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# Evaluation of single-use nylon-screened sieves for use with fine-grained sediment samples

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# Abstract

The authors set out to evaluate the use of three sieving methods when sieving the <250 µm heavy mineral concentrate (HMC) material. As the grain size to be evaluated decreases, unique concerns for sample loss and cross-contamination during processing arise and this study reports a methodology for sieving the <250 µm fraction of a HMC using disposable nylon mesh sieves. The disposable sieves result in a significant reduction in sample loss when tested against traditional stainless-steel sieves, and their single use nature eliminates the chance of sample cross-contamination of samples from reuse of a sieve and the need for sieve cleaning between samples.

# Introduction

Indicator mineral methods applied to glacial sediment samples are important exploration tools in glaciated terrain (McClenaghan and Paulen (2018) for diamonds (McClenaghan and Kjarsgaard, 2007) and gold (Averill and Zimmerman, 1984; Averill, 2001, 2013, 2014; McClenaghan and Cabri, 2011). More recently, their potential to aid porphyry Cu (Kelley et al., 2011; Hashmi et al., 2015; Plouffe et al., 2016), magmatic Ni-Cu-PGE (Averill, 2011; McClenaghan and Cabri, 2011), carbonate-hosted Pb-Zn (Oviatt et al., 2015; McClenaghan  et al., 2018a) and volcanogenic massive sulfide (VMS) exploration (McClenaghan et al., 2015) has been demonstrated.

Indicator minerals are recovered from large (10 to 30 kg) sediment samples at specialized commercial laboratories using a combination of sizing and density concentration methods to reduce the volume of material to be examined, usually to a non-ferromagnetic heavy mineral concentrate (HMC). These methods focus on the recovery of the medium (>250 µm) up to very coarse sand-sized (<2 mm) mineral fraction because it is the most cost-effective and relatively easy to recover and visually examine. For a detailed description of how a HMC is produced and used in mineral exploration, refer to McClenaghan (2011).  Developments in rapid scanning electron microscopy (SEM) such as Mineral Liberation Analysis (MLA) or QEMSCAN over the past 10 years now make it possible to identify indicator minerals in the <250 µm (fine sand and finer) heavy mineral fraction of sediment samples using automated technologies (Lehtonen et al., 2015).

As the grain size of the desired minerals to be recovered and examined decreases, the risk of losing these grains increases; the difficulty in ensuring thorough cleaning of tools and work surfaces also increases. Trapped mineral grains may not be readily visible without magnification, making thorough sieve and related lab equipment cleaning difficult and time consuming.

The use of disposable nylon screens for sieving samples has been employed in previous heavy mineral studies to eliminate tedious sieve cleaning as well as reduce contamination risks (e.g., Hulkki et al., 2018). Researchers at the Queen's University Facility for Isotope Research (QFIR), with the support of the Geological Survey of Canada's (GSC) Targeted Geoscience Initiative (TGI-5) Program, set out to evaluate the utility of three varieties of sieves for sieving the <250 µm heavy mineral concentrate (HMC) fraction of till samples. In this study, we tested 2" (5.08 cm) and 5" (12.7 cm) single-use nylon-screened sieves versus traditional 8" (20.32 cm) stainless-steel solderless reusable sieves to determine the differences in ease of use and sample loss between them. Because low concentrations of indicator minerals (a few grains in a 10 kg till sample) can constitute a significant 'anomaly' (Averill, 2001), the potential for false-positive results stemming from sample cross-contamination, or falsenegative results stemming from lost indicator grains, requires a method of sample processing that mitigates mineral grain loss or cross contamination.

# Method of Investigation

## Sample material

Sample material from three separate GSC study sites was used for the sieve testing:
1. HMC of the GSC's in-house till standard 'Almonte Till', collected from a borrow pit near Almonte, Ontario. It is typical of till derived from the southern Canadian Shield (Plouffe et al., 2013), contains relatively few indicator minerals, and is used by the GSC to monitor lab performance and contamination for heavy mineral sampling programs and subsequent processing at commercial labs.

2. HMC of four bulk till samples (09-MPB-060, 09-MPB-058, 09-MPB-075, 12-MPB-902) collected around the Izok Lake Zn-Cu-Pb-Ag volcanogenic massive sulfide (VMS) deposit. The deposit is located 300 km north of Yellowknife on the border between Nunavut and the Northwest Territories. The samples were collected in 2009 and 2012 as part of the GSC's Geo-mapping for Energy and Minerals (GEM) Program (2008-2013). Samples were collected from mud boils at varying distances up- and down-ice of mineralization, and the sampling locations are depicted in Figure 1. Information about sample sites, material collected, geochemical data and indicator mineral data are reported in Hicken et al. (2012) and McClenaghan et al. (2015).

3. An unprocessed bulk (30 kg) till sample from the Broken Hammer Cu-Ni-PGE-Au deposit on the North Range of the Sudbury Ni-Cu mining district. The sample was collected as follow-up to an earlier indicator mineral study of the deposit by McClenaghan and Ames (2013) and McClenaghan et al. (2018b). The till sample was collected at 2.0 m depth, adjacent to GSC sample 15-PMA-514 (Fig. 2).

## Sample Splitting

The Broken Hammer bulk till sample was split into five smaller samples of the following masses: 12 kg, 6 kg, 3 kg, 1.5 kg, and 0.75 kg, in order to test the heavy mineral yield of various masses of bulk till.

## Density Concentration

The HMC of all samples used in this sieving study were produced at the commercial lab Overburden Drilling Management Limited (ODM), Ottawa. The lab processed the till samples using a combination of sieving, tabling and heavy liquid separation and details of their processing procedures can be found in McClenaghan et al. (2015). The resulting non-ferromagnetic HMC was prepared at ODM and the <250 µm fraction of each HMC was made available for this sieving study.

## Single-use Sieve Construction

Single-use sieves were constructed from two diameters (2" and 5") of acrylonitrile butadiene styrene (ABS) tubing at QFIR. The tubes were cut using a bench-mounted power mitre saw fitted with a fine-toothed blade. The tubes were cut to 2" lengths, and cut ends were trimmed of excess material with a

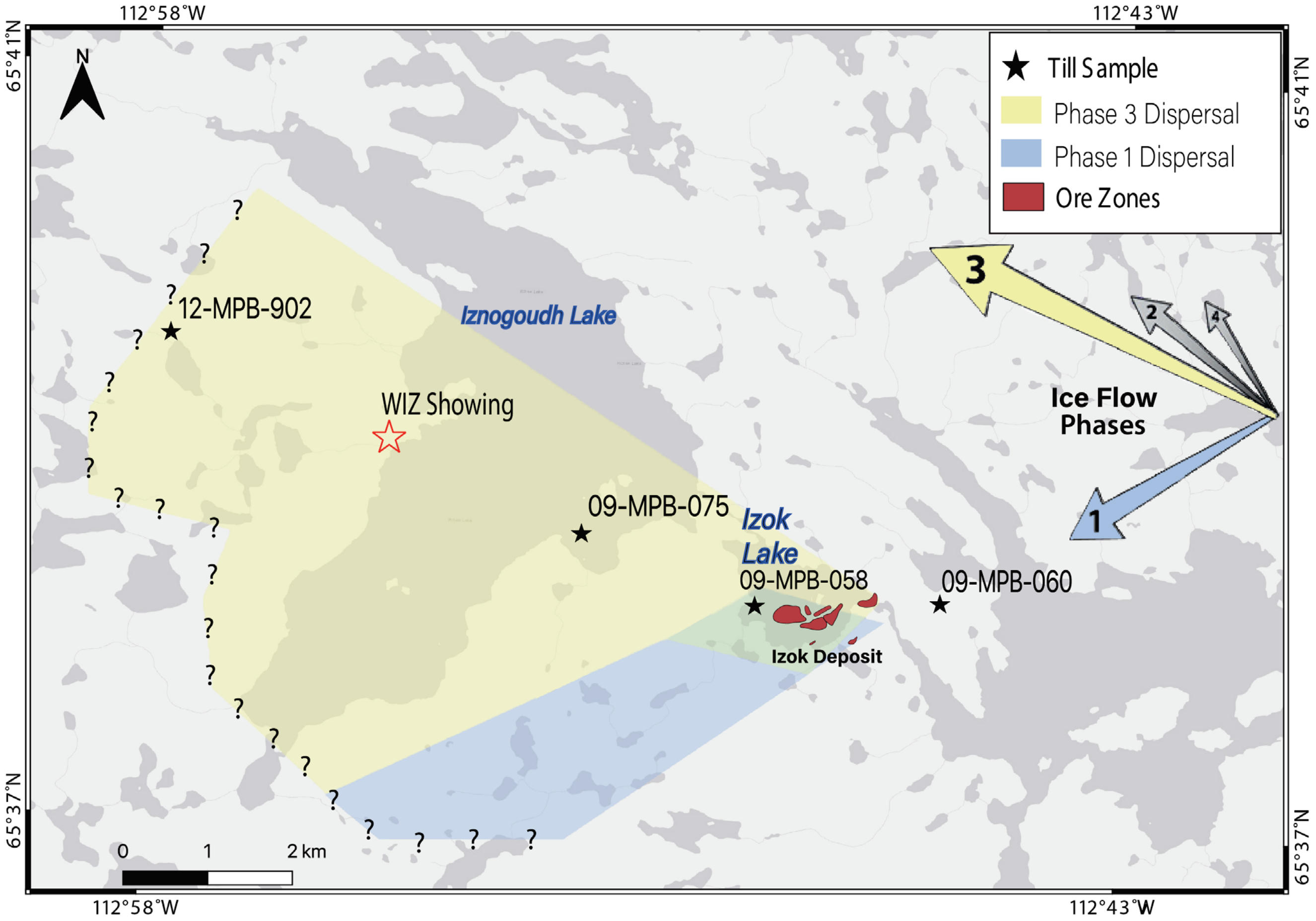

***Figure 1:Locations of four till samples collected near the Izok Lake Zn-Cu-Pb-Ag volcanogenic massive sulfide deposit in Nunavut, Canada and the dispersal fan for gahnite identified by McClenaghan et al. (2015) using 103 till samples. Question marks (?) indicate areas with no samples or data.***

box-cutter. Nylon screening was cut into squares large enough to fully cover all edges of the ABS tube and affixed with cyanoacrylate adhesive (Super-Glue™). Softer adhesives like rubber cement could serve as a potential surface for grain adhesion, while adhesives like epoxy require more preparation prior to application and longer curing times. Cyanoacrylate was chosen for the strength of its bond, short curing time, and its hardness once cured. Care was taken to ensure that there was a solid bead of cyanoacrylate joining the nylon mesh where it contacted the inner surface of each tube (Fig. 3). Once the cyanoacrylate had cured (~ 10 minutes), any excess nylon screen was trimmed from the outer edge of each tube.

One sieving assembly for one sample consisted of three nylon-screened ABS sieves, one of each desired mesh size (185 µm, 125 µm, 64 µm), and one ABS tube without screen. This tube served as the terminal section, to contain material passing the 64 µm mesh sieve. These sections were stacked together and secured with easily removed adhesive tape, providing a tight seal between sieves (Fig. 3). Coated weigh-paper cups were affixed to each end to cap the sieves and catch mineral grains (<64 µm passing) through all of the sieves.

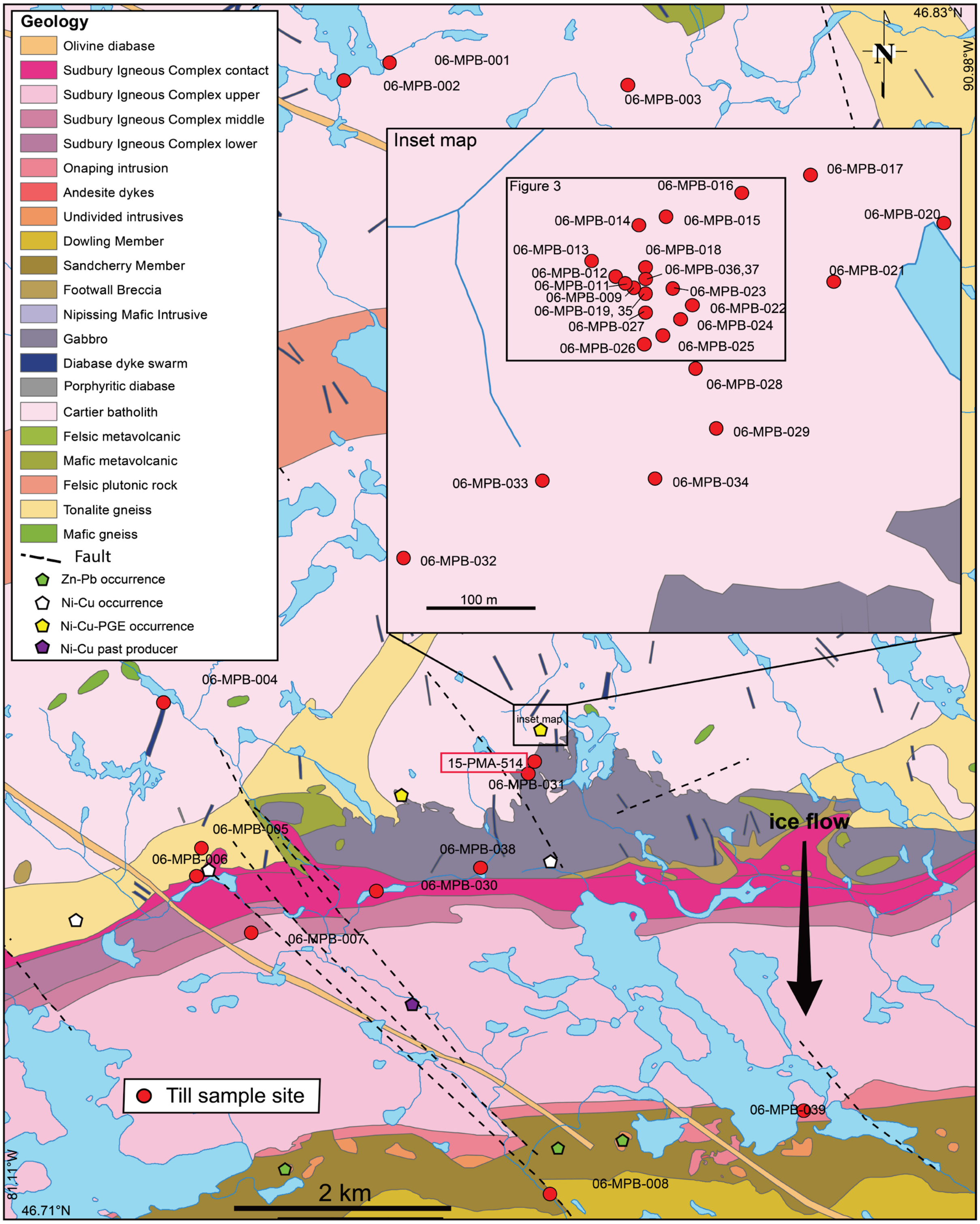

*Figure 2: Location of the bulk till sample collected near the Broken Hammer Cu-Ni-PGE-Au deposit, in the north part of the Sudbury Ni-Cu mining district. The sample used in this study was taken at the same site as sample 15-PMA-514, outlined on the map in a red box.*

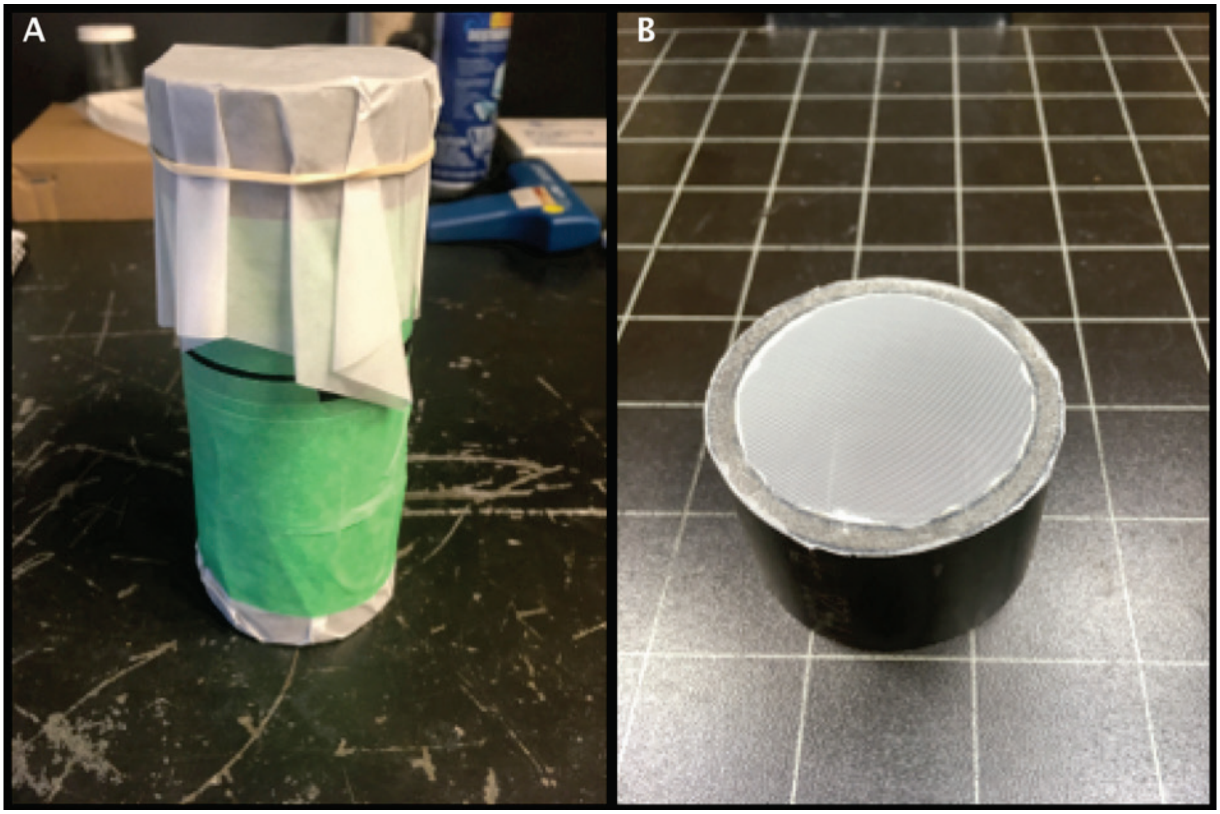

***Figure 3: Left: Single-use sieve assembly with sieve intervals at 185 µm, 125 µm, and 64 µm. Right: Disposable ABS sieve section displaying nylon screen affixed with cyanoacrylate adhesive.***

## Sample Sieving

Sieving and weighing of all <250 µm HMC samples were performed in the QFIR lab. Sample material sieved through nylon screen sieves was produced for use in a separate project, requiring size intervals at 185 µm, 125 µm, and 64 µm. Due to 8” stainless-steel sieves not being available in a 185 µm interval, 180 µm (80 mesh) was used for the stainless-steel sieve tests. One set of nested 8” stainless-steel sieves at the required size intervals (180 µm, 125 µm, and 64 µm) and a terminal section (<64 µm passing) was prepared, along with two sets of nested nylon-screened sieving assemblies (2” nylon-screened ABS and 5” nylon-screened ABS), consisting of one sieve at each desired size interval (185 µm, 125 µm, 64 µm) and a terminal section (<64 µm passing).

All Almonte Till HMC samples were sieved through 8” stainless-steel sieves. All Izok Lake till HMC samples were sieved through 2” nylon-screened ABS sieves, and all Broken Hammer till HMC samples were sieved through 5” nylon-screened ABS sieves. The entire mass of each <250 µm HMC sample was placed in the largest diameter sieve of a sieve assembly. The top sieve was covered with a folded paper “cup” (Fig. 3) and the sieve assembly was secured onto a Retsch AS200 sieve agitator. Four 2” and three 5” single-use assemblies could be placed onto this agitator at one time, while only one 8” stainless-steel assembly could be agitated at one time. The sieves were shaken at 3 mm amplitude for 5 minutes, and then allowed to sit for 3 minutes to allow any aerosolized material within to settle.

The material retained on each sieve was poured into pre-weighed folded paper pouches. Any residual material remaining on the sieve was removed by firmly upending the sieve over a clean white sheet of paper. Tabloid size (17"x11") paper was found to be the best material for this purpose, as it provides enough space to upend the section several times without disturbing any material already on the paper. Material gathered on the paper was carefully added to the previously mentioned paper sample pouch, and the pouch was folded closed and weighed. Paper pouches were used to store each sieved fraction instead of small plastic vials because the lids of plastic vials were found to be traps for fine-grained sediment grains. Paper pouches, folded from a single piece of coated weigh-paper, are simple to prepare and use. Pouches can be unfolded during material transfer and sediment grains can be easily removed, with the empty pouch being disposed of after. Figure 4 displays sediment being removed from an unfolded pouch.

A Milty Zerostat 3 anti-static device was used to remove static charge from all surfaces in contact with HMC prior to material transfer. This included weigh and transfer paper, sieve sections, and paper sample pouches. Use of the anti-static device released grains that adhered to surfaces through electrostatic attraction as a function of the sieving process.

A flowchart detailing the disposable sieving procedure is depicted in Figure 5. The sieving procedure for each till sample took 15 minutes to complete but placing multiple sieve towers onto a sieve agitating platform at once reduces the overall time needed to process several samples. Sieving of one sample, including weighing and packaging of the resultant size fractions, took ~25 minutes.

*Figure 4: Sediment being poured from a folded paper pouch.*

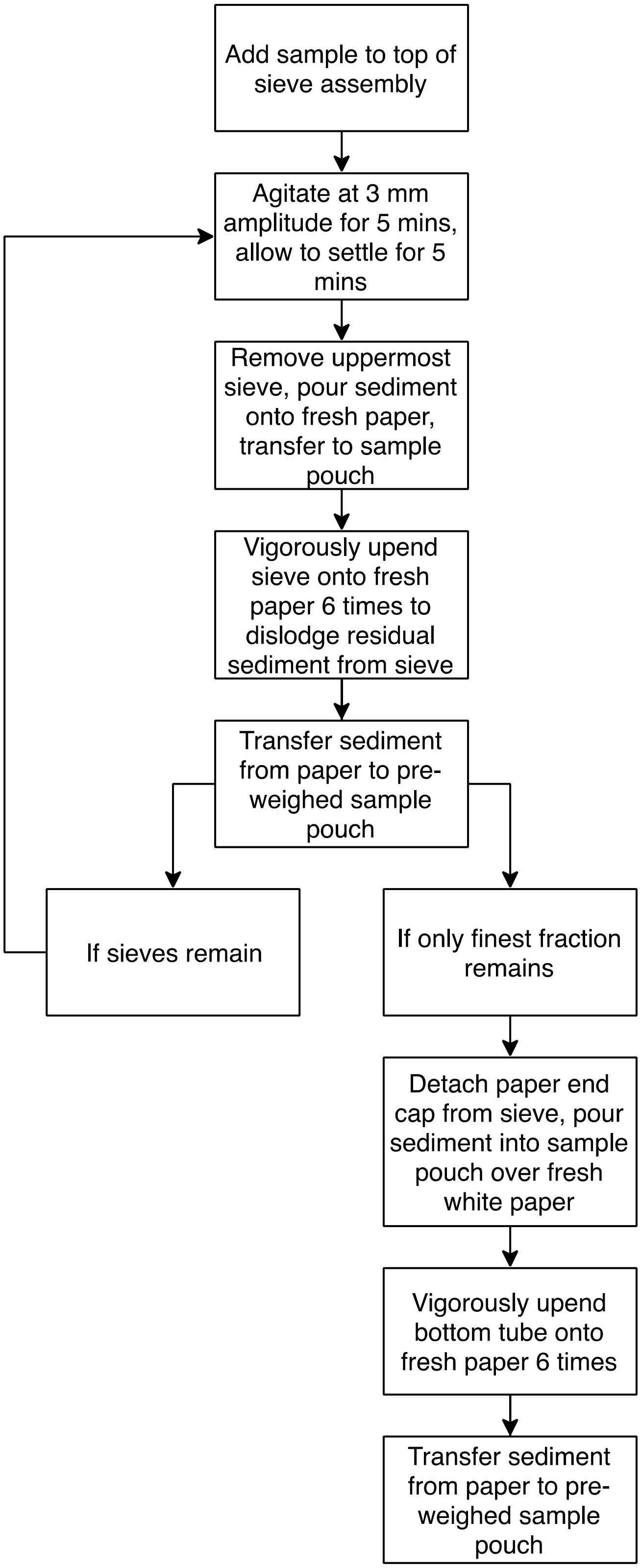

***Figure 5:Flowchart detailing the sieving process developed for this study.***

# Results

Table 1 lists the original mass of each HMC sample along with the masses of the individual size fractions after sieving. The average material loss for 4 samples (17-HDL-01 to -04) sieved through a reusable 8” stainless steel sieve assembly (180 µm, 125 µm, 64 µm) is 0.182 g. For single-use sieves, the average material loss following the sieving of samples through 2” nylon-screened ABS sieves (185 µm, 125 µm, 64 µm) is 0.092 g, and following sieving of 5 samples through 5” nylon-screened ABS sieves (185 µm, 125 µm, 64 µm) is 0.021 g.

# Discussion

## Stainless steel Sieves

There are multiple sources of cross-contamination when using reusable sieves to process multiple fine-grained sediment samples. Grains become entrained in sieve surfaces (void space, mesh screen), and thorough time consuming cleaning is required to remove them (Fig. 4). If cleaning does not remove all entrained grains, they can contaminate subsequent samples that are processed using the same sieve. Furthermore, grains can be entrained in the tools used to clean sieves (brushes, ultrasonic bath) and from there re-enter the processing workflow to contaminate subsequent samples. Grenier et al. (2015) performed a thorough investigation of contamination when using re-usable electro-welded stainless-steel sieves by evaluating the effectiveness of three cleaning methods. They found that the optimal method for reducing (but still not completely eliminating) cross-contamination between samples was to clean sieves using an ultrasonic bath following the sieving of each sample. This method requires subsequent oven drying, and the cleaning cycle takes 30 minutes to complete.

The only way to ensure zero cross-contamination between samples is to use single-use, disposable sieves. The nylon-screened ABS sieves constructed for this project qualify as single-use because the nylon screen can be removed from the ABS tube and disposed of following sieving.

## Costs and time

The average time to complete the sieving and packaging of a single sample is the same for stainless-steel and single-use nylon-screened ABS sieves. However, the size and shape of the single-use sieves allows several samples to be agitated at once, while only one 8” stainless-steel assembly can be shaken at a time. This difference in the number of samples that can be agitated at one time represents a considerable reduction in processing time when processing large batches of samples. Processing a single sample through single-use sieves, including weighing and packaging of the resultant size fractions, takes ~25 minutes.

After sieving and the removal of sieved fractions from each nested sieve, the sieves are disposed of, eliminating the need for time-consuming cleaning and the potential for cross-contamination between samples. The simple glued design reduces void space observed in commercial sieves for mineral grains to be entrained in, and material is liberated from the walls of each section easily and thoroughly.

The nylon screen material (~\$15/m$^2$) and ABS piping (\$0.38/inch) used to construct the single-use sieves are inexpensive and easily obtained. A 2” length of 5” diameter ABS tubing combined with 0.1m$^2$ nylon screen can be assembled for \$0.91 in materials cost. This does not include the cost of

***Table 1: Sample losses observed using various sieving materials, including the original mass of non-ferromagnetic heavy mineral concentrate (HMC) used and the size fractions separated.***

**8" Stainless-steel Sieve Tests**

| *Sample* | *Original Mass (g)* | *Fraction (µm)* | *Mesh Size* | *Mass (g)* | *Mass Weighed (g)* | *Total Loss (g)* |
|---|---|---|---|---|---|---|
| 17-HDL-01 | 15.000 | 180-250 | 80 | 1.180 | 14.815 | 0.185 |
| | | 125-185 | 120 | 3.400 | | |
| | | 64-125 | 230 | 9.200 | | |
| | | <64 | -- | 1.035 | | |
| 17-HDL-02 | 15.000 | 180-250 | 80 | 1.765 | 14.802 | 0.198 |
| | | 125-185 | 120 | 3.185 | | |
| | | 64-125 | 230 | 8.826 | | |
| | | <64 | -- | 1.026 | | |
| 17-HDL-02 | 15.000 | 180-250 | 80 | 1.885 | 14.828 | 0.172 |
| | | 125-185 | 120 | 3.124 | | |
| | | 64-125 | 230 | 8.645 | | |
| | | <64 | -- | 1.170 | | |
| 17-HDL-04 | 15.000 | 180-250 | 80 | 1.097 | 14.824 | 0.176 |
| | | 125-185 | 120 | 3.551 | | |
| | | 64-125 | 230 | 9.173 | | |
| | | <64 | -- | 1.003 | | |

**2" Disposable Sieve Tests**

| *Sample* | *Original Mass (g)* | *Fraction (µm)* | *Mesh Size* | *Mass (g)* | *Mass Weighed (g)* | *Total Loss (g)* |
|---|---|---|---|---|---|---|
| 09-MPB-060 | 16.637 | 185-250 | 185 µm* | 2.668 | 16.544 | 0.093 |
| | | 125-185 | 120 | 5.145 | | |
| | | 64-125 | 230 | 6.624 | | |
| | | <64 | -- | 2.107 | | |
| 09-MPB-058 | 29.223 | 185-250 | 185 µm* | 3.426 | 29.124 | 0.099 |
| | | 125-185 | 120 | 7.060 | | |
| | | 64-125 | 230 | 12.064 | | |
| | | <64 | -- | 6.574 | | |
| 09-MPB-075 | 22.933 | 185-250 | 185 µm* | 3.132 | 22.848 | 0.085 |
| | | 125-185 | 120 | 5.959 | | |
| | | 64-125 | 230 | 9.584 | | |
| | | <64 | -- | 4.173 | | |
| 12-MPB-902 | 22.769 | 185-250 | 185 µm* | 2.949 | 22.679 | 0.090 |
| | | 125-185 | 120 | 4.814 | | |
| | | 64-125 | 230 | 9.716 | | |
| | | <64 | -- | 5.200 | | |
| *No mesh equivalent | | | | | | |

**5" Disposable Sieve Tests**

| *Sample* | *Original Mass (g)* | *Fraction (µm)* | | *Mass (g)* | *Mass Weighed (g)* | *Total Loss (g)* |
|---|---|---|---|---|---|---|
| 17-MPB-601 | 40.814 | 185-250 | 185 µm* | 4.792 | 40.761 | 0.053 |
| | | 125-185 | 120 | 7.955 | | |
| | | 64-125 | 230 | 22.831 | | |
| | | <64 | -- | 5.183 | | |
| 17-MPB-602 | 19.675 | 185-250 | 185 µm* | 2.812 | 19.653 | 0.022 |
| | | 125-185 | 120 | 4.595 | | |
| | | 64-125 | 230 | 10.255 | | |
| | | <64 | -- | 1.991 | | |
| 17-MPB-603 | 11.341 | 185-250 | 185 µm* | 1.441 | 11.335 | 0.006 |
| | | 125-185 | 120 | 2.310 | | |
| | | 64-125 | 230 | 5.704 | | |
| | | <64 | -- | 1.880 | | |
| 17-MPB-604 | 6.328 | 185-250 | 185 µm* | 0.970 | 6.312 | 0.016 |
| | | 125-185 | 120 | 1.373 | | |
| | | 64-125 | 230 | 2.791 | | |
| | | <64 | -- | 1.178 | | |
| 17-MPB-605 | 3.011 | 185-250 | 185 µm* | 0.508 | 3.002 | 0.009 |
| | | 125-185 | 120 | 0.661 | | |
| | | 64-125 | 230 | 1.252 | | |
| | | <64 | -- | 0.581 | | |
| *No mesh equivalent | | | | | | |

adhesive, but that cost was found to be minimal (i.e. < $0.10 per sieve). Many of the ABS sections can be cut and trimmed in rapid succession. The ABS pipe used in this study is constructed from a layer of porous ABS foam sandwiched between two solid layers of ABS. The porous surface on the exposed edges of each section presented a potential trap for fine-grained material and required sealing with super glue prior to affixing the nylon screen. This step could be eliminated with the use of another inexpensive plastic tubing with a solid construction such as clear polyvinyl chloride (PVC) tubing. The added benefit of using a clear material would be the ability to observe the sediment material during sieving to refine the time needed to completely sieve a sample, or the time needed to settle aerosolized material.

The time needed to cut nylon screen and affix it to the end of a sieve section is ~ 1 minute. Many sections can be prepared in rapid succession, and the curing time for the cyanoacrylate adhesive is 10 minutes. Because these sieves are intended for a single sample use, the tubes are disposed of following use, with new tubes being prepared for each project.

## Sample loss

Results from this study indicate that the use of disposable sieves reduces the overall sample loss when compared to conventional reusable stainless-steel sieves. Void space (Fig 4) where stainless steel mesh is electro-welded to an inner lip on stainless steel sieves presents a space where fine sediment grains can become trapped. Cleaning methods for stainless-steel sieves, described in Grenier et al. (2015), use brushes or compressed air to liberate these grains from void space, in concert with ultrasonic cleaning. Brushes used to clean multiple sieves represent a potential source of cross-contamination, and grains liberated by compressed air or ultrasonic cleaning cannot be recovered for analysis, increasing the risk of losing important indicator mineral grains.

While testing 2” single-use sieves, it was noted that the nylon screens were becoming occluded with mineral grains, preventing efficient passing of grains through the screen. To reduce this problem, the top section of the sieve assembly was removed, and the remaining sample material poured onto clean paper. The sieve was upended over another sheet of clean paper. The uppermost sieve section was reattached to the assembly and all remaining sample was re-added to the sieve assembly in small amounts, with 1 minute of agitation between each addition. This allowed the sample material to pass the screen efficiently. This issue was not observed in the 5” single-use sieves or in the 8” stainless-steel sieves, suggesting that the smaller surface area in the 2” sieves was the cause of the rapid occlusion. Material lost during the clearing of the 2” single-use screen following occlusion is likely the cause of the 2” sieves displaying higher sample loss than the 5” sieves. The use of appropriate sieve diameters for the mass of sample being sieved is thus important.

Results from this study indicate that sample loss is reduced using larger 5” diameter disposable sieves as compared to 2” diameter disposable sieves, for the range of sample mass in this study (3 – 40 g). However, larger diameter sieves are more difficult to manipulate, making it more difficult to efficiently empty and clear sample material following sieving, increasing the potential for grains to be lost. The increased difficulty of working with 8” sieves, combined with higher available void space for grain entrapment, is thought to be the reason for the increased sample loss from the 8” sieve tests as compared to the 5” sieve tests. Sieve diameter should therefore be selected as the smallest possible that will allow the sample material to pass efficiently. This will vary based on the mass of sample being sieved, but for samples in the range of this study (3 - 40 g), 5” diameter sieves are the most appropriate.

The inexpensive nature of single-use sieves, combined with the wide range of plastic tubing size available, allow the diameter of constructed sieves to be tailored to a project's specific needs. Reusable stainless-steel sieves are available in a range of sizes, but their higher relative purchase cost (>100x more expensive) makes having all sizes available in sufficient numbers a significant expense. Therefore single-use sieves reduce unit cost, remove the need for time-consuming sieve cleaning between samples, and eliminate the possibility of sample cross-contamination.

# Conclusions

Minimizing sample loss and preventing sample cross-contamination during sieving are both critical to ensure the overall quality of subsequent indicator mineral or geochemical analysis. Sieving <250 µm till HMC through single-use nylon-screened sieves eliminates contamination risk from inadequate sieve cleaning and saves sieve cleaning time between samples. Sieve diameter can be customized to suit the mass of material being sieved to maximize efficiency and minimize loss. The simple, void-free construction makes sample removal efficient and thorough. Results indicate that a 5" sieve disposable is the most efficient sieve diameter for sieving 3 to 40 g of <250 µm HMC.

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