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ASSESSMENT REPORT

GEOLOGICAL STRUCTURE AND ALTERATION STUDY of the POP, MOM, CHIEF, GLEE, TECH, BERG, STEN MIL Claims

Whitehorse Mining District, Yukon Territory, Canada

NTS 105D/3
60°11'N
135°17'W

094337

for

TAGISH LAKE GOLD CORP.
2130-21331 Gordon Way
Richmond, BC V6B 2W5

by

Christopher O. Naas, P.Geo.
CME Consulting Ltd.
February 28, 2003

This report has been examined by
the Geological Ev[illegible] Unit
under Se[illegible] Quartz
Mini[illegible]s
representation work in the amount
of $ 19,000.

M.B[illegible]

for Regional Manager, Exploration and
Geological Services for Commissioner
[illegible]

[illegible] associated with [illegible]
approved in the amount of $ 19,300.00
for assessment credit under Certificate of
Work No. QW27606

[illegible signature]

[illegible] Recorder
Whitehorse Mining District

SUMMARY

A detailed geological structure and alteration study was undertaken during July 2002 on the Skukum Property, located in the Wheaton River district of the southern Yukon Territory. The study focussed on the Skukum Creek, Chieftain Hill and Goddell areas of the property.

The principal objectives of the study included: improved understanding of the structural and hydrothermal setting of veins in the Skukum Creek, Chieftain Hill and Goddell Gully areas; detailed structural evaluation of the veins; detailed field and petrographic evaluation of alteration characteristics with emphases on zoning patterns, ore mineralogy, and the controls on Au and Ag distribution, and; recommendations for exploration target areas, geological, geochemical and geophysical exploration methods, and any further geological studies that might have exploration application.

Work undertaken to achieve the objectives included: examination of reports, data, drill core and underground workings; reconnaissance mapping and measurement of structural features in the underground workings; rapid, semi-detailed logging of structural and alteration characteristics in selected drill holes; collection and photographic documentation of representative and selected hand samples; preparation and optical petrography on 57 polished thin sections, and ; SEM examination of 26 polished thin sections.

Results of the study indicate the inferred structural setting of the Skukum Property is an Eocene left lateral strike slip fault system with a reverse, south side up component. This mineralization occurs either in the dilational northeast-trending structures, as at Skukum Creek, or in the main faults near northeast-trending splays, within this area of high structural permeability.

Hydrothermal characteristics follow a similar theme across the district. Main alteration types include pervasive and fracture-controlled K-feldspar, sericite, chlorite, epidote and carbonate assemblages. Gold-silver and base metal mineralization are related to quartz-sulphide veins of initially extensional character subsequently deformed during movement on controlling structures, but is also disseminated and on micro-fractures. The relative importance of the hydrothermal assemblages varies across the district.

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1.0 INTRODUCTION

The following report has been prepared on behalf of Tagish Lake Gold Corp. (TLG) for fulfillment of assessment requirements on the POP, MOM, GLEE, CHIEF, TECH, BERG, STEN and MIL Quartz Claims in the Whitehorse Mining District of the Yukon Territory.

Abbreviations and conversion factors are presented in Appendix I.

2.0 PROPERTY DESCRIPTION

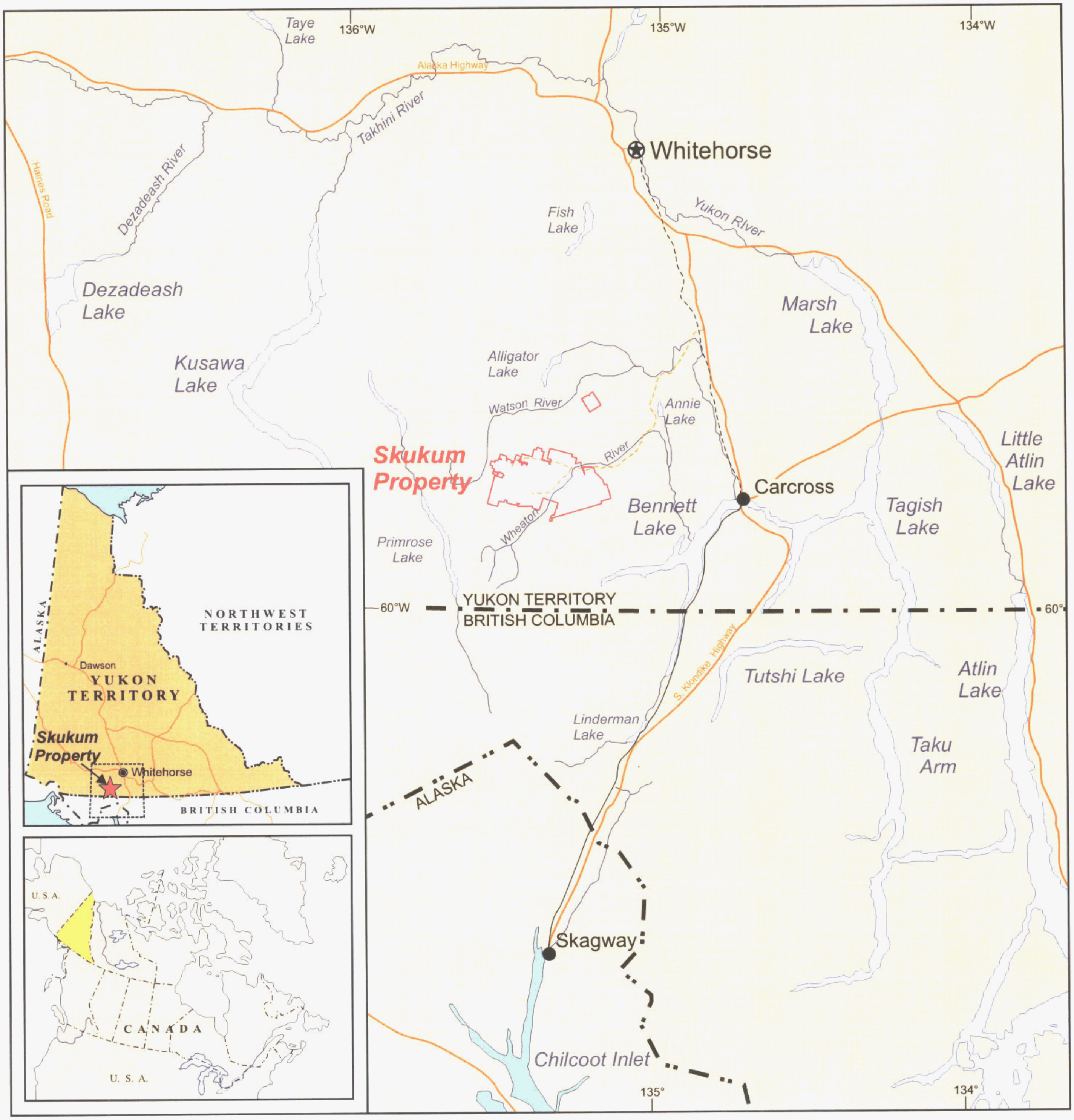
2.1 LOCATION AND ACCESS

The Skukum property ("the Property") is located within the Whitehorse Mining District in southwestern Yukon Territory, approximately 80 kilometres south of Whitehorse (Figure 1). The property is centred at approximately 60°10'N latitude and 135°30'W longitude within NTS map sheet 105D/3.

The Property can be accessed by all-weather road from Whitehorse. Road access from Whitehorse is gained by travelling southeastward on the Alaska Highway for 19 kilometres to Carcross Corner, then south on the South Klondike Highway a further 22 kilometres to the Annie Lake turnoff. The 28 kilometre Annie Lake road is a government-maintained 2 lane gravel road that heads west to the Wheaton River. From the Wheaton River crossing, a 4-wheel drive non-maintained gravel road continues southwestward to the Property and on to the TLG trailer camp. The trailer camp is located in the north-central portion of the Property, from which numerous roads and trails provide final access to the individual deposits and showings.

As of the date of this report, the Becker Creek, Wheaton River (second crossing), and Skukum Creek crossings have been repaired. Butte Creek crossing has still not been repaired but can be easily forded by truck.

Alternately, the Property can be reached by helicopter from Whitehorse airport, which is 65 kilometres to the north-northwest of the Property.



TAGISH LAKE GOLD CORP.

LOCATION MAP

Skukum Project
Whitehorse M.D., Yukon Territory, Canada

Project No:	CP56B	By:	NH
Scale:	1:1,000,000	Drawn:	TV
Figure:	1	Date:	February 2003

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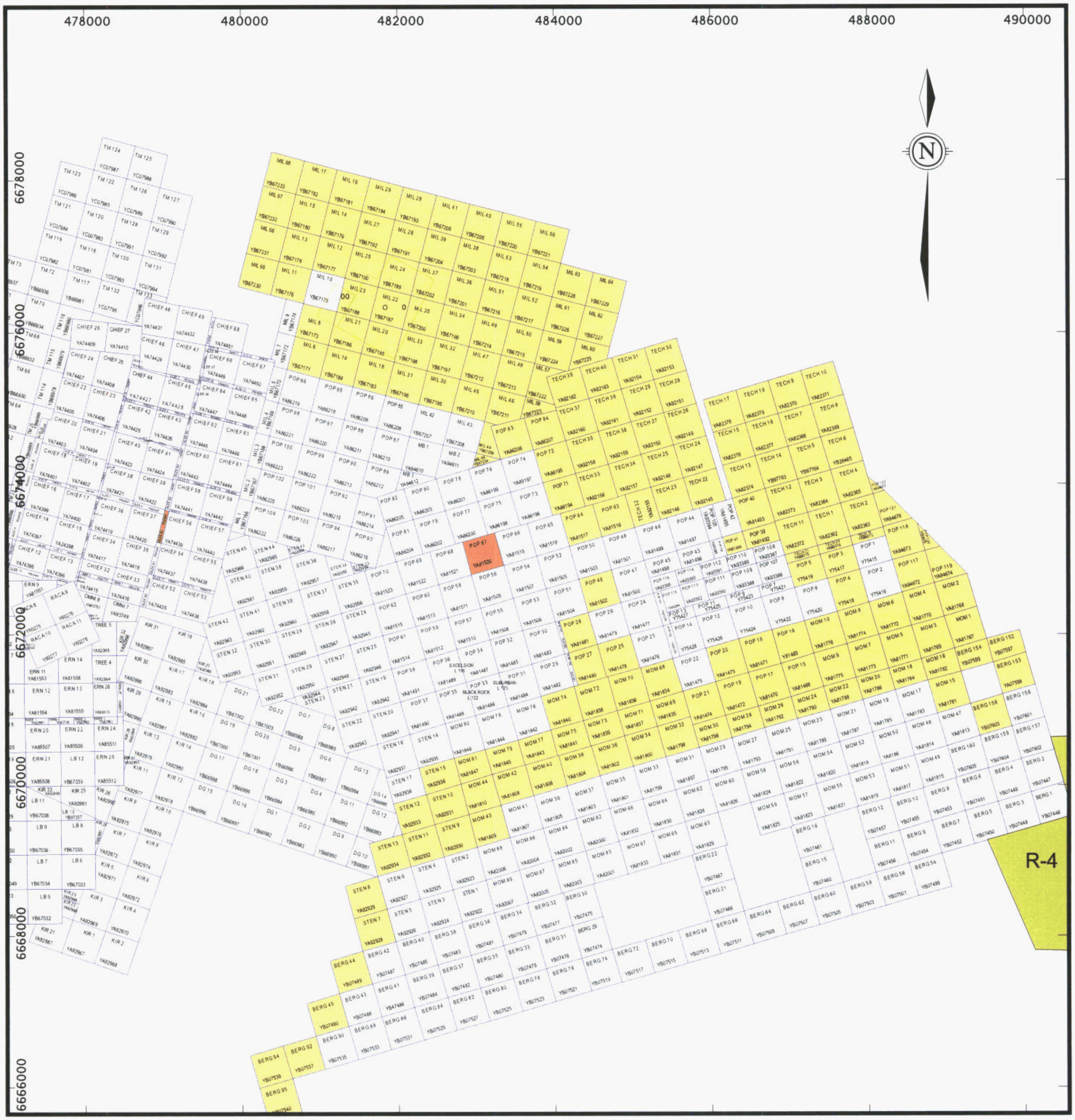
2.2 TITLE

All Quartz Mineral claims covered by this assessment report are summarized in Table 1. A map of the claims is presented in Figure 2.

Table 1: Claim Data

Claim Name	Claim Number(s)	Grant Number(s)	Owner	% Ownership
POP	3-5	Y75417-Y75419	TLG	100
	15-21	YA81468-YA81474	TLG	100
	25	YA81478	TLG	100
	27-28	YA81480-YA81481	TLG	100
	39-41	YA51492-YA81494	TLG	100
	49	YA81502	TLG	100
	63-64	YA81516-YA81517	TLG	100
	71-72	YA86194-YA86195	TLG	100
	83-84	YA86206-YA86207	TLG	100
	117-122	YA94672-YA94677	TLG	100
MOM	1-10	YA81767-YA81776	TLG	100
	15-16	YA81781-YA81782	TLG	100
	18	YA81784	TLG	100
	20	YA81786	TLG	100
	22	YA81788	TLG	100
	24	YA81790	TLG	100
	26	YA81792	TLG	100
	28	YA81794	TLG	100
	30	YA81796	TLG	100
	32	YA81798	TLG	100
	34	YA81800	TLG	100
	36	YA81802	TLG	100
	38	YA81804	TLG	100
	40	YA81806	TLG	100
	42-44	YA81808-YA81810	TLG	100
	68-75	YA81834-YA81841	TLG	100
	77	YA81843	TLG	100
	79	YA81845	TLG	100
	81	YA81847	TLG	100
TECH	1-4	YA82362-YA82365	TLG	100
	7-13	YA82368-YA82374	TLG	100
	15-18	YA82376-YA82379	TLG	100
	19-21	YA86013-YA86015	TLG	100
	22-40	YA92145-YA92163	TLG	100
	6	YB26465	TLG	100
	14	YB97763	TLG	100
	5	YB97764	TLG	100
STEN	7-13	YA92928-YA92934	TLG	100
	15	YA92936	TLG	100
BERG	44-45	YB07489-YB07490	TLG	100
	94-95	YB07539-YB07540	TLG	100
	152-154	YB07597-YB07599	TLG	100
	158	YB07603	TLG	100
MIL	6	YB67171	TLG	100
	8	YB67173	TLG	100
	11-22	YB67176-YB67187	TLG	100
	24-69	YB67189-YB67234	TLG	100



LEGEND

POP 67 YA81520 Skukum Property work claim

BERG 95 YB07540 Skukum Property assessment claim

BERG 90 YB07535 Other Skukum Property claim

First Nation staking reserve (Carcross-Tagish)

Surface lease (Mt. Skukum mill and tailings site)

0 2km

UTM Zone 8 North
NTS 105D/3

TAGISH LAKE GOLD CORP.

CLAIM MAP
SKUKUM PROPERTY

Skukum Project
Whitehorse M.D., Yukon Territory, Canada

Project No:	CP56B	By:	W.M.R.
Scale:	1:75,000	Drawn:	TV
Figure:	2	Date:	February 2003

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3.0 STRUCTURE AND ALTERATION STUDY

A detailed structural and alteration study on the Skukum Creek, Chieftain Hill and Goddell areas, with particular emphasis on relationship to mineralization was undertaken in July, 2002 by Dr. James Lang and Mr. David Rhys.

The principal objectives of the study included:

- An improved understanding of the structural and hydrothermal setting of veins in the Skukum Creek, Chieftain Hill and Goddell Gully areas.
- Detailed structural evaluation of the veins, with particular emphasis on the relationship of the Sterling zone and Ridge Zone 2 to the principal mineralized structures.
- Detailed field and petrographic evaluation of alteration characteristics with emphases on zoning patterns, ore mineralogy, and the controls on Au and Ag distribution.
- Recommendations for exploration target areas, geological, geochemical and geophysical exploration methods, and any further geological studies that might have exploration application.

Work undertaken to achieve the objectives included:

- Examination of reports, data, drill core and underground workings for 14 days in the field by both authors, and discussions with the project geologists.
- Reconnaissance mapping and measurement of structural features in the underground workings.
- Rapid, semi-detailed logging of structural and alteration characteristics in numerous selected drill holes, including several magnetic susceptibility traverses.
- Collection and photographic documentation of representative and selected hand samples.
- Preparation and optical petrography on 57 polished thin sections.
- SEM examination of 26 polished thin sections to verify and expand mineralogical and textural interpretation.
- Preparation of report.

For purposes of this assessment report, only work undertaken on the Chieftain Hill and Goddell areas has been applied to the renewal of claims listed in Table 1, therefore the portions of the report concerning the Chieftain Hill and Goddell areas have been summarized below. The complete report is presented in Appendix II.

3.1 CHIEFTAIN HILL AREA

The Chieftain Hill area is underlain by a series of parallel, east-trending and steeply-dipping quartz-sulphide veins and shear zones that are hosted by portions of the Cretaceous Mt. Ward granite, a medium-grained biotite granite that forms part of the Mt. McIntyre plutonic suite (Hart and Radloff 1990). The veins occur principally on the south and north slopes of Morning Gulch, on the eastern, lower slopes of Chieftain Hill. The veins occur east of the Chieftain Hill fault system, which forms multiple strands that locally separate the granite from Upper Jurassic and Eocene intermediate volcanic rocks to the north and west. Only the stibnite-rich Evening vein occurs northwest of the fault system (INAC, 1992). The Chieftain Hill veins are mainly parallel to, and often spatially associated with, numerous east-trending rhyolite and andesite dykes that intrude the host granite.

Structure

The most significant vein system in the Chieftain Hill area is the Ocean vein system, which is more appropriately termed a shear zone. The structure has been traced in surface trenches and drill holes for approximately 900 metres along strike, from its western end in the Chieftain fault system to the east into the Wheaton River valley. The shear zone comprises a distributed, anastomosing, semi-brittle structure that varies from 3 to 15 metres in true thickness in the holes examined. It generally comprises one or more foliated cataclasites 0.3 to 3 metres thick with dark grey matrices that occur within foliated, sericite-altered granodiorite with multiple narrow slip surfaces and dark grey, sulphide-bearing stylolitic pressure solution seams that define a spaced foliation. Like their counterparts in the Skukum Creek zones, the cataclasites typically contain altered wallrock and quartz-sulphide vein fragments. Although oblique foliations and other kinematic indicators are visible in the drill core, it is not possible to determine the shear sense because the split core could not be re-oriented.

Rhyolite dykes, often flow-banded, are common within or on the margins of the shear zone, and are locally affected by shear zone foliation. Rhyolite also occurs as fragments in cataclastic breccia. Rare polylithic breccia comparable to those at Skukum Creek is also spatially associated with the dykes.

Grey quartz-sulphide veins occur as lenses within the shear zone. The veins are composed of highly fractured grey quartz with numerous stylolitic pressure solution surfaces, fractures and shear zone slip surfaces that contain fine-grained sulphides. Dark grey quartz-sulphide matrix breccia occurs locally. In western portions of the shear zones, veins locally make up much of the shear zone width, and individual veins may range up to approximately 5 metres in true thickness. Narrower veins generally less than 0.5 metres thick are more typical of the eastern parts of the Ocean shear zone tested by holes OC97-1 to OC97-5. Multiple veins may occur across the width of the shear zone in any location.

Clay gouge seams overprint the shear zone fabrics, veins and cataclasites and record late, post-mineral brittle displacement along the shear zone. Narrow intervals of the Ocean shear zone and veins in drill core (<3 metres) commonly contain abundant gouge, which suggests possible thinning of the shear zone by late faulting in these areas.

Other veins in the Chieftain Hill area include the Johnny B and Better B veins located to the south of the Ocean shear zone, and the Morning, Evening and Pristine veins, located upslope to the north. Individual veins have been traced for up to 200 metres along strike, principally in outcrop, but are generally open into areas lacking exposure. All are generally less than 0.6 metres wide, although they locally range to >1 metres thick. Maps made by Mt. Skukum Mines geologists indicate that east strikes with steep dips predominate, except for the Pristine vein which is a minor structure that strikes north. A brief examination of drill core through several of these veins indicates that they are either extensional veins that lack associated shear zones, or that they are bounded by narrow, minor shear zones. Apart from the Evening vein located to the northwest, the east-trending veins may terminate westward in strands of the northeast-trending Chieftain Hill fault system, from which they may emanate. The veins are parallel to, and often closely associated with, rhyolite and andesite dykes.

Alteration

The Ocean vein was examined in two polished thin sections. Other veins in the Chieftain Hill area were not sampled for petrography. Only a brief summary of the significant hydrothermal features of the Ocean vein are provided below in light of the limited available observations and data.

a) Patterns of alteration and mineralization are typical of those described from veins at Ridge, Rainbow and Goddell but, much like Rainbow East, combine characteristics of the two areas;
b) Host rock is Mt Ward granite, which is strongly bleached within tens of metres of the vein;
c) Alteration in the host rock includes possible pervasive silicification, but is mostly a pervasive quartz-sericite-(carbonate) assemblage with minor (<0.5%) but variable pyrite and trace rutile. Additional pyrite is commonly present on narrow sericite-carbonate veinlets that cut the pervasive alteration (but which could be temporally related to it); and
d) Chlorite with local concentrations of carbonate is common as pervasive alteration and in shears peripheral to mineralized zones in the intrusive host rock. Chlorite yields to sericite as the main alteration phase as the veins are approached. Pyrite concentration is commonly higher in the areas with chlorite than in areas with only or predominantly sericite. Epidote is locally present in minor concentrations on fractures peripheral to the ore zones. Chloritic alteration extends at least 50 metres from the veins.

Mineralization

The following observations of mineralization of the Chieftain Hill area veins are based on the polished section descriptions of the Ocean Vein:

a) Most mineralization occurs in a quartz-sulphide extension vein that was subsequently sheared and brecciated. Early sulphides are arsenopyrite (non-acicular) and pyrite, and possibly sphalerite (with chalcopyrite disease, and light colour indicating low Fe concentration).
b) Much of the sulphide mineralization is related to a later stage of fine-grained quartz with minor carbonate that replaces and brecciates the early coarse-grained extensional quartz, pyrite, arsenopyrite, and locally some of the sphalerite. Ore minerals in this later stage include freibergite, galena, minor stibnite, and trace inclusions of native bismuth in galena.
c) Ore minerals have typical temporal relationships, with early brecciated pyrite and arsenopyrite replaced by other sulphide minerals including freibergite and galena.
d) Silver is probably hosted almost exclusively in freibergite. No native gold or electrum was observed, but the absence of acicular arsenopyrite and/or arsenian pyrite suggests that they are probably the principal form taken by gold. There are, however, several notations in old drill logs that suggest the presence of minor amounts of acicular arsenopyrite.
e) Quartz-sulphide extension veins are found peripheral to the main ore zones, but in low densities.

3.2 GODDELL AREA

Mineralization at Goddell Gully has been intersected in numerous drill holes and surface exposures over a strike length of at least 500 metres along the trace of the Goddell fault on the east side of the Wheaton River valley. The principal host rock to mineralization is the Carbon Hill quartz monzonite (INAC, 1992; see section 3.2.1), and several generations of dykes that cut the quartz monzonite and which are spatially related to the fault system including:

a) east-trending rhyolite dykes of at least three textural varieties that are parallel to, and localized within, the fault system (see section 3.2.2 for dyke descriptions); and
b) a sheeted set of west-northwest trending, subvertical to steeply southeast-dipping andesite dykes that trend obliquely to the southeast from the Goddell fault. Crosscutting relationships indicate that the rhyolite dykes are younger than the andesite dyke swarm (Coster 1988).

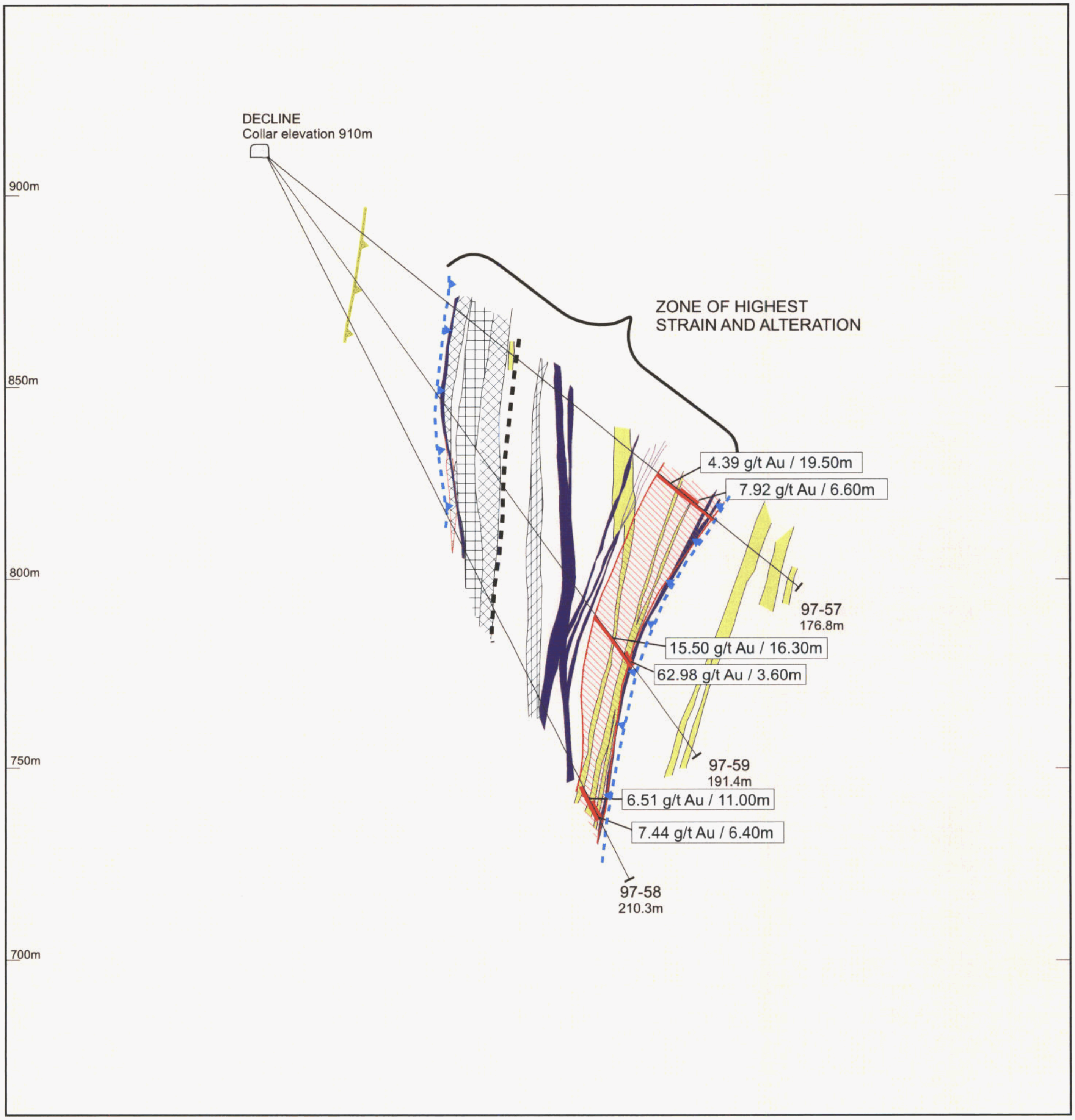
Structure

Within the Goddell Gully area, the Goddell fault system forms a prominent gossanous lineament that defines the main part of the gully. Like the shear zones in the Skukum Creek area, the Goddell fault system is a heterogeneous zone of braided, anastomosing shear zones dominated by lithified, foliated cataclastic breccias and phyllitic shear zone strands, and by spatially associated rhyolite and andesite dykes. Mapping and diamond drilling indicate an east-southeast strike and subvertical to steep south dip to the main fault system and rhyolite dykes. The fault system typically consists of multiple discrete zones of foliated cataclasite that vary widely from <0.1 up to 5 metres thick developed over widths of 20 to 150 metres that define a wide but distributed shear zone. The core of the fault system, which contains the thickest, master cataclasite and shear zone strands, is typically 5 to 30 metres wide and occurs along the southern part, or immediately south of, the set of rhyolite dykes (Figure 3). This core area typically grades outward into a broad damage zone that contains common minor cataclastic zones, numerous slip surfaces, and areas of spaced pressure solution cleavage development. The widest exposure of the fault system and its associated damage zone are at or near the surface, where exposures and drill intercepts of the fault system occur in both Goddell and Golden Tusk gullies over a width of almost 200 metres.

In the PD zone, which was drilled from underground, the main shear zone strands also occur principally along the southern portion of the sheeted rhyolite dyke swarm. The fault system and its associated damage zone here are 40 to 90 metres wide, and consistently widen upward as splays off the south side extend off the main core of cataclastic fault surfaces (Figure 3). Intervening quartz monzonite between cataclastic surfaces is affected by numerous minor slip surfaces filled with green sericite and anastamosing, spaced pressure solution seams. These define an irregular, spaced foliation that reflects the damage zone of the fault system, which in turn corresponds to the area of most strongly developed green sericite alteration.

Cataclasites define the main surfaces of fault movement in the structure and are dark grey and lithified with fragments of altered quartz monzonite, andesite, quartz and quartz-sulphide veins in a foliated sericite-quartz-fine grained sulphide matrix. Fragments typically comprise 10 to 30% of the cataclasite breccia, although where multiple slivers of wallrock are incorporated as augen shaped lenses, fragment abundance can be significantly higher. Fragments, particularly those of fine-grained quartz, are generally internally unstrained or show only minor undulose extinction in thin section, and indicate that more ductile crystal plastic deformation processes were not active. Like other cataclastic shear zones in the area, stylolitic pressure solution seams commonly overprint, or are localized along, cataclasite

margins and narrow seams, and commonly developed as a spaced foliation in adjacent foliated wallrocks within the shear zone. Pervasive to spaced foliation defined by alignment of sericite commonly surrounds cataclastic seams and slip surfaces and defines a pervasive to spaced foliation that may grade outward into less strained wallrocks. The combination of cataclastic textures and pressure solution fabrics records the synchronous activity of brittle and low temperature ductile deformation processes that are



LEGEND

GEOLOGY

- Quartz monzonite
- North rhyolite dike
- Central rhyolite dike
- South rhyolite dike
- Andesite dykes
- Gold mineralization
- Shear zone/cataclasite
- Brittle fault, gouge filled
- Limits of apple green sericite alteration and fault damage zone
- Limits of bleached sericite alteration

0 30m

TAGISH LAKE GOLD CORP.

DDH CROSS SECTION
SECTION 44+50E
Goddell Deposit
Skukum Project
Whitehorse M.D., Yukon Territory, Canada

Project No:	CP56B	By:	TV
Scale:	1:1,500	Drawn:	TV
Figure:	3	Date:	February 2003

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characteristic of the semi-brittle style of deformation also observed at Skukum Creek and in the Chieftain Hill area. Shear bands and oblique foliations are commonly visible in the core within shear zones, but could not be used as kinematic indicators to determine shear sense because it was not possible to re-orient the split core.

Rhyolite dykes are not usually affected by significant shear zone fabrics, because cataclastic surfaces and associated foliated shear zone material either form preferentially outside them in altered quartz monzonite or along their contacts. Shear zones can also penetrate the margins of rhyolite dykes or displace the dykes, and are accompanied by the development of foliation defined by green sericite phyllite and local breccia textures within the dykes. These textures and crosscutting relationships indicate that dykes formed either pre- or early syn-displacement along the cataclastic surfaces and shear zones in the fault system.

Late brittle faults filled with clay gouge commonly are developed within the Goddell fault system and record late brittle displacement on the fault that post-dates the cataclasites. The largest of these are typically 0.15 to 0.4 metres thick, and they are distributed as multiple seams across the width of the Goddell fault zone. These fault gouges are thinner, and less disruptive to both the mineralization and earlier fault fabrics, than was observed in other mineralized zones within the project area, possibly because they are more distributed over the width of the system.

Alteration

At Goddell Gully, lateral zoning is not strongly developed, and alteration drops off much more abruptly outside of the main zone of shearing. Chlorite and epidote are much less abundant at Goddell Gully compared to Ridge-Rainbow.

The boundaries of the main Goddell shear zone are defined by an intense sericitic alteration with a characteristic apple green colour that is described below. This central alteration is surrounded, in an envelope that extends only up to a few tens of metres beyond the main shear zone, by a sericitic alteration that commonly weathers to a distinct brownish cast in affected drill. The outer contact of this alteration is typically abrupt, although there are commonly alternating zones of least-altered and sericitically-altered intrusion.

Within the zone of main shearing at Goddell, the alteration becomes markedly more intense and is visually distinguished by a prominent apple-green phase present as disseminations and on many veinlets, shears and pressure solution surfaces. Most samples of this alteration are strongly sheared. The typical alteration is an intense quartz-sericite-carbonate alteration.

The three marker QFP dykes that are present along the drilled length of the Goddell shear zone have similar alteration in each of these dykes, comprising mostly sericite although much of the primary igneous K-feldspar remained stable. The North and South marker dykes have little or no sulphide in most intervals. The Central marker dyke, which is more accurately termed a quartz eye rhyolite, almost invariably contains several percent disseminated pyrite.

Most of the alteration directly associated with sulphide mineralization is carbonate, with lesser sericite and commonly with quartz.

Mineralization

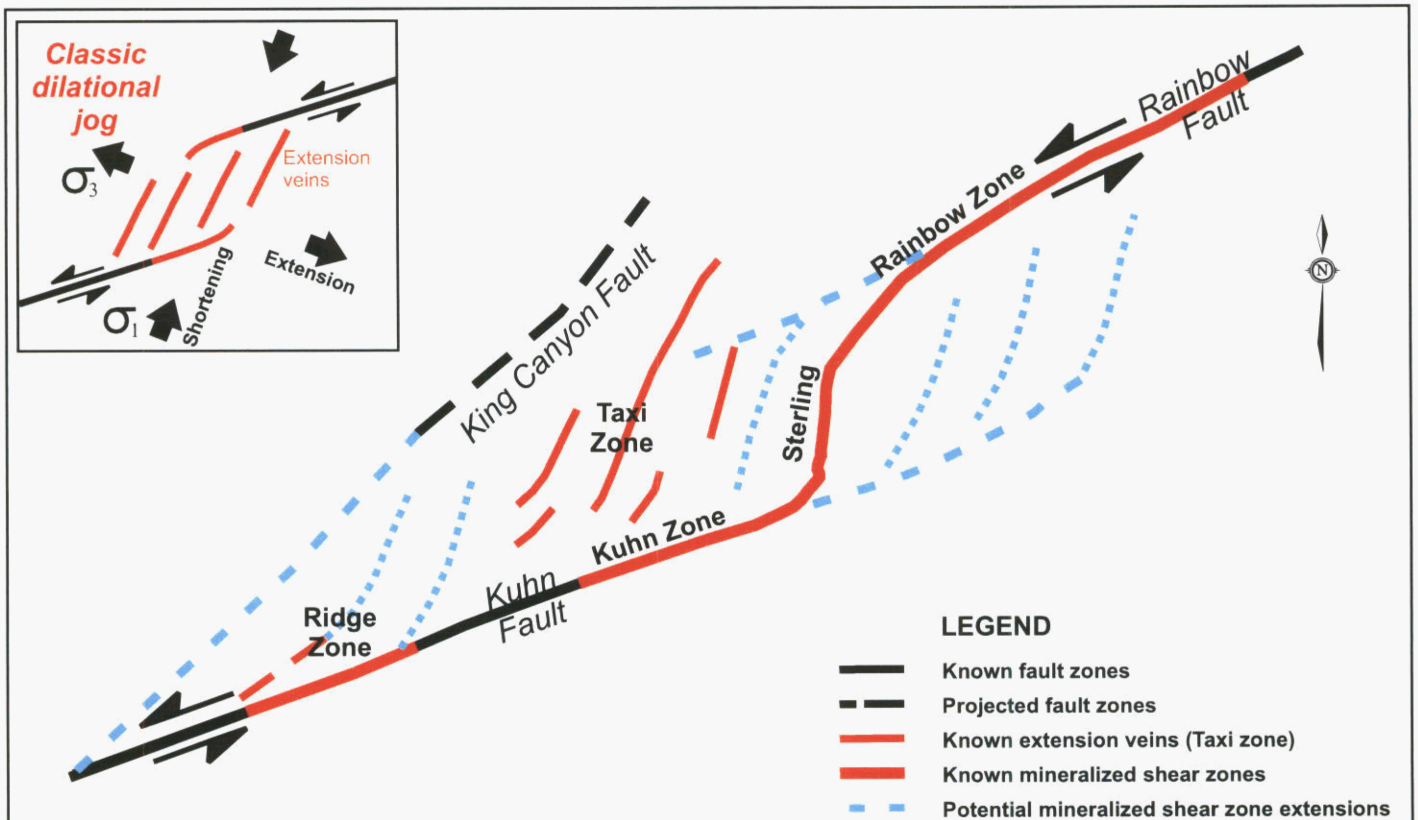
Mineralization at Goddell Gully is developed within, and to the south of, the main strands of the Goddell fault, and occurs in crudely tabular, moderate to steeply north-dipping, and possibly westerly plunging zones within the damage zone of the Goddell fault. Mineralized zones may in part be localized along minor north-dipping splays off the main Goddell fault that might occur in stacked arrays with potential for additional zones above and below known mineralization in the PD zone. Local mineralization in the main cataclastic strands of the Goddell fault also suggests potential for steeply dipping, laterally continuous mineralization in the main controlling fault.

Most gold at Goddell Gully has an empirical relationship to zones of disseminated acicular arsenopyrite or arsenian pyrite that mostly replaces andesite dykes intersected by shear zones. Goddell Gully lacks native gold or electrum, and gold is inferred to be refractory in the arsenopyrite or arsenian pyrite. The low silver concentration at Goddell Gully corresponds to the near absence of freibergite.

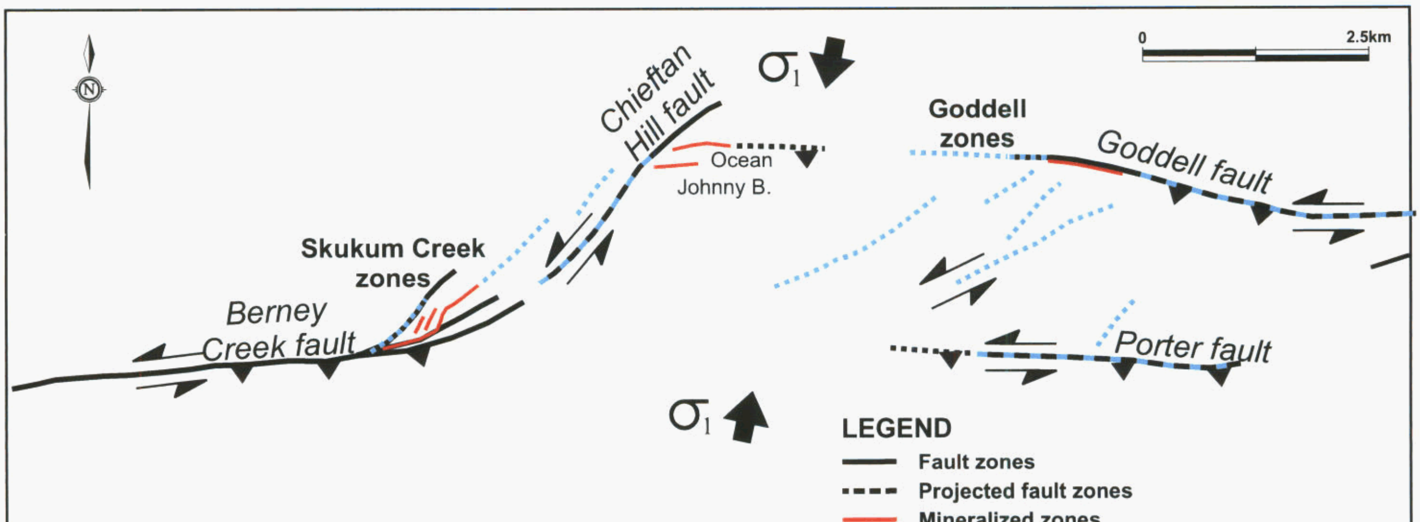
Quartz extension veins are also common at Goddell, although less prominently so than at Rainbow-Ridge. Stibnite is commonly the main sulphide phase, and is typically accompanied by minor amounts of pyrite and sphalerite, and traces of galena.

3.3 INTERPRETATION

The inferred structural setting of the Skukum Property is an Eocene left lateral strike slip fault system with a reverse, south side up component (Figure 4). Master structures are the Berney Creek, Goddell and Porter faults. Mineralization thus far identified occurs in the dilational zone that links these structures, at a potential jog where displacement on the Goddell fault is transferred on northeast-trending structures to the Berney Creek and Porter faults. This mineralization occurs either in the dilational northeast-trending structures, as at Skukum Creek, or in the main faults near northeast-trending splays, within this area of high structural permeability. At a more local scale in the Skukum Creek area, mineralization occurs in areas of second order dilational stepovers and bifurcations in the northeast-trending faults (Figure 4).



Skukum Creek Area Structural Model



Skukum Creek - Goddell Trend Structural Model

TAGISH LAKE GOLD CORP.

SCHEMATIC STRUCTURAL MODELS

Skukum Project
Whitehorse M.D., Yukon Territory, Canada

Project No:	CP56B	By:	TV
Scale:	schematic	Drawn:	TV
Figure:	4	Date:	February 2003

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Structurally-defined exploration targets include:

(1) northeast-trending extensions of shear zones in the Skukum Creek area (e.g. Rainbow East under Chieftain Hill);

(2) the Chieftain hill fault system, which occurs in a prospective, northeast-trending orientation;

(3) down dip extensions of potentially dilational chutes on the Ocean shear zone;

(4) lateral and vertical extensions of mineralization in the PD and Golden Tusk zones at Goddell, which may occur in vertically stacked mineralized bodies at minor fault splays off the Goddell fault;

(5) prospective structural sites along the Goddell and Porter faults, including linking structures and fault splays and bends.

Evaluation of structural exploration targets in the Chieftain Hill and Carbon Hill areas (Goddell and Porter faults) will require a program of surface mapping, prospecting and systematic geochemical sampling and, possibly, magnetite and/or IP surveys in conjunction with compilation of historical data.

Hydrothermal characteristics follow a similar theme across the district. Main alteration types include pervasive and fracture-controlled K-feldspar, sericite, chlorite, epidote and carbonate assemblages. Gold-silver and base metal mineralization are related to quartz-sulphide veins of initially extensional character subsequently deformed during movement on controlling structures, but is also disseminated and on micro-fractures. The relative importance of the hydrothermal assemblages varies across the district.

A general eastward change in hydrothermal character compatible with a temperature decrease from Ridge (Skukum Creek) to Goddell Gully is indicated. Features that support a lower temperature or more distal setting for Goddell Gully include:

a) less dispersion of alteration around the main shear zone;

b) an absence of K-feldspar alteration, which occurs only at Skukum Creek;

c) lack of molybdenite which has been found only at Ridge;

d) less cyclical development of veins suggesting a lower, more passive fluid flux;

e) more abundant sulphate minerals compatible with a higher oxidation state in the fluids;

f) the dominance of acicular arsenopyrite, which is typically the last, presumably lowest temperature, stage of mineralization at Rainbow, Ocean and Rainbow East;

g) much lower silver and base metal concentrations and higher Sb; and

h) predominance of Fe and Mg-enriched carbonates, which occur as later, lower temperature phases at Skukum Creek.

This pattern may reflect exposure of veins at shallower paleodepths to the east, a simple decrease in temperature regime, and/or a significant lateral component of fluid flow from a thermal and fluid source in the west.

The hydrothermal fluids have an important link to rhyolite dykes that reflects more than structural coincidence. Monolithic rhyolite breccias may reflect interaction of rhyolite dykes with fluids in the controlling structures, but several rhyolite dykes that lack such breccias in the Taxi zone (Skukum Creek) contain disseminated sulphide and are cut by quartz-sulphide veinlets anomalous in gold, silver and base metals that suggest a direct link between metals, fluids and at least some stages of rhyolite. This is compatible with associations of mineralization and dykes at Goddell Gully, and with a substantial background enrichment of gold in rhyolite dykes and subvolcanic rhyolitic intrusions near the Mount Skukum mine. It is probable that one or more stages of rhyolite dyke, or their deeper source magmas, supplied or significantly contributed to the fluid and metal budget of the district.

Well-mineralized shear zones also contain substantial volumes of rock with abundant pyrite, whereas poorly- to un-mineralized shear zones lack or have only narrow zones of strong pyrite. Use of geophysical surveys to look for coincidence of magnetic lows with IP chargeability highs may be an excellent method for focusing exploration and drilling on specific, more prospective segments of larger shear zones, particularly those compatible with extensional settings in the structural model.

Respectfully submitted,

Christopher O. Naas, *P.Geo.*
February 28th, 2003.

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5.0 STATEMENT OF QUALIFICATIONS

I, Christopher O. Naas, do hereby certify that:

1. I am a graduate in geology of Dalhousie University (*B.Sc.*, 1984);

2. I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia;

3. I am presently a Consulting Geologist and have been so since November 1987;

5. The opinions and conclusions contained herein are based on a review of previous records and fieldwork carried out under my supervision from June 16th to September 29th, 2002;

6. I own shares of Tagish Lake Gold Corp.;

7. In the disclosure of information relating to legal, title and related issues, I have relied on information provided to me by the Mining Recorder of Whitehorse, Yukon Territory, and Tagish Lake Gold Corp.

Dated at Richmond, British Columbia, this 28th day of February, 2003.

Christopher O. Naas, *P.Geo.*

APPENDIX I

ABBREVIATIONS AND CONVERSION FACTORS

ABBREVIATIONS AND SYMBOLS

Ag	silver
As	arsenic
Au	gold
Az	azimuth
C$	Canadian dollars
cm	centimetre
cu. cm	cubic centimre
cu. m	cubic metre
cu. yd	cubic yard
eq Au	equivalent gold
ft	foot
g	gram
g/cu. m	grams per cubic metre
g/t	grams per metric ton
kg	kilogram
kg/t	kilograms per metric ton
km	kilometre
lb	Pound avoirdupois
m	metre
l	litre
mi	mile
mm	millimetre
n	number of items in a statistical array
oz	troy ounces
oz/cu. yd	troy ounces per cubic yard
oz/T	troy ounces per short ton
ppb	parts per billion
ppm	parts per million
sq. km	square kilometre
sq. mi	square mile
T	short ton
t	metric ton (tonne)
tpd	short tons per day
t/d	metric tons per day
yd	yard
UTM	Universal Transverse Mercator
x	statistical mean
%	percent
±	plus or minus
o / ' / "	degree/minute/second of arc

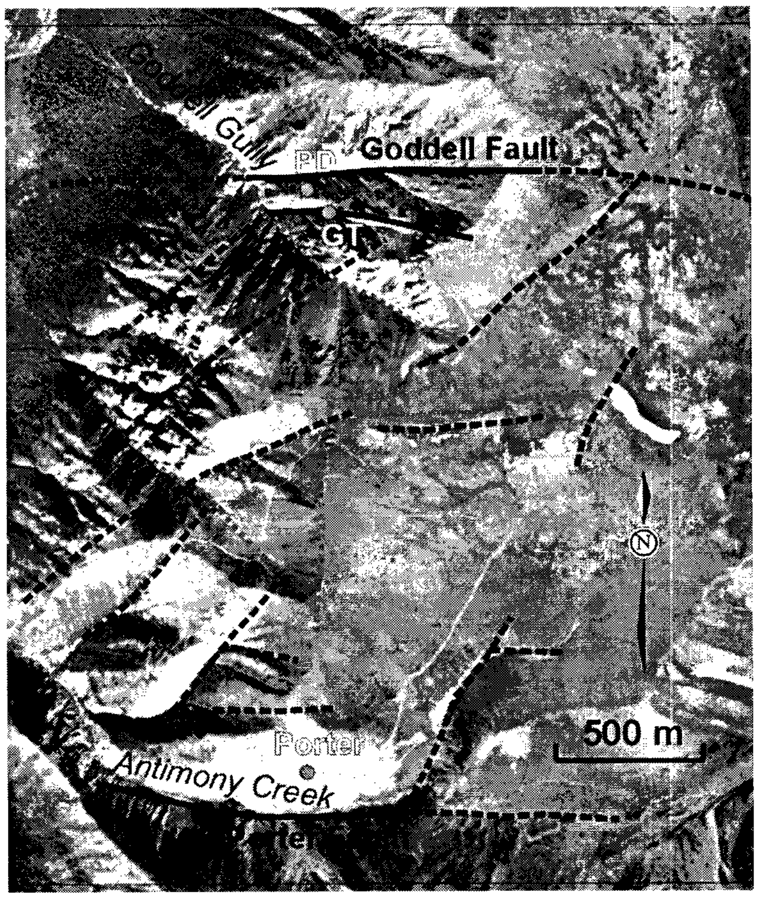
CONVERSION FACTORS

Length			
1 millimetre (mm)	0.03937 inches (in)	1 inch (in)	25.40 millimetre (mm)
1 centimetre (cm)	0.394 inches(in)	1 inch (in)	2.540 centimetres (cm)
1 metre (m)	3.281 feet (ft)	1 foot (ft)	0.3048 metres (m)
1 kilometre (km)	0.6214 mile (mi)	1 mile (mi)	1.609 kilometres (km)
Area			
1 sq. centimeter (cm^2)	0.1550 sq. inches (in^2)	1 sq inch (in^2)	6.452 sq. centimetres (cm^2)
1 sq. metre (m^2)	10.76 feet (ft^2)	1 foot (ft)	0.0929 sq. metres (m^2)
1 hectare (ha) (10,000 m^2)	2.471 acres	1 acre	0.4047 hectare (ha)
1 hectare (ha)	0.003861 sq. miles (m^2)	1 sq. mile (m^2)	640 acres
1 hectare (ha)	0.01 sq. kilometre (km^2)	1 sq. mile (m^2)	259.0 hectare (ha)
1 sq. kilometre (km^2)	0.3861 sq. miles (mi^2)	1 sq. mile (m^2)	2.590 sq. kilometres (km^2)
Volume			
1 cu. centimetre (cm^3)	0.06102 cu. inches (in^3)	1 cu. inch (in^3)	16.39 cu. centimetres (cm^3)
1 cu. metre (m^3)	1.308 cu. yards (yd^3)	1 cu. yard (yd^3)	0.7646 cu. metres (m^3)
1 cu. metre (m^3)	35.310 cu. feet (ft^3)	1 cu. foot (ft^3)	0.02832 cu. metres (m^3)
1 litre (l)	0.2642 gallons (U.S.)	1 gallon (U.S.)	3.785 litres (l)
1 litre (l)	0.2200 gallons (U.K.)	1 gallon (U.K.)	4.546 litres (l)
Weights			
1 gram (g)	0.03215 troy ounce (20dwt)	1 troy ounce (oz)	31.1034 grams (g)
1 gram (g)	0.6430 pennyweight (dwt)	1 pennyweight (dwt)	1.555 grams (g)
1 gram (g)	0.03527 oz avoirdupois	1 oz avoirdupois	28.35 grams (g)
1 kilogram (g)	2.205 lb avoirdupois	1 lb avoirdupois	0.4535 kilograms (kg)
1 tonne (t) (metric)	1.102 tons (T) (short ton)	1 ton (T) (short ton) (2000 lb)	0.9072 tonnes (t)
1 tonne (t)	0.9842 long ton	1 long ton (2240 lb)	1.016 tonnes (t)
Miscellaneous			
1 cm/second	0.01968 ft/min	1 ft/min	50.81 cm/second
1 cu. m/second	22.82 million gal/day	1 million gal/day	0.04382 m^3/second
1 cu. m/minute	264.2 gal/min	1 gal/min	0.003785 m^3/minute
1 g/cu. m	62.43 lb/ cu. ft	1 lb/cu. ft^3	0.01602 g/m^3
1 g/cu. m	0.02458 oz/cu. yd	1 oz/cu. yd	40.6817 g/m^3
1 Pascal (Pa)	0.000145 psi	1 psi	6985 Pascal
1 gram/tonne (g/t)	0.029216 troy ounce/ short ton (oz/T)	1 troy ounce/short ton (oz/T)	34.2857 grams/tonne (g/t)
1 g/t	0.583 dwt/short ton	1 dwt/short ton	1.714 g/t
1 g/t	0.653 dwt/long ton	1 dwt/long ton	1.531 g/t
1 g/t	0.0001 %		
1 g/t	1 part per million (ppm)		
1 %	10,000 part per million (ppm)		
1 part per million (ppm)	1,000 part per billion (ppb)		
1 part per billion (ppb)	0.001 part per million (ppm)		

APPENDIX II

STRUCTURE AND ALTERATION STUDY

Field and Petrographic Evaluation of Structural Geology, Alteration and Mineralization in the Skukum Creek Project Area, Yukon Territory, With Recommendations for Exploration



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November 1, 2002

EXECUTIVE SUMMARY

A study of reports, data, underground workings and drill core from the Skukum Project area was undertaken for 14 field days in July, 2002, to provide guidelines for exploration and further development of the Skukum Creek deposits. Mineralized zones examined during this study lie within the Skukum Creek, Chieftain Hill and Goddell Gully areas.

The Skukum Creek deposits are hosted principally by Jurassic and Cretaceous intrusive rocks of the Coast Plutonic complex. These rocks intrude metasedimentary units of the Nisling Terrane, and stratigraphically and structurally juxtapose Jurassic volcanosedimentary rocks. Eocene rocks of the Skukum Volcanic complex unconformably overlie the Mesozoic rocks in the northwest part of the study area. Numerous east- to northeast-trending rhyolite and andesite dykes represent probable feeders to the Mount Skukum volcanic complex and intrude possible caldera-bounding faults of similar orientation that include the Berney Creek, Chieftain Hill and Goddell fault zones.

In the Skukum Creek area, zones of mineralization are hosted primarily by a series of linked, northeast-trending faults that may represent splays off the Berney Creek fault system. At present the Rainbow and Kuhn zones are the most economically significant, along with the less well explored Ridge, Ridge 2 and Rainbow East zones. The Rainbow and Kuhn zones occur along parallel, northeast-trending faults of the same name that are defined by intermixed andesite and rhyolite dykes, monolithic and polylithic phreatomagmatic breccias, semi-brittle shear zones and quartz-sulphide veins. These two zones are linked by the north-trending Sterling zone, a dilational stepover that connects the eastern end of the Kuhn zone with the western end of the Rainbow zone.

Within the Rainbow and Kuhn zones, mineralization occurs in quartz-sulphide veins that are intimately associated with an anastomosing network of shear zones that cross and/or are developed along dyke contacts. Multiple generations of veins are present that exhibit varying degrees of strain, including early veins incorporated as fragments into cataclasites and younger veins that overprint cataclastic breccias; these indicate a syn-tectonic mineralizing event. Shear zones are composed of lithified, foliated cataclasites with grey to tan matrices that form the main slip surfaces in the core of the structures. The shear zones are generally surrounded by foliated wallrocks that contain pervasive foliation defined by both phyllosilicate alteration minerals and stylolitic pressure solution cleavage. Synchronous brittle (cataclasites) and low temperature ductile (pressure solution fabrics) strain is indicated by the superposition of foliation and pressure solution seams on cataclasites, and the presence of rotated fragments of foliated shear zone material in cataclastic breccias.

Kinematic indicators on semi-brittle shear zones in the Rainbow zone suggest a left lateral shear sense with a reverse (south side up) component. This slip vector is at a high angle to steep, east-plunging, thickened chutes of veining, high Au and Ag grade X thickness, and total zone thickness in the Rainbow, Kuhn and Sterling zones, consistent with dilation and bends at steps in the structures during displacement. Subsidiary, moderate to shallow east-plunging chutes are parallel to left lateral normal slip indicated on late faults that overprint the shear zones, and may modify the main, steeply plunging chutes.

Mineralization in the Ridge and Ridge 2 zones may occur at or near the junction of the Kuhn and King Canyon faults. This may be a zone of dilation and splays that links the two structures. Rainbow East may represent an extension of the Rainbow zone, and exploration potential exists to both the northeast under Chieftain Hill and to the southwest. North-northeast trending, steeply dipping quartz-sulphide extension veins in the Taxi zone, and similar veins developed throughout the underground workings, have orientations consistent with formation during sinistral displacement along the Rainbow and Kuhn faults.

Similar relationships to those observed at Skukum Creek are present at Chieftain Hill and Goddell Gully, although fewer generations of vein are present and phreatomagmatic breccias are rare. An early set of sheeted andesite dykes cut by both rhyolite dykes and mineralized shear zones is present in both areas. Cataclasites are relatively more important at Goddell Gully, in contrast to the higher proportion of foliated shear zone material at Skukum Creek, and suggests more brittle deformation styles to the east. This trend corresponds with the easterly decrease in the amount of vein development and the near absence of phreatomagmatic breccias. A decrease in the total budget of syn-tectonic, hydrothermal fluid from west to east, and a probable fluid source to the west, is indicated.

Mineralization at Goddell Gully is developed within, and to the south of, the main strands of the Goddell fault, and occurs in crudely tabular, moderate to steeply north-dipping, and possibly westerly plunging zones within the damage zone of the Goddell fault. Mineralized zones may in part be localized along minor north-dipping splays off the main Goddell fault that might occur in stacked arrays with potential for additional zones above and below known mineralization in the PD zone. Local mineralization in the main cataclastic strands of the Goddell fault also suggests potential for steeply dipping, laterally continuous mineralization in the main controlling fault.

The inferred structural setting of the Skukum Creek district is an Eocene left lateral strike slip fault system with a reverse, south side up component. Master structures are the Berney Creek, Goddell and Porter faults. Mineralization thus far identified occurs in the dilational zone that links these structures, at a potential jog where displacement on the Goddell fault is transferred on northeast-trending structures to the Berney Creek and Porter faults. This mineralization occurs either in the dilational northeast-trending structures, as at Skukum Creek, or in the main faults near northeast-trending splays, within this area of high structural permeability. At a more local scale in the Skukum Creek area, mineralization occurs in areas of second order dilational stepovers and bifurcations in the northeast-trending faults. Structurally-defined exploration targets include: (i) northeast-trending extensions of shear zones in the Skukum Creek area (e.g. Rainbow East under Chieftain Hill); (ii) splays, junctions and extension veins at stepovers of mineralized shear zones in the Skukum Creek area; (iii) the Chieftain hill fault system, which occurs in a prospective, northeast-trending orientation; (iv) down dip extensions of potentially dilational chutes on the Ocean shear zone; (v) lateral and vertical extensions of mineralization in the PD and Golden Tusk zones at Goddell, which may occur in vertically stacked mineralized bodies at minor fault splays off the Goddell fault; (vi) prospective structural sites along the Goddell and Porter faults, including linking structures and fault splays and bends. Diamond drilling will be necessary to further outline mineralized zones and test target areas in the vicinity of the Rainbow, Kuhn, Rainbow East, Sterling and Ridge zones, whereas evaluation of structural exploration targets in the Chieftain Hill and Carbon Hill areas (Goddell and Porter faults) will require a program of surface mapping, prospecting and systematic geochemical sampling and, possibly, magnetite and/or IP surveys in conjunction with compilation of historical data.

Hydrothermal characteristics follow a similar theme across the district. Main alteration types include pervasive and fracture-controlled K-feldspar, sericite, chlorite, epidote and carbonate assemblages. Au-Ag and base metal mineralization are related to quartz-sulphide veins of initially extensional character subsequently deformed during movement on controlling structures, but is also disseminated and on micro-fractures. The relative importance of the hydrothermal assemblages varies across the district.

Zoning phenomena are present within individual zones and across the district. At Skukum Creek, chlorite changes from green and Mg-rich to black and Fe-rich peripheral and proximal to main shear zones, respectively. The intensity of shearing and of pervasive and fracture-controlled sericite and carbonate alteration also increases toward mineralization. There is a distinct stage of epidote-rich shear veinlets that occur preferentially in the footwall of the Ridge and Rainbow zones. Quartz-sulphide extension veins are Ag-rich with low Au outside the main shear zones, but contain substantially higher Au grades proximal to the main shears. At Goddell Gully, lateral zoning is not strongly developed, and alteration drops off much more abruptly outside of the main zone of shearing. Chlorite and epidote are much less abundant at Goddell Gully compared to Ridge-Rainbow.

Gold at Skukum Creek occurs mostly as electrum and minor to trace native Au. The Au is found in quartz-sulphide extension veins or their deformed equivalents, and is directly related to a late stage of galena-stibnite mineralization that replaces earlier arsenopyrite-pyrite-sphalerite. Silver is hosted predominantly in freibergite, with trace to minor native Ag and argentite at Skukum Creek, and trace amounts also occur within galena, chalcopyrite, stibnite and sphalerite. The timing of Au and Ag precipitation is similar, and variations in Au/Ag values along and outward from the main shear zones reflect changes in P-T-X conditions of the fluid. Most Au at Goddell Gully has an empirical relationship to zones of disseminated acicular arsenopyrite or arsenian pyrite that mostly replaces andesite dykes intersected by shear zones. Goddell Gully lacks native Au or electrum, and Au is inferred to be refractory in the arsenopyrite or arsenian pyrite. The Rainbow East and Ocean veins have both free milling and refractory Au components. The low Ag concentration at Goddell Gully corresponds to the near absence of freibergite.

A general eastward change in hydrothermal character compatible with a temperature decrease from Ridge to Goddell Gully is indicated. Features that support a lower temperature or more distal setting for Goddell Gully include: 1) less dispersion of alteration around the main shear zone; 2) an absence of K-feldspar alteration, which occurs only at Skukum Creek; 3) lack of molybdenite which has been found only at Ridge; 4) less cyclical development of veins suggesting a lower, more passive fluid flux; 5) more abundant sulphate minerals compatible with a higher oxidation state in the fluids; 6) the dominance of acicular arsenopyrite, which is typically the last, presumably lowest temperature, stage of mineralization at Rainbow, Ocean and Rainbow East; 7) much lower Ag and base metal concentrations and higher Sb; and 8) predominance of Fe and Mg-enriched carbonates, which occur as later, lower temperature phases at Skukum Creek. This pattern may reflect exposure of veins at shallower paleodepths to the east, a simple decrease in temperature regime, and/or a significant lateral component of fluid flow from a thermal and fluid source in the west.

The hydrothermal fluids have an important link to rhyolite dykes that reflects more than structural coincidence. Monolithic rhyolite breccias may reflect interaction of rhyolite dykes with fluids in the controlling structures, but several rhyolite dykes that lack such breccias in the Taxi zone contain disseminated sulphide and are cut by quartz-sulphide veinlets anomalous in Au, Ag and base metals that suggest a direct link between metals, fluids and at least some stages of rhyolite. This is compatible with associations of mineralization and dykes at Goddell Gully, and with a substantial background enrichment of Au in rhyolite dykes and subvolcanic rhyolitic intrusions near the Mount Skukum mine. It is probable that one or more stages of rhyolite dyke, or their deeper source magmas, supplied or significantly contributed to the fluid and metal budget of the district.

Studies of magnetic susceptibility document volumetrically significant zones of igneous magnetite destruction within and around the main mineralized shear zones. These zones range up to at least 100 to 150 metres in width, and largely outline the lateral extent of sericitic alteration related to the main sulphide-precipitating event. Barren and weakly mineralized shear zones lack the large zones of magnetite destruction. Magnetic surveys should be able to: 1) locate new, concealed shear zones with strong alteration, shearing and potential for ore-grade mineralization; 2) track extensions of known mineralized shear zones under cover; and 3) distinguish between barren and well-mineralized shear zones or sub-segments of shear zones. Well-mineralized shear zones also contain substantial volumes of rock with abundant pyrite, whereas poorly- to un-mineralized shear zones lack or have only narrow zones of strong pyrite. Use of geophysical surveys to look for coincidence of magnetic lows with IP chargeability highs may be an excellent method for focusing exploration and drilling on specific, more prospective segments of larger shear zones, particularly those compatible with extensional settings in the structural model.

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Disclaimer of Responsibility to Third Parties

This report was prepared by Lang Geoscience Inc and Panterra Geoservices Inc for the account of CME Consulting Ltd. The material in it reflects the best judgement of Lang Geoscience Inc and Panterra Geoservices Inc in light of the information available to them at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Lang Geoscience Inc and Panterra Geoservices Inc accept no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

1.0 INTRODUCTION, AND SCOPE AND OBJECTIVES OF PROJECT

In July, 2002, James Lang (Lang Geoscience Inc) and David Rhys (Panterra Geoservices Inc) completed a field-based geological investigation of Au-Ag mineralization in the Skukum Project area of the Wheaton River Mining District (Figure 1) in southwestern Yukon at the request of CME Consulting Ltd. The district produced Au-Ag ores from the Mount Skukum mine in the 1980s (McDonald 1990), but the area of this study comprises the Skukum Creek, Chieftain Hill and Goddell Gully zones (Figure 2) which are located east and east-southeast of the Mount Skukum mine (Figure 1). These zones have been explored for Au-Ag mineralization by several operators since 1984.

The principal objectives of the study included:

- An improved understanding of the structural and hydrothermal setting of veins in the Skukum Creek, Chieftain Hill and Goddell Gully areas.
- Detailed structural evaluation of the veins, with particular emphasis on the relationship of the Sterling zone and Ridge Zone 2 to the principal mineralized structures.
- Detailed field and petrographic evaluation of alteration characteristics with emphases on zoning patterns, ore mineralogy, and the controls on Au and Ag distribution.
- Recommendations for exploration target areas, geological, geochemical and geophysical exploration methods, and any further geological studies that might have exploration application.

Work undertaken to achieve the objectives included:

- Examination of reports, data, drillcore and underground workings for 14 days in the field by both authors, and discussions with the project geologists.
- Reconnaissance mapping and measurement of structural features in the underground workings.
- Rapid, semi-detailed logging of structural and alteration characteristics in numerous selected drill holes, including several magnetic susceptibility traverses.
- Collection and photographic documentation of representative and selected hand samples.
- Preparation and optical petrography on 57 polished thin sections.
- SEM examination of 26 polished thin sections to verify and expand mineralogical and textural interpretation.
- Preparation of report.

The report which follows presents the observations and interpretations of the authors. It first describes the general geological and structural setting of the district in light of previous studies and new observations. It then details the geological, structural and petrographic characteristics of the Skukum Creek, Chieftain Hill and Goddell Gully zones, and assesses the exploration potential in each area. The results of magnetic susceptibility studies are then described. The report then discusses camp-scale zoning patterns in structure and alteration, and proposes a model that accommodates timing, patterns of zoning and deposit genesis. It concludes with recommendations for exploration methodology and areas of focus.

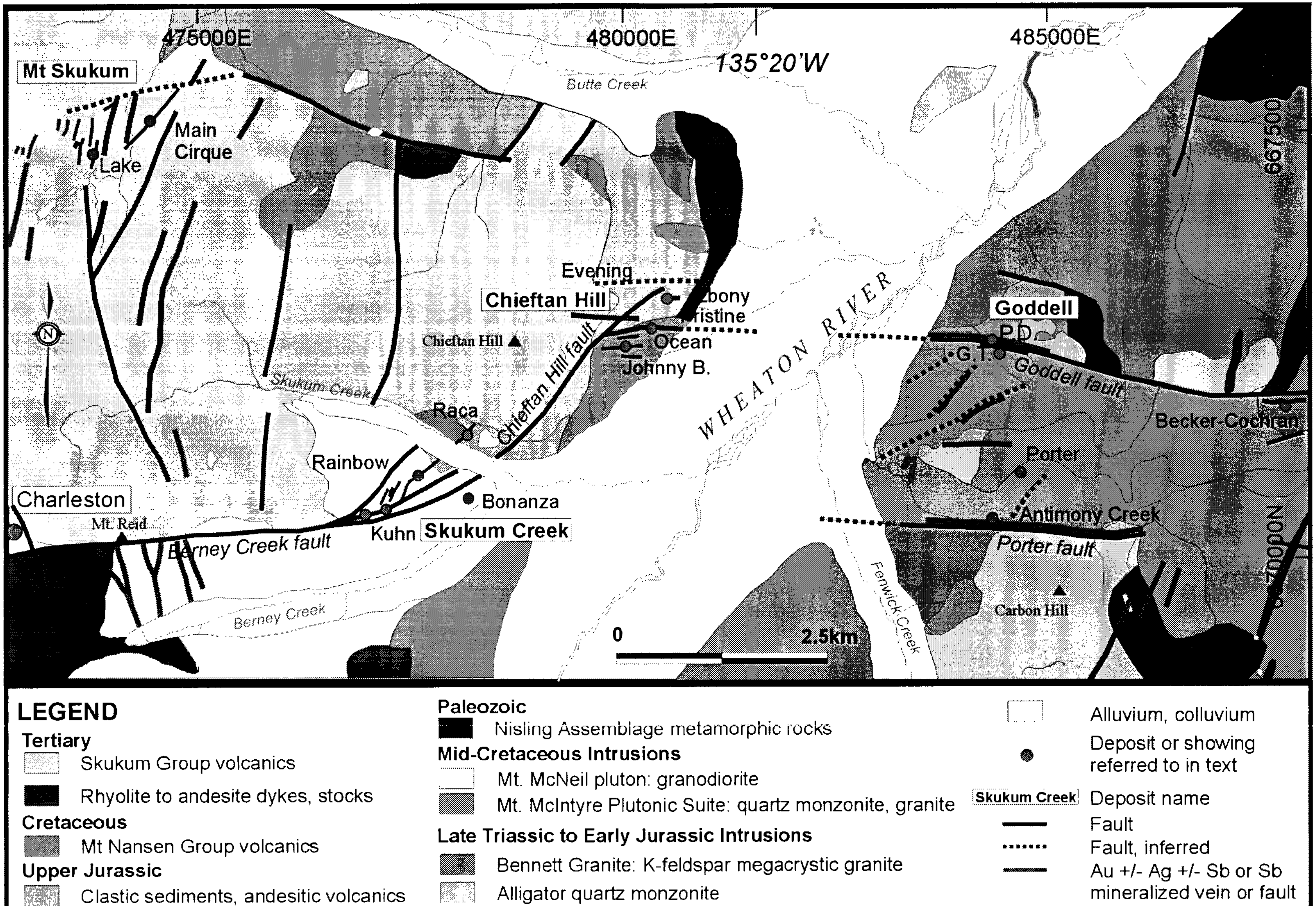


Figure 1: Geology of the central Skukum Creek Property

Geology compiled from Hart and Radloff (1990) and company maps

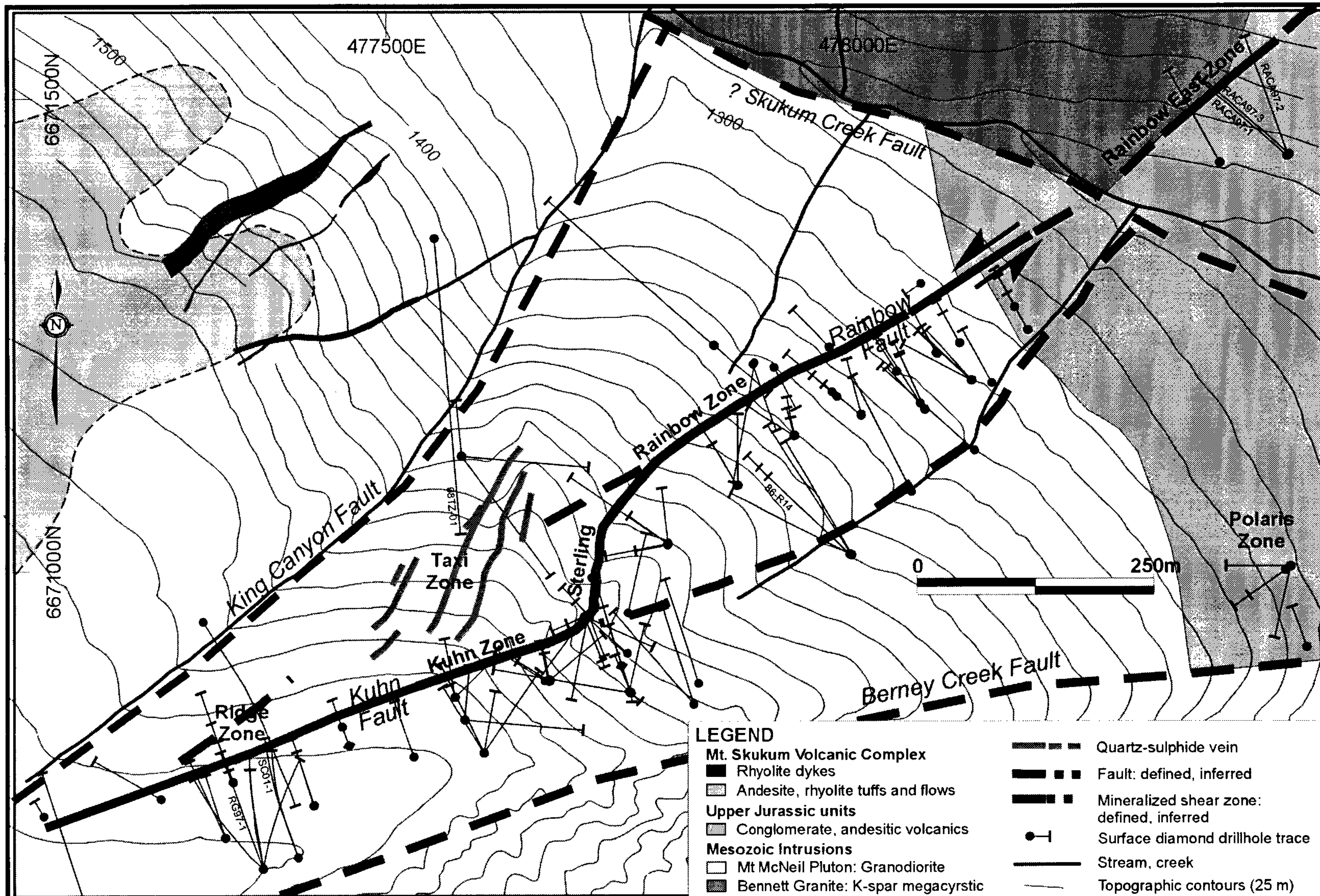


Figure 2: Geology Plan Map: Skukum Creek Deposit area

2.0 REGIONAL GEOLOGICAL SETTING OF THE SKUKUM PROJECT

The regional geological setting of the Skukum project area is described in Hart and Radloff (1990), from which the following information is summarized. The project area is located within the Intermontane belt of the Canadian Cordillera. Oldest rocks in the area comprise domains and screens of probable Paleozoic gneiss, assigned to the Nisling Terrane by Hart and Radloff (1990), and Jurassic andesitic volcanic and siliciclastic sedimentary rocks of the Stikine Terrane and Whitehorse Trough overlap assemblage (Figure 1). Stratigraphic and contact relationships are commonly obscured by the many intrusions associated with the Coast Plutonic Complex.

Strata of the Jurassic Whitehorse trough are affected by a series of open to tight, northwest-trending folds that probably formed in Upper Jurassic to Lower Cretaceous time, approximately coeval with activity of the Skeena Fold Belt to the south in British Columbia. The folds are superimposed on earlier, probably pre-Triassic, metamorphic fabrics and the northwest-trending Tally-Ho shear zone, a major Late Triassic shear zone that is developed approximately 15 km to the northeast of the project area and which forms the easternmost limit of exposures of the Nisling Terrane.

Mesozoic plutonic rocks which underlie much of the project area separate the Jurassic units and Nisling Assemblage into isolated domains and screens. Major intrusions include the Alligator Quartz Monzonite and the late Triassic or early Jurassic K-feldspar megacrystic Bennett Granite that are widespread east of the Wheaton River in the Skukum project area (Figure 1). The most abundant rock types in the region comprise metaluminous Cretaceous intrusions of the Coast Plutonic Complex, which are subdivided into several plutonic suites by Hart and Radloff (1990). The dominant Cretaceous suites in the project area include the Mt. McIntyre plutonic suite (96 to 119 Ma), comprising the Mt. Ward granite and Carbon Hill quartz monzonite (Figure 1), and the Whitehorse plutonic suite (116 to 119 Ma), locally represented by the Mt. McNeil granodiorite pluton (Figure 1). Isolated accumulations of mid- to late-Cretaceous volcanic rocks of intermediate composition of the Mt. Nansen Group are present regionally and are approximately coeval with the Coast Plutonic Complex. In the Skukum project area, these rock types occur on the eastern flanks of Carbon hill and southeast of Goddell Gully near the Becker-Cochran deposit (Figure 1), where they comprise green tuff and tuff breccia that unconformably overlie the Bennett Granite and Jurassic strata (Figure 1).

Late Cretaceous and Early Paleocene brittle dextral displacement associated with widespread dextral displacement throughout the Cordillera is related to reactivation of the Triassic Tally-Ho shear zone. This phase of displacement formed a brittle fault system, termed the Llewellyn fault by Hart and Radloff (1990), which exploited parts of the earlier Tally-Ho structure. Subsidiary faults generated during this tectonic episode may subsequently have been remobilized during Eocene volcanic activity to locally form caldera-bounding structures; these may also have acted as permeable structural sites for the formation of the late-volcanic vein deposits hosted by faults and shear zones in the Skukum project area.

Pre-Tertiary rock types in the region are unconformably overlain by at least four Late Paleocene to Early Eocene volcanic complexes that form the Skukum Group, and are intruded by numerous associated rhyolite and andesite dykes. In the project area, these are the youngest exposed rocks and are represented by the Early Eocene Mount Skukum volcanic complex, a caldera sequence which underlies western portions of the project area (Figure 1). The complex comprises a bimodal sequence of subaerial volcanic and volcaniclastic rocks with a total thickness that locally exceeds 800 m, and an areal extent of approximately 200 km^2. Exposures of the complex adjacent to the study area near the Skukum Creek deposits and in the Chieftain Hill area (Figure 1) are composed mainly of massive to poorly bedded, plagioclase porphyritic andesitic flows and tuff (McDonald et al. 1990). Rocks of the Skukum Creek volcanic complex are locally separated from pre-Tertiary rock types by east- to northeast-trending, curved faults such as the Berney Creek fault and Wheaton lineament that may have been active synchronously with volcanism and which potentially form caldera-bounding structures (Figure 1; Hart and Radloff

1990). These structures, which locally may represent reactivated older faults, and parallel faults within the volcanic complex are host to or control probable synvolcanic vein and shear zone hosted Au-Ag mineralization in the district. This mineralization includes: (i) epithermal vein systems at the Mt. Skukum mine; and (ii) probable intrusion-related, Au-Ag-Sb-As mineralization that formed principally within pre-Tertiary igneous rocks to the southeast of the volcanic complex and which include the Skukum Creek, Chieftain Hill and Goddell areas focused upon here.

3.0 PRINCIPAL ROCK TYPES IN THE STUDY AREA

During this study, work was confined to drillcore and underground workings in the Skukum Creek deposit area, and to drill core at Chieftain Hill and Goddell Gully. Host rocks in these areas are principally intrusions and dykes, mainly of Cretaceous and Tertiary age, respectively, which are described in detail below. The only other rock types observed in the areas of study were foliated gneiss found in one hole at the Bonanza zone that may comprise part of the Nisling Assemblage (not described here), and potential Jurassic volcanic and clastic rocks encountered in the eastern Rainbow zone. All areas examined occur outside the limits of the Mt. Skukum Volcanic Complex.

3.1 Probable Jurassic volcanic and siliciclastic rocks, Rainbow and Rainbow East (Raca) zones

3.1.1 Conglomerate

Pebble conglomerate is present in several drill holes completed historically at the eastern end of the Rainbow zone, immediately southwest of Skukum Creek (Figure 2). The unit is composed of clast-supported conglomerate with rounded clasts of chert and quartzite in a pale green sericitic matrix. This unit probably belongs to the Jurassic Tantalus Formation (cf., Hart and Radloff 1990). It is present in an area of no outcrop and core is incomplete and partially lost for the holes containing this unit, so its contact relationships and orientation could not be assessed. Conglomerate that has been mapped along the southeastern flanks of Chieftain Hill by Mt. Skukum Mines (unpublished mine maps; Hart and Radloff 1990), and which is intercalated with Jurassic volcanic rocks, may also correlate with this unit.

3.1.2 Intermediate volcanic rocks

Holes drilled in the Lower Raca zone east of Skukum Creek (RACA97-1 to RACA97-3) first pass through thick, recent talus of fresh Tertiary volcanic rocks, and then intersect pale grey, sericite-pyrite±magnetite altered, locally plagioclase±pyroxene porphyritic volcanic rocks of probable intermediate composition. Main rock types include massive, grey lapilli to block tuff and tuff breccia, and massive porphyritic flows or subvolcanic intrusive rocks. These units are distinctive from the fresh Tertiary volcanic units present in talus higher on the slope. Their altered state, close spatial association with Jurassic conglomerate of the Tantalus Formation that is present immediately across Skukum Creek, and occurrence of Cretaceous intrusive rocks within them suggest that they may correlate with Jurassic pyritic andesite volcanic rocks present on the eastern flank of Chieftain Hill 2 km to the northeast (Figure 1), to which they are assigned in Figures 1 and 2. Since these volcanic units are present in an area of poor exposure under talus, their contact relationships with adjacent rock types could not be determined.

3.2 Intrusive rock types

Ten types of intrusive rock of widely variable composition and texture were identified in the project area during the study. In general, the rocks comprise at least three larger intrusive masses and numerous dykes, including andesitic and rhyolitic dykes of Tertiary age. The dykes are most abundant within and immediately adjacent to major fault zones, which probably provided the structural control for their emplacement. In some cases, the appearance of certain types of dykes can be significantly modified by hydrothermal alteration and lead to confusion in assignment; this is discussed further in section 5.

3.2.1 Pre-Tertiary intrusions

Biotite-hornblende granodiorite (Mt McNeil pluton; Cretaceous)

Within the Skukum project area, the Mt. McNeil pluton underlies the valley of Berney Creek, Mt. Reid and the south side of Skukum Creek, immediately to the south of the Mt. Skukum volcanic complex (Figure 1). Hart and Radloff (1990) report a 111 Ma U-Pb zircon age from the pluton in the Skukum project area. This intrusion is the most common host rock to the Skukum Creek deposits. It is characterized by large, euhedral hornblende grains that locally exceed 1 cm in length but which are mostly 3 to 6 mm long. The unit is coarse-grained and equigranular to seriate (Photo 3.1). It typically contains approximately 10% hornblende, 5% biotite, 25 to 30% quartz, 30 to 35% plagioclase and 20% K-feldspar, providing an IUGS classification as biotite-hornblende granodiorite. Fresh rock contains abundant magnetite. Partially disaggregated cognate xenoliths of fine-grained diorite are common. Where fresh, it is strongly and evenly magnetic. Hornblende and biotite have been at least partially replaced by greenish chlorite in even the freshest samples. Alteration is pervasive and much stronger close to major shear zones.

K-Feldspar megacrystic biotite-hornblende granite (Bennett Stock; Triassic-Jurassic)

Drill holes completed in the Rainbow East (Raca) zone on the northeast side of Skukum Creek (holes RACA97-1 to 3; Figure 2) intersected a foliated K-feldspar megacrystic granite, which based on textural and mineralogical similarities is interpreted to be the Bennett granite which is widespread in the region. Doherty and Hart (1988) report a U-Pb zircon age for the Bennett granite of about 220 Ma, although other U-Pb dates in the region return approximately 175 Ma (J. K. Mortensen, pers. comm. 2002). This unit is broadly similar to the biotite-hornblende Mt. McNeil granodiorite at Skukum Creek, but is distinguished by: (i) the presence of megacrysts of euhedral K-feldspar up to several centimeters in size (Photo 3.2) in a coarse-grained, equigranular matrix; and (ii) a higher K-feldspar/plagioclase ratio. It is properly called granite. This unit is invariably altered near veins and shear zones.

Porphyritic hornblende monzonite to quartz monzonite

This unit is present as irregular bodies and dark dykes within the Mt. McNeil pluton in the vicinity of the Skukum Creek deposits. It commonly contains inclusions of the Mt. McNeil granodiorite (Photo 3.3). The unit typically has a salt and pepper texture that reflects subequal concentrations of euhedral hornblende prisms and equant, white plagioclase phenocrysts. The groundmass is dark and fine-grained. Some variations on this rock type contain minor quartz. Plagioclase phenocrysts typically form approximately 40% of the rock, but locally exceed 50% requiring it to be called a porphyry. The moderate response to K-feldspar staining is consistent with monzonite. This rock type is common in the Skukum Creek area, but it was not observed at Goddell Gully or Chieftain Hill. Where present within or near mineralized shear zones, this unit is invariably altered (Photo 3.3). The rock locally contains minor cognate diorite xenoliths, but their concentration is markedly less than in the Mt. McNeil granodiorite.

Biotite-pyroxene monzodiorite

This rock type was observed only in the Skukum Creek area within the Taxi zone, and in DDH 98GE-1 located southeast of the Rainbow and Kuhn zones. In the Taxi zone, a diorite cross cuts the Mt McNeil granodiorite, whereas at Golden Eagle an opposite relationship was observed (Photo 3.4). The intrusions in each example are medium-grained and equigranular. Quartz is locally present in minor (<5%) concentrations, and the rock is moderately magnetic. Biotite and pyroxene together make up 30 to 35% of the rock. K-feldspar staining indicates that this rock type is most appropriately described as a biotite-pyroxene monzodiorite or quartz monzodiorite. Both dioritic bodies that were encountered have a weak foliation and are cut by chloritic and/or sericitic veinlets.

Biotite granite

This is a medium-grained, equigranular intrusive rock (Photo 3.5) that occurs locally in the Taxi zone and in drill holes south of the Kuhn Fault. It typically has no or only minor alteration or fabric (Photo 3.5, bottom). Dykes of this rock type cross cut the Mt McNeil granodiorite (Photo 3.5, top), but were not observed in contact with other intrusions. The rock is moderately magnetic and the only ferromagnesian phase is biotite. It is cut locally by chlorite or sericite veinlets.

Hornblende-biotite quartz monzonite (Carbon Hill pluton of Mt. McIntyre Plutonic Suite)

This is the main host rock to the Goddell Gully and Porter fault zones on the east side of the Wheaton River valley. Hart and Radloff (1990) report a poorly constrained K-Ar date of 96±15 Ma for this intrusion, which is broadly consistent with 107 to 110 Ma U-Pb zircon results obtained from other plutons of the same plutonic suite in the area. It is a medium-grained, equigranular rock with subequal K-feldspar and plagioclase and about 20% combined hornblende and biotite (Photo 3.6). It is moderately magnetic, but less so than the Mt McNeil stock. It has invariably been affected by strong alteration where close to the Goddell Gully and Porter fault zones. No temporal relationships were observed with other intrusions except for cross-cutting Tertiary rhyolite and andesite dykes.

Pegmatites and aplites

These were observed mainly in the Mt. McNeil granodiorite in the Skukum Creek area. They are most abundant in areas that are also cut by biotite granite dykes, to which they might be related. They are late magmatic features that are cut by minor shear zones and altered. None of these dykes observed during this study exceed 0.5 m in width (most are <5 cm wide), and they are widely dispersed through the host intrusions. One small aplite graded to a core of clear quartz, a pattern common to aplites in many systems.

3.2.2 Tertiary dykes and stocks

Andesite dykes

These intrusions are widespread throughout the project area, but are generally most common within or adjacent to major fault zones (cf., rhyolite dykes below). The most common types are either aphanitic and dark grey, or have a porphyritic texture defined by hornblende and plagioclase (Photo 3.7). Both types of dyke may be altered and locally mineralized. Some of the aphanitic dykes may be narrow equivalents of the porphyritic monzonite phase described above (Photo 3.7C). The porphyritic examples are relatively more common at Goddell Gully. Staining indicates that the dykes are actually monzonites and porphyritic hornblende monzonites, rather than andesites, although it is probable that all of these intrusive types are present. The andesites were observed to cut most of the pre-Tertiary phaneritic intrusive rocks, but with respect to rhyolites it can only be said that some andesite dykes are older than some rhyolite dykes (Photo 3.8). Several types of andesite dyke are probably present in the area, but work was inadequate for full delineation. Andesite dykes that intrude pre-Tertiary rocks in the region may represent subvolcanic feeders to the Mt. Skukum volcanic complex.

Rhyolite dykes

These intrusions comprise a diverse group of felsic dykes that are variable in mineralogy, texture, and their spatial and temporal relationships to hydrothermal alteration and mineralization. Rhyolite dykes were observed to cut most intrusions on the property, but have variable timing relative to andesites as noted above, suggesting multiple pulses of both intrusive types. Like the andesite dykes, rhyolite dykes commonly have a spatial association with, or are developed within, major east- and northeast-trending fault systems. In the Skukum Creek area and at Chieftain Hill, the most typical appearance of the dykes (Photo 3.8) includes a buff to light grey colour, and a aphanitic texture with up to 10% clear, rounded to square and locally resorbed quartz phenocrysts mostly <3 to 4 mm in size. Prominent flow banding is well-developed near the contacts of many of the larger dykes.

Three distinctive quartz±Kfeldspar porphyritic dykes that are present in the Goddell Gully area along the Goddell fault belong to the rhyolite dyke group. These have been termed the North, Central and South marker dykes in old drill logs, based on a consistent and predictable distribution along strike. The North and South Marker dykes (Photo 3.8 upper and lower) lack flow banding and have a higher concentration of K-feldspar phenocrysts and more variable concentrations of quartz phenocrysts than the Center Marker dyke. The Center Marker dyke (Photo 3.8, middle) has well-developed flow banding, overall texture, equant quartz phenocrysts, and alteration and disseminated pyrite that makes it much more similar to the mineralized rhyolite dykes at Skukum Creek. The relative age of the three rhyolite dykes at Goddell was not established.

A single, narrow spherulitic rhyolite dyke was observed in the Ridge zone (sample RG97-1-49.2). It is characterized by spherules <4 mm in size and several percent disseminated pyrite; the age of this intrusion relative to other types of rhyolite dyke is unknown but similar intrusions at Mount Skukum were considered by McDonald (1990) to be among the youngest rock types in the area.

Post-hydrothermal amygdaloidal andesite dykes

These occur in several places at Skukum Creek. They are invariably fresh and undeformed, even where located close to known mineralization, and are consequently interpreted as post-hydrothermal. These dykes range up to several metres in width. They have a fine-grained to aphanitic, dark-coloured groundmass, and are distinguished by white to clear amygdules infilled by quartz and/or calcite. Similar dykes were interpreted to be the latest stage of intrusive activity in the vicinity of the Mount Skukum mine (McDonald 1990).

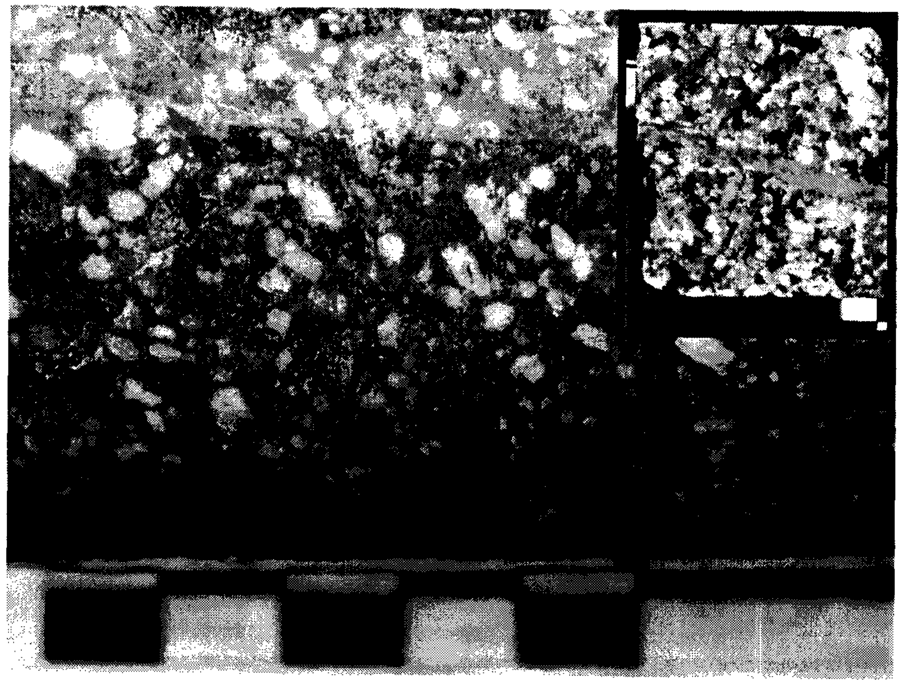


Photo 3.1. Biotite-hornblende granodiorite of the Mt McNeil pluton of Cretaceous age isthe main host rock in the Skukum Creek area. It is a medium to coarse-grained and equigranular to seriate texture, and commonly contains large euhedral hornblende crystals to >1 cm in length. In most cases hornblende is altered by chlorite; disseminated epidote is also present in this sample. Inset shows results of K-feldspar staining. Sample 86R14-708'; inset 86R14-159'.

Photo 3.2. The Bennett granite is a Triassic-Jurassic (?) intrusion with K-feldspar megacrysts that forms the footwall to the Rainbow East (Raca) vein. The K-feldspar megacrysts can reach several centimeters in size. This sample is strongly altered by quartz-sericite and its mineralogy is partially masked. Sample Raca97-1-242.5.

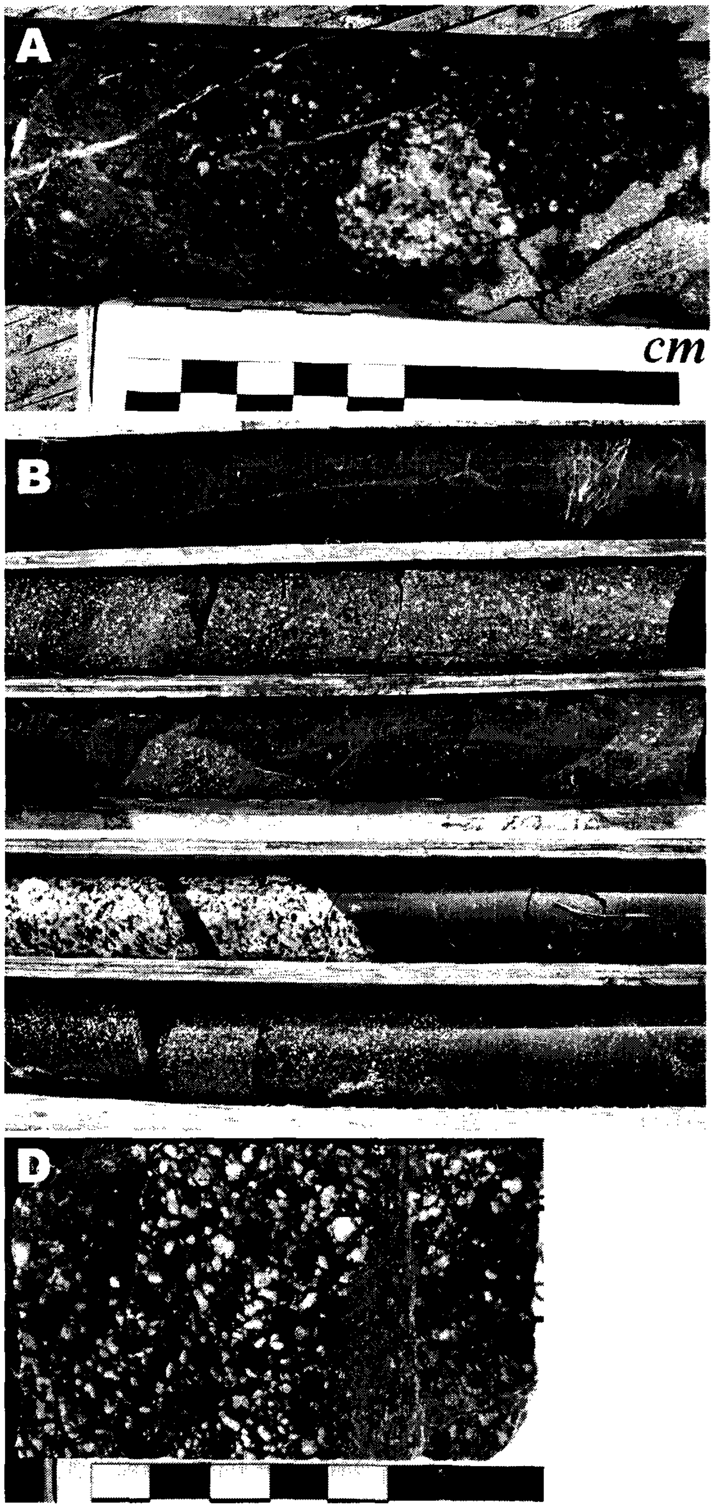


Photo 3.3. Monzonite porphyry is common in the Skukum Creek area. It is typically porphyritic with small, equant to elongate phenocrysts of white plagioclase and hornblende in a fine-grained, dark matrix that imparts a salt and pepper appearance.

A: Xenolith of Mt McNeil granodiorite in a strongly altered monzonite dyke establishes relative age of these phases..

B: Relationships to andesites are complex. In this photo the monzonite appears to intrude an andesite dyke. In other cases the opposite timing has been observed.

C: Here a monzonite varies in texture along a single intersection, with a fine-grained, dark, chilled margin that alone would be logged as andesite. This highlights potential problems with rock type assignments during logging.

D: Sample stained for K-feldspar.

Samples: A, R96-203-??; B, 98TZ1-??; C, 98GE1-269; D, 86R14-708'.

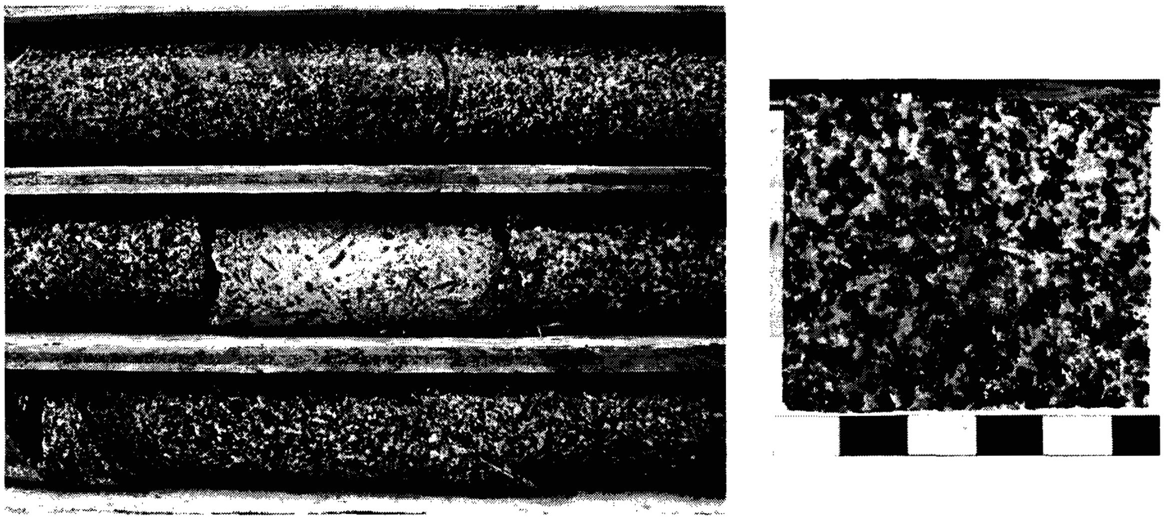


Photo 3.4. Diorites to quartz monzodiorites are uncommon, and where present constitute older, pyroxene-bearing bodies with accompanying hornblende and biotite. On left a small dike of Mt McNeil granodiorite cuts a quartz monzodiorite, which is stained in the photo on right. Samples: left, 98GE-1-290; right 98GE-1-292.

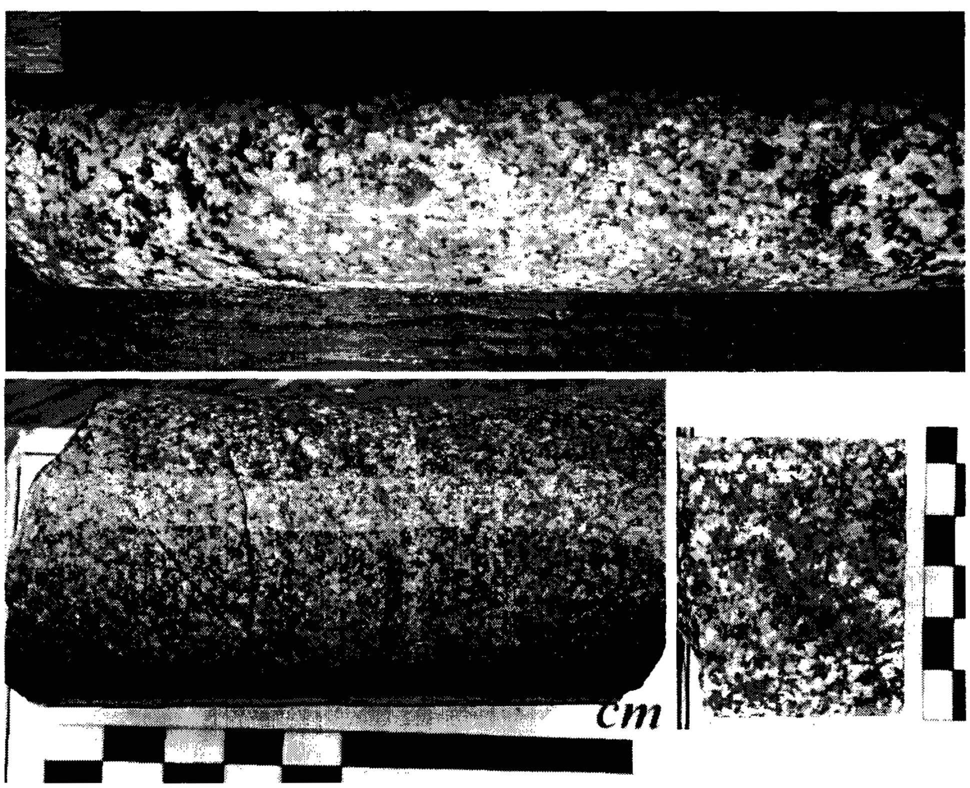


Photo 3.5. Biotite granites are found in several areas, particularly in the Taxi Zone and south of the Kuhn Fault. Intersections are mostly narrow suggesting dykes, but larger intersections could be small plutons. Biotite granites cut the Mt McNeil phase (upper photo), but relationships to other intrusive rock types is not known. Sample at lower left is weakly altered by sericite-chlorite, and lower right photo shows K-feldspar staining results. Samples: upper, 98GE1-217; lower left, 86R14-551'; lower right, 98GE1-242.

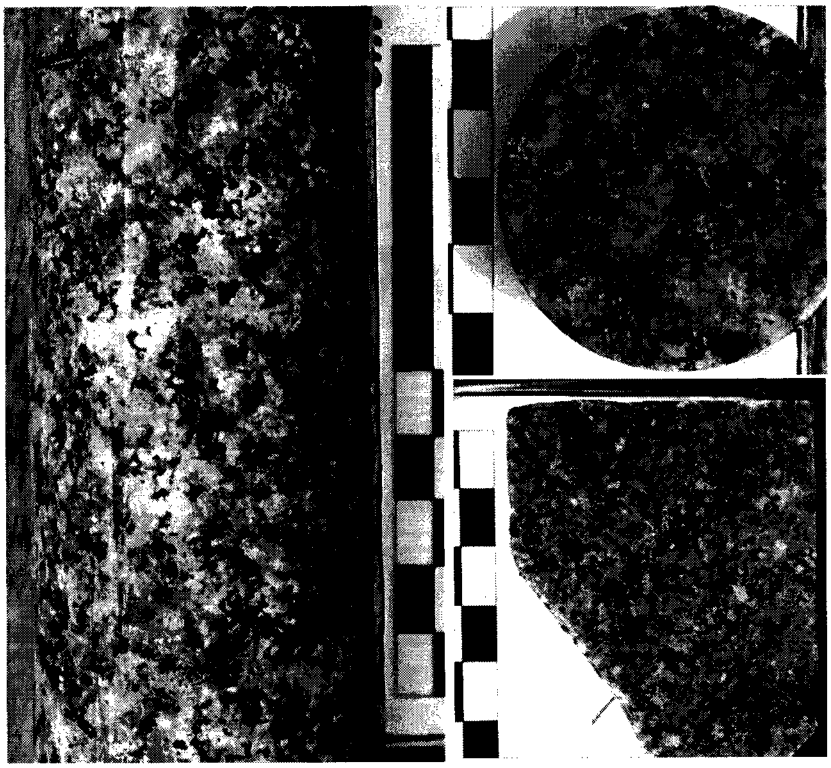


Photo 3.6. Biotite quartz monzonite is the main rock type enclosing the western end of the Goddell Gully shear zone. It is also found less commonly elsewhere, and may comprise plugs and/or dykes. K-feldspar stained samples on right show some variation in KF concentration. Samples: left and upper right, G97-59-16; lower right, 98GE1-72.5.

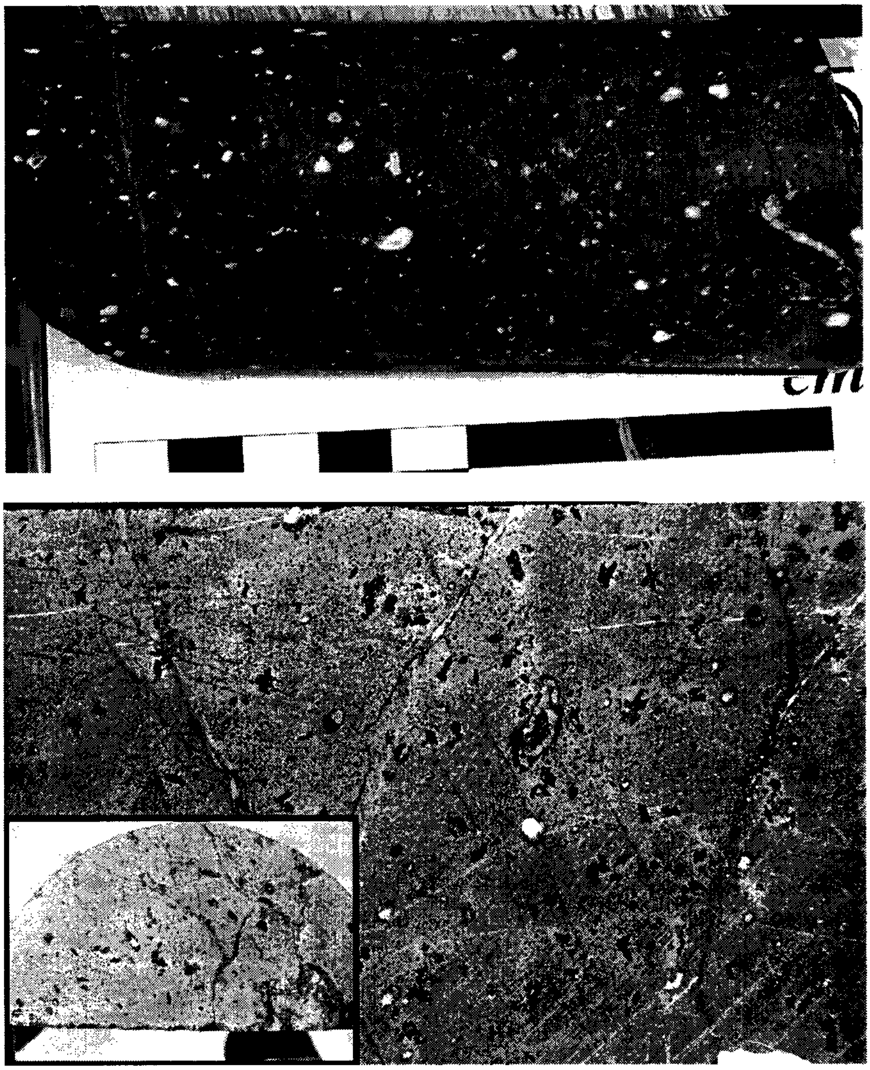


Photo 3.7. Andesite dikes are widespread and an important host to ore-grade mineralization at both Skukum Creek and Goddell Gully. Some of these dikes are aphanitic and dark in colour. but many. particularly at Goddell. are porphyritic with white plagioclase and euhedral hornblende phenocrysts. Most are at least weakly altered by sericite, chlorite. carbonate and epidote, and they are cross cut by at least some types of rhyolite dike. Inset at lower left shows a significant response to K-feldspar staining. suggesting that at least the porphyritic varieties may be more comparable to monzonite (consistent with textural gradations between monzonite and andesite dikes noted above). Samples: upper, SC01-1-116; lower and inset. SC01-3-214.2.

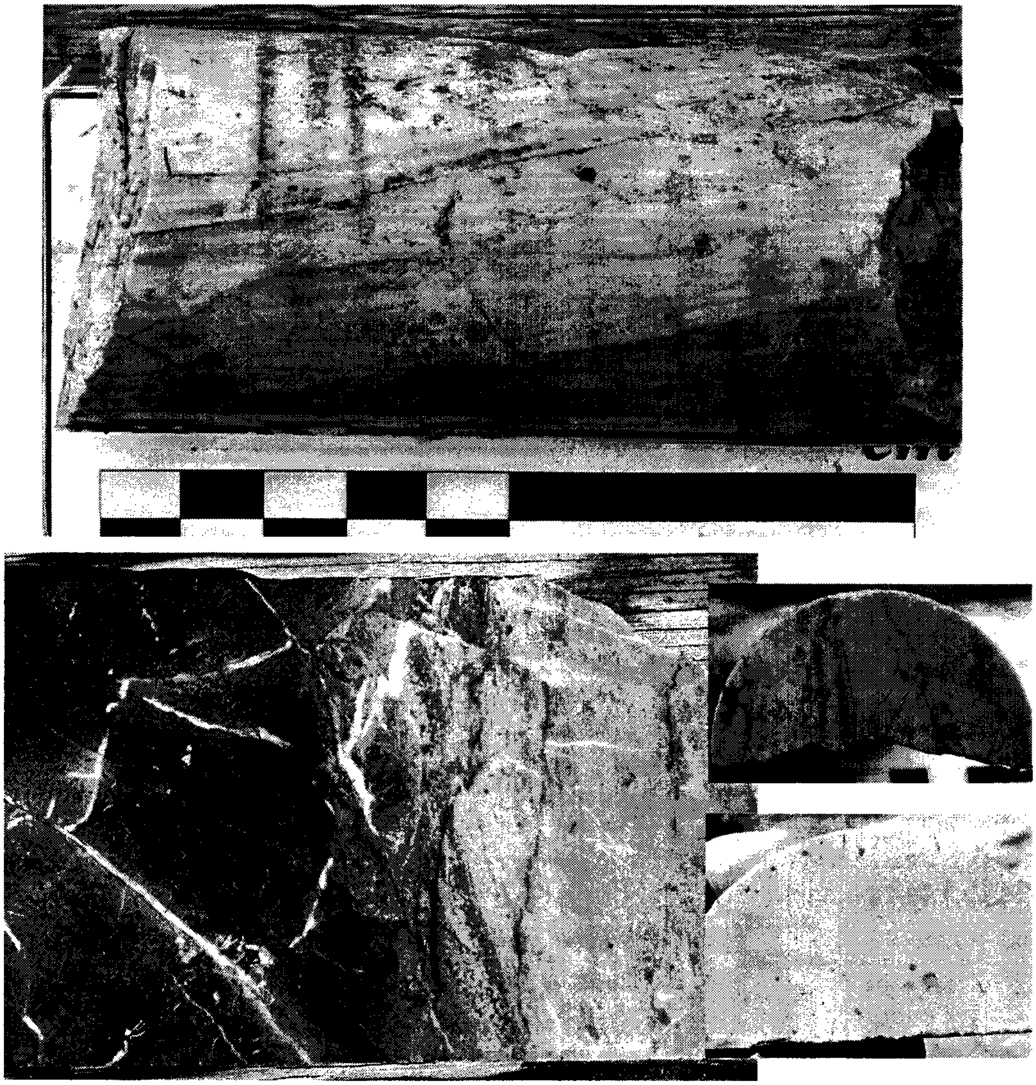


Photo 3.8. Rhyolite dikes are widespread at both Skukum Creek and GoddellGully. They are an important host to ore-grade mineralization at Skukum Creek, but are not significantly mineralized at Goddell. They manifest a wide variety of forms and degree of alteration and deformation, and were probably emplaced along the shear zones before, during and after hydrothermal activity. Many dikes logged as rhyolite within the boundaries of the shear zones are probably andesites that have been bleached by strong sericite-dominated alteration (see later section). Upper photo shows a typical rhyolite; it contains rounded to square quartz eyes and prominent flow banding (in larger dikes banding only occurs at the margins). Many of these dikes, where they are found outside the larger shear zones, contain abundant disseminated pyrite and base metal sulphides, are commonly cut by mineralized quartz veins, and return highly anomalous Au and Ag values: this firmly establishes a genetic link between at least some phases of rhyolite dike and ore-forming fluids. Lower photo shows rhyolite on right cutting a porphyritic andesite on left (note the curvature of the flow banding adjacent to the contact). Results of K-feldspar staining at lower right. Samples: upper and top stained, R96-213-119.8; lower and lower stained, SC01-3-225.

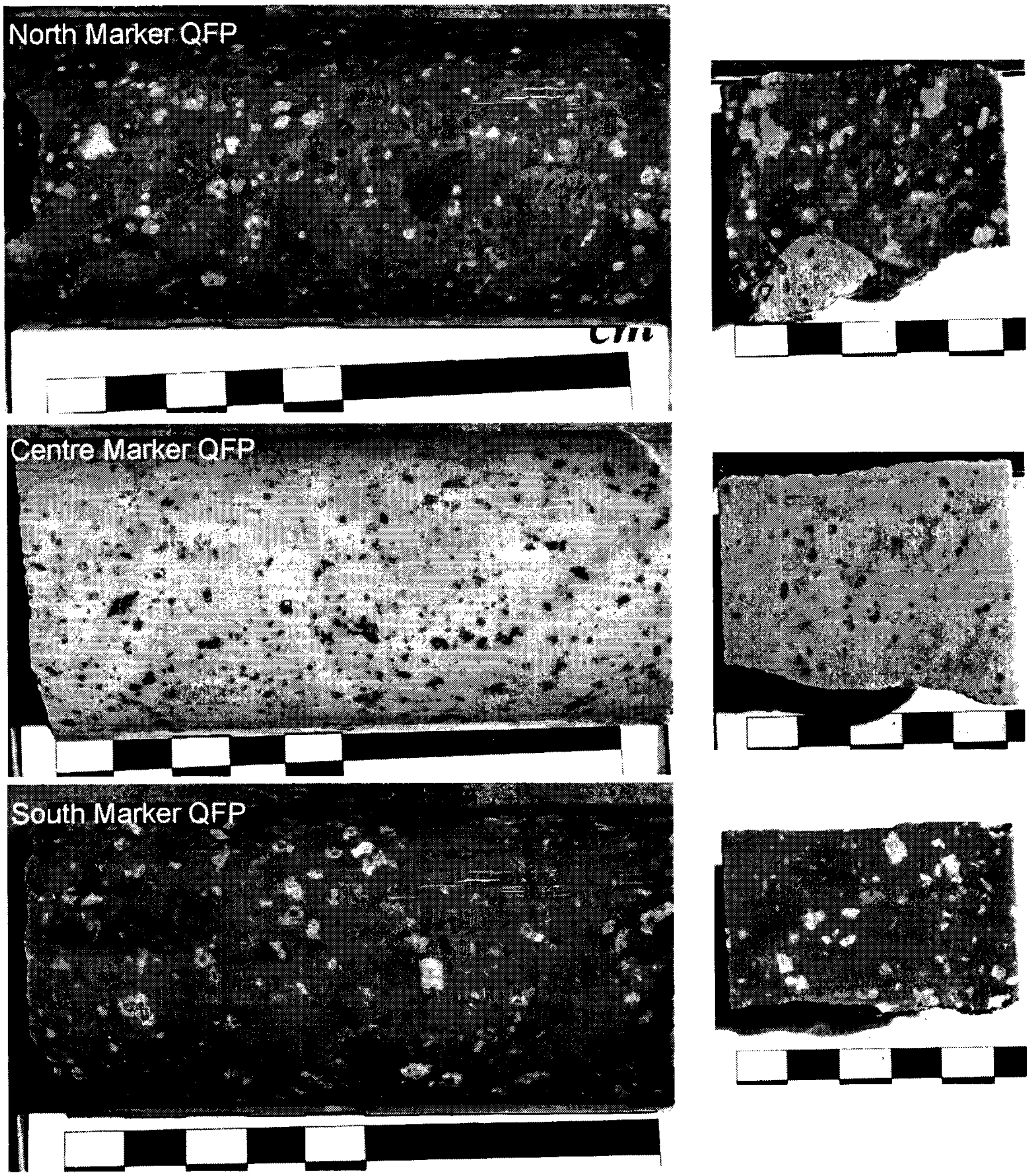


Photo 3.8 continued. Rhyolite dikes are common at Goddell Gully, where most have been referred to as QFP marker dikes because of their consistent orientation and location with respect to each other and to the Goddell shear zone. Each of these dikes is of rhyolitic composition, and they can be readily distinguished. The most interesting of the three is the Centre Marker, which consistently contains several percent disseminated pyrite and stronger alteration than the North and South Markers, as well as strong flow banding and prominent quartz eyes with a much lower concentration of accompanying feldspar: these features may link the Centre Marker more closely to mineralized rhyolite dikes in the Ridge-Taxi area (see text). Corresponding stained samples shown on right. Samples: North, G97-58-118; Centre, G97-58-128; South, G97-37-82.

3.3 Structural setting of the Skukum project area

Rocks in the Skukum project area have been affected by several phases of faulting, and Jurassic and older rocks have also been subjected to regional penetrative strain manifested by one or more phases of foliation development and, locally, by folding. Foliation is best developed in rocks of the Nisling Terrane which commonly contain a shallowly dipping schistosity and associated minor folds (Hart and Radloff 1990). The Late Triassic/Early Jurassic Bennett Granite is also commonly foliated. Foliation and lineation developed in K-feldspar granite on the northeast side of Skukum Creek, which is assigned here to the Bennett granite; the deformation records significant post-magmatic strain where intersected in drill holes in the Rainbow East (Raca) zone, and could be coeval with foliation development in nearby outliers of the Nisling terrane. At least one and probably several phases of pre-Middle Jurassic deformation are indicated regionally by Hart and Radloff (1990), with which the observed fabrics are probably associated, including probable Triassic deformation associated with the Tally Ho shear zone to the northeast. Apart from local fabrics developed adjacent to younger shear zones, no other phases of penetrative strain were identified in the study area. Northwest-trending folds reported in Jurassic rocks in the region were not identified in the few examples of rocks of this age examined during the present study.

Faults and shear zones developed in the Skukum project area comprise predominantly east- and northeast-trending structures in all rock types, and additional significant north-trending faults developed in the Mt. Skukum volcanic complex. Major northwest-trending, Cordillera-parallel faults and shear zones, such as Tally-Ho/Llewellyn, are not well-represented in the area, apart from some northwest-trending lineaments defined by valleys and drainages which do not accommodate regionally significant displacement but which may have local significance. Given the restricted scope of the present work, timing relationships between faults on a property scale could not be established; some general comments on the distribution, kinematics and timing of some major faults and fault sets are, however, outlined below.

3.3.1 East and northeast trending faults, Wheaton River Valley corridor

Major faults in this area probably form part of a single, anastomosing and bifurcating fault system. These structures include the Berney Creek and Chieftain Hill faults developed on the west side of the Wheaton River valley, and the Porter and Goddell faults developed to the east (Figure 1). All of these structures are spatially associated with rhyolite and andesite dykes, and with Au-Ag±Sb and Sb mineralization. Apart from work reported here in section 4.0 and general relationships based on rock type distribution and fault history in Hart and Radloff (1990), McDonald et al. (1990) and Hart (1992A-C), no work on the internal structural style, history and kinematics has been undertaken on these structures. Major faults in this set include the following.

Berney Creek fault

This structure is visible as a rusty, east-northeast trending lineamant running along the southern, upper part of Mt. Reid ridge for up to 5 km southwest of the Skukum Creek deposits. It dips vertically or steeply to the southeast. The fault system locally defines, or occurs near, the contact between rocks of the Mt. Skukum volcanic complex to the north and Cretaceous granodiorite to the south. Multiple fault strands over a width of several hundred meters contain slivers of Tertiary volcanic rocks and conglomerate and Cretaceous granodiorite. Rapid thickening of the Skukum Creek volcanic rocks to the north of the fault, their dip away from this structure, and the occurrence of several rhyolite and andesite dykes within the fault zone that may in part represent feeders to the volcanic rocks suggest that this structure may have been active synchronously with volcanism and may therefore form a caldera-bounding fault (McDonald et al. 1990; Hart 1992C). Between several hundred meters and 1 km of north side down displacement are estimated by McDonald et al. (1990), based on the thickness of Mt. Skukum volcanic rocks to the north. It is unclear whether this phase of displacement represents remobilization of an older structure, or a principal phase of displacement along it. Faults that host the Skukum Creek deposits display a protracted history that is discussed in the context of the Berney Creek fault in section 4.0.

The Berney Creek fault curves to more northeasterly trends at the Skukum Creek deposits, and may be continuous with the Chieftain Hill fault system on the northeast side of Skukum Creek. Northeast-trending splays and fault steps off the north side of the Berney Creek fault at its northeastern, bending end include the Kuhn and Rainbow faults, which are host to mineralization at the Skukum Creek deposits. These structures and their associated mineralization are also described in section 4.0.

Chieftain Hill fault system and Wheaton Lineament

The Chieftain Hill fault system is defined by a set of northeast-trending, vertical to steeply southeast-dipping faults developed along the eastern and southeastern flanks of Chieftain Hill, possibly as the northern continuation of the Berney Creek fault. Like the Berney Creek fault, this fault system locally forms the faulted contact between the Mt. Skukum volcanic complex to the northwest and Cretaceous and older intrusions and supracrustal rocks to the southeast. It may also represent a northwest side down, synvolcanic, caldera-bounding structure with significant displacement, possibly localized on an older structural feature. The Chieftain Hill fault system is also associated with rhyolite and andesite dykes of probable Eocene age. Multiple fault strands are present over widths of up to several hundred meters in the area of the Ocean vein (see section 8.0) and comprise gouge and cleaved wallrock. The fault system is associated with east-trending veins and shear veins along Morning Gulch in the central-eastern parts of Chieftain Hill that include the Ocean, Johnny B and Morning veins, and which are further described in section 8.0. Splays off the Chieftain Hill fault in this area, including the fault system associated with the Ocean vein, trend east and project across the Wheaton River valley toward the Goddell fault.

The Chieftain Hill fault system is parallel to and developed approximately 400 m southeast of the Wheaton Lineament, a linear, northeast-trending, 30 km long feature defined by Hart and Radloff (1990) based on air photo and enhanced Landsat TM imagery. Its southwestern end is interpreted to pass through the eastern flanks of Chieftain Hill. Because this feature has not been confirmed as a fault it is not shown on Figure 1, and its relationship to fault systems in the area remains unknown. If a fault is present, it may represent an extension of, or a fault parallel to, the Chieftain Hill fault.

Goddell fault

The Goddell fault is a steeply dipping, east-southeast trending fault system that is developed in pre-Tertiary rocks over a minimum 5 km strike length east of the Wheaton River valley. Further faults trending northeast are developed along strike from it to the east of Becker Creek (outside of Figure 1) and may represent its eastern continuation (see maps in Hart and Radloff 1990). Like other east-trending faults in the area, the structure is intruded by rhyolite and andesite dykes along its length and has associated Au-Sb and Sb mineralization developed at the Goddell Gully and Becker-Cochran deposits, respectively. In drillcore, the fault comprises an anastomosing set of brittle to semi-brittle fault strands developed over widths of 20 to 100 m. Kinematics and magnitude of displacement are unknown. Structural style, metallogenic associations, and associated dykes are comparable to that at Chieftain Hill, and the Goddell structure may represent the eastern projection of strands of the Chieftain Hill fault system across the Wheaton River valley. The fault is described in further detail in section 9.0.

Porter fault

This structure is parallel to and developed 2 km south of the Goddell fault (Figure 1). Descriptions are similar to that of the Goddell fault, including an association with rhyolite and andesite dykes, several anastomosing cataclasite slip surfaces, and spatially associated alteration and Au-Sb mineralization (Wesa and Elliott 1999). Displacement magnitude and direction are undetermined. This structure is outside the area of the current study and has not been tested by drilling. It may represent an eastern continuation of a splay off the Berney Creek fault across the eastern side of the Wheaton River Valley.

3.3.2 Other fault orientations

North-trending, typically normal faults are common within the Mt. Skukum volcanic complex. These structures may represent syn-volcanic growth faults. Listric morphologies are locally common.

Northwest-trending faults and lineaments are present throughout the district, but in the Skukum project area they rarely form major structures. Where reported, faults of this orientation display apparent dextral displacements of up to several tens of meters (e.g., McDonald et al. 1990; Wesa and Elliott 1999). Their timing and structural style are not documented.

4.0 SKUKUM CREEK AREA: STRUCTURAL SETTING AND STYLE OF AU-AG MINERALIZATION

The Skukum Creek area contains two styles of structurally controlled mineralization: (i) within northeast-trending faults and shear zones that are associated with the Berney Creek fault system; and (ii) within north-northeast trending quartz-sulphide extension veins (e.g. Taxi zone) that are genetically related to the mineralization hosted by the major northeast-trending shear zones.

Five deposits and prospects have been identified over a strike length of 1.3 km along a network of northeast-trending shear zones in the Skukum Creek area. These comprise from southwest to northeast: (i) the Ridge and adjacent Ridge 2 zones; (ii) the Kuhn zone; (iii) the Sterling zone; (iv) the Rainbow zone; and (v) the Rainbow East (Raca) zone (Figure 2). These deposits occur on at least two steeply southeast-dipping shear zones: (i) the Kuhn fault, which hosts the Ridge and Kuhn zones; and (ii) the Rainbow fault, that developed to the northeast of the Kuhn fault and which hosts the Rainbow zone and, probably, the Rainbow East (Raca) zone. The Sterling zone is a north-trending, steeply east-dipping zone similar in style to the Rainbow and Kuhn faults and which may link them structurally (Figure 2). Other faults in the area include the King Canyon fault, a northeast-trending splay off the Kuhn fault which forms a prominent gully to the north of the Taxi and Rainbow zones, and the Skukum Creek Fault, a west-northwest trending structure postulated to run along the lineament defined by Skukum Creek but not verified by geological evidence (Figure 2).

Principal host rocks are Cretaceous granodiorite of the Mt. McNeil pluton, several other minor pre-Tertiary igneous phases described in section 3, and probable Jurassic volcanic, igneous and clastic rocks that occur in the lower parts of the Skukum Creek valley and northeast of Skukum Creek (Figure 2). Andesite and rhyolite dykes of probable Tertiary age are intimately associated with the shear zones throughout the Skukum Creek zones.

The focus of work in the Skukum Creek area was the Rainbow and Kuhn zones because they are exposed in several crosscuts and drifts, have been tested by many diamond drill holes, and are currently the most economically significant zones in the Skukum Creek area. As a result, their geological setting and structural style are described first below. Most of the comments regarding structural style of the mineralization are based on observations from the Rainbow zone, due to a paucity of complete drill intersections and inaccessibility of workings in the Kuhn zone. Due to the presence of widespread Fe-oxides on underground walls and backs, poor ground conditions in areas of mineralization, and dirty walls, systematic underground mapping could not be undertaken; structural measurements and observations were recorded only where conditions permitted.

4.1 Structural setting of the Rainbow and Kuhn zones

Host rocks to the Rainbow and Kuhn zones were examined principally in underground workings at Skukum Creek, where development is primarily in the footwall (north side) of the zones. Except within or near shear zones, the host rocks, which consist mainly of Mt McNeil granodiorite with subordinate dykes and bodies of plagioclase porphyritic monzonite, are massive and unfoliated. A series of faults, shear zones and veins are superimposed on these igneous bodies and include semi-brittle shear zones, veins and veinlets that consist of variable combinations of quartz, chlorite, carbonate, epidote and sulphide, and brittle faults filled with gouge.

4.1.1 Minor shear zones peripheral to the Rainbow and Kuhn zones

Minor shear zones are present throughout the Skukum Creek workings, although they are most abundant in several domains and corridors, particularly near the Rainbow and Kuhn zones. Although these are the earliest structural features recognized in the workings, they may overprint and obscure characteristics of earlier structures. These shear zones are of similar structural style, timing and character to those within the Rainbow and Kuhn zones, with which they are probably coeval, but they lack significant alteration and veining. Shear zones in the Rainbow and Kuhn zones are described separately below.

Style and internal character

Shear zones in host rocks to the Rainbow and Kuhn zones range from narrow slip surfaces <2 mm thick to anastomosing zones 5 to 50 cm wide that contain alternating slip surfaces, bands of foliated wallrock and lithified cataclasite (Photo 4.1). Cataclastic bands are typically 0.25 to 3 cm thick, very fine-grained, and pale green to tan in colour. They comprise 3 to 15% fragments of fine-grained, subrounded igneous quartz grains, sericite-chlorite altered fragments of wallrock and, locally, igneous plagioclase grains in a very fine-grained matrix of chlorite-sericite-quartz±carbonate (Photo 4.2). The phyllosilicate-rich matrix is commonly foliated, with foliation defined by the alignment of chlorite and sericite, calcite grains and elongated blebs, and by stylolitic pressure solution surfaces. Contacts with adjacent wallrock are sharp to gradational over several millimeters. Where not recrystallized, quartz fragments in the cataclasite are commonly unstrained or show only minor undulose extinction (Photo 4.2), which indicates that ductile crystal-plastic processes were not widely active during shear zone formation.

Foliated cataclastic bands define the principal slip surfaces in thicker (>1 cm) shear zones. Laterally these may thin to hairline surfaces that contain chlorite and sericite that accommodate slip with little cataclasite development. Minor shear zones may also be cored by hairline slip surfaces that lack cataclasite.

Cataclasites and slip surfaces are commonly surrounded by envelopes of penetratively-foliated wallrock several millimeters to 15 cm in width, beyond which the host rocks are massive and unstrained. Where multiple slip surfaces occur, wallrock between them is also generally foliated. Foliation is defined by alignment of medium- to coarse-grained chlorite, carbonate and sericite that replace igneous minerals, and by pressure solution surfaces that commonly display stylolitic textures (Photo 4.1). The foliation is typically developed at oblique angles of 10 to 30^0 to slip surfaces and cataclasites (Photo 4.1), which allows determination of shear sense using oblique fabric relationships (see below).

Shear zone mineralogy varies on small scales throughout the underground workings, and exhibits at least some degree of host rock control on accessory mineralogy. Chlorite-sericite-carbonate assemblages predominate in granodiorite. Epidote and pyrite are common accessory minerals in monzonite units, where they occur in envelopes to slip surfaces, as discontinuous veinlets and disseminations within the core of the shear zone, and concentrated on pressure solution surfaces within the shear zone. Sphalerite, galena and chalcopyrite also locally occur with, and in the same habit as, pyrite in some shear zones.

Orientations, distribution and kinematics

The orientation of minor shear zones varies in the Skukum Creek workings. Shear zones of different orientation will commonly link and join without displacing each other, which along with their similar structural style, mineralogy, relative timing and overall compatibility in shear sense suggests that they formed collectively during one event. Three orientations are most common, each with different shear sense (Figure 3A): (i) east-northeast trending, southeast-dipping shear zones that range from <1 mm up to

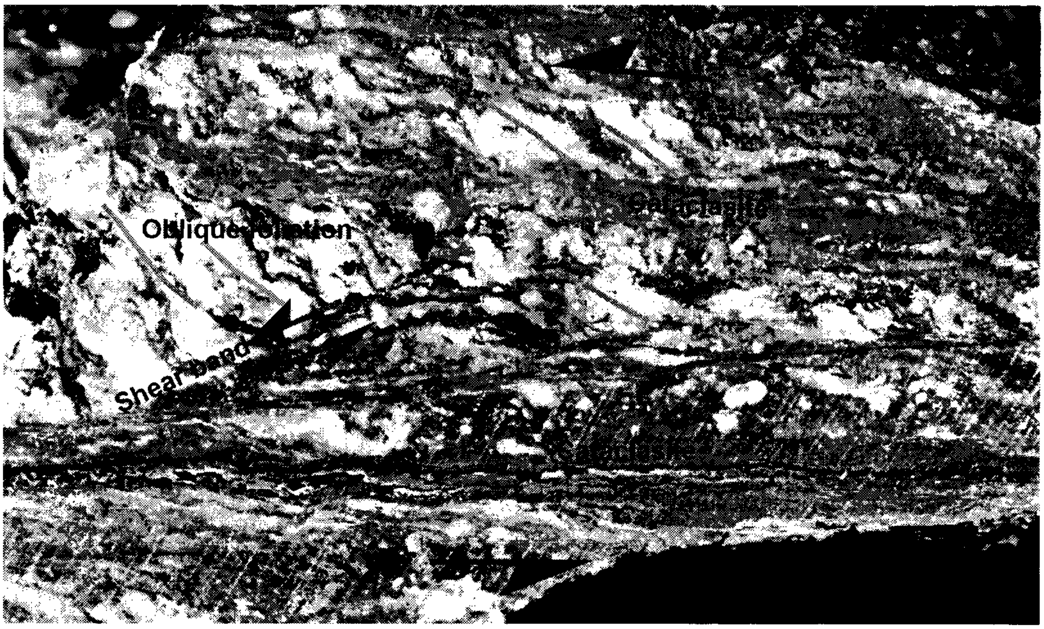


Photo 4.1. Slab of a minor shear zone from 1300 level west, northwest of the Sterling zone. Seams of fine-grained, pale green sericite-chlorite cataclasite with local dark grey, pyritic slip surfaces separate slivers of foliated granodiorite. Foliation in granodiorite slivers is a pressure solution fabric defined by stylolitic seams of chlorite-sericite. Note shear band and obliquity of pressure solution fabrics to cataclasite surfaces, which indicate an apparent left-lateral shear sense in this view which, when in place, corresponded to a true northeast-side down shear sense on this northwest-trending, steeply-dipping shear zone. Field of view is 20 cm.

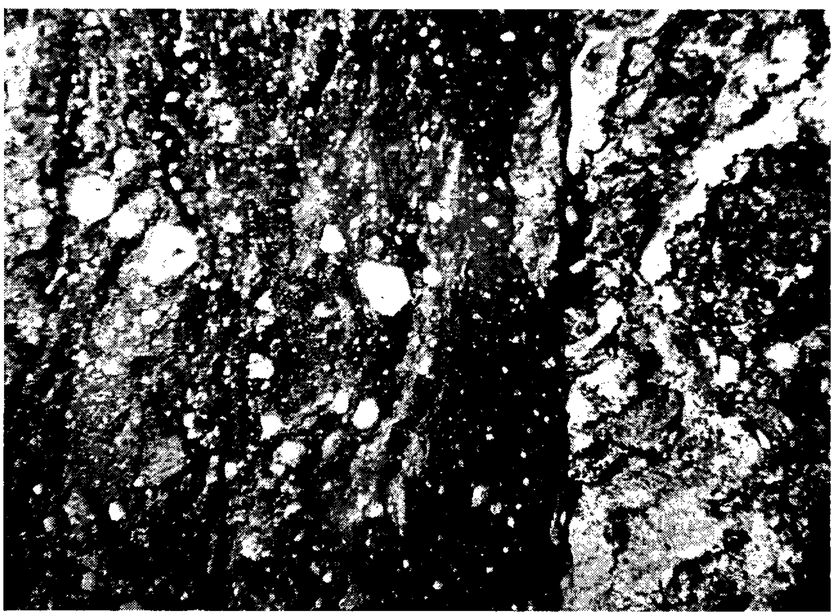
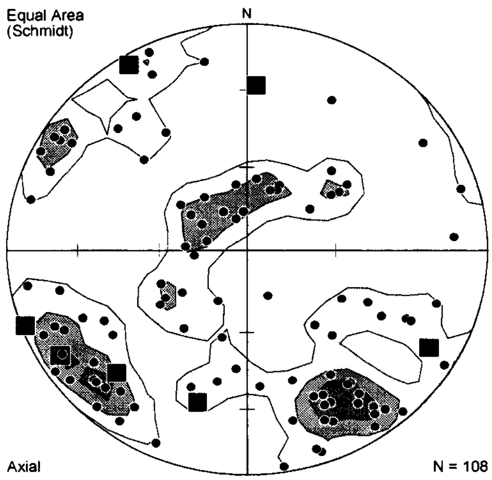


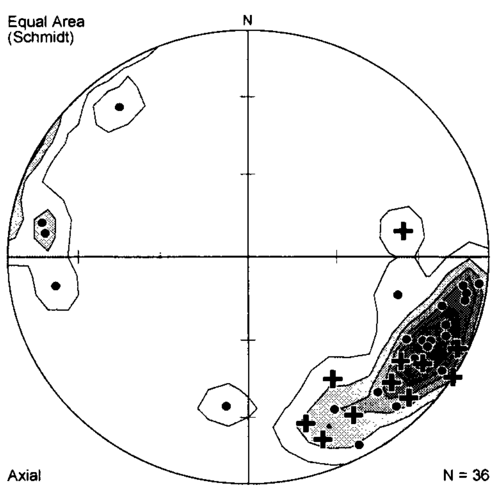
Photo 4.2. Photomicrograph of a foliated cataclasite from a minor shear zone on 1300 level west. Brown-grey, cataclasite matrix rich in sericite-chlorite (left) contains fragments of unstrained quartz. Dark streaks are pressure solution seams. In right hand portion of photo, pressure solution foliation that is oblique to the sharp margin of the cataclasite affects altered granodiorite. Plane polarized light, field of view 2.63 mm.

0.5 m wide – parallel to the Rainbow and Kuhn zones -- with predominantly sinistral (left lateral) shear sense; (ii) northwest-trending, steeply northeast-dipping shear zones up to 0.3 m, but generally less than 2 cm, in width, with mainly northeast side down, vertical displacement; and (iii) shallow south- to southeast-dipping minor shear zones, generally less than 1 cm wide and mostly with top to the southwest displacements. Shear sense on all of these structures was determined by the use of several kinematic indicators, including elongation lineations – mainly elongate blebs of chlorite and sericite after igneous minerals – defining slip direction, oblique foliations (see Photo 4.1) and pressure shadows on quartz grains and wallrock fragments in cataclasites. Because the shear zones are developed mainly within massive igneous rock, no markers are present to gauge total displacement. Based on their character and the local offset of veinlets, however, displacement on most of the minor structures in the Skukum Creek workings outside the main Rainbow and Kuhn shear zones is interpreted to be minor, probably between a few centimeters on narrow slip surfaces to less than 3 m on larger structures 5 to 15 cm wide.

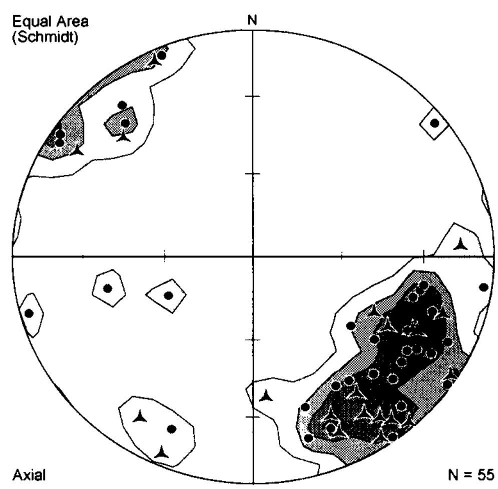


A. Minor shear zones outside the Rainbow and Kuhn zones. Squares = shear zones >5cm thick

Figure 3: Equal area projections of poles to minor structures measured outside of the Rainbow and Kuhn zones in the Skukum Creek underground workings. See text for details.



B. Quartz-sulphide extension veins. Contouring peak = 209/75. + = Taxi zone veins from maps; dots = veins measured underground.



C. Calcite veinlets. Contouring peak = 207/74. Triangle = veinlets hosted by minor shear zones.

Minor shear zones in the wallrocks to the Rainbow and Kuhn zones are most abundant within 5 to 10 m of each zone, principally in their footwalls, and define a damage zone that surrounds the major structures. Shear zones of all three common orientations described above are present in this area. Minor shear zones are also common in several corridors outside of the Rainbow zone. A high concentration of minor shear zones with predominantly northwest trends and northeast dips occurs on the 1300 level between sections 47775E and 477820E (UTM), in the footwall of the Rainbow and Sterling zones near their junction (Figure 4). These structures may accommodate strain from the Rainbow shear zone where it makes a significant bend into the Sterling zone.

The minor, shallowly south-dipping shear zones present in the Skukum Creek workings record only minor displacements, probably of <0.5 m, and have no recognized larger equivalents. These structures may represent the remobilization of pre-shear jointing or minor faults.

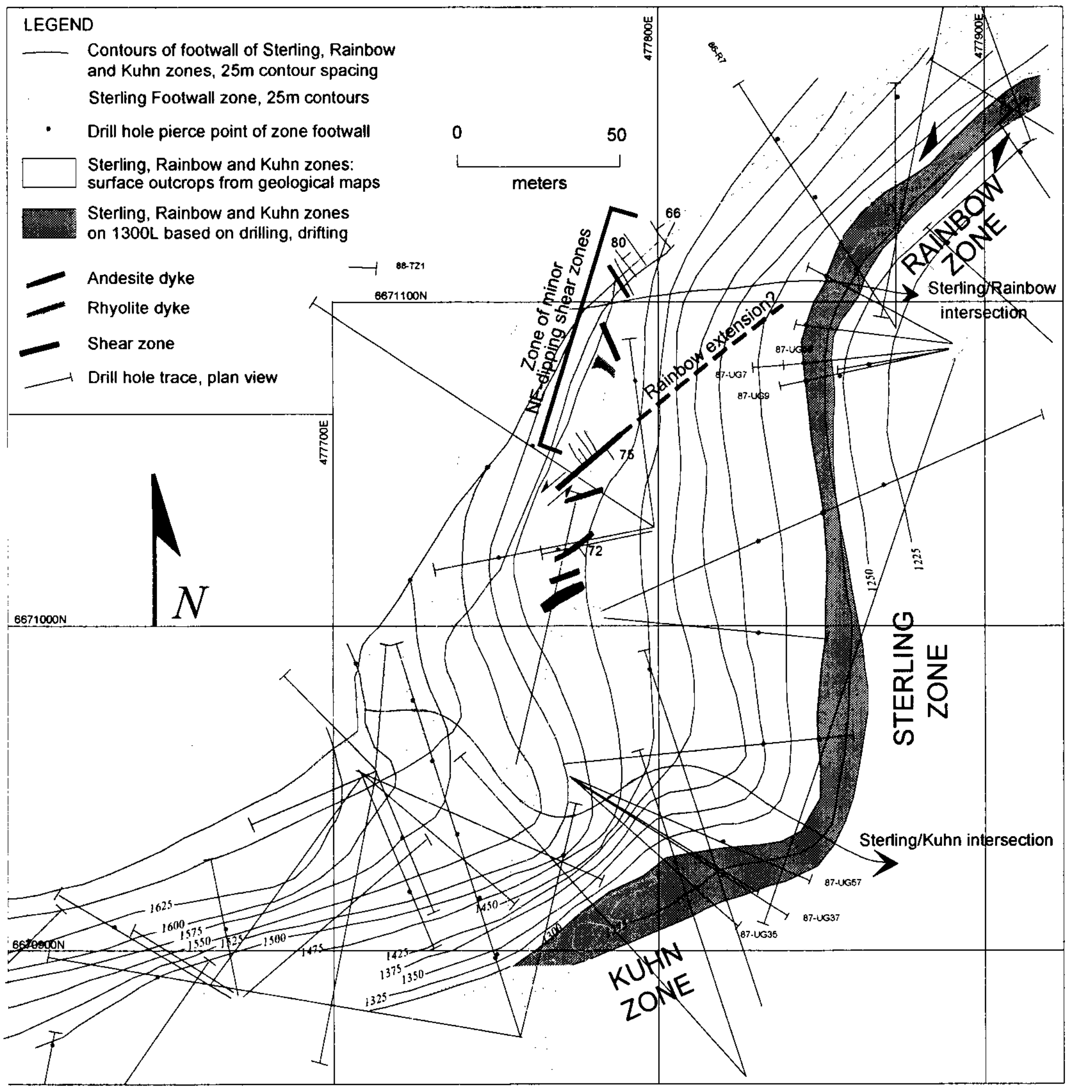


Figure 4: Plan map of the Sterling zone area, at the junction of the Rainbow and Kuhn zones. The footwall surface of the Sterling, Rainbow and Kuhn zones is contoured based on diamond drilling information, surface mapping and underground maps. Shear zones and dykes on 1300 level are shown.

Rainbow extension

The most significant shear zone observed outside of the currently defined boundaries of the Rainbow, Kuhn and Sterling zones within the workings, which probably has significantly more displacement than on those shear zones described above, occurs on the 1300 level west of the Sterling zone at approximately 6671050N, 477778E (Figure 4). Here a northeast-trending, steeply southeast-dipping shear zone 10 to 50 cm wide crosses the 1300 drift. The structure contains cataclasite and foliated granodiorite with chlorite-sericite alteration. It has been remobilized by several clay gouge seams. Kinematic indicators include oblique foliation, shear bands and elongation lineations that indicate a predominantly sinistral shear sense. This structure occurs at the southwestern strike projection of the Rainbow zone (Figure 4), of which it probably represents an extension. Like the Rainbow zone shear zones, it is also associated with Tertiary dykes that include a set of andesite dykes developed for up to 40 m to the south (Figure 4).

4.1.2 Veins and veinlets

Quartz-sulphide extension veins

Quartz-sulphide extension veins generally spaced >5 m apart are common in the Skukum Creek underground workings. These veins typically range from 0.5 to 5 cm in thickness, are commonly traceable across the width of a drift (>4 m), and generally have northeast-trending, steeply northwest-dipping orientations (Figure 3B). Where quartz-rich they may have fibrous or prismatic quartz growth, with quartz fibres and grains oriented at high angles to vein walls suggesting predominantly dilational, extensional opening (see section 5). No significant alteration envelopes were noted on extension veins underground, although locally sericite and chlorite are present in vein selvages. Where they cross minor shear zones the extension veins are commonly displaced, although some join or are preferentially developed around minor shear zones which suggests a temporal and genetic relationship (see section 4.2). They are parallel and mineralogically similar to quartz-sulphide extension veins developed in the Taxi zone, with which they are probably coeval. The Taxi zone veins are locally >25 cm thick, and some have been traced for more than 200 m along strike (Figure 2).

Carbonate veinlets

Carbonate±chlorite±pyrite veinlets with predominantly northeast strikes and steep northwest dips (Figure 3C) are common in the Skukum Creek workings. Carbonate species include calcite and much less abundant ferruginous species. Veinlets are mostly <2 cm thick and can be vuggy. They are commonly developed in minor shear zones, where they can contain a shear zone parallel foliation imparted by chlorite partings. They are probably coeval with, or formed during the late stages of, movement on the shear zones. Their timing, similarity in orientation to quartz-sulphide extension veins, and occurrence locally along the margins of quartz extension veins suggest that they may represent a late hydrothermal equivalent to the quartz-sulphide extension veins formed under the same tectonic conditions.

Other vein types

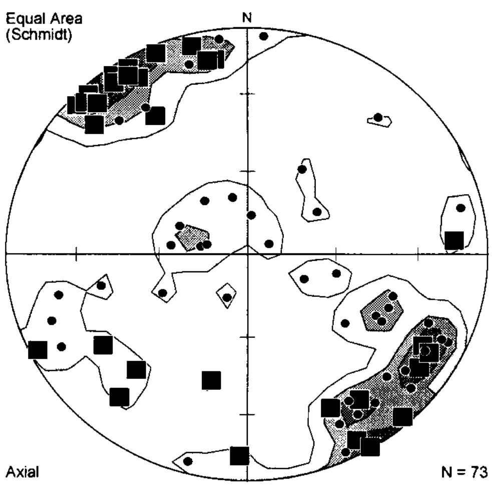
Epidote veinlets with K-feldspar envelopes, and minor magnetite-sulphide veins were observed in some drill holes and are described in section 5. These are overprinted by shear zones and other vein types, and may represent an early phase of vein formation associated with cooling of the Mt. McNeil granodiorite. They were rarely observed underground.

4.1.3 Gouge-filled faults

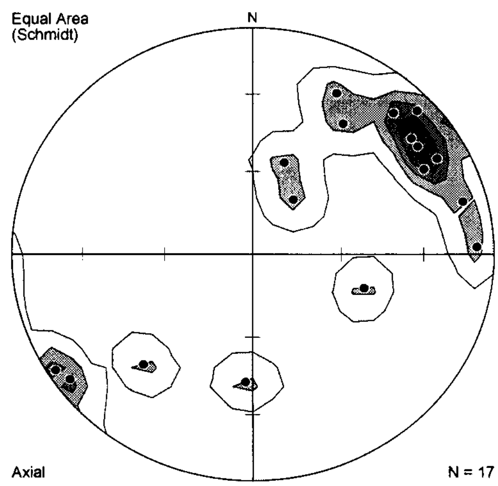
Faults that contain pale grey to green clay gouge commonly exploit earlier structures including shear zones, quartz-sulphide extension veins, carbonate veinlets and dyke contacts. These are the youngest structures recognized in the Skukum Creek workings. The largest of these are developed in the Rainbow and Kuhn zones, and are described further in section 4.2. Outside the Rainbow zone, faults filled with clay gouge are generally minor structures <1 cm in width. They are most commonly developed along earlier semi-brittle shear zones of all orientations, and along carbonate veinlets. This is illustrated with a plot of fault orientations (Figure 5A), which displays the same common orientations as earlier shear zones (Figure 4A) including: (i) steeply dipping and northeast-trending, (ii) shallow south- to southeast-dipping; and (iii) northwest-trending with steep dips.

Shear sense was not determined on most minor faults due to a lack of kinematic indicators. Slickensides measured mainly on northeast-trending, southeast-dipping faults that exploited the Rainbow zone and parallel, minor shear zones typically plunge shallowly to the northeast (Figure 5B); gouge fabrics and synthetic Riedel shear fractures indicate a predominantly left lateral/normal shear sense (see section 4.2.6).

Steps in surface topography of the slopes above the 1300L and 1350L portals have been previously interpreted as preferential erosion above shallow-dipping faults. Shallow-dipping faults are present in underground workings, but all that were observed were minor structures that mainly exploited older, minor shear zones. Shear sense was not determined due to the lack of consistent kinematic indicators in these features. Core from holes drilled in the area of topographic steps did not intersect any significant faults that might have contributed to their formation, and no related displacements of shear zones or dykes are apparent. The steps may represent glacial plucking along shallow-dipping joint planes or minor faults/shear zones.



A. Poles to gouge-filled faults, measured throughout the underground workings. Includes faults measured within the Rainbow zone. Squares = >1 cm clay gouge. Most NE-trending faults >1cm thick were measured in the Rainbow zone.



B. Fault slickensides. All gouge-filled faults. Contouring peak = 18 → 053.

Figure 5: Equal area projections illustrating gouge-filled fault and associated slickenside orientations measured in the Skukum Creek underground workings.

4.2 Structural geology of the Rainbow and Kuhn zones

4.2.1 Relationships between the Rainbow, Kuhn and Sterling zones

The Rainbow and Kuhn zones are heterogeneous zones of faulting, shear zone development, andesite-rhyolite dyke emplacement, and alteration and accompanying Au-Ag-quartz-sulphide mineralization (Figure 6). The Rainbow zone trends east-northeast, with typical orientations of 050 to 070 and with dips of 65 to 85^0 to the southeast, and has been traced by drilling and underground development (Figure 8; Figures 8 to 15 are several long sections that illustrate various aspects of the Rainbow zone and are presented together below for ease of comparison) over a strike length of 400 m from its junction with the Sterling Zone to just above Skukum Creek (Figure 2); the zone extends at least 400 m down dip (Figures 2 and 9). Mineralized shear zones intersected in the Rainbow East (Raca) zone on the north side of Skukum Creek may represent its eastern continuation (Figure 2). The Kuhn zone represents a mineralized part of the Kuhn fault/shear zone system that has been traced by drilling over a strike length of approximately 200 m, and which trends slightly more easterly (065-080) and dips slightly more steeply to the southeast than the Rainbow zone.

Thickness of each zone is highly variable. Both are defined mainly by the distribution of rhyolite and andesite dykes, associated breccias, shear zones and veins that collectively form generally semi-tabular zones that range from 1 to more than 20 m in true thickness (Figure 9). In the Rainbow zone, thickness typically ranges from 4 to 16 m, whereas the Kuhn zone is typically 2 to 10 m thick; both zones exhibit thicker central chutes with steep easterly plunges (Figure 9).

The Kuhn and Rainbow zones are linked at their northeast and southwest ends, respectively, by a north-trending, steeply east-dipping zone of dykes, shear zones and local quartz-sulphide veins of similar character to the Rainbow and Kuhn zones (Figure 4). This zone is called the Sterling zone and has a strike length of approximately 180 m. Surface geological mapping and the distribution of diamond drill intersections of all three zones (see contoured footwall in Figure 4) suggest that the zones are continuous and joined, and define an S-shaped bend with steep, east-plunging inflection points (Figures 4 and 9) in a single complex of dykes, veins and shear zones. Although the bulk of the dykes and shear zones in the Rainbow and Kuhn zones bend into the Sterling zone, a series of northeast-trending andesite dykes and the northeast-trending, 10 to 50 cm wide shear zone ("Rainbow extension") described in section 4.1.1 occur along strike from the Rainbow zone on the 1300 level (Figure 4); this indicates that at least part of the Rainbow and Kuhn zones may continue beyond the Sterling zone and warrant future exploration. The Sterling zone is of similar thickness to the Kuhn zone, and limited drilling suggests it also contains a thickened, steeply-plunging core (Figure 9) with some associated Au-Ag mineralization; down plunge mineralization could be comparatively more continuous.

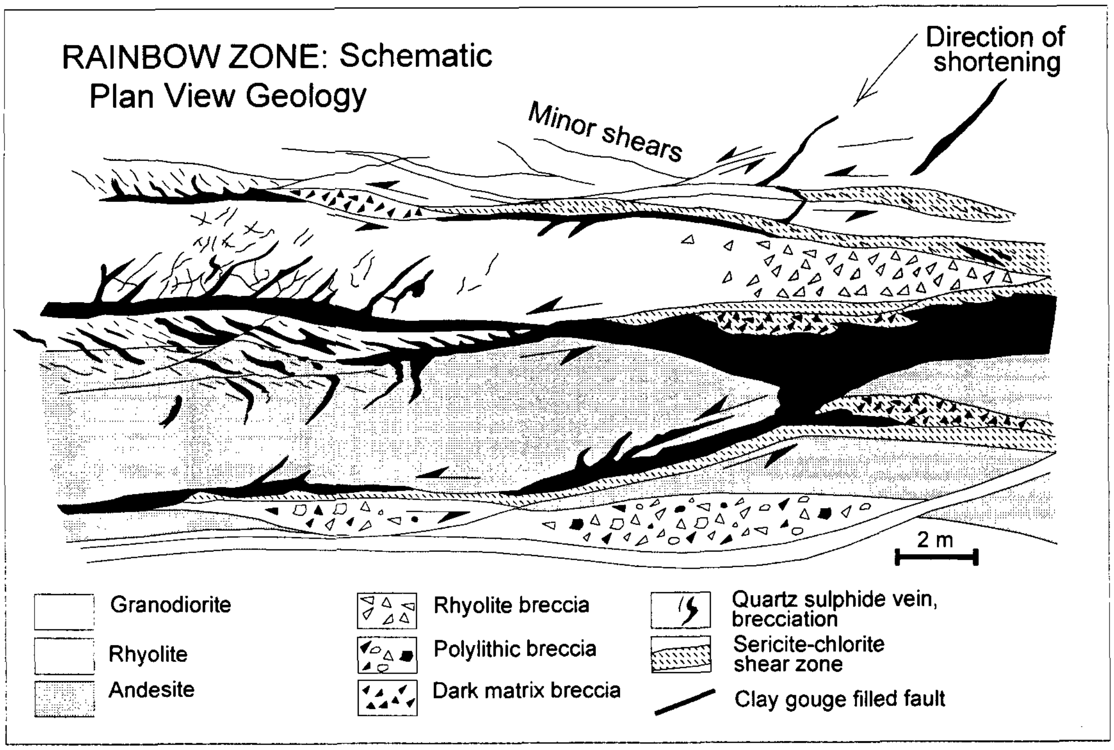
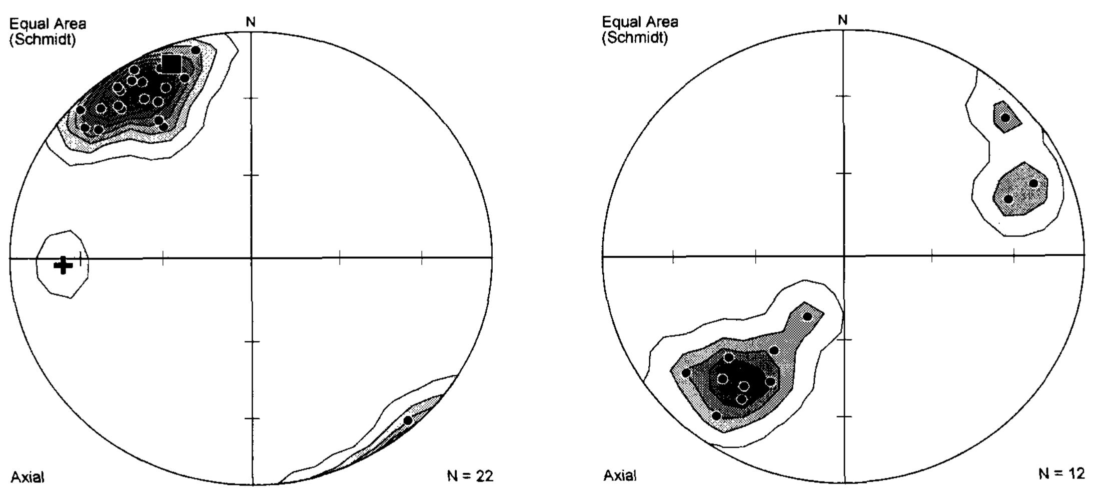


Figure 6: Schematic plan view of a portion of the Rainbow zone to illustrate typical features and relationships. The zone is a well layered heterogeneous zone of andesite and rhyolite dykes, hydrothermal and phreatic breccias, shear zones, quartz-sulphide veins and clay gouge filled fault surfaces.



A (left). Poles to Rainbow zone slip surfaces (shear zones), and typical Kuhn and Sterling orientations. Contouring peak = 056/79. Typical Sterling zone orientation, measured from plans = cross; typical Kuhn zone orientation, measured from plans = square.

B. Calculated slip direction on Rainbow zone shear zones. Based on orientation of oblique fabrics with respect to shear zone boundaries, including oblique foliation and shear bands. See text for details. Contouring peak = 29 → 215.

Figure 7: Equal area projections illustrating slip directions on shear zones and faults features in the Skukum Creek underground workings. Calculated slip direction in B is based on the use of oblique foliation developed within the shear zones.

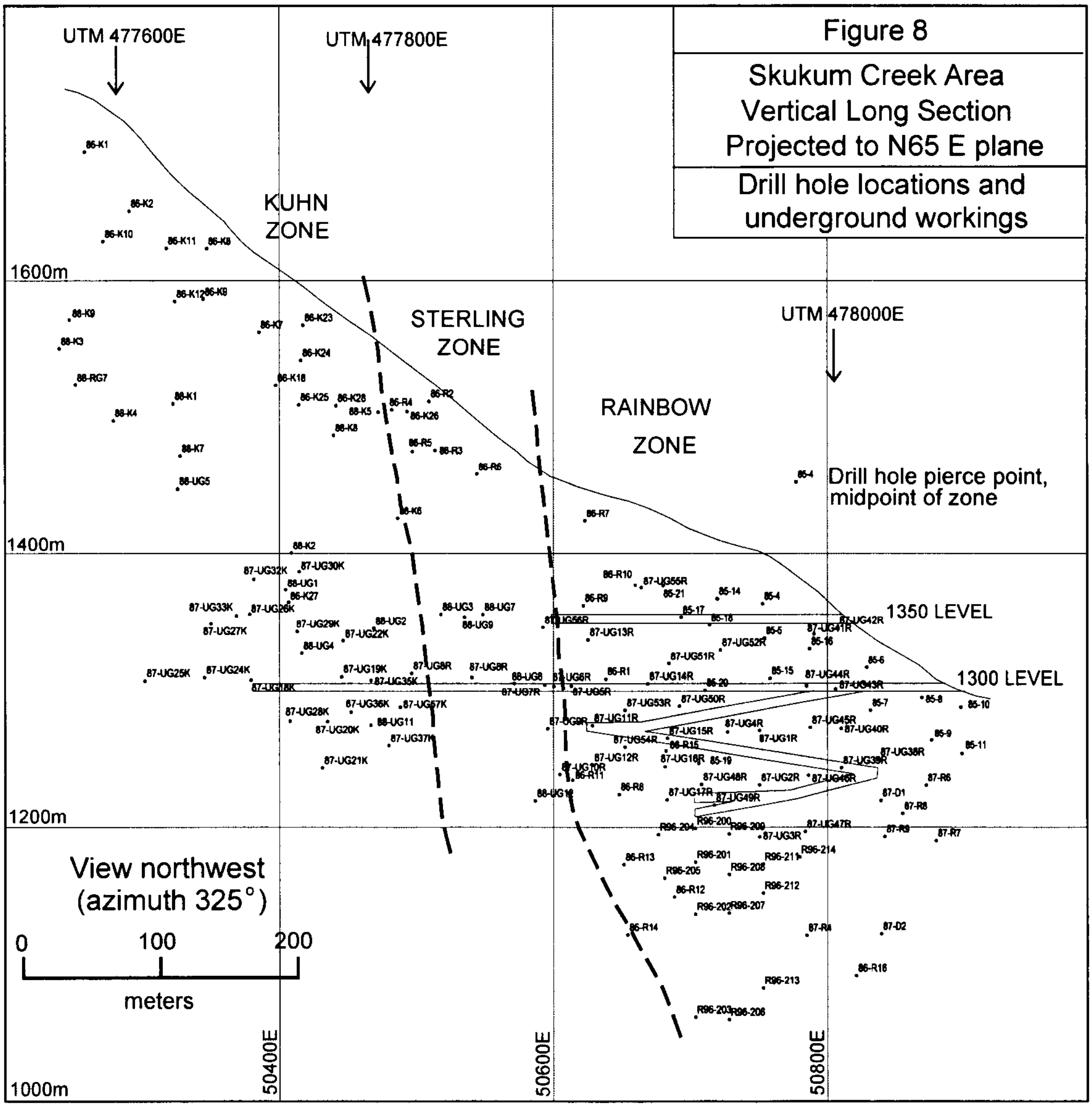


Figure 8
Skukum Creek Area
Vertical Long Section
Projected to N65 E plane
Drill hole locations and
underground workings
UTM 477600E
UTM 477800E
UTM 478000E
KUHN
ZONE
STERLING
ZONE
RAINBOW
ZONE
Drill hole pierce point,
midpoint of zone
1350 LEVEL
1300 LEVEL
1600m
1400m
1200m
1000m
View northwest
(azimuth 325°)
0
100
200
meters
50400E
50600E
50800E

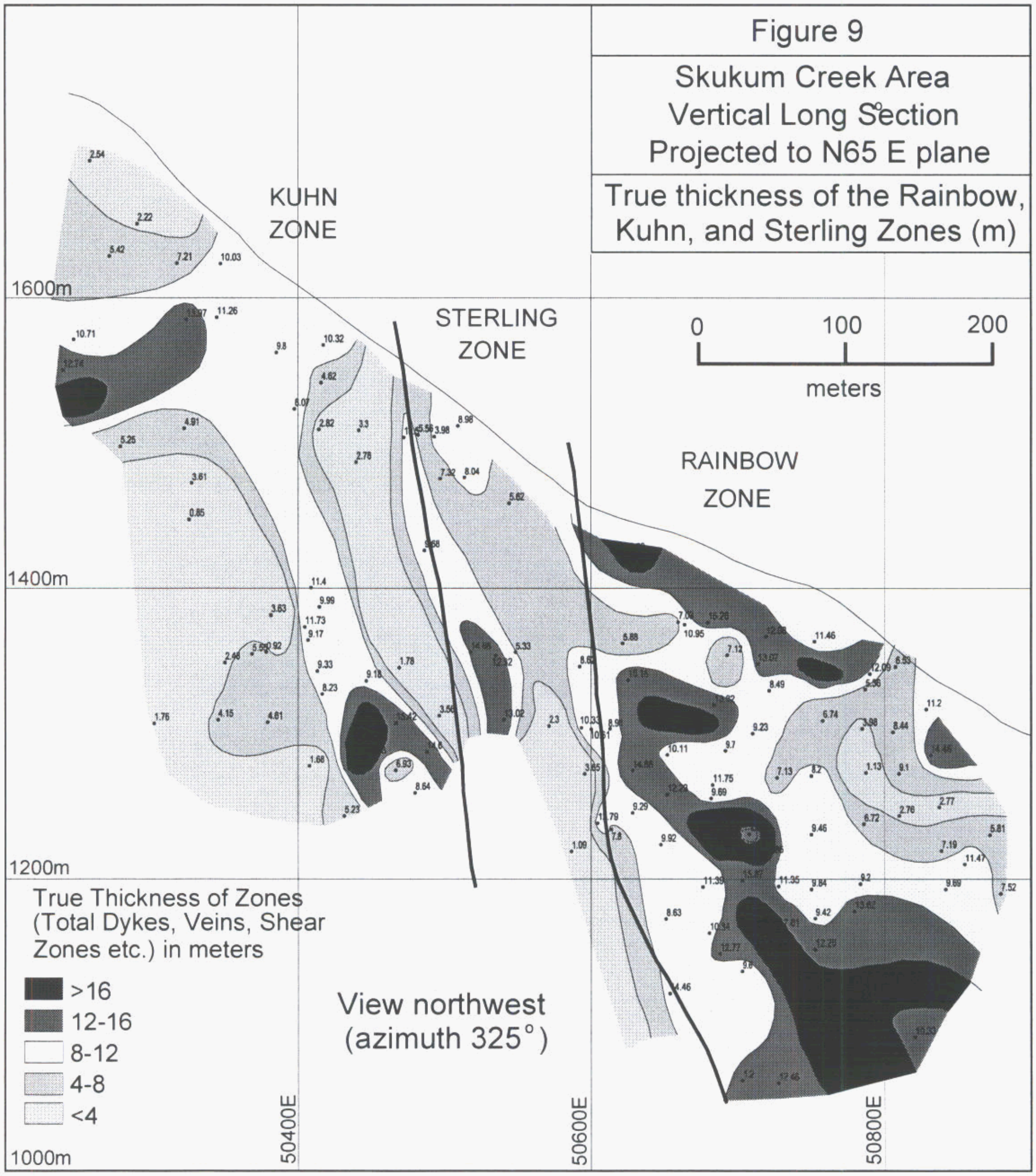


Figure 9
Skukum Creek Area
Vertical Long Section
Projected to N65 E plane
True thickness of the Rainbow, Kuhn, and Sterling Zones (m)
KUHN ZONE
STERLING ZONE
RAINBOW ZONE
0 100 200
meters
1600m
1400m
1200m
1000m
50400E
50600E
50800E
True Thickness of Zones (Total Dykes, Veins, Shear Zones etc.) in meters
>16
12-16
8-12
4-8
<4
View northwest (azimuth 325°)

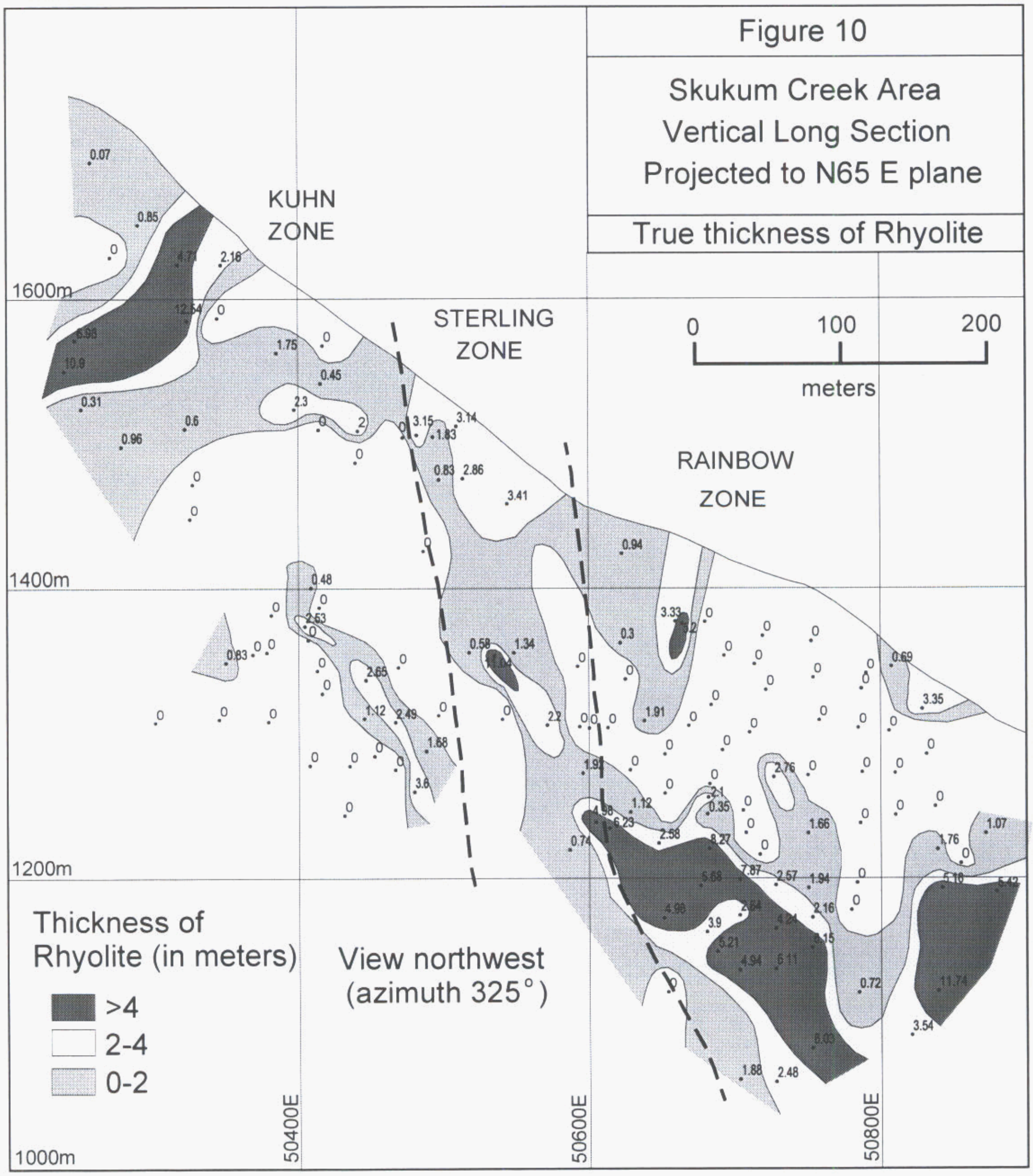


Figure 10
Skukum Creek Area
Vertical Long Section
Projected to N65 E plane
True thickness of Rhyolite
KUHN ZONE
STERLING ZONE
RAINBOW ZONE
0
100
200
meters
1600m
1400m
1200m
1000m
50400E
50600E
50800E
Thickness of Rhyolite (in meters)
>4
2-4
0-2
View northwest (azimuth 325°)

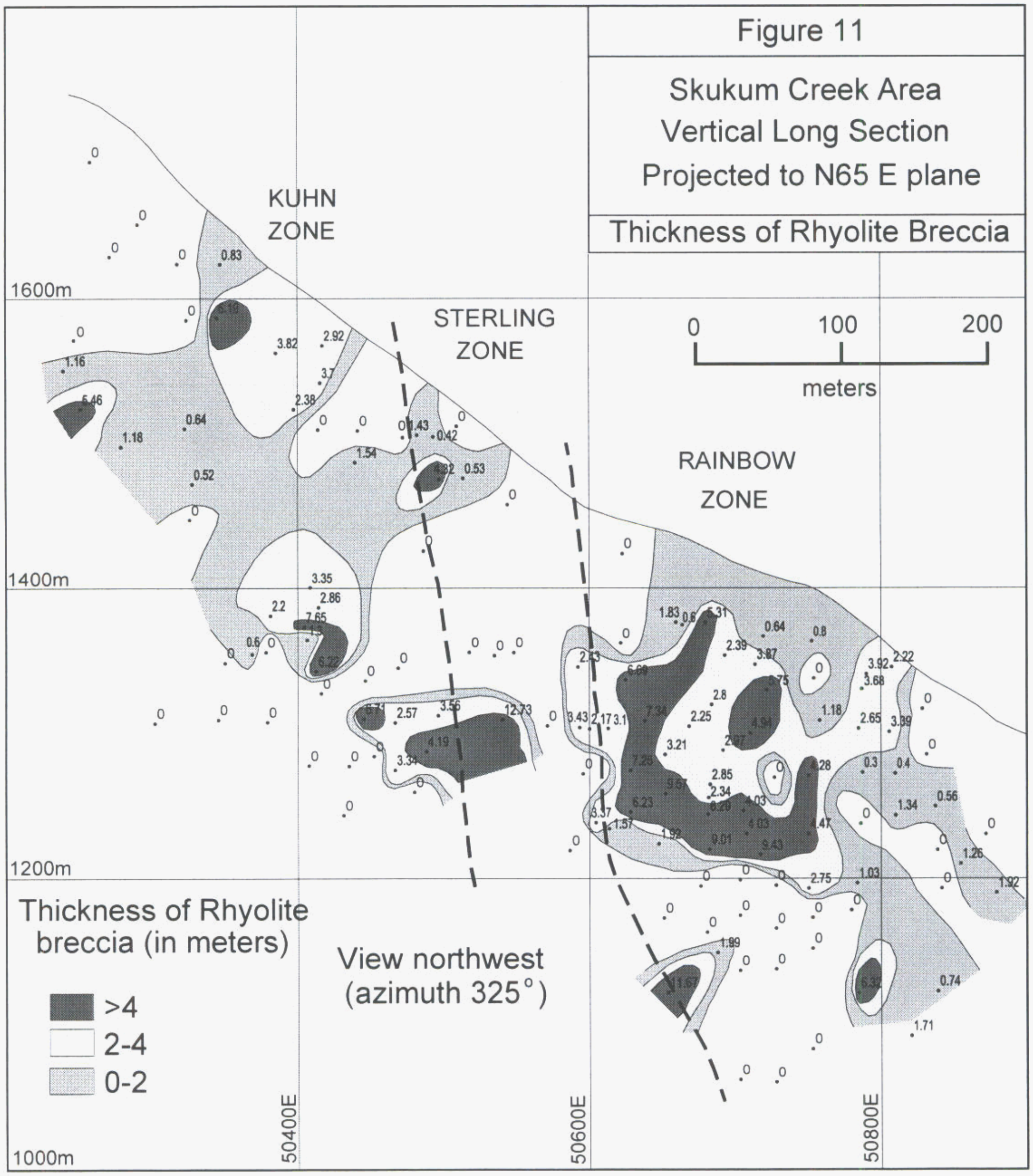


Figure 11
Skukum Creek Area
Vertical Long Section
Projected to N65 E plane
Thickness of Rhyolite Breccia
0
100
200
meters
KUHN ZONE
STERLING ZONE
RAINBOW ZONE
1600m
1400m
1200m
1000m
50400E
50600E
50800E
Thickness of Rhyolite breccia (in meters)
>4
2-4
0-2
View northwest (azimuth 325°)

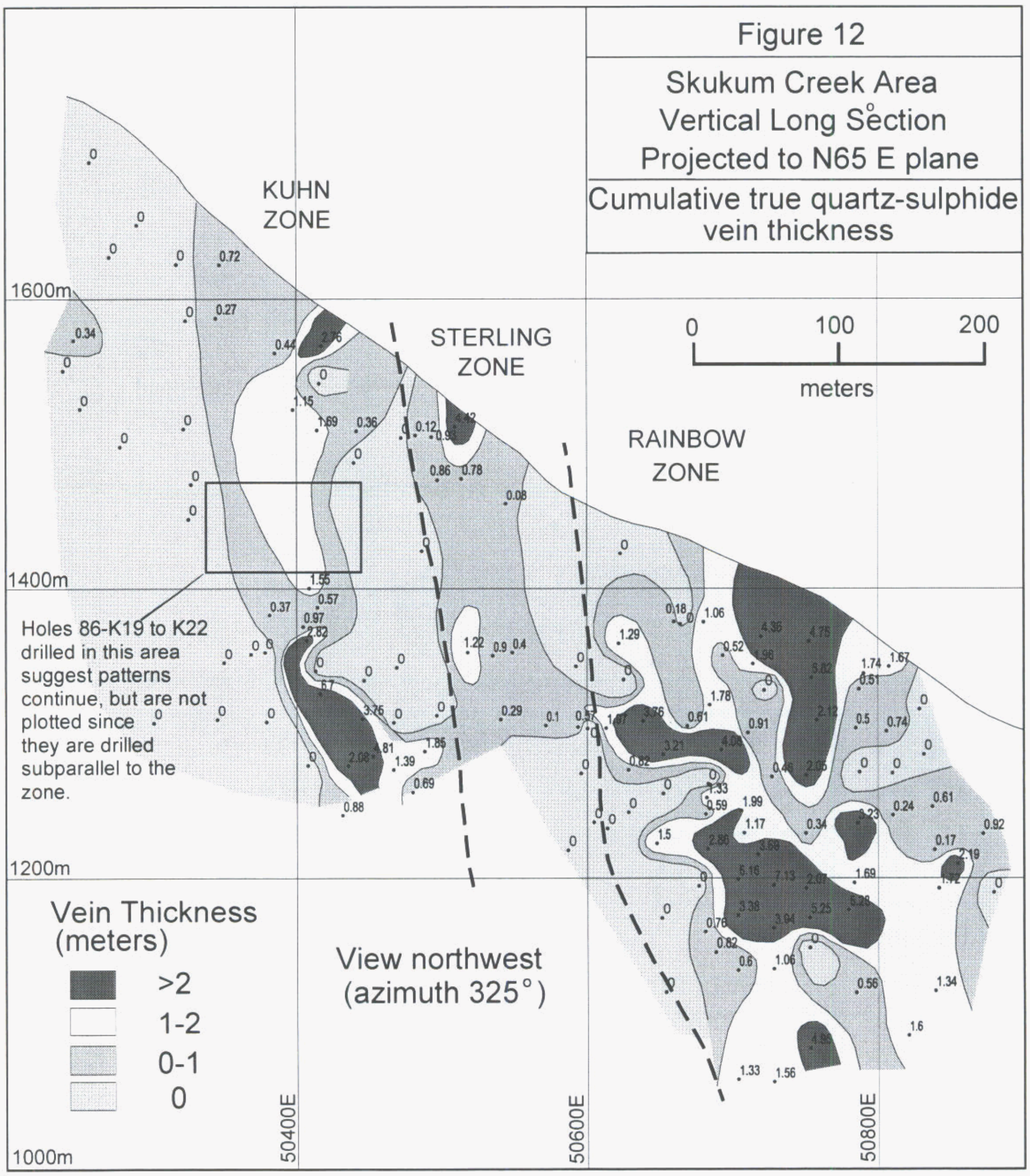


Figure 12
Skukum Creek Area
Vertical Long Section
Projected to N65°E plane
Cumulative true quartz-sulphide vein thickness
0
100
200
meters
KUHN ZONE
STERLING ZONE
RAINBOW ZONE
1600m
1400m
1200m
1000m
50400E
50600E
50800E
Holes 86-K19 to K22 drilled in this area suggest patterns continue, but are not plotted since they are drilled subparallel to the zone.
Vein Thickness (meters)
>2
1-2
0-1
0
View northwest (azimuth 325°)

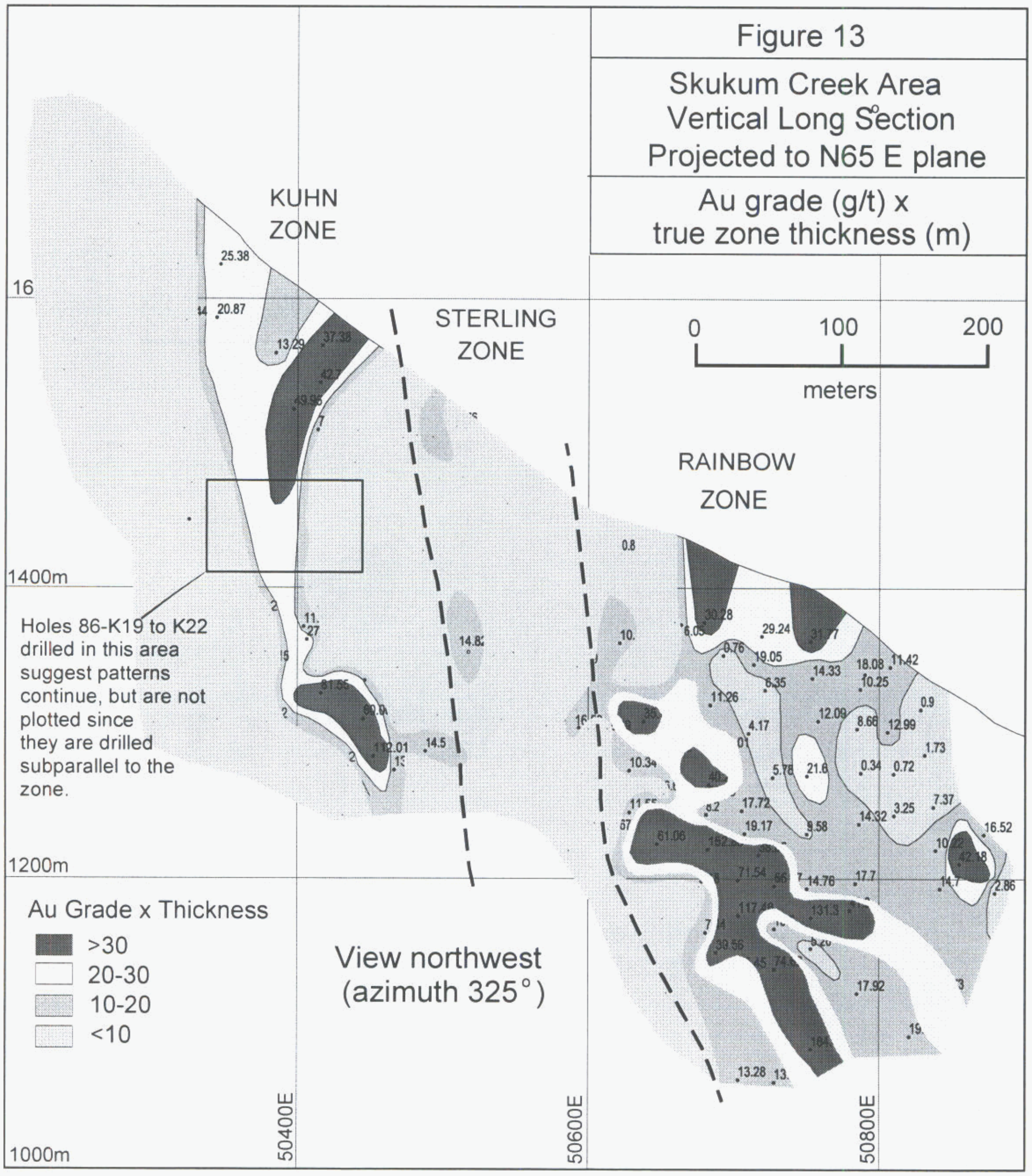


Figure 13
Skukum Creek Area
Vertical Long Section
Projected to N65 E plane
Au grade (g/t) x
true zone thickness (m)
KUHN ZONE
STERLING ZONE
RAINBOW ZONE
0 100 200
meters
1400m
1200m
1000m
50400E
50600E
50800E
Holes 86-K19 to K22 drilled in this area suggest patterns continue, but are not plotted since they are drilled subparallel to the zone.
Au Grade x Thickness
>30
20-30
10-20
<10
View northwest (azimuth 325°)

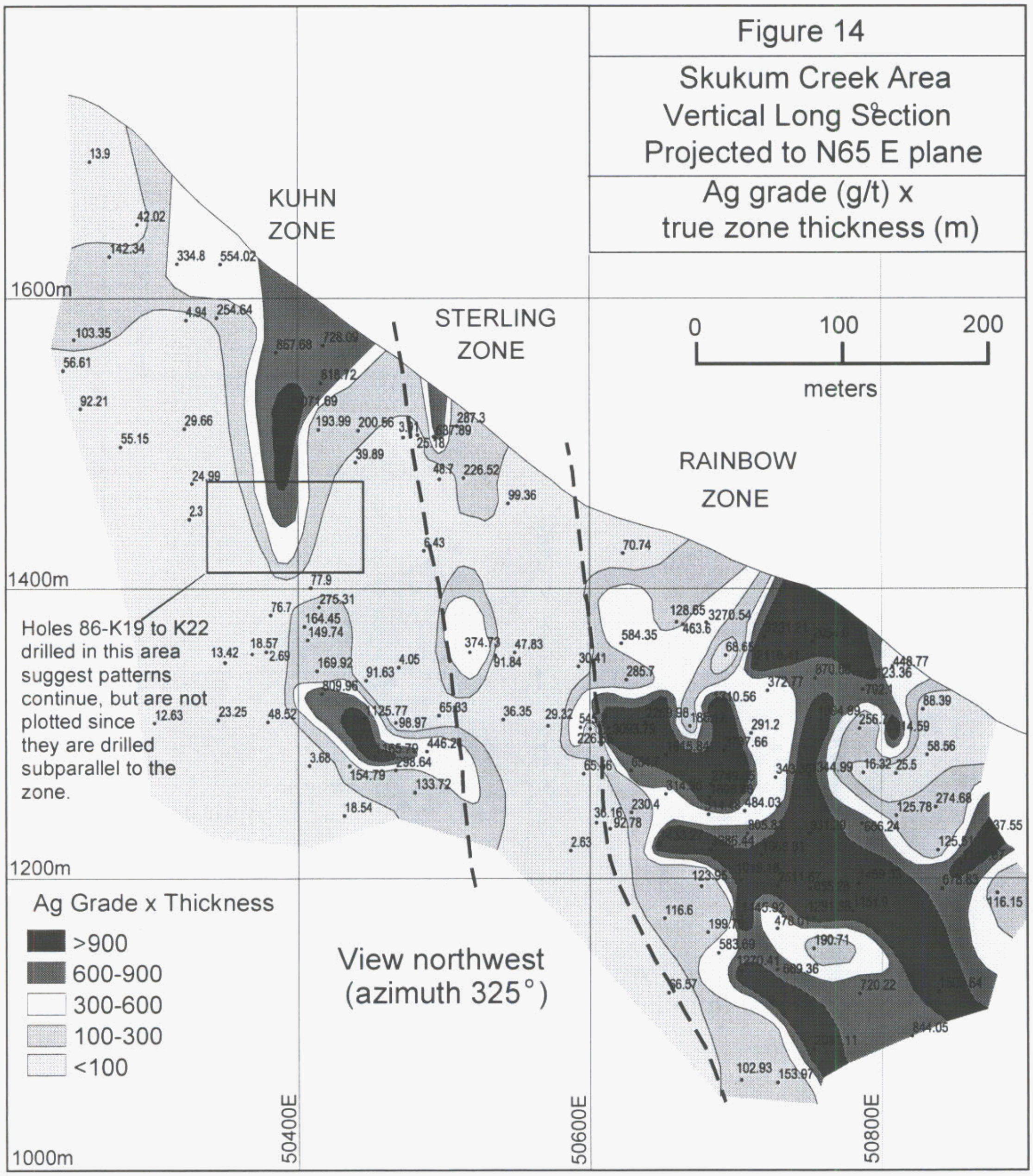


Figure 14
Skukum Creek Area
Vertical Long Section
Projected to N65 E plane
Ag grade (g/t) x
true zone thickness (m)
0
100
200
meters
KUHN
ZONE
STERLING
ZONE
RAINBOW
ZONE
1600m
1400m
1200m
1000m
50400E
50600E
50800E
Holes 86-K19 to K22 drilled in this area suggest patterns continue, but are not plotted since they are drilled subparallel to the zone.
Ag Grade x Thickness
>900
600-900
300-600
100-300
<100
View northwest
(azimuth 325°)

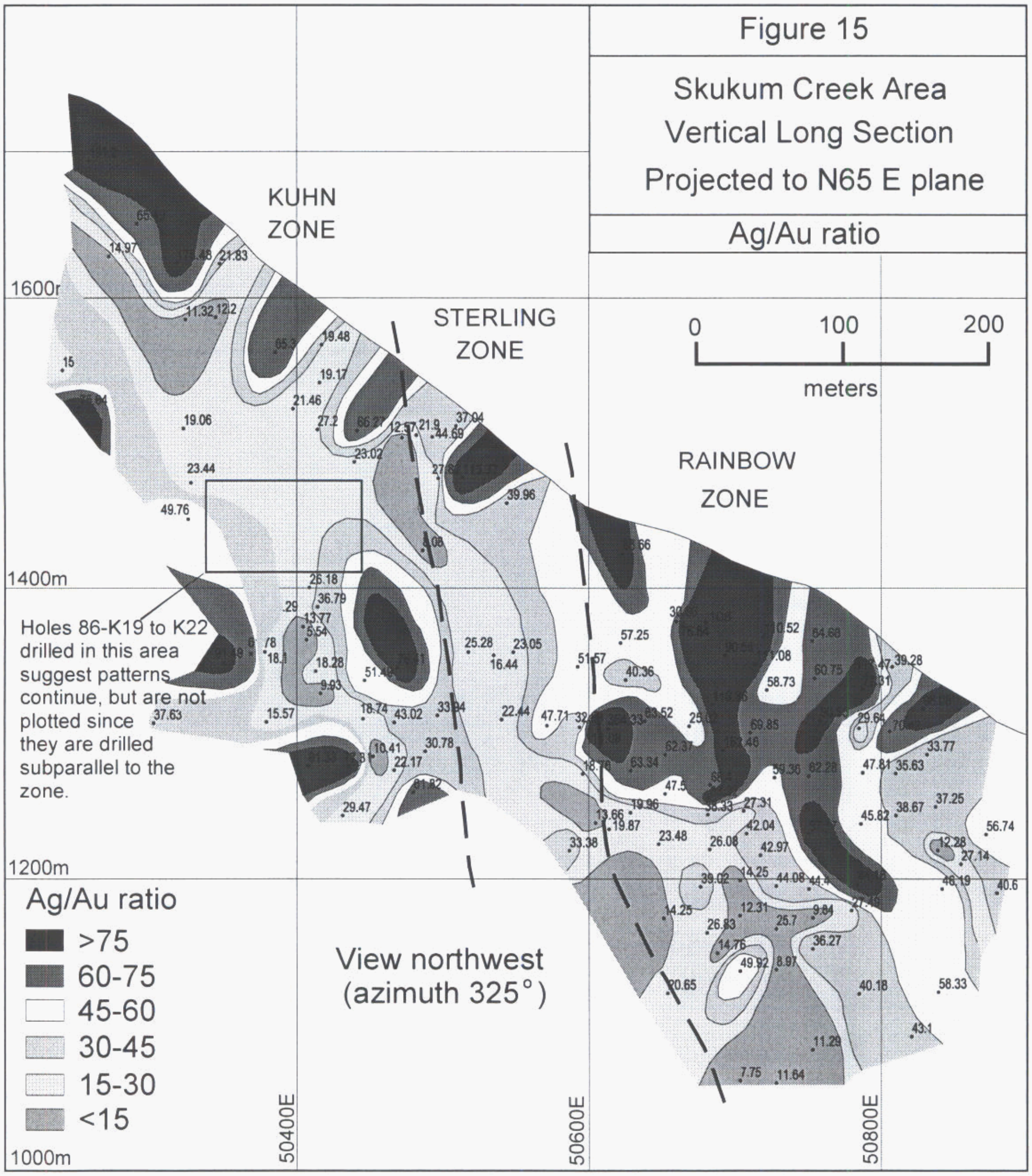


Figure 15
Skukum Creek Area
Vertical Long Section
Projected to N65 E plane
Ag/Au ratio
KUHN ZONE
STERLING ZONE
RAINBOW ZONE
0
100
200
meters
1600m
1400m
1200m
1000m
50400E
50600E
50800E
Holes 86-K19 to K22 drilled in this area suggest patterns continue, but are not plotted since they are drilled subparallel to the zone.
Ag/Au ratio
>75
60-75
45-60
30-45
15-30
<15
View northwest (azimuth 325°)

4.2.2 Rhyolite and andesite dykes in the Rainbow and Kuhn zones

Rhyolite and andesite dykes make up the bulk of the thickness of the Rainbow and Kuhn zones (Figure 6). Abundance of the different dyke species is variable. Some areas contain 2 or 3 rhyolite dykes that range from <1 to 10 m thick and which are separated by slivers of altered and foliated granodiorite, shear zones and quartz-sulphide veins. Andesite dykes show a similar distribution and multiple dykes may occur over the width of a shear zone, intercalated with rhyolite, shear zone and veins. Elsewhere dykes of either variety may be absent, or a single large andesite or rhyolite dyke may span almost the entire width of the zone. As described in section 5, sericitic alteration of andesite dykes can make it difficult to distinguish them from rhyolite dykes, and consequently andesite dykes may be under-represented with a corresponding over-representation of rhyolite dykes in mine plans and drill logs. Dykes of both varieties are typically lenticular along strike; individual rhyolite dykes may be traceable for more than 70 m in some areas, but in underground workings most dykes are discontinuous and terminate after 10 to 50 m of strike length, depending on their width. Terminations can commonly be attributed to dismemberment within the shear zones and by later, brittle faults, and can be abrupt (Photo 4.3). Dykes may be more continuous down dip than along strike and may mimic the patterns on contoured plots of total thickness of the zones (Figure 9) and the plunge of areas of thickest dyke material (Figure 10).

The close spatial association of dykes with the shear zones in the Skukum Creek deposits and the evidence for syn-hydrothermal magmatic activity as evidenced by probable phreatomagmatic breccias that are intimately associated with the dykes (see below) implies that dyke intrusion overlapped with shear zone displacement and hydrothermal activity. Apart from the clearly early timing of many altered andesite and rhyolite dykes, and the presence of phases of late andesite and rhyolite dykes described in section 3.0, a sequence of diking could not be established.

4.2.3 Monolithic and polylithic breccias

Two main types of breccia are intimately associated with dykes in the Rainbow and Kuhn zones: (i) monolithic rhyolite breccias; and (ii) polylithic breccias. Both varieties probably reflect syn-magmatic phreatic breccias formed through the explosive interaction of magma with hydrothermal fluid in the shear zones. Breccia textures are also common in the Rainbow zone as cataclasites, within quartz-sulphide breccia veins, and in granodiorite adjacent to the Rainbow zone. These latter styles of breccia often have gradational contacts, are spatially associated with shear zones in the Rainbow zone, and probably reflect a combination of tectonic and hydrothermal activity; they are discussed further below in the descriptions of shear zones and mineralization.

Rhyolite breccias typically comprise angular to subrounded rhyolite fragments in a pale green to tan, sericite-rich matrix (Photo 4.4). Fragment size and abundance are variable. Fragments generally are less than 5 cm in diameter, although they locally exceed 30 cm. Matrix and clast-supported breccias are present and both may occur in the same dyke. Rhyolite breccias commonly grade laterally or vertically into unbrecciated rhyolite dykes. Most rhyolite breccias are pre-or syn-mineral and are overprinted by shear zone foliation, quartz-sulphide veins, disseminated sulphides and sericite-carbonate-chlorite alteration. Rare sulphide-rich vein fragments locally found in altered dykes suggests a syn-hydrothermal timing for some (Photo 4.5). Contacts with adjacent granodiorite, monzonite or andesite dykes are generally sharp. Thickness varies from narrow zones <10 cm in diameter to partially to wholly brecciated rhyolite several meters thick. A long section plot (Figure 11) shows that rhyolite breccia is most abundant between 1200 and 1350 m elevations in the Rainbow zone, and sporadically in the Kuhn and Sterling zones.

Polylithic breccias are generally composed of angular to rounded, 0.1 to 10 cm fragments of granodiorite, rhyolite, andesite, monzonite and, locally, quartz-sulphide veins in a pale green, fine-grained sericite-chlorite-quartz±(pyrite) matrix (Photo 4.6). Contacts are generally sharp with host rocks, but are locally gradational with monolithic rhyolite breccias. Fragment abundance rarely exceeds 30%, and most

Photo 4.3 (left): Discontinuous rhyolite dyke in shear zone, Rainbow zone, 1225 crosscut. View west. The dyke is flow banded and terminates abruptly upward in the shear zone. Flow banding in the dyke follows the sharp upper contact, suggesting that this is a primary igneous morphology. Fabrics in the shear zone wrap around the dyke margins. Approximate horizontal field of view is 1 m.

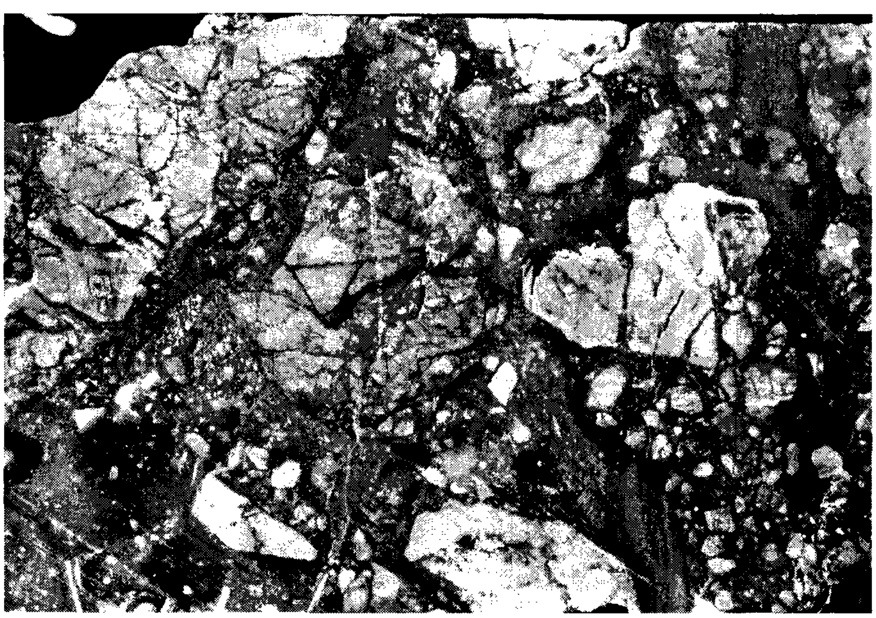


Photo 4.4: Rhyolite breccia from the Ridge zone in the Kuhn fault. Fractured pale grey to cream-coloured rhyolite fragments, some of which contain grey sulphide-quartz veinlets, occur in a fine-grained, pale green sericite-quartz matrix. Two phases of brecciation are apparent in this sample, as fragments of an early phase of brecciation have been re-brecciated, and occur in a paler green matrix. SC01-2 at 338.8 m. Field of view is 7 cm.

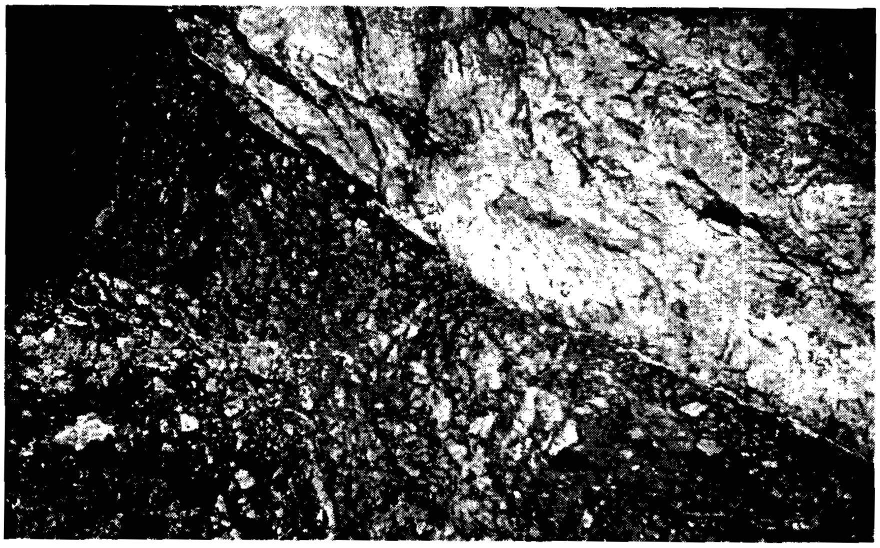


Photo 4.5. 1350 level, view up at back. Oxidized rhyolite breccia (dark, lower left) is in sharp contact with altered rhyolite (top right) that contains quartz-sulphide stringers. The breccia contains a clast of quartz-sulphide vein (pale grey with rusty rim, lower left) that indicates that brecciation occurred either during or after quartz-sulphide vein formation. Approximate field of view is 1.5 m.

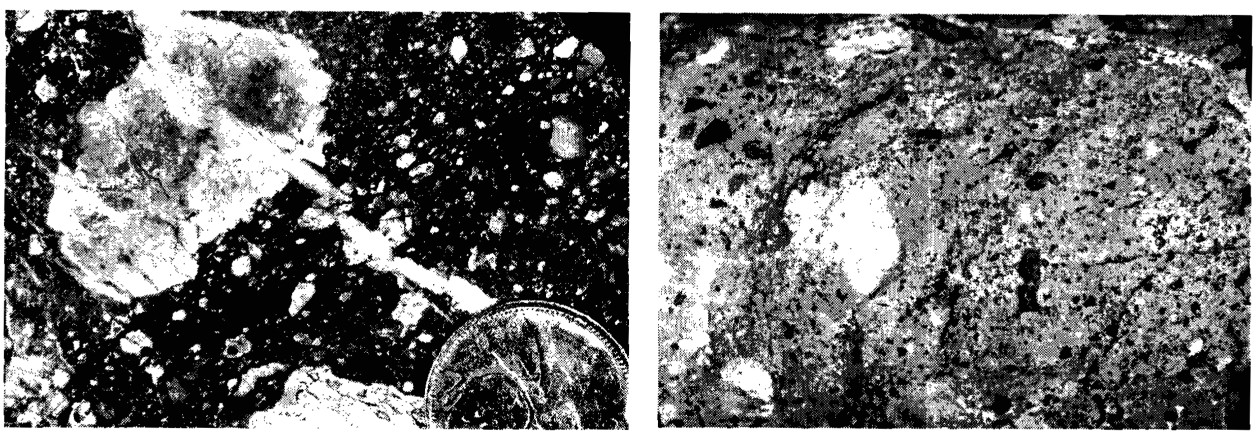


Photo 4.6. Polylithic breccias in the Rainbow zone. Angular to rounded rhyolite (white, cream colour) and quartz-sulphide vein (grey) fragments occur in a sericite-rich, lithified, pale to dark green matrix. Note dark grey pressure solution seams cutting across sample at left and the post-breccia calcite-quartz veinlet that is locally affected by the pressure solution seams. Left sample: 1350 level, Rainbow zone. Right sample: Rainbow zone from approximately the 1200 level. Field of view 5 cm.

are matrix-supported. Breccias of this variety were observed in several locations in the Rainbow zone, most notably in several holes in the lower portions of the zone between 1000 and 1200 m elevation (e.g. holes 87-R4, R96-202), where they commonly exceed 2 m in true thickness and range up to 10 m thick. A polylithic breccia is traceable for approximately 40 m along strike in the footwall portions of the Rainbow zone on the 1350 level near its east end; this breccia attains a maximum thickness of 3 m. Drill logs suggest that breccias of this type >4 m thick also occur in the Kuhn zone, mostly in the central, thickest chute below 1400 m elevation.

Polylithic breccias are structurally late and generally post- or late-mineral in timing as they: (i) commonly contain fragments of quartz-sulphide veins (Photo 4.6, left); (ii) may contain rotated fragments of foliated shear zone material and cataclasite; and (iii) are only affected by local, weak foliation (pressure solution cleavage) development and sulphide stringers/disseminations. Common rounding and local exotic diversity of fragments suggests some transportation as opposed to the angular, monolithic and more in-situ nature of clasts in monolithic rhyolite breccias. Timing with respect to rhyolite and andesite dykes in the Rainbow zone is unclear. Because many rhyolite and andesite dykes are affected by significant alteration, cataclasis and shear zone development, and both rhyolite and andesite fragments are present in the breccias, the polylithic breccias must post-date many, if not all, dykes in the Rainbow zone.

4.2.4 Shear zones in the Rainbow, Kuhn and Sterling zones

The Rainbow, Sterling and Kuhn zones exhibit evidence for at least two different phases of displacement that were active under different temperature-pressure and fluid conditions, similar to interpretations of the minor shear zones in the surrounding wallrocks. The older event is a protracted phase of shear zone development associated with cleavage and lithified cataclastic breccias, quartz-sulphide veins, sericite-chlorite alteration and Au-Ag mineralization. The younger event is a late phase of brittle faulting represented by unconsolidated clay gouge that overprints and locally displaces components of the earlier phase, including Au-Ag mineralization.

Shear zones in the Skukum Creek zones are similar in style to the minor shear zones in the surrounding wallrocks, but are thicker and are associated with more intense hydrothermal alteration, magmatic activity and veining which result in differences in mineralogy and texture. The shear zones form a braided network that is commonly developed on the margins of, or between, andesite dykes, rhyolite dykes, and associated monolithic and polylithic breccias. They locally cut across the dykes to form lenticular, discontinuous lozenges of dyke separated by thin slivers of shear zone material (Figure 6). Multiple shear zones are commonly present across the width of the zones, particularly in their widest parts, and typically vary in width from narrow (<1 cm thick) slip surfaces to broader zones of foliated cataclasite up to several meters thick. Shear zone fabrics are best developed in altered granodiorite and monzonite slivers and wallrocks to the zones, locally in andesite dykes where they are sericite-chlorite altered, and most rarely in rhyolite dykes, which have generally behaved as rigid blocks within the shear zones.

The Rainbow and Kuhn shear zones consist of cleaved, foliated sericitic to chloritic phyllite and cataclasite. Interlayering of cataclasites, foliated wallrock and quartz-sulphide veins commonly results in a crudely layered appearance to the zones (Photos 4.7 to 4.9). Like the minor shear zones in wallrocks outside of the main zones, shear zones in the Skukum Creek zones are commonly cored by lithified, foliated, fine-grained cataclasites (Photo 4.8). Cataclasites are composed predominantly of tan to yellow sericite-carbonate-quartz±chlorite assemblages. A dark grey colour predominates where disseminated and fracture-controlled sulphides are present (Photo 4.9). Angular to subrounded fragments of quartz, rhyolite, quartz-sulphide vein and/or sericite-chlorite-carbonate altered granodiorite (Photo 4.8) are abundant. Fragments are generally less than 1 cm in diameter, and normally comprise <30% of the cataclasite, except where in situ cataclastic brecciation of vein material produces more abundant quartz-sulphide vein fragments. Fragments are generally unstrained or exhibit only low strain internally. In quartz fragments internal strain is typified by undulose extinction; deformation lamellae and subgrain development characteristic of more ductile, crystal plastic deformation processes are absent (Photo 4.10).

Cataclasite matrix is usually affected by a pervasive foliation defined by the alignment of phyllosilicate minerals, and/or a spaced, locally stylolitic pressure solution cleavage defined by trails of phyllosilicate grains and sulphides (Photo 4.10). Foliation commonly wraps around breccia fragments (Photo 4.10). Foliated shear zone material may also occur as rotated clasts within cataclastic breccias. The coexistence and mutually overprinting relationships of foliation and pressure solution fabrics with cataclastic breccias in the shear zones and with quartz and sulphide veins suggests that all formed as part of a single, progressive, protracted, multi-stage event, with variations in texture probably reflecting fluctuations in fluid pressure and flux, temperature and strain rate within the shear zone.

Cataclasites commonly grade outward into foliated wallrocks with well developed pressure solution fabrics (photo 4.11) defined by spaced stylolitic surfaces defined by thin laminae or trails of sericite, chlorite and/or sulphides. These zones of spaced cleavage can extend several centimeters to tens of centimeters from cataclasites and slip surfaces, and affect internal slivers of wallrock within the shear zones. Pressure solution fabrics commonly overprint cataclastic breccia matrix, but may also occur within rotated wallrock fragments in cataclasites, indicating that pressure solution processes were active synchronously with cataclasis This semi-brittle structural style with co-existing brittle and ductile processes with predominance of pressure solution fabrics as the dominant ductile deformation process is compatible with formation at relatively low temperature (probably $<250^0$ C) and pressure conditions.

4.2.5 Kinematics of shear zones

The underground workings at Rainbow exhibit several kinematic (shear sense) indicators that consistently document a predominantly left lateral shear sense with a south side up (reverse) component was accommodated on the zone during formation of the fabrics and veins (see vein descriptions below). The most common kinematic indicator is the common obliquity of internal foliation and pressure solution fabrics to the shear zone boundaries, which typically strikes more northerly (anticlockwise) than the shear zone slip surfaces and cataclasites (Photos 4.7, 4.11). Synthetic shear bands (Figure 6; photos 4.11 top, 4.12) are also locally developed. These are subsidiary, minor structures akin to Riedel shear fractures that have compatible shear sense to the host structure. Using the orientation of both the oblique cleavage or shear bands and the shear zone, it is possible to calculate the absolute slip direction indicated as the line within the shear zone (fault boundaries) that is 90 degrees from the intersection of the oblique cleavage or shear band with the shear zone boundary. A plot of the calculated slip direction from measured oblique foliations and shear bands in the Rainbow zone is shown in Figure 7B; the indicated shallow westerly plunge is parallel to and consistent with an early west-plunging elongation lineation that is locally developed on slip surfaces in the zone, and which is defined by elongated blebs of chlorite, sericite and pyrite. An absence of marker units precluded estimation of absolute displacement on the Skukum Creek shear zones.

The shallow southwest-plunging sinistral/reverse slip vector on the Rainbow and Kuhn zones is approximately orthogonal to the steep plunge of the thickest parts of the zones, and to the corresponding steep plunge to the thickest portions of the vein systems within the zones (Figures 9, 12). Ore shoot plunge that is orthogonal to the slip vector is common in many shear zone hosted gold deposits, and results from dilation at bends and steps in the controlling shear zones during active displacement along the structure.

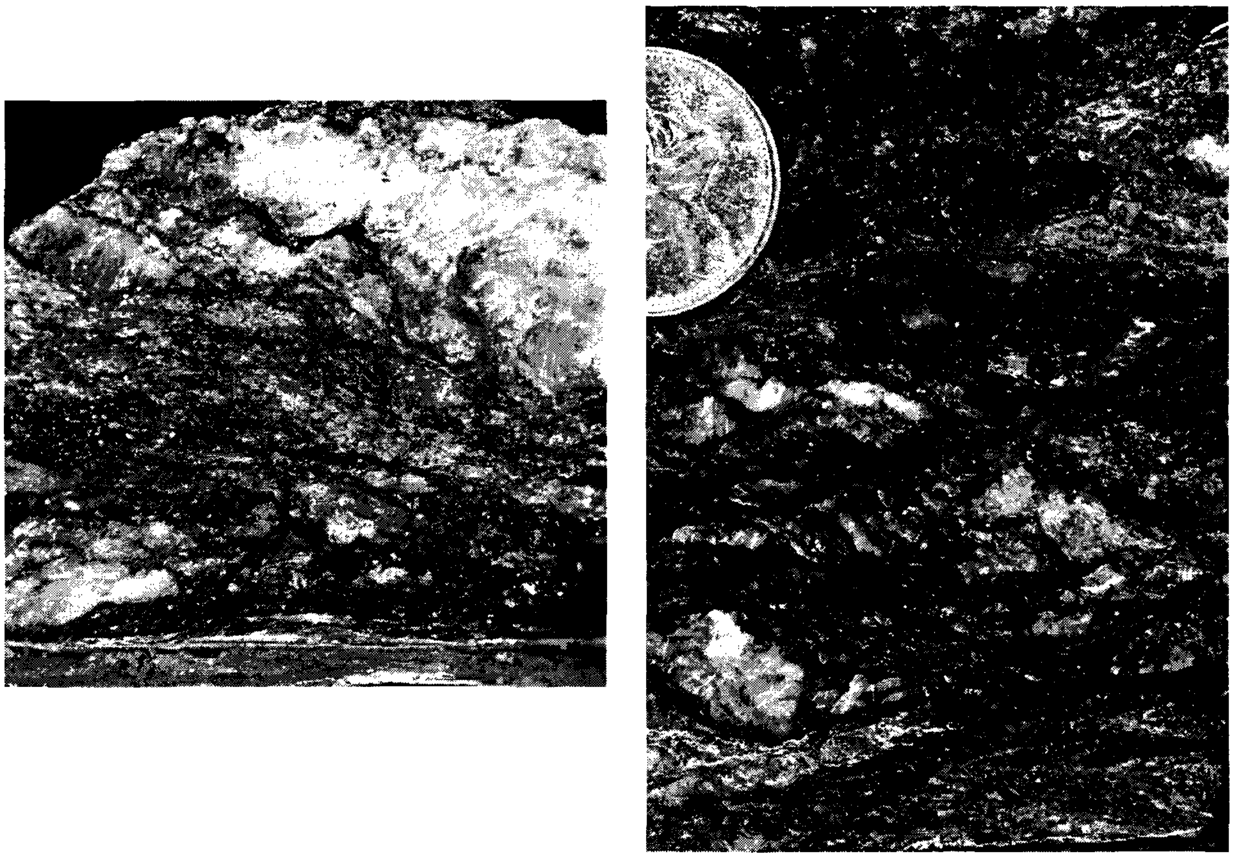


Photo 4.7. Shear zones in the Rainbow zone containing comminuted, transposed vein material. Shear zones consist of foliated cataclasite and cataclastic breccia (lower part of left sample), and foliated sericitic phyllite with quartz-sulphide lenses after deformed quartz veins that are affected by undulating, spaced pressure solution surfaces. Cataclasites, shear zones and deformed vein material merge with indistinct boundaries. Dark grey colour of shear zones is imparted by disseminated sulphides and deformed, fine-grained quartz. Note pale green, very fine-grained cataclastic slip surface in bottom of left sample. Also note the obliquity of pressure solution foliation in deformed quartz domains to slip surfaces in shear zones, which indicate a left lateral shear sense to both samples in these views: these are oriented samples viewed in true plan view as they were oriented in the Rainbow zone, so the left-lateral shear sense indicated is the true shear sense. Left sample: 1300 level, #2 crosscut. Right sample: 1225 crosscut.

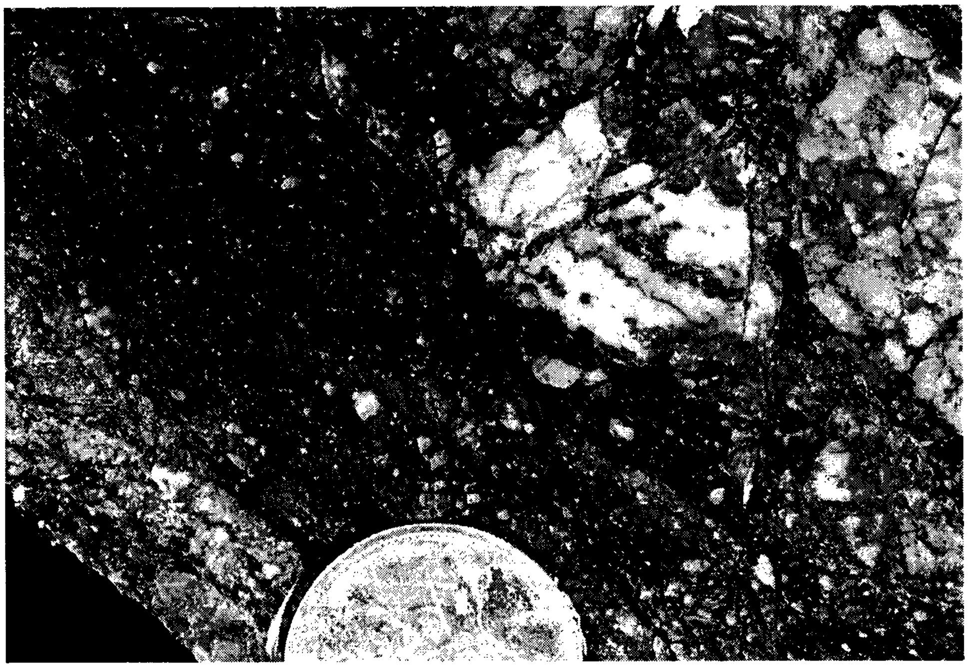


Photo 4.8. Layered shear zone with deformed quartz-sulphide veins, Ridge zone in Kuhn fault. Foliated, grey-brown sericite matrix cataclasite with quartz and rhyolite fragments (lower left) is inter-layered with brecciated grey to dark grey quartz-sulphide veins (upper right) and sericite-altered, foliated wallrocks (upper right and lower left). SC01-3, 240.2 m.

Photo 4.9. Layered shear zone in Rainbow zone, 1225 crosscut. Strongly foliated grey shear zone and cataclasite contains finely disseminated pyrite and arsenopyrite that impart the grey colour. Quartz fragments and coarser-grained blebs of pyrite occur at left. Note sharp boundary with tan-coloured sericitic shear zone material in altered granodiorite at right, reflecting margin of highly strained cataclasite.

Photo 4.10. Photomicrograph of foliated cataclasite from Rainbow zone, 1225 level crosscut. Unstrained quartz fragments occur in a tan, sericite to dark grey pyrite-sericite matrix that is affected by undulating, stylolitic pressure solution seams. A sericitic slip surface runs through the lower part of the photo. Note the obliquity of pressure solution fabrics to the slip surface and dominant foliation at bottom of photo, which suggests a sinistral (left lateral) shear sense in this view. Plane polarized light, field of view 2.63 mm.

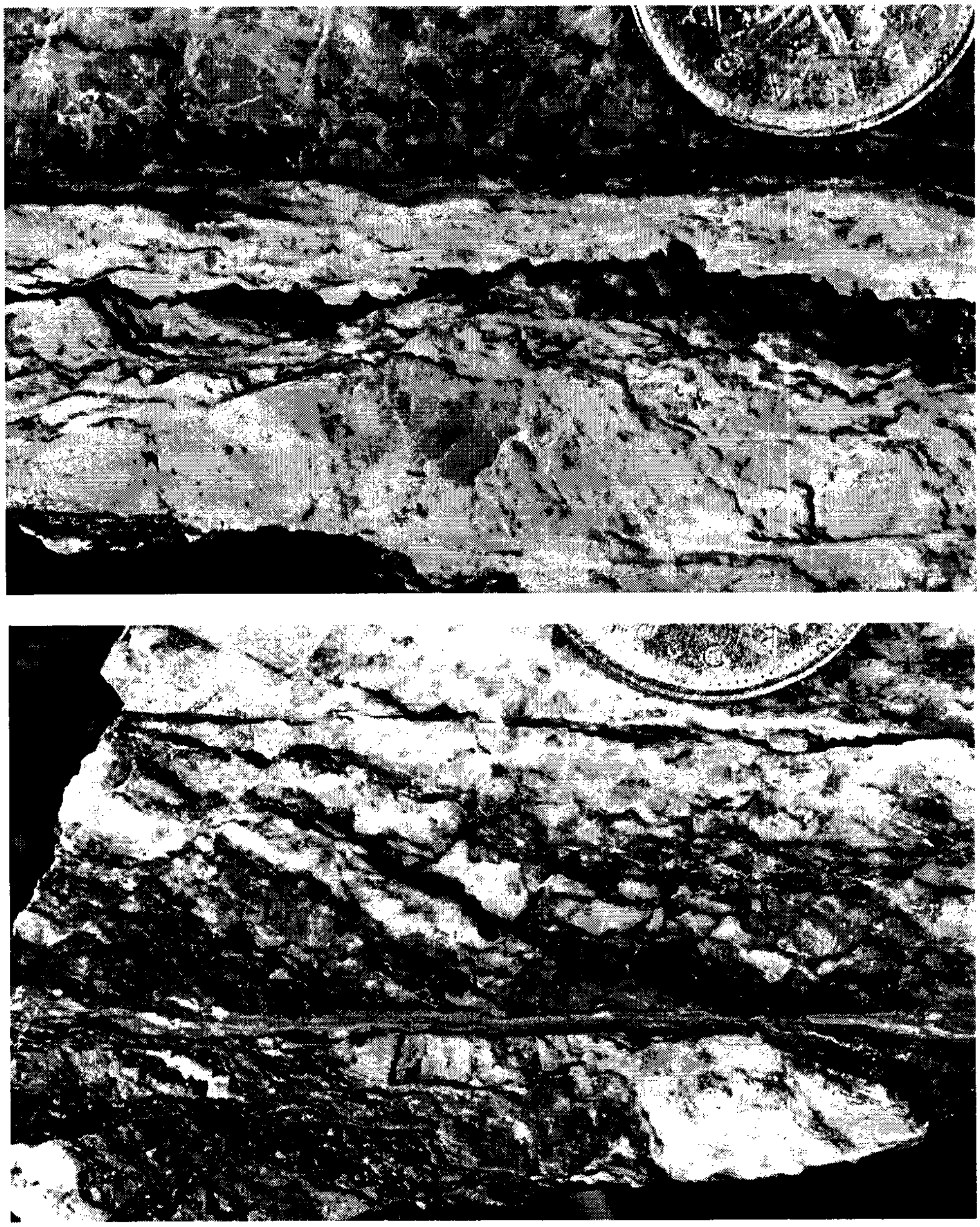


Photo 4.11. Pressure solution fabrics associated with shear zones in the Rainbow zone, 1350 level. Sericite-rich, phyllitic shear zones affecting granodiorite (bottom photo and upper part of top photo) and rhyolite (lower part of top photo) are associated with well developed, spaced, dark grey stylolitic pressure solution seams defined by fine-grained sulphides and phyllosilicate minerals. Note discrete slip surfaces defined by thin zones of cataclasite in both samples. Pressure solution foliation and cleavage are developed at angles of 10 to 50° clockwise to the slip surfaces and, along with shear bands, suggest a left-lateral shear sense in these views which are true plans from oriented samples.

Photo 4.12: Rainbow zone, 1225 level: View up at back. Quartz-sulphide veins (marked) occur in a grey, phyllitic shear zone. The veins are transposed into an internal shear zone foliation that is oblique to the shear zone boundaries (top and bottom). The oblique foliation and shear bands (minor slip surfaces mainly in upper part of photo) together indicate a predominantly left lateral shear sense on the shear zone. Note that shear sense is reversed in this view which is looking up at the back.

4.2.6 Faults filled with clay gouge in the Skukum Creek zones

Seams of green to grey clay gouge are developed in all of the Skukum Creek zones, and most commonly exploit earlier cataclastic slip surfaces and dyke contacts. Gouge varies from hairline to seams up to several tens of centimeters thick. They comprise unconsolidated chloritic clay with fragments of wallrocks, shear zone and vein, and may carry significant Au-Ag concentrations where they affect earlier mineralized vein material. The gouge seams record one or more periods of remobilization of the Rainbow and Kuhn zones that are both post-shear and post-mineralization, and which are probably related to late displacement along the Berney Creek fault.

Gouge seams may form a network of multiple, braided fault surfaces that is developed throughout or near either the hangingwall or footwall of the Rainbow and Kuhn zones, or may locally occur as a single dominant seam. In underground exposures of the Rainbow zone on the 1350 level, the fault system passes from the footwall of the zone in the eastern parts of the workings into the hangingwall of the zone to the west. A similar pattern is apparent on the 1300 level, where the fault system is developed in the central parts of the Rainbow zone in the eastern parts of the level and migrates into the hangingwall to the west near the Sterling zone. The faults create poor ground conditions, particularly when developed in the central and immediate footwall portions of the Rainbow zone where large blocks of the Rainbow zone and its contained dykes have spalled into the drifts. The faults mimic the overall pattern of the shear zones in the Rainbow and Kuhn zones and pass from the Rainbow into the Kuhn zone through the Sterling area. Some faults continue southwestward from the Rainbow zone along a similar strike, and these comprise several gouge seams that collectively form the Rainbow extension shear zone (Figure 4). Splays off the hangingwall of the fault system at the west end of the Rainbow zone reflect the linking of the gouge seams associated with the Kuhn and Rainbow zones.

Kinematic indicators associated with the gouge surfaces in the Rainbow zone, including oblique gouge fabrics, Riedel shear fractures and slickensides, consistently suggest a left lateral shear sense with a normal component (Photo 4.13). The slip vector plunges shallowly to the northeast (Figure 5B). Whereas the dominantly left lateral shear sense is consistent with that on the earlier shear zones, the dip component differs (compare Figure 5B to 7B). The consistency of the shear sense in the faults suggests that one dominant post-mineral and post-shear zone phase of displacement, or multiple episodes with a similar shear sense, was accommodated on the gouge surfaces. Alternatively, the gouge surfaces may be the latest part of a single, protracted phase of displacement that commenced with the earlier, syn-mineral period of shear zone development in the Rainbow and Kuhn zones, forming after termination of hydrothermal fluid flow and commensurate semi-brittle shear zone activity on the structures.

As the gouge-filled faults pass through the Rainbow and Kuhn zones, the fault surfaces commonly displace internal components of the zones including dykes, shear zones and quartz-sulphide veins, resulting in either tectonic thinning or thickening of these features. Given the predominantly left lateral shear sense, the pattern should be predictable, resulting in thickening of the zones where the fault seams pass, from west to east, from hangingwall to footwall across the zone, and thinning where the fault seams pass, also from west to east, from footwall to hangingwall across the zone. Magnitude of displacement across individual fault surfaces could not be determined.

The shallow east-plunging slip vector indicated on the brittle faults is parallel to a subsidiary, second order east plunge apparent on contoured long section plots of total vein thickness, zone thickness, Au grade X thickness, and Ag grade X thickness for the Rainbow and Kuhn zones; these possibly reflect modification of the principally steep plunges by the late faulting event (Figures 9, 12-14).

4.2.7 Quartz-sulphide veins and breccias in the Skukum Creek zones

Au-Ag mineralization in the Rainbow and Kuhn zones is developed mainly as quartz-sulphide veins and breccia veins that are typically developed within and peripheral to shear zones. This is illustrated in Figures 12-14, which demonstrate that areas of greatest cumulative vein thickness correspond closely with Au grade X thickness and Ag grade X thickness distributions. Cataclastic breccias and shear zones without veins can also host significant Au-Ag grades where they contain brecciated or dismembered vein fragments, have high disseminated sulphide content, or are crosscut by minor quartz-sulphide veinlets. Quartz-sulphide stringers that locally developed in altered rhyolite dykes can also carry significant Au-Ag values if present in sufficient density, although these areas are usually of much lower grade than larger veins. Vein mineralogy and paragenesis are described in detail in section 5.

Veins in the Rainbow and Kuhn zones consist of two main varieties: a) shear zone parallel, northeast-trending, steeply southeast-dipping quartz-sulphide veins and breccia veins developed along shear zone slip surfaces and dyke margins (Photos 4.14, 4.15); and b) quartz-sulphide extension veins typically <10 cm thick, developed either as sheeted sets within the shear zone that are commonly transposed into the shear zone foliation and oblique to shear zone boundaries (Photo 4.16), or as north-northeast trending extension veinlets in dykes and wallrocks peripheral to the main shear zones and veins (photo 4.14, splays off main vein). Both styles are mineralogically similar, and comprise several generations of quartz-pyrite±sphalerite±galena±arsenoprite±stibnite±chalcopyrite veins that are affected by varying degrees of strain, and which may have formed originally as extensional veins filling shear zone slip surfaces and extensional fractures, respectively.

Within shear zones, deformed veins are typically grey in colour and contain numerous sulphide-filled fractures and pressure solution seams, as well as domains of grey sulphide-matrix breccia. The grey colour is imparted by fine-grained recrystallized quartz and sulphides. Less strained veins are locally banded to laminated, with alternating sulphide and quartz-rich bands (photos 4.14, 4.17) that may reflect multiple opening episodes. White, prismatic quartz is common on vein margins or as bands in veins (Photo 4.18) where strain has not obscured primary vein textures. Coarse-grained pyrite, arsenopyrite and sphalerite are locally abundant in the core of some less deformed veins, but generally sulphides are fine-grained and form wispy aggregates, disseminations, local massive sulphide-rich intervals, and stylolitic pressure solution coatings. Multiple veins and stringers may be present across the width of the Rainbow and Kuhn zones, although locally only a single vein or closely spaced set of veins/veinlets may be present within the zone.

Several generations of veins may locally be present, including early brecciated, highly strained varieties, and younger, less strained, more continuous and texturally intact veins that commonly are developed along shear zone foliation surfaces, and which locally cut across hydrothermal and cataclastic breccia matrix (photo 4.19). The progressive sequence of veining, which also displays a crude progressive paragenetic sequence as discussed in section 5, suggests that vein development occurred synchronously with semi-brittle displacement along shear zones in the Rainbow, Kuhn and Sterling zones.

Breccia textures are common in veins within the Rainbow, Kuhn and Sterling zones, particularly in veins that are localized along, or exploited by, shear zones. The breccias exhibit textural relationships suggestive of formation by both cataclastic and hydrothermal processes. Breccias are typically composed of quartz-sulphide vein and altered wallrock fragments in a grey matrix. In cataclastic breccias, breccia matrix commonly varies from grey, fine-grained, highly strained quartz and sulphides that probably reflect mainly deformed quartz vein material (Photo 4.8), to grey-phyllosilicate-rich material (Photo 4.7) that represents mainly non-vein, sulphide-bearing shear zone matrix. These breccia styles may grade laterally into one another, reflecting varying degrees of tectonic intermixing of shear zone matrix and brecciated quartz vein material. A component of hydrothermal brecciation is probably also present in this style of breccia. Quartz-sulphide matrix hydrothermal breccia is also locally present, containing fragments of earlier deformed quartz (photo 4.20). Although locally a significant part of veins, breccia

Photo 4.13. Clay gouge-rich fault zone on hangingwall of Rainbow zone, 1350 level east. A 30 cm wide fault zone (pale grey) contains a peripheral clay gouge seam (at bottom) flanked by a cleaved, gouge-bearing fault zone that contains oblique cleavage (dotted) and Riedel shear fractures (dashed with shear sense marked). These features suggest a sinistral > normal shear sense on this structure.

Photo 4.14: Veins in the Rainbow zone, 1350 level. View up at the back. A quartz-sulphide vein occurs between massive rhyolite (top) and foliated sericitic shear zone (bottom of photo). Extension veinlets with northeast trends merge into the vein in the rhyolite (top of photo). Quartz sulphide veinlets in the shear zone are more highly strained and are transposed into the shear zone foliation and boudinaged (lower part of photo). A slip surface occurs along the lower part of the main vein.
Oblique foliation in the shear zone suggests a sinistral shear sense (reversed in this view of the back). Approximate field of view is 1 m.

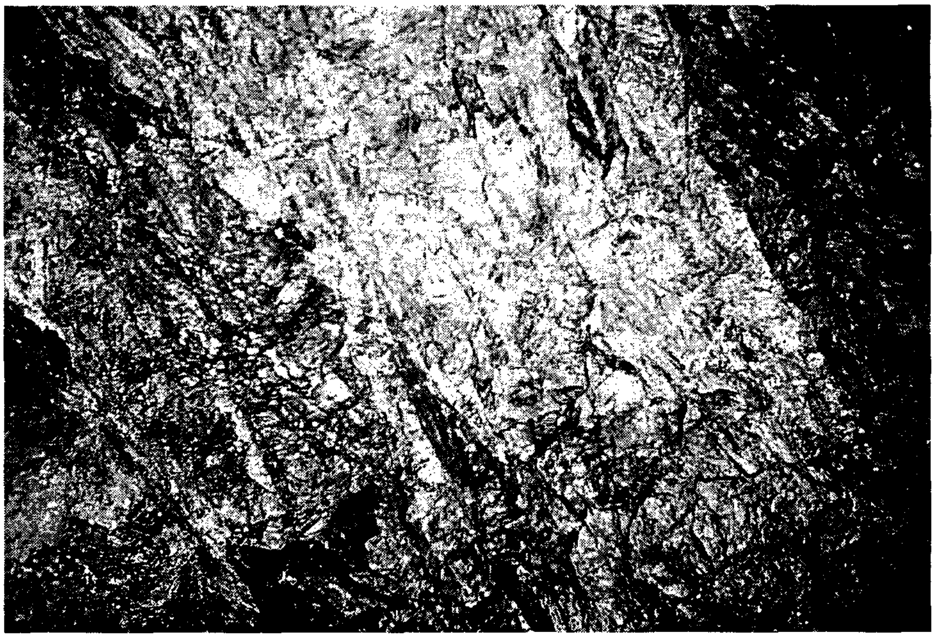


Photo 4.15. View of mineralized shear zone in back of crosscut, Rainbow zone, 1275 level. Quartz-sulphide veins (grey: left and right) and quartz-sulphide stringers occur in a tan-coloured, sericitic shear zone.

Photo 4.16. Rainbow zone, 1225 level crosscut. View of west wall showing the same shear zone as illustrated in photo 4.14. Note quartz veins developed in shear zone are transposed into the dominant foliation within the zone.

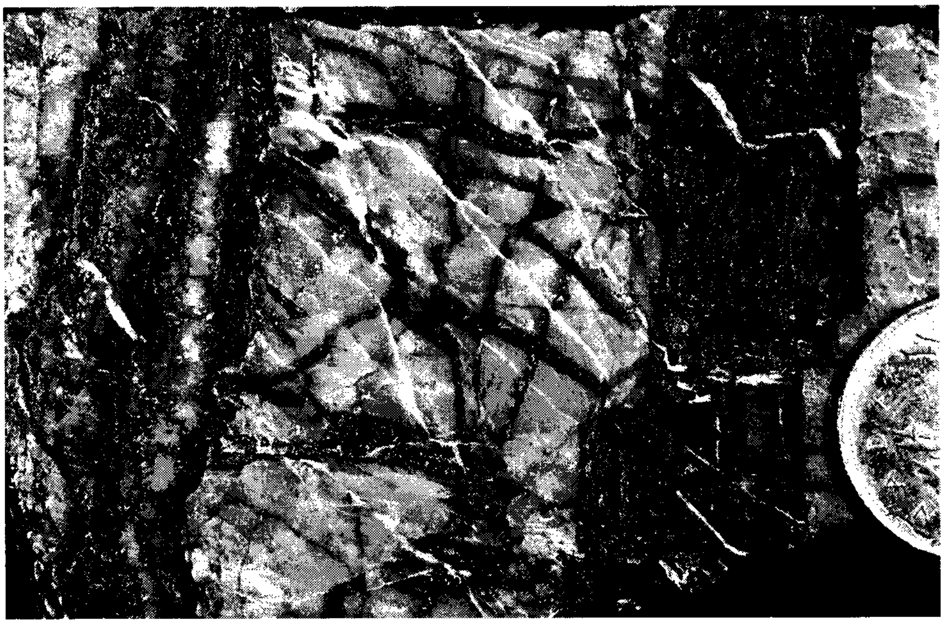


Photo 4.17. Style of veining, Rainbow zone, 1250 crosscut. Laminated grey quartz-sulphide veins occur in sericitized rhyolite. Note quartz-sulphide veinlets linking main veins, and late calcite veinlets.

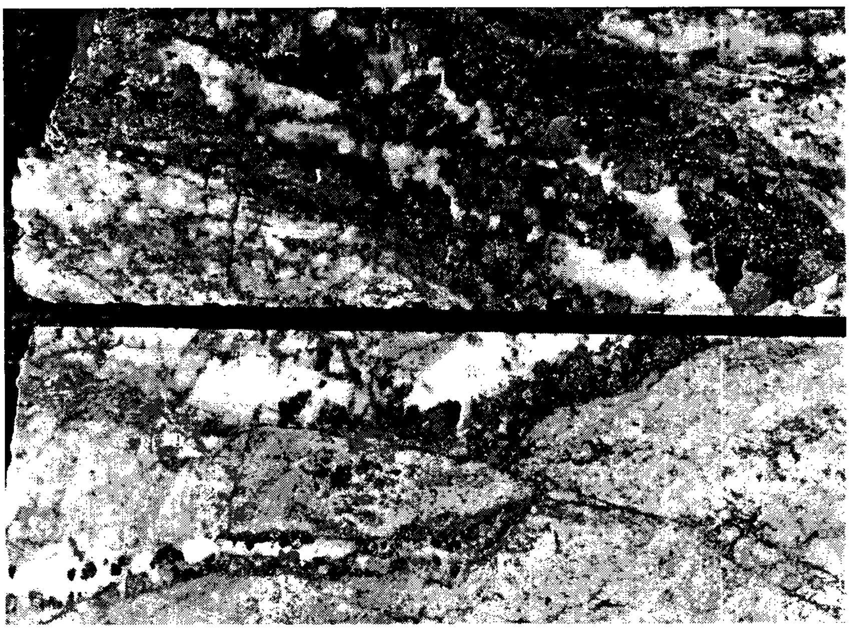


Photo 4.18. Quartz-sphalerite-pyrite-galena extension veins in sericite-altered granodiorite, Ridge zone shear zone in the Kuhn fault system. White, prismatic quartz is intergrown with sulphides. Typical veins shown in intersection in RG97-2. Similar veins and textures occur in the Rainbow and Kuhn zones. Core is 5 cm wide.

Photo 4.19. Shear zone in the Rainbow East (Raca) zone illustrating variation in shear zone textures and vein generations. Cataclastic breccia (top) with quartz-sulphide vein fragments and dark grey sulphide-rich matrix occurs adjacent to tan, foliated, sericitic shear zone material in lower portion of photo that contains a coarse-grained quartz-sulphide vein. This latter vein and other quartz sulphide veins in the same drill intersection are affected by significantly less strain and brecciation than the brecciated veins in the cataclasite, and cut across cataclastic breccia (outside of photo) with minimal brecciation. Although this sample is from the Rainbow East (Raca) zone, the same textures and vein timing relationships are apparent in the Rainbow and Kuhn zones.

Photo 4.20. Quartz-sulphide breccia vein. Quartz vein fragments and sericitic shear zone fragments occur in a grey, stylolitic quartz -sulphide matrix. Hole UG97-36 at 164.3 m.

textures are less widespread, or pervasive, than previous drill logs and underground maps suggest; many veins coded as breccias have only a component that is brecciated or comprise mottled quartz-sulphide veins with common slip surfaces and sulphide-filled fractures that impart a fragmental texture, although in many cases no fragment rotation of breccia matrix is present. Shear zones and cataclasites may also grade laterally into quartz sulphide veins through transitional zones of brecciation, with a progressive increase in quartz and sulphide concentration.

Thickness of individual veins in the Skukum Creek zones is highly variable. Veins are typically lenticular in plan view, and occur as multiple lenses laterally along strike and/or across the width of the zone. Shear zone parallel, northeast-trending, southwest-dipping veins are most continuous, and range up to several meters thick with local true thickness of >5 m, and may be present for tens of meters along strike. The steep easterly plunge of cumulative vein thickness on long section plots (Figure 12) suggests that veins may be more continuous down dip than along strike. Note that in addition to the steep easterly plunge, a shallow easterly, second order plunge is also apparent in cumulative vein thickness on long section (Figure 12). This is parallel to the slip direction on late gouge filled faults, and may reflect modification of ore shoot geometry by late faulting.

The most continuous vein in the underground workings has been mapped historically on the 1300 and 1350 levels of the Kuhn zone. Unfortunately, this vein is inaccessible due to collapse of part of the workings, but it can be inferred that it hosts most of the significant Au and Ag concentrations obtained in drill core in the Kuhn zone between 1250 and 1400 m levels where typical Au grades are 10 to >30 g/t. Maps indicate that the vein is cut and displaced by a gouge filled brittle fault localized along the Kuhn zone.

Veins mapped thus far in the Rainbow workings on the 1300 and 1350 levels are less continuous than the main vein in the central Kuhn zone, but they are more numerous and several veins may occur across the width of the zone. The veins persist for up to 40 m along strike in mapped workings, although most mapped historically on the 1300 and 1350 levels have strike lengths of <20 m. Thick intervals of veining intersected by drilling below the 1300 level in the Rainbow zone suggest that several more continuous veins, that may be similar in style to the large vein mapped in the Kuhn zone, occur in the Rainbow zone at depth. Note that on previous underground geological maps from Omni Resources, many areas mapped as quartz-sulphide breccia veins are actually foliated cataclasites and shear zones with variable proportions (5-50%) of comminuted, deformed vein material and transposed veins (e.g. photo 4.16: entire width of shear zone was previously mapped as vein). These areas should be distinguished from pure quartz-sulphide veins in future drill logging and mapping.

A late set of calcite and Fe-carbonate veinlets and stringers occurs throughout the Rainbow, Kuhn and Sterling zones. These typically manifest narrow, <2 mm wide carbonate (calcite or Fe-carbonate)±quartz±chlorite stringers that are developed in all rock types in the zones, and which commonly cut cataclastic, hydrothermal and lithic breccias as well as quartz-sulphide veins (photo 4.17). Although many stringers cut cataclastic breccia matrix, some are partially dismembered in some breccias which suggests a late syn-breccia timing. The principal orientations of these veinlets remain largely unknown, as most are obscured in the underground workings by surface oxidation and dirt which precluded accurate measurement and even identification. However, they are of similar style, mineralogy and timing to the generally northeast-trending, steeply-dipping carbonate veinlets present outside the Rainbow and Kuhn zones (see section 4.1.2), with which they may be coeval.

4.2.8 Structural timing and kinematics of veins

Quartz-sulphide veins display orientations and temporal and spatial relationships to the shear zones that suggest that they formed syn-tectonically with left-lateral displacement along the Rainbow and Kuhn zones. A syn-tectonic timing is suggested by: i) the occurrence of both early, highly strained veins and younger, less deformed veins which, as discussed above, indicate that vein formation overlapped shear strain (e.g. photo 4.19); ii) the intimate relationship of veins and shear zones, with the common occurrence of shear veins localized along shear zone slip surfaces; iii) the close relationship between sericite-chlorite-sulphide alteration, veins and shear zones, and the definition of shear zone fabrics by alteration minerals; and iv) vein orientations, including shear veins and northeast-trending extension veins, are kinematically compatible with the shear sense on shear zones in the Rainbow zone as discussed below. Shear zone parallel veins, effectively shear veins that have localized shear strain, locally merge with northeast-trending, steeply-dipping quartz-sulphide extension veins (Photo 4.14). The latter are parallel to, mineralogically and texturally similar to, and probably form part of the same vein set as the quartz–sulphide extension veins that are developed in the outlying host rocks to the Rainbow and Kuhn zones and in the Taxi zone. The association of north-northeast trending, steeply-dipping quartz-sulphide extension veins with east-northeast trending shear veins and shear zones is compatible with the left lateral reverse shear sense indicated on shear fabrics in shear zones within the Rainbow zone, and forms a typical shear zone/extension vein relationship.

4.2.9 Other zones in the Skukum Creek area

Other mineralized zones in the Skukum Creek area include the potential strike extensions of the Rainbow and Kuhn zones – the Rainbow East (Raca) and Ridge zones, respectively – and sheeted quartz-sulphide extension veins in the Taxi zone. Potential also exists on other structures and in possible steps and branches of the Rainbow-Kuhn-Sterling shear zone system for the discovery of further zones of mineralization.

Ridge zone

The Ridge zone comprises a mineralized portion of the Kuhn fault system located approximately 450 m southwest of the Skukum Creek underground workings in the Kuhn zone (Figure 2). Here, several drill holes have intersected quartz-sulphide veins and shear zone hosted disseminated sulphide mineralization within the Kuhn fault zone that is of similar structural style, mineralogy and texture as that developed in the Rainbow and Kuhn zones. Like the Rainbow and Kuhn zones, in the Ridge zone area the Kuhn fault system comprises a composite, heterogeneous, southeast-dipping, and 10 to 25 m wide (true thickness) zone of rhyolite and andesite dykes, polylithic and rhyolite breccia, semi-brittle shear zones, gouge-filled faults, and quartz-sulphide veins. Drill holes that have intersected mineralization of >1 g/t Au over >1 m width in the Ridge zone include RG97-1, RG97-2, RG97-4, SC01-1, SC01-2 and SC01-4, which indicate a mineralized zone of approximately 50 m along strike and 300 m down dip. Mineralization is open at depth and along strike below elevations of 1600 m, where the fault system has only been tested by isolated, widely spaced drill holes. The Kuhn fault system contains one or more flow banded rhyolite dykes in the Ridge zone area which locally exceed 15 m in thickness, several altered and probably narrower and less extensive andesite dykes, and intervals of monolithic (photo 4.4) and late polylithic breccia (e.g. in holes SC01-1, RG97-1) that may contain fragments of mineralized quartz veins.

Mineralization in the Ridge zone occurs in quartz-sulphide veins and veinlets within, or developed adjacent to, sericitic shear zones that are defined by foliated cataclasite and cleaved, foliated wallrocks with foliation defined by alignment of phyllosilicate minerals, transposed veinlets, wallrock fragments and trails of disseminated sulphides (photos 4.8, 4.21). Spaced pressure solution cleavage occurs locally. The shear zones form a braided network that crosses the associated rhyolite and andesite dykes, and varies from concentrated zones of shear strain in foliated cataclasite over narrow intervals of <1 m, to more distributed shear zones developed over intervals of several meters and comprising multiple slip surfaces, narrow cataclasites, and foliated wallrocks separated by less foliated and deformed wallrock. The shear zones are best developed on the footwall and central parts of the dykes that define the Kuhn zone fault system in most drill holes, with narrower shear zone intervals generally occurring in the hangingwall portions of the dykes. Unconsolidated clay gouge seams and broken core are common across the width of the Kuhn zone, generally concentrated in various parts of the zone in any particular drill hole, and overprint the earlier shear zones, veins, breccias and dykes.

Quartz-sulphide veins in the Kuhn fault system within the Ridge zone are generally narrow (<30 cm thick), and occur as multiple, closely spaced veinlets or brecciated vein material in dark grey matrix cataclastic shear zones. In some cases, shear zones with disseminated sulphides and a component of brecciated vein material have been shown on recent cross sections as 'quartz-sulphide breccia'. These areas are distinct from purer quartz-sulphide veins, which will generally carry higher Au and Ag grades, and should be distinguished as such. In addition, broad intervals of 'sheared granodiorite' are shown on some cross sections immediately in the footwall of the Kuhn zone, and give the appearance of a wide shear zone. These areas comprise massive granodiorite with local, narrow, isolated shear zones, slip surfaces and quartz-sulphide veins that define a broad damage zone to the Kuhn zone, but which do not define a continuous shear zone.

The close similarities in characteristics of the Ridge zone to the other Skukum Creek zones suggest that there is exploration potential laterally and at depth for mineralization over widths and at grades comparable to those intersected in the Rainbow and Kuhn zones, with potential for steep easterly plunging chutes of thicker mineralized material. In particular, the potential intersection points of the Kuhn fault with footwall zones and adjacent faults, such as the King Canyon fault, form highly prospective exploration targets at optimal dilational sites on the main structure (see below).

Ridge 2 zone: Footwall mineralization to the Ridge zone and the King Canyon Fault

Mineralized shear zones and veins have been intersected thus far for up to approximately 100 m into the footwall of the Ridge zone and Kuhn fault. The most significant intersection in this area, termed the Ridge 2 zone, was encountered in drill hole RG97-2, which intersected 7.82 g/t Au and 234.3 g/t Ag over an apparent thickness of 13.0 m approximately 40 m (true width) into the footwall of the Ridge zone. This intersection comprises 30 to 60% quartz-sphalerite-galena-pyrite±arsenopyrite extension veins (photo 4.18) developed at shallow angles to core axis that occur in a distributed sericitic shear zone. The veins are locally affected by shear strain (photo 4.22), and may be transposed and partially brecciated in the shear zones.

The up dip continuation of the mineralized shear zone in hole RG97-2 was probably encountered in hole RG97-1, where a 8 m thick (apparent thickness) sericite-chlorite shear zone that contains approximately 50% quartz-sulphide veins in its hangingwall 3 m has been intersected in the same structural position as, but 65 m above, the mineralized RG97-2 shear zone. This up dip intersection is partially developed in an altered andesite dyke. The mineralized hangingwall portion of the shear zone returned 8.48 g/t Au and 88.0 g/t Ag over 3.3 m. Re-orientation of drill core in this structure suggests a similar, left lateral shear sense on shear zone fabrics, as in the Rainbow zone. Drill holes SC01-3, 85-2 and 85-3 on the same cross section may not have been drilled to sufficient depth to test the Ridge 2 shear zone.

Approximately 40 m to the east of the RG97-1 and RG97-2 mineralized shear zone intersections, holes RG97-4, SC01-1 and SC01-2 each intersected a shear zone representing its probable continuation 50 to 75 m into the footwall of the Ridge zone (Kuhn fault). Shear zone intersections include 490 to 498 m in hole SC01-2, 385.8 to 387.7 m in hole SC01-1, and 516.2 to 517.9 m in hole RG97-4. These comprise sericitic shear zones with disseminated sulphides, and broken core with clay gouge seams that are locally associated spatially with andesite dykes. No significant (> 1 g/t) Au intersections were obtained. The RG97-4 intersection occurs at the end of the drill hole and was terminated in the shear zone. All three of these intersections are narrower than, and less well-mineralized than, those on the RG97-01/RG97-02 section. They are also 50 to 75 m deeper into the Ridge zone footwall, and suggest that the shear zone may be diverging from the Ridge/Kuhn fault to the east, with possible further splays to the north, deeper into the footwall, and beyond the limits of drilling.

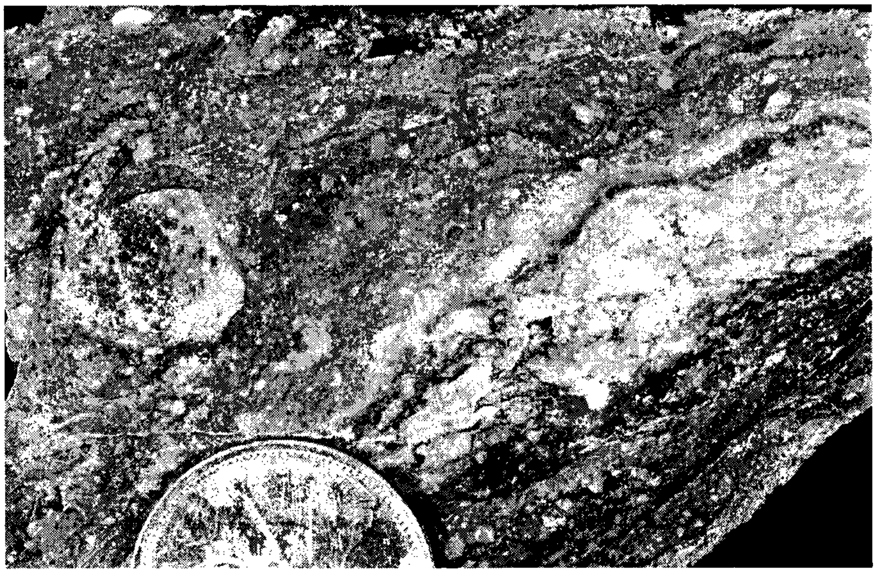


Photo 4.21. Foliated cataclasite within the Kuhn fault zone, Ridge zone. Altered rhyolite and granodiorite fragments occur in a fine-grained, tan colored lithified and foliated cataclasite matrix. Hole SC01-1 at 297.6 m.

Photo 4.22. Deformed quartz-sphalerite-arsenopyrite-pyrite-galena extension vein in shear zone, Ridge 2 zone. The vein occurs in foliated, sericite-pyrite altered granodiorite in a distributed shear zone that forms much of the width of the high grade intersection in hole RG97-2. The vein is truncated by a shear zone slip surface that obliquely crosses the photo.

The Ridge 2 and associated footwall shear zones project upward into the approximate trace of the King Canyon gully, beneath which a shear zone associated with a rhyodacite dyke was intersected in hole SC01-4, and which has been interpreted as the King Canyon fault. If so, the Ridge 2 shear zone may represent the down dip projection of the King Canyon fault. Its divergence to the east from the Kuhn fault/Ridge zone in the drill sections suggests a more northerly strike than the Kuhn fault, and is consistent with the strike of the King Canyon fault (Figure 2).

Other minor mineralized shear zones and veins occur in granodiorite between the Ridge (Kuhn fault) and Ridge 2 footwall shear zones, defining a broad zone of widely-spaced veins between the two structures. The distribution of these structures corresponds with a broad, geochemically anomalous area within the footwall of the Kuhn fault that extends northward to the King Canyon fault, and which is discussed further in section 5. Another shear zone is also present in the footwall of the Ridge 2 zone near the end of hole RG97-2, but was not fully tested by that hole. Together, these minor shear zones, the Ridge 2 zone and veins of the Taxi zone to the east may define a zone of northeast-trending footwall splays off the Kuhn fault that may be associated with the splitting of the King Canyon and Kuhn faults, and may also be influenced by the stepover from the shear zones in the Rainbow zone to the Kuhn zone that occurs further to the east. This area makes a priority target area, particularly near the potential divergence point of the shear zones from the Kuhn fault/Ridge zones, which could occur approximately 50 to 100 m west of the RG97-2 intersection. Potential also exists to further trace the Ridge 2 mineralization up dip, where holes SC01-3, 85-2 and 85-3 were probably terminated prior to reaching the zone, and in holes RG97-4, SC01-1 and SC01-2 which may have only intersected a hangingwall component to the shear zone - the main mineralized structure may therefore lie deeper. Based on orientations of known veins in the area and the King Canyon fault, structural intersections are likely to plunge moderately to steeply to the east with comparable plunges to mineralized chutes in the Rainbow and Kuhn zones.

Sterling footwall zone

Several drill holes have intersected quartz-sulphide veins and minor shear zones in a consistent corridor 20 to 40 m into the footwall of the Sterling zone above 1350 elevation. These features align along a northeast-trending, southeast-dipping orientation that is approximately parallel to the Sterling zone (Figure 4). They may also represent a single or set of quartz-sulphide extension veins like those in the Taxi zone. Further exploration of this area is warranted, particularly in conjunction with drill testing between the Sterling and Kuhn zones, along the western extension of the Rainbow fault system.

Rainbow East (Raca) zone

The Rainbow East (Raca) zone is a set of mineralized shear zones and veins that have been intersected in several drill holes on the northeast side of Skukum Creek in an area covered by talus and overburden and lying along the possible northeast strike extension of the Rainbow zone (Figure 2). It has also been called the Raca zone in recent reports and company maps, but to avoid possible confusion with the Cu showing located near the ridge top to the northeast and which formed the original Raca zone (cf., Hart 1991D), the term Rainbow East has since been adopted (C. Naas, pers. comm. 2002).

The area of the Rainbow East (Raca) zone has been tested by five diamond drill holes, three of which (RACA97-1 to 3) are preserved and were examined during this study. The mineralized shear zones in the Rainbow East (Raca) zone are separated from the Raca Cu prospect that occurs high on the slope above by an extensive area of talus. The lack of exposure hinders interpretation of the relationship between these two different styles of mineralization.

Mineralized shear zones in the Rainbow East (Raca) zone are of the same style as those in the Rainbow and Kuhn zones. Host rocks differ, however, and mineralized shear zones and veins here occur in pyrite-sericite altered fragmental volcanic rocks of intermediate composition and K-feldspar megacrystic (Bennett?) granite of probable syn- or pre-Jurassic age (Figure 2; see section 3). On the section that contains holes RACA97-1 and RACA97-3, the contact between volcanic and intrusive rocks has an apparent steep southeast dip, with volcanic rocks lying stratigraphically or structurally above the intrusion to the southeast. Several ribboned quartz-sulphide extension veins that are locally associated with minor shear zones and which range up to 2 m in thickness occur within the volcanic sequence. These are not associated with any obvious alteration envelopes, apart from the widespread pyritization present throughout the volcanic pile. Anomalous, but not significant, Au-Ag concentrations have been obtained from these veins.

The most significant area of mineralization in the Rainbow East (Raca) zone is a distributed shear zone/fault system that is localized at and below the volcanic-intrusive contact. In hole RACA97-1, the shear zone system is localized around a 12 m (apparent) thick rhyolite dyke that occurs in granite 6 m below the contact with the overlying volcanic rocks. Above the dyke, a 1 m wide sericitic shear zone occurs at the granite-volcanic contact, followed by a 3.3 m wide zone of faulted pyritic shear zone with quartz-sulphide veins (214.8-218.1 m down hole) localized immediately above the dyke contact which has returned 3.05 g/t Au and 205.7 g/t Ag over 1.3 m between 216.8 and 218.1 m. A second mineralized shear zone interval occurs immediately below the lower dyke contact between 230.1 and 233.4 m. This tan sericitic shear zone contains approximately 15% quartz-sulphide veins and cataclastic breccia with a dark matrix (photo 4.19), and has returned assays of 2.66 g/t Au and 561.4 g/t Ag over 3.6 m. In hole RACA97-3 several brittle, gouge-filled faults occur between 270 and 290 m in basal portions of the volcanic sequence, followed by a 3.3 m sericitic shear zone interval that contains multiple quartz-sulphide veins, cataclastic breccia with a dark matrix and cataclasite along the granite contact between 298.7 and 293 m; values of up to 4.83 g/t Au and 155.7 g/t Ag over 0.9 m have been obtained from this latter interval. Isolated minor shear zones occur below the main shear zone in granite within both RACA97-1 and RACA97-3.

Only parts of hole RACA97-2 were available for examination. This hole was drilled east of holes RACA97-1 and RACA97-3 and intersected a weak shear zone between 148 and 150 m in pyritic volcanic rocks, with 0.6 m of clay gouge below its base. If this is the same shear zone as the one shown on the adjacent section, it is much thinner and weaker, possibly due to truncation by the associated fault. Other core further down hole, however, was not available, and more shear zones may be present at greater depth. The historical drill log records some zones of sericitic alteration and higher strain deeper in the hole, including from 220 to 230 m in granite immediately beneath a rhyolite dyke, which also could represent the Rainbow East (Raca) shear zone.

The Rainbow East (Raca) zone is of similar style to the Rainbow and Kuhn zones, and shares the spatial association with rhyolite and andesite dykes. The occurrence of multiple mineralized shear zones over broad intervals suggests that this shear zone corridor will have persistence, and although no potentially economic Au and Ag values have been obtained to date, the potential for Rainbow and Kuhn style mineralization is present here. Further drilling is warranted along strike and down dip to better outline the extent and potential of this poorly tested area. Future drill holes should be drilled to greater distances below the main shear zones, since further splays and parallel structures may occur below, as is indicated by the deeper shear zone intersected in hole RACA97-2. The Rainbow East (Raca) zone is directly along strike form the Rainbow zone. If it represents its northeastern continuation, there is potential for mineralization between the Rainbow East (Raca) and Rainbow zones in the intervening Jurassic volcanic and clastic units. Several widely spaced drill holes could test this possibility.

Taxi zone

The Taxi zone comprises a series quartz-sulphide extension veins that are exposed in outcrop and float 50 to 200 m west and southwest of the Sterling zone (Figure 2). The surface showings were not visited during this study.

The Taxi zone veins are a series of sheeted, north-northeast trending, and steeply northwest-dipping quartz-sulphide extension veins developed principally in granodiorite. Individual veins can locally be traced for up to 200 m along strike, and have widths of up to 25 cm. Narrow extension veins <5 cm thick are also common. Surface maps indicate that veins are widely spaced.

Several diamond drill holes were oriented to undercut the outcropping veins of the Taxi zone. Drill hole 98TZ-01 was examined during this study. Anomalous Au-Ag values were found to be related to quartz-sulphide extension veins that are narrower than the veins observed on surface. The veins are hosted within a wide zone of distributed chlorite and sericite shearing that cuts granodiorite and monzonite. The zone of distributed shearing also contains numerous rhyolite, monzonite and andesite dykes. The best Au-Ag values were encountered in sericitically altered rhyolite dykes affected by pervasive sericite alteration and which were cut by narrow quartz-sulphide veinlets; at least one andesite/monzonite dyke was also altered and cut by a similar, but much less abundant, quartz-sulphide veinlets. Outside the zone of distributed shearing, only rare examples of narrow quartz-sulphide extension veins were encountered.

The Taxi zone veins are similar in orientation, texture and mineralogy to the northeast-trending extension veins present in the wallrocks to the Rainbow zone, and to extension veins localized within and immediately adjacent to the Ridge 2, Rainbow and Kuhn zones, with which they are probably coeval. They may have formed in response to left lateral displacement along the Rainbow and Kuhn zones in a dilational step setting as displacement steps from the Rainbow to the Kuhn zones (see structural model below).

Other mineralized structures

Three showings, the Polaris Hidden, Golden Eagle and Bonanza showings, are present to the southeast of the Skukum Creek zones, along and southeast of the projected trace of the Berney Creek fault system. Only a few drill holes have been completed on these, and no significant results have been obtained. A chloritic shear zone several metres in width was noted in the lower part of hole 98BZ-01, but it is not associated with any mineralization.

5.0 ALTERATION AND MINERALIZATION, SKUKUM CREEK AREA

Observations and sampling were completed in drill core from the Ridge, Taxi, Rainbow and Rainbow East (Raca) zones, and underground in the Rainbow zone. Most observations come from the Rainbow zone. Throughout the area, alteration effects manifest pervasive, selectively pervasive and fracture-controlled styles. Most alteration can be related to fluids that traversed the major shear zones, their surrounding damage zones and related extensional structures, and which were directly related to formation of precious and base metal mineralization. Several hydrothermal effects predate this event and are more closely related to cooling of the intrusive igneous bodies that host the deposits.

The descriptions which follow are based upon optical petrography of 33 polished thin sections, scanning electron microscopic (SEM) examination of many of these sections to further document mineralogy and confirm optical observations, and field and drill core observations. The SEM data provide qualitative to semi-quantitative information on mineral compositions, but it must be noted that in most cases only the presence or absence, and to a limited extent the relative concentration, of a given element can be confidently documented. Reference to shear zones is restricted to the main zones of deformation as described above; all other fracture-related features are called veinlets regardless of indications of shearing. In the following sections, selvage refers to minerals that line the wall of a dilatant fracture (i.e., the initial infill of open space), whereas envelope denotes alteration of the wall rock that encloses the vein or fracture. Finally, mineral phases enclosed by parentheses are minor to trace phases.

5.1 Pre-shear zone hydrothermal alteration

The styles of alteration that pre-date formation of the main shear zones are fracture-controlled and are found mostly or wholly within the coarse-grained granitoids. None of these effects are strongly developed, but they are widespread within the volume of rock examined. Three types of hydrothermal alteration effects exhibit evidence of formation prior to the onset of the main, shear-related hydrothermal system: 1) barren quartz veins; 2) magnetite±sulphide veins; and 3) epidote-Kfeldspar veins.

5.1.1 Barren quartz veins

These veins (Photo 5.1) are uncommon and were observed mostly in the Mt McNeil pluton. They are planar to sinuous, are <2 cm in width and have sharp to diffuse contacts with their wall rocks. They are typically composed completely of clear quartz, but locally they can also contain small amounts of white K-feldspar; one vein may have had a thin selvage of molybdenite. They lack alteration envelopes. Cross cutting relationships were not observed with other vein types, but their physical characteristics and occurrence are consistent with formation at relatively high temperatures. They are interpreted to be genetically related to cooling of the intrusive complex and are not directly related to formation of Au-Ag mineralization.

5.1.2 Magnetite±sulphide veins

These veins (Photo 5.2) have a distribution similar to that of the barren quartz veins. They are planar and <1 cm in width. Staining reveals a narrow zone of K-feldspar destruction adjacent to these veins, but feldspar is still present and may be partially albitized. Most contain only magnetite, but in fewer cases pyrite and chalcopyrite are abundant (Photo 5.2). One small magnetite veinlet was cross cut by an epidote-Kfeldspar veinlet, but no other temporal relationships were observed. These veins are also consistent with formation at relatively high temperatures and are interpreted to be a pre-shear zone effect genetically related to cooling of some phase(s) of the intrusive complex.

5.1.3 Epidote-Kfeldspar veins

These veins (Photo 5.3) are very abundant, but are almost completely restricted to phaneritic intrusions in the Skukum Creek area. They are planar to curvilinear, and range from tight fractures to dilatant veinlets mostly <1 cm in width (most are 1 to 5 mm wide). They are dominated by epidote, with trace to minor calcite and/or quartz, and locally contain hematite and/or chlorite. The veinlets can be internally banded. They have envelopes from <1 to several cm in width in which grey igneous feldspars are altered to a white to light pink K-feldspar (Photo 5.3). The envelopes also contain disseminated epidote and calcite and, more rarely, pyrite; igneous magnetite mostly remained stable but was locally destroyed. The alteration envelopes can be developed around tight fractures with no mineral fill. Locally the veins form in orthogonal sets, and in general do not occur with any obvious preferred orientations. The epidote-Kfeldspar veins have no observed zoning relationships to the mineralized shear zones and are cut by sericite-carbonate and chlorite veinlets (Photo 5.4); they are rather evenly distributed throughout the Mt McNeil pluton and are provisionally interpreted to be intrinsic to the intrusive complex with, at most, a very indirect relationship to the mineralized shear zones (see, however, additional comments in the section on epidote shear veinlets below).

5.2 Hydrothermal alteration related to mineralized shear zones

The most important hydrothermal effects are those that are related to formation of the Au-Ag vein and shear-hosted mineralization. Alteration effects can be represented by a few specific, but typically temporally and spatially overlapping, mineralogical assemblages that are here defined by a major mineral phase. The principal features of each assemblage are summarized below in anticipation of the more detailed discussions that follow. In addition, there are many significant differences between the Rainbow-Ridge and Goddell Gully zones, and these are described in a later section. The Rainbow East (Raca) vein, which has been grouped on geological bases with the Rainbow-Kuhn-Ridge system, exhibits some interesting characteristics that are also discussed separately.

1) **K-silicate alteration** formed relatively early and to only a minor extent, although it could have been substantially overprinted by later alteration effects. It is most common in the Ridge and Taxi zones, and largely or wholly predates sulphide precipitation.

2) **Chloritic alteration** is the most laterally extensive assemblage and spanned most of the life of the hydrothermal system. It is Mg-rich and Fe-rich peripheral and proximal to ores, respectively. Proximal to ores it is substantially overprinted by sericitic alteration. Pyrite is typically the only sulphide directly associated with chlorite alteration outside the main shear zones.

3) **Sericitic alteration** is most directly related to mineralization. It is the most intense alteration, and forms pervasive envelopes tens to perhaps 100 metres in width around the main shear zones, with an outward decrease in strength and transition to smaller, usually fracture-controlled zones. Outside of the main shear zones, pyrite is normally the only sulphide encountered (with rare galena and chalcopyrite).

4) **Epidote alteration** takes two forms: 1) the epidote-Kfeldspar veins already described and which do not appear to have a direct relationship to mineralization at the current scale of observation; and 2) well-developed, relatively early epidote veinlets with sulphides (mostly pyrite) immediately adjacent to the ore zones and which are probably a separate event related to mineralization (or possibly shearing along existing epidote-Kfeldspar veinlets). Epidote associated with pervasive and fracture-controlled chlorite alteration is locally common within the main shear zones.

5) **Carbonate minerals** are common in all of the alteration assemblages noted above, and generally have the closest mineralogical association with sulphides. Most carbonate is calcite, with volumetrically minor phases that contain significant Fe, Mg and/or Mn.

6) **Sulphide mineralization** occurs as brecciated quartz-sulphide veins (originally extensional in origin and later sheared) within the main shear zones, and as comparatively unstrained quartz-sulphide extension veins outside of and cross cutting the shear zones. There is commonly an early

stage of pyrite-arsenopyrite without associated precious metals; most Au (electrum) and Ag (mostly in freibergite) precipitated with later base metal mineralization. Refractory Au (related to acicular arsenopyrite) may be a trace component of the Rainbow zone but was not observed in the Ridge zone.

7) **Argillic alteration** is a very minor assemblage that was only found within and immediately adjacent to some late, brittle faults. It is interpreted to be post-mineralization.

Many complicated cross cutting and replacement relationships have been observed among the alteration assemblages. Many of these complexities reflect the structural setting, which almost certainly underwent much syn-hydrothermal movement that led to cyclicity in formation of the various mineralogical assemblages. The more fundamental aspects of the Rainbow-Ridge zones are emphasized below, because they are more basic to understanding the evolution of the hydrothermal system, rather than smaller scale spatial and temporal variations.

5.2.1 K-Feldspar alteration

K-silicate alteration is not a volumetrically important assemblage, but is relatively more common in the Ridge and Taxi zones with only trace indications in the Rainbow zone. The only mineral identified in this assemblage is hydrothermal K-feldspar. The visually obvious epidote-Kfeldspar veins (Photo 5.3) and the uncertainty in their relationship to mineralization have been described above. Staining is required to recognize other forms of K-feldspar alteration. The more common manifestations related to ore zones are narrow envelopes to fractures and chlorite veinlets (Photos 5.5A-C). Many of these fractures and veinlets are comparatively more sinuous, irregular and discontinuous than younger stages of fracture-controlled alteration. Only one example was found of a planar, dilatant veinlet infilled by K-feldspar and cut by mineralized veinlets (Photo 5.6).

5.2.2 Pervasive and fracture-controlled chlorite alteration

Hornblende and biotite in the Mt McNeil granodiorite, and in other intrusions at Skukum Creek, are at least incipiently chloritized throughout the areas examined (Photo 5.7). Chlorite is accompanied by calcite, rutile and, more rarely, epidote, in variable proportions. Incipient chlorite alteration is also commonly related to partial conversion of igneous magnetite to hematite, and to weak dusting of igneous feldspars by sericite. Apatite is present in more strongly chloritized hornblende, and more rarely in biotite, crystals. This ubiquitous, low intensity alteration may be a deuteric effect related to cooling of the host granodiorite or other intrusive phases, or it could be a wide halo of low intensity alteration around the mineralized shear zones; the scale of observation precludes confident interpretation. As the ore zones are approached there is a marked increase in the degree of replacement of hornblende and biotite, and chlorite veinlets become more common. With increasing intensity, some of the matrix to the intrusion can also be replaced. The most intense chloritic alteration occurs in areas cut by irregular to planar fractures that range from hairline to several centimeters in width and which are filled with chlorite and lesser quartz, carbonate and sericite, locally accompanied by minor pyrite and rarely by trace chalcopyrite and galena. Overall, the concentration of pyrite related to chlorite alteration increases significantly as the ore zones are approached. Chlorite veinlets in the Ridge zone contain relatively more epidote than similar veinlets at Rainbow. In general the density and total aperture of chlorite veinlets is highest adjacent to ore zones where they largely define the structural damage zones that surround the main shears, although their distribution is very irregular and they clearly extend beyond the damage zone with diminished intensity. Chlorite distal to ore zones is green, including the (potentially) pervasive background alteration noted above, and comparatively Mg-rich (Figure 13A), whereas proximal to and within the main mineralized shear zones it is black and relatively Fe-enriched (Figure 13B). Chlorite veinlets commonly have sericitic envelopes (Photo 5.8), and in many cases coexist with pervasive sericite-quartz-(pyrite) alteration; as ore zones are approached, however, chlorite is increasingly overprinted by sericite, although the two assemblages commonly have mutually crosscutting relationships. Chlorite alteration is ubiquitous at

Ridge, Rainbow, Taxi and environs, is less intense around veins on Chieftain Hill, and is nearly absent at Goddell Gully. A minor, very late stage of Fe-rich chlorite has been recognized within the main shear zones, where it occurs as a matrix to brecciated sulphides and as late, barren veinlets (Photo 5.9).

5.2.3 Pervasive and fracture-controlled sericite alteration

This alteration has the most direct relationship to the main mineralized shear zones. The effects can begin up to at least 200 metres, and perhaps farther, from the shear zones (limited by distribution of examined holes), and intensity increases toward the shear zones. Sericitic alteration is more strongly and more extensively developed in the hangingwalls of the main shear zones. Peripherally this alteration manifests faint green colouration of feldspars in the intrusions (e.g., Photo 5.8). Although the peripheral effects are sporadically distributed through the core, they can form intense alteration of narrow, discrete zones up to a few metres in width that are typically cored by veinlets with chlorite or quartz-carbonate (Photos 5.8, 5.10 and 5.11) and separated by less altered intrusion. Intense alteration gives a strong green cast to the rock (Photo 5.12). Igneous texture ranges from well-preserved (Photo 5.13) to obliterated (Photo 5.14). Some of the most intense alteration contains igneous biotite and hornblende crystals that now have a tan colour that reflects complete replacement by muscovite (Photos 5.14 and 5.15), commonly accompanied by apatite, titanite (sphene), rutile, and very rare actinolite (only found in two samples). K-feldspar is locally preserved, even in strongly altered samples (e.g., pink minerals in Photo 5.12), but is more typically destroyed (Photo 5.12, inset).

Minerals that accompany sericitic alteration include quartz, chlorite, pyrite, carbonate (variable and commonly later), rutile (from breakdown of biotite and hornblende), and rare traces of chalcopyrite, arsenopyrite, hematite and galena. Where the alteration is simple pervasive and of low intensity, pyrite is either absent or found only in trace concentrations; in more intense alteration, particularly in areas where alteration has a clear structural control, pyrite can be >10%.

Close to the main Rainbow zone, some intervals of sericitically-altered rocks weather to a distinct Fe oxide stain related to altered plagioclase crystals (Photo 5.16). In DDH 86R-14 this effect starts at about 850 feet in depth (this hole was drilled in feet) and extends with increasing intensity toward the main zone of mineralization at about 1125 feet (i.e., within about 75 metres of the ore zone true width). The magnetic susceptibility of the rock drops abruptly at the onset of this oxidation effect, and reflects coincidence with stronger magnetite destructive alteration. The oxidation effect is not present farther from the main shear zones, which suggests that it reflects a compositionally discrete assemblage related directly to sericite or to an accompanying mineral phase too small to identify confidently with hand lens (it could be Fe-bearing carbonate, although this was not recognized by SEM). Similar effects were noted in the Goddell Gully and Ridge zones, and as narrow envelopes up to 30 cm in width around weakly mineralized rhyolite dykes in DDH 98TZ-01 from the Taxi zone.

Narrow veinlets dominated by sericite are found in rock that can have either strong or weak pervasive sericitic alteration (Photo 5.17). The veinlets can contain quartz and minor sulphide, and carbonate can be either coeval or later (Photo 5.18). These veinlets appear to be relatively more abundant proximal to the main zones. Where relationships can be observed, pervasive sericite most commonly replaces black chlorite; this mostly occurs proximal to the main shear zones, but sericitic alteration can also be cross cut by un- or poorly-mineralized chlorite veinlets.

An important field observation is that pervasive sericitic alteration can convert dark-coloured andesite or monzonite dykes to a light colour that can easily lead to confusion with rhyolite dykes (Photo 5.19). This effect can occur at all scales from envelopes to veins (Photo 5.20) to totally pervasive discolouration of dykes several metres in width. Staining for K-feldspar can help distinguish between rhyolites and altered andesites, as the presence of K-feldspar will indicate a relict igneous component that would have been present in rhyolite but largely absent from andesite; the reverse does not apply, however, as intense sericitic alteration can destroy all of the igneous K-feldspar in affected rhyolites.

5.2.4 Epidote veinlets

These are found within a few to tens of metres of the main shear zones, with a strong preference for their footwall (Photo 5.21). They take a form similar to that of the chloritic and sericitic veinlets, with which they have partial spatial overlap. The epidote veinlets typically contain minor sericite and carbonate (calcite with minor Mn peaks on SEM), and can also contain pyrite and rare hematite. The veinlets range from millimeters to several centimeters in width. They do not have alteration envelopes, but K-feldspar can remain stable in these zones (Photo 5.21). This suggests that they may have a relationship to the epidote-Kfeldspar veins described above, although no definitive evidence was found to document this. Epidote veinlets close to the main shear zones can contain abundant sulphide (mostly pyrite; Photo 5.22) and sericite, and are known to cut mineralized quartz veins (Photo 5.23). It is possible that at least some of these veinlets reflect an overprint of shearing and younger alteration on pre-existing epidote-Kfeldspar veinlets close to or within the main shear zones. In addition to these veinlets, epidote can occur as an accessory to chlorite and sericite alteration and veinlets within the main shear zones as described above.

5.2.5 Mineralization: quartz-sulphide shear veins, extension veins and breccias

The structural and geological characteristics of the main shear zones have been described above. In general, mineralization occurs within and immediately adjacent to major, strongly sheared fault structures that also controlled the emplacement of the rhyolite and andesite/monzonite dykes that have both indirect and direct genetic associations with the mineralization. The mineralization comprises a minor component of little- to un-strained quartz-sulphide extension veins that formed as shearing waned, and shear veins that represent an older stage of extension veins that were subsequently sheared and commonly brecciated. The most important observations for understanding hydrothermal history of the deposit include: 1) recognition of a direct genetic relationship between ore mineral assemblages and rhyolite dykes in the Taxi zone; and 2) constraints on the origin and timing of Au-Ag precipitation from examination of un- to little-deformed quartz-sulphide extension veins.

Mineralized dykes in the Taxi zone

Important constraints on the relationship between intrusions and hydrothermal activity were obtained from examination of DDH 98TZ-1. This hole was drilled beneath the quartz-sulphide veins exposed on surface in the Taxi zone. Mineralization was essentially absent in this drill hole, except where it intersected several rhyolite dykes. These are narrow rhyolite or QFP intrusions that range up to a few metres in width. They are hosted within a zone of distributed shearing and are accompanied by andesite and/or monzonite dykes. Each of the rhyolite dykes was observed to be strongly altered by a sericite-carbonate-sulphide (mostly pyrite) assemblage, to be cut by numerous mineralized quartz-carbonate veinlets with significant base metal sulphide concentrations (Photo 5.24), and to have envelopes of sericite-carbonate-sulphide alteration up to a few metres in width in the enclosing Mt McNeil pluton. Similar mineralization was not observed in this drill hole outside of the immediate rhyolite environment. Although overall grades are low, these observations document a direct genetic relationship between specific rhyolite dykes and hydrothermal activity that precipitated Au, Ag and base metals. The Central Marker QFP at Goddell Gully (see below) has similar hydrothermal characteristics, whereas the North and South Marker QFPs do not, indicating that mineralization there probably also has specific relationships to certain phases of rhyolite/QFP dykes (see discussion below). There are also much weaker indications of similar relationships of mineralization to andesite/monzonite dykes in the Taxi zone.

Quartz-sulphide extension veins

These veins (Photo 5.25) are found throughout the area examined, where they cross cut or are located adjacent to the main shear zones. They can also be found well outside of the main shear zones, such as the extensional vein set that characterizes the Taxi zone. Quartz-sulphide extension veins manifest very similar characteristics throughout the property. They are laterally discontinuous, vary from millimeters to tens of centimeters in width, and have sharp contacts with their wall rocks (Photo 5.25). They typically comprise an early stage of very coarse-grained, commonly euhedral quartz that grew into open space (Photos 5.26 and 5.27). In most veins, the coarse-grained quartz was accompanied by an early stage of coarse-grained pyrite and/or arsenopyrite that forms several percent of the veins (Photo 5.28). Sphalerite with chalcopyrite disease (disseminations of chalcopyrite within sphalerite and resulting either from exsolution or replacement along cleavage) commonly accompanies the pyrite-arsenopyrite, but its precipitation continued after early pyrite-arsenopyrite ceased to form.

Petrography suggests that little or no Au or Ag mineralization formed during the early, coarse-grained quartz-pyrite-arsenopyrite stage. Many of the poorly mineralized extension veins, primarily those within the main shear zones, were subsequently sheared and brecciated, and the main stage of precious metal mineralization was introduced at this time. The assemblage related to Au-Ag mineralization consists of fine-grained quartz, carbonate, commonly sericite, and more rarely epidote and/or chlorite. The sulphide assemblage comprises additional pyrite and arsenopyrite (mostly fine-grained), sphalerite, galena, and trace to minor freibergite, electrum or native Au, argentite, stibnite and chalcopyrite (Photos 5.29 and 5.30). Rare minerals include barite (in one vein from Ridge), native Ag and specular hematite (also rare and typically along the central axis of veins), and in sample 98TZ-1-76.7 molybdenite that formed an abundant phase associated with galena. Extension veins are commonly cut by late, barren chlorite and/or carbonate veinlets, which can also form a matrix to zones of brecciated sulphides within the veins (e.g., Photo 5.9).

Most Au occurs as electrum (Photo 5.31) with variable Au/Ag ratios (Figure 13 C and D; the peak height on the SEM spectra are only relative indications of composition, and electron probe data would be required for full determination). Electrum is most commonly found as inclusions within sphalerite (Photo 5.32), or on or very close to the surface of pyrite and/or arsenopyrite; in most cases it is clear that electrum precipitated during replacement of these host minerals by galena and/or stibnite (Photo 5.31).

Freibergite precipitation was broadly coeval with electrum, and indicates a close relationship between Au and Ag in the mineral paragenesis. Empirically, however, assays indicate that quartz-sulphide extension veins peripheral to the main shear zones commonly have much higher Ag/Au ratios than do more proximal veins; this primarily reflects a paucity of electrum in the veins as freibergite abundance and Ag grades remain high. Deposit scale variations in Ag/Au ratios cannot, therefore, be reconciled simply by varying proportions of separate Au-rich and Ag-rich mineral assemblages, and must instead reflect differences in the P-T-X conditions of the hydrothermal fluids away from the main shear zones.

Mineralization in the main shear zones

The main shear zones contain essentially all of the potentially economic Au-Ag mineralization and can be understood within the framework for quartz-sulphide extension veins as outlined above, with accommodation for syn-hydrothermal deformation as described above in section 4.0.

Mineralization is found in breccias and brecciated quartz veins related to shearing, and in minor amounts in comparatively unstrained quartz-sulphide veins. The highest Au-Ag grades are contained within brecciated quartz veins (Photo 5.33). The veins were probably originally extensional in origin (Photo 5.34), based upon quartz grain morphology, and were subsequently deformed. The deformation primarily manifests brecciation, which in some cases occurred in multiple episodes (see sections above). The degree of brecciation varies significantly, from crackle formation (Photo 5.35) to strong cataclasite (Photo 5.36). The matrix to the breccias does not vary significantly, and typically comprises various combinations of quartz, sericite, carbonate, chlorite and sulphide. The ore mineral assemblage is identical to that in quartz-sulphide extension veins as described above and includes pyrite and arsenopyrite (commonly early and more coarse-grained), sphalerite (with low Fe and with chalcopyrite disease) and galena, trace to minor freibergite, argentite and native Ag (the latter two phases are very rare), and chalcopyrite and stibnite (locally abundant). Electrum is the main form of Au, with greatly subordinate native Au. The primary Ag mineral is freibergite; in rare cases chalcopyrite, galena, stibnite and sphalerite exhibited Ag peaks on SEM spectra, but these are volumetrically insignificant and should have little affect upon the overall Ag budget. Ore mineral parageneses are also similar to the extension veins, with electrum/native Au and freibergite related primarily to later stages of base metal sulphide precipitation rather than to early pyrite-arsenopyrite. This temporal pattern explains why high grades of Au-Ag can be found in mineralization that is visually dominated by either arsenopyrite or pyrite. Acicular arsenopyrite, which is the characteristic ore mineral at Goddell Gully and which is inferred to carry refractory gold, was observed in only two cases in the Rainbow zone (Photo 5.37), and not at all in the Ridge zone. In one case at Rainbow, it was found within rounded fragments of an early stage of quartz veining, with the main stage of base metal mineralization later and in the matrix of the breccia; this differs from most observations where acicular arsenopyrite is relatively late in the mineral paragenesis.

Lower grades of mineralization are commonly found in brecciated rhyolite dykes (Photos 5.38 and 5.39), or andesite dykes that have been strongly bleached by sericitic alteration and/or brecciated (see sections above). In these cases Au-Ag mineralization is also contained within quartz-sulphide vein material (e.g., Photo 5.39) which occurs in the matrix to the breccia associated with quartz, chlorite, sericite and carbonate (i.e., an assemblage similar to the main vein forms of mineralization).

Rhyolite and quartz-sulphide breccias commonly grade into, or are in sharp contact with, polylithic breccias. These breccias (Photo 5.40) contain fragments of barren and mineralized quartz vein, and altered granodiorite, rhyolite and/or andesite/monzonite. The matrix comprises various combinations of quartz, carbonate, sericite and lesser chlorite and is similar to the matrix to the mineralized breccias. The matrix to these breccias can also contain pyrite, and minor to trace sphalerite and galena. Au-Ag grade is typically anomalous only where fragments of mineralized quartz-sulphide vein are present.

5.2.6 Comments on carbonate alteration

Carbonate is one of the most widespread alteration minerals at Skukum Creek and occurs as an important phase in all of the alteration assemblages described above. It can be the main mineral phase present, or an important accessory. Some interesting features of carbonate alteration include the following. 1) Narrow, barren, post-mineralizatoin carbonate veins are locally present. 2) Quartz-sericite alteration has minor to several percent pyrite, but in most intervals higher concentrations of pyrite have a petrographic relationship to carbonate that partially replaces the quartz-sericite. 3) Carbonate also commonly has a petrographic relationship to sulphide in chlorite shears. 4) Carbonate is an important component of the assemblage of fine-grained quartz and sulphides that form the matrix to brecciated quartz extension veins as well as within the main shear veins. 5) Carbonate varies significantly in composition. SEM shows that most of the carbonate is calcite with a small Mn component (Figure 13E). A small proportion of carbonate can be described as ferroan dolomite or ankerite (Figure 13F; ankerite has >20 mol % of the Mg position filled by ferrous Fe, which cannot be determined accurately from SEM spectra). Very minor amounts of late carbonate, including some late veinlets and minor carbonate related to chlorite that forms the matrix to brecciated sulphide, comprises manganosiderite (dominated by Fe-Mn) and Fe-Mg phases (Figure 13G and H). Overall, the abundance of Fe-enriched carbonates at Rainbow-Ridge is minor compared to that at Goddell Gully (see below). The key observations about carbonate minerals at Rainbow-Ridge are that they commonly have a direct relationship to sulphide and associated Au-Ag precipitation, and that their composition is, on average, distinct from carbonates at Goddell Gully.

5.2.7 Argillic alteration

This type of alteration was only observed within and immediately adjacent to brittle fault zones. It manifests strong, pervasive clay alteration of intrusive rock and is interpreted to be a post-hydrothermal effect of minimal importance. It is not considered further.

5.2.8 Fluid inclusions

The petrographic characteristics of fluid inclusions were routinely examined during optical petrography. No microthermometry or other analytical methods were attempted. Because fluid inclusion types and habit of occurrence are virtually identical among samples from Ridge, Rainbow, Chieftain Hill and Goddell Gully, the summary comments below apply across the study area. Descriptions of fluid inclusion characteristics in individual samples may be found in the petrographic appendix.

- Fluid inclusions are common in most samples that contain vein quartz.
- Inclusions are mostly small with nearly all <10, and most <2, microns in size. Geometries range from irregular to negative crystal form. Evidence for necking (i.e., post entrapment modification) is common.
- Nearly all inclusions are either secondary (forming after the host mineral had crystallized) or indeterminate (no timing constraints) in habit. Most occur on fracture planes that cut across the host quartz grains. Some clusters of inclusions that lack a clear fracture control could be primary (entrapped during precipitation of the host mineral), but constraints are only permissive.
- All inclusions appear to be aqueous. No carbonic (e.g., CO_2 or CH_4) fluids were observed. Similarly, no high salinity (i.e., salt-bearing) inclusions were confidently observed, although one sample from the Ridge zone may have contained tiny examples of such fluids.
- Inclusions in most samples comprise both liquid-rich and vapour-rich populations. The two types are commonly interspersed and/or found along the same fracture. Where phase ratios are constant, this relationship is compatible with boiling conditions. Some groups of liquid-rich inclusions contain birefringent (non-salt) daughter minerals; the form of the crystals is compatible with carbonate, although this could not be confirmed.
- Some primary inclusions were observed along growth planes in coarse-grained quartz in little or undeformed quartz-sulphide extension veins. These inclusions also comprise coexisting liquid- and vapour-rich types that are petrographically indistinguishable from the secondary inclusions in deformed quartz. Some also contain birefringent daughter minerals.
- Based upon visual estimation of the volume of vapour in liquid-rich inclusions and the previous experience of the author, it is qualitatively estimated that most inclusions would homogenize at temperatures at or below approximately 300°C, and most would probably homogenize below 225°C. On average, it appears possible that the liquid-rich inclusions that contain birefringent daughter minerals would homogenize at a higher average temperature than those without daughter minerals.
- **Conclusion.** The only observed fluids entrapped during or after formation of the quartz-sulphide veins were aqueous, of low to moderate salinity, and commonly boiling. The deformation of the host quartz largely precludes using the inclusions to constrain P-T-X conditions during mineralization. Study of the late, little- to un-deformed quartz-sulphide extension veins could be used to constrain and compare paleodepth of formation of veins in different parts of the district. This could improve interpretation of the relative level at which veins are currently exposed, and thereby influence interpretation of how prospective they might be. A fairly ambitious study would be required to develop confidence in the interpretation, however, and at this time such a fluid inclusion study is not recommended.

Photo 5.1. A barren quartz veinlet cutting Mt McNeil granodiorite. One example may have had a selvage of molybdenite, and some contain white K-feldspar. These veins are interpreted to pre-date the main hydrothermal system, and to be relatively high temperature features related to cooling of the intrusive complex. Sample 86R14-159'.

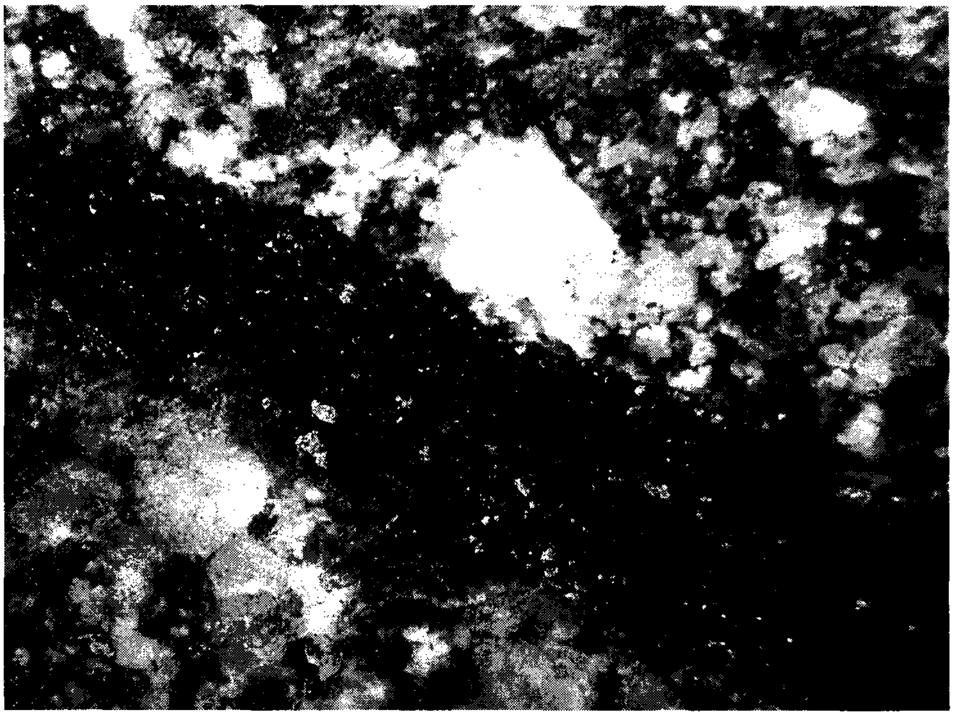


Photo 5.2. Magnetite veinlet with pyrite and chalcopyrite. These have narrow envelopes in which K-feldspar is destroyed (and feldspars may possibly have been albitized). These are cut by epidote-Kfeldspar veinlets. Sample SC01-1-170.

Photo 5.3. Black magnetite veinlet to left. A typical epidote veinlet with K-feldspar envelope (stained sample shown in inset), that is interpreted to have formed prior to the main stage of hydrothermal activity. Sample 86R14-122'.

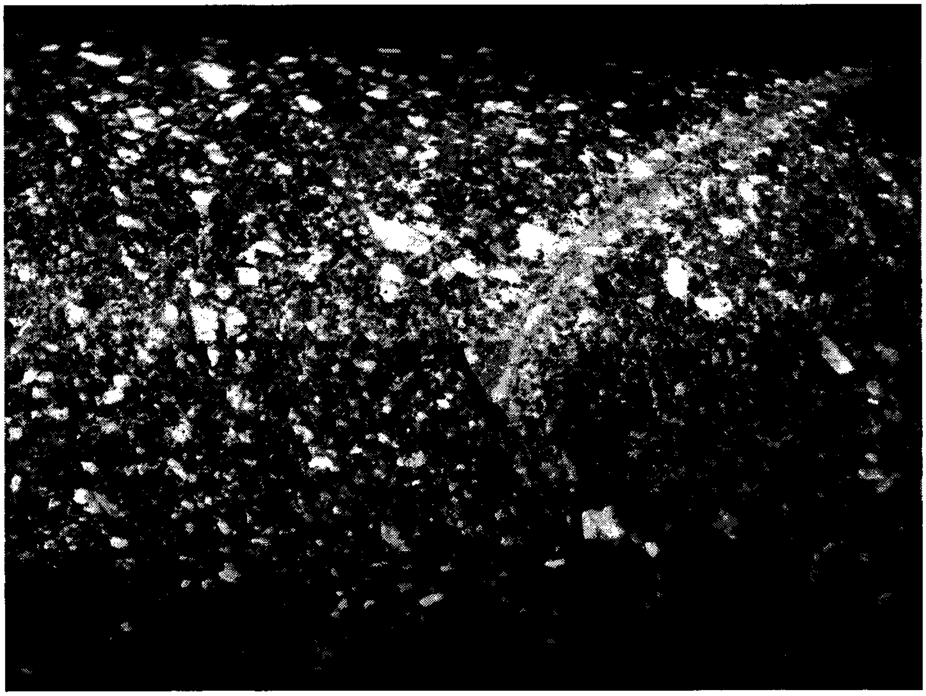


Photo 5.4. Epidote-Kfeldpsar vein cut by a chlorite veinlet, establishing an early age for at least some epidote-Kfeldspar veins. Sample 98TZ-1-??.

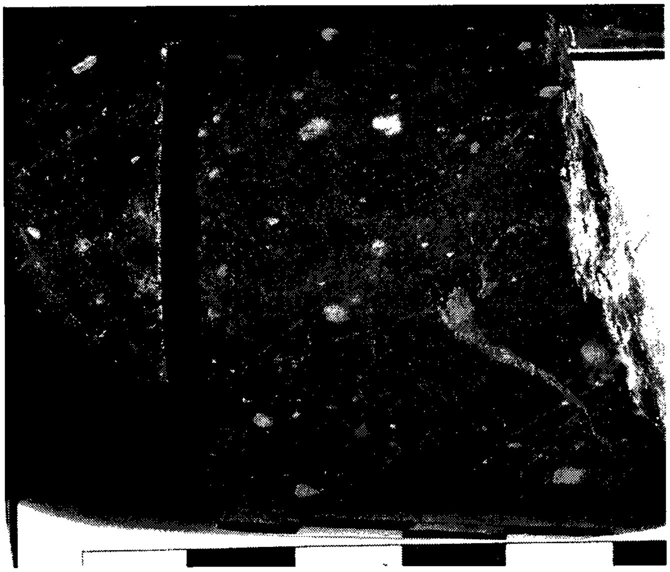


Photo 5.5A. Porphyritic andesite or monzonite dyke with chlorite-pyrite alteration and diffuse secondary K-feldspar on fractures; such effects are common in the Ridge and Taxi zones, but are largely absent farther to the east. Sample SC01-1-116.

Photo 5.5B. K-silicate alteration is much more common in the Ridge and Taxi zones than at Rainbow. Here an early quartz-(carbonate)-pyrite vein has a distinct K-feldspar alteration envelope, and is cut by a quartz-carbonate vein with base metal sulphides that lacks an envelope. Host rock is a rhyolite/QFP dyke. Sample 98TZ-1-76.5.

Photo 5.5C. Barren chlorite-quartz shear veinlet with a narrow K-feldspar alteration envelope. Minor remnant igneous K-feldspar is present at lower left. K-feldspar alteration is cut by a quartz-pyrite vein. This sample documents K-feldspar alteration and stability in Rainbow, but in this zone it is rare and typically absent. Sample 496-200-39.6.

Photo 5.6. In sample SC01-1-126.5, an early, barren, extensional veinlet with K-feldspar and carbonate is cut and replaced by later carbonate-sulphide mineralization. Crossed polars; FOV 2.63 mm.

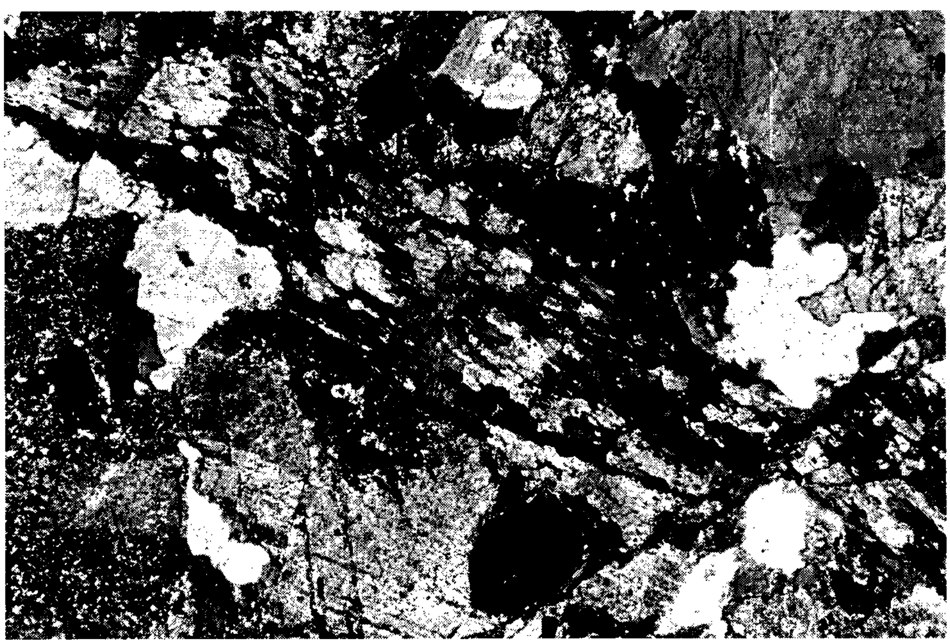


Photo 5.7. Pervasive alteration of Mt McNeil granodiorite includes purple-coloured, Mg-rich chlorite after hornblende and biotite, here accompanied by carbonate and pervasive sericitic alteration. Sample 86R14-933', crossed polars, FOV 1.32 mm.

Photo 5.8. This sample is from the Golden Eagle zone, located south of the Kuhn Fault. It illustrates the typical relationship of sericite±pyrite alteration as envelopes around fractures, in this case fractures filled with chlorite, variably accompanied by quartz, carbonate and pyrite. Sample 98GE-1-28.

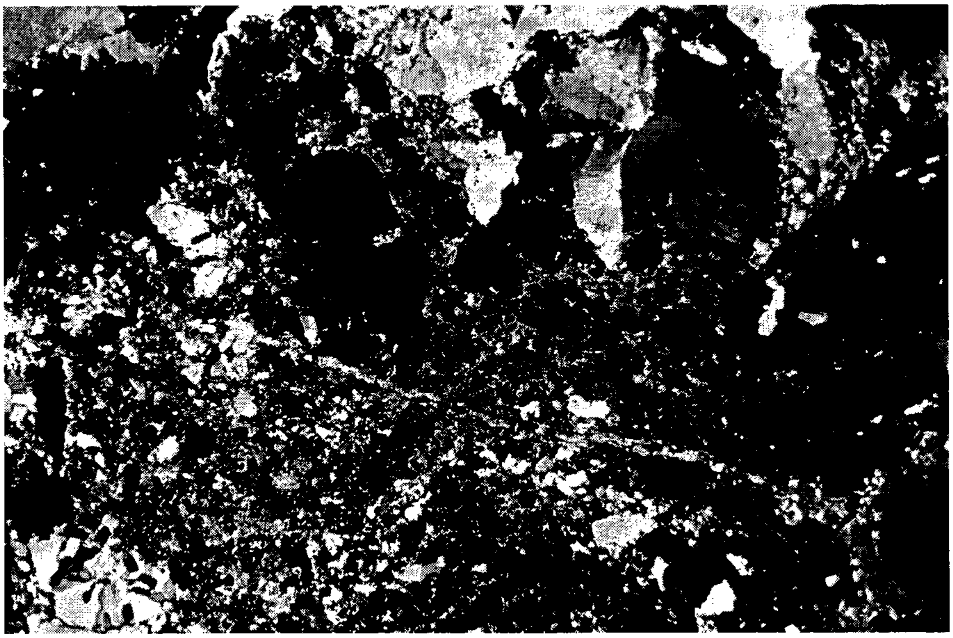


Photo 5.9. Late assemblage of Fe-rich carbonate and chlorite that surround and replaces brecciated, early arsenopyrite-pyrite mineralization (opaque grains). Sample R96-213-134.5, crossed polars; FOV 2.63 mm.

Photo 5.10. Intense sericite-pyrite-quartz alteration envelope to a quartz-(calcite)-sphalerite-galena-pyrite-chalcopyrite veinlet, documenting the relationship of sericitic alteration to mineralization. Upper sample shows the host rock with minor pervasive and fracture-controlled chlorite-sericite. Sample 98GE-1-59.7.

Photo 5.11. Andesite dyke cut by planar quartz-calcite-pyrite veinlets with sericite envelopes. The sericitic alteration changes the colour and texture to resemble rhyolite. Chloritically altered domains are early and replaced by the sericite. Sample 98TZ-1-92.

Photo 5.12. Pervasive sericite alteration of Mt McNeil pluton (Sample R96-201-7.3). Here pyrite concentration is low, but it comprises several percent in many samples. Chlorite, carbonate and rutile replace hornblende and biotite. Pink grains are remnant igneous K-feldspar; this locally remains partially stable during sericitic alteration but is more typically destroyed, along with magnetite, by intense alteration (Inset; sample SC01-1-137.3), as is magnetite.

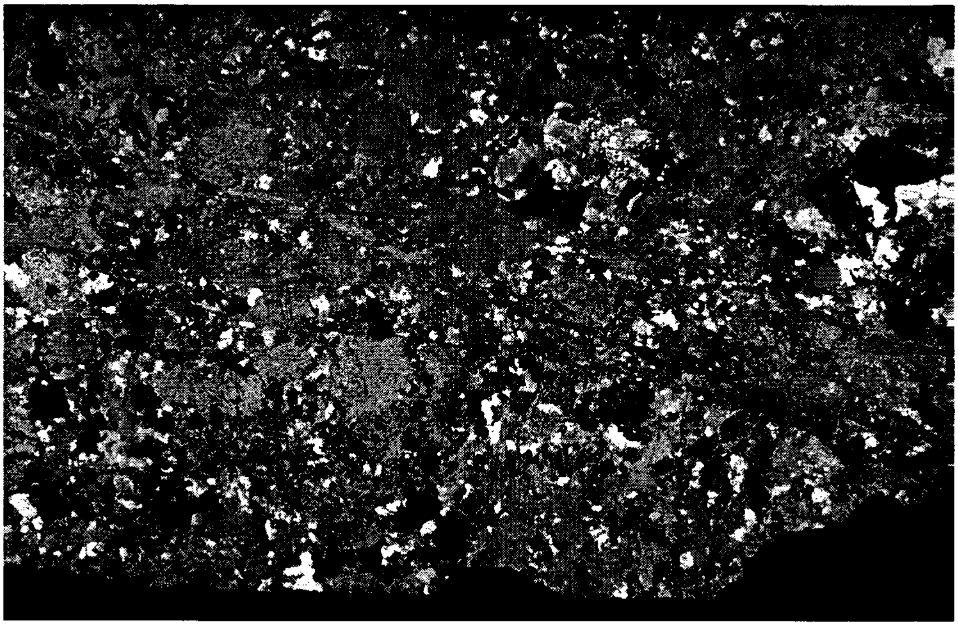


Photo 5.13. Intense, texturally-destructive sericite-quartz-(pyrite)-(rutile)-(carbonate) alteration of Mt McNeil granodiorite. In most cases, igneous texture is at least partially preserved, even in the most intensely altered samples. Sample R96-213-114.2, full section view in crossed polars.

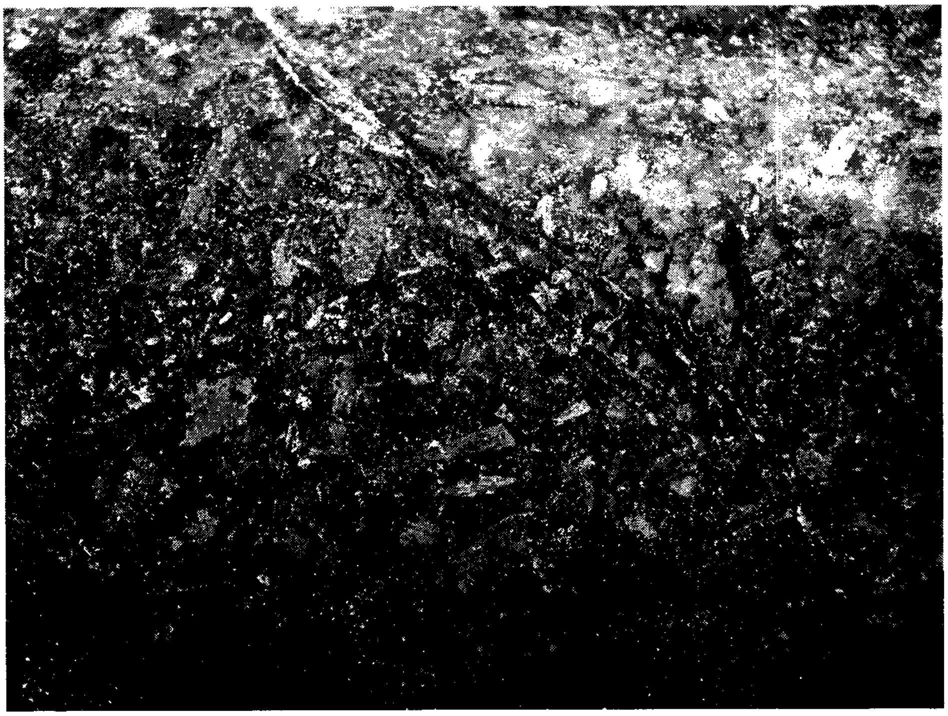


Photo 5.14. Intense alteration locally yields tan hornblende and biotite that reflects complete replacement by muscovite. This sample has strong sericite (green in plagioclase), chlorite and pyrite. Sample RG97-1-47.3.

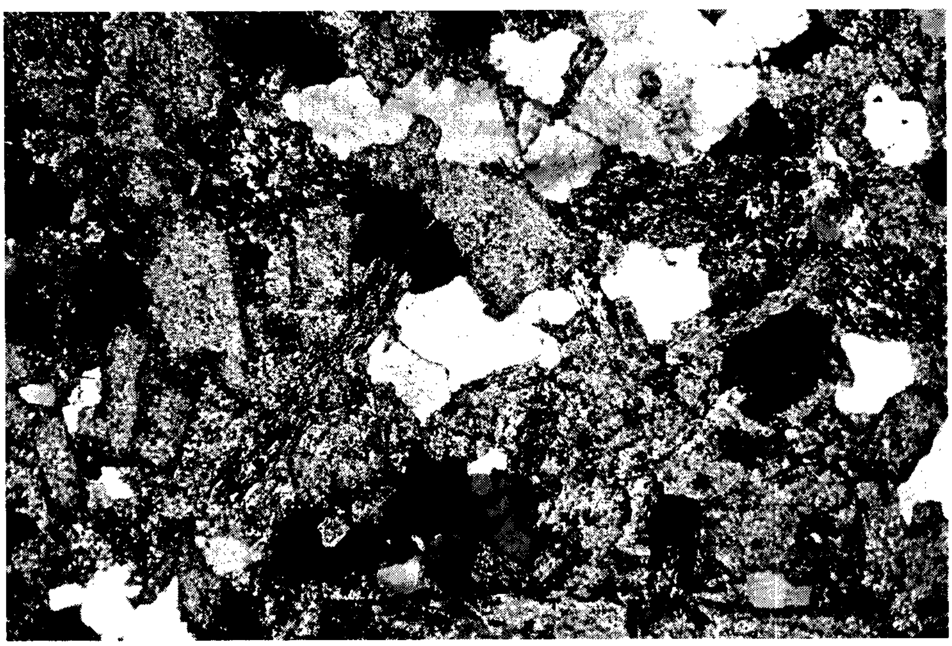


Photo 5.15. View of typical proximal sericite-quartz-carbonate-(pyrite)-(rutile) alteration of Mt McNeil granodiorite. This sample has tan biotite and hornblende, which reflects replacement by muscovite. In general, most carbonate is slightly younger than sericite in these samples, and is commonly related to pyrite. Sample RG97-1-49.4, crossed polars, FOV 2.63 mm.

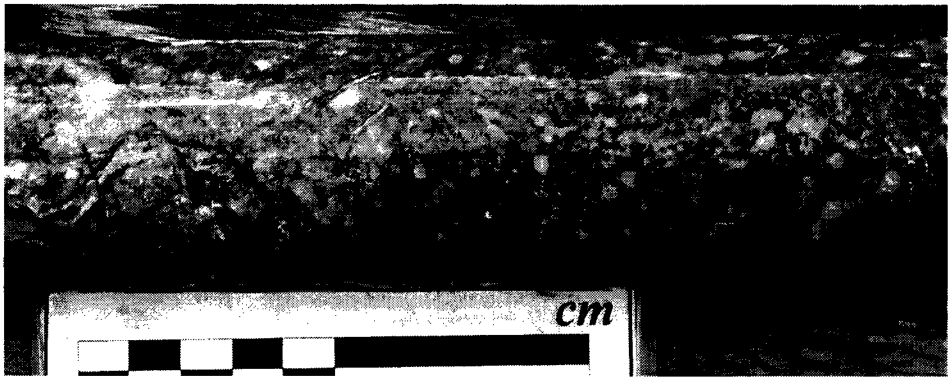


Photo 5.16. The footwall of the Rainbow and Ridge zones commonly acquires a strong Fe oxide stain to weathered sericitic alteration that is not found elsewhere. On the left, the fractures contain carbonate, which may be ferruginous and cause the stain effect (it is not controlled by pyrite concentration). Sample R96-213-114.2.

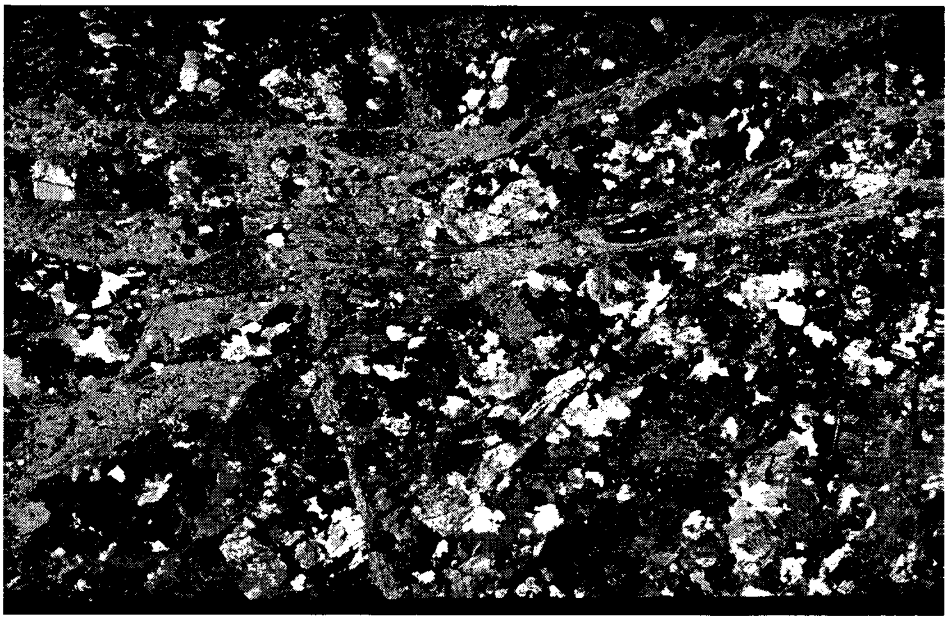


Photo 5.17. Sericite-(chlorite)-(pyrite) shears cutting Mt McNeil granodiorite. These are cut and replaced by later carbonate (see photo 5.18). Sample R96-200-34.6, full section view in crossed polars.

Photo 5.18. Sericite-(chlorite)-(pyrite) shear veinlet in Mt McNeil granodiorite is cut by later carbonate-dominated material. It is typical for most of the carbonate to be later than the sericite and chlorite, and to have a closer relationship to sulphide. Sample R96-200-34.6, crossed polars, FOV 2.63 mm.

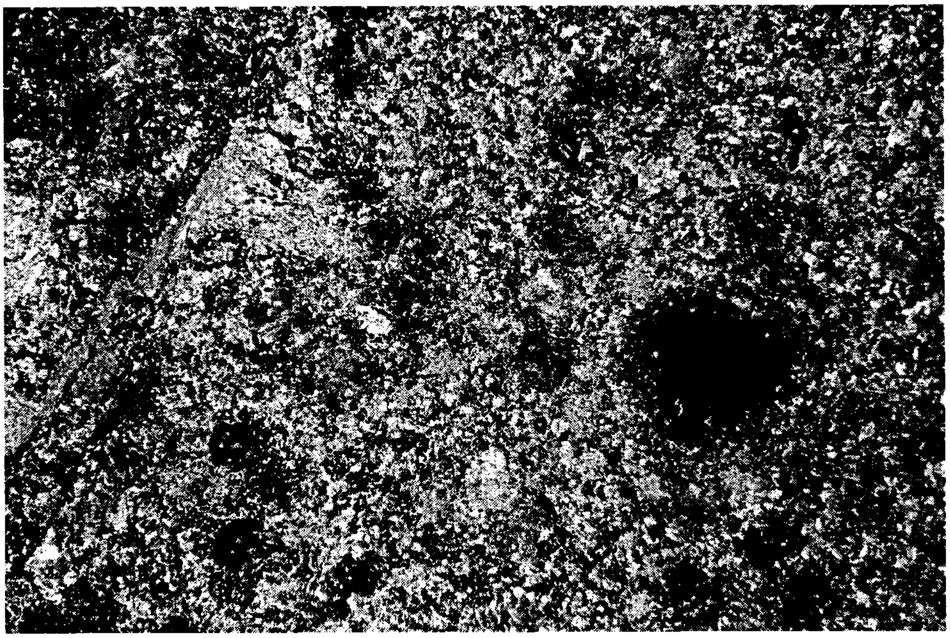


Photo 5.19. Typical intense pervasive sericite-quartz-(carbonate)-(pyrite) alteration of a QFP/rhyolite dyke (relict quartz phenocryst is the round, dark crystal at right). Sample is cut by a late carbonate-sulphide veinlet upper left. Sample R96-203-157.3, Crossed polars, FOV 2.63 mm.

Photo 5.20. Sample that illustrates how an andesite can be strongly bleached and acquire the appearance of rhyolite due to sericitic alteration. Here the alteration is intense sericite-quartz related to a quartz-carbonate veinlet with high concentration of base metal sulphides. Similar effects occur on larger scales. Sample RG97-4-502.5.

Photo 5.21. Epidote-rich shears are locally abundant proximal to the main shears in the Ridge, and to a lesser extent the Rainbow, zone. They are sulphide poor, locally with minor pyrite, and commonly contain abundant sericite and lesser carbonate. They may differ from epidote-Kfeldspar veins, but K-feldspar does locally remain stable (pink grains; stained sample in inset). They may, in some cases, be sheared and altered epidote-Kfeldspar veinlets. Sample SC01-1-325.2.

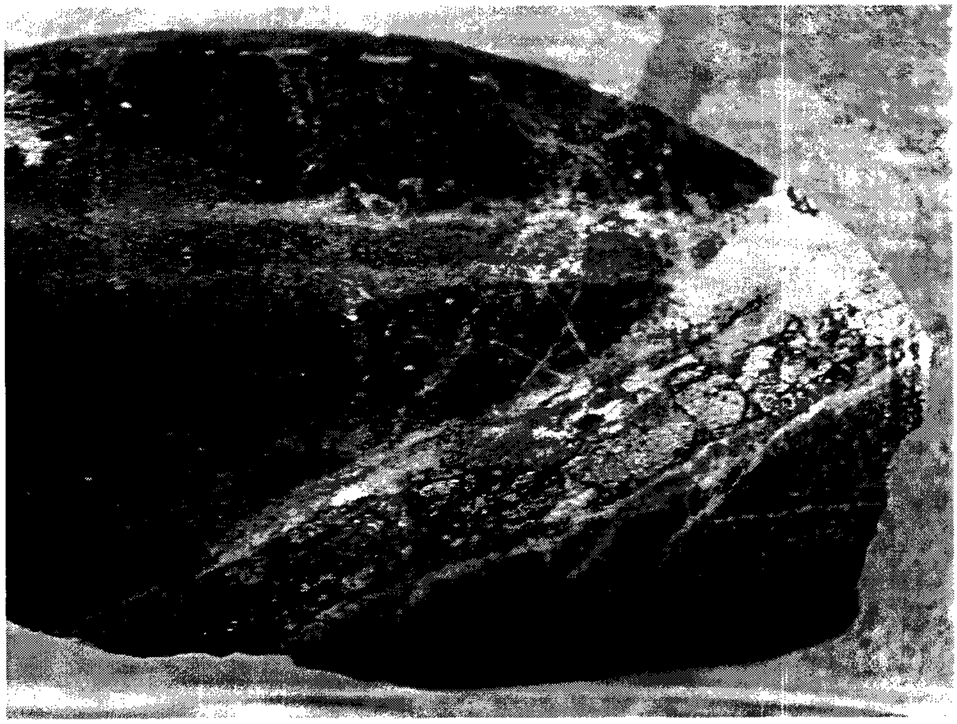


Photo 5.22. Example of a sheared epidote-carbonate vein with strong sulphide mineralization. The strong sulphide and lack of a K-feldspar alteration envelope suggest that these veins are distinct from early epidote-Kfeldspar veins, or have been overprinted by later shearing and alteration effects. Sample RG97-3-376.2.

Photo 5.23. A sheared epidote-carbonate veinlet cuts a mineralized quartz vein. Documents formation of some epidote after sulphide mineralization. Sample identification not logged.

Photo 5.24. Rhyolite dyke with abundant disseminated sulphide and cut by quartz veins with pyrite and base metal sulphides and white calcite. These can be irregular, but are mostly planar, weakly to strongly dilatant veins. Pervasive alteration is sericitic, but K-feldspar commonly remains stable. In the Taxi zone there are several dykes with these features that lie outside the major shear zones and document a genetic relationship between at least some phases of rhyolite intrusion and fluid generation and sulphide mineralization. Sample 98TZ-1-62.7.

Photo 5.25. Quartz extension vein with minor carbonate and base metal sulphides. Interval has high Ag but low Au grades, typical of such veins peripheral to the main shear zones. Similar veins, or brecciated equivalents, within the main shear zones carry significant or most of the Au grade. Sample SC01-1-126.5.

Photo 5.26. A quartz –sulphide extension vein on right is cut by a later stage of fine-grained quartz-sulphide related to shearing on left. This sample contains the most electrum observed in the sample suite. Sample R1300-drift.

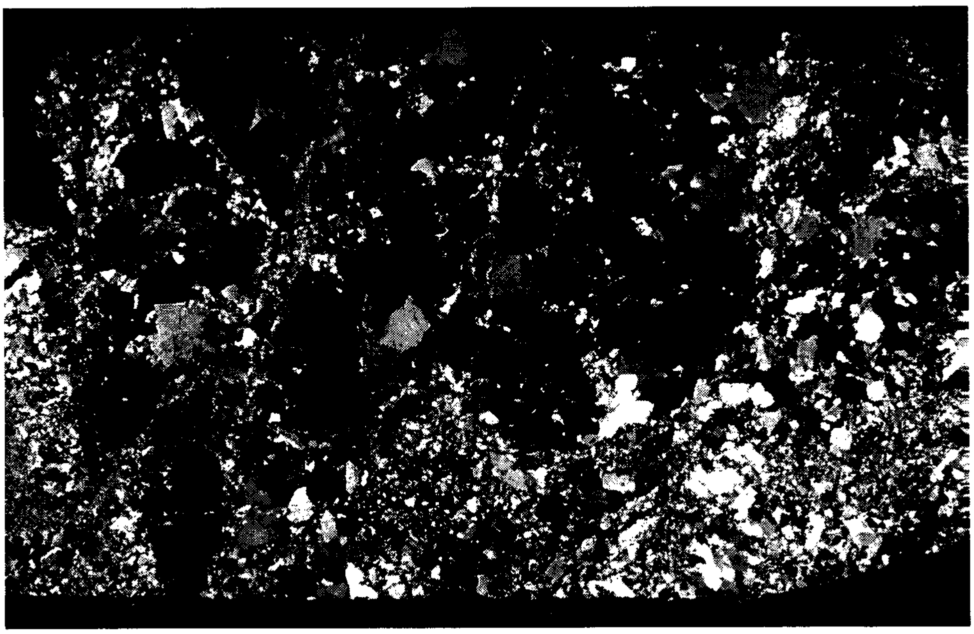
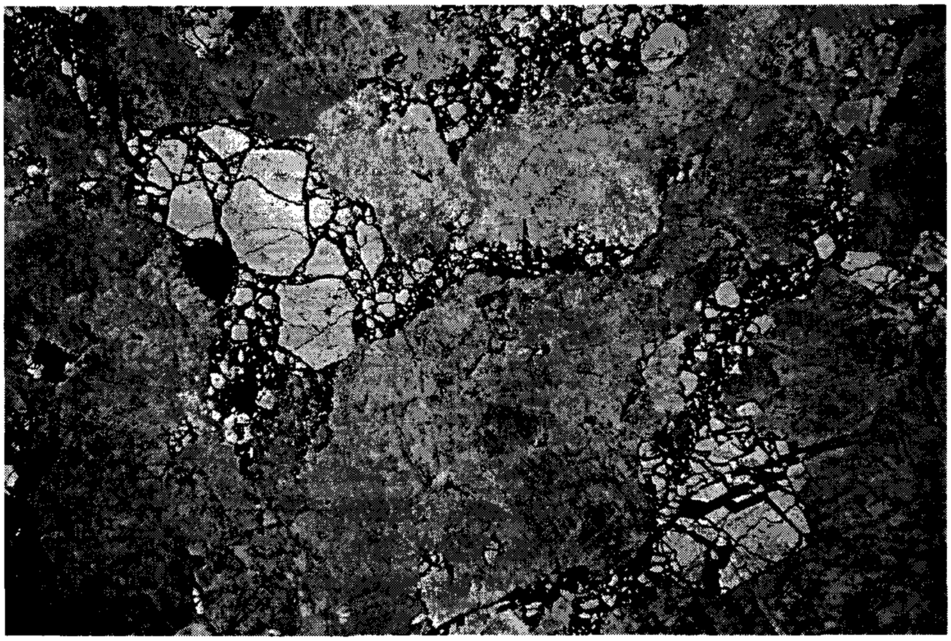


Photo 5.27. Typical pattern of an early, coarse-grained quartz extension vein with coarse pyrite and arsenopyrite that was strained and brecciated, with a matrix of fine-grained quartz, carbonate and sulphides. Sample R96-213-134.5, full section view in crossed polars.



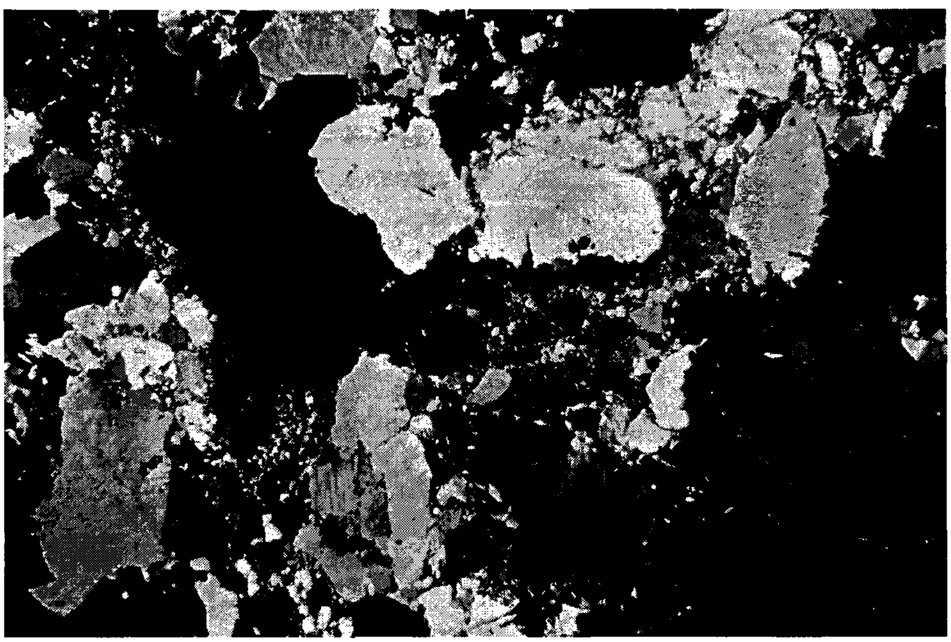


Photo 5.28. Early, coarse-grained quartz is strained and recrystallized. The sulphide is early, coarse-grained arsenopyrite associated with the quartz. It has been brecciated and is replaced and rimmed by the later stage of fine-grained quartz, carbonate and sulphide that is related to Au mineralization. Sample R96-213-134.5, upper view plane and reflected light, lower view crossed polars; FOV 2.63 mm.

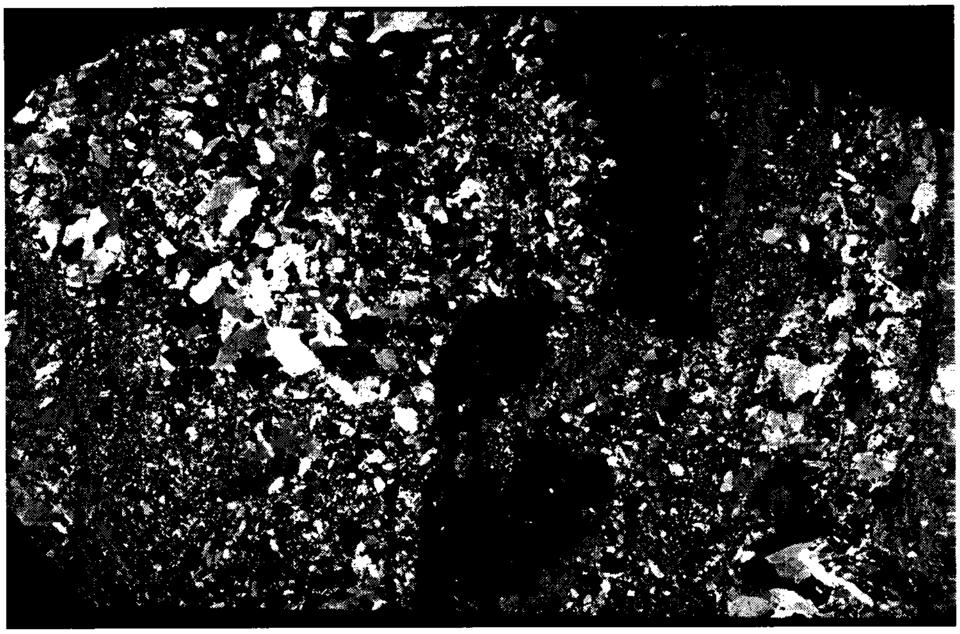


Photo 5.29. This is an early quartz extension vein with minor coarse sulphide that has been cut by an assemblage of fine-grained quartz, chlorite, carbonate and abundant base metal sulphides with Au and Ag minerals (dark band; see next photo). Sample R96-206-135.3, full section view in crossed polars.

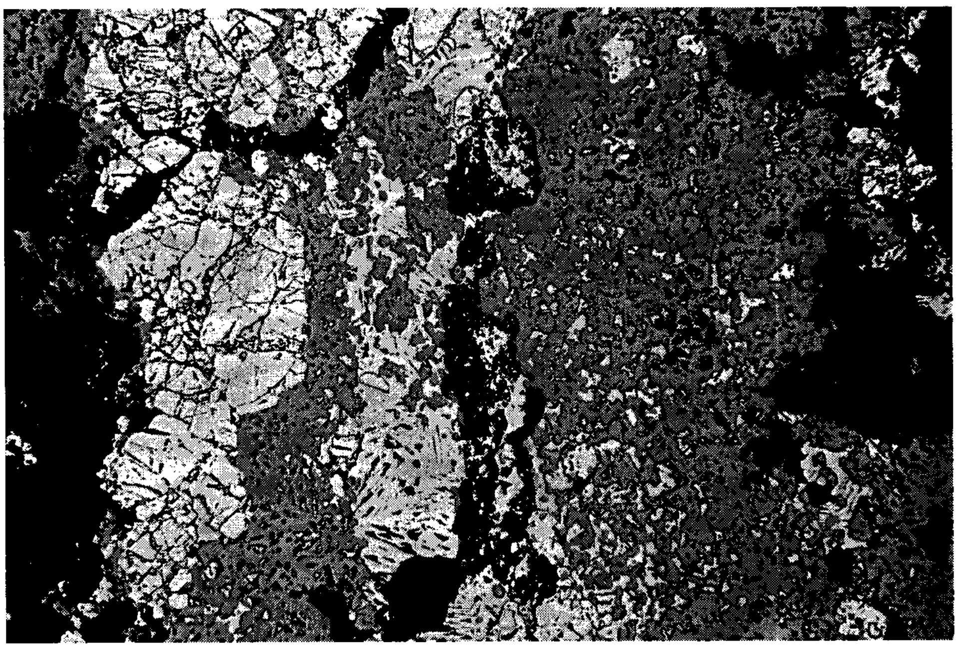


Photo 5.30. Detail of the base metal sulphide event with contained electrum and Ag minerals from previous photo. Ore minerals include galena, sphalerite, minor to trace freibergite, argentite, chalcopyrite, stibnite and electrum (as inclusions in sphalerite). The fractured pyrite at the margin of the vein may be part of this assemblage or older and related to early coarse-grained quartz. Sample R96-206-135.3, reflected light, FOV 2.63 mm.

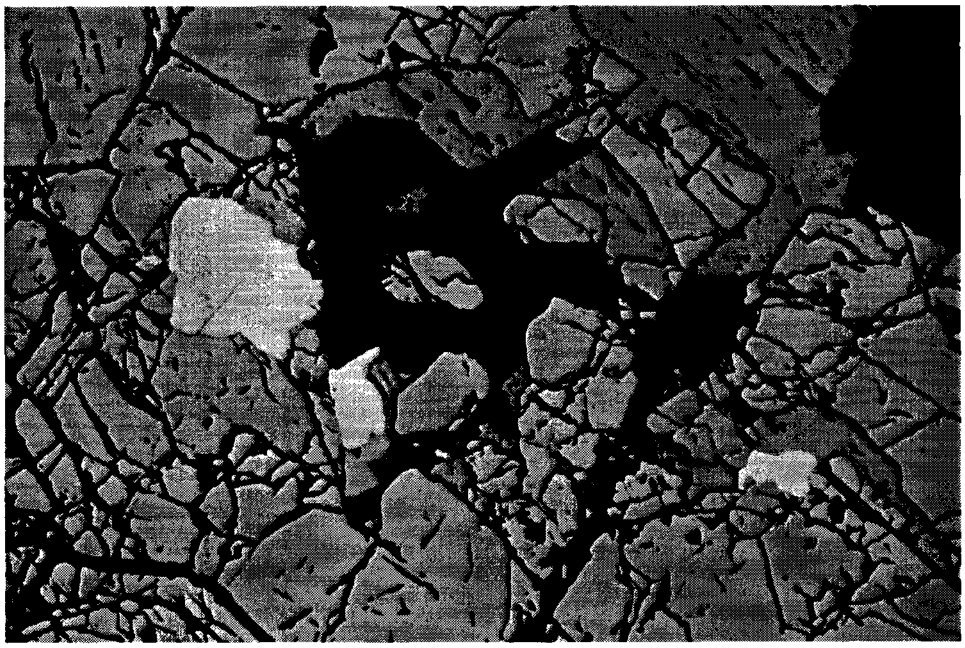


Photo 5.31. Three grains of electrum (largest ~200 microns in size), which is common throughout this sample of quartz-sulphide extension vein. The main sulphide is pyrite, but electrum is only found where pyrite is replaced by sphalerite and galena (medium grey; note Au grain on right). Sample R1300-drift, reflected light, FOV 0.16 mm.

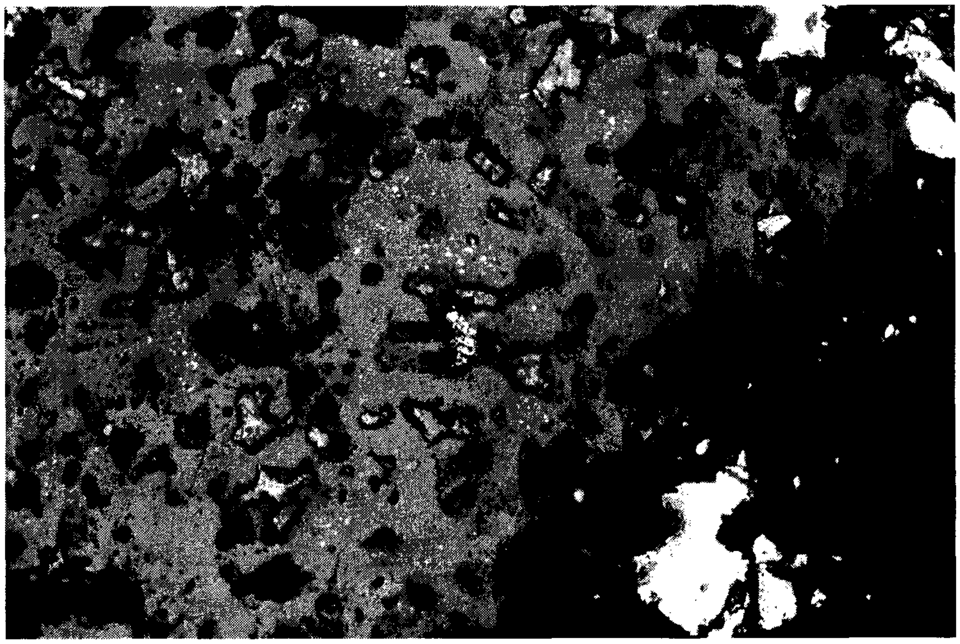


Photo 5.32. A grain of electrum ~20 microns in length is hosted within sphalerite (darker grey with chalcopyrite inclusions), and is directly related to inclusions/replacements of stibnite and galena (medium and light greys). Sample R96-213-134.5, reflected light, FOV 0.16 mm.

Photo 5.33. Representative ore from a 35 g/t Au interval in the Rainbow zone. The ore is arsenopyrite rich here, and related to a brecciated quartz-carbonate vein. Sample R96-201-74.

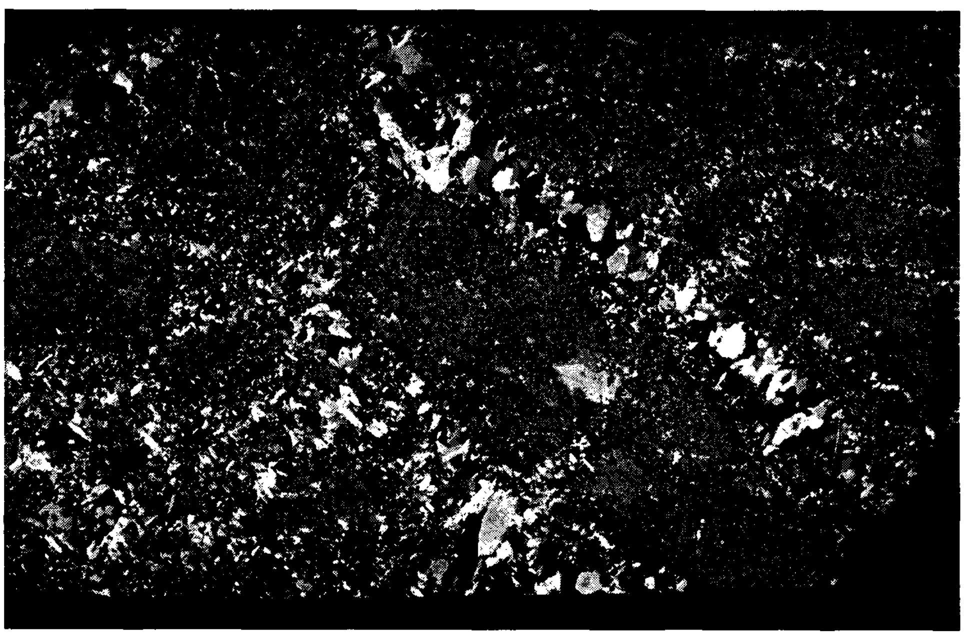


Photo 5.34. Crackled rhyolite with intensely pervasive quartz, sericite, carbonate and minor chlorite alteration, cut by an orthogonal pattern of quartz-(sulphide) extension veinlets that have not effected rotation of fragments. Sample R96-213-127.6, full section view in crossed polars.

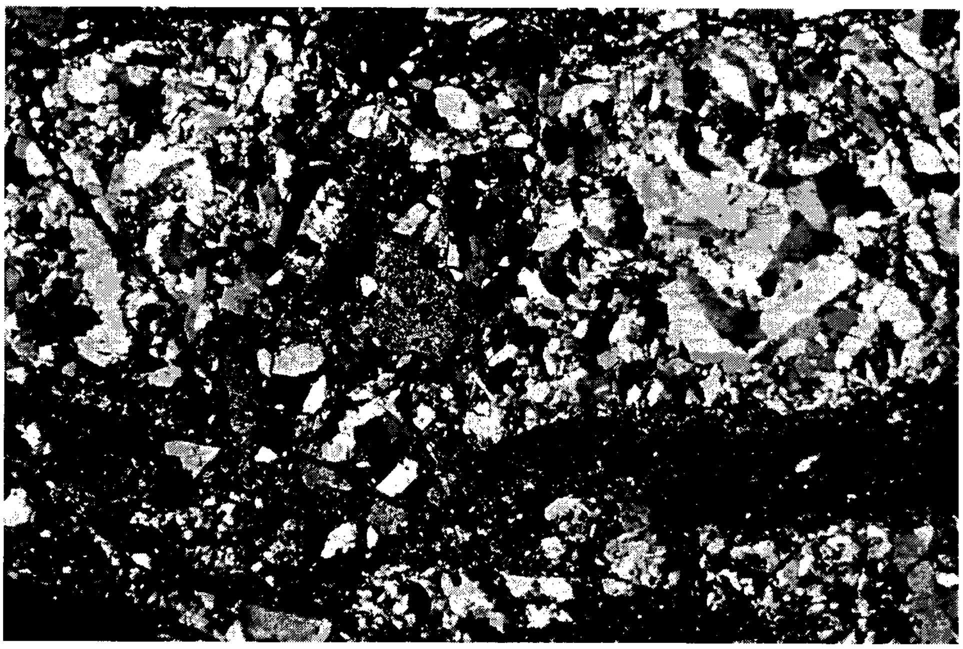


Photo 5.35. Early, barren, coarse-grained, initially extensional quartz is brecciated and has a matrix of chlorite, carbonate and minor sericite. Most sulphides and Au-Ag minerals are related to the matrix; early quartz commonly has coarse-grained pyrite and/or arsenopyrite that is not strongly Au-Ag mineralized. Sample RG97-1-366.5, cupper view plane light and lower crossed polars; FOV 1.32 mm.

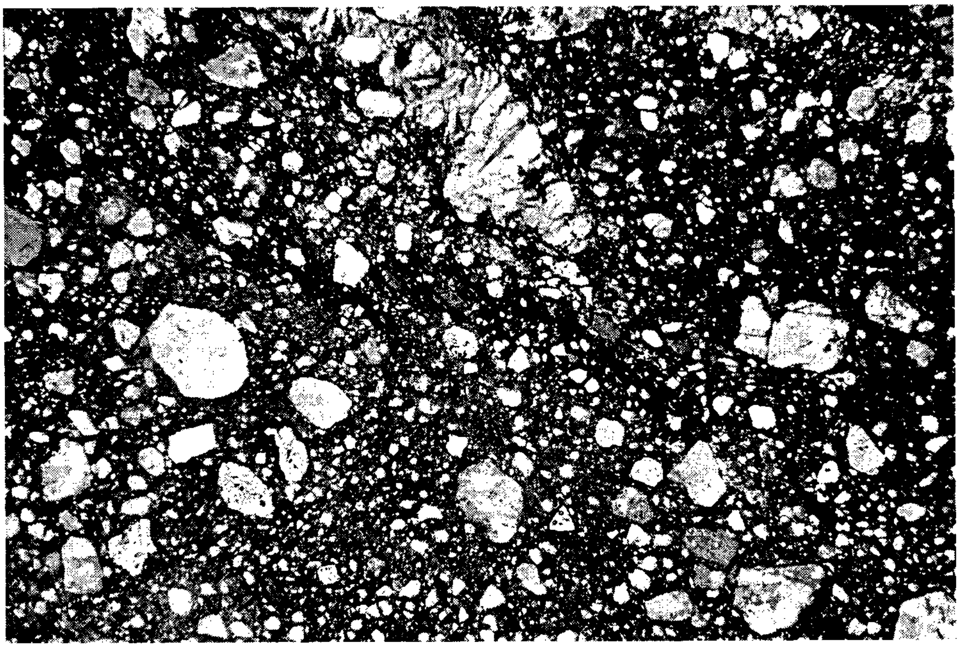


Photo 5.36. A quartz-pyrite-arsenopyrite (?) breccia in a quartz-carbonate-(sericite) matrix, cut by a shear with sphalerite, galena, pyrite and trace chalcopyrite, freibergite and stibnite, an assemblage typically associated with Au-Ag mineralization. R96-211-63.3, combined reflected and plan light, FOV 2.63 mm.

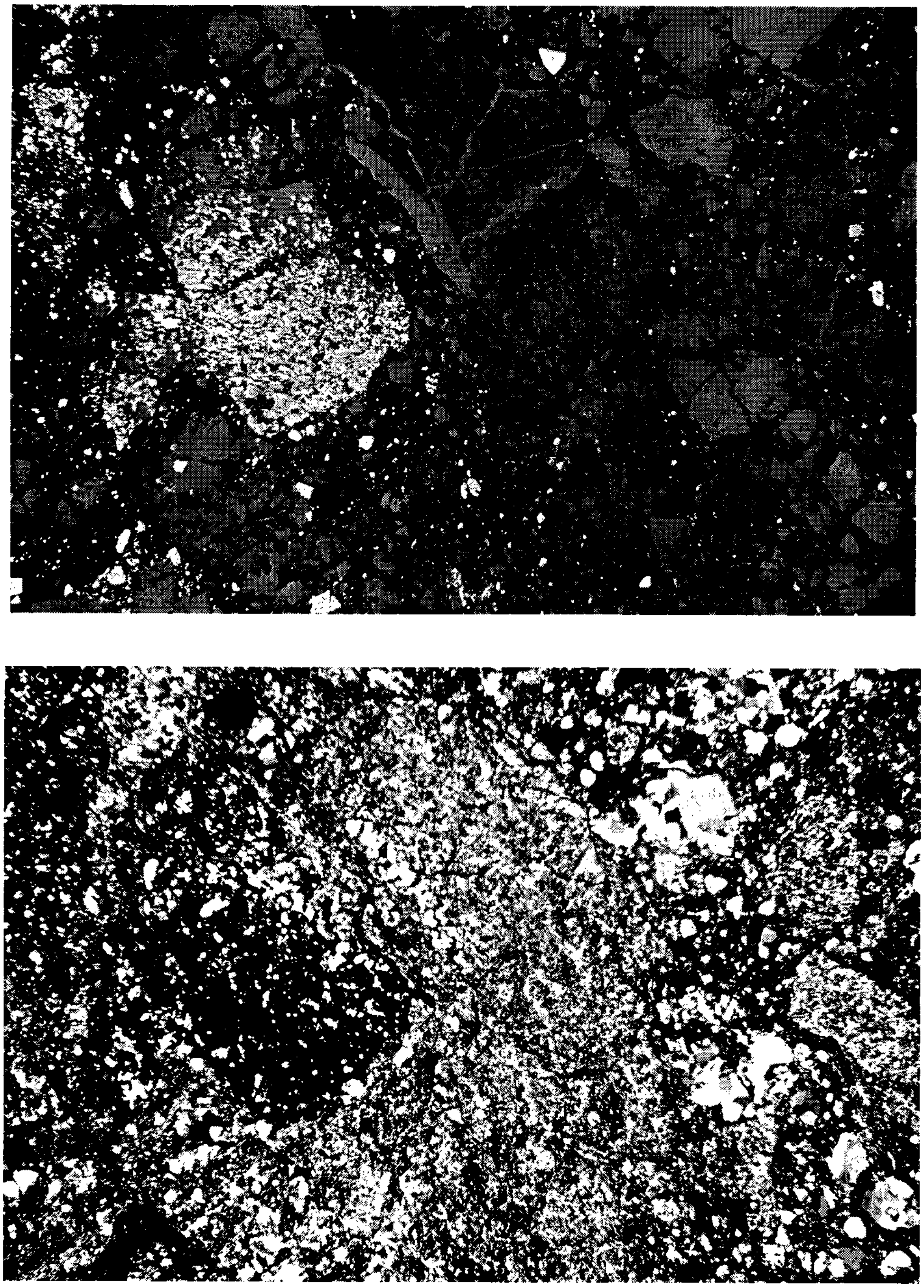


Photo 5.37. Breccia with fragments of Mt McNeil pluton altered to quartz, sericite and carbonate, and fragments of barren and quartz-(acicular) arsenopyrite mineralized extension vein. R96-211-63.3, upper view reflected light, lower crossed polars; FOV 2.63 mm.

Photo 5.38. Rhyolite breccia bounding main mineralization zone. Fractured, rounded to angular, rotated to crackled rhyolite fragments in a matrix of quartz with minor to major sulphide-chlorite-carbonate. Such zones typically only carry up to a few g/t Au. Inset shows staining for K-feldspar. Sample R96-213-127.6.

Photo 5.39. Intense brecciation of rhyolite with fragments of mineralized quartz vein with pyrite and arsenopyrite, but few base metal sulphides. Grades 6.1 g/t Au. Quartz-sericite-chlorite present as irregular stringers and matrix to the breccia. These commonly grade to polylithic breccias with similar matrices but little to no grade. Sample R96-213-150.9.

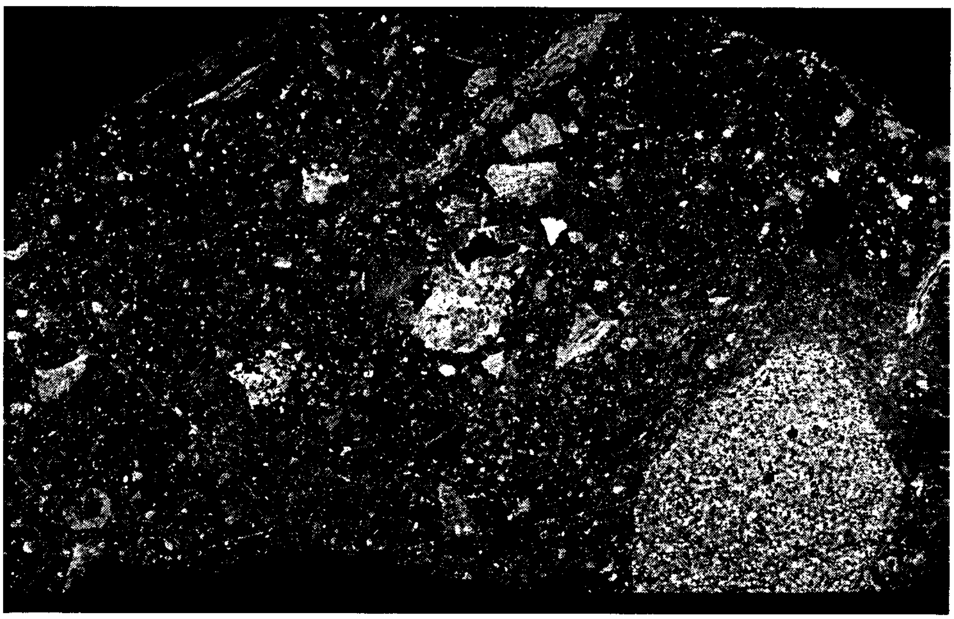


Photo 5.40. Thin section view of a polylithic breccia. Some sulphide is in mineralized fragments, but most comprises minor pyrite with traces of galena, sphalerite and chalcopyrite in the sericite-carbonate matrix. Most are post- or very late-ore. Sample R96-202-92, full section view in crossed polars.

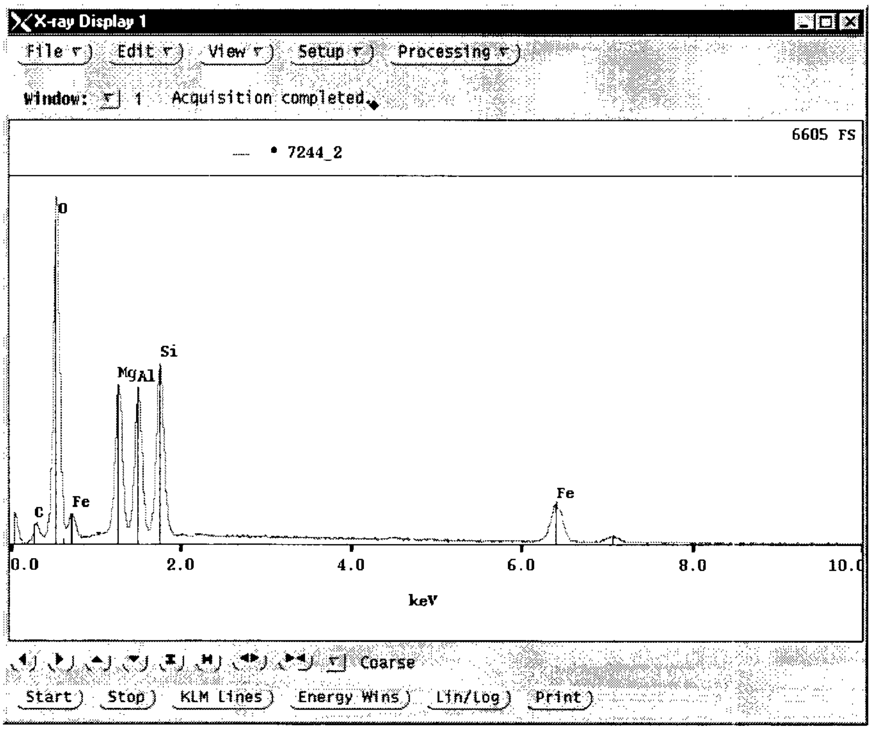


Figure 16A. Peripheral alteration. although intense around a set of shears or fractures, still has a Mg-rich composition for chlorite. This is purple coloured chlorite after biotite in the Mt McNeil granodiorite. Sample 86R14-597'.

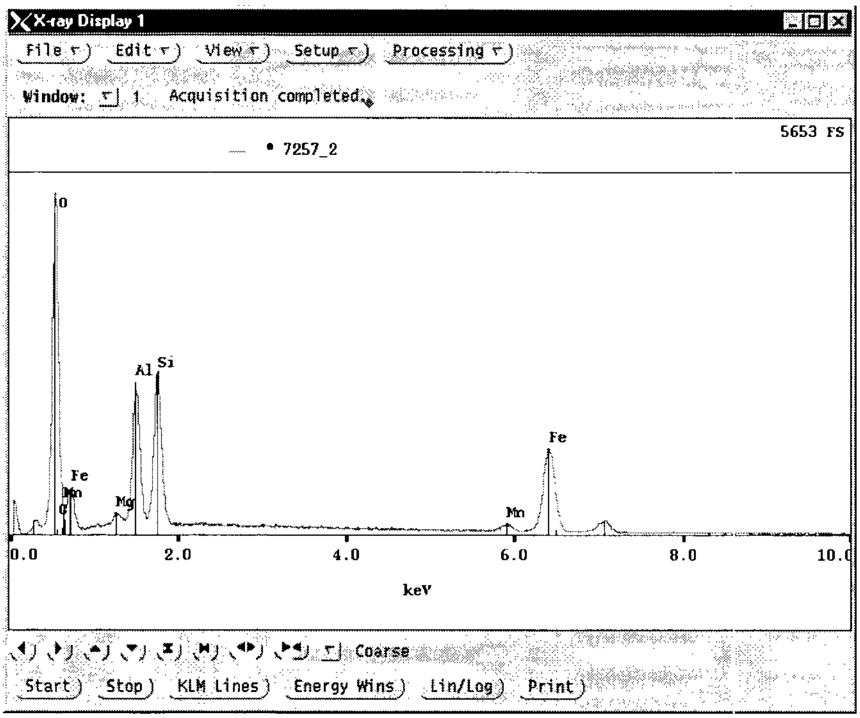


Figure 16B. Fe-rich proximal chlorite typical of the environment close to mineralization at Rainbow-Ridge. From mineralized chlorite-carbonate±sericite veinlet in the main shear zone. Sample RG97-1-366.5.

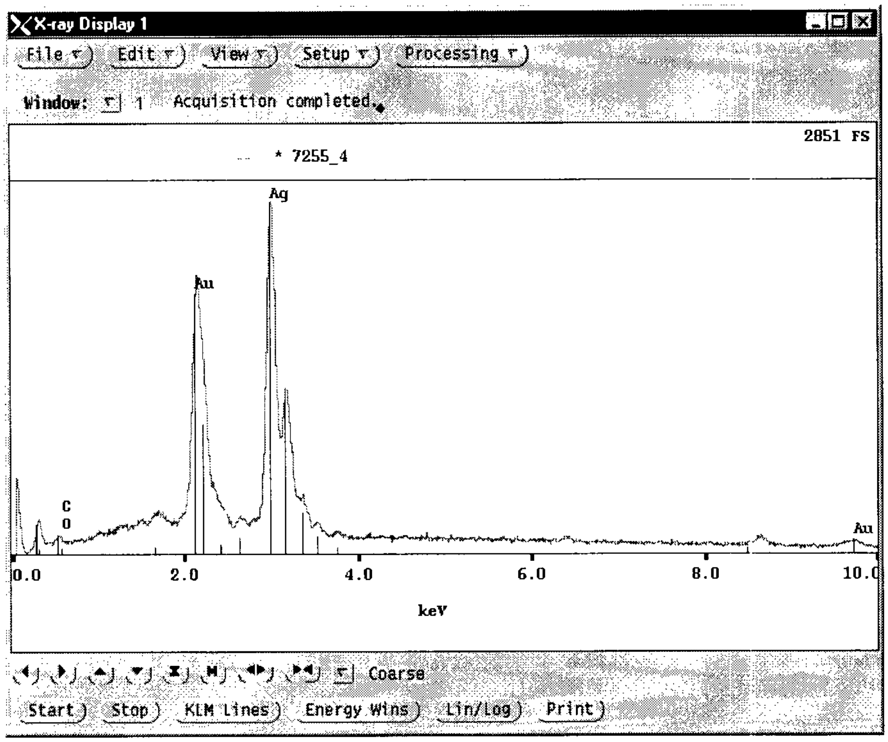


Figure 16C. Electrum with a Ag peak larger than theAu peak. The peaks are only broadly proportionate to concentration, and a composition cannot be determined. Sample R96-213-134.5.

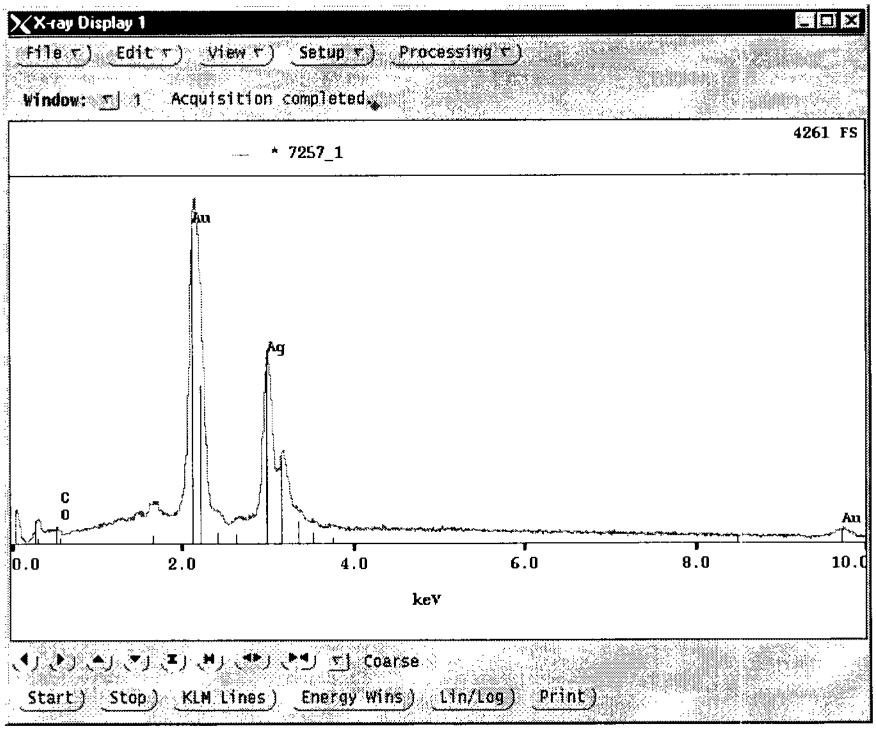


Figure 16D. Electrum in the Ridge ore zone, here with a Au peak significantly higher than the Ag peak. Sample RG97-1-366.5.

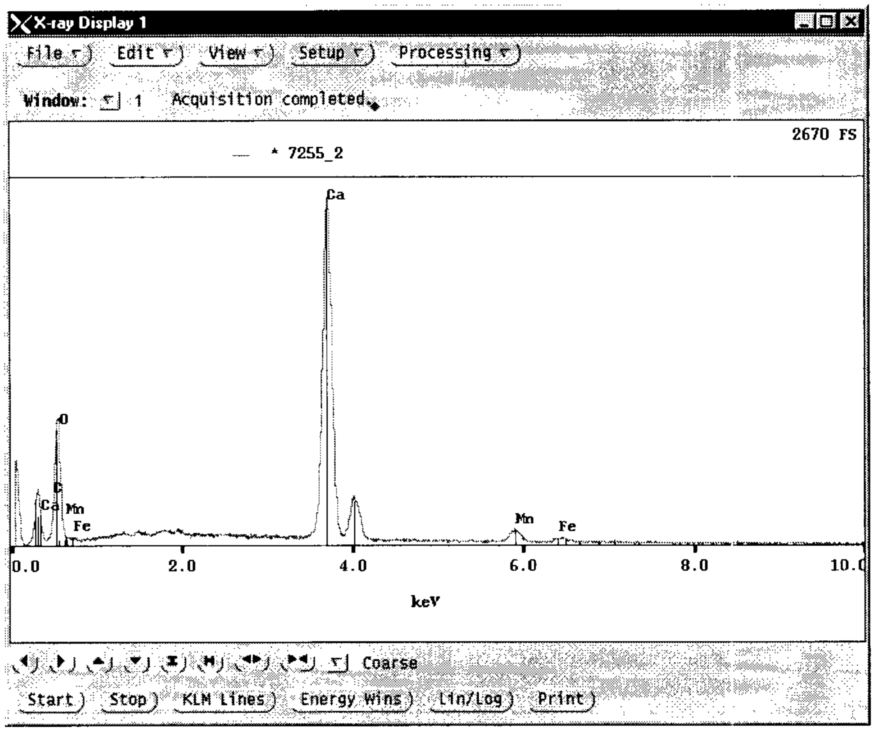


Figure 16E. Carbonate within the main shear zone. This pattern is typical of most carbonate in the Rainbow-Ridge zone, comprising calcite with a small Mn peak. Sample R96-213-134.5.

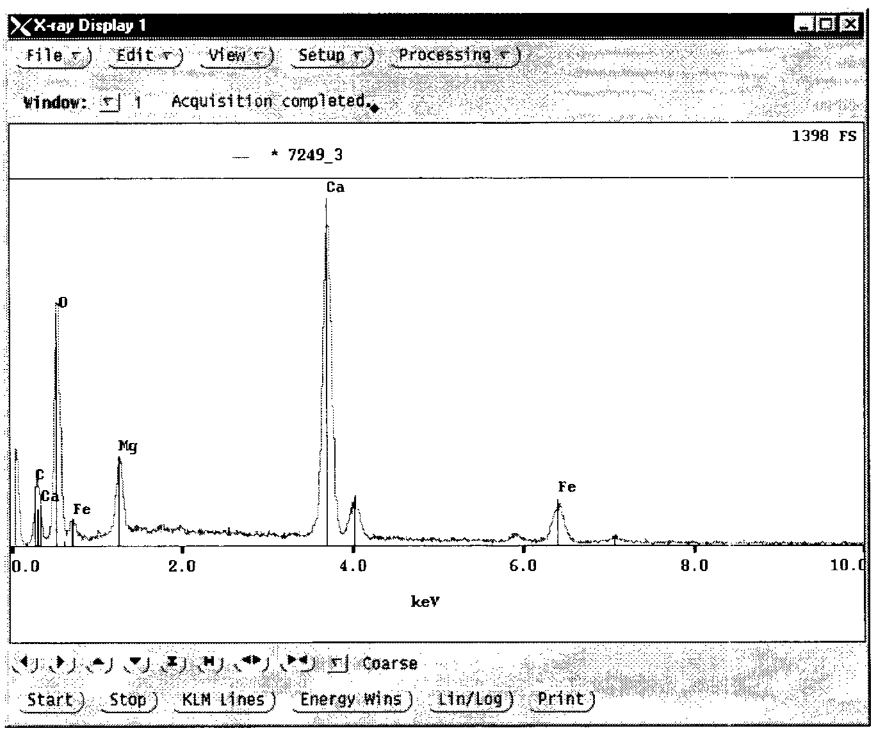


Figure 16F. A Ca-Fe-Mg carbonate in a mineralized quartz-chlorite (Fe-rich)-sericite-carbonate shear in the immediate hanging wall of the Rainbow zone. This is ankerite or a ferroan dolomite and is the second most common carbonate type at Rainbow-Ridge. Sample R96-213-114.2.

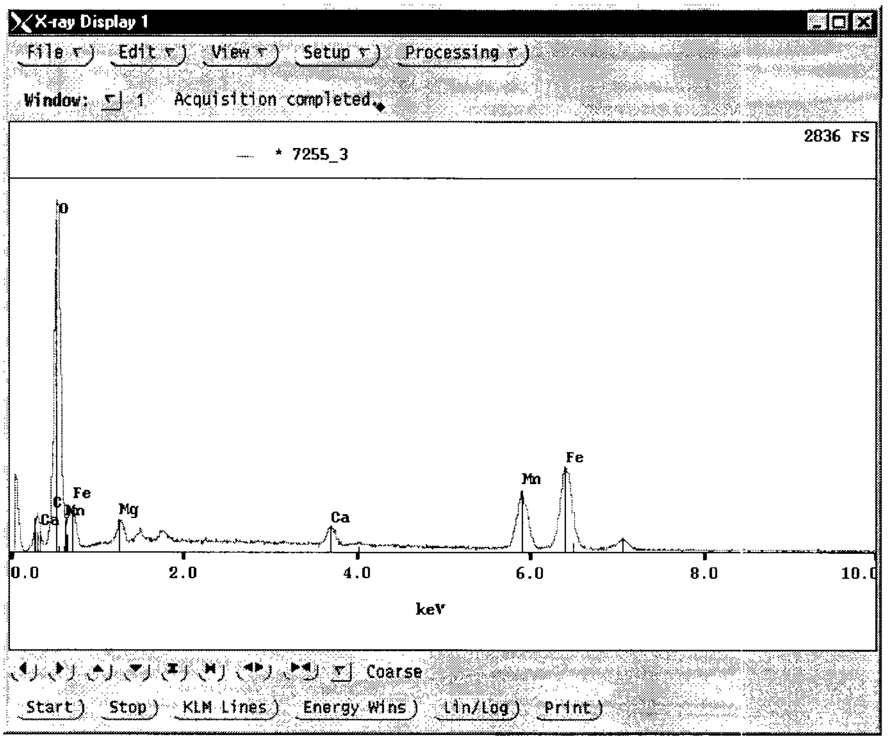


Figure 16G. Minor amounts of carbonate have the pattern of manganosiderite. In most cases it is a late phase that forms the matrix to brecciated sulphides. Sample R96-213-134.5.

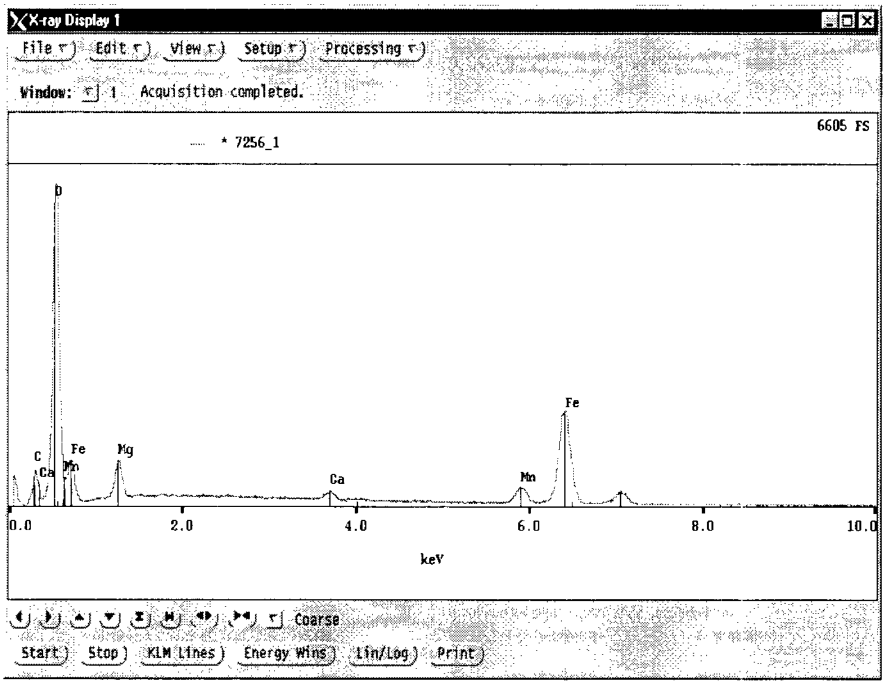


Figure 16H. Another example of an Fe-rich carbonate, here with strong Mg and minor Ca-Mn. This is also a late carbonate that replaces earlier sulphides. Sample R96-202-99.5.

5.3 Alteration and mineralization in the Rainbow East (Raca) vein

The Raca vein is now interpreted to be the northeastern extension or equivalent of the Rainbow zone, and has been renamed the Rainbow East (Raca) zone. It was examined briefly in three drill holes and four polished thin sections. The Rainbow East (Raca) vein exhibits characteristics that overlap those of the Rainbow-Ridge and Goddell Gully Zones. Major hydrothermal features of the Raca Zone are summarized below.

- The hanging wall of the vein is a (probably) Jurassic volcanic sequence with very strong pyrite-sericite-(carbonate) alteration and locally high concentrations of hydrothermal magnetite (see above). The footwall of the vein is Jurassic Bennett Granite (Photo 5.41). There is a rhyolite dyke in the ore zone in DDH RACA97-3.
- The Bennett Granite is strongly bleached, reflecting strong silicification and sericitic alteration with variable pyrite concentration. This alteration extends only a few to tens of metres from the vein. Silicification forms envelopes around some quartz-sericite-(pyrite) veinlets. Farther from the vein, chlorite and minor epidote are also present. Sulphide in the wall rock is mostly associated with quartz-carbonate±sericite veinlets. Barren calcite veinlets cut the altered rock.
- Alteration in the hanging wall volcanic rocks extends for at least 150 metres above the vein. It mostly comprises intense, texturally destructive sericitic alteration with up to >10% pyrite. Locally there are also zones with several percent hydrothermal magnetite. It is not clear how or if these alteration effects are directly related to the Rainbow East (Raca) vein.
- Mineralization is found in brecciated and variably strained quartz extension veins and vein breccias (Photo 5.42). Early material is brecciated, coarse-grained quartz with pyrite and arsenopyrite. Most mineralization is related to younger quartz-(calcite) extension veins with strong base metal sulphides (Photos 5.43, 5.44 and 5.45).
- Assay intervals in DDH RACA97-1 have very high Ag/Au ratio (mostly 100 to 400). Ag and Au grades correlate with quartz extension veins with high base metal sulphide concentrations (e.g., Photo 5.44). Where these veins are absent, both Ag and Au grades are very low (e.g., 0.X g/t Au and up to tens of g/t Ag). The high Ag/Au ratio reflects abundant freibergite in the extension veins.
- Ore minerals include arsenopyrite (both acicular and non-acicular), pyrite, stibnite, sphalerite (light colour, low Fe), galena, freibergite and chalcopyrite (as disease in sphalerite) (Photo 5.45). Freibergite and stibnite are commonly found as inclusions in sphalerite.
- Early extensional quartz typically contains coarse grains of pyrite and/or arsenopyrite, and locally sphalerite may also be part of this stage. Precious metal mineralization is related to zones of fine-grained quartz, sericite, carbonate (calcite±Mn) and sulphides that cut or form the matrix to early, brecciated quartz-sulphide vein.
- There is commonly a late stage of quartz with acicular arsenopyrite (Photos 5.41 and 5.46 to 5.48). These veins contain minor stibnite (Photo 5.47), and traces of freibergite and galena. One example has sphalerite with a Fe peak on SEM. Stibnite has small Ag peaks on SEM, as at Goddell. Arsenopyrite is compositionally zoned (Photo 5.48), reflecting variation in Sb (main control), and possibly As and S. Carbonate in one late vein was enriched in Fe-Mn.
- Native Au or electrum was not encountered. It can be confidently inferred that, by analogy with Rainbow-Ridge and Goddell, the Au includes a refractory component related to acicular arsenopyrite, and a free electrum component associated with base metal mineralization.

Photo 5.41. Jurassic Bennett Granite in the immediate footwall of the Rainbow East (Raca) vein is strongly bleached. The sample has strong silicification with pervasive sericite and minor pyrite. Quartz veinlets with minor pyrite are cut by apple green sericite on shears, and these are cut by barren quartz veinlets. K-feldspar is partially preserved in the K-feldspar megacrysts that typify this unit. This type of alteration extends up to a few tens of metres form the vein. Sample RACA97-1-242.5.

Photo 5.42. Typical style of mineralization in the Rainbow East (Raca) vein. An early stage of massive, low-sulphide quartz vein has been brecciated and is surrounded by a matrix with quartz, sericite, pyrite and minor chalcopyrite and sphalerite. The sample was then cut by a late, irregular quartz vein with acicular arsenopyrite and minor stibnite (dark zone cutting sample). Sample data not recorded.

Photo 5.43. Upper view shows a distinct and typical paragenesis of mineralization. Early mineralization is strongly sheared with very strong pyrite. This is cut by a quartz extension vein with minor calcite and sphalerite, galena, pyrite, arsenopyrite and minor chalcopyrite. The latest stage comprises quartz with acicular arsenopyrite and minor stibnite. Lower photo shows detail of the cross cutting relationships. Sample RACA97-1-232.5.

Photo 5.44. Detail of an unstrained quartz-sulphide extension vein along shear foliation in pyrite-rich Rainbow East (Raca) vein. Sample RACA97-1-228.

Photo 5.46. Late quartz veinlet with acicular arsenopyrite (dark band) cross cuts earlier shear hosted pyrite mineralization and a dilatant quartz-sulphide extension vein. Sample Raca97-1-232.3.

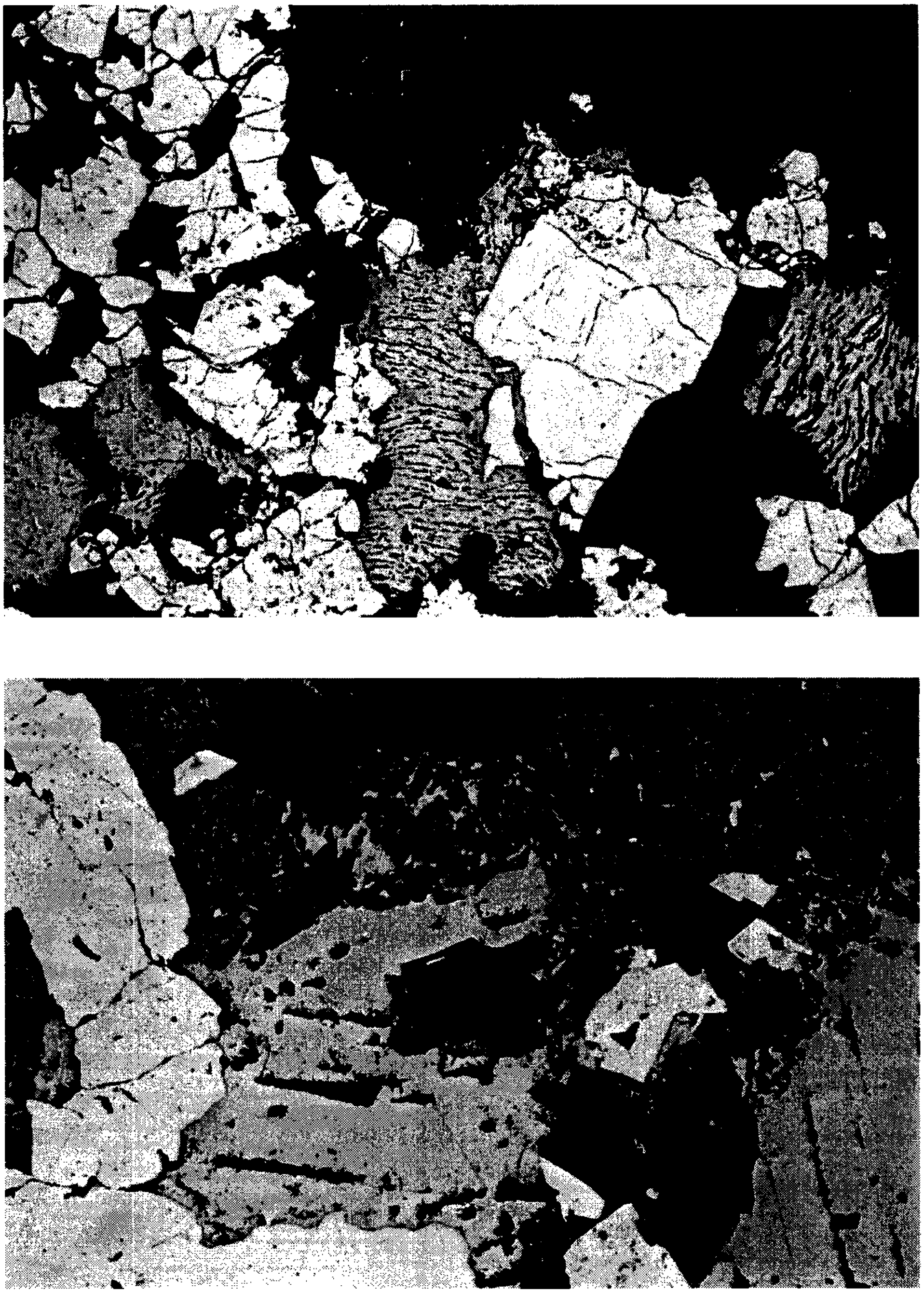


Photo 5.45. Typical quartz extension vein assemblage of early arsenopyrite (non-acicular) and pyrite, slightly later sphalerite, chalcopyrite (disease in sphalerite) and galena, and minor, late-stage stibnite and freibergite. Sample Raca 97-1-232.3 in reflected light; FOV upper photo 2.63 mm, lower 0.64 mm. \

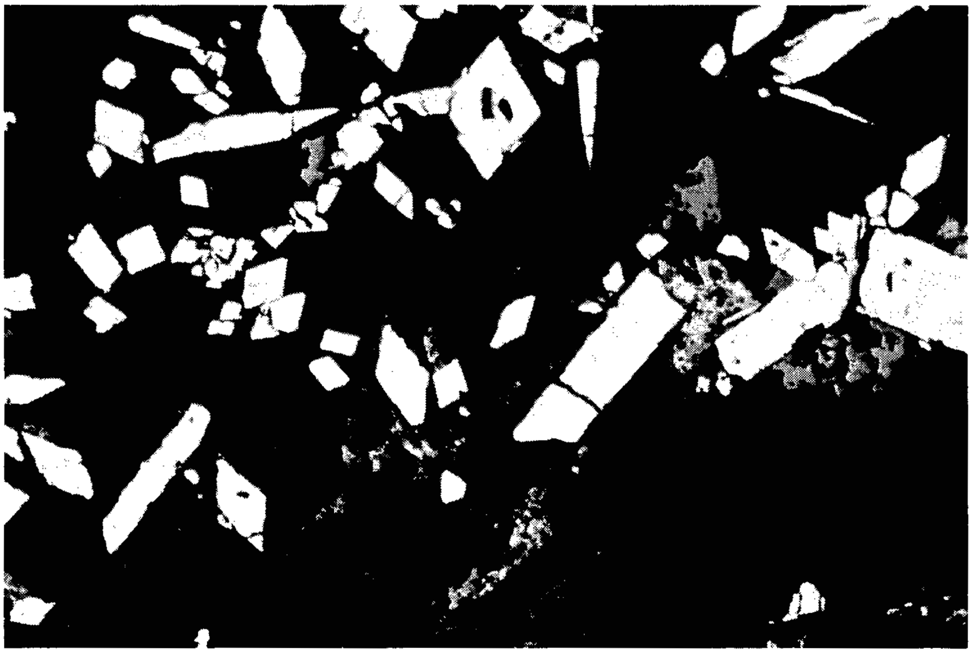


Photo 5.47. Late-stage acicular arsenopyrite weakly replaced by later stibnite, and trace sphalerite (with chalcopyrite disease) and freibergite. Sample Raca97-1-232.3 in reflected light; FOV 0.64 mm.

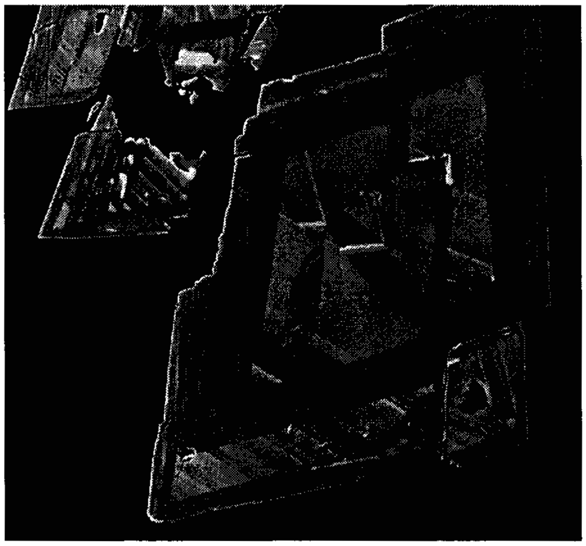


Photo 5.48. BSE image of a compositionally-zoned, late-stage, acicular arsenopyrite crystal. Zoning reflects variation in Sb, As and S. This is typical of late acicular arsenopyrite, but such patterns are absent from earlier, non-acicular arsenopyrite. Black is quartz. Sample Raca97-1-232.3; FOV ~50 microns.

6.0 SUMMARY AND RECOMMENDATIONS: SKUKUM CREEK AREA

6.1 Structural setting and geology of the Skukum Creek zones

1. Mineralization in the Skukum Creek zones is hosted principally by heterogeneous fault systems comprising rhyolitic to andesitic dykes, at least two varieties of probable phreatomagmatic breccias, semi-brittle shear zones, quartz-sulphide veins, and late gouge-filled faults. Formation of hydrothermal alteration, Au-Ag mineralization, shear zone displacement, brecciation and intrusive activity during a protracted, syn-tectonic igneous and hydrothermal event is supported by: a) the presence of mineralized vein fragments in dyke related igneous/phreatomagmatic breccias; b) multiple generations of veins that range from early veins affected by faulting and brecciation to younger veins that overprint shear zone fabrics and breccias; c) the presence of quartz-sulphide matrix to some hydrothermal breccias; d) the intimate relationship of veins, alteration, shear zones and dykes; and e) the compatible orientations of extension and shear veins with shear sense on the associated shear zones.
2. Shear zones in the Skukum Creek zones are semi-brittle in style and composed of lithified, foliated cataclasite, and sericite±chlorite phyllite with well-developed pressure solution foliation. The shear zones form an anastomosing network that wraps around dykes and slivers of altered granodiorite. Individual shear zone surfaces commonly contain quartz-sulphide veins which may occur as multiple lenticular veins developed over the width of the zone. Kinematic indicators, including shear bands, oblique foliation, pressure shadows on cataclastic fragments, and lineations together suggest a left-lateral shear sense with a reverse (southeast side up) shear sense on the shear zones during vein formation.
3. Compilation of drilling data and historical surface mapping suggest that the Sterling zone occurs at a fault stepover between the Rainbow and Kuhn zones that links the two zones through a northeast-trending, east-dipping bend in the trace of most of the dykes and shear zones in each zone. Possible along-strike continuations of mineralization and quartz-sulphide extension veins in the Rainbow and Kuhn zones may exist beyond the Sterling zone, as is indicated by the Rainbow Extension shear zone. The Sterling zone is in a prospective north-trending dilational orientation with respect to shear zones in the Rainbow and Kuhn fault systems, and further exploration down dip is recommended.
4. Gouge filled faults generally localized along shear zone surfaces and dykes margins form a fault zone within the Rainbow and Kuhn zones that overprints shear zones, veins and dykes. Within the Rainbow zone, these post-mineral structures contain kinematic indicators including Riedel shear fractures, slickensides and oblique gouge fabrics that suggest a predominantly left lateral shear sense with a normal (southeast side down) component. As the fault system obliquely crosses the zone, veins, dykes and shear zones are locally displaced, with potential thinning or thickening (duplexing) of these features depending on whether the fault system passes from hangingwall to footwall or the converse, in different parts of the zones.
5. Long sections indicate that mineralized chutes in zone thickness, vein thickness, Au grade X thickness and Ag grade X thickness have two plunge directions: a) a steep northeasterly, first order plunge that controls the overall distribution of these features and larger mineralized chutes, which occurs at a high angle to the shear zone slip direction and probably formed by dilation of bends and steps in shear zone surfaces; and b) shallow to moderate secondary northeast plunges that form subsidiary chutes. The origin of the latter is unclear, but may be related to late fault displacement along the zones, the main slip direction on which is close to parallel to the chutes.
6. The Ridge zone occurs near the projected junction of the King Canyon and Kuhn faults, and mineralization developed in that area may reflect the interaction of those two structures. Like the

Sterling zone, the King Canyon fault extends off the footwall off the Kuhn fault. The Zone 2 mineralization in the footwall of the Ridge zone, with its principal drill hole intercept in hole RG97-2, may represent the actual trace of the King Canyon fault at depth, or a northeast-trending set of shear zones and veins that links the King Canyon and Kuhn faults.

7. A structural model for the Skukum Creek area during the mineralizing event is shown in Figure 17, and highlights areas with exploration potential. Dominant structures are the Berney Creek, Rainbow and Kuhn faults, the latter two of which represent probable splays off the Berney Creek fault. Kinematic indicators in the shear zones and extension veins suggest that shear zone displacement occurred in response to northeast-southwest directed shortening with: a) resultant left lateral displacement on shear zones; and b) formation of northeast-trending, steeply-dipping extension veins at a high angle to the σ_3 extensional direction (see inset in Figure 17). Most mineralization identified thus far occurs at or near the step-over between the Rainbow and Kuhn faults in the zones of the same names, forming a dilational jog setting (Figure 17 inset). Northeast-trending quartz-sulphide extension veins that are present throughout the Skukum Creek underground workings and in the Taxi zone are coeval with shear zone hosted veins in the Skukum Creek zones, and formed as extensional structures in response to left-lateral displacement along the shear zones. The Taxi zone veins emphasize the potential for mineralized extension veins (blue dashed lines in Figure 17) at and both to the east and west of the step-over between the two faults around the Sterling zone. Additional mineralization may also be present: a) where the King Canyon fault splays off the Kuhn fault in and near the Ridge zone forming prospective areas at shear zone junctions and in associated extension veins – the possible relationship of the Ridge and Ridge Zone 2 zones; and b) in potential extensions to the Rainbow and Kuhn zones beyond their bends into the Sterling structure.

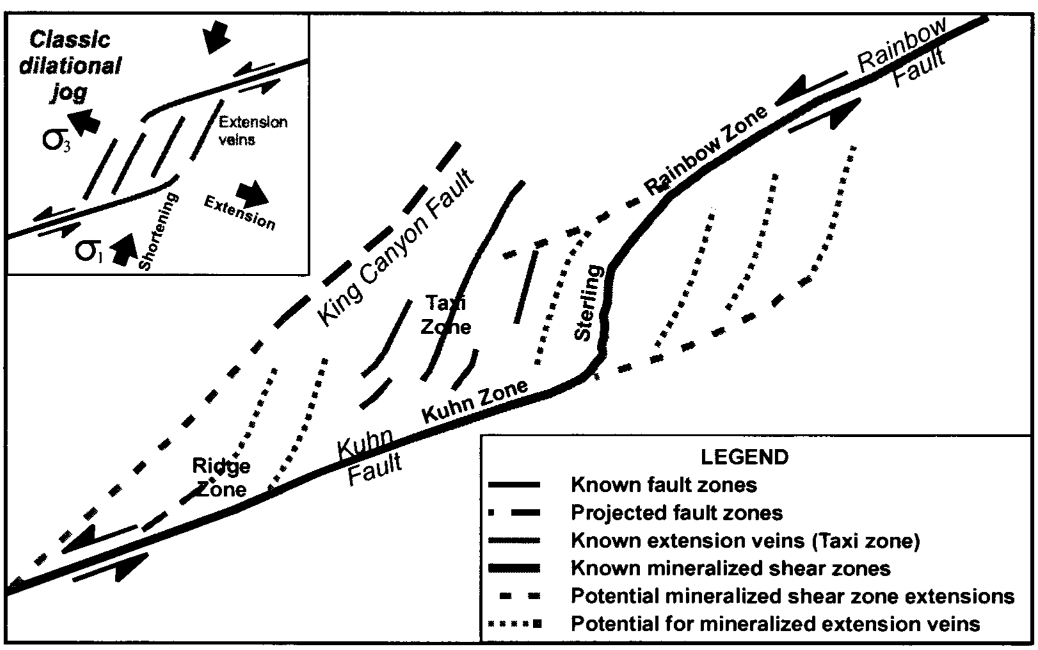


Figure 17. Structural model of the Skukum Creek area during Au-Ag mineralization and sinistral displacement along controlling shear zones, with potential exploration targets. See text for details. The interpreted shear sense is opposite the dextral shear sense suggested by Hart (1992b), who interpreted kinematics on general vein morphology and orientation, which contradicts shear sense indicators exposed underground.

6.2 Alteration and mineralization

1. Alteration effects are generally similar throughout the Rainbow East (Raca), Rainbow, Kuhn and Ridge zones and are focused upon the main controlling shear zones. Alteration assemblages include pre-mineral quartz and magnetite veins, and possibly epidote-Kfeldspar veins. Syn-mineral alteration includes K-feldspar, chlorite, sericite and epidote assemblages. Carbonate is an important component of each alteration assemblage. Mineralization includes Au-Ag and base metals, and is directly related to formation of quartz veins that include extensional varieties with little or no shearing that occur both within and outside the main shear zones, and strongly deformed veins the form the main host to mineralization within the main shear zones. In general, K-feldspar alteration is pre-sulphide, whereas chlorite, sericite, epidote and carbonate assemblages are syn-mineral and appear to have formed in approximate contemporaneity.
2. Lateral zoning patterns are characterized by an increase in fracture density and intensity of alteration toward the main shear zones. Chlorite changes from green and Mg-rich peripheral to mineralization, to black and Fe-rich in proximal settings. Sericitic alteration is closely related to sulphide mineralization; peripheral to the main shear zones it is developed as intense envelopes around chlorite shear veinlets, whereas proximal to the main shear zones it is a completely pervasive alteration of the igneous host rocks, typically in areas with stronger shearing. Carbonate alteration is in part later than the chlorite and sericite assemblages and has a close temporal relationship to most sulphide mineralization; it is dominated by calcite with a minor Mn component, with lesser and mostly later-stage species that contain Fe and/or Mg. K-feldspar alteration is most abundant in the Ridge and Taxi zones, is minor at Rainbow and appears to be absent from Rainbow East (Raca). Acicular arsenopyrite mineralization with an inferred component of refractory Au is minor at Rainbow East (Raca), is trace at Rainbow and is absent from Ridge and Taxi.
3. Most quartz-sulphide veins have an early stage of coarse quartz with coarse-grained pyrite and/or arsenopyrite that lacks significant base or precious metal mineralization. Both Au and Ag are directly related to the precipitation of the main bulk of base metal sulphides, principally sphalerite and galena, which are typically associated with a later stage of fine-grained quartz, carbonate and sericite. Post-sulphide effects are restricted to brecciation and enclosure by Fe and/or Mg enriched carbonates or chlorite. The highest grades of mineralization are found in large quartz veins that were initially extensional in character but were subsequently deformed. Lower grades of mineralization are found in monolithic rhyolite and/or andesite breccias. Most mineralization in late polylithic breccias is found in entrained fragments of quartz-sulphide vein; only trace sulphide, or in places abundant pyrite without significant base metal sulphides, is found in the matrix of these breccias.
4. The Au occurs almost exclusively as electrum, with trace native Au. The Ag is hosted predominantly by freibergite; in a few cases, Ag peaks was also noted on SEM spectra for galena, sphalerite, chalcopyrite and stibnite, but these are not a significant part of the overall Ag budget.

6.3 Exploration procedural recommendations

1. **Logging and mapping documentation.** Historical logs do not always adequately distinguish between several important structural, mineralogical and textural features. Improved documentation of these features and more consistent coding in drill logs and future underground mapping are recommended. Particular features include:
   - **Shear zones and faults.** Historical logging typically fails to distinguish between semi-brittle shear zones and gouge-filled brittle faults. As a consequence these two temporally distinct styles of structure are often not distinguished and may consequently be incorrectly linked during interpretation of sections and plans. In addition, it is important to distinguish between

distributed, weak shear zones and fault damage zones with widely spaced slip surfaces, and more intense, significant structures that form zones of continuous cataclasite and/or foliation. The former have often been logged as single, large shear zones which are indistinguishable in logs from the true main shear zones.

- **Breccias.** Multiple types of breccia are present within the Skukum Creek zones including: a) cataclastic breccias with tan to dark grey matrix; b) quartz-sulphide breccias, which normally occur in veins and have quartz-sulphide breccia matrix; c) probable phreatomagmatic breccias, which vary from polylithic to monolithic; and d) local fault gouge breccias. Historical drill logs often fail to distinguish between these diverse breccia types, and commonly over-represent areas of brecciation. The term breccia should only be used on fragmental rocks that have clasts, a matrix, and show evidence of rotation or transport of the fragments. It should not be applied to highly fractured rock unless the above criteria are met. The term quartz-sulphide breccia in particular is greatly overused in historical logs, and has commonly been applied to unbrecciated quartz-sulphide veins, or cataclastic breccia and shear zones that contain disseminated sulphides in the matrix.
- **Veins and alteration.** Separate coding for extensional veins and sheared or brecciated veins is recommended. Codes should be developed to record the various types of veins identified during this study. A relative intensity scale (perhaps 0 to 5) might also be used to more accurately reflect the degree of development of pervasive and/or fracture-controlled chlorite, sericite and epidote alteration assemblages, along with pyrite; this will aid construction of alteration sections that can be used to evaluate possible geophysical exploration methods.

2. **Drill density.** Increased drill density will ultimately be required to more adequately assess the lateral continuity of mineralized veins and to thereby produce more accurate estimations of contained resources. Based upon observations of lateral variations in veins exposed in the underground workings and in adjacent drill intersections, it is recommended that a spacing of 12.5 m, approximately half the current spacing, be employed to more adequately define the distribution of mineralization for possible mining purposes.
3. **Core Salvage and Storage.** A great deal of useful, but currently disorganized and disordered, drill core remains on the property, particularly at the core racks on the road to the mine portals. This core was expensive to obtain and contains a great deal of useful information that should not be needlessly lost. In particular, it may prove necessary in the future to relog mineralized and immediately adjacent intervals to more accurately assess the relationship of mineralized material to late brittle faults for mine planning. It is recommended that additional heavy-duty core racks be constructed at the camp, and that core in the old racks be salvaged, reorganized, labeled and moved to the main storage area.
4. **Viability of K-feldspar staining.** The limited amount of K-silicate alteration in the Skukum Creek area, and the lack of any apparent relationship to precious metal mineralization, suggests that staining on a routine basis will not be useful. In addition, staining is not consistently diagnostic for distinguishing rhyolite and andesite dykes, subdivision of which may not be of any notably pragmatic application in any event.

6.4 Exploration target areas

1. **Sterling Zone.** Tracking of the thickened central core of the zone to depth by drilling. Selected drill holes should be allowed to penetrate up to at least 50 m into the footwall of the zone to test for additional veins such as those intersected above the 1300L in the Sterling footwall zone.
2. **Northeastern Extensions of the Rainbow Zone.** Several widely spaced drill holes should be placed in the approximately 300 m long section between the eastern end of the Rainbow zone and

the RACA97 drill holes. These will test for continuation of the Rainbow shear zone in this nearly untested interval. Additional drilling could also test for continuation of mineralization northeast of the RACA97 drill holes beneath Chieftain Hill.

3. **Taxi and Rainbow Extension.** A fan of holes should be drilled from the 1300 level toward the west and northwest to test for extensional veins similar to, but larger and more continuous than, those in the Taxi zone, and for extensions of the Rainbow shear zone into this area. These should be drilled at different angles to test several levels and azimuths.
4. **Kuhn East and Area East of Sterling Zone**. This area comprises a structural setting similar to that in the Rainbow Extension/Taxi target just noted. The drilling would test for extensional veins between the Kuhn and Rainbow shear zones, and potential extensions of the Kuhn zone to the east. As above, a fan of drill holes from the 1300 level is recommended.
5. **Ridge Zone**. This zone has been tested by only a limited number of drill holes, and it remains open in most directions. Additional drilling should be contemplated to further assess the distribution, continuity and grade of this zone to depth.
6. **Intersection of Kuhn and King Canyon Faults.** The Zone 2 intersections in the footwall of the Ridge zone may represent the down dip projection of the King Canyon fault. Based on correlation of Zone 2 between adjacent sections, it appears to trend more northeasterly than the Kuhn fault. Drill holes are recommended to the west of the section containing RG97-2 to test the potential intersection of Zone 2 mineralized shear zones with the Kuhn fault. In addition, several historical drill holes in this and the main Ridge zone have terminated in shear zones, and may not have fully penetrated all of the structurally prospective ground in the footwall of the Kuhn fault and Zone 2; a minimum of 100 m drilling into the footwall of the Kuhn fault is recommended, but exact depths will have to be guided by the presence or absence of shear zones, veining and alteration.
7. **Berney Creek and King Canyon Fault Zones.** Further prospecting is recommended outside the main Skukum Creek mineralized zones to assess the potential for both fault-hosted mineralization and associated extensional veins.

7.0 CHIEFTAIN HILL AREA

7.1 Introduction

The Chieftain Hill area is underlain by a series of parallel, east-trending and steeply-dipping quartz-sulphide veins and shear zones that are hosted by portions of the Cretaceous Mt. Ward granite, a medium-grained biotite granite that forms part of the Mt. McIntyre plutonic suite (Hart and Radloff 1990). The veins occur principally on the south and north slopes of Morning Gulch, on the eastern, lower slopes of Chieftain Hill approximately 2.5 km northeast of the Skukum Creek underground workings. The veins occur east of the Chieftain Hill fault system, which forms multiple strands that locally separate the granite from Upper Jurassic and Eocene intermediate volcanic rocks to the north and west (Figure 1). Only the stibnite-rich Evening vein occurs northwest of the fault system (Hart 1992c). The Chieftain Hill veins are mainly parallel to, and often spatially associated with, numerous east-trending rhyolite and andesite dykes that intrude the host granite.

Several continuous veins have been identified in the Chieftain Hill area, but only one significant Au value, 0.275 oz/t Au and 2.56 oz/t Ag over 1.42 m in hole 87-405 from the Ocean vein, has been obtained in drilling or trenching (McDonald et al. 1990). Elsewhere values rarely exceed 0.04 oz/t Au over the width of any vein. Ag concentrations commonly range from 0.2 to 5 oz/t.

During this study, 10 diamond drill holes were examined from the Ocean vein along much of its known strike length, and several other holes were briefly examined from other veins in the Chieftain Hill area.

7.2 Structural style of Chieftain Hill veins

7.2.1 Ocean shear zone (vein)

The most significant vein system in the Chieftain Hill area is the Ocean vein system, which is more appropriately termed a shear zone. The structure has been traced in surface trenches and drill holes for approximately 900 m along strike, from its western end in the Chieftain fault system to the east into the Wheaton River valley. The shear zone comprises a distributed, anastomosing, semi-brittle structure that varies from 3 to 15 m in true thickness in the holes examined. It generally comprises one or more foliated cataclasites 0.3 to 3 m thick with dark grey matrices (Photo 7.1 left) that occur within foliated, sericite-altered granodiorite with multiple narrow slip surfaces and dark grey, sulphide-bearing stylolitic pressure solution seams that define a spaced foliation (Photo 7.1, right). Like their counterparts in the Skukum Creek zones, the cataclasites typically contain altered wallrock and quartz-sulphide vein fragments. Although oblique foliations and other kinematic indicators are visible in the drill core (Photo 7.1), it is not possible to determine the shear sense because the split core could not be re-oriented.

Rhyolite dykes, often flow banded, are common within or on the margins of the shear zone, and are locally affected by shear zone foliation. Rhyolite also occurs as fragments in cataclastic breccia. Rare polylithic breccia comparable to those at Skukum Creek is also spatially associated with the dykes.

Grey quartz-sulphide veins occur as lenses within the shear zone. The veins are composed of highly fractured grey quartz with numerous stylolitic pressure solution surfaces, fractures and shear zone slip surfaces that contain fine-grained sulphides (Photo 7.2, right). Dark grey quartz-sulphide matrix breccia occurs locally. In western portions of the shear zones, veins locally make up much of the shear zone width, and individual veins may range up to approximately 5 m in true thickness. Narrower veins generally less than 0.5 m thick are more typical of the eastern parts of the Ocean shear zone tested by holes OC97-1 to OC97-5. Multiple veins may occur across the width of the shear zone in any location.

Clay gouge seams overprint the shear zone fabrics, veins and cataclasites and record late, post-mineral brittle displacement along the shear zone. Narrow intervals of the Ocean shear zone and veins in drill core (<3 m) commonly contain abundant gouge, which suggests possible thinning of the shear zone by late faulting in these areas.

7.2.2 Other veins in the Chieftain Hill area

Other veins in the Chieftain Hill area include the Johnny B and Better B veins located to the south of the Ocean shear zone, and the Morning, Evening and Pristine veins, located upslope to the north. Individual veins have been traced for up to 200 m along strike, principally in outcrop, but are generally open into areas lacking exposure. All are generally less than 0.6 m wide, although they locally range to >1 m thick. Maps made by Mt. Skukum Mines geologists indicate that east strikes with steep dips predominate, except for the Pristine vein which is a minor structure that strikes north. A brief examination of drill core through several of these veins indicates that they are either extensional veins that lack associated shear zones, or that they are bounded by narrow, minor shear zones. Apart from the Evening vein located to the northwest, the east-trending veins may terminate westward in strands of the northeast-trending Chieftain Hill fault system, from which they may emanate (Photo 7.3). The veins are parallel to, and often closely associated with, rhyolite and andesite dykes (Photo 7.3).

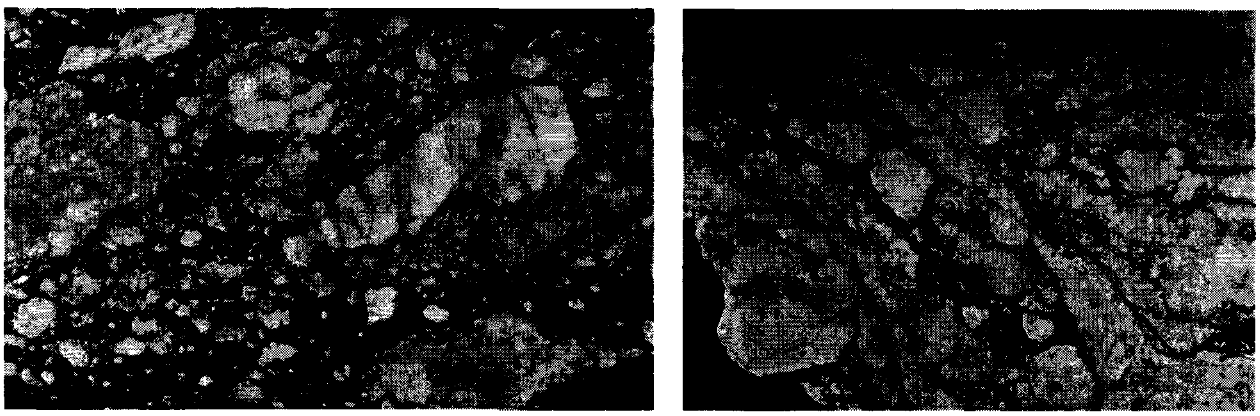


Photo 7.1: Shear zones associated with the Ocean vein. Shear zones that host veins of the Ocean vein system commonly contain dark grey matrix foliated cataclasite (left) with altered wallrock and quartz-sulphide vein fragments. Stylolitic pressure solution fabrics (dark gray, undulating seams at right) are common; they are often localized along, and define the margins of, cataclasite breccia seams. Note the slip surface that runs through the center of the right sample. Wallrock fragments and shear zone envelopes are commonly altered by tan sericite. Left sample: DDH OC-97-1 at 72.3 m; right sample: DDH OC-97-2 at 80.5 m.

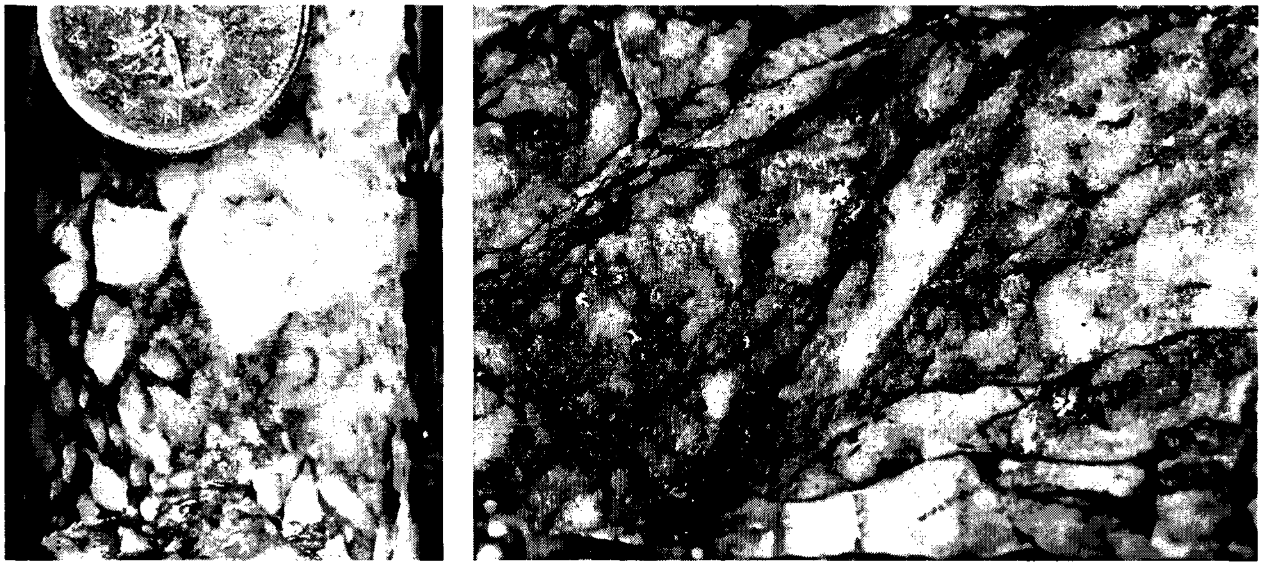


Photo 7.2: Texture of the Ocean vein. The Ocean Vein system typically comprises shear zone hosted, highly fractured grey quartz veins with local breccia textures (left), and numerous dark grey fractures, slip surfaces and pressure solution seams (right) that are commonly sulphide-filled. Left sample: DDH 88-399 at 103.2 m; right sample: DDH OC-97-3 at 64.5 m, field of view is 6cm.

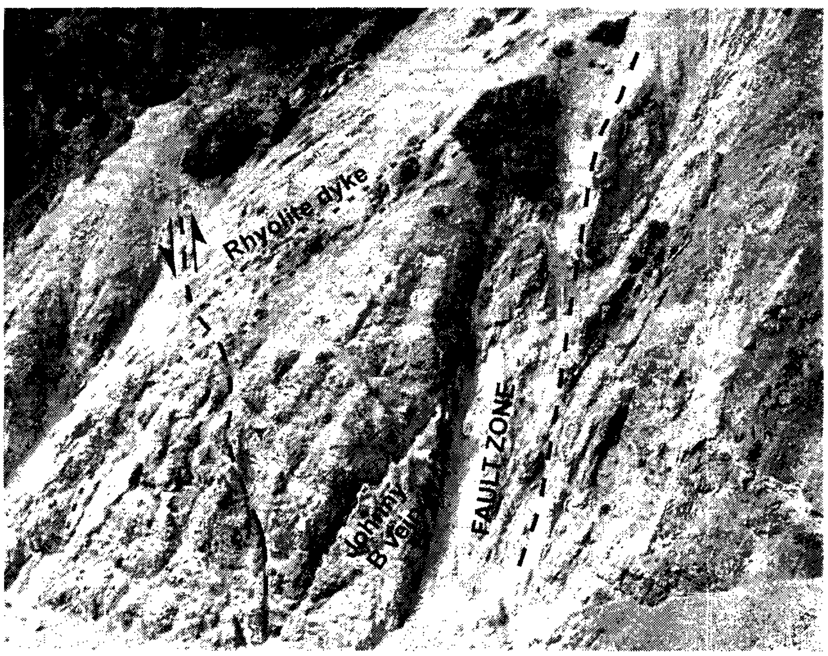


Photo 7.3: Relationship of the Johnny B vein to faults and dykes in the Chieftain Hill area. Photo taken looking southwest at the south slope of Morning Gulch; modified from annotated photos in Mt. Skukum mine files. The west end of the east-trending, steeply dipping vein is shown where it intersects a major fault that is part of the Chieftain Hill fault system. Note the rhyolite dyke that is parallel to the vein. The dyke is offset in a left lateral shear sense in the upper left hand part of the picture, in a sense compatible with parallel shear zones that host mineralization in the Skukum Creek area. A vein segment to the right of the fault (in red) may represent a continuation of the Johnny B vein, or another vein. Field of view is approximately 150 m.

7.3 Alteration and mineralization in the Ocean vein

The Ocean vein was examined in two polished thin sections. Other veins in the Chieftain Hill area were not sampled for petrography. Only a brief summary of the significant hydrothermal features of the Ocean vein are provided below in light of the limited available observations and data.

- Patterns of alteration and mineralization are typical of those described from veins at Ridge, Rainbow and Goddell but, much like Rainbow East (Raca), combine characteristics of the two areas.
- Host rock is Mt Ward granite, which is strongly bleached within tens of metres of the vein (Photo 7.4).
- Alteration in the host rock includes possible pervasive silicification, but is mostly a pervasive quartz-sericite-(carbonate) assemblage with minor (<0.5%) but variable pyrite and trace rutile. Additional pyrite is commonly present on narrow sericite-carbonate veinlets that cut the pervasive alteration (but which could be temporally related to it).
- Chlorite with local concentrations of carbonate is common as pervasive alteration and in shears peripheral to mineralized zones in the intrusive host rock. Chlorite yields to sericite as the main alteration phase as the veins are approached. Pyrite concentration is commonly higher in the areas with chlorite than in areas with only or predominantly sericite. Epidote is locally present in minor concentrations on fractures peripheral to the ore zones. Chloritic alteration extends at least 50 metres from the veins.
- Most mineralization occurs in a quartz-sulphide extension vein that was subsequently sheared and brecciated (Photos 7.5 and 7.6). Early sulphides (Photos 7.8 and 7.9) are arsenopyrite (non-acicular) and pyrite, and possibly sphalerite (with chalcopyrite disease, and light colour indicating low Fe concentration).
- Much of the sulphide mineralization is related to a later stage of fine-grained quartz with minor carbonate that replaces and brecciates the early coarse-grained extensional quartz, pyrite, arsenopyrite, and locally some of the sphalerite (Photos 7.8 and 7.9). Ore minerals in this later stage include freibergite, galena (no Ag peaks, but some is Sb-bearing on SEM), minor stibnite, and trace inclusions of native Bi in galena (Photos 7.7 and 7.9)
- Ore minerals have typical temporal relationships, with early brecciated pyrite and arsenopyrite replaced by other sulphide minerals including freibergite and galena (Photo 7.9).
- Ag is probably hosted almost exclusively in freibergite. The high Ag/Au ratio in sample OC97-3-63.5 can be attributed to the anomalously high concentration of freibergite. No native Au or electrum was observed, but the absence of acicular arsenopyrite and/or arsenian pyrite suggests that they are probably the principal form taken by Au (compare with section on Goddell Gully). There are, however, several notations in old drill logs that suggest the presence of minor amounts of acicular arsenopyrite.
- Quartz-sulphide extension veins are found peripheral to the main ore zones, but in low densities.
- Late, barren carbonate veinlets without shearing are locally present.

Photo 7.4. Strongly bleached hornblende-biotite granodiorite host rock to the Ocean vein. This alteration extends 15 to 20 metres outward from the vein, and is dominated by quartz-sericite-(carbonate) alteration with only very minor pyrite and traces of rutile. Sample OC97-1-65.5.

Photo 7.5. Typical mineralization in the Ocean vein, comprising brecciated quartz-sulphide veins with matrices of fine-grained quartz and base metal sulphides. Samples OC97-3-63.5 and 64.1.

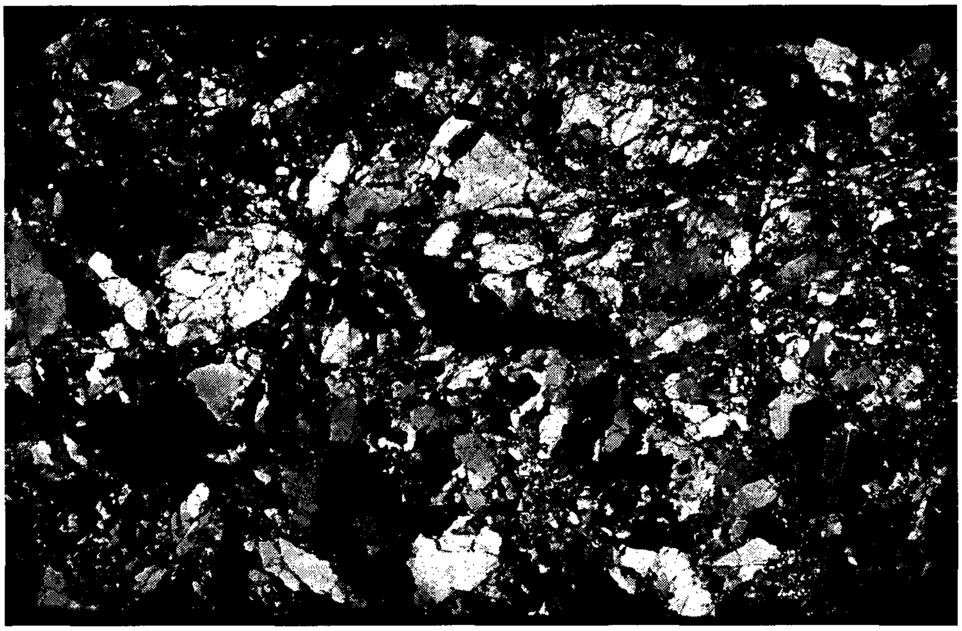


Photo 7.6. This sample is a brecciated quartz-sulphide extension vein. Most sulphide is related to the early, strained, coarse-grained quartz, and comprises pyrite, arsenopyrite, and possibly sphalerite. A later stage of fine-grained quartz is related to later base metal sulphides. This pattern is common in many quartz extension veins from the district. Sample OC97-3-63.5, full section view in crossed polars.

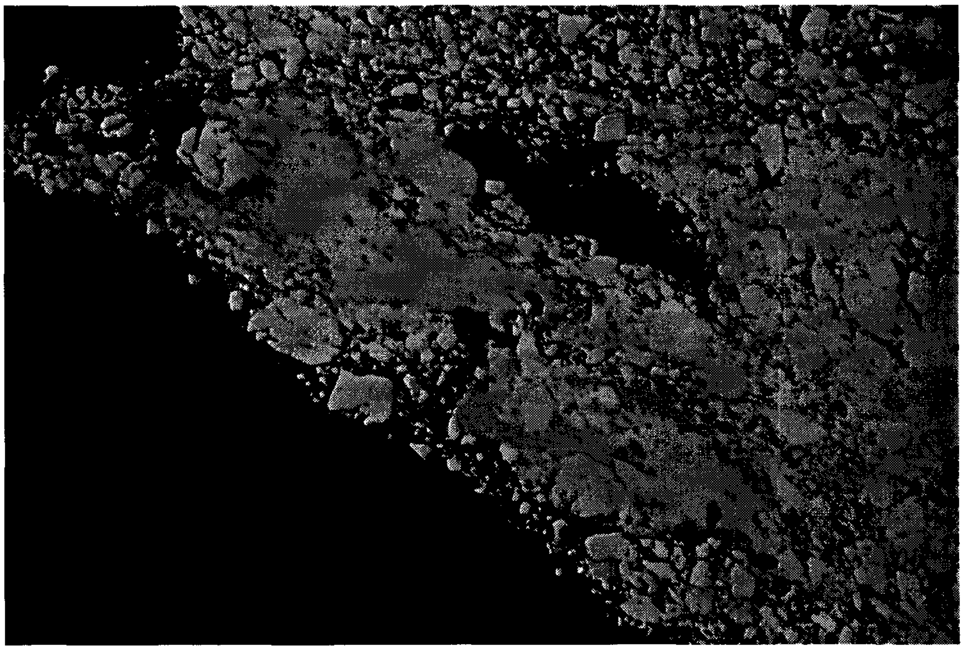


Photo 7.7. Stibnite (light grey) is rimmed and replaced by freibergite (medium grey); these are later than the brecciated arsenopyrite-pyrite-sphalerite associated with coarse-grained quartz in the extension veins. Dark zone on lower left is quartz. Sample OC97-3-63.5 in reflected light; FOV 0.64 mm.

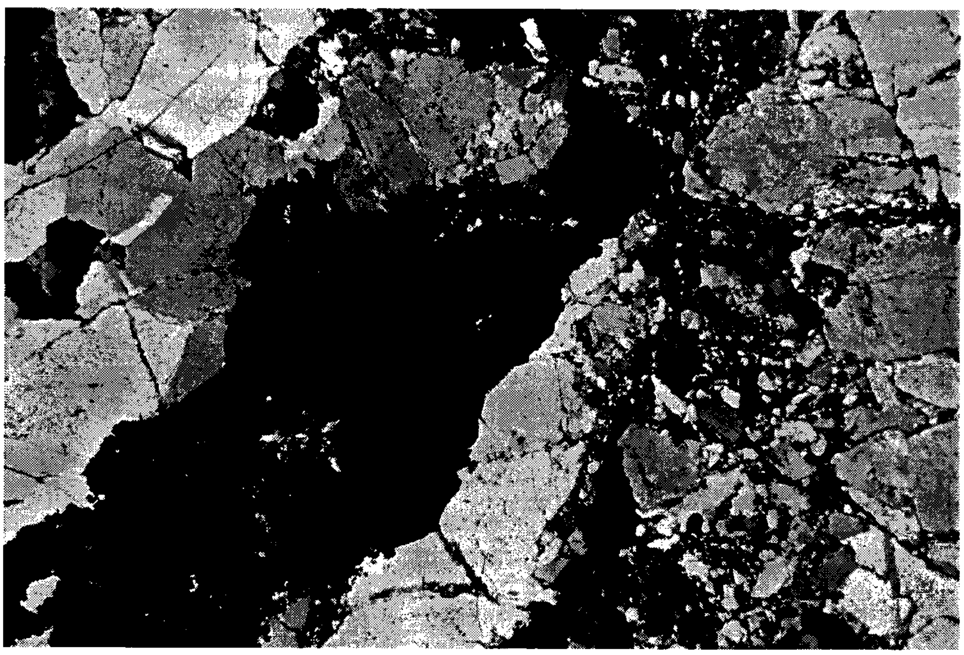


Photo 7.8. Strong brecciation in pyrite (bright grains centre of view), with a matrix of pyrite and sphalerite, associated with fine-grained quartz that cuts the early, weakly strained, coarse-grained extensional quartz and sulphide. Sample OC97-3-63.5; top view reflected light and bottom in crossed polars; FOV 2.63 mm.

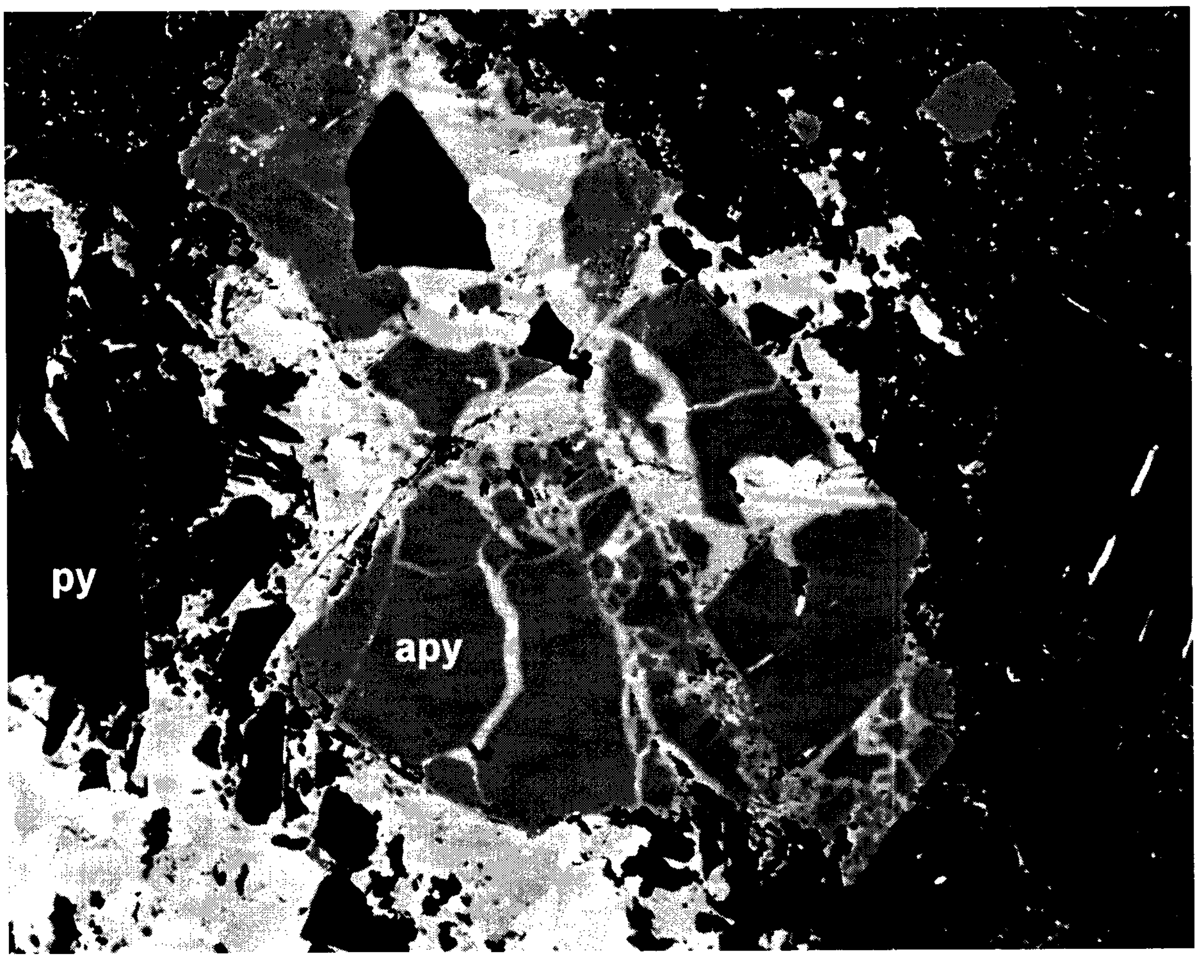


Photo 7.9. A BSE image of sulphide mineral relationships in the Ocean vein. Early pyrite (py) and arsenopyrite (apy) are brecciated, with replacement and infill of fractures by freibergite (frb) associated with galena (gl). Matrix to brecciated pyrite includes very fine-grained quartz and minor carbonate Sample OC97-3-63.5; FOV 170 microns

7.4 Conclusions and exploration recommendations, Chieftain Hill area

1. The Ocean shear zone is the most significant mineralized structure thus far identified in the Chieftain Hill area and consists of a 3 to 15 m wide shear zone which has been traced over a strike length of nearly 1 km and which hosts quartz-sulphide veins. The shear zone is of similar structural style to the Skukum Creek shear zones, and comprises lithified, foliated cataclasite slip surfaces and surrounding foliated wallrock with pressure solution fabrics. The localization of veins and alteration in the shear zone, and definition of shear zone fabrics by alteration minerals, suggests that shear zone activity was coeval with vein formation and sulphide mineralization.

2. Alteration in the Ocean vein is very similar to that observed in the Skukum Creek zones. The main alteration minerals are chlorite, sericite and carbonate, and alteration extends well into the intrusive host rock of the vein. Mineralization is found in quartz-sulphide extension veins and their deformed equivalents, and includes an early coarse-grained quartz-pyrite-arsenopyrite-sphalerite stage, and a younger stage of fine-grained quartz, sericite and carbonate with freibergite, stibnite and galena. Freibergite probably controls the Ag budget in the veins; native Au or electrum were not observed, but are probably the principal hosts to Au, although drill logs indicate the presence of minor acicular arsenopyrite. As such the Ocean vein may manifest characteristics that overlap those of the Skukum Creek and Goddell Gully zones.

3. The Au and Ag values thus far obtained from the Chieftain Hill veins have only rarely yielded economically significant values, and the veins therefore are low priority exploration targets. The Ocean shear zone is, however, of sufficient size and persistence to host significant volumes of mineralization, and further testing of potentially dilational, wider portions of this structure either along strike or at depths below current levels of drilling may be warranted as a second priority target. To establish potential structural targets along strike, or projections of potentially favorable sites that may form mineralized chutes down dip, additional structural examination of vein exposures on surface are recommended to determine shear zone kinematics and potential drill targets. This work could be undertaken in conjunction with surface work recommended on the Chieftain Hill fault system below. The indicated presence of acicular arsenopyrite mineralization should also be re-assessed to determine if it preferentially formed in andesite dykes as it did at Goddell Gully, thereby constituting a specific target type.

4. The Chieftain Hill veins have been tested by surface sampling and drilling, but only very limited exploration has been carried out on the Chieftain Hill fault itself. The fault system is of similar orientation to, and along strike from, the shear zones that host or are spatially associated with the Skukum Creek mineralization. Along with the spatially associated Chieftain Hill veins described above, there may be local zones of dilation along its strike length with the potential to host Au-Ag mineralization, particularly at bends or bifurcation points with fault strands and veins. Prospecting and geological mapping along the fault system from north of the Ocean shear zone to Skukum Creek are recommended. In areas that lack exposure, the use of soil sampling with weak (partial) extraction methods may aid target identification. Structural examination of fault exposures in outcrop, such as the exposure in Photo 7.3, may aid in the assessment of fault kinematics (shear sense) and, consequently, areas of potential dilatancy along strike.

8.0 GODDELL GULLY AREA

8.1 Introduction

Mineralization at Goddell Gully has been intersected in numerous drill holes and surface exposures over a strike length of at least 500 m along the trace of the Goddell fault on the east side of the Wheaton River valley. The principal host rock to mineralization is the Carbon Hill quartz monzonite (Hart 1992a; see section 3.2.1), and several generations of dykes that cut the quartz monzonite and which are spatially related to the fault system including: a) east-trending rhyolite dykes of at least three textural varieties that are parallel to, and localized within, the fault system (see section 3.2.2 for dyke descriptions); and b) a sheeted set of west-northwest trending, subvertical to steeply southeast-dipping andesite dykes that trend obliquely to the southeast from the Goddell fault (Figure 18). Crosscutting relationships indicate that the rhyolite dykes are younger than the andesite dyke swarm (Coster 1988).

The Goddell area was evaluated during this study through the examination of diamond drill holes from several 1997 underground drill fences through the PD zone. Observations outlined below are mainly from core in that area combined with historical exploration data from near surface areas in other parts of the system. Observations and conclusions reported here are consistent with those in Coster (1988), Baril (1989) and Hart (1992a), who provide the most comprehensive previous descriptions of the Goddell zone.

8.2 Structural setting of Goddell Gully mineralization

8.2.1 The Goddell fault system

Within the Goddell Gully area, the Goddell fault system forms a prominent gossanous lineament that defines the main part of the gully. Like the shear zones in the Skukum Creek area, the Goddell fault system is a heterogeneous zone of braided, anastomosing shear zones dominated by lithified, foliated cataclastic breccias and phyllitic shear zone strands, and by spatially associated rhyolite and andesite dykes. Mapping and diamond drilling indicate an east-southeast strike and subvertical to steep south dip to the main fault system and rhyolite dykes. The fault system typically consists of multiple discrete zones of foliated cataclasite that vary widely from <0.1 up to 5 m thick developed over widths of 20 to 150 m that define a wide but distributed shear zone. The core of the fault system, which contains the thickest, master cataclasite and shear zone strands, is typically 5 to 30 m wide and occurs along the southern part, or immediately south of, the set of rhyolite dykes (Figures 19, 20). This core area typically grades outward into a broad damage zone that contains common minor cataclastic zones, numerous slip surfaces, and areas of spaced pressure solution cleavage development. The widest exposure of the fault system and its associated damage zone are at or near the surface, where exposures and drill intercepts of the fault system occur in both Goddell and Golden Tusk gullies (Figure 18) over a width of almost 200 m.

In the PD zone, which was drilled from underground, the main shear zone strands also occur principally along the southern portion of the sheeted rhyolite dyke swarm. The fault system and its associated damage zone here are 40 to 90 m wide, and consistently widen upward as splays off the south side extend off the main core of cataclastic fault surfaces (Figures 19, 20). Intervening quartz monzonite between cataclastic surfaces is affected by numerous minor slip surfaces filled with green sericite and anastamosing, spaced pressure solution seams. These define an irregular, spaced foliation that reflects the damage zone of the fault system (photo 8.3, left), which in turn corresponds to the area of most strongly developed green sericite alteration.

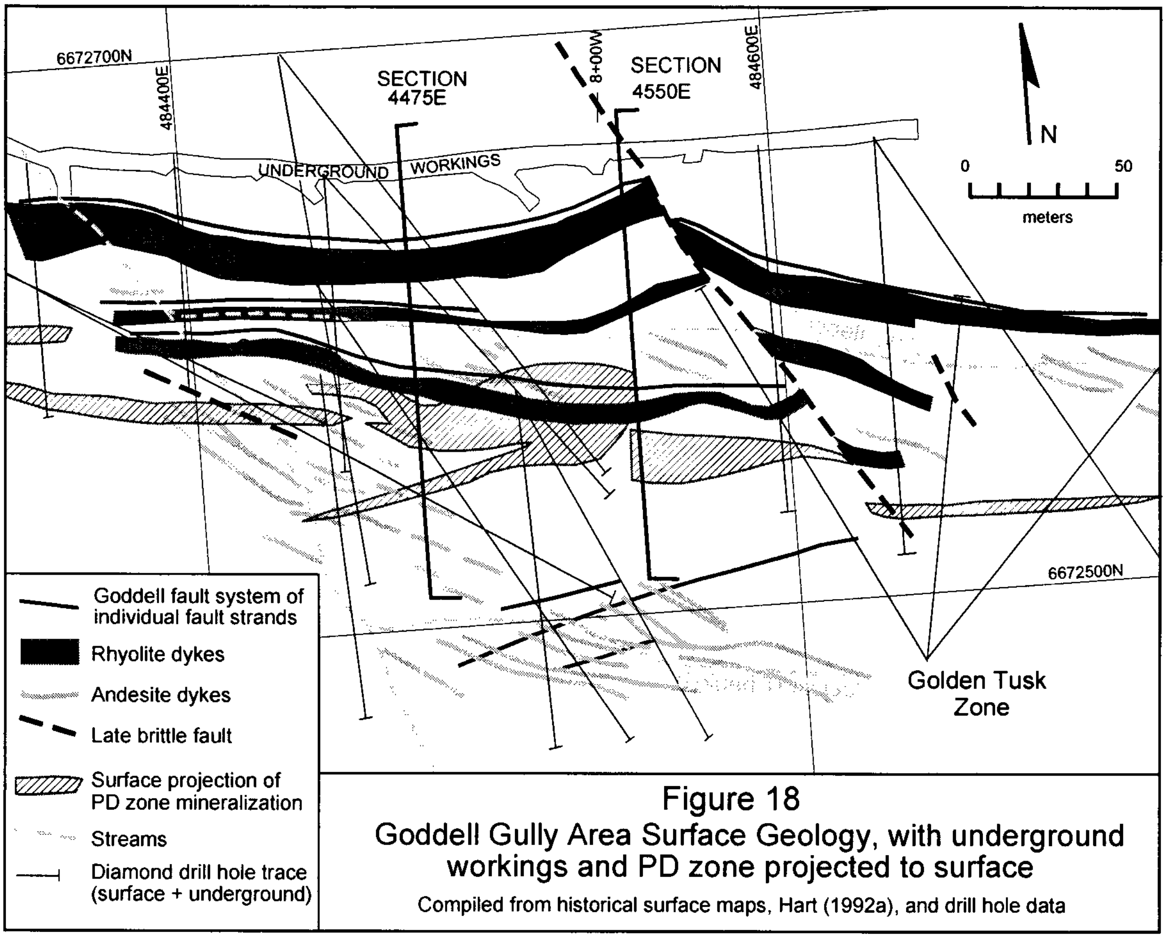


Figure 18
Goddell Gully Area Surface Geology, with underground workings and PD zone projected to surface
Compiled from historical surface maps, Hart (1992a), and drill hole data

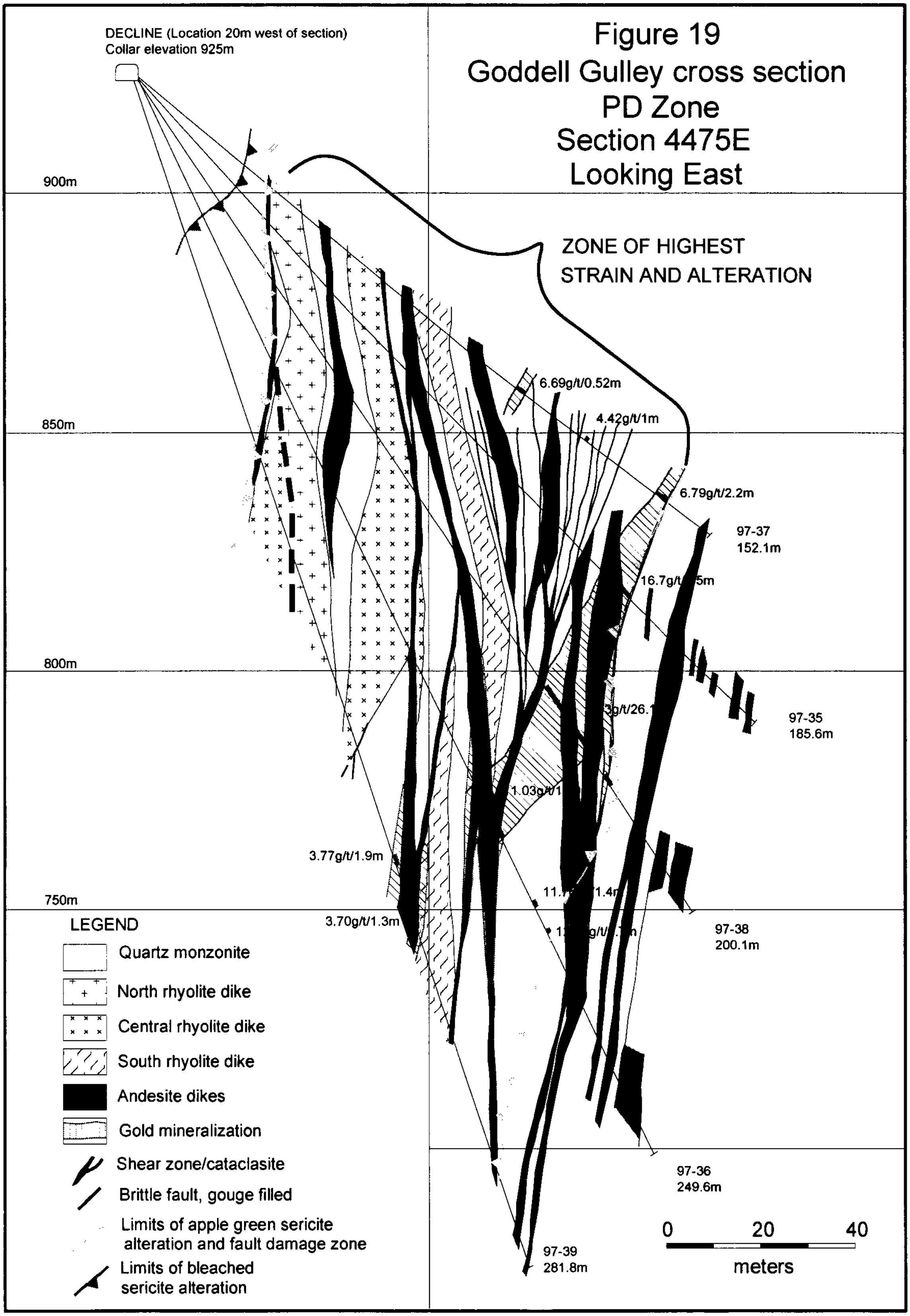


Figure 19
Goddell Gulley cross section
PD Zone
Section 4475E
Looking East
DECLINE (Location 20m west of section)
Collar elevation 925m
ZONE OF HIGHEST
STRAIN AND ALTERATION
900m
850m
800m
750m
6.69g/t/0.52m
4.42g/t/1m
6.79g/t/2.2m
97-37
152.1m
97-35
185.6m
3.77g/t/1.9m
3.70g/t/1.3m
97-38
200.1m
97-36
249.6m
97-39
281.8m
LEGEND
Quartz monzonite
North rhyolite dike
Central rhyolite dike
South rhyolite dike
Andesite dikes
Gold mineralization
Shear zone/cataclasite
Brittle fault, gouge filled
Limits of apple green sericite
alteration and fault damage zone
Limits of bleached
sericite alteration
0
20
40
meters

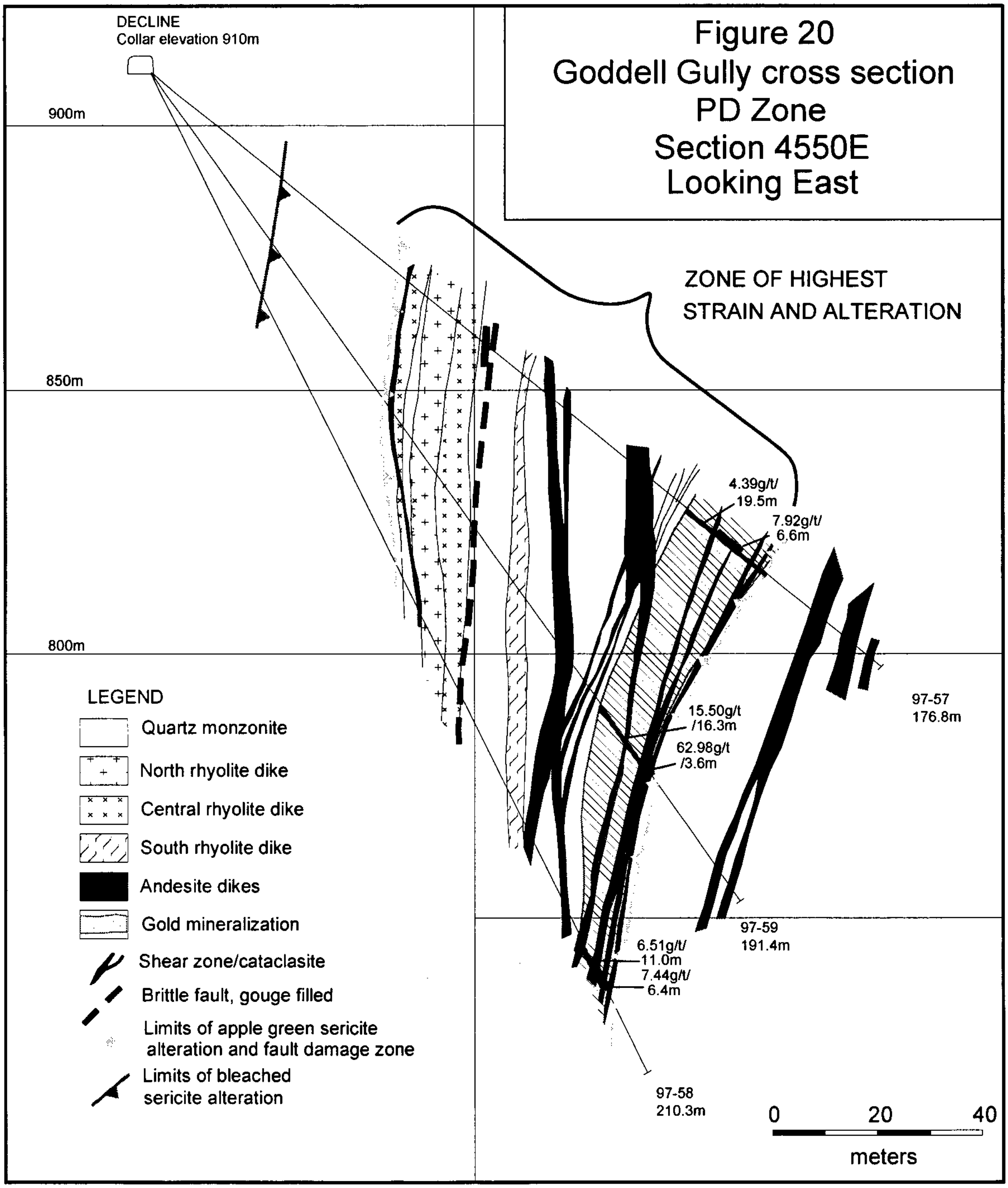


Figure 20
Goddell Gully cross section
PD Zone
Section 4550E
Looking East
DECLINE
Collar elevation 910m
900m
850m
800m
ZONE OF HIGHEST
STRAIN AND ALTERATION
4.39g/t/
19.5m
7.92g/t/
6.6m
15.50g/t
/16.3m
62.98g/t
/3.6m
6.51g/t/
11.0m
7.44g/t/
6.4m
97-57
176.8m
97-59
191.4m
97-58
210.3m
0
20
40
meters
LEGEND
Quartz monzonite
North rhyolite dike
Central rhyolite dike
South rhyolite dike
Andesite dikes
Gold mineralization
Shear zone/cataclasite
Brittle fault, gouge filled
Limits of apple green sericite alteration and fault damage zone
Limits of bleached sericite alteration

Cataclasites define the main surfaces of fault movement in the structure and are dark grey and lithified with fragments of altered quartz monzonite, andesite, quartz and quartz-sulphide veins in a foliated sericite-quartz-fine grained sulphide matrix (Photo 8.1). Fragments typically comprise 10 to 30% of the cataclasite breccia (photo 8.1, right), although where multiple slivers of wallrock are incorporated as augen shaped lenses, fragment abundance can be significantly higher (Photo 8.1, left). Fragments, particularly those of fine-grained quartz, are generally internally unstrained or show only minor undulose extinction in thin section, and indicate that more ductile crystal plastic deformation processes were not active. Like other cataclastic shear zones in the area, stylolitic pressure solution seams commonly overprint, or are localized along, cataclasite margins and narrow seams, and commonly developed as a spaced foliation in adjacent foliated wallrocks within the shear zone (Photo 8.2). Pervasive to spaced foliation defined by alignment of sericite commonly surrounds cataclastic seams and slip surfaces and defines a pervasive to spaced foliation that may grade outward into less strained wallrocks. The combination of cataclastic textures and pressure solution fabrics records the synchronous activity of brittle and low temperature ductile deformation processes that are characteristic of the semi-brittle style of deformation also observed at Skukum Creek and in the Chieftain Hill area. Shear bands and oblique foliations are commonly visible in the core within shear zones, but could not be used as kinematic indicators to determine shear sense because it was not possible to re-orient the split core.

Rhyolite dykes are not usually affected by significant shear zone fabrics, because cataclastic surfaces and associated foliated shear zone material either form preferentially outside them in altered quartz monzonite or along their contacts. Shear zones can also penetrate the margins of rhyolite dykes or displace the dykes, and are accompanied by the development of foliation defined by green sericite phyllite and local breccia textures within the dykes (Photo 8.3, right). These textures and crosscutting relationships indicate that dykes formed either pre- or early syn-displacement along the cataclastic surfaces and shear zones in the fault system.

Late brittle faults filled with clay gouge commonly are developed within the Goddell fault system and record late brittle displacement on the fault that postdates the cataclasites. The largest of these are typically 0.15 to 0.4 m thick, and they are distributed as multiple seams across the width of the Goddell fault zone. These fault gouges are thinner, and less disruptive to both the mineralization and earlier fault fabrics, than was observed in other mineralized zones within the project area, possibly because they are more distributed over the width of the system.

8.2.2 Structural style and setting of Au mineralization

Gold mineralization in the Goddell Gully area occurs within and south of the main strands of the Goddell fault. Different parts of this area have been assigned various names; exposures of mineralization at surface south of the main fault have been termed the Golden Tusk zone, whereas deeper, higher grade intersections at depths of 300 to 700 m below surface and drilled from the underground workings have been called the PD zone. The two areas are separated by a gap in drilling and may be continuous. Both are of similar style. Mineralization is open in the PD zone on several sections, and potential exists for the identification of further mineralization of similar style.

Au mineralization in the PD zone that has been intersected from underground drilling occurs principally to the south of the rhyolite dykes and main cataclastic strands of the Goddell fault system, along the southern margin of the fault (Figures 19, 20). Au mineralization in this area is associated with: a) disseminated, fine-grained acicular arsenopyrite-arsenian pyrite that are pervasively disseminated, primarily in andesite dykes and locally in cataclastic shear zones; and b) quartz-sphalerite-stibnite extension and shear veins, which commonly have a spatial relationship to the disseminated mineralization. Mineralogy and paragenetic relationships are described in detail in section 8.3. Mineralization is principally associated with the disseminated arsenopyrite style which occurs as pervasive disseminations that are often localized in dykes adjacent to shear zones, or are spatially associated with widely spaced quartz-sphalerite-stibnite extension veins of the second mineralization style. Where the extension veins are developed, envelopes of abundant dark grey disseminated arsenopyrite commonly surround them and extend from 0.5 to 4 cm outward from the veins, indicating a genetic link and contemporaneity between the two mineralization styles. Mineralization in cataclastic breccias also locally occurs where andesite fragments contain disseminated acicular arsenopyrite.

Quartz-sphalerite-stibnite extension veins that are developed in dykes with disseminated arsenopyrite mineralization are typically 0.2 to 3 cm thick, tabular, macroscopically unstrained and spaced 1 to 5 m apart. Core axis angles indicate moderate north dips to the veins that are parallel to the overall dip of the mineralized sheets described below, and to the moderate to shallow dipping veins of similar style reported in surface outcrops of mineralization in Goddell Gully (Hart 1992a). Quartz-sphalerite-stibnite veins are also locally present in cataclasites as 1 to 15 cm wide, commonly ribboned shear veins that are typically parallel to shear zone fabrics, or may be brecciated into fragments or augen within the cataclastic matrix (photo 8.1, right, at top). When compared to the abundance and thickness of veins in shear zones in the Skukum Creek and Chieftain Hill areas, the quantity of veining at Goddell is significantly less, and mineralization is instead dominated by non-dilational replacement styles. Early, unmineralized and variably oriented pre-mineral quartz veinlets are also locally developed (Photo 8.4), but show no consistent relationship to mineralized zones.

Mineralization of both styles described above occurs entirely within the damage zone of the Goddell fault system. In several intercepts on sections 4475 to 4550E, the highest grade mineralization is localized directly above a narrow (10 to 50 cm), steeply north-dipping shear zone that forms the southernmost strand of the fault system, and the limits of the Goddell fault damage zone (Photo 8.2). On other sections, minor shear zones may also occur at the top of well mineralized intervals. Drill intercepts suggest that the best mineralized areas occur in moderately to steeply north-dipping sheets that dip more shallowly than the main strands of the Goddell fault, but follow minor associated splaying shear zones such as those described above as well as andesite dykes. The mineralized areas may cross between andesite dykes, which generally have steeper or southerly dips. Multiple, stacked, north-dipping zones are apparent on some cross sections, often associated with north dipping splays of minor shear zones off the south side of the Goddell fault; this suggests potential for further stacked zones above and below the main areas of underground drilling where further splays off the Goddell fault system occur. A westerly plunge to some mineralized zones is apparent on long section within the PD zone and may coincide with the westerly plunge of the intersection of the main cataclastic shear zone surfaces with the splaying, minor faults off the south side of the structure that locally appear to control mineralization. Mineralization also locally developed directly within dark grey cataclasites both as disseminated and vein types, which further suggests the potential for continuous mineralization to be developed along the main shear zone strands; this style has not thus far been traced laterally or vertically for more than one or two drillholes.

The morphology and structural controls on near-surface mineralization in the Golden Tusk zone and Goddell Gully were not evaluated during this study because much of the core is in either poor condition or missing. Descriptions by Coster (1987) and Baril (1988) indicate that mineralization is of similar style to that in the PD zone at depth, although it has been intersected over narrower intervals and lower grades with more abundant associated quartz-stibnite veins. Difficulties of correlation of faults and mineralization are also reported for near surfaces drill holes. More accurate relocations of many old surface collars would allow a more comprehensive data compilation and interpretation to link these data to information derived from surface mapping and drill hole information from the PD zone; this will provide a better understanding of the morphology and mineralization distribution in the Goddell system before further drilling is completed.

8.2.3 Surface distribution of faults in the Goddell area and their exploration potential

Several prominent northeast-trending lineaments occur south of the Goddell fault and north of the Porter fault, located 2 km to the south and associated with Au-Sb mineralization (Figure 21). These lineaments are locally associated with and/or bound gossans. Several samples collected during prospecting from this area have also returned anomalous Au values, and mapping has confirmed that some of these lineaments are faults with apparent sinistral displacement and associated quartz-sulphide extension veins (Robertson 1987; 060 fracture zone). If these lineaments represent faults associated with hydrothermal alteration, they have the potential to host Au-Ag mineralization because they sit in orientations that are similar to known dilational structures in the area such as Rainbow-Kuhn, and they form a potential zone of high structural permeability that may link the Goddell and Porter fault systems in a dilational step or crossover environment. Compilation of historical exploration data followed by prospecting and geological mapping are recommended for this area. This work should also explore the traces of both the mineralized Porter fault and extensions of the Goddell fault. The Goddell fault has potential for mineralization to, and beyond, the Becker-Cochran Sb deposit to the east, and to the west where bulldozer trenching has uncovered Sb-bearing float west of Goddell gully (Coster 1988). In areas of cover, soil sampling with use of partial extraction techniques may aid in target generation and prioritization.

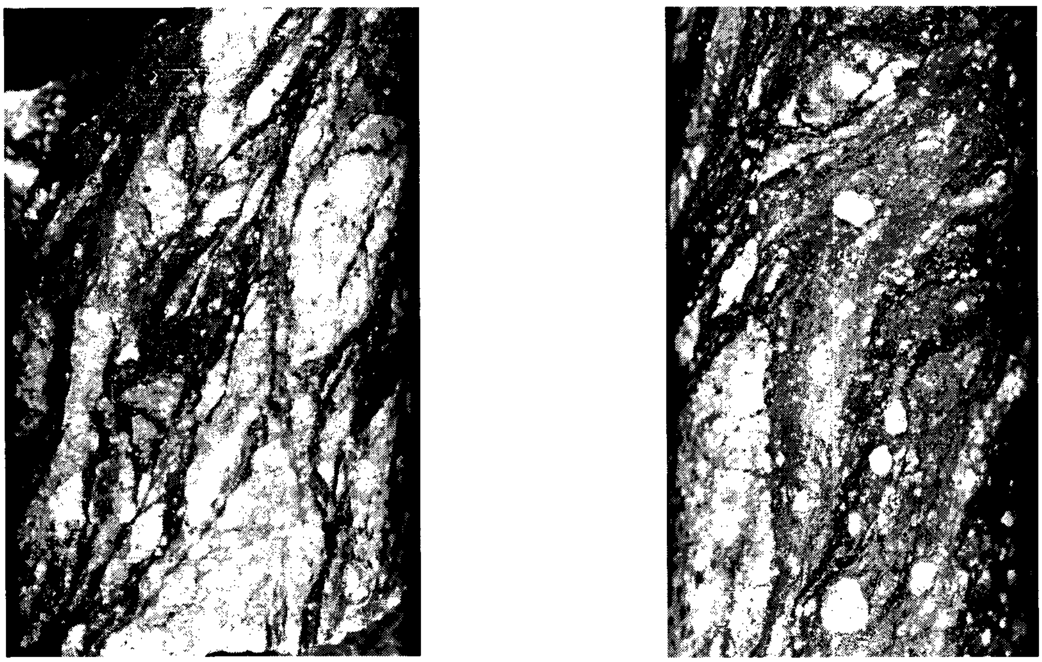


Photo 8.1: Foliated cataclasites in the Goddell fault system. These comprise the core of the Goddell shear zone and typically occur as multiple strands up to 5 m thick that are separated by altered quartz monzonite. Dark grey matrix is composed of fine-grained phyllosilicate minerals (mainly sericite, quartz and fine-grained sulphides with fragments of altered quartz monzonite, quartz and quartz vein (grey fragment in right photo at top)). Note foliation defined by flattening of wallrock fragments, phyllosilicate and sulphide domains in cataclastic matrix, and discrete slip surfaces and pressure solution seams. Left sample: 97-58, 159 m; right sample: hole 97-59, 135.9 m.

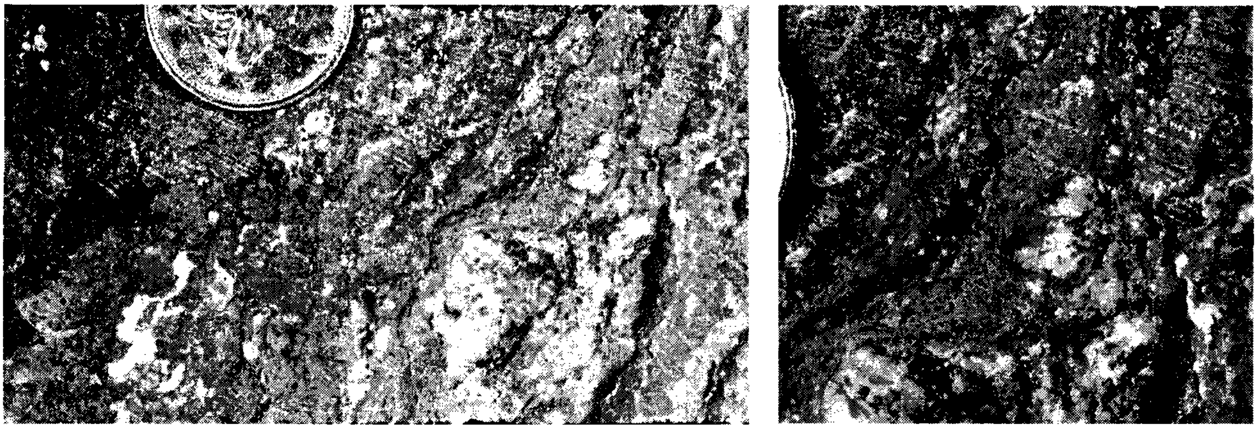


Photo 8.2: Shear zones on southern margin of Goddell fault system with well developed pressure solution fabrics. This structure forms the southern bounding shear zone to dyke-hosted mineralization on section 4550E (Figure 18). It is 0.3 m wide. The deformed and dark grey arsenopyrite altered margin of an andesite dyke occurs in the upper left corner of the left photo. Note the undulating dark grey stylolitic pressure solution seams in the inset at right that are localized along grey quartz-sulphide domains in foliated tan sericite matrix. DDH 97-59 at 162.3 m.

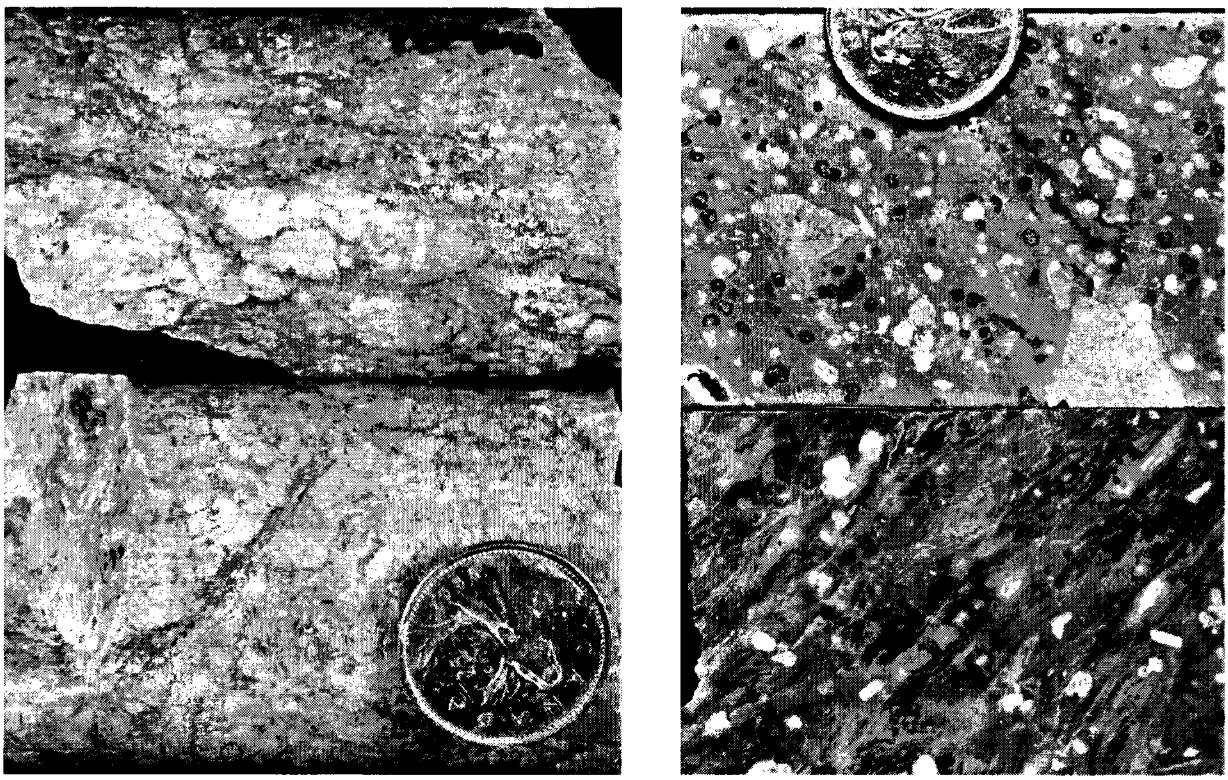


Photo 8.3: Shear zone textures, Goddell fault system. Left: Damage zone to the Goddell fault. Spaced apple green colored sericitic pressure solution foliation and slip surfaces affect orange-red sericite-carbonate altered quartz monzonite between cataclastic shear zone strands in the Goddell fault system. Samples are from DDH 97-51 at 184 m (top) and 182.7 m (bottom). **Right:** North Marker QFP dyke (see section 3.2.2) with xenoliths of earlier rhyolite dyke material (top sample) is affected by shear zone strands associated with the Goddell fault system, which impart a pervasive foliation defined mainly by alignment of apple green sericite (lower sample). Samples are from DDH 97-52 at 18 m (top) and 15.2 m (bottom).

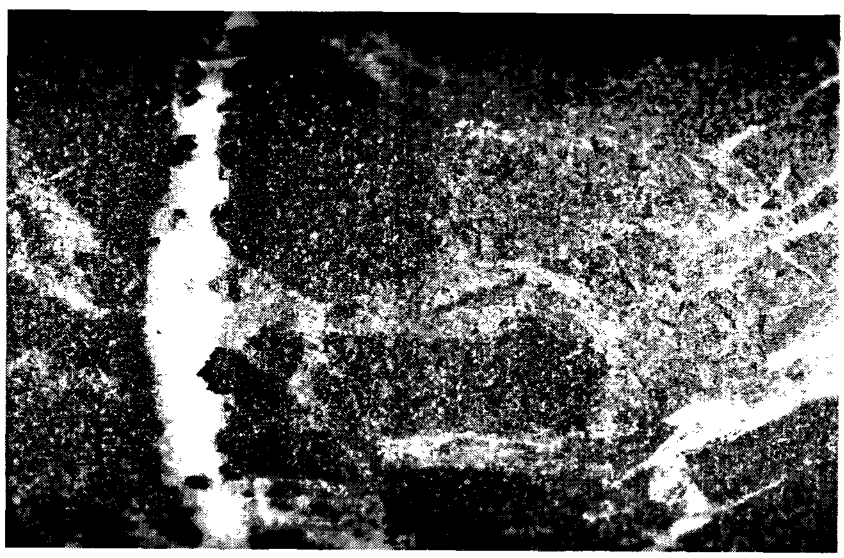
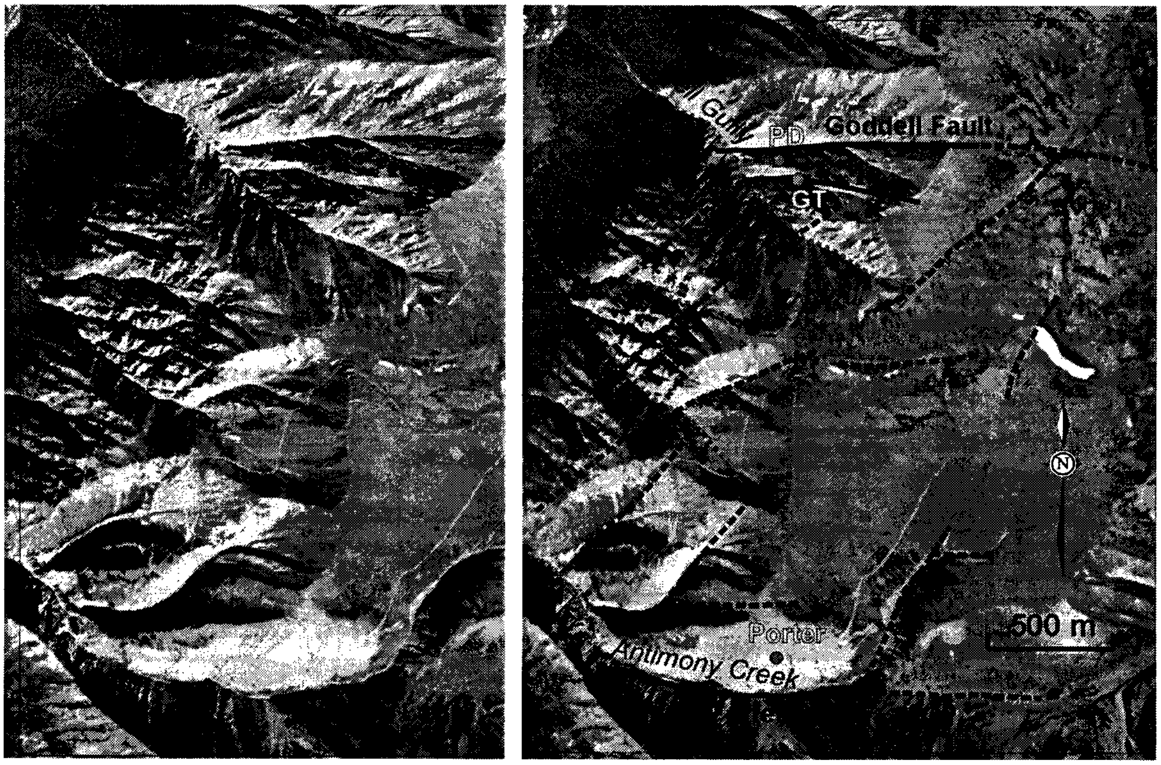


Photo 8.4: Quartz-sphalerite extension vein in arsenopyrite-bearing, mineralized andesite dyke, PD zone. Note arsenopyrite abundance decreases away from vein. An early set of variably oriented quartz veinlets is also present in the dyke adjacent to the extension vein. Field of view is 8 cm, DDH 97-58 at 199.2 m.



Faults, defined

NW and N trending lineaments, inferred faults

NE and E trending lineaments, inferred faults

PD zone, approximate surface projection of resource

Deposit or prospect: PD = PD zone; GT = Golden Tusk

Figure 21: Airphoto stereopair of the Goddell Gully area. Shown are the distribution of known faults associated with Au-As-Sb mineralization (Goddell and Porter faults), east- and northeast-trending lineaments that probably represent faults, lineaments of other orientations (northwest, north in green) that possibly represent faults, and deposits or prospects referred to in the text. Scale (500 m) is approximate. Northeast- and east-trending structures may represent extensional splays or associated parallel faults to the Goddell and Porter structures, respectively, and are consequently potential hosts to further mineralization. Prospecting and geological mapping are recommended, with evaluation of each prospective lineament. Only major northwest- and north-trending lineaments are shown.

8.3 Alteration and mineralization, Goddell Gully zone

The physical characteristics of Goddell Gully have been described in section 8.2, and petrographic characteristics are discussed here. Note that observations at Goddell do not extend very far laterally from the main zones of mineralization, due to the distribution and orientation of available drill holes, which limits recognition of any larger scale zoning patterns that might be present.

8.3.1 Least-altered hornblende-biotite quartz monzonite

The host rock to the Goddell zone is an equigranular hornblende-biotite quartz monzonite that has been correlated with the Carbon Hill pluton of the Mt McIntyre suite of Cretaceous age. The freshest rock is sample G97-59-16 (Photos 8.5 and 8.6), which has minor chlorite (Mg>Fe by SEM) after biotite and hornblende, possible traces of epidote, and minor sericite after plagioclase. Igneous K-feldspar remained largely stable during this weak alteration, although it also commonly has a weak dusting of sericite. Magnetite is mostly fresh, but locally is replaced weakly by hematite. Rutile is present in the altered parts of hornblende and biotite crystals. Late, barren carbonate veinlets cut the intrusion. The single sample of least altered intrusion contains no sulphide.

8.3.2 Peripheral brown alteration zone

The boundaries of the main Goddell shear zone are defined by an intense sericitic alteration with a characteristic apple green colour that is described below. This central alteration is surrounded, in an envelope that extends only up to a few tens of metres beyond the main shear zone, by a sericitic alteration that commonly weathers to a distinct brownish cast in affected drill core (Photo 8.7; the best sample is G97-58-85). The outer contact of this alteration is typically abrupt, although there are commonly alternating zones of least-altered and sericitically-altered intrusion. The brownish sericitic alteration is, in most cases, not obviously controlled by fractures. In all cases igneous textures remain visible (Photo 8.8). Magnetite is completely hematized, but only traces of pyrite are present. Plagioclase is pervasively altered to sericite and carbonate (Photo 8.9). Carbonate has two compositions: 1) Fe-Mg>>Ca; and 2) Ca>Mg>Fe>(Mn); the second type is by far the more common and is either ankerite or ferroan dolomite (Figure 22A). K-feldspar is mostly altered to sericite, but some remained stable (Photo 8.7). Biotite is completely altered to carbonate (both compositional types noted above) with lesser sericite, quartz, apatite and rutile. A significant concentration of barite was noted in thin section. There is a complete absence of chlorite and epidote, and overall the principal alteration phase is carbonate. There is also minor carbonate in late veinlets. Generally this type of altered intrusion shows little evidence for strain, except where cut by discrete shear veinlets.

8.3.3 Intense apple-green alteration within the main Goddell shear zone

Within the zone of main shearing at Goddell, the alteration becomes markedly more intense (Photos 8.10, 8.11 and 8.12) and is visually distinguished by a prominent apple-green phase present as disseminations and on many veinlets, shears and pressure solution surfaces. Most samples of this alteration are strongly sheared. Petrography was completed on sample G97-59-126. The typical alteration is an intense quartz-sericite-carbonate alteration (Photo 8.12). The main alteration mineral is carbonate, which ranges widely in size and composition (including Ca>Mg>>Fe-(tr Mn), Fe-Mg>>Ca and Fe>Mg; the Fe-rich types typically appear to have formed relatively later in the paragenesis). Ferromagnesian minerals and magnetite are completely destroyed. The apple green colour is caused by massive sericite-muscovite clots; in many drill logs the apple green colour is attributed to fuchsite, but SEM results show that it is all sericite/muscovite with no green colour activators such as V, U or Cr. Only traces of pyrite were found in the thin section, but in drill core it ranges up to 10 % (high concentrations are, however, very rare). Minor to trace rutile and locally hematite are present, mostly in carbonate-sericite veinlets. The examined sample also contains significant disseminated barite. As in the brown alteration zone, chlorite and epidote are absent. The near absence of sulphide in the intense sericitic alteration within the main Goddell shear zone distinguishes it from Rainbow-Ridge, as does the common presence of (locally) abundant barite and the absence of chlorite and epidote. The intense sericitic alteration at Goddell pervasively affects all of the intervening rock between mineralized and unmineralized shears, with little visual variation in either mineralogy or intensity.

The three marker QFP dykes that are present along the drilled length of the Goddell shear zone have been described above. Alteration is similar in each of these dykes, comprising mostly sericite although much of the primary igneous K-feldspar remained stable. The North and South marker dykes have little or no sulphide in most intervals. The Central marker dyke, which is more accurately termed a quartz eye rhyolite, almost invariably contains several percent disseminated pyrite. The Central Marker dyke carries little or no grade, but it is locally cut by narrow, discontinuous quartz-sulphide extension veinlets that are much smaller and less continuous than the strongly mineralized quartz-sulphide veins described below.

8.3.4 Sulphide mineralization and occurrence of gold

Sulphide mineralization and the occurrence of Au at Goddell are quite distinct from Rainbow-Ridge. Most mineralization is found in andesite dykes (Photos 8.13, 8.14 and 8.15) that are intersected by veinlets and smaller shear zones within the main shear structure. Where mineralized, the dykes acquire a dark colour that reflects the presence of abundant, very fine-grained disseminated sulphide (Photos 8.15 and 8.16). SEM analysis shows that most of the sulphide is euhedral arsenopyrite with acicular geometry and with lengths of individual needles a few to tens of microns in length (Photo 8.17). A very small proportion of the sulphide can be sphalerite and/or stibnite. Back-scatter electron images from the SEM also show that this arsenopyrite has strong, internal compositional zoning in complex patterns that reflect variations in S, As and Sb (Figure 23). Long EDS count times were employed on the SEM in an attempt to identify Au peaks in the acicular arsenopyrite, as it has a direct empirical relationship to Au grade, but the concentrations were apparently too low to detect (EDS requires several hundred ppm for confident identification of trace elements). In contrast, non-acicular arsenopyrite from all zones (i.e., Rainbow, Ridge, Goddell, Taxi and Chieftain Hill) lacks compositional zoning. In some cases the main sulphide in dark alteration zones or envelopes around veins is an As-rich pyrite. In several samples, an early stage of normal pyrite was overgrown by arsenian pyrite with arsenopyrite inclusions, indicating that normal pyrite was the initial sulphide to precipitate. Neither native Au nor electrum was observed in any of the Goddell samples. Where stibnite is present in areas of acicular arsenopyrite mineralization, it is invariably later and replaces arsenopyrite and arsenian pyrite. Freibergite, even in the rare cases where it is present (Figure 24), has lower Ag concentrations than at Rainbow-Ridge; most is actually tetrahedrite with an As component indicating an intermediate tetrahedrite-tennantite composition. The low concentration of Ag at Goddell can be attributed to the near absence of freibergite (found only in one sample), argentite and native Ag (not observed), and Ag peaks in most sulphide minerals. Several instances of small Ag peaks on SEM were noted in stibnite, which might host much of the low grade Ag mineralization in light of its abundance.

Most of the alteration directly associated with sulphide mineralization is carbonate, with lesser sericite and commonly with quartz. Two main types of carbonate are present (Figure 22). One is ankerite or ferroan dolomite (Figure 22A; Ca>Mg>Fe±Mn), and the other is a Mg-Fe>>Ca±Mn (Figure 22B). Nearly all carbonate is Fe-bearing or Fe-rich at Goddell, which contrasts markedly with Rainbow-Ridge where Fe is very low in all but minor, late-stage carbonates. Rutile is also common in trace concentrations, most commonly in pervasive alteration of andesite. Acicular arsenopyrite can be associated with either quartz-sericite or carbonate alteration. In both cases, however, it is common for the mineralization to be brecciated and cut by later, typically more pyrite-rich alteration that can also be either carbonate or sericite-quartz rich (Photo 8.18); these patterns indicate some cyclicity in mineralization events, but it does not appear to have operated as commonly as in Rainbow-Ridge. In general, mineralization in breccias appears to be largely confined to fragments of quartz-sulphide vein material.

Alteration envelopes that formed adjacent to a veinlet in sample G97-56-155.1 (Photo 8.19) clearly illustrate alteration relationships to mineralization. The alteration effects mimic the variations observed in least-altered (peripheral zone), intensely altered without significant mineralization (buff coloured zone; outer alteration envelope), and intensely altered with strong Au- and sulphide-enriched mineralization (dark inner alteration envelope). The associated vein is dominated by an early, barren, coarse-grained ankerite or ferroan dolomite with minor associated quartz. This is cut by a fine-grained, Fe-Mg>Ca carbonate with quartz, sericite and trace apatite that is associated with arsenian pyrite. The dark, inner alteration envelope contains very abundant arsenian pyrite, and pervasive alteration identical to the material that cuts the core veinlet. Carbonate includes early ankerite/ferroan dolomite replaced by the Fe-Mg>Ca carbonate. Pervasive alteration in the outer, light-coloured envelope is nearly identical, but there is only trace Fe-Mg>Ca carbonate and pyrite does not contain As; K-feldspar is partially stable in this zone, and there are traces of rutile, sphalerite, stibnite and galena. Outside the alteration envelope there is still very minor pyrite, both kinds of carbonate, traces of chlorite, and less intense sericite-quartz alteration. The main sulphide event is an overprint atop early, low-sulphide pervasive alteration similar to that shown in Photos 8.13 and 8.14. It can also be noted that some drill logs record veins with dark envelopes that are in intervals with no significant grade; this suggests either that there are different generations of acicular arsenopyrite that have distinct relationships to Au, or that some are acicular arsenopyrite and some are arsenian pyrite, and that only one or the other is related to Au. Data are insufficient to distinguish between these two possibilities.

8.3.5 Quartz-sulphide extension veins

Quartz extension veins (Photo 8.20) are also common at Goddell, although prominently so than at Rainbow-Ridge. As at Rainbow-Ridge, the quartz typically shows less strain than in earlier mineralization styles. Stibnite is commonly the main sulphide phase, and is typically accompanied by minor amounts of pyrite and sphalerite, and traces of galena. Although most of the quartz is coarse-grained, it is common to find sulphides along locally broken or brecciated intergranular boundaries where a later stage of fine-grained quartz is also present. Carbonate can be a minor phase in these veins. It is not clear how widespread these veins are at Goddell, due to the location of examined drill holes. Veins range from millimeters to >15 centimeters in width, but most are <1.5 cm wide. They are commonly at a high angle to the main shear fabrics in their host intervals, and have sharp contacts with wall rocks. In some locations they can be observed to cut the main stage of Au-enriched acicular arsenopyrite and/or arsenian pyrite mineralization. One vein was observed to have a selvage with red sphalerite and an axial zone with black sphalerite; this is similar to zoning observed by Littlejohn (1986) within individual sphalerite grains. Intervals in which quartz-sulphide extension veins are the only mineralized feature almost invariably report significant Au; electrum/native Au was not observed, however, and the residence of Au remains unknown. In rare cases, quartz extension veinlets with acicular arsenopyrite selvages were noted to carry grade; in DDH G97-58 these veins are cut by pyrite-rich quartz veinlets with trace to minor stibnite and sphalerite.

In DDH G97-38, two intervals grading 45.5 and 28 g/t Au are localized in a zone of shearing and brecciation in intensely sericitized hornblende-biotite quartz monzonite with locally strong pyrite and cut by quartz-sulphide extension veins; nearby there are more Au spikes directly related to quartz extension veins with base metal sulphides. It is not clear how the Au occurs in this interval, but there is a clear indication that areas with sufficiently high densities of quartz-sulphide extension veins can carry sufficient Au to attain ore grades. In Au anomalous intervals with breccia, the grade appears to be all or mostly in quartz-sulphide vein fragments.

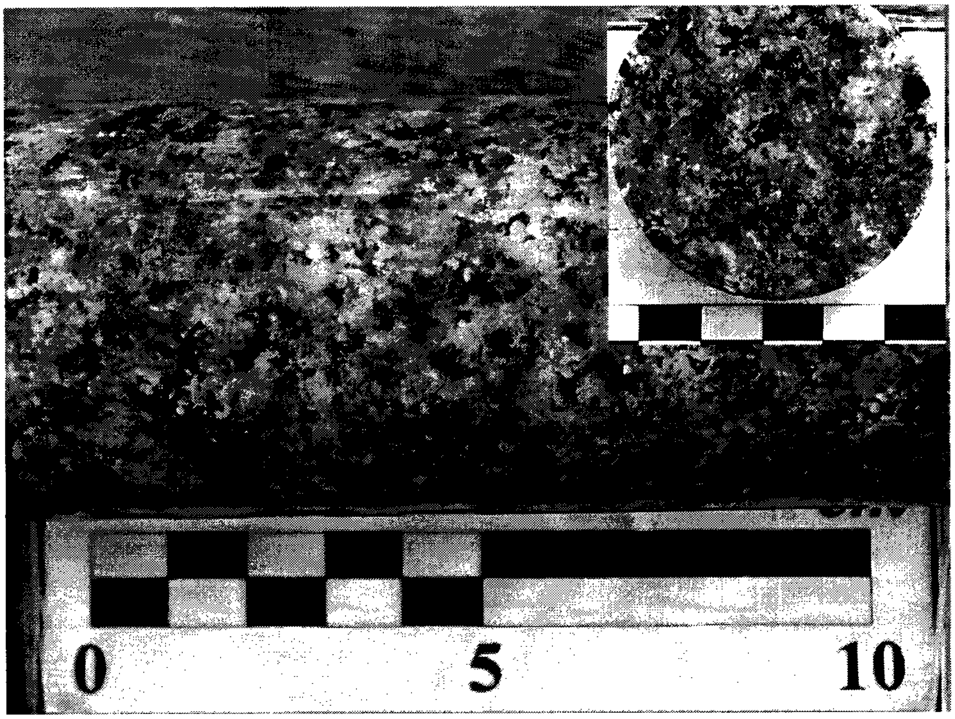


Photo 8.5. Least-altered biotite quartz monzonite host rock at Goddell. Inset shows that igneous K-feldspar is largely stable, even though this sample is only a short distance from the onset of shearing. Sample G97-59-16.

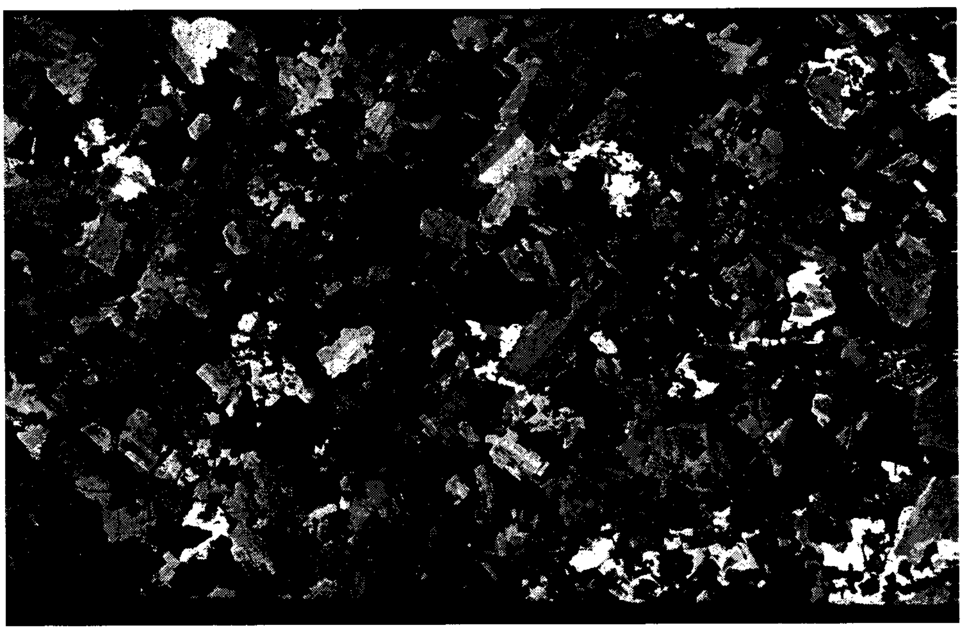


Photo 8.6. Full section view in crossed polars of sample G97-59-16, also shown in Photo 8.5. Alteration comprises only minor sericite, chlorite and carbonate, and sulphide is absent.

Photo 8.7. Brownish-coloured peripheral alteration at Goddell, characterized mostly by sericite and lesser carbonate. Chlorite and epidote are absent, and pyrite is trace. Inset of stained sample shows the weak, partial destruction of K-feldspar in this zone. Sample G97-58-85.

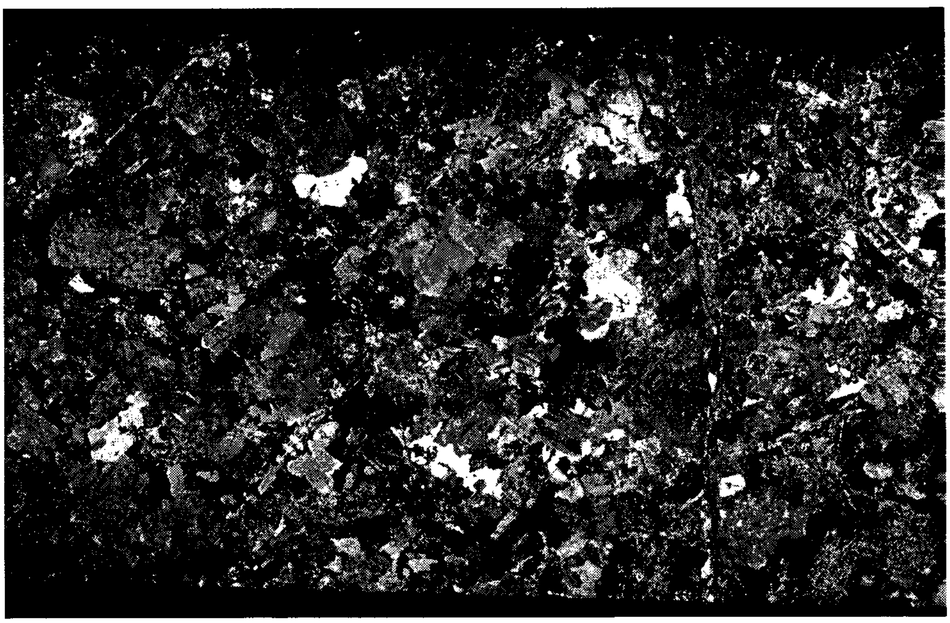


Photo 8.8. Pervasive alteration in the biotite quartz monzonite shown in Photo 3. This is the brownish alteration that forms an envelope to the main zone of shearing, and comprises mostly sericite and carbonate (Fe-bearing), and lacks chlorite and epidote with only trace pyrite. Sample G97-58-85.

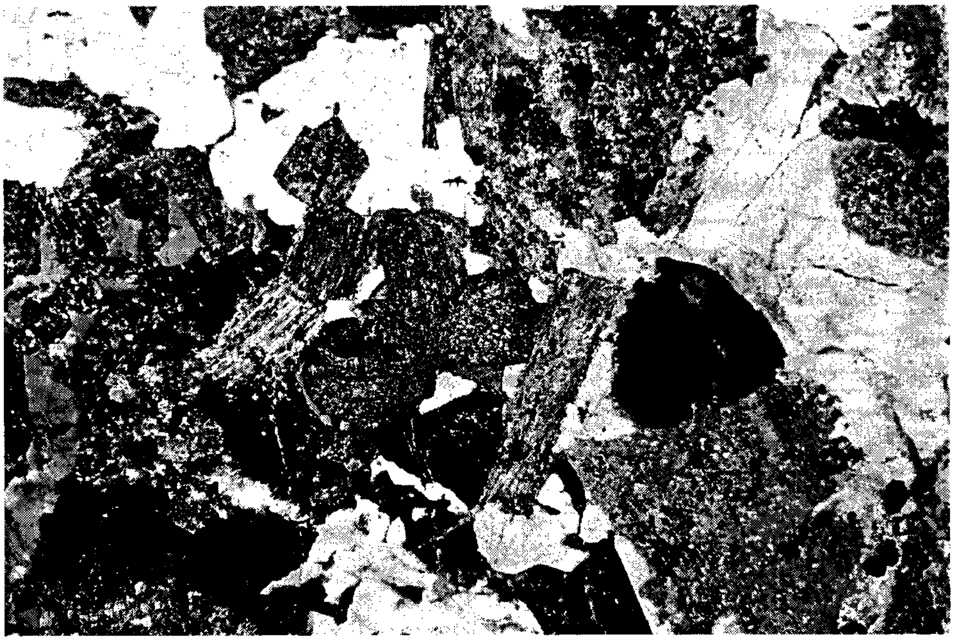


Photo 8.9. Detail of alteration in Photo 8.7. Sericite and carbonate are the main alteration phases and they mostly replace plagioclase and biotite. Sample G97-58-85 in crossed polars; FOV 2.63 mm.

Photo 8.10. Intense proximal alteration of biotite quartz monzonite within the zone of principal shearing. This alteration comprises mostly sericite (which commonly imparts an apple green colour), Fe-bearing carbonate, and quartz; pyrite is minor to trace in most samples. Insets show results of K-feldspar staining; orthoclase remains at least locally and partially preserved. Upper sample G97-59-126, lower G97-38-143.7.

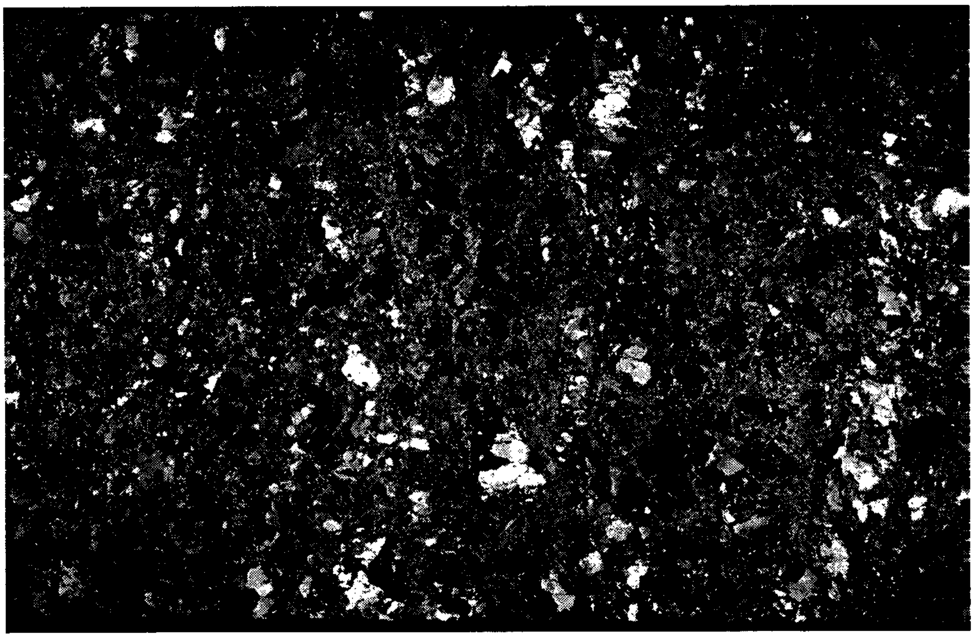


Photo 8.11. Full section view in crossed polars of sample G97-59-126, showing intense alteration of biotite quartz monzonite within the main zone of shearing at Goddell. The main phases are Fe-bearing carbonate and sericite. The sample is also notable for the presence of disseminated barite.

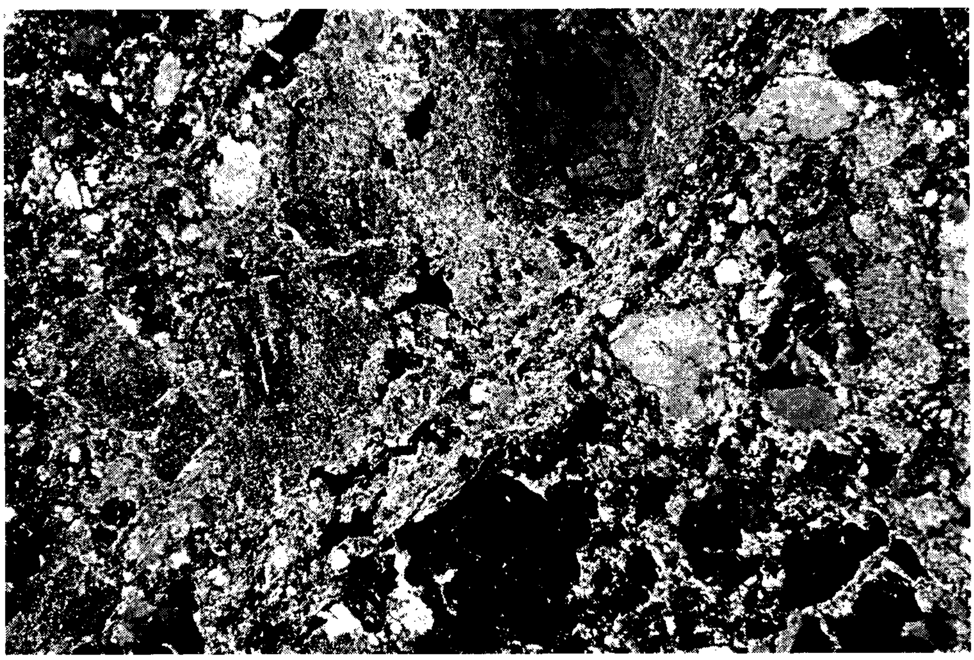


Photo 8.12. Detail of intense proximal alteration at Goddell. Here carbonate-sericite-quartz shears cut and replace biotite quartz monzonite. Sample G97-59-126 in crossed polars; FOV 2.63 mm.

Photo 8.13. Incipient alteration, dominated by sericite, in an andesite dyke, cut by late quartz-carbonate extension vein. Sulphide concentration is low in this sample and it carries little to no Au grade. Sample G97-35-60.2.

Photo 8.14. Andesite dyke with stronger sericitic alteration, here accompanied by carbonate and pyrite, but again without significant Au grade. Sample G97-35-126.6.

Photo 8.15. Altered andesite dyke with disseminated, acicular arsenopyrite and lesser pyrite. Alteration is more intense, particularly carbonate alteration, than in Figures 10 and 11, and this sample carries significant Au. Sample location not recorded.

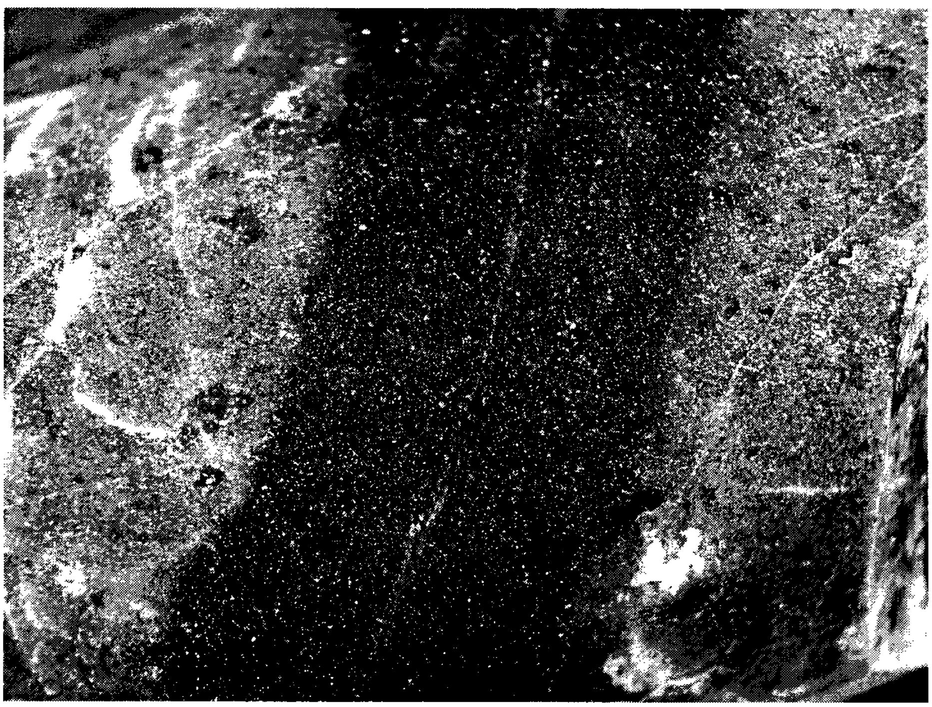
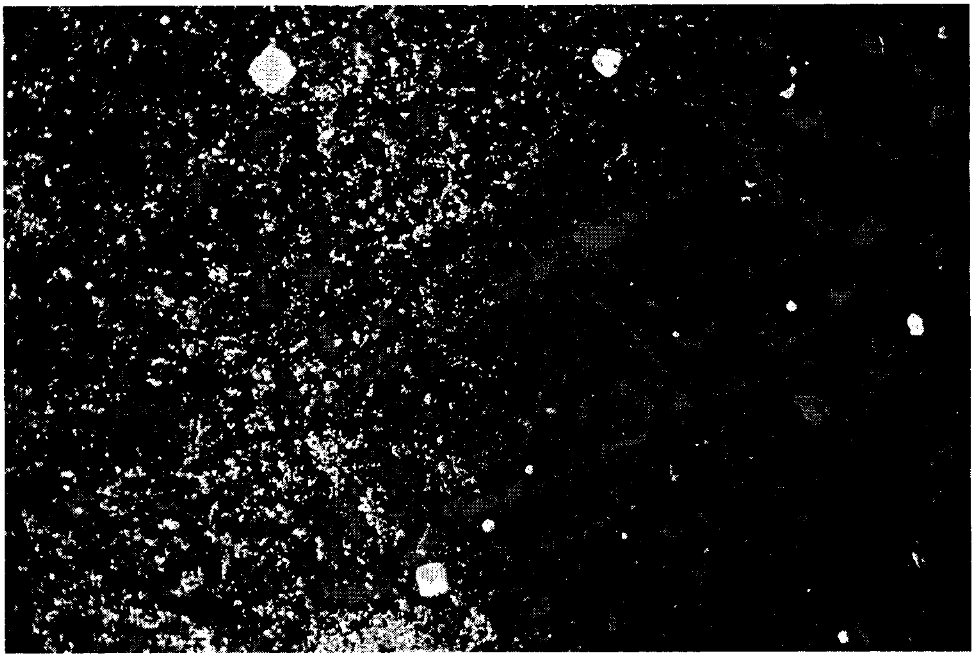


Photo 8.16. Closeup of a quartz-carbonate veinlet with a sharply bounded alteration envelope defined here by disseminated arsenopyrite (the more common type) and in some samples by arsenian pyrite. Host rock is andesite with sericite-carbonate alteration; note the 'fuchsitic' colour of coarse sericite clots. Sample G97-37-138.4.



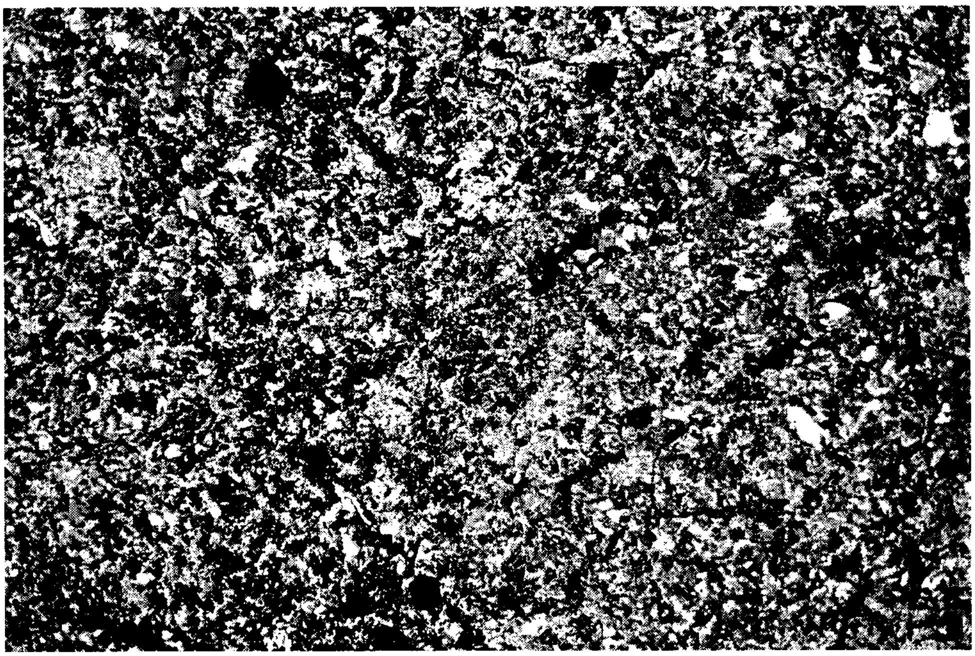


Photo 8.17. Outer contact of dark alteration envelope shown in Photo 8.16. The pervasive alteration comprises quartz, sericite and ferruginous dolomite, minor pyrite, and traces of apatite and rutile, and does not change across the contact indicating that it is an early stage of alteration. The envelope on left reflects abundant, later acicular arsenopyrite. Normal pyrite cores of grains in the envelope have overgrowths of As-bearing pyrite with arsenopyrite inclusions (i.e., syn-arsenopyrite). Upper view reflected light, lower crossed polars; FOV 2.63 mm.

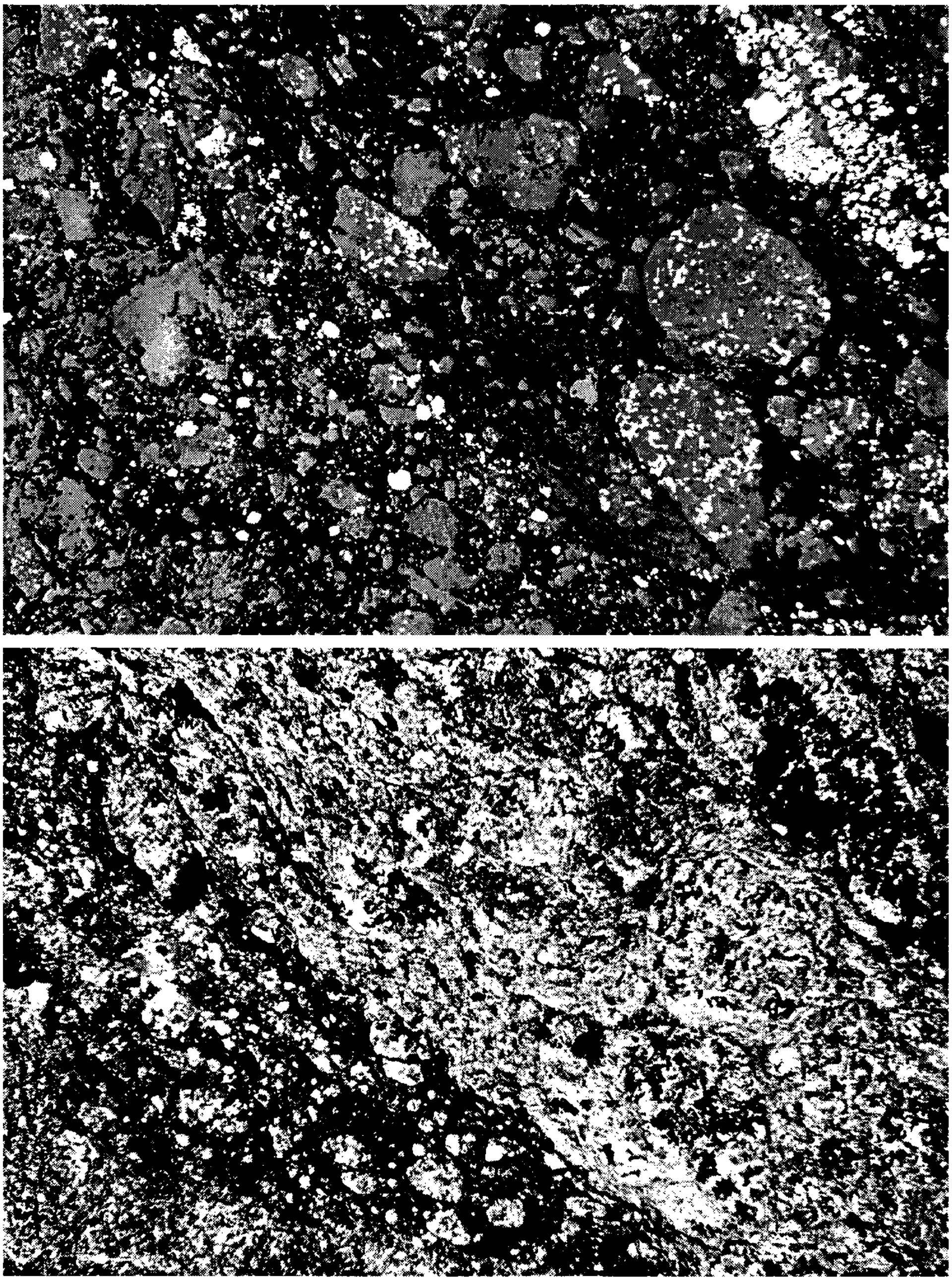


Photo 8.18. It is common for acicular arsenopyrite mineralization to be an early stage that is subsequently brecciated. Here, in sample G97-38-159.6, early acicular arsenopyrite mineralization in pervasive quartz-sericite alteration has been brecciated and cut by a later stage of quartz-sericite shears that are carbonate-rich and which contain mostly pyrite and only minor arsenopyrite. Early arsenopyrite can also be associated with carbonate alteration and later cut by sericite-rich alteration/shears. In either case, multiple stages of mineralization are indicated, although it is not clear which stage might be more closely related to Au. Upper view reflected light, lower crossed polars; FOV 2.63 mm.

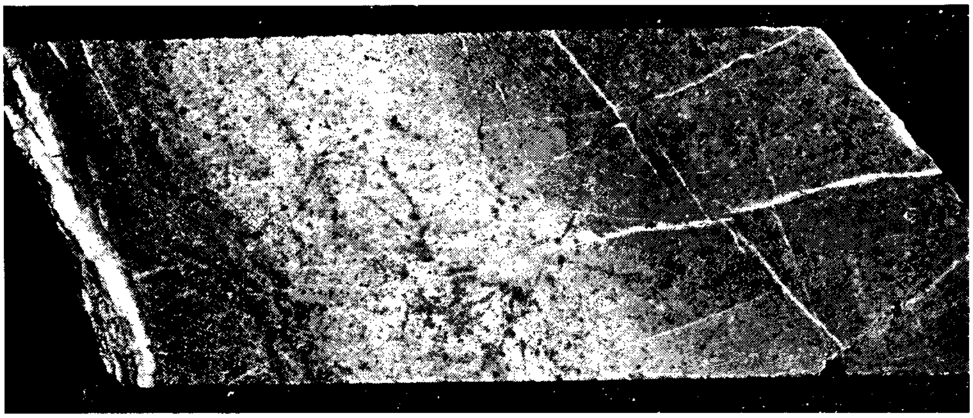


Photo 8.19. Zoning of alteration around a quartz-carbonate veinlet (at left). Inner envelope is dark due to abundant disseminated arsenian pyrite or arsenopyrite, and yields to a strongly bleached envelope with much less sulphide but similar non-sulphide alteration. At right is more weakly altered andesite dyke with sericitic clots and pervasive sericite-carbonate alteration of lower intensity but similar composition. Fractures contain Fe-bearing carbonates. Sample G97-56-155.1.

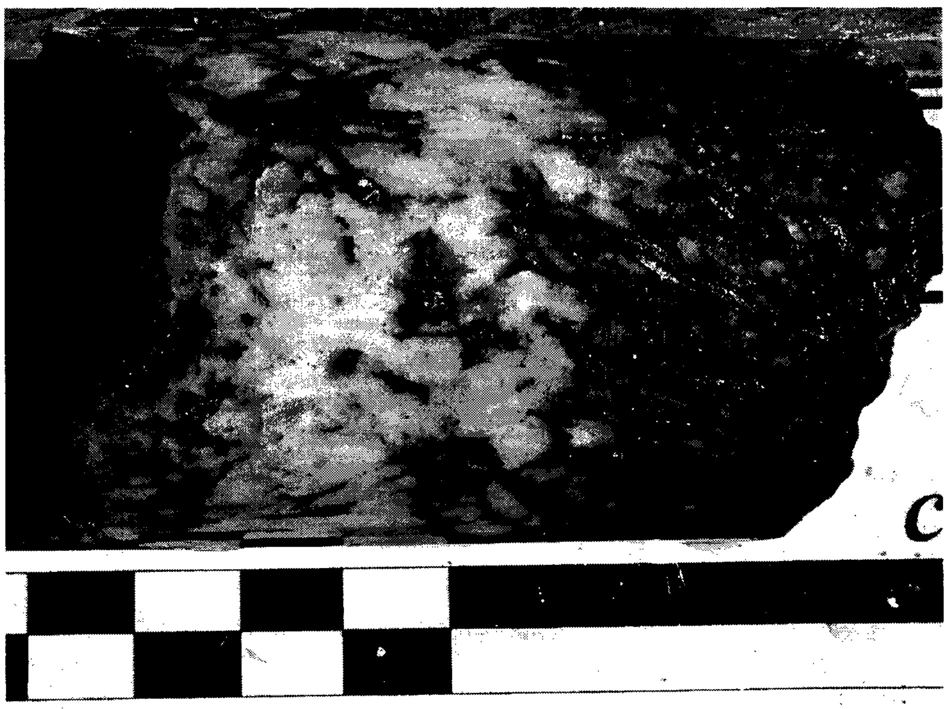


Photo 8.20. Example of a quartz-sulphide extension vein from Goddell. In this zone, many of these veins are dominated by stibnite, with minor sphalerite, pyrite and/or galena. They apparently carry some Au grade, as intervals that contain such veins as the only mineralized feature commonly have several g/t Au. The stibnite and accompanying sulphides typically occur along the broken boundaries of early, coarse-grained quartz where it is replaced by a later stage of fine-grained quartz. Carbonate is not common in these veins. Sample G97-35-149.7.

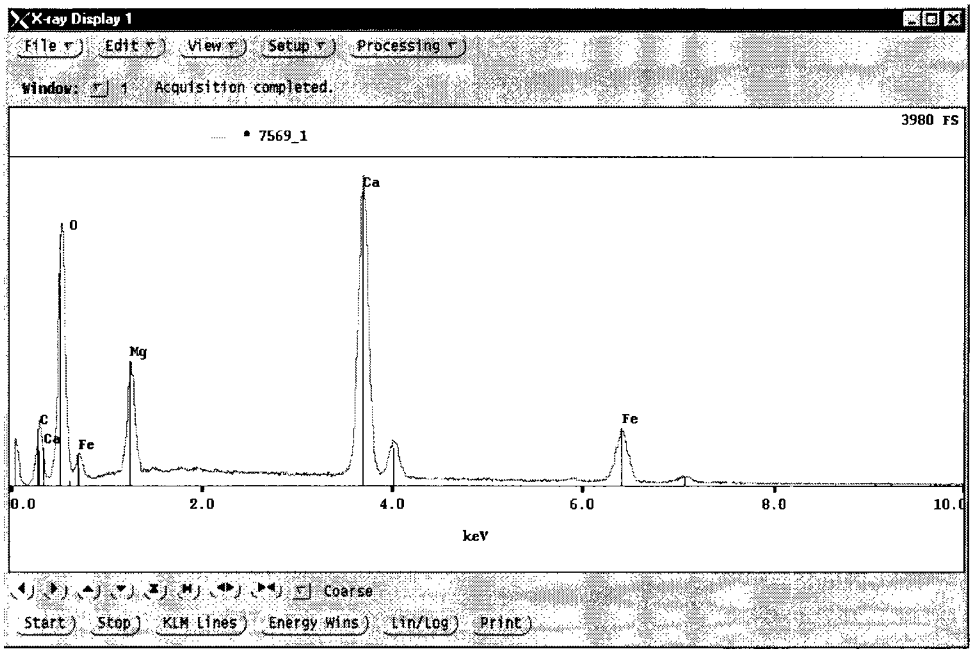


Figure 22A. Ferruginous dolomite or ankerite in pervasive peripheral (brownish) alteration around the Goddell Zone. Most carbonate is Fe-bearing at Goddell, which distinguishes it from Rainbow-Ridge. Spectrum obtained from an altered biotite grain in sample G97-58-85. Similar compositions, with variable Fe and commonly with minor Mn, are found in all types of alteration at Goddell.

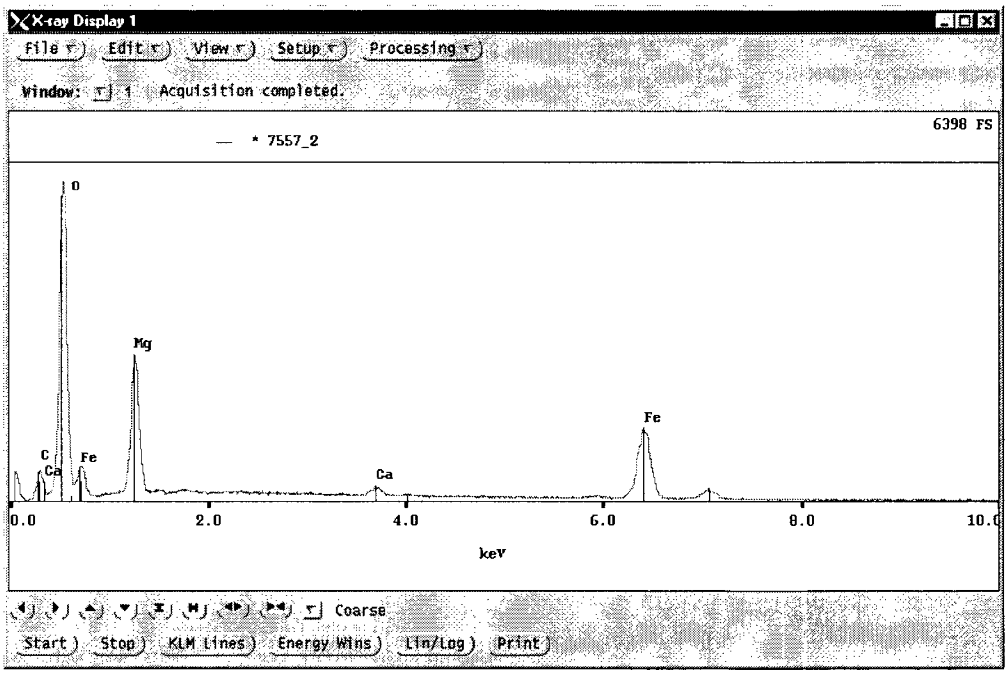


Figure 22B. Mg-Fe-(Ca) carbonate common in the Goddell Zone. Similarly Fe-rich carbonates are very rare at Rainbow-Ridge. Sample G97-56-155.1B.

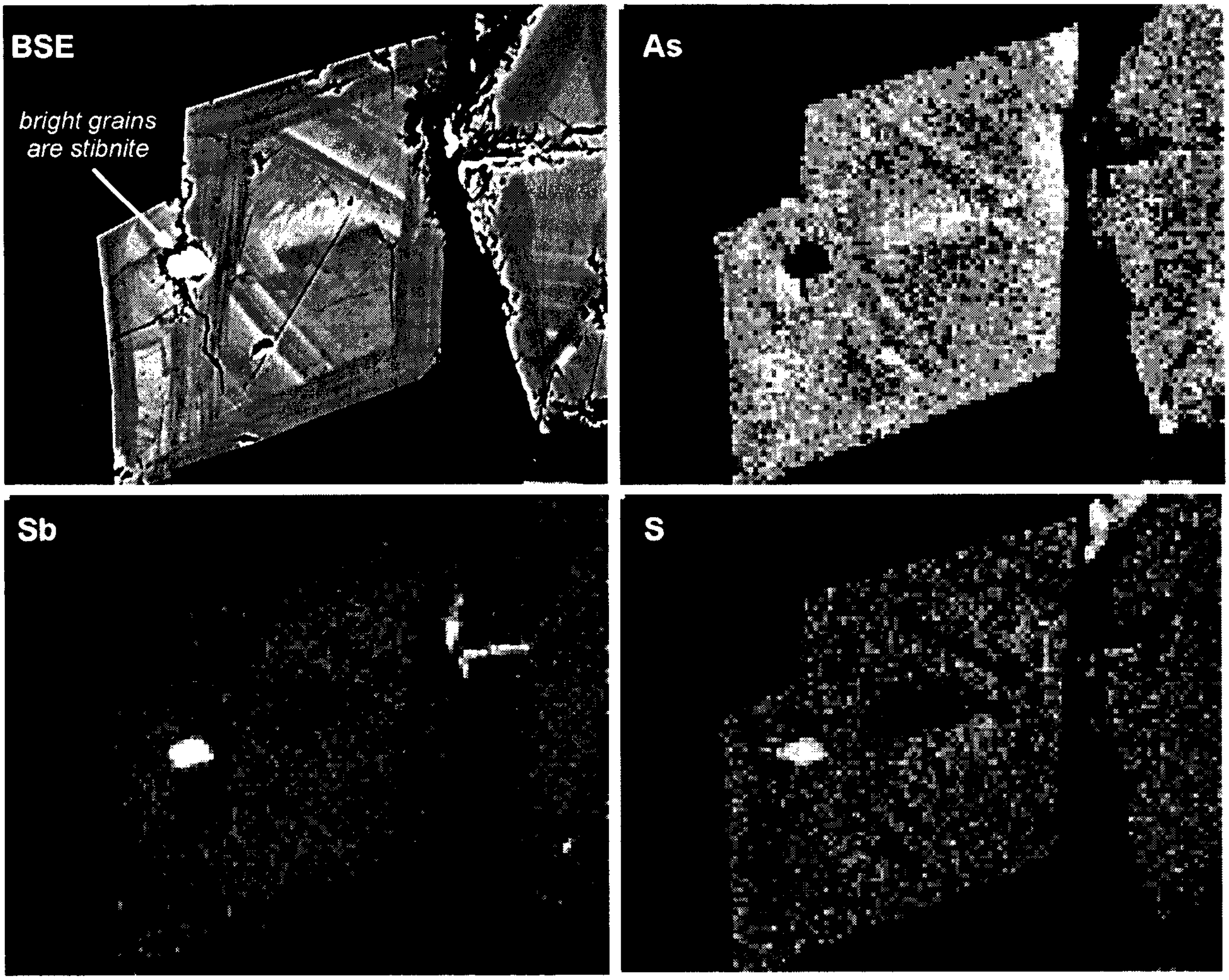


Figure 23. BSE image and accompanying X-ray maps for As, Sb and S in zoned, euhedral, acicular arsenopyrite from sample G97-38-167.8. Grain is about 15 microns across, and is hosted by quartz (black parts of image). Bright grains are stibnite. Zoning is geometrically complex and is defined by variations in Sb, As and S. A high detection limit precluded detection of Au peaks, even for long count times, in this or similar grains, even though empirical observations suggest that most or all Au at Goddell must be hosted in such material (and/or arsenian pyrite).

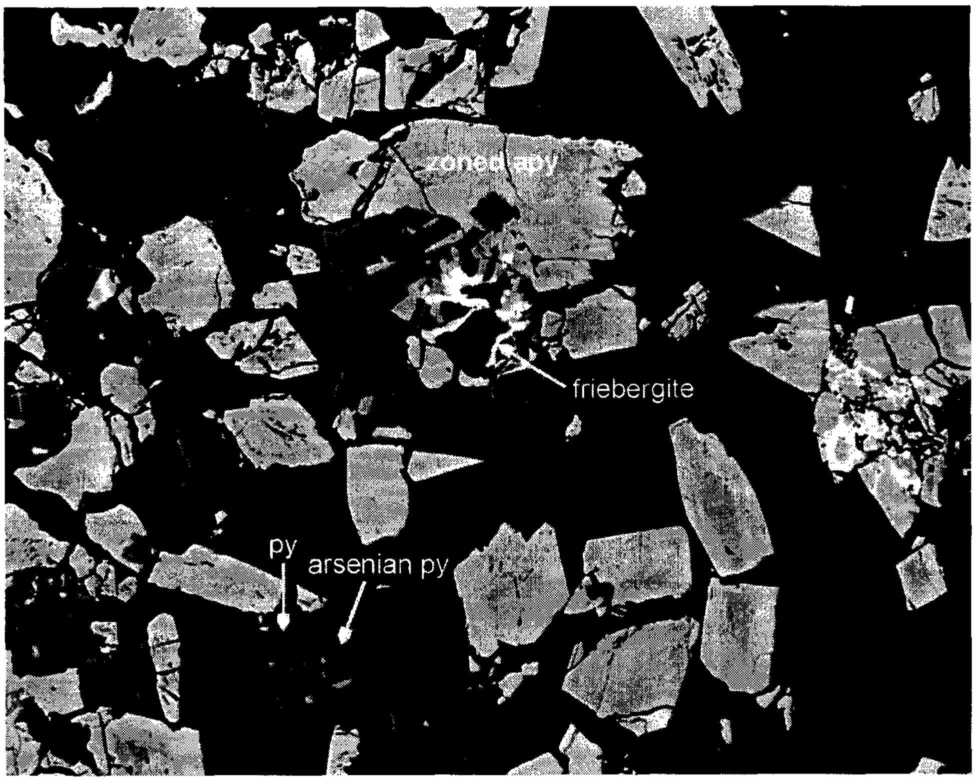


Figure 24. Back-scatter electron image of typical ore in altered andesite. Zoned, commonly acicular arsenopyrite grains are associated with pyrite that has As-rich and As-poor zones. This sample also contains a late stage of freibergite that replaces the pyrite and arsenopyrite; freibergite is very rare at Goddell, but is extremely common and the main carrier of Ag at Rainbow-Ridge. Sample G97-59-159; FOV ~400 microns.

8.4 Conclusions and exploration recommendations, Goddell Gully zone

1. The Goddell fault comprises an anastomosing network of dark grey matrix lithified cataclastic shear zone surfaces that are spatially associated with a set of rhyolite dykes. The shear zone and its associated damage zone form a distributed zone of cataclastic zones separated by altered wallrock that widens upwards to nearly 200 m at surface, although the principal shear zones and cataclastic slip surfaces of the fault system occur in a 10 to 30 m wide core. The structural style and timing relationships between dykes, shear zones and mineralization/alteration in the Goddell fault are similar to those in the Skukum Creek and Chieftain Hill areas, and suggest early phases of probable syn-tectonic dyke intrusion, overlapping semi-brittle shear zone displacement and cataclasis, and syn-tectonic mineralization and alteration. Structural style of the Goddell fault most closely resembles that of shear zones in the Chieftain Hill area which occur along strike to the west.

2. Mineralization in the Goddell Gully area is developed within, and to the south of, the main strands of the Goddell fault. It occurs in areas of pervasively disseminated arsenopyrite mineralization with local associated quartz-sphalerite-stibnite extension and shear veins, that form crudely tabular, moderate to steeply north-dipping mineralized zones within the damage zone of the Goddell fault system. These mineralized zones may in part be localized along minor north-dipping splays off the main Goddell fault system that have potential to occur in a stacked array with further zones developed at intervals above and below the mineralization in the PD

zone. A westerly plunge is suggested by the intersection of some areas of mineralization with the main Goddell fault in the PD zone. Local occurrence of mineralization in the main cataclastic strands of the Goddell fault also suggests the potential for steeply dipping, laterally continuous mineralization in the main part of the Goddell fault.

3. Petrographic samples from Goddell Gully show that alteration and mineralization differ significantly from the Rainbow-Ridge, and to a lesser extent the Chieftain Hill, areas. The main differences at Goddell Gully compared to other zones include: 1) much lower concentrations of chlorite and epidote; 2) much higher concentrations of barite; 3) closer confinement of intense alteration to the interior or immediate wall rocks to the main shear zone with little development of lateral zoning patterns; 4) much lower pyrite concentrations in sericitic alteration outside of strongly mineralized intervals; 5) virtual absence of native Au or electrum, with Au inferred to be bound in the crystal structure of acicular arsenopyrite and/or arsenian pyrite; 6) the main host to Au mineralization is andesite dykes, with only minor Au mineralization in rhyolite/QFP or plutonic host rocks; 7) very low Ag concentrations that result from only trace precipitation of freibergite, and a relatively greater proportion of the Ag budget may be hosted by stibnite; 8) base metal sulphides are much less abundant, especially galena; 9) disseminated mineralization is relatively more important; 10) carbonate is mostly Fe-enriched, with only rare calcite; 11) late quartz-sulphide extension veins are much less common and have comparatively higher concentrations of stibnite; 12) the mineralizing event appears to have been less cyclical; and 13) indications are for lower temperatures and higher oxidation states. Petrographic work was completed only within the main PD zone. As new compilation efforts and surface examination continues in the area of the Goddell Gully – Porter Fault – Becker-Cochrane block, it is recommended that additional petrography of altered and mineralized samples be undertaken for comparison to results from the PD zone as an aid to interpretation of possible lateral variations in the hydrothermal setting.

4. A complete compilation of drilling, geological mapping, and geochemical sampling data for the Goddell area is recommended, including the construction and interpretation of cross sections that incorporate both surface and underground drill holes. Emphasis should be placed on defining the limits of the fault system and associated damage and alteration zones for further drilling. Construction of a new and complete set of cross sections through the Goddell zone is required. This may necessitate salvage and relogging of drill core, using the observations on the relationship of alteration, mineralization, faults and dykes outlined herein.

5. Further underground drilling on the PD zone should be conducted after the recommended re-evaluation outlined above. Potential targets include: 1) areas of open mineralization, and in particular areas down or up plunge of westerly plunging mineralization apparent on long section; and 2) potential repetitions of mineralized zones with depth, as stacked splaying faults intersect the main Goddell shear zone. Additional targets in such a program might be identified after core relogging and construction of new cross sections. Further underground development may ultimately be required to test areas to the east that are under greater depths from surface beneath Carbon Hill. Future drill holes should be planned to pass across the entire damage zone of the Goddell fault system, since these is potential for mineralization across its entire width.

6. Surface mapping and prospecting of the entire Carbon Hill area is recommended with emphasis on the distribution of potentially mineralized structures and alteration. Evaluation of gossans and northeast-trending lineaments that may reflect linking extensional structures between the Goddell and Porter faults should be emphasized. Further evaluation of the Goddell and Porter faults should also be undertaken, with structural examination of any fault exposure to determine fault kinematics to constrain structurally favorable segments. Systematic rock chip and soil geochemical sampling should accompany the mapping program to aid target identification.

9.0 MAGNETIC SUSCEPTIBILITY STUDY

9.1 Introduction

Magnetic susceptibility (MS) simply measures the ability of a substance to be magnetized. In felsic to intermediate intrusive rocks, MS primarily reflects the abundance of fresh magnetite and can be used to subdivide fresh intrusions. Many types of alteration in the magmatic-hydrothermal setting are, however, magnetite destructive and MS can also be used to document such alteration. In particular, MS results can be used to anticipate the probable size and intensity of magnetite-destructive alteration zones related to ore deposits and thereby aid design of magnetic exploration surveys.

MS traverses were completed in six drill holes from the Skukum Creek area. A KT-9 hand-held magnetic susceptibility meter was used. The typical method was to plot the average of 5 to 10 measurements from a given core box at its mid-point in depth. Where more than one rock type was present, measurements were mostly collected on the predominant phase. Results of these traverses are plotted on Figures 25 to 30, and principal observations are described below. Interpretation was aided by the predominance of relatively homogenous hornblende granodiorite in most of the drill holes, which minimizes background variation.

9.2 DDH 98GE-1, Golden Eagle Zone (Figure 25)

This hole was examined as a background case because it did not intersect any mineralization but did encounter zones of at least minor shearing.

- The overall pattern primarily reflects different background MS values for the three distinct types of intrusion (quartz monzonite, hornblende granodiorite and diorite) that were intersected.
- Dips in the MS value can generally be related directly to zones of stronger alteration, mostly centred upon individual or groups of fractures/shears (some are marked on Figure 25).
- There are two zones of shearing marked on Figure 25. Dykes, which are largely absent elsewhere in the hole, are found in or adjacent to the two shears. These shears are not strongly developed, however, and are more akin to the damage zones found around the major mineralized shears.
- The shearing has had little to no effect on MS patterns.
- Results suggest that poorly or unmineralized shears may not have a significant MS expression, and therefore would not generate interesting anomalies in magnetic surveys.

9.3 DDH 98BZ-1, Bonanza Zone (Figure 26)

This hole was examined as a possible transitional example between poorly to unsheared rock, such as 98GE-1 above, and well-mineralized shear zones as described below. DDH 98BZ-1, in contrast to 98GE-1, has at least one major shear zone that contains strong pyrite mineralization but which returned no significant base or precious metal values. The traverse is less detailed than in other holes examined, and evaluated only the effects around the major shear zone.

- The MS pattern very clearly defines the boundaries of the shear zone, which occurs in homogeneous hornblende granodiorite host rock.
- Reconnaissance examination of drill core above and below the shear suggests that distributed shearing and alteration are not significantly developed outside the main shear, and that there is little or no significant variation in background MS values.
- Although the MS effects of the main shear zone define extremely abrupt changes, there is essentially no effect peripheral to the shear. This can be compared to the effects around strongly mineralized shears as described below.

- **Conclusion.** Un- or weakly-mineralized shear zones may have a marked, but structurally very confined, MS reduction. The lack of dispersion of MS effects reflects the absence of peripheral, pervasive, magnetite-destructive alteration effects. The narrow zones of MS reduction around such features suggests that, although they might be recognized by magnetic surveys, it is probable that they could be distinguished from more strongly mineralized shear zones.

9.4 DDH 86-R14, Rainbow Zone (Figure 27)

This hole was examined to assess MS and alteration variations in the hanging wall to the Rainbow Zone (only a short interval was drilled in the footwall of the zone).

- The wall rocks to the shear zone are homogeneous hornblende granodiorite. It is cut only by two monzonite porphyry dykes, one in the hanging wall and the other in the immediate footwall of the shear zone.
- The upper part of the drill hole has a choppy MS pattern that reflects the sporadic presence of weak zones of sericite, chlorite, epidote and pyrite alteration, mostly controlled by discrete shears/fractures or zones of the same.
- Beginning at ~575', the intensity of pervasive sericite±pyrite alteration increases, on average. At this point most of the very high MS numbers disappear, although the overall MS signature is not substantially different from that found higher in the hole.
- At about 850', sericitized plagioclase acquires the strong Fe oxide stain in weathered core that has been described in section 5.0; as discussed in the text, onset of this phenomenon appears to mark the periphery of hydrothermal effects directly related to the main shear zones.
- At ~900', there is a marked increase in the density of chloritic shears and disseminated pyrite. The pervasiveness of sericitic alteration also increases. It is at this point that MS values drop significantly.
- This hole was drilled at -70° and oblique to the ore zone. The true width of the strongly depleted MS values is probably <150' (about 50 m). The extent of footwall MS depletion could not be assessed due to termination of the hole just into the footwall.
- **Conclusion.** The data suggest that magnetic surveys could have easily identified this well-mineralized portion of the Rainbow Zone, whose magnetic signature is significantly different from that in the un- and poorly-mineralized shear zones in DDH 98GE-1 and 98BZ-1..

9.5 DDH RG97-1, Ridge Zone (Figure 28)

This hole was used to assess MS variations in the Ridge Zone, and in particular the relationship between ICP geochemistry, alteration and MS.

- The host rocks to the shear zone are mostly hornblende granodiorite, cut by several andesite and rhyolite dykes. The uppermost andesite is a post-hydrothermal, amygdaloidal andesite.
- The pattern in the hornblende granodiorite is very choppy, alternating between relatively fresh igneous domains and areas cut by chlorite, sericite and/or epidote shears (±pyrite and quartz).
- A direct correlation between the intensity of sericitic alteration (estimated visually on a scale of 0 to 7) and MS is readily apparent in the hanging wall of the shear zone. All dykes lie within zones of low MS, except for the post-hydrothermal andesite.
- There is a visual increase in the concentration of disseminated pyrite, quartz veinlets, brown carbonate and shearing at approximately 235 metres. MS may begin to drop at this point.

- At ~265 metres, there is an almost total loss of MS response in the core. This effect continues to the end of the hole, and corresponds to a very strong increase in shearing and pervasive sericite alteration, and to the onset of a strong base metal geochemical anomaly. The zone of highest grade occurs near the end of this interval of alteration and MS depletion. The zone of MS depletion is ~100 metres in length (slightly narrower for true width).
- The last interval has a higher MS that reflects reduction in alteration intensity. It appears that the drill hole passed through a bounding shear zone and back into relatively less altered hornblende granodiorite. It is not clear if this marks the end of the main shear zone or is merely a screen of less altered rock within a larger shear zone.
- **Conclusion.** The Ridge zone, or at least the wider zone of significant shearing and geochemical anomalies, should be readily identifiable by magnetic surveys.

9.6 DDH SC01-1, Ridge Zone (Figure 29)

This hole was examined for the same reasons as RG97-1, and because it passed through the Upper Quartz Vein, Ridge, and Ridge 2 mineralized zones.

- The overall MS pattern is very similar to that of RG97-1.
- A weak base metal anomaly surrounds the Upper Quartz Vein, but has no obvious pattern of MS related to it. This is consistent with the very weakly developed mineralization, which essentially comprises a few narrow quartz-sulphide extension veins typical of those peripheral to the main shear zones.
- The strong base metal anomaly deeper in the hole and related to the main Ridge zone is well-defined by MS values. A decrease occurs in the hanging wall and its onset coincides with a marked increase in the number of chloritic and/or sericitic shears. The missing interval, which was evaluated later, contains intensely altered granodiorite, and rhyolite and andesite dykes along with breccias and veins. These rocks would certainly return no MS signature, and this pattern continues unabated into the Ridge 2 zone. Mineralization in the interval is not particularly strong, and its base is marked by a major brittle fault. Below this fault the alteration intensity is much greater, although the base metal anomaly is high throughout.
- The drill hole stopped within a zone of strong alteration and shearing and low MS values, suggesting that it may have been terminated prematurely (this has also been discussed above).
- **Conclusion**. The MS signature of the mineralized interval in this hole would be very easily recognized on magnetic surveys. The interval of strong MS depletion is at least 140 metres in length (true width somewhat narrower), and its extent into the footwall was not defined.

9.7 DDH 98TZ-1, Taxi Zone (Figure 30)

This hole was examined to both look for extensional veins similar to those at surface, and to assess MS behaviour outside of the mineralized Rainbow-Kuhn shear zones. The hole encountered no significant mineralization, although several intervals of anomalous Au-Ag values related to rhyolite and andesite dykes were encountered.

- The hole can be subdivided into three sections: 1) a zone of lowered MS in hornblende granodiorite that is cut by abundant distributed shears and several dykes; 2) an interval of hornblende granodiorite with choppy MS patterns, affected by much weaker shearing and alteration; and 3) nearly fresh hornblende granodiorite in the bottom parts of the hole.

- The area of dykes coincides with strong shearing in hornblende granodiorite. Where the shearing decreases markedly, the dykes are no longer present. Mineralization is only present within this zone of distributed shearing, and has a direct relationship to rhyolite dykes (see section 5.0).
- The MS values throughout most of the shear/dyke zone interval are low. The reduction in MS is not, however, as consistent or as extreme as that found in the main mineralized shear zones as described above.
- This drill hole shows that similar controls on dykes and alteration by zones of shearing occur outside of the main mineralized shear zones, but that the effects are not as extreme.
- **Conclusion.** The MS results suggest that the Taxi zone, which at depth comprises a broad zone of comparatively weaker shearing and dyke emplacement, would manifest a more diffuse magnetic low than the main mineralized shear zones. Although it might not be possible to confidently distinguish between zones with characteristics like those in the Rainbow-Ridge and Taxi zones, the results do confirm the viability of using magnetic signatures to track the subsurface extent of larger shear zones that may have significant exploration potential.

9.8 Implications for exploration and recommendations

The major observations that arise from the MS study are summarized below, and implications for exploration methodology are described.

- The main, strongly mineralized shear zones at Skukum Creek are enclosed by prominent envelopes of low to no MS response. The reduction in MS reflects destruction of igneous magnetite by hydrothermal alteration. The width of the effect varies, but extends for up to at least 100 metres into the hanging wall of some zones; termination of most holes after short penetration into altered footwall precludes estimation of the total width of the zones of MS reduction.
- Un- and weakly mineralized shear zones have either no or only narrow MS reduction zones.
- Data were not obtained from Chieftain Hill or Goddell Gully, but their features indicate that similar MS patterns will be present within and immediately adjacent to the main shear zones.
- Results suggest that magnetic surveys can: 1) locate new, concealed shear zones with strong alteration, shearing and potential for ore-grade mineralization; 2) track extensions of known mineralized shear zones; and 3) distinguish between barren and well-mineralized shear zones.
- Pyrite is abundant in strongly altered and better mineralized shear zones (e.g., Rainbow, Ridge), but is either absent or spatially very restricted in barren and weakly mineralized shear zones (e.g., Bonanza, Golden Eagle, Taxi). Segments of major shear zones with greater exploration potential should express IP chargeability anomalies. The low overall pyrite concentration at Goddell Gully zone suggests that IP anomalies might be much weaker than at Skukum Creek.
- The best target areas along major shear zones would be coincident magnetic lows and IP chargeability highs. These geophysical methods should be applied to those specific parts of the shear systems that are consistent with extensional domains in the structural model, and that surface mapping and geochemical sampling suggest may have potential for mineralization, as a guide to drill target identification. Example applications include tracking and assessment of the east-trending Goddell Gully and Porter faults and dilational, northeast-trending connecting structures, and west-southwest extensions of the Kuhn fault system. It may also be possible to trace prospective shear zones beneath cover in the Wheaton River valley that may connect the Chieftain Hill and Goddell/Porter areas, depending upon depth of alluvial fill.

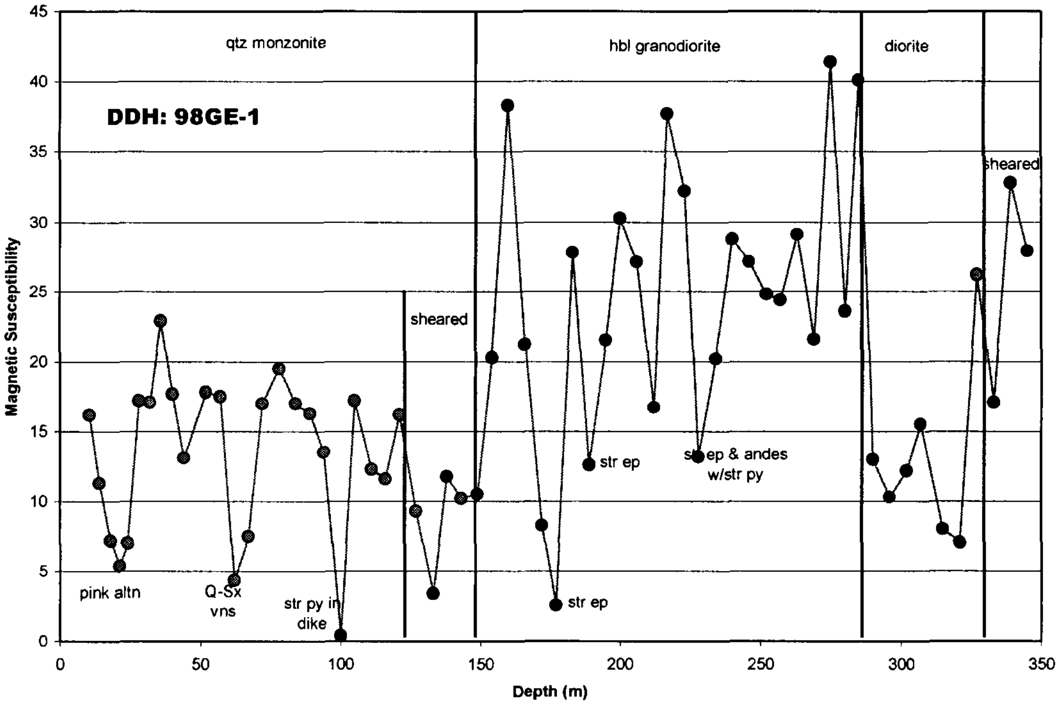


Figure 25. Magnetic susceptibility traverse through DDH 98GE-1 in the Golden Eagle zone, located south of the Kuhn fault. Traverse was completed across entire drill hole. In this and following figures points are coded for rock type: red, Mt McNeil granodiorite; brown, diorites; orange, quartz monzonite; blue rhyolite; dark green andesite; light green monzonite; pink granite.

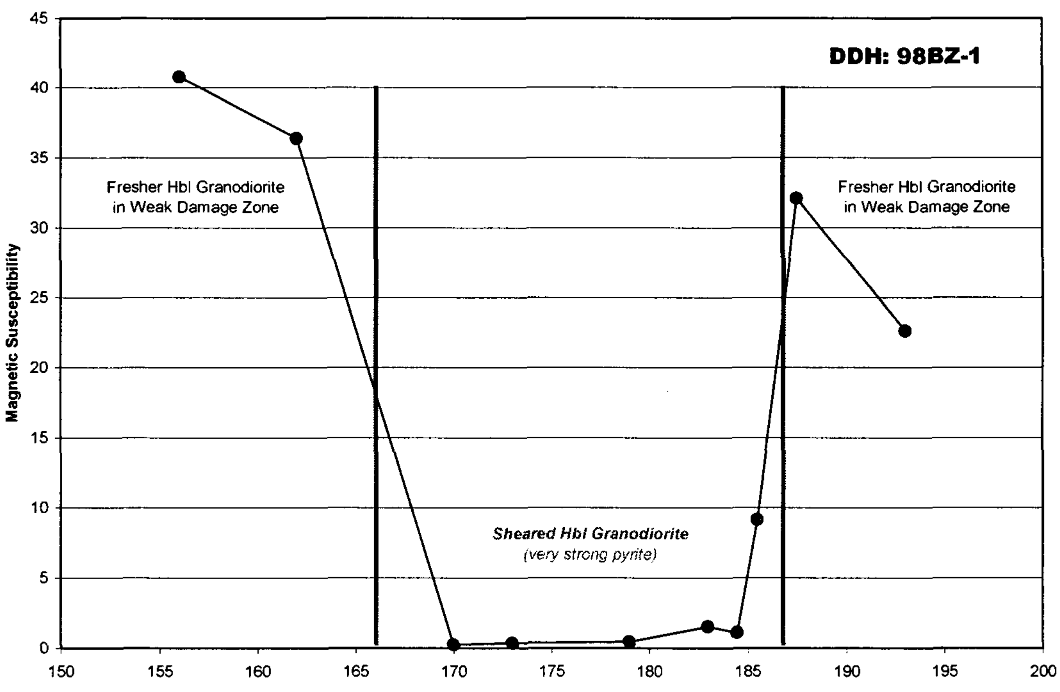


Figure 26. Magnetic susceptibility traverse through DDH 98BZ-1, the Bonanza zone located south of the Kuhn fault. Measurements were only obtained from a small part of the hole around an unmineralized (except for minor pyrite) chloritic shear zone of significant width.

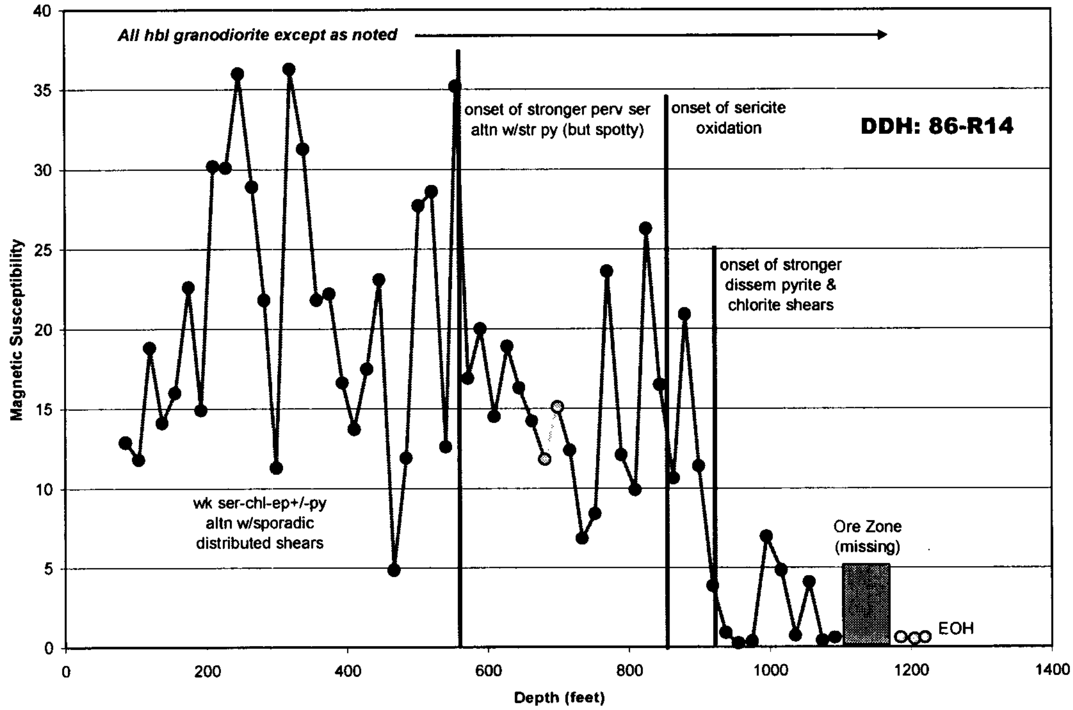


Figure 27. Magnetic susceptibility traverse through DDH86-R14, Rainbow zone. X axis is in feet to conform to original logging. Drill hole did not penetrate significantly into footwall.

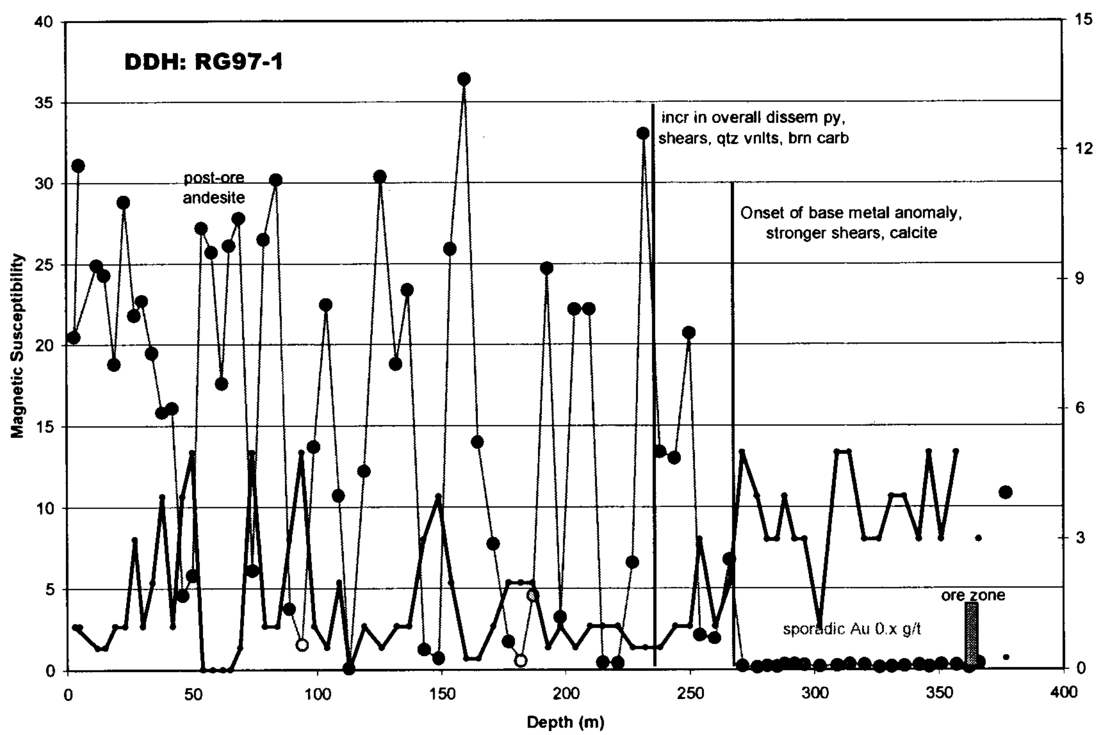


Figure 28. Magnetic susceptibility traverse through DDH RG97-1, Ridge zone. Entire hole was examined, but drilling terminated within a zone of strong alteration and geochemical anomaly.

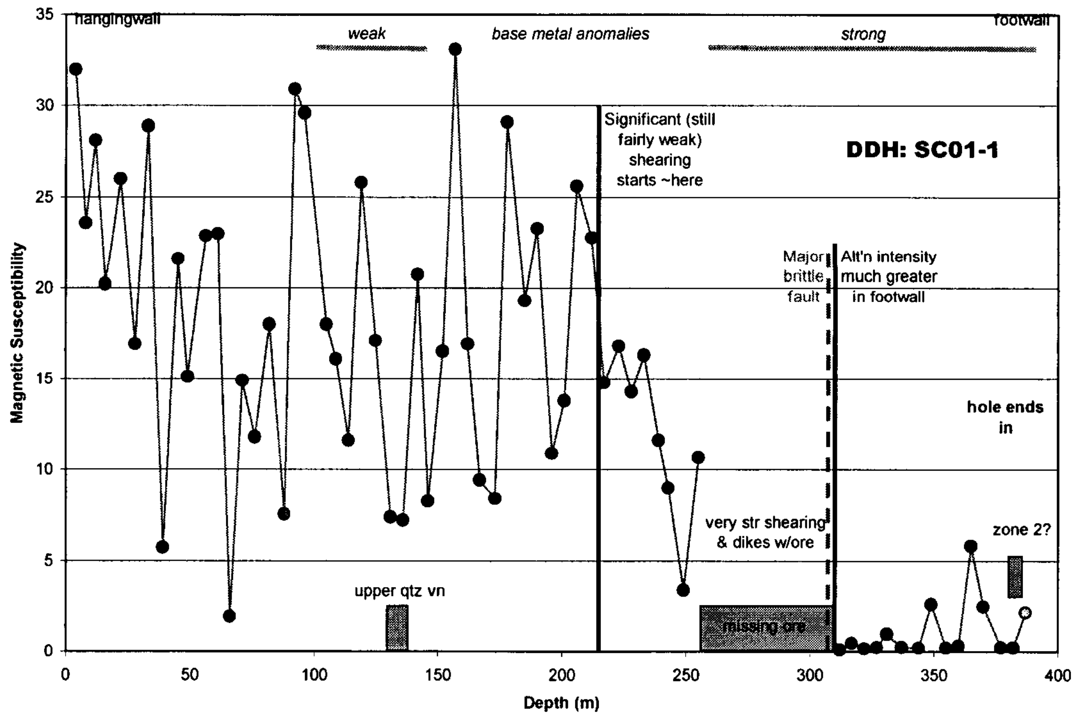


Figure 29. Magnetic susceptibility traverse through DDH SC01-1, Ridge zone. Drill logs for missing intervals indicate intensely altered rhyolite dykes, shears and veins; MS values near zero are anticipated.

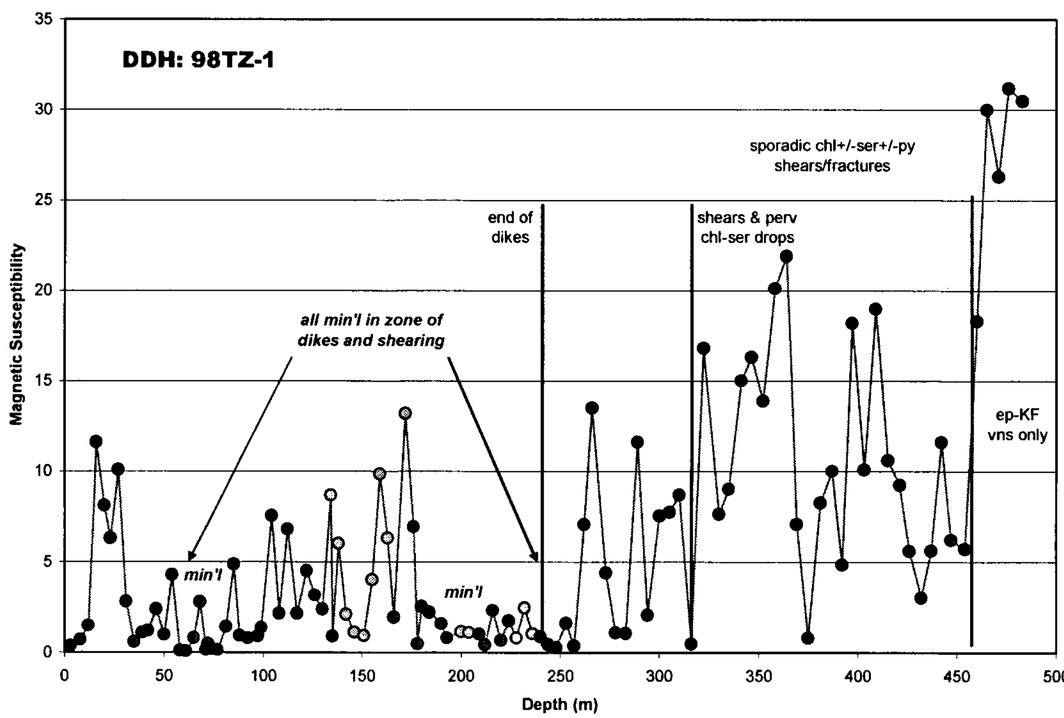


Figure 30. Magnetic susceptibility traverse through DDH 98TZ-1, Taxi zone. No significant Au-Ag grades were encountered, but mineralization directly related to rhyolite dykes is found in the upper part of the hole. See text for discussion.

10.0 CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

10.1 Structural setting

1) Au-Ag mineralization in the Skukum Creek district is hosted by semi-brittle fault systems that are spatially associated with, and in part defined by, parallel rhyolite and andesite dykes. Timing relationships between shear zones and dykes are clearest in the Rainbow zone where multiple generations of dykes include early- or pre-shear zone and also late, mainly post- or late-tectonic varieties. Phreatomagmatic monolithic and polylithic breccias are spatially associated with the dykes and locally incorporate fragments of foliated shear zones and quartz-sulphide veins, but are also affected to varying degrees by shear zone fabrics and quartz-sulphide veins. A syn-tectonic timing is suggested. The breccias may have formed by explosive interaction of magma and hydrothermal fluid in the shear zones during the mineralizing event, possibly augmented by contributions of fluids from the rhyolite dykes themselves or the magmas from which they were derived. Similarly, quartz-sulphide veins display multiple generations that exhibit varying degrees of strain, including early veins incorporated as fragments into cataclasites and younger veins that overprint cataclastic breccias; these also indicate a syn-tectonic mineralizing event. Similar relationships are present at Chieftain Hill and Goddell Gully, although fewer generations of vein are present in these areas and phreatomagmatic breccias are rare. An early set of sheeted andesite dykes is present at both Goddell and Chieftain Hill, which is cut by both rhyolite dykes and mineralized shear zones.

2) The fault systems that host mineralization in the Skukum Creek district are semi-brittle in style, and composed of lithified, foliated cataclasites with grey to tan matrices that form the main slip surfaces in the core of the structures, which are generally surrounded by foliated wallrocks that contain both pervasive foliation defined by phyllosilicate alteration minerals (sericite, chlorite), and by stylolitic pressure solution cleavage. Synchronous activity of brittle (cataclasites) and low temperature ductile (pressure solution fabrics) strain is indicated by the superposition of foliation and pressure solution seams on cataclasites, and the presence of rotated fragments of foliated shear zone material in cataclastic breccias. Cataclasites are more dominant in eastern parts of the system at Goddell and Chieftain Hill, whereas a higher proportion of shear zone material is foliated in the Skukum Creek zones, which suggests more brittle styles of behaviour to the east. This trend also corresponds with a decrease in the quantity of veining from west to east in mineralized zones, and a marked decrease in the abundance of phreatomagmatic breccias in the zones. Together, these factors suggest a decreasing total budget of syn-tectonic hydrothermal fluid from west to east, and a probable fluid source to the west.

3) A structural model for the Skukum Creek district during the mineralizing event in the area is shown in Figure 31. The model hinges on the interpretation of left-lateral/reverse kinematic indicators from underground in shear zones within the Rainbow zone, and reported apparent left lateral displacements on faults and shear zones in the Chieftain Hill area and south of the Goddell fault. Due to the restricted locations from which kinematic data were obtained, further field checking of fault and shear zone kinematics in outcrop exposures will ultimately be necessary to verify and refine the model. The inferred setting of the district is in a left lateral strike slip fault system with a reverse, south side up component. Master structures are the Berney Creek, Goddell and Porter faults. Mineralization identified thus far occurs in the dilational linking zone between these structures, at a potential jog where displacement on the Goddell fault is transferred on northeast-trending structures to the Berney Creek and Porter faults. This mineralization occurs either in the dilational northeast-trending structures, as at Skukum Creek, or in the main faults near northeast-trending splays, within this area of high structural permeability. At a more local scale in the Skukum Creek area, mineralization occurs in areas of second order dilational

stepovers and bifurcations in the northeast-trending faults, as is shown in Figure 31. The left lateral shear sense and overall structural architecture of the system are compatible with similar relationships between northeast-trending veins and east-trending faults, and with a general sinistral strike slip environment reported at the Mt. Skukum epithermal deposit by McDonald (1990).

4) Timing of shear zone activity and mineralization in the district with respect to the Skukum Creek Caldera complex could not be fully assessed due to the limitations of the scope of this study. Hart (1992B) reports that a rhyolite dyke associated with Rainbow zone mineralization has returned a 58 Ma K-Ar whole rock age, which is 5 to 7 Ma older than 51 to 53 Ma isotopic ages from the Skukum Creek volcanic complex, suggesting that the mineralization and associated shear zones predate, or formed early during the formation of, the complex. If this is the case, the assertion that the mineralized structures and associated fault systems such as Chieftain Hill and Berney Creek are caldera-bounding structures may not be valid, as the low degree of displacement and sinistral shear sense on both syn-and post-mineral displacement are incompatible with the major northwest side down displacements required if these are caldera-bounding faults. As an alternative, it is possible that the 58 Ma date may not be representative and that further, more precise dating, such as U-Pb dates on zircon, is required to better constrain timing, and thereby to assess the alternative possibility that the mineralization, shear zones and dykes may be younger than and exploit older caldera-bounding structures.

5) In the Skukum Creek area, kinematic indicators on semi-brittle shear zones in the Rainbow zone suggest a left lateral shear sense with a reverse (south side up) component. This slip vector is at a high angle to steep, easterly plunging, thickened chutes of veining, high Au and Ag grade X thickness, and total zone thickness in the Rainbow, Kuhn and Sterling zones, consistent with dilation and bends at steps in the structures during displacement. A subsidiary, moderate to shallow east-plunging set of chutes is parallel to left lateral normal slip indicated on late faults that overprint the shear zones, suggesting modification of the steeply plunging chutes by this late stage. North-northeast trending, steeply dipping quartz-sulphide extension veins, including those in the Taxi zone and veins developed throughout the underground workings, have orientations consistent with formation during dominantly sinistral displacements along the zones.

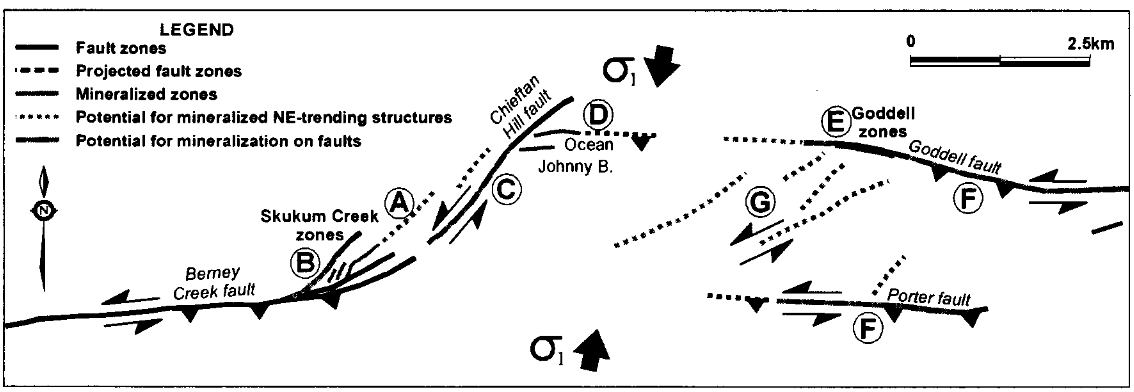


Figure 31: Structural model of the Skukum Creek district during mineralization, in a predominantly sinistral fault environment. Potential areas of further mineralization in dilational structures and shear zones are shown. See text for details. Letters A-G refer to exploration target areas in the text (see point 6).

6) Exploration target areas inferred by the structural model include:
    a. Northeast-trending extensions of shear zones in the Skukum Creek area (e.g. Rainbow East under Chieftain Hill),
    b. Splays, junctions and extension veins at stepovers of mineralized shear zones in the Skukum Creek area (e.g. Ridge zone; Kuhn fault/King Canyon fault junction in Ridge 2 zone area; extension veins in Sterling, Rainbow west extension and Kuhn East areas),
    c. The Chieftain hill fault system, which occurs in a prospective, northeast-trending orientation;
    d. Down dip extensions of potentially dilational chutes on the Ocean shear zone;
    e. Lateral and vertical extensions of mineralization in the PD and Golden Tusk zones at Goddell, which may occur in vertically stacked mineralized bodies at minor fault splays off the Goddell fault;
    f. Prospective structural sites laterally along the Goddell and Porter faults, including at fault splays and bends;
    g. Potential northeast-trending linking faults between the Goddell and Porter faults on Chieftain Hill, which may be reflected by lineaments and associated gossans.
7) Evaluation of the structural exploration targets in the Chieftain Hill and Carbon Hill areas (Goddell and Porter faults) requires a program of surface mapping, prospecting and systematic geochemical sampling in conjunction with compilation of historical data. Structural examination of fault exposures is recommended as part of this program to assess the kinematics and exploration potential of faults not observed in outcrop during this study, and to refine the camp scale structural exploration strategy. Diamond drilling will be necessary to further outline mineralized zones and test target areas in the vicinity of the Rainbow, Kuhn, Rainbow East (Raca), Sterling and Ridge zones, as discussed above, and detailed in section 6.4.

10.2 Alteration and mineralization

1) Hydrothermal characteristics follow a broadly similar theme across the district. Main alteration types include pervasive and fracture-controlled K-feldspar, sericite, chlorite, epidote and carbonate assemblages. Au-Ag and base metal mineralization is related to quartz-sulphide veins of initially extensional character subsequently deformed during movement on the controlling structures, but also occurs disseminated or controlled by micro-fractures. The presence or absence and relative importance of these hydrothermal assemblages and characteristics vary across the district, as outlined in Table 1 which compares the Rainbow-Ridge, Ocean-Rainbow East (Raca), Goddell Gully and Mount Skukum vein systems, and discussed briefly below.
2) The hydrothermal fluids have an important link to rhyolite dykes that almost certainly reflects more than simple structural coincidence. It has been validly noted that monolithic rhyolite breccias may reflect interaction of rhyolite dykes with fluids in the controlling structures. In DDH 98TZ-1 in the Taxi zone there are also several rhyolite dykes that lack marginal brecciation, but do contain abundant disseminated sulphide and are cut by numerous quartz-sulphide veinlets anomalous in Au, Ag and base metals. This suggests a direct link between metals, fluids and at least some stages of rhyolite. At Goddell Gully, only the Central Marker dyke, which is texturally and mineralogically similar to mineralized rhyolite dykes in the Taxi zone, is significantly altered and mineralized; the South and North Marker dykes are texturally and mineralogically distinct quartz-feldspar porphyries that lack significant hydrothermal effects. A genetic link between felsic magmas and Au-Ag ores is also suggested by McDonald (1990), who reports a substantial background enrichment of Au in rhyolite dykes and in rhyolitic subvolcanic

intrusions near the Mount Skukum mine. It is probable that one or more stages of rhyolite dyke, or their deeper source magmas, supplied or significantly contributed to the fluid and metal budget of the district.

3) Gold has two principal manifestations. In the Skukum Creek deposits, most Au occurs as electrum with trace to minor native Au. The Au occurs in quartz-sulphide extension veins, or their deformed equivalents, and is commonly related to a relatively late stage of fine-grained quartz and base metal sulphides that replace early coarse-grained quartz, pyrite, arsenopyrite, and possibly sphalerite. At Goddell Gully, Au grades have a direct spatial relationship to zones of disseminated acicular arsenopyrite and/or arsenian pyrite; a smaller amount of Au of unidentified mineralogical residence occurs in coarse-grained quartz-stibnite-sphalerite extension veins that lack acicular arsenopyrite. At Skukum Creek the Au is free milling, whereas at Goddell Gully it is inferred to be largely refractory. The Ocean and Rainbow East (Raca) veins contain Au in both main styles, and traces of acicular arsenopyrite are also found at Rainbow; the acicular arsenopyrite mineralization is almost always late in the hydrothermal paragenesis. Electrum at Skukum Creek has a clear temporal and spatial relationship to base metal sulphide mineralization, and in particular with galena and stibnite that replace earlier base metal sulphides; stibnite and trace galena are also associated with acicular arsenopyrite at Goddell Gully, further suggesting a temporal link between Pb, Sb, Ag (see below), and Au.

4) The main host to Ag is freibergite (Ag-rich tetrahedrite). This mineral is abundant at Skukum Creek and locally on Chieftain Hill, where high Ag grades are common, but is nearly absent at Goddell Gully which has very low Ag grades. Minor concentrations of Ag are also present within galena, stibnite, chalcopyrite and sphalerite, and at Skukum Creek both native Ag and argentite are also present; but even in aggregate these minerals probably do not contribute significantly to the overall Ag budget in the district. The main episode of Ag precipitation was contemporaneous with precipitation of base metal sulphides and Au. Variations in Ag/Au ratios do not, therefore, reflect differences in the relative proportion of distinct paragenetic stages of mineralization, but must instead reflect P-T-X variations in the fluids; this is compatible with the marked increase in Ag/Au ratio in quartz-sulphide extension veins with distance from the main shear zones which form the thermal and fluid flow centres of the hydrothermal system.

5) Zoning phenomena are present within individual zones and across the district as a whole. At Skukum Creek, chlorite changes from green and Mg-rich to black and Fe-rich peripheral and proximal to main shear zones, respectively. The intensity of shearing and of pervasive and fracture-controlled sericite and carbonate alteration also increases toward mineralization. There is a distinct stage of epidote-rich shear veinlets that occur preferentially in the footwall of the Ridge and Rainbow zones. Quartz-sulphide extension veins are Ag-rich with low Au outside the main shear zones, but contain substantially higher Au grades proximal to the main shears. At Goddell Gully, lateral zoning is not strongly developed, and alteration drops off much more abruptly outside of the main zone of shearing on the Goddell fault. Chlorite and epidote are much less abundant at Goddell Gully compared to Ridge-Rainbow.

6) Many characteristics support a general eastward change in hydrothermal character from the Ridge zone to Goddell Gully. Structural features have been outlined above that support an eastward decrease in temperature regime. Some hydrothermal features that support a lower temperature or more distal setting for Goddell Gully include: 1) less dispersion of alteration around the main shear zone; 2) an absence of K-feldspar alteration, which occurs only at Skukum Creek; 3) lack of molybdenite which has been found only at Ridge; 4) less cyclical development of veins suggesting a lower, more passive fluid flux; 5) more abundant sulphate minerals compatible with a higher oxidation state in the fluids; 6) the dominance of acicular arsenopyrite, which is typically the last, presumably lowest temperature, stage of mineralization at Rainbow and Ocean/Rainbow East (Raca), as the main style of Au mineralization; 7) much lower Ag and base metal

concentrations, particularly of Cu, and possibly higher concentrations of Sb; and 8) predominance of Fe and Mg-enriched carbonates, which form only a late, plausibly lower temperature stage of carbonate precipitation at Skukum Creek. This pattern may reflect exposure of veins at increasingly shallower paleodepths to the east, a simple decrease in temperature regime, and/or a significant lateral component of fluid flow from a thermal and fluid source in the west. Fluid inclusion studies, although not recommended at this time, could be used in future to compare paleodepth indications obtained by microthermometry on boiling assemblages in late, undeformed quartz-sulphide extension veins across the district.

7) Studies of magnetic susceptibility document volumetrically significant zones of igneous magnetite destruction within and around the main mineralized shear zones. These zones range up to at least 100 to 150 metres in width, and largely outline the lateral extent of sericitic alteration related to the main sulphide-precipitating event. Barren and weakly mineralized shear zones lack the large zones of magnetite destruction. Magnetic surveys should be able to: 1) locate new, concealed shear zones with strong alteration, shearing and potential for ore-grade mineralization; 2) track extensions of known mineralized shear zones under cover; and 3) distinguish between barren and well-mineralized shear zones or sub-segments of shear zones. Well-mineralized shear zones also contain substantial volumes of rock with abundant pyrite, whereas poorly- to un-mineralized shear zones lack or have only narrow zones of strong pyrite. Use of geophysical surveys to look for coincidence of magnetic lows with IP chargeability highs may therefore be an excellent method for focusing exploration and drilling on specific, more prospective segments of larger shear zones, particularly those compatible with extensional settings in the structural model.

Table 1. Comparison of Skukum Creek, Ocean Goddell and Mount Skukum vein systems.

	Ridge-Rainbow-Rainbow East (Raca)	Ocean	Goddell Gully	Mount Skukum (McDonald 1990)
structural style	strong ENE-trending central shear zone with a wide surrounding zone of distributed shearing that creates a diffusely bounded zone overall	well-defined NE and E-trending shear zones with less widely distributed shearing	well-defined E-ESE trending shear zone that may flare upward; distributed shearing in surrounding wall rocks weak to absent	large, NNE-NE trending brittle faults without significant shearing
mineralization style	mainly in strongly brecciated and sheared quartz-sulphide veins that were probably extensional in origin initially; minor mineralization in undeformed extension veins; lower grade material in monolithic breccias	very similar to Rainbow-Ridge comprising mainly brecciated quartz-sulphide veins and lesser undeformed extension veins; also contains acicular arsenopyrite mineralization similar to main style at Goddell Gully	mainly as pervasive alteration of andesite dykes by quartz, carbonate and acicular arsenopyrite and/or arsenian pyrite; quartz-sulphide extension veins insignificant	carbonate>quartz veins best host to Au ore; abundant dilation with ores in crustiform veins and banded matrices to breccias
mineralization host	main hosts are rhyolite dykes and Mt McNeil granodiorite; minor amounts in altered andesite dykes	Mt Ward granodiorite (Cretaceous; Ocean vein); possibly in some rhyolite dykes but insufficient examination	highest grades and greatest volume in andesite dykes with pervasive acicular arsenopyrite mineralization; minor, lower grade mineralization in Carbon Hill pluton; trace mineralization in rhyolite/QFP dykes	volcanic rocks of the Skukum Volcanic complex; some mineralization in rhyolite and andesite dykes and brecciated equivalents
extension veins	widely dispersed around the main shear zones but volumetrically minor, and some larger veins close to main shears; commonly contain high grades of Au and Ag proximal and distal to main shear zones	insufficient examination; strongest mineralization appears to be related to quartz-sulphide extension veins within the main shear zone	are common but contain more stibnite than in other zones; dispersion around the main shear zone is uncertain due to distribution of drill holes examined	the main veins formed as extensional features along major faults; peripheral extension veinlets rare to absent
breccias	major component of main shear zones; includes monolithic rhyolite breccias, polylithic breccias, and brecciated quartz-sulphide veins; probably multiple episodes of brecciation	similar to Rainbow-Ridge but at diminished intensity and scale	much less common than at Rainbow-Ridge; polylithic and monolithic varieties are only rarely present and do not appear to have formed in multiple episodes	mostly hydrothermal; also breccias at margin of rhyolite dykes, and 'pebble dykes' that may be an equivalent of polylithic breccias in other zones
cyclicity	multiple stages of mineralization and passage of hydrothermal fluids	appears to be limited	appears to be very limited	single stage of Au-Ag precipitation, but may also be cycles present
pyrite-arsenopyrite assemblages	early assemblage, mostly predates main Au-Ag; also present in later stages that may reflect cyclical nature of quartz-sulphide mineralization	mostly early, but observations are limited	pyrite is the main early mineral but is not as abundant as at Rainbow; arsenopyrite is mostly of intermediate to late age and in acicular form	minor to locally important, typically older than Au-Ag mineralization; dominated by pyrite, and arsenopyrite not reported
pyrite	normal, abundant	normal, abundant	mostly arsenian composition with early stage of normal composition; overall less abundant than at Rainbow-Ridge	no chemical data, but probably normal (based solely upon petrographic descriptions)
arsenopyrite	normal (non-acicular), locally abundant, probably not directly related to Au mineralization; traces found in acicular form, mostly in Rainbow zone	combination of normal and (usually later) acicular forms; suggests a combination of refractory Au and free Au/electrum	only acicular observed, dominates high grade Au zones where the Au may be almost completely refractory	not reported
chalcopyrite	common, mostly associated with late stages of base metal introduction	minor, in base metal association	rare and associations not clear	traces in Lake vein only
sphalerite	mostly, but not invariably, low Fe concentrations and light colours; chalcopyrite disease very common	no data; mostly light colours with implied low Fe	almost no Fe; chalcopyrite disease rare to absent	important phase in Lake vein but no other information
tetrahedrite/ freibergite	abundant as friebergite	present as limited or more erratically distributed amounts of friebergite	very rare freibergite; tetrahedrite-tennanite without Ag more common but still very minor	not reported

Table 1. Continued.

base metal sulphide assemblages	very abundant comprising major sphalerite and galena, minor to abundant stibnite, trace to minor chalcopyrite, and one case of molybdenite	very abundant and similar to Rainbow-Ridge (without molybdenite)	very minor overall; possibly contains a relatively greater proportion of stibnite, and much less chalcopyrite and sphalerite	Absent from Main Cirque vein, but up to several percent sphalerite, galena and trace chalcopyrite in Lake vein
sulphates	one sample with trace barite	none	barite common	barite and anhydrite very common
Ag	highest grades mostly in freibergite, lesser in argentite and native Ag, trace in crystal structure of galena, sphalerite, chalcopyrite and stibnite	intermediate grades; mostly in freibergite with minor argentite and native Ag	very low grade; traces in stibnite which may be the main host, and in trace freiberite	native Ag (some exsolved from electrum?)
Au	mostly as electrum with trace native Au; main association is with sphalerite-galena-stibnite-friebergite	none observed; by analogy is probably a combination of a free electrum component related to base metal sulphide mineralization, and a late-stage refractory component related to acicular arsenopyrite	no native Au or electrum observed and no apparent base metal association; interpreted as a refractory component of acicular arsenopyrite or arsenian pyrite; some stibnite-rich extension veins carry high grades, but neither Au minerals nor arsenopyrite were observed	electrum
Ag/Au	variable and commonly high; many values >100	variable and commonly high, although more erratic than at Rainbow-Ridge; many values >100	typically close to 1	0.8 at Main Cirque vein
chloritic alteration	very abundant throughout and most widely dispersed alteration; varies from Mg-rich peripheral to Fe-rich proximal to main shear zones	intermediate concentrations, most distal to main shear zones	almost none except minor amounts peripheral to main shear zones	found as the main component in peripheral propylitic alteration
sericitic alteration	major alteration mineral most closely related to the main shear zones	major alteration phase, but not as extensive as at Rainbow-Ridge	main alteration phase within and immediately adjacent to the main shear zone; comparatively low Mg and Fe	only found close to and within the ore zones; also a pervasive phase in altered rhyolite dykes
carbonate alteration	strong association with sulphide mineralization; mostly calcite with minor Mn concentrations, lesser ankerite or ferroan dolomite, and minor to trace Fe-Mn and Fe-Mg species	no data	much less important than at Rainbow-Ridge with three main compositions: 1) calcite with minor Mn (rare); 2) Ca>Mg>Fe>>(Mn) (ankerite or ferroan dolomite); and 3) Fe-Mg>>(Ca-Mn); generally has a direct association with sulphide	mostly calcite, but minor ankerite and rhodochrosite also present in main veins; strong association with Au-Ag ores
epidote alteration	locally important proximal to veins; early stage of epidote-Kfeldspar veins may not be directly related to main shear zones	minor phase only	very minor phase only found in weak peripheral alteration	locally important in propylitically-altered andesite volcanic rocks
K-silicate alteration	common but minor; fracture-controlled and related to chloritic veins	traces only, related to chloritic alteration	not observed; K-feldspar remained near stability on altered margins of system	up to 10% adularia (but mostly about 1%) in discrete crustiform bands in veins
fluid inclusions	mostly coexisting types 1/1A and 2, but in most cases host quartz is highly strained; some indications of comparatively high temperature populations (possibly over 300oC)	coexisting types 1/1A and 2, but again hosted by strained quartz and utility for interpretation of zone in doubt	coexisting types 1/1A and 2, but mostly of apparently low or moderate temperature; interpretation limited by high strain state of most host quartz.	coexisting types 1 and 2 in boiling population; temperature peaks at 310, 270 and 190oC, and very low salinities
pressure/depth	no constraints; probably deepest paleodepth and/or highest pressure regime; fluctuations between lithostatic and hydrostatic probable due to structural regime	no constraints; probably broadly comparable to Rainbow-Ridge	no constraints; indications that it formed at shallower paleodepths or lower pressures than Rainbow-Ridge; lithostatic to hydrostatic fluctuations possible but less evidence than at Rainbow-Ridge	470 m below paleo water table; varied from hydrostatic to lithostatic due to sealing and throttling of structures

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Certificate of Author

1. I am a Professional Geoscientist employed by Lang Geoscience Incorporated, with offices at 10556 Suncrest Drive, Delta, B.C., Canada.

2. I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia, registration #25376.

3. I am a graduate of Michigan State University (1983 B.Sc in geology) and the University of Arizona (1986 M.Sc and 1991 Ph.D in economic geology).

4. I have been engaged in mineral exploration and ore deposit research continuously since graduation in 1983, and have been involved in mineral exploration in Canada, the United States, Bolivia, Mexico, Spain and Portugal.

5. I am president of Lang Geoscience Incorporated, a geological consulting firm incorporated in the Province of British Columbia

6. As a result of my experience and qualification, I am a qualified person as defined in N.I. 43-101.

7. I am an independent qualified person as defined by N.I. 43-101

8. The foregoing report is based on:
   - A study of available data and company reports
   - My personal knowledge of the geology of the property gained through my activities as an on-site consulting geologist during June, 2002.

10. I, or Lang Geoscience Incorporated, do not own or expect to receive any interest (direct, indirect or contingent) in the property described herein nor in the securities of Tagish Lake Gold Corporation or any of its affiliates.

Dated at Vancouver, British Columbia, this 28th day of October, 2002.

James Lang, P.hD., P.Geo.

David Alan Rhys
14180 Greencrest Drive
Surrey, B.C. V4P 1L9

Certificate of Author

1. I, David A. Rhys, P. Geo., am a Professional Geoscientist, employed by Panterra Geoservices Inc. at 14180 Greencrest Drive, Surrey, British Columbia, Canada.

2. I am a member in good standing of the Association of Professional Engineers and Geoscientists of British Columbia.

3. I am a graduate of the University of British Columbia with a B.Sc. (1989) and a M.Sc. (1993) in geology.

4. I have practiced my profession continuously since graduation in 1989, and have been involved in mineral exploration in Canada, Australia, Mexico, the United States, Ecuador and Peru.

5. I am president of Panterra Geoservices Inc., an independent geological consulting firm incorporated in the Province of British Columbia

6. As a result of my experience and qualification, I am a qualified person as defined in N.I. 43-101.

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9. I, or Panterra Geoservices Inc., do not own or expect to receive any interest (direct, indirect or contingent) in the property described herein nor in the securities of Tagish Lake Gold Corporation or any of its affiliates.

Dated at Vancouver, British Columbia, this 28th day of October, 2002.

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David A. Rhys, M.Sc., P.Geo.

APPENDIX III

STATEMENT OF COSTS

STATEMENT OF COSTS

Labour Costs

J. Lang	13.5 days @ $650/day	$8,775.00
D. Rhys	10.5 days @ $650/day	$6,825.00
		$15,600.00

Disbursement Costs

Petrographic Work	**$2,727.83**

Room and Board Costs

24 days @ $55.00/day	**$1,320.00**

Total Costs for Assessment: $19,647.83