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GEOCHEMICAL RE-ANALYSES OF 1017 ARCHIVED TILL SAMPLES FROM THE BURIN PENINSULA

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INTRODUCTION

This contribution presents new geochemical results from 1017 archived till samples (Figure 1) including 92 lab duplicates (46 duplicate pairs) and 46 standards. Samples were sieved to a fine (silt and clay <0.063 mm) till fraction, *aqua regia* digested and finished with Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) for the elements Ag, As, Ba, Bi, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Ga, Gd, Ge, Hf, Ho, La, Lu, Mo, Nb, Nd, Ni, Pb, Pr, Rb, Sb, Sm, Sn, Sr, Ta, Tb, Th, Tl, Tm, U, V, W, Y, Yb, Zn and Zr, and Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) for the elements Al, Ca, Fe, K, Li, Mg, Mn, Na, P, S, Sc and Ti. The samples were also submitted to Actabs in Ancaster, Ontario, for mercury analysis using Cold Vapour-Atomic Absorption Spectrometry (CV-AAS).

The *aqua regia* method is a weak digestion that primarily targets sulphides in the silt and clay fraction that are adsorbed to oxidized particles in till (*e.g.*, iron or manganese oxyhydroxides; Kauranne *et al.*, 1992). It minimally attacks silicates that could dilute base-metal signatures in till (Hu and Qi, 2014). The trace-element analytical finish using ICP-MS provides a lower detection limit than the ICP-OES (Balaram and Subramanyam, 2022). The efficacy of this method to detect pathfinder elements related to epithermal deposits (*e.g.*, Ag, Bi, Cu, Mo, As, Sb, Hg and Zn) in the finer (silt + clay) fraction of the re-analyzed till samples was tested on a smaller set of archived samples collected above or down-ice from known epithermal occurrences (Campbell *et al.*, 2023). Some of these elements are not included or under-reported in the till geochemical results of standard Geological Survey of Newfoundland and Labrador's (GSNL) till geochemical analytical protocols (Finch *et al.*, 2018).

The original till geochemical results from the Burin Peninsula were obtained using 4-acid digestion ICP-OES finish and Instrumental Neutron Activation Analysis (INAA) and were presented in an earlier open-file report along with site descriptions and surficial geology (Batterson and Taylor, 2009). The analytical methods used in the original study were detailed in Finch *et al.* (2018).

Samples for this study were collected in areas of Quaternary cover that hinders exploration in the western, central and southern parts of the Burin Peninsula. This open file data release includes the results of till geochemical analyses submitted to the GSNL geochemical lab for determination by *aqua regia*, and the results for mercury (in till).

METHODS

The samples were sieved to <0.063 mm to include only silt- and clay-sized particles. Samples were digested using *aqua regia* (3HCl:1HNO₃) and then analyzed using ICP-MS for trace elements Ag, As, Ba, Bi, Cd, Ce, Co, Cr, Cs, Cu, Dy, Er, Eu, Ga, Gd, Ge, Hf, Ho, La, Lu, Mo, Nb, Nd, Ni, Pb, Pr, Rb, Sb, Sm, Sn, Sr, Ta, Tb, Tl, Tm, U, V, W, Y, Yb, Zn and Zr and ICP-OES for the elements Al, Ca, Fe, K, Li, Mg, Mn, Na, P, Sc and Ti (Table 1). A sample split was sent to Actlabs in Ancaster, Ontario, for CV-AAS mercury analysis.

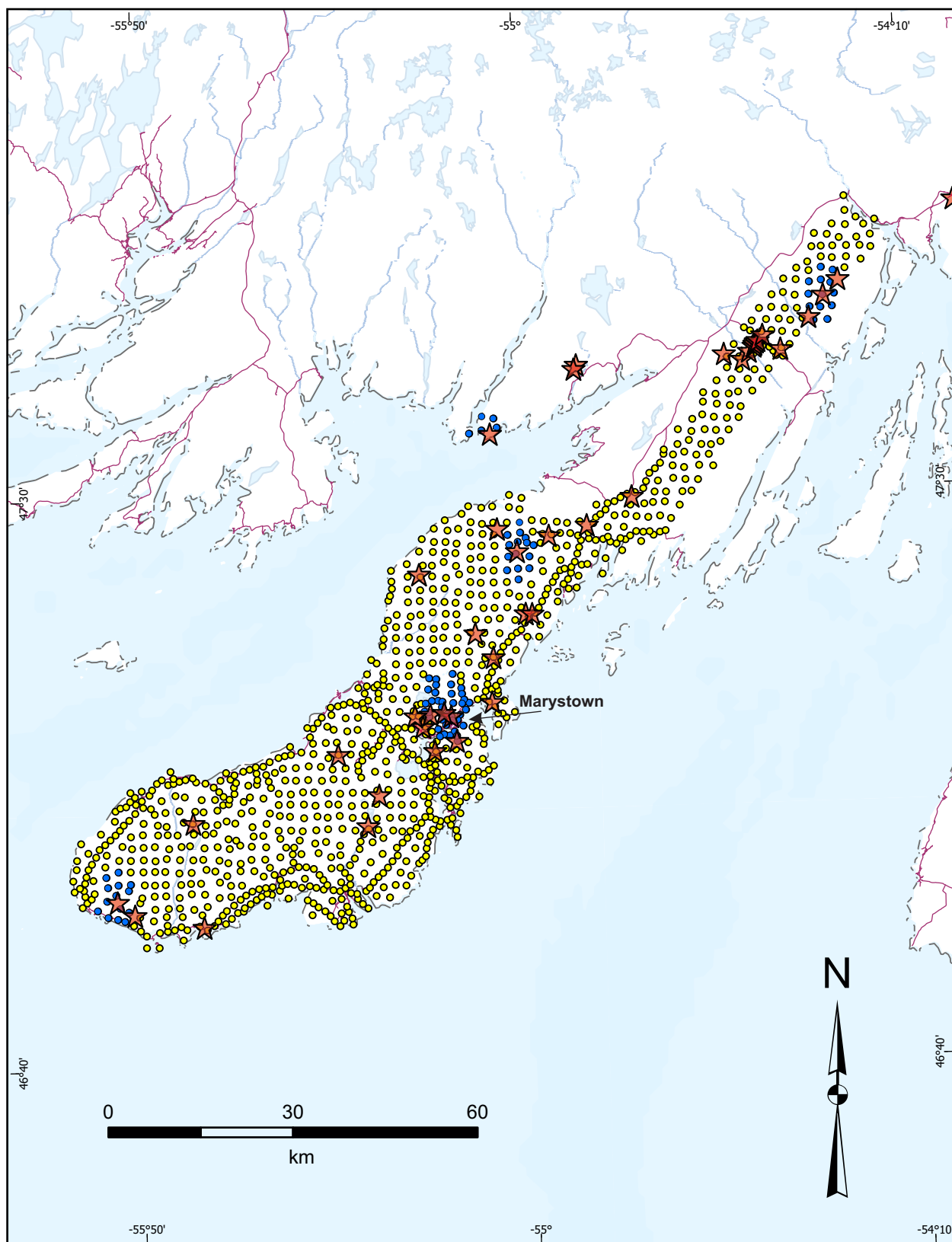


Figure 1. Location map showing the study area and sample sites (yellow dots) relative to known epithermal showings, occurrences and deposits (red stars). The blue dots are sample sites from the pilot study (Campbell et al., 2023).

Sixteen samples of the OREAS 46 standard, fifteen samples of the OREAS 47 standard, and fifteen samples of the TILL-4 standard were submitted to the geochemical lab for determination of accuracy or recovery, which is in accordance with the lab measurements of the certified and provisional values for the standards. Forty-six lab duplicates were inserted in the batch to determine the precision or closeness of the measurements to each other.

The metadata for the survey are presented in Appendix A, Geochemical results are presented along with location data in Appendix B (includes the results discussed in this report and the results from re-analyzed samples (Campbell *et al.*, 2023). The duplicates are presented in Appendix C with the modified Thompson-Howarth (1977) precision charts for ICP-MS and ICP-OES analyses in Appendices D and E, respectively. Results for the certified reference materials (CRMs) are presented in Appendix F, along with Actlabs Internal lab QC data in Appendix G. The results from the lab are presented in Appendix H (including mercury results presented in analytical chronology, the results of the *aqua regia* digestion ICP-MS trace analysis, the results of *aqua regia* digestion ICP-OES analysis and the metadata for the GSNL laboratory methods. The original certificates of analysis from Actlabs are presented as a pdf in Appendix I, and the Actlabs brochure of analytical methods is presented in Appendix J.

Table 1 summarizes the results of the analysis including the minimum and maximum values for each element, the amount and percent of samples below detection limit. In Table 1, the methods column includes suffixes indicating the analysis technique: suffix 22 denotes samples analyzed using *aqua regia* digestion with an ICP-OES finish, suffix 31 represents samples analyzed using *aqua regia* digestion with an ICP-MS finish, and suffix 18 indicates mercury analysis using CV-AAS. The accuracy and analytical precision for the CRMs are summarized in Tables 2–4. The precision for the lab duplicate measurements is summarized in Table 5.

QUALITY CONTROL AND QUALITY ASSURANCE

Duplicate samples (splits) are used to measure analytical precision (Appendices C–E), whereas the reference standards are used to measure the accuracy (Appendix F) of the analytical methods. Accuracy of the analyses were determined by calculating the average measurements in each analytical batch relative to the provisional CRM values expressed as a percentage (Piercey, 2014) for elements digested by *aqua regia* digestion and analyzed by ICP-OES (Table 2), and by ICP-MS (Table 3) and mercury by CV-AAS (Table 4). The precision for the CRM measurements is expressed as relative standard deviations (*see* Piercey, 2014). The individual lab duplicate variations are illustrated by Thompson-Howarth short method plots (*ibid.*) in Appendices D and E, and the variability for the combined duplicates (Table 5) for each element was estimated using the average coefficients of variation of each of the duplicate pairs (Stanley and Lawie, 2007).

The elements below detection limits include Ag (86%), Cd (24%), Ge (42%), S (32%) Ta (94%) and Tl (73%) (Table 1). The detection limits for the trace elements Ag, Bi, Cd, Ce, Co, Cr, Cs, Dy, Er, Eu, Ga, Gd, Ge, Hf, Ho, La, Lu, Mo, Nb, Nd, Pb, Pr, S, Sb, Sn, Sm, Sn, Ta, Tb, Th, Tl, Tm and U from this study have more confidence associated with them than the smaller batch from the original pilot study (Appendix B), due to the greater number of blanks used to calculate the detection limit.

Table 1. Elements analyzed and relevant information

Element	Method code (GSNL Atlas)	Digestion <i>aqua regia</i>	Analytical method	Measurement Unit	Detection limit	Min	Max	BDL*	TOTAL	% BDL*
Ag	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	1	821	925	89
Al	22	3HCl:1HNO3	ICP-OES	pct	0.01	0.36	9.12	0	925	0
As	31	3HCl:1HNO3	ICP-MS	ppm	0.1	0.4	125.3	0	925	0
Ba	31	3HCl:1HNO3	ICP-MS	ppm	0.50	2.8	1694.5	0	925	0
Bi	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	10.16	41	925	4
Ca	22	3HCl:1HNO3	ICP-OES	pct	0.01	<0.01	1.97	10	925	1
Cd	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	2.53	210	925	23
Ce	31	3HCl:1HNO3	ICP-MS	ppm	0.05	3.37	924.52	0	925	0
Co	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.18	134.68	0	925	0
Cr	31	3HCl:1HNO3	ICP-MS	ppm	0.2	0.7	605.2	0	925	0
Cs	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.23	35.33	0	925	0
Cu	31	3HCl:1HNO3	ICP-MS	ppm	1	<1	354	77	925	8
Dy	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.21	32.27	0	925	0
Er	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.11	14.64	0	925	0
Eu	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	4.86	2	925	0
Fe	22	3HCl:1HNO3	ICP-OES	pct	0.01	0.17	10.56	0	925	0
Ga	31	3HCl:1HNO3	ICP-MS	ppm	0.05	1.5	26.16	0	925	0
Gd	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.31	47.07	0	925	0
Ge	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	0.72	418	925	45
Hf	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	1.69	70	925	8
Hg	18		CV-AAS	ppb	5	<5	447	21	925	2
Ho	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	5.48	6	925	1
K	22	3HCl:1HNO3	ICP-OES	pct	0.01	<0.01	0.995	3	925	0
La	31	3HCl:1HNO3	ICP-MS	pm	0.05	1.42	159.91	0	925	0
Li	22	3HCl:1HNO3	ICP-OES	ppm	0.1	0.2	61.1	0	925	0
Lu	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	1.39	103	925	11
Mg	22	3HCl:1HNO3	ICP-OES	pct	0.01	<0.01	5.86	1	925	0
Mn	22	3HCl:1HNO3	ICP-OES	ppm	1	31	7606	0	925	0
Mo	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	27.4	7	925	1
Na	22	3HCl:1HNO3	ICP-OES	pct	0.01	0.003	0.052	0	925	0
Nb	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	42.7	9	925	1
Nd	31	3HCl:1HNO3	ICP-MS	ppm	0.05	1.34	196.77	0	925	0
Ni	31	3HCl:1HNO3	ICP-MS	ppm	0.2	0.2	277.8	0	925	0
P	22	3HCl:1HNO3	ICP-OES	ppm	1	32	3508	0	925	0
Pb	31	3HCl:1HNO3	ICP-MS	ppm	0.05	1.74	1899.07	0	925	0
Pr	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.37	50.84	0	925	0
Rb	31	3HCl:1HNO3	ICP-MS	ppm	0.1	1	107.6	0	925	0
S	22	3HCl:1HNO3	ICP-OES	ppm	100	<100	3799	268	925	29
Sb	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	2.43	10	925	1
Sc	22	3HCl:1HNO3	ICP-OES	ppm	0.1	0.4	49.7	0	925	0
Sm	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.32	47.81	0	925	0
Sn	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.22	9.01	0	925	0
Sr	31	3HCl:1HNO3	ICP-MS	ppm	0.1	1.6	88.3	0	925	0
Ta	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	0.19	875	925	95
Tb	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	6.27	7	925	1
Th	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.06	28.7	0	925	0
Ti	22	3HCl:1HNO3	ICP-OES	ppm	5	10	9328	0	925	0
Tl	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	1	688	925	74
Tm	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	1.62	64	925	7
U	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.1	53.84	0	925	0
V	31	3HCl:1HNO3	ICP-MS	ppm	0.1	3.8	300	0	925	0
W	31	3HCl:1HNO3	ICP-MS	ppm	0.05	<0.05	8.02	53	925	6
Y	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.87	170.31	0	925	0
Yb	31	3HCl:1HNO3	ICP-MS	ppm	0.05	0.11	9.62	0	925	0
Zn	31	3HCl:1HNO3	ICP-MS	ppm	1	<1	1108	4	925	0
Zr	31	3HCl:1HNO3	ICP-MS	ppm	0.1	<0.1	62.3	1	925	0

* BDL—below detection limit

Table 2. Certified Reference Material (CRM) values and comparisons for elements analyzed using *aqua regia* ICP-OES digestion and analysis. Recommended values in black are from OREAS, recommended values in red are from Lynch, 1996, and recommended values in blue are from Burnham and Schweyer, 2004

	CRM recommended values	GSNL average (internal CRM)	Batch average	Batch standard deviation	Recovery relative to CRM (%)	Recovery relative to GSNL Ave (%)	Relative standard deviation batch (%)	Total number of samples BDL	Total measured
OREAS 46 Aqua Regia ICP-OES Finish									
Al %	0.76	0.78	0.78	0.02	101.69	100.11	2.24	0	16
Ca %	0.61	0.65	0.65	0.02	106.28	99.93	3.00	0	16
Fe %	1.47	1.49	1.49	0.03	101.11	99.96	2.14	0	16
K %	0.111	0.090	0.090	0.005	80.69	99.96	5.28	0	16
Li ppm	6.8	6.5	6.5	0.3	95.03	100.15	4.56	0	16
Mg %	0.48	0.49	0.49	0.02	102.99	99.90	3.48	0	16
Mn ppm	250	270	270	5	107.83	99.99	1.95	0	16
Na %	0.081	0.068	0.068	0.003	83.95	99.91	5.07	0	16
P ppm	540	518	518	8	96.00	100.01	1.62	0	16
S ppm	<0.005	25	25	9	-	100.13	37.83	0	16
Sc ppm	2.8	2.5	2.5	0.1	89.12	99.97	3.83	0	16
Ti ppm	640	752	752	18	117.55	100.00	2.40	0	16
OREAS 47 Aqua Regia ICP-OES Finish									
Al %	0.82	0.82	0.82	0.02	100.57	100.05	2.24	0	15
Ca %	0.55	0.59	0.59	0.02	106.52	100.13	3.47	0	15
Fe %	1.67	1.66	1.66	0.04	99.60	99.94	2.36	0	15
K %	0.117	0.096	0.096	0.005	81.94	100.03	4.94	0	15
Li ppm	8.6	8.2	8.2	0.3	95.98	99.96	3.52	0	15
Mg %	0.50	0.52	0.52	0.02	103.33	100.08	2.99	0	15
Mn ppm	280	292	292	6	104.31	100.00	2.00	0	15
Na %	0.091	0.076	0.076	0.003	83.59	99.91	4.32	0	15
P ppm	550	532	532	7	96.72	100.01	1.35	0	15
S ppm	450	432	432	14	96.00	100.02	3.14	0	15
Sc ppm	3.0	2.9	2.9	0.1	96.72	99.93	4.37	0	15
Ti ppm	690	790	789	33	114.42	99.99	4.13	0	15
TILL-4 Aqua Regia ICP-OES Finish Element									
Al %	1.85	1.99	1.99	1.43	107.42	99.99	1.43	0	15
Ca %	0.11	0.12	0.12	4.84	111.52	99.62	4.84	0	15
Fe %	3.3	3.52	3.52	1.17	106.75	99.95	1.17	0	15
K %	0.290	0.259	0.26	3.04	89.43	100.04	3.04	0	15
Li ppm	19.5	19.0	19.01	1.79	97.50	99.98	1.79	0	15
Mg %	0.49	0.53	0.53	1.40	108.44	100.00	1.40	0	15
Mn ppm	260	315	314.80	0.92	121.08	100.02	0.92	0	15
Na %	0.026	0.027	0.03	4.03	104.87	99.49	4.03	0	15
P ppm	730	736	736.27	1.36	100.86	100.00	1.36	0	15
S ppm	600	693	693.33	2.52	115.56	99.98	2.52	0	15
Sc ppm	4.4	4.4	4.37	1.66	98.79	100.18	1.66	0	15
Ti ppm	1070	1267	1266.67	2.17	118.38	100.00	2.17	0	15

Table 3. Certified Reference Material (CRM) values and comparisons for elements analyzed using *aqua regia* ICP-MS analysis. Recommended values in black are from OREAS, recommended values in red are from Lynch, 1996, and recommended values in blue are from Burnham and Schweyer, 2004. Pink values indicate provisional certified reference values from OREAS

	CRM recommended values	GSNL average (internal CRM)	Batch average	Batch standard deviation	Recovery relative to CRM (%)	Recovery relative to GSNL Ave (%)	Relative standard deviation batch (%)	Total number of samples BDL	Total measured
OREAS 46 Aqua Regia ICP-MS Finish									
Ag ppm	0.03	0.01	BDL	-	-	-	-	16	16
As ppm	0.7	1.3	1.3	0.12	177.08	101.92	9.28	0	16
Ba ppm	55	53	53	1	95.77	99.25	2.40	0	16
Bi ppm	0.03	0.03	BDL	-	-	-	-	16	16
Cd ppm	0.04	0.03	BDL	-	-	-	-	15	16
Ce ppm	27.5	27.02	27.03	0.66	98.29	100.02	2.46	0	16
Co ppm	5.67	5.67	5.56	0.38	97.98	97.99	6.80	0	16
Cr ppm	24.3	25.4	25.5	1.17	104.76	100.38	4.60	0	16
Cs ppm	0.35	0.34	0.33	0.03	92.86	96.58	9.53	0	16
Cu ppm	23	24	22	4.71	93.22	92.42	21.58	0	16
Dy ppm	1.15	0.98	0.99	0.09	86.20	100.71	8.82	0	16
Er ppm	0.55	0.51	0.53	0.03	95.57	102.74	5.47	0	16
Eu ppm	0.46	0.43	0.44	0.02	95.11	100.96	3.49	0	16
Ga ppm	2.99	2.59	2.63	0.09	88.00	101.66	3.36	0	16
Gd ppm	1.64	1.64	1.63	0.14	99.43	99.28	8.61	0	16
Ge ppm	0.06	0.05	0.07	0.02	117.10	136.60	22.03	9	16
Hf ppm	0.17	0.16	0.16	0.02	92.28	100.84	11.09	0	16
Ho ppm	0.20	0.18	0.17	0.02	87.19	99.26	10.46	0	16
La ppm	15.6	15.28	15.24	0.30	97.70	99.76	1.99	0	16
Lu ppm	0.07	0.05	0.01	0.06	9.33	11.59	7.41	8	16
Mo ppm	0.65	0.60	0.59	0.04	90.19	97.90	6.90	0	16
Nb ppm	0.42	0.33	0.32	0.17	75.60	95.62	52.38	0	16
Nd ppm	13.2	12.65	12.52	1.08	94.86	99.00	8.65	0	16
Ni ppm	16.2	15.9	15.7	0.77	97.15	99.27	4.92	0	16
Pb ppm	2.02	2.08	2.13	0.27	105.48	102.39	12.72	0	16
Pr ppm	3.75	3.51	3.53	0.08	94.25	100.58	2.37	0	16
Rb ppm	6.1	6.0	5.9	0.12	96.15	98.65	2.00	0	16
Sb ppm	0.07	0.06	0.01	0.06	99.26	118.12	27.14	8	16
Sm ppm	2.11	2.01	2.00	0.19	94.99	99.61	9.53	0	16
Sn ppm	0.38	0.30	0.31	0.03	80.59	100.98	10.85	0	16
Sr ppm	27.8	23.9	24.9	1.22	89.39	104.06	4.91	0	16
Ta ppm	<0.005	BDL	BDL	-	-	-	-	16	16
Tb ppm	0.2	0.18	0.18	0.02	90.94	98.63	10.08	0	16
Th ppm	2.84	2.59	2.53	0.23	89.00	97.76	9.20	0	16
Tl ppm	0.06	0.06	0.00	0.06	6.84	7.81	6.02	8	16
Tm ppm	0.08	0.06	0.05	0.04	77.68	77.53	82.50	2	16
U ppm	0.43	0.38	0.38	0.03	88.37	99.04	8.86	0	16
V ppm	23.1	21.9	22.7	1.05	98.08	103.65	4.62	0	16
W ppm	0.07	0.14	0.05	0.07	66.78	33.63	55.46	4	16
Y ppm	5.00	4.82	4.88	0.47	97.56	101.19	9.59	0	16
Yb ppm	0.48	0.43	0.44	0.03	92.45	102.84	6.04	0	16
Zn ppm	20	20	20	1.15	100.63	99.36	5.70	0	16
Zr ppm	5.2	4.9	5.0	0.41	96.89	102.09	8.24	0	16

Table 3. Continued

	CRM recommended values	GSNL average (internal CRM)	Batch average	Batch standard deviation	Recovery relative to CRM (%)	Recovery relative to GSNL Ave (%)	Relative standard deviation batch (%)	Total number of samples BDL	Total measured
OREAS 47 Aqua Regia ICP-MS Finish									
Ag ppm	0.11	0.10	0.09	0.01	85.53	91.11	14.12	0	15
As ppm	9.6	9.4	9.5	0.46	98.51	100.66	4.84	0	15
Ba ppm	62	60.5	60.6	0.76	97.75	100.10	1.26	0	15
Bi ppm	0.15	0.13	0.13	0.01	86.67	97.04	10.07	0	15
Cd ppm	0.51	0.52	0.50	0.01	98.69	97.69	2.45	0	15
Ce ppm	44.9	43.70	43.96	0.60	97.90	100.58	1.36	0	15
Co ppm	48.8	48.09	46.71	2.92	95.72	97.13	6.26	0	15
Cr ppm	29.8	32.0	32.6	3.31	109.53	102.09	10.13	0	15
Cs ppm	1.19	1.09	1.07	0.05	89.52	97.67	4.51	0	15
Cu ppm	157	153	149	7.07	94.73	97.26	4.75	0	15
Dy ppm	1.26	1.06	1.08	0.04	85.50	101.26	4.13	0	15
Er ppm	0.58	0.54	0.56	0.03	96.09	102.93	5.40	0	15
Eu ppm	0.59	0.56	0.58	0.02	97.51	102.98	3.14	0	15
Ga ppm	3.28	2.87	2.98	0.13	90.73	103.54	4.27	0	15
Gd ppm	1.92	1.99	1.97	0.08	102.57	98.74	4.29	0	15
Ge ppm	0.08	0.07	0.03	0.07	118.50	133.30	13.13	6	15
Hf ppm	0.20	0.17	0.18	0.02	91.33	105.45	12.50	0	15
Ho ppm	0.21	0.19	0.19	0.01	89.52	101.36	5.39	0	15
La ppm	25.0	25.24	25.23	0.36	100.92	99.98	1.44	0	15
Lu ppm	0.07	0.06	0.04	0.05	56.57	107.56	122.11	3	15
Mo ppm	12.6	12.27	12.15	0.41	96.45	99.04	3.35	0	15
Nb ppm	0.92	0.72	0.90	0.20	97.61	124.12	22.22	0	15
Nd ppm	17.8	16.95	16.63	0.53	93.44	98.13	3.18	0	15
Ni ppm	77	77.0	75.6	2.65	98.21	98.24	3.50	0	15
Pb ppm	282	262.75	251.80	20.93	89.29	95.83	8.31	0	15
Pr ppm	5.30	5.08	5.12	0.08	96.58	100.66	1.52	0	15
Rb ppm	7.2	6.9	6.9	0.20	95.58	99.82	2.91	0	15
Sb ppm	0.21	0.18	0.18	0.01	86.67	99.97	5.95	0	15
Sm ppm	2.66	2.51	2.49	0.09	93.51	99.02	3.42	0	15
Sn ppm	2.54	2.10	2.27	0.13	89.24	107.75	5.89	0	15
Sr ppm	32.3	27.2	28.9	1.00	89.47	106.22	3.46	0	15
Ta ppm	<0.005	BDL	BDL	0.00	-	-	-	15	15
Tb ppm	0.23	0.21	0.21	0.01	89.86	99.41	5.38	0	15
Th ppm	3.25	2.93	2.86	0.18	88.00	97.68	6.35	0	15
Tl ppm	0.08	0.07	0.06	0.01	76.31	90.72	14.21	0	15
Tm ppm	0.08	0.06	0.06	0.01	80.00	101.97	14.22	0	15
U ppm	0.47	0.40	0.40	0.02	84.54	100.13	5.34	0	15
V ppm	25.7	23.6	24.9	1.39	97.04	105.81	5.59	0	15
W ppm	0.11	0.10	0.12	0.02	107.88	117.28	18.81	0	15
Y ppm	5.69	5.00	5.09	0.26	89.42	101.72	5.02	0	15
Yb ppm	0.50	0.45	0.47	0.02	94.27	104.94	5.25	0	15
Zn ppm	207	207	207	4.53	99.81	99.62	2.19	0	15
Zr ppm	6.2	5.5	5.7	0.36	92.51	104.33	6.21	0	15

Table 3. Continued

	CRM recommended values	GSNL average (internal CRM)	Batch average	Batch standard deviation	Recovery relative to CRM (%)	Recovery relative to GSNL Ave (%)	Relative standard deviation batch (%)	Total number of samples BDL	Total measured
TILL-4 Aqua Regia ICP-MS Finish Element									
Ag ppm	0.19	0.19	0.18	0.02	95.44	96.54	9.52	0	15
As ppm	102	100	101	2	98.92	100.47	2.43	0	15
Ba ppm	71	69	69	1	97.63	99.94	1.37	0	15
Bi ppm	45.9	45.4	45.1	0.9	98.33	99.33	2.01	0	15
Cd ppm	0.175	0.14	0.14	0.01	80.00	96.81	10.10	0	15
Ce ppm	48.6	50.0	52.2	1.6	107.33	104.22	2.99	0	15
Co ppm	6	6	6	0	97.50	98.18	4.98	0	15
Cr ppm	26	23	24	1	90.72	100.47	4.70	0	15
Cs ppm	8.51	7.63	7.43	0.57	87.27	97.31	7.67	0	15
Cu ppm	254	230	228	5.92	89.66	98.94	2.60	0	15
Dy ppm	1.97	2.07	2.11	0.14	107.07	101.97	6.84	0	15
Er ppm	0.85	0.92	0.96	0.03	112.39	103.67	3.56	0	15
Eu ppm	0.48	0.52	0.53	0.02	110.65	102.37	4.10	0	15
Ga ppm	6.1	6.0	6.0	0.1	98.99	101.14	2.32	0	15
Gd ppm	3.07	3.21	3.31	0.23	107.82	102.97	6.86	0	15
Ge ppm	<0.1	0.07	0.03	0.07	-	112.91	21.20	6	15
Hf ppm	0.09	0.11	0.09	0.02	106.06	82.45	17.50	0	15
Ho ppm	0.33	0.34	0.34	0.02	103.73	101.56	4.88	0	15
La ppm	26	27	28	1	106.52	103.39	2.61	0	15
Lu ppm	0.10	0.10	0.09	0.01	97.92	98.21	9.68	0	15
Mo ppm	14	15	15	0	104.82	100.48	1.90	0	15
Nb ppm	2.39	2.28	2.57	0.30	107.64	112.70	11.78	0	15
Nd ppm	19.2	19.4	19.9	1.6	103.80	102.69	8.04	0	15
Ni ppm	15	14	14	1	93.29	101.18	5.69	0	15
Pb ppm	39.7	35.6	35.4	2.4	98.36	99.35	6.72	0	15
Pr ppm	5.4	5.5	5.7	0.1	106.31	104.32	2.46	0	15
Rb ppm	36.4	34.9	34.8	0.67	95.60	99.73	1.92	0	15
Sb ppm	0.74	0.56	0.57	0.05	77.31	102.34	8.23	0	15
Sm ppm	3.6	3.7	3.8	0.3	105.94	102.61	7.26	0	15
Sn ppm	5.27	4.88	5.14	0.22	97.60	105.38	4.33	0	15
Sr ppm	9.3	9.2	9.4	0.22	101.69	102.22	2.29	0	15
Ta ppm	0.01	0.01	<0.05	-	-	-	-	15	15
Tb ppm	0.43	0.40	0.40	0.02	93.55	100.34	4.70	0	15
Th ppm	11.5	10.4	10.3	0.7	89.70	99.42	6.68	0	15
Tl ppm	0.43	0.38	0.36	0.02	84.71	95.45	6.30	0	15
Tm ppm	0.12	0.12	0.12	0.01	100.29	98.85	6.44	0	15
U ppm	2.57	2.35	2.35	0.17	91.60	100.21	7.10	0	15
V ppm	38	38.44	39.12	1.18	102.95	101.77	3.01	0	15
W ppm	157.8	151.6	167.5	4.6	106.12	110.48	2.75	0	15
Y ppm	7.7	7.7	8.0	0.6	103.39	103.11	7.36	0	15
Yb ppm	0.71	0.76	0.79	0.04	110.80	103.70	5.10	0	15
Zn ppm	63	57	57	2.45	90.69	99.53	4.28	0	15
Zr ppm	4.34	4.5	4.2	0.16	96.31	91.90	3.75	0	15

Table 4. Certified Reference Material (CRM) values and comparisons for mercury analyzed by CV-AAS. Recommended values in black are from OREAS

	CRM recommended values (ppb)	Average batch (ppb)	Standard deviation batch	Recovery	Recovery standard deviation (%)
Hg (OREAS 46)					
Batch 1	7	7.00	0.00	100.00	0.00
Batch 2	7	8.00	0.58	114.29	7.22
Batch 3	7	7.00	0.00	100.00	0.00
Batch 4	7	7.00	0.00	100.00	0.00
Batch 5*	7	7.33	0.58	104.76	7.87
Hg (OREAS 47)					
Batch 1	14	15.50	0.71	110.71	4.56
Batch 2	14	15.67	1.15	111.90	7.37
Batch 3	14	14.67	0.58	104.76	3.94
Batch 4	14	15.25	0.50	108.93	3.28
Batch 5	14	15.67	0.58	111.90	3.69
Hg (Till 4)					
Batch 1	39	26.00	1.41	66.67	5.44
Batch 2	39	26.00	0.00	66.67	0.00
Batch 3	39	28.00	0.82	71.79	2.92
Batch 4	39	28.33	0.58	72.65	2.04
Batch 5	39	28.75	1.71	73.72	5.94
* 1 value below detection limit					

ACCURACY

Recoveries of all the elements for the standards OREAS 46, OREAS 47 and TILL-4, which have been analyzed using *aqua regia* digestion with an ICP-OES finish, are all within 20% of the CRM, indicating acceptable accuracy (Table 2).

Most of the elements analyzed using the *aqua regia* digestion and an ICP-MS finish show acceptable accuracy. Poor accuracy was observed in recoveries for Ge, Lu, Hf, Sb and Tl in the OREAS 46 standard using the *aqua regia* digestion and an ICP-MS finish, returning less than 80%, and the element Ta was not recovered at all. Recovery of Ge, Lu and Tl in the standard OREAS 47 measurements were less than 80%. For TILL-4, recovery of Sb was less than 80% (Table 3).

All of the mercury recoveries were within 20% of the certified reference value (Table 4).

Table 5. Analysis of duplicates for all elements including the number of duplicate pairs measured (*e.g.*, above detection limits) and the coefficient of variation (Stanley and Lawie, 2007)

Element	Method <i>aqua regia</i>	Number of duplicate pairs measured	Coefficient of variation of all pairs	Element	Method <i>aqua regia</i>	Number of duplicate pairs measured	Coefficient of variation of all pairs
Ag ppm	ICP-MS	2	1100.01	Ni ppm	ICP-MS	46	7.62
Al %	ICP-OES	46	1.89	P ppm	ICP-OES	46	1.68
As ppm	ICP-MS	46	5.34	Pb ppm	ICP-MS	46	4.43
Ba ppm	ICP-MS	46	3.31	Pr ppm	ICP-MS	46	1.99
Bi ppm	ICP-MS	45	7.76	Rb ppm	ICP-MS	46	3.56
Ca %	ICP-OES	46	6.08	S ppm	ICP-OES	46	3.42
Cd ppm	ICP-MS	40	8.99	Sb ppm	ICP-MS	45	8.56
Ce ppm	ICP-MS	46	2.40	Sc ppm	ICP-OES	46	3.80
Co ppm	ICP-MS	46	3.36	Sm ppm	ICP-MS	46	2.06
Cr ppm	ICP-MS	46	6.05	Sn ppm	ICP-MS	46	4.81
Cs ppm	ICP-MS	46	3.42	Sr ppm	ICP-MS	46	4.99
Cu ppm	ICP-MS	42	18.55	Ta ppm	ICP-MS	5	439.64
Dy ppm	ICP-MS	46	2.35	Tb ppm	ICP-MS	46	3.29
Er ppm	ICP-MS	46	2.62	Th ppm	ICP-MS	46	4.55
Eu ppm	ICP-MS	46	2.72	Ti ppm	ICP-OES	46	3.19
Fe %	ICP-OES	46	1.76	Tl ppm	ICP-MS	14	446.90
Ga ppm	ICP-MS	46	2.86	Tm ppm	ICP-MS	44	5.65
Gd ppm	ICP-MS	46	2.33	U ppm	ICP-MS	46	2.91
Ge ppm	ICP-MS	32	15.76	V ppm	ICP-MS	46	2.38
Hf ppm	ICP-MS	43	7.74	W ppm	ICP-MS	44	12.47
Ho ppm	ICP-MS	46	3.15	Y ppm	ICP-MS	46	2.49
K %	ICP-OES	46	4.75	Yb ppm	ICP-MS	46	2.67
La ppm	ICP-MS	46	2.07	Zn ppm	ICP-MS	46	5.41
Li ppm	ICP-OES	46	3.23	Zr ppm	ICP-MS	45	6.22
Lu ppm	ICP-MS	44	7.12				
Mg %	ICP-OES	45	2.41		Batch		
Mn ppm	ICP-OES	46	1.93	Hg ppb	1	6	6
Mo ppm	ICP-MS	46	6.84	Hg ppb	2	9	4
Na %	ICP-OES	46	7.13	Hg ppb	3	10	2
Nb ppm	ICP-MS	44	5.22	Hg ppb	4	7	2
Nd ppm	ICP-MS	46	2.16	Hg ppb	5	10	3

DUPLICATES

Most elements in the dataset indicate good overall precision (Table 5) but variation is observed in Ag, Ta and Tl greater than 20% and greater than 10% for Cu, Ge and W, largely because some or most of the duplicate pairs returned values below the detection limit. Individual sample precision demonstrated in Thomson-Howarth short method charts indicate poor precision (greater than 20%) in a few duplicate pairs for the elements Bi, Cd, Cr, Ni, Cu (>5 duplicate pairs), Zn, Sb (>5 duplicate pairs), Ta, Tl, W (>5 duplicate pairs) and Zr.

DISCUSSION

The analytical results of till geochemical re-analysis from the Burin Peninsula provide detectable values for several trace elements (*e.g.*, Ag, Bi and Cd) whose concentrations in till are commonly below the detection limits of the ICP-OES (Campbell *et al.*, 2023). These elements, as well as mercury, are often associated with epithermal occurrences (O'Brien *et al.*, 1999; Sparkes, 2012; Sparkes and Dunning, 2014). In addition, detectable elemental concentrations of Bi, Sn, W and Mo, associated with granite-related mineralization have been reported on the island (*e.g.*, Davenport *et al.*, 1984), and can be relevant to surface exploration efforts for granites on the Burin Peninsula.

Analyses of standards show less than acceptable recoveries for the elements Ge, Lu, Hf, Sb, Ta and Tl. The elements Lu, Hf and Ta are commonly enclosed within the crystal structures of minerals such as zircon that are commonly resistant to weak digestions (*e.g.*, Crock and Lamothe, 2011; Hu and Qi, 2014). For these elements, accurate results could be obtained using a stronger digestion method (Hu and Qi, 2014). Similarly, Sb may not be fully recovered from samples using the weaker *aqua regia* digestion; analytical instrumental neutron activation analysis results may be more representative of the total Sb in the sample. Elements like Ge and Sb are commonly volatilized, and while closed vessel digestion methods were used to retain a higher concentration of these elements in the vessel during preparation for analysis, an NaOH solution is required for full recovery of the element germanium (Biver and Filella, 2018).

While the lab duplicate analytical variability may seem high for certain elements, some of the imprecision is likely due to incongruent dissolution of the resistant mineral phases (*e.g.*, Cr, Hf, Ni, Ta, W and Zr, (Hu and Qi, 2014). The elements Cd, Bi and Sb have greater than 20% variability in till surveys from elsewhere (*e.g.*, British Columbia–Heberlein, 2010; Alaska–Anderson *et al.*, 2011) utilizing the same analytical method *aqua regia* digestion and ICP-MS finish. The overall precision of the lab duplicates is considered acceptable, and the data is usable.

CONCLUSIONS

This report presents results from the re-analysis of 1017 samples, including quality control samples. The examination of 46 standards and 92 (46 duplicate pairs) indicates acceptable overall accuracy and precision. The re-analyzed geochemical data are presented in Appendix B and can assist with exploration efforts on the Burin Peninsula.

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APPENDICES

Appendices A–J are included in the OF_NFLD_3480 zip folder as Excel (.xlsx) and Adobe (pdf) files.

APPENDIX A: Analytical Metadata

APPENDIX B: Geochemical Database

APPENDIX C: Duplicates

APPENDIX D: Precision Charts ICP-MS

APPENDIX E: Precision Charts ICP-OES

APPENDIX F: CRMs

APPENDIX G: Actlabs Internal QC

APPENDIX H: Analytical Results from GSNL and Actlabs

APPENDIX I: COA for Hg from Actlabs

APPENDIX J: Actlabs Geochemistry Schedule of Services 2024-CAD

