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Front cover: Collecting a bulk sediment sample from Surprise Creek, northwestern British Columbia.

Back cover: Field testing for water sulphate, Surprise Creek, northwestern British Columbia.

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Heavy mineral and geochemical data from detailed stream-sediment, stream-water, and moss-mat sampling in northwestern British Columbia

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Abstract
Preliminary results from a detailed geochemical survey carried out in 2004, which included analysis of sediments from 34 streams in northwestern British Columbia, revealed geochemically anomalous Ag, Au, Bi, Cd, Cu, Hg, Mo, Pb, Sb, Se, Tl, and Zn in sediment from streams draining the area near the Eskay Creek gold mine. In the present contribution, we release all of the geochemical and mineralogical analysis of the heavy mineral concentrates, stream sediment, and water samples.

Keywords: geochemistry, geochemical survey, heavy minerals, stream sediment

1. Introduction

Since 1959, the federal and provincial governments have conducted more than 30 drainage surveys in British Columbia in which bulk sediment was collected for heavy mineral analysis. During collection, sediment was also taken at the same site for preparing the minus 80 (< 0.177 mm) fraction and analyzing this material for trace elements (Lett and Rukhlov, 2017). Whereas some of the heavy mineral surveys were regional in scope, such as carried out in southern British Columbia by Jackaman, (2021), others were more detailed and carried out with a specific objective in mind. One such detailed study, carried out jointly by the British Columbia Geological Survey and the Geological Survey of Canada, was a follow-up of multi-element anomalies revealed by a regional stream-sediment survey in northwestern British Columbia (Friske et al., 2005; Jackaman, 2005). An objective of this study was to determine if the mineralogy of heavy mineral concentrates could be more effective for detecting gold mineralization compared to the chemistry of the minus 80 (< 0.177 mm) fraction of silt and moss-mat samples. Bulk sediment (for heavy minerals), silt, water, and moss-mat samples were collected at 34 sites in the Bowser Lake (NTS 104A), Iskut River (NTS 104B), and Telegraph Creek (104G) map sheets (Fig. 1).

Preliminary results from these samples (Lett et al., 2006) revealed a geochemically anomalous Ag, Au, Bi, Cd, Cu, Hg, Mo, Pb, Sb, Se, Tl, and Zn signature in sediment from streams draining the area near the Eskay Creek gold mine. Furthermore, gold grains were found in the heavy mineral concentrates which, on the basis of pristine shapes, were considered to have been derived from a relatively local source (Lett and Friske, 2006). However, only preliminary results were available at the time that Lett and Friske (2006) was released. In the present contribution, we release all of the geochemical and mineralogical analysis of the heavy mineral concentrates, stream sediment, and water samples in MS Excel format (BCGS_GF2022-11.zip). A metadata file for this data set is reported in Appendix 1. A statistical analysis and an interpretation of the sediment geochemistry and mineralogy results was published by Lett and Friske (2006); further analysis of the complete dataset presented herein may help identify additional exploration targets.

2. Sample collection, preparation, and analysis

Sample collection, preparation, and analytical methods are described in detail by Lett and Friske (2006) and will only be summarized here. Samples of stream sediment, bulk sediment for heavy mineral concentrates, and stream water were collected from mid-channel and lateral bars in active stream channels at 34 sites in NTS map sheets 104A, 104B and 104G (Fig. 1). Moss-mat samples were collected at three of the sites. The site information (e.g., sediment texture, drainage size, and water flow) is listed in Appendix 2. Stream-sediment and moss-

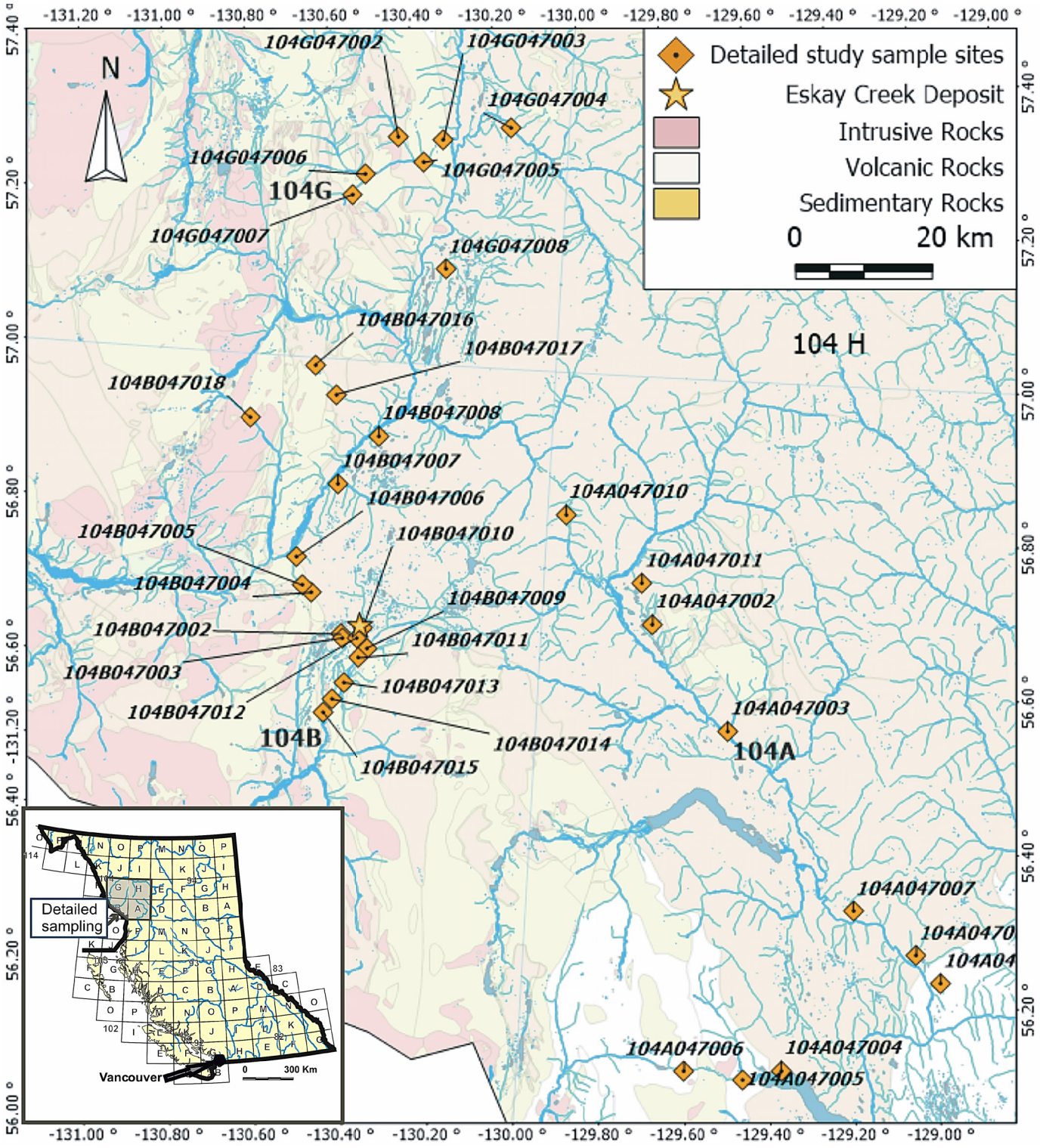

Fig. 1. Location of detailed study sampling sites and Eskay Creek deposit, northwestern British Columbia.

mat samples were transported from the field sites in high wet-strength Kraft paper sample bags.

Where feasible, bulk sediment from the upstream point on a mid-channel bar was collected for a heavy mineral concentrate. At each site the sediment was wet-sieved through a 12-mesh (1.68 mm) stainless steel sieve into a 15 litre plastic pail lined with a heavy-duty polyethylene plastic bag to recover 7 to 14 kilograms of the <1.68 mm fraction. The bulk sediment was transported from the field in the plastic bag.

At each site an unfiltered, un-acidified stream water sample was taken for measurement of pH and conductivity within 24 hours of collection. A second water sample was collected in a rinsed High Density Poly Ethylene (HDPE) bottle and filtered through a 0.45 glass fibre filter before acidification of the filtered water to pH 2 with ultrapure nitric acid.

After air drying, the -18 mesh (<1 mm) fraction of the non-bulk sediment and moss mats were disaggregated and sieved through a 1 mm stainless steel screen. Samples of the <1 mm fraction were sieved to create -80 mesh (<0.177 mm) and -230 mesh (<0.063 mm) fractions. Three duplicate samples of both size fractions were included with the 34 samples analyzed for elements in commercial laboratories.

The bulk sediment samples were processed by Overburden Drilling Management (ODM) Ltd., Ottawa to concentrate heavy minerals and identify and count gold grains and kimberlite indicator minerals in the heavy mineral concentrate (Fig. 2). Before processing, a 500 gram character sample was split from the bulk sample and stored. The bulk sample was then wet sieved through a 2 mm screen, and the <2 mm fraction processed on a shaking table to isolate gold grains, which were

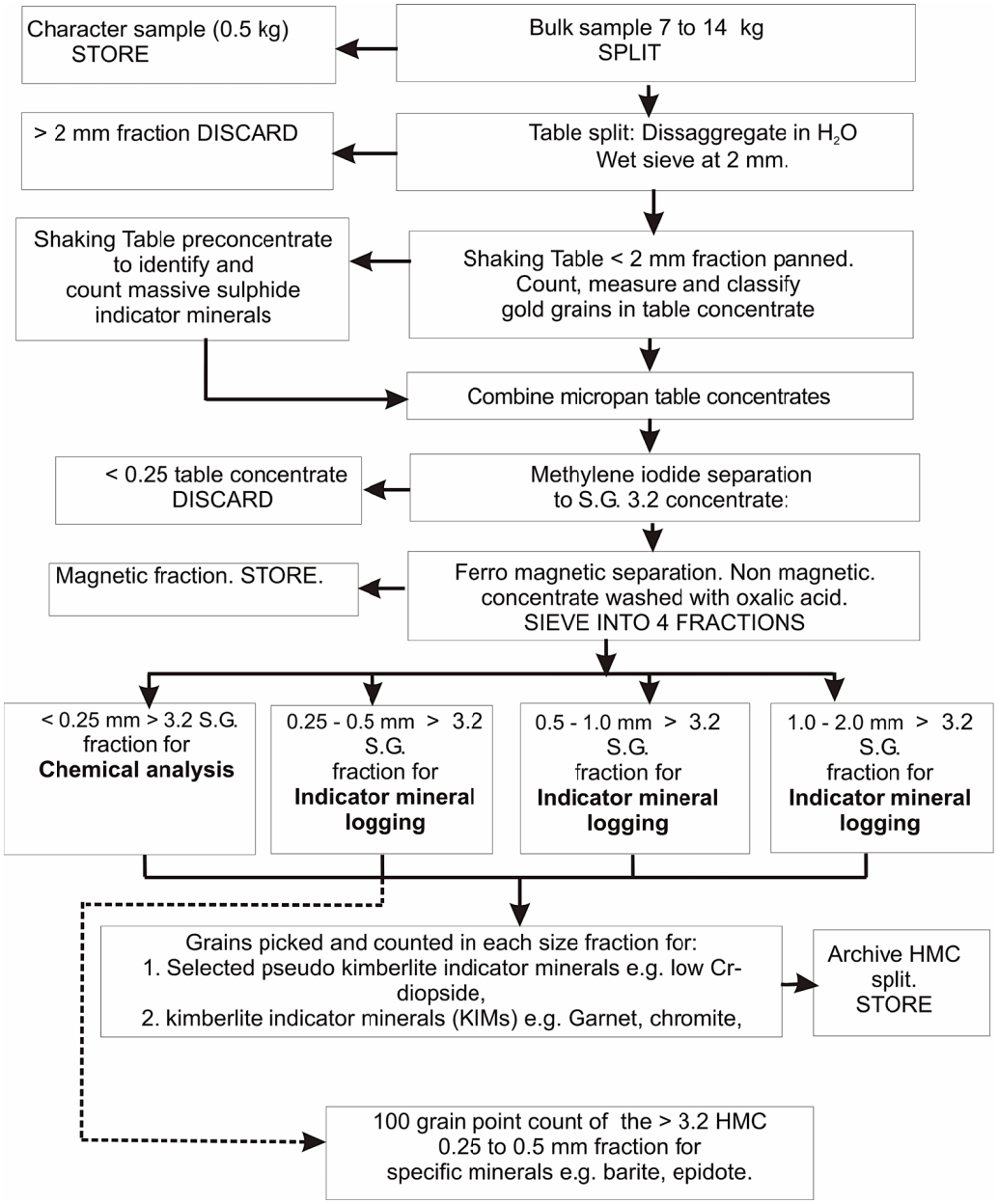

Fig. 2. Flow diagram for recovering heavy minerals from bulk sediment samples used by Overburden Drilling Management (ODM) Ltd., Ottawa (modified from McClenaghan and Layton-Matthews, 2017).

Table 1. Detection limits for elements by modified aqua regia and inductively coupled plasma mass spectrometry (ICP-MS), instrumental neutron activation (INAA), sodium hydroxide fusion-ion selective electrode (NaOH-Fus), loss on ignition at 500°C (LOI) and lithium metaborate fusion (LMB-Fus).

Element-Method	Units	DL	Element-Method	Units	DL
Ag ICP-MS	ppb	2	Mo ICP-MS	ppm	0.01
Ag INAA	ppm	2	Mo INAA	ppm	1
Al ICP-MS	%	0.01	Na ICP-MS	%	0.01
As ICP-MS	ppm	0.1	Na INAA	%	0.01
As INAA	ppm	0.5	Ni ICP-MS	ppm	0.1
Au ICP-MS	ppb	0.2	Ni INAA	ppm	100
Au INAA	ppb	2	P ICP-MS	%	0.001
B ICP-MS	ppm	1	Pb ICP-MS	ppm	0.01
Ba ICP-MS	ppm	0.5	Rb INAA	ppm	15
Ba INAA	ppm	50	S ICP-MS	%	0.02
Bi ICP-MS	ppm	0.02	Sb ICP-MS	ppm	0.02
Br INAA	ppm	0.5	Sb INAA	ppm	0.1
Ca ICP-MS	%	0.01	Sc ICP-MS	ppm	0.1
Cd ICP-MS	ppm	0.01	Sc INAA	ppm	0.1
Cd INAA	ppm	5	Se ICP-MS	ppm	0.1
Ce INAA	ppm	3	Se INAA	ppm	3
Co ICP-MS	ppm	0.1	Sm INAA	ppm	0.1
Co INAA	ppm	5	Sn INAA	ppm	100
Cr ICP-MS	ppm	0.5	Sn LMB-Fus	ppm	1
Cr INAA	ppm	2	Sr ICP-MS	ppm	0.5
Cs INAA	ppm	1	Ta INAA	ppm	0.5
Cu ICP-MS	ppm	0.01	Tb INAA	ppm	0.5
Eu INAA	ppm	0.2	Te ICP-MS	ppm	0.02
F NaOH-Fus	ppm	10	Te INAA	ppm	10
Fe ICP-MS	%	0.01	Th ICP-MS	ppm	0.1
Fe INAA	%	0.01	Th INAA	ppm	0.2
Ga ICP-MS	ppm	0.1	Ti ICP-MS	%	0.001
Hf INAA	ppm	1	Ti INAA	ppm	
Hg ICP-MS	ppb	5	Tl ICP-MS	ppm	0.02
Ir INAA	ppb	5	U ICP-MS	ppm	0.1
K ICP-MS	%	0.01	U INAA	ppm	0.5
La ICP-MS	ppm	0.5	V ICP-MS	ppm	2
La INAA	ppm	0.5	W ICP-MS	ppm	0.1
LOI	%	0.01	W INAA	ppm	1
Lu INAA	ppm	0.05	Yb INAA	ppm	0.2
Mg ICP-MS	%	0.01	Zn ICP-MS	ppm	0.1
Mn ICP-MS	ppm	1	Zn INAA	ppm	50
			Zr INAA	ppm	200

counted, measured, and classified according to their degree of wear. The table reject fraction was re-tabled to capture any massive sulphide indicator mineral grains, and the concentrate from both tablings then combined before separation of a >3.2 SG density fraction in methylene iodide diluted with acetone. Ferromagnetic minerals were removed from the concentrate after the heavy liquid separation and the remaining concentrate cleaned with oxalic acid to remove limonite coating on the minerals. The dried concentrate was sieved into four size fractions, (<0.25 mm; 0.25 mm to <0.5 mm; 0.5 mm to <1.0 mm; 1.0 mm to <2.0 mm). The unwashed <0.25 mm (60 mesh) fraction was used for chemical analysis. Selected magmatic or metamorphosed massive sulphide indicator minerals indicator minerals (e.g., gahnite, chalcopyrite) and pseudo kimberlite indicator minerals (e.g., low-Cr diopside) were identified and counted in the 0.25 mm to <0.5 mm; 0.5 mm to <1.0 mm; 1.0 mm to <2.0 mm fractions. One hundred grains were randomly selected from the > 3.2 SG, 0.25 to 0.5 mm size fraction for mineral identification and counting. All of the gold grain counts, mineral grain counts, grain size, and density weights are reported in Appendix 3a. The original ODM report forms Appendix 3b.

The -80 and -230 mesh fraction of the stream silt samples, the moss-mat samples, and the <0.25 mm non-magnetic heavy mineral concentrates were analyzed for 36 trace and minor elements by a modified aqua regia digestion ($1HCl:1HNO_3:1H_2O$ v/v) followed by inductively coupled plasma mass spectrometry (ICP-MS) at Bureau Veritas (formerly Acme Analytical Ltd) Laboratories, Vancouver. The stream silt (-80 mesh and -230 mesh) and moss-mat samples were also analyzed for loss-on-ignition (LOI) at 500° C, F by sodium hydroxide fusion-specific ion electrode and Sn by lithium metaborate-ICP-MS. In addition, the stream silt and heavy mineral concentrate samples were analyzed for 35 trace and minor elements by instrumental neutron activation analysis (INAA) at Becquerel Laboratories, Mississauga, Ontario. Table 1 lists the detection limits for elements determined by these methods. The results are in Appendices 4 to 7.

Table 2. Percent average coefficient of variation (CVavg %) for elements in the -80 and -230 fractions of three duplicate silt samples.

Element, units, method	- 230 mesh CV_{AVG} %	- 80 mesh CV_{AVG} %
Ag ppb ICP-MS	16.66	7.58
Al pct ICP-MS	1.85	2.08
As ppm ICP-MS	4.75	3.74
As ppm INAA	0.10	2.21
Au ppb ICP-MS	41.48	12.85
Au ppb INAA	47.59	84.50
B ppm ICP-MS	29.61	27.22
Ba ppm ICP-MS	1.66	4.72
Ba ppm INAA	1.90	4.61
Bi ppm ICP-MS	8.16	12.71
Br ppm INAA	10.64	7.26
Ca pct ICP-MS	2.30	3.26
Cd ppm ICP-MS	3.73	2.06
Ce ppm INAA	5.39	9.71
Co ppm ICP-MS	0.99	3.19
Co ppm INAA	1.48	7.66
Cr ppm ICP-MS	1.08	1.75
Cr ppm INAA	6.35	38.81
Cs ppm INAA	6.98	7.03
Cu ppm ICP-MS	0.91	8.79
F ppm NaOH-Fus	7.91	7.84
Fe pct ICP-MS	1.79	2.83
Fe pct INAA	2.25	4.61
Ga ppm ICP-MS	1.17	1.81
Hf ppm INAA	11.66	16.33
Hg ppb ICP-MS	7.82	8.21
K pct ICP-MS	5.44	7.42
La ppm ICP-MS	2.52	4.12
La ppm INAA	3.31	8.00
LOI pct Ignition	13.53	2.39
Lu ppm INAA	27.22	42.46
Mg pct ICP-MS	1.59	2.59
Mn ppm ICP-MS	1.80	2.96
Mo ppm ICP-MS	19.82	8.87
Na pct ICP-MS	6.69	6.70

Table 2. continued

Na pct INAA	2.13	9.13
Ni ppm ICP-MS	2.33	3.58
P pct ICP-MS	1.27	3.98
Pb ppm ICP-MS	4.57	16.20
Rb ppm INAA	11.52	6.74
S pct ICP-MS	9.30	2.54
Sb ppm ICP-MS	4.80	3.86
Sb ppm INAA	3.55	3.08
Sc ppm ICP-MS	2.20	1.68
Sc ppm INAA	3.77	9.72
Se ppm ICP-MS	4.89	3.27
Sm ppm INAA	1.82	3.65
Sr ppm ICP-MS	2.48	2.75
Tb ppm INAA	21.49	4.80
Te ppm ICP-MS	11.66	12.70
Th ppm ICP-MS	2.63	0.00
Th ppm INAA	5.68	6.65
Ti pct ICP-MS	1.90	4.42
Ti pct INAA	22.79	2.20
Tl ppm ICP-MS	2.21	4.20
U ppm ICP-MS	0.00	0.00
U ppm INAA	2.63	4.33
V ppm ICP-MS	2.94	3.05
W ppm INAA	69.28	56.04
Yb ppm INAA	11.66	40.82
Zn ppm ICP-MS	1.51	0.48
Zn ppm INAA	8.57	14.47

The filtered, acidified portion of each water sample was analysed for 62 trace elements by ICP-MS at the Geological Survey of Canada, Ottawa. The results are in Appendix 8.

3. Data reliability

Reliable interpretations of geochemical data cannot be made unless the variability introduced by sampling and the sample analysis is known. Average coefficient of variations, or CV_{AVR} (%), calculated with the formula proposed by Abzalov (2008) from the element data for three blind duplicate samples imbedded with the - 80 and - 230 mesh fractions of the sediment are listed in Table 2. Eighty seven percent of the elements have CV_{AVR} (%) values smaller than 15% indicating good precision for most of the elements. Of the 13% remaining elements the greater variability can be attributed to a nugget effect (e.g., Au) or element concentrations in the duplicate samples close to their detection limit. Appendix 9 shows scatter plots comparing: 1) As and Sb in the - 80 mesh fraction by modified aqua regia ICP-MS to analysis by INAA; 2) As in the - 230 mesh fraction by modified aqua regia ICP-MS to analysis by INAA; 3) As by modified aqua regia ICP-MS in the -80 mesh fraction to the - 230 mesh fraction; and 4) Au and As in the heavy mineral fraction (< 0.25 mm > 3.2 SG) by modified aqua regia ICP-MS compared to analysis by INAA. Except for Au in the heavy mineral fraction, all of the regression correlation coefficients are greater than + 0.9.

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