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ABSTRACT
As part of the Geological Survey of Canada's Targeted Geoscience Initiative 4 (TGI-4) Program, till, stream sediment, and bedrock samples around the Sisson W-Mo deposit in west-central New Brunswick were collected to determine the indicator minerals and their trace element signatures that are indicative of intrusion-hosted W-Mo deposits. The purpose of this open file is to report the raw indicator mineral weight and abundance data for bedrock, till, and stream sediment samples collected in 2011 and 2012 for this case study. Samples were processed by the commercial laboratory Overburden Drilling Management Limited, Ottawa, ON, using a combination of tabling, panning, and heavy liquids to recover potential indicator minerals. Sample locations, weights of various fractions produced during sample processing, and indicator mineral grains identified are reported in this open file.

INTRODUCTION
Several case studies have been published that document the indicator mineral signatures for gold and kimberlites in till, however, few have been published that document indicator mineral signatures of intrusion-hosted W-Mo deposits. To address this knowledge gap, the Geological Survey of Canada (GSC), through its Targeted Geoscience Initiative 4 (TGI-4) Program (2010-2015), and the New Brunswick Department of Energy and Mines initiated a study of till, stream sediment, and bedrock samples around the Sisson W-Mo deposit in west central New Brunswick (Fig. 1). This study is being carried out in collaboration with Northcliff Resources Limited and Hunter Dickinson Inc. (HDI).

The Sisson deposit was chosen as a W-Mo indicator mineral test site because the deposit: (1) and district geology are well known and bedrock samples were available from drill core; (2) subcrops and thus was exposed to direct glacial erosion; (3) is till covered; (4) is easily accessible by road; and (5) has a previously identified till geochemical dispersal train down-ice from known mineralization and thus metal-rich till should be available for sampling in this study.

The specific objectives of the TGI-4 indicator mineral research project are**:** 1) to determine the indicator minerals and their trace element signatures that are indicative of intrusion-hosted W-Mo deposits; and 2) to establish practical methods for their recovery from glacial sediments and their identification that can be routinely applied in W-Mo exploration in glaciated terrain. The purpose of this open file is to report the raw indicator mineral abundance data for the bedrock, till, and stream sediment samples collected in 2011 and 2012 for this specific case study. Interpretations of these indicator mineral data, as well as till and stream sediment geochemical data for the <0.063 mm fraction of the same till and stream sediment samples, will be published in subsequent GSC Open Files.

METHODS
Field sampling
Till, stream sediment, and bedrock samples were collected in the summers of 2011 and 2012 in the Sisson deposit area. A total of 12 bedrock samples, weighing between 1 and 5 kg, were collected for recovery of indicator minerals to document the indicator mineral signatures of the host rocks and mineralization for comparisons with mineralogy and geochemistry of till. Eleven bedrock samples were collected and processed in 2011 (11-MPB-R01 to -R11) and one sample

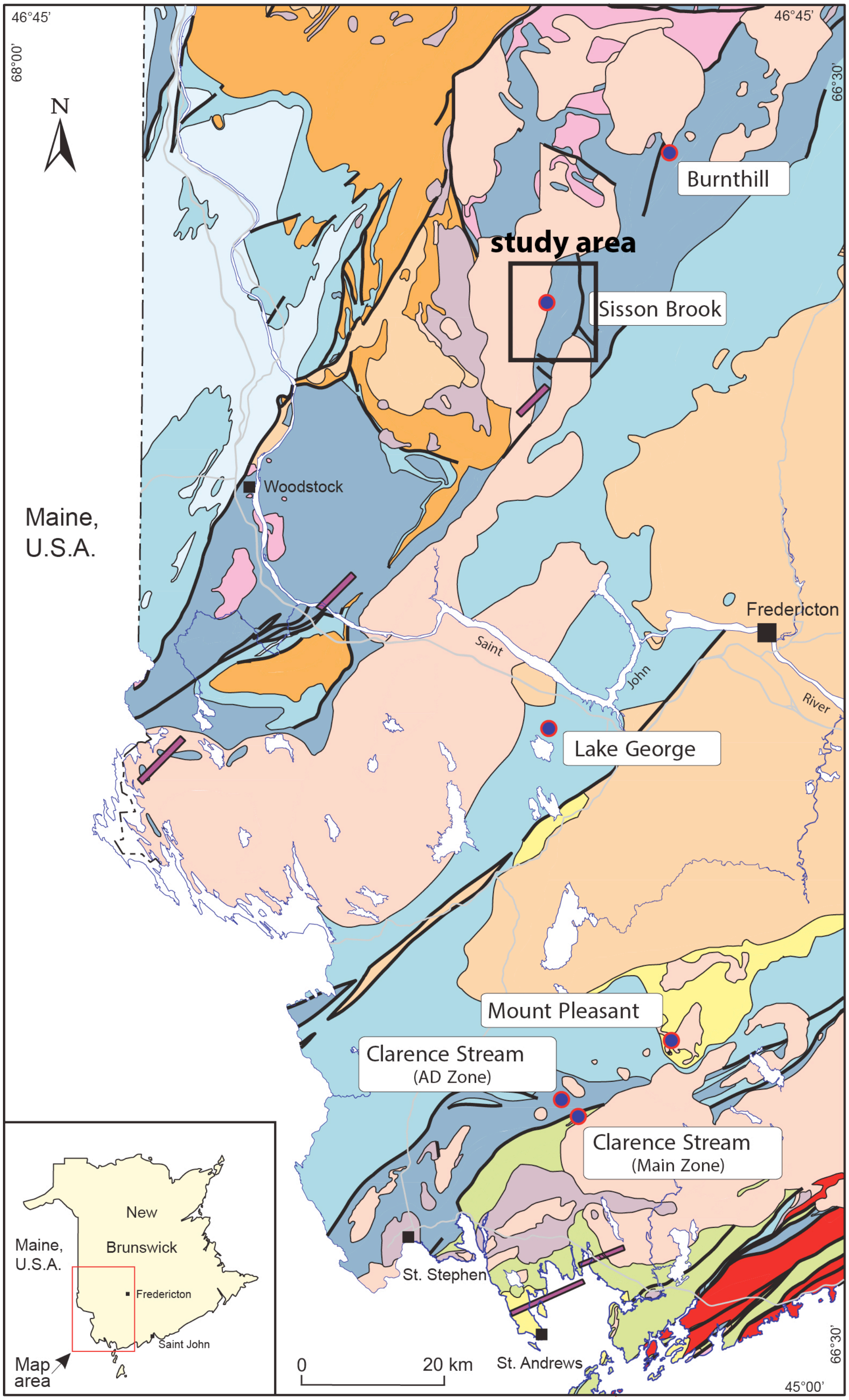

Figure 1. Location of the Sisson W-Mo deposit in central New Brunswick (modified from Fyffe et al., 2010).

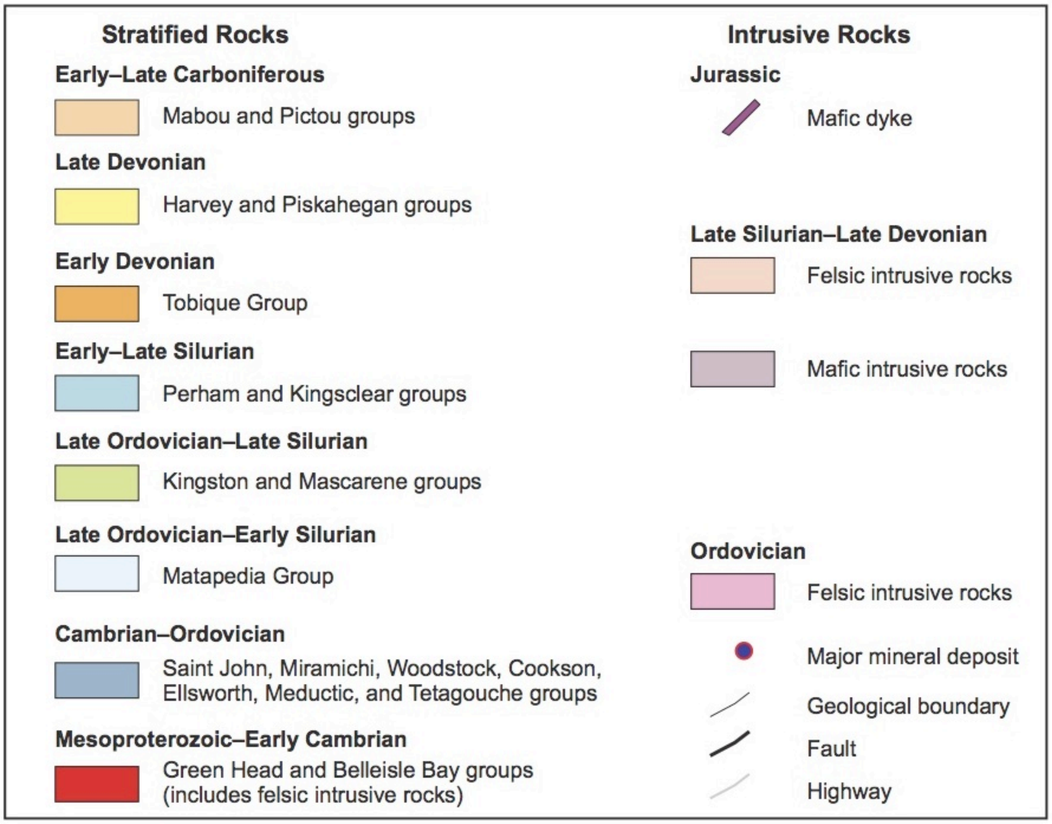

Figure 1. (cont.) Bedrock geology legend (from Fyffe et al., 2010).

was collected and processed in 2012 (12-MPB-1025). Bedrock sample locations and depths are listed in **Appendix A**. Bedrock samples were collected in collaboration with HDI geologists from mineralization and surrounding host rocks intersected in drill core. Three bedrock samples were collected by GSC from bedrock subcrops. Lithologies sampled included: 1) high grade W mineralization, 2) quartz feldspar porphyry dykes, 3) Howard Peak Gabbro, 4) Howard Peak Granodiorite, 5) Nashwaak Granite, 6) altered Nashwaak Granite, and, 7) felsic and mafic tuff of the Turnbull Mountain Formation.

In 2011, 56 large (~15 kg) till samples (11-MPB-502 to -553) were collected up-ice (to the NW), proximal to, and at varying distances down-ice (generally SE) of the Sisson deposit (Figs. 2 and 3). Till samples were collected from hand dug holes and surface trenches as well as from drill core (blue dots in Figure 3) and one small exploration pit exposing the deposit. In 2012, one additional till sample was collected over the north end of the deposit (12-MPB-1026). Three field duplicate till samples were collected in 2011 to assess field variability: 11-MPB-504 is a duplicate of 11-MPB-503; 11-MPB-522 is a duplicate of 11-MPB-521; and 11-MPB-556 is a duplicate of 11-MPB-555. All till sample locations are listed in **Appendix A**. Detailed notes and photos were taken at each sample site and will be included in a subsequent GSC open file.

A total of 17 large (10-13 kg) sand-rich stream sediment samples were collected from 16 sites at upstream ends of mid-channel boulder bars in first, second, and third order streams within the study area in August 2012 (Figs. 2 and 3). Material was collected by shovel from one (preferred)

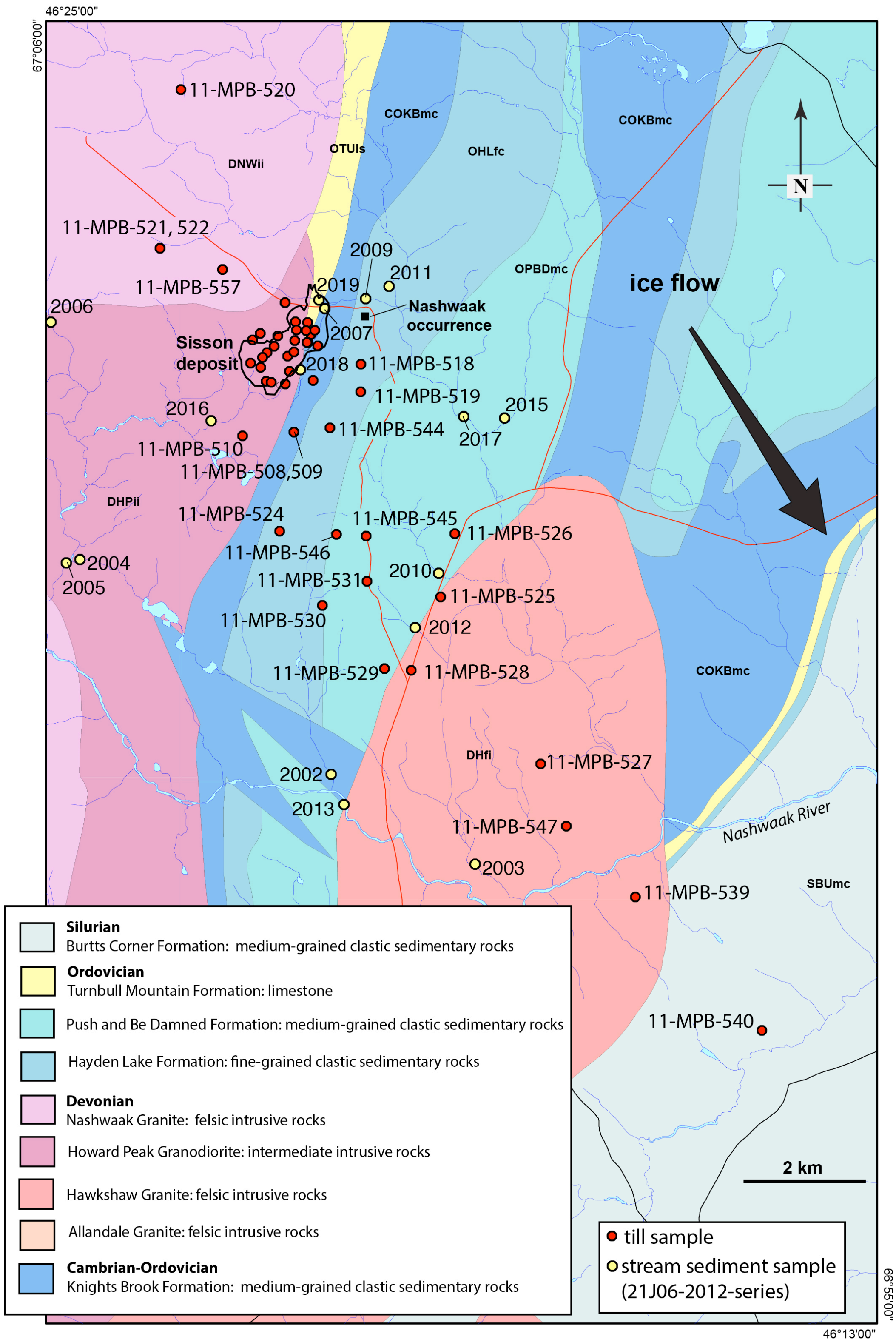

Figure 2. Till and stream sediment sample location map. Bedrock geology modified from Smith and Fyffe (2006a-d). Extent of W-Mo mineralization shown with thick black line from Rennie, (2012). Yellow dots are stream sediment sampling sites. Red dots are till sampling sites.

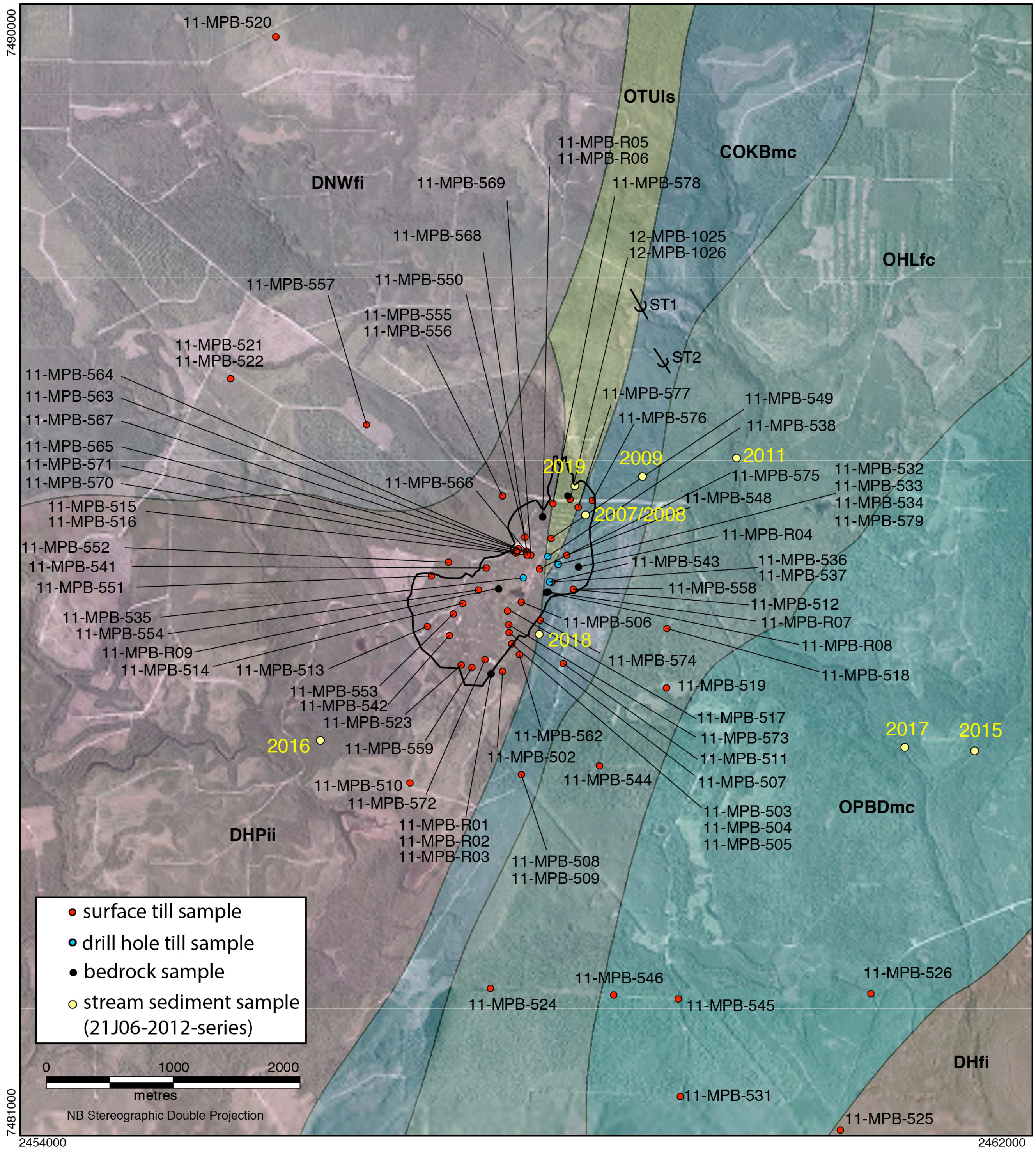

Figure 3. Detailed till, stream sediment, and bedrock sample location map for the deposit area. Deposit outline in thick black line is from Rennie (2012). Bedrock geological units are the same as in Figure 2. Bedrock geology modified from Smith and Fyffe (2006a-d). Background aerial photograph from Northcliff Resources Ltd.

or more holes dug in the stream bed (commonly to depths of a few 10s of cm). Material was wet-sieved into the pail through a 12-mesh (1.68 mm) stainless steel sieve until a sample weight of 10-15 kg was attained. One field duplicate stream sediment sample was collected to assess field variability: 21J06-2012-2008 is a duplicate of 21J06-2012-2007. All stream sediment samples were processed to recover the heavy mineral fraction for indicator mineral picking. Detailed notes and photos taken at each sample site will be included in a subsequent GSC Open File. Stream sediment sample location coordinates are included in **Appendix A**.

Sample processing and indicator mineral picking

All samples were shipped to Overburden Drilling Management Limited (ODM), Ottawa, ON for processing and production of heavy mineral concentrates. Laboratory data for these samples are reported in **Appendices B1 to B5**.

Bedrock samples

Bedrock samples were processed such that the most mineralized samples were processed last to limit carry over of ore minerals between samples. Samples are listed in the ODM raw data files in **Appendix B1 and B2** in the order that they were processed at ODM. Bedrock samples were processed following the flow chart depicted in Figure 4. Each bedrock sample was first examined and described by geologists at ODM (**Appendix C**) and then disaggregated at ODM using a custom built CNT Spark-2 electric pulse disaggregator (EPD) instead of a conventional rock crusher to preserve natural grain sizes, textures, and shapes. The weight of material disaggregated ranged from 172 to 2780 g. Each sample was placed in a metal chamber that was then filled with water and sealed. Electric pulses were then applied to the sample. The rapid scattering of electric pulses through the sample leads to explosions, which occur preferentially along grain boundaries, the natural zones of weakness in a rock sample. The explosions along grain boundaries result in liberated individual, undamaged mineral grains that are recovered in their original shape and form regardless of grain size (Rudashevski et al., 2002; Lastra et al., 2003; Cabri et al., 2008). The <2.0 mm material of each bedrock sample was then processed at ODM to produce a non-ferromagnetic heavy mineral concentrate for picking indicator minerals, and weights for all fractions produced are reported in **Appendix B1 and B2**. The <2.0 mm material was passed over a shaking table and the heavy table concentrate further refined using heavy liquid separation in methylene iodide diluted to a specific gravity (SG) of 3.2. The table concentrates were recovered and micro-panned to recover any gold, sulphides, and tungsten minerals that might be present in the <0.25 mm fraction. The minerals in the panned concentrates were counted and their size and shape characteristics recorded and then returned to the sample. The heavy table concentrate was then sieved at 0.18 mm. The 0.18 to 2.0 mm pre-concentrate was then further refined using heavy liquid separation in methylene iodide diluted to a specific gravity (SG) of 3.2.

The ferromagnetic fraction was then separated using a hand magnet. The non-ferromagnetic heavy mineral fraction was sieved into four size fractions: 0.18-0.25, 0.25-0.5, 0.5-1.0, 1.0-2.0 mm. The 0.18-0.25 mm fraction was archived and the 0.25-0.5 mm fraction was further subjected to paramagnetic separations using a Carpco® magnetic separator at 0.6, 0.8 and 1.0 amps to assist picking this fine-grained fraction.

At ODM, eleven quartz blank bedrock samples were inserted into the 2011 bedrock batch at the beginning and after each bedrock sample and one quartz blank was processed prior to the processing of 2012 bedrock sample 12-MPB-1025. Quartz blanks were used to monitor and reduce the chance of cross contamination between samples. Blank samples are identified by the letters 'QBK' in their sample number. The results for the quartz blank samples are reported along with the bedrock samples in **Appendix B1** and **B2**.

Till samples

Till samples were also shipped to ODM for processing, production of heavy mineral concentrates, and indicator mineral picking. In 2011, 56 till samples plus seven quality control samples for a total of 63 samples were processed at ODM. In 2012, one till sample was collected and processed along with a batch of till samples from the Mount Pleasant Sn-W-Mo-Bi-In deposit area. The quality control samples include: 1) GSC in-house 'blanks', informally referred to as the Bathurst blank, a weathered granite collected near Bathurst New Brunswick (see below) and 2) field duplicate samples. The blank samples were inserted into the 2011 till batch by GSC prior to processing to monitor carry over contamination in the indicator mineral processing laboratory: 11-MPB-501, -507A, and -560. They are identified as Bathurst blank in **Appendix A**. These "blank" samples are weathered Silurian-Devonian granite (grus) of the South Nepisiguit River Plutonic Suite (Wilson, 2007) collected in the Miramichi Highlands approximately 66 km west of Bathurst, New Brunswick (McClenaghan et al., 2012; Plouffe et al., in press). The material is unconsolidated and has the appearance of moderately sorted, monolithologic sand. It does not contain any precious or base metal indicator minerals except for rare gold grains (Plouffe et al., in press). Results for these three samples are reported along with the till samples.

Similar to the bedrock samples, the <2.0 mm fraction of till was processed to produce a non-ferromagnetic heavy mineral concentrate for selection of indicator minerals as outlined in Figure 5 and weights for all fractions produced are reported in **Appendix B3** and **B4**. First, 10 to 15 kg of the <2.0 mm material was passed over a shaking table and the heavy table concentrate recovered and micropanned to recover any gold, sulphides, and tungsten minerals in the <0.25 mm fraction. The minerals in the panned concentrates were counted and their size and shape characteristics recorded and then returned to the sample. Concentrates were then sieved at 0.25 mm. The 0.25 to 2.0 mm pre-concentrate was then further refined using heavy liquid separation in methylene iodide diluted to a SG of 3.2. After panning and heavy liquid separation, the 0.25-2.0 mm ferromagnetic fraction was then removed and the non-ferromagnetic heavy mineral fraction was sieved into three size fractions: 0.25-0.5, 0.5-1.0, 1.0-2.0 mm. The <0.25 mm fraction of all till samples was processed to recover the non-ferromagnetic fraction and then archived. The 0.25-0.5 mm fraction was further subjected to paramagnetic separations using a Carpco® magnetic separator to produce <0.6 amp (strongly paramagnetic), 0.6 to 0.8 amp (moderately paramagnetic), 0.8 to 1.0 amp (weakly paramagnetic) and >1.0 amp (non-paramagnetic fractions) to assist counting and picking indicator minerals in this fine-grained fraction. The 0.25-0.5 mm fraction was cleaned with oxalic acid to remove oxidation stains (tarnish) from the grains and restore their natural colour, most importantly for sulphide minerals, which facilitates optical mineral identification.

Stream sediment samples

Seventeen stream sediment samples and two blanks samples were shipped to ODM for processing, production of heavy mineral concentrates, and indicator mineral picking.

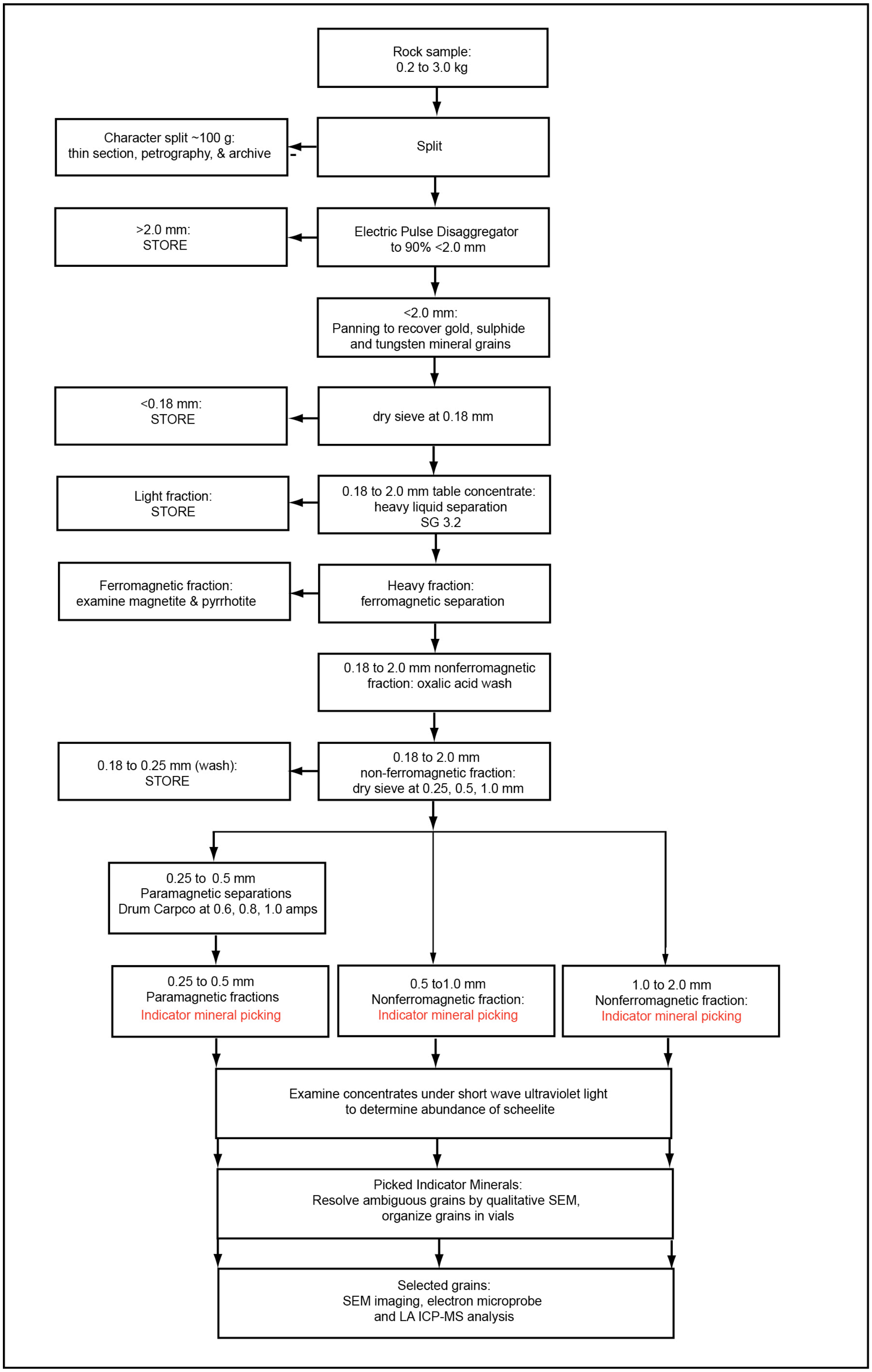

Figure 4. Flow sheet outlining the sample processing and picking procedures used for Sisson bedrock samples at Overburden Drilling Management Limited.

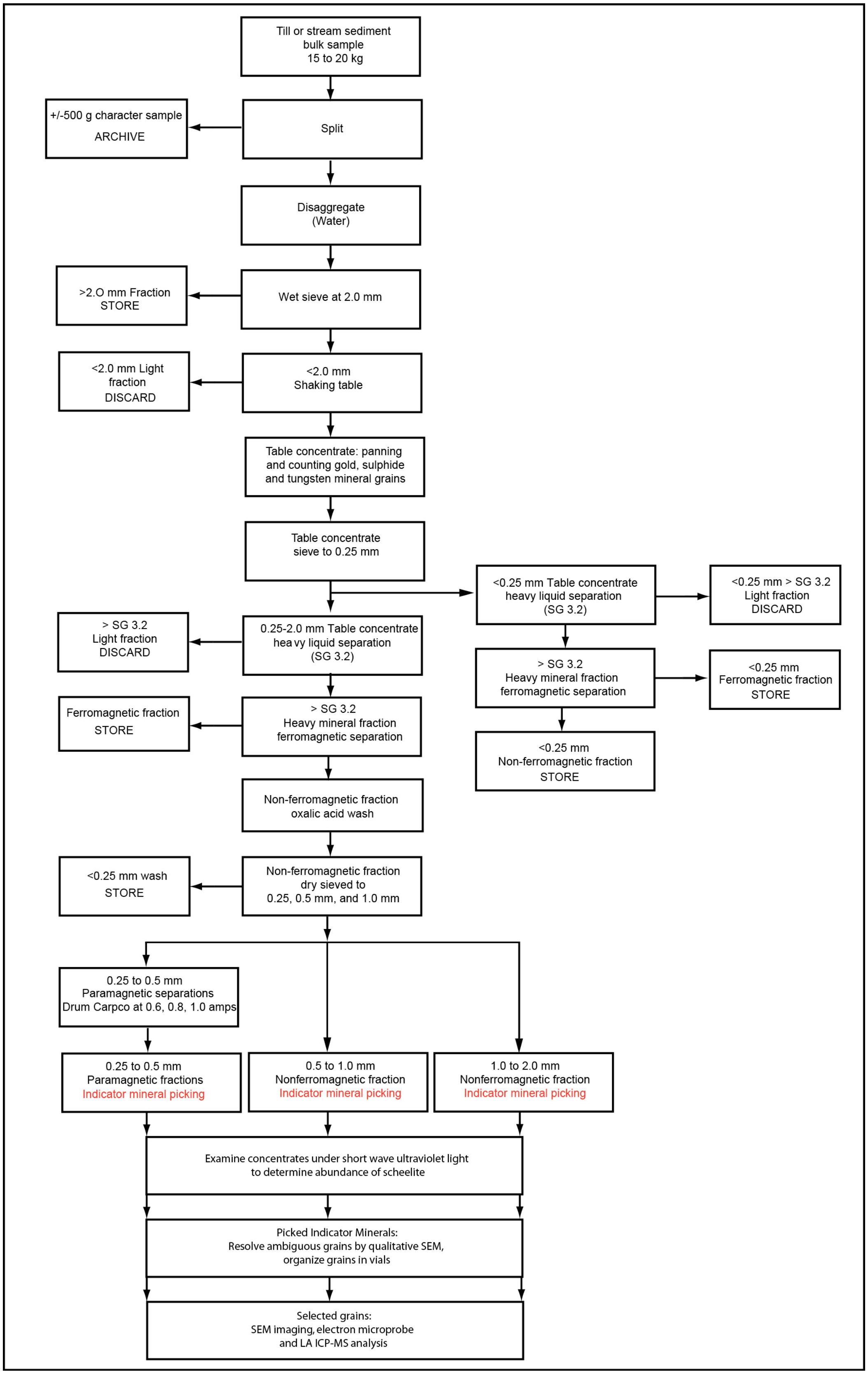

Figure 5. Flow sheet outlining the sample processing and picking procedures used for Sisson till and stream sediment samples at Overburden Drilling Management Limited.

Approximately 8 to 14 kg of material was processed for each sample in a similar manner as the till samples (Fig. 5). Two 'Bathurst blank' samples (21J06-2012-2001, 21J06-2012-2014) were inserted into the batch prior to processing to monitor the quality of processing and picking at the laboratory. The blank samples inserted with the stream sediment samples are of the same type as for the till samples, i.e. weathered granite from New Brunswick (see above). Weight data for all 19 samples are reported in **Appendix B5**.

Mineral picking

The 0.25-0.5, 0.5-1.0, 1.0-2.0 mm non-ferromagnetic fractions of till, stream sediment, and bedrock samples were examined by ODM and indicator minerals counted/selected including scheelite and wolframite, gold and sulphide minerals, as well as potential oxide and silicate indicators of massive sulphide deposits. ODM's magmatic or metamorphosed massive sulphide indicator mineral (MMSIM®) suite is an indicator mineral assemblage used to explore for a broad spectrum of sulphide-associated deposits (Averill, 2001). The visual identification of a number of limited mineral grains was verified with a scanning electron microscope (SEM). The abundance of various mineral species in a random 100 grain point count of the 0.25-0.5 mm non-ferromagnetic fraction of the stream sediment samples was carried out to document their mineralogy.

Digital data files

ODM produced a digital data file for each sample batch processed: (1) 2011 bedrock samples (**Appendix B1**); (2) 2012 bedrock sample (**Appendix B2**); (3) 2011 till samples (**Appendix B3**); (4) 2012 till sample (**Appendix B4**); and (5) 2012 stream sediment samples (**Appendix B5**). Each data file consists of several worksheets: For both till batches, the weights of the fractions produced during sample processing are reported in four worksheets: "Tabling Data"; "Processing Wts"; "HM Fractions" (<0.25 mm table concentrate weights); and "Paramag" (weights for the paramagnetic fractions).

For stream sediments, the weights of the fractions produced during sample processing are reported in four worksheets: "Tabling Data"; "Processing weights"; "Table concentrates"; and "Paramag" (weight of the paramagnetic fractions produced).

For bedrock samples, the weights of fractions generated during bedrock disaggregation and subsequent heavy liquid separation are listed in the worksheets: "EPD weights"; " Processed weights"; "Paramag" (weights for the paramagnetic fractions); and "0.18 HMC" (<0.18 mm table concentrate weights).

Gold grain data generated from panning each till, stream sediment and bedrock sample are reported in two worksheets: "Gold summary" and "Detailed VG", which describe the abundance, size and shape of the visible gold and sulphide grains observed during panning.

Indicator minerals (0.25-2.0 mm in size) of W-Mo deposits are listed in worksheets: "MMSIM"; and "Scheelite grains".

The abundance of various mineral species in a random 100 grain point count of the 0.25-0.5 mm non-ferromagnetic fraction of the 2012 stream sediment samples is listed in "100 count".

ACKNOWLEDGMENTS

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Appendix C: Bedrock (2011+2012) binocular microscope hand sample descriptions by Overburden Drilling Management Ltd.

by S.A. Averill

11-MPB-R01 MINERALIZED GABBRO.
Bedrock unit: W-Mo mineralization in Howard Peak Gabbro
Drill core. Dark grey, strongly foliated, nonmagnetic, finely porphyritic intrusive rock consisting of 20 to 80% (average 60%) small (0.3-1 mm), subhedral, fresh (visibly albite-twinned) to cloudy white (saussuritized) plagioclase phenocrysts in a finer-grained groundmass consisting mainly (~40% of sample) of brown biotite (potassic alteration) with 2% quartz. Rock is crosscut by 5% planar quartz veinlets of 3-10 mm width mineralized with local traces of pyrite, scheelite (SEM confirmed) and molybdenite and also contains local clots of coarse-grained (1-2 mm) hornblende (~2% of sample; SEM confirmed) and fine-grained biotitic shear seams (5% of sample), each mineralized with up to 10% pyrite.

11-MPB-R02 TRONDHJEMITE.
Bedrock unit: mineralized quartz feldspar porphyry dyke
Drill core. Pale grey-white (leucocratic), massive, nonmagnetic, coarse-grained (1-3 mm), equigranular intrusive rock consisting of 60% cloudy white, saussuritized, subhedral to mostly anhedral plagioclase, 40% quartz, 3% biotite (mostly chloritized) and trace pyrite as interstitial clots.

11-MPB-R03 GABBRO.
Bedrock unit: Howard Peak Gabbro
Drill core. Speckled black and white, massive to weakly foliated, mostly nonmagnetic to patchily moderately magnetic intrusive rock consisting of coarse-grained (1-3 mm), subhedral, locally fresh and albite-twinned to mostly cloudy white, saussuritized plagioclase (60%) and colourless, unaltered alkali feldspar (5%) with interstitial to locally oikocrystic hornblende (35%) and minor quartz (1%). Hornblende is patchily replaced up to 100% by finer-grained (0.3-0.5 mm) brown biotite (potassic alteration) within which is concentrated 1% disseminated pyrite. Gabbro contains 5% partly assimilated, 5-15 mm xenoliths of recrystallized, sugary, very fine grained (<0.1 mm) metapsammite or chert containing up to 5% finely disseminated magnetite.

11-MPB-R04 METAPELITE.
Bedrock unit: Turnbull Mountain Formation metasedimentary rock
Drill core. Alternating, 2-15 mm thick, very fine-grained (0.05-0.2 mm), faintly graded, nonmagnetic slate grey and grey-brown bedding laminae consisting mainly of either chlorite and sericite (grey beds) or biotite (brown beds). The brown beds tend to be slightly coarser grained and were evidently more permeable as they contain up to 0.5% diagenetic pyrite metamorphically reconstituted to 0.2-0.3 mm crystals.

11-MPB-R05 MINERALIZED QUARTZ VEIN.
Bedrock unit: mineralization in quartz vein
Drill core. Vein of white quartz >10 cm wide shear-brecciated and cemented with 10% calcite, 2% sericite, 2% chlorite and 1-2% each of pyrrhotite, pyrite, chalcopyrite and sphalerite (Fe-rich

blackjack type).

11-MPB-R06 DACITIC TUFF AND SULPHIDIC CHERT.
Bedrock unit: Turnbull Mountain Formation felsic tuff
Drill core. Sample consists mainly (80%) of a pale buff-grey, strongly foliated, nonmagnetic, felsic volcaniclastic rock consisting of 40% wispy, flattened, lenticular, 0.5-5 mm long leucocratic volcanic fragments of probably dacititc composition and 10% cloudy white, saussuritized, 0.5-2 mm plagioclase augen crystals in a matrix of finer-grained (0.1-0.3 mm), metamorphically recrystallized feldspar, quartz (20%) and biotite + sericite (5%). Foliation distinctly crosscuts primary bedding defined by 20% moderately magnetic chert bands which are 5-20 mm thick and consist of fine-grained, 0.1-0.2 mm, recrystallized quartz with 5% disseminated pyrrhotite.

11-MPB-R07 BASALT.
Bedrock unit: Turnbull Mountain Formation mafic tuff
Drill core. Dark grey-black, strongly and uniformly foliated and lineated, amphibolitized, nonmagnetic mafic volcanic rock consisting subequally of 0.3-0.5 mm hornblende crystals and finer-grained, sugary, colourless, recrystallized plagioclase with 1% leucoxene streaks and 0.5% pyrite, mainly as coarser, 1-2 mm, irregularly scattered “spots” suggestive of former amygdules, implying that the volcanic protolith was a flow rather than tuff. Some pyrite also occurs as a film in planar fractures with biotitic selvages.

11-MPB-R08 GRANITE.
Bedrock unit: Howard Peak Granodiorite
Drill core. White, black-flecked, nonmagnetic, moderately foliated, coarse-grained (0.5-3 mm), felsic intrusive rock consisting of 45% unaltered, colourless, perthitic (string-type), anhedral to locally glomerophyric (3-5 mm clots) K-spar, 20% cloudy white, saussuritized plagioclase, 25% quartz and 10% brown biotite.

11-MPB-R09 GABBRO.
Bedrock unit: Turnbull Mountain Formation
Drill core. Dark grey, white speckled, nonmagnetic, strongly foliated and significantly sheared (anastomosing with local brecciated zones), distinctly porphyritic, mafic intrusive rock consisting of 5 to 50% (average 20%) subhedral, 0.5-2 mm, cloudy white (saussuritized) plagioclase to colourless K-spar phenocrysts in a finer-grained, 0.2-0.3 mm groundmass consisting of 40% colourless K-spar (presumed potassic alteration) and 60% brown biotite (potassic alteration). Rock is cut by 10% anastomosing shears 1-5 mm wide variably consisting of biotite schist or sugary quartz (silicified), is locally incipiantly brecciated and cemented with patches of sugary silica measuring up to 10 mm, and is mineralized with 1% pyrite occurring both in post-shear fractures and as disseminated clusters up to 1 mm in diameter within the biotite.

11-MPB-R10 GRANITE.
Bedrock unit: Nashwaak Granite
Hand specimen. Speckled black and white, nonmagnetic, weakly foliated, very coarse-grained (1-5 mm), inequigranular, felsic intrusive rock consisting of 30% euhedral, cloudy white, saussuritized plagioclase laths, 30% coarse, interstitial to oikocrystic, colourless, unaltered, pethitic (string-type) K-spar, 30% quartz and 10% biotite.

11-MPB-R11 GRANITE.
Bedrock unit: altered Nashwaak Granite
Leucocratic, apple-green, white-veined, nonmagnetic, massive, partly saprolitized felsic intrusive rock consisting of 35% soft, apple-green, completely clay-altered plagioclase, 30% fresh, colourless to pale pink, perthitic (string-type) K-spar, 30% quartz, 3% muscovite and 5% leached vugs. Rock is cut by a 1 cm wide barren white quartz vein (10% of sample).

12-MPB-1025 MINERALIZED QUARTZ VEIN.
Bedrock unit: W (wolframite) mineralization at Zone 1
White to grey, fractured vein quartz locally oxidized brown along fracture surfaces with 5% buff sericitic wallrock. Sample is mineralized with 0.5-1%, disseminated, red-black wolframite crystals ranging from <0.1 mm to 4 mm in size. Sample also contains trace to 0.5% sulphides, typically occurring as finely (<0.2 mm) crystalline fracture fillings and comprising pyrite >chalcopyrite and a possible trace of arsenopyrite.