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Introduction

Gossans are a visible surface manifestation of sulphide mineralization. Although gossans consist mainly of silica and iron oxides such as limonite and jarossite derived from the weathering of pyrite-bearing rock, they may also have high trace element contents reflecting the chemistry of bedrock mineralization. The analysis of gossan material can be a useful complement to other types of geochemical exploration such as stream sediment and till surveys.

In 1997 and 1998, the British Columbia Geological Survey and the Geological Survey of Canada conducted till geochemistry surveys north of Kamloops (Figure 1). Trace, minor, and major element analyses from 1513 till samples (Bobrowsky et al., 1998; Paulen et al., 2000; Paulen and Lett, 2005) contributed to the Eagle Bay Project, an integrated regional exploration program that focused on Devonian-Mississippian rocks of the Eagle Bay assemblage and Permian to Devonian rocks of the Fennell Formation (Bobrowsky et al., 1997; Paulen et al., 1999). Results from the till geochemistry surveys stimulated mineral exploration and staking in the region.

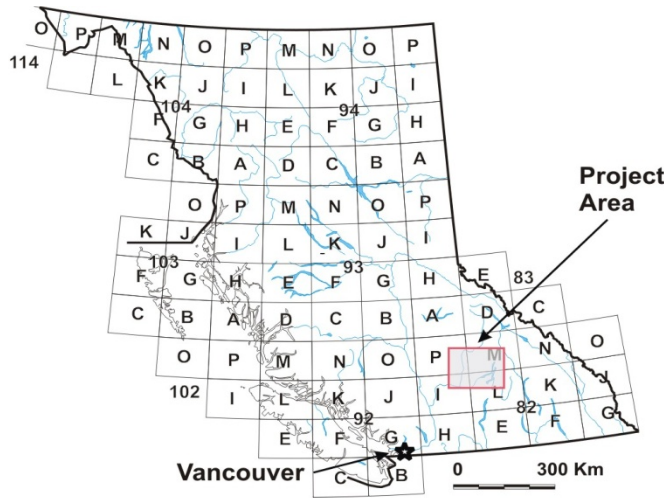

Figure 1 – Location of the Eagle Bay project area.

Of particular interest are block faulted, brecciated mafic to andesitic volcanogenic rocks of the Nicola Group (Upper Triassic-Jurassic) in NTS 92P/9. The area has considerable mineral potential, as indicated by: volcanogenic massive sulphides in the Fennell Formation; volcanogenic sulphide-barite in the Eagle Bay assemblage; and the highly mineralized package of Nicola Group volcanic, sedimentary, and associated intrusive rocks. Furthermore, gold potential is indicated by: tombstone-style gold prospects in the Baldy Batholith; polymetallic Au-bearing veins in volcanic assemblages of the Fennell Formation; and anomalous gold values in altered quartz vein float near the margin of the Thuya River Batholith. Among related exploration studies were those of mineral deposits in volcanogenic sedimentary rocks of the lower Eagle Bay Formation (Höy 1999), detailed property scale ice-flow dispersal geochemistry (Lett et al. 1999), and reconnaissance mineralized boulder tracing.

During the till geochemistry surveys, 60 grab samples were collected, 37 from gossanous outcrops and 23 from mineralized float. Herein we present analytical data derived from these samples. Several large multi-element anomalies discovered by the 1998 till survey (Paulen et al. 2000), such as Rock Island Lake and Crazy Fox (MINFILE 092P185), lack known local mineralized bedrock sources (Bourdon and Addie 2000a, b; Schiarizza et al., 2002). The data from this study further characterize the geochemical attributes of the region and, providing comparisons to the bedrock chemistry of the Slide Mountain and Eagle Bay rocks (Schiarrizza and Preto, 1987; Paulen et al. 2005), may be useful to account for the unexplained elevated trace element and major oxide concentrations reported in the till samples.

Previous work

Prospecting in the region has continued since the early 1900s (Barazzuol and Stewart 2003). To date, 317 mineral occurrences (MINFILE) are documented in the areas where the gossan and float samples were collected (NTS 82L/13, 82L 14, 82M/3 92P/8, 92P/9). These occurrences include 236 mineral showings, 38 prospects, 14 developed prospects, 28 past producers, and 1 till anomaly. Regional surveys in the same area include till geochemistry (Paulen et al., 2000 Plouffe et al., 2009; 2010), boulder geochemistry (Lett and Earle, 2000), and regional bedrock geochemistry (Paulen et al., 2005).

Physiographic setting

Our sampling focused on the southwestern part of the Shuswap Highland and the northeastern part of the Thompson Plateau in the Interior Plateau. Elevations range from 360 m above sea level in the North Thompson River Valley to the west, to about 2290 m above sea level at Baldy Mountain in the northeast. Along the northeast border of 92P/8, peaks rise over 200 m to an extensive plateau, approximately 1300 m above sea level, which is dissected by numerous prominent valleys, the largest of which is the North Thompson River valley. This prominent topographical and hydrological feature corresponds to the Louis Creek Fault and is the boundary between the Adams Plateau to the east and the Bonapart Hills to the west. The higher land surface of the Bonaparte Hills and the Nehalliston Plateau to the northwest contains numerous small lake and stream systems. Most of the area is covered by moraine (till) of variable thickness, with lesser glaciofluvial, fluvial, colluvial, and organic sediments.

Regional bedrock geology

The area lies in a belt of deformed low-grade metamorphic rocks distributed along the western margin of the Omineca Belt. This belt is flanked by high-grade metamorphic rocks of the Shuswap Complex to the east and by rocks of the Intermontane Belt to the west (Schiarrizza and Preto 1987). Lower Paleozoic to Mississippian rocks of the Eagle Bay assemblage (Kootenay terrane) underlie the eastern part of the area. These consist of calcareous phyllite, calc-silicate schist, and skarn or mafic metavolcanic rocks that are overlain by felsic (locally intermediate) metavolcanic rocks and siliciclastic metasedimentary rocks (Figure 2) .

North of Barriere, Permian to Devonian rocks of the Fennell Formation comprise imbricated oceanic rocks of the Slide Mountain terrane. These rocks consist of bedded cherts, gabbro, diabase, pillowed basalt, and volcanogenic metasedimentary rocks. This succession is in fault contact with Permo-Triassic andesites, tuffs, argillites, greywacke, and limestone of the Nicola Group (Schiarrizza and Preto 1987) and Early Jurassic porphyritic andesite breccia, tuff, and flows of the Quesnel terrane. Mid-Cretaceous granodiorite and quartz monzonite intrusions of the Baldy batholith and late Triassic - early Jurassic monzo-granite and granodiorite of the Thuya batholith (Campbell and Tipper 1971) underlie the area.

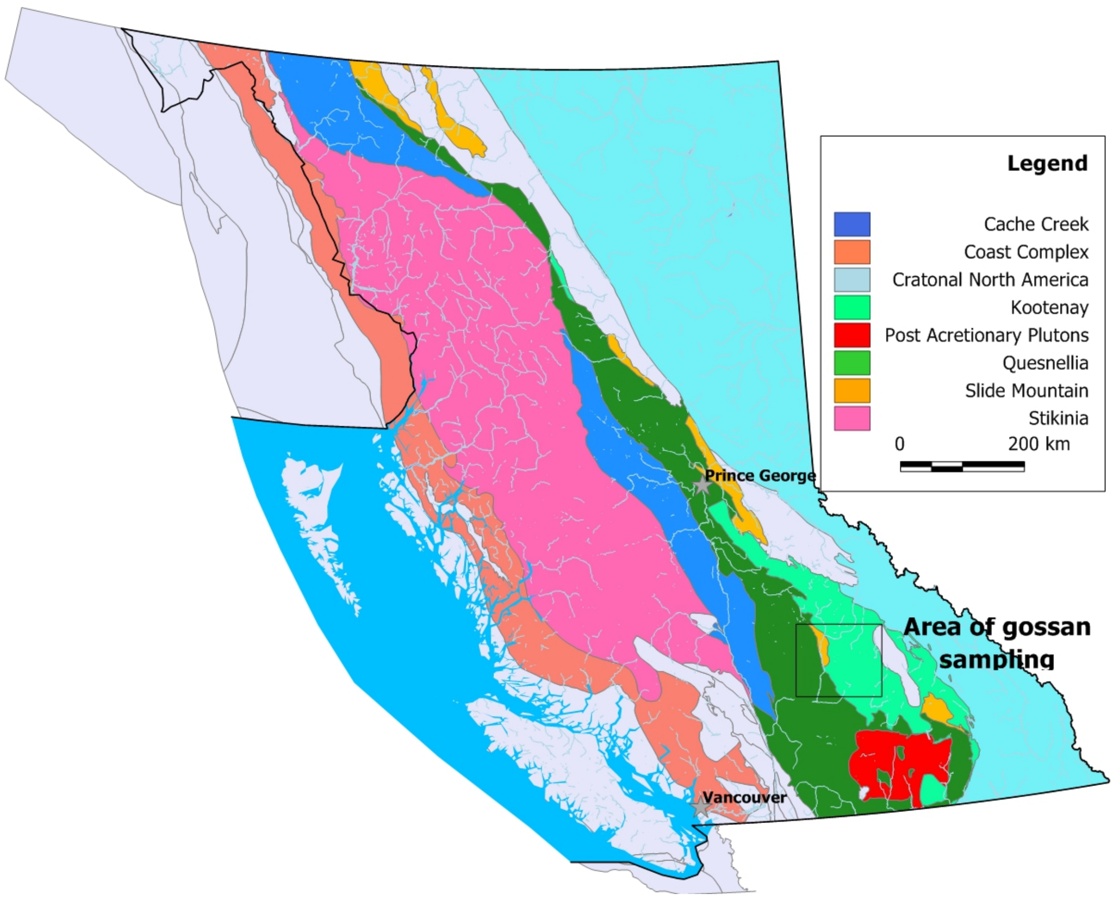

Figure 2 – Geotectonic terranes in the project area.

A major north-trending fault, paralleling the North Thompson River valley, separates the Kootenay and Slide Mountain terranes from the younger Quesnel terrane. The faults signify a major, unknown structural event (Campbell and Tipper 1971) in a highly mineralized package of Nicola Group rocks in the northwest trending Quesnel trough. Eocene breccias are distributed sporadically along the western edge of the Thompson River valley.

Polymetallic precious sedimentary exhalative and Noranda/Kuroko type VMS base metal massive suphide occurrences are hosted by Devonian-Mississippian felsic to intermediate metavolcanic rocks of the Eagle Bay assemblage. Massive suphides are in oceanic basalts of the Fennell Formation, and skarn and silver-lead-zinc mineralization define numerous vein deposits in the Fennell Formation near the Cretaceous granitic intrusions. Porphyry copper and copper-gold skarns are in the Nicola Group and molybdenite mineralization occurs near the southern margin of the Raft batholith (Schiarrizza and Preto 1987; Höy and Dunne 1997; Höy 1999; Schiarizza and Israel 2001; Schiarizza et al. 2002).

Methods

Rock samples were jaw crushed and ground in a steel mill to -150 mesh (< 0.075 mm). Pulp splits were analysed for trace and minor elements by aqua regia digestion and inductively coupled plasma emission spectroscopy (ICPES) at Acme Analytical, Vancouver, BC, and for Au and 32 additional elements by instrumental neutron activation (INAA) at Activation Laboratories, Ancaster, Ontario. The reliability of the aqua regia –ICPES and INAA data was monitored by analysis of a BC Geological survey standard (GSB Till 99) and duplicate field samples.

Tables 1 and 2 list laboratory-reported detection limits. Also listed are the average of three percent difference values (i.e. the difference between duplicate values/mean of the two values expressed as a percent), the mean of two GSB Till 99 standard determinations compared to the mean of 10 archived till GSB Till 99 standard determinations, the percent relative standard deviation of two GSB Till 99 determinations, and the percent relative standard deviation of 10 archived GSB Till 99.

For most common pathfinder elements determined by INAA or aqua regia-ICPES (e.g., As, Cu, Mo, Pb, Zn) the relative standard deviation (RDS) of the two GSB till 99 standard determinations is less than 10 percent, and the RDS values are similar to those for archive GSB till 99 data. For most elements, the mean values for GSB till 99 are also comparable to the archive GSB Till 99 data. For many of the elements, especially those determined by aqua regia – ICPES there is a large average of the mean difference between the two duplicate values. This may reflect values in one or more of the duplicates that are close to the instrument detection limit or uneven distribution of sulphide and oxide minerals in the samples.

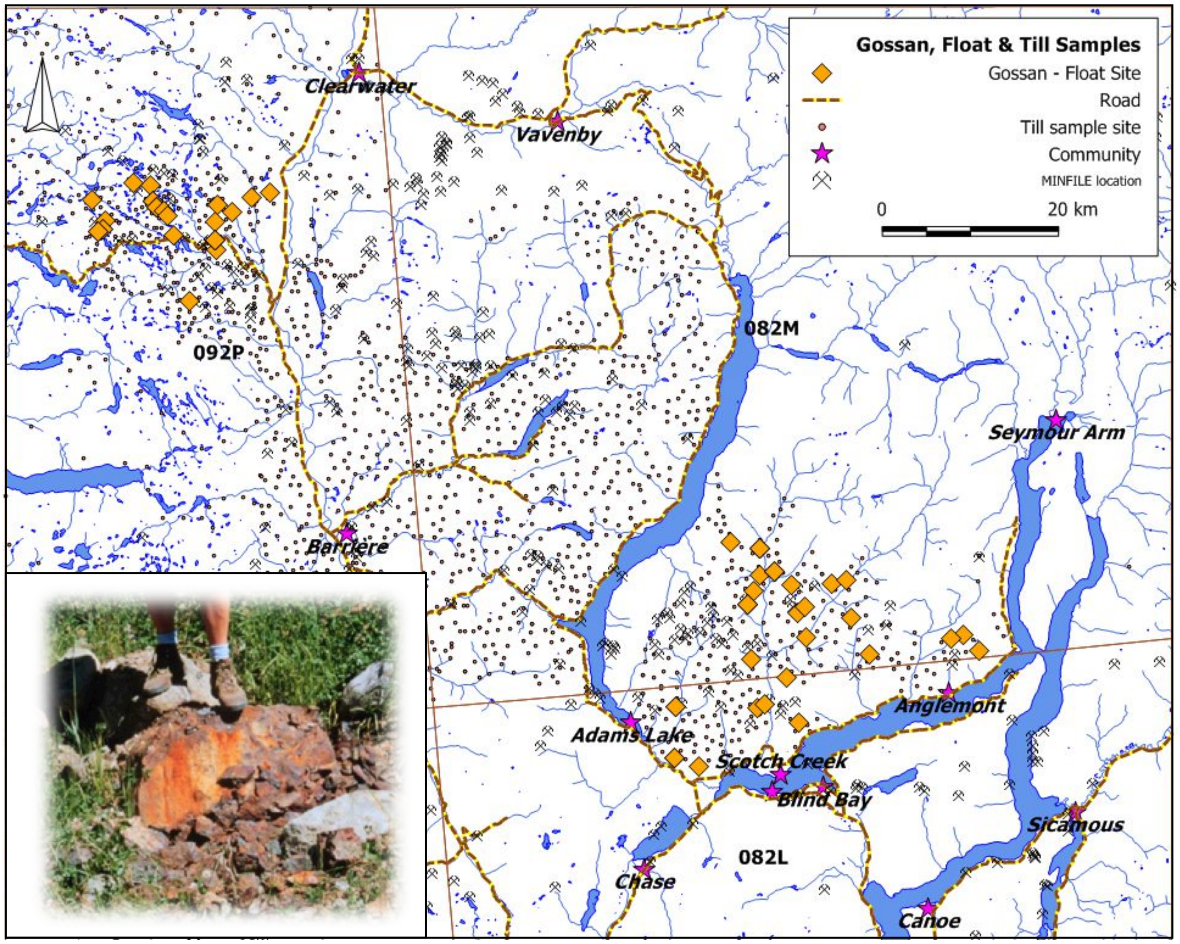

Figure 3. Locations of gossan and float samples, till samples and MINFILE occurrences. Insert is an example of gossanous float sampled (site RCP98202, Appendix 1). For detailed locations, see Figures 4 and 5.

Element	DL	Mean Diff.(3)	Mean GSB 99	Mean GSB 99 Arc.	Pct RSD_till 99	Pct RSD till99 Arc.
Ag_ppb	1	14.1	1353.0	1361	0.6	3.0
Al_pct	0.01	179.5	2.9	2.93	1.5	3.4
As_ppm	0.1	189.5	64.2	57.9	5.7	3.2
Au_ppm	2	0.0	-0.1	21.6	0.0	7.4
Ba_ppm	1	193.6	269.0	302.1	1.1	6.0
Bi_ppm	0.1	204.5	-0.2	0.26	0.0	4.8
Ca_pct	0.01	85.7	0.3	0.34	6.5	2.0
Cd_ppm	0.2	0.0	0.7	0.65	10.4	2.1
Co_ppm	1	0.0	48.0	45.2	0.0	4.6
Cr_ppm	1	145.9	260.0	264.9	1.6	1.9
Cu_ppm	0.1	57.0	183.5	165.96	2.7	2.4
Fe_pct	0.01	147.0	7.2	6.58	1.3	1.7
Ga_ppm	0.1	161.3	9.9	9.40	11.4	2.5
Hg_ppb	10	275.5	381.0	362	14.5	3.1
K_pct	0.01	186.7	0.1	0.05	0.0	11.1
La_ppm	1	230.8	15.0	17.2	0.0	5.0
Mg_pct	0.01	155.6	2.7	2.80	0.8	2.1
Mn_ppm	1	21.3	1475.0	1264	2.1	1.8
Mo_ppm	0.1	29.4	0.7	0.86	10.9	4.1
Na_pct	0.01	600.0	0.0	0.005	0.0	10.5
Ni_ppm	1	100.0	208.5	207.1	0.3	2.8
P_pct	0	187.5	0.1	0.109	1.4	4.1
Pb_ppm	0.1	82.4	225.6	213.04	3.9	3.6
Sb_ppm	0.1	1000.0	9.9	9.86	0.0	3.3
Se_ppm	0.3	215.8	0.8	0.6	17.7	12.4
Sr_ppm	1	169.2	17.0	18.4	0.0	3.8
Te_ppm	0.2	206.7	0.5	0.29	15.7	3.9
Th_ppm	1	360.0	3.0	3.9	0.0	5.7
Ti_pct	0.01		0.1	0.114	8.3	10.7
Tl_ppm	0.2		0.4	0.09	60.6	5.2
U_ppm	5	0.0	-5.0	0.4	0.0	11.1
V_ppm	1	133.3	101.5	105	3.5	2.6
W_ppm	2	140.7	-2.0	-0.2	0.0	0.0
Zn_ppm	0.1	58.4	327.0	345.8	1.4	1.8

Table 1. Detection limits (**Element DL**) for elements determined by aqua regia-ICPES. Boron is not reported because all values are below detection limit. Also listed are the average mean difference (**Mean Diff.)** of three duplicate sample values, the mean of two GSB Till 99 standard determinations (**Mean GSB 99**), the mean of 10 archived till GSB Till 99 standard determinations (**Mean GSB 99 Arc.),** the percent relative standard deviation of two GSB Till 99 determinations (**Pct RSD_till 99**), and

the percent relative standard deviation of 10 archived GSB Till 99 (**Pct RSD_till 99 Arc.**).

Element DL		Mean Diff.(3)	Mean GSB 99	Mean GSB 99 Arc.	Pct RSD_till 99	Pct RSD till99 Arc.
Au_ppb	2		45.5	42.75	45.07	38.5
Ag_ppm	5	2.4	-5	-5	0.00	0.0
As_ppm	0.5	207.5	77.65	91.35	4.83	7.0
Ba_ppm	50	1.7	880	1422.5	6.43	10.4
Br_ppm	0.5	0.0	1.55	-0.5	187.04	0.0
Ca_pct	1	5.9	1	0.25	282.84	1000.0
Co_ppm	1	1.8	60.5	60	5.84	3.6
Cr_ppm	5	26.4	439.5	460.5	2.09	6.0
Cs_ppm	1	0.0	-1	0.75	0.00	466.7
Fe_pct	0.01	9.8	10.16	9.8025	3.34	5.7
Hf_ppm	1	9.5	4	3.75	0.00	33.6
Na_pct	0.01		1.98	2.1575	3.57	2.1
Ni_ppm	20	3.3	165	-20	184.28	0.0
Rb_ppm	15	12.3	63.5	61.25	45.66	83.6
Sb_ppm	0.1	99.4	16.65	21.7	5.52	2.9
Sc_ppm	0.1		34.65	35.05	3.88	5.5
Se_ppm	3	22.2	-3	-3	0.00	0.0
Sn_ppm	0.01	0.0	-0.02	-0.02	0.00	0.0
Sr_ppm	0.05	0.0	-0.05	-0.05	0.00	0.0
Ta_ppm	0.5	140.7	-0.5	-0.5	0.00	0.0
Th_ppm	0.2	108.0	6	6.775	21.21	8.2
U_ppm	0.5	8.3	2.4	-0.5	5.89	0.0
W_ppm	1	61.1	1	1	282.84	400.0
Zn_ppm	50	5.0	484	502.5	9.64	25.0
La_ppm	0.5	4.9	32	34.175	5.30	7.6
Ce_ppm	3	23.5	57.5	63.75	6.15	10.1
Nd_ppm	5	241.2	26.5	29.25	8.00	14.1
Sm_ppm	0.1	1.6	6.55	7.475	5.40	9.4
Eu_ppm	0.2	12.7	2.45	2.6	8.66	7.0
Tb_ppm	0.5	0.0	-0.5	0.35	0.00	289.0
Yb_ppm	0.2	14.4	3	3.65	9.43	12.8
Lu_ppm	0.05		0.48	0.5925	2.95	25.4

Table 2. Detection limits (Element DL) for elements determined by INAA. Mercury, Ir and Mo are not reported because all values are below detection limit. Also listed are the average mean difference (**Mean Diff.**) of three duplicate sample values, the mean of two GSB Till 99 standard determinations (**Mean GSB 99**), the mean of 10 archived till GSB Till 99 standard determinations (**Mean GSB 99 Arc.**), the percent relative standard deviation of two GSB Till 99 determinations (**Pct RSD_till 99**), and the percent relative standard deviation of 10 archived GSB Till 99 (**Pct RSD_till 99 Arc.**).

Results

The regional distribution the 60 grab samples analyzed in the present study is plotted in Figure 3, together with till sampling sits and MINFILE locations; detailed sample location and geological maps are provided in Figures 4 and 5. Sample locations, in UTM and latitude/longitude, are listed in Appendices 1-3. The suite of samples includes 35 from gossanous outcrops, 2 from unmineralized bedrock, and 23 from mineralized float (source unknown). Appendix 1 provides descriptions of host rocks and mineralization, Appendix 2 lists complete aqua regia-ICPES results, and Appendix 3 lists complete INAA results.

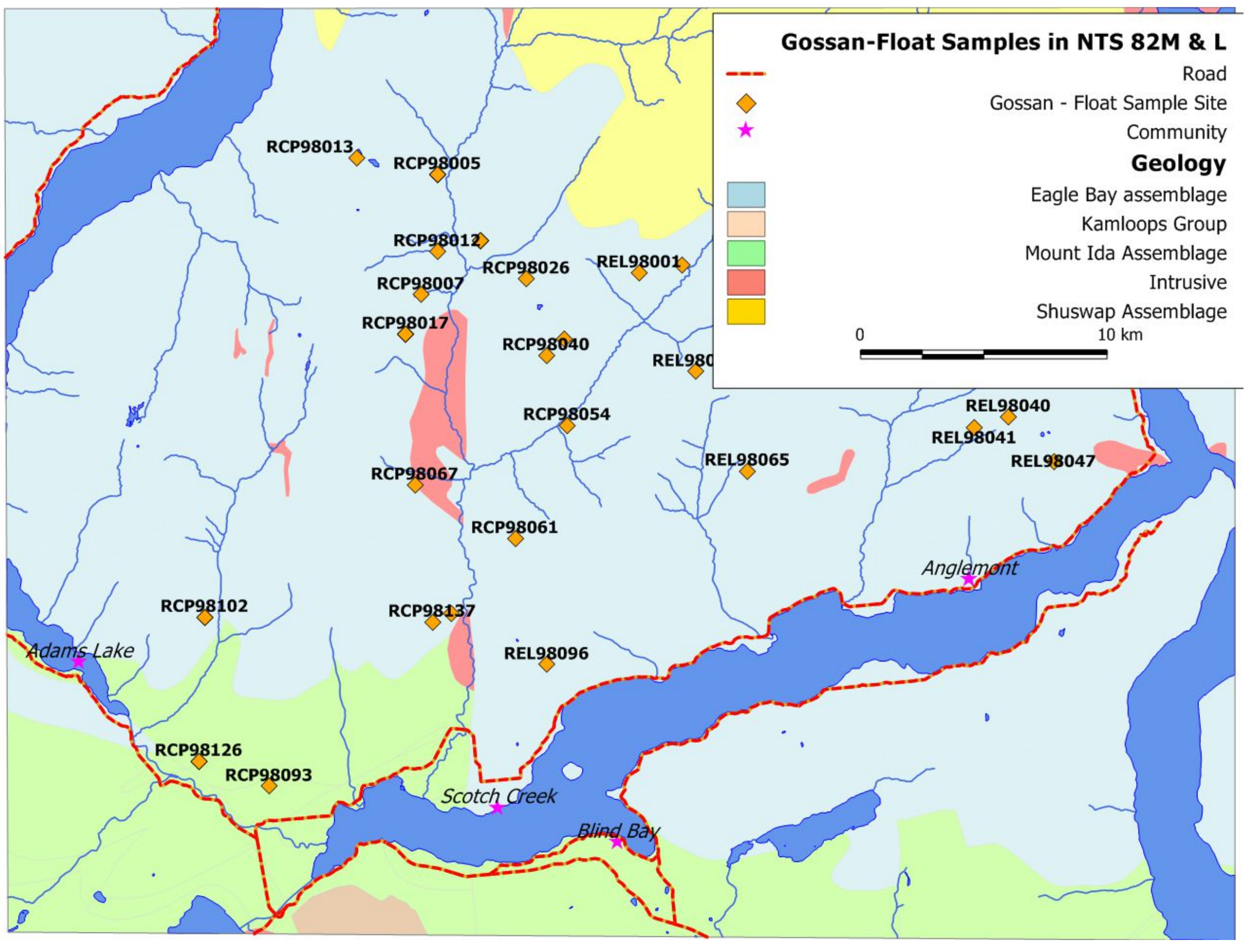

Figure 4. Bedrock geology, gossan and float sample locations in NTS 82 M and L.

Conclusion

The data presented herein provide site-specific information on mineralized outcrop and float occurrences observed during the 1997 and 1998 regional till geochemistry surveys. Many of the samples are from known MINFILE occurrences, but some of the interesting float samples are from unknown sources, such as the Crazy Fox till anomaly (MINFILE 092P185). Establishing the bedrock source of float samples requires an understanding of regional and local glacial ice-flow dispersion. Ice-flow information for this study area is provided by Paulen et al. (1999), Paulen (2001) and Paulen and Lett (2005) and should be consulted to aid drift prospecting.

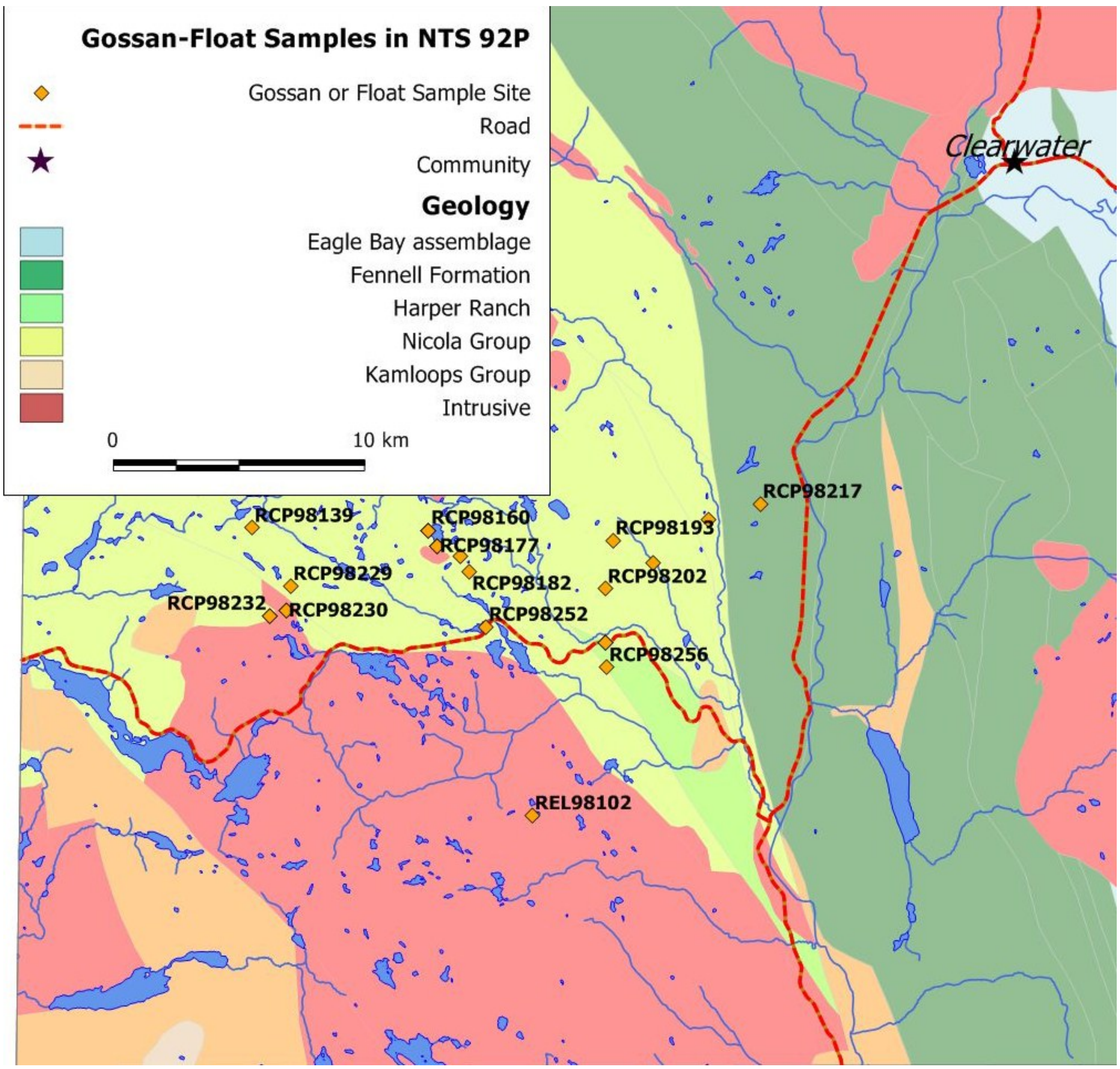

Figure 5 Bedrock geology, gossan and float sample locations in NTS 92P.

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