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Aerochem: An Introduction and Comparison with Traditional Stream Sediment Sampling

Hildes, D. [1], Turanich-Noyen, C. [1], Washington, D. [2], Lagersson, M. [2]

1. Aurora Geosciences Ltd.
2. Capital Helicopters (1995) Inc.

ABSTRACT

Stream sediment sampling is a commonly practiced method in early-stage exploration. Aerochem is an airborne sampling system (patent pending) that reduces the helicopter overhead inherent with conventional sampling, particularly in difficult to reach areas such as rugged terrain or dense vegetation. The airborne system must maintain the integrity of the sample material and render cross-sample contamination insignificant. To this end, a comprehensive wash method is developed and a successful contamination test recorded. Although beneficial from cost-efficiency and safety perspectives over conventional hand stream sediment sampling, a key question is whether the data gathered by the airborne technique are equivalent to those collected by the conventional technique. A comparison test to assess whether sampling biases exist and are significant to the geochemical outcome was performed in August of 2015, in the Kluane area of the Yukon Territory. Three samples were collected from each of 68 sites, one using the Aerochem technique and two using conventional hand sampling. A comparative analysis between Aerochem and the two hand samplers shows variability between the three samples taken at the same sites with modestly higher variability between airborne and conventional techniques than between the two samples collected with the conventional technique. The difference is not such that all datasets cannot be used effectively together. The airborne and conventional techniques are effective at identifying anomalous stream sediment geochemistry.

INTRODUCTION

Stream sediment sampling is a standard in early-stage exploration. This paper introduces Aerochem (patent pending), a helicopter-borne stream sediment sampling system and examines the similarities and differences between conventional and Aerochem stream sediment sampling techniques.

Although beneficial from both cost-efficiency and safety perspectives over conventional hand stream sediment sampling, a key question is whether the data gathered by the airborne technique are equivalent to those obtained by the conventional technique. There are systematic differences for both the choice of a specific sample location and the ability to sample that location between the airborne and land-based sample. A test to assess whether these sampling biases are significant to the geochemical outcome was performed in the summer of 2015 in the Kluane area, Yukon Territory.

SURVEY METHODOLOGY

Sample locations for the survey were located at the north end of Kluane Lake, Yukon Territory close to Burwash Landing, and to the south of the past-producing Wellgreen mine (Figure 1). The terrain is generally very rugged. Approximately 90% of the samples were collected in the alpine zone.

Sample material was collected and field observations documented at 68 sites in the study area by two hand samplers and Aerochem to compare the geochemical variance both between airborne and land-based samples, as well as between two independent ground samplers. Some subsequent figures in this report highlight the northwest and southeast areas of Figure 1 individually.

Aerochem Sampling

The Aerochem system was created to address the high costs associated with regional stream sediment sampling. By operating in a small, low budget helicopter and requiring only two personnel at the central processing station, users can realize cost savings not possible through conventional methods. In addition, the technique offers safety benefits by mitigating several important hazards: injuries sustained while wading through steep, rugged creeks, encounters with wildlife, and the hazards of constantly entering/exiting helicopters often on precarious toe-in landings. Finally, Aerochem provides the ability to acquire geochemical data in areas that thus far remain unexplored due to conditions such as steep terrain or dense vegetation.

Aerochem is designed to operate within the limits of a Robinson R44, operated by Capital Helicopters (1995) Inc. As illustrated in the photo-montage of Figure 2, the two-person ground crew sets up a mobile processing station near the centre of the target area and all ground equipment and personnel can be mobilized in a single Robinson R44 load. The pilot collects a sample with the mechanically assisted airborne sampler and then flies back to the central processing station. The ground crew manually releases the sample on the wash station, transferring the sample into a holding bucket. To ensure samples are not cross-contaminated, one ground personnel thoroughly washes the sampling bucket using a methodology identical to that used in the contamination test (see below) before the pilot proceeds to the next sample station. Finally, the sample is sieved to -12 mesh and placed in a spun polyester sample (*Hubco*) bag.

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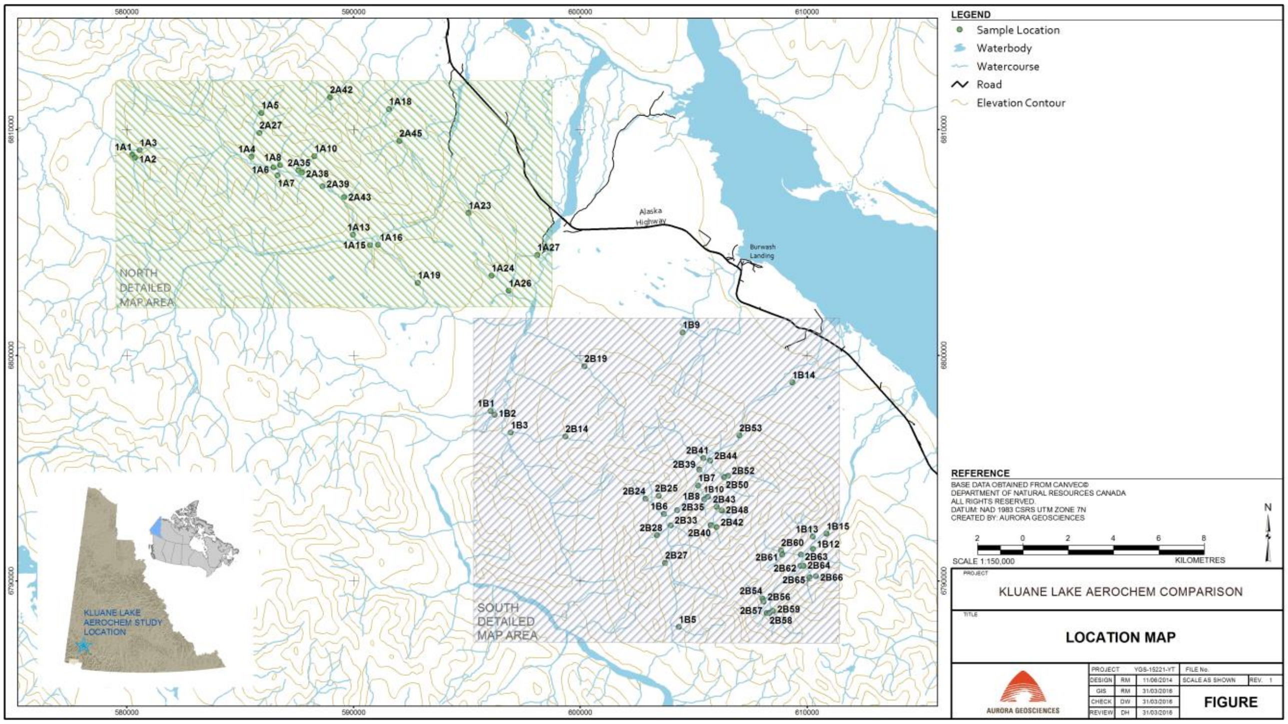

Figure 1: Location map for Aerochem / traditional stream sediment sampling test.

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Cross-sample Contamination

To assess the extent of inter-sample contamination in the airborne sampling system, a cross-contamination experiment was performed. Sand from Grey Mountain Road (Whitehorse) was collected as a source of blank material. Material from a copper showing adjacent to the historic War Eagle mine in the Whitehorse Copper Belt was crushed (70% < 2 mm), pulverized (85% passing 75 microns or better) and then mixed by hand with blank material to produce a suitable volume of contaminated sample.

Three samples were taken from the blank material and two from the contaminated sample. A suite of 14 samples were then taken, alternating between the contaminated and blank sample bin. The samples were processed as per the field protocol; however, for cost purposes, a forklift was used instead of a helicopter. All samples were coarse sieved to -12 mesh and then to -80 mesh at the sample preparation laboratory. Only the blank samples in the alternating rotation of the contamination test are shown in Figure 3; all contaminated samples are beyond the detection limit of 10,000 ppm.

Although the level of copper in the blank sample does increase, the test was designed to accentuate this. Sampling 3% copper stream sediment is not a realistic consideration in actual field deployment; however, the test shows that the cross-sample contamination level is very low at 0.04% and is therefore not a significant consideration.

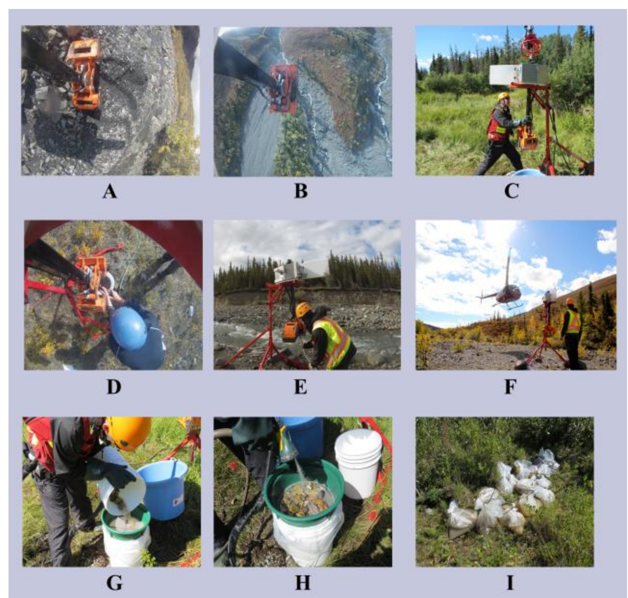

Figure 2: General Aerochem methodology. **A**–Pilot collects sample with mechanically assisted airborne sampler. **B**–Helicopter flies back to central processing station. **C**–Ground crew docks the sampler. **D**–Ground crew removes sample into holding bucket. **E**–A standard and thorough washing regimen is critical to avoid cross-sample contamination. **F**–Once washing is complete (< 1 minute), pilot flies to next sample site. **G**–While the next sample is being collected, ground crew sieves to -12 mesh. **H**–Careful cleaning of all equipment ensures full collection of sample precludes contamination. **I**–Final processing takes place after daily collection is complete.

Blank material from Grey Mountain		Blank material contaminated with War Eagle mineralization		Alternate sampling - contaminated then blank	
	Cu		Cu		Cu
	PPM		%		PPM
	0.01		0.001		0.01
Blank	12.07	War Eagle	3.05	Blank	19.53
Blank	12.26	War Eagle	2.84	Blank	29.39
Blank	11.28			Blank	23.22
				Blank	21.79
				Blank	19.47
				Blank	22.36
				Blank	30.69
Average	11.87	Average	2.95	Average	23.78
Average - ppm	**11.87**	**Average - ppm**	**29450**	**Average - ppm**	**23.78**
Level of contamination-ppm				**11.91**	
Level of contamination-%				**0.040**	

Figure 3: Contamination test results.

Conventional Stream Sediment Sampling

Conventional stream sediment samples were collected using National Geochemical Reconnaissance (NGR) protocol.

- A 1 to 1.5 kilogram sample of silt/clay rich material (when possible) was collected either by hand or using a trowel.
- The target locations, when possible, were either at the 'tail' of a sandbar, active over bank deposit, or a quiet water zone – where there existed a relatively moderate to low energy transition within the stream.
- Material was collected from multiple sites over a 5–10 m length of the stream bed, approximately an inch (2.54 cm) below the surface.
- A photo was taken at each station, showing the sample bag with ID number in the foreground and the stream setting in the background.
- The material was placed in a spun bond polyester sample (*Hubco*) bag, which was then stored and dried in Whitehorse, before being delivered to Bureau Veritas Mineral Laboratories in Whitehorse.

No cross-sample contamination test was performed for the conventional stream-sediment sampling technique.

Geochemical Analysis

Sample analysis follows protocols established by the Geological Survey of Canada (GSC) for their national Regional Geochemical Surveys (RGS) for stream sediments. In every batch of 20 sequential numbers, there are 18 field samples, a blind duplicate sample and a control reference sample. Field duplicates were not collected as the survey methodology already required two samples at each station. The blind duplicates were randomly selected, and recorded at the laboratory, from one of the 18 collected samples and inserted as the first sample in the batch (1001, 1021, 1041…). Standards were inserted as the 15th sample of each sequence.

Samples were sent to Bureau Veritas Mineral Laboratories in Whitehorse, observing a chain of custody sufficient to meet regulatory reporting requirements. All samples are analysed after a modified Aqua Regia digestion of a 15-gram sample of -80 mesh material split by ICP-MS using the ultra-trace detection limits. The package includes 53 elements. Analytical results were compiled with the site data. Upon completion of the analysis, sample pulps were returned to Whitehorse and weighed.

SAMPLE VOLUME

A systematic difference between conventional and airborne sampling is the superior ability of the hand sampler to target fine material. This is mitigated to some degree by the increased volume of raw sample taken by the airborne system, but this larger volume of sample includes cobbles and boulders that are discarded in the preliminary processing.

The samples are sieved to -80 mesh at the sample preparation laboratory followed by a 15-gram split removed for analysis; the weight of the pulp that is returned, therefore, is a direct measurement of the amount of fines in the original sample. A larger sample is preferable, particularly for some elements (e.g., Au) where a nugget effect is common.

Although the Aerochem sample was generally enough for an assay, there were four sites with insufficient material for a 15-gram assay. In addition, the remaining pulp from Aerochem, on average, is less than those of the hand samplers by approximately 15 grams.

ANOMALOUS GEOCHEMISTRY

Figures 4 and 5 show example plots of anomalous Ni and Ag for both hand and Aerochem sampling. These figures illustrate that, in general, all samples—regardless of the technique—are consistent in whether a site is geochemically anomalous. Ag and Ni were chosen as example elements because both have greater spatial variability over the survey area and are generally of economic interest. From an exploration perspective, both techniques provide valuable grassroots data to assess the economic potential of a catchment basin.

Data Analysis

Prior to the data analysis, sites that did not have a complete triplet of samples (two hand samplers and one airborne sample) were removed from the analysis.

Principle Component Analysis

As shown by Figures 4 and 5, when elements are viewed individually, hand and airborne sampling produce consistent results. To capture the variability over the entire suite of analyzed elements, a principal component analysis is used.

A natural logarithmic transform is applied to all the geochemical data in order to approach a normal (Gaussian) distribution of each element prior to the principal component analysis; this converts the 52 (non-zero) elemental variables into 52 orthogonal components (eigenvectors). The first three principal components cumulatively account for greater than 55% of the dataset variability and each further component contributes 5% or less.

The data are sorted and binned into three datasets: hand sample 1, hand sample 2 and Aerochem sample. The purpose of the study is to critically examine the two sampling methods and whether they are compatible. To heighten the sensitivity of the analysis to variability between the datasets, the principal component factors are differenced and examination of the differenced data reveals that the variability between hand and airborne sampling data is greater than the variability between that of the two hand samplers.

The variability is quantified through a statistical analysis of the distribution of the principal component factor differences. The median and mean are consistently lower for the differences between the hand samples than between hand and helicopter samples. However, the differences between the means of the datasets are all less than the standard deviation of the datasets, indicative of the large level of overlap between the populations. It should be noted that the distributions are non-Gaussian and therefore caution must be exercised when interpreting the standard deviation.

Mean Normalized Difference

In addition to the principal component analysis, another method to contrast Aerochem and conventional sampling is the difference between normalized means. Robust estimators are calculated from a reduced dataset by trimming below the 10^{th} and above the 90^{th} percentiles of the natural log transformed dataset. A normalized dataset is produced by subtracting the robust mean from every element and dividing by the robust standard deviation

Similarly, as for the principal component analysis, differences are calculated at each station; however, some elements are excluded from the analysis based on a large number of low-censored or nearly low-censored data. Elements W, S, Te, Ge, In, Re, Pd, Pt and Ta are excluded based on the visual assessment of histograms. Additionally, a ceiling of two standard deviations from the mean is imposed to prevent outliers from exerting undue influence on the result. The absolute value of the difference between the normalized values for each element is summed over all elements. A mean normalized difference is then calculated for each sample site to give a single estimator of the variability over all well-distributed elements. The average variability of the normalized mean over all stations is 0.46 and 0.48 for the difference between airborne and each hand sampler. Expanding on the interpretation of this analysis, as the two datasets approach a single value at each site for each elemental analysis, the average of the normalized mean will approach zero. If the two datasets being compared differ for each element at identical stations by one standard deviation of that element (calculated from all stations) the average of the normalized mean will be 1. Therefore, the values of 0.46 and 0.48 represent significant differences between the airborne and hand sampled datasets.

DISCUSSION

Sample Volume

When sampling with Aerochem, the pilot targets fine material but this capacity is diminished compared to conventional sampling. And although the Aerochem sample is generally enough for an assay the remaining pulp from Aerochem, on average, is less than those of the hand samplers by approximately 15 grams. The weight discrepancy between hand sampler and Aerochem could be addressed by a larger bucket.

Anomalous Geochemistry

The average variability of the normalized mean at each station between the two hand samplers is 0.36, also showing significant differences between two instances of the same technique. The variability between the two different techniques is larger than the internal variability within a single technique, but only modestly so and is small enough that combining existing hand sampled stream geochemistry and Aerochem samples into a single analysis is a reasonable endeavor.

One reason for the greater variability between the techniques is a sampling bias and homogenization that is inherent to micro-site choice of each technique. Additionally, although the sites are considered coincident in the analysis, in reality there is spatial variability between the three samples and a greater spatial distance between airborne sampler and hand sampler is expected than between hand samplers. However, this is accentuated by the design of the experiment which is a compromise between two truly independent hand samplers and cost effectiveness. In order to maximize the number of samples collected for this study, the two hand samplers travelled together to reduce helicopter time. Although the samplers made efforts to act independently by the nature of their simultaneous exit from the aircraft, the spatial distribution of the two hand samples may be less than what it would have been if the hand samples were truly independent.

CONCLUSIONS

Aerochem (patent pending) is a new airborne sediment sampling technique that offers safety and cost benefits over traditional hand sampling, particularly in difficult to reach areas such as rugged terrain or dense vegetation.

In this test, the Aerochem system collected approximately 15 grams less fine material than the hand samplers. As the mean mass of the fine fraction from the Aerochem technique is much greater than the 15 grams required for assay, this is not considered to be a serious drawback of the system.

A comparative analysis between Aerochem and two hand samplers show significant variability between the three samples taken at the same sites with modestly higher variability (33%) between techniques than within a single technique. The difference is not such that the two cannot be used effectively together, as both techniques are effective at identifying anomalous stream sediment geochemistry.

ACKNOWLEDGEMENTS

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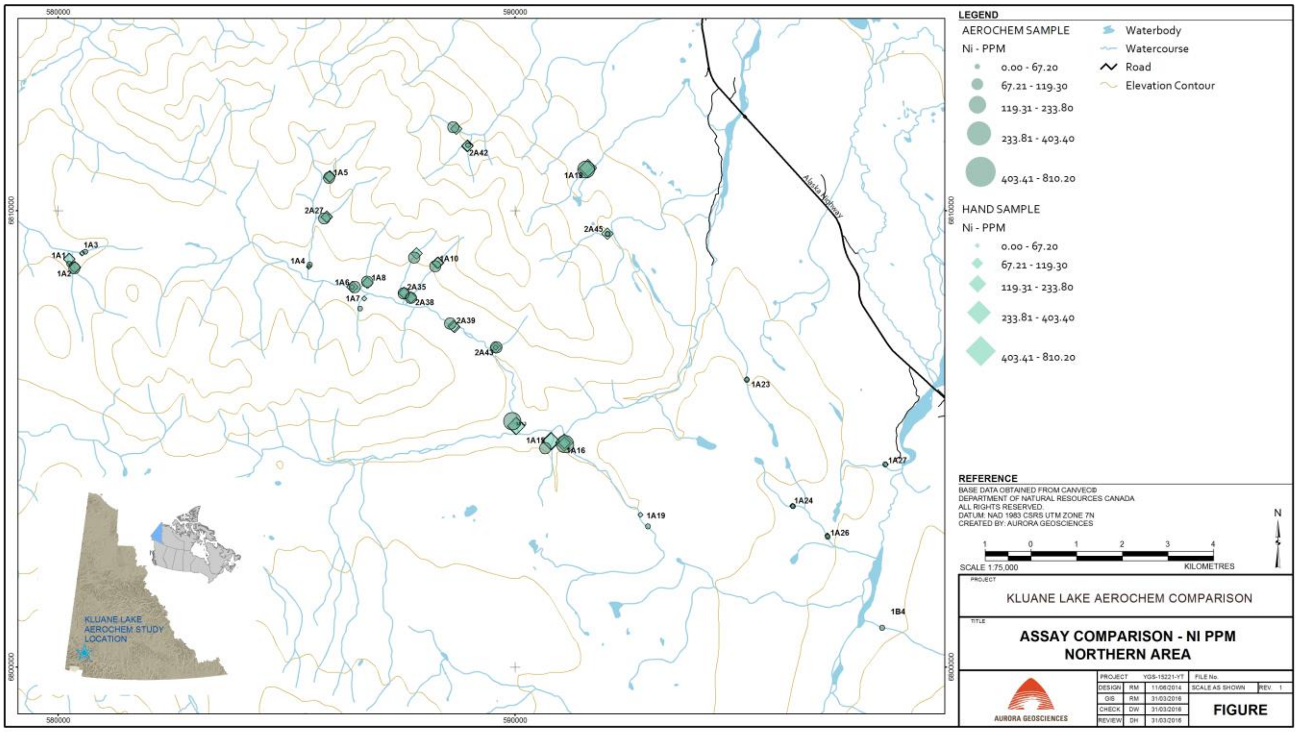

Figure 4: Assay comparison – Ni ppm, northern area.

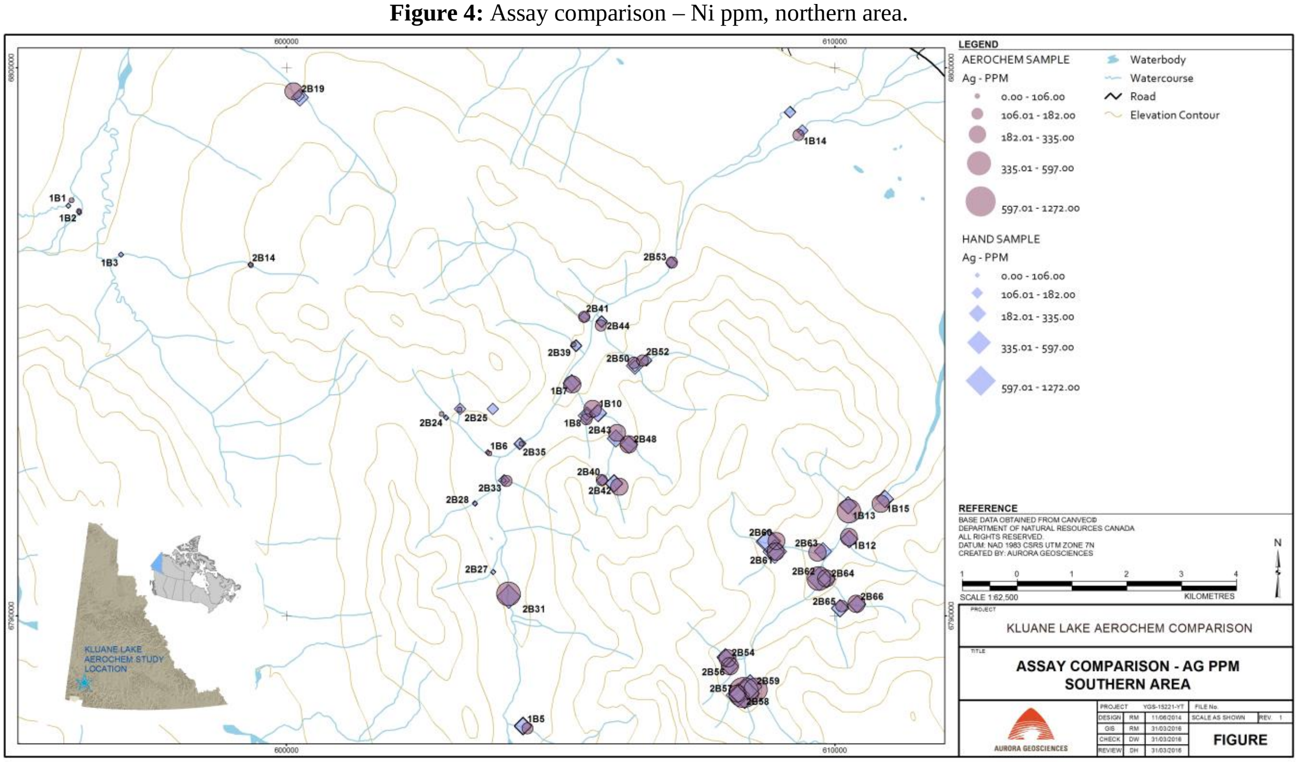

Figure 5: Assay comparison – Ag ppm, southern area.