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SHORT WAVELENGTH INFRARED SPECTROMETRY OF HYDROTHERMAL ALTERATION ZONES ASSOCIATED WITH VOLCANOGENIC MASSIVE SULPHIDE MINERALIZATION, BUCHANS–ROBERTS ARM BELT, CENTRAL NEWFOUNDLAND

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ABSTRACT

The central portion of the Buchans–Roberts Arm belt is host to several known deposits of volcanogenic massive sulphide (VMS) mineralization, along with a number of well-defined zones of hydrothermal alteration locally hosting anomalous base-metal enrichment. Short wavelength infrared (SWIR) spectrometry is used to collect spectral measurements from drillcore in order to characterize the hydrothermal alteration surrounding the known VMS deposits. From this dataset, it is evident that notable changes in the composition of both white mica and chlorite alteration associated with the development of these deposits are detected. This includes the development of Fe-chlorite–muscovite-bearing mineral assemblages proximal to ore within mafic dominated host rocks, and muscovite-dominated assemblages within more felsic host rocks.

The systematic collection of spectral measurements, generally at 3 m intervals, enables the recognition of mineral changes within the hanging wall, mineralized and footwall zones of the deposits. Locally identified signatures, such as the development of biotite and phlogopite in association with red chert-bearing horizons, within the immediate hanging wall of the Gullbridge deposit, highlight the importance of similar signatures developed at the Handcamp prospect, some 10 km to the north. These and other identified features surrounding known deposits will be used in the comparison with the mineral assemblages obtained from hydrothermal alteration zones elsewhere in the belt to aid in their characterization and classification with respect to their overall prospectivity.

INTRODUCTION

The development of zoned alteration systems in association with the formation of volcanogenic massive sulphide (VMS) mineralization is well documented, and discrete zones within such systems are characterized by distinct mineral assemblages (*e.g.*, Barrie and Hannington, 1999; Galley *et al.*, 2007). The identification of key minerals within these assemblages can provide valuable information with respect to vectoring toward areas of potentially economic mineralization. The use of portable reflectance spectrometers to gather short wavelength infrared (SWIR) data is ideally suited for deciphering the fine-grained alteration minerals associated with the development of hydrothermal systems (*e.g.*, Kerr *et al.*, 2011). The systematic collection of spectral data from drillcore provides a fast and effective means of determining key mineral assemblages that can be utilized in outlining the zones of hydrothermal alteration formed in association with the development of VMS-style mineralization. For example, SWIR analysis can provide semi-quantitative compositional data for certain minerals, such as Fe- *vs*. Mg-rich chlorite and varying compositions of white micas (paragonite, muscovite, phengite), which can be utilized as vectors within alteration systems.

Drillcore from select areas of the central portion of the Buchans–Roberts Arm belt have been analyzed in order to determine the mineral assemblages associated with the development of known VMS deposits (*e.g.*, Gullbridge, Southwest Shaft and Lake Bond; Figure 1). In addition, drillholes targeting select VMS-related prospects along the Buchans–Roberts Arm belt were also examined (*e.g.*, Handcamp and Sam prospects; Figure 1). Data collected from the Buchans–Roberts Arm belt highlight the spatial association of Fe-chlorite and muscovite alteration with development of VMS-style mineralization. The SWIR data enable the characterization of mineral assemblages at known deposits, while the occurrence of similar mineral assemblages elsewhere in the region highlights the potential prospectivity of these alteration zones.

The regional geology of the central portion of the Buchans–Roberts Arm belt is structurally complex (*cf.* O'Brien, 2007). The following discussion is preliminary and

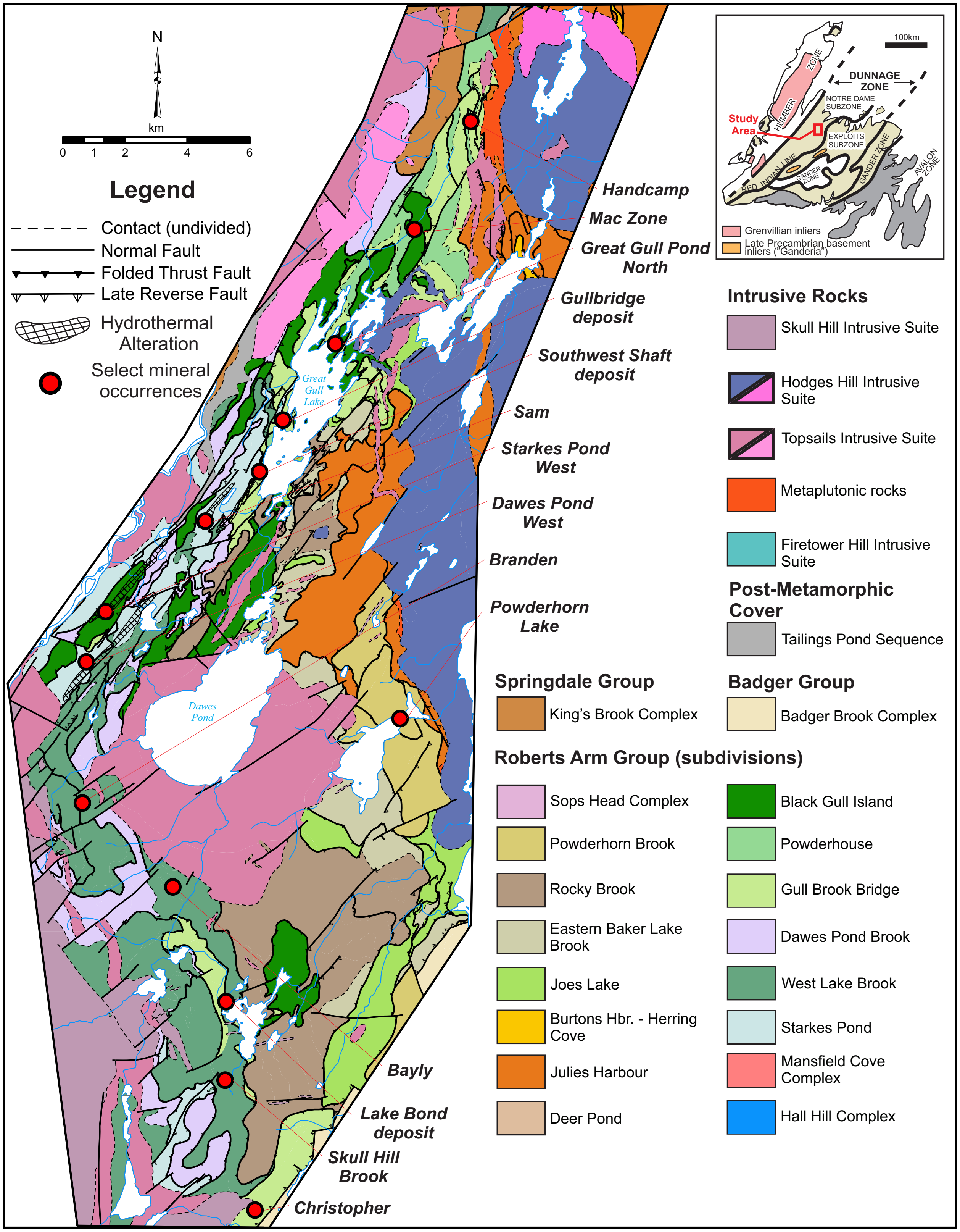

Figure 1. *Simplified regional geology map of the central portion of the Buchans–Roberts Arm belt, outlining select sulphide occurrences within the study area along with the distribution of related alteration zones; modified from O'Brien (2009, 2016a, b, c).*

does not factor in the potential structural complexities that may exist between the various identified alteration zones discussed below. As such, additional modifications of the distribution of these zones maybe required with further study.

SPECTRAL DATA BACKGROUND

Spectral data obtained from drillcore are processed utilizing the 'The Spectral Geologist' (TSG) software program (version 7.1.0.062). This program provides the two most abundant minerals present (Min 1 and Min 2) within individual analysis by comparing the spectral data against a reference library of known minerals. The predominant minerals contained in the spectral data from the region include chlorite and white mica (paragonite, muscovite, phengite), both of which are demonstrated to show spectral variations with proximity to VMS-related mineralization. Chlorite alteration is subdivided into Fe-chlorite, Mg-chlorite and Fe–Mg-chlorite on the basis of distinct spectral features. In some instances Fe-chlorite is noted to be associated with the core of VMS-related alteration systems, whereas Mg-chlorite is more characteristic of the peripheral alteration (*e.g.*, Galley *et al.*, 2007). However, some SWIR studies have also shown that chlorite compositions tend to be more Mg-rich toward ore (Pontual *et al.*, 1997; Herrmann *et al.*, 2001; Jones *et al.*, 2005). The spectral characteristics of white mica can also be shown to display systematic trends from more phengitic compositions in peripheral alteration zones to more muscovitic compositions proximal to ore (Herrmann *et al.*, 2001; Jones *et al.*, 2005; Hinchey, 2011; McKinley, 2013).

Previous studies of the Gullbridge deposit have demonstrated that the ore zone is associated with a characteristic cordierite–anthophyllite-bearing assemblage, interpreted to be the result of thermal metamorphism of the Mg-rich alteration associated with the mineralized zone (Upadhyay and Smitheringale, 1972; Pope *et al.*, 1991). Regional metamorphism or local contact metamorphism of alteration minerals associated with VMS-systems result in distinct mineral assemblages, which include phlogopite, cordierite, anthophyllite, muscovite, staurolite, garnet, andalusite, and kyanite (Galley *et al.*, 2007). However, only phlogopite and muscovite from these mineral assemblages can be identified by the TSG software, as only these two minerals have spectra within the reference library of the software program.

Within the spectral dataset collected from the region, 'Null' values produced by the software program represent spectra that are classified as being either dark or containing a signal-to-noise ratio below a defined threshold, and therefore are considered to be too noisy to classify; these spectra have been excluded from the following discussion. Spectra that are classified as 'Aspectral' represent those spectra that contain no identifiable features, or spectra with features with amplitudes that are too small, relative to the noise level of the spectrum to be classified by the software. All spectral measurements were collected at 3 m intervals, unless otherwise noted.

PREVIOUS WORK

The previous mineral exploration and academic work conducted within the central portion of the Buchans–Roberts Arm belt is summarized in Sparkes (2018). Much of the work targeting the various VMS-related occurrences in the area was conducted prior to the 1990s, and therefore did not utilize the more innovative analytical techniques that are currently available. SWIR spectrometry has largely only come into common usage since the late 1990s, and as such, studies of this nature have yet to be applied to alteration zones related to VMS systems within the current study area. Some deposit-level studies have been conducted farther to the northeast within similar rocks (*e.g.*, Pilley's Island deposit, McKinley, 2013) as well as on deposits elsewhere in central Newfoundland (*e.g.*, Boundary deposit, Buschette, 2015; Tulks Volcanic Belt, Hinchey, 2011). Results from these studies, of VMS mineralization primarily hosted within felsic volcanic rocks, demonstrate that muscovitic alteration is commonly developed proximal to stringer and massive sulphide mineralization.

REGIONAL GEOLOGY

The geology of the central portion of the Buchans−Roberts Arm belt has been discussed by Swinden (1991), Dickson (2000) and O'Brien (2007). The Buchans−Roberts Arm belt forms part of the larger Notre Dame Arc (*cf.* Swinden *et al.*, 1997; van Staal *et al.*, 1998) and is inferred to have been accreted to older oceanic rocks of the Dunnage Zone along the Laurentian continental margin during the Taconic orogeny (Cawood *et al.*, 1995; Kusky *et al.*, 1997; Draut and Clift, 2002; Lissenburg *et al.*, 2005). Early interpretations of stratigraphic relationships within the central portion of the Buchans−Roberts Arm belt inferred a westward younging of the overall succession (*cf.* Kalliokoski, 1955; Swinden and Sacks, 1986). However, re-interpretations of this region now recognize the complex structural nature of the tectonostratigraphy, within which stratigraphic units are locally repeated (*cf.* Pope *et al.*, 1991; Pope and Calon, 1993; O'Brien, 2007). The structural reinterpretation of the region by Pope and Calon (1993) noted that although the stratigraphy within individual structural panels is younging westward, the overall stacking of these structural panels of older, on top of younger, results in an eastward younging of units within the region.

O'Brien (2007) subdivided the rocks occurring in the central Buchans−Roberts Arm belt into four main faultbounded structural tracts, namely the Gullbridge, Baker Brook, Burnt Pond and the Powderhorn Lake tracts. This tectonic subdivision was further expanded to include the South Brook and Catamaran Brook structural tracts by O'Brien (2008). The Gullbridge tract comprises altered greenschists, mineralized mafic flows and/or felsic pyroclastic rocks, iron formation, and volcaniclastic turbidities. Rocks contained within the South Brook tract include pillowed tholeiitic basalt and gabbro sills along with lesser clastic limestone and red siltstone. Volcanosedimentary rocks of the Baker Brook tract are characterized by thinning-upward and fining-upward epiclastic turbidities, which structurally overlie and underlie gossanous basalt and associated felsic pyroclastic rocks. The Catamaran Brook tract consists of calc-alkaline and tholeiitic basalt and related volcaniclastic rocks, gabbro, wacke and pyritic black shale and chert. Rocks of the Burnt Pond tract are characterized by regionally metamorphosed metasedimentary schist along with higher grade migmatite and gneissic intrusive rocks. Finally, the metamorphic rocks of the Powderhorn Lake tract are composed of variably altered metavolcanic and overlying metasedimentary rocks that are regionally metamorphosed to upper amphibolite facies.

Most of the VMS-related occurrences in the region are hosted within rocks associated with the Gullbridge structural tract. These and other units within the region have been further refined by O'Brien (2009, 2016a, b, c) and the unit terminology used in the following discussion is taken from these sources.

LOCAL GEOLOGY AND SWIR RESULTS

GULLBRIDGE DEPOSIT

VMS-style mineralization at the Gullbridge deposit is primarily hosted within altered pillow basalt of the Gullbridge structural tract (Gull Brook Bridge division of O'Brien, 2016a, b). To the west of the Gullbridge deposit, rocks of the Gull Brook Bridge division are structurally overlain by felsic volcanic rocks of the Starkes Pond division (O'Brien, 2016a, b; Figure 2). The main mineralized zone occurs proximal to this structural contact. Although the mineralization and alteration is largely conformable to the regional stratigraphy, detailed studies indicate that the alteration locally transects stratigraphic contacts (Upadhyay and Smitheringale, 1972; Pope *et al.*, 1991). The Gullbridge deposit is interpreted to represent stockwork-style mineralization, with the main ore body forming two overlapping, steeply westward-dipping, tabular lenses, extending 430 m along strike (Upadhyay and Smitheringale, 1972; Pope *et al.*, 1991). The main ore body, which extends to approximately 210 m depth and varies in thickness from 30 to 75 m, primarily consists of pyrite, pyrrhotite and chalcopyrite (Upadhyay and Smitheringale, 1972). The mineralization is contained within a zone of cordierite–andalusite–chlorite schist, which is, in turn, enveloped by a zone of cordierite–anthophyllite alteration. Gullbridge ore is associated with a magnesium-rich stockwork that has been structurally disrupted and thermally metamorphosed due to the regional plutonic activity, which has resulted in the cordierite, andalusite and anthophyllite-bearing alteration assemblages (Upadhyay and Smitheringale, 1972; Pope *et al.*, 1991).

Two drillholes were selected from the Gullbridge deposit for this study. The first, GB-135 (572.41 m), is drilled toward the southeast, and intersects the mineralized sequence approximately 250 m to the south of outcropping mineralization, but does not intersect any high-grade copper (maximum assay of 3250 ppm Cu over 0.6 m; 341.5–342.1 m; Figure 2). This hole collars in felsic volcanic rocks, inferred to represent the structural hanging wall of the deposit, and then passes through the defined thrust fault separating the felsic volcanic rocks from the mineralized mafic to intermediate volcanic rocks. For this drillhole, 180 spectral measurements were collected, of which 157 produced useable spectra. The second drillhole, GB-148 (510.55 m), is drilled toward the northwest and crosscuts the central portion of the Gullbridge deposit (maximum assay of >1.0% Cu over 0.45 m; 382.85–383.30 m; Figure 2), ending in felsic volcanic rocks. For this drillhole 166 measurements were collected, of which 121 produced useable spectra.

Figure 3A displays a schematic drill log, corresponding downhole SWIR results, copper assays and magnetic susceptibility measurements for drillhole GB-135. From the figure it is evident that the felsic volcanic sequence (0–110 m), which is located within the hanging wall of the thrust fault to the west of the deposit, is dominated by phengite and Fe–Mg-chlorite alteration. Minor muscovite alteration is developed within the immediate area of the thrust fault separating the felsic volcanic succession from the underlying mafic to intermediate volcanic rocks (110–120 m). The area between the thrust fault and the first development of muscovitic alteration and accompanying elevated copper mineralization is inferred to represent the hanging-wall zone (120–230 m). Within this interval the predominant alteration minerals include Mg-chlorite, hornblende, biotite, phlogopite and Fe–Mg-chlorite along with lesser phengite and rare muscovite. This zone is noted to contain interbedded red chert and local iron formation along with rare examples of exhalative-style sulphide mineralization (Plate 1A). The locally developed iron formation is associated with elevated magnetic susceptibility values within the hanging-wall zone (Figure 3A).

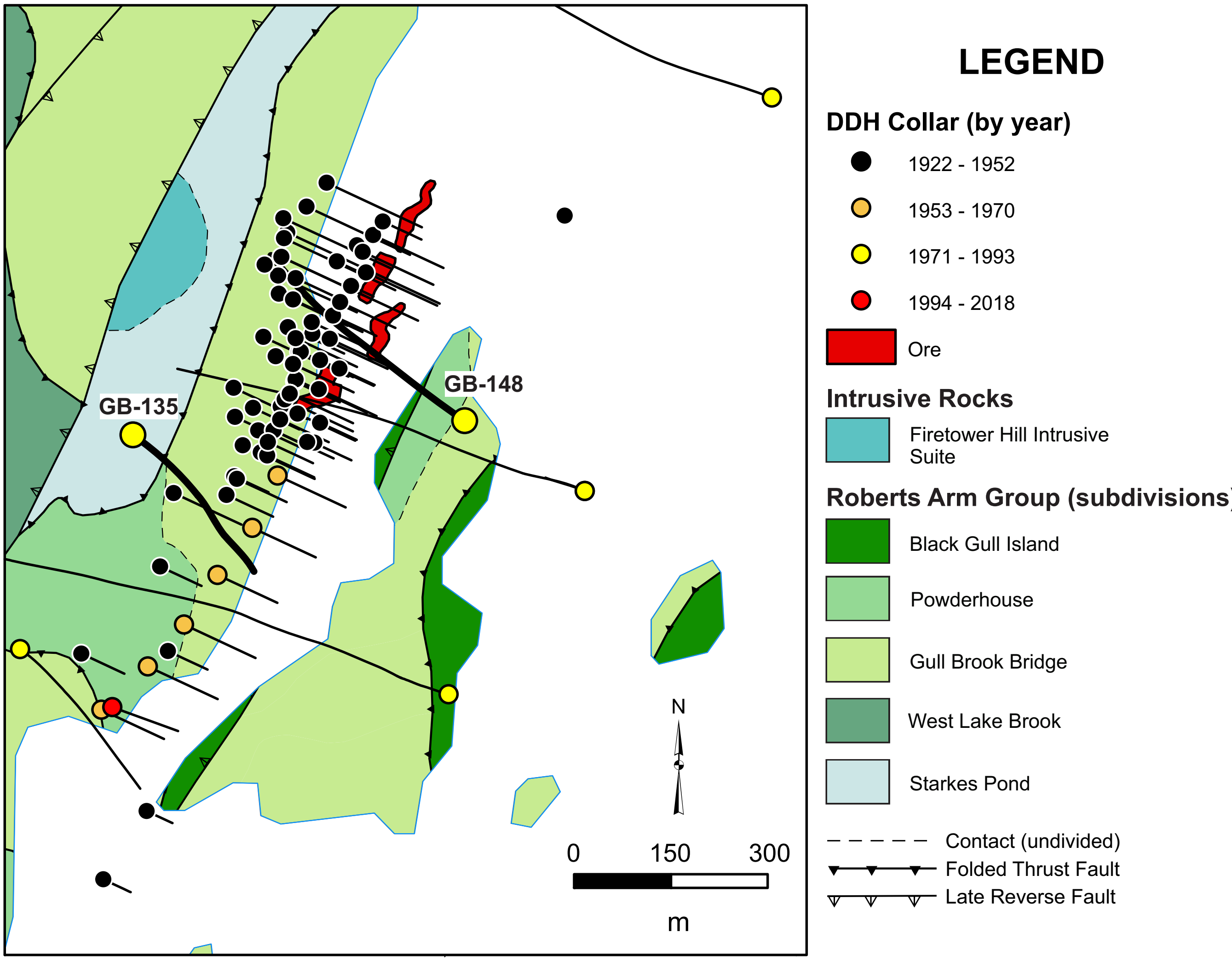

Figure 2. *Simplified geology map of the Gullbridge deposit outlining the distribution of diamond-drill holes (coloured by the year completed), and surface projection of the ore zone; modified from O'Brien (2016b). Note the locations of the drillholes analyzed as part of this study have been highlighted.*

The occurrence of muscovite within the spectral data is used to mark the beginning of the mineralized zone (230–460 m), which contains elevated copper values within two discrete intervals (240–260 m and 330–350 m; Figure 3A). The weakly developed mineralized zone is also characterized by the presence of cordierite, identified through visual observations of drillcore. The mineralized zone is dominated by muscovite and Fe–Mg-chlorite alteration along with rare occurrences of Mg-chlorite and hornblende, all of which are hosted within interbedded intermediate and mafic tuffs (Plate 1B). The rare occurrence of Mg-chlorite at ~340 m coincides with the highest copper values within the zone, which is also accompanied by elevated magnetic susceptibility measurements highlighting localized magnetite alteration. Below the mineralized zone (footwall; 460–572 m), the volcanic sequence is dominated by Fe–Mg-chlorite and lesser hornblende, epidote and Mg-chlorite, which is hosted within more massive mafic volcanic rocks displaying weakly elevated magnetic susceptibility measurements (Figure 3A). These rocks locally display moderate, network-style, epidote–carbonate veining (Plate 1C).

Drillhole GB-148, which collars in the footwall and is drilled toward the northwest (Figure 2), is located approximately 500 m to the northeast of the previous drillhole. The footwall sequence (0–140 m; Figure 3B) consists of Fe–Mg-chlorite, hornblende and lesser Mg-chlorite and epidote. The development of Fe-chlorite within the spectral data is inferred to mark the beginning of the main mineralized zone. This zone extends from 140–400 m, contains variably developed cordierite alteration, and locally significant copper values in association with stockwork-style sulphide min-

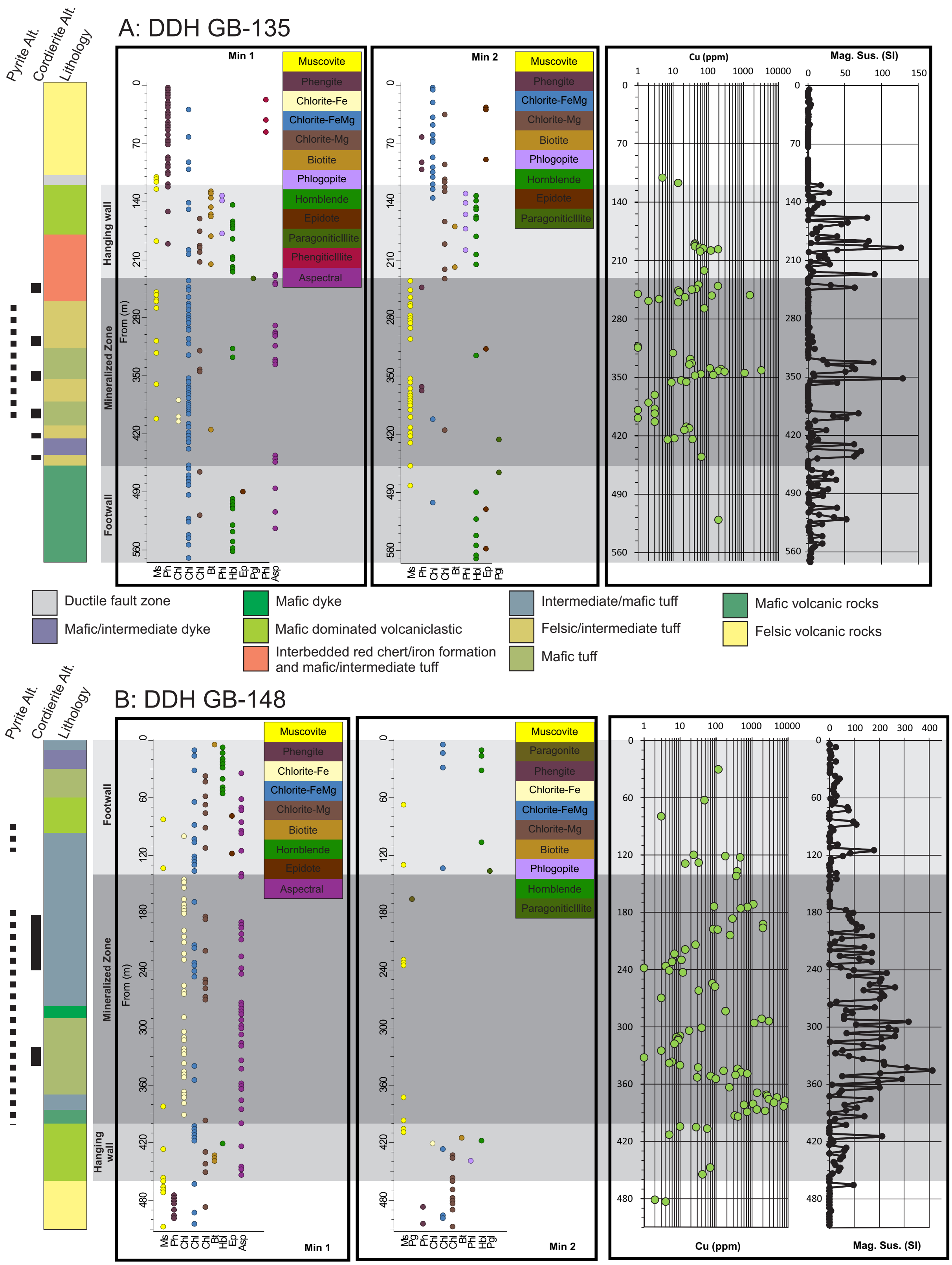

Figure 3. *Representative drillholes from the Gullbridge deposit. A) Strip log outlining the general geology, spectral results, copper assays and magnetic susceptibility measurements for drillhole GB-135; assay data from Lenters and Sears (1990a); B) Strip log outlining the general geology, spectral results, copper assays and magnetic susceptibility measurements for drill-hole GB-148; assay data from Pudifin* et al. *(1991). For the location of the drillholes refer to Figure 2.*

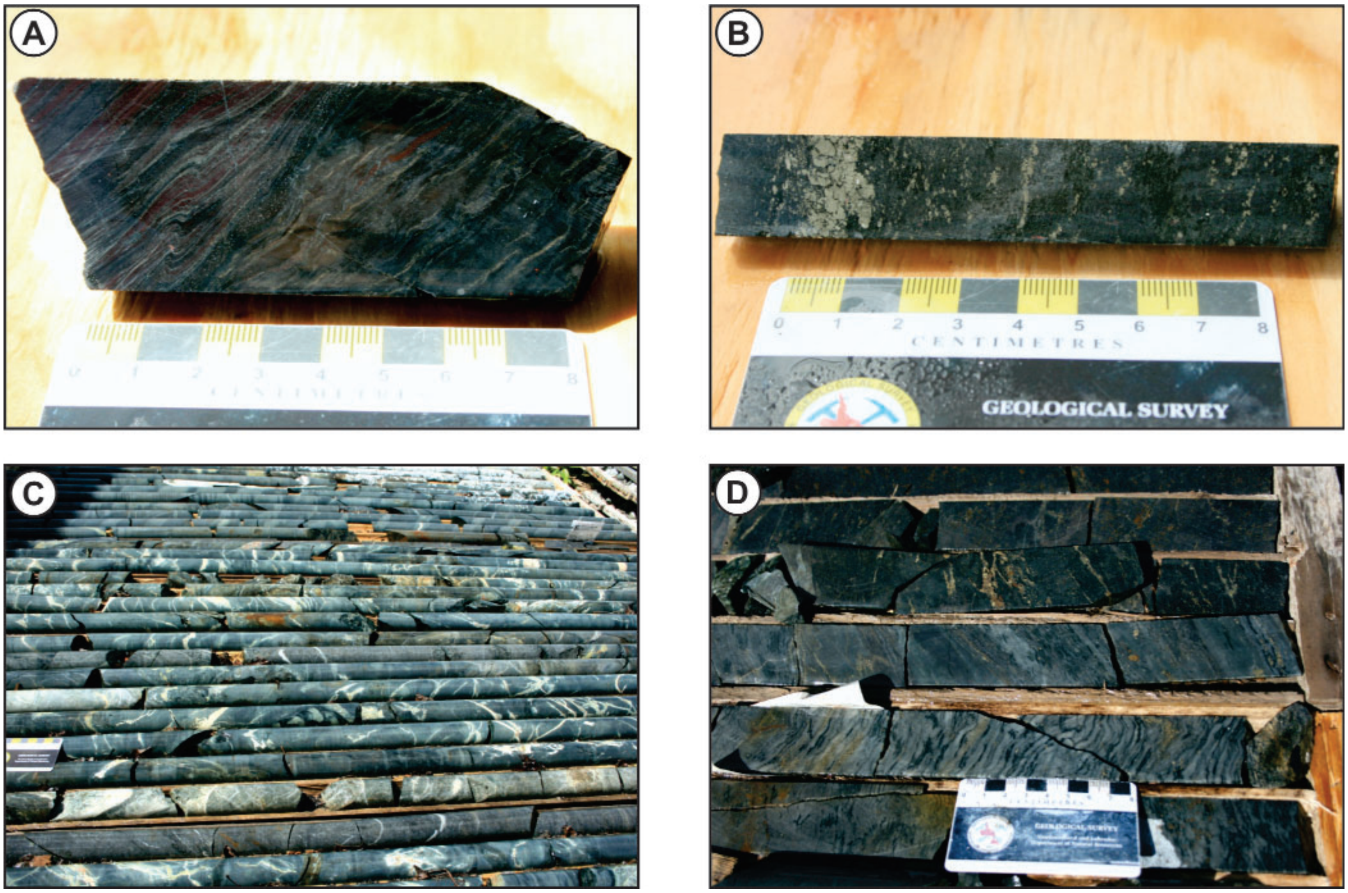

Plate 1. *Select photographs of drillcore from the Gullbridge deposit. A) Representative sample of thinly bedded red chert overlying the mineralized zone (225 m; DDH GB-135); B) Disseminated sulphide in association with pervasive Mg-chlorite alteration hosted within a moderately magnetic mafic volcanic rock (347.7 m; DDH GB-135); C) Moderately developed epidote–carbonate veining within the footwall mafic volcanic rocks (520 m; DDH GB-135); D) Variably developed, stockwork-style sulphide mineralization at the contact between mafic and intermediate tuffs; intermediate tuff contains muscovite–Fe-chlorite alteration in association with elevated copper values (380 m; DDH GB-148).*

eralization (Plate 1D). In addition, this zone is associated with elevated magnetic susceptibility measurements, which is at least locally the result of magnetite alteration. The spectral data from this portion of the hole indicates that Fe-chlorite dominates the zone along with lesser Fe–Mg- and Mg-chlorite and rare muscovite. Areas dominated by Fe–Mg-chlorite within the mineralized zone generally correspond with lower copper values (*e.g.*, ~235 m), potentially representing some of the least altered rocks within this zone. Downhole from the mineralized zone (400–460 m), the hanging-wall sequence is dominated by Fe–Mg-chlorite, Mg-chlorite, and rare biotite and phlogopite, similar to that observed within the hanging-wall sequence of drillhole GB-135. Here the alteration is hosted within volcaniclastic rocks with rare interbedded red chert. The thrust fault separating the volcaniclastic rocks from the structurally overlying felsic volcanic rocks is identified by a zone of muscovite alteration at about 460 m, after which phengite and Mg-chlorite dominate the felsic volcanic rocks above the thrust fault.

SOUTHWEST SHAFT DEPOSIT

The Southwest Shaft deposit is located 2.3 km along strike to the southwest of the Gullbridge deposit and occurs within a similar structural setting, but within different host rocks (Figure 1). This deposit is primarily hosted within felsic tuffs and interbedded volcaniclastic rocks inferred to structurally overlie basaltic rocks similar to those hosting the Gullbridge deposit (Gull Brook Bridge division; O'Brien, 2016c). The rocks hosting mineralization within the Southwest Shaft deposit are visually similar to those structurally overlying the deposit to the west (Starkes Pond division, O'Brien, 2016c; Figure 4), but their relationship to these rocks remains uncertain. The alteration zone associat-

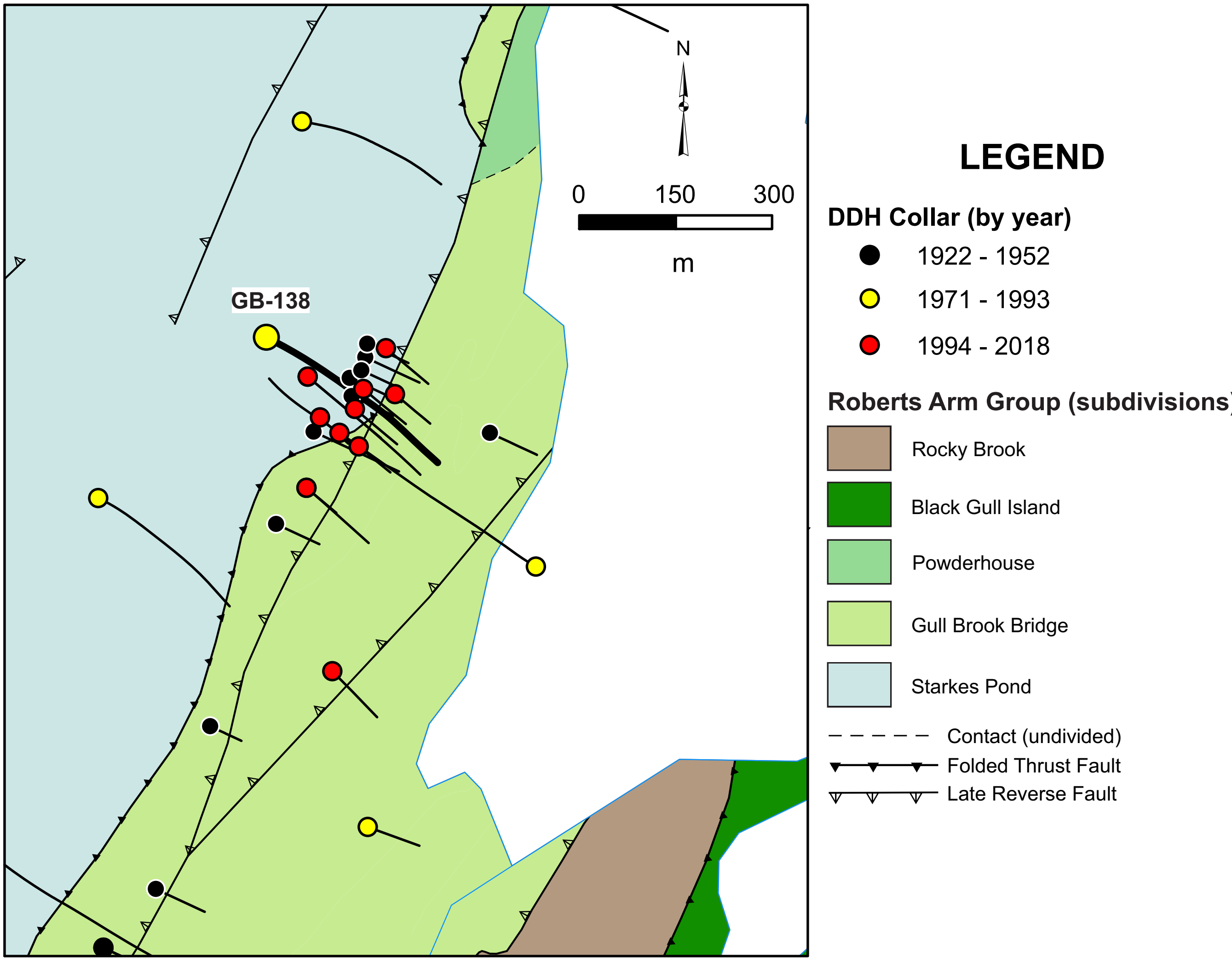

Figure 4. *Simplified geology map of the Southwest Shaft deposit outlining the distribution of diamond-drill holes (coloured by the year completed); modified from O'Brien (2016c). Note the location of the drillhole analyzed as part of this study is highlighted.*

ed with the deposit averages 200 m in width and contains similar mineral assemblages to that developed within the Gullbridge area, aside from the development of significant anthophyllite (Healing, 1980). Sulphide mineralization occurs as fine-grained disseminations and stringers, and is dominated by pyrite, pyrrhotite and chalcopyrite (Pope *et al.*, 1991).

The deposit is undercut by drillhole GB-138 (495.91 m), which is drilled toward the southeast (Figure 4). From this drillhole, 165 spectral measurements were collected, of which 156 produced useable spectra. This drillhole displays similar relationships to drillhole GB-135 at the Gullbridge deposit whereby it is collared within the stratigraphic footwall felsic volcanic sequence, now inferred to structurally overlie the mineralized zone. However, at the Southwest Shaft deposit, pyritic alteration and accompanying copper mineralization is observed within felsic volcanic rocks immediately below the inferred location of the thrust fault (100–110 m; Figure 5). The exact affinity of these felsic volcanic rocks occurring within the footwall of the thrust remains unclear, but these rocks are tentatively included with the felsic volcanic rocks of the Starkes Pond division.

The felsic volcanic rocks located above the thrust fault (0–100 m) are dominated by phengite alteration, similar to that observed in the area of the Gullbridge deposit (Figure 5). Immediately below the thrust fault, similar felsic volcanic rocks along with lesser interbedded or structurally interleaved mafic tuff contain muscovite and pyrite alteration, representing the mineralized zone (110–195 m; Plate 2A). This zone contains two discrete intervals of anomalous

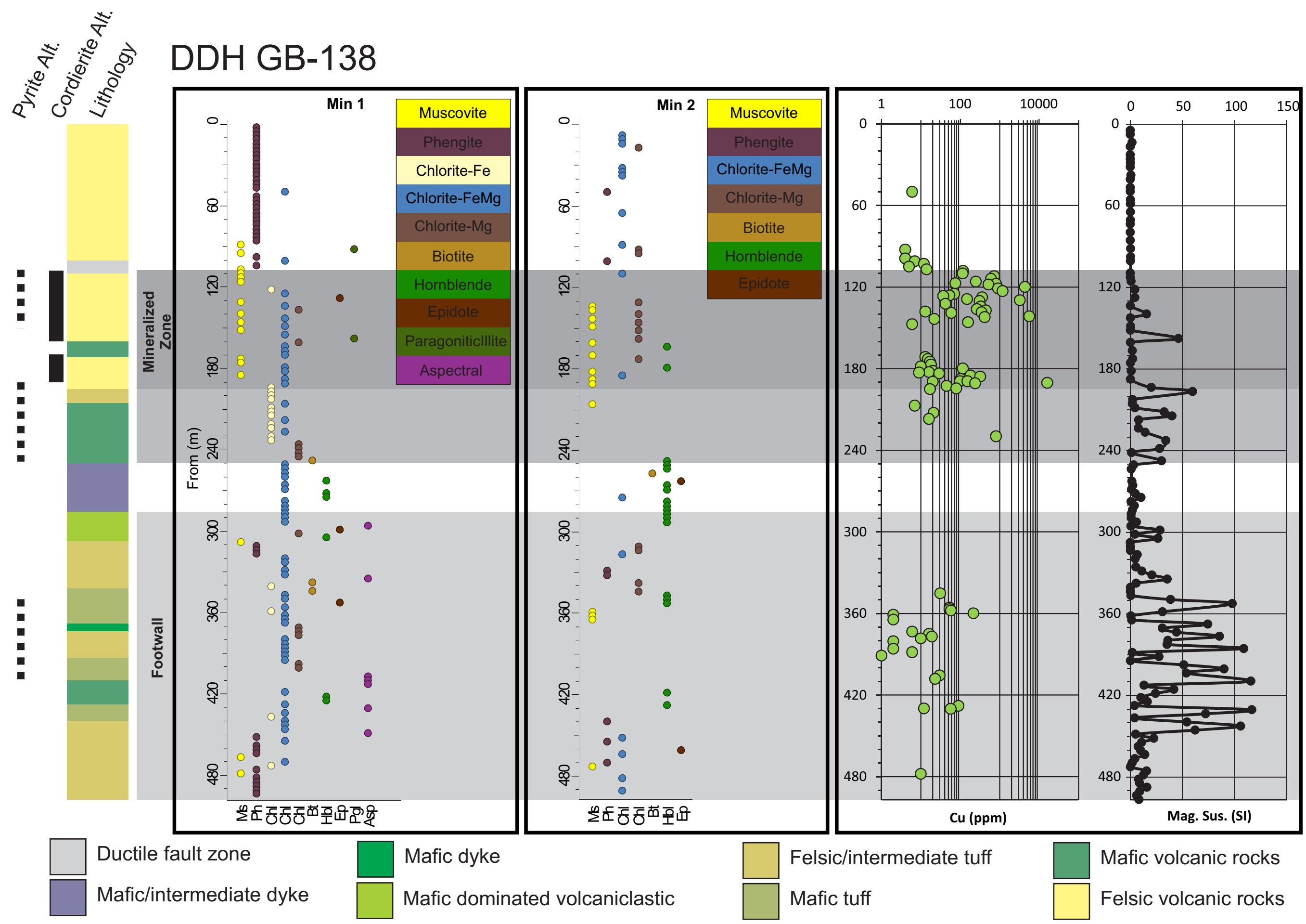

Figure 5. *Strip log outlining the general geology, spectral results, copper assays and magnetic susceptibility measurements for drillhole GB-138, Southwest Shaft deposit. For the location of the hole refer to Figure 4; assay data from Lenters and Sears (1990b).*

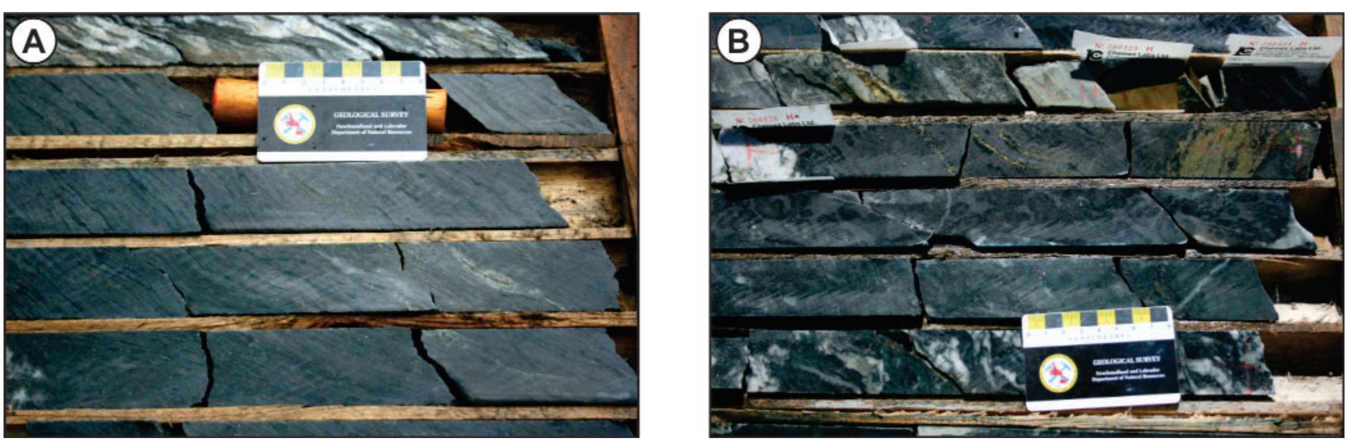

Plate 2. *Select photographs of drillcore from the Southwest Shaft deposit. A) Strongly foliated felsic/intermediate volcanic rock hosting muscovite–pyrite alteration immediately below the thrust fault (110 m; DDH GB-138); B) Mineralized zone containing 1.61% Cu over 0.35 m near the lower portion of the zone; note the marginal "spotted" texture resulting from cordierite alteration (190 m; DDH GB-138).*

copper mineralization (110–150 m and 185–190 m; Figure 5; Plate 2B). In addition to muscovite alteration, the mineralized zone also contains Fe–Mg-chlorite along with lesser Mg-chlorite, hornblende and epidote. The lower contact of the mineralized zone marks the end of the felsic volcanic rocks and is defined by a sharp structural contact separating the felsic rocks from mafic to intermediate volcanic rocks (~195 m).

The mafic to intermediate volcanic rocks immediately below the structural contact (195–250 m) contain weakly disseminated pyrite throughout, and the upper portion of this zone is dominated by Fe-chlorite alteration, but there is no associated copper mineralization with the alteration. This interval also contains elevated magnetic susceptibility measurements in association with the mafic volcanic unit. The exact affinity of this alteration zone remains unclear, but it is inferred to represent a distinct zone that is separate from the underlying footwall zone. The lower contact of this zone is marked by the intrusion of a medium-grained mafic intrusive (250–285 m), which separates the upper zone of Fe-chlorite–pyrite alteration from the footwall zone (285–496 m). Rocks within the footwall zone are dominated by Fe–Mg-chlorite alteration, but also contain irregularly distributed zones of phengite, Mg-chlorite, hornblende, biotite and epidote. A localized zone of Fe–Mg-chlorite–muscovitic alteration is developed between 355–365 m, within a broader interval of disseminated pyrite, and contains weakly anomalous copper values (Figure 5). Elevated magnetic susceptibility measurements between 350–450 m are associated with interbedded or structurally interleaved mafic and intermediate tuff hosting variably developed disseminated pyrite–pyrrhotite–magnetite alteration in addition to rare beds of red chert/iron formation. The felsic to intermediate volcanic rocks near the end of the drillhole are dominated by phengite and Fe–Mg-chlorite along with rare muscovite.

LAKE BOND DEPOSIT

The Lake Bond deposit represents one of the southernmost occurrences of sulphide mineralization within the study area (Figure 1). The deposit is hosted by variably altered pillow basalt assigned to the West Lake Brook division and is, in turn, structurally overlain to the west by rocks correlated with the Gull Brook Bridge division (O'Brien, 2009; Figure 6). Within the pillow basalt sequence, sulphide mineralization occurs as disseminations, stringers, veinlets and small pods, consisting of pyrite, sphalerite, lesser chalcopyrite and rare galena (Swinden and Sacks, 1986; Swinden, 1988; Hudson and Swinden, 1990). The mineralized zone displays pervasive chloritic alteration and silicification and has been inferred to represent a volcanogenic-style of mineralization (Harris, 1976; Swinden and Sacks, 1986; Swinden, 1988). However, Hudson and Swinden (1990) proposed an alternative style for at least part of the mineralization at the deposit. Observations based on petrological, mineralogical and structural evidence suggest the presence of two generations of sulphide mineralization; the first being related to an early volcanogenic-style of mineralization, which was subsequently overprinted by a later syn- to posttectonic, shear-hosted mineralizing event. Hudson and Swinden (1990) noted that the first generation of sulphide within the Lake Bond deposit occur as disseminations, stringers and pods, predominantly consisting of sphalerite and pyrite, and lesser chalcopyrite. In contrast, the second generation of sulphide mineralization occurs as veins that crosscut the dominant foliation and consist of sphalerite, chalcopyrite, pyrite, and trace galena along with anomalous enrichment in gold, arsenic, antimony and cadmium.

Two drillholes were selected from the Lake Bond deposit for spectral analysis, LB-92-01 (396.9 m) and LB-92-02 (338.4 m; Figure 6). These drillholes were previously sampled using a manual core splitter, so deciphering the nature of the host rock and corresponding contact relationships within the mineralized zone is complicated due to the state of the archived core. For drillhole LB-92-01, 129 spectral measurements were collected, from which 104 useable spectra were obtained. For drillhole LB-92-02, 95 spectral measurements were collected, of which 86 produced useable spectra. These two holes intersect the main portion of the deposit and are dominated by mafic volcanic rocks. The structural hanging-wall sequence displays variably developed hematization and contains locally interbedded red siltstone and lesser felsic tuff. A sharp structural contact is observed at surface separating the structural hanging-wall succession from the underlying mineralized zone, with phengite alteration and rare fuchsite developed in the immediate footwall of the structural contact (Sparkes, 2018).

The southernmost hole, LB-92-01, is dominated by massive, locally pillowed mafic volcanic rocks displaying moderate to strong epidote–carbonate veining and variable hematization throughout (Plate 3A). The mafic volcanic rocks are generally non-magnetic, aside from rare, <1 cm-scale, magnetite veins that crosscut the unit. The stratigraphic hanging wall of the drillhole (0–260 m) is dominated by sections of Fe–Mg- and Mg-chlorite along with epidote and rare hornblende and phlogopite (Figure 7A). Epidote appears to become predominant toward the mineralized zone based on the spectral data (Figure 7A). Magnetic susceptibility measurements throughout the drillhole are low expect for the intrusion of moderately magnetic mafic to intermediate dykes and their immediate contact zones. At the transition into the mineralized zone (260–380 m) there is a notable development of muscovite alteration (Figure 7A). This zone is dominated by Fe–Mg-chlorite but also contains lesser Fe- and Mg-chlorite and rare phengite in addition to

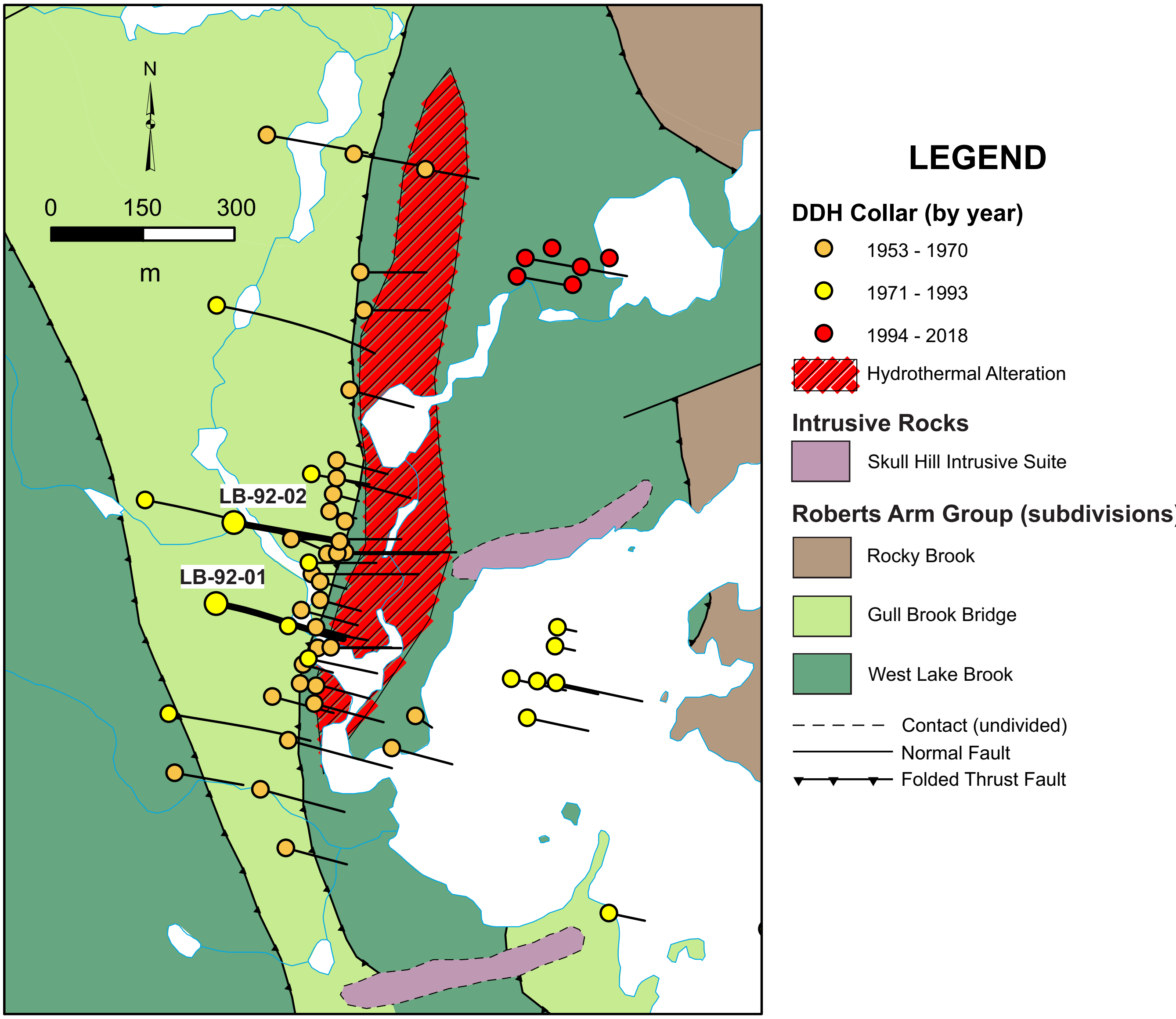

Figure 6. *Simplified geology map of the Lake Bond deposit outlining the distribution of diamond-drill holes (coloured by the year completed). Note the locations of the drillholes analyzed as part of this study are highlighted.*

the development of muscovite (Figure 7A; Plate 3B). The transition out of the mineralized zone is abrupt, but is not believed to be structural. The stratigraphic footwall zone (380–400 m) is dominated by Fe–Mg- and Mg-chlorite along with epidote, similar to that observed within the overlying hanging-wall zone.

Results from the second hole, LB-92-02, located approximately 150 m north of the previous drillhole, display a greater abundance of hematized fragmental mafic volcanic rocks along with interbedded red siltstone and lesser felsic tuff within the structural hanging-wall sequence (0–235 m). These units are locally crosscut by moderately magnetic mafic to intermediate dykes. This drillhole was not logged in its entirety but was mainly targeted for its anomalous gold enrichment developed proximal to the upper structural contact of the mineralized zone. As such, Figure 7B, does not include the bottom portion of the drillhole from 290 to 338.4 m.

Spectral data from the fragmental mafic volcanic and siliciclastic rocks of the structural hanging-wall sequence are dominated by muscovite along with lesser paragonite, phengite, Fe–Mg-chlorite and epidote (Figure 7B). The start of the mineralized zone (235–288 m) is marked by a sharp structural contact associated with the development of phengite and rare fuchsite alteration within the immediate footwall of the structure (Plate 3C). This zone is one of the

Plate 3. *Select photographs of drillcore from the Lake Bond deposit. A) Locally developed pillow features within variably vesicular, epidote–carbonate-veined, mafic volcanic rocks (180 m; LB-92-01); B) Stockwork-style sulphide veining consisting primarily of pyrite and sphalerite in association with Fe–Mg-chlorite and muscovite alteration; an assay from this interval returned 2.58% Zn over 1.0m (256.5–257.5 m, LB-92-01; Collins, 1992); C) Zone of phengite–pyrite alteration developed at the upper structural contact of the mineralized zone; assays from the upper contact zone locally return 1.0% Zn, 0.31% Pb, 0.28% Cu, 6.0 g/t Ag and 999 ppb Au over 0.5 m (239–239.5 m, LB-92-02; Collins, 1992); D) Representative sample of sphalerite-dominated stockwork-style sulphide mineralization developed within the mineralized zone (256.5 m, LB-92-02).*

few areas hosting anomalous (up to 999 ppb) gold within an otherwise zinc-dominated deposit. The main mineralized zone is dominated by stockwork-style mineralization, locally assaying up to 7.5% Zn over 0.5 m (Plate 3D). Within the main portion of the mineralized zone, the spectral data is dominated by Fe–Mg-chlorite along with rare Fe- and Mg-chlorite, muscovite, phengite and phengitic illite (Figure 7B).

HANDCAMP PROSPECT

Located approximately 10 km north-northeast of the Gullbridge deposit is the Handcamp prospect, which has historically been targeted as a gold prospect (Figure 1; Sparkes, 2018 and references therein). The genesis of the gold mineralization has been the matter of some debate, but has generally been inferred to represent an orogenic-style of mineralization (*cf.* Hudson and Swinden, 1989; Evans, 1996). The prospect occurs within a sequence of pillow basalt and associated iron formation (Gull Brook Bridge division of O'Brien, 2016a), containing a structurally bound, hydrothermally altered, exhalative horizon that hosts the mineralization. The exhalative horizon consists of fine-grained, metalliferous siliciclastic rocks interbedded with lesser chert and mafic tuff. This exhalative horizon measures up to 50 m in width and is traceable for up to 1.2 km along strike, dips steeply to the west, and is structurally bound by relatively unaltered pillow basalt and related mafic tuff. Within exploration trenches, the exposed mineralized zone contains relic beds of chert, but all other primary textures are obscured by the intense quartz–muscovite (± fuchsite)–pyrite–magnetite alteration. Mineralization developed within the zone also contains base-metal enrichment, which includes pyrite, sphalerite, galena and chalcopyrite, related

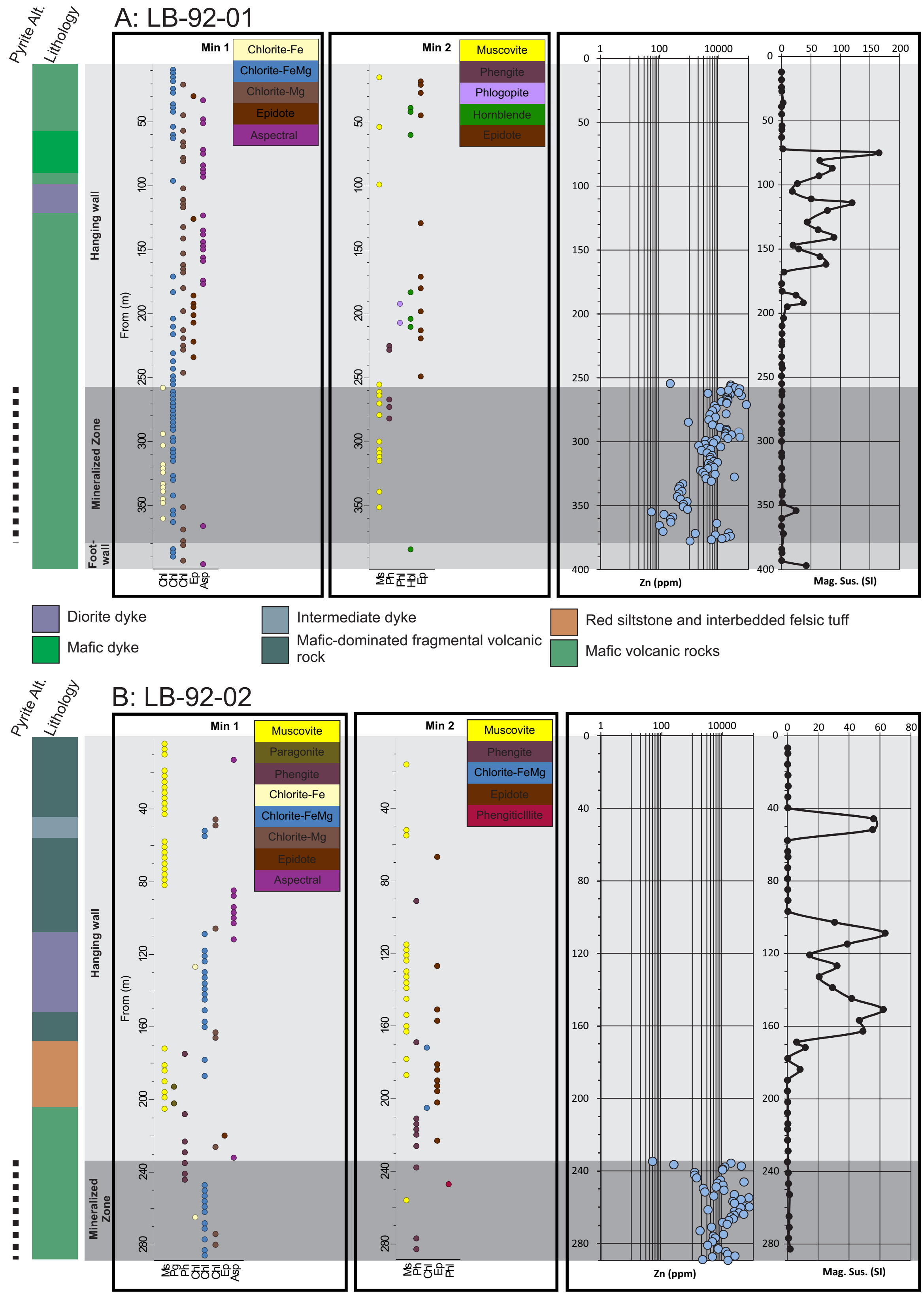

Figure 7. *Strip log outlining the general geology, spectral results, zinc assays and magnetic susceptibility measurements for drillholes from the Lake Bond deposit. For the location of the holes refer to Figure 6; assay data from Collins (1992). Note that no assay data is available for the core outside of the mineralized zone.*

to a volcanogenic-style of mineralization (Hudson and Swinden, 1989). In addition, samples collected from outcrop hosting appreciable gold mineralization are reported to contain significant barium (1.6 to >9.9%; Evans, 1996).

Drilling conducted at the prospect to date has intersected the alteration zone for up to 190 m vertical depth and it remains open both at depth and along strike (Figure 8). Spectral analyses of drillcore from the area have identified zones of phengite, muscovite and lesser biotite and phlogopite alteration in association with base- and precious-metal enrichment. The alteration and associated mineralization are hosted within a structurally bound exhalative horizon. A schematic cross-section through the central portion of the prospect is shown in Figure 9. Spectral results from two representative drillholes, DDH-004 and 007, are outlined in Figure 10. Measurements from drillhole DDH-004 (98.0 m) were collected at 1.5 m spacing, for a total of 69 spectra, of which 60 produced usable results. Data from drillhole DDH-007 was collected at 3.0 m intervals outside of the mineralized zone and at 1.5 m intervals within the mineralized zone, for a total of 76 spectra, of which 57 produced usable results.

Drillhole DDH-004 collars in a sequence of moderately magnetic mafic volcanic rocks that structurally overlie the exhalative horizon. These rocks are characterized by variable Fe–Mg- and Mg-chlorite, hornblende and epidote

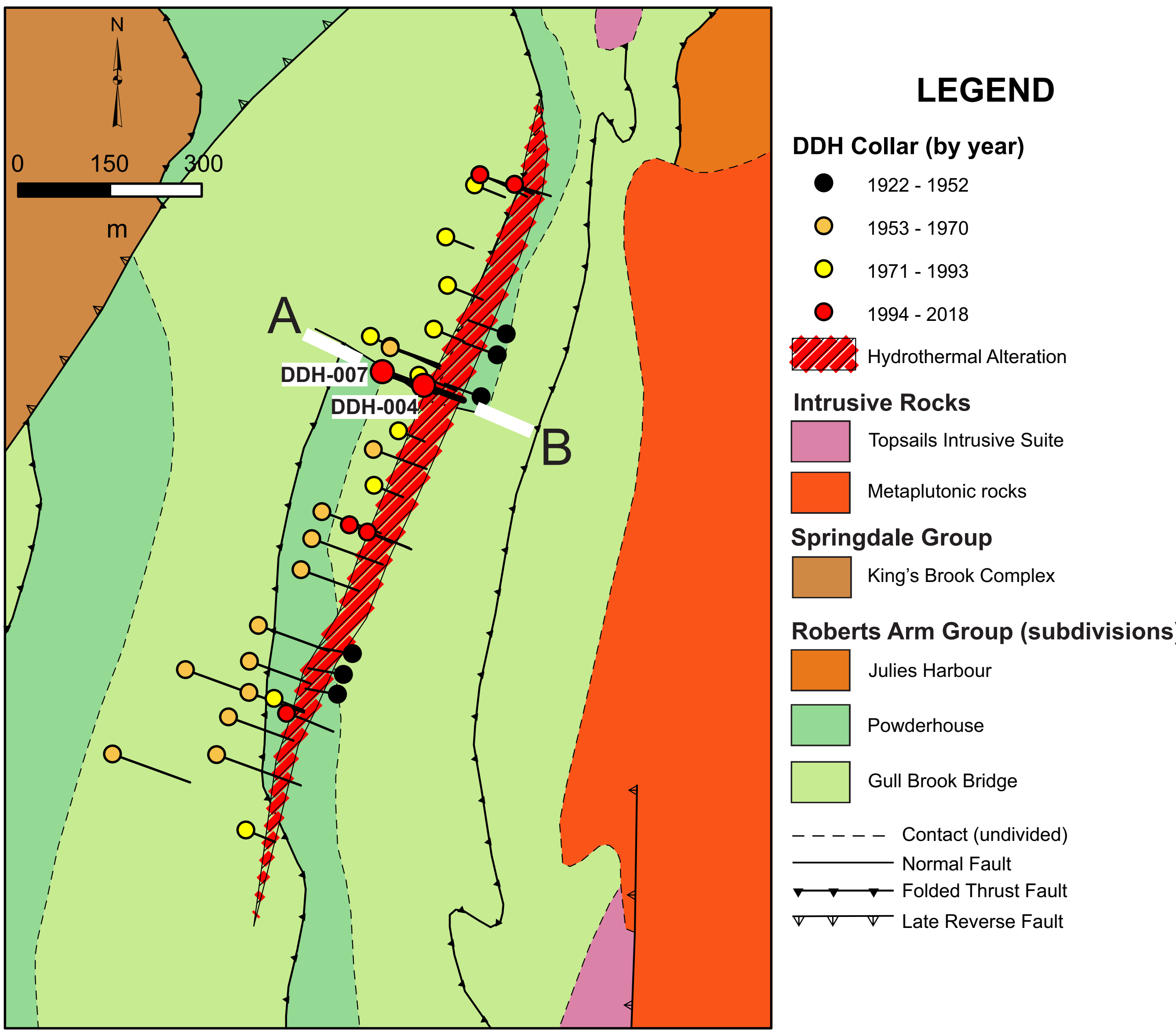

Figure 8. *Simplified geology map of the Handcamp prospect outlining the distribution of diamond-drill holes (coloured by the year completed). Note the locations of the drillholes analyzed as part of this study are highlighted.*

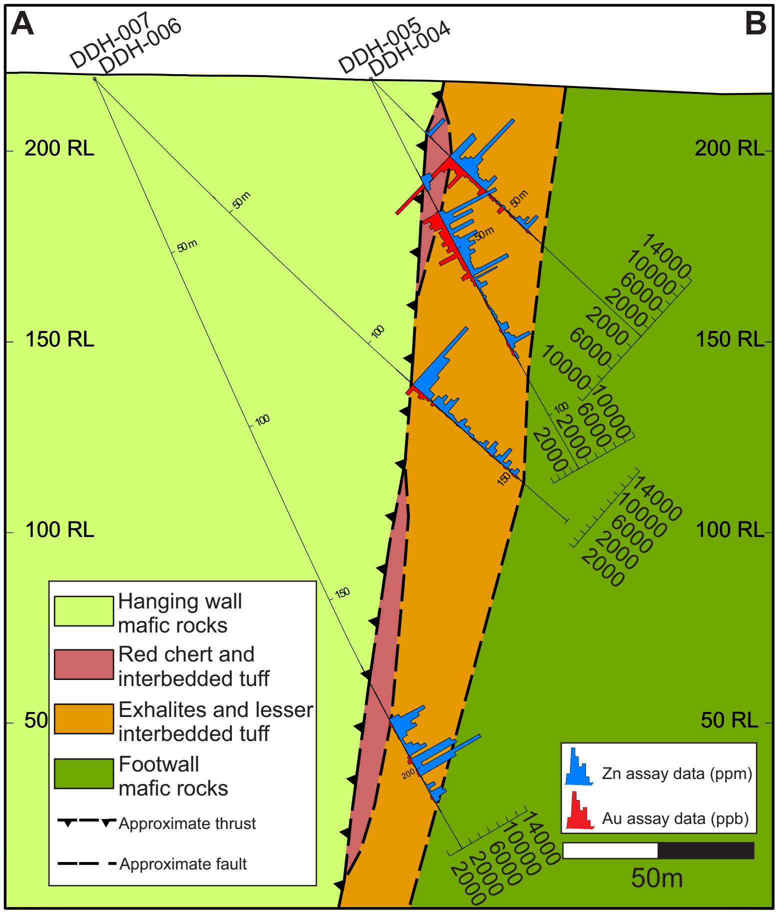

Figure 9. *Schematic cross-section through the central portion of the Handcamp prospect outlining the distribution of the main geological units and select assay data for the mineralized zone; assay data from Pickett* et al. *(2011). For the location of the section refer to Figure 8.*

(Figure 10A). The start of the hanging-wall sequence (20–29 m) relative to the mineralized zone is marked by a sharp structural contact. This inferred thrust fault separates the overlying mafic volcanic rocks from fine-grained siliciclastic rocks hosting bedding-parallel sulphides, locally accompanied by anomalous zinc values (up to 0.42% over 1 m), along with abundant red chert and interbedded mafic tuff (Plate 4A). The local occurrence of zinc mineralization above the red chert horizon supports the inclusion of the chert with the underlying alteration zone, illustrating that some mineralization postdates the deposition of the chert horizon. The hanging wall of the alteration zone is characterized by phengite along with lesser muscovite and Fe–Mg- and Mg-chlorite alteration, and is largely barren with respect to base- and precious-metal mineralization (Figure 10A). The mineralized zone (29–62 m) is marked by a thick sequence of exhalite occurring immediately below the red chert horizon of the hanging-wall zone, and is separated by a structurally modified depositional contact. The upper portion of the mineralized zone displays the highest precious-metal enrichment in association with discrete zones of pale-grey siliceous pyritic alteration accompanied by phengite (Plate 4B).

Spectral data from the mineralized zone indicates a transition from an upper phengite-dominated to a lower muscovite-dominated alteration, in addition to variable Fe–Mg and Mg-chlorite, and rare biotite and phlogopite throughout. In comparing the spectral data with the corresponding assay data in Figure 10A, it is evident that the upper zone of phengite-dominated alteration is accompanied by zinc and gold enrichment, whereas the zone of muscovite alteration is largely defined by somewhat lower concentrations of these two elements. The localized occurrence of biotite and phlogopite near the lower portion of the zone is accompanied by zinc enrichment without any corresponding enrichment in gold (Figure 10A; Plate 4C). The transition into the underlying footwall zone appears gradational in drillcore, transitioning from the exhalative sequence, through mafic tuff into more massive mafic volcanic rocks crosscut by abundant, cm-scale, network-style carbonate veining. However, at surface this contact is at least locally structural. The footwall zone (62–98 m) to the mineralization is dominated by mafic volcanic rocks, which are less magnetic relative to those occurring above the mineralized zone, but display similar Fe–Mg- and Mg-chlorite, hornblende and epidote mineral assemblages (Figure 10A).

Drillhole DDH-007 undercuts DDH-004, intersecting the mineralized zone at approximately 175 m vertical depth (Figure 9). The hole transects an extensive sequence of moderately magnetic mafic volcanic rocks hosting localized interbedded red chert and mafic tuff. The volcanic rocks within this sequence generally produce a poor spectral response, but rare Fe–Mg-chlorite, hornblende and epidote assemblages are identified, whereas the interbedded chert is characterized by phengite and muscovite. The chert and mafic tuff within the structurally overlying mafic volcanic succession does not contain any associated exhalative-style sulphide mineralization. A sharp structural contact separates the overlying mafic volcanic rocks from the red chert immediately overlying the exhalative horizon, which marks the start of the hanging-wall zone (172–185 m) to the mineralization. This zone is primarily characterized by phengite alteration along with lesser muscovite and rare Mg-chlorite. Immediately below the red chert-bearing horizon is the mineralized zone, which is marked by a

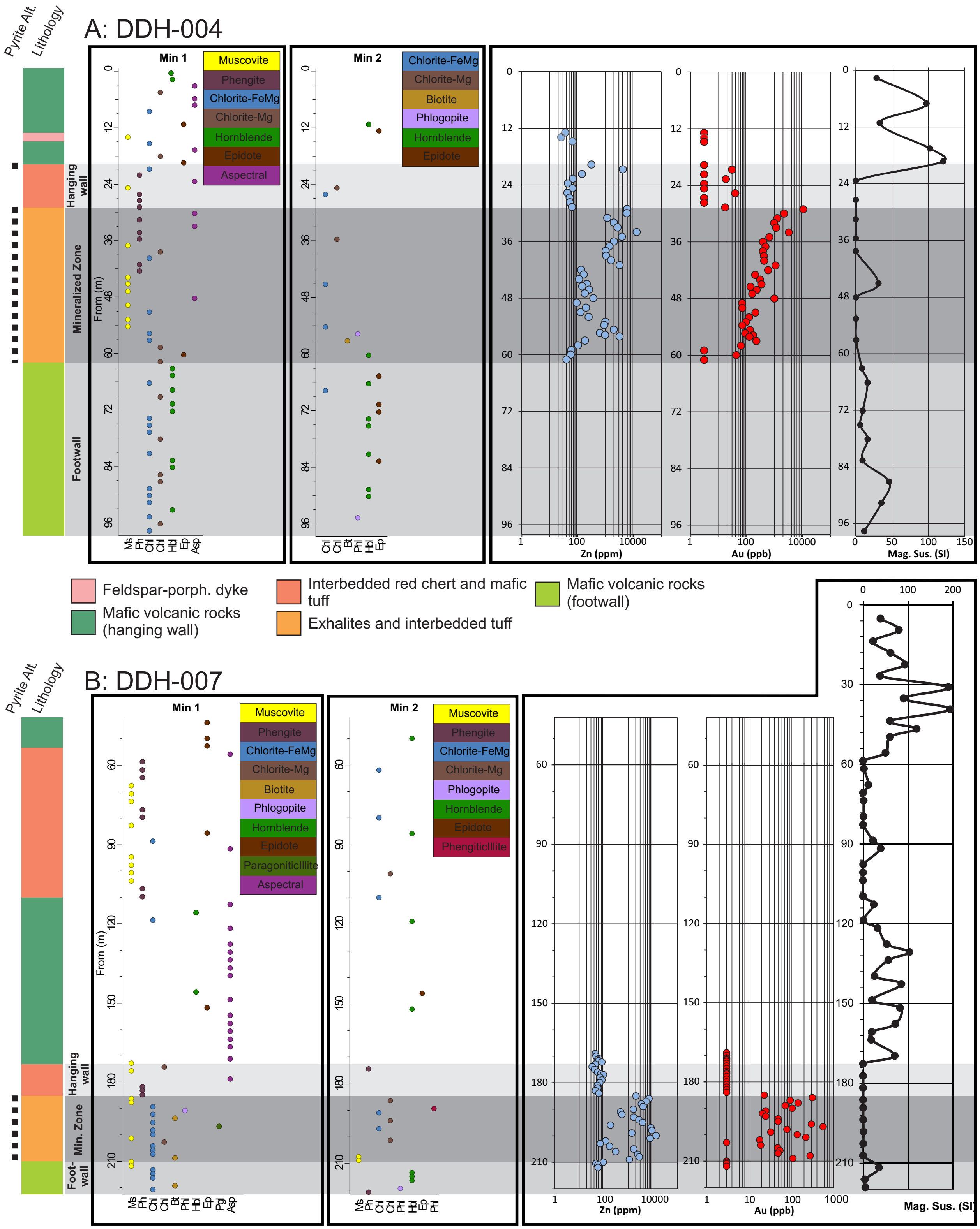

Figure 10. *Representative drillholes from the Handcamp prospect. A) Strip log outlining the general geology, spectral results, zinc and gold assays and magnetic susceptibility measurements for drillhole DDH-004; B) Strip log outlining the general geology, spectral results, zinc and gold assays and magnetic susceptibility measurements for drillhole DDH-007. For the location of the drillholes refer to Figure 8; assay data from Pickett* et al. *(2011).*

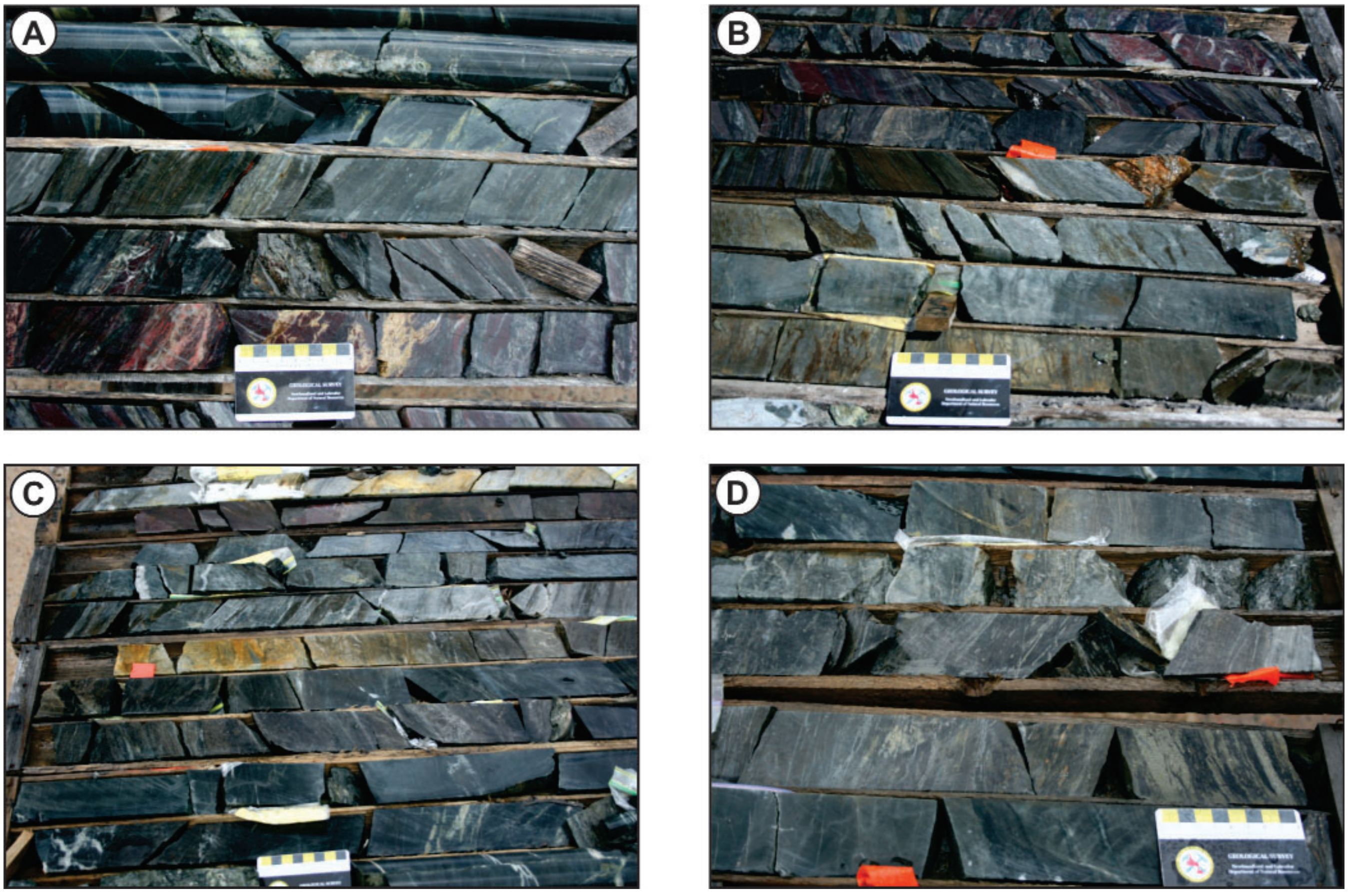

Plate 4. *Select photographs of drillcore from the Handcamp prospect. A) Upper structural contact separating mafic volcanic rocks from the moderately to strongly foliated exhalite contained between overlying volcanic rocks and the immediately underlying red chert; zone contains up to 0.42% Zn over 1 m (20.7–21.7 m, DDH-004; Pickett* et al.*, 2011); B) Sharp structural contact separating the red chert-dominated hanging-wall zone from the altered and mineralized exhalative sequence. Orange tape at center of photograph marks the beginning of the mineralized zone; an assay from this interval returned 0.60% Zn, 0.56% Pb, 0.07% Cu, 222 g/t Ag and 10 g/t Au over 0.9 m (29.1–30.0 m, DDH-004; Pickett* et al.*, 2011); C) Lower zone of Fe–Mg-chlorite, biotite and phlogopite alteration associated with anomalous Zn enrichment. An 0.9 m sample, beginning below the orange tape to the left of center in the photograph, returned 0.32% Zn, 0.15% Pb, 10.7 g/t Ag and 126 ppb Au (56.1–57.0 m, DDH-004; Pickett* et al.*, 2011); D) Exhalative-style sulphide mineralization characteristic of the mineralized zone; interval above the scale card returned 0.43% Zn, 0.63% Pb, 8.8 g/t Ag and 822 ppb Au over 1.0 m (119–120 m, DDH-006; Pickett* et al.*, 2011).*

notable increase in zinc and gold values (Figure 10B; Plate 4D). The mineralized zone (185–210 m) contains variable zinc and gold values throughout, locally assaying up to 0.83% Zn, 14g/t Ag and 562 ppb Au over 1.0 m in base- and precious-metal enriched intervals, and up to 1.34% Zn over 1.0 m in base-metal dominated intervals (Pickett *et al.*, 2011). The zone is dominated by Fe–Mg-chlorite and lesser muscovite, Mg-chlorite, and rare biotite and phlogopite alteration (Figure 10B). Below the mineralized zone there is a gradual transition into the mafic volcanic rocks of the footwall zone (210–224 m). This zone is again dominated by Fe–Mg-chlorite and hornblende along with rare biotite and phlogopite.

WESTERN ALTERATION ZONE

To the immediate west of the Gullbridge–Southwest Shaft alteration zone is a subparallel zone of stratiform pyritic alteration termed the Western Alteration Zone (Swinden, 1988). This zone consists of stratiform pyritic alteration, traceable for approximately 2 km along strike, and is hosted within the felsic volcanic sequence of the Starkes Pond division (Figure 11; O'Brien 2016c). The alteration zone is host to the Sam prospect, as well as several other occurrences of pyritic alteration accompanied by rare values of anomalous gold (230 ppb; Swinden, 1988). Trenching at the southern end of the Western Alteration

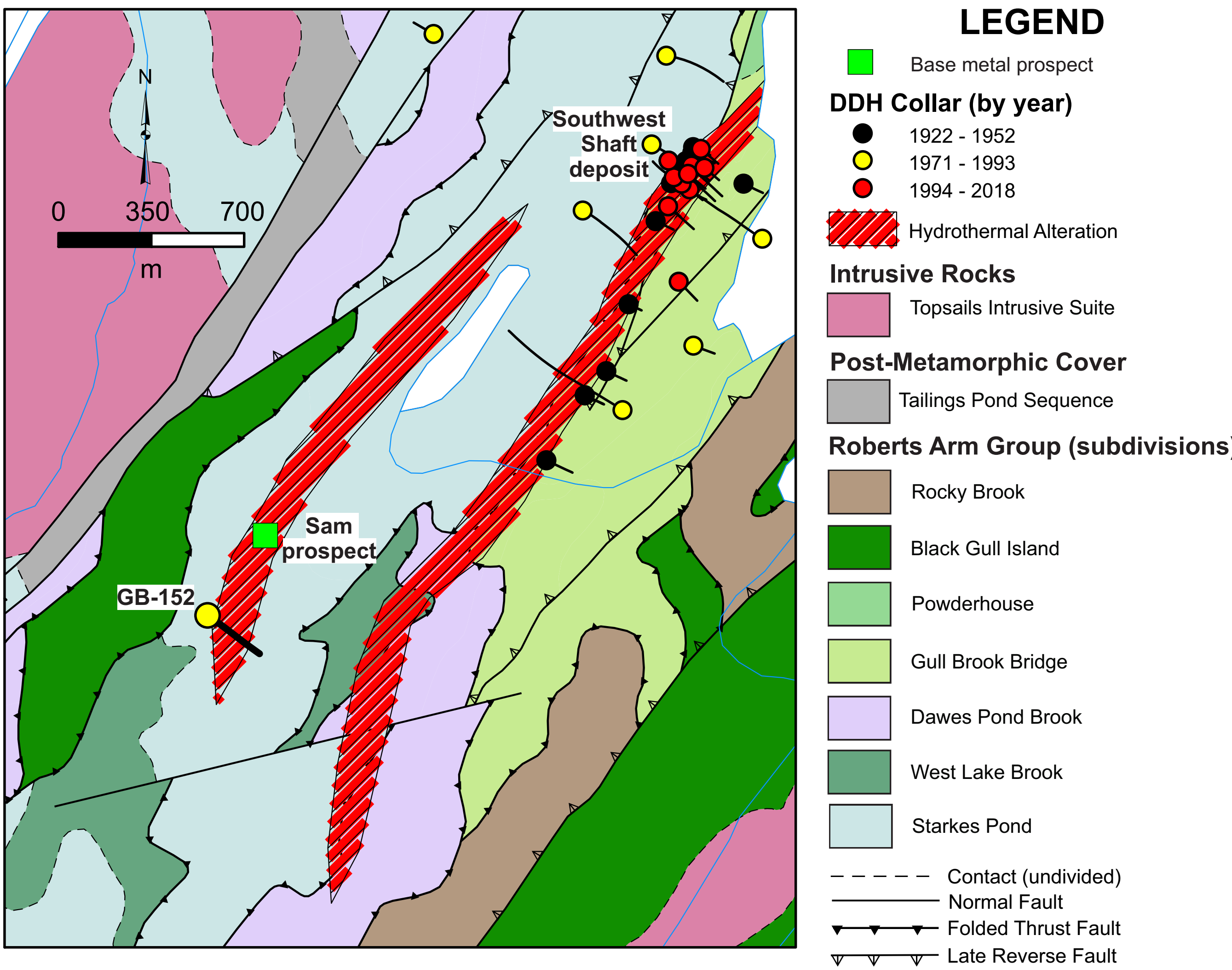

Figure 11. *Simplified geology map of the Western Alteration Zone outlining the location of the diamond-drill hole targeted for study (coloured by the year completed).*

Zone, targeting a soil anomaly containing anomalous values of zinc, exposed altered felsic and mafic tuffs hosting sphalerite and chalcopyrite from which a grab sample assayed 2.02% Zn, 0.41% Pb and 358 ppm Cu (Harris *et al.*, 1997). A single drillhole tested the alteration zone at its southern end, GB-152 (410.57 m; Figure 11), and locally intersected anomalous copper mineralization (up to 0.46% over 1 m; Pudifin and Watson, 1992), but no elevated values of zinc were obtained. From this drillhole, 130 spectral measurements were collected producing 123 usable spectra.

Drillhole GB-152 is collared in mafic to intermediate tuff hosting rare beds of red chert. This sequence is crosscut by several mafic and felsic dykes of varying widths. Throughout the drillhole, most units are relatively nonmagnetic aside from locally elevated magnetic susceptibility values associated with mafic dykes or the presence of rare iron formation interbedded within the volcanic sequence. The hanging wall relative to the alteration zone (0–200 m) is dominated by Fe–Mg-chlorite and phengite along with lesser Fe-chlorite and muscovite. Rare zones of disseminated pyritic alteration are locally developed along with zones of exhalative-style sulphide mineralization, primarily dominated by pyrite (Plate 5A; Figure 12). However, such zones are not accompanied by any significant alteration or base-metal enrichment. The beginning of the mineralized zone (200–290 m) appears to be gradational and is marked by the development of muscovite and Fe-chlorite alteration in association with a zone of pyritic alteration hosted within interbedded intermediate and mafic tuff. Disseminated and vein-hosted sulphide mineralization is variably developed throughout the interval, locally hosting anomalous copper mineralization. Within the mineralized zone, muscovite alteration is predominantly developed

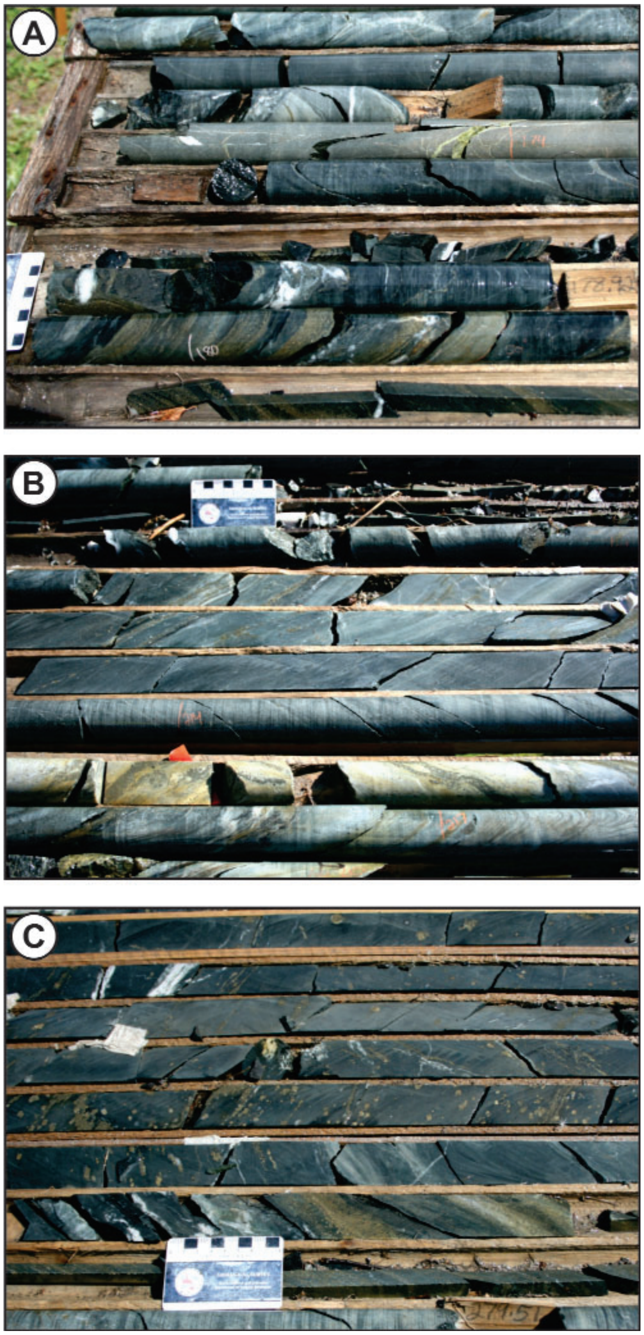

Plate 5. *Select photographs of drillcore from DDH GB-152, Western Alteration Zone. A) Exhalative-style pyrite mineralization hosted with interbedded mafic/intermediate tuff and green siltstone (180 m); B) Strongly foliated intermediate tuff hosting disseminated and vein-hosted sulphide mineralization; assays from this interval returned up to 0.37% Cu over 0.65 m in association with muscovitic alteration (211.10–211.75 m; Pudifin and Watson, 1992); C) "Blebby" disseminated sulphide mineralization contained within mafic tuff hosting Fe-chlorite alteration and anomalous copper mineralization, locally assaying up to 0.46% Cu over 1 m (266–267 m; Pudifin and Watson, 1992).*

within the intermediate tuff (Plate 5B), whereas the mafic tuff is dominated by Fe-chlorite alteration (Plate 5C). The transition into the footwall zone is sharp, potentially representing a structural contact, and is marked by a mafic dyke, which now separates the overlying volcanic sequence from the underlying mafic dominated volcaniclastic unit. The footwall zone (290–400 m) is characterized by phengite–Fe–Mg-chlorite alteration along with lesser muscovite, Fe- and Mg-chlorite and epidote.

DISCUSSION

The use of SWIR spectrometry, to characterize the various alteration assemblages associated with VMS mineralization within the central portion of the Buchans–Roberts Arm belt, provides valuable information. The noted changes in the compositions of chlorites and white micas marginal to mineralized zones correlates well with anomalous geochemical values from industry assay data. Comparison of identified alteration assemblages around known deposits, with those from other identified prospects and alteration zones in the region, highlight the potential prospectivity of some of these occurrences.

GULLBRIDGE DEPOSIT

In the area of the Gullbridge deposit, regional background mineral assemblages are inferred to be represented by those spectra that are most distal from the deposit. For the felsic volcanic rocks, those occurring above the thrust fault to the immediate west of the deposit are inferred to represent the least altered equivalents of this unit, being dominated by phengite and lesser Fe–Mg-chlorite. For the mafic volcanic assemblages within the main area of the deposit, those rocks occurring in the structural footwall zone displaying Fe–Mg-chlorite-dominated assemblages are taken to represent the least altered equivalents. The drillhole located to the south of the deposit, GB-135, supports this interpretation as it displays abundant Fe–Mg-chlorite throughout the weakly developed mineralized zone and into the underlying footwall zone. Within the hanging-wall sequence, relative to the mineralized zone, which is also best observed in GB-135, the area immediately above the mineralization is highlighted by the occurrence of rare, red chert and exhalative-style sulphide mineralization accompanied by biotite and phlogopite in association with Mg-chlorite-bearing assemblages. These features are attributed to represent the waning stages of hydrothermal activity related to the development of the deposit and display many similarities to the alteration zone developed at the Handcamp prospect (*see* below). The development of phlogopite potentially highlights the presence of a Mg-rich alteration, similar to the relationship inferred for the development of cordierite in the area.

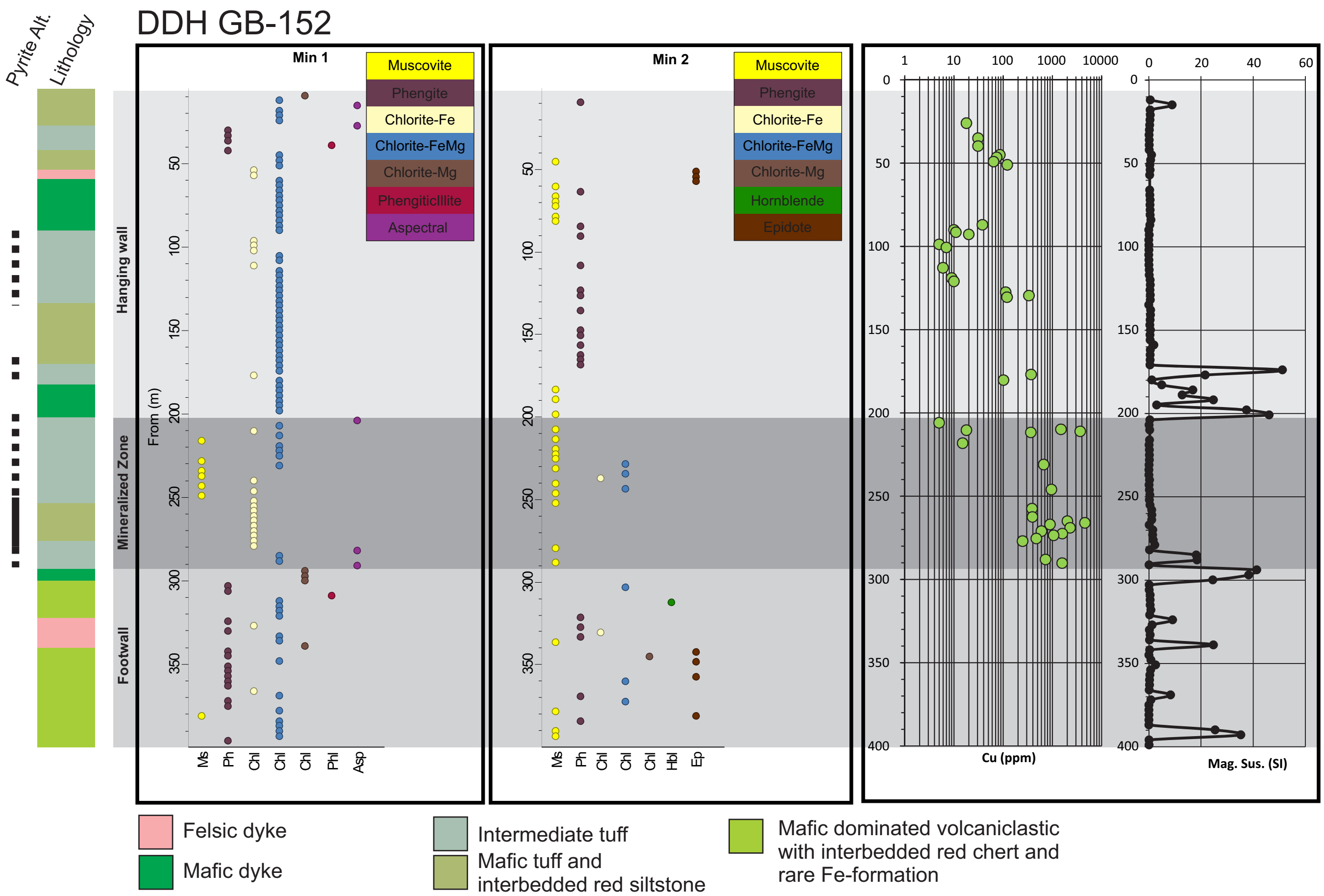

Figure 12. *Strip log outlining the general geology, spectral results, copper assays and magnetic susceptibility measurements for the drillhole through the southern portion of the Western Alteration Zone. For the location of the hole refer to Figure 11; assay data from Pudifin and Watson (1992).*

The development of the mineralized zone is associated with a distinct shift in the white mica alteration, with muscovite becoming the predominant white mica in the area of elevated copper values. However, individual mineralized samples from this zone are locally dominated by Mg-chlorite in association with magnetite alteration representing localized smaller scale alteration within the overall mineralized zone. Within the core of the deposit, the shift from Fe–Mg-chlorite to Fe-chlorite is inferred to highlight the main alteration associated with the high-grade copper mineralization. The results obtained from drillhole GB-148 support the mineralogical information gathered from surface samples collected from outcropping mineralization, whereby Fe-chlorite is the main alteration mineral developed in association with sulphide mineralization.

SOUTHWEST SHAFT DEPOSIT

The Southwest Shaft deposit differs from the Gullbridge deposit in that mineralization is primarily hosted within felsic volcanic rocks. However, similar mineral assemblages to those associated with the development of sulphide mineralization at Gullbridge are also noted here. A sharp contrast is observed within the relatively barren, phengite-dominated, felsic volcanic rocks above the thrust fault, to those dominated by muscovite and hosting mineralization within the immediate footwall of the structure. Immediately below the mineralized felsic volcanic rocks is a structurally bound zone of pyrite–Fe-chlorite alteration occurring in mafic to intermediate volcanic rocks. However, this zone does not contain any significant copper mineralization. The close spatial association of Fe-chlorite alteration and copper mineralization within the Gullbridge deposit would suggest that the observed Fe-chlorite alteration assemblage at the Southwest Shaft deposit is associated with the development of the overall hydrothermal system. Nevertheless, given the overall lack of mineralization associated with the alteration, the zone possibly represents a structurally transported lens of hydrothermal alteration that has been juxtaposed with the mineralized zone.

The Southwest Shaft deposit represents a smaller zone of copper-dominated sulphide mineralization relative to the Gullbridge deposit. As such, the related alteration zone is more restricted and potentially less intense. This may account for the predominant Fe–Mg-chlorite developed throughout the mineralized and footwall zones, similar to that observed in GB-135, which is located some distance from the main Gullbridge deposit. One notable difference within the Southwest Shaft deposit is the lack of associated magnetite alteration with the zone of copper mineralization, which may just be reflective of the different host rock to the mineralized zone. Rare zones of pyrite–pyrrhotite–magnetite mineralization, locally associated with red chert beds, are developed within the footwall zone, between 350–450 m, and are associated with elevated magnetic susceptibility values. Such occurrences are probably exhalative, and as there is no significant alteration associated with their development, these zones likely represent distal products relative to any major hydrothermal activity.

LAKE BOND DEPOSIT

The Lake Bond deposit represents one of the least structurally deformed and thermally metamorphosed areas of mineralization within the study area. The deposit is mapped on a regional-scale as being hosted within a different sequence of mafic volcanic rocks relative to the mineralization developed in the area of the Gullbridge deposit. The mafic volcanic rocks distal to the mineralized zone display both Fe–Mg-chlorite and Mg-chlorite within relatively unaltered country rock. In addition, the two drillholes display distinctly different mineral assemblages associated with the development of sulphide mineralization. The southernmost drillhole, LB-92-01, displays similar relationships to those in the area of the Gullbridge deposit with the development of muscovite and Fe-chlorite in association with sulphide mineralization.

However, drillhole LB-92-02, which is located approximately 150 m to the north of LB-92-01, does not have muscovite or Fe-chlorite assemblages in association with mineralization. Here, muscovite dominates the rocks within the hanging-wall sequence, with phengite becoming predominant in the area proximal to the mineralized zone. The phengite alteration displays a spatial association with a structure that forms the upper limit to the mineralized zone, and is also host to anomalous gold mineralization (*cf.* Collins, 1992). This apparent structurally controlled mineral assemblage of phengite-dominated alteration may represent the second generation of sulphide mineralization accompanied by anomalous gold enrichment noted by Hudson and Swinden (1990).

HANDCAMP PROSPECT

The Handcamp prospect is unique, as it was previously classified as an example of VMS-style mineralization overprinted by orogenic-style gold mineralization (*cf.* Hudson and Swinden, 1989; Evans, 1996). However, examination of the most recent drillcore from the prospect by the author indicates that the alteration and related mineralization are entirely related to the development of VMS-related mineralization; an observation earlier expressed by Pickett *et al*. (2011).

Drillcore from the area illustrates that the development of both base- and precious-metal mineralization is associated with a structurally bound zone of exhalative-style sulphide mineralization. This zone displays a spatial association with the development of red chert that immediately overlies, and is locally interbedded within, the alteration zone. The main mineralized zone is associated with phengite, muscovite, biotite and phlogopite alteration developed within metalliferous sedimentary rocks. This mineral assemblage closely resembles that developed in the immediate hanging wall of the Gullbridge deposit farther to the south, suggesting a potential vent proximal environment for the development of the accompanying mineralization.

With respect to the development of the precious-metal enrichment within the mineralized zone, preliminary geochemical data from surface trenches indicate a correlation between barium content and gold values within mineralized samples. In addition, the highest gold values also display a spatial association with siliceous cherty horizons containing disseminated and locally layered pyrite, suggesting a potential exhalative affinity for the precious-metal enrichment.

WESTERN ALTERATION ZONE

This zone of stratiform, pyrite-dominated, hydrothermal alteration is locally host to anomalous copper mineralization. The development of sulphide mineralization is accompanied by similar mineral assemblages to those observed in peripheral alteration assemblages immediately to the south of the Gullbridge deposit. This includes the presence of muscovite and Fe-chlorite alteration association with the disseminated and vein-hosted sulphide mineralization. Again, the regional background mineral assemblage is dominated by Fe–Mg-chlorite and lesser phengite in both the hanging wall and footwall zones relative to the mineralized zone. However, it has yet to be determined if this zone represents a stratigraphically distinct zone of hydrothermal alteration, or just the structural repetition of the Gullbridge–Southwest Shaft alteration zone developed farther to the east.

CONCLUSION

Preliminary investigations into the spectral signatures of the alteration, associated with the development of VMS mineralization, demonstrate that detectable changes, using SWIR spectrometry, are present within the host volcanic stratigraphy of the Buchans–Roberts Arm belt. The recognition of such zones associated with individual deposits may allow for more detailed modelling of the related alteration, given the complex structural environment in which it occurs. More detailed study of the main alteration assemblages, in combination with the evaluation of their geochemistry, may provide further insight into the development of these zones.

In addition, the local presence of precious-metal enrichment, with base-metal mineralization can be shown to be at least locally related to the development of VMS-style mineralization (*e.g.*, Handcamp prospect). However, some occurrences, such as that developed at the Lake Bond deposit, do, in fact, appear to be structurally controlled, potentially representing an overprinting, epigenetic-style of mineralization. Such examples will be the focus of more detailed study in order to characterize the genesis of this mineralization.

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