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ABSTRACT
Till, stream sediment and bedrock samples from and around the Pine Point Zn-Pb mine district in the Northwest Territories were collected to determine the indicator minerals and their trace element signatures that are indicative of Mississippi Valley-Type 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 2010 and 2011 for this case study. Samples were processed by the commercial lab Overburden Drilling Management Limited, Ottawa, 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 a broad range of mineral deposit types in till, however, few have been published that document indicator mineral signatures of Mississippi Valley-Type (MVT) deposits. To address this knowledge gap, the Geological Survey of Canada (GSC), through its Geo-mapping for Energy and Minerals (GEM) Program (2008-2013), and the University of Alberta, Tamerlane Ventures Incorporated and Teck Resources Limited initiated a study of till, stream sediment and bedrock samples around selected Pb-Zn deposits in the Pine Point MVT mining district (Fig. 1) in the Northwest Territories.

The Pine Point deposits were chosen as MVT indicator mineral test sites because: (1) the deposits and district geology are well known and bedrock samples were available from drill core; (2) the deposits subcrop and thus were exposed to direct glacial erosion; (3) the deposits are till covered; and (4) the deposits areas are easily accessible by road.

The specific objectives of the GEM indicator mineral research project are**:** 1) to determine the indicator minerals and their trace element signatures that are indicative of MVT deposits; and 2) to establish practical methods for their recovery from glacial sediments and their identification that can be routinely applied in MVT 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 2010 and 2011 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.

Figure 1. Location of the Pine Mining District in northern Canada (modified from Hannigan, 2007).

METHODS

Field sampling

Till, stream sediment and bedrock samples were collected in the summers of 2010 and 2011 in the Pine Point district. A total of 15 bedrock samples (1-10 kg) were collected in June 2010 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. Bedrock sample locations are listed in **Appendix A**.

Twenty-five large (~15 kg) till samples were collected up-ice, proximal to, and at varying distances down-ice (generally SW and NW) of the O-28 deposit (Fig. 2). Background till samples were collected up-ice (SE and NE) on the far side of the O-28 open pit. Additional till samples were collected in pits P-41, N-32 and P-24 (Fig. 2) to compare signatures of these deposits with the O-28 deposit. In 2011, an additional 65 till samples were collected southwest and northwest of the O-28 deposit to further document the distribution of specific indicator minerals found in the 2010 till samples. Also, till samples were collected in pits K-77, S-65 and K-62 (Fig. 2) to assist in characterizing the till stratigraphic successions. Three till samples were collected in 2010 and 2011 along the Buffalo River (Fig. 2), 35 km west of Pit O-28, to document the signature in till down ice of the main part of the mine district. All till sample locations are listed in **Appendix A**. Till samples were collected from sections exposed the walls of the open pits or river banks or from holes excavated to 2 m depth. Detailed notes and photos were taken at each sample site and will be included in a

Figure 2. Regional bedrock geology of the Pine Point Mining District showing the three trends (North, Main, and South) and the location of the Pb-Zn orebodies (modified from Hannigan, 2007). Regional till samples were collected from sites indicated with a green dot, multiple till samples were collected from open pits shaded yellow, and stream sediment samples were collected from sites indicated by red dots.

subsequent GSC open file. Till sample location coordinates are included in **Appendix A**. Two field duplicate samples were collected in 2010 to assess field variability: 10-MPB-016 is a duplicate of -009, and 09-MPB-034 is a duplicate of -033.

A total of eight large (10-13 kg) sand-rich stream sediment samples were collected from upstream ends of mid-channel boulder bars in first, second and third order streams within the study area in June 2010 (Fig. 2). Material was collected by shovel from one (preferred) 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. These samples will be processed to recover the heavy mineral fraction for indicator mineral picking. Detailed notes and photos were taken at each sample site and 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 for processing and production of heavy mineral concentrates. Lab data for these samples are reported in **Appendices B1 to B4**. Bedrock samples were first examined under a binocular microscope and described by ODM. Samples were then 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 B4** in the order that they were processed at ODM.

Each bedrock sample was first examined and described by geologists at ODM (**Appendix B5**) 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 47 to 283 g. A 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, as outlined in Figure 3 and weights for all fractions produced are reported in **Appendix B**. The <2.0 mm material was passed over a shaking table and the heavy table concentrate recovered and micro panned to recover any gold and sulphides 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, including magnetite and pyrrhotite, 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. The 0.25-0.5 paramagnetic fractions, and the 0.5-1.0 and 1.0-2.0 mm non-ferromagnetic fraction were then visually examined and potential indicator minerals counted and selected grains set aside for analysis.

Sixteen quartz blank bedrock samples were inserted into the batch at the beginning and after each bedrock sample to monitor cross contamination between samples. These samples include the letters QBlk in their sample number. The results for these 16 samples are reported along with the real rock samples in **Appendix B4**.

Till samples were also shipped to ODM for processing, production of heavy mineral concentrates and indicator mineral picking. In 2010, 25 till samples plus four quality control samples for a total of 29 samples were processed at ODM. Sixty-five till samples were collected and processed in 2011 along with four blanks for a total of 69 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 4 and weights for all fractions produced are reported in **Appendix B1 and B2**. 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 gold and sulphides 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 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 till all samples was 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.

Four 'blank' sand samples were inserted into each of the 2010 and 2011 till batches prior to processing to monitor the quality of processing and picking at the lab: 10-MPB-002, -022, -029, and 085B-2010-1001BT in the 2010 batch and 11-MPB-001, -015, -044, -063 into the 2011 batch. The 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, monolithogic sand. It does not contain any precious or base metal indicator minerals. Results for these eight samples are reported along with the real samples.

Eight stream sediment samples were shipped to ODM for processing, production of heavy mineral concentrates and indicator mineral picking. Approximately 9 to 15 kg of material was processed for each sample in a similar manner as the till samples (Fig. 4). One blank sample (O85B-2010-1013BS) was inserted into the 2010 stream sediment batch prior to processing to monitor the quality of processing and picking at the lab. Weight data are reported in **Appendix B3**.

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 gold and sulphide mineral grains, 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 including MVT deposits (Averill, 2001). 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.

The digital data files reported by ODM consist of several worksheets for each of the three batches of samples processed at ODM: (1) 2010 till samples (**Appendix B1**), (2) 2011 till samples (**Appendix B2**), (3) 2010 stream sediment samples (**Appendix B3**); and, (4) 2010 bedrock samples (**Appendix B4**). For both till batches, the weights of the fractions produced during sample processing are reported in four worksheets: "Tabling Data", "KIM data", "Paramag" (weights for the paramagnetic fractions) and "Table concentrates" (<0.25 mm table concentrate weights). For stream sediments, the weights of the fractions produced during sample processing are reported in four worksheets: "Tabling Data", "KIM data", and "Table concentrates" (<0.25 mm table concentrate weights). The weight of the paramagnetic fraction was not recorded for these samples.

Figure 3. Flow sheet outlining the sample processing and picking procedures used for Pine Point bedrock samples at Overburden Drilling Management Limited.

Figure 4. Flow sheet outlining the sample processing and picking procedures used for Pine Point till and stream sediment samples at Overburden Drilling Management Limited.

For bedrock samples, the weights of fractions generated during bedrock disaggregation and subsequent heavy liquid separation are listed in the worksheets "EPD data", " 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 MVT Pb-Zn deposits are listed in worksheets "MMSIM". Indicators of kimberlite (0.25-2.0 mm) are listed in worksheet "KIM". 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 2010 stream sediment samples is listed in "100 count".

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