Atlin
880412

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Klondike - Yukon Survey

An assumed "old" rhyolite from American Hill is highly altered and is contained in a quartz sericite schist. It is weakly to well foliated and contains quartz eyes. Quartz veins and veinlets cross-cut foliation at approximately 30° The samples contain the following interesting major, minor and trace element enrichment or depletion.

	SiO_2	Al_2O_3	CaO	Na_2O	K_2O	Ba ppm
Sample 43	79.2%	11.0%	0.28%	1.22%	7.21%	4800
Sample 44	78.7%	11.2%	0.26%	1.12%	7.70%	4700

	Ni ppm	As ppm	Sb ppm	Au ppb	Pb ppm	Zn ppm	Cu ppm	F ppm
Sample 43	120	3.8	0.5	2	9	18	5	190
Sample 44	110	14.0	7.3	63	11	10	5	130

These rhyolites are much different from the "younger" rhyolites on Germaine Creek - Tin Horn Gulch in that they contain much lower F, Sn, U, Th, and they are enriched in Ba, Au, As, Sb, and have obviously suffered severe K-metasomatism. It is possible that the surrounding quartz-sericite schist is a metamorphozed ignimbrite and that the more "solid" also deformed rhyolite are cores and/or feeders. In any case, the very high K-Ba and elevated As-Sb-Au indicate an epithermal overprint on these rocks.

The Adam's Bench "solution" breccia contains above background As (28 ppm), V (100 ppm) and Ba (3500 ppm) but no Au-Ag or base metals. Wayne Goodfellow's sample contained some gold values.

Samples collected from the north end of the top bench at Cheechako Hill where your previous sampling of an "in situ" quartz vein in sericite schist showed Au values were found to contain As concentrations ranging from 21 - 34 ppm, Ba from 2200 - 5500 ppm but no Au, Ag or base metals were found.

The so-called "listwainites" (green chromium-rich mica-quartz-carbonate alteration of ultramafics) do not have the required amount of pyrite present to be classified as true "listwainites". We sampled those found in the tailings outflow trench at Dago Hill and other "float" found on the tailings piles in Hunker Creek below the confluence of Last Chance Creek and Hunker Creek. Since the dredge has placed the deepest (up to 17 feet) samples on top of the piles these samples must be considered as bedrock samples and they would appear to be "on line" with the upper outcrop. If your geophysics is detailed enough, perhaps the Dago Hill ultramafics and the buried Hunker Creek ultramafics could be joined up. However, the extent of the ultramafics may be quite local due to faulting and/or shearing so that they could very well be just minor pods or slivers.

The Klondike altered ultramafics (green-chromium mica quartz-carbonates) are more silicified than those from the Atlin camp. As-Ba contents are also much higher (up to 700 ppm and 1000 ppm respectively) and, therefore, they would appear to have had an overprint of the "younger" epithermal alteration which has also affected the White Channel gravels. Gold content, however, is nil as compared to 5.3 ppb in similarly altered Atlin rocks.

Atlin, British Columbia Summary

Compositional analyses of gold and associated minerals from the Lakeview veins - Sharon zone, Atlin, British Columbia

	F_T	Au	Ag	Cu	Sb	Hg	Bi	Te	Pb	S	Total %
$F_T = \frac{Au}{Au + Ag} \times 1000$	809	79.2	18.7								97.9
	761	76.7	24.0								100.7
	751	75.9	25.1		$\bar{X} = 24.2$						101.0
	781	79.1	22.1								101.2
	750	75.8	25.7								101.5
Average	770	77.34	23.12								100.46

The gold fineness for native gold ranging up to 1.5 mm in size in samples we examined averages about 760 for (1) gold as discrete blebs in quartz, (2) gold replacing galena but when gold occurs as filaments or fracture fillings with hessite the gold fineness was much higher at 809. It should be noted that no Cu or other common contaminents of lode gold are present.

Other Analysis:

Sharon zone - Lake view vein

	Au	Ag	Bi	Te	Pb	S	Total
Hessite (Ag_2Te)		62.9		37.6			100.5
Galena grains (Pb S)		0.7	1.7		84.4	13.4	100.2
		1.4	3.3		81.8	13.2	99.7
		1.9	4.5		79.6	13.5	99.5
	Average	1.3	3.2		81.9	13.4	99.8
Tetradymite (Bi_2Te_2S)			59.9	36.1		4.5	100.5

Alteration rims - Lakeview vein

	Au	Ag	Bi	Te	Pb	S	Total
Galena		39.3	1.5	2.2	43.8	6.2	93.0
		57.3	2.1	2.4	25.3	8.4	95.5
	Average	48.6	1.8	2.3	34.6	7.3	94.6

Ore mineralogy includes, in order of abundance, galena (PbS), hessite (Ag_2Te) native gold and tetradymite (Bi_2Te_2S) in the quartz vein which has the associated alteration minerals Fe-Mg carbonate, talc and chromium mica. The quartz vein system is exposed both within altered ultramafics and metavolcanics of the Cache Creek Group for a distance of at least 1 kilometer.

Galena within the vein would appear to be one of first mienrals to come out of an ever-changing hydrothermal solution. It is enriched in Ag and Bi, with up to 1.9% Ag and 4.5% Bi in certain grains. Weak etching with chlorine bleach revealed that Ag and Bi occur as solid solutions within galena rather than inclusions. However, in this vein or possibly at this vertical level within the vein system, rim alteration is common among the ore minerals (except gold) (see attached photos). In galena, the rim is dramatically enriched in Ag (up to 60%) and Te (2.5%) and

depleted in Pb, Bi, and S, relative to the bulk of the grain (see microprobe analysis). This trend toward Ag rim enrichment may be a reflection of a change in precipitation temperatures (Hook, 1960; Goodell, 1975) and/or solution chemistry during vein formation.

The vein gold textures favour replacement over comagnetic origins, but either explanation may be possible. One could speculate that Bi-rich galena precipitated first and as the Pb contents of the hydrothermal solution fell the drastic Ag enrichment of galena rims took place with a relative increase in Te contents. Tetradymite may be co-existing at this time and changes between rim and core reflect relative abundances of Ag-Pb + Bi. The first gold replaces galena and is silver-rich since all of the Pb has precipitated and Ag can only find gold and/or hessite. Since the hessite and gold filaments are always intimately associated and the hessite gold is silver-poor this high fineness gold in hessite would suggest that most of the available gold contents in the mineralizing fluids were preferentially taken up by electrum rather than the telluride phase which was complexing with all of the available Ag to form Ag_2Te (hessite) during the waning period of hydrothermal activity.

The alteration assemblage related to the gold veins in the Atlin camp consists of Fe-Mg carbonates with some silicification, green chromium - mica development often with remanent black chromite grains centering mica sheets. Pyritization is rare and thus the altered ultramafics can not be called listwanites within the classical definition. I enclose a lithogeochemical write-up and table of some Atlin rock data.

Lithogeochemistry

Cache Creek and Atlin intrusion rock samples (162) of varying composition (Meta-andesite, cabbro, serpentinite, peridotite, diabase) and alteration (green-mica rich quartz-carbonate, i.e., listwanites, talc-magnesite, quartz-Mg-Fe-Ca carbonate, quartz-visible gold veins) were analyzed for thallium, palladium and platinum. Little or no thallium or platinum was detected in the rocks or veins. Pyrite abundance appeared to control palladium concentrations but only seven samples contained palladium between 10 to 35 ppb. However, in the Atlin area natural alloys of osmium-iridium and ruthenium, in nugget form, were reported by Harris and Cabri (1973). Our placer investigations confirmed the presence of similar nuggets (grains) in the four creeks studied. One grain contained chalcopyrite inclusions.

Boyle (1982) reports that the average concentration of gold in ultrabasic rocks is 4 ppb. Buisson and Leblanc (1985) investigated gold in carbonatized ultramafic rocks and they report gold values in liswaenites of 0.02 - 1 ppm while the associated ultramafic rocks contained 5 - 100 ppb gold. Their investigation of several gold-bearing listwaenites from the Upper Proterozoic and Alpine Ophiolite complexes showed them to be unusually gold-rich rocks (10 - 100 fold). Our data does not support these findings.

Care was taken not to include samples which contained any quartz veins or veinlets. The 18 relatively unaltered ultramafic rocks had gold contents ($\bar{X}$ = 1.7 ppb) ranging from <1.0 - 9.3 ppb while the 43 carbonate-altered-listwanite rocks had an average gold content of 5.3 ppb ranging from <1.0 - 75.5 ppb. Gold contents of economic concentrations appears to be restricted to the quartz-veins themselves. Fifteen quartz, quartz-carbonate vein samples were collected from

three mineralized vein systems. Gold contents ranged from 0.0094 - 216.0 g/t and averaged 21.8 ppm. Whole rock gold/silver ratios are highly variable and may reach as high as 12 or as low as 0.02 depending on the amount of gold or lead present.

Further pertinent lithogeochemical data is summarized in the following table:

		Au ppb	Ag ppm	Pb ppm	As ppm	Bi ppb	Cu ppm	Zn ppm	Co ppm	Ni ppm	Cr ppm	CaO %	CO_2 T %	K_2O %	MgO %
UNALTERED ULTRAMAFICS															
n = 18															
	$\bar{X}$	1.7	<0.5	11.0	7	<5.0	19	68	97	1917	2199	0.49	1.9	0.04	37.7
RANGE	MIN	<1.0	<0.5	-	-	<5.0	3	48	87	1700	690	0.03	0.2	-	34.8
	MAX	9.3	0.7	20.0	36	<5.0	52	110	110	2200	3400	2.48	9.3	0.06	41.4
CARBONATE-ALTERED ULTRAMAFICS															
n = 43															
	$\bar{X}$	5.3	<0.5	13.0	64	<5.0	24	68	68	1202	1645	3.05	4.9	0.37	27.0
RANGE	MIN	<1.0	<0.5	-	-	<5.0	1	18	18	90	110	0.07	-	0.01	1.7
	MAX	75.5	0.8	71.0	630	<5.0	110	140	100	2200	2900	25.80	16.2	3.62	42.2
QUARTZ, QUARTZ-CARBONATE VEINS															
n = 15		ppm		%											
	$\bar{X}$	21.83	26.8	0.83	289	122	85	25	13	37	18	NA	NA	NA	NA
RANGE	MIN	.009	<0.5	-	-	<5.0	1	1	-	-	2				
	MAX	216.00	49.9	8.00	2300	1216	460	180	58	240	75				

These data show the removal of Mg plus Ca, CO_2, K enrichment during the process of carbonatization of Atlin intrusion ultramafic rocks. Pb, Cu, Zn, Co, Ni, Cr remain relatively unchanged during these hydrothermal processes. Of important note to the explorationist is the somewhat broader halo of Au-As-Hg enrichment in the altred samples and the obvious Au-Pb-As-Bi association within the quartz veins. Further evidence for these geochemical characteristics is revealed in the mineralogical coloured plates provided.

I also enclose a small local geology write-up

Local Geology

In the Atlin area the most striking aspect of gold mineralization as seen in outcrop exposures, is its association with quartz and a pervasive carbonate alteration envelope.

Economic concentrations of gold are found in quartz-filled tension gashes or quartz stockwork-like veinlets which may pinch and swell or disappear both along strike and down dip. Probably of greater importance are the persistent quartz-vein systems of up to 1 - 2 m in width traceable in some cases for 2 km along strike. Fine chalcedony is sometimes present as rims on breccia fragments or as open space fillings in the veins and adjacent alteration envelope. All of these quartz systems occur in and around faults and/or shears or contacts between ultramafics, andesites-greenstones or dykes. This could be interpreted as indicative of fluid conduit channeling of mineralizing hydrothermal? solutions.

Carbonatization is most obvious in the ultramafic rocks although it is always also present where the veins contact andesite or greenstone. Using a term defined by Soviet geologists such as Goucharenko (1970), Boyle (1979) described heavily carbonatized, sericitized and pyritized ultramafic rocks as listwanites. Recent work by Buisson and LeBlanc (1985) use the spelling listwaenite. In our opinion the term should not be used in the Atlin gold camp. The typically intensely carbonatized ultramafics are quartz-talc-carbonates with minor green chromium muscovite (mariposite-fuchsite?) and chromite but they contain very little pyrite.

The altered ultramafics show a wide diversity of mineralogical, textural and compositional differences within the Atlin terrane. The complexity is obvious on the local property or vein system scale, however, a gradational alteration assemblage is proposed. Immediately adjacent to the quartz veins are the subordinate lithologies mariposite?-carbonate to quartz-carbonate. They are followed by a broader alteration envelope of quartz-talc-carbonates and talc-carbonate rocks in contact with serpentinites or relatively unaltered dunites and peridotites. The majority of carbonates present are Mg, Fe and Ca-rich (in order of abundance) but overprinting of the alteration assemblage and quartz open space filling would indicate complex and perhaps episodic mineralizing events.

Some preliminary ore mineralogy and lithogeochemical investigations of the veins and alteration assemblage are also given on the enclosed coloured plates.

The glacial geology of the terrane is complex and is reflected in the diverse topography. Those features which are of particular interest to the preservation of gold-bearing placer gravels and the utilization of lake sediment geochemistry for regional gold prospecting are as follows:

(1) Continental glaciers moved up the major valleys, resulting in ponding followed by deposition of lacustrine sediments and then ice sheet debris. The glaciers rafted over frozen sediments and/or scoured the valleys (Black, 1953; Milner, 1983).

(2) Extensive deposits of glaciofluvial sediments and till formed as the glaciers retreated. These deposits can reach depths of over 100 metres (Black, 1953).

(3) Isostatic rebound and rerouting of revers accompanied the glacial retreat. This resulting in the incising of streams and the reworking of many older sediments. Extensive stream capture and abandonment of former stream channels is evident. Much of the drainage pattern

disruption has resulted in low-lying swampy and lake covered areas especially along the Teslin suture zone on the eastern boundary of the Atlin terrane (Aitken, 1959).

For the Atlin gold camp our investigations to date suggest that Au, Ag, As, Ni, Co, Bi, Sb, Te and Pb are consistently present in the gold bearing quartz veins and more locally intimately associated with gold depositional sites with the vein(s). Native gold (electrum) compositions are variable between veins yet some showings such as Monarch Mountain, New Discovery - Standard Gold Mines show within vein consistent fineness ranges even when the site of native gold precipitation may vary. Compositionally the gold-electrum has no other elements greater than 1% as detected by the probe - work of Don Harris, GSC. It shows no rimming, i.e., Ag loss from the edges, however 75% of the Atlin nuggets showed compositional evidence of rim development. This suggests that refining by silver leaching of rims occurred during the weathering cycle as lode gold was being liberated from lost rocks and/or gossans from Tertiary time to the present.

Ore mineralogy between veins shows the above elemental association to persist as do the associated minerals themselves. However, the minor trace element compositions often change between veins. For example gersdorffite occurs in both the Yellowjacket samples and those of Monarch Mountain but the latter contains considerable Co and Fe while the former is almost stoichiometric in composition.

The Monarch Mountain mineralized samples collected from the highest elevation have the highest average fineness while those from the Yellowjacket claims in Pine Creek have the lowest fineness. I am not suggesting that the veins are interconnected merely illustrating what has been demonstrated before, namely, that gold compositions in vein system show considerable variation with depth. This of course is verified in the core composition of the gold nuggets which from Ruby Creek were found to range from almost pure gold to less than 50% gold.

The Atlin gold camp has strong similarities to the Motherlode District styles of mineralization genesis etc. The placer gold of Atlin has morphology and compositional-variability comparable to the host lodes, i.e., it is primary. Therefore, the large nuggets of Atlin must be considered as "bonanza" "pocket" gold concentrations which are from the host veins. In the Motherlode, "in situ" large masses of crystallized gold 6" x 13" weighing 67 troy ounces (5½ pounds) were found in vugs or pockets (see attached photo). A large gold leaf (5" x 6") or octahedral crystals (2' x 2") may easily be rolled and hammered into the larger nugget shapes often found in Atlin placer operations (see attached photos). Most of the large Atlin nuggets contain gangue (quartz) and some here at the GSC actually show gold around quartz vugs (pockets). Thus, it would seem reasonable that in the Atlin camp, gold can be found in the sizes and concentrations new exposed in the outcropping veins, however, assays may be sporadic. These same veins, however, should contain "pocket" gold concentrations of museum quality as indicated by the size of the coarse nuggets.

Systematic exploration and prospecting should continue without discouragement with the understanding that bonanza pockets and vugs and intermittent native gold (electrum) concentrations associated with the described pathfinder elemental assemblage and mineralogy will be present in a sporadic distribution within the veins.

I wish to keep the visible gold samples you kindly provided as more detailed work may be necessary.

Best wishes for a good field season. Give my best regards to your crews and co-workers.

S. B. Ballantyne.

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