861584

AVALANCHE CREEK PROPERTY
(Geology and Geochemistry)

on

Jennifer, Wind, Storm
Line, Glad Claims

Atlin Mining Division (~~103N-10W~~)
104-N-2

owned by

Canadian Johns-Manville Ltd.

for

Ranworth Explorations Limited
(J. J. Rankin)

&

Whiterock Explorations Limited
(Wm. McDonald)

by

J. R. Woodcock and Dennis Gorc

J. R. Woodcock Consultants Ltd.
806-602 West Hastings St.
Vancouver, B. C.

November 30, 1981

Lat. 59° 1.7′N
Long 132° 50′W
104N/2

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THE AVALANCHE CREEK PROPERTY

(Geology and Geochemistry)

INTRODUCTION

The Avalanche Creek property lies 32 miles (51 km.) east of Atlin, British Columbia, on the western slopes of Mount Sanford. The mineral claims extend from the valley of Gladys River, elevation 3000 feet, to the crest of Mount Sanford, elevation approximately 5500 feet. Line Lake and Angel Lake occur along the river in the bottom of the valley. The center of the property is at latitude 59° 1.7 minutes north, longitude 132° 50 minutes west, on N.T.S. map sheet 105N-10W.

Access must be by helicopter from Atlin which has a permanent helicopter base. Float planes could land in Line Lake or Angel Lake. However, this would entail a walk and climb to the rock exposures on the mountain.

This property was originally staked as the Boot 1 and 8 mineral claims by R. Fleming of Teslin, Yukon Territory in 1967. In 1969, geologists of Canadian Johns-Manville Limited became interested through prospecting and stream geochemical surveys. Canadian Johns-Manville Limited staked the properties in 1972 and 1973.

In 1973, a soil sample program was completed and anomalous tin, tungsten and arsenic were found in some of the rock and soil pulps. In 1976, additional geochemical sampling was done and a geological map was made by Dr. R. Mulligan.

In 1980, Messrs. Wm. McDonald and J. J. Rankin became interested in the property and in September requested J. R. Woodcock to examine the property. Woodcock spent two days (September 14th and 15th) on the property. This time was devoted to the headwaters of Avalanche and Outwash Creeks in making observations on the geology, especially the mineralization and alteration, and in collecting rock chip samples and specimens for geochemical analyses and petrographic work. On the basis of this examination and orientation survey, Woodcock recommended additional similar work.

Further information on the history of exploration can be obtained from the bibliography with its accompanying summaries.

In August 1981, Messrs. D. Gorc, H. Awmack and J. R. Woodcock returned to the property to get more information on the geology and mineralization and to take additional rock chip samples for geochemical analyses and rock specimens for alteration studies. 280 rock samples were analyzed by Vangeochem Lab Ltd.

A stadia survey (scale 1:1000) made by H. Awmack provided the base map for the more interesting lower reaches of Avalanche

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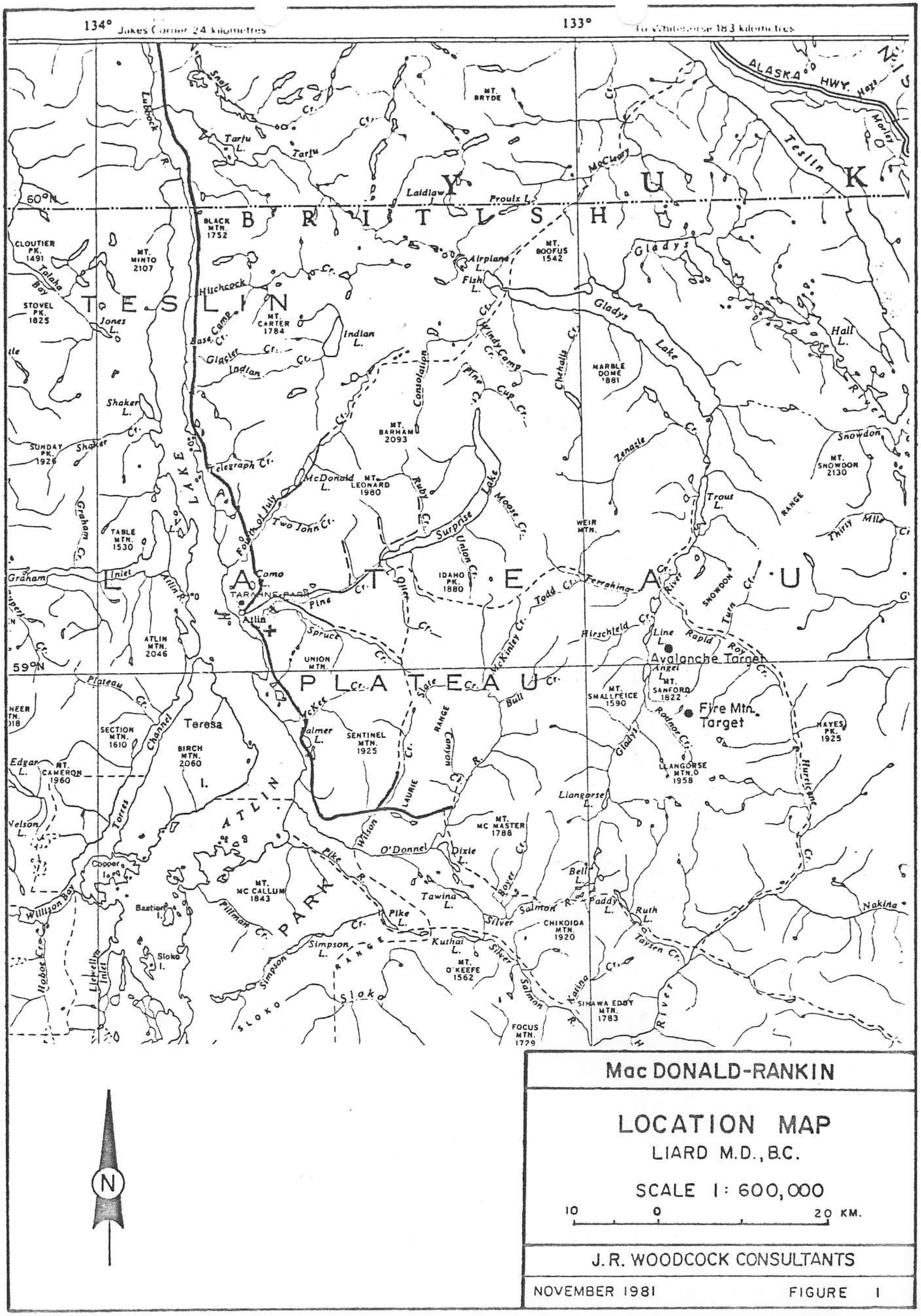

134° Jakes Corner 24 kilometres
133°
ALASKA HWY.
TESLIN
YUKON
BRITISH
TESLIN
PLATEAU
ATLIN PARK
60°N
59°N
BLACK MTN. 1752
CLOUTIER PK. 1491
MT. MINTO 2107
STOVEL PK. 1825
MT. CARTER 1784
MT. BRYDE
MT. BOOFUS 1542
MARBLE DOME 1881
MT. BARHAM 2093
MT. LEONARD 1980
SUNDAY PK. 1926
TABLE MTN. 1530
IDAHO PK. 1880
ATLIN MTN. 2046
UNION MTN.
MT. SNOWDON 2130
WEIR MTN.
MT. SMALLPEICE 1590
MT. SANFORD 1822
SECTION MTN. 1610
BIRCH MTN. 2060
SENTINEL MTN. 1925
MT. CAMERON 1960
LLANGORSE MTN. 1958
HAYES PK. 1925
MT. MC MASTER 1788
MT. MC CALLUM 1843
CHIKOIDA MTN. 1920
MT. O'KEEFE 1562
SIHAWA EDDY MTN. 1783
FOCUS MTN. 1729
Atlin
Avalanche Target
Fire Mtn. Target
Teresa I.
Gladys Lake
Surprise Lake
Indian L.
Line L.
Trout L.
Hall L.
MacDONALD-RANKIN
LOCATION MAP
LIARD M.D., B.C.
SCALE 1: 600,000
10 0 20 KM.
J.R. WOODCOCK CONSULTANTS
NOVEMBER 1981
FIGURE 1
N

and Outwash Creeks.

Note that the stadia stations were not checked and the traverses were not closed. Therefore, adjustments for errors could not be made; also mistakes may be present. The base map is considered accurate enough for the present work which involves deciphering the geology and detecting exploration targets.

The data from the surrounding area was plotted on an expanded aerial photograph. Photo B.C. 5677-023, scale 1" - 1/2 mile was expanded to approximately 1" = 800 feet. Thus the distortions of the original photograph have been incorporated into the resulting map. This map was then enlarged to scale 1:5000 for this report.

CLAIMS AND OWNERSHIP

The central claim groups are held by Canadian Johns-Manville Limited and include the adjoining Jennifer, Wind and Stormy claims and the three Line claims. These claims were staked under the two-post system.

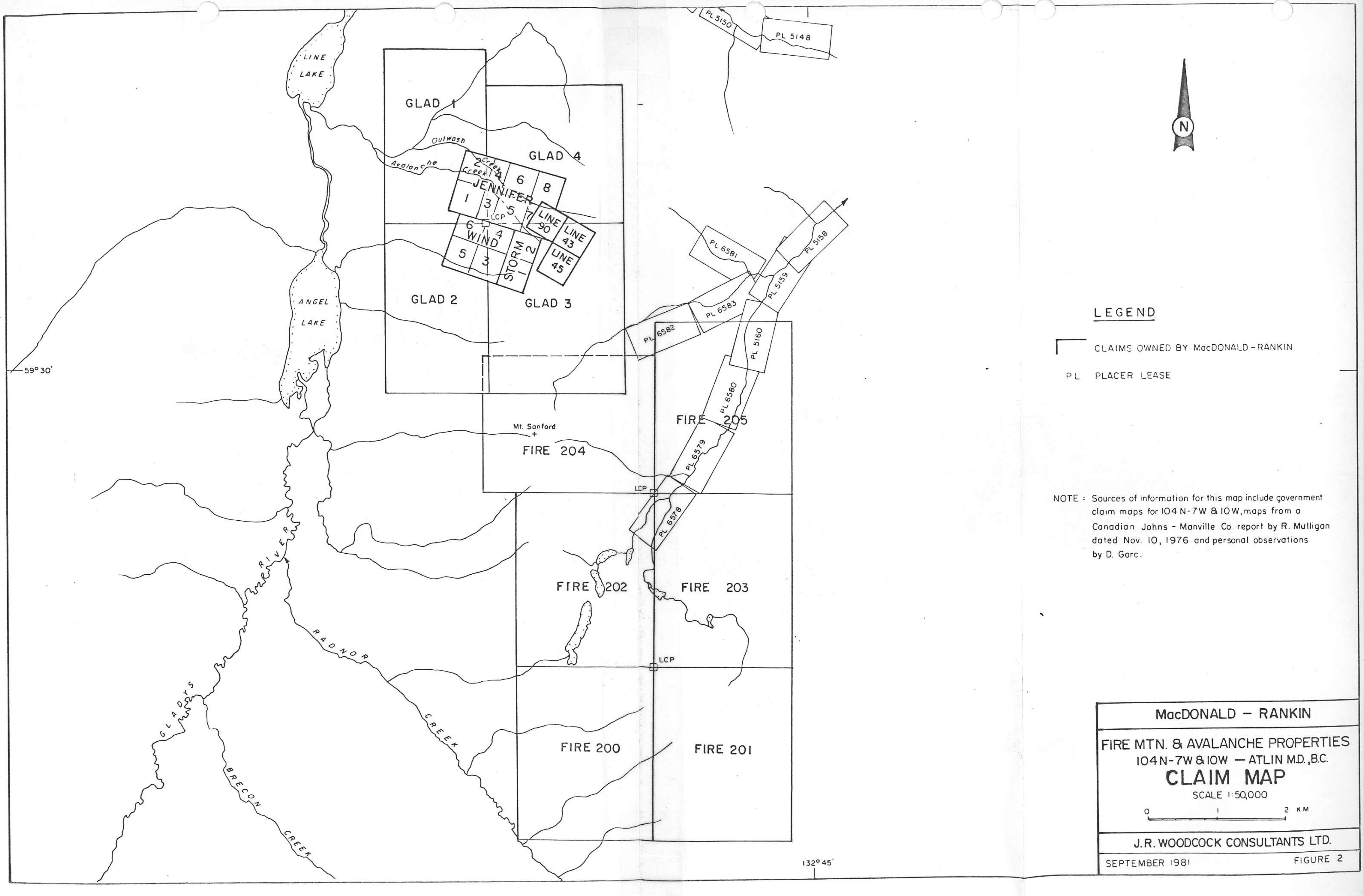
In September 1980, Mr. Clive Aspinall staked three new claims under the grid system as agent for John R. Woodcock. These new claims are presently in the name of John R. Woodcock. The new claims are named the Glad 1, Glad 2, and Glad 3. In August 1981, Mr. Dennis Gorc staked the Glad 4 claim as agent for John R. Woodcock. All claims are in the Atlin Mining Division.

The respective positions of the claims are shown on the claim map and the claim data is tabulated in Table I. Note that this claim map is an adjusted copy of the government claim map which has scale approximately 1:50,000. The adjustments were made to conform to field observations made by D. Gorc and the base map made by L.W. LeRoy and H.K. Conn.

REGIONAL GEOLOGY

The regional geology is described in G.S.C. memoir 307, Atlin map area (104 N) by J.D. Aiken, 1959 and in several G.S.C. reports for neighbouring areas. The regional geology is included in most of the prior reports written for Canadian Johns-Manville. In particular the report by R. Mulligan discusses the significances of some of the regional features.

The Avalanche Creek area is underlain by rocks of the Upper Palaeozoic Cache Creek Group. These rocks occupy part of a central trough in northern British Columbia and southern Yukon Territories between the Omineca-Cassiar and the Coast Range Crystalline Belts. In the Avalanche Creek area this formation



MacDONALD – RANKIN

FIRE MTN. & AVALANCHE PROPERTIES
104 N-7W & 10W — ATLIN M.D., B.C.

CLAIM MAP

SCALE 1:50,000

0 1 2 KM

J.R. WOODCOCK CONSULTANTS LTD.

SEPTEMBER 1981 FIGURE 2

TABLE I

CLAIM DATA

Name	Units	Record No.	Record Date
2-post claims			
Jennifer 1		19338	Sept. 21, 1973
2		19339	" " "
3		19340	" " "
4		19341	" " "
5		19342	" " "
6		19343	" " "
7		19344	" " "
8		19345	" " "
Wind 3		19027	Sept. 26, 1972
4		19028	" " "
5		19029	" " "
6		19030	" " "
Storm 1		19202	June 29, 1973
2		19201	" " "
Line 43		18016	Apr. 14, 1972
45		18018	" " "
90		18063	" " "
grid claims			
Glad 1	15	1166	Oct. 6, 1980
2	15	1167	" " "
3	20	1168	" " "
4	16	1481	Aug. 28, 1981

is composed of cherts, argillites and minor limestone. In places of the Atlin district some volcanic units are present and, in places, some fairly extensive limestone units are present.

Structurally the Cache Creek rocks of the Atlin terrain are folded dominantly on a north-west-trending access; but trends are much affected by major plutons, and are complex. On the Avalanche Creek property, the dominant strike appears to be northeasterly. Major faults are widespread; possibly the Gladys River Valley to the west of the property is controlled by a major fault. A strong linear feature in the cliffs along the north side of Outwash Creek has been interpreted by Mulligan as a thrust fault from the northeast.

GEOLOGY OF AVALANCHE CREEK AREA

The Avalanche Creek area is underlain by cherts, argillites and minor limestone of the Cache Creek Group. These rocks are folded, faulted and invaded by small plugs of feldspar-hornblende porphyry.

Cherts and Argillites

In the lower reaches of Avalanche Creek and Outwash Creek of the mapped area, the cherts and argillites have been metamorphosed to brown biotite hornfels. The characteristics of the unmetamorphosed cherts and argillites have to be drawn from observations away from this metamorphic center.

Cherts are the most abundant of the sedimintary rocks and these vary from medium to dark-grey and almost black, with minor amounts of light-grey chert. The rock is extremely fine-grained and very little can be distinguished under the normal petrographic microscope. However, sericite and silica are the predominant minerals. The cherts are massive with little evidence of bedding; occasionally some thin laminations are evident. The only reliable bedding occurs where there are interbeds of argillite. In places, the chert has a microconglomerate or clastic texture with small chert clasts (up to point 0.5 cm diameter). Such clasts are sub-angular and generally light grey. These clasts are emphasized in the hornfels zone by the differences in the content of the secondary biotite.

The argillite interbeds vary in thickness from 1 cm to 25 cms and generally between 1 cm and 5 cms. Cherts seem to be somewhat argillaceous where there are interbeds of argillite.

The argillite interbeds are black and the rock is relatively

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soft compared to chert. In places, a somewhat planar structure has developed giving the rock an almost slate appearance.

Although the argillite content of the sedimentary sequences is relatively low, there does seem to be an increase in the number of these interbeds in a southeasterly direction (the upper parts of Avalanche Creek above sample G 753; south of sample G 660). There may also be an increase in the northern part of the sampled area; however, sample spacing in this area is not plentiful.

Hornfels

The 1980 orientation survey indicated that biotite hornfels was increasing in intensity northwesterly down Avalanche and Outwash Creeks. The work done in 1981 confirms this. Specimens collected at each of the sample sites were later examined for their brown biotite content (the brown index). This is classified, according to intensity, from Nil through Low, Medium, to High. The results of this work are given in figures 6 and 7 Several contours seem to be significant, including the line separating Nil from Medium + Low and the line separating values that are generally Low to Medium from the values that are generally High to Medium. These contours again indicate a center at the lower parts of Avalanche Creek in the region of "erratic drainage".

The hornfels varies from the light brown to deep chocolate brown. However, the degree of brown is quite variable. Within the hornfels center, although the browns predominate, there are places of very light grey to almost white cherty rock.

The hornfels is characteristically mottled with very light grey mottles, 1 to 5 cms wide and irregularly shaped. Some of these mottles are sharply defined and, in places, appear to be related to bleaching along the minute quartz veinlets. Other mottles are less well defined and the browns slowly grade into the light grey. These appear to be remnants of the rock which have resisted hornfelsing and therefore are possibly clasts.

Two characteristics of the sedimentary rocks appear to affect the intensity of biotite alteration. Outside of the main hornfels zone, biotite formation is promoted in the vicinity of limestone horizons. Within the biotite hornfels zone, there does seem to be a decrease in the biotite content in the black carbonaceous (?) argillites.

Thin section examination, even with high power, does not give much information as the rocks are extremely fine-grained. In some sections the biotite, even in the chocolate brown coloured rocks, is so fine-grained that it is difficult to detect the colour in thin section. Therefore, it is difficult to distinguish extremely fine-grained biotite from extremely fine-grained sericite. The bleaching which one sees along the quartz veinlet is probably sericite; however, it is also fine-grained. There is no increase in grain size as one might expect with hydrothermal alteration. The biotite does seem to increase in grain size along some quartz lenses; but whether this is part of the hornfelsing phenomenan or subsequent hydrothermal alteration is not known. In some places, the light grey patches are caused by carbonate-rich rock versus the biotite-rich rock. In some of the mottled rock, the white mottles are merely quartz-rich chert within the brown rock. In a few places, quartz-muscovite veinlets are present and in some sections there are biotite-rich clasts versus the grey biotite-poor clasts.

These various types of irregularities in biotite content and in brown coloration within very short distances, and even within some individual thin sections, make the hornfels map somewhat erratic in detail. However, the overall picture seems to be reliable indicating that this metamorphism was caused by a heat source underlying the lower parts of Avalanche and Outwash Creeks. The hornfels pattern is not interrupted by Mulligans thrust fault north of Outwash Creek, although there may be some offset. This indicates a thrust fault of small displacement or of pre-hornfels age.

The secondary biotite is also abundant within the lowermost porphyry on Avalanche Creek, probably indicating that the hornfelsing is related to an intrusion other than this small porphyry body. One could also imply this when comparing the large size of the hornfels zone with the small size of this plug.

Pyrrhotite and pyrite always present in the hornfels zone, both disseminated and along fractures and quartz veinlets. Pyrrhotite predominates over pyrite; small chalcopyrite grains associated with the pyrrhotite are quite widespread. The amount of sulphides is not high compared to many porphyry systems; one could probably estimate 5% in places in the lower parts of Avalanche Creek. The weathering at the surface has created a gossan and probably removed some of the iron sulphide; however, the gossan, because of the resistant and unfractured nature of the rock is not well developed or conspicuous. The most conspicuous part of the gossan is in the more irregular parts of Avalanche Creek.

Limestone and Lime Silicates

The limestone bands are discontinuous and pinch out along strike quite sharply. Whether this is a phenomenon inherited from the deposition or whether it has been superimposed by folding is not known.

Most of the carbonate members within the mapped area, even outside of the hornfels zone, have been partially altered to lime silicate. The silication is not uniform in the exposures; in places, large blocks of unaltered bluish-grey limestone remain relatively unaltered. In some outcrops there is more silication at the contacts of the limestone bands and this grades into a relatively unaltered limestone towards the center. The silication is characterized by its irregularity.

The silicated rock is generally light green to light grey in colour. The light grey rock is predominantly tremolite whereas the greenish tint is probably imparted by diopside. In a few places, redish garnet crystals are present. In a few small outcrops there is a banding created by variations in garnet, tremolite, or limestone content. Dolomite occurs with diopside.

The limestone bands with the silication do have pockets of minor sulphides including galena, sphalerite and some chalcopyrite. Pyrrhotite is more widespread.

Within the lower part of Avalanche Creek is a series of discontinuous lenses of massive sulphides which occur within the chert but which could possibly be a replacement of the limestone lens. The rock is largely pyrrhotite with some pyrite, abundant chalcopyrite and some sphalerite and galena.

Feldspar Porphyry

Five small intrusions of feldspar porphyry have been mapped. These include:

1. In Avalanche Creek (station 255) the dyke or small sill appears to be gently dipping; but it has been affected by faulting and folding. This may account for its occurrench in three separate pieces.

2. North of Avalanche Creek at sample G81-676R a dyke strikes 065°, dips vertical, and is 4 to 5 m thick. It has no pyrite.

3. Further north at station G 81-678R a dyke strikes 075°, has a vertical dip, is 5 meters thick and contains a trace of pyrite.

4. A linear zone of felsenmeer (sample G81-711R) occurs between Outwash and Bear Creeks.

5. A small dyke at the head of Avalanche Creek (sample W81-226R) strikes 160° and dips 60° west. It is only 4 meters thick. It seems to be conformable to foliation in the adjacent argillites; however, at its northwest end the argillites also dip under it.

Two specimens of porphyry were examined in thin section. Specimen G678, away from the hornfelsed center, is a porphyry with sparse phenocrysts including 12% hornblende and about 8% plagioclase. The matrix is about 35% quartz and 65% feldspar, probably plagioclase. A few apatite crystals are present. The alteration includes minor chlorite in the hornblende phenocrysts and minor sericite alteration of the plagioclase phenocrysts. Another section (A414) from the Avalanche Creek intrusion also has mafic and plagioclase phenocrysts. However, the hornblende phenocrysts have been completely replaced by biotite. Biotite also occurs in veinlets, scattered throughout the matrix and in some of the plagioclase phenocrysts. The matrix in this case appears to be all plagioclase which is altered moderately to kaolinite, sericite and minor biotite.

Rock Slides and Cemented Gravel

Along the bed of Outwash Creek are some stream gravels which have been cemented by limonite. This limonite cement is dark brown to black goethite. The cobbles are rounded to subangular and include chert, and argillite. There is some indication that the coarser blocks occur at higher elevations.

Also along the lower reaches of Outwash Creek are some large rock exposures which are slump blocks. Most of these occur on the north side of the creek. Some of the exposures, on the south side of the creek, are resting on gravels. These are shown on the geological maps and are indicated on all of the geochemistry maps.

Structure

The massive nature of the chert throughout much of the Avalanche and Outwash Creeks drainage basins prevents resolution of the structural geology. In some of the area the cherts strike about 025° and dip about 35° southeast. However, the limestone bands have different attitudes with strikes 050° to 070° azimuth and with steep or vertical dips. Many of these limestone bands, especially the ones in the lower Avalanche Creek, are very discontinuous and pinch out along strike. In places, the cherts appear to wrap around the upper parts of these pinch-outs; whether this represents the crest of a small fold or whether it is merely the chert wrapping around the limestone lense is not known. In addition, some cross-faulting adds to the discontinuity of the limestone beds.

In general, there is more limestone along the southwest side of Avalanche Creek than there is north of Outwash Creek; the main bands have either thinned or been faulted out. Mulligan shows branching limestone bands. Just how accurate this interpretation is with the sparsity of good outcrops and whether it can be attributed to the faulting or to the folding is unknown.

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Small porphyry intrusions which occur at the head of and in the lower reaches of Avalanche Creek, have been offset by faulting. Some seem to be very thin intrusions which dip gently; whether they are folded and faulted sills or dykes is not known.

In addition to numerous faults with small displacements that are evident in the Avalanche and Outwash Creek drainages, there are some strong fracture sets. The predominant set strikes NNE and dips steeply to vertical. Mulligan suggests that this pattern may reflect the influence of the northeasterly striking fault along the east side of the valley of Gladys River.

Alteration and Mineralization

The distribution of the biotite hornfels has been discussed and illustrated on the accompanying figures. Presumably this has been caused by an underlying intrusion.

In the lower reaches of Outwash Creek there are numerous quartz veinlets and along many of these quartz veinlets there is a grey selvage. Some of this is sericite; and some could be carbonate. This bleached alteration is especially noticeable between sample sites G720 and G728 on Outwash Creek, with almost complete bleached rock in the vicinity of G728. It also occurs on Avalanche Creek in an area bounded by stations 208, 209, 228 and 230. Between this zone of bleaching and the porphyry intrusion upstream there are small pockets of similar alteration.

Abundant quartz veins and veinlets are found throughout much of the area; but these appear to be more prevalent in the central part of the hornfels zone. In places, the veinlets are abundant enough to form a stockwork over very limited areas. Such areas include sample sites G720 to G726 and G695 to G700 on Outwash Creek. Many of the small quartz veinlets are dark grey or black.

In addition to these quartz veinlets, the cliffs along the north side of Outwash Creek have abundant vuggy quartz veinlets; more accurately described as a network of quartz prisms along fractures.

In the present study, little attention was given to the sulphide mineralization and so the observations will include some data from Mulligan's report. The massive sulphide lenses in the lower Avalanche Creek are mainly pyrrhotite and contain chalcopyrite, sphalerite and some galena. Other heavy sulphide bands, with abundant pyrrhotite, occur below the porphyry intrusion (e.g. W250R). These are probably replacement deposits in silicated limestone.

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According to Mulligan, wolframite, scheelite and cassiterite occur in some quartz veins. Prior geochemical work and our goechemical work indicated high tin and tungsten content in many of the silicated limestone bands.

The various reports for Canadian Johns-Manville and other assessment work reports indicate that traces of cassiterite and tungsten are fairly widespread, probably extending beyond the zone of hornfels. Our analyses of silicated limestone outside of the hornfels zone also suggests widespread traces of tin and tungsten. In addition, copper, lead and zinc mineralization occur in the silicated limestone bands within and outside of the hornfels zone.

There is a distinct coincidence of fluorine with many of the above metallic minerals. Large amounts of fluorite have been noted in some of the silicated limestone bands. This is confirmed by our fluorine analyses.

GEOCHEMISTRY

Stream Silts

In an attempt to pinpoint the source of the highly anomalous metal values in Avalanche Creek, a series of silt samples were collected starting in the overburden area downstream and extending upstream to the end of the silts, below the upper skarn band. Sample sites have been projected to a profile down Avalanche Creek (A-B-C on Figure 9). The results of the silt sampling, along with the results of the magnetometer survey down this creek and the analytical results for corresponding rock samples are presented in profile on Figure 9. A number of geological rock units have also been added. These include the uppermost skarn zone, the porphyry intrusion, the small pyrrhotite band, the lower skarn band, and the sulphide band.

An examination of the sample results for the stream geochemistry show that all silts are anomalous in copper, lead, zinc and silver, including the uppermost silts of the creek bed and all of these metals have outstanding downstream decay patterns. These downstream decay patterns are interrupted by contributions from the non-chert units.

It is likely that much of the Cu, Pb, Zn and Ag is coming from the uppermost skarn band; however, this cannot be proven. Downstream decay pattern is interrupted by an increase in Cu, Pb, Zn, and Ag below the porphyry intrusion and a major increase below the massive sulphide-lower skarn zone * for Cu, Zn, Ag; but not for Pb.

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* As no silts were obtained between the sulphide band and the lower skarn, the contribution could be from either one or both of these; but most likely from the sulphide band since it does contain conspicuous chalcopyrite and some sphalerite.

Tungsten has background values (19 to 30 ppm) above the porphyry, but highly anomalous values (> 600 ppm) in all silts downstream from the porphyry.

Fluorine is very high (2250 ppm) below the sulphide-lower skarn bands, decreasing to 720 ppm downstream. All values above the lower skarn-sulphide zone are background, including those values below the porphyry.

Tin does not give such an outstanding pattern. The uppermost silt and the samples below the porphyry are anomalous (> 80 ppm). Also three samples taken below the sulphide-lower skarn zone are anomalous.

Arsenic yields erratic high background values with no good trends and no relationship to geology.

Molybdenum is also erratic and all values are anomalous. There is no trend or relationship to geology except for a slightly higher value (38 ppm) below the porphyry. These results might indicate high background molybdenum values in the sedimentary rocks of the Cache Creek Formation.

Soil and Talus Fines

Soil sampling done by Canadian Johns-Manville Company Ltd. over the mountains extending from Stormy Creek on the south to Landslide Creek on the north, and centered on Avalanche Creek was controlled by a grid of picket lines. The sample media included upland soils, generally on the glacial debris that covers the top of the hills and on the moraine between Avalanche and Outwash Creeks, and also talus fines on the steep slopes, especially north of Outwash Creek, south of Avalanche Creek and at the head of the cirque between Avalanche and Outwash Creeks. The samples were submitted to Bondar-Clegg and Company Ltd. for analytical work. The results for a number of metals are presented, with two per map. A perusal of the results shows that in general the anomalous values, especially the little peaks and single sample anomalies are largely confined to the talus slopes, mainly in the drainage basins of Avalanche Creek and Outwash Creeks.

Several metals have similar patterns. These include lead, zinc, and silver with the same patterns. Tin,bismuth, fluorine, and tungsten have the general same distribution of the anomalous peaks.

Copper has distribution somewhat similar to the tungsten-tin, with some distribution similarities to the lead-zinc pattern. Molybdenum and arsenic do not show such good correlation with the other metals.

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In general, all metals are anomalous in or around the limestone bands. Thus, in these places, the anomalous peaks are all superimposed.

Copper has very high background, with most values > 50 ppm and with anomalies up to and exceeding 1000 ppm.

Lead values in soil are also exceptionally high; I am suspicious of them. Many of these values are > 50 ppm; only those values > 400 ppm have been circled as anomalies.

Zinc also has quite high background values; but this could be contributed by the argillaceous terrain. Many of the values are > 100 ppm and anomalies are only circled when they are > 675 ppm.

Silver is also very high. Probably these silver values, especially those that date from the early part of the soil sampling programs, have not had a matrix correction. It is possible to get values of 1 or 2 ppm from interference of other metals such as calcium. Most of the reported values are over 0.5 ppm with many of them over 1 ppm. Anomalous values are > 5.2 ppm which is abnormally high. There is, however, some correlation with the lead and zinc and also with the limestone bands. Also, the results of the silt sampling profile along Avalanche Creek done in 1981, confirmed that silver is unusually high.

Tungsten shows background values generally under 15 ppm and anomalous values of up to and exceeding 120 ppm. This background range seems to be reasonable. However, the silts collected in 1981 did show some very high values (> 600 ppm) in the lower reaches of Avalanche Creek.

Tin is abnormally high throughout the whole survey area with many of the background values between 30 and 100 ppm. Anomalous values on the map are not circled unless they exceed 300 ppm. This is unusually high for tin, especially for the background values. I am suspicious of the background readings.* However, the relative values are probably significant as the anomalous peaks correspond with the anomalous peaks of tungsten, especially where these values occur in limestone bands.

Molybdenum is also a metal with a very high background. This conforms to the results of the silt sampling done in 1981. It could indicate a high background molybdenum content of some of the Cache Creek argillaceous rocks.

Arsenic analyses were also obtained for some of the samples. The values range from non-detectable to > 680 ppm. Little can be concluded from these values as the number of analyses are too limited. Again, the anomalous values appear very high; however, as stated previously such very high values can be obtained in talus fines.

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* Analyses for Sn and W are difficult and various labs report differing readings, especially in the background ranges.

The number of analyses for bismuth is not sufficient to establish background away from the anomalous zone. Values of nd (not detected) to 115 ppm are common and peak anomalies are > 115 ppm.

Fluorine shows normal background values (300 to 700 ppm) with extremely high values (up to 16000 ppm) associated with the silicated limestone bands.

The 1980 orientation studies indicated that the soil geochemistry was enhanced in the talus fines. This is a common characteristic of soil geochemistry in mountainous areas. The fines in the talus include mechanically abraided soft minerals such as limonites and sulphides which do carry a large proportion of the metals. Additional work in 1981 comparing soil geochemistry with adjacent rock geochemistry confirmed this. However, this phenomenon of enhanced talus fines is superimposed on another underlying concentrating medium and that is the silicated limestone. Outstanding metal values occur in most of these silicated bands and most of the local high peaks in the soil geochemistry are associated with silicated limestone bands.

Rock Geochemistry

The geochemical work done by Canadian Johns-Manville, mainly soil geochemistry, but including some silt samples and some rock samples, indicated a large target highly, but erratically, anomalous in a number of elements including Cu, Pb, Zn, Ag, Mo, As, W, Sn, Bi, and F. Woodcock's orientation study on the rock geochemistry was an attempt to define the target more closely; this work did indicate a hornfels zone in the lower reaches of Avalanche and Outwash Creeks and some corresponding anomalous rock geochemistry. The rock geochemistry of the cherts, argillites and hornfels showed that the best element to pinpoint this center is fluorine. The other elements tested did not give any conclusive trends in the cherts and hornfels. However, the silicated limestones that were tested did show highly anomalous metal values.

In the 1981 field work, rock chip samples were collected over a large part of the target area, with closer spacing in the more interesting lower reaches of Avalanche and Outwash Creeks. At each of these sample sites a hand specimen was collected for estimates of biotite, (brown index) and for possible petrographic studies.

In addition to the rock samples, twelve silt samples were collected along Avalanche Creek in an attempt to correlate the anomalous silt samples with the rock geochemistry along the

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same stream. The results of the rock geochemistry and of the stream geochemistry are given in Figure 9.

All rock samples, including cherts, hornfelses, porphyries, and silicated limestones, were analyzed for fluorine and the results of this are given on Figure 10. In addition, about 30 samples in the profile down Avalanche Creek were analyzed for W, Sn, Cu, Pb, Zn, Mn, Ag, and F. Seven samples of porphyry were also analyzed for W, Sn, Cu, Pb, Zn, Mn, and As. Because the skarn samples collected previously did show anomalous values, an additional 35 samples of silicated limestone were submitted for analyses for Sn, W, Cu, Pb, Zn, Ag in addition to the F. These are plotted on Figures 12, 13, and 14. Six rock samples of a variety of types, including hornfels, bleached hornfels, grey lime silicates, and massive sulphides were submitted for analysis for Bi, B, Sb, and Mo, in addition to other elements.

Fluorine in Rock

The fluorine technique is generally effective in appraising a large gossan area and detecting an underlying intrusive center Fluorine values for all rock types are presented in Figures 10 and 11. On both of these figures the values for the hornfels and the argillites have been contoured, neglecting any of the high and erratic values for the lime silicates and sulphide bands and the somewhat lower values for the feldspar porphyry. The contours of the detailed sampling in lower Avalanche and Outwash Creeks (Figure 11) has been reduced and incorporated in the small scale map (Figure 10).

A comparison of the contour pattern of this map with the contours on the map of "Brown Biotite Index" (Figure 7) reveals a similarity in overall distribution and in the location of the central high. When more detail is added the contours become erratic (e.g. lower Avalanche Creek). The data could probably be contoured in detail in a number of ways; however, the overall picture and the central high will remain the same. In the case of Avalanche Creek, incomplete data to the southwest precludes reliable completion of the contours, even the 2000 ppm contour.

Avalanche Creek Profile

A profile of rock chip samples down Avalanche Creek was taken to determine if elements, other than fluorine, could be used to establish trends across the zone of mineralization; and to correlate the rock geochemistry with the silt geochemistry. The results of this rock chip sampling are plotted on Figure 9.

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This work confirmed that other elements, including the sulphur, do not give good trends in the chert-argillite hornfels unit. The results prove that much of the anomalous metal content in the silt samples is contributed by the zone between the Lower Avalanche porphyry intrusion and the massive sulphide band. The results indicate that the silicated limestone horizons, and the massive sulphides contribute most of the metal values.

Except for moderately anomalous tungsten values, the porphyry is not particularly anomalous in any of the metals.

The very high tungsten values in silt do start just below the small porphyry intrusion. However, whether the porphyry is an important contributor or whether the contributions just below this intrusion are from sulphide-rich or altered horizons in the hornfels is not known. In regard to this, note that a hornfels sample (G 81-740) from Outwash Creek is from any area of abundant quartz veinlets. It has about 4500 ppm W.

Geochemistry of the Lime Silicates, Sulphides, and Porphyries

Because the lime silicates and the associated sulphide lenses show very high metal values in comparison to the cherts and argillites throughout the area, samples of these rocks were analyzed for a variety of elements (Figures 12, 13, and 14) in an attempt to develop trends.

The samples of lime silicate and of relatively massive sulphides show erratic values for Pb, Zn, Ag, including some very high values. The feldspar porphyries; however, are mainly background, including the intrusion in Lower Avalanche Creek. The only exception is in the small intrusion in the cirque at the head of Avalanche Creek in which the three metals are obviously anomalous (Figure 12).

Copper is generally parallel to Pb, Zn (Figure 13). The silicated limestone has very erratic values, mostly moderately anomalous but up to 1680 ppm. The sulphides have some very high values, especially the main sulphide band in Lower Avalanche Creek. The feldspar porphyries north of Outwash Creek have very low background values (up to 13 ppm). The highest values found in porphyries are in Lower Avalanche Creek (up to 212 ppm). Slightly lower values occur in the "Cirque Porphyry" at the head of Avalanche Creek.

Manganese is also parallel to Pb, Zn, and Cu. It is very erratic. The feldspar porphyry in the lower Avalanche Creek has very low values (up to 185 ppm).

Tungsten has only background values in samples from the southwest part of the sampled area. Many of the remaining calc-silicate samples are very erratic with values up to 350 ppm. The sulphides have very high values with some > 600 ppm in Lower Avalanche Creek.

In contrast, the sulphide-rich skarn band just below the Lower Avalanche Creek porphyry is not anomalous. Feldspar porphyries generally have background values (≤ 20 ppm). However, the Lower Avalanche Creek porphyry does have values up to 200 ppm.

Tin is generally low in the limestones and the silicated limestones (< 50 ppm) but does have a few erratic highs (up to 350 ppm). The sulphides are not particularly anomalous; the highest value obtained is 70 ppm. Feldspar porphyries are not anomalous and all values are ≤ 5 ppm.

In general, although values are erratic, there is a greater preponderance of highly anomalous values in Lower Avalanche Creek. This contrasts with some of the outlying areas, especially samples of silicated limestone and limestone from the southwest part of the map, where values are generally background.

MAGNETOMETER SURVEY

In addition to the geochemical profiles down Avalanche Creek, magnetometer readings were taken. These are also included on the profiles of Figure 9. This preliminary work indicated low values (725 gamas according to our local arbitrary base level) in the upstream talus area, gradually increasing to about 1400 gamas at the lower side of the porphyry intrusion. In the zone between the porphyry and the lower sulphide zone, the highest values (1375 to 1600 gamas were obtained. Below the lower sulphide zone, values generally decrease to 1250 gamas near the lowermost outcrops in the creek bed. Downstream, in the area of increasing overburden, values are between 1210 and 1250 gamas. Thus it appears that, for a width of about 170 meters, values have increased and that the values gradually drop off both downstream and upstream from this central high. However, results from such limited work may not be significant.

Two additional lines of magnetometer readings were taken at right angles to Avalanche Creek; these did not add much to the picture. Damage to the magnetometer curtailed this work.

Prior to this work, Mulligan in 1976, did a small magnetometer grid over the area of the sulphide and lower skarn (No.1 limestone). This did not show any local anomalies. Also, it did not indicate any larger scale trend because the survey was too limited.

The magnetometer map * submitted by C. Aspinall (Assessment Report 4912) has been contoured to emphasize the local northeasterly stratigraphic bedding. Possibly a statistical analyses designed to separate local trends due to bedding from significant local anomalies, and at the same time eliminate the single or double station erratic highs, might give a more significant

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* The assigned base level for the Avalanche Creek profile is 680 gammas higher than that used in the Aspinall survey.

pattern. A rough estimate of this type of treatment can be done by colouring the individual stations according to a colour chart, before attempting to place contours.

Woodcock has superimposed more generalized contours on Aspinall's map and the map is included (Figure 15). The resulting map has replaced some of the stratigraphic and "crossline" biases with Woodcock's biases! This map still reflects the northeasterly trend, with low values in the southeast corner of the survey area, increasing to relatively high values in the northwestern area. In the lowermost outcrop area of Avalanche Creek (in the area of erratic drainage pattern) extending south from this to Wind Creek is a positive magnetic anomaly. This magnetic anomaly is about 300 meters wide and about 600 meters long. One might ask whether this is actually an anomaly with some specific underlying cause or whether it is merely a continuation of the high stratigraphic values of the north part of the surveyed area. Such a southwest continuation is interrupted by some complications (magnetic lows) in the lower reaches of Avalanche Creek and terminated sharply on the west against a fault (?) which lies along the side of the valley of Gladys River.

CONCLUSIONS AND RECOMMENDATIONS

The rock geochemistry and petrology have indicated anomalous fluorine and co-extensive biotite formation in hornfels over an area, about 1600 meters in diameter. Iron sulphides (pyrrhotite and pyrite in the more central zone) are also present although not in large amounts (0.5% to 1%). In this anomalous gossan-hornfels area and extending outward for at least another 500 meters, the limestone bands are silicated and highly anomalous in a number of metals.

Within the central part of the anomalous area is a zone, 700 meters in diameter, with more intense mineralization, including fluorine (> 2000 ppm), abundant secondary biotite in hornfels, some pyrite along fractures and some grey alteration selvages to some of the quartz veinlets. The lime silicate and massive sulphide bands and lenses within this central zone have extremely high metal values.

The anomalous metals in the main target and the outlying lime silicate bands, include Sn, W, F, As, Bi, Mo, Pb, Zn, Ag, Cu.

The biotite hornfels zone and its co-extensive fluorine anomally were formed by an underlying heat center (i.e. a stock). This stock is unroofed; the depth to its apex is unknown. However, one would expect better metal concentrations at its intrusive contact with the hornfels and with the limestone bands.

Four models for possible comparison are presented in Appendix I, including porphyry tin deposits, porphyry molybdenum deposits, a specific family of tungsten-tin-skarn deposits, and the Logjam tungsten-molybdenum deposit.

Porphyry related deposits, including the copper, the molybdenite, and the tin deposits and the Logjam tungsten-molybdenum deposit are associated with stock complexes which have diameters ranging from 500 meters to 1000 meters, averaging about 800 meters.

In contrast tungsten skarn deposits are associated with the contacts of much larger plutons. sometimes even small batholiths. The tungsten skarn deposits generally lie along these contacts, although they can be concentrated along silicated limy beds that lie a few hundred meters away from the contact. The plutons and the environment of the skarn deposits are not "juicy"; the extensive biotite hornfels zones with iron sulphides typical of porphyry deposits and the alteration and the restricted "heat center" are lacking. Therefore, although the metal mineralogy in the Avalanche Creek target are is suitable for this Russian type of tungsten-tin-skarn deposit (Model 3) other features are not typical.

Some of the characteristics at Avalanche Creek fit the tin model, especially the associated metals including silver and bismuth. However, the published descriptions of the porphyry tin deposits do not mention associated pyrite halos although I would suspect some pyrite is present. Moreover these descriptions do not mention the widespread biotite hornfels. The hydrothermal alteration associated with the porphyry tin deposit occurs within the stock. The stock is not exposed so no comparison of alteration can be made.

The prophyry-molybdenite model does in many aspects fit the Avalanche Creek picture. The similarities indicate widespread hornfels, the associated fluorine metasomatism, the associated tungsten and tin and some anomalous molybdenum values (i.e. the stream silts). However, the arsenic is not particularly characteristic of the stockwork molybdenite deposits; moreover stockwork molybdenite deposits generally have a much higher pyrite content in the iron sulphide halo near the ore zones.

The Logjam Creek model, which is essentially a molybdenite deposit with unusually rich tungsten halo, lower than normal iron pyrite content and somewhat lower than normal molybdenite content and abundant fluorine fits the Avalanche Creek picture remarkably well. Similarities include the high tungsten values, the other associated metals, the biotite hornfels zone and the tungsten-bearing skarn bands. Moreover both properties are in the same region.

The anomalous metal values within this large target area are outstanding, the center of this system has been pinpointed by

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the 1981 field work. It is now important to learn the metal content at the contact or apex of the interpreted underlying stock. Therefore, a deep drill hole (about 700 meters) is recommended.

The topography in this area precludes setting up a drill hole in many places; however, suitable locations are present, including the bench south of Avalanche Creek and the interfluve area between Avalanche and Outwash Creeks. A hole collared on the bench (between survey stations 31 and 32) and drilling along azimuth 45° and dip 65° would reach the center of the fluorine anomaly. The upper part of the hole would also intersect some of the enriched silicated limestone bands south of Avalanche Creek. Although this direction is not parallel to some of the observed bedding in the cherts and argillites, it is parallel to many of the limestone bands. Another possible drill site is in the vicinity of the Jennifer claim posts (Jennifer 3, 4, 5, 6) drilling with azimuth about 20° and dip 75° to 80°. Unfortunately this is parallel or sub-parallel to a main fracture system in the area. Both of these locations must be given further consideration. Potential campsites are present near both localities.

November 30, 1981

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Aspinall, C., October, 1973, Magnetometer Survey of the Wind, Storm, Jennifer, Line Mineral Claims, Avalanche Creek Area, Atlin Mining Division: Assessment Report 4912.

The work was done using a Jalander fluxgate magnetometer. The results are plotted on a map of the grid lines with magnetic contours trending northeasterly, parallel to the fractures and bedding.

Aspinall, C., January, 1973, Report on Geochemical Reconnaissance in the Gladys Valley Area between Mt. Llangorse and Line Lake, Atlin Mining Division: Assessment Report 4277.

For this survey of the mountains east of the Gladys River valley, 145 silt samples and 147 soil and talus samples were collected along traverses and along streams. Samples were analyzed in the Whitehorse laboratory of Bondar-Clegg Company Ltd. for copper and molybdenum. A large number were also analyzed for silver, lead, zinc and gold.

Aspinall, C., December, 1953, A Geochemical Report on the Avalanche Creek Area near Line Lake, Atlin Mining Division: Assessment Report 4910.

This report is accompanied by maps showing the soil geochemistry in the vicinity of Avalanche Creek and creeks to the south, with results presented for copper, lead, zinc, silver and molybdenum. Analytical work was done by the Whitehorse Laboratories of Bondar-Clegg Company Ltd.

Aspinall, C. and Conn, H.K., October, 1973, Reconnaissance Geology of the Wind, Storm, Jennifer Claims, Avalanche Creek Area, Atlin Mining Division: Assessment Report 4911.

This report describes the various coloured cherts and the intercalated limestone beds. The structure is discussed and assay results on some of the mineralized skarn zones are included.

Das Gupta, Udayan, November, 1978, Geological and Geochemical Assessment Work Report on the Rob Claims: Assessment Report 7281.

The Rob Claims are due east of the Avalanche Creek properties. The claims covered a U-Zn-Cu-Co-Hg-Mo anomaly of the G.S.C. release. The report gives the results of sampling at 16 sites along the streams.

Das Gupta, Udayan, August, 1978, Geological and Geochemical Assessment Report on the Hir Claim, Atlin Mining Division for Cominco Ltd.: Assessment Report 7285.

The Hir property, staked west of Line Lake, covered the unconformity between some tertiary flows and underlying gravels. It was explored for uranium. This report gives the results of analyses for stream samples from 8 locations.

LeRoy, L.W. and Conn, H.K., January, 1978, Supplemental Geochemical Report on the Jennifer, Storm, Wind, Mineral Claims, Avalanche Creek Area, Atlin Mining Division: Assessment Report 6615.

This report presents the uranium analyses from the soil samples collected in 1976 program. The authors conclude that the uranium results are low and that there is little potential for a uranium deposit. However, these uranium values do correlate with the molybdenum values in the soils.

LeRoy, L.W., October, 1976, Geochemical Report on the Jennifer, Storm, Wind, Line Mineral Claims, Avalanche Creek Area, Atlin Mining Division: Assessment Report 6128.

This report combines the results of all soil surveys carried out previously, including the results of the 1973 survey and the additional soil sampling done in 1976. It also includes the analytical work done on the same pulps in 1974 and 1976. Additional elements added to this prior geochemical data include tin, tungsten, fluorine, antimony, arsenic, bismuth, uranium, beryllium, boron, and manganese. Analytical work was done in a North Vancouver laboratory of Bondar-Clegg and Company Ltd.

Mulligan, Robert, November, 1976, The Geology of the Wind, Storm, Jennifer Mineral Claims, Avalanche Creek Area, Atlin Mining Division: Assessment Report 6127.

This report is concerned mainly with the geology and gives considerable descriptions of the cherts and of the scarn rocks. The work was done in conjunction with additional geochemical work by L.W. LeRoy.

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Woodcock, J.R., November, 1980, Avalanche Creek Project: A Report for Ranworth Explorations and Wm. McDonald.

This report describes a two-day orientation survey followed by petrography to determine any trends in the rock geochemistry and the alteration in the Avalanche Creek area.

A number of geochemical elements were tested; fluorine seemed to give the best trend. The biotite alteration in the hornfels also gave a trend which is somewhat similar to that of the fluorine.

APPENDIX I

MODELS FOR COMPARISON

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Porphyry Tin Model

The Bolivian Tin-Silver Belt includes two main types of tin deposits, the tin-tungsten deposits in the northern part (Cordillera Real), associated with batholithic intrusions and the tin-silver deposits of the central and southern parts of the belt, associated with sub-volcanic intrusions. The geological features of the southern sub-volcanic deposits posses similarities to porphyry copper deposits, although they diverge even more than do the porphyry molybdenite deposits from the classical porphyry-copper model. The data for this tin model is taken from the paper "Porphyry Tin Deposits in Bolivia" by R. H. Sillitoe, C. Halls and J. N. Grant, 1975 Economic Geology page 913-927. Although the following characteristics are taken from a number of the deposits, the Llallagua, the Potosi and the Oruro deposits are the main examples.

The stocks are multi-phase and commonly one to two square kilometers in area. They have the form of inverted cones rather than upright cylinders. For example, the Salvadora stock at Llallagua has dimensions of 1700 meters by 1000 meters at the surface but diminishes in cross-section downward to 1000 meters by 700 meters. Below this depth the walls appear to become vertical, and some authors have suggested that this vertical column will extend downward to the apex of a stock.

The stocks are sub-volcanic in character and are beneath the vent regions of volcanos. Coeval volcanics are preserved adjacent to several deposits. The stocks possess sharp contacts with their wall rocks, but contacts are complicated by dykes and sills projecting outward. The stocks were, emplaced passively, although local evidence of a forcefull component to intrusion is present in places. The intrusive rocks are highly altered; however, by comparison with dykes, they are thought to consist of quartz-latite porphyry.

Many of the stocks intrude sedimentary strata of the Silurian-Devonian age. The thermal metamorphic aureoles are narrow and not very high grade.

Hydrothermal intrusion breccia is commonly developed at the contact of the stock with the surrounding clastic sediments and is also prevalent within both the stock and its host rocks. The breccia occurs as irregular pipe-like bodies up to 50 meters across and as narrow dykes. Fragments are angular to sub-rounded and rounded and consist of porphyry or sedimentary rocks in all proportions. The matrix of the breccia consists of finely com-

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minuted porphyry and sedimentary rock. Brecciation spans the period of mineralization: the emplacement of economic amounts of cassiterite in the breccias was evidently synchronous with their final stages of emplacement; breccias containing fragments of pyrite with some cassiterite are seen at several localities; and pyrite veinlets and tin veins cut the breccias.

The quartz-latite porphyry and some sedimentary rocks, marginal to the stock, have been pervasively altered to sericite. The broad geometry of the alteration zone is not controlled by fractures or veins. This alteration has resulted in the conversion of the stock to an aggerate of quartz, sericite and tourmaline. Pyrite and cassiterite occur in a stockwork of multi-directional veinlets up to two centimeters wide and as disseminations in the altered rock. Pyrite is, at least locally, more widespread near the borders of the sericitic zone. In the main hydrothermal breccias alteration is predominantly to quartz and tourmaline. Chlorite has replaced mafics in porphyry dykes beyond the central zone of alteration.

Patches of silification also occur within the sericite zones. In some deposits a zone of fine-grained silication occurs near the Apex of the stock above the sericitized zone. The K-feldspar alteration found in porphyry molybdenite and many porphyry copper deposits is lacking.

Through going veins within peripheral to the stocks postdate the sericite alteration and the disseminated and stockwork tin mineralization. The veins are also later than the main period of brecciation. Several stages of mineralization occur in the lodes. In the early stages of mineralization, quartz, pyrite, cassiterite, arseno-pyrite and bismuthinite are formed. In subsequent stages stannite, sphalerite, and chalcopyrite are introduced. Subsequently tetrahedrite, sphalerite, siderite, and pyrite are introduced, followed by ruby silvers in some deposits, and finally hydrous phosphates or alunite and white clay are formed. In the marginal zones, pyrite occurs in the veins along with some sphalerite and barite.

Porphyry Molybdenite Model

Another model that one should consider is that of the stockwork molybdenite deposit within an argillite terrain. The main example for this model is the Kitsault Mine at Alice Arm with adaptations from other stock-related porphyry-molybdenite deposits.

The stock complex intrudes an area of argillaceous rocks and these are converted to chocolate-brown biotite hornfels for several hundred feet outward from the stock. Tract amounts of pyrrhotite are formed by this contact metamorphism. Adjacent to the stock and especially surrounding the molybdenite ore

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deposit, the biotite hornfels is bleached to a sericite-rich zone. This is especially evident as selvages along fractures, along pyrite veinlets and along some quartz veinlets.

The ore deposit occurs near the border and/or apex of the stock, generally coincident with the zone of sericite alteration and the outer parts of a zone of K-feldspar-quartz alteration. Underneath the umbrella-shaped ore deposit or inside of the ring of mineralization, the rock has been converted totally to K-feldspar plus quartz and this corresponds with the massive silica zones which underlie the Climax ore bodies in Colorado. Some clay or argillic alteration can occur in the outer parts of the sericitized zone; however, much of the clay alteration is relatively late stage and occurs in cross-cutting faults.

Metal zoning is particularly characteristic with the molybdenite' being central and with overlapping and successive halos of copper, pyrite, fluorine. Some of these associated elements, especially the fluorine, can be used to give trends toward the center of alteration and mineralization. This is very useful in exploring for buried ore deposits.

Other associated metals include lead, zinc, and bismuth which occur in late stage veins of carbonate or quartz. These occur within the ore zone, especially in the outer parts of the ore zone. By comparison with porphyry copper deposits these base metals are suppose to form a halo; however, this halo aspect is somewhat irregular and less definite in porphyry molybdenite deposits. Tungsten also is later than the molybdenite although it does occur before the lead and zinc phase. It forms another somewhat indefinite halo outside of the molybdenite zone.

Scarn Tin-Tungsten Model

Good examples of deposits of tin-tungsten in scarn are found in Russia and are described in the Russian literature. The Lost River deposits in Alaska are somewhat similar.

Batholithic plutons intrude dolostones or dolomitic limestones resulting in scarn alteration with associated tin and tungsten mineralization forming at the contact. Tin and tungsten mineralization can be associated with this scarn. The alteration and the mineralization are best developed in areas of increased fracturing or in irregularities and reentrances in the contact of the batholith.

Most of the descriptions describe dolomites and manganeseum scarns in which the associated tin mineralz include tin sulfides as well as cassiterite. Some of the Russian papers separate out scarn deposits which occur with limestones and limy shales, in which case most of the tin occurs in cassiterite associated

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with abundant magnetite.

Some of the papers assign the skarn formation to the magmatic (contact metamorphic) stage and some of the subsequent alteration and tin mineralization to a post-magmatic (hydrothermal) stage. Other papers refer both phases to post-magmatic stages. In this paper I will refer to the magmatic (contact metamorphic) and the subsequent hydrothermal stages.

In the magmatic stage a large variety of minerals may form including spinal diopside, forsterite, magnetite, periclase and garnet. Relic dolomite is also present.

The post-magmatic or hydrothermal stage of mineralization is divided, by some authors, into an early alkaline stage, an acid stage, and a late alkaline stage. The "early alkaline" stage is characterized by intensive fluorine-boron metasomatisim which transforms the early scarn minerals into phlogopite (mica), serpentine, humites, magnetite and ferromagnesian borates. The "acid" stage of mineralization is marked by the deposition of abundant fluorite and of disseminated cassiterite. Also, some of the Russian authors, attribute the superimposition of calcarious skarns to the acid stage of hydrothermal activity. During the late alkaline stage of mineralization, the phlogopite is partially hydrated.

These deposits are characterized by abundant boron in boro silicates (axinite), borates, etc. Tourmaline, a boron-bearing mineral common in the Bolivian deposits is not mentioned. Fluorine is also very abundant in the form of fluorite and in a number of silicated minerals. Tin occurs in some silicate minerals (garnet), in a number of boron minerals, as stannite, and especially as cassiterite. Other somewhat unique associated minerals include bismuth, bismuthinite, and arsenopyrite and some molybdenite. Other common associated minerals include sphalerite, pyrrhotite, pyrite, chalcopyrite, and galena.

Logjam Creek Tungsten-Molybdenum Deposit

The Logjam Creek deposit of Logtung Resources Ltd. lies on the British Columbia-Yukon boundary. The property was optioned by AMAX Minerals Exploration Ltd. and this company has conducted the large exploration programs. The following data has been taken from technical talks, short government publications and press releases of work done prior to 1980.

The deposit is southwest of the Cassiar Batholith and along the southwest side of Seagull Creek Batholith. The Seagull Creek Batholith is an unusual pluton, about 16 kilometers long and 11 kilometers wide. It is composed of granite characterized by numerous miarolitic cavities, by associated tourmaline, fluorite, topaz and arsenopyrite, and by associated tin-tungsten

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mineralization.

The Logjam Creek deposit is along the southwest side of the Seagull Creek Batholith where it is associated with a stock composed of biotite quartz-monzonite with slightly porphyritic, medium phaneritic texture. The stock contains miarolitic cavities, fluorite veinlets, quartz veinlets and smoky quartz. Aplite, porphyritic quartz-monzonite, and porphyritic alaskite dykes occur as off shoots.

This stock intrudes a host terrain consisting of Carboniferous sedimentary rocks and some diorite sills or dykes. The intrusions metamorphosed the sedimentary rocks, converting the argillaceous rocks to hornfels and the limy rocks to skarn.

There are three modes of mineralization. These include the porphyry system, the skarn mineralization, and late vein mineralization.

The main mineralization is essentially a tungsten-molybdenum porphyry system with scheelite and molybdenite in narrow quartz veinlets and also as fracture coatings. The most intense mineralization occurs in the stockwork of the porphyry, but similar mineralization also extends over a much larger area in large quartz veins. There is a definite zoning to the porphyry system. The core of it has some molybdenite and molybdo-scheelite. Outward from this central zone, there is a gradation to schellite of a pure variety, with the molybdenite falling off. On the fringes are still trace amounts of schellite; however, sphalerite and galena begin to appear. This porphyry center accounts for about 75% of the scheelite and 90% of the molybdenite reserves.

Skarn mineralization, which can fall outside of the central stockwork zone, consists largely of the molybdo-scheelite, either the yellow or the white variety. The molybdo-scheelite is generally with pyroxene-garnet skarn with a low sulphide content (1-2%). In 1978, it was estimated that the skarn would contribute about 10% of the total scheelite, but negligible amounts of molybdenite. There is also a base metal skarn which contains sphalerite, galena and some scheelite.

The third mode of mineralization includes the vein type, This is a strong set of parallel steeply-dipping quartz veins trending northeast and cutting right through the center of the stockwork. These are relatively young and cut the stockwork and also the felsic dykes. The veins are larger than the veinlets of the quartz stockwork, generally from 1 cm to 1 m in width. Many of them are pure quartz, but a large number contain a variety of minerals including pyrite, pyrrhotite, minor chalcopyrite, white scheelite, molybdenite, beryl, fluorite, bismuthinite, arsenopyrite, and galena. These quartz veins were estimated to contain 15% of the tungsten and 10% of the molybdenum.

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The porphyry zone of mineralization measures 700 meters in diameter and extends to a depth of over 300 meters. In a report published in September, 1980, AMAX had defined geological reserves of 163 million tons grading 0.1% WO_3 + 0.05% MoS_2, including a central zone within quartz feldspar porphyry which contains 27 million tons grading 0.1% MoS_2 and having a tungsten halo which averages 0.3% WO_3. Bench scale metallurgical tests on core samples indicated recovery of 80% of the scheelite and 85% of the molybdenite.