Finlayson Lake Targeted Geoscience Initiative (southeastern Yukon), Part 2: Quaternary geology and till geochemistry

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ABSTRACT

A regional till geochemistry survey and Quaternary geology investivations were carried out across poorly exposed terrain of the Finlayson Lake map area. Two sampling teams collected 331 till samples, including regional and deposit orientation samples from Wolverine, Kudz Ze Kayah and the Argus properties. In total, 489 till samples were analysed by ICP-MS, including 158 samples collected in 2000. Quaternary exposures were logged and interpreted in order to reconstruct the Late Wisconsinan glacial history of the area (McConnell Glaciation). Ice-flow patterns during glacial maximum generally trended towards the west-northwest. Basal till is widespread across plateau surfaces and glaciofluvial sand and gravel dominate in low-lying terrain. Multi-element anomalies are present near known mineralized zones. High lead and zinc concentrations are measured in till down-ice from the massive sulphide bedrock mineralization at Kudz Ze Kayah. In addition, multi-element anomalies particularly enriched in base metals are found northwest of Wolverine Lake and southwest of Finlayson Lake, where no mineral occurrences are known. Results of the 2000 survey indicated the presence of a multi-element anomaly suggestive of epithermal mineralization in the northwest corner of the study area. Staking has ensued in the area. Follow-up sampling on the anomaly confirmed the 2000 results and has yielded highly anomalous gold levels. Another sample collected south (up-ice) from the Kudz Ze Kayah deposit returned an unexpected high gold concentration. Samples with high copper/nickel/chromium concentrations are located in the northwest part of the study area and southwest of Finlayson Lake.

RÉSUMÉ

Un programme d'échantillonage régional du till et une étude de la géologie du Quaternaire ont été entrepris dans une région située à l'intérieur des limites du feuillet topographique de Finlayson Lake où il y a peu d'affleurements rocheux. Deux équipes ont recueilli 331 échantillons de till afin d'en analyser la composition géochimique incluant des échantillons régionaux et des échantillons obtenus près de gisements connus tels Wolverine, Kudz Ze Kayah et Argus. Des données géochimiques sont maintenant disponible pour un total de 489 échantillons de till incluant 158 échantillons receuillis en 2000. Des coupes stratigraphiques de sédiments quaternaires ont été mesurées et interprétées dans le but de reconstituer l'histoire de la Glaciation de McConnell dans la région, au Wisconsinien tardif. En général, la glace s 'est écoulée vers l'ouest-nord-ouest pendant le maximum glaciaire. Le till de fond est largement répandu sur les plateaux alors que du sable et gravier fluvioglaciaires dominent dans les régions plus basses. Plusieurs éléments sont présents en concentrations anomales dans le till près des zones minéralisées connues. De hautes teneurs en plomb et zinc sont mesurées dans le till en aval glaciaire de la minéralisation de sulfure massif de Kudz Ze Kayah. D'autres éléments, plus particulièrement des métaux de base, sont présents en fortes teneurs au nord-ouest du lac Wolverine et au sud-ouest du lac Finlayson où il n'y a pas de minéralisation connue. Suite au programme d'échantillonnage effectué en 2000, de fortes concentrations de plusieurs éléments ont été détectées dans la partie nord-ouest de la région d'étude suggérant la présence d'une zone de minéralisation épithermale. Par la suite, la région a été jalonnée. Un échantillonnage subséquent de l'anomalie a confirmé les résultats obtenus en 2000 et permis de trouver des concentrations hautement anomales en or. On a également découvert des valeurs d 'or anomalement élevées au sud du gisement Kudz Ze Kayah. De fortes valeurs en cuivre, nickel et chrome ont été observées dans la partie nord-ouest de la région d'étude et au sud-ouest du lac Finlayson.

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INTRODUCTION

As part of the Targeted Geoscience Initiative (TGI), the Geological Survey of Canada and the Yukon Geology Program carried out a joint bedrock geology mapping (see TGI , Part 1, Murphy et al., this volume) and a regional till geochemistry survey in the northern sector of the Finlayson Lake map area (NTS 105G; Fig. 1, this report). The goal of this part of the TGI project is to enhance the regional geochemical database with the intention of finding new exploration targets in this poorly exposed area. The objective of this paper is to present the results of the till geochemistry, along with new data on the Quaternary stratigraphy.

The abundance of mineral occurrences and deposits in the Finlayson Lake region (e.g., Kudz Ze Kayah, Wolverine, Fyre Lake, Ice, Yukon MINFILE, 2001; Fig. 1) clearly reflect the high mineral potential of the area. Combined probable reserves from the Kudz Ze Kayah and Wolverine deposits are estimated at 14.57 million tonnes grading 7.23% Zn, 1.53% Pb, 0.97% Cu, 184.5 g/t Ag and 1.39 g/t Au (Burke, 2001). Poor bedrock exposure has hindered mineral exploration in the northern half of the Finlayson Lake map area. Previous regional geochemical surveys in the area made use of stream sediments. This was successful in areas of high relief where drainage density is high. In low-relief terrain, where drainage density is low, stream sediment geochemistry provided limited regional coverage. Till was favoured as a sampling medium in this regional geochemical drift prospecting survey for the following reasons: 1) it occurs abundantly on plateaus and hills in areas of poor bedrock exposure; 2) it is considered as the first derivative of bedrock (Shilts, 1976, 1993), which implies that mineralized debris found in till generally has a simple transport history; and 3) one dominant ice-flow direction persisted during most of the last glaciation, which also suggests a simple transport history and facilitates tracing to the potential bedrock source of anomalies in till.

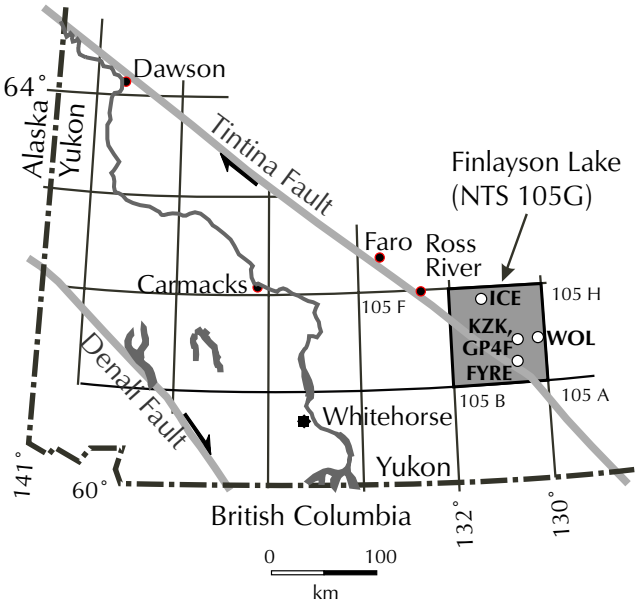

Figure 1. *Location of Finlayson Lake map area (NTS 105G). Major mineral deposits are shown: KZK = Kudz Ze Kayah, Wol = Wolverine and Fyre = Fyre Lake.*

PREVIOUS STUDIES

Surficial geological mapping and Quaternary stratigraphic investigations were carried out by Jackson (1994) for the Pelly River region, including the Finlayson Lake map area. The surficial geology of the Frances Lake map area (105H) was mapped by Dyke (1990), the Wolf Lake map area (105B) by Klassen (1983), and the Watson Lake map area (105A) by Klassen and Morison (1982) (see Fig. 1). Building on the stratigraphic framework developed by Jackson (1989) and Plouffe (1989), Plouffe and Jackson (1992) presented a detailed study of the Quaternary succession and the regional till geochemistry of a region extending from Wolverine Lake to Faro. More recently, two studies on surficial geology and till geochemistry were completed in the Anvil district (105K) and the Weasel Lake map area (105G/13) with the objective of promoting exploration and developing the application of drift prospecting in Yukon (Bond, 2001a,b).

PHYSIOGRAPHY AND GEOLOGY

The northern sector of the Finlayson Lake map area is part of the Yukon Plateau, which consists of a low-lying region with isolated plateaus reaching 1219 m in elevation and intermittent summits reaching 1828 m in elevation. Inter-plateau regions are generally poorly drained (Figs. 2,3). The Yukon Plateau is flanked by the Pelly and Logan mountains to the south and east, respectively. Till sampling was only conducted over the Yukon Plateau.

The drainage west and north of Finlayson Lake is part of the Pelly River watershed. The main tributaries include Hoole River and Big Campbell, Campbell, Mink and Fortin creeks. The region east of Finlayson Lake drains easterly via the Finlayson River. The continental drainage divide between the Liard River (Beaufort Sea) and Pelly River (Bering Sea) is part of the study area.

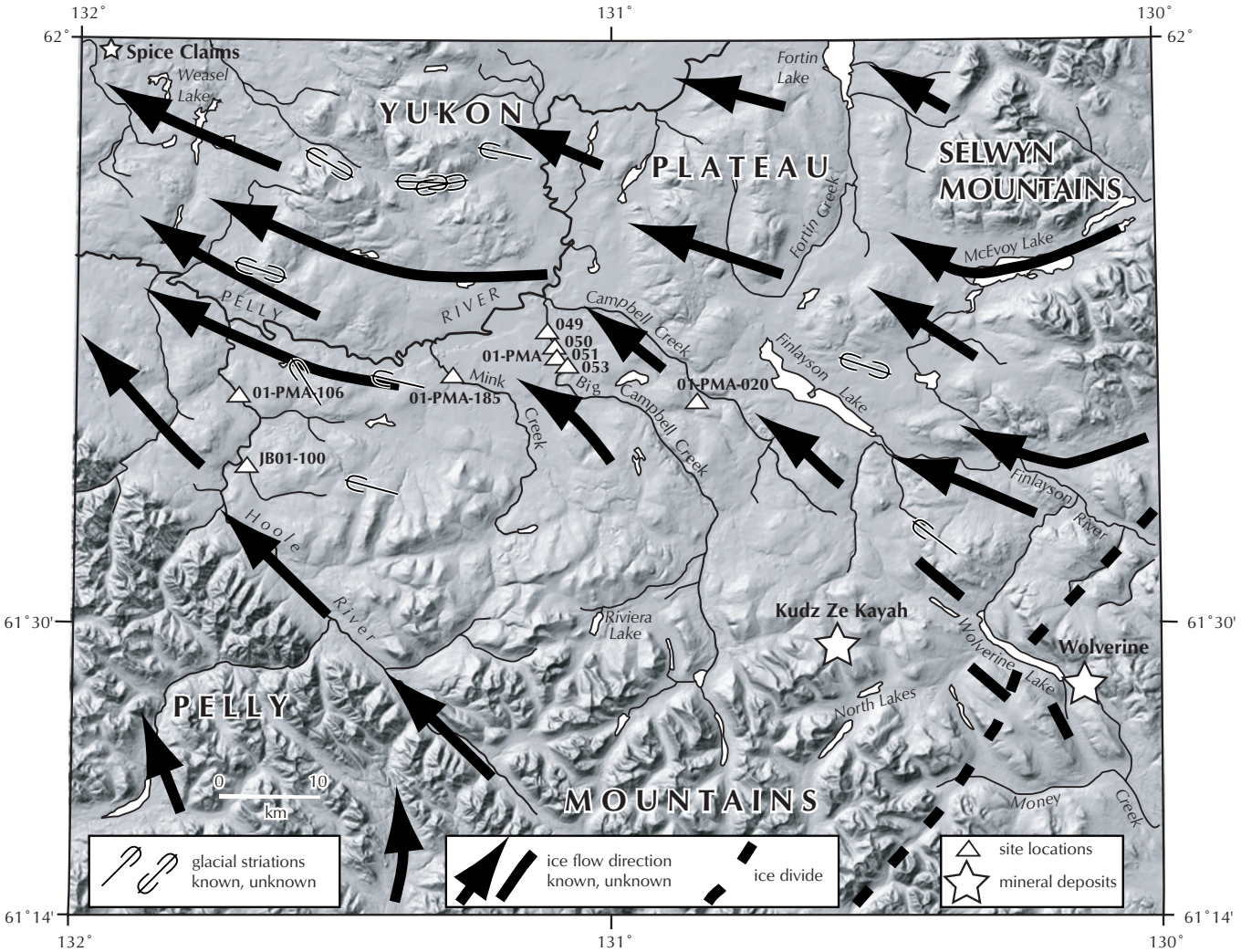

Figure 2. *Location map with 2001 section locations, and regional ice-flow patterns simplified from Jackson (1993a,b,c,d). Glacial striations measured during the 2001 field season are also shown.*

The study area lies at the boundary between the Yukon-Tanana Terrane (YTT) and ancient North America. The YTT consists of a large crustal fragment of mafic and felsic meta-volcanic rocks, carbonaceous meta-clastic rocks, marble and granitic orthogneiss that was accreted to North America in Mesozoic time. The YTT is host of the most significant mineral deposits of the area: e.g., Fyre Lake, Kudz Ze Kayah and GP4F. See Murphy et al. (2001, 2002, this volume) for details on the bedrock geology.

Figure 3. *Low rolling topography with isolated uplands in northern Finlayson Lake map area (105G).*

METHODOLOGY

Existing surficial geology, bedrock geology and geophysical maps, along with Yukon MINFILE (2001) occurrences, were compiled and evaluated prior to the

field season. Existing surficial geology maps by Jackson (1994) were used as the primary guide to the distribution of surficial deposits. Air photo interpretation was also completed prior to sample collection to confirm the surficial geology.

Fieldwork was completed from a base camp located at the Finlayson air strip (105G/10). Bedrock geologists, surficial geologists, a Geographic Information System (GIS) technician, and the helicopter pilot and mechanic shared the base camp. A Bell 206 helicopter provided access to the survey areas. Road traverses were also completed along the Robert Campbell Highway and the Kutz Ze Kayah exploration road. All samples, apart from those taken on the road traverses, were collected during daily foot traverses. Till samples were collected along traverse lines oriented perpendicular to sub-perpendicular to the former ice-flow direction. Such orientation of the traverse lines provides the maximum coverage of the underlying geology. Sample spacing was approximately 1 km and an average of 6-8 samples were collected on a daily traverse.

At each sample station, a 2-kg and a 1-kg bulk sediment sample were collected for geochemical analysis of the silt plus clay-size fraction (–230 mesh or <0.063 mm) and the clay-size fraction (<0.002 mm), respectively. In addition to the geochemical samples, approximately 50 pebbles were collected for a lithologic record. Emphasis was placed on sampling basal till, although colluviated basal till and meltout till were also collected. Samples were collected from the C-horizon (the unweathered parent material) at an average depth of 55 cm, in hand-dug pits (Fig. 4). Natural exposures from stream cuts were sampled along the Hoole River, Pelly River, Big Campbell Creek, Mink Creek and some unnamed streams. Where thick till is exposed, samples were collected at different depths to assess the vertical variability of the till geochemistry.

Figure 4. *Digging for a till sample, northwest of Wolverine Lake.*

Site and sample information were recorded onto data sheets, or digitized in the field using a hand-held device (Compaq iPAQ). Both techniques were used in order to test the efficiency of the latter method. The information was downloaded at base camp into an Access database. The database, which includes site and sample descriptions and results of geochemical analyses, will be released in digital form (CD-ROM) in 2002. Additional information that was recorded in the field included the location of outcrops (where samples were taken), general bedrock descriptions, and presence and orientation of glacial ice-flow features.

Unreported exposures of Quaternary sediments present along stream banks were logged during the 2001 field season in order to reconstruct the glacial history of the study area. Each stratigraphic unit was characterized with respect to its texture, sedimentary structures, colour, clast composition, contact relationships, and lateral continuity. A proper understanding of the glacial and ice-flow histories of a region is crucial for the interpretation of the till geochemistry. Tracing the source of a geochemical anomaly in till depends directly on the understanding of local and regional ice-flow patterns.

SAMPLE PREPARATION AND ANALYSIS

Preparation of the silt and clay-size fractions for asssay was conducted by Acme Analytical Laboratories in Vancouver, British Columbia. Samples were oven dried at 60°C and dry-sieved to separate the silt and clay-size fractions (<0.062 mm or –230 mesh). Samples of 15 g of combined silt and clay were analysed for 39 elements by inductively coupled plasma mass spectrometry (ICP-MS) after an aqua regia digestion. The aqua regia attack dissolves most sulphide minerals and therefore can be considered as a total digestion for base and precious metals held in sulphide minerals. On the other hand, aqua regia is a partial leach for silicate minerals and does not dissolve barite. Therefore, certain elemental concentrations (e.g., Cr, Ti, Fe, Mg, Ba) should be considered as partial concentrations. Detection limits for ICP-MS analyses are shown in Table 1. Separations of the clay-size fraction were conducted in the Sedimentology Laboratory of the Geological Survey of Canada. Results of the geochemical analyses of the clay-size fractions were not available at the time this paper was prepared, but will be released in a later publication.

Table 1. *Detection limits for elements analysed in the 2000/2001 study.*

Element	Detection limit	Element	Detection limit
Au	0.2 ppb	**Na**	0.001 %
Ag	2 ppb	**Ni**	0.1 ppm
Al	0.01 %	**P**	0.001 %
As	0.1 ppm	**Pb**	0.01 ppm
B	1 ppm	**Pd**	10 ppb
Ba	0.5 ppm	**Pt**	2 ppb
Bi	0.02 ppm	**S**	0.02 %
Ca	0.01 %	**Sb**	0.02 ppm
Cd	0.01 ppm	**Sc**	0.1 ppm
Co	0.1 ppm	**Se**	0.1 ppm
Cr	0.5 ppm	**Sr**	0.5 ppm
Cu	0.01 ppm	**Te**	0.02 ppm
Fe	0.01 %	**Th**	0.1 ppm
Hg	5 ppb	**Ti**	0.001 %
Ga	0.02 ppm	**Tl**	0.02 ppm
K	0.01 %	**U**	0.1 ppm
La	0.5 ppm	**V**	2 ppm
Mg	0.01 %	**W**	0.2 ppm
Mn	1 ppm	**Zn**	0.1 ppm
Mo	0.01 ppm		

QUALITY CONTROL

Quality control measures were carried out during the till sampling program to ensure data reliability. In every block of 20 samples, 2 field duplicates and 1 control standard were inserted. In total, 33 field duplicates and 16 control standards were included with the 331 samples collected during the 2001 field survey. The control standards were obtained from the Canada Centre for Mineral and Energy Technology (CANMET). The field duplicates consist of an additional sample collected at random from one in every ten till sampling stations. These duplicates are used to test the geochemical variation within the till, whereas the control standards test the accuracy of the analytical laboratory. Analytical duplicates (sieved splits) were inserted by the analytical laboratory during sample preparation to evaluate analytical precision. Similarly, 16 pairs of field duplicates and 9 control standards were inserted in the 156 samples from the 2000 field season (Bond, 2001a).

Analytical precision is judged as satisfactory based on the good correlation between the field and laboratory duplicate pairs (Fig. 5). The analytical accuracy is also judged as satisfactory for all of the elements herein

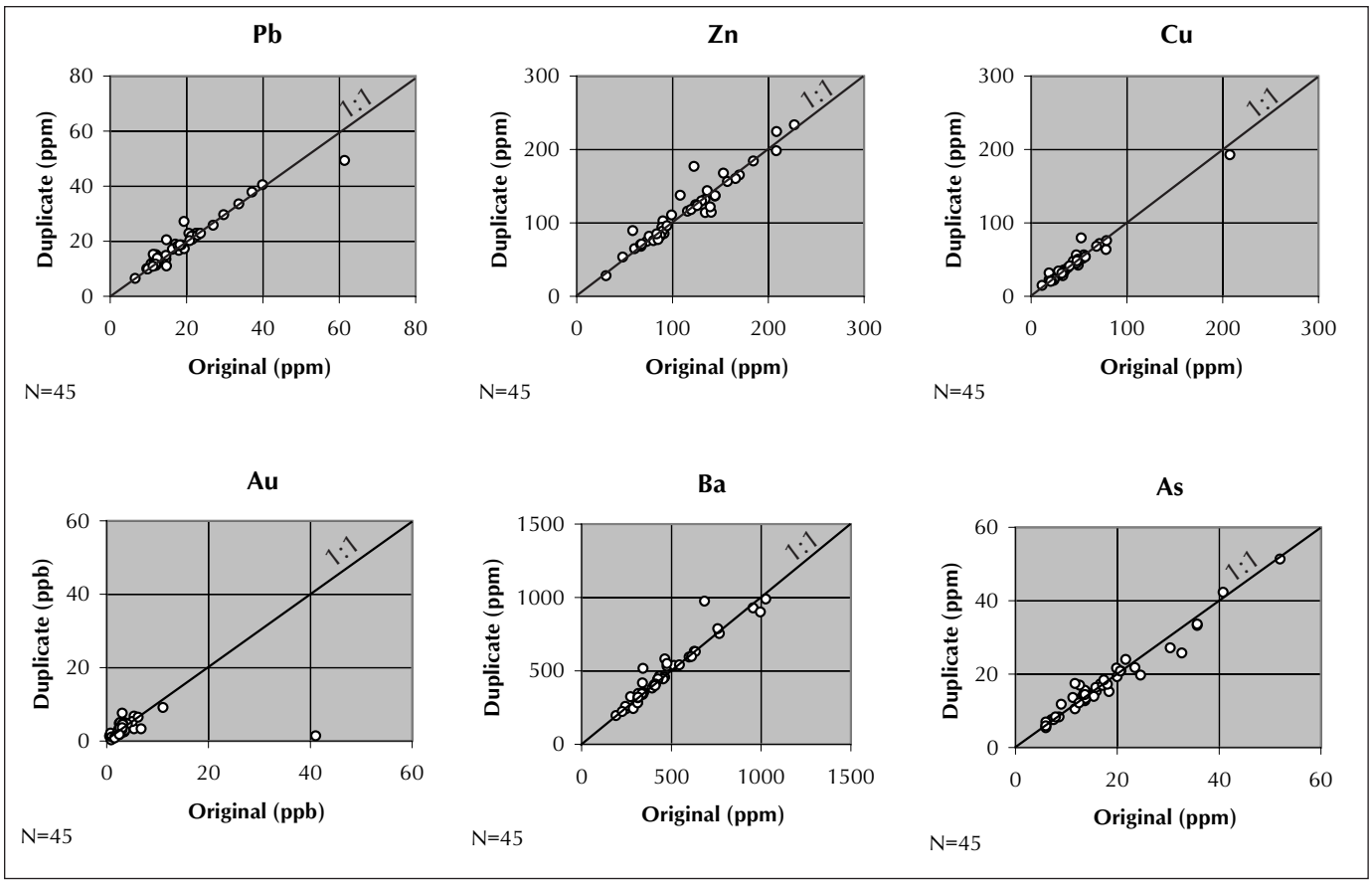

Figure 5. *Correlation plots of field and laboratory duplicate samples. N = the number of samples.*

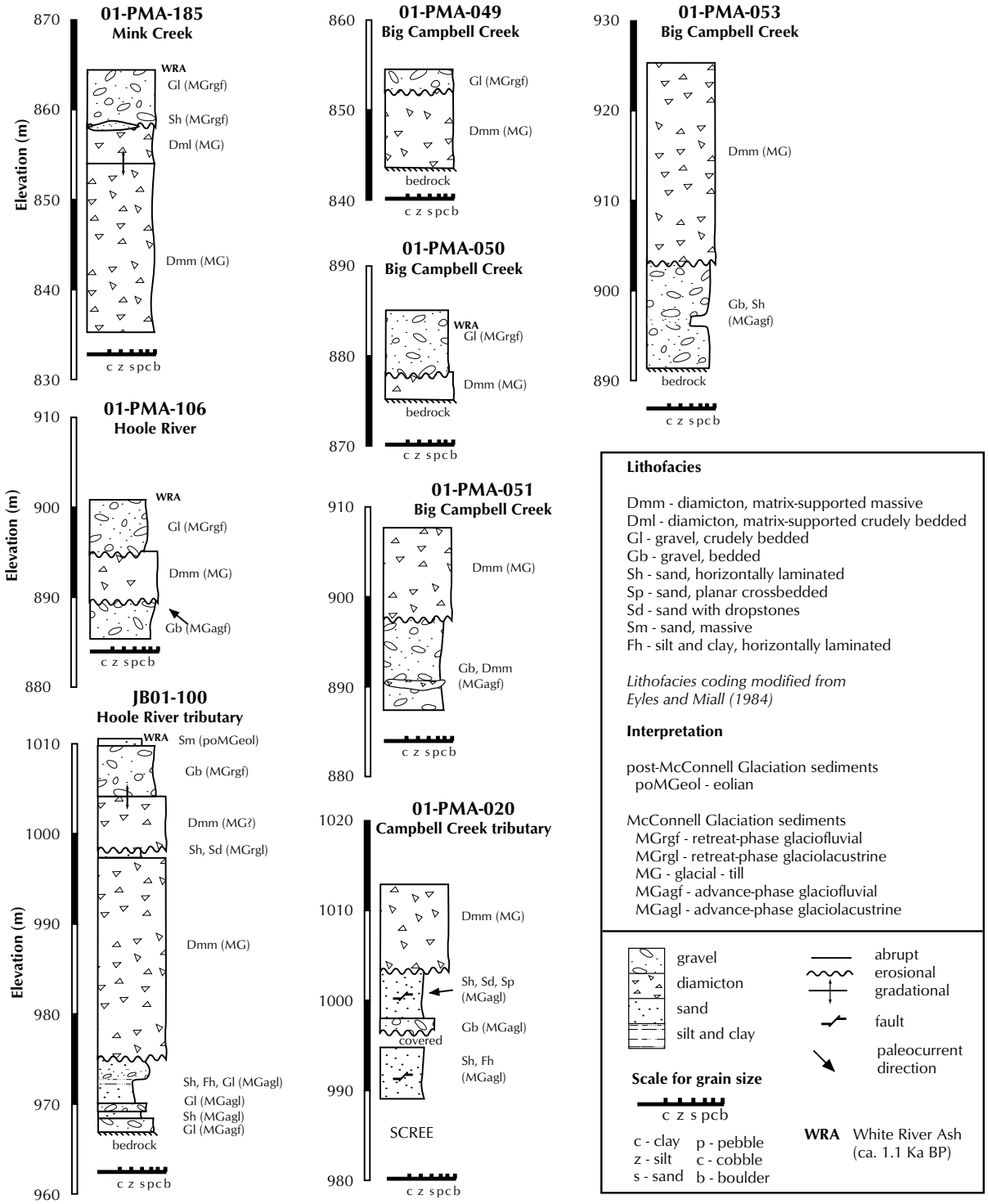

Figure 6. *Quaternary stratigraphy logged during the 2001 field season.*

Table 2. *Elemental concentrations of standard Till-2 obtained in this study compared to reported values.*

Elements	Pb ppm	Zn ppm	Cu ppm	Ba ppm	Ni ppm	Cr ppm	Co ppm	Au ppb	Ag ppb	As ppm	Hg ppb
Till-2; average value, this study	25.48	108.21	142.45	105.47	31.95	38.75	13.86	1.7	218.62	22.2	65.75
Elemental values (Till-2; Lynch, 1996)	21	116	149	95	31	40	13	n/a	200	22	74

reported, based on comparison between the nine analyses of the standard conducted during this study and values obtained from previous reports (Till 2 - Lynch, 1996; Table 2).

QUATERNARY STRATIGRAPHY

Most of the sediments observed in sections are deposits of the Late Wisconsinan McConnell Glaciation, that is the last glacial event that affected the region (Fig 6; Bostock, 1966; Jackson, 1994). The oldest sediments were deposited during the advance phase of the McConnell Glaciation. These sediments are overlain by the McConnell till and retreat-phase deposits.

ADVANCE-PHASE SEDIMENTS

Sediments directly under the McConnell till that show a degree of weathering similar to the overlying till, and that contain, in places, clasts of distal lithologies, are interpreted to have been deposited during the advance-phase of the last glaciation. However, in the absence of absolute dating, the greater antiquity of these sediments can not be ruled out.

Advance-phase sediments were observed in the Campbell Creek, Big Campbell Creek, Hoole River, and Pelly River valleys. Advance-phase sediments were deposited into two broad depositional environments: glaciolacustrine and glaciofluvial. Glaciolacustrine sediments are typically well-sorted fine sand and silt, horizontally laminated and bedded, and contain sporadic dropstones (Fig. 7). Sporadic sand and gravel beds and lenses observed within the units of glaciolacustrine sediments were likely deposited near the mouth of meltwater streams. Advance-phase glaciolacustrine sediments indicate that the drainage was blocked by glaciers during glacial advance.

Units of clast-supported sand and gravel, which are generally poorly sorted and crudely to well bedded, are thought to reflect glaciofluvial sedimentation (Fig. 8). Diamicton lenses were observed within the advance-phase glaciofluvial sediments, and they are interpreted as sediment gravity flow or flow till. Advance-phase glaciofluvial sediments indicate free drainage conditions during glacial advance.

Advance-phase glaciofluvial and glaciolacustrine sediments are well compacted. Some faults observed in the advance-phase sediments are likely the product of glacio-tectonic deformations as suggested by their consistent orientation transverse to the known ice-flow

Figure 7*. Advance-phase glaciolacustrine sediments exposed at section 01-PMA-020 in a tributary valley of Campbell Creek. Knife measures 20 cm.*

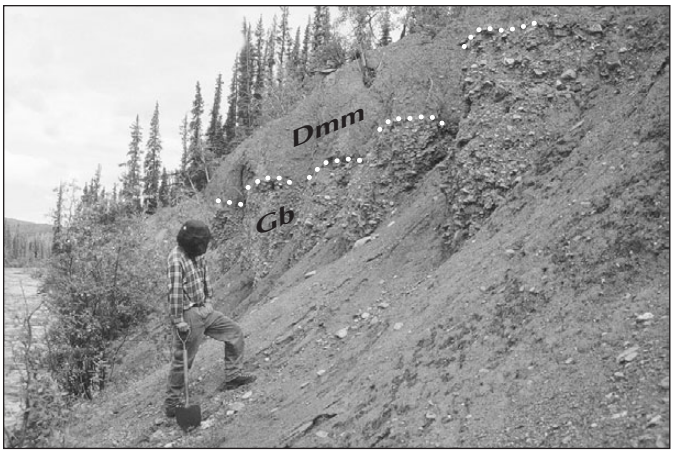

Figure 8. *Advance-phase glaciofluvial gravel (Gb) overlain by till (Dmm) at section 01-PMA-106 in the Hoole River valley.*

Figure 9. *Fault in advance-phase glacial lake sediments of section 01-PMA-020. Pick measures approximately 65 cm.*

Figure 10. *McConnell Till exposed at section JB01-100 in a tributary valley of the Hoole River. Pick measures approximately 65 cm.*

movement and dip in the up-ice direction (up-paleo-ice flow; Fig. 9).

McCONNELL TILL

Till is a sediment that is directly deposited by glacier ice. Only one lithostratigraphic unit of till found within the study area represents the till deposited during the McConnell Glaciation. McConnell Till consists of a poorly sorted diamicton with clasts of pebble to boulder size in a sandy to clayey matrix (Fig. 10). Abundant faceted and striated clasts are found in the till reflecting the glacial origin of the sediment. McConnell Till is on average 1-3 m thick on plateaus and hills but can reach a thickness of up to 20 m in some valleys (e.g., Big Campbell Creek, Hoole River; Fig. 6). On plateau summits where the till is thin, it contains abundant angular to subangular clasts of local lithologies. However, in the valleys, till contains a mixture of subangular to rounded clasts with lithologies from distal and local sources. Therefore, the provenance region of the till in a valley could be distal or proximal.

McConnell Till was likely deposited by a combination of meltout and lodgement processes. Plouffe (1989), and Plouffe and Jackson (1992) have reported strong till fabrics parallel to ice flow in McConnell Till suggesting lodgement sedimentation. However, sand and gravel lenses and crude layering were generally observed in the upper portion of McConnell Till (see section 01-PMA-185, Fig. 6) suggesting sedimentation by meltout.

RETREAT-PHASE SEDIMENTS

As for the advance-phase, the retreat-phase of the last glaciation was also marked by glaciofluvial and glaciolacustrine sedimentation. Jackson (1993c) reported several metres of well-sorted fine sand, silt and clay underlain by McConnell Till in the Pelly River valley, which he interpreted to be glaciolacustrine sediments. Elsewhere in the study area, clast-supported, pebbly to cobbly, and crudely to well-bedded gravel overlying McConnell Till was interpreted as retreat-phase glaciofluvial sediments deposited by meltwater streams. Therefore, the stratigraphic evidence found by Jackson (1993c) indicates that a glacial lake developed in the Pelly River valley during the retreat-phase of the glaciation (Jackson, 1994). Elsewhere, the drainage was free during ice retreat, except where local glacial lakes formed in tributary valleys by drainage impoundment.

NONGLACIAL SEDIMENTS

A thin veneer, generally less than 1 m, of eolian sediments caps several sections in the study area. Only in the Hoole River valley, at section JB01-100, is this unit thick enough to be represented on the stratigraphic log. The White River Ash, dated at 1147 calendric years BP (Clague et al., 1995), is often present near the top of the eolian sediments indicating that these deposits are Holocene in age. The Stewart neosol (modern brunisolic soil) is visible in the eolian cap.

GLACIAL LANDFORMS

During the field investigation, particular attention was paid to micro- and macro-landforms indicative of ice-flow patterns: streamlined landforms (drumlins, flutes and crag-and-tails), glacial striations, and roche moutonnée. Streamlined landforms predominantly occur in the less rugged portion of the northern sector of the Finlayson Lake map sheet. They reveal a general westward to northwestward ice-flow direction with minor deflections near topographic highs (Jackson, 1993a,b,c,d).

Glacial striations measured on bedrock surfaces generally represent important ice-flow indicators, but very few striated sites were observed in the study area (Fig. 2). Only two roches moutonnées were recorded during fieldwork. Roches moutonnées and striations were found to be parallel to sub-parallel to streamlined landforms.

Ice marginal features such as frontal and lateral moraines, and lateral meltwater channels are used to reconstruct ice configuration during ice retreat (e.g., Dyke, 1990). Potential late glacial ice-flow patterns can be suggested knowing the ice configuration during deglaciation. Few moraines are present in the Finlayson Lake map area (see Jackson, 1994), but two provide clues on the pattern of deglaciation. North and east of Riviera Lake, and at about 8 km west of Wolverine Lake, Jackson (1993b,d) mapped morainic complexes that suggested high ground was deglaciated before the valleys. In other words, an ice mass was probably still present in the Wolverine Lake valley and in the vicinity of Finlayson Lake while most of the Pelly Mountains were deglaciated. The lack of lateral continuity in these morainic complexes suggests that the still stand of the ice front might have only been local. The amount of glacial transport that occurred during this late glacial episode is yet to be evaluated.

GLACIAL HISTORY

What is known to date of the ice-flow patterns at the onset of the McConnell Glaciation comes from the detailed stratigraphic investigation of the Lapie River region presented by Plouffe (1989). Plouffe suggested, based on the interpretation of till fabrics and lithologies, that ice first formed in the Pelly Mountains. Valley glaciers advancing from the Pelly Mountains later coalesced in the Tintina Trench to form an ice tongue advancing to the northwest, parallel to the Tintina Trench. Valley glaciers likely formed also in the portion of the Selwyn Mountains north and south of McEvoy Lake. During the ice advance, trunk valleys and low areas were invaded first, and glacial lakes developed in tributary valleys as their drainages were blocked by ice in the main valleys. For example, such glacial lakes developed in tributaries of the Hoole River (JB01-100, Fig. 6) and Campbell Creek (01-PMA-020, Fig. 6).

At glacial maximum, ice was generally flowing to the northwest within the Finlayson Lake map area and was thick enough to cover the highest mountains (Jackson, 1994). However, ice-flow patterns were influenced by topography, such as east of Weasel Lake where striations and streamlined landforms indicate a deflection around a topographic high (Fig. 2). In the rugged portion of the Pelly Mountains, ice flow was more complex than on the Yukon Plateau, and was highly controlled by topography (Jackson, 1994). On the Glacial Map of Canada (Prest et al., 1967), orientation of streamlined landforms suggests the presence of an ice divide centred on the Selwyn Mountains, northwest of Frances Lake. The

position of the ice divide was refined following mapping by Jackson (1994) and Dyke (1990) and is thought to have been located in the Wolverine Lake region. Consequently, east and southeast of Wolverine Lake, ice flow was generally to the southeast for a good part of the McConnell Glaciation. This is corroborated by the presence of abundant boulders of Cretaceous granite (see Murphy and Piercey, 1999) transported to the south of their bedrock source. The presence of an ice divide in the Wolverine Lake region indicates that an ice dome was continuous between the Pelly and Selwyn mountains. As a result, the greatest ice thicknesses in the study area were likely located over lowlands immediately north of the Pelly and west of the Selwyn mountains.

Jackson (1994) envisaged a rapid down-wasting of the Selwyn Lobe of the Cordilleran Ice Sheet at the close of the McConnell Glaciation. This was initiated by a rapid rise in the firn line (equilibrium line). The alpine regions, where ice was thinnest, were the first to be deglaciated. However, it is possible that local valley glaciers remained active for some time during deglaciation. Deglaciation was marked by local glacial readvance(s) originating from glaciers in the lowlands (Plouffe, 1989; Jackson, 1994; Bond, 2001a). For instance, during an ice readvance, clasts of South Fork volcanics, originating north of the Tintina Trench, were transported at least 9 km into the Lapie River valley (Plouffe, 1989). Bond (2001a) documented two tills in the Anvil district, the upper one being associated to a late glacial readvance originating from the Tintina Trench. Morainic complexes that surround the Anvil Range also supported this glacial readvance. However, no evidence of a late glacial readvance was identified in the Finlayson Lake map area during the 2001 field season. If a readvance occurred in the study area, it was likely related to the ice mass that occupied the Finlayson Lake and Wolverine Lake region at the end of the glaciation. Jackson (1994) suggested that the retreat-phase glacial lake that developed in the Pelly River valley was at least partly ponded by isostatic rebound.

In summary, in tracing the source of geochemical anomalies in till, the best estimate of the main vector of glacial transport corresponds to the regional ice-flow pattern at glacial maximum, which is generally to the northwest for most of the northern sector of the Finlayson Lake map area. Only in the Pelly Mountains region was ice flow dominantly controlled by topography.

TILL GEOCHEMISTRY: RESULTS

ORIENTATION SURVEY – KUDZ ZE KAYAH

More detailed sampling was completed near the Kudz Ze Kayah (KZK) massive sulphide mineralization to define the level of metal enrichment in till in areas of known mineralization. This data was used to aid regional data interpretation elsewhere in the study area. At Kudz Ze Kayah, the ice-flow direction was to the north and topographically confined by the valley.

In total, 14 till samples were collected in a north transect that passes directly over the deposit (Appendix 1). All samples were derived from hand-dug pits, stream-cuts or road cuts. The sampling and analytical methods are the same as those used during the regional survey.

Lead

Lead concentrations in till are only enriched immediately down-ice of the massive sulphide deposit (maximum of 559 ppm; Appendix 1). Such enrichment is directly related to northward glacial transport. A value of 441 ppm was derived from glaciofluvial gravel in a kame terrace, also down-ice flow of the KZK deposit. A stratigraphic sample from a stream cut on Fault Creek returned a value of 250 ppm. A source area for this anomaly could lie immediately south of Fault Creek.

Zinc

Zinc values north of the KZK deposit range from 1068 to 1711 ppm. Similar to lead, the zinc levels in till clearly reflect the presence of the massive sulphide deposit in the valley bottom. The three low zinc values to the northeast may be derived from the east, rather than from the south. Samples derived from the Fault Creek exposure also contain high zinc levels, ranging from 534 to 861 ppm. Sample 01-PMA-047-01 is high in zinc (637 ppm) and may indicate a down-slope dispersion of zinc from a similar source area as the Fault Creek samples. Site notes from 01-PMA-047 indicate the sample was derived from a colluviated till.

Silver

The distribution pattern of silver concentrations in till in the KZK valley is similar to the ones of lead and zinc. Silver enrichment in till is only found north of the mineralization. Immediately down-ice of the deposit, a maximum value of 5387 ppb was measured in till.

Gold

Gold enrichment in till is more subtle compared to the previous elements. The transport of gold from the massive sulphide is clearly reflected in sample JB01-067 (73 ppb). Sample 01-PMA-045-01, located nearly 3 km south of the known mineralization at KZK, yielded an unexpected gold concentration of 153 ppb. A source area for this sample is likely proximal (to the south) and somewhat up-slope from the station. Mississippian granite underlies this region (Murphy et al., 2000) and could be the host of intrusion-related mineralization.

REGIONAL TILL GEOCHEMISTRY

The till geochemistry presented here combines data from the 2000 and 2001 field seasons (number of samples, N=489). The element maps present the data in percentiles and concentration range. The elements discussed here are considered to be significant for mineral exploration in the northern half of the Finlayson Lake map area. See Appendix 2 for the sample location map and the related element concentration maps. All references to bedrock geology are derived from Murphy et al. (2001).

Lead

The lead values range from 2 ppm to 559 ppm with a mean concentration of 15 ppm and a median value of 15 ppm. The four highest lead values, corresponding to values above the 97th percentile, are discussed below.

The highest lead values were obtained from the orientation surveys conducted at the Kudz Ze Kayah (559 ppm) and Wolverine (275 ppm) deposits. The highest lead value from the regional data set was 234 ppm collected from JB01-001-08 in the northwest part of 105G. The sample was derived from a follow-up survey conducted near a multi-element mercury/gold anomaly identified during the 2000-sampling program (JB00-155; Bond, 2001). As part of the follow-up survey, nine samples were collected on a sample spacing of 200 m. The purpose was to test the reproducibility of the 2000 anomaly that is now staked as the Spice claims on NTS 105G/13 (Fig. 11). The sample line spans the width of a Permian conglomerate, which is expected to host mineralization; the mineralization might extend into the adjacent Carboniferous dark grey phyllite. Sample JB01-001-08 was collected over the Carboniferous dark grey phyllite. In addition to a high lead level, sample JB01-001-08 contains high copper (161 ppm), zinc (362 ppm), manganese (1165 ppm), arsenic (157 ppm), mercury (5892 ppb) and gold (29 ppb) concentrations. This sample contains numerous angular clasts suggesting a potential proximal volcanogenic massive sulphide (VMS) or sedimentary exhalative (SEDEX) deposit source. The multi-element anomaly could also be related to mineralization at the nearby Spice target. The elemental signature at Spice, which is discussed further under 'Gold' (later in this section), is suggestive of an epithermal source focused in the conglomerate. Epithermal fluids may have interacted with the nearby phyllites and re-deposited base metals within the conglomerate unit.

The second highest concentration of lead, 67 ppm, was collected from station 01-PMA-169-01, approximately 14 km south of Wolverine Lake. The sample also contains moderately elevated levels of zinc (147 ppm), antimony (12 ppm) and gold (6 ppb) and is located within muscovite-quartz phyllite of the Wolverine succession. This sample site is not located on the regional maps. Its UTM location is 439001E, 6797333N.

The third highest lead value, 67 ppm, was collected from station 01-PMA-027-01. The sample is located southwest of Finlayson Lake within Devonian schist. The location of the sample is immediately down-ice from a large area of Fire Lake metavolcanic rocks, which are considered a favourable target for mineralization. This sample also yielded high zinc (182 ppm) and arsenic (32 ppm) values.

The fourth highest concentration of lead, 61 ppm, is from sample 01-PMA-176-01. This sample is located immediately down-ice from the northwestern extent of the Wolverine succession. Samples in this area generally contain high zinc (95^{th} percentile), silver (99^{th} percentile), molybdenum, gold, selenium and mercury concentrations.

Zinc

Zinc concentrations range from 20 ppm to 4900 ppm, with mean and median values of 137 ppm and 104 ppm, respectively. The six highest values (>96.5^{th} percentile) are discussed below.

The highest zinc concentrations are derived from the orientation surveys at Wolverine (4900 ppm), Kudz Ze Kayah (1711 ppm) and Argus (457 ppm). Sample JB01-114, located along the Pelly River in the northern sector of the study area, yielded the highest zinc value of the regional samples (387 ppm). Numerous high zinc values are present in till in this area and are attributed to the high background level of zinc in the underlying Earn

Group shale. A potential bedrock source area for the high zinc value in JB01-114 could lie within 2 km to the east.

The second highest concentration of zinc, 361 ppm, was recorded from a colluviated basal till veneer overlying Carboniferous dark grey phyllite on the Spice claims. See the reference to this sample (JB01-001-08) under 'Lead'.

The third and fourth highest zinc values, 348 ppm and 337 ppm, overlie Carboniferous dark grey phyllite at stations JB00-047 and JB00-006. Based on metal association, VMS or SEDEX-style mineralization could be present in the phyllite.

The fifth highest zinc anomaly, 299 ppm, is from sample JB01-133, southwest of Fortin Lake above dark grey phyllite of the North American miogeocline. SEDEX-style mineralization may be the source of this high value.

The sixth highest concentration of zinc, 295 ppm, is derived from the Mink Creek drainage. The sample overlies black carbonaceous phyllite of the Fire Lake metavolcanic unit. These rocks may have a high background level in zinc, which could explain the high zinc level in till.

Copper

Copper concentrations range from 6 to 480 ppm with mean and median values of 48 ppm and 43 ppm, respectively. The four highest regional copper values, corresponding to values above the 98th percentile, are discussed below.

Orientation samples taken at Kudz Ze Kayah (KZK; 315-480 ppm) and Wolverine (247 ppm) contain the highest copper concentrations. A sample collected along the KZK road, approximately 10 km north of the deposit, yielded the highest copper value of the regional data (218 ppm). A bedrock source for this anomaly could lie to the east-southeast, probably within 2 km of the sampling site. The sample was collected from a relatively thin till unit and the local bedrock consists of lower Mississippian chlorite-muscovite phyllite. Rocks of the Wolverine succession lie approximately 3 km to the east.

The second highest regional copper value, 208 ppm, is from a sample collected in upper Big Campbell Creek, northeast of Riviera Lake. Sample JB01-040 was collected from a thin till deposit overlying Jurassic granite.

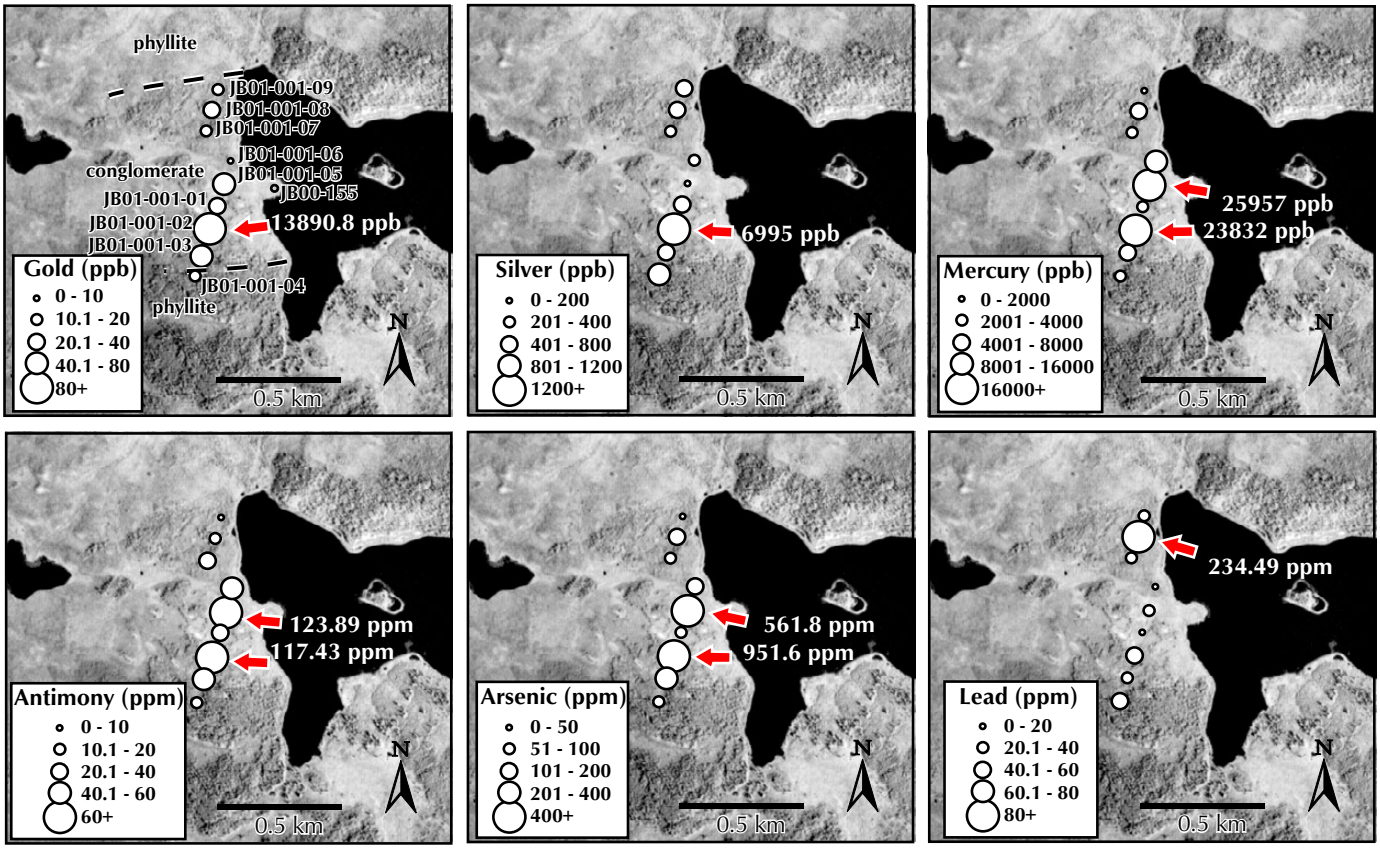

Figure 11. *Spice claims exploration till geochemical survey, overlaid on aerial photograph (northwest corner of 105G/13, see Figure 2).*

Ultramafic rocks in the area could be the source of copper in till.

The third highest regional copper value, 189 ppm, was obtained near Late Devonian ultramafic bedrock, within the Fire Lake metavolcanic unit. The sample JB01-028 also contains high cobalt and chromium values. Approximately 94% of the pebbles collected from the sample site are angular to subangular chloritic phyllite, suggesting a source within the metavolcanic unit.

Sample 01-PMA-178-01 yielded the fourth highest regional copper value of 145 ppm. The sample is derived from a basal till veneer located between two outcrops. A source for the anomaly could be proximal (within 2 km) to the east-southeast. The sample is located immediately down-ice of prospective Wolverine stratigraphy and also contains elevated cobalt (41 ppm), iron (8.75%), vanadium (255 ppm) and barium (1974 ppm) concentrations. This element suite may correspond to the baritic iron formation of the Wolverine succession.

Barium

Barium concentrations range from 76 to 2906 ppm with a mean value of 521 ppm and a median value of 476 ppm. The four highest values (>99th percentile) are discussed below.

The highest barium concentration, 2906 ppm, was collected from station JB00-064, in the northwest part of the study area. The sample was collected from a till blanket which contains some oxidized clasts and overlies Carboniferous phyllite, chert, sandstone and conglomerate. This sample also contains high copper (96 ppm), gold (12 ppb) and mercury (1062 ppb) levels. Platinum and palladium concentrations are 2 ppb and 5 ppb, respectively.

The second highest barium concentration, 2780 ppm, was collected southwest of Fortin Lake at station 01-PMA-139-01. The sample was collected from a till veneer that overlies chert of the Permian Mount Christie Formation. No other elements are anomalous in this sample.

The third highest barium concentration, 1974 ppm, was previously discussed under 'Copper' and is derived from sample 01-PMA-178-01.

The fourth highest barium concentration, 1893 ppm, is from sample JB00-147 collected in the northwest part of the study area. The area is underlain by Earn Group rocks, which could have potential for SEDEX mineralization. Station JB00-146, located 400 m to the southeast, also contains a high barium level (1562 ppm). No other elements were anomalous in these two samples.

Nickel/Chromium/Cobalt/Platinum/Palladium

Given the common association of high nickel, chromium and cobalt concentrations in bedrock (e.g., ultramafic rocks), these three elements will be discussed together. Notes on platinum and palladium are included as these elements generally occur in ultramafic rocks. Nickel concentrations range from 4 to 1015 ppm, with a mean value of 65 ppm and a median value of 51 ppm. Chromium concentrations range from 9 to 1073 ppm, with mean and median values of 52 ppm and 39 ppm, respectively. Cobalt concentrations range from 1 to 63 ppm, with a mean value of 14 ppm and a median value of 12 ppm. Five of the most significant multi-element anomalies are discussed below.

The highest concentrations for each of nickel, chromium and cobalt are derived from sample JB01-026 (Ni: 1015 ppm; Cr: 1073 ppm; Co: 63 ppm). The sample is located immediately down-ice from a Late Devonian ultramafic unit, southwest of Finlayson Lake. The underlying bedrock consists of the Fire Lake metavolcanic unit. Pebbles consist of 88% ultramafic rocks. Other elements are present in high concentration in this sample including gold (15 ppb), magnesium (7.06%) and boron (22 ppm). Copper, platinum and palladium levels are not anomalous in this sample.

Sample JB00-112 yielded high nickel (897 ppm), chromium (322 ppm) and cobalt (34 ppm) concentrations. The sample was collected above Campbell Range basalts. Numerous samples collected near JB00-112 also contain high nickel, chromium and cobalt values. Platinum and palladium values were at, or near, the detection limit (2 ppb) in this area. Gold values reached 13 ppb at station JB00-110, which is 1 km south of JB00-112.

Sample JB00-046 contained high chromium (368 ppm) and cobalt (43 ppm) concentrations, but only a moderately elevated nickel (132 ppm) level. This sample is located over Campbell Range basalts and likely reflects nearby ultramafic rocks. Other elements also present in elevated concentrations in these samples are vanadium (182 ppm), scandium (21 ppm) and gallium (18 ppm).

Sample JB01-149, located in the Mink Creek drainage, contains high nickel (199 ppm), chromium (191 ppm) and

cobalt (55 ppm) concentrations. This sample was collected from a till blanket that overlies highly altered, pyritic, felsic metavolcanic bedrock exposed along Mink Creek (Murphy et al., this volume). Chip samples from the outcrop assayed 835 ppm Cu, 3079 ppm As and up to 163 ppb Au. JB01-149 also contains elevated arsenic (386 ppm) and moderately elevated copper (88 ppm) values. The topography of this area is very flat and blanketed by glacial meltout deposits. This sample was collected from a stratigraphically lower level in the till unit. Samples collected stratigraphically higher in the till would most likely reflect distal sources.

Sample 01-PMA-083-01, located on the Kudz Ze Kayah road about 8 km north of the deposit, contains the following concentrations: nickel 179 ppm, chromium 341 ppm, and cobalt 43 ppm. The sample was collected from a till veneer containing angular and subangular clasts, which suggests a relatively nearby source for the anomalies. The underlying bedrock consists of phyllite and schist of the Kudz Ze Kayah felsic metavolcanic unit. Carbonaceous phyllite and quartzite of the Grass Lakes succession lie to the east (up-ice).

Gold

As indicated in the methodology section, gold concentrations were determined by ICP-MS analyses but some re-analyses were conducted by fire assay for comparison purposes. The mean and median concentrations of gold are 5 ppb and 3 ppb, respectively. Values ranged from 0.4 to 153 ppb for the 489 samples analysed. Discussion will also include results from the exploration survey completed at the Spice claims. The four highest gold values are discussed below.

The highest concentration of gold, 153 ppb, was recorded about 2.5 km south of the Kudz Ze Kayah deposit. The sample was collected at station 01-PMA-045-01 from a colluvial apron on the valley side. The colluvium consists of both local bedrock fragments and till. Ice flow in this valley was to the north, so a source for this anomaly would lie up-slope and to the south. The bedrock in the area consists of granite of the early Mississippian Grass Lakes plutonic suite. This anomaly suggests potential for intrusive-hosted gold in the Mississippian granite of the Finlayson Lake district.

The second highest regional gold anomaly, 41 ppb, was collected at station 01-PMA-075-01, approximately 10 km southeast of the confluence of the Hoole and the Pelly rivers. The sample is derived from a till veneer collected on a small outcrop, suggesting a proximal bedrock source for the anomaly. The underlying bedrock consists of the early Mississippian granite with augen texture.

The third highest regional gold anomaly, 39 ppb, was collected at station JB01-073. This sample is located near the margin of the same granite mentioned in the previous anomaly, and is less than 1 km east of the Robert Campbell Highway. A till blanket covers the area, and meltout deposits are widespread in surrounding low areas. A duplicate sample was also collected at this station and returned a gold value of 5 ppb. Such a large difference between both analyses is related to the well-known nugget effect, that is, the heterogeneous distribution of gold in till.

The fourth highest regional gold anomaly, 28 ppb, was collected during the 2000 field season at station JB00-155. The sample was taken from a mudflow-like deposit on a small peninsula of a lake. The soil at the site was highly iron-oxidized. Numerous other elements are anomalous at this site including arsenic (485 ppm), antimony (151 ppm), mercury (21,020 ppb), thallium (1 ppm) and silver (1374 ppb). Most notable is the extremely high mercury concentration. As suggested by Bond (2001b), such elemental association could be indicative of gold epithermal mineralization. The area was staked early in 2001 as the Spice claims by Tanana Exploration. As part of a follow-up survey, nine samples were taken in 2001 along a north transect that appears to crosscut a bedrock structure (Fig. 11). The line traversed across, from south to north, Carboniferous dark grey phyllite, into Permian conglomerate, and back into dark grey phyllite. All samples have a high mercury concentration, with the highest reaching 25,957 ppb. A significant multi-element anomaly is present at JB01-001-02 (Fig. 11) including gold (13,891 ppb), silver (6995 ppb), arsenic (952 ppm), antimony (117 ppm) and mercury (23,832 ppb). Re-analysis of the remaining pulp by fire assay, as well as ICP-MS assays on the –230 mesh and -80 mesh from the sample split, confirmed the anomaly with nearly identical gold values. Angular pebbles of grey quartz with breccia fragments and hair-like black veinlets, collected from the till pit, gave a gold concentration of 1.05 g/t. Given the thin till cover and the abundance of angular bedrock fragments in till at this site, the source of the anomaly is likely proximal, possibly within 50 m of the sample site.

Silver

Silver concentrations ranged from 14 to 5387 ppb with a mean concentration of 305 ppb and a median concentration of 221 ppb. The four highest regional values are discussed below.

The highest silver values were obtained from the orientation survey at Kudz Ze Kayah (5387 ppb). The highest regional values, 2980 ppb and 2582 ppb, were obtained from stations 01-PMA-177-01 and 01-PMA-176-01, down-ice of the Wolverine succession rocks, northwest of Wolverine Lake. These samples also contain high concentrations of lead, gold, antimony, mercury and selenium.

The second highest regional silver value was collected at the Spice claims (JB00-155). See discussions under the 'Gold' section for follow-up sampling completed at this location.

The third highest regional silver value, 1243 ppb, was collected southwest of Fortin Lake at station JB01-135. The underlying bedrock consists of Permian chert and upper Triassic dark grey phyllite.

The fourth highest regional silver value, 1153 ppb, was collected at station JB00-076. The sample was collected from a till blanket exposed along a creek cut. The sample site is near the contact between Carboniferous dark grey phyllite and early Permian Campbell Range basalt. Zinc (172 ppm) and mercury (988 ppb) are also elevated in this sample.

Arsenic

The concentration of arsenic ranged from 2 to 485 ppm, with mean and median concentrations of 21 ppm and 15 ppm, respectively. Stations with the four highest arsenic concentrations are discussed below.

The highest arsenic concentration from the regional data, 485 ppm, was collected from the Spice claims or regional station JB00-155 (Fig. 11). The geochemistry of this station was discussed previously under the 'Gold' section.

The second highest arsenic concentration in till, 386 ppm, was found at station JB01-149. This station was also discussed earlier for its anomalous nickel, chromium and cobalt values.

The third highest regional arsenic value, 230 ppm, was collected at station 01-PMA-185-01, located along Mink Creek, immediately south of the Robert Campbell Highway. The sample was collected from a thick till unit exposed on a stream cut. The underlying bedrock consists of early Mississippian granite of the Grass Lakes plutonic suite. No other elements are anomalous at this station.

The fourth highest regional arsenic value, 96 ppm, was collected south of the Wolverine deposit at station 01-PMA-169-01. This sample was discussed earlier for its high lead concentration.

CONCLUSIONS

The northern sector of the Finlayson Lake map area lies within the influence of the Late Wisconsinan McConnell Glaciation. At the onset of the glaciation, ice advanced from the Pelly and Selwyn mountains. Local ice-marginal ponding occurred in tributary valleys. At glacial maximum, the highest peaks were glaciated and ice flow maintained a general west-northwest trajectory, with only minor deviations across isolated highlands. Jackson (1994) indicated that deglaciation was marked by a rapid raise in the firn line. The last ice mass to disappear was located in the Finlayson and Wolverine lake areas.

Massive sulphide mineralization at KZK is well reflected in till with strong enrichment of lead, zinc, silver and gold down-ice (north) of the deposit. In addition, high base-metal concentrations in till near Fault Creek, and a high gold value almost 3 km south of the deposit might be related to concealed bedrock mineralization.

Data from the 2000 and 2001 regional till geochemistry surveys highlighted elevated concentrations of gold and base metals. High base-metal concentrations were identified northwest of Wolverine Lake, on the Spice claims, between Big Campbell Creek and Mink Creek, and west of Fortin Creek. High gold values were identified over Mississippian granite 10 km southeast of the confluence of the Hoole and the Pelly rivers, and results of the follow-up survey over the Spice claims define a multi-element gold anomaly characterized by gold concentrations reaching 13,891 ppb in till.

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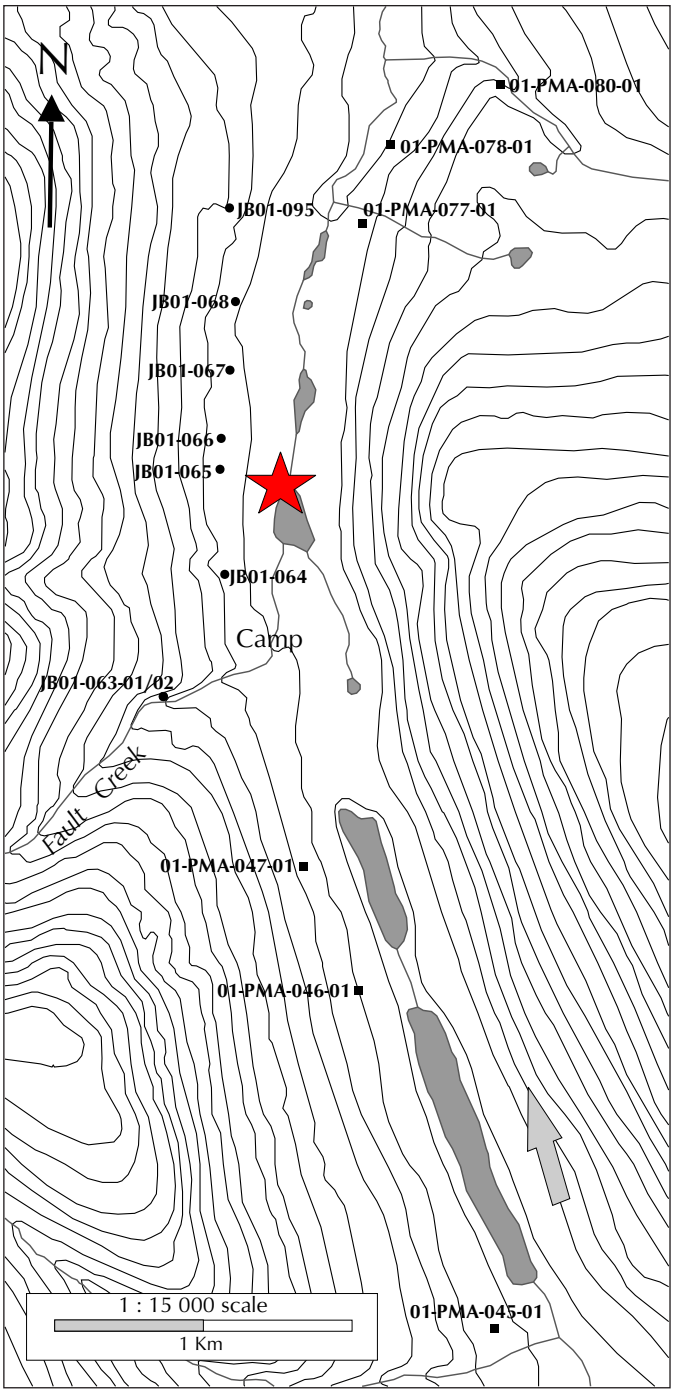
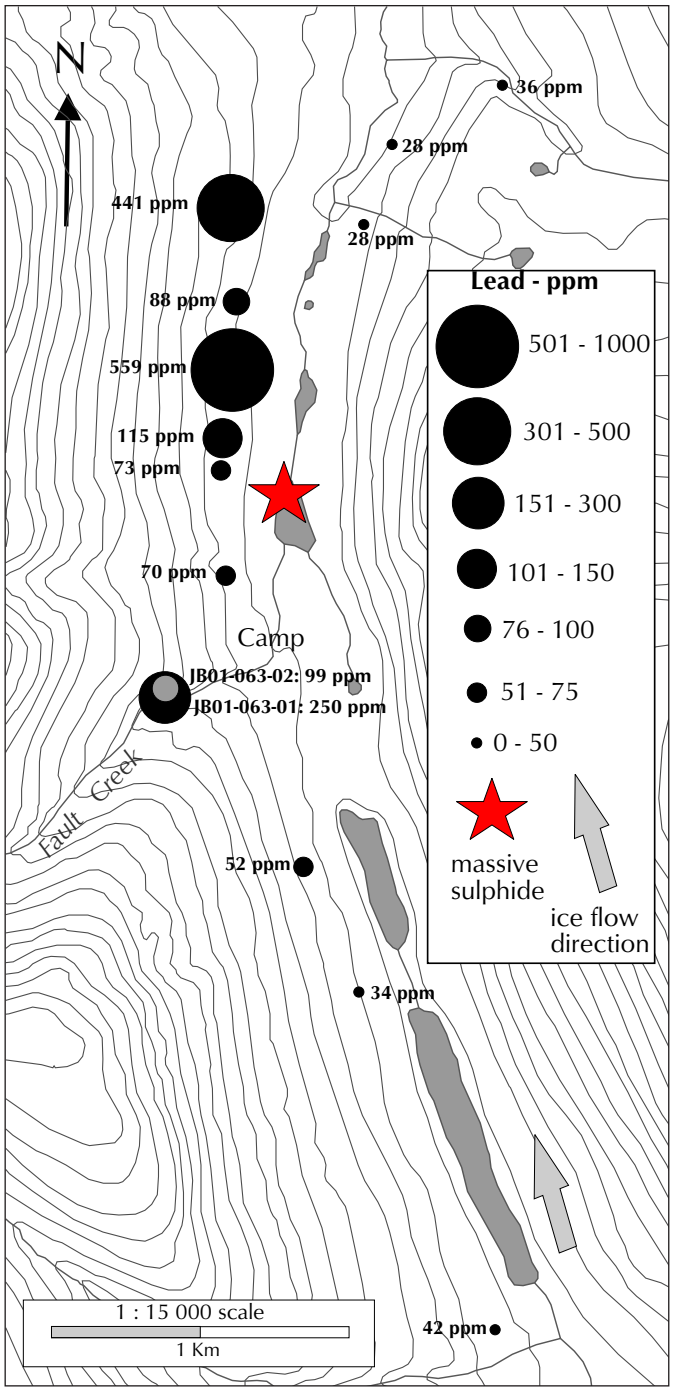
APPENDIX 1. Kudz Ze Kayah orientation till geochemistry

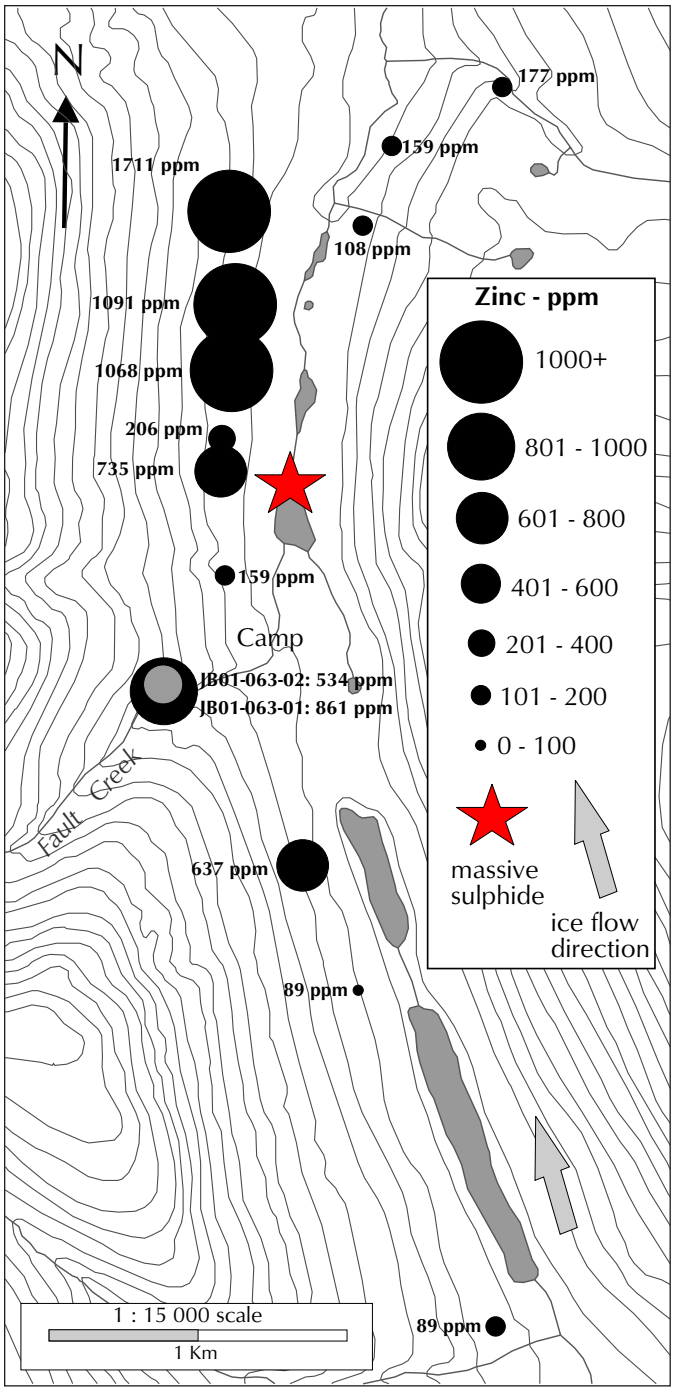


Till sample locations, Kudz Ze Kayah – 2001

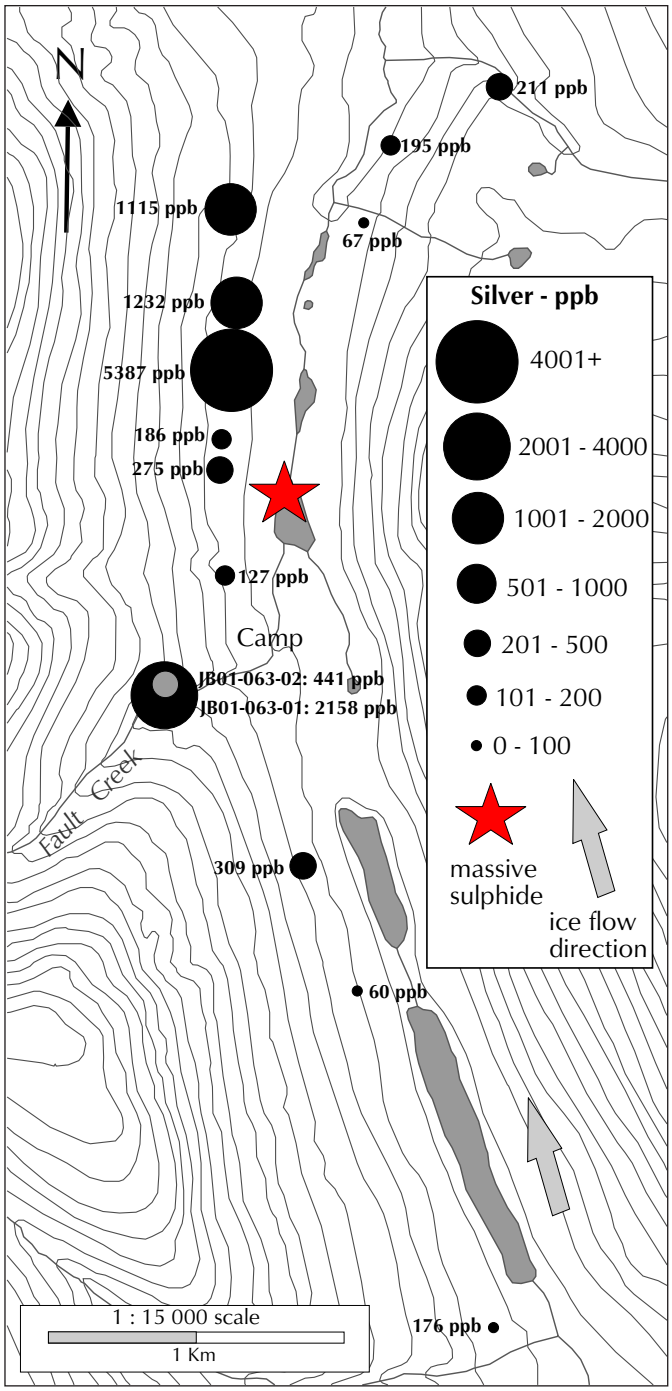


Lead

APPENDIX 1. Kudz Ze Kayah orientation till geochemistry (continued)

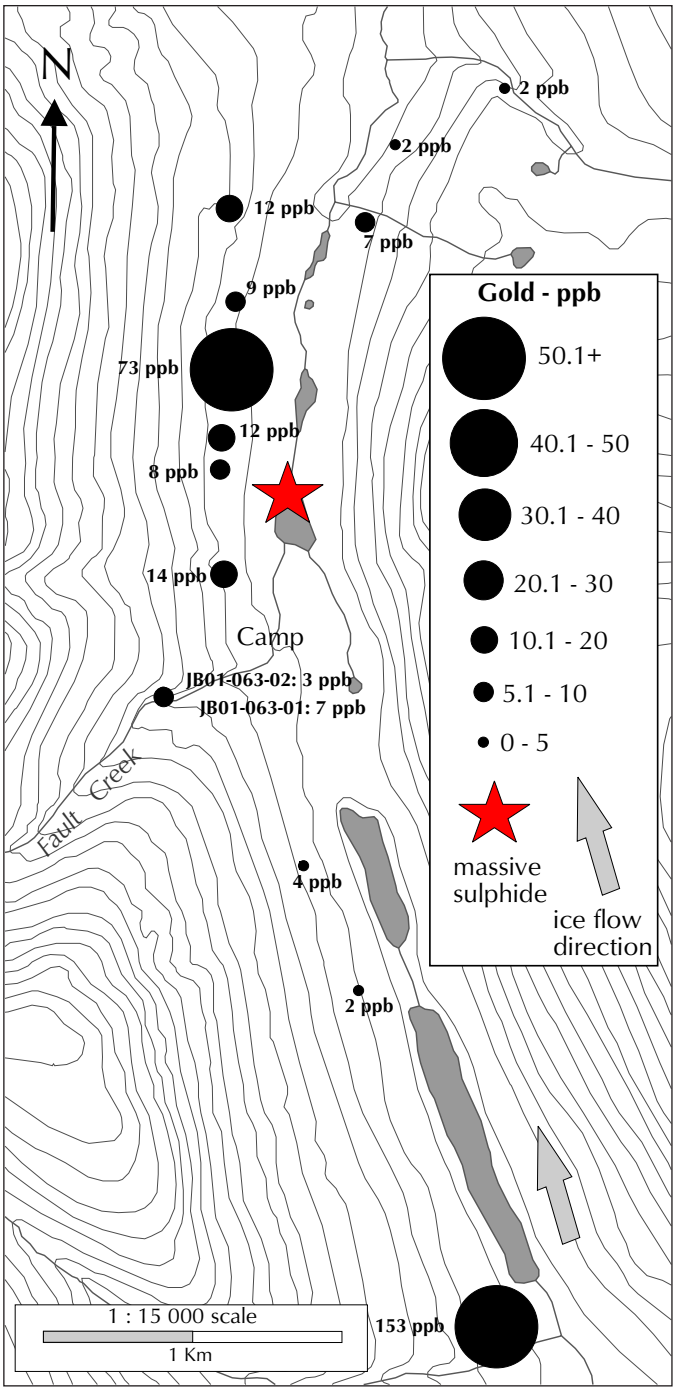


Zinc



Silver

APPENDIX 1. Kudz Ze Kayah orientation till geochemistry (continued)



Gold