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**GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7769**

**Assessment of cleaning methods for electro-welded sieves to
reduce/eliminate carry over contamination between
till samples**

A. Grenier, S. Connell-Madore, M.B. McClenaghan, M. Wygergangs,
and C.S. Moore

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Abstract

The Sedimentology Lab, with the support of the Geo-mapping for Energy and Minerals (GEM) and Targeted Geoscience Initiative (TGI4) Programs, set out to verify existing sieve cleaning methods used in geological sample preparation laboratories to ensure no cross contamination between samples. Three cleaning methods were tested using till samples with varying degrees of mineralization.

The purpose of this study is to determine the effectiveness of commonly used cleaning methods at preventing cross contamination while sieving. This is critical to the quality of the geochemical analysis. Cleaning Method 1, while the quickest, does not remove contamination effectively for the two deposits sampled for this study. The addition of an extra step in Method 2 lowered the level of the potential contaminants without significant time increase. If known high mineralization exists, cleaning Method 3 is recommended otherwise Method 2 should be sufficient.

In addition to sample preparation it would be a good practice, when submitting samples to be processed for geochemical analysis, to provide a processing order to the laboratory if they are aware of any potentially metal-rich samples. Metal-rich samples should be positioned at the end of the list to avoid any possible contamination due to sample preparation or analytical memory effect. Clean silica blanks should be inserted at the start of the batch and sieved blanks should be inserted to verify possible contamination in the preparation lab. The insertion of control reference materials (CRMs) and duplicates are also recommended for quality control.

Introduction

The Geological Survey of Canada (GSC) Sedimentology Laboratory (Sed Lab) in Ottawa, with the support of the Geo-mapping for Energy and Minerals (GEM-1) and Targeted Geoscience Initiative (TGI-4) programs, set out to determine the effect of various cleaning methods to limit contamination when sieving till samples with varying contents of metal-rich material. The lab processes more than one thousand samples each year. With the majority of the samples being sieved prior to being submitted to commercial laboratories for geochemistry analysis, it is important to know that the sieve cleaning method used is effective. Moreover, sieving represents the step where the contact time between the sample and laboratory equipment is the longest, increasing the risk for the occurrence of possible cross-contamination. Three sieve cleaning methods were tested using till samples with varying contents of metal-rich material. The specific purpose of the study is to determine how effective commonly used sieve cleaning methods are at preventing cross contamination between till samples.

Background

The Sed Lab has been sieving till samples in preparation for geochemical analysis since it opened in the early 1970s. Brass sieves are known to be a potential source of high contamination in Cu, Pb and Zn (Thompson and Bankston, 1970). Stainless steel sieves with solder are a source of Pb and Sn contamination if the solder is not adequately covered with epoxy. In response to reported contamination of GSC till samples, the Sed Lab purchased stainless steel electrowelded sieves manufactured by Retsch® in 2010 to decrease the chances of Pb and Sn from sieve solder wearing down and contaminating till samples. Prior to testing, the Sed Lab routinely cleaned sieves by tapping them gently in a down draft dust hood, blowing them with compressed air and wiping the screen surface and sides with a low-linting precision tissue moistened with distilled water (DW). The sieves are dried with the compressed air before processing the next sample. The sieve stacks are cleaned in a sonic bath three times a day after 4 to 6 sediment samples have been sieved. The question raised was - Is this cleaning method sufficient to prevent cross contamination between till samples containing potentially metal-rich debris intermixed with samples that will be submitted for geochemical analysis?

In order to answer this question, metal-rich till samples were collected for the sole purpose of this study and silicic acid powder was used as a blank to control any cross contamination transferred between samples. Sieving was then performed in three phases using these new sieves, metal-rich till and 3 different sieve cleaning protocols. The sieved material was then geochemically analyzed in order to detect cross contamination caused by sieving.

Method of Investigation

Sample material

A 25 kg pail of metal-rich till sample was collected from the Sisson Brook W-Mo deposit in west-central New Brunswick (Fig. 1a). The bulk till sample was collected as part of the GSC's TGI-4 indicator mineral research activities under the Porphyry-Intrusion Ore System project. Till sample 11-MPB-507 was collected at 2.0-2.5 m depth overlying the east part of the deposit. The sample site, material collected and geochemical data are reported in McClenaghan et al. (2013a, b).

A second metal-rich till sample (25 kg pail) was collected from the Pine Point MVT Pb-Zn District 129 km south of Yellowknife, Northwest Territories. The Pine Point District consists of more than 30 open pit mines hosted in sedimentary carbonate rocks. The bulk till sample was collected as part of the GSC's GEM-1 indicator mineral research activities in the District. Till sample 11-MPB-200 was collected from the P-24 open pit in the east part of the Pine Point Mine District (Fig. 1b), at the till-bedrock interface. The sample site description and geochemical analysis of <0.063 mm fraction of till collected are described in more detail in Oviatt et al. (2013) as till sample 10-MPB-014.

Silicic Acid n-Hydrate, powder, BAKER ANALYZED* Reagent. 84% min. (as SiO₂, 2.5 kg pail) was used as blank material sieved between till samples. This material, produced by J. T. Baker, was chosen for its purity

and known chemical content along with its grain size distribution that interacts with the sieving process. Refer to Table 1 for test specifications of the blank material.

Sample splitting

The 25 kg Pb-Zn rich till was laid out on a large piece of Kraft paper (40 lb weight) on a 3 m section of counter in a clean analytical prep room. In order to achieve homogenization of the metal-rich till, the material was slowly poured back and forth across the Kraft paper with multiple passes. With a large spatula and rubber mallet, the till sample was broken down into aggregates no larger than 5 mm. The material was then mixed along the pile with plastic rectangular scoops. The material is shaped into a semi-uniform elongated pile across the Kraft paper and allowed to air dry (Fig. 2a). Large pebbles and cobbles were removed.

Material was sampled across the pile along its length at regular intervals to fill a small plastic dish using a plastic rectangular scoop (Fig. 2b). Material was scooped out using the same process until a total of twelve extra-large octagonal weighing dishes were filled (Fig. 2c). This method of subsampling/splitting is referred to as one-dimension Japanese slab cake (Gerlach and Nocerino, 2003).

The twelve weigh dishes were divided into 3 groups. The 3 groups were labelled as split 1, 2 and 3. Four weigh dishes made up each split. Each was identified as follows: split 1-1, split 1-2, split 1-3 and split 1-4 backup/archive. This step was repeated for split 2 and split 3. Refer to Figure 3 for the sample flow chart. This process of splitting and sub splitting was used for both the Sisson and Pine Point Phases of the study.

Sieve Cleaning Methods

Retsch®'s suggested cleaning method for sieves with a mesh size below 0.5 mm includes tapping it lightly upside down to dislodge particles followed by sonic bath cleaning (Retch®, 2007, 2014). Vacuum or compressed air is not recommended. This suggested procedure was not followed for cleaning between samples during this study. Instead, three cleaning techniques that are used by geological sample preparation laboratories were evaluated in this study.

The sieve cleaning methods evaluated are described as follows (Fig. 4):

- **Method 1** was the fastest cleaning method. The 2 mm and 0.250 mm sieves were first lightly tapped to dislodge dust and weakly trapped grains. A stiff black nylon bristled brush was used to dislodge the remaining grains that were trapped in the sieve mesh. The 0.063 mm sieve was lightly tapped upside down and gently brushed using a soft brush. Finally, the sieves were further cleaned using compressed air from a distance of approximately 10 cm. The pan and the lid were also blown with compressed air. This cleaning cycle takes approximately 5 minutes.

- **Method 2** included the same steps involved in Method 1 with the addition of wiping down the sieves (rim and both sides), the pan and lid with a low-linting precision tissue moistened with DW water to remove any fine residual dust. This step was followed by the use of compressed air to quickly dry the sieves prior to moving on to the next sample. This cleaning cycle takes approximately 7 minutes.
- **Method 3** was the most rigorous and time consuming cleaning method. The sieves, pan and lid were cleaned using compressed air and then further cleaned upside down in a sonic bath for a minimum of 2 minutes. Sieves were then rinsed with tap water, rinsed with DW, dried in a clean oven at 80 ° C and cooled for few minutes in a clean area before sieving the next sample. This cleaning cycle takes approximately 30 minutes.

A photograph was taken of each of the three 0.063 mm sieves after sieving the till and then cleaning by each of the three methods. The sieve's mesh was divided up into quadrants and images taken from three of the four sections. Sieves observation were made with an Olympus SZH10 binocular microscope, equipped with 10X oculars, DF Plano 1X and a ring light source. Pictures were taken with an Infinity 2 camera mounted on the binocular. Grains were counted on randomly chosen pictures representing an area of 19.5 by 19.5 mm section.

Sample sieving

Each sample split was sieved through a stack consisting of 2 mm, 0.250 mm, and 0.063 mm Retsch® stainless steel solderless sieves with O-rings. The O-ring is a rubber/synthetic ring positioned at the base of each sieve creating a seal between each sieve minimizing sample loss and providing stability to the sieve stack. A new sieve set was used for each of the three cleaning methods to be tested (Fig. 4). Prior to the first sieving, each set of three new sieves (sieve stack) were cleaned by washing in a sonic bath, drying in an oven, sieving a silica blank through the sieve stack (Fig. 5a) and washing in the sonic bath again. Each sieve in each of the three stacks were labelled A, B and C, corresponding to cleaning methods 1, 2 and 3 respectively. Sieving time was 10 minutes in order to achieve “complete sieving”, which implies that most of the < 0.063 mm material had passed through the <0.063 mm sieve (bottom sieve in the stack) and that sieving was not stopped early even if a sufficient volume of material had collected in the pan (Fig. 5b).

The labelling system used in this study for the sieved products were designated as follows: (sample name)-(cleaning method)-(split number). For example, in the Sisson Phase of the study, sample number 11-MPB-507-1-1 represents sample 11-MPB-507, sieved through sieves cleaned using Method 1 from sample split 1 (Fig. 3).

For each phase and each cleaning method, approximately 70 g of silica powder was dry sieved first through the sieve stacks. When the sieving was completed, material collected in the pan (< 0.063 mm) was transferred entirely into a 16 DR vial which amounted to 30-35 g of material. The sample was set aside for geochemical analysis and labelled (i.e. Silica Blank-1-0, Fig. 5a). This sample formed the silica blank background prior to the sieving of metal-rich till through the sieve stack. Following this initial sieving step, the sieve stacks were cleaned using the assigned cleaning method (i.e. Method 1; Figure 3 flow sheet).

Once the initial silica blank had been sieved through stack A, the metal-rich till sample (approximately 300 g) was sieved on the sieve shaker (Fig. 5b). The sieves were removed from the sieve shaker and the oversized material on the two coarser sieves was set aside. Approximately 50 g of the < 0.063 mm material was placed in

a 16 DR vial, labelled (i.e. 11-MPB-200-1-1) and set aside for geochemical analysis. Material collected in the pan was subsampled using a stainless steel scoopula in parallel segments across the accumulated material. The excess < 0.063 mm was retained. The sieves were then cleaned using Method 1 and a photograph of the sieve mesh was taken (Fig.6). Following this step, 70 g of silica sand was sieved and the < 0.063 mm fraction was collected entirely, labelled (i.e. Silica Blank 1-1) and put aside for geochemical analysis. This process was repeated for the remaining two till samples alternating with silica blanks for sieve stack A to generate the remaining samples (Fig. 3). These procedures were followed for sieve stack B using cleaning Method 2 and for sieve stack C using cleaning Method 3. Procedures for sieve stacks A, B, and C were repeated for the Pine Point Phase.

Analytical Packages

Samples from the Sisson phase were analyzed by ICP Mass Spectroscopy for 53 elements by aqua regia digestion on up to 35 g samples. Another group of 50 elements were also reported from a lithium meta/tetraborate fusion. Samples from the Pine Point phase were analyzed by ICP Mass Spectroscopy for 53 elements by aqua regia digestion on up to 35 g samples. Another group of 50 elements were also reported from a lithium meta/tetraborate fusion which included rare earth elements (REEs). In this package, the precious metals, base metals and associated pathfinder elements were obtained from an aqua regia digestion. These packages were selected in the hopes that with a complete digestion of the sample submitted any possible contamination would be detected. Special instructions were provided to the analytical laboratory to perform the whole rock major and trace element package first (on approximately 5 g) and to use all the remaining material (up to 35 g) for the aqua regia digestion. Bureau Veritas Commodities Canada Ltd (ACME Analytical Laboratories) completed the geochemical analyses for this study.

The first till samples of each method were chemically analyzed to characterize its metal content. Silica blanks sieved at the beginning of each batch (Sample 0) were analyzed to characterize the baseline pre-contamination composition. The post-till sieving silica blank samples (Sample 1-1, 1-2, 1-3 – for cleaning method 1; Sample 2-1, 2-2, 2-3 for cleaning method 2; Sample 3-1, 3-2, 3-3 for cleaning method 3) were analyzed to detect and characterize any contamination from the metal-rich till that remained on the sieves and was picked up by the silica blank.

Experimental Results

Sisson Phase

Complete analytical results for the Sisson till sample sieving test are listed in Appendix A in the first worksheet labelled 'Sisson Phase'. Results for Silica Blank 0-0, which was not processed through any sieve prior to geochemical analysis, are listed first. These values represent pristine (unsieved) silica blanks and are compared with values for silica blanks that have been sieved to identify possible contamination from sieving. Sample 0-0

contains 86.45 % silica, which is similar to values reported by the supplier (Table 1). Values for all other major and trace elements, both by borate fusion and aqua regia, are low or less than detection limit. This is expected for the silica blanks.

Results for Silica Blank 1-0, 2-0, and 3-0, sieved prior to sieving of any metal-rich till, are similar to those reported for sample 0-0 with the exception of:

- (1) Sample 3-0 contains 2.3 ppm W (borate fusion), as compared to values for the other initial silica blank samples of <0.5 ppm.
- (2) Sample 1-0 contains 6.0 ppb Ag, as compared to values for the other initial silica blank samples of <2 ppb.

Results for three analyses of metal-rich Sisson till (sample 11-MPB-507-1, -2, -3) are listed in the same worksheet, at the bottom of the page. This data listing for the three samples shows the range in values that can be expected for this metal-rich till sample. The till has high contents of W (borate fusion) (1000 ppm), Mo (85 to 92 ppm), Cu (273 to 303 ppm), Pb (342 to 387 ppm), Zn (280 to 302 ppm), and Ag (393 to 418 ppb) as compared to background till in the Sisson deposit area (McClenaghan et al., 2014) where this till was collected, and compared to the silica blank used in this study. Contamination of the sieve equipment from sieving this till would be expected for these six elements.

Results from silica blank samples sieved after the metal-rich till samples are listed in the order they were sieved and then analyzed. For Method 1, silica blank samples sieved after the metal-rich till (1-1, 1-2, 1-3) have higher contents of Ag (2 to 3 ppm). For Methods 2 and 3, silica blank samples sieved after metal-rich till (2-1, 2-2, 2-3 and 3-1, 3-2, 3-3) do not have higher contents of metals. These results indicate that negligible contamination from the metal-rich till occurred while using Method 1 and no detectable sieve contamination occurred while using Methods 2 and 3.

Pine Point Phase

Complete analytical results for the Pine Point sieving test are listed in Appendix A in the second worksheet labelled 'Pine Point Phase'. Results for Silica Blank 0-0 to 0-4, which were not processed through any sieve prior to geochemical analysis, is listed first. These values represent pristine (unsieved) silica blank and are compared with values for silica blanks that have been sieved to identify possible contamination from sieving. Silica Blank 0-0 contains 88.08 % silica, which is similar to values reported by the supplier (Table 1). Values for all other major and trace elements (borate fusion and aqua regia), are low or less than detection limit, as expected for the silica blank.

Results for three analyses of metal-rich Pine Point till (sample 11-MPB-200-1, -2, -3) are listed in the same worksheet, at the bottom of the page. This data listing for the three samples shows the range in values that can be expected for this till sample. The till has very high contents of Pb, Zn (>1%) and high contents of Cd (aqua regia) as compared to background till in the Pine Point deposit area (Oviatt al., 2013) where this sample was collected, and compared to the silica blank used in this study. Contamination of the sieve equipment from sieving this metal-rich till would be expected for these three elements.

Results from silica blank samples sieved after each metal-rich till sample are listed in the order they were sieved and then analyzed. For Method 1, silica blank (1-1, 1-2, 1-3) samples sieved after the metal-rich till has higher contents of Pb (3 to 4 ppm higher) and Zn (7 to 10 ppm higher). For Method 2, silica blank samples (2-1, 2-2, 2-3) sieved after the metal-rich till have higher contents of Pb (2 to 3 ppm higher) and Zn (5 ppm higher). For Method 3, silica blank samples (3-1, 3-2, 3-3) sieved after metal-rich till do not have higher geochemical values than the unsieved silica blank. There is no detectable difference for Cd content in the silica blank samples sieved before and after the metal-rich till. These results indicate that some contamination from the metal-rich till occurred while using Methods 1 and 2 and no detectable sieve contamination occurred while using Method 3.

Sieves were also examined to evaluate the effectiveness of the cleaning method to remove potential contamination that could be lodged in the sieve mesh. Over an area of 19.5 mm², the Sisson Phase, an average of 15 grains was observed after cleaning with Method 1, 5 grains after Method 2 and 0 grains after cleaning with Method 3 (Fig. 7). The Pine Point Phase showed an average of 18 grains observed after cleaning with Method 1, 53 grains after using Method 2 and 0 grains with Method 3.

The two metal-rich tills used for the study show similar grain size distributions (Fig. 8). Both are fine sand, very poorly sorted and finely skewed (Folk and Ward method description obtained using GRADISTAT software; Blott and Pye, 2001). Sample 11-MPB-200 (Pine Point Phase) was mainly composed of sand (75.7%). The silt content represented 21.3% while the clay content was 2.9%. A similar pattern was observed in sample 11-MPB-507 (Sisson Phase) with a slightly lower amount of sand (72.4%), a higher amount of silt (27.3 %) and a lower amount of clay (0.2%).

Discussion

Results from the Sisson Phase are highlighted in Table 2. An analytical order was provided to the lab with the samples so that the metal-rich till samples were analyzed at the end of the batch so that they could not contaminate/affect the clean silica blanks. The order of the different cleaning methods used was also modified. Samples from the cleanest method were analyzed first (Method 3), followed by Method 2, then Method 1. The results do not indicate any obvious sample contamination resulting from the application of any of the three cleaning methods between samples. The level of mineralization of the till was not sufficient to induce contamination to the silica blank processed after the tills.

For the Pine Point Phase, contamination from the sieving process was evident when using cleaning Method 1 (Table 3). Silica Blank-1-1, Silica Blank-1-2, and Silica Blank-1-3 all showed elevated values for Pb and Zn. In Method 2, Silica Blank-2-1, Silica Blank-2-2 and Silica Blank-2-3 showed lower amounts of Pb and Zn which were observed well above the detection level. Samples run through sieves cleaned by Method 3 (Silica Blank-3-1, Silica Blank-3-2, and Silica Blank-3-3) showed no signs of contamination associated with the sieving process.

Visual evidence of potential contamination was observed during examination of the sieves following each cleaning method (Fig. 6). Cleaning Method 3 was by far the best for removing grains trapped in the sieve mesh and other possible sources of contamination such as fine dust on the inside walls of the sieve. There was little

difference in the number of grains trapped in the sieve mesh between cleaning Methods 1 and 2 but analytical results suggest a significant difference between these two methods. Moreover, the Pine Point Phase of the study showed a greater amount of the trapped grains for Method 2 when compared to the number of grains counted for Method 1. This raised the question of what is the primary source of contamination: fine dust collected in the sieves or mineral grains stuck in the sieve mesh? Interpretation of the data indicates that the primary source of contamination was the fine residual dust still present on the sieve following cleaning. The addition of wiping the sieves with wet low-linting precision tissues (Method 2) appeared to be sufficient for removing a significant portion of possible cross-contamination from the sieves.

The texture of the till is another variable to consider in this study. The grain size analyses of the two metal-rich tills used indicates that sample 11-MPB-200 contained greater amount of clays (Fig. 8). The clay size particles are more difficult to dislodge from sieves by blowing with compressed air. Moreover, residual dust remaining after applying each of the cleaning methods is harder to detect visually than silt or sand sized residue. General observation during the study indicates that sieves used for sample 11-MPB-507 were easier to clean and the number of grains lodged in the sieve mesh (Fig. 7) was lower.

Conclusions

The method used for cleaning metal sieves when sieving till samples is critical to the overall quality of the subsequent geochemical analysis. Cleaning Method 1, while the quickest, did not remove contamination efficiently. The addition of an extra step in Method 2 lowered the level of the potential contaminants without a significant time increase in the process. This cleaning method is sufficient for regional till geochemical studies or in areas of similar composition to the sample used in the Sisson Phase. However, if metal-rich till is known to be entering the Sed Lab, cleaning Method 3 will be used. The Sed Lab is confident in processing special metal-rich samples collected for the GEM2 and TGI4 Programs. Implementing cleaning Method 3 for these types of samples will ensure that contamination from sieving is unlikely.

To ensure high quality sample preparation, Sed Lab collaborators should provide the lab with a processing order if they are aware of any potentially metal-rich samples. Metal-rich samples should be positioned at the end of the batch to avoid any possible cross-contamination during sieving and any potential analytical error due to carry over during the geochemical analysis. Silica blanks should be inserted at the start of every batch and at regular intervals within the batch to monitor possible cross-contamination in the preparation lab. The insertion of control reference materials (CRMs) and duplicates are also recommended for quality control when submitting sieved samples to a lab for further analysis.

Future Work

The Sed Lab would like to test contamination introduced by till samples enriched with metals from different types of mineral deposits. Other elements to consider could be Au, PGEs and REEs. Varying specific gravities and hardness' would play an important role in determining the potential for contamination.

Another possible area to test would be to determine how effective the silica blank material is for helping to remove contamination that has remained on the sieve. For example, two silica blanks could be sieved following each metal-rich till sample to determine the effectiveness at removing contamination during sieving.

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Tables

Table 1. Test specifications for Silicic Acid n-Hydrate, manufactured by J.T Baker®, BAKER ANALYZED* Reagent. 84% min. (as SiO₂). Supplier #: 0324-05. Lot # J29623. A certificate of analysis can be found at the following web address: <http://www.avantormaterials.com/documents/cofa/USA/B/J/0324J29623.htm> (March 2015)

Test for Laboratory, Research, or Manufacturing Use	Specification	Result
Assay (as SiO ₂) min.	84%	100%
Nonvolatile with HF max.	0.2%	0.1%
Chloride (Cl) max.	0.01%	< 0.003%
Sulfate (SO ₄) max.	0.02%	< 0.005%
Heavy Metals (as Pb) max.	0.002%	< 0.001%
Iron (Fe) max.	0.007%	< 0.003%
Loss on Ignition (as H ₂ O) max.	16%	13%

Table 2. Summary of results from the Sisson Phase. Samples are listed in the order that they were sieved in the Sed Lab. The samples shaded in blue were sieved but not sent out for geochemical analysis. Sieving contamination is shaded in pink.

	MDL	Mo ppm 0.01	Cu ppm 0.01	Pb ppm 0.01	Zn ppm 0.1	Ag ppb 2
	Silica Blank 0-0	0.02	0.10	0.02	1.0	<2
Method 1	Silica Blank 1-0	0.03	<0.01	0.07	0.2	6.0
	11-MPB-507-1-	91.96	302.92	387.14	294.6	409.0
	Silica Blank 1-1	0.05	0.02	0.05	0.4	3.0
	11-MPB-507-1-					
	Silica Blank 1-2	0.03	0.14	0.05	0.2	2.0
	11-MPB-507-1-					
	Silica Blank 1-3	0.03	0.15	0.06	0.2	3.0
Method 2	Silica Blank 2-0	0.02	0.21	0.07	0.2	<2
	11-MPB-507-2-	89.46	292.18	364.73	301.8	418.0
	Silica Blank 2-1	0.03	<0.01	<0.01	0.1	<2
	11-MPB-507-2-					
	Silica Blank 2-2	0.02	0.03	<0.01	0.1	<2
	11-MPB-507-2-					
	Silica Blank 2-3	0.03	0.02	0.02	0.20	<2
Method 3	Silica Blank 3-0	0.03	0.16	<0.01	0.3	<2
	11-MPB-507-3-	85.39	273.23	341.85	280.8	393.0
	Silica Blank 3-1	0.02	<0.01	<0.01	0.3	<2
	11-MPB-507-3-					
	Silica Blank 3-2	0.04	0.10	<0.01	0.2	<2
	11-MPB-507-3-					
	Silica Blank 3-3	0.03	0.04	<0.01	0.4	<2
	Sample sieved but not analyzed					
	Sieving contamination					

Table 3. Summary of results from the Pine Point Phase. Samples are listed in the order that they were sieved in the Sed Lab. The samples shaded in blue were sieved but not sent out for geochemical analysis. Sieving contamination is shaded in pink.

	MDL	Pb ppm 0.01	Zn ppm 0.1	Cd ppm 0.01
	Silica Blank 0-0	0.02	0.4	<0.01
	Silica Blank 0-1	0.03	0.2	<0.01
	Silica Blank 0-2	<0.01	0.1	<0.01
	Silica Blank 0-3	<0.01	0.2	<0.01
	Silica Blank 0-4	<0.01	0.1	<0.01
	Silica Blank 1-0	<0.01	<0.1	<0.01
	11-MPB-200-1-1	>10000.0	>10000.0	223.25
	Silica Blank 1-1	3.52	7.3	0.01
	11-MPB-200-1-2			
	Silica Blank 1-2	4.26	9.0	0.02
	11-MPB-200-1-3			
	Silica Blank 1-3	3.69	9.8	0.01
	Silica Blank 2-0	<0.01	<0.1	<0.01
	11-MPB-200-2-1	>10000.00	>10000.	206.10
	Silica Blank 2-1	2.46	5.1	0.02
	11-MPB-200-2-2			
	Silica Blank 2-2	2.63	5.4	<0.01
	11-MPB-200-2-3			
	Silica Blank 2-3	2.89	5.1	0.02
	Silica Blank 3-0	<0.01	0.1	<0.01
	11-MPB-200-3-1	>10000.00	>10000.	207.37
	Silica Blank 3-1	0.02	0.5	<0.01
	11-MPB-200-3-2			
	Silica Blank 3-2	0.03	0.5	<0.01
	11-MPB-200-3-3			
	Silica Blank 3-3	0.04	0.2	<0.01
	Sample sieved but not analyzed			
	Sieving contamination			

Figures

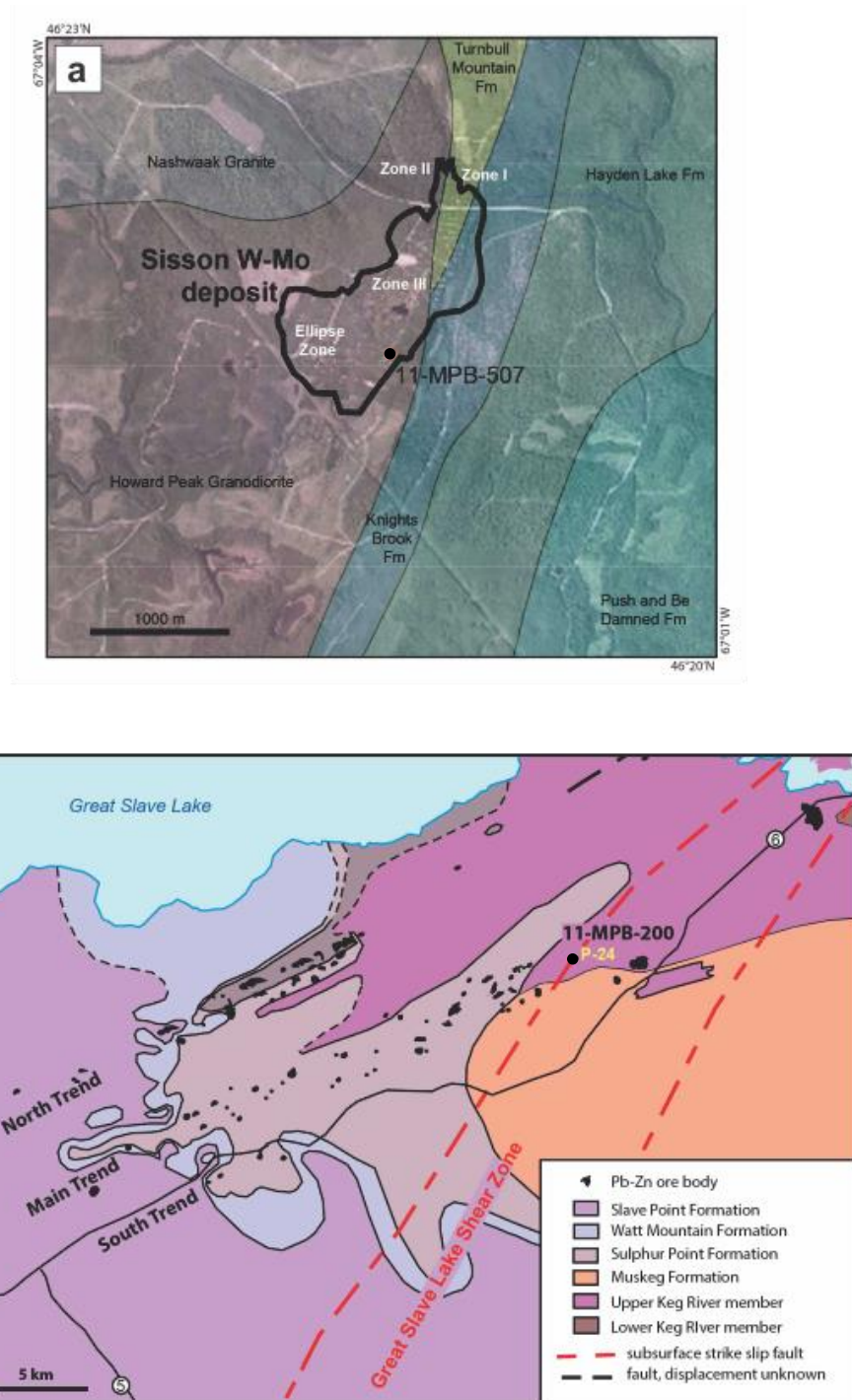


Figure 1: Location of metal-rich till sites: a) Location of till sample 11-MPB-507 from the Sisson W-Mo deposit in New Brunswick (modified from McClenaghan et al. 2013b); b) Location of till sample 11-MPB-200 collected from the open pit at the MVT Pb-Zn deposit O-24 in the Pine Point Mining District, NWT (modified from Hannigan, 2007).

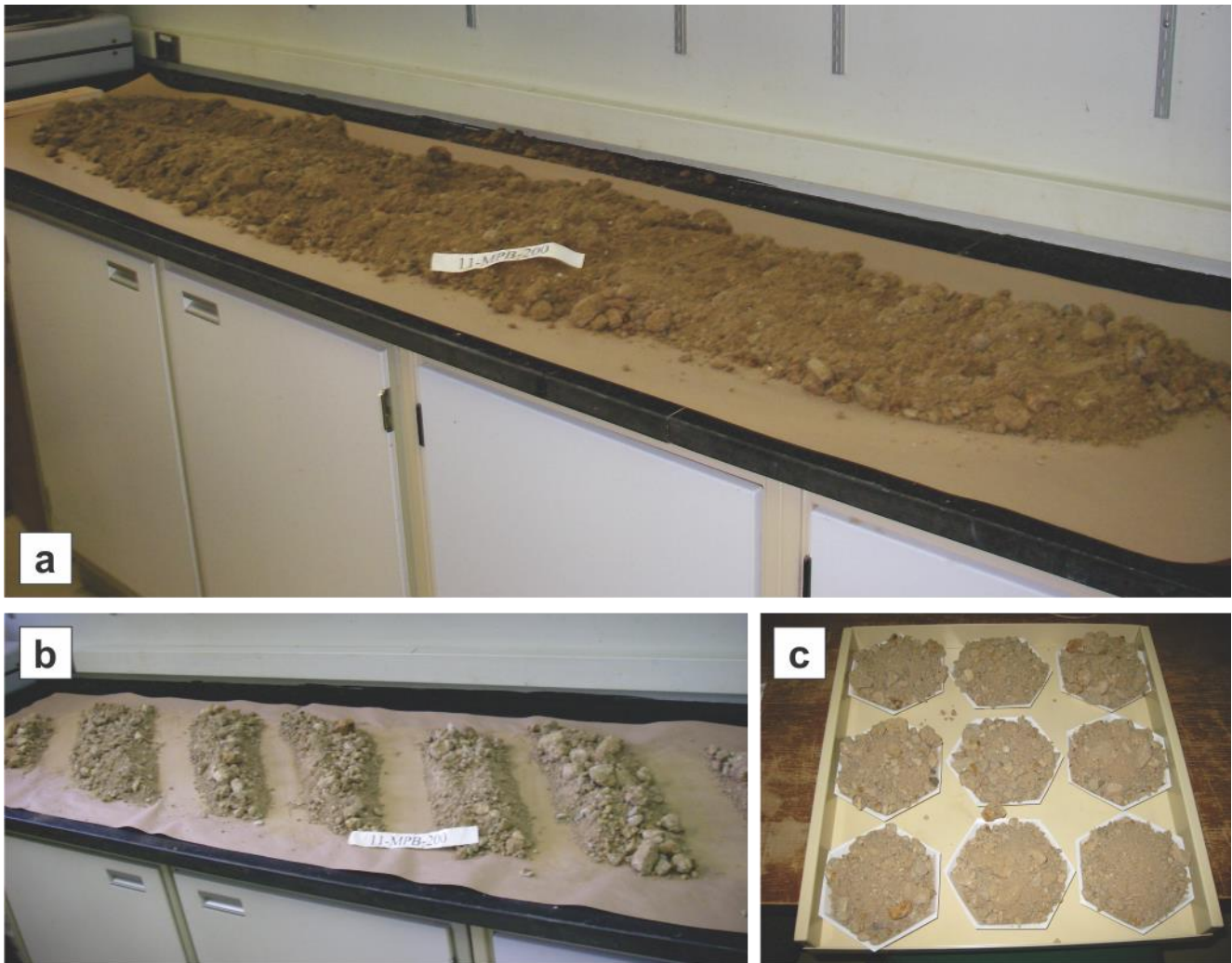


Figure 2: a) Sample of 11-MPB-200 air drying on Kraft paper prior to splitting in the Sedimentology Laboratory (GSC-Ottawa). b) Elongated piles were formed along the length of the sample. c) The final splits in XL hexagonal weigh dishes prior to sieving.

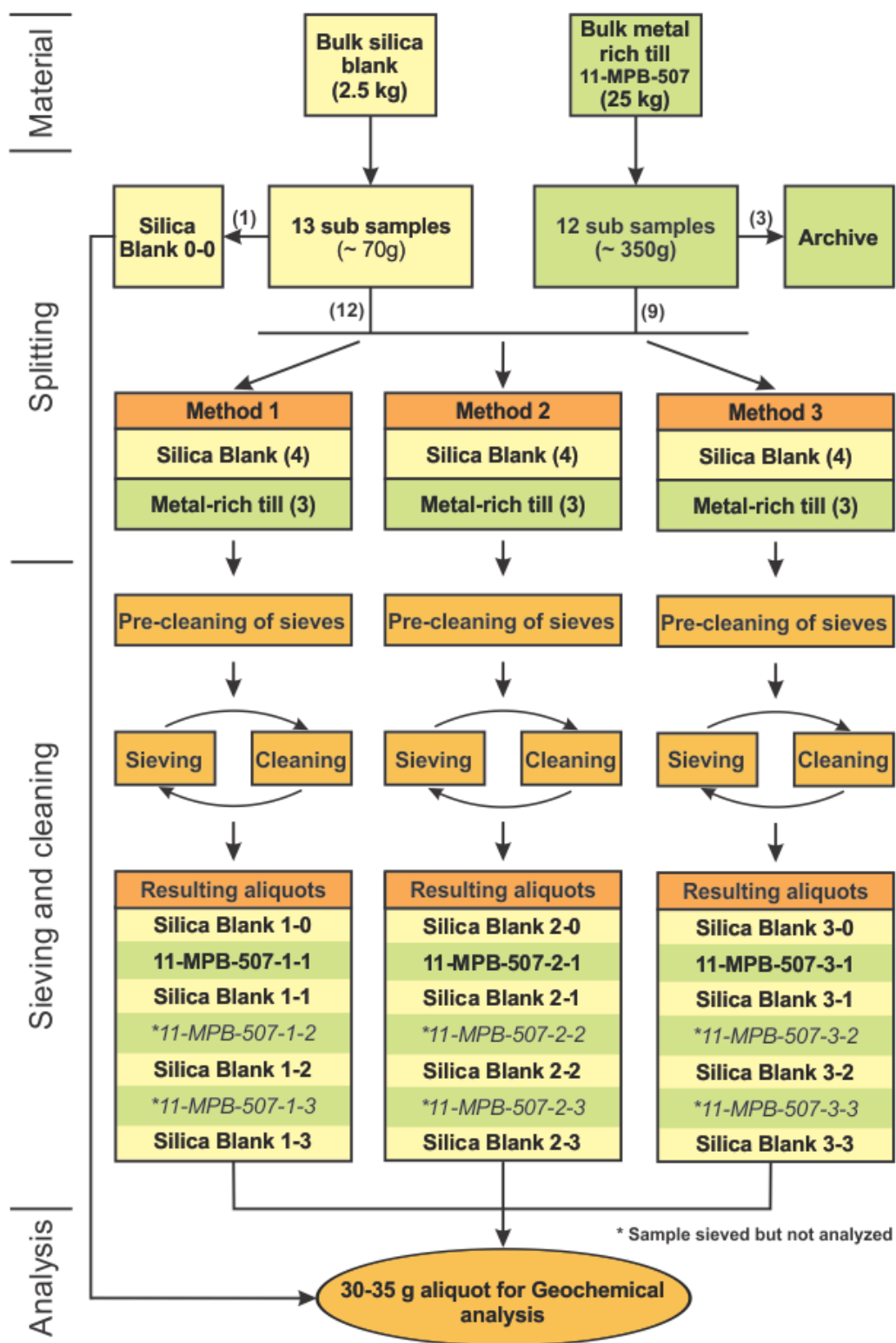


Figure 3: Flow diagram illustrating methodology and sample labelling for the Sisson Phase. The same methodology was used for the Pine Point Phase.

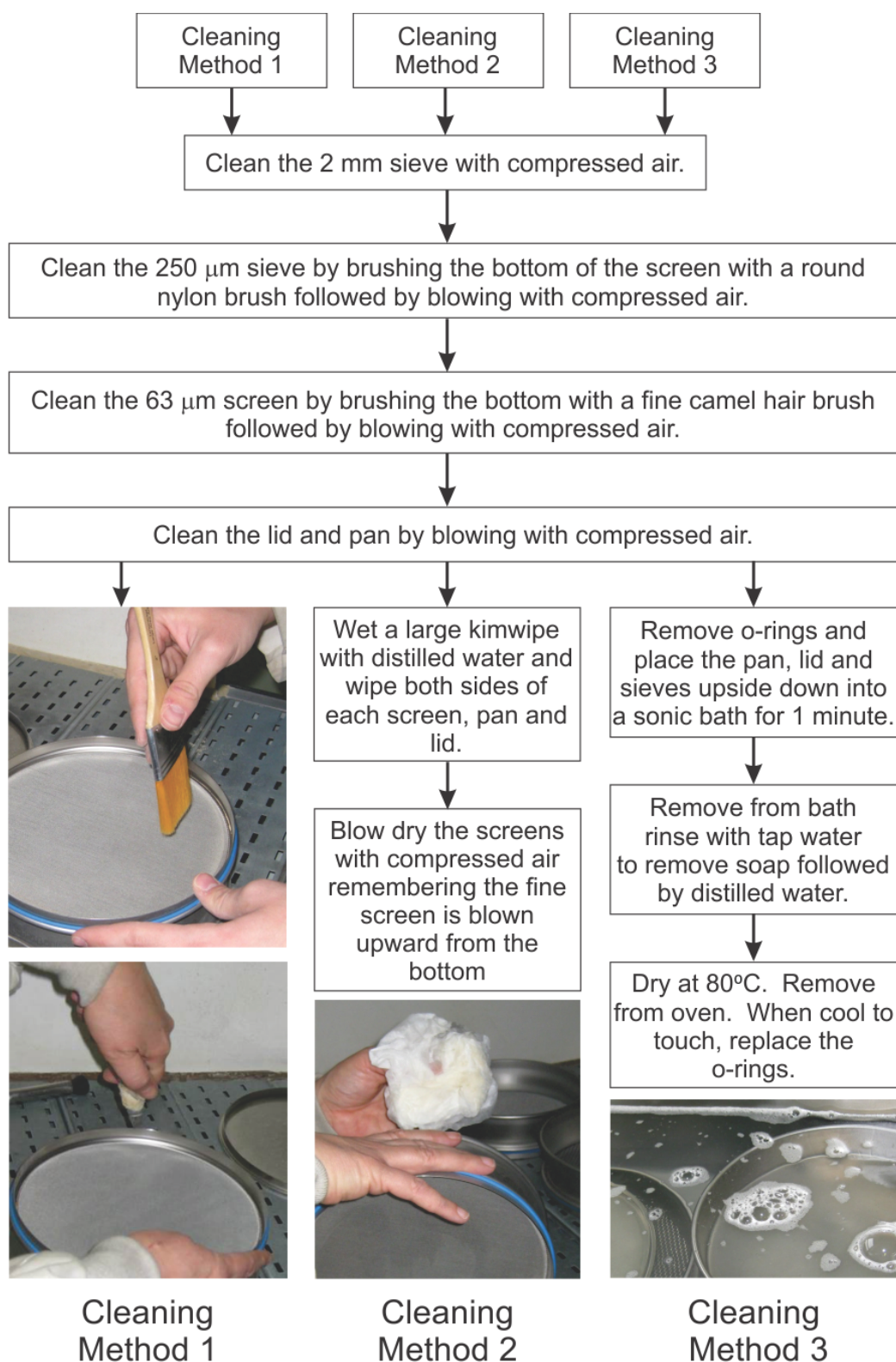


Figure 4: Flow chart describing the sieve cleaning methods.



Figure 5: a) Sieving completed, Silica blank material retained on each sieve. Material in the pan was sent for geochemical analysis. b) Sieving completed, till material retained on each sieve. Material in the pan was sent for geochemical analysis.

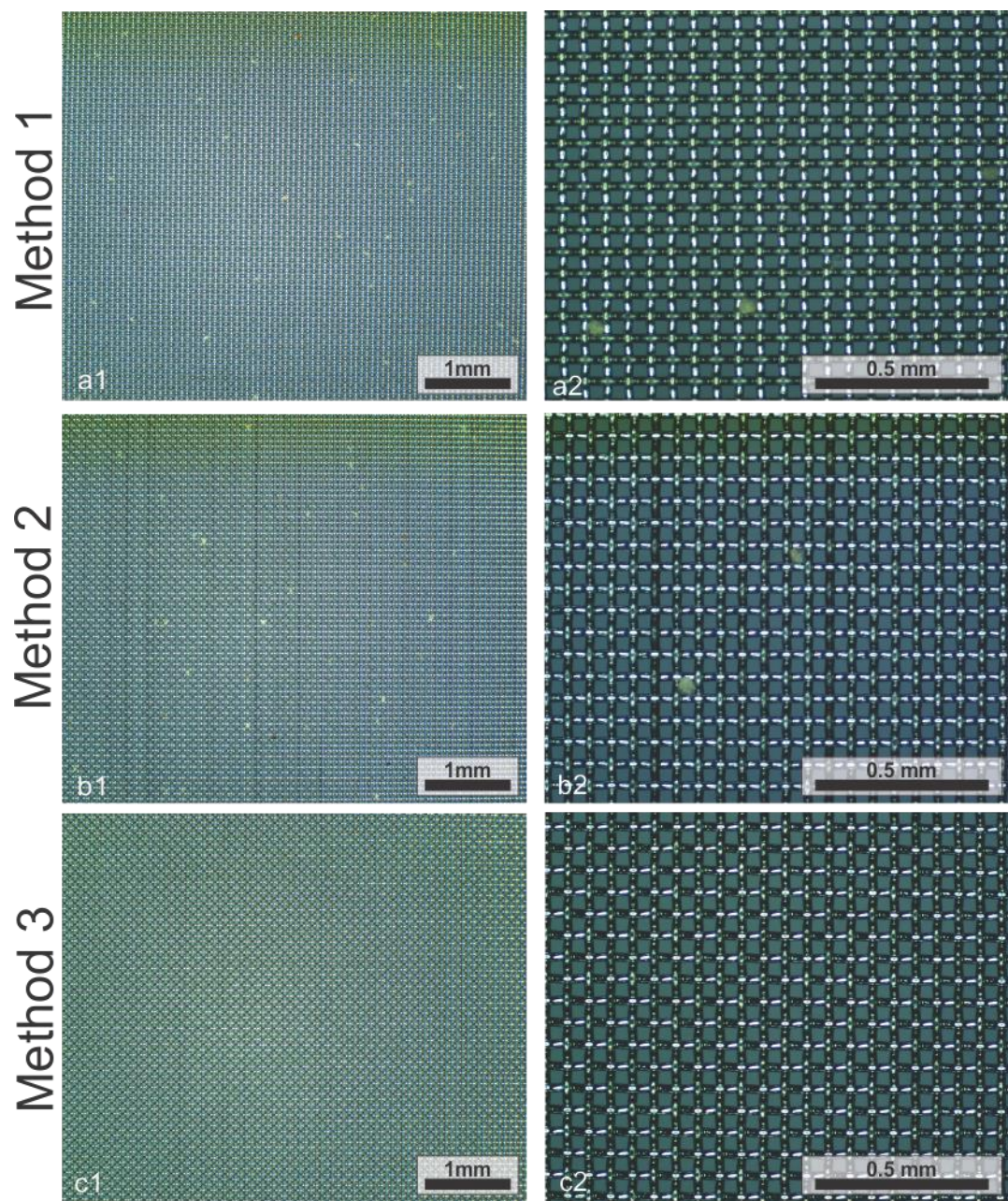


Figure 6: Photo of 0.063 mm sieve mesh following a) cleaning Method 1; b) cleaning Method 2; c) cleaning Method 3

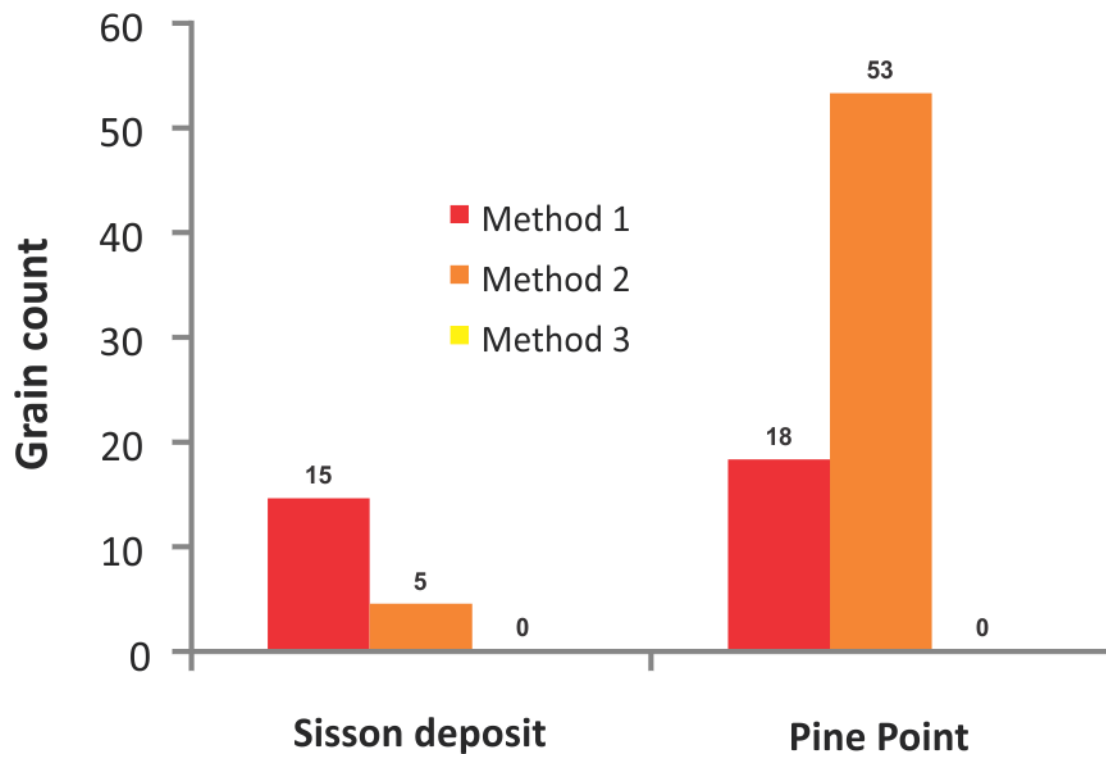


Figure 7: Bar graph showing average Number of grains remaining on the 0.063 mm sieve after being cleaned using Methods 1, 2 and 3.

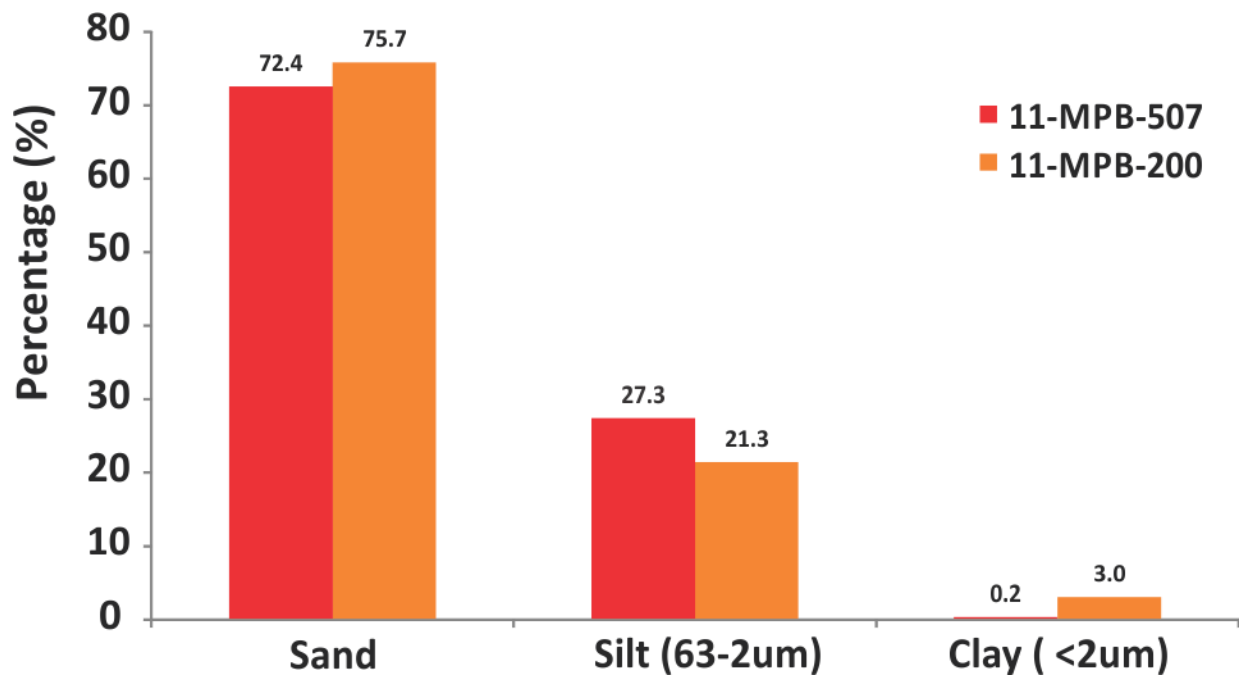


Figure 8: Bar graph comparing the % sand, silt and clay in metal-rich till samples 11-MPB-507 and 11-MPB-200.