



**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7388**

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from the footwall-type Cu-Ni-PGE Broken Hammer
occurrence, Sudbury, Ontario**

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ABSTRACT

Till and bedrock samples around the Broken Hammer Cu-Ni-PGE occurrence in Wisner Township, 30 km north of Sudbury, Ontario were collected to determine the indicator minerals and their trace element signatures that are indicative of footwall-type deposits in the Sudbury structure. Additional till and bedrock samples were collected around the Wisner West occurrence (Fig. 1) and one bedrock sample was collected from the McCreedy West PM zone for comparison with Broken Hammer. This open file reports the raw indicator mineral weight and abundance data for bedrock and till samples collected in 2006 for this case study. Samples were processed by the commercial laboratory 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 as well as bedrock sample descriptions are reported in this open file.

INTRODUCTION

Several case studies have been published that document the indicator mineral signatures in till for a broad range of mineral deposit types, however, few have been published that document indicator mineral signatures of base metal deposits. To address this knowledge gap, the Geological Survey of Canada (GSC), through its Targeted Geoscience Initiative 3 (TGI-3) (2005-2010) in collaboration with Wallbridge Mining Company Limited initiated a study of till and bedrock samples around the footwall-type Cu-Ni-PGE Broken Hammer occurrence in the North Range of the Sudbury structure in northern Ontario (Fig. 1) (Ames et al., 2007). The Broken Hammer occurrence was chosen as an indicator mineral test site because the occurrence is: (1) known to contain coarse-grained sperrylite (PtAs_2); (2) is geologically well known and information and bedrock samples were available from outcrops and drill core; (3) subcropping and thus was exposed to direct glacial erosion; (4) till covered; and (4) easily accessible by road.

The specific objectives of this TGI-3 indicator mineral research project are: 1) to determine the indicator minerals and their trace element signatures that are indicative of footwall-type Cu-Ni-PGE deposits of the Sudbury structure; and 2) to establish practical methods for their recovery from glacial sediments and their identification that can be routinely applied in exploration in glaciated terrain. The purpose of this open file is to report the raw indicator mineral abundance data for the bedrock and till samples collected in 2006 for this specific case study. Interpretations of these indicator mineral data, as well as till geochemical data for the <0.063 mm fraction of the same till samples, will be published in subsequent GSC Open Files.

METHODS

Field sampling

Till and bedrock samples were collected in the summer of 2006 in Broken Hammer and Wisner area of the North Range of the Sudbury Structure. A total of 15 bedrock samples 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. One of these samples (06-MPB-10) is from a postglacial gossan which had developed on a weathered part of the main chalcopyrite vein. In contrast to the other 14 fresh bedrock samples collected for study, this sample consisted of a 8 kg bag of small chunks of gossan. Bedrock sample locations and lithologies are listed in **Appendix A**.

Twelve of the bedrock samples (06-MPB- series) are from the Broken Hammer occurrence. Two bedrock samples (06AV-54 and -56) are from the Wisner West occurrence, 3.5 km to the west. Sample 05AV-23 is from the McCreedy West PM zone, 30 km to the southwest.

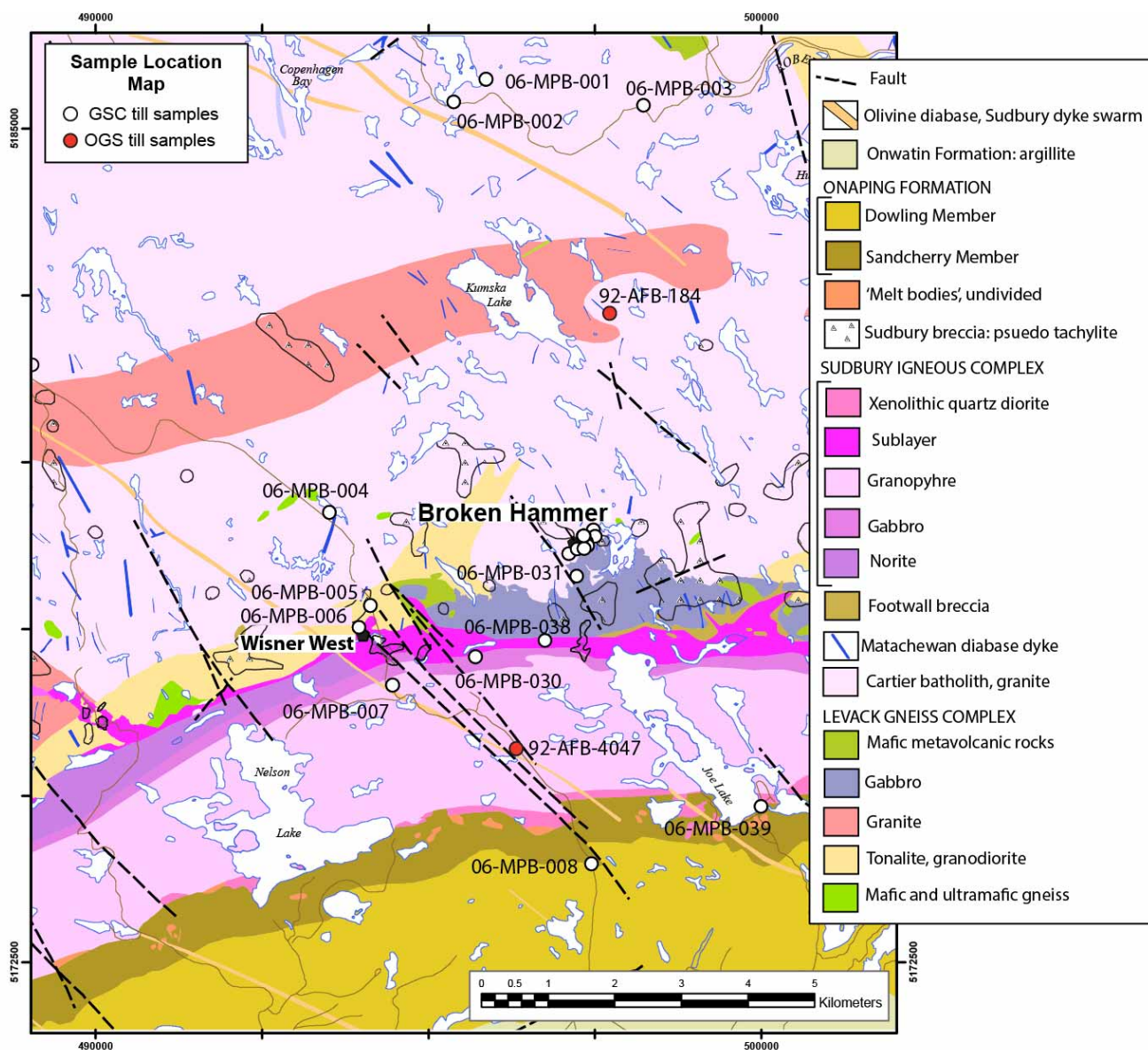


Figure 1. Regional bedrock geology and location of GSC till samples collected around the Broken Hammer occurrence in 2006 and two till samples (red dots) collected by Bajc and Hall (2000) in 1992 (bedrock geology from Ames et al., 2005).

A total of 38 till samples were collected in 2006 (Figs. 1, 2) for indicator mineral analysis. Sites included sections exposed in the main Big Boy trench excavated to expose the subcropping surface of the Big Boy vein and associated trenches or clearings nearby. Samples were also collected from road cuts between 9 and 600 m south (down-ice) of the deposit (Bajc and Hall, 2000). Three samples were collected 6 km north of the deposit to establish background concentrations. Four till samples were collected north of, overlying, and just south of the Wisner West Cu-PGE deposit to compare till mineralogical signatures of similar mineralization styles. Heavy mineral concentrates of two till samples down-ice of

the Broken Hammer occurrence, collected by Bajc and Hall (2000), were re-examined with the GSC till samples: 92-AFB-4047 and 92-AFB-184 (Fig. 1). All till sample location coordinates are listed in **Appendix A**. Detailed notes and photos were taken at each sample site and will be published in a subsequent GSC open file.

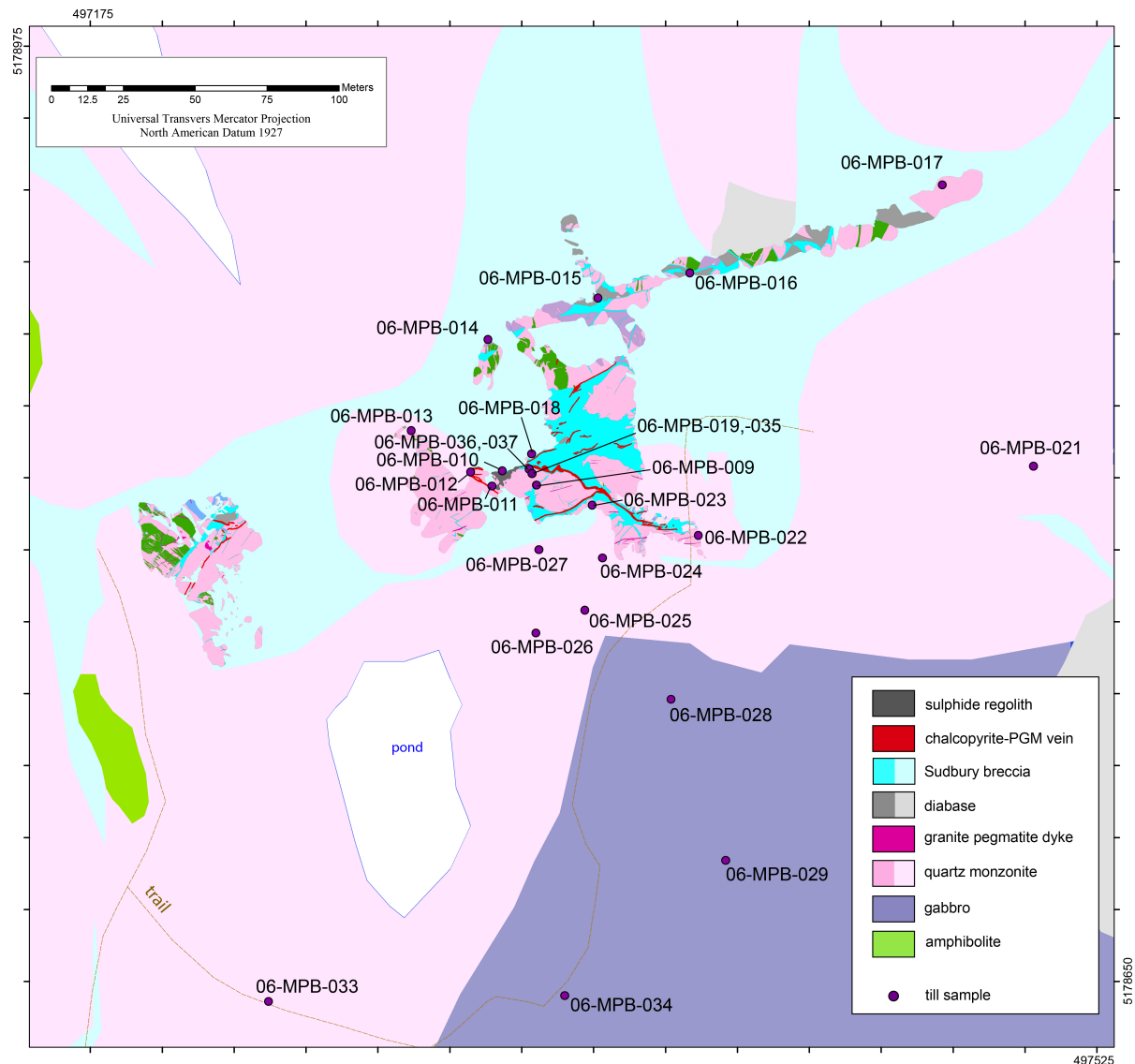


Figure 2. Detailed bedrock geology of the area exposed by stripping on the Broken Hammer property superimposed on the regional bedrock geology and location of GSC till samples collected in 2006 proximal to the deposit. Detailed bedrock geology shown by darker shades of each colour from Peterson et al. 2004; regional bedrock geology shown by lighter shades of each colour from Ames et al., 2005).

Sample processing and indicator mineral picking

Bedrock and till samples were shipped to Overburden Drilling Management Limited (ODM), Ottawa for processing and production of heavy mineral concentrates. The 14 fresh rock samples were first examined under a binocular microscope and described by ODM (**Appendix B1**). Samples were then processed in order such that the most mineralized samples were processed last to limit carry over of ore minerals between samples. Samples are listed in the raw data files (**Appendix B1, B2**) in the order that they were processed at ODM.

Each bedrock sample was disaggregated (milled) using a conventional rock crusher. Eleven of the 14 bedrock samples were milled to <2.0 mm at ALS Chemex. The crushed material of each bedrock sample, weighing between 70 g and 1300 g 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 B2**. The <2.0 mm material was micro panned to recover gold, sulphide and platinum group minerals (PGM). The minerals in the pan were counted and their size and shape characteristics recorded and then returned to the sample. The material was then sieved at 0.18 and 1.0 mm. The 0.18 to 1.0 mm material was then refined using heavy liquid separation in methylene iodide diluted to a specific gravity (SG) of 3.2. The ferromagnetic fraction of each bedrock sample, 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 Carpc® magnetic separator at 0.6, 0.8 and 1.0 amps to assist picking this fine-grained fraction. The 0.25-0.5 mm paramagnetic fraction, and the 0.5-1.0 and 1.0-2.0 mm non-ferromagnetic fractions were then visually examined and potential indicator minerals counted and selected grains set aside for analysis.

Three small bedrock samples (05AV-23, 06-MPB-R01, 06-MPB-R16) were milled to <1.0 mm at ODM, and the <1.0 mm fraction was processed using a similar procedure to recover indicator minerals, according to the flow sheet in Figure 4.

Although both batches of bedrock samples outlined in Figures 3 and 4 were sieved at 1.0 mm and only this <1.0 mm proceeded through the entire processing flow sheet, some >1.0 mm was recovered as a result of sieving at 1.0 mm after heavy liquid and ferromagnetic separations. Some ~1.0 mm grains have a dimension >1.0 mm, allowing them to be retained on the >1.0 mm screen, thus a few grains were reported for the 1.0-2.0 mm fraction.

One 'blank' bedrock sample of unmineralized granite was inserted at the beginning of the batch ('Chemex blank') to help purge the rock crusher and to monitor cross contamination between rocks. The data for this sample are reported with the real samples in Appendix B2

Till samples and the gossan bedrock sample were also shipped to ODM for processing, production of heavy mineral concentrates and indicator mineral picking. In 2006, 38 till samples and one gossan sample were processed at ODM. 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**. 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, sulphides and PGM 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 0.25-2.0 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. The non-ferromagnetic heavy mineral fraction was then 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

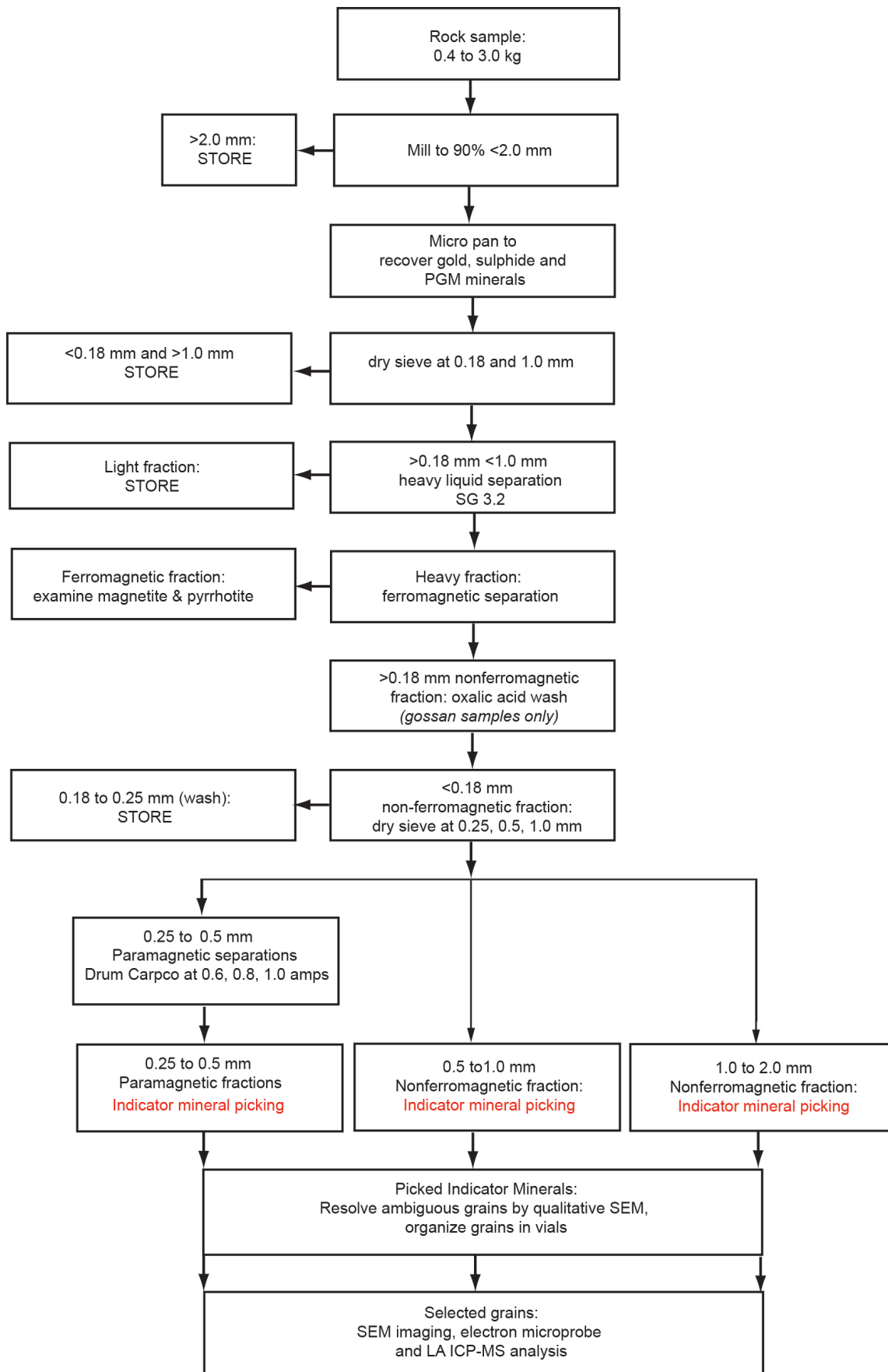


Figure 3. Flow sheet outlining the sample processing and picking procedures used for bedrock samples used in this study at Overburden Drilling Management Limited.

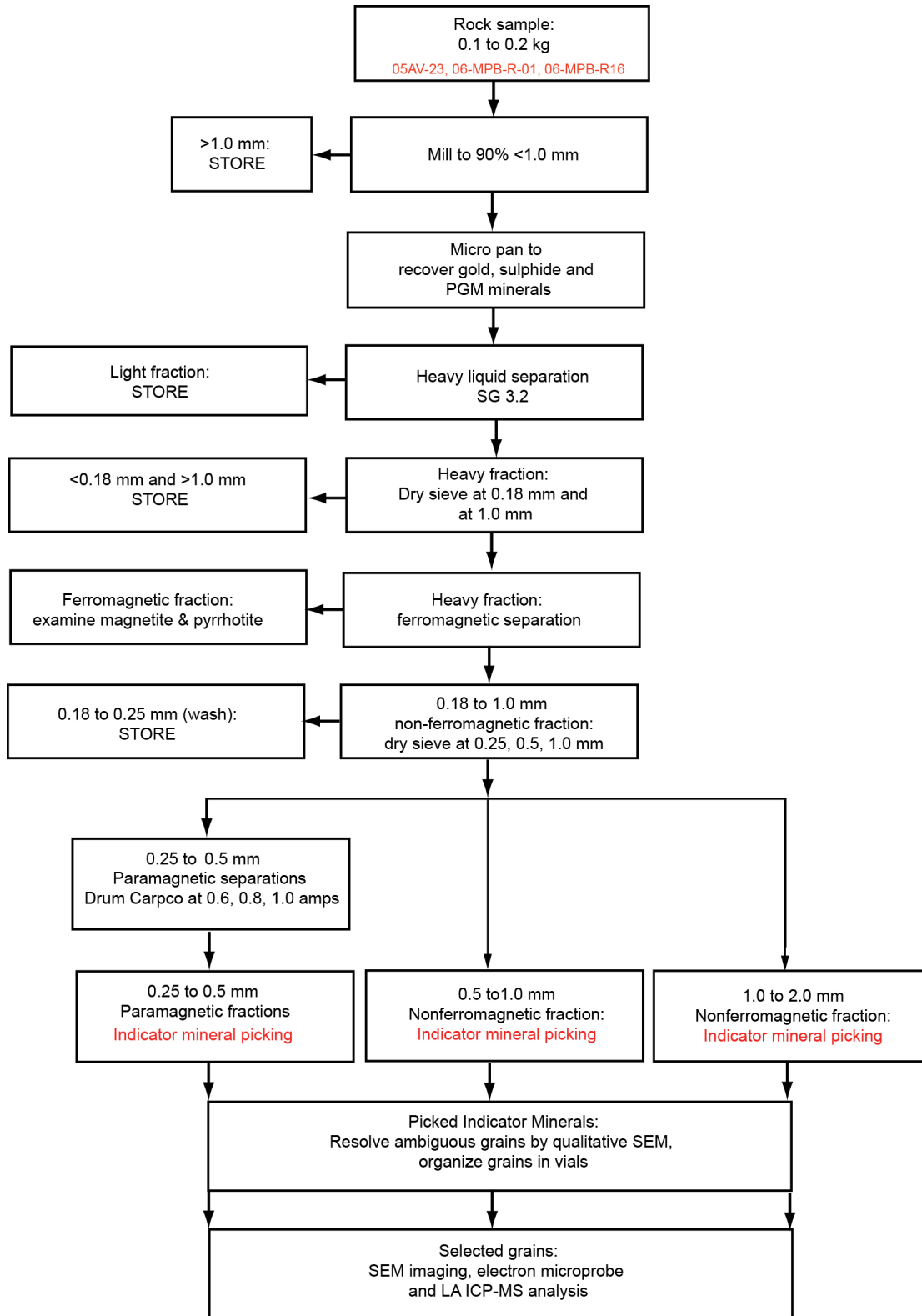


Figure 4. Modified flow sheet outlining the sample processing and picking procedures used for three small bedrock samples (05-AV-23, 06-MPB-R01, 06-MPB-R16) at Overburden Drilling Management Limited.

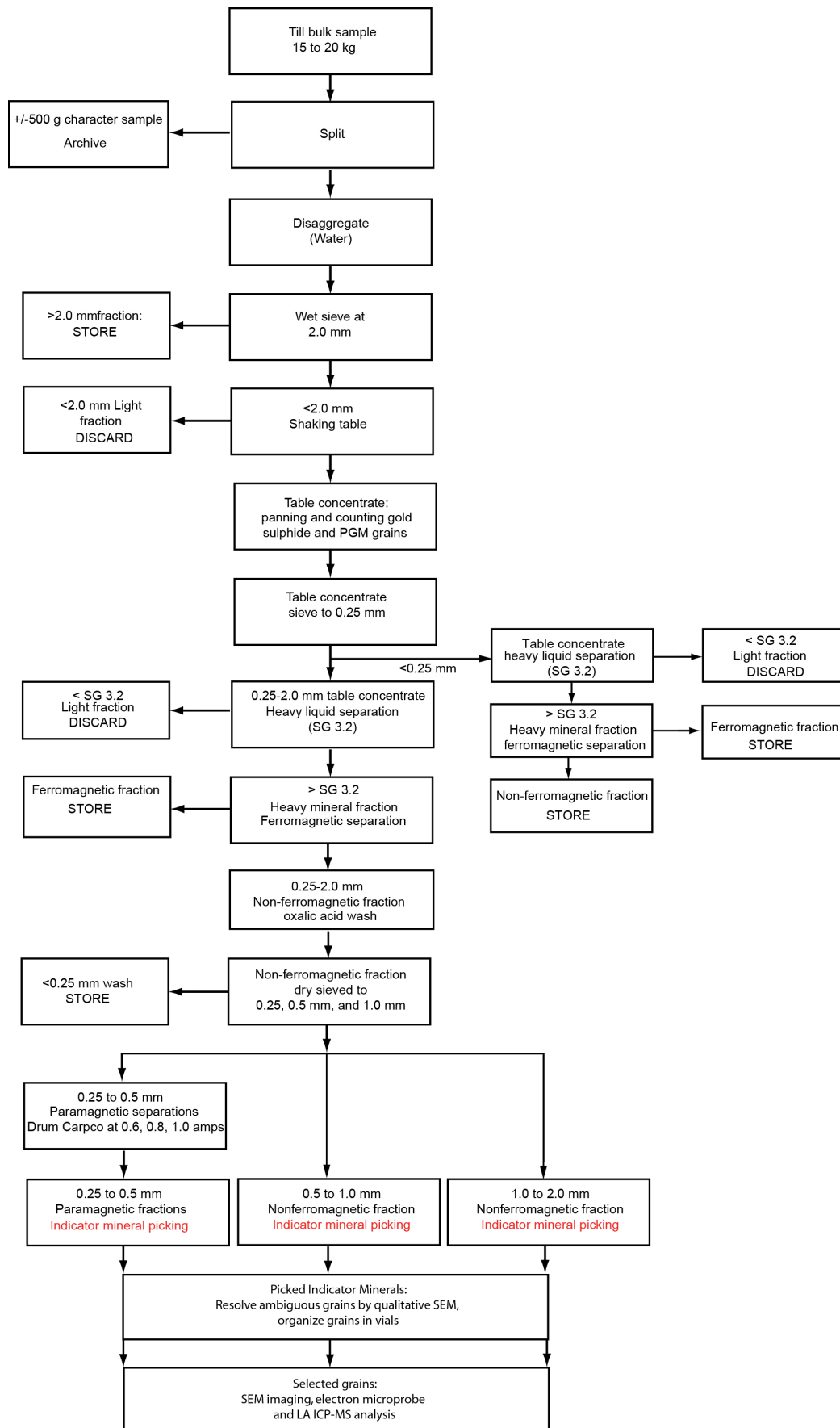


Figure 5. Flow sheet outlining the sample processing and picking procedures used for till samples and gossan sample 06-MPB-10 at Overburden Drilling Management Limited.

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, 0.5-1.0, 1.0-2.0 mm non-ferromagnetic fractions of till and bedrock samples were examined by ODM and indicator minerals counted/selected including gold, sulphide and PGM 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 massive sulphide base metal deposits (Averill, 2001).

The digital data files reported by ODM consist of several worksheets for each of the two batches of samples processed at ODM: (1) 2006 bedrock samples (**Appendix B2**), (2) 2006 till samples (**Appendix B3**). For till samples, 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 "TC weights" (<0.25 mm table concentrate weights). Weight data for the two OGS till samples (92AFB-4047 and 92AFB-184) are reported in the "OGS samples" worksheet and in OGS Open File Report 6033 (Bajc and Hall, 2000). For bedrock samples, the weights of fractions generated during bedrock crushing and subsequent heavy liquid separation are listed in four worksheets: "Lab data", "Milled", "Paramag" (weights for the paramagnetic fractions) and "TC weights" (<0.18 mm table concentrate weights).

Gold and PGM grain data generated from panning each till and bedrock sample are reported in three worksheets: "Gold summary", "Detailed VG", and "PGMs" which describe the abundance, size and shape of the visible gold, sulphide and PGM grains observed during panning. Indicator minerals (0.25-2.0 mm in size) of massive sulphide deposits are listed in worksheets "MMSIM". Indicators of kimberlite (0.25-2.0 mm) in till samples only are listed in worksheet "KIM Data".

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REFERENCES

- Ames, D.E., Davidson, A., Buckle, J.L., and Card, K.D. 2005. Geology, Sudbury bedrock compilation, Ontario. Geological Survey of Canada, Open File 4570.
- Ames, D.E., McClenaghan, M.B. and Averill, S. 2007. Footwall-hosted Cu-PGE (Au, Ag), Sudbury Canada: towards a new exploration vector. In: Exploration 07, Exploration in the New Millennium, Proceedings of the Fifth Decennial International Conference on Mineral Exploration, p. 1013-1017.

Averill, S.A. 2001. The application of heavy indicator mineralogy in mineral exploration with emphasis on base metal indicators in glaciated metamorphic and plutonic terrains, *In: McClenaghan, M.B., Bobrowsky, P.T., Hall, G.E.M., Cook, S.J. (eds) Drift Exploration in Glaciated Terrain*. Geological Society of London, Special Publication 185, p. 69-81.

Bajc, A.F. and Hall, G.E.M. 2000. Geochemical response of surficial media, north and east ranges, Sudbury Basin. Ontario Geological Survey, Open File Report 6033.

Peterson, D.M., Kutluoglu, R.A., and Little, T.L. 2004. Bedrock geology map of the Broken Hammer and Bog Boy vein trench area for Wallbridge Mining Company Ltd., unpublished map.