potential size and grade. Since the Fog area was so large and surface exposure limited it was recommended that a geophysical survey be completed over the Fog Target to help identify anomalies and further define drill targets.

It was decided that the best way to test the Fog area would be to complete a reconnaissance style three-dimensional induced polarization (3D-IP) combined with magnetotellurics (MT) survey over the areas containing the best surface mineralization. The aim of the survey was to identify and map out any geophysical anomalies that could possibly be caused by mineralization associated with a porphyry system. These anomalies would then represent targets for a future drilling. From late July to early August, 2016 a 10 day, helicopter supported program was completed over a large portion of the Fog Target on the S2 property where a total of 44 3D-IP and 42 MT stations were collected. This report outlines the work completed at S2 in 2016. The total expenditure for this program was $235,062.85.

# 2 Location, Access and Physiography

The S2 property is located in the Omineca Mining Division of north-central British Columbia, Canada. The property is approximately 75 km northeast of Hazelton, centered at 55° 54’ 56.37” N latitude and 127° 29’ 53.30” W longitude within map sheet NTS 93M (Figure 1). It is situated within the Atna Range of the Skeena Mountains, and includes Shedin Peak, the highest point in the Skeena Range at 2,588m (Figure 2).

The property is located in a remote area that consists of rugged mountainous terrain with steep, U-shaped glacial and river valleys, due to the difficult terrain access to the property is via helicopter only (Plate 1). The closest usable forest service road (FSR), the Kuldo Main FSR is 6 km from the northwest margin of the property. Field crews and helicopter can be staged from nearby towns however remote fishing lodges provide closer staging options. Access within the property is limited to small traverses in river valleys or along mountain ridges with field crews utilizing helicopter for transportation throughout the property.

Elevation throughout the property typically ranges from about 2,500 m ASL along the mountain tops to as low as 800 m ASL in the valleys. Approximately 20% of the property is covered by alpine glaciers which cover the highest areas of elevation. These glaciers generally lead into cirques, which are abundant throughout the property. The cirques are predominantly bowl shaped, containing outcrop along the wall edges and boulders mixed with glacial debris collecting in the center; the exposure of outcrop and the fact that the boulders represent rocks immediately surrounding the cirque makes them a great place to explore. The cirques then lead to cliff faces which are very steep and are generally greater than 500 m in height. Outcrop along these faces cannot be reached but can be roughly mapped from a distance. Boulders and debris collect in the river valleys forming a talus slope along the bottom of the cliff, which thickens and flattens towards the middle of the valleys. Outcrop exposure in this area is rare but boulders, representing a large area, can be easily investigated. Vegetation throughout the property varies from limited grass, moss and shrubs on the mountain tops to thick grass, shrubs, bushes and spruce forest on the lower hill slopes and valleys. The center of each valley consists of glacier fed, fast moving streams of various sizes.

**Plate 1:** Typical view of the S2 property within a U-shaped valley looking towards a mountain ridge. Dikes can easily be seen in the cliff face.

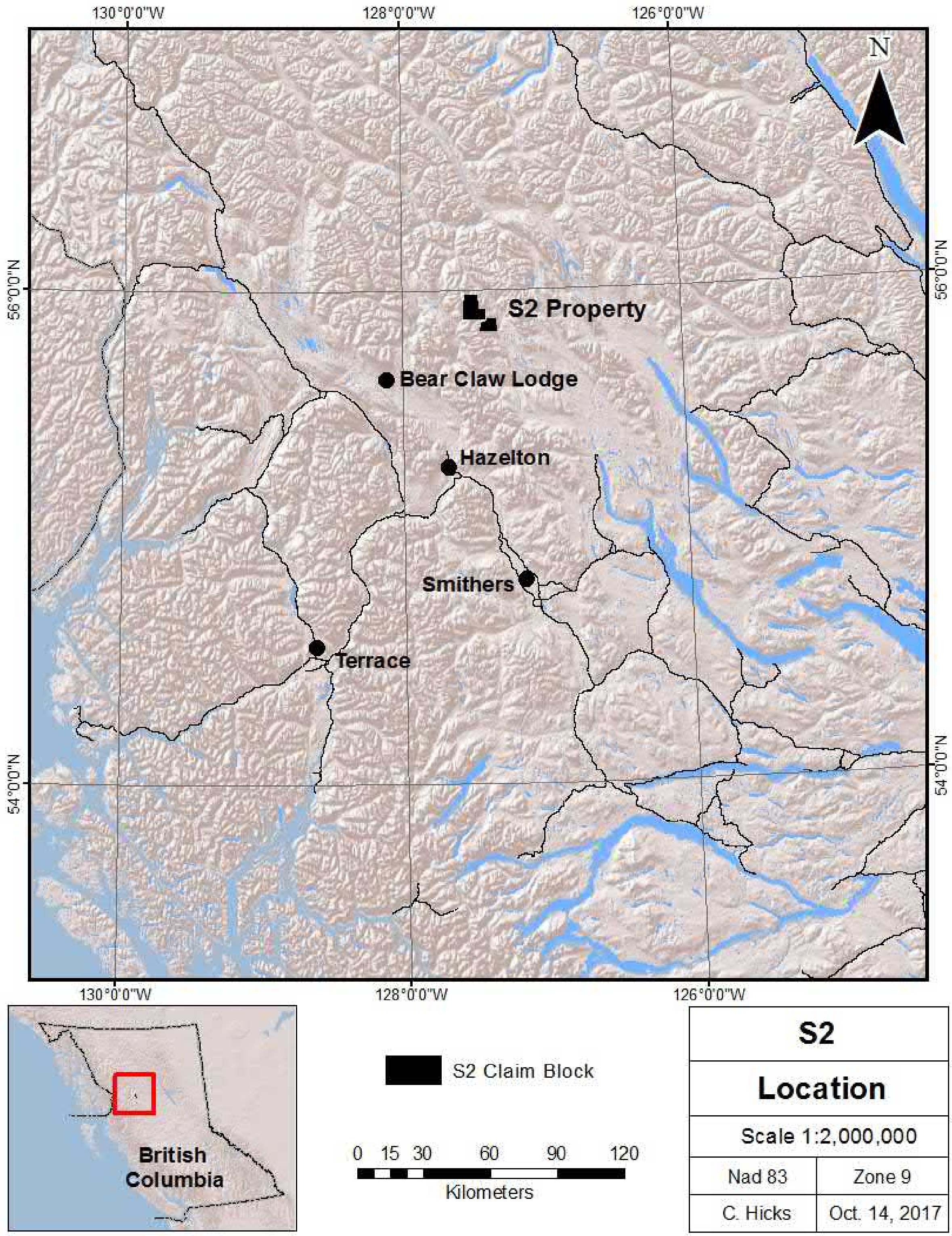


**Figure 1:** Location map for the S2 property relative to the town of Hazelton.

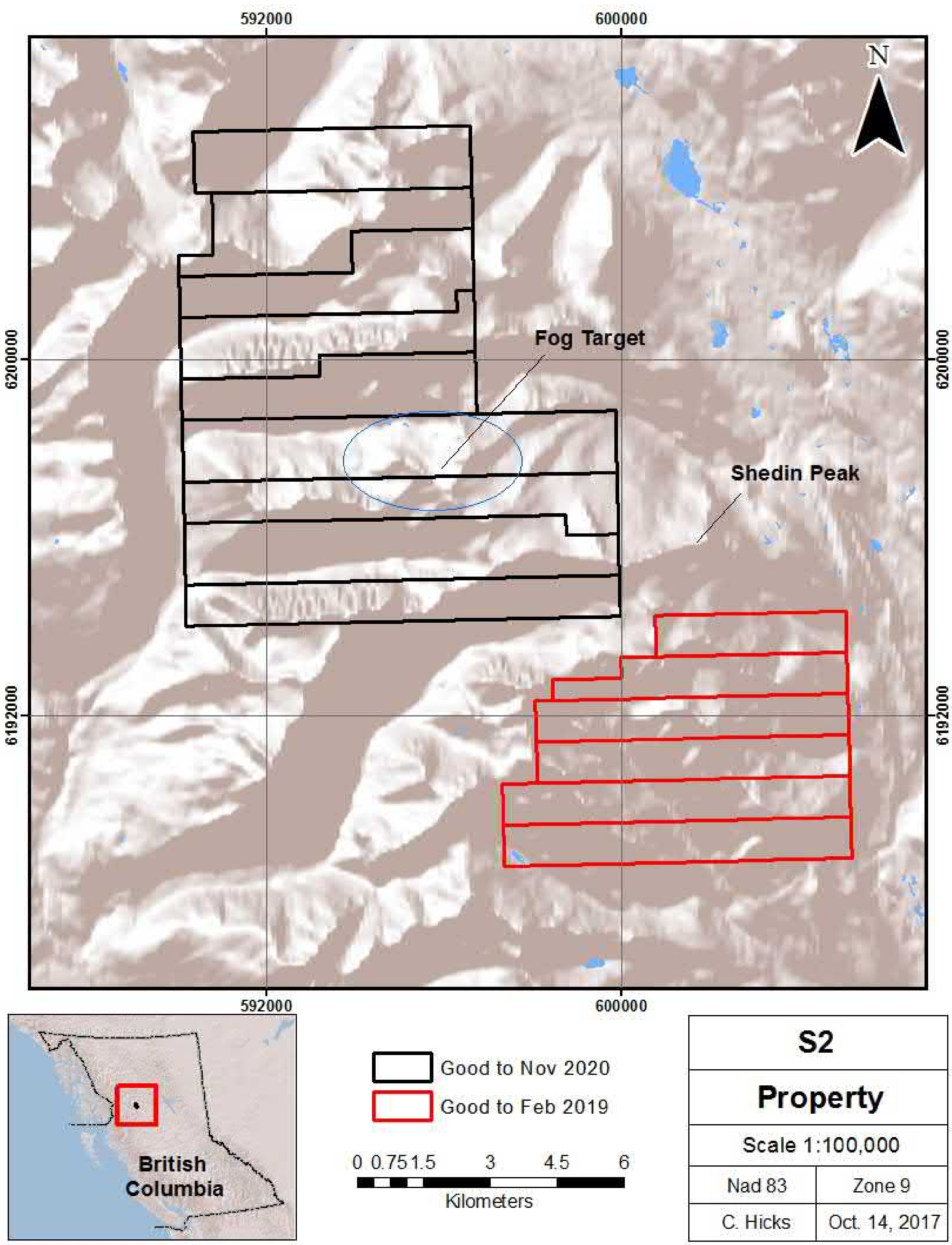


**Figure 2:** S2 property map showing the property boundary over a digital elevation model which highlights the steep cliffs and deep valleys that constitute much of the property. Shedin Peak (2,588m) is just outside the current property but its range extends west into the property, just south of the Fog target.

# 3 Land Tenure

The current S2 property is 100 % owned by Vale Canada Limited, and consists of fifteen claim blocks covering an area of 12,386.03 hectares. The property was originally staked on October 2$^{nd}$, 2013 and consisted of eighteen contiguous claim blocks covering an area of 31,333 hectares; all claims were in the Omineca Mining Division and 100% held by Vale. After the 2014 field season lower priority areas in the northwestern and southwestern parts of the property were allowed to lapse on their anniversary date. This resulted in newly designed claim blocks, consisting of 15 contiguous claims totaling 18,204.23 hectares. Exploration expenditures applied to these claims at that time put them in good standing until February 14$^{th}$, 2019. Following the results of the 2016 3D-IP/MT survey the exploration expenditures were again applied to a portion of the 15 claim blocks, with some claims becoming split and adjusted in size. The current property consists of two separate claim blocks (Figure 3). The first block consists of nine contiguous mining claims covering an area of 8,681.81 hectares. All of the 2016 exploration expenditures were applied to these nine claims and they were adjusted in size removing low priority areas. These are now in good standing until November 16$^{th}$, 2020. The second block consists of six contiguous claims covering an area of 3,704.22 hectares. None of the 2016 exploration expenditures were applied to these claims but they remain in good standing until February 14$^{th}$, 2019. Additional information regarding the individual claims can be found in Table 1 and 2.

A Multi-Year Area-Based (MYAB) permit was granted by the BC Ministry of Energy and Mines on July 10, 2014 and is valid until March 31, 2019. The MYAB permit included consultation of the First Nations which was done by the Ministry of Forestry, Lands and Natural Resources (FLNR) by letter with a response requested within 30 days of delivery.

**Table 1:** S2 claim information for the six claims that had no exploration expenditures applied to them.

| Tenure # | Claim Name | Hectares | NTS | Company | Ownership | Staking Date | Expiry Date |
|---|---|---|---|---|---|---|---|
| 1031008 | S2-7 | 399.24 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Feb 14, 2019 |
| 1031010 | S2-6 | 544.53 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Feb 14, 2019 |
| 1031012 | S2-5 | 653.71 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Feb 14, 2019 |
| 1031014 | S2-4 | 653.71 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Feb 14, 2019 |
| 1031017 | S2-3 | 726.50 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Feb 14, 2019 |
| 1031019 | S2-2 | 726.66 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Feb 14, 2019 |

**Table 2:** S2 claim information for the nine claims that had the exploration expenditures applied to them.

| Tenure # | Claim Name | Hectares | NTS | Company | Ownership | Staking Date | Expiry Date |
|---|---|---|---|---|---|---|---|
| 1022735 | S2-8 | 907.18 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1022736 | S2-9 | 1305.99 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1022737 | S2-10 | 961.10 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1022738 | S2-11 | 1359.68 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1030996 | S2-16 | 868.90 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1030998 | S2-15 | 869.20 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1031001 | S2-14 | 851.33 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1031003 | S2-13 | 779.11 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |
| 1031005 | S2-12 | 779.32 | 93M | Vale Canada Limited | 100% | Oct 2, 2013 | Nov 16, 2020 |

# 4 Geological Setting

## 4.1 Regional Geology

British Columbia is comprised of arc, oceanic and continental platform terranes developed along the margin of Ancestral North America from the Paleozoic to the Jurassic. Subduction and accretion of the arcs and intervening oceanic terrane began in the late Jurassic and continued into the Cretaceous with the development of a continental arc along the margin of North America. Syn-accretion clastic sedimentary basins were deposited on the collisional margin of North America in the early Jurassic until the mid-Cretaceous (e.g. Bowser Basin). Another peak of subduction occurred in the Tertiary with both volcanic and intrusive events. The Triassic/Jurassic offshore island arcs, including Quesnellia and Stikinia terranes, contain most of the known porphyry Cu+/-Au+/-Mo mineralization in British Columbia (e.g. Highland Valley, Mt. Polley, Red Chris), but porphyry Cu-Mo+/-Au deposits are also associated with the Cretaceous continental arc (e.g. Huckleberry) and the Eocene continental arc (e.g. Bell-Granisle).

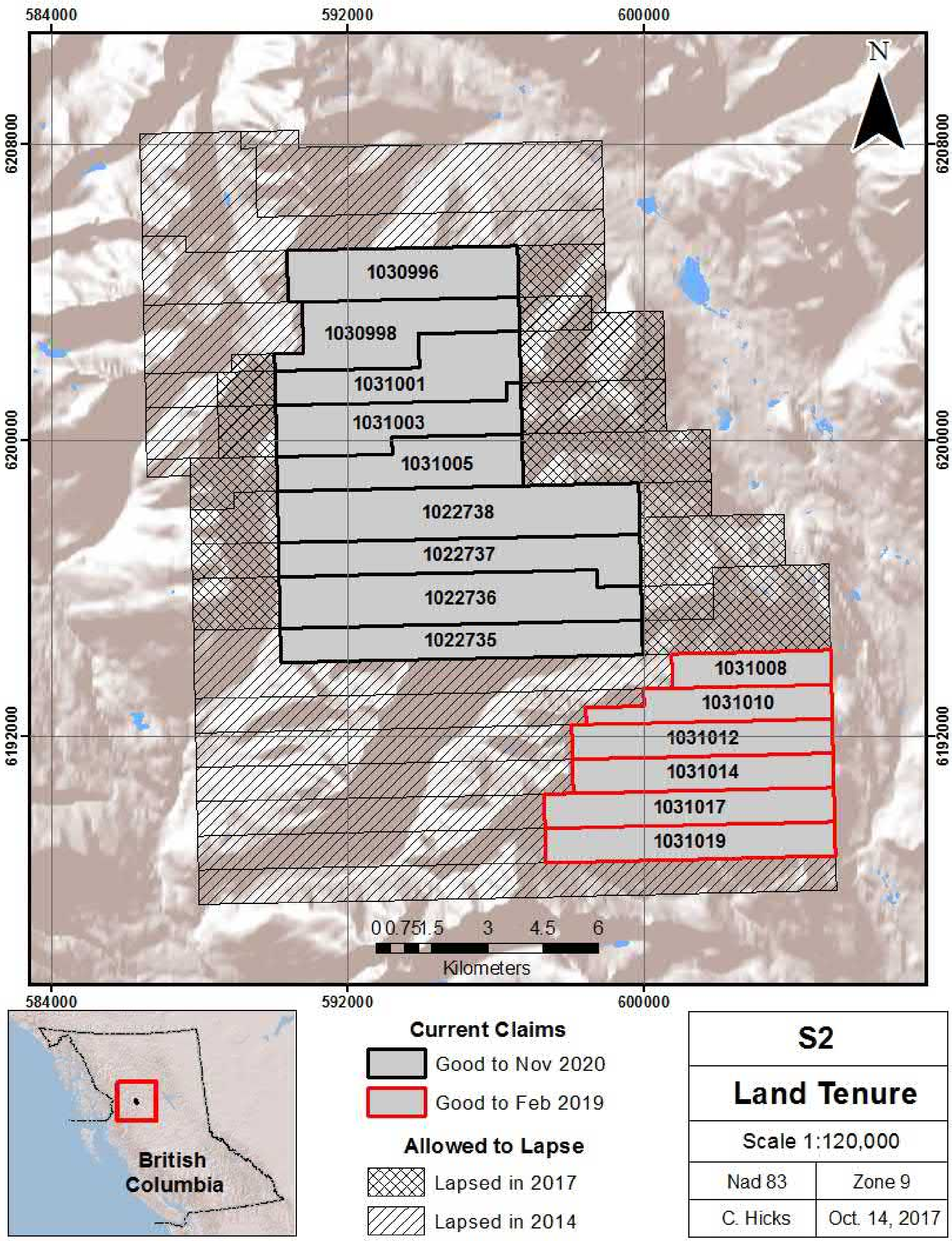


**Figure 3**: Current S2 claim block after splitting and filing assessment credits. Cross-hatched areas were allowed to lapse, current claim block covers areas where porphyry-style alteration/mineralization was identified in the field.

The Jurassic-Cretaceous Bowser Basin, which underlies much of the S2 region, was deposited on the Triassic to Lower Jurassic Stikinia arc. The Bowser Basin is comprised of dominantly clastic sedimentary deposits including deep distal marine through to fluvial and lacustrine environments. The sedimentary sequence is up to 6 km thick and the dominant rock type is dark grey mudstone, siltstone and greywacke with minor sandstone and limestone. Portions of the Bowser Basin Group are highly carbonaceous and coal seams occur in the north-central part of the basin which has been the focus of thermal coal and coal-methane exploration. Compression during the Cretaceous from the SW caused folding and thrust faulting of the Bowser Basin along NNW trending axes which is referred to as the Skeena Fold Belt. These sediments are moderately deformed and metamorphosed to greenschist facies, with local hornfels in contact aureoles of younger intrusions. Cretaceous granitoid plutons of the Bulkley Suite (82 Ma) and smaller granitoid bodies of Eocene Babine Suite (52 Ma) intruded the Bowser Groups sediments. Quaternary glacio-fluvial and alluvial deposits are found in valleys.

Mineralization in the S2 region includes porphyry deposits that formed during the Jurassic- Cretaceous collision and Eocene extension. The Bulkley Plutonic Suite hosts the Huckleberry porphyry Cu-Au-Mo deposit (2011 P+P 164Mt @ 0.47% Cu, 0.01% Mo), and the Babine Plutonic Suite hosts the Bell/Granisle/Morrison porphyry Cu-Au-(Mo) deposits (Bell-296 Mt @ 0.46% Cu, 0.2 g/t Au). Polymetallic veins have been mined historically on a small scale throughout the region and may be related to the Cretaceous porphyry event.

## 4.2 Property Geology

The S2 Property covers Jurassic-Cretaceous Bowser Basin sediments intruded by two 20 km diameter bodies and several smaller bodies of monzonite interpreted to be part of the Cretaceous Bulkley Plutonic Suite (Figure *). The Bowser Basin Group sediments are mapped as interbedded epiclastic feldspathic and volcanic conglomerate, sandstone, siltstone, shale and argillite, with minor limestone units (GSC OF 720). The sedimentary units on the property include dark grey argillite, medium grey feldspathic greywacke, and quartz-rich arenite with local discontinuous lenses of carbonate. Bedding in the sediments is folded and faulted related to NE verging thrusting. Portions of the argillite package appear to have had primary disseminated sulfides.

Intrusions within the S2 Property area as mapped include undifferentiated granitic rocks, equigranular to porphyritic monzonite, quartz diorite, minor andesite, felsite, aplite, alaskite and intrusive breccia, stocks, plugs, sills and dikes (GSC OF 720). A 2 km long oblate intrusive body located 10 km south of the S2 Property has been dated (K-Ar) as Eocene at 50.7 +/- 2.3 Ma (Wanless et al, 1979) which suggests that with further geochronology, other Eocene intrusions could be identified.

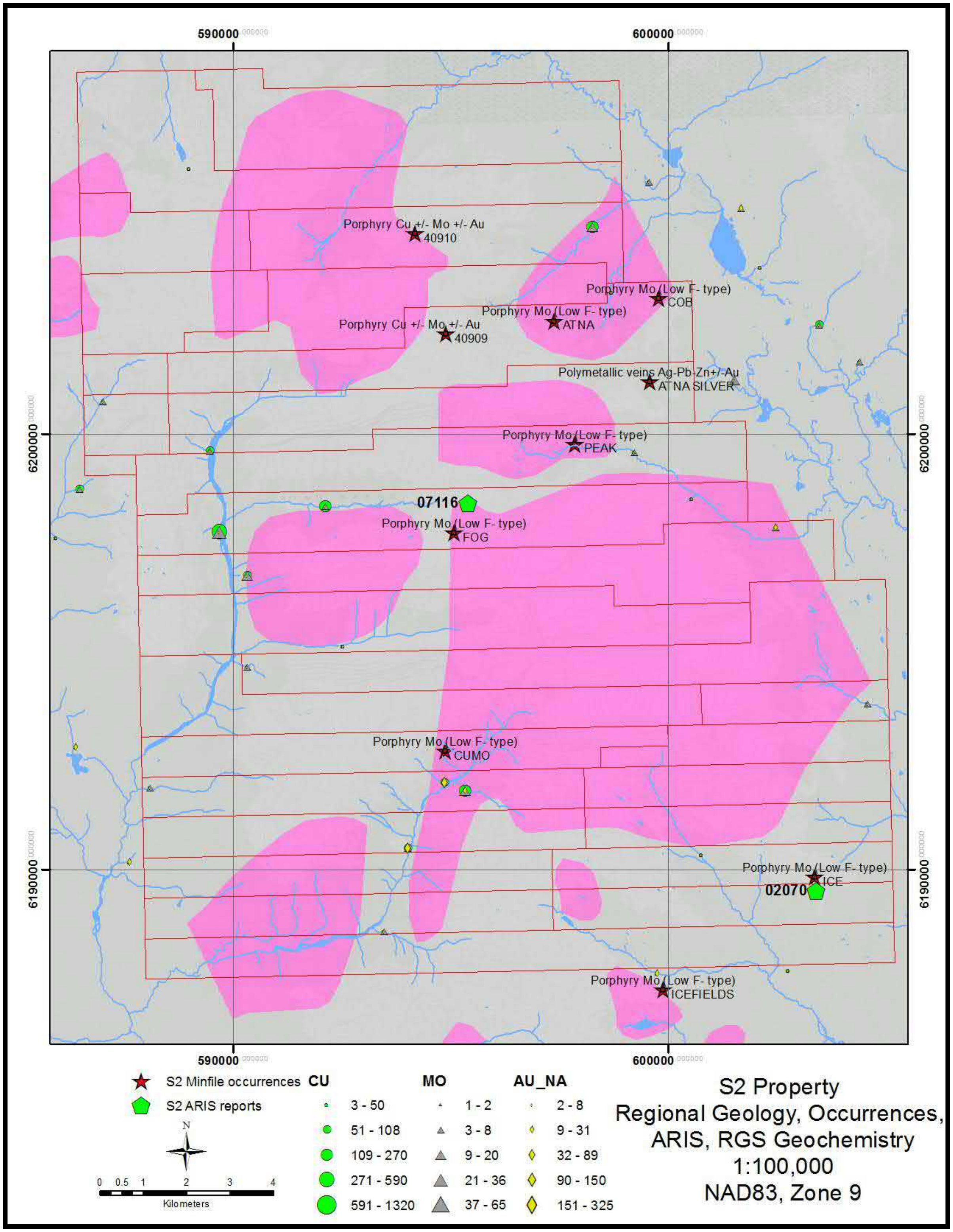


**Figure 4:** Regional geology (pink Cretaceous granitoids, grey Bowser Basin sediments), regional BCGS stream sediments (Cu ppm, Mo ppm, Au ppb), ARIS reports, BCGS Minfile mineral occurrences.

Mineralization on the S2 Property identified from historic reports and Minfile occurrences includes the porphyry Cu-Mo and low-F porphyry Mo type mineralization at the Ice, Fog/Peak, and Cob/Atna showings (Figure 4) where quartz veins host molybdenum and chalcopyrite within the granitoid and, to a lesser extent, the sediments. Zinc-lead polymetallic veins occur both south and north of the S2 claim block. Historic BCGS stream sediment sampling includes 28 samples collected on the property with the highest Cu value of 340 ppm coinciding with the highest Mo of 36 ppm along Rosenthal Creek in the west-central part of the S2 Property. Two other samples with Cu>100 ppm and coincident anomalous Mo >5 ppm are draining the Fog showing and within Sperry Creek in the south-central part of the property. The highest Au value is 68 ppb which clusters with two other samples with >20 ppb Au and on anomalous Cu-Mo sample from Sperry Creek. One anomalous Cu-Mo sample is from and unnamed creek in the northeast part of the property.

# 5 Historic Work

Due to the rugged, mountainous terrain and remote location of the S2 property there has been limited historical work conducted within the area. Government campaigns covering the area were sparse and consisted of regional mapping, airborne geophysics and geochemical sampling programs. Mineral exploration activity within the property consisted of two phases, the first in the late 1960's with companies following up on molybdenum and copper anomalies, and the second being in the late 1970's with a company looking at the porphyry-style mineralization at the Fog target. In its entirety the S2 property has seen minimal mapping and sampling, covering only a small area of the property. Below is a short breakdown of the historical work conducted on the property.

## 5.1 Government Surveys

**1969:** The B.C. Ministry of Energy, Mines and Petroleum Resources mapped this region at 1:250,000; Carter and Kirkham (1969), Geological Compilation Map of the Smithers, Hazelton and Terrace Area, Preliminary Map 69-1, (93L, 93M). Copper and molybdenum mineralization was identified on the preliminary map in the S2 claim area. GSC flew airborne magnetics including the S2 target area; E-W flight lines, 800m to 2000m line spacing; hand contoured and then digitized as part of the current magnetic map for BC.

**1979:** GSC mapping of the 93M map sheet; Richards 1980, Geology of the Hazelton (93M) map area; GSC Open File 720, 1:250,000. No changes from the preliminary map of 1969.

**1983:** Regional stream sediment and water sampling on NTS sheet 93M by GSC with BC Ministry of Energy, Mines and Petroleum Resources with data released in 1984. A total of 1,099 stream sediment and 1,092 water samples were collected from 1,037 sites. Stream sediments were analyzed by AR/AAS, colorimetry, or neutron activation (Zn, Co, Pb, Ni, Co, Ag, Mn, As, Hg, Sb, Fe, Mo, W, U) and waters were analyzed for pH, U, and F. Several Cu and Mo anomalies were identified in the S2 claim block in the Rosenthal and Sperry Creeks.

**1998:** A total of 1,030 archived stream sediment samples from original RGS survey for 93M were re-analyzed by INAA (Au, Sb, As, Ba, Br, Ce, Cs, Cr, Co, Hf, Fe, La, Lu, Mo, Ni, Rb, Sm, Sc Na, Ta, Tb, Th, W, U, Yb). Several samples with Au anomalies were identified on the S2 claim block.

**2005:** Regional stream sediments from NTS sheet 94D were re-analyzed by INAA (Au, Sb, As, Ba, Br, Ce, Cs, Cr, Co, Hf, Fe, La, Lu, Mo, Ni, Rb, Sm, Sc Na, Ta, Tb, Th, W, U, Yb).

**2009:** Portions of map sheet 93M and 94D's archived stream sediment samples were re-analyzed by AR/ICP-MS as part of the QUEST-West project, but these samples do not include those in the S2 claim block.

## 5.2 Exploration Activity

**1967-69:** Minfile report for the COB/ATNA/JAN/PAT/MAD Porphyry Mo showing (no ARIS report filed); Canadian Superior Exploration Ltd. carried out mapping, geochemical sampling and 26 trenches on Graham Peak located near the central-eastern boundary of the S2 claim block. Molybdenite mineralization occurs in quartz veins/veinlets within porphyritic monzonite and diorite intruding argillaceous sediments. The geochemical sampling and trenching identified two zones of mineralization with grades of up to 0.091% $MoS_2$ over 12 m, only $MoS_2$ is reported on maps and files. In 1968-69, 1,587 m of drilling in six holes was completed with one intersection of 0.13 % $MoS_2$ over18 m.

**1969:** ARIS# 02070: Sicintine Mines Ltd. carried out a geochemical soil survey on the Ice claims over a 15-day period to explore the extent of chalcopyrite-molybdenite mineralization hosted in a quartz-diorite intrusion in the SE corner of the S2 Property. The soil grid covered an irregular area of ~2.8 x 2 km with a total of 411 samples collected and analyzed by AR/AA for Cu and Ag with ion-specific analysis for Mo. Coincident Cu (>150 ppm up to 1,300 ppm) and Mo (>10 ppm up to 250 ppm) anomalies in soils cover an area approximately 250 x 365 m that coincides with known vein and disseminated Cu-Mo mineralization located on a steep slope. Silver results are erratic within the Cu-Mo zone (>2.5 ppm to 35 ppm). Rock pits were blasted across outcrops in this area with results of 0.02% Cu, 0.02% Mo, but much of this area is covered by talus.

**1978:** ARIS# 07116: St. Joseph Exploration Ltd. carried out geological, geochemical and prospecting work on the Fog and Peak claims that lie 3 km SW of Shedin Peak and east of Rosenthal Creek. Occurrences of molybdenite-chalcopyrite porphyry style vein mineralization are described in the monzonite stock and adjacent sediments. Five days of mapping, sampling and prospecting were completed in 1978 with an area of 8 $km^2$ covered. Twenty-four rock chip samples were collected and analyzed for Cu, Mo, Ag with a subset of five samples analyzed for Au, Ag, and W. Five chip samples across a vein yield 0.27% Mo, 0.11% Cu over 3.9 m and the best result from an individual rock chip sample is 0.22% Cu, 25 ppm Mo, 2.1 ppm Ag.

## 5.3 Vale Canada Limited 2013 Field Work

The 2013 field program at S2 was a short reconnaissance program to quickly assess the potential of the property prior to staking. A total of two and a half days were spent evaluating the target area during the latter part of September. Poor weather limited access to certain areas of the target, and only the western portion of the target area, a 20 x 20 km area could be evaluated. The field visit focused on visiting streams that contained anomalous Cu and Mo geochemistry and cirques located at the headwaters of these streams to evaluate lithologies, alteration and mineralization at each location. The following reports by Shriver (2013) and Shriver (2014) provide a more detailed analysis of the results of this program.

Field work identified mineralization within a granodiorite and host sediment consisting of disseminated pyrite and chalcopyrite; quartz-chalcopyrite veins; quartz-molybdenite veins; and sulfide-only (chalcopyrite-pyrite) veins cross cutting earlier vein sets or as center-lines in quartz veins. The veins appear to be B and D type quartz veins that are either cross cutting or sheeted/parallel sets that locally form a weak stockwork (Plate 2). Alteration surrounding the veins are dominated by K-feldspar with sericitic alteration seen locally in the sediments and green muscovite found in the granite.

A total of 3 moss mat and 25 rock samples, mostly from boulders and/or talus, were collected. The metal contents of the mineralized samples range from 1,093 to 4,403 ppm Cu, 27 to 131 ppm Mo, and 10 to 53 ppb Au with the highest results of each of these metals from one sample with 3-5% sulfide in a potassic altered granodiorite with chalcopyrite-pyrite-molybdenite in quartz-sulfide veins. Based on the field observations for the S2 area, potential for a Cu-Mo porphyry deposit was identified. Claims were then staked on October 2nd, 2013 to cover the areas where the mineralized intrusive phases and altered/mineralized meta-sediments were found in the field.

Late in the fall of 2013 a heli-stinger magnetic survey was flown over the property. A total of 3,278 line km were flown on north-south oriented lines at 150 m spacing's. Magnetic data was inverted using the 3D UBC magnetic inversion code to remove a large portion of the topographic and geometrical influences in the data. The magnetic survey resolved the magnetic signatures from the wide-spaced GSC surveys. The granite/granodiorite phases stand out, having the strongest magnetic anomalies. A northeast trend of smaller magnetic anomalies that bisects the two large granite/granodiorite bodies was also identified (Figure 5).

**Plate 2:** Examples of boulders found during the 2013 program. Upper photo contains sheeted B veins with rare blobs of sulfide cut by thin D veins. Lower photo contains veins with sulfide.

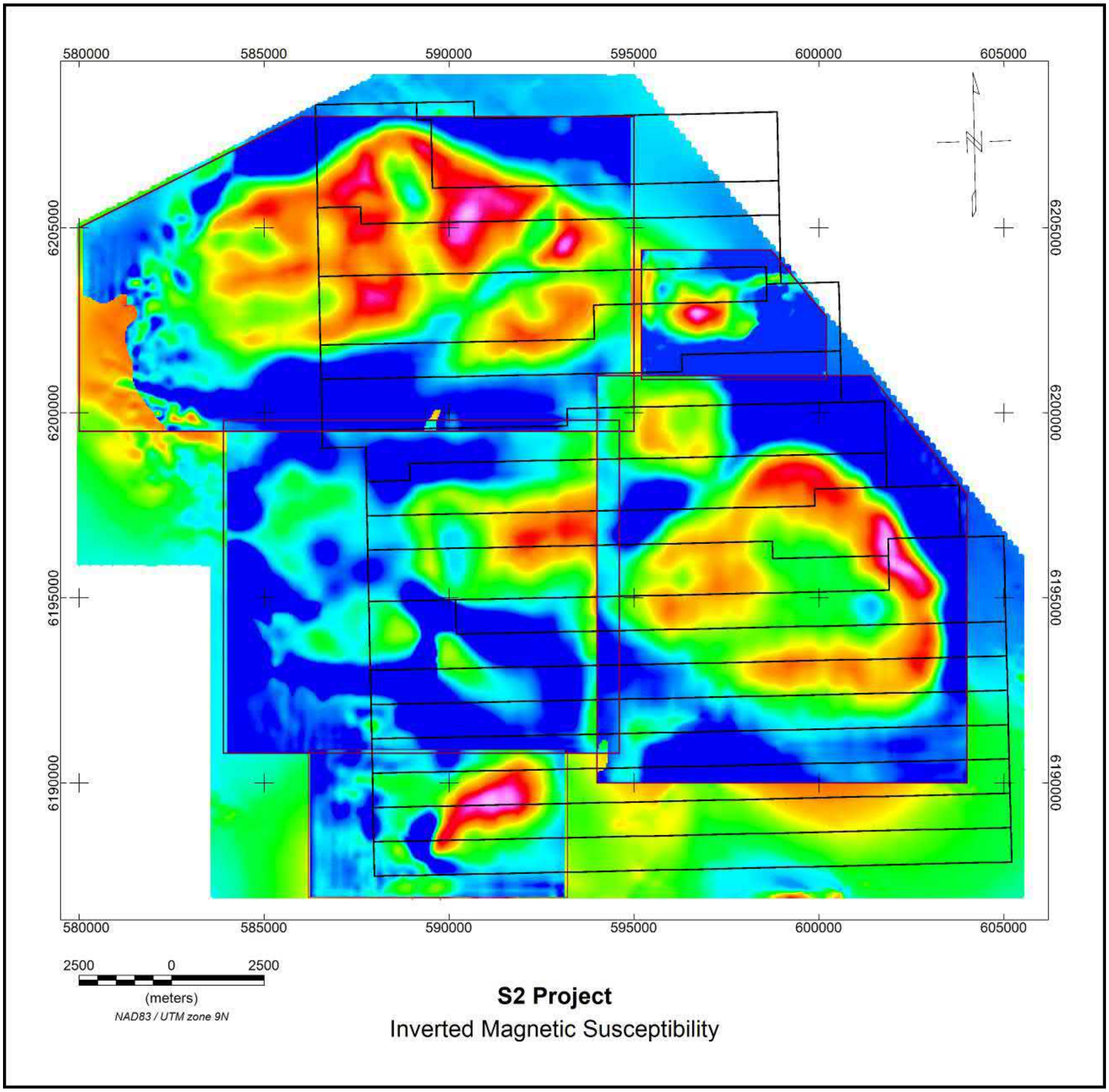


**Figure 5:** Magnetic inversions of the heli-stinger survey shown over the non-inverted magnetics.

## 5.4 Vale Canada Limited 2014 Field Work

Two phases of field work were completed on the S2 Property in 2014. Phase one was from July 8th through 22nd and consisted of four field teams comprised of four Vale geologists and four locally-hired technicians, which completed reconnaissance and focused exploration throughout the S2 property. The second phase was from August 13th through 27th with two Vale geologists and two locally-hired technicians that focused on the Fog Target area where detailed mapping and channel sampling were completed. A detailed account of the 2014 program and results can be found in Shriver (2014).

The phase one program consisted of over 120 km of traverses concentrated along creeks, cirques, and accessible ridges to evaluate these areas for porphyry potential by collecting geological stations and rock and moss mat/stream sediment samples. A total of 317 rock samples and 79 moss mat/stream sediment samples were collected and submitted for analysis (Figure 6).

Field observations identified several phases of intrusion. Most of the intrusives contained primary magnetite and were unaltered; however, weak potassic alteration was identified in areas where intense veining occurred. Bowser Basin sediments were also identified within the S2 area ranging from argillite to quartz-rich arenite. Some sediments were strongly metamorphosed and hornfelsed near the contact with the intrusions, and contained up to 10% disseminated pyrite in places; pyrite mineralization appeared to be syn-sedimentary in origin. A variety of dikes cut both the intrusions and sediments. These dikes were typically <3 m in width and were porphyritic with phenocryst populations including: quartz-feldspar, feldspar-biotite, and quartz-feldspar-hornblende. The quartz-feldspar porphyry dike with glassy quartz eyes commonly contains disseminated pyrite or pyrrhotite, and trace chalcopyrite. The dikes had a variety of orientations, sometimes occurring as sills, and were well exposed in cliff faces. There appears to be no alteration or mineralization effects away from the contacts of the dike within either the sediments or intrusions.

Quartz veins with minor sulfide, predominantly pyrite, but locally containing molybdenite and chalcopyrite, were identified on the property. These veins crosscut all rock types, but were best developed in the monzonite. Sulfide content was generally <1% and typically alteration was limited to vein halos where present. Several areas with increased veining, K-feldspar and/or muscovite alteration halos, disseminated sulfide, and abundance of pyrite, molybdenite and chalcopyrite were identified that typify porphyry-style mineralization. The strongest mineralization was seen in angular talus boulders from 50 cm to 3 m in size in a cirque in the central part of the property on an east-west ridge where the Fog and Peak claim blocks were explored in 1978; this area is now known as the Fog Target.

Of the 320 grab samples collected during this phase of field work, the maximum metal results were: Sample RX399285 with 5,830 ppm Cu, 602 ppm Mo, and 14 ppb Au from an oxidized quartz vein with pyrite and chalcopyrite; sample RX398063 with 806 ppm Cu, >10,000 ppm Mo, and 83 ppb Au in a sample of a quartz vein with molybdenite envelopes; and sample RX399386 with 15.5 ppm Au, 56 ppm Cu, 177 ppm Mo from an oxidized pyritic quartz vein/fault breccia in arenite. Most mineralized samples were from the monzonite with quartz-(K-feldspar)-sulfide veins, but sulfide-bearing veins were also observed to cross the porphyry dikes which also hosted weak disseminated mineralization.

The phase two program focused on following-up on the Fog Target to further investigate the porphyry style veining and mineralization identified during phase one. Field work during this program consisted of detailed mapping (1:2,500) of the ridge line and cirques, and channel sampling across mineralized zones in talus boulders and outcrop. A total of 50 channels were cut and 183 samples were collected (Figure 7).

Detailed mapping was completed to catalogue the lithologies and vein types in the area and their timing relationships. Detailed mapping identified two phases of monzonite and three phases of dikes. The oldest monzonite is a moderately foliated medium to coarse grained intrusion with up to 5% feldspar phenocrysts. The unit has K-feldspar stockwork, barren grey quartz veins, aplite dikes and many cross-cutting vein types that appear to increase in intensity towards the east at and/or below the contact with the sediments. The younger monzonite outcrops extensively in the Fog Target area and is a buff to pink, medium-coarse grained megacrystic intrusion with up to 10% pink K-feldspar phenocrysts. The contact with the MZ1 is not exposed and the two units may be gradational into each other. Geochemically, the two units are similar.

Three generations of dikes were identified in the eastern part of the mapped area. The first dike is a quartz-feldspar-biotite porphyry with 5% small white (sericitized) feldspar phenocrysts, 3% glassy quartz eyes to 2 mm, and 3% fine grained red, shreddy biotite and disseminated pyrite. The second dike is a white feldspar porphyritic dike with smaller quartz and biotite phenocrysts and a grey matrix. The third dike event is a fine grained mafic dike found in the central and NE part of the Fog area. The dikes are dark green, chloritic with 1cm hornblende or pyroxene phenocrysts.

Mineralization in the Fog Target area is concentrated in talus boulders in a cirque on the eastern end of an approximate 3.5 km long mineralized trend. These talus boulders track towards the steep cirque walls towards the south of the 3.5 km ridge line. Field mapping identified up to 11 different vein types in the Fog area. To test the mineralization within these veins channel samples were marked on larger well-mineralized talus boulders (>1m) and on outcrop where sulfide-bearing veins were mapped. A total of 50 channels were cut, 17 from talus boulders and the remaining from the outcrop north and northeast of the mineralized talus field, for a total of 183 samples.

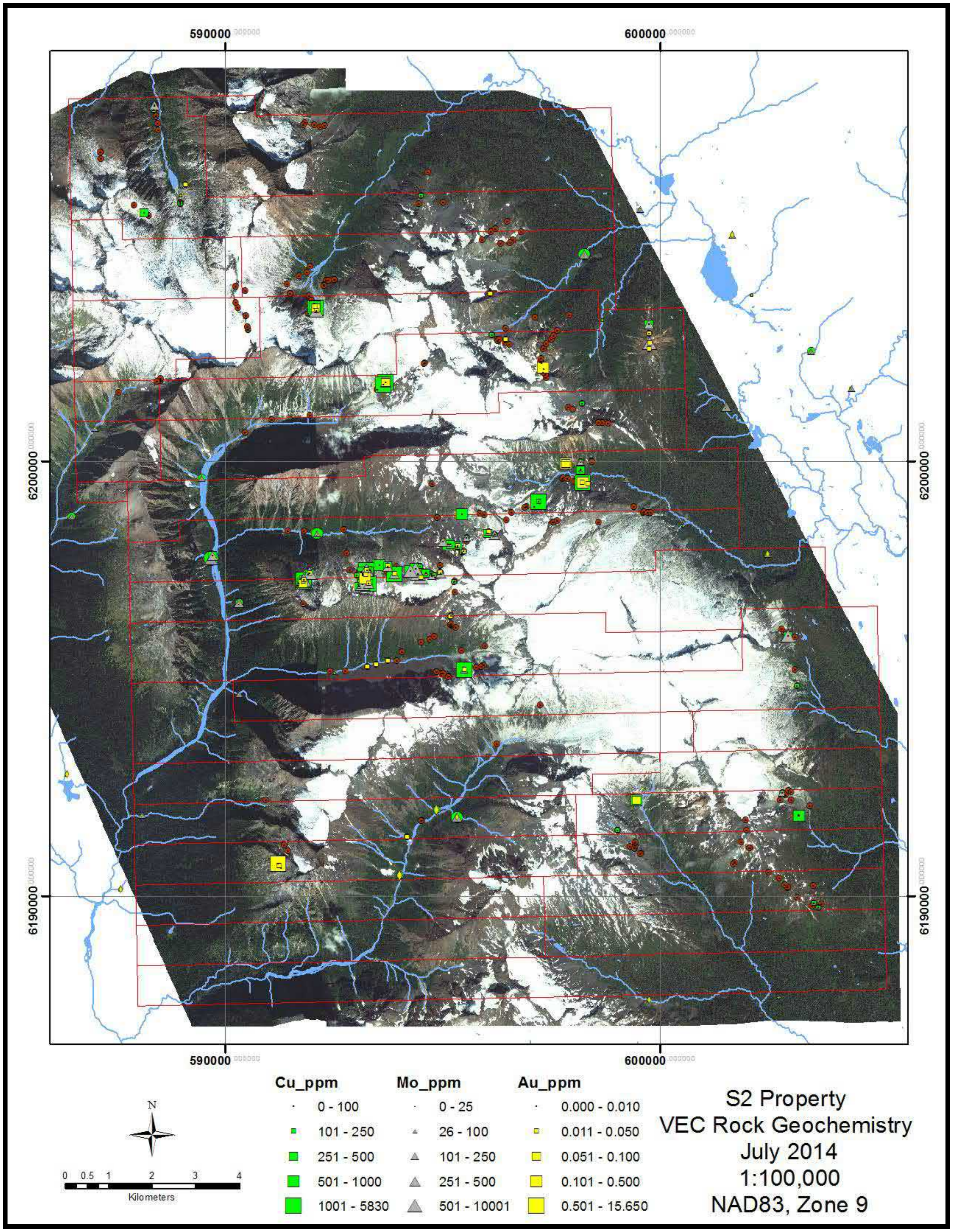


**Figure 6:** Results from the 2014 Phase One exploration program. The four target areas (Fog, Ice, Atna, and Shedin) are shown in boxes. The main target area (Fog) is located along a 3.5 km ridge in the center of the property.

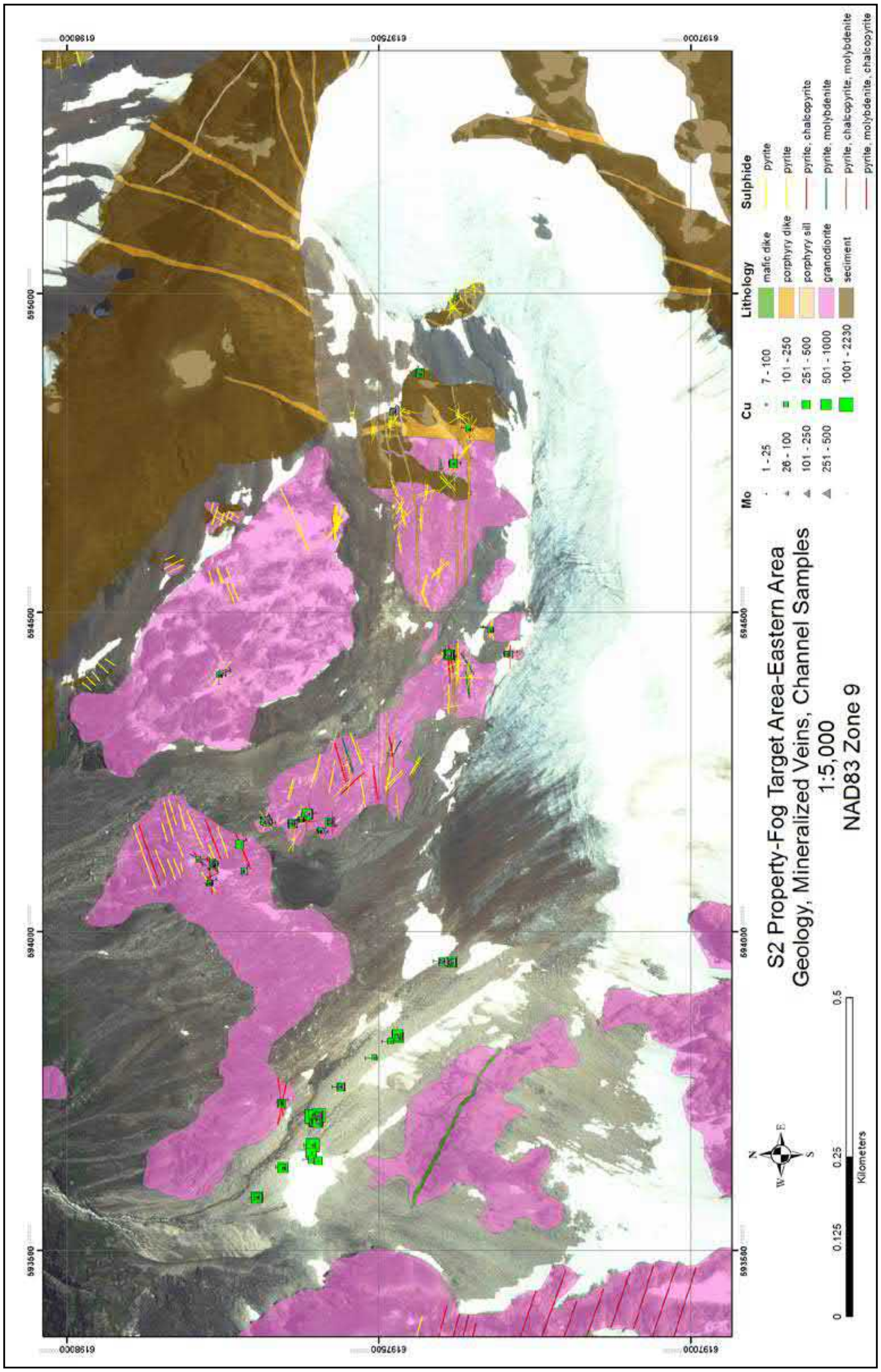


**Figure 7:** Fog Target, east area; geology, alteration, and results of channel sampling.

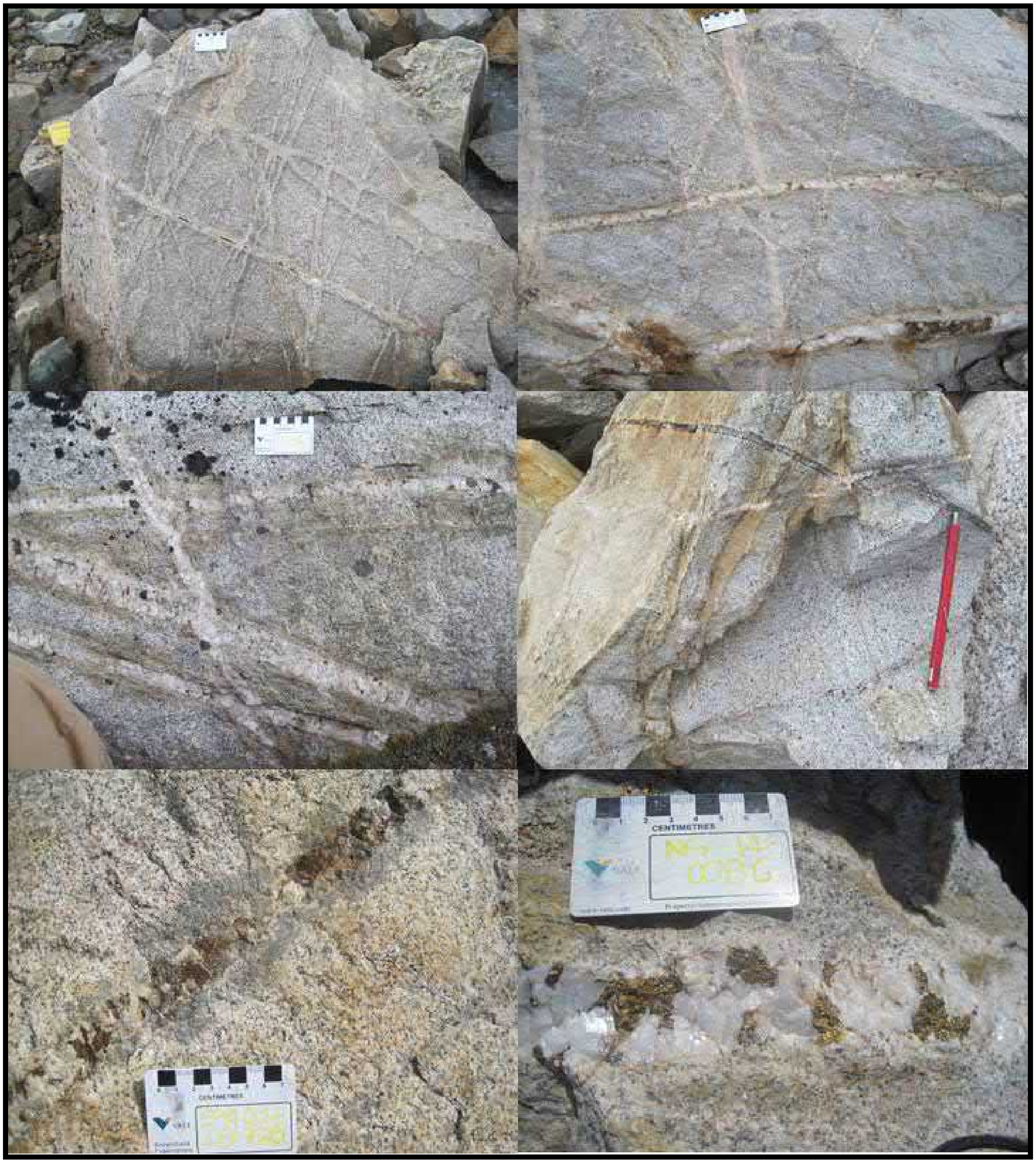


**Plate 3:** Example of vein types in the Fog Target area: top left) Kspar network cut by quartz +/- pyrite; top right) quartz-Kspar-carbonate with muscovite halo and quartz-kspar-pyrite with kspar halo; middle left) quartz-kspar +/- pyrite with muscovite halo; middle right) magnetite vein with muscovite halo cutting milky white quartz vein; bottom left) quartz-kspar-carbonate-pyrite with muscovite and kspar halo; bottom right) quartz-kspar-pyrite-molybdenite-chalcopyrite vein with kspar halo.

The oldest vein set in the Fog Target area was a network of thin K-feldspar veins that were pervasive but contained little to no sulfide mineralization. The dominant mineralized vein sets were straight-walled, drusy quartz-K-feldspar with halos of K-feldspar or muscovite/sericite, and rare sulfide-only (typically pyrite) veins found in talus and outcrop. Sulfide content varied with vein type to include pyrite, chalcopyrite and molybdenite with the main mineralized vein set. Disseminated sulfide was also found in some of the halos of the sulfide-mineralized veins. Overall the Fog Target area is dominated by pyrite, but higher chalcopyrite content was seen in the talus field. Chalcopyrite and molybdenite typically occur in separate veins (Plate 3).

The highest Cu result from the channel sampling was from NAS-CH-04 with 0.22% Cu and 7 ppm Mo over 59 cm from a talus boulder. Five other samples had >0.1% Cu over 50 to 60 cm lengths, and were all from the talus boulder sampling. The highest Mo result was 492 ppm Mo with 574 ppm Cu over 72 cm in outcrop on the north side of the east-central Fog Cirque; 21 samples had >100 ppm Mo over widths of 40 to 98 cm. The higher Cu results from the talus boulders indicate that the source of the better mineralized talus was not mapped or sampled in the outcrops exposed in the north part of the cirques and the likely source is the cirque wall due south of the Mo mineralization. The vein compositions including alteration halo indicates that the Fog Target area is a potassic zone and is visually similar to the mineralized area of Highland Valley.

# 6 2016 3D-IP/MT Survey

The recommendation for S2 following the 2014 field program was that the Fog Target area was an exploration target that needed to be tested further via drilling to determine the size and grade of a potential porphyry system. Instead of drilling blindly into the Fog Target based off limited surface exposure it was decided that geophysics could help in pin-pointing the best drill targets within the Fog Target. The aim of the geophysical survey would be to map out any geophysical anomalies that could possibly be caused by mineralization associated with a porphyry system. These anomalies would then represent targets for a future drill program. It was with this premise that a reconnaissance based 3D-IP/MT geophysics program would be completed over the target. Both IP and MT data would be collected to complement each other in an attempt to define the best possible drill targets.

Due to the difficult topography in the Fog area a traditional, grid-based IP survey could not be completed. Instead a reconnaissance style survey was designed where the transmitter dipoles were deployed as a gradient source and the IP and MT stations were deployed in areas of interest that were safely accessible. The S2 grid was divided into five areas of interest which coincided with different cirques located throughout the Fog Target area. The dimensions of each area varied and therefore the number of sites that could be surveyed in each cirque varied. At each location a rough grid was used with an approximate distance between sites set at 200 m. In total 42 MT stations were recorded and 48 IP stations were surveyed from six different transmitter configurations during the program (Figure 8 and 9).

The geophysics program took place over 12 days from July 27th to August 8th, 2016. SJ Geophysics, based out of Vancouver, British Columbia, was contracted for the survey to acquire both the IP and MT data. SJ consisted of a crew of six people that were on site for the entire duration of the program. Their crew consisted of two geophysical operators, one research physicist, and three field technicians. Helicopter support was provided by Canadian Helicopters, who provided an A-Star B2, based out of the Smithers, BC base for the duration of the program. The SJ crew, pilot, and fuel were all staged out of the Bear Claw Lodge for the duration of the program.

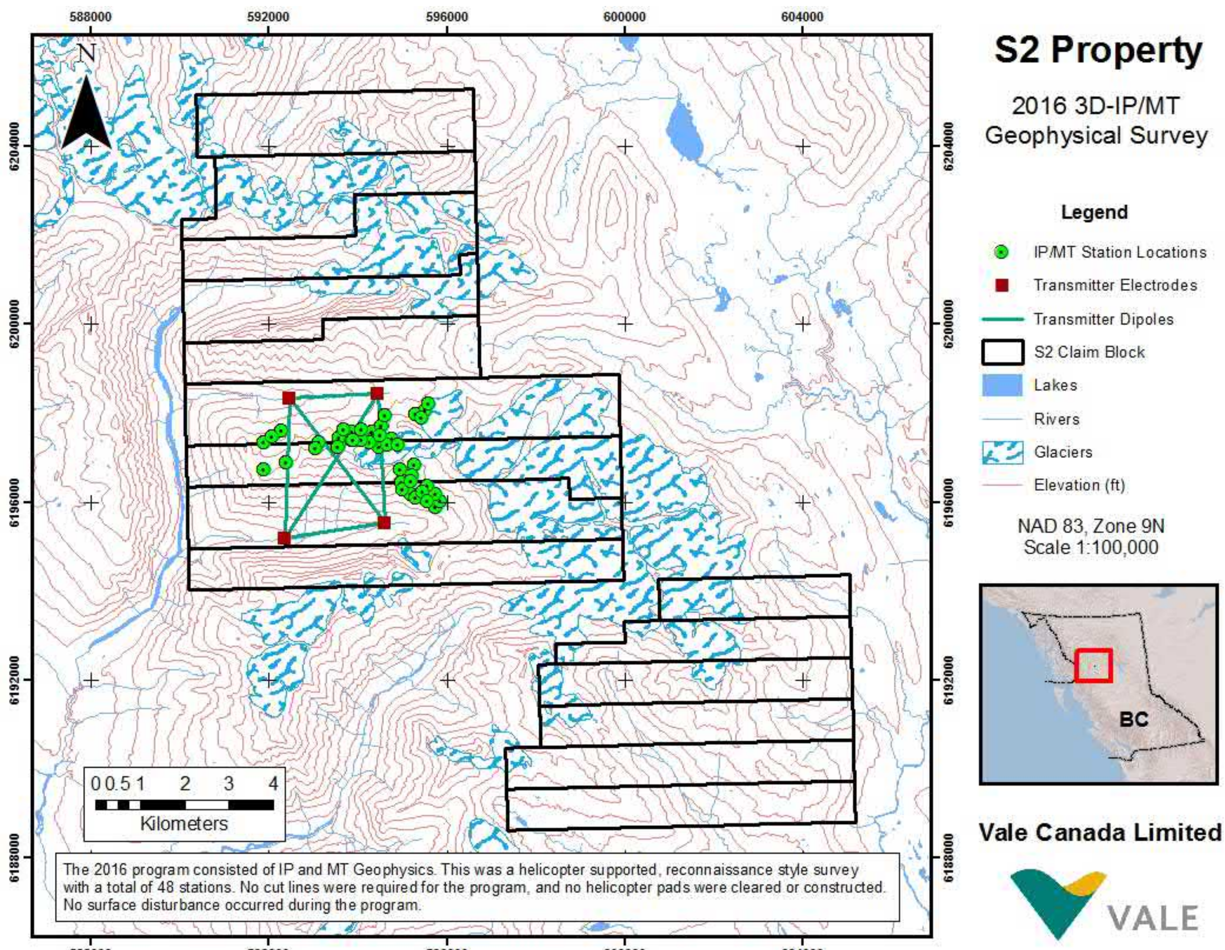


**Figure 8**: Location map of the IP/MT stations and transmitter dipoles for the 3D-IP/MT survey over the Fog target.

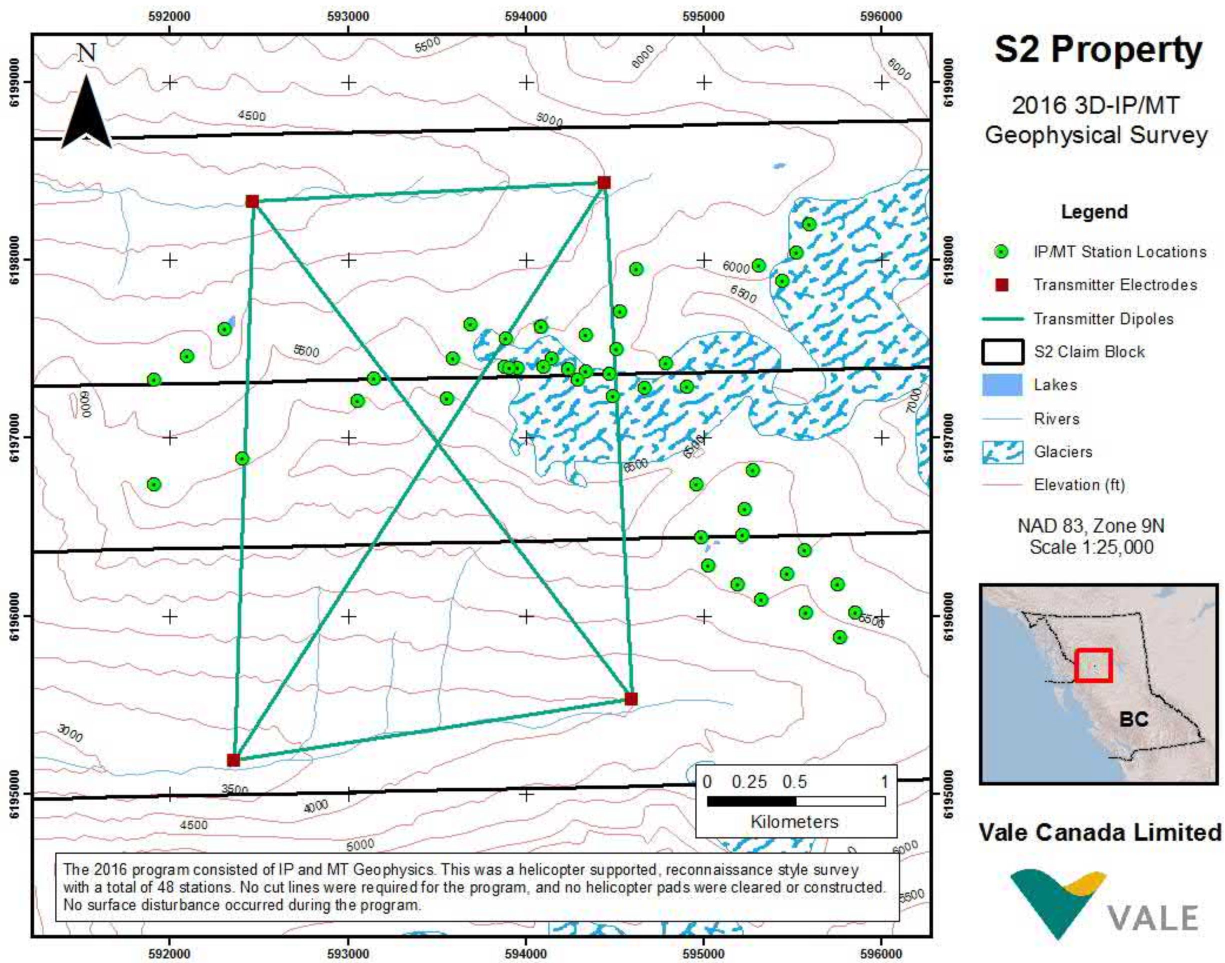


**Figure 9**: Close-up view of the survey points and transmitter dipoles for the survey.

## 6.1 Data Acquisition

SJ Geophysics would utilize their internally developed Volterra Distributed Acquisition System for this survey in the collection of both the IP and MT data. This system consisted of Dabtube 24-bit four-channel receivers that record the full waveform signal from various sensor configurations. The survey setup involved equipping each receiver station with two orthogonal 100 m electric dipoles, two orthogonal MT coils (both the electric and magnetic components oriented in the north and east directions), and both an IP and MT data logger. The IP data was collected while the transmitting dipoles were active and the MT data was collected when the transmitting dipoles were off. A detailed description of the survey can be found in SJ Geophysics logistical report found in Appendix 3.

For the IP survey current injections were controlled using a GDD Tx ll transmitter, and the resulting ground response was measured using the Volterra data acquisition unit. The 3D-IP system was initially configured to use both a diamond and cross array, which were used in conjunction with each other. A total of 4 IP stations were collected using a diamond configuration with 70 m dipoles, however this design was abandoned as it was simpler to only use the cross array to collect both MT and IP data. The cross array had a dipole length of 100 m and was to be utilized in parallel with the MT receivers to record the electric field and IP data. The location of each transmitter and receiver electrode was determined using GPS. The IP data was collected using an 8 second period 50% duty cycle square wave with a 5 minute recording time.

The MT data was also collected using the Volterra distributed acquisition system. Acquisition of the MT data occurred whenever the IP transmitter was not actively transmitting. The orthogonal magnetic coils at each MT site were utilized concurrently with the electric dipoles for the IP survey. The electric dipoles varied from 50 to 100 m in length and the magnetic coils were highly sensitive ANT-23 B-field coils. The coils were oriented in the north and east directions and leveled to ensure zero dip. A far remote reference station with a north and east electric dipole and magnetic coils was setup sufficiently far from the grid, located within 15 km of the survey grid. The MT data was collected to achieve data in the frequency bandwidth of 1 – 10,000 Hz, requiring 45 minute readings at each station.

## 6.2 Data Quality

Throughout the duration of the program the utmost care was taken by SJ Geophysics to make sure that data quality was as high as possible. Location information was collected using Garmin GPSMAP 62's and 64's handheld GPS. Locations were checked daily using GPS management software to make sure location data was collected correctly; any false data was discarded and re-acquired the following day. SJ tested the quality of the Volterra 3D-IP system daily, both in the field and in the office to ensure the quality of data. Data was then imported into their QA/QC software package. Any bad data points were flagged and then rejected. The MT data also goes through a series of quality assurance checks both in the field and office. A detailed explanation of the quality controls that SJ Geophysics puts in place can be found in their Logistics Report in Appendix 3.

The IP data collected on the S2 grid was of adequate quality. In general the observed primary voltages were low, with a range between 0.1 and 40 V. The low voltages were due to the large distances between the transmitting dipoles and the receiving dipoles, as well as high contact resistances. The observed chargeability responses were of reasonable quality, with some being removed from the dataset due to weak signal or from the effects of null coupling.

The MT data collected on the grid was of good quality, due to limited cultural noise in the data and consistent weather. A typical reason for reduced data quality was attributed to poor contact in rocky areas. The bandwidth of the dataset ranges from 1 – 10,000 Hz, with the range of 1 – 5 Hz containing noisy data and the range of 1 – 3.5 kHz containing no MT signal within the “dead band”.

### 6.3 Survey Results

The IP data shows that the host geology is resistive, with apparent resistivities observed as high as 9,000 ohm-m. Regions of low apparent resistivity between 10 and 100 ohm-m have been detected, and seem to correlate to cirques on the side of the mountain ridge as well as to stations recorded in the eastern portion of the survey (Figures 10 and 11). Background chargeability in the survey area is moderate, with values in the range of 10 to 20 mV/V pervasive throughout the survey. The most pervasive zone of high chargeability is observed in the southeastern portion of the survey, with chargeabilities reaching as high as 55 mV/V when the region is energized by E-W orientation transmitting dipoles (Figures 12 and 13).

The MT data shows mainly resistive lithologies, with resistivities ranging between 1,000 and 10,000 ohm-m, with minimal variation with depth. An example of a typical MT response is shown in Figure 14. The exception to this is in the southeast section of the survey where shallow resistivities are in the range of 10 to 1,000 ohm-m, and show signs of decreasing resistivity with depth (Figure 15).

Due to the extremely large amount of IP and in particular MT data acquired during the survey, processing and interpretation of the data is still ongoing. This survey was designed to collect a large amount of high quality data in a short amount of time. It will take a lot of time to properly process the data. Only when the data has been fully processed and the IP and MT anomalies identified can an accurate interpretation of the data can be attempted. Ideally the IP and MT anomalies will be examined along with the mapped geology and mineralization to determine the best possible drill targets.

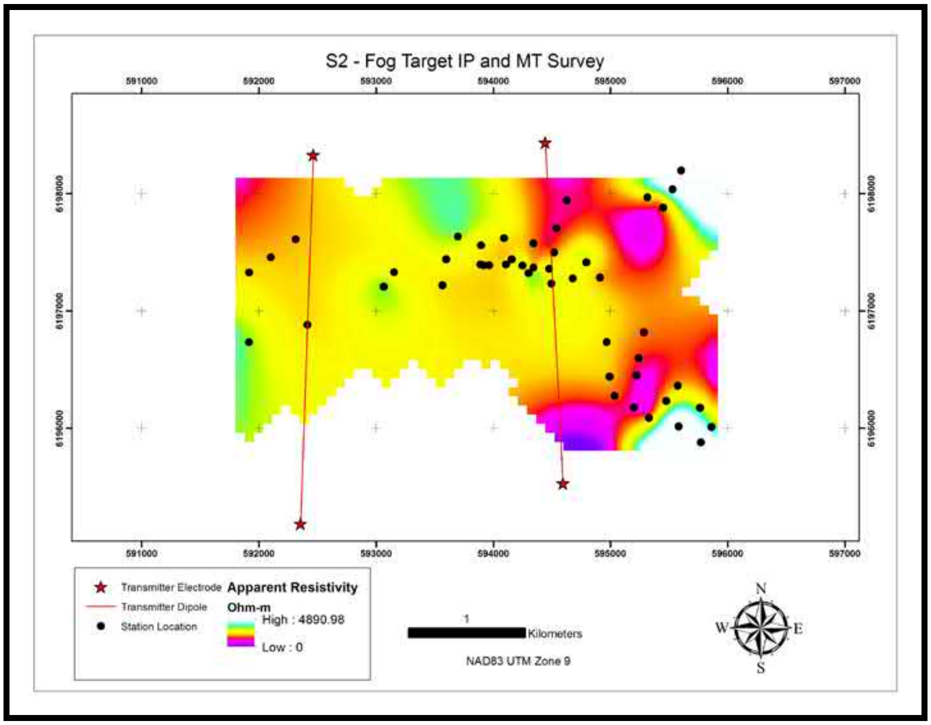


**Figure 10:** Observed apparent resistivity, as energized and measured from the north-south oriented dipoles and receivers.

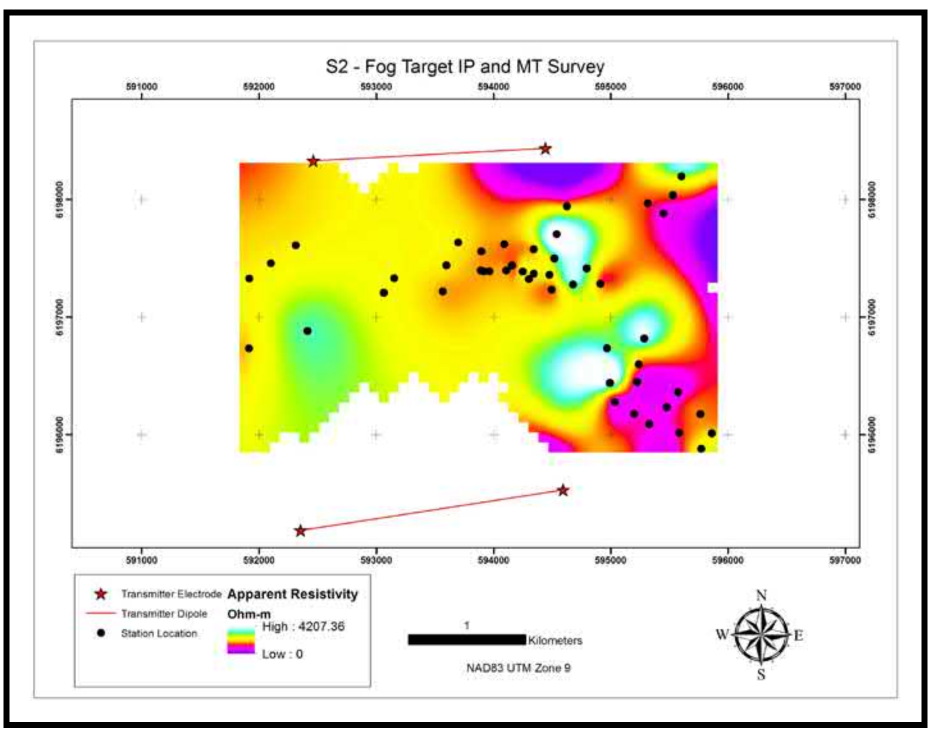


**Figure 11:** Observed apparent resistivity, as energized and measured from the east-west oriented dipoles and receivers.

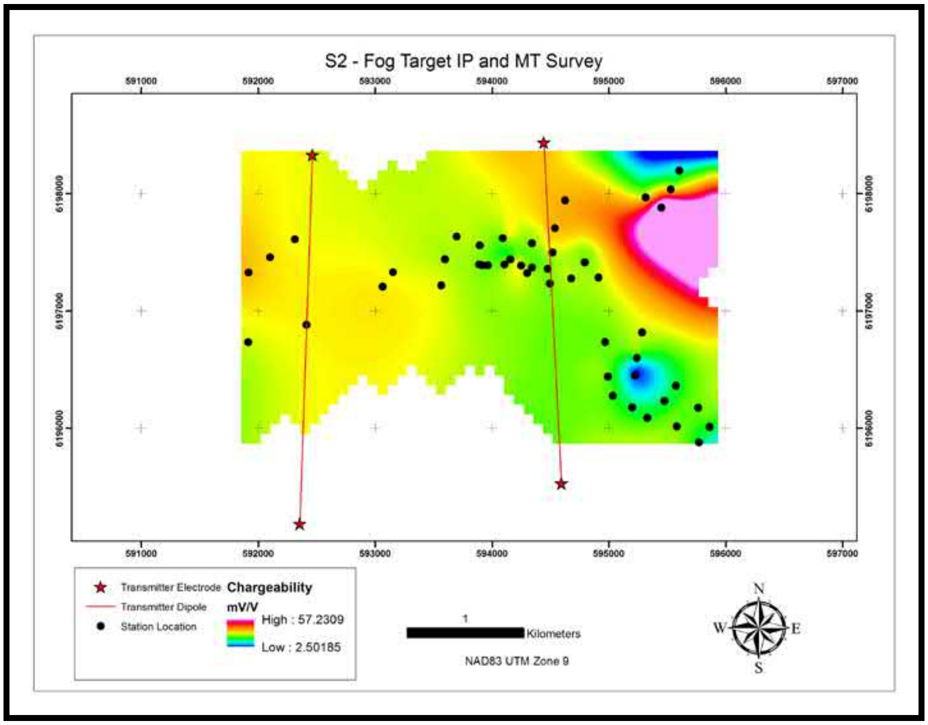


**Figure 12:** Observed chargeability, as energized and measured from the north-south oriented dipoles and receivers.

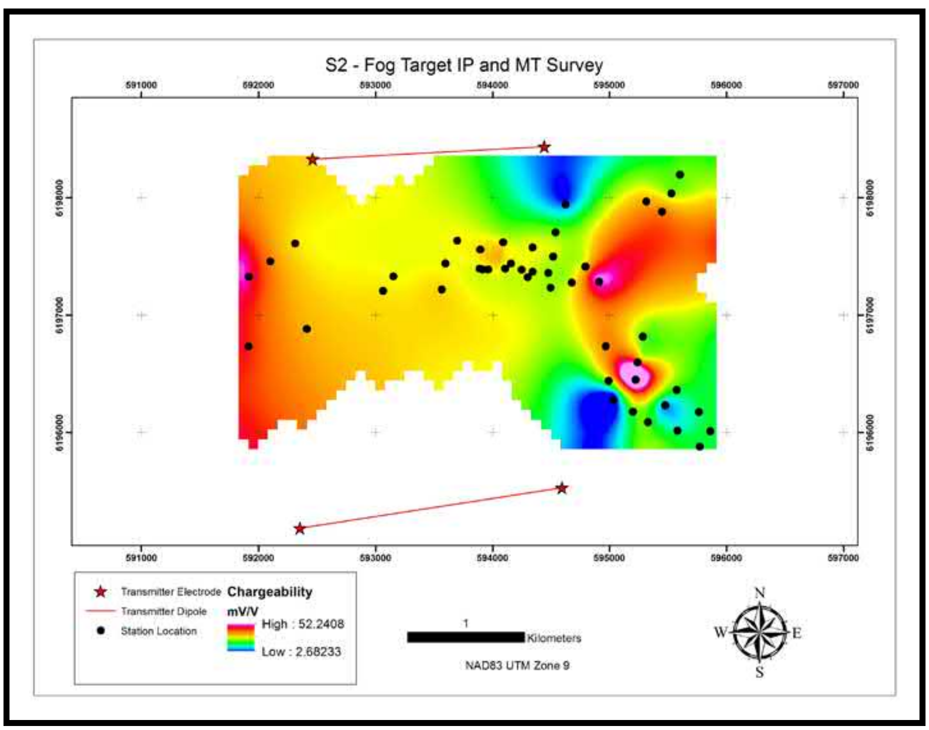


**Figure 13:** Observed chargeability, as energized and measured from the east-west oriented dipoles and receivers.

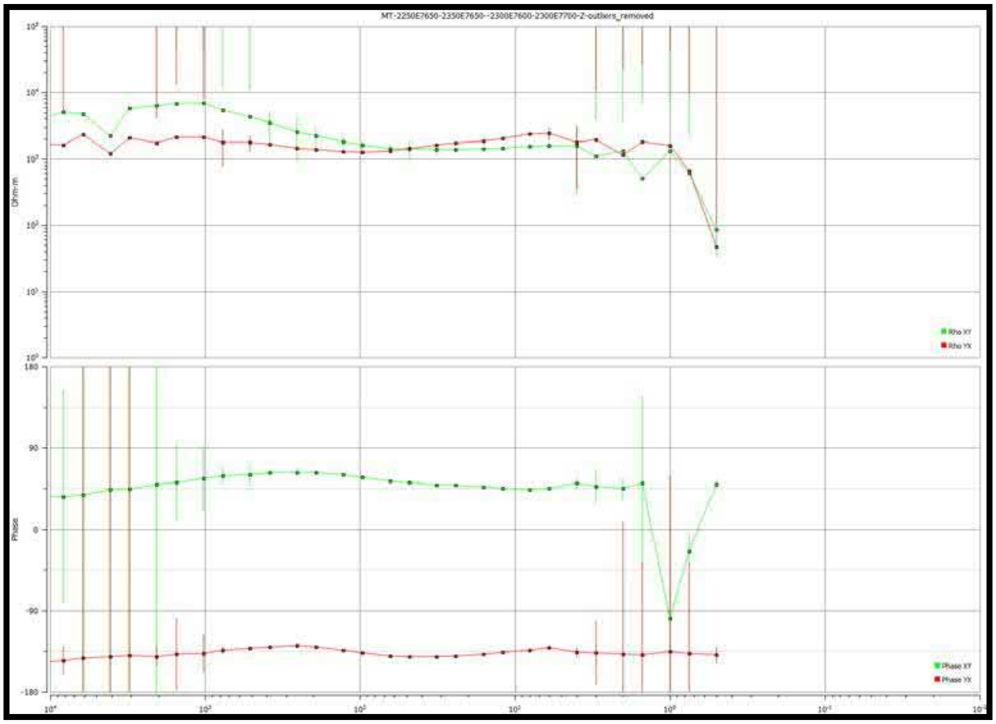


**Figure 14:** An example of a typical MT sounding showing little variation in resistivity with depth.

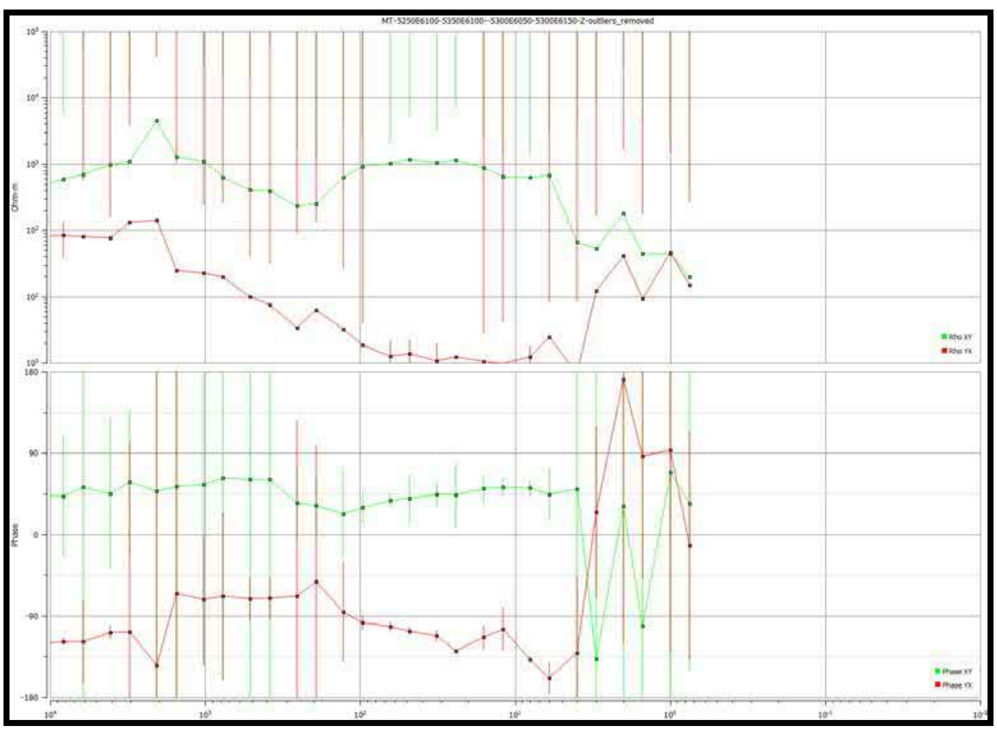


**Figure 15:** An example of a MT sounding in the southeast portion of the survey showing a conductive response.

# 7 Conclusion

The 3D-IP/MT survey covering portions of the Fog Target at S2 was a successful attempt in completing reconnaissance-style geophysics in a remote and very rugged terrain. The difficult survey was a technical success, completed in a very timely manner while at the same time acquiring high quality IP and MT data. To date, only very preliminary interpretation of the vast amount of data has been completed, but preliminary results show something interesting in the southeastern area of the Fog Target, a couple of hundred meters to the southeast of the well mineralized talus boulders. The IP indicates that there is a chargeability high in this area which coincides with a low resistivity MT anomaly. Further interpretation will be needed to determine if this anomaly or any other anomaly identified is of interest. It does seem certain though that this geophysical data, when combined with the detailed mapping and sampling already completed over the property will identify the best possible drill targets for the Fog Target area.

# 8 References


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# Appendix 1

# Geologist's Certificate

**Statement of Qualifications**

I, Christopher Larry Hicks, of 2425 Cavendish Court, Sudbury, in the province of Ontario, certify that:

- I am a graduate of Memorial University of Newfoundland, St. John's, Newfoundland, Canada and hold a B.Sc. (hons) degree in Earth Sciences (2007) and a M.Sc degree in Earth Sciences (2015).
- I am a registered Professional Geoscientist of the province of Newfoundland and Labrador (PEGNL) in good standing (Registration Number 06909).
- I have worked in my profession as a geologist since 2007.
- I am a full-time employee with Vale Canada Limited as a Project Geologist based in Sudbury, Ontario, Canada.
- This report was prepared by myself and is based on field work carried out by Vale Canada Limited, and to the best of my knowledge, information and belief, all scientific and technical information in this report is accurate.

Dated the 26th day of October, 2017 at Sudbury, Ontario, Canada.

Signed Christopher L. Hicks, P.Geo

Christopher Hicks

# Appendix 2

# Exploration Expenditures

**Break down of the exploration expenditures for the 2016 3D-IP/MT Geophysical survey at S2.**

| Company | Item | Total ($ Can) | Comment |
|---|---|---|---|
| Canadian Helicopters | Flying Time (42.8 hours) | $66,286.50 | $1,475 per hour |
| Canadian Helicopters | Fuel (7,650 liters) | $18,073.13 | $2.25 per liter |
| SJ Geophysics | Survey | $76,524.56 | Mob, demob and survey |
| SJ Geophysics | Data | $7,407.75 | Data Processing |
| Bear Claw Lodge | Accommodations and Meals | $57,000.00 | Room plus meals for 7 people for 12 days |
| Vale | Senior Geophysicist | $5,467.87 | 7 days of field work to oversee and assist the SJ crew |
| Vale | Project Geologist | $3,073.60 | 5 days to assist at the beginning of the survey |
| Vale | Project Geologist | $1,229.44 | 2 days Assessment Report Writing |
| **Total** | | **$235,062.85** | |

Field work: July 29 – August 07, 2016

# Appendix 3

# SJ Geophysics S2 Logistical Report

# Logistics Report Prepared

## for

# Vale Canada Limited

# Volterra-3DIP/MT

## on the

# S2 Project

Kispiox, British Columbia, Canada
Latitude: 55° 54' N Longitude: 127° 30' W

BCGS SHEET: 9866, 9917

NTS SHEET: 093M13, 093M14

MINING DIVISION: Omineca

Survey conducted by SJ Geophysics Ltd.
July-August 2016

Report prepared by
Darren Pinkerton, Jordan Perk
August 2016

## Table of Contents

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# 1. Survey Summary

SJ Geophysics Ltd. was contracted by Vale Canada Limited to acquire Volterra-3DIP and MT data on their S2 property. Table 1 provides a brief summary of the project.

| | |
|---|---|
| **Client** | Vale Canada Limited |
| **Project Name** | S2 |
| **Location**<br>(approx. centre of grid) | Latitude: 55º 54' 33.96 N<br>Longitude: 127º 30' 44.1406 W<br>6196000N 593800E; NAD83 Zone 9N |
| **Survey Type** | Volterra 3D Induced Polarization<br>Volterra Magnetotelluric |
| **Total Sites Surveyed** | 3DIP: Diamond = 4 Sites<br>3DIP: Cross = 44 Sites<br>MT: 42 Sites |
| **Production Dates** | July 29 – August 07, 2016 |

Table 1: Survey Summary

The purpose behind the survey is to attempt to verify the presence of a halo structure in the area's of interest. The IP will be used to compliment the MT data and give a better idea of any anomalies present in the survey grid.

# 2. Location and Access

The S2 project is located in British Columbia, Canada (Figure 1).


*Figure 1: Overview map of the S2 project*

The closest town to the survey area is Kispiox, BC, which is approximately 64 km southeast of the S2 project. The project area can be accessed only by helicopter.

A map of the project area is shown in Figure 2.

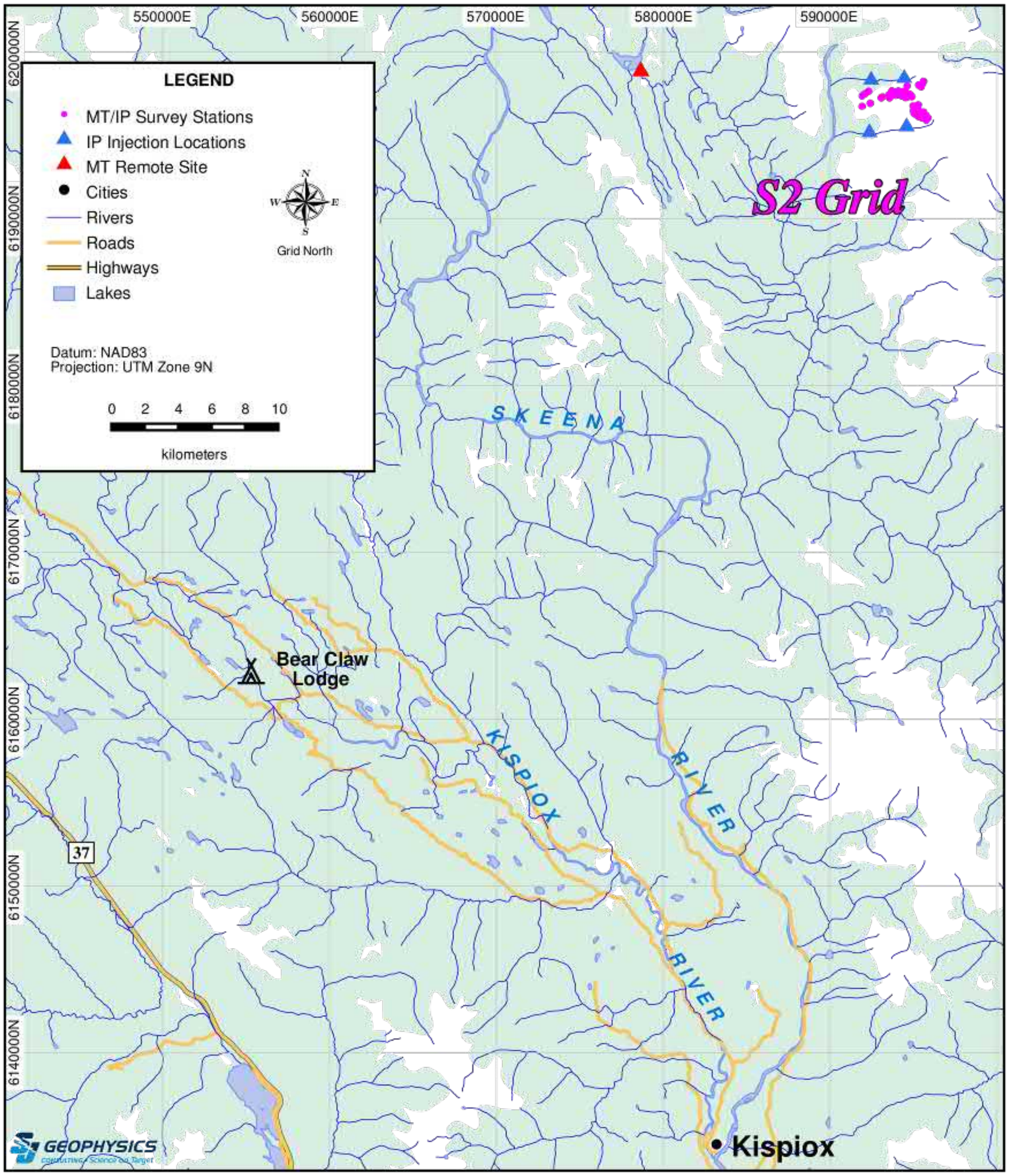


Figure 2: Location map for the S2 project

The survey area is located in a humid continental/subarctic climate, this climate contains cold and cloudy winters with the most snow accumulated in the month of February. The climate in the summer time is rather mild with temperatures averaging around 25 degrees Celsius. The temperatures at night during summer tend to drop down into the single digits and precipitation during the summer months can vary by year. Autumn and spring are short with the transition to summer or winter occurring rapidly. The survey grid contains little flora or fauna, mostly mosses or lichens are found in the middle of the grid with balsam, spruce, and hemlock trees observed in the valleys surrounding the survey grid. A few low lying shrubbery was also seen around the grid, mostly at the lower levels of elevation and in the valleys surrounding the grid. Animals observed in the area are mostly mountain goats, the occasional bear or moose, and a few smaller rodents. Due to the remote location of the grid, very little human activity is present in the surrounding area.

# 3. *Survey Grid*

## *3.1. Survey Grid*

The S2 grid has 5 areas of interest divided up into different cirques. Each area varies greatly and the number of sites that could be surveyed in each cirque varied. A general outline was produced, but sue to the difficult terrain and timeline of the S2 grid, survey sites were set up at attainable sites with an approximate distance between sites set at 200 m.

The survey grid parameters are summarized in Table 2 and displayed in Figure 3.

| **Grid** | S2 |
|---|---|
| **Number of Surveyed Stations** | 3DIP: 44<br>MT: 42 |
| **Survey Line Azimuth** | 0º |
| **Line Spacing** | ~200 m |
| **Station Spacing** | ~200 m |
| **Elevation Range** | 920 – 2572 m |

Table 2: Grid parameters

The line and station labels for the grid were based on UTM coordinates, with the line labels represented by the last four digits in the UTM easting and the station labels represented by the last four digits in the UTM northing.

Please refer to Appendix A for a detailed breakdown of the survey lines.

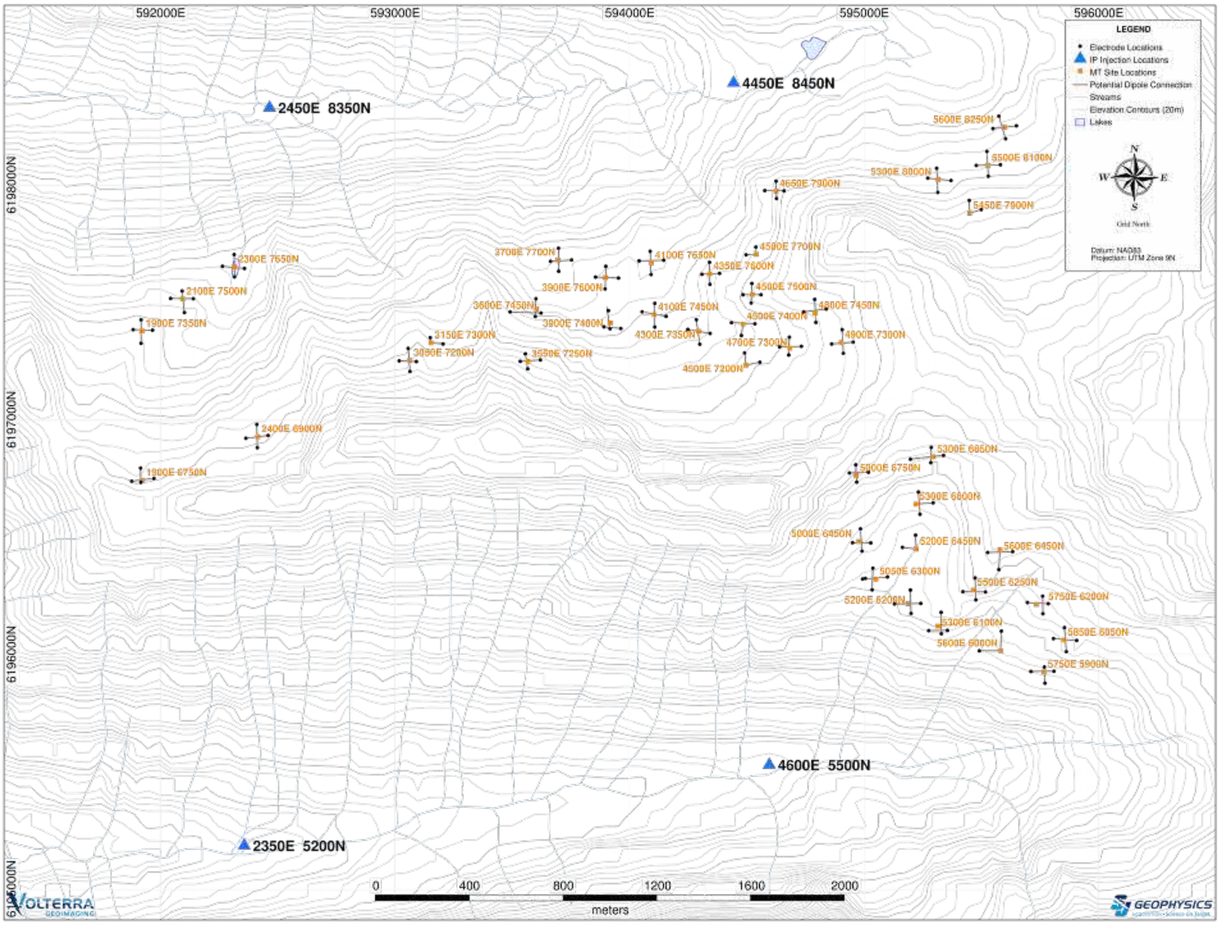


*Figure 3: Grid map showing the S2 grid.*

# 4. Survey Parameters and Instrumentation

## 4.1. Volterra Distributed Acquisition System

The Volterra Distributed Acquisition System was developed internally by SJ Geophysics. The heart of the system are the Volterra data acquisition units, internally known as Dabtubes. Each four-channel Volterra acquisition unit contains 24-bit analog-to-digital electronics that record the full waveform signal from various sensor configurations. This allows for varying suites of geophysical techniques such as induced polarization (IP), electromagnetics (EM), magneto tellurics (MT), controlled source audio-frequency magneto tellurics (CSAMT), etc. to be measured. The recorded full-waveform data is then passed through proprietary signal processing software to calculate the relevant geophysical attributes (ie. apparent resistivity/chargeability for IP surveys).

## 4.2. Volterra-3DIP Survey

SJ Geophysics Ltd.'s proprietary Volterra Distributed Acquisition System was utilized for the induced polarization (IP) survey. Current injections were controlled using a GDD TxII transmitter and the resulting ground response was measured using each Volterra data acquisition unit.

The distributed nature of the Volterra-3DIP system allows for highly customizable array and survey configurations. The resulting flexibility is a huge benefit in challenging terrain conditions where rivers, roads, cliffs, or other obstacles can easily be avoided. The crew took full advantage of these features to optimize the field logistics and maximize production.

The transmitter and IP signal recording/processing parameters used for the survey are described in Table 3. The full instrument specifications are listed in Appendix B.

| | |
|---|---|
| **IP Transmitter** | GDD TxII |
| Duty Cycle | 50% |
| Waveform | Square |
| Cycle and Period | 2 sec on / 2 sec off; 8 second |
| **IP Signal Recording** | Volterra Acquisition Unit (Dabtube) |
| Reading Length | 300 seconds |
| **IP Signal Processing** | CSProc (SJ Geophysics proprietary software) |
| Vp Delay, Vp Integration | 1200 ms, 600 ms |
| Mx Delay, # of Windows<br>Width (Window Width) | 50 ms, 26<br>26, 28, 30, 32, 34, 36, 39, 42, 45, 48, 52, 56, 60, 65, 70, 75, 81, 87, 94, 101, 109, 118, 128, 140, 154, 150 (50–1950 ms) |
| Mx Integration | 236-1950 ms |
| Properties Calculated | Vp, Mx, Sp, Apparent Resistivity and Chargeability |

Table 3: 3DIP transmitter and reading parameters

Receiver dipoles were set up using 50 cm long and 10 mm diameter stainless steel electrodes hammered into the ground and connected into the array by single or double conductor wire. The electrodes used for current injections were significantly bigger (1 m x 15 mm) with two to four electrodes used at each injection site to improve ground contact. Current electrodes were connected to the current transmitter by a single conductor wire.

The Volterra-3DIP system was configured using both a diamond and cross array. Details of the survey configuration are described in Table 4.

| | |
|---|---|
| **Array Type** | Volterra 3D Distributed Array |
| **Acquisition Set** | 4 Sites |
| **Dipole Length** | Diamond: 70.7 m<br>Cross: 100 m |

Table 4: Volterra-3DIP Survey parameters

The S2 survey grid utilized a total of 2 IP array configurations, the diamond array and the cross array. The two arrays were to be used in conjunction with each other. The cross was to be utilized in parallel with the MT receivers to record the electric field while the diamond was to collect IP data. All sixe dipoles were intended to aquire IP data. The diamond configuration was initially designed for redundancy and multi-azimuth data collection, which provides added quality control. The diamond array was later dropped as logistically it would be simpler to only use the cross array to collect both MT and IP data. The cross array utilizes two channels for IP. The first channel runs south to north and the second channel from west to east.

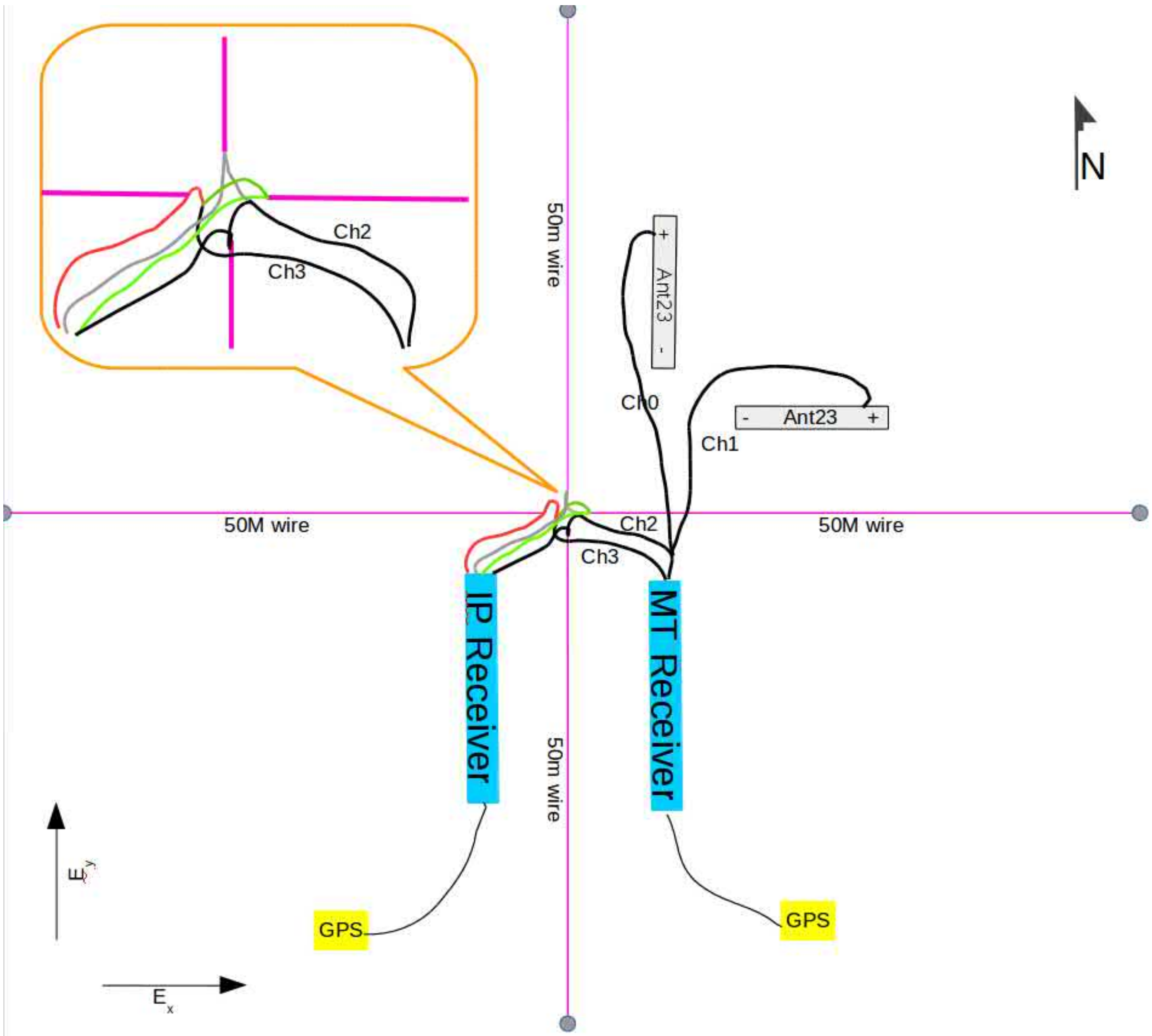


*Figure 4: Schematic representation of the combined MT/IP receiver site.*

A total of 4 different remote electrode stations were utilized over the course of the survey. The locations of the remote current electrodes are listed in Table 5 below.

| Name | Label | Easting<br>Nad 83 / UTM Zone 9N | Northing<br>Nad 83 / UTM Zone 9N |
|---|---|---|---|
| SW Current Injection Site | 2350E 5200N | 592357 | 6195187 |
| NW Current Injection Site | 2450E 8350N | 592465 | 6198332 |
| SE Current Injection Site | 4600E 5500N | 594596 | 6195531 |
| NE Current Injection Site | 4450E 8450N | 594444 | 6198438 |

Table 5: Location of 3DIP remote sites

### *4.3. MT Survey*

Magnetotelluric (MT) data was collected on the S2 grid using the Volterra Distributed Acquisition System. Acquisition of MT data occurred whenever the IP transmitter was not actively transmitting. The primary data acquisition periods was once in the morning after the first sites were set-up then again in the afternoon once another set of sites were setup. Any gaps of sufficient duration in the IP data acquisition throughout the day were also used when poor signal was observed. Care was taken to maintain MT sites undisturbed during the acquisition periods, by shouting down any crews/helicopter activity in the vicinity of sites.

The orthogonal magnetic coils at each MT site were utilized concurrently with the electric dipoles for the IP survey. The electric dipoles varied from 50 m to 100 m long, and the magnetic coils were highly sensitive ANT-23 B-field coils. The coils were oriented in the UTM North and East directions and they were leveled to ensure zero dip. The electric field at MT stations was calculated using a pair of crossing north- and east-oriented electric dipoles.

A far remote reference station with a north and east electric dipoles and magnetic coils was setup sufficiently far from the grid. The far remote reference station was setup with one 50 m north and a 50 m long east electric dipole and two magnetic coils oriented the same way. The remote reference site was located within 15 km of the survey grid and is shown in figure 5. The MT reference stations were configured as illustrated in Figure 6. The UTM location of the MT remote reference sites East and North dipole points are listed in Table 6. The detailed instrument specifications are described in Appendix A.

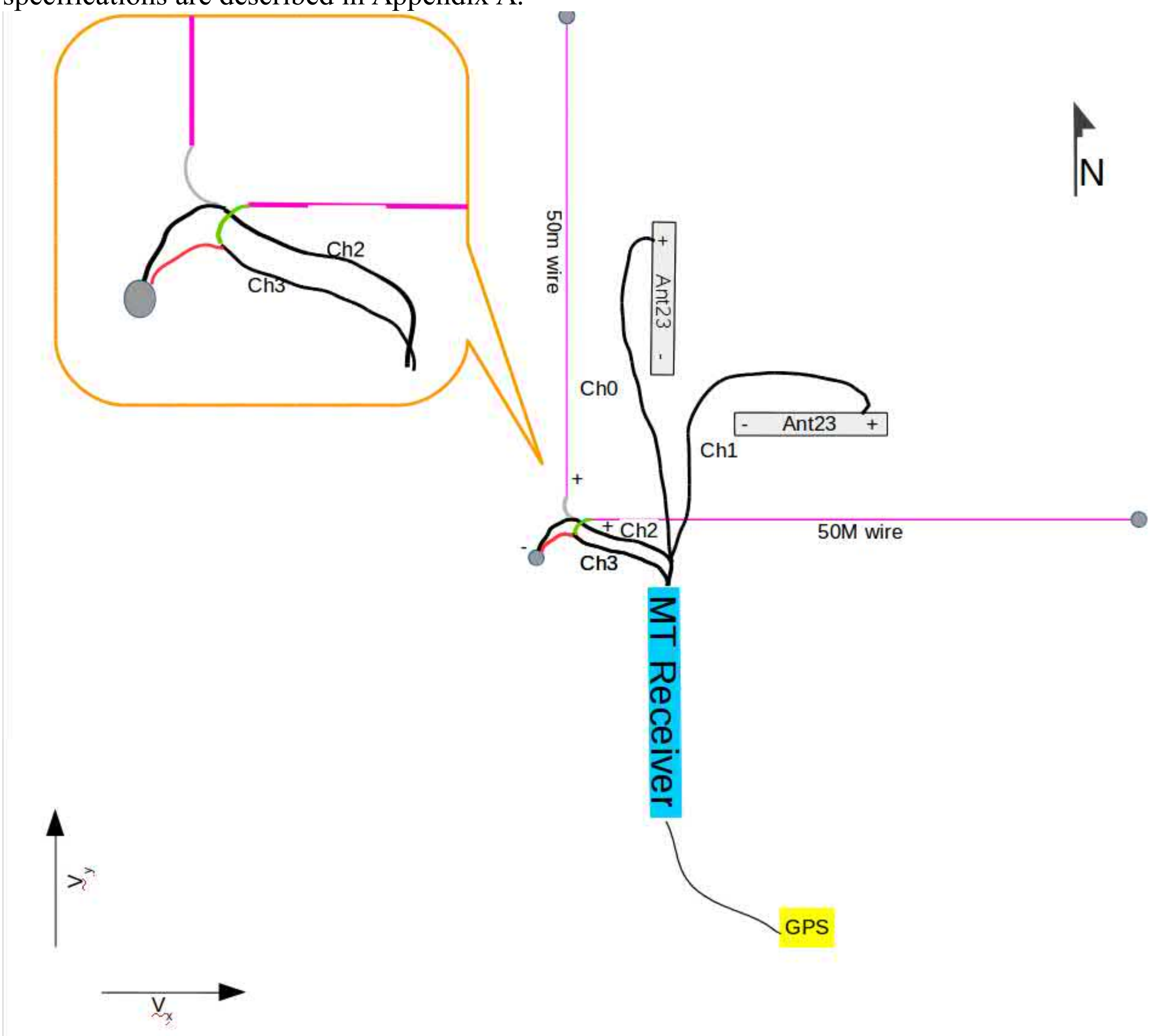


*Figure 5: MT remote reference site*

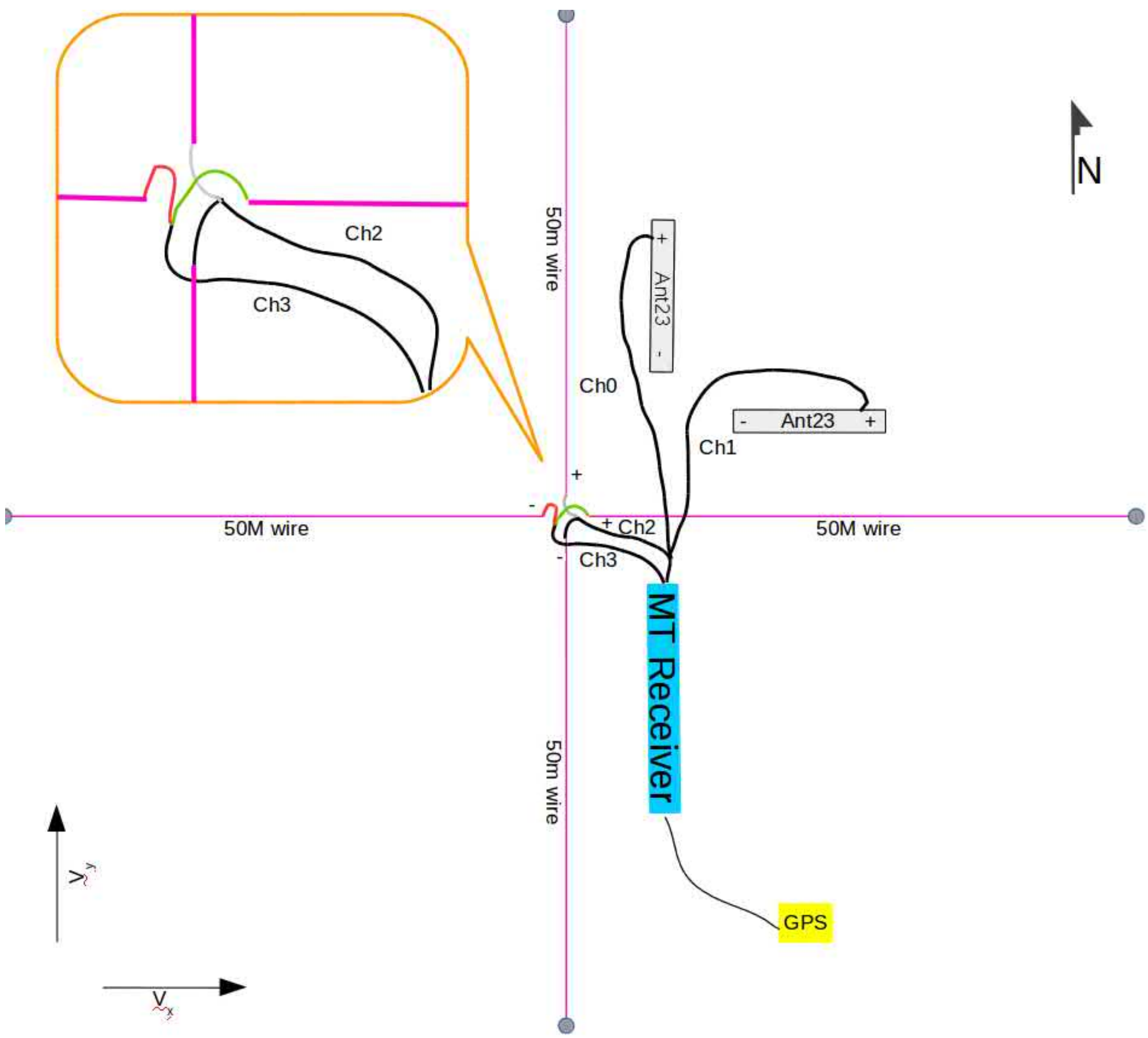


*Figure 6: MT receiver configuration*

| Name | Label | Easting Nad 83 / UTM Zone 9N | Northing Nad 83 / UTM Zone 9N |
|---|---|---|---|
| Remote Reference - N | -11350E 8900N | 578658 | 6198887 |
| Remote Reference - E | -11300E 8850N | 578706 | 6198838 |
| Remote Reference Site | -11350E 8850N | 578659 | 6198836 |

Table 6: Labels and location of the coils and site of magnetic remote reference station.

### *4.4. GPS Location Data*

Garmin 62s and Garmin 64s GPS units were used to collect GPS location data. The GPS data was collected in WGS 84 format and then projected into NAD 83 UTM Zone 9N. Compasses were also utilized during the survey to orientate the MT coils into the east and north directions. A declination of 18.5 was used to orientate all the compasses.

## 5. *Field Logistics*

The SJ Geophysics field crew consisted of 2 geophysical operators, 1 research physicist, and 3 field technicians to perform the day-to-day operations of the survey. This team oversaw all operational aspects including field logistics, data acquisition and initial field data quality control. Table 7 lists the SJ Geophysics crew members on this project.

| Crew Member Name | Role | Dates on Site |
|---|---|---|
| Jordan Perk | Geophysical Operator | July 29 – August 7, 2016 |
| Darren Pinkerton | Geophysical Operator | July 29 – August 7, 2016 |
| Evgeny Sorkin | Research Physicist | July 29 – August 7, 2016 |
| Jeff Moorcraft | Field Technician | July 29 – August 7, 2016 |
| Daniel Scanks | Field Technician | July 29 – August 7, 2016 |
| Justin Hall | Field Technician | July 29 – August 07 2016 |

*Table 7: Details of the SJ Geophysics crew on site*

The SJ Geophysics crew's first day on site at the S2 grid was July 29, 2016 and they remained on site through August 7, 2016. Mobilization to the project occurred between July 27, 2016 and July 28, 2016 and demobilization from the project site was from August 8, to August 9, 2016.

The first day on site, orientation and client specific safety training was attended by the field crew as well as the client. During the course of the geophysical survey, the SJ Geophysics crew conducted weekly safety meetings as well as daily tailgate meetings during the mornings before work began. The safety meetings included a comprehensive review of safe work practices specific to our geophysical surveys and field operations. At the tailgate meetings, personnel discussed issues related to weather conditions (including ramifications on the survey/personal safety), encounters with or sightings of potentially problematic wildlife, efficient organization of daily tasks, and any other work-related questions or concerns.

The SJ Geophysics crew was accommodated by the client at the Bear Claw Lodge, which is a fishing lodge located approximately 52 km north of the town of Kispiox. The accommodations included 3 double rooms for SJ personnel to stay in and an additional room for the helicopter pilot. The lodge also provided three meals a day, breakfast and dinner at the lodge and a bag lunch to take to the field. There was no cell reception at the lodge or on grid. However, the lodge does provide an Internet connection with the best access from midnight to 7:00 am. The power was stable at the lodge but due to their remote location they are located off grid so power is provided by both solar panels as well as a generator located at the lodge. The lodge can be accessed via the Kispiox road, but the grid can only be accessed by helicopter. SJ Geophysics provided two pick-up trucks that were used to transport equipment from the SJ Geophysics office to the lodge. A helicopter and pilot was provided by the client. The pilot was on standby at the grid whenever workers were present. The lodge contained a lot of open flat space allowing the helicopter ease of access to pick up the SJ crew as well as slinging equipment to the grid.

The first production day included a half day training session to ensure worker competence in safety standards as well as orientation for the provided helicopter. The latter half of the day was spent scouting out the grid, locating transmitter sites, and setting up the remote reference site off grid. Some additional time was used on the first day to locate areas the radio repeater could be set-up. The radio repeater was utilized by the crew for communication between the teams split up over the survey area.

Due to the remote location and difficult terrain in the survey grid, survey stations were set up where possible with an attempt to space them 200 m apart. Four injection sites were set up in a square around the survey grid and size current dipole combinations were used for each station.

Data acquisition began in the largest cirque in the northeast at the base of the glacier. The survey began in this cirque due to the client's interest in that area of the grid. The survey was conducted by teams of two. Each team would set up multiple sites during the day using the same set of equipment.

The survey progressed by the teams splitting up with one team focusing on the highest priority cirque, and another team working on the southern side of the same cirque heading towards the west. The third team that was operating the transmitter later began to set-up sites as well, focusing their efforts on the northeastern-most cirque that is located closest to the transmitter. Teams of two would set up one to two sites each and then continue preparing sites as the IP and MT readings were occurring. Prior to IP field data acquisition, a contact resistivity test was performed using a small waveform generator attached in parallel to a given Volterra acquisition channel. This was done for each dipole in the array, and allowed the operator to identify breaks in the wire or areas of poor ground contact which could degrade input signal quality. Furthermore, this test allowed the operator to inspect the raw signal, ensuring that the Volterra acquisition units were functioning correctly, and to ensure that the receiver was synchronizing with the correct GPS time. A similar test was performed on the MT channels utilizing the same small waveform generator attaching it to a toroid placed near the coil.

GPS points were acquired at each acquisition station as well as at each receiver electrode utilized during the survey. The locations of the injection sites were also recorded as they are required by our processing software.

Upon completion of the high priority areas, the teams moved towards the west, collecting data in the remaining three cirques. Data collection was fairly consistent with an average of 4 - 8 stations collected per day.

Wire breaks were a slight issue, an average of one remote would be broken per day. Locating and fixing the breaks was normally quite quick with the assistance of the provided helicopter. The 2$^{nd}$ of August was the only day that required some additional time to arrive at the survey site. The delay was due to the cloud cover at the survey grid. During this delay the team in the helicopter took the time to set-up the MT remote reference site while the two processors had additional time to review the previous day's data. A single incident occurred during the survey. Due to a misstep, a crew member incurred a small cut on his face. The crew member was given first aid and the incident was recorded by both the client as well as SJ Geophysics.

A few sites were resurveyed on August 6, 2016. These sites provided noisy data so additional collection was required to verify the data.

# 6. Field Data Processing & Quality Assurance Procedures

## 6.1. Locations

Good quality location data is the first step to the successful analysis and interpretation of geophysical survey data. For the survey, Garmin GPSMAP 62s and 64s handheld GPS units were utilized to collect location information. Measurements are taken at every survey station where satellite reception was acceptable. The quality of the location data and labeling were checked every night using GPS management software such as Garmin BaseCamp or GIS packages like QGIS and GRASS. Any missing or discarded survey station locations were re-acquired the following day.

GPS measurements typically have a much lower accuracy in the vertical direction compared to the horizontal direction. The National Topographic System (NTS) digital elevation model (DEM) was available for the survey area. The DEM model was compared to the GPS elevations and found to be of higher quality, so the GPS elevation points were replaced.

The second step consisted of reviewing the quality of the locations and double checking the labelling using a GIS package such as QGIS or GRASS. Once the operator was satisfied with the data quality, the locations were stored in a database using proprietary software called Location Manager.

## 6.2. Volterra-3DIP Data

The Volterra-IP data go through a series of quality assurance checks both in the field and in the office to ensure that the data are of good quality. At the end of each acquisition day the recorded signal was downloaded from the Volterra acquisition units to a personal computer. The signals were then clipped to the GPS time windows of each current injection, lightly filtered for noise, and imported into SJ Geophysics' proprietary QA/QC software package called JavIP. This software package integrates location data with DCIP data in order to calculate the apparent resistivity and apparent chargeability values. JavIP contains interactive quality control tools to allow the field geophysicist to display decay curves, view a dot plot of the calculated parameters, and manually reject bad data points.

The majority of the data points flagged for removal were due to non-coupling, a phenomena typical in IP surveys related to the survey configuration. Non-coupling occurs when a receiver dipole is sub-parallel to lines of constant potential, leading to a significant decrease in signal strength and corresponding poor data quality. Additional data can also be deemed untrustworthy due to low signal quality or dipoles being inadvertently disconnected (usually due to animal activity).

After the first data quality review in the field, the database was delivered to SJ Geophysics' head office for a second review. The data were then carefully checked to ensure that erroneous data points had been removed and were not passed along to the final stage of processing: the inversion.

### *6.3. MT Data*

The MT data go through a series of quality assurance (QA) checks both in the field and in the office to ensure that the data are of good quality. The synchronized MT time-series data recorded for each coil and electric dipole were trimmed and prepared for each MT acquisition period. A basic QA procedure included verification that each data channel was recording useful MT signal. In particular, spectrum was verified for presence of the characteristic peaks corresponding to the first a few Schumann resonances, occurring around 8 Hz, 14 Hz, 21 Hz. Time-series were verified to be free of overwhelming local noise (e.g. resulted by helicopter hovering it site's vicinity).

An important part of the survey was utilizing data collected at a Remote Reference (RR) site. To ensure good choice of location for the RR station, time-series were recorded and analyzed on the first day of set up. This analysis verified that, indeed, a good MT signal was observed, uncontaminated by low frequency wind noise and/or by local human activity.

More detailed checks of the data were performed at the processing stage using proprietary SJ Geophysics software tools. Those included calculating correlations between time-series in the relevant channels, and coherencies between Fourier transforms of the data channels. In particular, good correlations must exist between parallel coils in RR and local MT stations. In addition, the orthogonal components of electric and magnetic fields must be better correlated than the parallel ones. We use these facts to detected flipped polarities in the dipoles, swapped channels, and remove particularly noisy data points.

# 7. Data Quality

## 7.1. Locations

The location data was of good quality; open skies provided good reception on the GPS's and no tree cover also aided in the quality. The steep terrain had the potential to interfere with the satellite signal, however most stations were set far enough back from the steep cliffs that this was not an issue. All applicable locations were taken with the GPS so no points were interpolated to determine there location.

## 7.2. Volterra-3DIP data

The S2 grid contained adequate IP data. Due to the type of survey as well as the distance between the bipoles the observed voltage potentials (Vp's) were low. The highest observed Vp's were in the double digits were the smallest was in the single decimals.

The contact resistances seen on the S2 grid for the majority of the surveyed points are good. A few sites contained very high contact resistance due to the poor soil quality or the area being too rocky. The areas where high contact resistances were observed are the more rocky areas where very little soil is exposed. The southern side of the grid contained some of the higher contact resistances seen. The poor contact was alleviated slightly in some cases by increasing the number of electrodes, but, for some sites, the amount of electrodes used had little to no effect on the contact resistance.

The observed chargeability (Mx) curves were, for the most part, good attributed to long injection times and increased sampling rate for the receivers. The Mx curves were visibly better on the northern side of the cirques. The poorer data observed on the south side could have been caused by the higher contact resistance observed in that area. The vast majority of the removed Mx curves were from weak signal or from the effects of null coupling. Null coupling was expected given the bipoles and array type.

Figure 7 shows an example of clean data and Figure 8 shows an example of slightly noisier data.

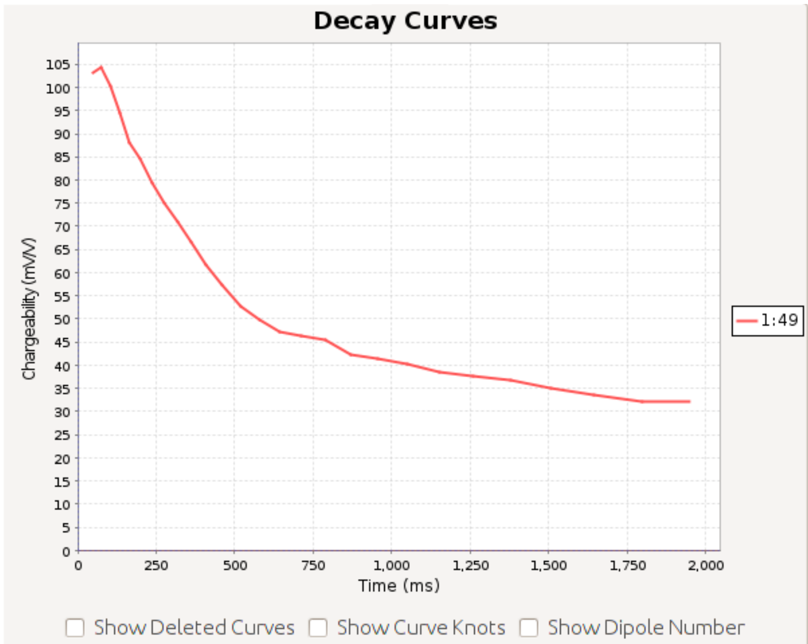


*Figure 7: Example of clean decay curve: site 5450E/7900N, bi-poles 2350E/5200N and 4600E/5500N*

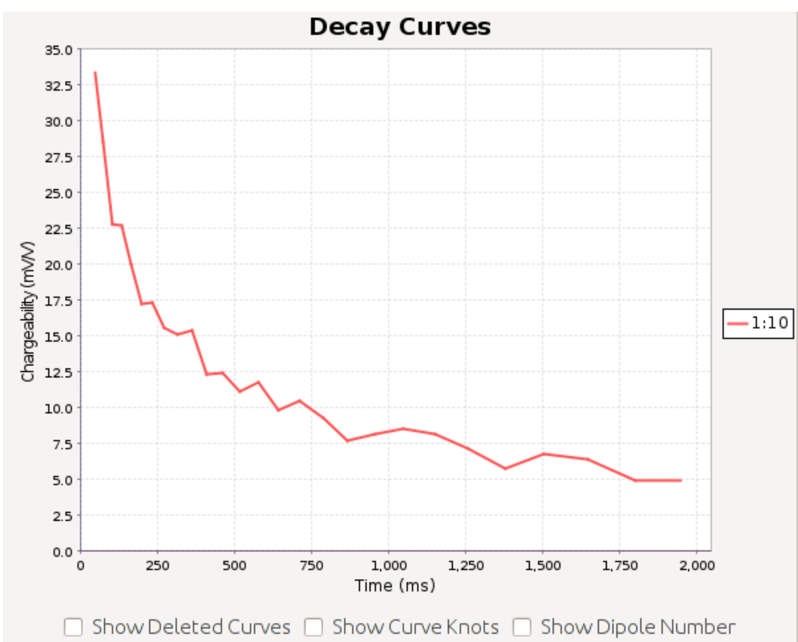


*Figure 8: Example of relatively noisy decay curve: site 5450E/6250N, bi-poles 2350E/5200N and 4600E/5500N*

### *7.3. MT data*

MT data collected at S2 generally were of high quality, due to very limited regional human activity and fairly consistent clear and dry weather. A typical reason for reduced data quality was the noisy signal measured in electric dipoles which we attribute to either a poor contact in particularly rocky areas, or specifics of the local geology.

The data were collected at 32000 samples per second for periods of 45 minutes. This setup allows calculating the MT impedance tensor in the requested range of [1,10000] Hz. In practice, we were able to process and get reliable estimates of the impedance tensor for the ranges [5,1000] Hz and [3500,10000] Hz. The lower frequencies between 1 Hz and 5 Hz turned out to be noisy. The gap between 1 kHz and 3.5 kHz corresponds to a “dead band” with nearly non-existing MT signal.

SJ Geophysics proprietary software was used to process all data, calculate impedance tensor and plot sounding curves at each MT station. Robust processing was utilized to remove outliers and alleviate influence of the noise. Typically, smooth and continuous sounding curves with narrow error bars were obtained. The error bars tend to grow bigger near the edges of the aforementioned frequency bands, to the level of up to 20% of the signal.

Two stations, MT5300E6100 and MT5050E6300, were surveyed twice due to particularly noisy results. The results of the separate surveys were repeatable for both stations, and in the case of MT5300E6100, signal measured by the South-North electric dipole appeared consistently noisy. We attribute this to the local topography (steepness) of the terrain.

# *8. Deliverables*

This logistics report and maps are provided as two paper copies and digitally in PDF format. All data including the geophysical survey and location data are also provided digitally. A brief description of the provided data is below.

- 3DIP Data – Raw DCIP data exported as a .txt file
- MT Data – Raw time-series 45 minutes in length, for all channels of each MT station; EDI files calculated for each stations using 10 minutes and 45 minutes trims.
- Location - Locations of survey stations with DEM elevation
- Maps
    - Location map of project
    - Grid map
- Reports
    - Logistics Report

# Appendix A: Survey Details

## S2 Grid

| Line | Series | Type | Station | Reading Length (min) |
|---|---|---|---|---|
| 1900 | E | IP/MT | 6750 | 5/45 |
| 1900 | E | IP/MT | 7350 | 5/45 |
| 2100 | E | IP/MT | 7500 | 5/45 |
| 2300 | E | IP/MT | 7650 | 5/45 |
| 2400 | E | IP/MT | 6900 | 5/45 |
| 3050 | E | IP/MT | 7200 | 5/45 |
| 3150 | E | IP/MT | 7300 | 5/45 |
| 3550 | E | IP/MT | 7250 | 5/45 |
| 3600 | E | IP/MT | 7450 | 5/45 |
| 3700 | E | IP/MT | 7700 | 5/45 |
| 3900 | E | IP/MT | 7600 | 5/45 |
| 3900 | E | IP/MT | 7400 | 5/45 |
| 4100 | E | IP/MT | 7450 | 5/45 |
| 4100 | E | IP/MT | 7650 | 5/45 |
| 4300 | E | IP/MT | 7350 | 5/45 |
| 4350 | E | IP/MT | 7600 | 5/45 |
| 4500 | E | IP/MT | 7200 | 5/45 |
| 4500 | E | IP/MT | 7400 | 5/45 |
| 4500 | E | IP/MT | 7500 | 5/45 |
| 4500 | E | IP/MT | 7700 | 5/45 |
| 4650 | E | IP/MT | 7900 | 5/45 |
| 4700 | E | IP/MT | 7300 | 5/45 |
| 4800 | E | IP/MT | 7450 | 5/45 |
| 4900 | E | IP/MT | 7300 | 5/45 |
| 5000 | E | IP/MT | 6450 | 5/45 |

| Line | Series | Type | Station | Reading Length (min) |
|---|---|---|---|---|
| 5000 | E | IP/MT | 6750 | 5/45 |
| 5050 | E | IP/MT | 6300 | 5/45 |
| 5200 | E | IP/MT | 6450 | 5/45 |
| 5200 | E | IP/MT | 6200 | 5/45 |
| 5300 | E | IP/MT | 6100 | 5/45 |
| 5300 | E | IP/MT | 6600 | 5/45 |
| 5300 | E | IP/MT | 6850 | 5/45 |
| 5300 | E | IP/MT | 8000 | 5/45 |
| 5450 | E | IP/MT | 7900 | 5/45 |
| 5500 | E | IP/MT | 6250 | 5/45 |
| 5500 | E | IP/MT | 8100 | 5/45 |
| 5600 | E | IP/MT | 6000 | 5/45 |
| 5600 | E | IP/MT | 6450 | 5/45 |
| 5600 | E | IP/MT | 8250 | 5/45 |
| 5750 | E | IP/MT | 5900 | 5/45 |
| 5750 | E | IP/MT | 6200 | 5/45 |
| 5850 | E | IP/MT | 6050 | 5/45 |

*Total Different Stations = 42*

*IP = IP Station, MT = MT Station*

# Appendix B: Instrument Specifications

## Volterra Dabtube 24-bit four-channel acquisition unit

| | |
|---|---|
| **Technical:** | |
| Input impedance: | 15 MΩ |
| Input overvoltage protection: | 5.6 V |
| Internal memory: | Variable USB flash memory stick (currently 16 GB) |
| Number of inputs: | 4 galvanically isolated inputs |
| Synchronization: | GPS |
| Selectable Sampling Rates (samples/second): | 128000, 64000, 32000, 16000, 8000, 4000, 2000, 1000 |
| Common mode rejection: | More than 80 dB (for Rs=0) |
| Voltage sensitivity: | Range: 10 V (peak to peak, ± 5 V)<br>Resolution: 0.24 µV |
| Communication: | Bluetooth and USB |
| Serial Port: | 4 RS-232 full duplex |
| Digital I/O: | 6 time stamped ports |
| **General:** | |
| Dimensions: | Diameter: 5.5 cm, Length: 60 cm |
| Weight: | 0.85 kg |
| Battery: | 4.8 V internal |
| Operating temperature range: | -40 ºC to 40 ºC |

## GDD TxII IP Transmitter

| | |
|---|---|
| Input voltage: | 120V / 60 Hz or 240V / 50Hz (optional) |
| Output power: | 3.6 kW maximum |
| Output voltage: | 150 to 2200 V |
| Output current: | 5 mA to 10 A |
| Time domain: | 1, 2, 4, 8 second on/off cycle |
| Operating temp. range: | -40 °C to +65 °C |
| Display: | Digital LCD read to 0.001 A |
| Dimensions: | 34 x 21 x 39 cm |
| Weight: | 20 kg |

## *Surface Axial B Field Coil (Ant-23)*

| | |
|---|---|
| Frequency range: | 0.1 Hz to 40,000 Hz |
| Sensitivity in passband: | 100 mV/nT |
| Noise Level: | 12 fT per √Hz at 1 Hz |

# Appendix C: Geophysical Techniques

## IP Method

The time domain IP technique energizes the ground by injecting square wave current pulses via a pair of current electrodes. During current injection, the apparent (bulk) resistivity of the ground is calculated from the measured primary voltage and the input current. Following current injection, a time decaying voltage is also measured at the receiver electrodes. This IP effect measures the amount of polarizable (or "chargeable") particles in the subsurface rock.

Under ideal circumstances, high chargeability corresponds to disseminated metallic sulfides. Unfortunately, IP responses are rarely uniquely interpretable as other rock materials are also chargeable, such as some graphitic rocks, clays, and some metamorphic rocks (e.g., serpentinite). Therefore, it is prudent from a geological perspective to incorporate other data sets to assist in interpretation.

IP and resistivity measurements are generally considered repeatable to within about five percent. However, changing field conditions, such as variable water content or electrode contact, reduce the overall repeatability. These measurements are influenced to a large degree by the rock materials near the surface or, more precisely, near the measurement electrodes. In the past, interpretation of a traditional IP pseudosection was often uncertain because strong responses located near the surface could mask a weaker one at depth. Geophysical inversion techniques help to overcome this uncertainty.

## Volterra-3DIP Method

Three dimensional IP surveys are designed to take advantage of recent advances in 3D inversion techniques. Unlike conventional 2DIP, the electrode arrays in 3DIP are not restricted to an in-line geometry. This means that data can be collected from a large variety of azimuths simultaneously leading to a highly sampled dataset containing more information about the Earth's physical properties. In an ideal world, a 3DIP survey would consist of randomly located current injections and receiver dipoles with random azimuths. Unfortunately, logistical considerations usually prohibit a completely randomized approach.

The Volterra-3DIP distributed acquisition system is based on state-of-the-art 4-channel, full-waveform, 32-bit Volterra acquisition units. The system is highly flexible and can utilize any number of Volterra units. The Volterra-3DIP system's untethered, distributed design, eliminates the need for specialized receiver cables and a centralized receiver control station. The dipoles can be in any orientation, can have varying lengths, and completely avoid inaccessible areas if necessary.

A typical Volterra-3DIP configuration establishes alternating current and receiver lines in sets of 5, but can be customized based on the project. The current lines are located on adjacent lines to the receiver line and current injections are performed sequentially at fixed increments (25 m, 50 m, 100 m, 200 m) along each current line. By injecting current at multiple locations along each current line, the data acquisition rates are significantly improved over conventional surveys. Customized receiver arrays are utilized to provide greater cross-line focus for a better azimuthal distribution of the data. Cross-dipoles are frequently used to maximize signal coupling and improve the surface resolution.

### *MT Survey Method*

The magnetotelluric (MT) method is a geophysical technique that uses naturally occurring electromagnetic (EM) fields for resistivity measurements. In traditional MT processing, data is collected from individual stations, each consisting of magnetometers (to give Hx, Hy) and a pair of non collinear dipoles (to give Ex and Ey.) The end result is an electromagnetic sounding at a specific location. MT data are analyzed in the frequency domain to obtain estimates of the resistivity of the subsurface.

The processing of the data involves calculation of auto and cross-powers of periodgrams of components of the magnetic and electric fields. Since the autopowers typically amplify errors, the results suffer from bias. A technique to mitigate the bias is to deploy a Remote Reference and use the date recorded by it to form necessary autopowers. Therefore, a good RR location is an essential part of of the survey design, and care is taken to ensure useful RR data.