

# Update on the Minto deposit (Yukon MINFILE 1151021, 022)

*Patrick J. Sack\**  
Yukon Geological Survey

*Roisin Kerr and Douglas McIlveen*  
Capstone Mining Corp., Minto Mine

Sack, P.J., Kerr, R. and McIlveen, D., 2017. Update on the Minto deposit (Yukon MINFILE 1151021, 022). *In: Yukon Exploration and Geology Overview 2016*, K.E. MacFarlane (ed.), Yukon Geological Survey, p. 75-87, plus digital appendices.

## **ABSTRACT**

The Minto property is located in central Yukon, 75 km northwest of the village of Carmacks. Copper-gold-silver mineralization was discovered on the property in 1971 and the mine has been in continuous production since 2007. The deposits are hosted by the Minto pluton, a Late Triassic to Early Jurassic granitoid that is one of many plutons of similar age which extend the length of the northern Cordillera. Mineralization at Minto is hosted in a variety of foliated rocks with individual bodies up to tens of metres thick and one kilometre laterally. The origin of these foliated bodies is enigmatic. They are typically high-grade (>1% Cu) with sulphides ranging in form from disseminated or foliaform lenses through to semi-massive or massive lenses. Primary hypogene ore minerals are chalcopyrite, bornite, and euhedral chalcocite with minor pyrite; less abundant ore minerals include covellite, silver, native gold and electrum.

\* [patrick.sack@gov.yk.ca](mailto:patrick.sack@gov.yk.ca)

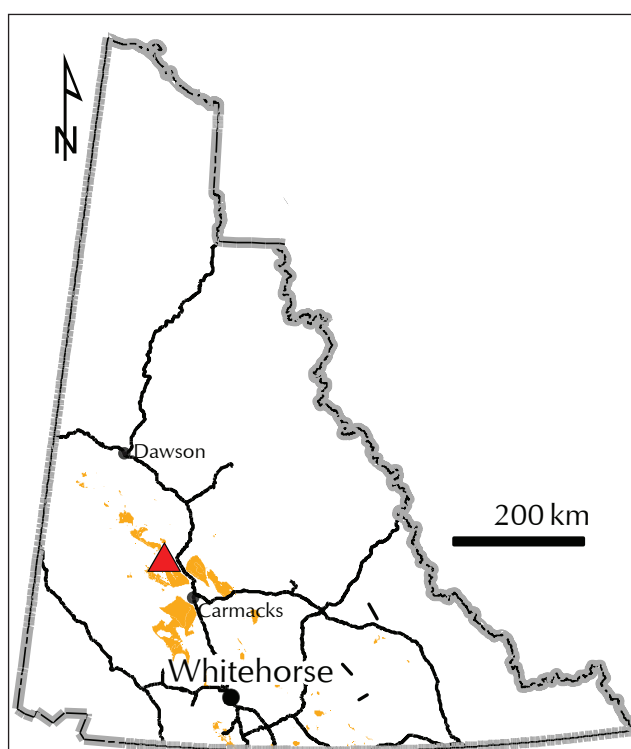
## INTRODUCTION

The Minto copper-gold-silver (Cu-Au-Ag) mine has a global resource of more than 725 000 tonnes of copper (Table 1) in several deposits and is located in central Yukon, 75 km northwest of the village of Carmacks (Fig. 1). The mine is accessed via the Klondike Highway to a seasonal barge across the Yukon River and then via a private 27 km road to the mine site. Mineralization on the property was discovered in 1971 and the mine has been in continuous production since 2007. Since the mid-1990s, core from 18 diamond drill holes has been donated to the Yukon Geological Survey (YGS) core collection, which is housed at the H.S. Bostock Core Library. In 2016, core from three additional diamond drill holes was donated by Capstone Mining Corporation, owners and operators of the Minto mine, to ensure a robust set of core from the Minto property is available to the geologic community. In addition to the donation of core, Capstone provided associated data (e.g., drill logs, assays, collar coordinates etc.) for all Minto holes in the YGS collection. This additional data enables the YGS to put each Minto diamond drill hole in the collection into a consistent and complete geologic context.

The addition of the new Minto core to the YGS collection coincides with the final stages of a collaborative research project between the YGS, University of British Columbia Mineral Deposit Research Unit (MDRU) and the Geological Survey of Canada (GSC). The project was initiated to investigate the regional metallogenic and petrogenetic character of Late Triassic to Jurassic plutonic rocks of the Intermontane terranes in Yukon. In the northern Cordillera, the Intermontane terranes (Yukon-Tanana, Stikinia, Quesnellia and Cache Creek) are host to a large number of low-grade, bulk-tonnage copper deposits. Most of these deposits are well understood Late Triassic to Early Jurassic porphyry deposits in British

Columbia (Logan and Mihalynuk, 2014). In Yukon, coeval plutonic rocks also host copper (gold±silver) mineralization, such as that seen on the Minto property, but the deposits are typically high-grade and relatively small tonnage, of ambiguous origin and thus significantly different to those in British Columbia.

The present contribution provides an update on the regional context for the Minto deposits, outlines the main geologic characteristics of the deposits, and puts the core in the YGS core collection into a consistent deposit context. The donated Minto core and associated data will provide a lasting resource for future geologists to learn about this intriguing deposit.



**Figure 1.** Location of Minto property shown by red triangle. Late Triassic to Jurassic plutons shown in orange, main highways in black.

**Table 1.** Global Minto resource recalculated from Mercer and Sagman (2012) for Minto South, Ridgetop, Minto North and Minto East deposits (their Tables 1-2 through 1-5 respectively). Minto Main deposit estimate is from SRK (2008; their Table 1-5, Dec. 2007 Model). The Dec. 2007 model, was done after approximately 6 months of mining and doesn't include mined out material; it is considered a slight underestimate. A cut-off grade of 0.5% Cu was used for each estimate. M&I=Measured & Indicated.

	Tonnes	Cu (%)	Au (ppm)	Ag (ppm)	Cu (lbs)	Cu (tonnes)	Au (oz)	Au (tonnes)	Ag (oz)	Ag (tonnes)
<b>Total M&amp;I</b>	54 513 000	1.21	0.45	4.4	1,449,715,364	657,579.29	771,233	21.9	7,696,197	218.2
<b>Total Inferred</b>	8 491 000	0.81	0.24	2.9	151,741,000	68,828.50	64,300	1.8	787,000	22.3
<b>Global Resource (M&amp;I plus Inf)</b>	63 004 000	1.15	0.42	4.2	1,601,456,364	726,407.80	835,533	23.7	8,483,197	240.5

## EXPLORATION AND MINING HISTORY

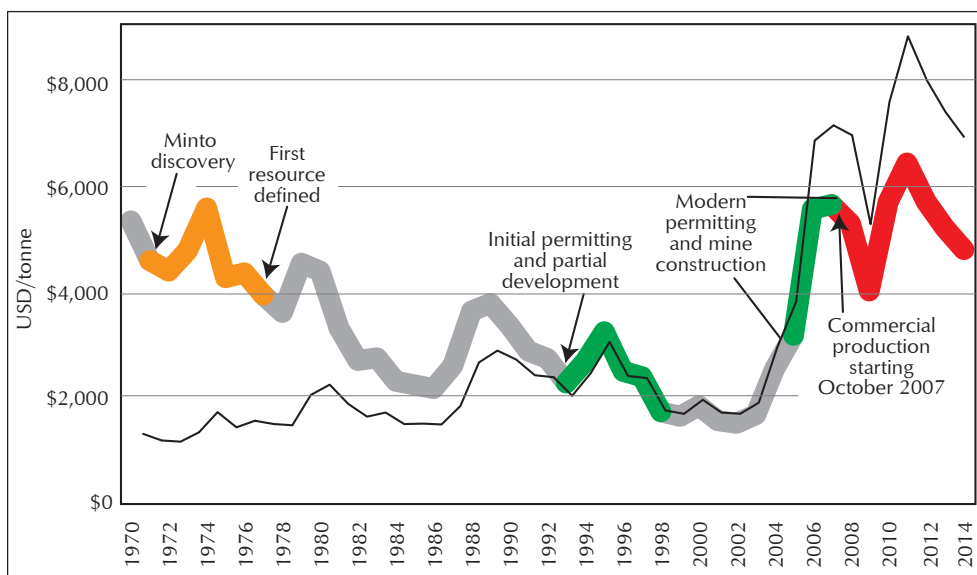
The initial Minto portion of the current claim package was staked by the Dawson Syndicate (Silver Standard Mines Ltd. and Asarco) in 1971 based on anomalous results of a regional stream sediment geochemical program shortly after the discovery of the Williams Creek, now Carmacks Copper, deposit (Yukon MINFILE 1151008). In 1973, United Keno Explorations discovered mineralization on the adjoining DEF claims, and between 1973 and 1977 exploration was mostly a joint venture between the Dawson Syndicate and United Keno Explorations. In 1977, the results of a joint feasibility study were released and cited Main zone reserves (pre-NI 43-101) of 6 550 748 t grading 1.86% Cu, 0.51 g/t Au and 6.86 g/t Ag. This initial economic study was released as copper values were declining (Fig. 2), consequently, work on the Minto/DEF claim package was suspended until the early 1990s. Various corporate activities and exchanges resulted in all of the claims being owned by Minto Explorations Inc., a company created specifically to acquire and develop the Minto property.

Beginning in 1994, Minto Explorations performed engineering and geotechnical studies to support a feasibility study and to begin the process of acquiring various environmental permits required for mining and production. Minto Explorations also calculated an initial

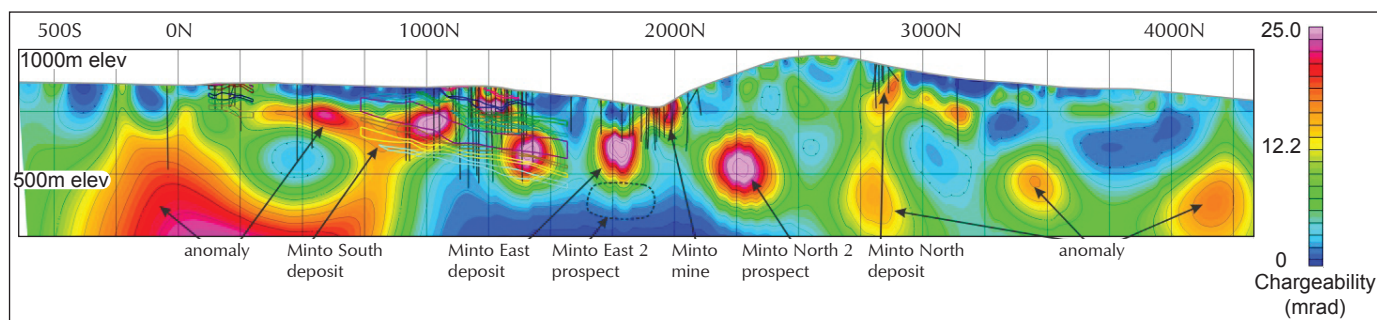
*in situ* geological reserve (also pre-NI 43-101) for the property using a cut-off grade of 0.5% Cu. The company reported 8 818 000 tonnes grading 1.72% Cu, 0.48 g/t Au and 7.5 g/t Ag (Yukon MINFILE, 2016). Between 1995 and 1998, company efforts were largely directed towards putting the previously defined resource into production. Some exploration, mostly on the fringe of the existing deposit, was conducted throughout this period. By 1998, the value of copper was approaching a 40 year low (Fig. 2) and operations were again suspended.

In early 2005, Sherwood Mining Corp. took over Minto Explorations and within five months released the first NI 43-101 resource for the property at 8 340 000 t grading 1.83% Cu, 0.55 g/t Au and 7.95 g/t Ag in the measured and indicated categories, with a further 700 000 tonnes grading 1.41% Cu, 0.45 g/t Au and 6.0 g/t Ag in the inferred category (Giroux, 2005). All major permits were received by June 2006, with pre-stripping of the Main zone and mill construction occurring in the latter half of the year. In early 2007, Sherwood Copper completed the mill and pre-stripping of the Minto Main deposit. The first copper-gold concentrates were produced on May 1, 2007 and the first load of concentrates were delivered to the port of Skagway, Alaska on July 16, 2007. On October 1, 2007 commercial production was announced. The discovery of mineralization in Area 2 in early 2006 demonstrated the property potential, and between 2006

and 2011, nine zones of Cu-Au-Ag mineralization were discovered, including the Minto South (made up of earlier Area 2, Area 118, Wildfire and Copper Keel discoveries), Ridgetop, Minto East, Minto North and Minto North 2 deposits. Significant exploration potential, particularly for deeper resources, remains on the property (Fig. 3).



**Figure 2.** Historical value of copper. Thick line shows historical average annual copper price in 1998 constant U.S. dollars per tonne with coloured segments indicating periods of activity on the Minto property. Thin black line shows copper price in dollars of the day per tonne. Data for both lines from Kelly and Matos (2014). Annotated milestones for Minto property based on Yukon MINFILE, accessed November 25, 2016.



**Figure 3.** Titan-24 survey Line 3. Smooth IP chargeability from DC resistivity reference, Line 3 shown by bold line on Figure 5 (Mercer and Sagman, 2012). Note correspondence of high chargeability anomalies with known deposits.

## GEOLOGY

### REGIONAL GEOLOGY

The Minto pluton is one of a series of Late Triassic to Jurassic plutons that occur along the length of the northern Cordillera (Fig. 4). These plutons are associated with two paired magmatic arcs preserved as the Quesnellia and Stikinia terranes (Fig. 4; Logan and Mihalynuk, 2014). In Yukon, these Late Triassic to Jurassic plutons are mostly located at, or near, the contact between the Paleozoic Yukon-Tanana terrane and late Paleozoic to Mesozoic Stikinia/Quesnellia terranes (Fig. 4). The plutons can be divided into five suites, from oldest to youngest these are Late Triassic Stikine Suite, latest Triassic to Early Jurassic Minto suite, Early Jurassic Long Lake Suite, Middle Jurassic Bryde suite, and Middle to Late Jurassic McGregor suite (Colpron *et al.*, 2016; Joyce *et al.*, 2016; Woodsworth *et al.*, 1991).

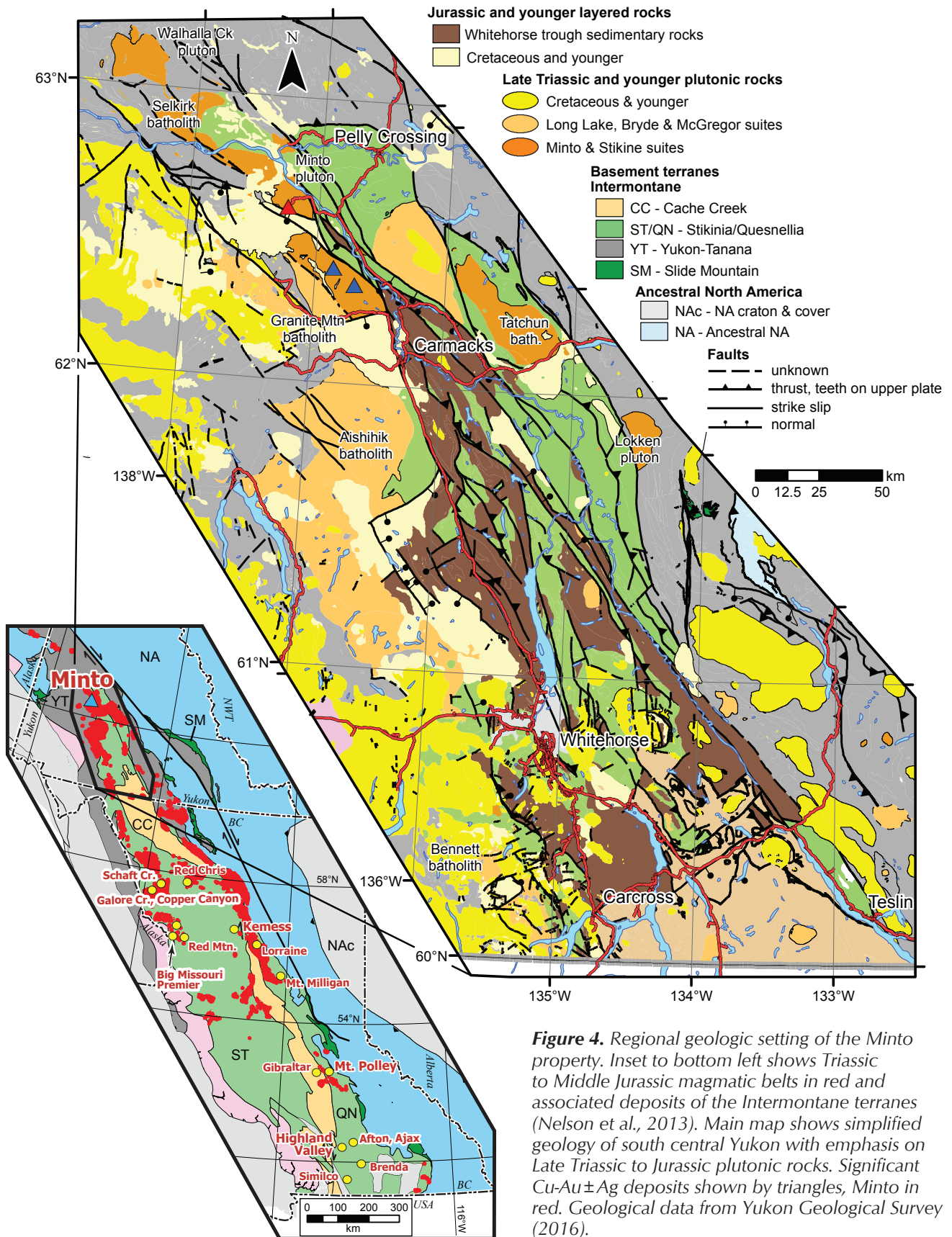
The Minto property is located in the centre of the Carmacks map area (NTS 115I) within the Carmacks copper belt of west-central Yukon. This mineralized belt is made up of several similar Cu-Au±Ag mineral occurrences hosted by the Minto suite. Occurrences similar to those at the Minto property include the Carmacks Copper deposit, and the Stu prospect (Yukon MINFILE 115I011), restricting known mineralization to the Granite Mountain batholith and Minto pluton. The Minto suite includes other plutonic bodies such as the Tatchun and Selkirk batholiths that may have potential to host similar mineralization (Fig. 4; Topham *et al.*, 2016).

The Minto pluton is interpreted to be part of the Minto suite (e.g., Colpron *et al.*, 2016), which is broadly intermediate (granodioritic) in composition. Based on the modal mineralogy QAP based classification of Le Bas and Streckeisen (1991), the Minto suite varies between

granite, monzonite to monzodiorite, granodiorite and tonalite. Major and trace element contents are typical of calc-alkaline volcanic arc granite. Magnetic susceptibility measurements from outcrop are  $\geq 1 \times 10^{-3}$  SI units indicating most Minto suite plutons are weakly oxidized to oxidized magnetite series, though a few plutons have values  $< 1$  indicating locally they can be reduced ilmenite series (Ishihara, 1977). The range of U-Pb zircon ages from samples of the Minto suite is approximately 204 Ma to 194 Ma, straddling the Late Triassic to Early Jurassic boundary. Emplacement depths ranging from 30 to 20 km ( $7.2 \pm 1.0$  to  $6.4 \pm 0.8$  kbar, respectively) have been calculated for several plutons of the Minto suite using the aluminum-in-hornblende geothermobarometer (McCausland *et al.*, 2002; Tafti, 2005; Topham *et al.*, 2016).

### PROPERTY GEOLOGY

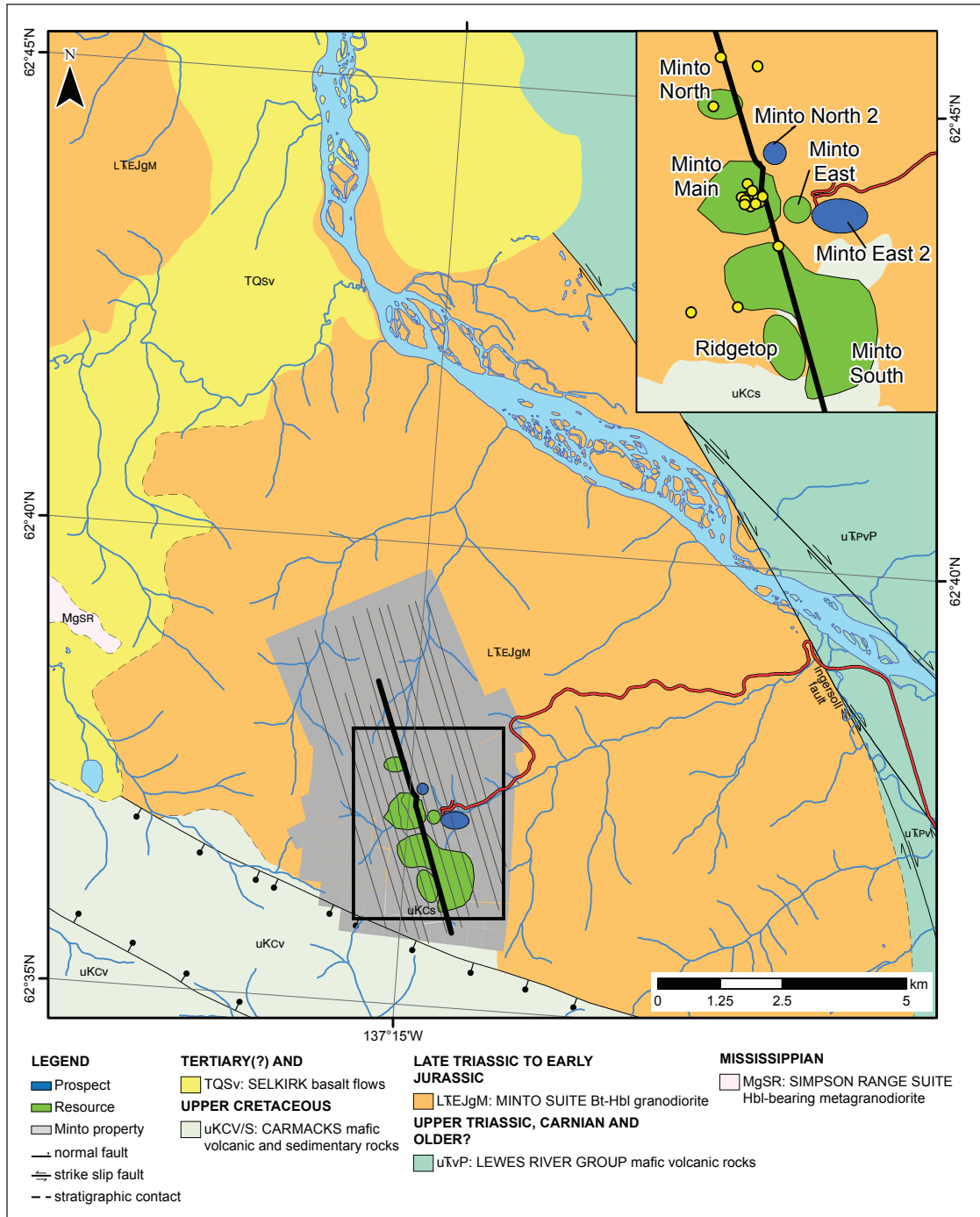
The Minto pluton has an exposed surface area of 170 km<sup>2</sup>; the local geology of the area is shown in Figure 5. The Minto pluton intrudes the Late Triassic augite-phyric basalt of the Stikine terrane (Lewes River Group) to the east and north, and presumably the Late Devonian-Early Mississippian metaplutonic rocks of Yukon-Tanana terrane (Simpson Range plutonic suite) to the west (Tempelman-Kluit, 1984). The contact between the Minto pluton and Yukon-Tanana rocks is covered by younger rocks of the Carmacks and Selkirk Volcanic groups, and so the exact nature of that contact is unknown (Fig. 5). The northern end of the Minto pluton is covered by Pliocene and younger basalt flows of the Selkirk Volcanic Group (Tempelman-Kluit, 1984). The eastern margin of the Minto pluton is locally faulted against rocks of the Lewes River Group by the dextral Ingersoll fault (Tempelman-Kluit, 1984). The southern margin of the Minto pluton is overlain by volcanic and sedimentary rocks of the



**Figure 4.** Regional geologic setting of the Minto property. Inset to bottom left shows Triassic to Middle Jurassic magmatic belts in red and associated deposits of the Intermontane terranes (Nelson et al., 2013). Main map shows simplified geology of south central Yukon with emphasis on Late Triassic to Jurassic plutonic rocks. Significant Cu-Au ± Ag deposits shown by triangles, Minto in red. Geological data from Yukon Geological Survey (2016).

Cretaceous Carmacks Group, and is defined by an unnamed normal fault (Tempelman-Kluit, 1984). The Cretaceous Carmacks Group unconformably overlies the Minto pluton, as demonstrated locally by a clast-supported cobble to boulder conglomerate that includes clasts of

mineralized Minto lithologies (Hood, 2012). The Minto pluton may link to the south, under Carmacks Group cover, with the Granite Mountain batholith and to the northwest, under the Selkirk Volcanic Group cover, with the Selkirk batholith.



**Figure 5.** Simplified geology on the Minto property. Top right inset map shows location of deposits and prospects on the Minto property with collar location of diamond drill holes in the YGS collection shown as yellow circle. Titan-24 geophysical survey lines from 2009 and 2010 are on the Minto property (light grey) and oriented north-northwest; Line 3, shown as a pseudo-section in Figure 3, is bold.

## DEPOSIT GEOLOGY

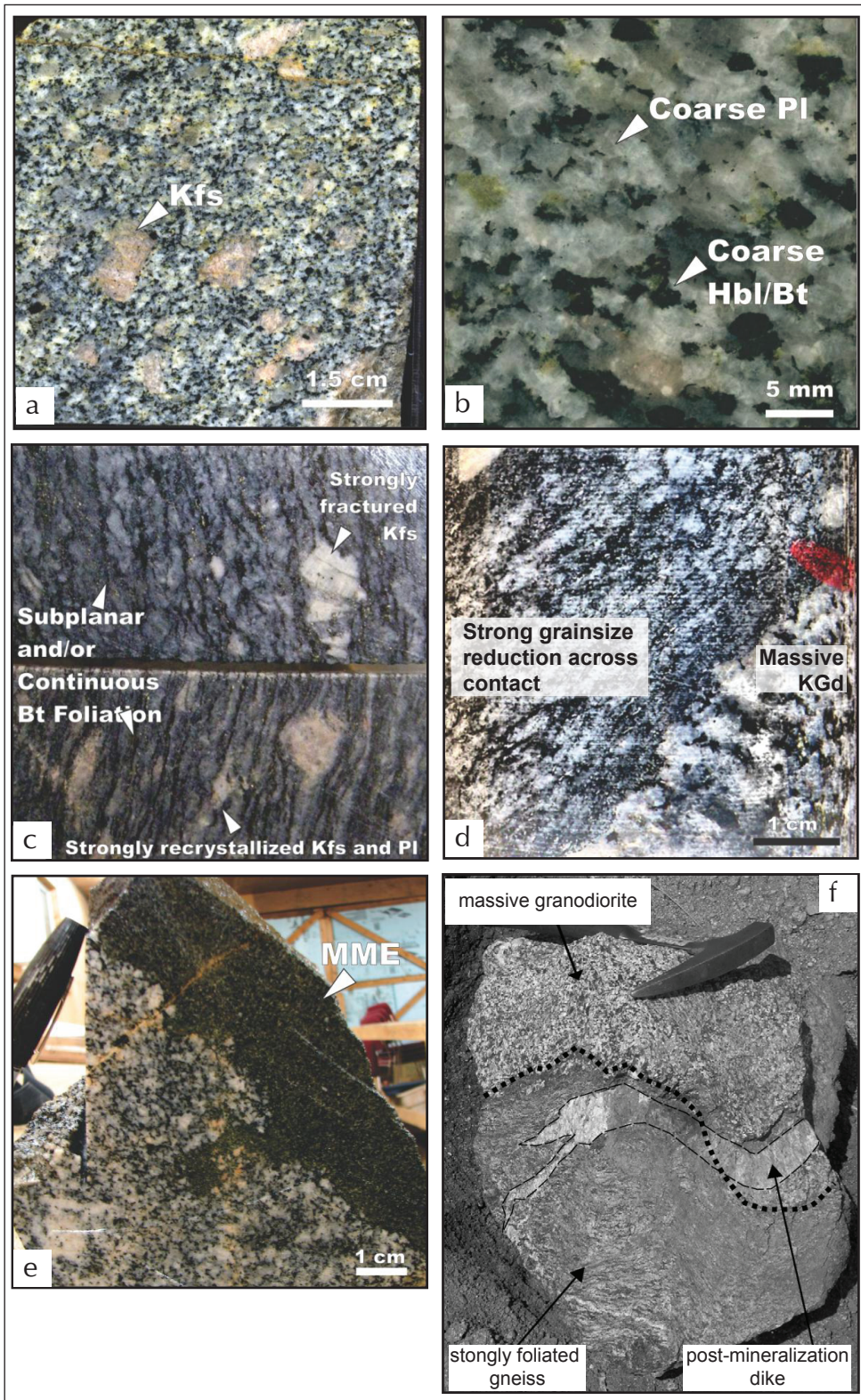
The Minto deposits are hosted within the Minto pluton, a relatively simple intrusive body mainly composed of medium to coarse-grained, K-feldspar phyric to equigranular, unfoliated granodiorite (Hood, 2012; Tafti, 2005). The orebodies are associated with foliated rocks. At various times since discovery, the deposit type for Minto has been interpreted as porphyry copper, volcanogenic massive sulphide (VMS), redbed copper, magnetite skarn (Pearson and Clark, 1979) or iron oxide copper gold (IOCG; Mercer and Sagman, 2012). The range of deposit styles in the literature is likely because workers have ascribed different interpretations to similar observations based on their background and the popular models of the day (Mercer and Sagman, 2012). Early descriptions of the foliated rocks were interpreted to represent various stages of digestion of previously foliated rocks (Pearson and Clark, 1979). More recent interpretations suggest foliated rocks represent various stages of deformation of the same unit, likely the Minto pluton granodiorite (Hood, 2012). In this contribution, we will focus on descriptive aspects and not on interpreted genesis of lithologies.

Granodiorite (Fig. 6a) is the dominant rock type of the Minto pluton. The actual composition and texture varies from crowded K-feldspar megacrystic syenite to equigranular tonalite or quartz diorite (Hood, 2012), similar to the range seen regionally within the Minto suite. In general, the granodiorite contains approximately 30 to 50% plagioclase, 10 to 50% K-feldspar, 20 to 25% quartz, and total biotite ± hornblende 10 to 15% (Hood, 2012). Accessory minerals include magnetite, epidote, titanite, apatite, and zircon, all of which have sharp euhedral crystal faces in thin section (Hood, 2012). K-feldspar occurs most commonly as phenocrysts 1 to 3 cm long, with inclusions of biotite, plagioclase, hornblende, epidote, and zircon commonly along growth zones (Hood, 2012). Compositions tending to tonalite or diorite (Fig. 6b) are generally slightly coarser grained and typically contain anhedral K-feldspar as well as plagioclase that occurs both as euhedral crystals up to 1 cm in length and anhedral equigranular crystals that are evenly distributed (Hood, 2012). Quartz forms anhedral masses interstitial to feldspar, but locally forms glomeroporphyritic masses up to 1 cm in diameter. Biotite and hornblende are the most common mafic minerals; they are typically <1 cm, and comprise up to 15% of the granodiorite (Hood, 2012). Both magmatic epidote and secondary epidote are present; magmatic epidote has sharp euhedral boundaries

with mafic phases and growth zoning (as described by Zen and Hammarstrom, 1984). The age of the Minto pluton is best constrained by U-Pb zircon ages from Hood (2012) that range from  $197.6 \pm 1.6$  Ma to  $200.1 \pm 1.1$  Ma.

Deformed rocks vary from moderately to strongly foliated and recrystallized (Fig. 6c,d) with mafic content up to 80% (Fig. 6e; Tafti, 2005). Foliated rocks consist of alternating mafic and felsic layers. Mafic layers are millimetres to centimetres thick and consist of moderately aligned biotite, hornblende, epidote, magnetite, and titanite separated by thicker felsic layers that are centimetres to tens of centimetres and composed of medium to coarse-grained quartz and plagioclase with lesser amounts of biotite, hornblende, epidote, magnetite and titanite (Hood, 2012). Foliated rocks contain most of the sulphides at the Minto deposits, and individual bodies are up to tens of metres thick. Higher grade ore tends to occur with thicker layered, coarser grained and more siliceous lithologies while lower grade ore is often associated with thin, discontinuous layering and mafic rocks (Fig. 7a-c; Mercer and Sagman, 2012). Contacts between foliated and unfoliated rocks are typically sharp, marked by rapid grain-size change (Fig. 6d,e). Locally, k-feldspar phenocrysts from unfoliated granodiorite impinge on foliation suggesting the contacts are, at least locally, intrusive in nature (Hood, 2012). Individual foliation planes or mafic-felsic bands vary from regular to irregular in orientation, often at a high angle to contacts with unfoliated rocks (Mercer and Sagman, 2012). Despite the internal variation, the zones of foliated rock form consistently subhorizontal horizons that can be traced laterally for more than one kilometre in diamond drill core. The zones are often stacked in parallel to subparallel sequences (Mercer and Sagman, 2012).

Four types of relatively late, volumetrically insignificant dikes crosscut the Minto pluton; from youngest to oldest these are (i) hornblende diorite dikes, (ii) andesite dikes, (iii) aplite dikes, and (iv) granitoid pegmatite (Hood, 2012). The hornblende diorite dikes are unaltered, undeformed and likely related to the Selkirk mafic volcanic rocks found to the north of the deposit. The andesite dikes are similarly undeformed but can be locally altered and are likely related to the volcanic rocks of the Carmacks Group. The aplite and pegmatite dikes (Fig. 8) are mutually crosscutting suggesting a similar age for both; a pegmatite dike dated at  $195.5 \pm 0.7$  Ma by Tafti (2005) indicates they are essentially coeval with crystallization of the Minto pluton.



**Figure 6.** Lithologies on the Minto property. **(a)** Granodiorite is the most common host rock and is typically medium-grained granodiorite with centimetre-scale K-feldspar phenocrysts. Kfs=K-feldspar. Sample S09-13-03A. **(b)** The other common host lithology is less potassic and coarser grained tonalite (Tlt) which contains plagioclase (Pl) and euhedral hornblende (Hbl) and biotite (Bt) that are typically >5mm long. **(c)** Moderately deformed and recrystallized gneiss is the most common foliated unit at Minto. **(d)** Strongly deformed gneiss in contact with undeformed granodiorite (KGd), contact defined by an abrupt reduction in grain size. Very fine grained chalcopyrite and magnetite are present in the gneiss but not in the incipiently deformed rock. **(e)** Mafic-rich schist (MME) sharing irregular boundary with granodiorite, suggesting granodiorite engulfed the mafic-rich schist. **(f)** Contact between a well-foliated gneiss and massive KGd with a small crosscutting dike. (a - e) from Hood (2012); (f) from Tafti and Mortensen (2004).

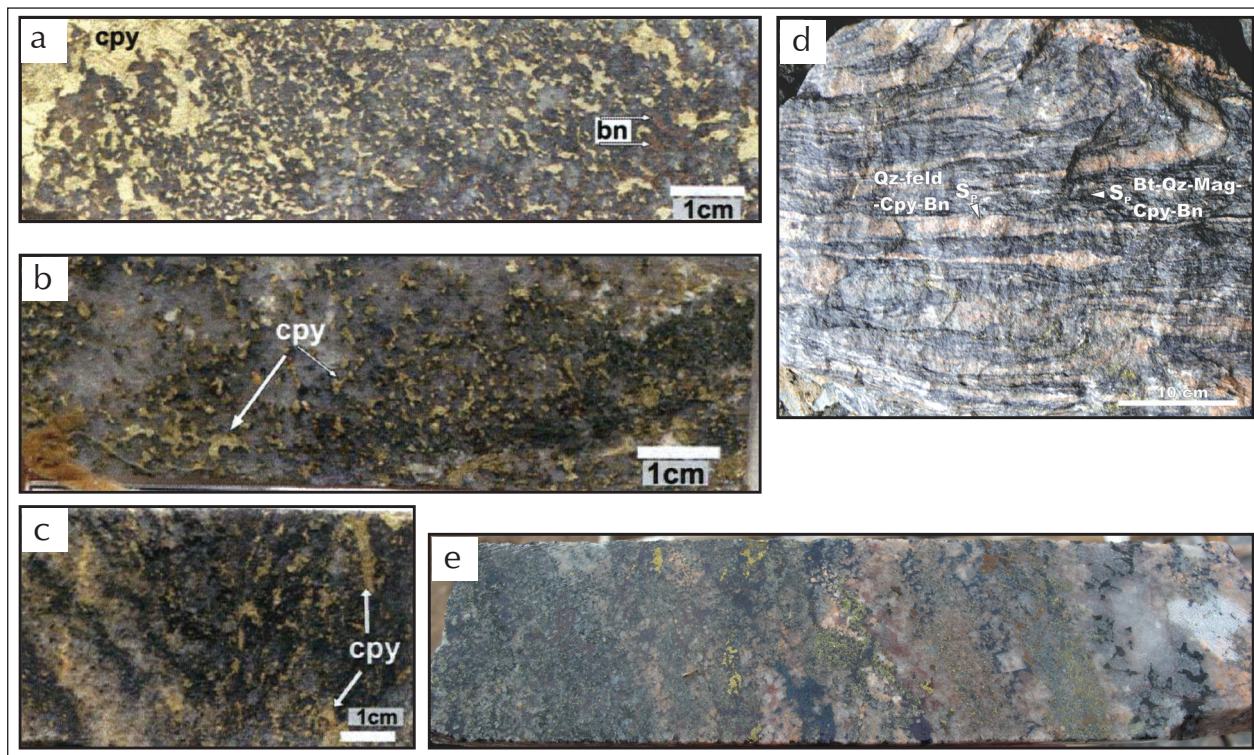
Late brittle fracturing and faulting is noted throughout the area (Mercer and Sagman, 2012). The Minto Creek fault bisects the Main deposit, dividing it into north and south areas, and is modeled as a steeply dipping east-northeast sinistral reverse fault (Mercer and Sagman, 2012). Both the vertical and horizontal displacements are evident by offsets in mineralized horizons, and appear to be minimal. The DEF fault defines the northern end of the Main deposit, strikes west, dips north-northwest and cuts off mineralization in the Main deposit. It may share a similar sense of movement to the Minto Creek fault, but a significant amount of displacement is inferred (Mercer and Sagman, 2012). The Minto and DEF faults are interpreted as late block faults with a rotational component, a style common to the area (Tempelman-Kluit, 1984). One example is documented by Tafti and Mortensen (2004) south of the Minto deposits where Cretaceous Carmacks Group sedimentary rocks are rotated up to 60° from horizontal. Several poorly defined faults are also noted on the property. For example, the boundary between Area 2 and Area 118 is a northeast-dipping fault with significant displacement, and at least two parallel structures displace mineralized horizons in Area 118. A similar northwest-striking fault zone appears to define the northeastern boundary of the Ridgetop deposit and the southwest extent of the Wildfire resource area (Mercer and Sagman, 2012).

### **Mineralization and alteration**

The primary hypogene sulphide mineralization of the Minto deposits consists of chalcopyrite, bornite, euhedral chalcocite and minor pyrite; metallurgical testing also indicates the presence of covellite (Mercer and Sagman, 2012). Silver telluride (hessite) is observed in polished samples, and native gold and electrum have both been reported as inclusions within bornite accounting for the high gold recoveries in test copper concentrates (Mercer and Sagman, 2012). Locally, coarse free gold is observed associated with chloritic or epidote-lined fractures that crosscut the sulphide mineralization and are attributed to secondary enrichment during a process overprinting the main copper sulphide mineralization (Mercer and Sagman, 2012). Sulphide mineralization is almost always accompanied by increased amounts of magnetite and biotite thought to be the result of potassic alteration (Mercer and Sagman, 2012).

Texturally, sulphide minerals predominantly occur as disseminations and foliaform stringers along foliation planes in the deformed rocks (*i.e.*, sulphide stringers tend to follow the foliation planes; Fig. 7). However, sulphide mineral content tends to increase where foliation is intensely disrupted and can result in semi-massive sulphide accumulations up to several metres thick or, locally, massive sulphide accumulations up to 0.5 m in thickness (Mercer and Sagman, 2012). In these sulphide-rich areas, sulphides are found interstitial to the rock-forming silicate minerals and texturally resemble magmatic sulphide accumulations (*e.g.*, net textured sulphides). The highest concentrations of bornite are associated with coarse-grained disseminated and stringer-style magnetite mineralization, up to 20% by volume locally (Mercer and Sagman, 2012). The stringers of magnetite are often folded or boudinaged, suggesting that at least some of the magnetite mineralization predates peak ductile deformation (Mercer and Sagman, 2012). Sulphide minerals on the other hand, locally show both evidence and absence of ductile deformation (Mercer and Sagman, 2012) possibly the result of different rheologic properties compared to magnetite. The best geochronologic constraints on the age of mineralization come from Re-Os molybdenite dates by Hood (2012) that range from  $197.4 \pm 0.8$  Ma to  $201.8 \pm 0.8$  Ma. It is notable that there are two morphologies of molybdenite grains (Hood, 2012), suggesting that there may be more than one generation of mineralization.

At the orebody scale, the Minto Main, Minto North and Minto East deposits each exhibit crude zoning from higher grade bornite-dominant ore in the west to lower grade chalcopyrite-dominant ore in the east. The bornite-dominant mineralization has a metallic mineral assemblage of magnetite-chalcopyrite-bornite. In these deposits, bornite mineralization occurs as strong disseminations and foliaform stringers, locally >10%, and locally as semi-massive to massive lenses up to 2 m thick. The chalcopyrite zone is characterized by chalcopyrite-pyrite  $\pm$  very minor bornite and magnetite. Chalcopyrite mineralization typically contains 1 to 2% sulphides, but locally can reach concentrations greater than 10%. The only significant supergene mineralization on the Minto property is near surface at the Ridgetop deposit and the Wildfire resource sub-domain of the Minto South deposit where the near surface horizons have been affected by supergene oxidation (Mercer and Sagman, 2012). The deeper zones are similar to the other Minto South sub-domains described below.



**Figure 7.** Representative altered and mineralized samples from the Minto deposits. **(a to c)** Slabs of siliceous ore with increasing amount of biotite and decreasing amounts of quartz, magnetite, chalcopyrite and bornite representing a gradation in alteration intensity and grade of mineralization from higher **(a)** to lower **(c)**. **(d)** A typical sample of gneissic banding at Minto taken from a high-grade zone in the Minto open pit. Melanocratic bands (black) are mostly composed of quartz, magnetite, mafic minerals (biotite and hornblende) and sulphides (chalcopyrite and bornite). Leucocratic bands (pink) are mostly composed of quartz, plagioclase and K-feldspar. **(e)** Mineralized core from the Copper Keel zone, diamond drill hole 08SWC389, chalcopyrite and bornite occurring as coarse grained blebs coincident with medium-coarse grained biotite-magnetite. **(a to c)** from Tafti and Mortensen (2004), **(d)** from Hood (2012).



**Figure 8.** Granitic pegmatite in diamond drill hole 08SWC278 crosscutting unfoliated granodiorite of the Minto pluton. Core diameter is NQ2, 5.7 cm.

Mineralization at the Area 2/118/Copper Keel sub-domains of the Minto South deposit are distinct in that mineralization is predominantly disseminated, with localized foliaform stringers, but is lacking the semi-massive to massive sulphide mineralization typical of the Minto Main, North and East deposits. The primary mineral

assemblage in the Area 2/118/Copper Keel resource sub-domains includes chalcopyrite-bornite-magnetite with minor amounts of pyrite (Fig. 7e); the northern half of the Minto South deposit shows increased bornite concentrations, up to 8% locally, and is higher grade (Mercer and Sagman, 2012).

## DIAMOND DRILL CORE IN YGS CORE COLLECTION

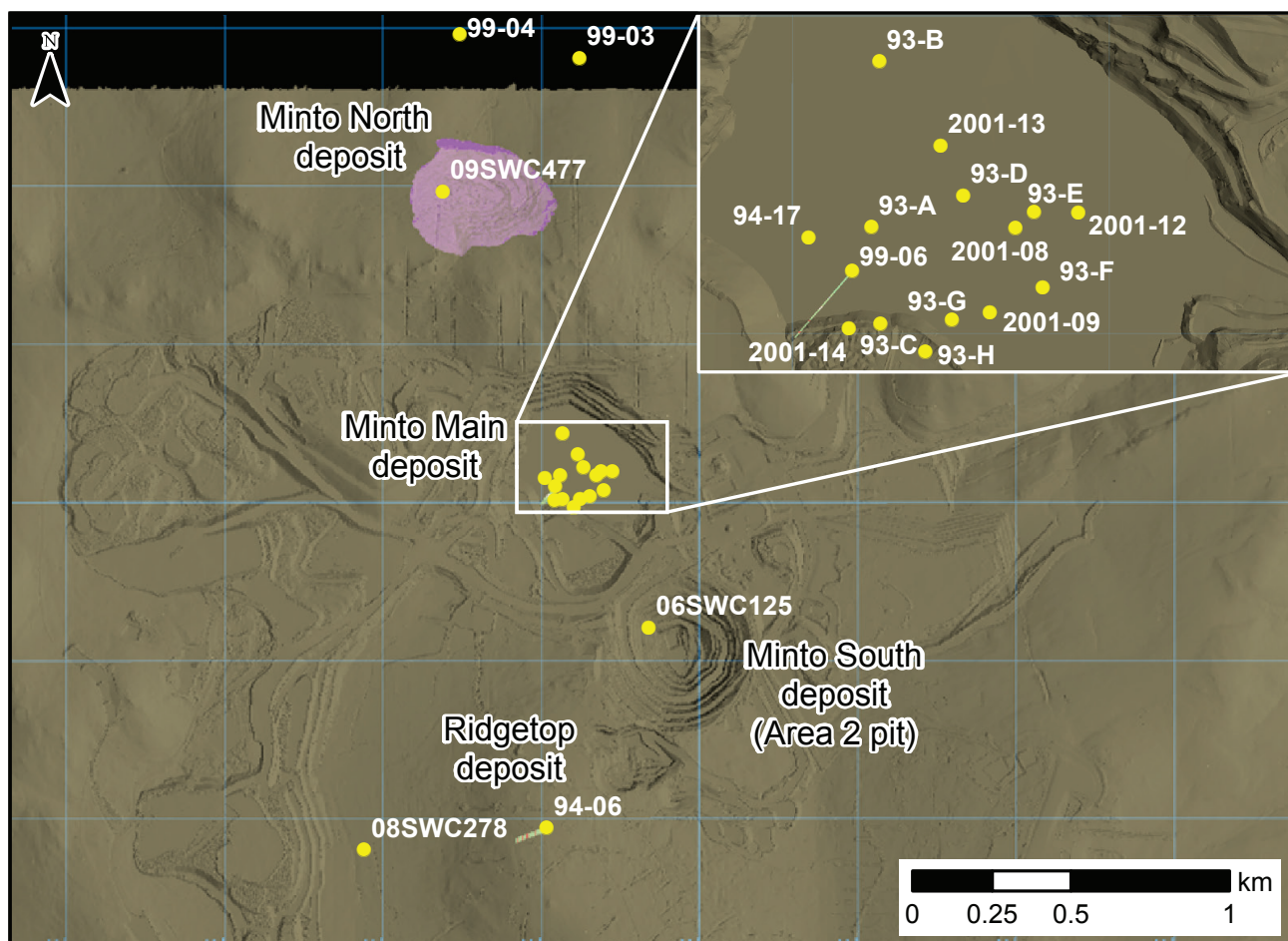
Core from a total of 21 holes, 14 complete and 7 partial, from the Minto property has been donated to the YGS core collection over the years (Table 2; Fig. 9). The majority of core is from the Minto Main deposit but

there is also core from the Minto South and Minto North deposits (Fig. 9). There is also core from four exploration holes outside of current deposit limits. The core from all of these diamond drill holes covers the variety of mineralization on the property (e.g., disseminated, foliaform, semi-massive and massive) as well as the various foliated and unfoliated rocks.

**Table 2.** Summary table of Minto diamond drill core currently in the YGS core collection.

Hole No.	Easting (m)*	Northing (m)*	Year drilled	Length (m)	Entire hole at YGS	No. of boxes at YGS	Area	Details
06SWC125	384841	6944601	2006	179.22	Yes	31	Area 2 (South Minto deposit)	
08SWC278	383940	6943900	2008	246.80	Yes	39	Exploration west of Ridgetop deposit	
09SWC477	384191	6945979	2009	174.00	Yes	31	Minto North deposit	
2001-08	384676	6945083	2001	122.53	Yes	28	Minto Main deposit	
2001-09	384656	6945016	2001	90.53	Yes	22	Minto Main deposit	
2001-12	384725	6945095	2001	113.39	Yes	27	Minto Main deposit	
2001-13	384617	6945148	2001	131.67	Yes	31	Minto Main deposit	
2001-14	384544	6945004	2001	96.16	Yes	18	Minto Main deposit	
93-A	384562	6945084	1993	100.89	No*	22	Minto Main deposit	*Have boxes 1-19, 22-24
93-B	384569	6945214	1993	150.88	Yes	38	Minto Main deposit	
93-C	384569	6945007	1993	96.01	No*	17	Minto Main deposit	*Have boxes 1-10, 16-22
93-D	384635	6945108	1993	104.24	Yes	22	Minto Main deposit	
93-E	384691	6945096	1993	230.73	No*	35	Minto Main deposit	*Have boxes 1-9, 14, 21-45
93-F	384698	6945036	1993	108.81	No*	18	Minto Main deposit	*Have boxes 1-6, 15-26
93-G	384626	6945010	1993	76.81	Yes	16	Minto Main deposit	
93-H	384605	6944985	1993	91.44	Yes	21	Minto Main deposit	
94-06	384518	6943969	1994	152.40	No*	2	Exploration west of Ridgetop deposit	*Have boxes 33 & 34
94-17	384513	6945075	1994	100.89	Yes	20	Minto Main deposit	
99-03	384623	6946401	1999	79.55	No*	2	Exploration north of Minto North deposit	*Have boxes 2 & 3
99-04	384244	6946476	1999	154.53	No*	1	Exploration north of Minto North deposit	*Have box 4
99-06	384547	6945048	1999	136.25	Yes	32	Minto Main deposit	

\*UTM NAD 83, Zone 8



**Figure 9.** Plan view orthophoto of area around Minto deposits showing collar locations (yellow circles) of diamond drill holes in YGS core collection.

## REFERENCES

- Colpron, M., Israel, S. and Friend, M., 2016. Yukon plutonic suites, Yukon Geological Survey, Open File 2016-37.
- Giroux Consultants Ltd., 2005. Technical report on the Minto project for Sherwood Mining Corporation.
- Hood, S., 2012. Mid-crustal Cu-Au mineralisation during episodic pluton emplacement, hydrothermal fluid flow, and ductile deformation at the Minto deposit, YT, Canada. MSc thesis, University of British Columbia, 231 p.
- Ishihara, S., 1977. The magnetite-series and ilmenite-series granitic rocks. *Mining Geology*, vol. 27, p. 293-305.
- Joyce, N.L., Colpron, M., Allan, M.M., Sack, P.J., Crowley, J.L. and Chapman, J.B., 2016. New U-Pb zircon dates from the Aishihik batholith, southern Yukon. *In: Yukon Exploration and Geology 2015*, K.E. MacFarlane, and M.G. Nordling (eds.), Yukon Geological Survey, p. 131-149.
- Kelly, T.D. and Matos, G.R., 2014. Historical statistics for mineral and material commodities in the United States (2016 version). U.S. Geological Survey, Data Series 140.
- Le Bas, M.J. and Streckeisen, A.L., 1991. The IUGS systematics of igneous rocks. *Journal of the Geological Society*, London, vol. 148, p. 825-833.

- Logan, J.M. and Mihalynuk, M.G., 2014. Tectonic controls on Early Mesozoic paired alkaline porphyry deposit belts (Cu-Au±Ag-Pt-Pd-Mo) within the Canadian Cordillera. *Economic Geology*, vol. 109, p. 827-858.
- McCausland, P.J.A., Symons, D.T.A., Hart, C.J.R. and Blackburn, W.H., 2002. Paleomagnetism and geobarometry of the Granite Mountain batholith, Yukon: Minimal geotectonic motion of the Yukon-Tanana Terrane relative to North America. *In: Yukon Exploration and Geology 2001*, D.S. Emond, L.H. Weston and L.L. Lewis (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 163-177.
- Mercer, B. and Sagman, J., 2012. Phase VI Preliminary Feasibility Report Minto Mine. Minto Explorations Ltd., p. 368.
- Nelson, J.L., Colpron, M. and Israel, S., 2013. The Cordillera of British Columbia, Yukon, and Alaska: Tectonics and metallogeny. *In: Tectonics, metallogeny and discovery: The North American Cordillera and similar accretionary settings*, M. Colpron, T. Bissig, B.G. Rusk and J.F.H. Thompson (eds.), Society of Economic Geologists, Special Publication No. 17, p. 53-109.
- Pearson, W.N. and Clark, A.H., 1979. The Minto copper deposit, Yukon Territory; a metamorphosed orebody in the Yukon crystalline terrane. *Economic Geology*, vol. 74, p. 1577-1599.
- SRK, 2008. Technical Report. Minto Mine, p. 229.
- Tafti, R., 2005. Nature and origin of the Early Jurassic copper (-gold) deposits at Minto and Williams Creek, Carmacks copper belt, western Yukon: Examples of deformed porphyry deposits. MSc thesis, University of British Columbia, 227 p.
- Tafti, R. and Mortensen, J.K., 2004. Early Jurassic porphyry(?) copper (-gold) deposits at Minto and Williams Creek, Carmacks Copper Belt, western Yukon. *In: Yukon Exploration and Geology 2003*, D.S. Emond and L.L. Lewis (eds.), Yukon Geological Survey, p. 289-303.
- Tempelman-Kluit, D.J., 1984. Geology of Laberge (105E) and Carmacks (115I) map areas, Yukon. Geological Survey of Canada, Open File 1101.
- Topham, M.J., Allan, M.M., Mortensen, J.K., Hart, C.J.R., Colpron, M. and Sack, P.J., 2016. Crustal depth of emplacement of the Early Jurassic Aishihik and Tatchun batholiths, west-central Yukon. *In: Yukon Exploration and Geology 2015*, K.E. MacFarlane and M.G. Nordling (eds.), Yukon Geological Survey, p. 233-251.
- Woodsworth, G.J., Anderson, R.G. and Armstrong, R.L., 1991. Plutonic Regimes, Chapter 15. *In: Geology of the Cordilleran Orogen in Canada*, H. Gabrielse and C.J. Yorath (eds.), Geological Survey of Canada, Geology of Canada, no. 4, p. 491-531; also *Geological Society of America, The Geology of North America*, vol. G-2.
- Yukon Geological Survey, 2016. Yukon Digital Bedrock Geology. <[http://www.geology.gov.yk.ca/update\\_yukon\\_bedrock\\_geology\\_map.html](http://www.geology.gov.yk.ca/update_yukon_bedrock_geology_map.html)> [accessed November 25, 2016].
- Yukon MINFILE, 2016. Yukon MINFILE - a database of mineral occurrences, Yukon Geological Survey, <http://data.geology.gov.yk.ca> [accessed December 6, 2016].
- Zen, E. and Hammarstrom, J.M., 1984. Magmatic epidote and its petrologic significance. *Geology*, vol. 12, p. 515-518.

## APPENDICES

Available data for each diamond drill hole includes digital data in the form of Excel files, pdfs of original logs, and wet and dry core photographs. The Excel files include collar, survey, lithology, assay and geochemistry data. The digital appendix to this paper includes two summary pages for each drill hole. Each summary is designed to be printed as a double-sided sheet. The first page has a plan map, a table summarizing collar information, and strip logs showing downhole lithology and selected assay data. The second page has a section with the drill hole highlighted and a table of the key assay data for the hole.

