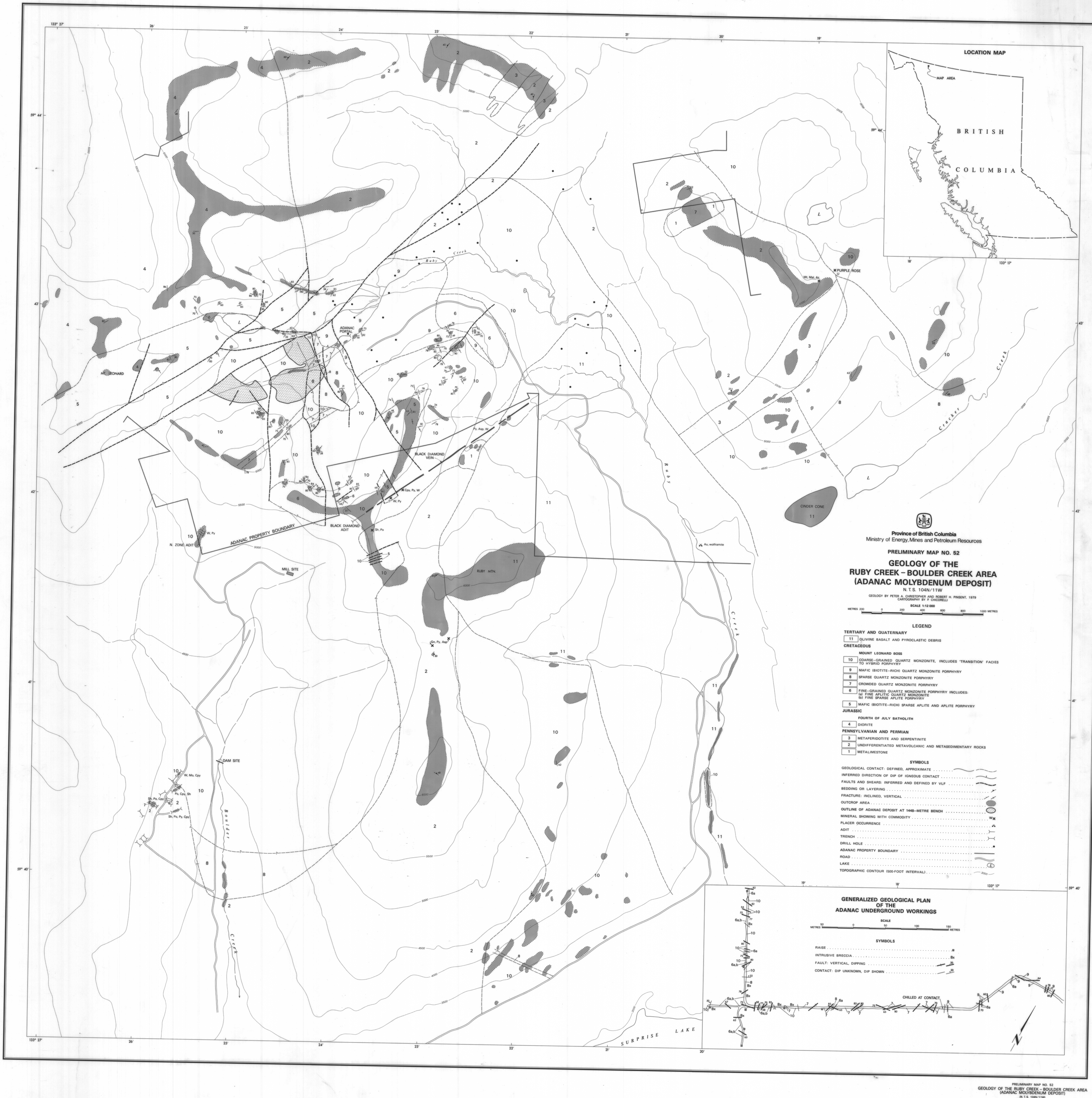

PRELIMINARY MAP NO. 52
GEOLOGY OF THE RUBY CREEK – BOULDER CREEK AREA
(ADANAC MOLYBDENUM DEPOSIT)
(N. T. S. 104N/11W)
ISSUED DECEMBER 1982

Province of British Columbia
Ministry of Energy, Mines and Petroleum Resources

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NOTES TO ACCOMPANY PRELIMINARY MAP 52

GEOLOGY OF THE RUBY CREEK AND BOULDER CREEK AREA NEAR ATLIN (104N/11W)

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INTRODUCTION

Geological mapping of the Ruby Creek and Boulder Creek area was undertaken in order to better define the setting of the Adanac porphyry molybdenum deposit. Surface and underground mapping was sponsored by the British Columbia Ministry of Energy, Mines and Petroleum Resources during a six-week period in the 1979 field season and by Placer Development Limited during their 1979, 1980, and 1981 exploration programs. The authors appreciate the cooperation and assistance of Placer Development Limited and Adanac Mining and Exploration Ltd. during field work and for allowing the use of private company data. The assistance and cooperation of the entire staff, especially Stuart Tennant and Richard Cannon is acknowledged. Doug Forster was a very capable field assistant during the 1979 field season. K/Ar age determination by Joe Harakal at the University of British Columbia Geochronology Laboratory helped define the geological setting.

LOCATION AND ACCESS

The map-area covers 70 square kilometres which includes Ruby Creek, Boulder Creek, Mount Leonard, and Ruby Mountain. The area is in the Atlin Mining Division in the northwestern part of British Columbia, approximately 40 kilometres northeast of the town of Atlin. The geodetic coordinates of the Adanac molybdenum deposit are latitude 59 degrees 43 minutes north and longitude 133 degrees 24 minutes west.

The area is reached from Atlin via a good gravel road to the Surprise Lake Bridge (19 kilometres) then secondary mining roads up Boulder and Ruby Creeks.

HISTORY

Placer mining on Boulder Creek dates back to 1899 and sporadic activity continued to the present time on both Ruby and Boulder Creeks. The recovery of minor amounts of tungsten and tin mineralization from the Boulder Creek placer operations in 1950 made this one of the few tin producing areas in British Columbia. Search for lode gold started shortly after the placer discoveries but to date only uneconomic veins have been located.

In 1942 Consolidated Mining and Smelting Company of Canada Limited explored wolframite showings in the Boulder Creek Valley. In 1950 Black Diamond Tungsten Limited acquired claims at the head of Boulder Creek and drove a 400-foot adit in 1951-1952 to explore what is now called the Black Diamond vein.

The Adanac molybdenum deposit was staked in 1967 by Adanac Mining and Exploration Ltd.; nearly 13 000 metres of diamond drilling was completed by 1970. During 1970-1971 Kerr Addison Mines Limited conducted an extensive drilling and underground bulk sampling program. Limited additional programs were carried out between 1971 and 1978 by Adanac Mining and Exploration Ltd., Noranda Exploration Company, Limited, and Climax Molybdenum Company. Placer Development Limited, who optioned the property in 1978, completed the additional exploration and development work necessary for Stage I and Stage II reports to be submitted to the British Columbia Ministry of Energy, Mines and Petroleum Resources.

The YKR tungsten property is situated south and west of Adanac. The old Black Diamond, Tungsten, Silver Diamond, and Bud properties are included in the present holdings of Yukon Revenue Mines Limited.

REGIONAL GEOLOGICAL SETTING

The map-area is situated in the Atlin Terrane, a structural division of the Intermontane Belt (Wheeler, *et al.*, 1972). The geology of this area has previously been studied by Aitken (1959), Sutherland Brown (1970), Janes (1971), and White, *et al.* (1976). The Surprise Lake batholith of Late Cretaceous age intrudes Cache Creek metamorphic rocks and Atlin ultramafic rocks of Pennsylvanian to Permian age, and Coast

Intrusions which have been assigned a Jurassic age (Aitken, 1959). Biotite K/Ar age for the Surprise Lake batholith range from 75.4±2.5 Ma (sampled by N. C. Carter) from the pegmatitic alaskite near Trout Lake, to 63.1±2.2 Ma (Christopher, *et al.*, 1972; revised age for PC15) from coarse-grained quartz monzonite on the Adanac property; the average value of six biotite K/Ar ages is 70.6±3.8 Ma. The westerly part of the Surprise Lake batholith, called the Mount Leonard boss, is separated by a pendant of Cache Creek rocks from the main batholith.

In the Ruby Creek drainage basin, a Tertiary olivine basalt stratovolcano and younger olivine basalt volcanic conelets and flows overlie auriferous gravels and granitic rocks of the batholith. Only the areal extent of these post-mineral rocks was determined.

The presence of grey or smoky quartz is characteristic of both the Mount Leonard boss and the entire Surprise Lake batholith. This grey colouration is related to the generally high uranium background of the Surprise Lake batholith (about 18 to 20 ppm, Pinsent, 1980, 1981). Geochemical data obtained from stream silt and water samples collected during the 1977 Uranium Reconnaissance Program demonstrate that the Surprise Lake batholith is anomalous in molybdenum, tin, tungsten, fluorine, and uranium.

LOCAL GEOLOGICAL SETTING

The bedrock geology of the Ruby Creek-Boulder Creek area is described in terms of 11 map units. The oldest rocks in the area are believed to be Permo-Pennsylvanian in age. They consist of crystalline limestone or skarn (unit 1) and undifferentiated metavolcanic or metasedimentary rocks (unit 2) of the Cache Creek Group, and serpentine or metaperidotite (unit 3) of the Atlin Intrusions. Metamorphic rocks generally strike northeasterly and dip westerly to the north of the Mount Leonard boss but have variable orientations southwest of it.

The Fourth of July batholith (unit 4) is a fairly uniform medium-grained biotite-hornblende diorite to granodiorite. This unit is generally fresh or weakly altered but contains minor quartz veining and aplitic dykelets near its contact with the Mount Leonard boss. The Atlin Ruffner silver-lead-zinc deposit, which is northwest of the map-area, is hosted by this unit.

The multiphase Mount Leonard boss is divided into six main units (5 through 10) that host the Adanac molybdenum deposit. The present writers expanded on Sutherland Brown's (1970) nomenclature and rock units. A post-mineral equigranular granite phase encountered at a depth of 412 metres in drill hole 1W-1N has not been seen in outcrop.

The various units generally represent textural and mineralogical varities of chemically similar units (Table 1). K/Ar ages (Table 2) of the various units also suggest a nearly coeval emplacement of the phases. Field relationships indicate that either the mafic quartz monzonite or the coarse-grained quartz monzonite is the oldest unit and the aplitic phases or the equigranular granite is the youngest phase.

Unit 5 (Mafic Sparse Aplite)

This unit is distinguished from other fine-grained quartz monzonite by higher biotite content and a mottled green colour. A sharp contact with unit 6 occurs just west of Molly Lake. Biotite appears to increase in this fine-grained phase near contacts with older metamorphic rocks.

Unit 6 (Fine-grained Quartz Monzonite)

Fine-grained quartz monzonite includes a variety of grey, aplitic, fine-grained equigranular and/or subporphyritic rocks. A gradation of equigranular to porphyritic varieties appears to occur. Crystallization of this rock type may have been controlled by fluid loss.

Unit 7 (Crowded Quartz Monzonite Porphyry)

Crowded quartz monzonite porphyry has an average of 60 per cent subhedral to euhedral plagioclase, orthoclase (perthite), quartz, and biotite phenocrysts. The matrix is commonly aphanitic or aplitic, but locally becomes medium grained and the unit would be mapped as a hybrid coarse-grained phase.

Unit 8 (Sparse Quartz Monzonite Porphyry)

Sparse quartz monzonite has similar mineralogy to crowded porphyry but carries between 10 to 30 per cent phenocrysts (2.0 to 6.0 millimetres). The matrix is brown aphanitic to fine grained or chilled (*see* Sutherland Brown, 1970, p. 31; plate showing phases 7 to 10).

TABLE 1. WHOLE ROCK ANALYSES* OF ADANAC ROCK TYPES (AGE DATED BY THE K/AR METHOD)

Weight per cent Oxide	22067 K/Ar-1 Coarse-grained Quartz Monzonite	22068 K/Ar-2 Equigranular Granite	22069 K/Ar-3 Sparse Porphyry	22070 K/Ar-4 Mafic Porphyry	22001 K/Ar-5 Diorite (Fourth of July)
SiO_2	73.47	75.80	75.76	73.10	56.88
Al_2O_3	13.44	13.29	13.19	14.58	19.36
Fe_2O_3	0.35	0.22	0.43	0.22	0.66
FeO	1.45	0.74	0.59	1.20	4.37
MgO	0.18	0.12	0.18	0.31	2.26
CaO	1.08	0.64	0.72	1.21	6.77
Na_2O	3.19	3.70	3.51	3.87	3.84
K_2O	4.96	4.54	4.86	4.03	2.91
TiO_2	0.21	0.15	0.16	0.17	0.83
MnO	0.03	0.04	0.03	0.05	0.10
H_2O	0.24	0.44	0.20	0.46	0.92
CO_2	0.22	0.07	0.07	0.07	0.10
P_2O_5	0.22	0.10	0.10	0.10	0.36
S	0.03	0.02	0.02	0.02	0.02
Total	99.07	99.87	99.82	99.39	99.37
Trace Elements (ppm)					
U	14	36	29	22	7
Th	23	30	39	28	3
Sn	75	49	58	94	-
W	6	24	25	31	-
Zr	185	113	108	108	-
Rb	194	200	240	194	-
Sr	75	49	58	94	-
Li	25	35	29	44	-
As	6	3	4	28	-

*Analyses by B.C. Ministry of Energy, Mines and Petroleum Resources Laboratory, Victoria; see Aitken (1959) and White et al. (1976) for additional data.

TABLE 2. K/AR AGES FROM THE SURPRISE LAKE BATHOLITH

Reference Number	Mineral Dated	Rock Type	Location	K per cent	Rad. Ar^{40} per cent	Apparent Age (Ma)
18751M	Biotite	Coarse Alaskite	West of Trout Lake	7.44±0.05	93.9	75.4±2.5
PC 15	Biotite	Coarse Quartz Monzonite	Mt. Leonard Boss Adanac	5.16±0.04	89.1	63.1±2.2
A-KAR-1	Biotite	Coarse Quartz Monzonite	DDH 36W 4N 500-600'	6.78±0.06	89.9	71.6±2.2
A-KAR-2	Biotite	Granite	DDH 1W 1N 2750-2850'	6.72±0.06	86.9	71.4±2.1
A-KAR-3	Biotite	Sparse Porphyry	DDH 1W 1N 440-500'	6.31±0.05	83.6	71.6±2.1
A-KAR-4	Biotite	Mafic Quartz Monzonite	DDH 4N 20E 242-251'	6.53±0.06	94.1	70.3±2.4
A-KAR-5	Biotite Hornblende	Granodiorite	Northeast of Molly Lake 500'	7.06±0.10 0.644±0.007	92.2 67.8	73.3±2.6 110±4

Unit 9 (Mafic Quartz Monzonite Porphyry)

Mafic quartz monzonite porphyry is a distinctive grey rock characterized by disseminated fine biotite, chalky white plagioclase phenocrysts, and a seriate texture. The ragged feldspar and rare quartz phenocrysts (6.0 to 10.0 millimetres) lie in a finer (1.0 to 4.0-millimetre) quartz monzonite matrix. Nearly 5 per cent biotite is dusted through the matrix. The rock is significantly more biotite-rich than any of the other phases. It was called granodiorite by Janes (1971) and quartz monzonite porphyry by Sutherland Brown (1970).

Unit 10 (Coarse-grained Quartz Monzonite)

This unit, called coarse alaskite by Sutherland Brown (1970) and coarse granite by White, *et al.*, (1976), is the most common rock type in both the Surprise Lake batholith and the Mount Leonard boss. It is weakly to moderately deformed and granulated and consists of pink to grey, equigranular, coarse-grained (0.5 to 3.0 centimetres) quartz monzonite. The rock consists of approximately equal amounts of perthitic potassium feldspar, intermediate plagioclase, and grey quartz. Much of the feldspar is seriate and there is commonly a small amount of fine-grained (2 to 4-millimetre) matrix. With increased abundance of matrix, the unit has been called 'transition' or 'hybrid.'

Olivine basalt (unit 11) of at least two ages was recognized by Aitken (1959). The stratified mass that forms Ruby Mountain is considered to be older than columnar lava flows that wall Ruby Creek. The younger basalts may be related to the conelet mapped at the head of Cracker Creek. Altered late-stage mafic dykes exposed in the Adanac adit may also be related to this unit.

STRUCTURE

The Adera fault zone is bounded by the Molly Lake fault on the west and the Adera fault on the east. It has many connecting splays and forms the northern boundary of the Adanac deposit. Between Molly Lake and Ruby Creek (White, *et al.*, 1976) the zone strikes north 65 degrees east and dips 80 degrees to the northwest. Geophysical surveys (EM and magnetic) by Richard Cannon, diamond drilling for the proposed dam site, and mapping indicate a strike of north 45 degress east for the eastern extension of the Adera fault. A dyke of crowded porphyry and the Black Diamond vein occupy structures which are subparallel to the Adera fault zone.

About 500 fracture measurements were used by White, *et al.* (1976) to define four principal trends: 36 degrees/82 degrees southeast, 330 degrees to 345 degrees/70 degrees to 80 degrees southwest, 83 degrees/77 degrees northwest, and nearly horizontal. Molybdenum veins occur in the nearly horizontal and 36-degree structures. Trends of 265 veins measured in the underground workings confirm that many mineralized veins are nearly horizontal and that a lesser number strike northeastward. However, the workings also cut mineralized east-west structures with nearly vertical dips. Similarly, analysis of 171 barren fractures showed strong 25 degrees/75 degrees northwest, 355 degrees/nearly vertical, and east-west/near vertical trends. Both studies illuminate the key role that nearly horizontal fractures play in producing ore grade molybdenite mineralization.

MINERALIZATION

Adanac Molybdenum Deposit

Molybdenum mineralization occurs in all phases of the Mount Leonard boss, except the post-mineral equigranular granite. The 1 448-metre bench outline shows a doughnut-shaped mineralized body of greater than 0.06 per cent molybdenum that has been truncated by the Adera fault. The mineralized zone occurs mainly in coarse-grained quartz monzonite and fine-grained quartz monzonite that form a trough-like structure around a weakly mineralized sparse quartz monzonite porphyry core (the Ruby Creek stock of White, *et al.*, 1976). An intrusive breccia body in the axis of the mineralized trough is well exposed in the underground workings.

Molybdenite occurs mainly as fracture coatings and in quartz veins. The modes of occurrence are:

(1) rosettes in smoky quartz veins
(2) fine-grained fracture coatings with quartz envelopes
(3) quartz-pyrite-molybdenite±carbonate veins
(4) molybdenite gouge on fault surfaces
(5) molybdenite-bearing quartz veins with potassium feldspar and/or biotite envelopes
(6) quartz-molybdenite-fluorite-potassium feldspar±biotite veins

Other vein and fracture types include:

(1) quartz veins
(2) fracture coatings of pyrite with rare chalcopyrite and copper carbonates
(3) pyrite-bearing quartz veins with rare chalcopyrite and copper carbonates
(4) quartz, calcite, and chalcopyrite veins
(5) potassium feldspar and/or biotite veins
(6) quartz, wolframite, arsenopyrite, scheelite, and fluorite veins
(7) fluorite, quartz, and pyrite veins
(8) carbonate veins

Chalcopyrite is rare within the deposit; pyrite is less than 1 per cent and is restricted to veins and fractures. Examination of the adit area east of the deposit confirms the existence of pyrite. However, pyrite is equally abundant within the molybdenum deposit and no obvious pyrite halo was identified. The density of fluorite-bearing veins appears to increase in the fine-grained 'core' in the adit but regional rock geochemical studies show a fluorine halo around the deposit. Only one quartz-wolframite vein was identified in drill core from the northern margin of the deposit. However, quartz-wolframite-arsenopyrite veins and breccia zones are more common in the peripheral areas.

The Stage II report submitted to the British Columbia government suggests a deposit with open pit mineable reserves of 151 971 000 tonnes of 0.063 per cent molybdenum with a 1.47 to 1 waste to ore stripping ratio.

Hydrothermal Alteration

The Adanac deposit lacks strong zonal alteration. The principal pervasive alteration consists of late chloritization of both biotite and feldspar, accompanied by minor sericite, clay, and carbonate alteration of feldspar. Locally, orthoclase develops peripheral to fractures, and silicification may extend a few centimetres beyond vein boundaries.

YKR PROSPECT

The YKR tungsten property is situated south and west of Adanac. It covers parts of the southerly contact between the Mount Leonard boss and Cache Creek metasedimentary rocks. The vein tungsten, contact skarn, and porphyry potential of the property is presently being examined. Vein mineralization occurs mainly in the granitic rocks but has also been found in the contact zone. The Black Diamond vein can be traced about 4 kilometres from near the Ruby Creek Valley, where it strikes north 70 degrees east, to Boulder Creek where the strike is about north 50 degrees east. Veins consist of quartz, muscovite, arsenopyrite, and wolframite, with minor amounts of chalcopyrite, scheelite, molybdenite, cassiterite, fluorite, and gold. Diopside-tremolite-garnet skarn occurs in pendants in the stock and in contact metamorphosed Cache Creek rocks. The skarn carries pyrrhotite, pyrite, chalcopyrite, scheelite, wolframite, tetrahedrite, sphalerite, and fluorite. Bismuthinite ($PbBi_2S_4$) and possible tetradymite ($BiTe_2S$) were reported by Schroeter (1979). Assays of up to 0.2 per cent tin have also been reported from the skarn occurrences.

URANIUM

Secondary uranium minerls, generally kasolite or zeunerite, occur in quartz veins or breccia zones with arsenopyrite, fluorite, tetrahedrite, chalcopyrite, and wolframite. Zeunerite has also been reported from the Black Diamond vein and the Purple Rose prospect.

More than 3 000 geochemical analyses of rocks from the Adanac deposit area indicate an average value of between 18 ppm and 20 ppm uranium. Values increased from about 13 ppm to 24 ppm as the phases evolved. No significant concentrations of uranium occur in the area of the Adanac deposit.

Eight holes were drilled by Cominco Ltd. to test for secondary uranium mineralization in paleostream sediments capped by olivine basalt flows on the Vol claim group between Boulder and Ruby Creeks. No significant uranium concentration was detected.

DISCUSSION

The Adanac molybdenum deposit occurs in the Mount Leonard boss, a composite quartz monzonite to granite stock, which is peripheral and probably related to the main body of the Surprise Lake batholith. The Mount Leonard boss and the Adanac deposit formed during a protracted Late Cretaceous (about 71 Ma by biotite K/Ar dating) intrusive and mineralizing event. Mineralization was localized in a trough-like structure that formed around the cupola of a sparse quartz monzonite porphyry intrusive. Intersecting north-south, east-west, and northeast structures controlled the location.

The Adanac area differs from other parts of the Surprise Lake batholith in that there are finer grained phases which probably reflect rapid crystallization due to fluid loss. Release of pressure in the magma chamber resulted in reduced vertical pressure and horizontal fractures formed in the cupola area. Ore grade mineralization occurs where mineralized horizontal fractures coincides with mineralized north-south and east-west structures. Late movement along the Adera fault zone truncated the deposit on the northwest.

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