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**GEOLOGY OF VOLCANOGENIC MASSIVE SULPHIDE
PROSPECTS OF THE PALMER PROPERTY,
HAINES AREA, SOUTHEASTERN ALASKA**

Darwin Green

Thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of
the requirements for the degree of Master of Science

Department of Earth Sciences

Carleton University
Ottawa-Carleton Geoscience Centre
Ottawa, Ontario, Canada
April, 2001

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**“GEOLOGY OF VOLCANOGENIC MASSIVE SULPHIDE PROSPECTS OF THE
PALMER PROPERTY, HAINES AREA, SOUTHEASTERN ALASKA”**

submitted by Darwin Green, B.Sc.
in partial fulfillment of the requirements for
the degree of Master of Science

A handwritten signature in black ink, appearing to be 'C. M. D. f.', written over a horizontal line.

Chairman,
Department of Earth Sciences

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Thesis Supervisor

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ABSTRACT

The Palmer property is underlain by mafic-dominated bimodal volcanic rocks and subordinate tuffaceous limestone and argillite that are constrained to Norian to Rhaetian age (Late Triassic) based on new conodont data. Zircon from a rhyolite flow yielded a U-Pb age of 213 ± 5 Ma. Rocks have undergone regional greenschist facies metamorphism, most likely at low- to mid- greenschist grade, and at least three phases of deformation, with the earliest and most evident being a north-south contractional deformation event. Three prospect areas – Glacier Creek, Cap and Mount Henry Clay – exhibit gross similarities in stratigraphy, alteration and mineralization, but the strata at each exhibit distinct chemical compositions and are likely not correlative. Mineralization consists of polymetallic (Zn-Cu-Pb-Ag-Au) stratiform baritic massive sulphide bodies, which are underlain by thick alteration zones consisting of quartz-sericite-pyrite $\pm$ chlorite. Baritic massive sulphide bodies are locally leached of sulphides and underlain by supergene Zn and Cu enrichment zones.

ACKNOWLEDGMENTS

This study was made possible by the generous support of Rubicon Minerals Corporation, who allowed access to all company data, covered field and analytical expenses, and provided positive encouragement throughout the duration of the study. Further financial support was provided by a Natural Sciences and Engineering Research Council of Canada–Rubicon Minerals Corporation industrial postgraduate scholarship, and a Hickok-Radford grant administered by the Society of Economic Geologists Foundation.

This study is built on a geological base for the property that was developed by numerous previous workers, including, but not limited to, geologists of the State of Alaska Division of Geological and Geophysical Surveys, the U.S. Bureau of Mines, the U.S. Geological Survey, Anaconda Copper, Kennecott Exploration, Newmont Exploration, Granges and Cominco Limited. Prospector Merrill Palmer deserves particular mention for his continued involvement and contribution to the understanding of the property. Geologists Garfield MacVeigh, Jim Oliver, Peter Lewis, Katherine Bull, Peter Daubeney, David Adamson, and Michael Gray are acknowledged for their contribution during the study. Also appreciated are the insights of the late Richard Walker after whom the new RW zone discovery at Palmer was named.

Dr. George Gehrels at the University of Arizona generously provided U-Pb geochronological analyses, and Dr. Michael Orchard of the Geological Survey of Canada conducted conodont and other microfossil analyses.

I wish to express sincere thanks to David Watkinson (my thesis supervisor at Carleton University), Harold Gibson at Laurentian University, and Garfield MacVeigh, David Adamson, and Michael Gray at Rubicon Minerals Corporation for their input to the thesis.

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CHAPTER 1

INTRODUCTION TO THESIS

Introduction

The Palmer property is located 55 km northwest of Haines, Alaska, on the eastern edge of the Saint Elias mountain range, and borders British Columbia to the west (Figure 1.1). It is underlain by a mafic-dominated, bimodal sequence of submarine volcanic rocks that host volcanogenic massive sulphide (VMS) style mineralization. The rocks are part of a 600 km long, discontinuously exposed belt of Late Triassic, rift-related volcanic and sedimentary rocks within the Alexander Terrane, which are host to numerous VMS occurrences, prospects and deposits throughout southeast Alaska and northwest British Columbia (Taylor, 1997). Major deposits in the belt include the giant Windy Craggy deposit, with reserves of 297.4 million metric tonnes at 1.38% Cu and 0.069% Co (Geddes Resources Ltd., 1991), and the precious metal-rich Greens Creek deposit, with a reserve estimate of the original orebody of 11.0 million tons grading 12.8% Zn, 4.0% Pb, 0.12 oz/ton Au, and 13.3 oz/ton Ag (Swainbank et al., 2000).

The mineralized occurrences at the Palmer property were first classified as being probably 'volcanogenic syngenetics' by Hawley (1976), and prior to the study presented within this thesis, are probably best documented by Still et al. (1991). Forbes et al. (1989)

described the geologic setting of the host volcanic rocks, yet the age, metamorphic grade, and deformation history of the rocks remained poorly constrained. These fundamental issues are addressed in Chapter 2, which presents new microfossil, U-Pb geochronologic, and petrographic data, and outlines the overall geologic setting of the property.

Massive sulphide, massive barite, and zones of intense hydrothermal alteration are exposed at numerous localities throughout the Palmer property (Figure 1.2). The different localities, or occurrences, have undergone exploration work ranging from collection of a few grab samples to diamond drilling and mapping. The three most intensively explored prospects – Glacier Creek, Cap, and Mount Henry Clay – were examined during this study. New description of these poorly understood areas is based largely on geological mapping and core logging by the author in the summers of 1998, 1999 and 2000. The structure, stratigraphy, mineralization, alteration and chemistry of the Glacier Creek prospect, site of Rubicon Minerals Corporation's new RW zone massive sulphide discovery, are presented in Chapter 3. Similar descriptions of the Cap and Mount Henry Clay prospects are presented in Appendices 1 and 2. Comparisons among the three prospect areas are presented in Chapter 4. Questions regarding tectonic setting are addressed in Appendix 3, in which new rare earth and high field strength element data for volcanic strata at the Glacier Creek prospect are discussed.

The results of the studies presented in this thesis are a major advancement in the understanding of the local geology and contribute to the growing knowledge base on Late

Triassic age VMS systems in the Alexander Terrane. Furthermore, the information will be of practical use to exploration at the Palmer property, and with a little luck perhaps aid in the discovery and development of an economic ore body.

Physiography and Access

The Palmer property covers an area of $\sim 27 \text{ km}^2$, ranging in elevation from 1000 ft to $>6500 \text{ ft}$ (305-1982 m), and is dissected by numerous alpine glaciers. Dense brush and lush forest predominate at elevations below 2500 ft (762 m) with outcrop primarily restricted to drainages. At higher elevations vegetation is sparse, consisting of lichen and alpine plants, and outcrop is excellent. The field season over most of the property is limited to the months of June to September because of early snowfall and late melting of the deep snowpack.

The eastern edge of the property lies within 3 km of the Haines highway, which connects the deep-sea port community of Haines with the Alaskan Highway at Haines Junction, Canada. Helicopter transport is the most convenient method of accessing the property, although access can be gained on foot from logging roads that approach the northeast corner of the property. ✓

Exploration History

Base-metal sulfides and barite were first discovered in 1969 by Merrill Palmer at the Main and Upper Main occurrences in the Glacier Creek prospect area. Early exploration focused on the economic potential of barite at these occurrences, and although tests showed the material to be suitable for production of drilling mud concentrates, the prospect was never developed. Many of the baritic units in the Glacier Creek prospect area are leached of most sulphides and it was not until the exploration success at Windy Craggy in the early 1980s and ensuing exploration boom throughout the belt of Late Triassic rocks of the Alexander Terrane that the base metal potential at Palmer was fully realized. In 1983, high-grade massive sulphide boulders, such as one with a diameter of 1.8 m grading 33% Zn and 2.5% Cu (Still et al., 1991), were discovered at the toe of a small ice sheet near Mount Henry Clay. Twenty-six samples of various boulders collected by the U.S. Bureau of Mines returned an average grade of 19.3% Zn, 1.0% Cu, 0.4% Pb, 38.2 g/t Ag, 0.22 g/t Au, and 20.6% Ba (Still, 1984). Four separate drill programs, totaling thirteen holes and 2958 m of core, were unsuccessful in locating the bedrock source of the boulders.

The precious metal potential at Palmer was pursued in the mid to late 1980s, with particular attention given to the Cap and Nunatak prospects. Massive pyritic barite and baritic breccia at the Cap prospect was drilled in 1988 and again in 1999. The best intercept of the four holes drilled contained 134 g/t Ag over 23.2 m. A 200 lb (91 kg)

sample from the Nunatak prospect, which was divided into thirteen separate samples, returned an arithmetic average grade of 11.84 oz/ton Ag and 0.092 oz/ton Au.

In the early 1990s, retreating ice exposed a new outcrop of massive sulphide that became known as the Little Jarvis occurrence. Chip samples from the occurrence yielded assays of 13.0% Zn, 7.0% Cu, 0.02 oz/ton Au, and 7.0 oz/ton Ag over 4.6 m (Wakeman, 1995). Rubicon Minerals' 1999 drill hole discovery of the RW zone was based on the interpretation that the Little Jarvis occurrence was correlative with the Upper Main occurrence that is located 610 m to the southeast on the other side of the mountain (Figures 1.2). Semi-massive to massive sulphide (or its leached oxide equivalent), of the RW zone has been intersected in six drill holes and the zone remains open at depth in all directions.

Figure 1.1. Location map of the Palmer property, showing terranes and major faults of southeast Alaska and adjoining parts of Canada, and major VMS deposits of Late Triassic age in the Alexander Terrane. Geology adapted from Gehrels and Berg (1994), and Monger and others (1991).

Figure 1.2. Property map showing location of major mineral occurrences, and areas of detailed study. Mineral occurrences: 1 = Gullies, 2 = Little Jarvis, 3 = Upper Main, 4 = Main, 5 = Red Creek, 6 = Mt. Henry Clay, 7 = Hanging Glacier, 8 = Cap, 9 = Nunatak, and 10 = Boundary

CHAPTER 2

GEOLOGIC SETTING

Tectonic Environment and Regional Geology

The Alexander tectonostratigraphic terrane extends along the coast of northwest British Columbia northward through the Alaskan panhandle into the Saint Elias Mountains of British Columbia and the Yukon, and westward into the Wrangell Mountains of Alaska (Wheeler and McFeely, 1991). According to Gehrels and Berg (1994), the Alexander terrane evolved along a convergent plate margin from Precambrian-Cambrian through Early Devonian time, with deposition of arc-type igneous and sedimentary rocks. These were subsequently deformed and metamorphosed during Middle Cambrian-Early Ordovician and Middle Silurian-earliest Devonian orogenies. The Middle Devonian through Early Permian was marked by relative tectonic stability with deposition of shallow marine carbonate, clastic rocks and subordinate mafic-intermediate volcanic rocks (Gehrels and Saleeby, 1987). Late Triassic rift-related volcanic and sedimentary rocks were deposited unconformably on the Permian and older rocks (Gehrels et al., 1986). Overprinting deformation and metamorphism occurred mainly during mid-Jurassic through Cretaceous accretion of the Alexander terrane to inboard Cordilleran terranes (Berg et al., 1972; Coney et al., 1980), with further

dismemberment occurring along regional-scale right-lateral strike slip faults during Tertiary and Recent times.

Regional mapping in the vicinity of the Palmer property indicates that the area is underlain by Paleozoic and lower Mesozoic metasedimentary and metavolcanic rocks that are locally intruded by Cretaceous and Tertiary granitic plutons (Redman et al. 1985; McKeveit et al., 1974; Campbell and Dodds, 1983). Paleontological data is sparse, and because of structural complexity and extensive glacial cover, stratigraphic relationships are poorly understood. Thin bedded limestone and massive marble that contain fossils of Devonian to Carboniferous age appear to be the oldest rocks in the area and are apparently overlain in depositional contact by pelitic rocks of undetermined age that are referred to as the Porcupine Slate (Redman et al. 1985; McKeveit et al., 1974). A dominantly mafic volcanic unit, which is host to VMS mineralization at the Palmer property, contains the youngest strata in the area, and is locally interfingered with the Porcupine Slate (Redman et al., 1985). The assumed Late Triassic age of the mafic volcanic rocks has been confirmed by new microfossil data described below. The unconformity that separates Late Triassic rocks from Paleozoic rocks observed elsewhere in the Alexander terrane (Gehrels et al., 1986) has yet to be recognized in the Palmer property region.

Late Triassic rocks at Palmer are correlative with the Hyd formation in central and southern southeast Alaska (Loney, 1964; Gehrels et al. 1986), as well as with the

informally named Tats group, exposed in fault bounded blocks northwest of the property in the Saint Elias Mountains in British Columbia (MacIntyre, 1986; Mihalynuk et al., 1993). The Hyd formation hosts the Greens Creek deposit, and the Tats group hosts the Windy Craggy deposit. If 150 km of Tertiary dextral offset along the Chatham Strait–Denali fault system (Hudson et al., 1982) were restored, the Palmer property would be located less than 50 km from the Greens Creek deposit (Figure 1.1), and perhaps not surprisingly, the two share similarities in their style of alteration and mineralization.

Microfossil Data

Four new conodont collections from limestone and calcareous siltstone intercalated throughout the mafic sequence yield Late Triassic, Norian to Rhaetian ages (Figure 2.1; Table 2.1), and confirm the suspected age of the rocks reported by MacIntyre (1986), which was based on a single conodont fragment from a sample collected near the Main showing. Massive cherty limestone, which is in structural contact with Late Triassic volcanic rocks northwest of the property, contains Middle Devonian age conodonts, and likely forms part of an overthrust block of Paleozoic basement.

It was hoped that detailed biostratigraphy would allow subdivision of the volcanic package and facilitate stratigraphic correlations among the numerous showings, which was otherwise difficult because of structural complexity, rapid facies changes, extensive glacier cover, and the general uniform appearance of the basaltic strata. Unfortunately,

out of the 27 samples that were collected only 11 were productive, and the fossil populations were commonly too small and/or poorly preserved to determine tightly bracketed ages.

U-Pb Geochronology

The Late Triassic age of the volcanic rocks as determined by microfossil analyses is corroborated by a new U-Pb date on zircon extracted from a rhyolite flow in the footwall to the RW zone in the Glacier Creek prospect area (Plate 1). A date of 213 ± 5 Ma was determined based on three analyzed fractions (Figure 2.2 and Table 2.2). No previous U-Pb age dates exist for the Palmer property. In general, the zircons were scarce, small and of relatively poor quality; nevertheless, there is reasonably good agreement amongst the data for the three fractions. Moderate to strong synvolcanic hydrothermal alteration may account for two of the fractions plotting above concordia (Figure 2.2).

Metamorphism

Mineral assemblages and colour alteration indices (CAI) of conodonts determined during this study indicate that rocks at Palmer have undergone regional greenschist-facies metamorphism. Mafic rocks outside zones of focused hydrothermal alteration contain

plagioclase (albite: An_0 – An_5), chlorite, calcite, magnetite, quartz, epidote, Fe-bearing carbonate (siderite or ankerite), biotite, and very rare actinolite. The scarcity of actinolite (a typical greenschist-facies mineral) suggests a high chemical potential of CO_2 , which favours formation of carbonates over Ca-bearing silicates (Miyashiro, 1994). A high chemical potential of CO_2 during metamorphism at Palmer is probable considering the abundance of intercalated calcareous sediments and a carbonate-rich pre-Triassic basement. The occurrence of biotite in slaty calcareous argillite and non-hydrothermal sericite in rhyolite is compatible with greenschist-facies metamorphism. Metamorphic mineralogy was determined by petrographic analysis of 37 thin sections of meta-igneous rocks and 4 thin sections of meta-sedimentary rocks from areas outside zones of strong synvolcanic hydrothermal alteration at the Cap, Mount Henry Clay, and Glacier Creek prospect areas (detailed petrographic reports are located in Appendix 5).

Conodont colour changes in a progressive irreversible sequence that is directly related to depth and duration of burial and the geothermal gradient (Epstein et al., 1977). The sequence of colours is divided into intervals referred to as colour alteration indexes (CAI), and the different CAI values are calibrated against a range of upper and lower geologic temperature limits (Figure 2.3; Epstein et al., 1977; Rejebian et al., 1987). Thus, by determining the CAI values of conodonts at Palmer, a range of peak metamorphic temperatures of the conodont-bearing rocks can be estimated.

In general, the CAI values of conodonts at Palmer range from 4 to 6, although a few specimens have values as low as 3 and as high as 7 (Table 2.1). Colour alteration index values between 4 and 6 correspond to a range of possible peak temperatures between 190° C and 435° C, when using 1 ma and 200 ma as limits on the duration of deep burial (Epstein et al., 1977; Rejebian et al., 1987). Some of the variation in CAI values is the result of thermal perturbations caused by igneous intrusions, and perhaps also the result of the interaction of conodonts with hydrothermal fluids. It is uncertain if there is a correlation at Palmer between stratigraphic position and CAI value, or if there is systematic variation in metamorphic mineralogy associated with different CAI values.

Conodonts of known Late Triassic age have an average CAI value of 5, which when assuming a geologically probable duration of burial between 5 and 50 ma, indicates peak temperatures between 315° C and 340° C. This temperature range lies in the lower half of the 310–475° C range under which greenschist-facies minerals typically form (Figure 2.4; Miyashiro, 1994), and suggests that the regional metamorphism that affected Late Triassic rocks at the Palmer property was lower to mid-greenschist facies, rather than upper greenschist facies as suggested by Forbes and others (1989).

A contact metamorphic aureole occurs around the Cretaceous-Tertiary granodiorite pluton exposed in the Cap prospect area. The contact metamorphism is identified petrographically by high modal abundance of biotite found in mafic country rock up to several hundred metres from the pluton contact. The thermal anomaly

introduced by the pluton is also reflected in the anomalously high CAI value of conodont fragments retrieved from the area (e.g. CAI = 7 for sample C-304755). There appears to be no significant contact metamorphism associated with Late Triassic gabbro and diorite intrusions.

Property-Scale Structure

Upper Triassic rocks at Palmer record at least 3 different episodes of deformation, with the earliest and most evident being a north-south contractional event (D1). D1 deformation is characterized by slaty to schistose cleavage (S1), and south vergent folds and thrust faults (Lewis, 1998). Fabric intensity is highly variable, reflecting the strong contrast in rheology of the massive basalts and thin-bedded silty rocks comprising the section. In most places preservation of primary rock textures is very good, although the rocks are locally deformed beyond recognition of the original protolith. In general, S1 fabric is most strongly developed within sedimentary strata and intensely altered volcanic rocks. Megascopic D1 folds have kilometre-scale wavelengths, closed to tight forms, and are commonly overturned. Mesoscopic D1 folds are scarce, and typically restricted to intercalations of sedimentary strata.

The second phase of deformation (D2) is less readily observed, and has no obvious associated fabric. It is revealed by megascopic folds that affect bedding and S1

foliation. The folds are generally tight, and have subangular hinges with axes that plunge variably to the northwest. Although important at a property scale, the effects of the D2 deformation event are not apparent in the Glacier Creek prospect area.

The D3 deformation is manifest by weakly developed northeasterly crenulation fabrics that are present only locally within some of the more schistose rocks (Lewis, 1998). They are interpreted to post-date D2 because the orientation of the crenulation cleavage is independent of position on D2 folds. Regional strain associated with D3 is minor and does not appear to have produced any megascopic structures.

Late southwest to northwest striking faults post-date D2 and possibly D3. They are brittle, high-angle structures that appear to have accommodated both vertical and horizontal movement.

Figure 2.1. Property map showing location of new conodont localities.

Figure 2.2. U-Pb concordia plot for zircon from a sample of a rhyolite flow that occurs in the immediate footwall to RW zone massive sulphide at the Glacier Creek prospect.

Figure 2.3. Arrhenius plot of fields for CAI 1 through 8 used to estimate a range of peak metamorphic temperatures for conodont-bearing rocks at Palmer (diagram adapted from Rejibian et al., 1987).

Figure 2.4. Plot of approximate temperatures and pressures of metamorphic facies. A: equilibrium curve for analcime + quartz = albite + H₂O. L: low-pressure limit for lawsonite + quartz in the presence of an H₂O fluid. H: triple point of Al₂SiO₅ minerals. J: equilibrium curve for albite = jadeite + quartz (diagram from Miyashiro, 1994).

Sample#	UTM E	UTM N	Zone	Genus	Species	Age	CAI Index
C-304193	417585	6585947	8	<i>Polygnathus</i>	<i>sp. cf. P. parawebbi Chatterton 1978</i>	Middle Devonian	5.5 - 7
C-304194	417262	6586185	8	<i>Pandorinellina?</i>	<i>sp. indet.</i>	Devonian?	5.5
C-304196	417555	6586536	8	<i>Epigondolella</i>	<i>bidentata Mosher 1968</i>	Norian - Rhaetian	5
C-304198	418966	6586337	8	<i>Epigondolella</i>	<i>bidentata Mosher 1968</i>	Norian - Rhaetian	5.5 - 6.5
				<i>Epigondolella</i>	<i>triangularis (Budurov 1972)</i>		
				<i>Norigondolella</i>	<i>sp. indet.</i>		
C-304199	419832	6586320	8	<i>Neogondolella</i>	<i>sp. indet.</i>	Norian	5
				<i>Epigondolella</i>	<i>sp. indet.</i>		
C-304200	423535	6585008	8	<i>Neogondolella</i>	<i>sp. indet.</i>	Permian - Triassic	6.5 - 7
C-304750	420581	6585085	8	ramiform elements		Ordovician - Triassic	3 - 4
C-304752	420490	6585498	8	<i>Mesogondolella?</i>	<i>sp. indet.</i>	Permian? (or Triassic)	5
C-304755	419373	6582751	8	ramiform elements		Ordovician - Triassic	7
C-304756	420443	6585228	8	<i>Epigondolella</i>	<i>ex gr. bidentata Mosher 1968</i>	Middle Norian - Rhaetian	3 - 4

Table 2.1. New conodont data from the Palmer property and surrounding area.

Grain type	wt. (μg)	Grain Pb _c (pg)	U (ppm)	Isotope ratios				Apparent ages (Ma)			
				$\frac{^{206}\text{Pb}_m}{^{204}\text{Pb}}$	$\frac{^{206}\text{Pb}_c}{^{208}\text{Pb}}$	$\frac{^{206}\text{Pb}^*}{^{238}\text{U}}$	$\frac{^{207}\text{Pb}^*}{^{235}\text{U}}$	$\frac{^{206}\text{Pb}^*}{^{238}\text{U}}$	$\frac{^{207}\text{Pb}^*}{^{235}\text{U}}$	$\frac{^{207}\text{Pb}^*}{^{206}\text{Pb}^*}$	$\frac{^{206}\text{Pb}^*}{^{207}\text{Pb}^*}$
				$\frac{^{204}\text{Pb}}{^{208}\text{Pb}}$	$\frac{^{206}\text{Pb}}{^{208}\text{Pb}}$	$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	$\frac{^{206}\text{Pb}}{^{207}\text{Pb}}$
3	6	6	815	1757	5.8	0.033439 ± 1.13	0.22998 ± 1.59	212.0 ± 2.4	210.2 ± 3.4	189 ± 25	189 ± 25
1	2	5	600	546	5.0	0.033825 ± 1.86	0.22530 ± 2.81	214.5 ± 4.0	206.3 ± 7.3	114 ± 47	114 ± 47
1	3	9	320	247	7.0	0.033637 ± 4.44	0.23666 ± 6.43	213.3 ± 9.5	215.7 ± 13.8	242 ± 100	242 ± 100

Notes: Number of grains analyzed is shown in first column. All grains were ~60 μ in length and ~30 μ in width, clear, and colorless.

$^{206}\text{Pb}/^{204}\text{Pb}$ is measured ratio, uncorrected for blank, spike, or fractionation.

$^{206}\text{Pb}/^{208}\text{Pb}$ is corrected for blank, spike, and fractionation.

All uncertainties are at the 95% confidence level.

Uncertainties in isotope ratios are in percent. Uncertainties in ages are in millions of years.

Most concentrations have an uncertainty of 25% due to uncertainty in weight of grain. Constants used:

$^{238}\text{U}/^{235}\text{U} = 137.88$. Decay constant for $^{235}\text{U} = 9.8485 \times 10^{-10}$. Decay constant for $^{238}\text{U} = 1.55125 \times 10^{-10}$.

Isotope ratios are adjusted as follows:

- (1) Mass dependent corrections factors of: 0.14 ± 0.06 ‰/amu for Pb and 0.04 ± 0.04 ‰/amu for UO_2 .
- (2) Pb ratios corrected for 0.005 ± 0.003 ng blank with $^{206}\text{Pb}/^{204}\text{Pb} = 18.6 \pm 0.3$, $^{207}\text{Pb}/^{204}\text{Pb} = 15.5 \pm 0.3$, and $^{208}\text{Pb}/^{204}\text{Pb} = 38.0 \pm 0.8$.
- (3) U has been adjusted for 0.001 ± 0.001 ng blank.
- (4) Initial Pb from Stacey and Kramers (1975), with uncertainties of 1.0 for $^{206}\text{Pb}/^{204}\text{Pb}$, 0.3 for $^{207}\text{Pb}/^{204}\text{Pb}$, and 2.0 for $^{208}\text{Pb}/^{204}\text{Pb}$.

All analyses conducted using conventional isotope dilution and thermal ionization mass spectrometry,

as described by Gehrels (2000).

Table 2.2. U-Pb zircon analytical data.

CHAPTER 3

GEOLOGY OF GLACIER CREEK PROSPECT

Introduction

This chapter contains a description of the geology of the Glacier Creek prospect map area, a 1.7-km² area that contains the RW and Main massive sulphide zones (Figure A7.1). The area is roughly centered on the informally named Mt. Morlan, located 2 km NW of the headwaters of Glacier Creek, and ranges from 3500 ft (1067 m) to 5720 ft (1743 m) in elevation (Figure 3.1; Plate 1). The area has received the most study of all the prospect areas, and its description forms the bulk of the thesis. Current understanding of the structure, stratigraphy, mineralization, and alteration is based on detailed mapping (1:500 to 1:2000 scale) and 16 diamond drill holes. Whole rock lithogeochemical data for 130 samples were examined, and 9 samples were analyzed for rare earth element abundances (REE data is discussed in Appendix 3). Petrographic analysis of 22 thin sections aided in characterizing rock types, metamorphism, alteration and mineralization (petrographic reports are in Appendix 5).

Structure

The RW and Main massive sulphide zones occur in a panel of shallowly to moderately NNE dipping strata in the hanging wall to the moderately NNE dipping MZ thrust fault, which records roughly 200-300 m of dip-slip displacement (Figure 3.1; Plate 1). Correlative pillow basalt units that exhibit opposing topping directions on either side of the fault indicate that the fault disrupts a tight, overturned anticline (Figures 3.2 and A7.2a). Bedding in the overturned limb typically dips steeply NNE to vertical. The faulted anticline is interpreted to have a near horizontal fold axis based on the near vertical plane defined by the best-fit great circle of poles to bedding on an equal area stereonet (Figure 3.3). Shallow plunging fold axes measured for minor folds support this interpretation (Figure 3.4).

S1 foliation is well developed in sedimentary strata and strongly hydrothermally altered rocks, and weak to absent in unaltered flows and intrusive rocks. S1 foliation dips steeply to the NNE and is interpreted to be axial planar to the faulted, overturned anticline. Poles to S1 foliation plot in a tight cluster on an equal area stereonet (Figure 3.5), and show no evidence of reorientation about D2 folds as observed elsewhere on the property (e.g., see Appendix 1 – Geology of the Cap Prospect).

The MZ thrust fault occurs as a 1-3 m wide recessive weathering deformation zone in areas of strong synvolcanic quartz-sericite-pyrite alteration (Figure A7.2b). In rocks outside zones of intense synvolcanic hydrothermal alteration, the surface expression of the fault is much more subtle, and is locally marked by minor iron oxide

weathering. The MZ thrust fault is dominantly a brittle structure; however, in intensely quartz-sericite-pyrite altered rocks it locally exhibits features that are more indicative of ductile shear. These features include highly attenuated and polygonalized quartz amygdules, tightly folded and boudinaged quartz micro-veinlets, and the local development of a second foliation oriented at about 30-35° to the dominant S1 foliation (Figure A7.2c).

Southwest to northwest striking, high-angle, brittle faults are common in the Glacier Creek prospect map area. The brittle faults post-date the MZ thrust fault, and appear to record dominantly vertical displacements. Neotectonic structures also appear to have been active in the Glacier Creek prospect map area. Scarps above the Main occurrence mark the location of large slumps that appear to have displaced strata by up to 50 m. The fault and slump structures likely contribute to the high permeability and deep oxidation evident in the vicinity of the Main and Upper Main occurrences.

Stratigraphic Units

The stratigraphic section described herein is 350 m thick, and is dominated by massive to pillowed basalt flows, with subordinate impure carbonate rocks, tuff, and felsic volcanic rocks (Figure 3.6). The rocks were subject to prolonged hydrothermal activity and host stacked zones of massive sulphide. The base of the section includes the

immediate stratigraphic footwall to the Main zone massive sulphide unit, which occurs 70-135 m stratigraphically below the RW zone massive sulphide unit. Unit descriptions and thicknesses are based primarily on examinations of rocks from the hanging wall to the MZ thrust fault. The same stratigraphic units that are described in the hanging wall to the MZ thrust fault also occur in the overturned footwall, including a leached baritic massive sulphide and chert unit that is correlative with the RW zone massive sulphide unit (Figure 3.2).

B7 basalt unit

The B7 basalt unit is the lowest unit found in the map area, and is only exposed in the Main occurrence area (Figure 3.1), where it forms yellow-orange gossanous outcrops in the footwall to the Main zone leached baritic massive sulphide unit. It consists of mafic flows and subordinate tuff that are intensely altered to an assemblage of quartz, sericite, pyrite, and chlorite. Alteration commonly obliterates primary textures and locally makes identification of protolith difficult. Weathered surfaces and fractures are locally coated with secondary Zn and Cu oxide minerals, presumably derived from stratigraphically overlying massive sulphide. The unit was not studied in detail and its chemical composition has not been characterized.

Main zone massive sulphide unit

The Main zone massive sulphide unit consists of stratiform massive vuggy barite and sulphide, and rare black shaley limestone (Figure A7.3a). It is exposed at the main occurrence, where it is 2-4 m thick and can be traced along surface for 120 m; it has been intersected in only one drill hole (RMC98-02), which was collared close to the surface exposure at the Main occurrence. The subsurface dimensions of the Main zone massive sulphide unit are unknown. Details of the mineralogy and effects of supergene oxidation are provided below in a section that describes mineralization.

B6 basalt unit

Overlying the Main zone, and locally forming the immediate footwall to the RW zone, is the B6 basalt unit, which consists of aphyric to feldspar porphyritic, massive and pillowed basalt flows and minor volcanic breccia or agglomerate and lapilli tuff (Figures A7.3b and A7.3c). Least altered rocks are blue-gray to olive-green, weakly amygdaloidal, and commonly contain 2-8 percent, 2-7 mm feldspar phenocrysts. Although exhibiting textural variability (aphyric vs. porphyritic), most of the unit maintains relatively uniform immobile element chemistry, which is characterized by a high Al_2O_3 content (up to 22.06% on a LOI-free basis). The lower contact of the B6 basalt is only exposed in the vicinity of the Main occurrence. There, the unit occurs in the immediate hanging wall to

the Main zone massive sulphide unit, is 70-90 m thick, and is strongly altered to chlorite, sericite, and pyrite near its base. In areas underlying the RW zone, quartz, sericite, pyrite, and chlorite alteration of the B6 basalt is widespread, primary textures are commonly destroyed, and chalcopyrite- and sphalerite-bearing pyritic stringers are common. In the vicinity of the Main and Upper Main occurrences, most of the quartz-sericite schist described as impure metacherts by Forbes and others (1989), is reinterpreted as intensely altered B6 basalt based on the quartz-sericite schist having the same immobile element signature as the unaltered B6 basalt unit.

Rhyolite unit

Underlying most of the RW zone massive sulphide is a locally amygdaloidal, generally aphyric, high Zr (300-450 ppm), rhyolite flow that averages 30-45 m in thickness. It is only exposed on the south and west sides of Mt. Morlan, and forms massive, rounded, yellow to deep orange gossanous outcrops along the edge of a spur of the Little Jarvis glacier (Figure A7.4a). It is pervasively altered to an assemblage of quartz, sericite, pyrite and rare chlorite, and locally hosts sphalerite and chalcopyrite bearing pyritic stockwork. Amygdules occur in irregular patchy zones and are composed of quartz, pyrite and sericite. The rhyolite typically contains 1-8% disseminated, very fine-grained, euhedral pyrite. Porphyroblasts of Fe-bearing carbonate occur locally. The bulk of the rhyolite appears to be a single flow with zones of breccia skirting its edge and

occurring locally along the upper contact. Generation of minor subsequent flows is indicated by a 12 m intersection of rhyolite in the hanging wall to RW zone massive sulphide mineralization in drillhole RMC99-13 (Figure 3.7). Rhyolite breccia exposed on the southwest flank of Mount Morlan contains lapilli and block size fragments that are completely replaced by chlorite and occur in a white siliceous matrix (Figure A7.4b). Limestone locally forms the matrix interstitial to quartz-sericite-pyrite altered rhyolite fragments in fragmental zones near the upper contact of the rhyolite unit north of the Little Jarvis occurrence.

RW zone massive sulphide unit

The RW zone consists of stratiform base and precious metal-rich baritic massive sulphide, with subordinate chert, altered tuff, and limestone (Figures A7.5a and A7.5b). It crops out on both the west and southeast flanks of Mt. Morlan, and has been intersected in drill holes between the two. The unit ranges from <1 m to 15 m in thickness, has a strike length of over 600 m, and appears to grade laterally and locally vertically into relatively homogeneous, thinly bedded tuffaceous limestone. Details of the mineralogy and effects of supergene oxidation are provided below in a section that describes mineralization.

Tuffaceous limestone unit

Thin, semi-continuous beds of pale buff-tan or dark gray, silty tuffaceous limestone occur intercalated between most of the major volcanic units in the Glacier Creek prospect map area (Figure A7.6a). The beds are finely laminated to massive, and average 1-6 m thick. Their composition varies from nearly pure limestone to pure ash tuff, although they typically are a mixture of carbonate, ash, clay and silt. Locally the unit contains 1-3 m thick sections of graphitic argillite, and 0.1-1 m thick lenses of chert. Tuffaceous limestone occurring in the immediate hanging wall to the RW zone massive sulphide unit locally has a component of felsic ash tuff and is variably altered to sericite. Conodonts in sample C-304752 (Table 2.1), collected from dark gray to black tuffaceous limestone that separates the B3 and B2 basalt units, are loosely constrained to Permian to Triassic age.

B5 massive and pillowed basalt unit

The B5 basalt is gray-green, weakly to strongly magnetic, weakly to non-amygdaloidal, and massive to pillowed. It locally contains hematite and jasper, and commonly contains carbonate filled fractures. The unit approaches 30 m in thickness in drill holes near the Upper Main occurrence, although it is either absent or only a few metres thick in drill holes on the west side of the mountain. It was not identified at all on surface at the Little Jarvis occurrence.

B4 spherulitic pillowed basalt unit

The B4 basalt consists of dark blue-green, aphyric, moderate to strongly magnetic, amygdaloidal, pillowed basalt flows that commonly exhibit a distinctive spherulitic texture. Spherulites weather pale gray to white, are 0.5-10 mm in diameter, and are most conspicuous along dark green, intensely chloritized pillow margins (Figure A7.6b). Amygdules are composed of calcite and are generally 5-30 mm in diameter. Flows also commonly contain carbonate in pillow interstices and cooling fractures. At one locality, the flows occur as a series of thin (0.5-1 m thick), stacked sheets, compatible with very low viscosity magma. The unit is 15-18 m thick above the Little Jarvis occurrence, thickens to the northeast to roughly 30 m in drillhole RMC99-13, and is absent in core from drill holes near the Upper Main occurrence.

Mafic tuff – lapilli tuff, limestone, and siliceous exhalite unit

A 2-10 m thick section of well-bedded tuffaceous rocks forms a good marker bed that is traceable around most of the mountain and recognized in the overturned footwall to the MZ thrust fault. In the vicinity of the Little Jarvis occurrence it consists of alternating layers of pale gray to dark brown variably calcareous fine to coarse ash tuff, and lapilli tuff, capped by a layer of pale buff-tan impure limestone. Minor layers containing rare siliceous lapilli fragments are a distinctive feature of this unit (Figure A7.6c), although overall the tuffaceous rocks are predominantly mafic, and some beds share the same chemical signature as the underlying B4 basalt unit. Conodonts in sample

C-304756, collected from the tuff-limestone-exhalite unit in drill hole P94-03, are Middle Norian to Rhaetian age (Table 2.1).

Two hundred metres north of the Little Jarvis occurrence, a lens of siliceous exhalite, up to 4.5 m thick and roughly 105 m in length, occupies the stratigraphic position of the mafic tuffaceous rocks. The exhalite consists of massive, white, fine-grained silica with local black, strongly magnetic cherty zones, and contains negligible sulphide.

B3 pillowed basalt unit

The B3 basalt is a 45-60 m thick unit composed of multiple pillowed flows and rare lava tubes or channels (Figure A7.7a). The flows are dark green-brown and commonly contain large (5-20 mm) carbonate amygdules densely distributed throughout. They also contain scattered coarse-grained (up to 15 mm) pyrite cubes in their otherwise aphyric matrix. Near the base of the unit pockets of carbonate locally form distinctive radial or rosette like forms that are up to 10 cm in diameter.

B2 massive and pillowed basalt unit

The B2 basalt consists of 12-15 m of medium to dark green, massive to pillowed basalt flows. It is weakly magnetic, and contains sparse carbonate amygdules.

Feldspar porphyritic trachyandesite unit

A massive, pale green to blue-gray, 10-20 m thick feldspar porphyritic trachyandesite flow is the only volcanic unit encountered in the Glacier Creek prospect map area that has an intermediate chemical composition. The rock is variably magnetic, hosts local patches of jasper, and contains scattered pods of carbonate (possible amygdules) that are 10-40 mm in diameter. Feldspar phenocrysts are up to 5 mm long, and the unit locally contains distinctive euhedral, mm-scale, Fe-bearing carbonate porphyroblasts.

B1 pillowed basalt unit

The B1 basalt is a black, non-magnetic, coarsely amygdaloidal, pillowed basalt that is 4.5-6 m thick. Amygdules are carbonate and are particularly abundant near pillow margins. Chemical composition of the B1 basalt is peculiar in that it contains high concentration of both Zr and TiO_2 (231 ppm Zr and 2.93% TiO_2 on a LOI-free basis).

Conglomerate (debris flow) unit

The uppermost stratigraphic unit is a poorly sorted, heterolithic conglomerate that contains angular to rounded granules to boulders of basalt, chert and/or rhyolite, and subordinate limestone (Figures A7.7b and A7.7c). It is only exposed near the peak of Mount Morlan, and has a minimum thickness of 25 m. The conglomerate occurs in two

distinct beds that are separated by 2-3 m of mafic ash to lapilli-tuff and tuffaceous limestone, which contain conodonts of undetermined age (sample C-304750, Table 2.1). Its massive character, local crude reverse grading, common angular clasts, and poor sorting suggest an origin as a high-density mass flow (debris flow). Basalt clasts are commonly highly vesicular to scoriaceous, reach up to 1 m in diameter, and in rare cases exhibit the form of pillows and pillow fragments. Siliceous fragments are commonly well rounded and therefore were probably derived from a subaerial environment. The carbonate-rich matrix weathers recessively, producing a distinctive knobby texture in outcrop.

Intrusive Rocks

Gabbro

A sill like gabbro body, up to 45 m thick, cuts gently up-section to the northeast in the hanging wall of the RW zone. It is moderately to strongly magnetic, very fine- to fine-grained, and contains minor disseminated pyrite and pyrrhotite. Along the contact of a tuffaceous limestone bed, an irregular breccia with a tuffaceous limestone matrix occurs within the gabbro. This may indicate that the gabbro intruded sediment that was only partially lithified. A similar gabbro body is exposed near the peak of the mountain where it overlies the debris-flow conglomerate in a down-dropped fault block. The gabbro has

undergone regional greenschist-facies metamorphism and is assumed to be part of the same overall magmatic system as the host volcanic sequence.

Mafic dykes

A series of northeast trending, 0.5-3 m wide, basalt and fine-grained diorite dykes cut all other lithologic units. The dykes pinch and swell, have moderate to steep dips and locally form thin sills along tuff and limestone beds. Disseminated fine-grained Fe-bearing carbonate, which possibly formed during regional metamorphism, is ubiquitous in the diorite dykes. Other dykes include variably altered mafic feeders to the volcanic strata, some of which can be tied to specific lithologic units based on their chemical composition.

Hornblende diorite to gabbro

A small plug, approximately 20 m in diameter, of coarse-grained hornblende diorite to gabbro is exposed in the Main occurrence area, south of hole GC-03. It contains 50-60% 1-2 cm long hornblende grains, is reasonably fresh, and appears to postdate the regional greenschist-facies metamorphic event. The hornblende diorite to gabbro is interpreted to be part of the same magmatic suite as the granodiorite pluton exposed in the Cap prospect area.

Mineralization

RW Zone Mineralization

The RW zone refers to a body (or bodies) of massive barite-sulphide and subordinate sulphide-rich carbonate that formed prior to deposition of the B5 basalt unit and after deposition of the majority of the rhyolite unit. It is exposed on the west side of Mt. Morlan at the Little Jarvis occurrence, where it can be traced sporadically along slope for about 50 m before it is covered by ice and rubble to the north and south (Figures 3.1 and A7.5b; Plate 1). Thickness of the RW zone at the Little Jarvis occurrence varies from a few tens of cm up to 4-5 m. Rare sulphide boulders and small windows of massive sulphide outcrop that occur in talus up to 120 m north of the Little Jarvis surface occurrence are interpreted to be a continuation of the RW zone. Further to the north, chert that is interpreted to be a lateral facies equivalent to massive barite and sulphide of the RW zone, is exposed along the upper contact of the rhyolite unit. A 3 m diameter massive silica-barite boulder in talus overlying altered rhyolite in the extreme northwest corner of the Glacier Creek map area, 500 m northwest of the Little Jarvis occurrence, suggests that exhalitive mineralization could occur along the entire length of the overburden covered upper contact of the rhyolite unit.

On the southeast side of Mt. Morlan, the RW zone is exposed at the Upper Main occurrence and the UMP occurrence, and in sporadic exposures between the two (Figure 3.1; Plate 1). Massive barite and sulphide at the Upper Main occurrence can be traced

along slope for about 70 m, are up to 7 m thick, pinch out to the west and are covered by overburden to the east. The UMP occurrence is a 1-2 m thick section of sphalerite-carbonate rubble that can be traced along slope for a few tens of metres before it is covered by overburden to the east and west (Figure A7.8a). Much of the area between the Upper Main and UMP occurrences is inaccessible or covered by overburden; however, where mapped, the stratigraphic interval that hosts the RW zone consists of variably mineralized calcareous tuff and argillite, and minor massive barite. In general, the exposures of the RW zone on the southeast side of Mt. Morlan appear to be more intimately associated with carbonate rocks than the exposures on the west side of Mt. Morlan.

The RW zone has been intersected in drill holes P94-02, RMC98-03, and RMC99-10 through 13. Based on these intersections the RW zone is interpreted to extend between the Upper Main and Little Jarvis occurrences through Mt. Morlan for a distance of 610 m. However, the lack of massive barite-sulphide at the upper contact of the rhyolite unit in drill holes P94-03 and RMC99-07 through 9, suggests that it may not be continuous over the entire 610 m length. Drill hole data indicate that the RW zone has a maximum dip extent of at least 200 m and a maximum thickness of at least 15 m (Figures 3.7 & 3.8). The zone remains open in virtually all directions.

A leached stratiform massive barite-sulphide unit, which is up to 2-3 m thick and occupies the same stratigraphic position as the RW zone, is exposed in the footwall to the

MZ thrust fault between the Main and Upper Main occurrence areas (Plate 1; Figure 3.1). The unit can be traced sporadically along slope for about 200 m, is truncated by the MZ thrust fault to the east, and appears to pinch out or grade into chert to the west. The occurrence of the unit in the overturned limb in the footwall to the MZ thrust fault indicates that RW zone equivalent originally formed over a large surface area, and greatly expands the area of exploration potential at the prospect.

Primary mineralogy of the RW zone consists of barite, sphalerite, pyrite, chalcopyrite, quartz, galena, and lesser calcite, magnetite, pyrrhotite, arsenopyrite and possible sulfosalts (see Appendix 5 for detailed petrographic descriptions). Significant assay results for drill hole samples are listed in Tables 3.1 and 3.2. Massive barite-sulphide contains mm to cm scale layers that are defined by variations in the concentration of different minerals. The layering is parallel to the bedding of enclosing strata, and is interpreted to reflect precipitation and accumulation of minerals at the seafloor. Replacement textures in sulphides are common and include sphalerite after pyrite, and chalcopyrite after sphalerite (Figures A7.8b & A7.8c). In some drill hole intersections the RW zone exhibits metal zoning, with copper rich massive sulphide grading upwards to zinc rich massive sulphide, which grades upwards into silver rich massive barite.

Sphalerite- and chalcopyrite-rich stockwork occurs locally within strongly quartz-sericite-pyrite+/-chlorite altered rhyolite and basalt in the footwall to the RW zone. Stockwork veins typically contain pyrite, chlorite, chalcopyrite, sphalerite, and quartz.

Parts of the RW zone massive barite-sulphide body have been extensively leached of sulphides during supergene oxidation and are underlain by a Cu and Zn supergene enrichment zone that extends vertically into the footwall 60 m or more. Highly leached sections of the massive barite-sulphide body typically consist of pale yellow to rusty orange, iron-oxide stained, variably siliceous, extremely vuggy (porous) barite and barite sand (Figure A7.9a). Degree of porosity is equated with the original sulphide content of the massive barite-sulphide body, and zones of disaggregated sandy barite are interpreted to occur in areas of highest original sulphide content. In thin section, open space cavities in the leached rock are commonly in the shape of euhedral crystals and mimic textures observed in non-leached massive barite-sulphide (Figures A7.9b and A7.9c). Leached massive barite-sulphide contains negligible Cu and Zn, whereas the concentrations of Pb, Au, and Ag remain close to those of non-leached massive barite-sulphide. The redistribution of Cu and Zn, and the relative immobility of Pb, Au and Ag in areas of strong supergene oxidation are graphically depicted on down-hole plots for diamond drill holes P94-02 and RMC98-03 (Figures 3.9 & 3.10). Most of the supergene Cu and Zn mineralization occurs in relatively weakly altered to unaltered rocks, and the

mineralization is commonly only identified with zinc-zap¹ or by chemical assay.

Secondary minerals identified in the supergene enrichment zone by X-ray diffraction analysis include smithsonite and gypsum (Appendix 6). A whitish sky blue to deep blue, fracture-coating precipitate, which was determined to have no crystalline structure by X-ray diffraction analysis, is believed to be an amorphous Cu-bearing mineral such as chrysocolla (Figure A7.10a). Incipient oxidation persists at considerable depth, as is indicated in drill hole RMC99-10 where pyrrhotite in massive sulphide intersected 150 m below surface is replaced by skeletal pyrite and hydrous iron oxide, and covellite rims chalcopyrite grains (Figures A7.10b and A7.10c).

Strong supergene oxidation and leaching of massive barite-sulphide occurs throughout most of the southeast side of Mt. Morlan, indicating that the area was likely not glaciated during the last episode of continental glaciation. There are, however, small non-leached remnants of massive barite-sulphide preserved locally within the area of widespread supergene oxidation and leaching. The non-leached remnants either contain calcite as the dominant gangue mineral or immediately underlie calcareous sediments, and it is believed that the carbonate buffered the metal-leaching acids that are generated during oxidation of sulphides.

¹ Zinc Zap: a solution that turns reddish-orange on contact with secondary zinc minerals. Solution is composed of a 50:50 mix of a solution of 3% potassium ferricyanide and a solution of 3% oxalic acid containing 0.5% diethylaniline.

Main Zone Mineralization

Main zone mineralization refers to a body of massive barite-sulphide that occurs at the base of the B6 basalt unit. It is exposed at the Main occurrence where it is 2-4 m thick and can be traced along slope for 120 m. It is truncated to the southwest by the MZ thrust, and appears to pinch out beneath talus cover into intensely quartz, sericite and pyrite altered rocks to the northeast. The Main zone has been intersected by only one drill hole (RMC98-02), which cut 4 m of near-surface leached baritic massive sulphide and footwall zones of containing supergene Cu and Zn oxide minerals. All drill holes that tested the RW zone stopped short of the stratigraphic interval that hosts the Main zone massive sulphide unit, leaving the subsurface extent of the Main zone virtually untested. Significant assays for the Main zone are listed in Table 3.3.

Massive barite-sulphide of the Main zone is very similar to that of the RW zone. Where examined, the Main Zone is typically leached of sulphides and consists of iron-oxide stained, variably siliceous vuggy (porous) barite and baritic grus (Figure A7.11a). Primary sulphide mineralogy is preserved in rare weakly oxidized enclaves (Figure A7.11b), in which sphalerite, chalcopyrite, galena, and pyrite can be identified in hand sample. Thin section, SEM, and SEM-EDAX examinations of samples collected for metallurgical tests by the U.S. Bureau of Mines reveal that the Main Zone also contains magnetite, bornite, and a zincian variety of tennantite (Still et al., 1991). In a sample of strongly oxidized and leached massive barite-sulphide, SEM examinations identified anglesite (PbSO_4) in voids and filling cracks in barite.

Alteration

Intense hydrothermal alteration exposed in the footwall to the RW and Main zones at the Main and Upper Main occurrences, forms a broad rusty yellow-orange recessive weathering zone that is visible from 5-10 km away (Figure A7.12). The rocks were subjected to prolonged hydrothermal activity that produced intense alteration that extends from the footwall of the Main zone up into the immediate hanging wall of the RW zone, a thickness of greater than 100 m. Rock within the alteration zone typically consists of pyritic, quartz-rich, micaceous phyllite and schist, which is referred to as quartz-sericite-pyrite (QSP) schist. Petrographic analysis indicates that the strongly altered rocks typically contain subequal amounts of quartz and a microcrystalline to very fine-grained micaceous mineral (sericite), and subordinate pyrite (Figure A7.12b). X-ray diffraction analyses of the QSP schist indicate that the microcrystalline to very fine-grained micaceous mineral is muscovite, and diffraction patterns best fit the $2M_1$ polymorph (Appendix 6). No other clay-like minerals were identified. Primary textures in the QSP schist are commonly obliterated, except for amygdules that are filled with quartz, and the protolith has been variably described in previous work as felsic schist and clay-rich chert (e.g., Still et al., 1991 and Forbes et al., 1989). Immobile element chemistry, however, indicates that most, if not all, of the QSP schist at the Main and Upper Main occurrences has a basaltic protolith, and the majority of the QSP schist shares the same immobile element signature as the B6 basalt unit. Moderately to strongly

altered B6 basalt locally exhibits a relict porphyritic texture, in which flattened feldspar phenocrysts that have been totally replaced by sericite have a distinctive scaly, 'silver-fish' like appearance (Figure A7.12c). The QSP schist grades outwards into rocks that consist of predominantly chlorite, calcite, plagioclase (albite), and epidote. This mineral assemblage is characteristic of propylitic alteration, but it is impossible to determine how much, if any, hydrothermal propylitic alteration has occurred, because the same mineral assemblage is associated with the regional greenschist-facies metamorphism.

In the Little Jarvis occurrence area, strong hydrothermal alteration occurs throughout the rhyolite unit that is exposed along the glacier's edge. The rhyolite is altered to an assemblage of quartz, sericite and pyrite, and, in general, is much more massive and resistant to weathering than the fine schistose QSP altered basalt at the Main and Upper Main occurrences.

Drill hole data indicates that the strong QSP alteration in the rhyolite and B6 basalt that is exposed at surface also occurs in the same units at depth. Alteration in both the rhyolite and B6 basalt units diminishes to the southwest, roughly coinciding with the southwest limit of RW zone massive barite-sulphide mineralization. The alteration does, however, pick up again in the overturned limb, and QSP schist exposed in creek drainages at lower elevations east of the Main occurrence (off the map area in Figure 3.1 and Plate 1) are believed to be an extension of the same system. To the north, QSP

alteration remains strong, and appears to intensify before it trends beneath overburden and ice.

At the scale mapped, the QSP alteration is crudely semi-conformable to strata, and does not appear to have any of the well-defined pipe-like geometries that are documented at many VMS deposits (e.g. Franklin et al., 1981). Hydrothermal chlorite is relatively rare, and is typically restricted to veins and vein selvages in Cu- and Zn-rich stockwork zones, which occur in pervasively QSP altered host rocks.

Chemical Composition

Rock Classification

Classification of rock units was based on the ‘immobile’ elements Zr, Ti, Al, Nb, and Y. Diagrams that rely on concentrations of K and Na are not used herein due to the potential mobility of these elements in environments of hydrothermal alteration and greenschist-facies metamorphism. Compositions of representative samples of the main igneous units are given in Table 3.4: all other geochemical data are listed in Appendix 8 and Table A3.2.

A bimodal grouping for the majority of the volcanic units is clearly displayed on the Zr/TiO₂ versus Nb/Y diagram (Figure 3.11a; Winchester and Floyd, 1977). Most

mafic rocks plot in the sub-alkaline basalt field, or are transitional between the sub-alkaline basalt and andesite/basalt fields. Felsic rocks all plot well within the rhyolite field. The only intermediate composition comes from the feldspar porphyritic unit that occurs high up into the hanging wall above the RW zone, which falls on the edge of the trachyandesite field. On the SiO_2 versus Zr/TiO_2 diagram (Winchester and Floyd, 1977), samples cluster in similar fields, but have a marked vertical spread due to addition and depletion of silica during alteration (Figure 3.11b). The effects of alteration are most pronounced in rocks in the footwall and immediate hanging wall to the RW zone massive sulphide, with rocks shifting out of the fields to which they are classified based on immobile element chemistry alone.

Using the Y versus Zr diagram of Barrett and MacLean (1994), most of the igneous rocks cluster in the tholeiitic field, although the data shows a fair degree of spread and a few of the samples lie within the transitional field (Figure 3.12).

Geochemistry of Volcanic Units

Each of the major volcanic units forms a tight cluster on a Zr/TiO_2 versus $\text{Zr/Al}_2\text{O}_3$ diagram (Figure 3.13), which permits effective geochemical discrimination of the units. This type of geochemical signature is extremely useful on the structurally complex Palmer property where different mafic units are commonly very similar in physical appearance. It allows for confident identification of units in areas of intense hydrothermal alteration, supports the correlation of strata in the hanging wall to the MZ

thrust fault with strata in the overturned footwall to the fault, and aids in the correlation of the Glacier Creek prospect area with occurrences elsewhere on the property.

A linear distribution of lithologic unit data points on the Al_2O_3 versus Zr diagram (Figure 3.14a), and the TiO_2 versus Zr diagram (Figure 3.14b), is interpreted to reflect mass gains and mass losses that are largely the result of hydrothermal alteration. The linear trends are most apparent in the rhyolite and B6 basalt units, which form the highly altered footwall to the RW zone mineralization. Linear distribution in units that were not strongly altered is interpreted to reflect variable abundance of amygdules, which dilute the concentration of the immobile elements in whole rock analyses. In general, strongly altered rocks are depleted in Na_2O , CaO and locally SiO_2 , and enriched in Fe_2O_3 , K_2O , and SiO_2 .

Figure 3.1. Simplified geologic map of the Glacier Creek prospect area.

Section through Glacier Creek prospect map area (looking toward 290 degrees)

Figure 3.2. Cross-section (A-A') with simplified geology from the Glacier Creek prospect map area. Section is oriented perpendicular to strike of bedding.

Figure 3.3. Equal area stereonet projection of poles to bedding, with density contours, from the Glacier Creek prospect map area. The sub-vertical attitude of the best-fit great circle of poles to bedding is interpreted to indicate a near horizontal fold axis.

Figure 3.4. Equal area stereonet projection of fold axes measured for minor folds in the Glacier Creek prospect map area.

Figure 3.5. Equal area stereonet projection of poles to S1 foliation, with density contours, from the Glacier Creek prospect map area. Tight clustering of poles indicates rocks in the area are unaffected by D2 folds at the scale mapped.

Glacier Creek Prospect Generalized Stratigraphic Section

Figure 3.6. Generalized stratigraphic section representing approximately 350 m of strata in the Glacier Creek prospect map area. Section is based on mapping and drill logs in the hanging wall to the MZ thrust fault. Stratigraphic intervals from which conodont samples were collected are indicated; data for conodont samples are listed in Table 2.1.

Figure 3.7. Drill section (B-B') through the RW zone with geological interpretation. Section is cut roughly perpendicular to strike of strata, view is towards an azimuth of 285 degrees.

C

C'

Figure 3.8. Long-section (C-C') through the RW zone, which is interpreted to extend in a near continuous manner from the Little Jarvis occurrence in the west to the leached oxide zone near the Upper Main occurrence in the east. View is toward an azimuth of 30 degrees.

Figure 3.9. Down-hole plot of base and precious metal contents through oxide zone in drill hole P94-02. Note the high values of secondary Cu and Zn in the mafic dyke and extending deep into the footwall below leached RW zone massive barite-sulphide. Pb, Au and Ag are relatively immobile and grades are similar to those in areas where the RW zone is not extensively oxidized.

Figure 3.10. Down-hole plot of base and precious metal contents through oxide zone in drill hole RMC98-03. Note the high values of Cu and Zn extending deep into the footwall below leached RW zone massive barite-sulphide. Pb, Au and Ag are relatively immobile and grades are similar to those from areas where the RW zone is not extensively oxidized.

Figure 3.11. Plots of (a) Zr/TiO_2 versus Nb/Y , and (b) SiO_2 versus Zr/TiO_2 for 130 rock samples from the Glacier Creek prospect map area (fields defined by Winchester and Floyd, 1977). The vertical spread in data points in Figure 3.11b is a function of alteration. Data is presented on a LOI-free basis.

Figure 3.12. Y versus Zr magmatic affinity plot for 130 rock samples from the Glacier Creek prospect map area (fields defined by Barrett and Maclean, 1994).

Figure 3.13. Plot of Zr/Al_2O_3 versus Zr/TiO_2 for 130 rock samples from the Glacier Creek prospect map area. Note how each of the different lithologic units plot in their own unique area. Data is presented on a LOI-free basis.

Figure 3.14. Plots (a) TiO₂ versus Zr, and (b) Al₂O₃ versus Zr for 130 rock samples from the Glacier Creek prospect map area. The effects of mass change during alteration can be seen in the linear distribution of data points for individual lithologic units in both Figures. Data is presented on a LOI-free basis.

RMC99-10

From (m)	To (m)	Width (m)	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
162.0	166.6	4.6	4.01	0.40	0.13	0.1	16	massive barite-sulphide
166.6	169.3	2.7	0.24	2.29	<0.01	0.3	20	semi-massive sulphide and stockwork veins
169.3	179.1	9.8	0.48	0.33	<0.01	<0.1	2	footwall stockwork
179.1	226.8 (EOH)	47.7	0.28	0.02	<0.01	<0.1	<1	footwall stockwork

RMC99-11

From (m)	To (m)	Width (m)	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
189.3	192.1	2.8	4.60	0.05	0.23	0.5	83	massive barite-sulphide
192.1	194.5	2.4	1.38	<0.01	<0.01	<0.1	<1	footwall stockwork
235.1	264.9	29.8	0.70	0.02	<0.01	<0.1	1	footwall stockwork

RMC99-12

From (m)	To (m)	Width (m)	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
164.0	166.6	2.5	5.85	1.89	0.29	0.2	33	Massive barite-sulphide
166.6	190.5	23.9	0.37	0.05	0.04	<0.1	3	heavy disseminated to semi-massive sulphide, and stockwork
194.2	195.4	1.2	0.82	0.03	0.05	<0.1	3	footwall stockwork

RMC99-13

From (m)	To (m)	Width (m)	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
181.7	183.9	2.2	13.51	0.21	0.07	<0.1	13	semi-massive to massive sulphide
183.9	186.2	2.3	1.01	0.01	0.13	<0.1	5	heavy disseminated sulphide

RMC99-14

From (m)	To (m)	Width (m)	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
192.2	199.3	7.1	1.22	0.35	0.01	<0.1	2	Zn-rich footwall stockwork
197.9	218.1	20.2	0.18	0.63	<0.01	<0.1	3	Cu-rich footwall stockwork
197.9	202.8	4.9	0.46	1.5	<0.01	0.1	5	higher grade section within Cu-rich footwall stockwork

Table 3.1. Assay summary of diamond drill core intercepts through RW zone massive barite-sulphide. For assay results in areas of strong supergene oxidation see Table 3.2.

P94-02

From (m)	To (m)	Width (m)	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
96.1	100.6	5.5	1.13	0.05	0.01	0.01	<1	fault zone at top of leached vuggy massive barite
100.6	109.7	9.1	0.12	0.06	0.63	0.44	64	leached vuggy massive barite
109.7	115.8	6.1	3.22	0.18	0.01	0.01	2	supergene mineralization in cross-cutting mafic dyke
115.8	117.7	1.8	0.15	0.02	0.28	0.11	14	leached vuggy massive barite + minor alt'd footwall fragmental unit
117.7	125.9	8.2	0.05	0.03	0.06	0.06	8	mod-strongly alt'd fp basalt footwall (supergene transition zone)
125.9	155.4	29.6	0.73	0.09	<0.01	<0.01	<1	supergene mineralization in weakly alt'd fp basalt footwall
155.4	158.5	3.0	No sample					
158.5	171.9	13.4	1.04	0.3	<0.01	<0.01	<1	supergene mineralization in weakly alt'd fp basalt footwall
171.9	176.8	4.9	No sample					
176.8	178.0	1.2	0.41	0.03	<0.01	0.01	<1	supergene mineralization in weakly alt'd fp basalt footwall
178.0	179.8	1.8	No sample					
179.8	186.5	6.7	0.66	0.07	<0.01	0.02	<1	supergene mineralization in weakly alt'd fp basalt footwall
186.5	194.5	7.9	No sample					
194.5	197.5 (EOH)	3.0	0.3	0.01	<0.01	?	<1	supergene mineralization in weakly alt'd fp basalt footwall

16.6 m wide intersection through RW zone leached vuggy massive barite (interval includes 6.1 m of mafic dyke with supergene Zn mineralization)
 supergene Zn in dyke cross-cutting ore horizon = 3.22% over 6.1 m
 combined total of supergene Zn in footwall = 0.77% over 53.9 m (excludes 6.1 m dyke that crosscuts ore horizon)

RMC98-03

From	To	Width	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
84.5	97.2	12.7	0.05	0.01	0.65	0.39	49	leached vuggy massive barite
97.2	100.3	3.1	0.05	0.02	0.09	0.11	30	massive baritic chert
100.3	125.3 (EOH)	25.0	0.61	0.13	0.03	0.02	2	supergene mineralization in weak to moderately alt'd mafic footwall

15.8 m interval of RW zone exhalative mineralization (leached barite + chert); includes a 11.1 m interval
 from 87.3 m to 98.4 m grading 0.02% Zn, 0.01% Cu, 0.76% Pb, 0.45 ppm Au, and 63 ppm Ag

Table 3.2. Assay summary of diamond drill core intercepts through leached RW zone vuggy massive barite-sulphide and secondary supergene mineralization.

RMC98-02

From (m)	To (m)	Width (m)	Zn%	Cu%	Pb%	Au ppm	Ag ppm	Rocktype
118.5	122.8	4.3	0.25	0.05	0.19	0.24	21	leached vuggy massive barite
122.8	147.8	25.0	0.13	0.08	0.02	0.03	1	strongly altered footwall basalt (supergene transition zone)
147.8	157.2	9.4	0.11	0.21	0.01	<0.01	1	supergene mineralization in moderately altered footwall basalt
157.2	176.8	19.6	1.1	0.14	<0.01	<0.01	<1	supergene mineralization in weakly altered footwall basalt

Table 3.3. Assay summary of diamond drill core intercepts through leached Main zone vuggy massive barite-sulphide and secondary supergene mineralization.

Sample	Unit	Al ₂ O ₃ (%)	CaO (%)	Cr ₂ O ₃ (%)	Fe ₂ O ₃ (%)	K ₂ O (%)	MgO (%)	MnO (%)	Na ₂ O (%)	P ₂ O ₅ (%)	SiO ₂ (%)	TiO ₂ (%)	LOI (%)	Total (%)	Ba ppm	Rb ppm	Sr ppm	Nb ppm	Zr ppm	Y ppm
RMR30279	B1	14.81	3.68	<0.01	14.19	0.33	7.86	0.11	3.13	0.93	44.80	2.67	6.30	98.81	485	12	96	30	210	46
RMC60504	Trachyandesite	14.90	4.60	<0.01	6.37	2.17	6.73	0.06	4.13	0.12	51.88	0.47	8.21	99.62	1045	38	246	24	168	38
RMR30280	Trachyandesite	14.97	4.35	<0.01	7.50	0.98	8.99	0.08	3.13	0.10	50.02	0.52	8.93	99.57	600	20	182	20	153	30
RMC60505	B2	14.21	9.91	<0.01	11.76	1.59	6.84	0.21	1.52	0.18	41.20	1.04	9.64	98.10	8370	26	232	10	66	18
RMR30296	B2	15.80	6.48	<0.01	11.99	1.64	6.06	0.14	2.12	0.20	45.15	1.24	8.16	98.98	2580	22	130	14	81	22
RMR30295	B3	12.51	12.03	<0.01	10.21	0.27	5.00	0.11	4.18	0.15	42.08	0.66	12.18	99.38	140	12	318	10	60	22
RMR31802	B3	14.74	7.89	0.03	8.98	0.22	6.98	0.13	4.60	0.18	44.35	0.82	10.30	99.22	560	12	380	8	81	18
RMC60560	B3	14.57	6.61	0.03	10.07	0.72	4.38	0.11	5.87	0.23	48.51	0.89	6.91	98.90	320	26	234	10	75	24
RMC60506	B3	13.69	8.75	<0.01	9.63	1.86	5.38	0.14	4.36	0.16	45.38	0.73	8.96	99.04	610	36	264	10	63	22
RMC60548	B3	13.88	7.52	<0.01	10.40	0.46	5.81	0.14	4.46	0.13	46.69	0.73	9.34	98.56	305	20	200	12	69	24
RMC60511	B3	13.04	9.50	0.01	9.65	1.97	3.92	0.13	3.96	0.17	43.10	0.65	13.54	99.64	505	44	192	12	69	28
RMR30271	B4	13.04	8.07	<0.01	12.54	0.06	5.98	0.14	3.94	0.18	44.89	1.14	8.57	98.55	110	8	208	12	87	24
RMR30283	B4	12.71	8.02	<0.01	11.16	0.64	5.28	0.16	3.81	0.28	46.10	1.10	9.56	98.82	1170	20	218	12	84	22
RMR30298	B4	13.46	11.73	<0.01	10.36	0.15	5.47	0.16	3.61	0.27	40.73	1.25	12.25	99.44	810	8	220	10	96	22
RMR31806	B4	12.92	10.72	0.02	11.61	0.08	5.32	0.17	3.92	0.22	41.63	1.14	11.39	99.14	85	12	206	10	84	22
RMR31813	B4	13.82	7.96	0.05	19.18	0.08	11.38	0.20	0.55	0.22	32.38	1.69	11.51	98.02	90	16	168	10	120	22
RMR31820	B4	14.32	7.19	0.02	11.28	0.07	5.88	0.13	3.99	0.25	45.84	1.46	8.80	99.23	130	10	174	14	108	20
RMC60562	B5	13.69	7.94	0.01	14.48	0.17	5.08	0.17	4.41	0.31	43.25	1.75	8.50	99.76	485	18	162	10	90	26
RMC60563	B5	12.73	7.54	<0.01	15.46	0.22	5.04	0.20	3.15	0.25	45.16	1.66	7.66	99.07	2100	18	206	10	84	24
RMC60191	B5	13.31	7.95	<0.01	15.48	0.16	4.69	0.19	3.81	0.25	43.05	1.78	8.33	99.00	480	14	172	10	90	22
RMC60541	B5	13.52	6.79	<0.01	15.14	0.06	6.28	0.18	3.15	0.26	42.75	1.87	8.95	98.95	95	10	122	14	93	28
RMC60514	B5	13.69	7.18	<0.01	15.38	0.06	5.50	0.16	2.82	0.31	43.44	1.72	9.33	99.58	55	12	140	12	90	22
RMC60522	B5	13.49	6.53	<0.01	14.97	0.16	4.86	0.16	3.78	0.28	46.17	1.73	7.45	99.58	135	12	152	12	93	26
RMR30273	Rhyolite	11.91	1.56	<0.01	2.81	2.63	1.79	0.05	1.28	0.03	73.19	0.23	3.05	98.53	4300	54	44	46	345	98
RMR30286	Rhyolite	9.70	0.05	<0.01	3.42	3.00	0.40	0.01	0.13	0.03	79.43	0.18	2.78	99.13	1455	60	20	44	294	72
RMR30290	Rhyolite	12.57	0.44	<0.01	5.84	3.02	3.10	0.06	0.33	0.05	69.37	0.23	3.97	98.98	1695	62	22	44	375	96
RMR30291	Rhyolite	11.57	0.03	<0.01	4.18	2.87	2.11	0.03	0.16	0.03	74.80	0.22	3.26	99.26	1985	56	12	44	357	88
RMR30299	Rhyolite	10.87	0.16	<0.01	1.30	3.46	0.54	0.01	0.08	0.02	79.99	0.20	1.87	98.50	3440	64	10	38	327	82
RMC60537	Rhyolite	13.64	1.15	0.01	5.04	2.50	3.12	0.08	1.65	0.03	67.33	0.25	3.32	98.12	3030	52	88	52	423	105
RMC60385	Rhyolite	13.58	0.26	<0.01	3.35	3.61	1.63	0.07	0.57	0.05	72.57	0.24	3.14	99.07	2750	74	36	44	396	115
RMC60321	Rhyolite	12.55	0.63	<0.01	2.91	3.81	0.77	0.04	0.14	0.05	73.76	0.23	3.77	98.66	3730	74	38	48	381	115
RMC60374	Rhyolite	11.09	0.36	<0.01	4.50	3.17	0.97	0.04	0.10	0.01	74.93	0.19	3.42	98.78	5110	58	24	42	315	72
RMC60524	Rhyolite	14.13	0.71	<0.01	4.73	2.57	3.01	0.08	1.35	0.05	68.85	0.28	3.14	98.90	2140	54	80	50	405	92
RMC60564	B6	17.81	5.42	<0.01	9.80	0.27	5.03	0.12	6.02	0.11	47.65	0.73	6.51	99.47	110	18	294	8	54	20
RMC60566	B6	18.16	5.62	0.03	10.29	1.33	4.40	0.11	5.05	0.11	48.84	0.74	3.68	98.36	470	42	450	6	54	16
RMC60270	B6	19.53	0.43	<0.01	12.72	2.38	4.31	0.24	3.80	0.09	48.37	0.80	5.46	98.13	1650	44	58	6	54	22
RMC60502	B6	19.84	0.34	<0.01	13.92	3.11	5.75	0.48	1.63	0.10	47.03	0.85	5.66	98.71	3390	50	48	6	60	26
RMC60540	B6	17.66	0.35	<0.01	15.52	1.86	4.84	0.37	2.66	0.10	49.00	0.75	5.43	98.54	1010	30	58	6	51	22
RMC60547	B6	19.69	2.81	<0.01	8.63	3.15	4.88	0.29	2.81	0.10	49.63	0.71	5.43	98.13	10780	42	132	6	51	20
RMC60651	B6	18.00	6.92	<0.01	7.67	3.69	1.93	0.37	1.86	0.09	49.18	0.73	7.63	98.07	3960	58	112	8	51	20
RMR30297	Gabbro	11.78	8.51	<0.01	16.23	0.65	4.40	0.22	2.61	0.35	43.90	2.05	8.40	99.10	945	28	268	16	117	26
RMC60507	Gabbro	12.92	8.62	<0.01	17.01	0.48	5.07	0.23	2.73	0.39	46.91	2.03	3.03	99.42	215	16	292	18	126	28
RMC60557	Mafic dyke	13.38	9.16	0.07	9.81	0.20	8.94	0.30	2.58	0.17	41.71	0.78	11.71	98.81	505	18	360	6	63	16
RMC60558	Mafic dyke	15.56	6.96	0.05	9.17	1.16	6.82	0.40	2.33	0.13	47.60	0.74	8.60	99.52	2210	28	272	6	69	18

Table 3.4. Chemical compositions of representative suite of main igneous units in the Glacier Creek prospect map area.

CHAPTER 4

COMPARISON OF THE GLACIER CREEK, CAP, AND MOUNT HENRY CLAY PROSPECTS

Introduction

The Palmer property contains at least 10 major VMS occurrences and prospects over an area of roughly 27 km² (Figure 1.2). The prospects are a few hundred metres to several kilometres apart, and large expanses of ice commonly occur between them. Structural complexity, rapid facies changes, monolithic strata, and cover have impeded property-scale stratigraphic correlations, and the stratigraphic position of many of the different occurrences relative to one another is unknown.

This chapter presents comparative data on stratigraphy, chemistry, mineralization and alteration at three of the most intensively explored prospect areas – Cap, Mount Henry Clay (MHC), and Glacier Creek. Detailed studies were made at each of the prospect areas (see Appendices 1 & 2 for detailed descriptions of the Cap and MHC prospects), which aid the description of the overall character of mineralization on the Palmer property and the determination of potential correlations between prospects.

Comparisons of Stratigraphy

Overall, the three prospect areas exhibit gross stratigraphic similarities: all are in mafic volcanic-dominated sections that contain subordinate felsic rocks and mafic intrusions. However, when looking at the stratigraphic sections in detail, there are some significant differences. One difference is the presence of feldspar porphyritic basalt units at the Glacier Creek prospect, but not at the Cap and MHC prospects. The dominantly feldspar porphyritic B6 basalt unit at the Glacier Creek prospect is at least 70-90 m thick, and is an important stratigraphic interval that forms the immediate hanging wall to the Main zone, and locally forms the immediate footwall to the RW zone. Another important unit in the Glacier Creek prospect map area is a massive rhyolite flow that occurs in the immediate footwall to the RW zone. At the Cap prospect, massive rhyolite occurs in an 'island' of monolithic rubble engulfed by the receding Saksia glacier, roughly 450 m to the SW of the surface exposure of massive barite, but no rhyolite was identified at surface or in drill core within the immediate area of the Ag-rich massive barite beds. At the MHC prospect, rhyolite dykes are not uncommon, but no rhyolite flows have been identified.

At both the Glacier Creek prospect and the Cap prospect narrow intercalations of tuffaceous limestone and mafic tuff are relatively common. In contrast, fine-grained sediments are extremely rare throughout the stratigraphic section at the MHC prospect. The scarcity of fine-grained sediments at the MHC prospect is interpreted to reflect near

continuous volcanic activity in the area, and that there were very few breaks in volcanism long enough for pelagic sediments to collect and form bedded layers. Both the Cap and MHC prospects appear to have a much higher abundance of mafic fragmental rocks (a roughly 50/50 ratio of fragmental rocks versus flows) than the Glacier Creek prospect.

Intrusive mafic igneous rocks are common at all of the prospect areas. Gabbro bodies, which are presumably comagmatic with the Late Triassic volcanic rocks, intrude the hanging wall strata to the RW zone at the Glacier Creek prospect, as well as the hanging wall strata to massive barite at the Cap prospect. At the MHC prospect, a large, crudely sill-like diorite to gabbro intrusion, which contains Cu-rich stringers, occurs in close proximity to the interpreted stratigraphic interval that was the source of high-grade massive sulphide boulders distributed along the terminus of the Mount Henry Clay glacier. Some of the mafic dykes at the MHC prospect exhibit peperitic textures in mafic fragmental dominated strata, a feature not observed in mafic dykes at either the Cap prospect or the Glacier Creek prospect.

Comparisons of Chemical Composition

The volcanic rocks at each of the prospect areas have similar tholeiitic to transitional magmatic affinity based on a Y versus Zr diagram (Figure 4.1). No differences in fractionation trend can be distinguished between the different prospects on

the Y versus Zr diagram, which suggests that the volcanic rocks at each of the different prospects were derived from similar primary magmas. Excluding samples of rhyolite the strata at the MHC prospect appear to be more evolved, or fractionated, than the majority of rocks in the Glacier Creek prospect map area. The evolved nature of the mafic rocks at the MHC prospect is marked by a high average content of Zr (100-200 ppm), and many of these rocks are best classified as basaltic andesite (see Appendix 2 for details on MHC rock classification). Samples of mafic rocks from the Cap prospect overlap with those from Glacier Creek prospect and the MHC prospect on the Y versus Zr diagram.

Data from multiple samples of stratigraphic units in the Glacier Creek prospect map area define distinct, discrete fields on a Zr/TiO_2 versus Zr/Al_2O_3 diagram (Figure 4.2), which allows effective discrimination of the volcanic strata. Comparison of these fields with strata at the Cap and MHC prospects shows that there is little overlap among them, excepting the B4 basalt unit. Although some of the strata at the Cap and MHC prospects have a similar immobile element signature to the B4 basalt unit, stratigraphic correlation is unlikely based on dissimilar stratigraphic sections, and the lack of spherulites (which are a distinctive feature of the B4 basalt unit) in strata at the Cap and MHC prospects. One sample of a rhyolite dyke at the MHC prospect plots within the field defined by the rhyolite unit that occurs in the footwall to the RW zone at the Glacier Creek prospect, and the two may be comagmatic. All other rhyolite dykes at the MHC prospect appear to have had a different parental magma than the rhyolite unit at the Glacier Creek prospect. The one sample of rhyolite at the Cap prospect appears to be

closer chemically to dykes at the MHC prospect than to the Glacier Creek prospect rhyolite unit.

A subset of samples from the Cap prospect map area overlaps with the main cluster of samples from the MHC prospect on the Zr/TiO_2 versus Zr/Al_2O_3 diagram (Figure 4.2), which indicates that some of the strata at the two prospects may be correlative. Most of the Cap prospect samples that overlap the MHC prospect samples are not from strata in the immediate footwall or hanging wall to the Ag-rich massive barite mineralization at the Cap prospect.

Comparisons of Mineralization and Alteration

The Glacier Creek, Cap, and MHC prospects share many similarities in style of alteration and mineralization. At each of the prospects, massive sulphide and/or barite bodies (and boulders) exhibit bedding or banding that is interpreted to have formed mainly by mineral precipitation at or near the seafloor. Massive barite-sulphide at the RW and Main zones, located at the Glacier Creek prospect, contains low- to high-grade Zn, Cu, Pb, Ag and Au. Mineralization at the Cap prospect is Ag-rich and contains high concentrations of Au, Zn and Pb. Boulders at the MHC prospect yield some of the highest Zn and Cu grades at Palmer, are Ag-rich and contain high concentrations of Au and Pb. Minerals that are common to massive sulphide and/or barite bodies (and

boulders) at all of the prospects include sphalerite, barite, pyrite, and subordinate galena. Chalcopyrite is locally abundant in the RW and Main zones at the Glacier Creek prospect, and is a component of many of the massive sulphide boulders at the MHC prospect, but was not observed at the Cap prospect. The lack of chalcopyrite at the Cap prospect is interpreted to be due to lower temperature mineralizing fluids there (at least within those areas exposed at surface and intersected in drill core) than at the other prospect areas. The abundance of barite, and local occurrence of magnetite in beds of massive barite and sulphide, indicate that the mineralizing fluids at the three prospect areas vented into oxygenated seawater.

Hydrothermal alteration in each of the prospect areas is characterized by broad zones that are pervasively altered to an assemblage of quartz, sericite, and pyrite. Hydrothermal chlorite is volumetrically minor, and was only observed at the Glacier Creek and MHC prospects, where it occurs in areas of chalcopyrite-bearing stockwork veins. Rocks peripheral to zones of strong quartz, sericite, and pyrite (QSP) alteration may have been altered to lower temperature mineral assemblages, although many of the low-temperature alteration minerals would likely have been replaced during the regional greenschist-facies metamorphism, or, as in the case with propylitic alteration, the alteration mineralogy is the same as that formed during metamorphism (e.g. chlorite, albite, calcite and epidote) and the two cannot be distinguished. At the MHC and Cap prospects areally extensive zones of disseminated secondary magnetite occur outside

zones of strongly QSP altered rocks, and may be remnants of large-scale low-temperature alteration related to the massive sulphide forming hydrothermal system. Alternatively, the disseminated magnetite and pyrite may be related to a later phase of alteration, perhaps associated with intrusive activity, or to the regional metamorphic event.

Long lived hydrothermal systems appear to be the norm on the Palmer property. Stacked layers of exhalative style mineralization are well documented at both the Cap and Glacier Creek prospects, and are strongly suspected to occur at the MHC prospect. At Cap, there are at least 4 different beds of massive pyritic barite and/or chert that are 3 m thick or greater within a 110 m thick section of pervasive QSP alteration. The RW and Main zones are separated by roughly 70-100 m, and occur in strong QSP alteration that spans three different volcanic units that have a cumulative thickness of >120 m. At the MHC prospect there are two zones of strong QSP alteration of undetermined thickness that appear to occur at different stratigraphic intervals, and at least one is known to host semi-massive to massive barite and sulphide.

Summary

In summary, the three prospects share similar baritic bedded, or banded, stratiform units, albeit with significant variations in the abundance of different sulphide minerals. In general, the prospects are enriched in Zn, Cu, Pb, Ag, and Au, with variation in metal concentration occurring within and between the different prospects. Broad

zones of pervasive quartz-sericite-pyrite alteration are associated with the stratiform mineralization at all of the prospects, and hydrothermal chlorite is associated with Cu- and Zn-rich stockwork mineralization at the Glacier Creek and MHC prospects.

Gross similarities in the character and chemical composition of strata at the three prospects, indicate that the volcanic rocks at each prospect were likely deposited in the same subaqueous, mafic-dominated, rift-related environment. A dominantly tholeiitic to transitional magmatic affinity is common to all strata and no differences in fractionation trends could be distinguished between the three prospect areas, which indicates that the volcanic rocks were probably derived from similar primary magmas.

Although containing similar rock types, the stratigraphic sections at the three prospect areas vary in abundance of fragmental- versus flow-dominated strata, presence or absence of feldspar porphyries and rhyolite flows and dykes, and the amount of intercalated fine-grained sediment. Immobile element chemistry permits discrimination of volcanic strata that is otherwise extremely difficult because of their similar physical appearances. Most of the stratigraphic units in the Glacier Creek prospect map area have different immobile element signatures than the strata at the Cap and MHC prospects, and are likely not correlative. The volcanic strata that occupy the immediate footwall and hanging wall to the stratiform massive barite at the Cap prospect do not correlate with

rocks at the MHC prospect; however, potential correlations exist between some of the other strata in the Cap prospect map area with strata at the MHC prospect. The stratigraphic sections at the Cap and MHC prospects are not markedly different and given that the two prospect areas are roughly along strike from one another, the likelihood that two areas have some strata in common is not unreasonable.

Magmatic Affinity - Y vs Zr plot (Fields after Maclean & Barrett, 1994)

Figure 4.1. Y versus Zr magmatic affinity plot for 245 rock samples from the Glacier Creek, MHC, and Cap prospects (fields defined by Barrett and Maclean, 1994). Samples with Zr values of greater than 250 ppm are predominantly rhyolite, those with less than 250 ppm Zr are predominantly basalt and basaltic andesite. No apparent distinction in fractionation trends exists between the three different prospect areas, which suggests that the volcanic rocks at each of the different prospects were derived from similar primary magmas.

Fields for volcanic units from the Glacier Creek prospect map area:

- B1 = B1 pillow basalt unit
- TA = feldspar porphyritic trachyandesite unit
- B2 = B2 massive and pillowed basalt unit
- B3 = B3 pillow basalt unit
- B4 = B4 spherulitic pillow basalt unit
- B5 = B5 massive and pillowed basalt unit
- Rhy = massive rhyolite flow unit
- B6 = B6 variably feldspar porphyritic basalt unit

Figure 4.2. Plot of Zr/Al_2O_3 versus Zr/TiO_2 for samples of volcanic strata at the Cap and MHC prospects with superimposed fields for volcanic units from the Glacier Creek prospect map area. With the exception of the B4 basalt unit, there is very little overlap among the units in the Glacier Creek prospect map area with volcanic rocks at either the Cap or the MHC prospects. A subset of samples from the Cap prospect overlaps with the main cluster of samples at the MHC prospect (immediately below and to the right of the 'B1' field on the diagram), which suggests that some strata at the two prospects may be correlative.

CHAPTER 5

SUMMARY AND CONCLUSIONS

The Palmer property, centered roughly 55 km north of Haines, Alaska, contains numerous occurrences of VMS style mineralization at a district-scale. It is hosted by mafic-dominated bimodal volcanic rocks and subordinate tuffaceous limestone and argillite that are constrained to Norian to Rhaetian (Late Triassic) age based on new conodont data. This age is in agreement with a new U-Pb date of 213 ± 5 Ma for zircon from a rhyolite flow at the Glacier Creek prospect. Limestone northwest of the property yielded Middle Devonian age conodonts, and is assumed to be an overthrust block of the Paleozoic basement.

The Late Triassic volcanic rocks at Palmer are correlative with rocks at the Greens Creek and Windy Craggy deposits. If 150 km of Tertiary dextral offset along the Chatham Strait-Denali fault system is restored, the Palmer property would be located less than 50 km from the Greens Creek deposit. The Late Triassic proximity of the Palmer property to the Greens Creek deposit in conjunction with similarities such as Zn-rich mineralization and the abundance of barite suggest that the two formed in a similar geological environment.

Mineral assemblages and conodont data indicate that the rocks on the Palmer property have undergone regional greenschist facies metamorphism, most likely at low- to mid-greenschist grade. At least three phases of deformation have been identified at the Palmer property, the earliest and most evident being a north-south contractional deformation event (D1), which is characterized by slaty to schistose cleavage (S1) and south vergent folds and thrusts. S1 foliation is reoriented about north-northwest plunging open to tight D2 folds that have no associated fabric. Deformation post-dating D2 includes rare crenulation fabrics and NW to SW striking high-angle faults.

The Glacier Creek prospect map area was subject to prolonged hydrothermal activity, with intervals of volcanism and sedimentation, and contains stacked zones of massive barite-sulphide – the RW and Main zones – which occur in a panel of moderately NNE dipping strata that form the hanging wall to the MZ thrust fault. The stratigraphic section preserved in the thrust panel is more than 350 m thick, and is dominated by massive to pillowed basalt, with subordinate rhyolite, mafic tuff, tuffaceous limestone, trachyandesite, conglomerate, and gabbro. Volcanic units have distinct immobile element signatures, which permits effective geochemical discriminations. This provides an extremely useful tool for correlating units across structures, through zones of hydrothermal alteration, and between different prospect areas.

The RW zone consists of a body (or bodies) of stratiform barite-, sphalerite- and chalcopryrite-rich, massive sulphide and subordinate sulphide-rich carbonate. It has been

intersected in drill core intermittently over a strike length of about 600 m between the Upper Main and Little Jarvis occurrences, has a down-dip extent of at least 200 m, a maximum known thickness of 15 m, and remains open in virtually all directions. The zone is underlain by intensely quartz-sericite-pyrite+/-chlorite altered rhyolite and basalt that locally host a sphalerite- and chalcopyrite-rich stockwork. The Main zone, which is 70-135 m stratigraphically below the RW zone, consists of similar stratiform mineralization. It has only been intersected by one drill hole and its subsurface extent remains virtually untested. Supergene processes have played an important role in modifying both the RW and Main zones. Along the southeast side of Mount Morlan, the zones have been extensively leached of sulphides and are underlain by Zn and Cu oxide enrichment zones. Previous work at the prospect failed to recognize that iron-oxide stained, variably siliceous vuggy barite and barite grus in both outcrop and drillcore was leached massive sulphide, resulting in the under evaluation of the prospect's potential to host significant massive sulphide mineralization.

Strata in the Cap prospect map area are characterized by pillowed basalt flows, mafic volcanic fragmentals, and interflow slaty tuffaceous limestone and chert. Mineralization is Ag-rich and consists of stratiform pyritic massive barite and baritic stringers and breccia in pervasively quartz-sericite-pyrite altered basalt. Concentrations of Zn, Pb, and Au, are high and, along with Ag, exhibit a positive correlation with barite. Unlike the other prospect areas, base metal-rich stratiform massive sulphide is absent, and Cu concentrations are negligible. The hydrothermal alteration at the Cap prospect is

extensive, and it is possible that the mineralization exposed at surface and intersected in drill core was precipitated from a zone of relatively cool hydrothermal fluids that was located on the outer edge of a larger, potential massive sulphide forming, hydrothermal system.

Strata in the MHC prospect map area are characterized by massive to pillowed flows and fragmental rocks of basalt to basaltic andesite composition that are intruded by diorite, gabbro, and minor rhyolite. The stratigraphic section at the MHC prospect area is the least well understood of the three studied prospect areas, largely due to paucity of bedding, extensive glacial cover, and relatively homogenous strata. Nevertheless, strata are divisible into a lower, fragmental-dominated section and an upper, flow dominated section. The broadly defined contact zone between the two sections is marked by variably developed quartz-sericite-pyrite+/-chlorite alteration and is the potential source of the high-grade massive sulphide boulders that occur around the terminus of the Mount Henry Clay glacier. A second zone of hydrothermal alteration, which is associated with stratiform massive barite and semi-massive to massive pyrite, may also be a source area for massive sulphide boulders, and indicates potential for stacked massive sulphide bodies.

Available data indicates that rocks in the MHC prospect map area likely formed in an effusive, vent-proximal, environment with minimal pelagic sedimentation, and was the site of largely uninterrupted volcanism. Mafic volcanic rocks show little variation in

immobile element contents, and most were likely derived from a common magmatic source. Potential breaks in the volcanic sequence, marked by sedimentary strata, are key exploration targets as they are prospective time-stratigraphic intervals for massive sulphide accumulation. Also important, are mafic fragmental units bearing QSP altered clasts, which may mark stratigraphic intervals of ore-forming hydrothermal activity.

Overall, the Glacier Creek, Cap, and MHC prospect areas exhibit gross similarities in stratigraphy, alteration and mineralization, and are assumed to have formed in the same subaqueous, mafic-dominated, rift-related environment. A dominantly tholeiitic to transitional magmatic affinity is common to all strata and no differences in fractionation trends could be distinguished between the three prospect areas, which indicates that the volcanic rocks were probably derived from similar primary magmas. Based on rare earth and high field strength element concentrations in basalt and rhyolite at the Glacier prospect, the Late Triassic strata were most likely deposited in a back-arc or attenuated continental lithosphere tectonic setting.

Structural complexity, rapid facies changes, relatively indistinct stratigraphy, and glacial cover have impeded property-scale stratigraphic correlations, and the stratigraphic position of many of the different occurrences relative to one another is unknown. Consequently, potential correlations between strata at the Glacier Creek, Cap, and MHC prospects were determined based on detailed comparisons of the stratigraphic sections and the immobile element chemistry of strata at each of the prospect areas.

The stratigraphic section studied at the Glacier Creek prospect area is distinct from that exposed at the Cap and MHC prospects. Most notably, feldspar porphyritic basalt, which forms a thick unit in the footwall to the RW zone (and hanging wall to the Main zone) at the Glacier Creek prospect, is not found at either the Cap or MHC prospect areas. Rhyolite, which occurs at all three prospect areas, is substantially more abundant at the Glacier Creek prospect, and does not appear to be intimately associated with mineralization at any prospects but the Glacier Creek prospect. Most of the stratigraphic units in the Glacier Creek prospect map area have different immobile element signatures compared to the strata at the Cap and MHC prospects, and are likely not correlative.

The volcanic strata that occupy the immediate footwall and hanging wall to stratiform massive barite at the Cap prospect are chemically distinct from strata at the MHC prospect. However, other strata from within the Cap prospect map area have similar immobile element signatures to the strata at the MHC prospect, and potential correlations may exist between the two. The stratigraphic sections at the Cap and MHC prospects are not markedly different and given that the two prospect areas are roughly along strike from one another, the possibility that the two areas have some strata in common is not unreasonable.

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Appendix 1

GEOLOGY OF THE CAP PROSPECT

Introduction

The Cap prospect contains massive exhalative barite associated with intensely altered (quartz-sericite-pyrite) rocks. It is exposed at an elevation of 3800 ft (1160 m), near ice level, along the northern edge of the Saksia glacier (Figures A1.1 and A7.13a). Current understanding of the mineral occurrence and surrounding geology is based on 1:2500 scale mapping and four diamond drill holes: Cap-01, Cap-02, Cap-04 and RMC98-01. Whole rock lithogeochemical analyses have been obtained for 36 samples from drillcore, and 11 samples from surface exposures. ICP analyses have been obtained for 169 core samples, and 17 surface samples. Thin sections were made for most whole rock samples, and additional sections were made to characterize mineralization and alteration.

Structure

A single foliation is common to rocks at Cap, and is assumed equivalent to the S1 axial planar cleavage that is observed elsewhere on the property. No large-scale folds related to S1 were mapped, although rare tight to isoclinal folding was noted at the outcrop scale, and it is possible that larger scale folds and or thrusts may have gone unnoticed. In the immediate vicinity of the Cap mineral occurrence foliation dips steeply to the WNW and roughly parallels the strike of bedding, which dips moderately to the WNW.

A second deformation event (D2) is revealed by folding of the earlier formed S1 foliation. The attitude of S1 foliation changes from moderately to steeply WNW-NNW dipping in the northwest half of the map sheet to steeply SW-SSW dipping in the southwest half of the map sheet, and poles to S1 show excellent great circle distribution on stereonet plots (Figure A1.2). The nature of the fold is poorly understood because of inadequate stratigraphic control, although it is appealing to interpret it as a synform as this would allow correlation of the Cap occurrence with a QSP alteration zone located about 450 m up ice to the west. No penetrative fabric generated during D2 folding was observed in the map area.

Only one fault of significance was identified at Cap. It is located in the far northwest corner of the map area, where it was traced on surface for over 230 m (Figure A7.13b). The fault dips moderately to the west, and the sense of displacement is unknown. It is a late stage brittle structure that appears to post date formation of the S1

foliation. Synvolcanic fault structures are likely responsible for some of the rapid facies changes within the area, but none have yet been identified.

Metamorphism

Regional metamorphism appears to have affected all rocks within the Cap area except for the granodiorite pluton and related dykes. Mafic rocks outside zones of focused hydrothermal alteration contain chlorite, albitic plagioclase, calcite, +/- epidote, +/- biotite, +/- magnetite, +/- quartz. This assemblage is similar to that observed elsewhere on the property, and is consistent with greenschist-facies metamorphism.

A contact metamorphic aureole occurs around a Cretaceous-Tertiary granodiorite pluton. It is identified petrographically by high modal abundance of biotite in mafic country rocks up to several hundred metres from the pluton contact. The thermal anomaly introduced by the pluton is also reflected in the anomalously high CAI value of conodont fragments retrieved from the area (e.g. CAI = 7 for sample C-304755).

Stratigraphy

Stratified Rocks

Stratigraphy at Cap is characterized by pillowed basalt flows, mafic volcanic fragmentals, and interflow calcareous argillite and chert (Figures A1.1 and A1.3). The lowermost known unit of the footwall sequence is a massive, poorly sorted, matrix supported mafic volcanoclastic. It has a minimum thickness of 200 m, and contains lapilli and rare blocks of finely amygdaloidal basalt hyaloclastite in a relatively pure carbonate matrix (Figure A7.14a). The angular, and often delicate shapes of the fragments indicate minimal transport. A distinctive knobby texture results from accelerated weathering of the less resistant calcite matrix. Although extensive on surface, this unit was not intersected in drillcore. Its absence is likely the result of a rapid lateral change of facies, or faulting.

Overlying the mafic volcanoclastic is a 3-5 m thick lens of jasperoidal chert, which in turn is overlain by a roughly 90 m thick sequence of amygdaloidal to scoriaceous pillow basalts. Most of the footwall hydrothermal alteration has been localized within this sequence of pillow basalts. Alteration is focused within the pillow interstices on the periphery of the alteration zone at the Cap occurrence, and becomes pervasive and texturally destructive towards the center of the system. Local zones of fragmentation were noted within intensely altered sections of the pillow basalt sequence. These zones represent areas of hydrothermal brecciation, and/or primary fragmental deposits whose porosity may have helped focus the hydrothermal alteration. Massive barite and cherty exhalite found within the pillow basalt sequence well below the main

exhalative horizon indicates prolonged hydrothermal activity in which the hydrothermal alteration worked its way up through successive flows.

Approximately 450 m to the southwest of the Cap occurrence, and completely engulfed by the Saksia glacier, is a large monolithic pile of angular, very sparsely quartzphyric, sericite altered rhyolite rubble that is becoming exposed as the ice recedes. It is in proximity to a zone of intense QSP alteration separate from that which is associated with the massive barite exposed at the Cap occurrence, and potentially occupies a similar stratigraphic position to the above described footwall sequence.

The main exhalative unit at the Cap prospect is a massive, up to 7-8 m thick, bed of banded pyritic barite that grades laterally, and locally vertically, into chert (Figure A7.14b). The hanging wall to the main exhalative unit is a 12 m thick section of black slaty carbonate, with pale gray to cream tuffaceous carbonate interbeds (Figure A7.14c). Along strike, 120 m to the northeast of the Cap occurrence in DDH Cap-03, a 12 m section of mafic tuff and tuffaceous sediment occurs between chert of the main exhalite unit and the black slaty carbonate. Two microfossil samples were collected from the hanging wall carbonates, one of which was unproductive. The other, yielded ramiform elements that loosely constrain the rocks to Ordovician-Triassic age. Overlying the section of black slaty carbonate is a package of amygdaloidal pillow basalts and lapilli tuff that contain rare intervals of fine-grained sediment/tuff and ankerite stained white

chert. Extensive overburden cover and lack of drill data prohibit detailed description of the upper hanging wall strata.

Intrusive Rocks

Intruding into the hanging wall strata is a gabbroic body that appears to have a crudely sill-like geometry. The gabbro is fine to medium grained and poikilitic, with pyroxene oikocrysts totally replaced by chlorite (Figure A7.15a). A similar, but much smaller gabbro was mapped in the extreme southwest corner of the map area. Aphanitic to fine-grained mafic dykes are quite common, and in the main occurrence area cross-cut the quartz-sericite-pyrite alteration. The dykes do not share the same intensity of alteration as the host rocks; however, moderate concentrations of sericite and pyrite suggest that they have been subject to alteration beyond that of just the regional metamorphism. It is possible that some dykes were intruded during the waning stages of the hydrothermal system and are feeders to overlying flows.

A medium to coarse-grained, biotite-hornblende granodiorite pluton borders the eastern edge of the map area. Locally, it hosts weak to moderate epidote alteration, although, in general, it is quite fresh in appearance with 'flashy' well-preserved biotite, and is believed to postdate the regional greenschist-facies metamorphism that affected the Late Triassic country rocks. The pluton is assumed to be correlative with Cretaceous to Tertiary age granitic plutons indicated on regional geological maps (McKevett et al., 1974; Campbell and Dodds, 1983). A distinctive feature of the pluton in the Cap map

area is a cupola of intrusive breccia, which contains coarse angular blocks of meta-sediments and meta-volcanics in a granodiorite to aplite matrix (Figure A7.15b). Minor aplite, granodiorite, and feldspar porphyry dykes emanate from the pluton, and rare basalt dykes cut the pluton itself.

Alteration and Mineralization

Cap is a silver-rich, barite-dominated system that contains locally high concentrations of zinc, lead, and gold. Base and precious metal mineralization is hosted by veined and brecciated, intensely QSP altered, highly amygdaloidal, basalt (Figure A7.16a) and a capping bed of massive pyritic barite (Figure A1.4). Mineralized seams and layers (0.1 – 4.2 m thick) of massive barite +/- chert, and massive to semi-massive pyrite occur throughout the section of QSP altered basalt. Veins and breccia matrix in QSP altered rocks mainly consist of barite, quartz, pyrite, and sericite. Veins commonly have irregular ‘wormy’ forms, and are typically zoned, with pyrite along vein margins and quartz-barite cores (Figure A7.16b). Sulphide minerals identified in thin section include pyrite, sphalerite, galena, and acanthite/argentite with possible pyrargyrite inclusions. There is a positive correlation of metal values and barium concentration, as can be seen on the downhole assay plots for drill hole RMC98-01 (Figures A1.5a, A1.5b, and A1.5c). Assay highlights of the four holes drilled at Cap are listed in Table A1.1.

Within the core of the alteration zone, basalt is completely replaced by quartz, sericite, and pyrite, and amygdules are typically the only primary textures left in the rock. Amygdules are composed of quartz and minor barite and sericite, and are locally cored by sphalerite and galena (Figure A7.16c). Chemically the QSP alteration is characterized by depletion of sodium, and enrichment of silica and potassium. Drillhole data indicates pervasive QSP alteration has a maximum thickness of at least 110 m, and grades at depth into rocks containing chlorite, sericite, calcite, pyrite, epidote and magnetite. These minerals may define a propylitic alteration zone that envelopes the QSP alteration; however, a similar mineral assemblage is associated with the greenschist-facies metamorphism and it is difficult, to impossible, to distinguish between the two. Accompanying the change in alteration with depth is a transition from barite-quartz-pyrite veins to carbonate-quartz-pyrite veins, and a corresponding drop in metal values. Moderate to strong calcite and sericite alteration extending at least 50-100 m into the hanging wall of the main massive barite layer was identified petrographically in basalt that in hand sample looked moderately fresh. The hanging wall alteration is far less pervasive than the QSP alteration in the footwall to the massive barite, and may be related to diffuse, lower-temperature hydrothermal activity that produced the barren chert beds that are intercalated throughout the hanging wall strata. Secondary magnetite, identified in basaltic rocks up to several hundred metres from known exposures of strong hydrothermal alteration, may be related to large-scale low-grade synvolcanic hydrothermal alteration. Alternatively, the magnetite may be a product of the regional greenschist-facies metamorphism, or be related to intrusive activity.

The size, longevity and intensity of the alteration zone at Cap, and the common occurrence of precious metal rich, barite lenses on the flanks of massive sulphide ore bodies in known Phanerozoic deposits (Franklin et al., 1981), suggest that there is the potential that Cap is on the edge of a large massive sulphide system. Both surface and drill data indicate that the hydrothermal system is diminishing in strength along strike to the northeast, but in the down dip and the southwest (sub-ice) strike directions the hydrothermal system appears to be strong and remains untested.

Chemical Composition

Rock Classification

Chemical composition of a representative suite of rocks at the Cap prospect and surrounding area are given in Appendix 8. Classification of volcanic rocks was based on the 'immobile' elements Zr, Ti, Al, Nb, and Y. Diagrams that rely on concentrations of K and Na were not used for the volcanic rocks due to the potential mobility of these elements in environments of hydrothermal alteration and greenschist-facies metamorphism.

Volcanic rocks plot in the sub-alkaline basalt field on the Zr/TiO_2 versus Nb/Y diagram (Figure A1.6; Winchester and Floyd, 1977), excepting three highly altered samples, which plot in the andesite/basalt and alkaline basalt fields, and one sample of

rhyolite. On the SiO_2 versus Zr/TiO_2 diagram (Figure A1.7; Winchester and Floyd, 1977), most samples cluster in and around the sub-alkaline basalt field, but there is a marked vertical spread to the data points due to addition and depletion of silica in strongly altered samples. A sample of the relatively fresh, apparently non-metamorphosed, pluton that is exposed east of the Cap prospect plots in the granodiorite field on the $\text{Na}_2\text{O}+\text{K}_2\text{O}$ versus SiO_2 diagram (Figure A1.8; Middlemost 1985), which matches the composition determined from modal abundance of essential minerals in hand specimen.

Volcanic rocks have predominantly tholeiitic to somewhat transitional magmatic affinity based on Zr versus Y ratios (Figure A1.9; Barrett and MacLean, 1994). The granodiorite pluton is calc-alkaline, and is intruded by a late-stage basalt dyke that has borderline tholeiitic to transitional magmatic affinity.

Geochemistry of Host Rocks

The majority of drillcore samples (9 out of 13) of variably altered basalt, which are from the footwall to the main bed of massive barite, and host to Ag-rich baritic stockwork, plot within a fairly tight cluster on the Zr/TiO_2 versus $\text{Zr/Al}_2\text{O}_3$ diagram (Figure A1.10). These rocks are interpreted to have had a common magmatic source, and differ from the weak to moderately altered hanging wall basalts intersected in drillcore, which plot in a different area on the Zr/TiO_2 versus $\text{Zr/Al}_2\text{O}_3$ diagram. Samples of variably altered footwall basalt, especially those that do not plot within the tight cluster

described above, have a positive-sloped linear distribution. The linear distribution is interpreted to be a result of nugget-effect in Zr analyses, in which erratic values are produced because of inhomogeneous Zr distribution in the rock at the scale sampled. Alternatively, samples plotting outside the tight cluster may have different magmatic sources, have had sample contamination, been subject to analytical error, or one or more of the so-called immobile elements Zr, Ti, and Al may have been mobile during alteration.

Figure A1.11, is a Zr/TiO_2 versus $\text{Zr/Al}_2\text{O}_3$ diagram that incorporates both surface and drillcore data, and allows comparison of rocks at the Cap occurrence with those in the surrounding area. It is apparent from the diagram that the intensely QSP altered rocks at the Cap occurrence have a different basaltic protolith than the intensely QSP altered rocks located about 450 m to the west. A loose cluster is defined by the rocks at the western QSP alteration zone, unaltered pillow basalt 600 m northwest of the western QSP alteration zone, and basaltic volcanoclastic/tuff that stratigraphically underlies the amygdaloidal pillow basalts that host alteration and mineralization at the Cap occurrence. The loose clustering of these samples permits tentative stratigraphic correlations between them.

Figure A1.1. Simplified geologic map of the Cap prospect area.

Figure A1.2. Schmidt equal area stereonet projection of poles to S1 foliation from the Cap prospect map area. Diagram includes density contours and trace of best-fit great circle.

CAP PROSPECT

Generalized Stratigraphic Section

Figure A1.3. Generalized stratigraphic section for the Cap prospect. Based on drill hole data and mapping proximal to the Cap stratiform massive barite occurrence.

Figure A1.4. Drill section (A-A') through the Cap prospect, looking toward an azimuth of 230°.

Figure A1.5a. Bar graph plot for drill hole RMC98-01 showing positive correlation between barium (left of hole trace) and silver (right of hole trace). Absolute assay values are in Appendix 8.

Figure A1.5b. Bar graph plot for drill hole RMC98-01 showing positive correlation between barium (left side of hole trace) and gold (right side of hole trace). Absolute assay values are in Appendix 8.

Figure A1.5c. Bar graph plot for drill hole RMC98-01 showing positive correlation between barium (left side of hole trace) and zinc (right side of hole trace). Absolute assay values are in Appendix 8.

Figure A1.6. Plot of Zr/TiO_2 versus Nb/Y for 22 samples of volcanic rock from the Cap prospect and surrounding area (fields defined by Winchester and Floyd, 1977). Data is presented on a LOI-free basis.

Figure A1.7. Plot of Zr/TiO_2 versus SiO_2 for 22 samples of volcanic rock from the Cap prospect and surrounding area (fields defined by Winchester and Floyd, 1977). Vertical spread to data points is largely a function of alteration. Data is presented on a LOI-free basis.

Figure A1.8. Plot of $\text{Na}_2\text{O} + \text{K}_2\text{O}$ versus SiO_2 for a sample of fresh (non-metamorphosed?) granodiorite exposed along the eastern edge of the Cap prospect map area (fields defined by Middlemost, 1985). Fields are: 1 = alkali feldspar syenite, 2 = alkali feldspar quartz syenite, 3 = alkali feldspar granite, 4 = syenite, 5 = quartz syenite, 6 = granite, 7 = monzonite, 8 = quartz monzonite, 9 = monzodiorite, 10 = quartz monzodiorite, 11 = granodiorite, 12 = diorite and gabbro, 13 = quartz diorite, 14 = tonalite. Data is presented on a LOI-free basis.

Figure A1.9. Y versus Zr magmatic affinity plot for 28 samples of igneous rocks from the Cap prospect area (fields defined by Barrett and MacLean, 1994). Asterisk = granodiorite pluton, filled circle = all other igneous rocks

Figure A1.10. Plot of Zr/Al_2O_3 versus Zr/TiO_2 for 16 samples of drill core from rocks in the immediate footwall and hanging wall to stratiform massive barite at the Cap prospect. Open circles = strongly QSP altered footwall basalt, half filled circles = chlorite-calcite-epidote-sericite-pyrite altered footwall basalt, open squares = hanging wall basalt.

Figure A1.11. Plot of Zr/Al_2O_3 versus Zr/TiO_2 for 28 surface and drill core samples from strata throughout the Cap prospect map area. Open circles = strongly QSP altered footwall basalt; half filled circles = chlorite-calcite-epidote-sericite-pyrite altered footwall basalt; open squares = hanging wall basalt; open triangle = rhyolite; triangle open up = QSP alteration located ~450m west of the Cap occurrence; triangle filled down = basaltic volcanoclastic/tuff that stratigraphically underlies the amygdaloidal pillow basalts that host alteration and mineralization at the Cap occurrence; triangle filled up = unaltered pillow basalt 600 m northwest of the western QSP alteration zone; half filled box = basalt up section from the Cap occurrence; asterisk = granodiorite pluton; X = gabbro; cross (+) = mafic dykes.

Drillhole	From (m)	To (m)	Width (m)	Au (ppm)	Ag (ppm)	Zn (%)	Pb (%)	Cu (%)	Ba (%)
Cap-01	9.0	32.2	23.2	b.d.	134	0.24	0.16	0.02	d.u.
Cap-02	5.7	17.0	11.3	b.d.	15	0.03	0.02	<0.01	1.49
Cap-03*									
RMC98-01	38.7	45.7	7.0	0.19	74	0.33	0.09	<0.01	20.11
RMC98-01	60.7	71.6	10.9	0.19	62	0.21	0.05	0.01	16.13
RMC98-01	34.4	125.0	90.6	0.10	31	0.09	0.03	<0.01	8.57

b.d. = below detection limit

d.u. = data unavailable

* no significant mineralized intercepts

Table A1.1. Assay highlights from drill holes in the Cap prospect map area.

Appendix 2

GEOLOGY OF THE MOUNT HENRY CLAY PROSPECT

Introduction

The Mount Henry Clay (MHC) prospect area is located on the north flank of Mount Henry Clay, near the head of the Jarvis Glacier, and abuts the Canada-U.S.A. international border to the west (Figure 1.2). The area is host to high-grade massive sulphide boulders that are distributed along the toe of a small ice sheet that is informally named the Mount Henry Clay glacier (Figure A7.17a). Work on the prospect has focused on an approximately 1 km² area (Figure A2.1) that ranges in elevation from 4000 ft (1220 m) to 5500 ft (1675 m). Outcrop is less than 15%, and is limited to the sides and toe of the Mount Henry Clay glacier. Four separate drill programs, totaling thirteen holes and 2958 m of core, have tested the sub-ice bedrock, but have been unsuccessful in locating the source of the boulders.

Current understanding of the geology of the MHC area is built on the efforts of other workers – most notably, mapping and drill logs by Bear Creek Mining (Kennecott) and Granges geologists, U.S. Bureau of Mines data, mapping by Katherine Bull, and geological interpretations by J. Garfield MacVeigh. Original contribution by the author

includes limited field investigations, detailed logs of holes G89-11 and K85-05, petrographic analysis of 29 thin sections, analysis of 98 whole rock lithogeochemical analyses, and geological interpretations.

Structure

Rocks at MHC show some of the highest strain on the Palmer property. They contain a well-developed foliation, which is assumed equivalent to the S1 axial planar cleavage that is observed elsewhere on the property, and fragments and amygdules are typically highly flattened. In intensely quartz-sericite-pyrite-chlorite altered rock, foliation is locally mylonitic (Figure A7.17b) and contains a weak elongation lineation (Lewis, 1998). Foliation trends roughly NW-SE, and typically dips moderately to steeply SW (Figure A2.2).

Bedding measurements could not be obtained from surface exposures throughout most of the map area, yet bedding is suspected to strike roughly NW based on gross distribution of alteration and massive volcanic dominated strata versus fragmental volcanic dominated strata. Rare, well-preserved pillows near the collar of hole K84-02, and normally graded volcanoclastic rocks in hole G89-11 indicate that strata in these areas top to the NE, whereas strata in the far southwest corner of the map area dip moderately SW. The axial trace of a large-scale antiform is interpreted to trend NW between these

two areas (Figure A2.1). The same antiform is visible in cliffs about 1000 m to the south-southeast across the Jarvis Glacier from the MHC map area.

Metamorphism

Mafic rocks contain an assemblage of chlorite, plagioclase (An_{0-10}), calcite, magnetite, +/- Fe-bearing carbonate, +/- epidote, +/- biotite, +/- quartz (Appendix 5). This assemblage is similar to that observed elsewhere on the property, and is consistent with greenschist-facies metamorphism. Where fabric development is strongest and grain size is coarsest, mafic rocks are true chlorite schists.

Calcite occurs as a component of the rock matrix, in amygdules and in veinlets, whereas Fe-bearing carbonate occurs as very fine- to fine-grained porphyroblasts. Most mafic rocks are moderate to very strongly magnetic, and contain two generations of magnetite. Primary magnetite is typically very fine-grained and has a magmatic origin. Secondary magnetite is cryptocrystalline to microcrystalline, commonly forms needle-like clusters, locally rims feldspar grains, and is believed to be a product of widespread low-grade hydrothermal alteration or regional metamorphism. Magnetite concentration averages about 5%, but locally is as high as 30-40% and imparts a dark blue-gray to black colour to mafic rocks.

Stratigraphy

Stratigraphy at MHC is characterized by massive to pillowed basalt to basaltic andesite flows and mafic volcanic fragmental rocks that are intruded by diorite to gabbro, and minor rhyolite (Figure A2.1). Limited exposure, relatively homogeneous strata, high strain, and paucity of interflow sediment are responsible for the current poor understanding of the stratigraphic sequence at MHC. In general, strata in the SW half of the map area are dominantly fragmental, and strata in the northwest half of the map area are dominantly flows. It is inferred from topping directions and rock type distribution with respect to the axial trace of the large-scale antiform (Figure A2.1) that the fragmental dominated strata lie stratigraphically beneath the massive flow dominated strata. Strong hydrothermal alteration is localized along the broadly defined contact zone that separates the two. The source layer of the high-grade massive sulphide boulders is suspected to lie within the same broadly defined contact zone.

Basalt to basaltic andesite flows are typically microlitic, weakly amygdaloidal, and strongly magnetic. Amygdules are composed of calcite, quartz, and chlorite, and are locally concentrated along flow contacts. Flows are predominantly massive and pillows are rare, although pillow textures may have gone unrecognized in some areas of high strain. Flows commonly contain zones of brecciation and hyaloclastite along their margins. Magnetite destructive ankerite alteration occurs in basalts proximal to late-stage brittle structures.

Mafic fragmental rocks consist of massive, chaotic breccias, and minor massive ash tuff to lapilli tuff. Most show little evidence of reworking, and bedding is uncommon. Rare flame like structures and subtly developed normal grading locally provide topping direction. Clasts are generally angular and locally have equant and delicate shard like forms that are indicative of hyaloclastite. In areas of high strain, lapilli and block size clasts are highly flattened resulting in a banded appearance to the rock. Fragmental rocks are typically composed exclusively of basalt to basaltic andesite, although in places contain very fine-grained diorite to quartz-diorite and strongly quartz-sericite altered basalt. The quartz-sericite altered clasts were altered prior to reaching their final site of deposition, and they mark time-stratigraphic intervals of potential ore-forming hydrothermal activity. Some of the quartz-sericite altered clasts were highly vesicular and look very similar to QSP altered rocks at the Cap prospect.

A large, medium to coarse-grained, diorite to gabbro intrusion is exposed in the north half of the MHC map area (Figure A2.1). It is correlated with fine to medium-grained, locally Cu-rich stockwork bearing, diorite intersected in drillcore beneath the MHC ice cap (e.g. in holes K8-01, G89-8, 9 & 10). The diorite to gabbro body roughly parallels the interpreted strike of bedding and may have a crudely sill like form.

Numerous dykes and/or sills of dioritic composition occur throughout the mafic volcanic package. The dykes are particularly abundant in fragmental dominated strata, and commonly have irregular brecciated contacts indicative of intrusion into

unconsolidated material. It is believed that isolated clasts of very fine-grained diorite and quartz-diorite(?) in volcanic breccia and lapilli tuff are clasts of dismembered peperite dykes.

Alteration and Mineralization

Exploration efforts at the MHC prospect have focused on finding the source of high-grade, rounded to sub-angular, massive sulphide boulders that are distributed around the terminus of the Mount Henry Clay glacier (Figure A7.17c). The boulders consist of sphalerite, pyrite, barite, chalcopyrite and minor galena, quartz and calcite, and commonly exhibit a crude banding that is defined by variations in the concentration of the different minerals. Twenty-six samples of various boulders collected by the U.S. Bureau of Mines returned an average grade of 19.3% Zn, 1.0% Cu, 0.4% Pb, 38.2 g/t Ag, 0.22 g/t Au, and 20.6% Ba (Still, 1984). A 1.8 m chip sample, collected across banding in the largest massive sulphide boulder at MHC, assayed 33% Zn, 2.5% Cu, 5% Ba, and 65 g/t Ag (Still et al., 1991). Samples of basal till from the terminus of the retreating MHC glacier contain high base metal values (e.g. 0.21-0.36% Zn), and confirm a sub-ice bedrock source for the boulders. Drill holes into bedrock beneath the MHC glacier have intersected minor massive barite and semi-massive to massive sulphide, strong quartz-sericite-pyrite+/-chlorite alteration and chalcopyrite-pyrite stockwork. However, none of the intersections have grades that are anywhere near those of the high-grade boulders, and the exact source of the boulders remains unknown.

There appear to be two roughly northwest trending zones of strong hydrothermal alteration (Figure A2.1). The eastern zone consists of variably quartz-sericite-pyrite-chlorite altered rocks and Cu-rich stockwork that are intersected in holes G89-8 & 9 and K85-1, 2 & 3, and exposed at surface at both the southeast and northwest edges of the MHC glacier. The western zone consists of variably quartz-sericite-pyrite altered rocks and local barite and semi-massive to massive pyrite. It is intersected in holes K85-5, 6 & 7 and is correlated with a thin bed of massive barite exposed near the collar of hole G89-11. Zones of strong hydrothermal alteration are typically devoid of magnetite, and would stand out as anomalous magnetic lows on magnetic susceptibility maps against the more weakly altered strongly magnetic host rocks.

Large-scale background hydrothermal alteration consists of disseminated pyrite (avg. 1-5%) occurring throughout extensive areas of flow-dominated strata. Disseminations of secondary magnetite, averaging 4-5% but locally as high as 30-40%, occurring throughout large areas of both flow and fragmental dominated strata may also be related to large-scale low-intensity alteration, and indicate a sulphur poor hydrothermal fluid.

Chemical Composition

Rock Classification

Chemical compositions of rocks at the MHC prospect area are given in Appendix 8. Classification of volcanic rocks was based on the ‘immobile’ elements Zr, Ti, Al, Nb, and Y. Diagrams that rely on concentrations of K and Na were not used due to the potential mobility of these elements in environments of hydrothermal alteration and greenschist-facies metamorphism.

On a Zr/TiO₂ versus Nb/Y diagram (Figure A2.3; Winchester and Floyd, 1977), nearly all samples of mafic volcanic rocks plot in the sub-alkaline basalt field and samples of felsic dykes plot in the rhyolite field. On a SiO₂ versus Zr/TiO₂ diagram (Figure A2.4; Winchester and Floyd, 1977), most samples of mafic volcanic rocks cluster in the sub-alkaline basalt and andesite fields and there is a marked vertical spread to the data points due to addition and depletion of silica in strongly altered samples. Samples of relatively weakly altered mafic rock that plot as andesite on the SiO₂ versus Zr/TiO₂ diagram and as basalt on the Zr/TiO₂ versus Nb/Y diagram, are considered to have a basaltic andesite composition. Volcanic rocks have tholeiitic to transitional magmatic affinity based on Zr versus Y ratios (Figure A2.5; Barrett and MacLean, 1994).

Geochemistry of Host Rocks

On a Zr/TiO₂ versus Zr/Al₂O₃ diagram, most samples of basalt and basaltic andesite plot within a moderately tight cluster within which samples of the flow dominated strata overlap those of the fragmental dominated strata (Figure A2.6). The immobile element ratios of these rocks are surprisingly uniform considering the size of

the area sampled, and suggest that most of the volcanic rocks in the MHC prospect area had a similar magmatic source. Many of the strongly hydrothermally altered rocks plotted within the same cluster defined by the basalt and basaltic andesite, although are difficult to discriminate in Figure A2.6 due to overlapping data. A notable feature of the mafic rocks at the MHC prospect area is their high concentration of zirconium (averaging 100-200 ppm; Figure A2.5; Appendix 8) as compared to mafic rocks elsewhere on the Palmer property, and in general the rocks are believed to be slightly more evolved, or fractionated, than most other mafic rocks at Palmer.

Samples of rhyolite dykes have a broad scattered distribution on the Zr/TiO_2 versus Zr/Al_2O_3 diagram (Figure A2.6), suggesting different felsic intrusions. Diorite and gabbro, presented on a separate Zr/TiO_2 versus Zr/Al_2O_3 diagram for clarity (Figure A2.7), also have a fairly scattered distribution. Some of the fine-grained diorite dykes plot in a similar area to the basalt and basaltic-andesite host rocks, which suggests that they may be comagmatic with the host strata, whereas most of the medium- to coarse-grained diorite and gabbro do not plot in the same area as the basalt and basaltic-andesite host rocks and likely were emplaced at a later date.

Summary

The MHC area represents an effusive vent proximal environment with minimal pelagic sedimentation, and was the site of largely uninterrupted volcanism. Mafic volcanic rocks show little variation in immobile element chemical composition, and most

were likely derived from a common magmatic source. Fragmental rocks are typically monolithic with angular clasts that record little evidence of significant reworking. Large-scale hydrothermal activity is indicated by broad zones of disseminated pyrite. Areally extensive zones of disseminated secondary magnetite may also be related to large-scale hydrothermal alteration; alternatively it may be a product of regional metamorphism. Two zones of strong quartz-sericite-pyrite+/-chlorite alteration, assumed to be at different stratigraphic levels, have been identified within the MHC area and indicate potential for stacked massive sulphide bodies. Potential breaks in the volcanic sequence, marked by sedimentary strata, are key exploration targets as they are prospective time-stratigraphic intervals for massive sulphide accumulation.

Figure A2.2. Schmidt equal area stereonet projection of poles to S1 foliation, with density contours, for the Mount Henry Clay prospect area.

Figure A2.3. Plot of Zr/TiO_2 versus Nb/Y for 85 samples of volcanic rocks and felsic intrusive rocks from the Mount Henry Clay prospect area (fields defined by Winchester and Floyd, 1977). Data is presented on a LOI-free basis.

Figure A2.4. Plot of Zr/TiO_2 versus SiO_2 for 85 samples of volcanic rocks and felsic intrusive rocks from the Mount Henry Clay prospect area (fields defined by Winchester and Floyd, 1977). Data is presented on a LOI-free basis.

Figure A2.5. Y versus Zr magmatic affinity plot for 98 samples of igneous rocks from the Mount Henry Clay prospect area (fields after Barrett and MacLean, 1994).

Figure A2.6. Plot of Zr/TiO_2 versus Zr/Al_2O_3 for 85 samples of volcanic rocks and felsic intrusive rocks from the Mount Henry Clay prospect area. Open circle = fragmental dominated mafic strata, open square = flow dominated mafic strata, open upwards facing triangle = strongly hydrothermally altered rock from the broadly defined contact zone between the flow dominated strata and the fragmental dominated strata, open diamond = felsic dyke.

Figure A2.7. Plot of Zr/TiO_2 versus Zr/Al_2O_3 for 12 samples of mafic intrusive rocks from the Mount Henry Clay prospect area. Asterisk = medium- to coarse-grained diorite and gabbro, cross = fine- to very fine-grained diorite and basalt dykes.

Appendix 3

RARE EARTH AND HIGH FIELD STRENGTH ELEMENT GEOCHEMISTRY AND TECTONIC SETTING

Introduction

Rare earth element (REE) geochemical data has been obtained for 10 samples on the Palmer property – 9 from volcanic strata at the Glacier Creek prospect area, and 1 from the Cretaceous-Tertiary age granodiorite pluton at the Cap prospect area. Only the data from the Glacier Creek prospect will be discussed here. The volcanic units that were sampled are: the B6 basalt unit, the rhyolite unit, the B5 basalt unit, the B4 basalt unit and the B3 basalt unit. Representative least-altered samples of the different units were selected based mainly on the criteria outlined in Table A3.1. The REE data are listed in Table A3.2, and the high field strength element (HFSE) data for the same samples are in Appendix 8. Interpretations of tectonic setting and magma type for basaltic rocks are based mainly on comparisons with data listed in Pearce (1996). The rhyolite samples were compared against data listed in Prior (1996), which presents REE and HFSE patterns for post-Triassic felsic rocks that are representative of modern tectonic settings in which VMS deposits can occur.

Discussion of REE and HFSE Data

Glacier Creek Prospect Basalt

Samples of the basalt units at the Glacier Creek prospect are plotted on Figure A3.1, which displays rare earth and high field strength elements normalized against N-type mid-ocean ridge basalt (MORB). The diagram consists of the elements that have the greatest discriminating power (Th, Nb, La, Ce, Zr, Ti and Y), and are listed from left to right in order of incompatibility during partial melting (Pearce, 1996). The different basalt units exhibit similar patterns, and presumably were derived from a common primary magma source (Figure A3.1). Minor variation in the abundances of the different REE and HFSE is attributed to modest differentiation or other adulteration during magma ascent and extrusion. Of the three end-member tectonic environments – mid-ocean ridge, within plate, and volcanic arc – the REE and HFSE patterns of basalt at the Glacier Creek prospect most closely resemble those of mid-ocean ridge basalts. Concentration of the REE and the HFSE that are very highly incompatible during mantle melting (e.g. Th, Ce, La, and Nb) are high with respect to average tholeiitic (N-type) MORB (Figure A3.1) and are closer to those of transitional (T-type) MORB, and basalt generated in plume-ridge interaction and attenuated continental lithosphere transitional settings (Pearce, 1996). On a Ti-Zr-Y tectonic setting discrimination diagram (Figure A3.2; Pearce and Cann, 1973) the samples of Glacier Creek basalt plot within the MORB and volcanic arc basalt field.

The lack of a negative Nb anomaly in Figure A3.1 with respect to La, Ce and by extrapolation Th (measured Th values for the basalt units are at or below the 1 ppm detection limit of the chemical analyses) excludes a volcanic arc setting.

Glacier Creek Prospect Rhyolite

The Glacier Creek rhyolite samples are plotted on a chondrite normalized diagram (Figure A3.3) that is identical to those listed in Prior (1996). The relatively immobile high field strength elements Y, Zr, Hf, Nb, Ta, Th and U are listed on the right side of the diagram in order of increasing incompatibility (neither Hf or Ta were analyzed in this study, but are listed on the diagram to aid comparison with the patterns in Prior, (1996)). The left part of the diagram consists of the familiar REE spider diagram, with La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb and Lu, listed in order of atomic number. The REE values for the two Glacier Creek prospect rhyolite samples are very similar and both display the same concave upward pattern with a moderate to strong negative Eu anomaly and a slight negative Y anomaly (Figure A3.3). Overall, the pattern is fairly smooth, and there is a moderate to steep negative slope between La and Eu, a very slight positive slope between Gd and Yb, and a moderate to steep positive slope between Y and U. The REE patterns and abundances of Glacier Creek rhyolite show greatest similarity with felsic rocks from ensialic back-arc settings, mature mid-ocean ridge settings such as Iceland, and continental rift settings, but important differences exist. For example, although exhibiting widely similar REE patterns and abundances, the Glacier Creek

samples do not exhibit the negative Nb anomaly that is characteristic of ensialic back-arc rhyolite. Rhyolites from mid-ocean ridge settings do not have a negative Y anomaly and have a shallower slope between Zr and U than the Glacier Creek rhyolite. Rhyolites from continental rift settings do not have a negative Y anomaly and have a slightly negative slope between Gd and Yb.

Summary and Discussion

Volcanic rocks that host VMS mineralization at the Glacier Creek prospect have similar rare earth and high field strength element chemistry to rocks of known mid-ocean ridge, attenuated (or rifted) continental lithosphere, and back-arc tectonic settings. The lack of a negative Nb anomaly in both the basalt and the rhyolite indicates that subducted crust was not involved in the generation of the Glacier Creek volcanic rocks. This suggests that if the Glacier Creek volcanic rocks were erupted in a back-arc setting, the basin was likely mature and extensional volcanism was distant from the concomitant subduction zone. Basalts from mid-ocean ridge settings that share similarities to the basalt at the Glacier Creek prospect are T-type MORB and basalt generated at ridges where there is interaction with mantle plumes. Chemical composition of the rhyolite also indicates a possible ridge-plume interaction tectonic setting. Based on field relations, however, a mid-ocean ridge tectonic setting for the eruption of the Glacier Creek volcanic rocks is unlikely. For example, debris flow conglomerate, which contains sub-aerially

derived clasts, occurs within the Glacier Creek stratigraphic section and is a rock type that is unlikely to be found in a mid-ocean ridge setting. Furthermore, the Glacier Creek volcanic rocks are in depositional contact with underlying pelitic rocks, which are in turn in apparent depositional contact with a thick section of thin bedded limestone and massive marble; this differs significantly from a typical ophiolite sequence generated at mid-ocean ridge settings. An attenuated continental lithosphere tectonic setting is perhaps the most likely tectonic setting for deposition of the volcanic rocks at the Glacier Creek prospect. Rare earth and high field strength element data for samples of both basalt and rhyolite are similar to data from basalt and rhyolite at known attenuated continental lithosphere tectonic settings. Some of the subtle differences in chemical composition may reflect differences in thickness and evolution of the underlying crust compared with crust at the localities with which the Glacier Creek data was compared. A depositional unconformity that occurs at the base of correlative Late Triassic basalts in the Alexander terrane to the south (Gehrels et al, 1986) supports a rift-related environment and is permissive of an attenuated continental lithosphere tectonic setting.

Without a thorough review of the geology and geochemistry at a regional-scale (which is beyond the scope of this study), it is imprudent to make definitive conclusions on the tectonic setting in which the Glacier Creek volcanic rocks were erupted. Nevertheless, based on REE and HFSE data and limited geological constraints, either a mature back-arc basin or attenuated continental lithosphere tectonic setting appears to be the most probable.

Figure A3.1. N-type MORB normalized plot of selected rare earth and high field strength elements for 7 basalt samples from the Glacier Creek prospect map area. Downward facing triangle = B6 basalt, upward facing triangle = B5 basalt, square = B4 basalt, circle = B3 basalt.

Figure A3.2. Tectonic setting discrimination diagram for 7 basalt samples from the Glacier Creek prospect map area (fields defined by Pearce and Cann, 1973). Downward facing triangle = B6 basalt, upward facing triangle = B5 basalt, square = B4 basalt, circle = B3 basalt. Key: VAB = volcanic arc basalt, MORB = mid-ocean ridge basalt, and WPB = within plate basalt.

Figure A3.3. Chondrite normalized plot of selected rare earth and high field strength elements for 2 rhyolite samples from the Glacier Creek prospect map area.

Criteria	Least-Altered Basalt Samples
Na ₂ O	>2%
K ₂ O	<1%
SiO ₂	45-53%
Loss on Ignition (LOI)	<8%
Least-altered samples selected based on anhydrous values	

Criteria	Least-Altered Rhyolite Samples
Na ₂ O	>1%
K ₂ O	<3%
FeO*	<3.75%
SiO ₂	68-78%
Loss on Ignition (LOI)	<3.5%
FeO* = FeO + Fe ₂ O ₃ x 0.89981 (total iron as FeO)	
Least-altered samples selected based on anhydrous values	

Table A3.1. Least-altered criteria used to select most of the samples submitted for REE analysis.

Sample	Unit	Ce ppm	Dy ppm	Er ppm	Eu ppm	Gd ppm	Ho ppm	La ppm	Lu ppm	Nd ppm	Pr ppm	Sm ppm	Tb ppm	Th ppm	Tm ppm	U ppm	Y ppm	Yb ppm
RMR 30424	B3 basalt	19	4.9	3.4	1	3.8	1.2	9.5	0.5	11.5	2.7	2.9	0.7	1	0.5	<0.5	30	3.3
RMR 30346	B4 basalt	12.5	3.6	2.4	0.7	3	0.9	5.5	0.4	8	1.9	2.3	0.6	1	0.4	0.5	19.5	2.5
RMR 30271	B4 basalt	21.5	4.2	2.6	1	3.6	0.9	9.5	0.4	12	2.8	3	0.7	1	0.4	0.5	22.5	2.7
RMR 30426	B5 basalt	18	4.1	2.8	1	3.4	0.9	8.5	0.4	10	2.3	2.7	0.7	<1	0.4	<0.5	23.5	2.5
RMR 30429	B5 basalt	16.5	4.4	2.8	1	3.4	0.9	7.5	0.4	10	2.2	2.7	0.6	<1	0.4	0.5	22.5	2.6
RMR 30421	B6 basalt	9	3.5	2.5	0.7	2.6	0.8	4.5	0.4	6	1.3	1.9	0.5	<1	0.3	1	19.5	2.6
RMR 30441	B6 basalt	7.5	3.4	2.6	0.6	2.6	0.9	3.5	0.4	5	1	1.7	0.5	<1	0.4	0.5	20.5	2.2
RMR 30273	Rhyolite	68.5	13.7	10	1.3	8.7	3.3	35	1.6	27.5	7.8	6.2	1.9	12	1.6	7.5	86.5	10.7
RMR 30341	Rhyolite	91	13.1	9.6	1.5	9.9	3.1	42	1.5	35	10.1	8.4	2.1	14	1.6	5.5	77	10.4
RMR 30443	Granodiorite	18	1.1	0.7	0.5	1.3	0.2	9.5	0.1	7.5	2.1	1.5	0.2	1	<0.1	0.5	6.5	0.7

Table A3.2. Rare earth element data for 9 samples of volcanic strata at the Glacier Creek prospect area, and 1 sample from the Cretaceous-Tertiary age granodiorite pluton at the Cap prospect area.

Appendix 4

ANALYTICAL TECHNIQUES

Chemical Analyses

All chemical analyses were performed by ALS Chemex Laboratories, North Vancouver, British Columbia. A variety of different analytical procedures were used, and some elements are reported more than once for the same sample. All samples were crushed in an oscillating steel jaw crusher, followed by pulverization of an ~200 g portion in a chrome steel ring mill. Samples were pulverized such that greater than 95% of the sample was less than 106 microns (~150 mesh).

The major elements (reported as oxides) were determined by wavelength-dispersive X-ray fluorescence spectrometry (XRF). A porcelain crucible is dried in an oven at 105°C, cooled and the weight recorded. A prepared sample (3.00 grams) is added to the crucible and then ashed at 1000°C for one hour. The sample is then cooled in a desiccator, weighed and the percent loss on ignition is calculated. A prepared sample (1.000 grams) is added to lithium tetraborate flux (9.000 grams), mixed well and fused in a furnace at 1100°C. A flat glass disc is prepared from the resulting melt. This disc is then analyzed by X-ray fluorescence spectrometry on a XRF Philips PW 1404 spectrometer calibrated using international standard reference materials. Instrument

precision is 5%. Lower detection limits for all of the major oxides and for L.O.I is 0.01 wt. %.

The elements Ba, Rb, Sr, Nb, Zr and Y were determined by X-ray fluorescence spectrometry (XRF). A finely ground sample powder (0.2 grams minimum) is mixed with a few drops of liquid binder. The sample is then compressed under approximately 20,000 kPa onto a backing of boric acid in an aluminum mold to form a disc. After pressing, the resultant disc is dried to remove the solvent and the pressed pellet is analyzed by XRF spectrometry on a XRF Philips PW 1404 spectrometer. Instrument precision is 10%. Detection limits are listed in Table A4.1.

Ag, Al, As, Ba, Be, Bi, Ca, Cd, Co, Cr, Cu, Fe, Ga, Hg, K, La, Mg, Mn, Mo, Na, Ni, P, Pb, Sb, Sc, Sr, Tl, Ti, U, V, W, and Zn were analyzed by inductively-coupled plasma (ICP) atomic emission spectroscopy following digestion in nitric aqua regia. A prepared sample (0.50 grams) is digested with nitric aqua regia for at least one hour in a hot water bath. After cooling, the resulting solution is diluted to 12.5 ml with demineralized water, mixed and analyzed by inductively coupled plasma-atomic emission spectrometry on a Perkin Elmer Optima 300 spectrometer. For low detection limit Hg analyses (i.e. 10 ppb – 100 ppm), a portion of the sample taken from the nitric aqua regia digestion is treated with stannous chloride to reduce the mercury. The resulting mercury is volatilized by argon-purging and measured by atomic absorption spectrometry on a Perkin Elmer FIAS 3100 spectrometer. Instrument precision is 15% for elements where

digestion is possibly incomplete, and 10% for all other elements. The analytical results are corrected for inter-element spectral interferences. Elements for which digestion is possibly incomplete include Al, Ba, Be, Ca, Cr, Ga, Mg, K, Sc, Na, Sr, Tl, Ti, and W, and the values reported for these elements may not accurately reflect the chemistry of the whole rock. Detection limits are listed in Table A4.1.

The elements Cu, Pb, and Zn, were determined by ore grade assay for samples that returned values >10,000 ppm by ICP analysis. Ag was analyzed by fire assay with a gravimetric finish for samples that returned values >100 ppm by ICP analysis. Au was determined by fire-assay fusion with atomic absorption spectroscopy, and Ba in selected samples was determined by XRF spectrometry.

The rare earth elements (REE) plus uranium, thorium and yttrium were determined by inductively-coupled plasma mass spectroscopy (ICP-MS). A prepared sample (0.200 grams) is added to lithium metaborate flux (0.90 grams), mixed well and fused in a furnace at 1050°C. The resulting melt is then cooled and dissolved in 100 ml of 4% nitric acid. This solution is then analyzed by inductively coupled plasma - mass spectrometry on a P.E. Sciex Elan 6000 mass spectrometer. Instrument precision is 10%. Detection limits are listed in Table A4.1.

X-ray Diffraction Analyses

X-ray diffraction analyses were carried out at Carleton University on a Phillips 1710 powder X-ray diffractometer. Mineral samples were ground to a fine powder with a mortar and pestle and then mixed with acetone and spread evenly over a glass slide. The powdered material on the glass slide was then bombarded with X-rays within the diffractometer, and the X-ray diffraction pattern collected. Samples were analyzed for a 2θ range of 3.1° - 70.0° , with 0.1° increments for a total run time of about 11 minutes. Identification of mineral species was determined by matching d-spacing values and relative intensity of measured peaks with mineral files listed in the International Centre for Diffraction Data search manual and databook.

Table A4.1. Range of detection limits for different analytical techniques

Element	Symbol	XRF (pressed pellet)	ICP	ICP-MS
Aluminum	Al		0.01-15%	
Antimony	Sb		2 ppm – 1%	
Arsenic	As		2 ppm – 1%	
Barium	Ba	5 ppm – 5%	10 ppm – 1%	
Bismuth	Bi		2 ppm – 1%	
Cadmium	Cd		0.5 – 500 ppm	
Calcium	Ca		0.01 – 15%	
Cerium	Ce			0.5 ppm – 1%
Chromium	Cr		1 ppm – 1%	
Cobalt	Co		1 ppm – 1%	
Copper	Cu		1 ppm – 1%	
Dysprosium	Dy			0.1 ppm – 0.1%
Erbium	Er			0.1 ppm – 0.1%
Europium	Eu			0.1 ppm – 0.1%
Gadolinium	Gd			0.1 ppm – 0.1%
Gallium	Ga		10 ppm – 1%	
Holmium	Ho			0.1 ppm – 0.1%
Iron	Fe		0.01 – 15%	
Lanthanum	La		10 ppm – 1%	0.5 ppm – 1%
Lutetium	Lu			0.1 ppm – 0.1%
Lead	Pb		2 ppm – 1%	
Magnesium	Mg		0.01 – 15%	
Manganese	Mn		5 ppm – 1%	
Mercury	Hg		1 ppm – 1%	
Mercury	Hg		10 ppb – 100 ppm	
Molybdenum	Mo		1 ppm – 1%	
Neodymium	Nd			0.5 ppm – 1%
Nickel	Ni		1 ppm – 1%	
Niobium	Nb	2 ppm – 5%		
Phosphorus	P		10 ppm – 1%	
Potassium	K		0.1 – 10%	
Praseodymium	Pr			0.1 ppm – 0.1%
Rubidium	Rb	2 ppm – 5%		
Samarium	Sm			0.1 ppm – 0.1%
Scandium	Sc		1 ppm – 1%	
Silver	Ag		0.2 – 100 ppm	
Sodium	Na		0.01 – 10%	
Strontium	Sr	2 ppm – 5%	1 ppm – 1%	
Terbium	Tb			0.1 ppm – 1%
Thallium	Tl		10 ppm – 1%	
Thorium	Th			1 ppm – 0.1%
Thulium	Tm			0.1 ppm – 1%
Titanium	Ti		0.01 – 10%	
Tungsten	W		10 ppm – 1%	
Uranium	U		10 ppm – 1%	0.5 ppm – 0.1%
Vanadium	V		1 ppm – 1%	
Ytterbium	Yb			0.1 ppm – 0.1%
Yttrium	Y	2 ppm – 5%		0.5 ppm – 0.1%
Zinc	Zn		2 ppm – 1%	
Zirconium	Zr	3 ppm – 5%		

Appendix 5**PETROGRAPHIC REPORTS**

Sample #: RMC60274

Location: Glacier Creek prospect (RW zone)

Easting: 420557 **Drill hole:** RMC99-10
Northing: 6585147 **Depth:** 162.7 m (533.8 ft)

Rocktype: semi-massive sulphide

Hand Sample Description: drill log indicates sample comes from a mafic dyke with oxidized barite, but off-cut looks like semi massive sulphide and QSP

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
quartz	40	mc-m	occurs throughout in quite a wide range in grain size; some may form veins	---
sericite	37	mc-vf	occurs as semi-massive to massive masses that form large sections of the groundmass, and as seams and patches in quartz rich zones	-----
barite	2-3	vf-m	fairly coarse grains found in areas of coarser quartz; often in proximity to chalco and galena mineralization (locally with anhedral sulphide grains in contact with euhedral barite)	---
sphalerite	7-8	mc-m	xenomorphioc grains commonly growing over, and locally replacing, euhedral pyrite	---
pyrite	5-6	mc-f	fairly cubic euhedral grains	--- ?-
chalcopryite	1-2	mc-m	found as anhedral grains interstitial to other minerals, and locally rimming sphalerite grains; commonly in contact with galena; margins of grains are commonly altered/oxidized(?) and often contain covellite	---
galena	0.5-1	mc-f	commonly found in contact with chalcopryite, and often has smooth, curved, embayed contacts; appears that it may have replaced the chalco in places? commonly has corroded looking grain margins	---
covellite	tr	cc	occurs as mod-strongly pleochroic blue to blue-white grains, with orange anisotrpism, along the margins of some chalcopryite grains	---
unknown	tr	cc	non-pleochroic green grains that remain greenish under x-polars, and have reflectance equivalent to quartz; found proximal to covellite rimmed chalcopryite grains; possibly a Cu oxide stain??	-?-

Notes: The presence of covellite along the margins of some chalcopryite grains suggests these rocks have been subject to some degree of oxidation. There is no preferred orientation to sulphides or any layered concentrations (i.e. no indication of the sulphides being bedded). Very disrupted contorted texture to sample, with irregular patches of sericite rich matrix cut by quartz-barite rich veins(?). Although quite contorted overall, sericite locally defines a good foliation.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60279

Location: Glacier Creek prospect (RW zone)

Easting: 420557 **Drill hole:** RMC99-10
Northing: 6585147 **Depth:** 167 m (548 ft)

Rocktype: semi-massive sulphide

Hand Sample Description: Altered rock with seams and disseminations of sulphide (high grade Cu)

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
quartz	65	mc-m	mc-f grained quartz forms dominant component of matrix, and f-m grained quartz is found in veins and amygs(??)	-----
sericite	18	mc-vf	mc sericite found throughout matrix, and mc-vf sericite found in veins; possibly a another mineral in veins that has similar properties to the sericite but is slightly more fibrous?	-----
barite	tr	vf-f		-?-
sphalerite	2-3	mc-	concentrated within a semi-massive sulphide seam, in quartz sulphide veins, and disseminated throughout matrix; typically intimately associated with chalcopyrite	-----
pyrite	8	vf-	forms massive patches with distinctive skeletal texture and abundant void space, typically closely associated with chalcopyrite – this texture most probably formed by oxidation and replacement of pyrrhotite; rare disseminated cubic euhedral grains appear to be unrelated to the skeletal pyrite	--- ---
chalcopyrite	7	mc-	primarily concentrated within a seam of semi-massive sulphide where it occurs as irregular xenomorphic masses with sphalerite and skeletal pyrite; subordinate mc-f grains occurring in quartz veins and disseminated in matrix	-----

Notes: Sample consists of quartz-sericite altered rock containing disseminations and veins of sulphide. Pyrite in sample displays a distinctive skeletal texture, which is thought to be indicative of oxidation and replacement of pyrrhotite. It is interesting to note that a sample at 162.7 m (just 4-5 m up hole) contains chalcopyrite grains that have covellite altered margins, also thought to be indicative of oxidation. No covellite was observed in this sample, perhaps because pyrrhotite oxidizes before chalcopyrite??

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60390

Location: Glacier Creek prospect

Easting: 420557 **Drill hole:** RMC99-10
Northing: 6585147 **Depth:** 200 m (656.2 ft)

Rocktype: Altered feldspar porphyry footwall to the RW zone

Hand Sample Description:

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
sericite	15	mc	completely replaces flattened fine lapilli size shards and fragments (feldspar phenos?), commonly having pale pink and/or green pleochroism, also found throughout the matrix	—
quartz	5	mc-vf	found in small to large amygdules (0.1 – 2.5 mm)	—
chlorite	15	mc	replaces matrix and locally found coring amygdules with quartz	—
mc groundmass (plagioclase)	63	mc	dense felted texture of mc plagioclase(?), that locally have a radial habit suggestive of spherulitic growth	—
opaques	2	cc-mc	primarily pyrite, rock is not magnetic, disseminated throughout matrix with slightly coarser grains found in composite amygdules	—
epidote	tr	mc	small euhedral grains localized in rare small clusters	—
sphalerite(?)	tr	mc	found in amygdules	—

Notes: Enigmatic texture of flattened looking fragments (commonly having blocky angular margins) and shards of sericite that appear to be supported in a finely amygdaloidal material that has a very fine grained felted texture (locally spherulitic). How do you get fragments supported in a quenched magma matrix?? Interpreted to be altered feldspar porphyry, in which feldspar phenocrysts have been completely replaced by sericite and have been deformed into flattened, locally trapezoidal, forms

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60280

Location: Glacier Creek prospect (RW zone)

Easting: 420557 **Drill hole:** RMC99-10
Northing: 6585147 **Depth:** 168 m (551 ft)

Rocktype: Semi massive Sulphide/QSP altered rhyolite

Hand Sample Description: Well-mineralized and altered rhyolite

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
quartz	43	mc-vf	mc quartz occurs with sericite throughout the groundmass, and minor vf quartz grains associated with late stage sulphide mineralization (local elongate overgrowths on coarse pyrite euhedra)	-----
sericite	44	mc	forms the groundmass with quartz, with quartz to sericite varying throughout the groundmass, resulting in a patchy texture; locally concentrated in seams with sulphide and chlorite	-----
chlorite	3-4	mc-vf	concentrated in seams associated with sulphide mineralization (irregular stringers), fairly pale green pleochroism compared to some metamorphic chlorite	---
pyrite	4-5	mc-m	3 generations of pyrite observed: the earlier consisting of coarse cubic euhedra containing ovoid inclusions of chalcopyrite, sphalerite, & pyrrhotite; these coarse euhedra appear to be rimmed by a second generation of pyrite that contains inclusions of host material, and locally have extremely fine seams of pyrite extending out from grain margins (minor metamorphic remobilization??); the latest generation of pyrite has a crudely skeletal habit, is associated with Fe-oxides, and presumably formed during oxidation of pyrrhotite	-----
chalcopyrite	3-4	mc-m	xenomorphic grains found interstitial to other minerals and as overgrowths on (and inclusions within) coarse pyrite euhedra; concentrated in chlorite/sericite rich seams, where it often is fairly intimately intergrown with the chlorite	---
sphalerite	tr-0.5	mc	xenomorphic grains associated with chalcopyrite mineralization; typical found in contact with chalcopyrite, and locally as inclusions in pyrite euhedra	---
pyrrhotite	tr	mc	locally cores skeletal pyrite/fe-oxide masses indicating that these masses likely all represent remnant pyrrhotite grains (if so rock would have originally contained ~2% pyrrhotite); also occurs as minor inclusions with chalcopyrite, and alone, in coarse pyrite euhedra	---

Notes: Sample consists of quartz-sericite-pyrite altered rhyolite(?) containing later stage copper->zinc mineralization that is associated with chloritic seams. The rock has been subject to partial oxidation, in which pyrrhotite is believed to have been altered to skeletal pyrite and various fe-oxides. Chalcopyrite, sphalerite and pyrite do not appear to have been affected by the oxidation.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60370

Location: Glacier Creek prospect (RW zone)

Easting: 420611 **Drill hole:** RMC99-13
Northing: 6585278 **Depth:** 183.3 m (601.4 ft)

Rocktype: sphalerite mineralized rhyolite

Hand Sample Description: disseminated to massive sphalerite +/- chalcopyrite in altered rhyolite

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
sphalerite	40	N/A	massive xenomorphic masses of sphalerite, commonly engulfing and replacing euhedral pyrite grains in dramatic fashion	---
chalcopyrite	1	mc-f	commonly occurs as xenomorphic grains replacing sphalerite along grains boundaries, and as fine inclusions within the sphalerite; often spatially associated with galena; margins are locally alt'd to covellite	----
pyrite	1-2	mc-m	occurs as fairly coarse grained euhedra that are partially resorbed/replaced by sphalerite, and galena; also found as mc grains that were likely precipitated at the same time as the chalcopyrite and galena	-- ----
galena	0.5	mc-vf	similar to chalcopyrite in that it occurs as xenomorphic grains replacing sphalerite along grains boundaries, and as fine inclusions within the sphalerite, and locally replaces pyrite; often occurs along boundary b/w chalcopyrite and sphalerite grains	----
covellite	tr			---

Notes: Enigmatic texture

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC99-14 - 677

Location: Glacier Creek prospect (footwall to the RW zone)

Easting: 420769 **Drill hole:** RMC99-14
Northing: 6585159 **Depth:** 206 m (675.9 ft)

Rocktype: Pyrite-chalcopryite stockwork vein

Hand Sample Description: Chalcopryite-rich pyrite vein with chlorite

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
pyrite	65-70	f-m	interconnected framework of reasonably well preserved euhedral and subhedral grains	—
chlorite	20-25	mc-vf	forms matrix to sulphide minerals	—
chalcopryite	5-7	mc-c	xenomorphic masses occurring interstitial to pyrite grains; locally occurs as embayments and blebs within pyrite	—
quartz	2	cc-vf	most occur in a 2 mm wide zone of dominantly massive quartz, minor quartz in matrix with chlorite	—
sphalerite	tr	vf	locally found associated with chalcopryite interstitial to pyrite	—
sericite	tr	vf	rare grain associated with chlorite in matrix to sulphides	—
unknown	1	vf-f	uniaxial, colourless, gray birefringence colours, at least 2 fairly good cleavages, some show gradational concentric zoning, low relief. possible porphyroblasts	—
calcite	tr	vf	rare grain along margin of quartz vein	

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31202

Location: Glacier Creek prospect (Little Jarvis occurrence)

Easting: 420394 **Drill hole:** N/A

Northing: 6585167 **Depth:** N/A

Rocktype: Semi-massive to massive sphalerite and barite

Hand Sample Description:

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
barite	50		framework forming mineral	—
sphalerite	44		interconnected xenomorphic mass that typically engulfs barite and pyrite; in barite rich parts of section sphalerite occurs interstitial to barite grains; locally replaces pyrite	—
pyrite	4		resorbed and fractured grains with sphalerite, chalcopryrite and freibergite(?) occurring in embayments and filling fractures;	—
quartz	1			—
chalcopryrite	0.5		occurs along grain boundaries, rimming sphalerite grains, and as fine blebs throughout sphalerite grains	—
galena	tr-0.5		occurs as blebs interstitial to sphalerite and barite	—
arsenopyrite	tr			—
freibergite?	tr			—

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31205A

Location: Glacier Creek prospect (Little Jarvis occurrence)

Easting: 420390 **Drill hole:** N/A

Northing: 6585166 **Depth:** N/A

Rocktype: Massive Sulphide

Hand Sample Description: Chalcopyrite rich massive sulphide

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
barite	30	vf-f	occurs in granular masses and seams throughout; dominant gangue mineral	-----
chalcopyrite	25-30	c	occurs as extensive anhedral masses with no apparent grain boundaries, enveloping resorbed sphalerite and pyrite; also is interstitial to quartz-barite gangue, often invading grain boundaries	-----
quartz	15-20	vf-f	occurs in granular masses and seams with barite	-----
sphalerite	10-15	vf-f	highly etched and resorbed by chalcopyrite, with "tattered" grain margins; local isolated pockets of unaffected/nonresorbed sphalerite found interstitial to barite	-----
pyrite	5	vf-f	grains are quite fractured and resorbed; fractures are both subparallel and perpendicular to layering	-----
magnetite	3	f-m	coarse euhedral grains concentrated along a narrow band (0.5 cm wide); fractured and corroded, with Fe-oxide along grain margins; sparse grains also found disseminated throughout thin section in minor abundance	-----
calcite	1	vf-f	restricted a narrow layer at top of thin section; occurs with quartz, barite and sulphides and appears to have formed at the same time as the barite and quartz (i.e. precipitated during early exhalative mineralization)	-----
goethite-hematite?	<1		rimming grain boundaries and infilling fractures of magnetite; strong orange internal reflectance	-----
covellite	tr		bright blue mineral occurring proximal to oxidized magnetite grains	-----

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31205B

Location: Glacier Creek prospect (Little Jarvis occurrence)

Easting: 420394 **Drill hole:** N/A
Northing: 6585167 **Depth:** N/A

Rocktype: Massive sphalerite and barite

Hand Sample Description:

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
sphalerite	70		xenomorphic mass engulfing barite, pyrite and quartz	----
barite	14		forms aggregates with quartz that are engulfed by massive sphalerite	----
pyrite	8		occurs as euhedral to subhedral grains that are typically fractured and embayed, or partially resorbed	----
quartz	1		forms aggregates with barite that are engulfed by massive sphalerite	----
galena	tr-0.5		occurs as anhedral to subhedral blebs that are commonly elongate sub-parallel to the overall layering in the rock; it also necks out along boundaries between other minerals	----
chalcopyrite	tr-0.5		occurs as fine blebs disseminated throughout the massive sphalerite and along grain boundaries; too fine grained to be seen at lower powered magnification	----

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: UMZ1

Location: Glacier Creek prospect (Upper Main occurrence)

Easting: 420945 **Drill hole:** N/A

Northing: 6584820 **Depth:** N/A

Rocktype: baritic massive sulphide

Hand Sample Description: Banded-layered, semi-massive sulphide in a baritic gangue. Brownish-red to black sphalerite and galena in a white barite matrix. Some layers are magnetic.

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
barite	84	vf-f	very fine to fine grained, fairly equigranular grains forming the dominant component of the sample	----
sphalerite	8-10	vf-f	dominant metallic mineral; occurs as anhedral grains that grow between and around barite grains; grains are often elongate parallel to layering in the sample and occurs in varying concentration defining sulphide rich vs sulphide poor layers	----
galena	5	mc-vf	typically occurs as irregular blebby grains interstitial to barite and sphalerite grains; mc galena commonly outlines barite grain boundaries; locally appears to be replacing sphalerite	----
quartz	tr-0.5	vf	trace grain occurring with massive euquigranular barite	----
pyrite	tr	vf	rare euhedral grain, locally overgrown by sphalerite	----
magnetite	tr		corroded/etched(?) remnants of locally equant euhedral grains, in places partially engulfed and/or replaced by sphalerite	----
chalcopyrite	tr	mc-f	occurs as irregular grains concentrated within a narrow layer parallel to the overall layering in the sample	----
sulphosalt(?)	tr	mc	isotropic gray metallic mineral with reflectance somewhere between sphalerite and galena (too fine grained to confidently identify); exclusively associated with chalcopyrite and galena	----
covellite	tr	NA	locally found along margins of grains of chalcopyrite	----

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: UMZ2

Location: Glacier Creek prospect (Upper Main occurrence)

Easting: 420945 **Drill hole:** N/A

Northing: 6584823 **Depth:** N/A

Rocktype: massive barite

Hand Sample Description: Moderately magnetic massive barite with minor red hematite stained spots.

Thin Section Type: regular/polished

Mineral	%	Size	Comment	Paragenesis
barite	69	vf-f	very fine to fine grained grains forming the dominant component of the sample; ratio of quartz to barite varies throughout sample and defines layering	----
quartz	30	mc-f	microcrystalline to fine grained grains occurring throughout most of the sample; ratio of quartz to barite varies throughout sample and defines layering	----
magnetite	1	mc-f	highly etched/corroded vf-f grained grains concentrated in narrow layers within otherwise massive quartz-barite rock; also occurs as mc grains disseminated throughout much of the barite; red staining in rock is presumed to be earthy hematite after magnetite	----
chalcopyrite	tr	mc-vf	extremely rare grain	----
covellite	tr		forms fairly thick rim around chalcopyrite	----

Notes: Layering defined by variation in grain size, the ratio of quartz to barite, and concentration of magnetite.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31067

Location: Glacier Creek prospect (stratigraphic hanging wall to RW Zone in overturned limb)

Easting: 421284

Drill hole: N/A

Northing: 6584764

Depth: N/A

Rocktype: Argillite

Hand Sample Description: black, shaly, calcareous mudstone +/- ash tuff(?) locally stained blue-green with Cu-Zn oxides; sample from chip line across altered and mineralized zone

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
calcite	30-35	mc-vf	anhedral grains disseminated throughout ; grains are slightly coarser grained than groundmass	—
groundmass	60-65	mc	fairly angular mc (silt) size grains with no preferred orientation; too fine grained to determine optical properties but a high plagioclase content is suspected	—
biotite	3-4	mc	concentrated in thin, sub-parallel seams that define a weak foliation	—

Notes: Calcite and biotite content vary across the thin section, presumably reflecting variable composition of the primary layers, or lamina. Although the groundmass composition was not discernable, a high feldspar content is probable given the low relief and clouded appearance of the grains and the predominantly mafic volcanic rocks in the vicinity.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31068

Location: Glacier Creek prospect (stratigraphic hanging wall to RW Zone in overturned limb)

Easting: 421285 **Drill hole:** N/A
Northing: 6584766 **Depth:** N/A

Rocktype: Cherty argillite

Hand Sample Description: fairly cherty sediment with argillite and carbonate interbeds, Cu-Zn oxide stains on some weathered surfaces; sample from chip line across altered and mineralized zone

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
calcite	50	mc-vf	anhedral grains disseminated throughout ; grains are slightly coarser grained than groundmass	---
groundmass	50	mc	fairly angular mc (silt) size grains; too fine grained to determine optical properties, but perhaps a fairly high quartz content given the cherty appearance of hand sample??	---
biotite	tr-1	mc	concentrated in very thin seams	----

Notes: Moderate alignment of elongate grains defines a fabric in the rock.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31069

Location: Glacier Creek prospect (stratigraphic hanging wall to RW Zone in overturned limb)

Easting: 421285 **Drill hole:** N/A
Northing: 6584767 **Depth:** N/A

Rocktype: Silty carbonate

Hand Sample Description: dark gray silty carbonate with minimal Cu-Zn oxide stain on weathered surfaces; sample from chip line across altered and mineralized zone

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
calcite	80-85	mc-vf	anhedral interlocking grains; grains are slightly coarser grained than the subordinate, silty groundmass	—
groundmass	15	mc	silt size grains; too fine grained to determine optical properties	—
biotite	3-4	mc	concentrated in very thin seams	—

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31073

Location: Glacier Creek prospect (RW zone in overturned limb)

Easting: 421287 **Drill hole:** N/A

Northing: 6584772 **Depth:** N/A

Rocktype: Silica-barite rock

Hand Sample Description: vuggy, banded, granular silica-barite rock with moderate Fe-oxide stain; sample from chip line across altered and mineralized zone

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
barite	40	vf-f	randomly oriented subhedral to anhedral grains	---
quartz	40	vf-f		---
voids/vugs	15	f	void space with subangular to subrounded outlines – sulphide casts.	---
Fe-oxide?	5	cc	masses of super fine grained red brown grunge that partially fills in sulphide casts	---

Notes: Rock has clearly been leached of a significant concentration of sulphide. No apparent penetrative fabric.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31075

Location: Glacier Creek prospect (RW zone in overturned limb)

Easting: 421288 **Drill hole:** N/A

Northing: 6584774 **Depth:** N/A

Rocktype: massive barite

Hand Sample Description: sample of leached barite from chip line across altered and mineralized zone

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
barite	65-70	f	subhedral to anhedral grains with good cleavage; no preferred orientation or fabric observed; individual grains commonly wrap around angular margins of voids (a.k.a. sulphide casts)	
void/vugs	30-35	f	void spaces commonly have angular outlines, and are interpreted to be boxwork after sulphides.	

Notes: Monomineralic rock showing little evidence of the strain observed in overlying intensely sericitic rocks. It is possible that the barite recrystallized after deformation? The high void content in this rock indicates a high original sulphide content that was subsequently been leached.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31080

Location: Glacier Creek prospect (stratigraphic footwall to RW zone in overturned limb)

Easting: 421288 **Drill hole:** N/A

Northing: 6584778 **Depth:** N/A

Rocktype: intensely sericite altered

Hand Sample Description: clay rich, intense sericite and weak silica altered sample from chip line across altered and mineralized zone, and within the surface trace of the MZ thrust fault

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
sericite	85-90	mc-vf	mc sericite groundmass with uniform optic orientation	—
quartz	3-5	mc-vf	occurs as isolated lenses, that consist of polygonized(?) aggregates, within the massive sericite groundmass, and in pressure shadows of weathered out sulphide grains	—
voids/vugs	5-10	vf	commonly with sharp angular outlines, and even cubic forms, that are clearly weathered out sulphides; two generations of sulphide development noted, one formed prior to deformation as evidenced by pressure shadows, the other postdates deformation.	-?— —

Notes: Rock has undergone intense alteration followed by intense strain. An oriented sample would likely provide useful kinematic indicators for movement along the MZ thrust fault.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31082

Location: Glacier Creek prospect (QSP alteration in structural hanging wall to overturned RW zone)

Easting: 421288 **Drill hole:** N/A
Northing: 6584782 **Depth:** N/A

Rocktype: QSP alteration

Hand Sample Description: White to jarosite-yellow stained, fairly siliceous QSP altered rock with a quartz stockwork. Sample from chip line across altered and mineralized zone.

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
sericite	50	mc	occurs as groundmass in massive bands or seams that contain up to 10% quartz, and as a minor component in quartz rich sections where it is interstitial to quartz grains	—
quartz	50	mc-vf	occurs as bands of 90-95% quartz, as thin lenses of polygonized(?) quartz isolated within the sericite groundmass, and as coarser grained material in later stage veinlets	————
voids/vugs	1-2	mc-vf	some with cubic outlines – boxwork after weathered out sulphides	

Notes: Intensely altered rock with a very strong penetrative fabric throughout. A second fabric that is at 30-40 degrees from the primary fabric is locally quite distinct – is this some sort of shear fabric? An oriented sample might be useful for obtaining sense of shear.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31084

Location: Glacier Creek prospect (QSP alteration in structural hanging wall to overturned RW zone)

Easting: 421289 **Drill hole:** N/A
Northing: 6584786 **Depth:** N/A

Rocktype: QSP alteration

Hand Sample Description: white to jarosite-yellow stained, fairly siliceous QSP altered rock with a quartz stockwork; sample from chip line across altered and mineralized zone.

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
sericite	35	mc	found as a minor component interstitial to quartz in quartz rich bands, and in massive seams where it makes up ~80% of the groundmass	—
quartz	50	mc-vf	occurs as bands of near massive mc quartz, as a minor component in sericite rich bands, as round aggregates (amygdules?) that locally display highly scalloped grain boundaries, and as elongate, undeformed late stage(?) overgrowths to sulphides (now weathered out).	-?—
voids/vugs	15	vf-f	typically have angular, and often cubic, outlines (weathered out sulphides) that are locally rimmed by elongate quartz grains; voids are typically concentrated in bands where they make up 40-50% of the rock	

Notes: Intensely altered rock with a very strong penetrative fabric. Sericite groundmass wraps around the rounded aggregates of quartz. These rounded aggregates are probably amygdules, and it isn't too much of a stretch to imagine that some of the quartz aggregate lenses observed in RMR31080 and 31082 are amygdules that have become attenuated in an environment of higher strain.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31086

Location: Glacier Creek prospect (QSP alteration in structural hanging wall to overturned RW zone)

Easting: 421289 **Drill hole:** N/A
Northing: 6584790 **Depth:** N/A

Rocktype: QSP alteration

Hand Sample Description: white to jarosite-yellow stained, fairly siliceous QSP altered rock; sample from chip line across altered and mineralized zone.

Thin Section Type: regular polished

Mineral	%	Size	Comment	Paragenesis
sericite	20-25	mc	found subordinate to quartz in the mc groundmass, where sericite needles typically form a x-hatched pattern; locally occurs as thin discontinuous massive mc seams	—
quartz	70-75	mc-vf	forms the dominant component in the mc groundmass; slightly coarser grains occur in veinlets and distorted spherical shapes (amygdules); quartz veinlets are variably folded and dismembered and may represent multiple generations	————
pyrite	1-2	mc-vf	sparsely disseminated throughout, and locally concentrated within sericite rich bands; locally occurs as glomerocrysts that, in places, may have filled vesicles (i.e pyritic amygdules)	————
voids/vugs	2-3	vf-f	voids with angular to subrounded outlines, some of which undoubtedly formed through the weathering of sulphides	

Notes: Intensely altered rock containing deformed quartz veinlets.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31089

Location: Glacier Creek prospect (QSP alteration in structural hanging wall to overturned RW zone)

Easting: 421290 **Drill hole:** N/A

Northing: 6584792 **Depth:** N/A

Rocktype: QSP alteration

Hand Sample Description: white to jarosite-yellow stained, QSP altered rock; sample from chip line across altered and mineralized zone.

Thin Section Type: regular polished

Mineral	%	Size	Comment	Paragenesis
sericite	50	mc	found as the dominant component forming the groundmass; there is potentially another clay mineral within the groundmass.	—
quartz	45	mc-vf	found in the groundmass as lozenge shaped mc-vf grains that are subordinate to sericite, as amygdale forming aggregates of vf quartz with glomerocrysts of pyrite, and within contoured veinlets	————
pyrite	2-4	mc-vf	occurs as mc-vf grains disseminated throughout and as glomerocrysts in quartz-pyrite amygdules	————
chlorite	<1	mc	occurs within vugs, and may be a later stage mineral????	-?-
voids/vugs	1-2		weathered out sulphides	

Notes: Rock is well strained; however, the primary amygdaloidal texture remains moderately well preserved. XRD should be done on sample to access the possibility of another clay mineral being present.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31091

Location: Glacier Creek prospect (structural hanging wall to overturned RW zone)

Easting: 421291 **Drill hole:** N/A
Northing: 6584795 **Depth:** N/A

Rocktype: Chloritic mafic volcanic

Hand Sample Description: dark green to black, chloritic, well foliated mafic; sample from chip line across altered and mineralized zone.

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	30-35	mc-vf	occurs as wisps and seams throughout that impart a foliation to the rock; partially replaces the plagioclase rich groundmass	—
plagioclase	65-70	mc-vf	grungy altered groundmass of felted plagioclase laths	—
quartz	1-2	vf	as amygdule forming aggregates and in the rare quartz veinlet	—
opakes	tr-1	mc	occur as irregular shaped grains disseminated throughout; sample is not magnetic	
unkown	tr-1	mc	randomly oriented, stubby, high relief, moderately high birefringent laths that are concentrated in narrow seams; may be a later stage mineral? epidote??	--?--

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61402

Location: Cap prospect

Easting: 419373
Northing: 6582751

Drill hole: RMC98-01
Depth: 12 m (39.5 ft)

Rocktype: Amygdaloidal basalt

Hand Sample Description: dark green, non-magnetic amygdaloidal basalt

Thin Section Type: Regular

Mineral	%	Size	Comment	Paragenesis
chlorite	40	cc-mc	replacing much of the groundmass and filling amygdules; typically intimately associated with sericite	—
calcite	7	mc-vf	as a component in some amygdules and disseminated throughout matrix	-?—
quartz	9	cc	as super fine grained aggregates within amygdules	—
sericite	30	cc-mc	intimately associated with chlorite, replacing groundmass and filling amygdules	—?-
opaques	2-3		anhedral grains that are commonly concentrated along grain boundaries of remnant plagioclase, and around amygdules; although similar in appearance to magnetite observed in other samples, the hand sample is not magnetic and the opaques must be something else. (?)	?
groundmass	15	cc-vf	incompletely replaced portions of the primary feldspar (+/- quartz?) groundmass; faint remnant texture of lathy plagioclase	—

Notes: Grungy mafic volcanic. Primary mineralogy has been extensively replaced by chlorite and sericite, and only a faint expression remains of the original texture of randomly oriented lathy plagioclase. The abundance of sericite suggests that the rock may have been subject to both hydrothermal alteration and regional metamorphism. The rock is highly amygdaloidal, and amygdules are filled with cryptocrystalline aggregates of quartz and or chlorite-sericite +/- calcite. Amygdules are typically quite flat and elongate, possibly a result of strain, but there is not the alignment of phyllosilicates that one would expect if the rock was indeed highly strained.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61405

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 26.6 m (87.3 ft)

Rocktype: Calcareous argillite

Hand Sample Description: black calcareous argillite

Thin Section Type: Regular

Mineral	%	Size	Comment	Paragenesis
calcite	65	cc-mc	dominant component of the groundmass	
brown grunge (organics?)	33	cc	found throughout groundmass as cc material that imparts a dark hue to the thin section; it is interpreted to be some form of organic material (not at high enough metamorphic grade to be graphite)	
siliciclastic grains (feldspar-quartz?)	2	cc-mc	subangular grains scattered throughout	
opaques (pyrite)	1	mc-f	euhedral grains, likely pyrite +/- pyrrhotite	

Notes: Fairly dark grungy looking slide composed primarily of calcite and cc brown grunge(?). The brown grunge is presumably an organic component. Minor silt sized feldspar-quartz? grains and euhedral opaques (pyrite). Rock has a fairly strong fabric, defined by flattened and elongate grains. Rock is really more of a limestone than an argillite based on the abundance of calcite and paucity of siliciclastic material.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61415

Location: Cap prospect

Easting: 419373 **Drill hole:** RMC98-01
Northing: 6582751 **Depth:** 37 m (121.5 ft)

Rocktype: Massive barite-pyrite

Hand Sample Description: massive granular barite with layers and laminations of pyrite

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
barite		vf-f	very equant, polygonalized looking grains (often five or six sided); judging by the habit, it is probable that the barite has been recrystallized	----
pyrite		mc-vf	occurs as vf-f euhedral grains and as variably disaggregated rounded masses (framboidal pyrite??), concentrated in discontinuous seams; local occurrence of pyrite rimming barite grains; pyrite grains are generally quite fractured and broken up	--?---- - ?-
sphalerite	tr	mc	high relief, transparent clouded grains that have fairly dull gray reflectance - most likely a pale sphalerite; occur as mc to vf grained subhedral blebs that are typically associated with pyrite; often growing around, or in the cracks of, pyrite and in places interstitial to barite grains	-----
unknown	tr	mc	even less abundant than the sphalerite, this mineral occurs interstitial to pyrite grains (within fractures and along grain boundaries), and has fairly high silver gray reflectance (is it a silver mineral ??)	-----
sericite	tr	mc-vf	sparsely distributed, very thin, elongate needles; most abundant near pyrite seams	?

Notes: Generally fairly simple mineralogy of massive granular barite and seams of pyrite. Sphalerite and an unknown opaque are very minor constituents of the sample, and both appear to have precipitated during a later stage mineralizing event (found within cracks of pyrite). The unknown mineral may be a silver mineral based on the high silver assay for this sample; however, micro probe is necessary for its proper identification. Pyrite appears to have been precipitated during or slightly after barite (as indicated by pyrite rimmed barite grains), and some of the rounded aggregates of subhedral pyrite may be framboidal. Other pyrite grains, however, are quite euhedral and cubic, and these may have formed later, and possibly represent partial recrystallization of the original pyrite during metamorphism??

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61425

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 44.4 m (145.6 ft)

Rocktype: QSP altered amygdaloidal mafic

Hand Sample Description: sample from thick section of baritic, hydrothermally brecciated, QSP altered amygdaloidal fragmental (possible basaltic lap-tuff protolith?)

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
groundmass	42	mc	grungy and of sufficiently fine a grain size to be beyond resolution; presumably quartz and lesser sericite; high quartz/sericite ratio suggested by poor development of deformation fabric as compared to other samples in this hole	—
quartz	40	vf-f	vf quartz filling amygdules, vf-f quartz in veins, and cc-mc quartz in groundmass	— — — —
barite	8	f-m	forms the dominant mineral in late stage, Ag rich, quartz-barite veins	— — — —
pyrite	8-10	mc-f	7-8% mc specks of "early" pyrite disseminated throughout groundmass of altered amygdaloidal rock; 1-2% vf-f subhedral pyrite occurring with sericite along margins of late stage quartz-barite veins	— — — — —
muscovite-sericite	0.5-2	vf-f	distinctive pale pink-green grains; occurs in quartz-barite veins, where it is often concentrated along vein margins, and occasionally with barite in amygdules; much coarser grained than the sericite which is associated with typical QSP alt'n	— — — — —
sphalerite	tr	vf-f	locally cores quartz amygdules and occurs as a minor constituent in quartz-barite veins	— — — — —
argentite	tr	f	anhedral irregular masses interstitial to quartz-Bar grains; rare inclusions of pyrargirite(?). Although fairly confident on the ID of argentite, probe work might be a good idea for confirmation of both it and the inclusions	— — — — —

Notes: Highly altered, extremely amygdaloidal rock with later stage Ag rich quartz-barite veins. At the mesoscopic scale these veins appear to form a stockwork and be related to the brecciation of this unit. Unlike Ag, Sphalerite appears to have been precipitated during two separate events a) early during quartz infilling of vesicles, and b) late during quartz-barite vein formation. Sample shows minimal strain, presumably due to a high quartz content.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61435

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 53.3 m (174.9 ft)

Rocktype: QSP phyllite

Hand Sample Description: sample from thick section of baritic, hydrothermally brecciated, QSP altered amygdaloidal fragmental (possible basaltic lap-tuff protolith?)

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
groundmass	65	cc-mc	grungy quartz-sericite groundmass, sericite/quartz ratio = 40/60 (approx)	_____
quartz	20-25	vf-f	as amygdules and locally occurring in veins with barite, pyrite, sericite	_____
pyrite	6-7	mc-vf	disseminated throughout groundmass (not within amygdules), minor amount within quartz-barite veins	_____
sericite	1-2	vf	associated with quartz-barite veins; abundant mc sericite in groundmass	_____
barite	1-2	vf-f	occurring primarily in quartz-barite, pyrite, sericite veins; minor amount found in composite quartz-barite amygdules	_____
sphalerite	tr-1	vf	identification uncertain because of poor polish to thin section	?

Notes: Extremely vesiculated rock, with sections of >80% amygdules (scoriated to pumiceous). Near complete silica-sericite replacement of protolith has occurred. Given the highly vesicular, frothy appearance, and total replacement of the rock, it is not unreasonable to think that the matrix was originally glassy.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61436

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 54.3 m (178.1 ft)

Rocktype: Basalt dyke

Hand Sample Description: medium green, fine grained, strongly carbonate altered, strongly magnetic mafic dyke

Thin Section Type: Regular

Mineral	%	Size	Comment	Paragenesis
chlorite	30	mc	replaces matrix interstitial to feldspar grains, and partially replaces feldspar	-----
sericite	19	mc	associated with chlorite in matrix interstitial to plagioclase, and partially replacing plagioclase	---
calcite	9	mc-vf	disseminated throughout and in veins with subordinate chlorite and quartz	-----
plagioclase	35	mc-f	grains in varying state of replacement by sericite, chlorite, and epidote; generally quite intensely altered with poor preservation of primary textures; far too altered to determine An content	---
epidote	4-5	cc-mc	small granular aggregates of cc epidote that have a grungy clouded appearance; minor individual mc grains	---
opaques	2	mc-vf	subhedral to euhedral grains that are commonly glomerocrystic; presumably predominantly magnetite given that the hand sample is strongly magnetic; grains appear to overgrow most other minerals – late metamorphic origin?	-?-?-
quartz	tr	mc	as a minor component in calcite vein	---

Notes: A quite strongly altered (mostly metamorphic alteration) mafic rock. Feldspars are quite pervasively replaced, although the relict textures are still somewhat discernable.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61439

Location: Cap prospect

Easting: 419373
Northing: 6582751

Drill hole: RMC98-01
Depth: 57 m (187 ft)

Rocktype: Silicified rock

Hand Sample Description: pale gray-white silicified rock with quartz-pyrite stockwork

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
quartz	70	cc-f	occurs as cc-mc grains throughout the groundmass, as small round aggregates of mc-vf quartz (amygdules?), and as mc-f grains within veins and veinlets	_____
barite	4	mc-vf	found as a fairly major component of veins and veinlets; quartz-pyrite-barite veins (+/- sericite, sphalerite and galena)	-?_____
sericite	19	cc-mc	disseminated throughout the cc-mc groundmass; slightly coarser grains form a minor component in some quartz-barite veins	_____
pyrite	7	cc-f	primarily found as mc-f anhedral to euhedral grains and aggregates in quartz-barite veins; also occurs as cc-mc grains sparsely disseminated throughout matrix; commonly quite broken and pitted	-?_____
sphalerite	tr	mc	typically found as anhedral grains in small quartz veinlets interstitial to quartz and barite, often associated with galena	_____
galena	tr	mc	typically found as anhedral grains in small quartz veinlets interstitial to quartz and barite, often associated with sphalerite	_____

Notes: Intensely silicified rock with numerous quartz and quartz-barite-pyrite veins and veinlets. The matrix of the rock consists of cc-mc quartz and subordinate sericite, (and possibly cc grains of barite as well). Numerous coarser grains and aggregates of quartz (mc-vf) occur within the cc-mc groundmass, many of which may be small amygdules. The sphalerite and galena appear to be concentrated in the smaller veinlets.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61448

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 66 m (216.5 ft)

Rocktype: Brecciated QSP alteration (baritic)

Hand Sample Description: Cherty silicified baritic zone of QSP breccia

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
quartz	81	cc-vf	mc-vf grains in amygdules and randomly oriented veinlets;	——
barite	1	vf	associated with quartz in narrow veinlets	——
sericite	13	mc-vf	makes up to 30-35% of the matrix of amygdaloidal fragments; slightly coarser grained material occurs with quartz in some amygdules and quartz-barite veinlets	——
pyrite	4-5	cc-vf	subhedral to euhedral grains disseminated throughout, locally concentrated in veinlets and seams	——

Notes: Intensely quartz-sericite-pyrite altered highly amygdaloidal clasts supported in a cc-mc quartz matrix that is cut by numerous narrow quartz and quartz-barite veinlets. Amygdules average about 0.5-1 mm, and make up 10-15% of the rock fragments. Amygdules are round and the sericite rich matrix wraps around them. Amygdaloidal clasts are composed of approx. 30-35% sericite, 3-4% pyrite, and the remainder is quartz.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61465

Location: Cap prospect

Easting: 419373
Northing: 6582751

Drill hole: RMC98-01
Depth: 79.7 m (261.5 ft)

Rocktype: QSP alteration

Hand Sample Description: Densely amygdaloidal, intensely QSP altered rock (tan sericite), with minor veins

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
quartz	25	mc-m	found as mc grains scattered throughout the groundmass, as vf-m grains filling amygdules, and as a major component of veins	-----
barite	1	mc-f	found within some veins and coring the rare amygdule	----
sericite	70	mc-vf	randomly oriented mc grains dominates the groundmass, and minor vf grains found in veins	-----
pyrite	1.5-2	cc-f	very finely disseminated cc-mc grains found throughout matrix in minor concentration (1%); mc-f irregular grains in veins, and the occasional amygdule	-----
sphalerite	0.5-1	cc-mc	very finely disseminated cc (very rarely mc) grains found throughout matrix, and the rare scattered mc grain in veins	-----
galena	tr	cc-vf	rare grains found in veins and at coring the rare amygdule where it is associated with sphalerite and barite	---
unknown	3	cc	grungy cc aggregates spotted throughout matrix; unknown clay?	?

Notes: Intensely quartz-sericite-pyrite altered highly amygdaloidal (20%, 0.1 – 10 mm amygdules) rock. Amygdules are composed primarily of quartz, although locally are cored by all or one of barite, galena, and sphalerite. Minor amounts of sphalerite also appear to be disseminated throughout the groundmass as cc grains. Veins are composed of quartz, barite, pyrite and sericite.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC61483

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 99.2 m (325.5 ft)

Rocktype: QSP alteration

Hand Sample Description: Densely veined, amygdaloidal intense QSP alteration

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
quartz	15	mc-f	found scattered throughout groundmass and as the primary mineral in amygdules; also principle component of veins	———
barite	1	vf-c	occurs subordinate to quartz and calcite in veins, and fills the rare amygdule	——
sericite	78	cc-vf	groundmass of near massive cc-mc sericite; minor mc-vf grains in quartz-cc-barite veins	———
pyrite	5-6	cc-c	~1% found as finely disseminated cc-vf pyrite throughout matrix; remainder found as vf-c grains and broken-up massive seams concentrated within veins	———
calcite	2	vf-f	forms one of the principle components of veins, and fills the rare amygdule	——

Notes: Intensely quartz-sericite-pyrite altered moderately-highly amygdaloidal (10-15%, 0.2 – 10+ mm amygdules) rock cut by numerous deformed (locally squiggly) veins and veinlets. Quartz was first to fill amygdules, and where quartz only partially filled the amygdules, calcite or barite fills cores. Veins are composed of quartz-calcite-pyrite-barite and minor sericite. Minor dull gray cc grains disseminated in matrix observed under reflected light (sphalerite(?), silver mineral(?), or artifact of polishing??)

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60057

Location: Cap prospect

Easting: 419373
Northing: 6582751

Drill hole: RMC98-01
Depth: 119.5 m (392 ft)

Rocktype: QSP altered amygdaloidal basalt

Hand Sample Description: QSP altered amygdaloidal basalt

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
sericite	80	cc-vf	primary component of the groundmass, and locally found in quartz-pyrite veins	—
pyrite	5-10	cc-f	abundant super fine grained (cc-mc) pyrite disseminated throughout matrix; and coarser grained (vf-f) anhedral-subhedral pyrite in quartz veins; coarser grained pyrite is commonly broken up and locally pitted and etched	—
quartz	10-15	mc-vf	forms irregular veinlets and amygdules, and locally a component of the groundmass	-?—
unknown (chloritoid or sillimanite??)	tr	vf	colourless, low birefringent tabular to fibrous mineral with rare bow-tie habit; possibly chloritoid but could also be sillimanite (parallel extinction and length slow) – neither is a perfect match?? (sample contains 17% Al ₂ O ₃)	—?—

Notes: Intensely altered, strongly foliated, moderately amygdaloidal rock. Mineralogy is quite simple (quartz-sericite-pyrite) except for one unknown mineral that occurs in trace concentration. The rock is quite aluminous and the unknown is thought to be either chloritoid or sillimanite, however, the optical properties don't appear to match exactly for either. Irregular veins of quartz-pyrite >> sericite are common. Amygdules average 0.5-2 mm and are filled by quartz and sericite

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60067

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 129.8 m (425.9 ft)

Rocktype: Footwall alteration

Hand Sample Description: Densely veined (quartz-calcite-pyrite veins), moderately QSP altered

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
sericite	59	cc-mc	dominant component of groundmass	-----
pyrite	25-30	cc-c	cc-mc grains finely disseminated throughout; mc-coarse subhedral grains in veins and seams	-----
quartz	2-3	mc-vf	found in veins, associated with calcite and pyrite	-----
chlorite	tr	vf	very minor component of quartz-calcite-pyrite veins	-----
calcite	3-4	mc-f	found in veins, associated with calcite and pyrite; typically cores the veins	-----
epidote?	6-7	cc-mc	small patches of grungy cc-mc aggregates throughout groundmass	?

Notes: Sample taken from a zone of transition that marks the gradual decrease in sericite, an increase in calcite and the introduction of chlorite. Sample is strongly sericitized rock with numerous pyritic quartz-carbonate veins. Most veins are subparallel to foliation and predate deformation (one narrow quartz veinlet was observed cross-cutting foliation).

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60078

Location: Cap prospect

Easting: 419373
Northing: 6582751

Drill hole: RMC98-01
Depth: 143.1 m (469.5 ft)

Rocktype: Quartz-Pyrite-Chlorite-Calcite altered basalt

Hand Sample Description: Gray-green amygdaloidal basalt with moderate quartz-pyrite-chlorite-calcite alteration

Thin Section Type: Regular

Mineral	%	Size	Comment	Paragenesis
chlorite	10-15	vf	found disseminated throughout matrix and within amygdules	----
calcite	5	mc-f	found in amygdules and within late stage veins	-----
opaques (pyrite)	10-15	cc-vf	subhedral to euhedral grains disseminated throughout; continuous range in grain size from cc-vf	----
epidote	30	cc-vf	aggregates of cc-mc epidote, and individual mc-vf grains, disseminated throughout	-----
clay (sericite?)	30-35	cc	super fine grained moderate relief clay (possibly sericite)	-----
quartz	tr-1	mc-vf	found in the rare amygdule	-----

Notes: Matrix is completely replaced by chlorite, epidote, pyrite, and clay (possibly sericite). Primary textures are totally obscured save for amygdules. Amygdules are composed of chlorite, calcite, and clay, and much less commonly by quartz and pyrite. Rare late stage calcite veins cross-cut section.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60096

Location: Cap prospect

Easting: 419373
Northing: 6582751

Drill hole: RMC98-01
Depth: 164.6 m (540 ft)

Rocktype: Altered footwall basalt

Hand Sample Description: Pale gray moderately altered (chlorite-calcite-pyrite), amygdaloidal basalt; alteration is patchy and veinlet/fracture controlled

Thin Section Type: Regular

Mineral	%	Size	Comment	Paragenesis
chlorite	2-3	mc-vf	minor component found in some amygdules and epidote-pyrite rich seams, and scattered throughout matrix	---
calcite	2-3	mc-vf	found in amygdules and veins	----
opaques (pyrite)	4-5	cc-vf	subhedral to euhedral grains disseminated throughout matrix; vf grains of pyrite locally concentrated in epidote rich seams/veins; Most of the opaque material is likely pyrite (hand sample is not magnetic)	---
epidote	20	cc-vf	as grungy cc aggregates throughout matrix; commonly rims amygdules and locally occurs in high concentration in pyritic seams/veins; vf subhedral to euhedral grains not uncommon and some grains show zoning with lower birefringence cores	---
clay (sericite?)	70	cc	forms the dominant component of the matrix and commonly is the primary mineral in amygdules; clay is probably sericite but its cc nature inhibits confident identification	-----
quartz	tr	mc		-----

Notes: Sample came from a section of drillcore described as being generally only moderately altered, with patches of slightly more intense alteration. The high clay content of this sample and the absence of any primary mineralogy or textures besides amygdules, indicates that it is actually quite highly altered. The thin section likely came from one of the areas of more intense alteration and may not be representative of the entire section. The clay is probably sericite. Amygdules make up ~4% of the rock, average 0.5-1 mm, and are most commonly composed of clay, although calcite, and chlorite are also found in amygdules.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60104

Location: Cap prospect

Easting: 419373

Drill hole: RMC98-01

Northing: 6582751

Depth: 175.9 m (577 ft)

Rocktype: Footwall basalt

Hand Sample Description: Gray-green moderately altered (chlorite-calcite-pyrite), strongly magnetic amygdaloidal basalt.

Thin Section Type: Regular

Mineral	%	Size	Comment	Paragenesis
chlorite	41	mc-vf	massive groundmass forming mc aggregates and scattered vf grains	
calcite	2	mc-vf	forming amygdules and minor amounts disseminated throughout matrix	
opaques (pyrite + magnetite)	5-6	cc-f	subhedral to euhedral grains disseminated throughout; hand sample is strongly magnetic and contains visible pyrite	
epidote	15	cc-f	grungy cc-mc aggregates and vf-f subhedral to euhedral grains scattered throughout	
sericite	30	mc-vf	patchy mc-vf masses throughout groundmass	
quartz	8	cc-vf	often found as cc-mc masses that have unusual semi-rectilinear shapes and wispy soupy semi-opaque laminations (some are likely amygdules, others are too angular); less commonly found as cc-mc grains within groundmass	

Notes: Sample is from near the bottom of DDH RMC98-01 and it is clear from the high sericite content that the rocks are still quit strongly hydrothermally altered. The chlorite and epidote content could be the result of either metamorphic or hydrothermal alteration. Primary mineralogy has been completely replaced and original mineral textures obliterated.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31051

Location: Cap prospect

Easting: 419241 **Drill hole:** N/A
Northing: 6582669 **Footage:** N/A

Rocktype: Gabbro

Hand Sample Description: Moderately chloritic medium grained gabbro

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase	58	f-m	randomly oriented laths with moderate chlorite alteration; composition determined to be An0 to An5	---
chlorite	37	f-m	poikilitic texture of individual anhedral chlorite grains growing around, and engulfing, smaller grains of plagioclase; the chlorite has undoubtedly replaced primary pyroxene grains; also found as fmc grains that partially replace plagioclase	---
calcite	2-3		often occurs in rounded aggregates, not unlike amygdules!?!; and as finer grained patches associated with chlorite, interstitial to plagioclase	---
opaques	2-3	mc-f	fine grained subhedral magnetite crystals that grow around plagioclase grains and are totally altered to some type of cc semi-opaque aggregate (hand sample is NOT magnetic); mc-vf grains of the same aggregate, appear to overgrow other minerals and may be metamorphic in origin?	-----?
epidote?	1	mc	high relief, high birefringent grains that commonly have a yellowish hue under plane polarized light; typically associated with chlorite	---

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31052

Location: Cap prospect

Easting: 418988

Drill hole: N/A

Northing: 6582627

Depth: N/A

Rocktype: QSP altered

Hand Sample Description: highly pyritic quartz-sericite-pyrite +/- barite alteration zone exposed in a gully up ice ~ 450 m west of the mineralization at the Cap occurrence; strongly foliated

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
sericite	70-75	cc-mc	dominant constituent of the matrix; locally occurs as massive seams (veins?), that are folded and deformed	---
opaques (pyrite)	25-30	cc-mc	cubic grains of varying size disseminated throughout; local patches of higher concentration	---
quartz	tr	mc	rare scattered grain	---

Notes: Intensely altered rock composed almost exclusively of sericite and pyrite

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31053

Location: Cap prospect

Easting: 418998
Northing: 6582614

Drill hole: N/A
Depth: N/A

Rocktype: QSP altered

Hand Sample Description: strong sericite alteration +/- quartz; from alteration zone exposed in a gully up ice up ice ~ 450 m west of the mineralization at the Cap occurrence

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
groundmass (sericite+ plagioclase)	95	mc-vf	plagioclase rich groundmass that has been severely altered to sericite; randomly oriented texture of primary plagioclase is preserved; some slightly coarser grained sericite in amygdules	———
opaques (pyrite)	2	mc	sparsely disseminated through matrix and commonly in amygdules	——
quartz	1-2	mc-vf	generally found in amygdules or partially filling in vesicles, and locally forms narrow veinlets	———
Fe-oxide	1-2	cc	grungy red-brown oxide along fractures and in vesicles	——
plagioclase	tr	f-m	extremely rare fine to medium grained lathy feldspar phenocrysts	——
calcite	tr	vf	locally associated with quartz in amygdules	———

Notes: Highly vesiculated (5-10%, 1-3 mm vesicles/amygdules), fairly intensely altered rock. A fair amount of sulphide has likely been weathered out of the vesicles and veinlets based on the abundance of Fe-oxide and void space. The primary textures of a feldspathic groundmass remain reasonably well preserved; however sericite replacement is extensive.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31054

Location: Cap prospect

Easting: 419609 **Drill hole:** N/A

Northing: 6582741 **Depth:** N/A

Rocktype: Basalt tuff/volcaniclastic

Hand Sample Description: Poorly sorted monolithic basalt lapilli tuff, which contains block, lapilli and tuff size volcanic material, in footwall to Cap occurrence alteration zone. Distinctive rough textured surface, with resistant black clasts in a recessive carbonate rich matrix.

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
calcite	50	vf	monomineralic matrix of calcite supporting clasts of massive biotite-chlorite +/- epidote(?) (alt'd mafic clasts); also commonly found in amygdules within the altered clasts	—
biotite	44	mc-vf	occurs as the primary constituent of the mafic clasts; mafic fragments are completely replaced by massive aggregates of biotite	—
chlorite	4-5	mc-vf	occurs subordinate to biotite in replaced mafic fragments	—
quartz	1-2	mc-vf	found in amygdules within altered mafic clasts; presumably the quartz filled in the amygdules prior to the clasts deposition within the carbonate matrix	—
opakes	tr-1	cc-mc	minor anhedral grains within the altered clasts	?
epidote?	tr	cc-vf	small euhedral grains and possibly as patchy cc aggregates	—

Notes: Angular and irregular shaped, highly amygdaloidal, locally scoriaceous, clasts (small amygdules, <1mm, of quartz + calcite), of mafic volcanic rock that are supported in a fairly pure carbonate matrix. Clasts (typically 1- 10 mm in size) are completely replaced by biotite-chlorite +/- epidote. Fragments have clearly not travelled far given their angularity, and many are quite equant, much as one would expect from hyaloclastite.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31055

Location: Cap prospect

Easting: 419306 **Drill hole:** N/A
Northing: 6583330 **Depth:** N/A

Rocktype: Pillow basalt

Hand Sample Description: Fresh looking, highly magnetic, black, amygdaloidal pillow basalt.

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	50	vf-f	randomly oriented laths; composition determined to be albitic; variably altered and replaced	---
calcite	25	vf	as the dominant component in amygdules and as random grains distributed throughout	----?--
chlorite	1-2	vf	found as a minor component in amygdules and scattered throughout groundmass; locally partially replaces plagioclase laths	---
epidote	2-3	mc	small subhedral grains disseminated throughout; possibly cc component in the groundmass	---
groundmass	15	cc	fairly dark grungy cc altered material that forms the matrix interstitial to plagioclase grains; fairly high birefringence to some of the groundmass (likely cc aggregates of epidote and or biotite)	---
opaques	5	cc	superfine grained magnetite disseminated throughout matrix (presumably of a metamorphic origin based on the grain size); hand sample is strongly magnetic	----
biotite	tr-1	cc-mc	minor component in matrix	----

Notes: Highly amygdaloidal basalt. Amygdules make up about 10-15% of rock and are typically 0.2 - 1.5 mm. This rock is far from zones of strong QSP alteration and the mineralogy is likely representative of the regional greenschist metamorphism.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 - 0.1 mm)
vf very fine grained (0.1 - 0.3 mm)
f fine grained (0.3 - 1.0 mm)
m medium grained (1.0 - 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31056

Location: Cap prospect

Easting: 418300 **Drill hole:** N/A

Northing: 6582906 **Depth:** N/A

Rocktype: Pillow basalt

Hand Sample Description: Strongly magnetic, little foliated, amygdaloidal pillow basalt

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite?)	40	mc	randomly oriented variably altered laths	---
chlorite	40	mc	forms groundmass interstitial to plagioclase and locally within amygdules	-----
opaques (magnetite)	12	cc-mc	commonly as elongate, rod-like glomerocrysts; and as cc equant euhedral grains; disseminated throughout and overgrowing all other mineral types; forms a dense interlocking network of rod like growths in finer grained material surrounding amygdule rich sections	-----
epidote	7	cc-vf	small patchy aggregates of cc epidote(?) disseminated throughout matrix; also found as fairly large massive patches in amygdules and scattered euhedral mc-vf grains in amygdules, groundmass and late stage veins	-----
quartz	tr-1	mc	restricted to late stage quartz-epidote vein	---
biotite	tr-1	mc	locally observed in amygdules and a minor component of the groundmass	---
calcite	tr	mc	very minor component of amygdules	?

Notes: Weakly amygdaloidal basalt. Contains a high concentration of magnetite that is interpreted to have a metamorphic origin. Mineralogy is consistent with greenschist grade metamorphism, i.e. chlorite-epidote-biotite and the plagioclase, although to small to determine composition, is more than likely albite (it is albite everywhere else!). Amygdules contain assemblages of epidote-chlorite +/- quartz +/- biotite +/- calcite. Sample is a fair distance from hydrothermal alteration and the mineralogy can be considered representative of the regional metamorphism.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31061

Location: Cap prospect

Easting: 419396 **Drill hole:** N/A

Northing: 6582762 **Depth:** N/A

Rocktype: Amygdaloidal basalt

Hand Sample Description: Weakly magnetic amygdaloidal basalt with calcite filled amygdules; 60-100 m into the hangingwall from the stratiform massive barite at the Cap occurrence.

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
calcite	60-70	cc-vf	cc-mc calcite disseminated throughout matrix and mc-vf grains found in amygdules	---
chlorite	25-30	cc-mc	patchy seams throughout	---
opaques (magnetite +/- pyrite?)	3	cc-mc	rock is weakly magnetite so some of the opaques must be magnetite; however, some grains have cubic outlines and these may be pyrite	?
epidote(?)	4-5	cc	small patchy aggregates of grungy cc material disseminated throughout— probably epidote	---
groundmass (quartz-feldspar??)	10-15	cc	super fine grained granular masses; possibly lesser altered quartz-feldspar matrix?? in places it appears to form patches that have a tabular morphology (alt'd granularized plagioclase grains??), and elsewhere it forms ovoid, small amygdule-like shapes	?

Notes: Rock contains an unusually high calcite content. The rock matrix appears to be almost completely replaced (calcite-chlorite-epidote(?)). It is quite highly amygdaloidal, and both calcite and cc quartz appear to form vesicles. To sum things up, this rock is very blitzed, and I wonder if being so close to the underlying barite horizon (60-90 m), that this rock is not somewhat hydrothermally altered?

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMR31063

Location: Cap prospect

Easting: 418945 **Drill hole:** N/A

Northing: 6582441 **Depth:** N/A

Rocktype: Massive rhyolite

Hand Sample Description: salmon pink to buff-orange fairly siliceous rock; weak fe-carbonate like orange staining; does not react to acid.

Thin Section Type: regular

Mineral	%	Size	Comment	Paragenesis
groundmass	95	cc	cc mass that appears to consist of quartz-feldspar and sericite; rare spherulite	
quartz	2	mc-vf	sparse, subhedral vf grained quartz phenocrysts; numerous anhedral mc-vf grains that are a little coarser grained than the matrix but don't exactly produce a good porphyritic texture; quartz also occurs in rare undeformed veinlets	
carbonate	tr-1	mc-vf	associated with quartz in late stage veins	
fe-oxide??	2	cc	small cc aggregates of grungy red-orange stuff disseminated throughout - fe-oxide??	

Notes: Weakly altered (sericite + fe-oxide) rhyolite.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: MHC1

Location: Mount Henry Clay prospect

Easting: 416788

Drill hole: N/A

Northing: 6584638

Depth: N/A

Rocktype: Massive Sulphide

Hand Sample Description: Massive sulphide boulder, matrix reacts to acid

Thin Section Type: Regular polished

Mineral	%	Size	Comment	Paragenesis
sphalerite	40		xenomorphic mass engulfing pyrite grains and occurring along fractures in pyrite.	——
pyrite	45	mc-f	broken and fractured subhedral grains that are commonly elongate parallel to foliation(?); fractures in the pyrite grains are commonly filled with sphalerite and chalcopyrite	——
chalcopyrite	1-2	cc-f	occurs cc-mc blebs throughout sphalerite and as masses rimming pyrite grains and within fractures in pyrite	——
calcite	5-10	vf-f	layers contain from 1-2% up to 30-40%, occurring interstitial to sulphides	——
quartz	1-2	vf-f	occurs as rare grains interstitial to sulphides	——

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60810

Location: Mount Henry Clay prospect

Easting: 416651

Drill hole: G89-11

Northing: 6584360

Depth: 13.6 m (44.5 ft)

Rocktype: mafic fragmental (tuff to lapilli tuff)

Hand Sample Description: chloritic, highly strained mafic fragmental; possible hornblende??

Thin section type: Large

Mineral	%	Size	Comment	Paragenesis
plagioclase	52	mc-vf	much of the plagioclase is fairly fresh looking and good euhedral laths are common. In places laths are randomly oriented, elsewhere they mineral grains are aligned with the penetrative fabric. Plagioclase composition appears to be An0-10; however, there is not 100% confidence in optic sign determination and a higher An content is possible	—
chlorite	36	mc-vf	groundmass interstitial to plagioclase; locally occurs as massive seams surrounding clasts. All have nearly the same optical orientation; i.e. darkest pleochroic colours are observed when the section is oriented such that the fabric in the rock is aligned with the lower polar (is true for all chlorite grains except those that occur within extension cracks in biotite).	—
biotite	5	vf-f	commonly contain narrow lamella of chlorite that fill extension fractures. Chlorite lamellae are roughly perpendicular to foliation in rock. Biotite occurs throughout, although concentration varies from clast to clast; locally up to 20%.	—
carbonate (calcite & Fe-carbonate?)	5	mc-vf	evenly disseminated mc-vf grained, dirty/clouded, high relief Fe-carbonate(?) rhombohedral porphyroblasts; lower relief, clear calcite(?) occurring in amygdules, in amygdaloidal clasts and as disseminations and micro veinlets	?—?
quartz	2	mc	lens shaped mc aggregates of quartz; possibly attenuated cherty fragments???	—
opaques	tr	mc	hand sample is v. weakly magnetic, suggesting opaque mineral is magnetite	?

Notes:

cc cryptocrystalline (< 0.01 mm)
 mc microcrystalline (0.01 – 0.1 mm)
 vf very fine grained (0.1 – 0.3 mm)
 f fine grained (0.3 – 1.0 mm)
 m medium grained (1.0 – 3.3 mm)
 c coarse grained (> 3.3 mm)

Sample #: RMC60811

Location: Mount Henry Clay prospect

Easting: 416651 **Drill hole:** G89-11
Northing: 6584360 **Depth:** 23.2 m (76 ft)

Rocktype: Diorite dyke

Hand Sample Description: fine-grained massive diorite dyke

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase	48	vf	variably replaced subhedral to anhedral grains	---
chlorite	44	vf	forms groundmass interstitial to plagioclase; near uniform optical orientation	---
biotite	4	vf		---
calcite	2	vf	occurs as irregular grains disseminated throughout matrix and as thin disrupted veinlets	---?-
opaques	2	mc-vf	finely disseminated magnetite	?

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60812

Location: Mount Henry Clay prospect

Easting: 416651 **Drill hole:** G89-11
Northing: 6584360 **Depth:** 45.4 m (149 ft)

Rocktype: mafic fragmental (block, lapilli and tuff size clasts)

Hand Sample Description: chloritic, highly strained mafic fragmental containing some quite grainy fragments

Thin section type: Large

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	51	mc-f	felted texture of interlocking, randomly oriented plagioclase laths common in some clasts; grain size is quite variable between clasts	—
chlorite	30	mc-vf	occurs as the groundmass interstitial to plagioclase in clasts and as near massive seams between clasts	—
carbonate (calcite & Fe-carbonate)	7	mc-vf	occurs as mc high relief euhedral rhombs, and as lower relief, slightly coarser grained disseminated material that is particularly abundant in the coarser grained clasts	—
quartz	2	mc-vf	occurs as aggregates of vf grains within small amygdules (up to 1 mm in diameter) in mafic volcanic clasts that in hand sample were interpreted to be quartz diorite	—
opaques	3	mc-vf	commonly concentrated along the margins of clasts along with minute carbonate rhombs – both are likely metamorphic in origin. opaques assumed to be magnetite b/c the hand sample is strongly magnetic. locally occurs as cc-mc acicular needles. Coarser subhedral grains (vf) may have a primary origin	-?— —
groundmass	7	cc-mc		

Notes: Grain size is quite variable between clasts as is the proportion of the different minerals present. The mineralogy, however, is the same throughout. It had been postulated previously that some of the coarser grained clasts noted in hand sample may have had an intrusive origin, but one of the coarsest grained clasts observed in thin section contains amygdules and is in fact volcanic. Strain is quite intense and locally some of the coarser feldspar crystals are broken and boudinaged.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60813

Location: Mount Henry Clay prospect

Easting: 416651
Northing: 6584360

Drill hole: G89-11
Depth: 63.1 m (207 ft)

Rocktype: mafic fragmental (tuff and lapilli size material)

Hand Sample Description: coarse lapilli, some amygdaloidal and some grainy; sample from lesser altered rock proximal to quartz-barite vein

Thin section type: Large

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite?)	39	mc-f	commonly as randomly oriented laths; could not determine An content	---
chlorite	26	mc-vf	interstitial to plagioclase and locally concentrated in semi-massive seams	-----
Sericite	8	mc	typically closely associated with chlorite, found both interstitial to plagioclase and in more massive seams	---
Biotite	1	vf-f	found in some clasts and not others	---
carbonate	6	mc-f	disseminated throughout, particularly abundant in coarser grained clasts	---
quartz	1		as aggregates forming amygdules	---
opaques	7	cc-vf	minor mc acicular needles (probably sulphide, arsenopy?), some mc-vf cubic grains, and cc-mc euhedral specks disseminated throughout (overprint all mineral types); hand sample is extremely magnetic, and from grain size distribution there appears to be two generations of magnetite formation	-----
groundmass	12	cc-mc	feldspar and quartz	-----

Notes: Highly flattened clasts of varying grain size. Amygdaloidal clasts are typically very fine grained (cc-mc), and have abundant disseminated magnetite. The high concentration of magnetite in these clasts (up to 35-40%) is likely responsible for their distinctive blue-black appearance in hand sample. Coarser grained clasts tend to have magnetite that has bimodal grain size (vf and cc-mc). It is interpreted that the larger grains are primary, and the finer grained magnetite has a metamorphic or hydrothermal origin.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60814

Location: Mount Henry Clay prospect

Easting: 416651

Drill hole: G89-11

Northing: 6584360

Depth: 91.7 m (301 ft)

Rocktype: Rhyolite dyke

Hand Sample Description: sparsely quartz, phyric rhyolite dyke/sill

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
quartz	1	f	euhedral phenocrysts	—
sericite	10	mc	fine needles disseminated throughout groundmass	—
microcline	.5	f	distinctive x-hatched twinned phenocrysts, with graphic quartz intergrowths; margins of grains are fringed by quartz-feldspar (+/- sericite) overgrowths	—
calcite	1	vf		—
groundmass	87	mc	quartz-feldspar rich groundmass; appears to be dominantly anhedral quartz	—
opaques	.5	cc-mc	magnetite and lesser pyrite; hand sample is weakly magnetic	—?—

Notes: Sparsely quartz, K-spar porphyritic rhyolite. Sericite likely has a metamorphic origin as opposed to hydrothermal alteration, based on the lack of any obvious hydrothermal alteration in surrounding rock.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60815

Location: Mount Henry Clay prospect

Easting: 416651
Northing: 6584360

Drill hole: G89-11
Depth: 118.7 m (389.5 ft)

Rocktype: Basalt

Hand Sample Description: moderate to well foliated mafic flow, with moderate to strong Fe-carbonate alteration (veinlets)

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	52	vf-f	simple twins common; plagioclase determined to have an albitic composition	—
chlorite	35	mc-vf	groundmass interstitial to plagioclase	—
Fe-carbonate	7-8	mc-vf	occurs as late stage micro veinlets and irregular patches that cross-cut all other mineral grains	—
opaques	3-4	mc-vf	interpreted to be primarily magnetite because of the mod-str magnetic nature of the hand sample; there appears to be two generations of – finely disseminated mc magnetite (likely metamorphic), and grungy altered slightly coarser grains (vf)	— —
quartz	1	mc	mc quartz in groundmass and attenuated recrystallized amygdules(?)	—?—

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60816

Location: Mount Henry Clay prospect

Easting: 416651
Northing: 6584360

Drill hole: G89-11
Depth: 139.1 m (456.4 ft)

Rocktype: Basalt

Hand Sample Description: Basalt flow, locally amygdaloidal

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase	45	vf-f	randomly oriented laths, with only minor alteration to chlorite	—
chlorite	45	mc-f	completely replaces groundmass interstitial to plagioclase laths; thin mc blades of chlorite partially indent and replace edges of plagioclase crystals	—
calcite	1	vf-f	occurs with and without quartz in amygdules, and less commonly as veins; locally displays bent/curved cleavage	— ?—
quartz	1	mc-vf	occurs as composite masses in amygdules	—
pyroxene(?)	tr	vf-f	highly corroded, high birefringent grain; one grain had a good equant outline in the shape of a basal section of pyroxene	—
opaques	8	vf-f	subhedral grains that locally grow around plagioclase grains (probable magmatic origin); finer grained disseminated magnetite may have a metamorphic origin?	— —?—

Notes: Generally fairly good preservation of plagioclase crystals. Little evidence of deformation except perhaps for the curved cleavage of calcite.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60817

Location: Mount Henry Clay prospect

Easting: 416651

Drill hole: G89-11

Northing: 6584360

Depth: 174.3 m (572 ft)

Rocktype: Andesite to andesitic basalt?

Hand Sample Description:

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite?)	52	mc-vf	extinction angle to the (010) composition plane of albite twins is ~15 deg, however grains are too f. grained to determine optic sign and thus An content is indeterminate.	—
chlorite	36	mc-vf	groundmass interstitial to plagioclase	—
carbonate	7	mc-vf	occurs in amygdules, with or without quartz, and as disseminations within the matrix.	—
opaques	5	cc-vf	hand sample is strongly magnetic, suggesting much of the opaque material is magnetic; irregular subhedral grains and aggregates	—?—
quartz	1	mc-vf	occurs as aggregates of mc-vf grains within flattened amygdules	—

Notes:

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60818

Location: Mount Henry Clay prospect

Easting: 416651 **Drill hole:** G89-11
Northing: 6584360 **Depth:** 192 m (630 ft)

Rocktype: mafic lapillistone

Hand Sample Description: normally graded, moderately well sorted lapillistone with rare block size fragments; mixed mafic fragments with minor altered (silicified/pyritized) clasts

Thin section type: Large

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	50	mc-vf	abundant randomly oriented thin blades that are commonly fairly grotty and altered (particularly for the finer grained material); plagioclase has an albitic composition	—
chlorite	24	cc-mc	occurs as groundmass interstitial to plagioclase and locally forms massive seams; rare small clast of near pure chlorite; some of the more siliceous and coarser grained clasts contain minimal chlorite	—
biotite	1	vf	random optical orientation; concentration varies between clasts from absent to up to 10%	----
carbonate	4	mc-f	grungy masses of mc carbonate disseminated throughout groundmass of most clasts; locally occurs as vf-f grains that fill in space between extended clast, and in veinlets with quartz and pyrite	————
quartz	2	mc-f	occurs as the dominant constituent of amygdules and as mc masses in the rare near monomineralic clast; rare vf grained equigranular clast containing perhaps 5-15% quartz and exhibiting a myrmekite like replacement texture	———
opaques	5	cc-vf	vf grained pyrite was noted rimming individual clasts and also disseminated within clasts; this pyrite mineralization is associated with quartz-carbonate veining and post dates deposition of the clasts; bimodal grain size to magnetite – coarser material is likely primary and the finer grained magnetite overprints all other minerals; magnetite concentration varies dramatically from clast to clast, with some clasts containing up to 35-40%	— — ? —
groundmass	14	cc-mc	typically quite grungy and altered in appearance (possibly saussuritized feldspar?); locally has a matted radial texture that is not unlike devitrification growths (i.e. coalesced spherulites?)	— — — —

Notes: Sample displays much less deformation than many of the other samples from this drill hole, with good preservation of angular clast morphology (even local cusped textures), and rounded amygdules. Quite high variability in texture and concentration of different minerals between the clasts; however, the mineralogy remains fairly consistent. The pyritic clasts in this sample appear to have been pyritized insitu and are not transported sulphide clasts.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60819

Location: Mount Henry Clay prospect

Easting: 416651
Northing: 6584360

Drill hole: G89-11
Depth: 208.6 m (684.5 ft)

Rocktype: Basalt

Hand Sample Description: basalt with zones of quench/shatter breccia

Thin section type: Large

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	47	mc-vf	thin randomly oriented laths	---
chlorite	43	mc	groundmass interstitial to plagioclase, and partially replacing individual plagioclase grains	---
quartz	1	cc-mc	occurs with minor chlorite and rare carbonate as matrix to small breccia zones	---
carbonate	3	vf	occurs as a subordinate component in cherty breccia matrix and concentrated in randomly distributed seams and patches scattered throughout section	-----
epidote?	2	cc-mc	grungy high relief, moderately high birefringent, anhedral masses that are too fine grained to determine optical properties; best guess is epidote but could easily be a carbonate or something else	---
opaques	4	mc	assumed to be predominantly magnetite as hand sample is strongly magnetic; occurs throughout groundmass, often as narrow elongate clusters, and locally found rimming plagioclase grains; appears to overprint all other minerals	----?

Notes: Uniform texture of randomly oriented mc-vf feldspar laths within a chloritic matrix. The breccia textures observed in this sample are likely a result of quench fragmentation during extrusion of the flow. Some of the small chloritic wisps within the quartz rich (cherty) breccia matrix are likely altered volcanic breccia shards.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60820

Location: Mount Henry Clay prospect

Easting: 416651
Northing: 6584360

Drill hole: G89-11
Depth: 228.4 m (749.5 ft)

Rocktype: Mafic breccia

Hand Sample Description: monolithic purplish blue-grey volcanic breccia, minimal f. grained material

Thin section type: Large

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	38	mc-vf	plagioclase composition is An0 – An5 (i.e. albite); found as randomly oriented laths throughout; grain size varies somewhat from clast to clast, but overall texture is the same	—
chlorite	33	mc-vf	occurs as groundmass interstitial to plagioclase, within breccia matrix and amygdules, and partially replacing plagioclase laths (typically as fine spines growing inwards from plagioclase margins)	—
quartz	tr-1	mc-vf	found as a component in breccia matrix and within amygdules	—
carbonate	1	cc-vf	found as a component in breccia matrix and within amygdules, and locally disseminated throughout groundmass	—
epidote?	6	cc-mc, vf	grungy, clouded granular aggregates of a cc mineral that has high relief and moderate to high birefringence – could potentially be epidote but is too fine grained to confidently identify with optical properties; confident identification of epidote comes from rare vf grained euhedral grains with faint greenish yellow to colourless pleochroism that are found in amygdules	—
opaques	23	cc-mc	found as slender cc-mc needles and equant grains forming a major component of the groundmass (locally indent and overgrow plagioclase laths); concentration of opaques is very high, up to 35-40% in places; slightly coarser grained anhedral grains that are associated with clasts containing coarser grained plagioclase, probably has a primary origin	—
biotite	tr	mc-vf	rare grains occurring in amygdules	—

Notes: A calcite, chlorite, quartz +/- biotite, +/- epidote assemblage fills amygdules and breccia matrix. The concentration of opaques is markedly high (23%), and is responsible for the blue-gray-black appearance to the rock in hand sample. Most of the magnetite appears to have a secondary origin (presumably metamorphic). The needle like habit of the magnetite observed in this thin section is curious, and individual needles might actually be aggregates of cc magnetite that grew in a linear manner, as opposed to being individual mineral grains. This needle like habit is not found in the coarsest grained clasts.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60821

Location: Mount Henry Clay prospect

Easting: 416651 **Drill hole:** G89-11
Northing: 6584360 **Depth:** 239.9 m (787 ft)

Rocktype: massive andesite-basalt fine tuff

Hand Sample Description:

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
groundmass	54	cc-mc	mc groundmass of fine tuff,	
chlorite	34	mc-vf	altered groundmass	
carbonate	6	mc-vf	disseminated throughout	
opaques	6	mc	subhedral to euhedral magnetite +/- pyrite?	

Notes: Tuff is too fine grained to determine composition of individual particles. One coarse tuff grain containing quartz amygdules confirms a clastic origin of this otherwise ambiguous fine-grained rock. Fairly well developed fabric.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60822

Location: Mount Henry Clay prospect

Easting: 416651 **Drill hole:** G89-11
Northing: 6584360 **Depth:** 274.3 m (900 ft)

Rocktype: mixed fragmental (block, tuff and lapilli sized material)

Hand Sample Description: poorly sorted fragmental of indeterminate composition; compare chemistry to flows and massive fine tuff

Thin section type: Large

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	45	mc-f	occurs as variably replaced laths in many clasts and as broken crystal fragments in the tuff matrix; is everywhere mc or smaller except for one lapilli fragment of equigranular quartz diorite in which the plagioclase is f. grained; composition determined to be albitic	-----
chlorite	40	mc-f	replacing groundmass throughout lapilli clasts and tuff matrix; in the quartz diorite fragment f grained chlorite may be replacing a primary mafic mineral	-----
quartz	1	mc-f	typically as a major component of amygdules, however, also found as minor component in a fine grained equigranular (quartz diorite) clast, and likely is a constituent of the tuff matrix	-----
carbonate	tr-1	mc-vf	minor component disseminated throughout the groundmass of the tuff matrix and certain clasts	-----
epidote	6	cc-mc	as granular aggregates of cc grains disseminated throughout the tuff matrix, and in places forming near monomineralic lapilli clasts	-----
opaques	5	cc-vf	disseminated throughout the tuff matrix and most clasts; content varies considerably from clast to clast, with the finer grained more densely amygdaloidal clasts general containing the greatest concentration (e.g. 25-35%); exsolution lamellae (illmenite that is likely replaced by leucoxene) are visible in magnetite in the quartz diorite	-----
biotite and/or stipnomelane	2	mc-vf	minor component of some amygdules, and in the groundmass of the tuff matrix and certain clasts	-----

Notes: This thin section contains lapilli clasts, of predominantly mafic volcanic composition, in a f-c tuff matrix. One lapilli sized clast is quite different from the others, having a fine-grained equigranular texture, and is clearly of an intrusive origin. This clast contains 3-4% quartz, 8-9% fine-grained chlorite that has potentially replaced a mafic mineral (although has no obvious pseudomorphed habit and is typically found interstitial to plagioclase laths), 85% plagioclase which has an albitic composition, 2-3% magnetite that has a distinctive banded texture produced by illmenite exsolution lamellae (that are now probably altered to fine grained leucoxene), and a trace of carbonate and epidote. A myrmekite-like(?) replacement texture is common in this clast and may reflect some component of primary alkali feldspar??. Thin section contains rare, near monomineralic clasts of epidote. Mafic volcanic lapilli are commonly highly vesicular (10-40% vesicles). Completely chloritized fine lapilli to coarse tuff sized shards containing angular broken vesicle margins were noted. Tuff matrix is composed of cc-mc broken plagioclase fragments +/- quartz, and is fairly extensively replaced by chlorite, epidote and biotite/stipnomelane(?). Magnetite is also abundant within the fine tuff matrix.

Sample #: RMC60870

Location: Mount Henry Clay prospect

Easting: 416622
Northing: 6584522

Drill hole: K85-5
Depth: 54.6 m (179 ft)

Rocktype: Basalt

Hand Sample Description: strongly magnetic, massive, aphanitic basalt

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	68	mc	forms a fibrous mass throughout matrix	---
biotite	4	mc-vf	platelets scattered throughout; locally intergrown with chlorite	---
calcite	3	mc	irregular grains disseminated throughout matrix, and as en echelon veinlets	--- --
plagioclase (+/- quartz)	13	mc-f	found throughout as anhedral to euhedral grains commonly lacking any twins; minor grotty looking f. grained phenocrysts	----
opaques	4	cc-mc	primarily subhedral magnetite grains, concentrated in narrow seams	--?--
epidote?	1- 2	cc-mc	grungy, clouded aggregates	---
sericite?	3- 4	cc-mc	fine fibers intimately associated with chlorite (higher birefringence than chlorite)	--?--

Notes: Fairly grungy looking rock, with intense chlorite replacement of much of the matrix. Some remnant plagioclase phenocrysts suggest rock was porphyritic. The occurrence of sericite suggests some degree of hydrothermal alteration.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60871

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 79.5 m (260 ft)

Rocktype: Basalt

Hand Sample Description: strongly magnetic massive aphanitic basalt

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	62	mc	dominates the groundmass	---
quartz	1-2	mc-vf	found in amygdules	---
carbonate (calcite & Fe-carbonate)	16	mc-vf	mc grains disseminated throughout matrix and abundant vf grained subhedral to euhedral porphyroblasts (fe-carbonate); some occurs as amygdules	-----
plagioclase (+/- quartz)	15	cc-mc	found throughout groundmass, commonly obscured by chlorite	-
opaques	6	cc-mc	predominantly magnetite with minor pyrite in veins/amygdules(?)	-?-

Notes: Intensely foliated amygdaloidal mafic volcanic with distinctive Fe-carbonate porphyroblasts.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: K85-5-293

Location: Mount Henry Clay prospect

Easting: 416622
Northing: 6584522

Drill hole: K85-5
Depth: 89.3 m (293 ft)

Rocktype: mafic fragmental

Hand Sample Description: amygdaloidal, basalt-rich fragmental, described in drill logs as containing diorite clasts but none were observed in thin section

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite?)	20	mc	variably altered mc grains randomly oriented throughout many clasts	—
calcite	15	mc-vf	occurs in amygdules and disseminated throughout many of the clasts as well as the "tuff" matrix between clasts	—
chlorite	20	mc	a dominant component of most fragments; completely replaces matrix of some of the more scorriaceous clasts	—
opaques (magnetite>> pyrite)	3	cc-mc	disseminated throughout most clasts although in quite variable concentration (tr – 25%); locally has a dendritic like habit and rims plagioclase grains; much of the magnetite is probably metamorphic in origin although some slightly coarser grains noted in one clast are interpreted to have a primary origin; trace mc pyrite	— —
quartz	15	mc	occurs in amygdules and disseminated throughout the "tuff" matrix between clasts (some of what has been interpreted as quartz may be fine plagioclase grains that have no evidence of twinning?)	—
actinolite?	tr	mc	acicular grains embedded in massive chlorite (high 1 st to low 2 nd order interference colours); grains too small to be confidently identified but would not be out of place with the mineral assemblage in this rock	—
indiscernible groundmass	27	cc		

Notes: The thin section contains numerous, variably flattened, coarse ash and fine to medium lapilli sized, highly amygdaloidal basalt and scoria clasts. Matrix of the fragments varies, from clasts containing a felted texture of mc feldspar to clasts that are entirely replaced by chlorite (presumably these are clasts that were originally glassy). Amygdules are composed of quartz and calcite and occur both together and separate. Many fragments have quite well preserved delicate morphologies that are locally shard like, and locally have textures indicative of quench fragmentation (i.e. clasts with angular breaks across multiple vesicles). No true phaneritic clasts were observed, and the calcite rich slightly coarser grained fragments may be what had been described in drill logs as diorite? The rock is clast supported with a fine tuff sized matrix that appears to be composed primarily of calcite and quartz.

Sample #: K85-5-301

Location: Mount Henry Clay prospect

Easting: 416622 **Drill hole:** K85-5
Northing: 6584522 **Depth:** 91.7 m (301 ft)

Rocktype: mafic fragmental w/ intrusive clast

Hand Sample Description: highly strained chloritic mafic fragmental containing "quartz-diorite" clast

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	38	mc-f	occurs as rounded broken grains in chloritic seams (likely a fine tuff matrix b/w fragments), and as mc to f grained laths in clasts	—
calcite	4-5	mc-vf	occurs disseminated throughout the "intrusive" clast (8-10%); occurs in minor veinlets and forms rare limey fragments	—
chlorite	50	mc	occurs throughout, commonly forming fairly massive seams; makes up to 10-15% of the "intrusive" clast	—
opaques (magnetite)	4-5	mc-vf	occurs as vf grains, somewhat irregular, primary euhedral grains in the "intrusive clast" (~7%); elsewhere in section occurs as mc grains that appear to be primarily of metamorphic origin	— —
quartz	2-3	mc-f	occurs in amygdules, and within the "intrusive" clast may also be a primary mineral (forms up to 6-7% of the "intrusive"); also occurs in rare dismembered veins	-?—

Notes: The thin section contains a large lapilli sized clast that looks somewhat intrusive, (sort of a porphyry that looks somewhere between a volcanic and an intrusive). It contains vf grained magnetite disseminated throughout that appears to have formed during crystallization from a melt, and vf-f grained plagioclase scattered throughout; however, locally looks amygdaloidal and is not entirely phaneritic. Quartz is present in the clast in what looks to be small amygdules, but it locally looks like it may also be a primary mineral that formed from the melt. The rest of the section is characterized by intensely foliated, chloritic material with fragments so highly flattened that they are difficult to distinguish from one another, and matrix. Other fragments include a mafic clast with flattened/stretched amygdules composed of aggregates of mc quartz, and mc needles of plagioclase in a chloritic matrix. In places the strain in the rock appears to have rotated rounded and broken plagioclase grains into the plane of foliation within massive chlorite.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60872

Location: Mount Henry Clay prospect

Easting: 416622
Northing: 6584522

Drill hole: K85-5
Depth: 92.4 m (303 ft)

Rocktype: Basalt

Hand Sample Description: strongly magnetic finely amygdaloidal basalt

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	35	mc	totally replaces matrix interstitial to plagioclase and also partially replaces plagioclase grains	—
plagioclase	50	mc-vf	fine randomly oriented fairly well preserved laths (albite)	—
calcite	7-8	mc-vf	disseminated throughout matrix and found in amygdules with quartz, and veinlets	—
quartz	1-2	mc-vf	found in amygdules with calcite, and as vf grains that may be phenocrysts or porphyroblasts	—
opaques	6	mc	primarily magnetite, sample is strongly magnetic	—
epidote	tr	mc	rare small clusters of mc grains	—

Notes: Fairly typical looking chloritic basalt except for the small (vf) grains of quartz. These could potentially be phenocrysts, very small amygdules filled by an individual grain of quartz, or, as is most likely, are metamorphic in origin.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60874

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 107.6 m (353 ft)

Rocktype: altered diorite

Hand Sample Description: weakly silicified diorite

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite)	85	mc-f	vf-f grained plagioclase laths form a fairly dense interlocking framework with mc plagioclase +/- quartz and later alteration/metamorphic minerals (i.e. calcite & chlorite) found in the interstitial area	—
calcite	8-9	mc-f	disseminated throughout, occurring as irregular grains and patches interstitial to plagioclase	—
chlorite	2-3	mc	forms a minor component of the matrix interstitial to, and partially replacing, plagioclase grains; does not appear to have replaced a major mafic mineral phase	—
opaques (magnetite)	2-3	vf	fairly coarse euhedral grains both overgrown by, and interstitial to, plagioclase laths; magnetite often looks partially altered or replaced, and locally contain thin skeletal lines of semi-opaque material (illmenite/leucoxene exsolution lamellae)	—
quartz	1-2	mc	minor quartz appears to be locally associated with patches of calcite, minor quartz may also be a primary mineral	-?- -?-

Notes: The sample is composed of interlocking vf-f grained plagioclase laths with minor interstitial microcrystalline material. The texture suggests the rock is intrusive but was cooled sufficiently fast that melt interstitial to the plagioclase and magnetite crystallized into relatively small grains. Both the carbonate and chlorite are likely products of metamorphism.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60875

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 119.2 m (391 ft)

Rocktype: mafic fragmental

Hand Sample Description: mafic fragmental with a fine white speckled texture

Thin section type: Regular

Mineral	%	Size	Comment	Paragenesis
plagioclase (albite?)	47	vf	good laths that are moderately well aligned with the rock fabric	—
chlorite	46	vf	massive aggregates interstitial to other grains; totally replaces matrix	—
quartz	2-3	mc-vf	fills amygdulites and occurs in small concentration disseminated throughout	----?--?
carbonate	2-3	vf-f	2 varieties, one of which occurs as darker, grungy, slightly corroded looking porphyroblasts that over grow plagioclase grains (likely Fe-carbonate), the other occurs as lower relief, clear grains (probably calcite) that formed later than the porphyroblasts	—
opaques	1	mc-f	probably magnetite; predominantly mc-vf grains disseminated throughout, and lesser f grained more euhedral grains scattered throughout (possibly 2 generations, one magmatic the other metamorphic)	-?- -?-

Notes: Thin section contains 2 clasts/fragments, one of which is a little coarser grained than the other. Mineralogy of the two is essentially the same. Rock is foliated and locally the fabric is intense. White speckled texture produced by fine Fe-carbonate porphyroblasts.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60876

Location: Mount Henry Clay prospect

Easting: 416622 **Drill hole:** K85-5
Northing: 6584522 **Depth:** 126.8 m (416 ft)

Rocktype: Feldspar porphyritic rhyolite

Hand Sample Description: described as a intensely silicified rock in drill logs; however, whole rock analysis reveals rock to have a major and trace element signature of rhyolite

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
feldspar (albitized sanadine?)	1-2	f-m	phenocrysts, commonly with carlsbad twins, look a lot like sanadine but have 2V angles between 80 and 90 and a positive optic sign; Possibly albitized sanadine? Minor feldspar is also found in some quartz veins (uncertain if it is plagioclase or k-feldspar?)	—
quartz	2-3	mc-vf	numerous quartz veinlets, locally associated with calcite, chlorite, and feldspar	---
sericite	5	mc	finely disseminated fibrous needles throughout matrix	----
chlorite	0.5	mc	occurs in veins and veinlets with quartz +/- calcite and feldspar, and in rare irregular seams with sericite	---
calcite	0.5	mc-vf	found in quartz veinlets and rare disseminated clots	---
opaques	1-2	mc	disseminated euhedral grains (magnetite), moderate to strongly magnetic hand sample	---
groundmass (quartz-feldspar)	88	cc-mc	cryptocrystalline to microcrystalline groundmass of feldspar and quartz in indeterminate relative abundance	---

Notes: Rock was misinterpreted as siliceous alteration in drill logs, and is in reality a feldspar porphyritic rhyolite. Feldspar phenocrysts have the morphology and appearance of sanadine; however, a positive optic sign and 2V angle of 80-90 degrees suggest they have been albitized. No quartz phenocrysts were observed. Numerous narrow quartz veinlets cut the rock and the rock may be somewhat silicified. Some of the quartz veinlets contain chlorite and feldspar (looks like k-feldspar, but uncertain)

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60877

Location: Mount Henry Clay prospect

Easting: 416622 **Drill hole:** K85-5
Northing: 6584522 **Depth:** 141.9 m (465.5 ft)

Rocktype: mafic fragmental containing hydrothermally altered clasts

Hand Sample Description: highly strained, strongly magnetic, chloritic mafic fragmental containing some strongly sericite altered clasts; clasts are commonly amygdaloidal

Thin section type: wide

Mineral	%	Size	Comment	Paragenesis
chlorite	60	mc-vf	replaces the matrix between clasts, and the groundmass interstitial to plagioclase grains in fragments; commonly occurs as near massive seams	---
plagioclase (albite?)	21	mc	variably altered, randomly oriented thin laths concentrated in fragments; chloritic matrix between fragments contains scattered plagioclase grains in much lower concentration	---
calcite	4	mc-f	fills amygdules, locally found disseminated throughout matrix, and occurs in late stage veins	-----
opaques (magnetite>> pyrite)	4	mc	concentration of magnetite is highly variably between different clasts (1 – 35%), and is locally in such high concentration that fragments take on a black colouration in hand sample; often occurs as aggregates of euhedral mc grains; minor pyrite	? ---
sericite	8	mc	replaces matrix of some clasts; sericite alteration is fairly pervasive, although relict felted feldspar texture is locally visible through the alteration; minor sericite locally occurs within chlorite rich sections	----
quartz	2	mc-f	fills amygdules in strongly sericite altered clasts, and some chloritic clasts; chlorite and calcite locally core quartz amygdules; quartz also occurs in dismembered seams or veinlets	---
epidote	1	mc	euhedral mc grains disseminated throughout most of sample, generally most conspicuous in areas of highest chlorite content	---

Notes: Rock shows evidence for strong hydrothermal alteration of some clasts, locally having an almost frothy amygdaloidal texture giving them an appearance not unlike that of QSP altered amygdaloidal rocks at the Cap prospect. Hydrothermally altered clasts were not altered insitu, although one might expect their source to be proximal. Rocks are quite highly strained with late stage calcite veinlets filling tension gashes in fragments. All fragments appear to be mafic in origin.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60878

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 156.2 m (512.5 ft)

Rocktype: Basalt

Hand Sample Description: massive aphanitic basalt (strongly magnetic)

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	35	mc	replaces groundmass interstitial to plagioclase grains	—
plagioclase (albite)	50	mc-vf	fairly well preserved plagioclase laths; albitic composition (An0-An5)	—
calcite	10	mc-vf	disseminated throughout groundmass	---
opaques (magnetite)	4	mc	small clusters and individual grains disseminated throughout	? ---
epidote	0.5- 1	mc	high relief mc grains assumed to be epidote	—

Notes: Massive, non-amygdaloidal, aphyric basalt with fairly simple mineralogy

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60879

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 164.8 m (540.8 ft)

Rocktype: mafic fragmental

Hand Sample Description: mafic fragmental containing some grainy (diorite) clasts and clasts that look silica-sericite altered

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	38	mc	replaces matrix throughout section, in most fragments and in the matrix between fragments; but, is not present in the coarsest grained, pale coloured fragments	—
plagioclase (albite)	52	mc-m	occurs as vf-f grains in pale fragments (intrusive, phaneritic texture), and locally found as jumbled up broken grains of variable grain size (mc-m); elsewhere in sample plagioclase grains are typically mc; all have an albitic composition (An0-An5)	—
calcite	3-4	mc-f	abundant in intrusive rock fragments, locally found in concentrations up to 10-20% by volume; minor amount disseminated throughout rest of sample	—
opaques (magnetite>>pyrite)	3-4	mc-vf	both primary magmatic and secondary metamorphic(?) magnetite; minor pyrite mineralization	— —
epidote	tr	mc	minor grains disseminated throughout	—
sericite	tr	mc	minor amount locally disseminated in chlorite rich zones	—
quartz	1	mc-f	forms 5-10% of vf-f grained clasts of intrusive rock; quartz not found elsewhere in sample except for the rare amygdale	—

Notes: Fragments that look silica-sericite altered in hand sample, are in fact fine grained clasts of intrusive rock that contain abundant disseminated carbonate and little if any sericite. Quartz is present in these clasts (~ 5-10% by volume), and appears to be a primary mineral rather than a product of alteration.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60880

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 173.9 m (570.5 ft)

Rocktype: sediment or altered mafic volcanic?

Hand Sample Description: strongly magnetic, med-dark gray, veined and deformed f. grained laminated rock, possible sedimentary origin

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
sericite	49	mc	occurs throughout thin section as the dominant component of the groundmass; mineral alignment defines a prominent foliation in rock; is this an alteration or metamorphic product?	—
calcite	3-4	mc-vf	occurs in veinlets and locally disseminated in the matrix	-?- ----
opaques (magnetite>>p yrite)	7-8	cc-mc	small euhedral grains densely disseminated throughout sample (strongly magnetic), minor pyrite noted in hand sample	—
groundmass (plag-quartz)	39	mc	small, fairly angular grains subordinate to sericite in the groundmass (no lath-like euhedral grains noted); proportion of quartz to plagioclase is indeterminate, twinning was not noted in any grains, although grain size is quite small	—
quartz	1-2	mc	occurs in fine veinlets, locally associated with calcite	—

Notes: Although having a medium gray colour and the appearance of a calcareous sediment, the sample contains only a minor amount of carbonate and a much higher sericite content than anticipated. The high sericite content suggests that the sample has been subject to hydrothermal alteration; however, a metamorphic origin for some of the sericite should not be excluded. It is also possible that the sample may not be a sediment, and is perhaps a strongly sericite altered, well foliated mafic volcanic. Could the magnetite have formed at the expense of pyrite (i.e. was this originally a QSP altered rock)?

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60892

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 228 m (748 ft)

Rocktype: dacite/rhyolite

Hand Sample Description: described in drill log as zone of silicification, but chemistry and petrography indicate it is a felsic dyke or flow

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
Albite (after sanadine?)	tr	f	rare broad tabular phenocrysts that locally display simple twins and lack albite twins (look like sanadine and not plagioclase) but are biaxial (+), with $2V = 80$ more akin to albite; perhaps they are albitized k-feldspar	—
calcite	0.5	mc	occurs in rare mini veinlets and as a minor component in the groundmass	—
chlorite	5-6	mc	ubiquitous component of the groundmass	—
opaques (magnetite>> pyrite)	0.5-1	mc	small euhedral magnetite grains that are likely primary in origin although could potentially be metamorphic (sample is weakly magnetic), rare py grain visible in hand sample	-?- -?-
quartz	3-4	mc-vf	numerous irregular anhedral mini-phenocrysts, slightly coarser grained than the groundmass; grain margins are quite wavy and irregular and may be partially resorbed	—
groundmass	89	mc	dense felted texture of indistinguishable grains; likely feldspar and quartz	—
epidote?	tr	cc	rare masses of high birefringent cc grains	—

Notes: Although described in drill log as silicified mafic, petrography in union with chemistry reveals sample to be a felsic rock. Rock contains a high Na content (>6%), which corroborates the interpretation that the feldspar phenocrysts have been albitized.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60893

Location: Mount Henry Clay prospect

Easting: 416622

Drill hole: K85-5

Northing: 6584522

Depth: 230.4 m (756 ft)

Rocktype: mafic fragmental

Hand Sample Description: strongly magnetic, chloritic, mafic fragmental

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	35	mc	replaces matrix throughout, and locally cores quartz filled amygdules	---
plagioclase (albite)	42	cc-vf	grain size varies from cryptocrystalline in some highly amygdaloidal fragments to vf grained in what looks to be an intrusive clast	---
calcite	8-9	mc-vf	occurs in amygdules and disseminated throughout matrix of fragments, particularly abundant in the coarser grained clasts; also occurs in rare late stage veinlets	-----
quartz	3	mc	occurs as mc aggregates, and individual grains that fill amygdules, locally associated with calcite	---
epidote(?)	1-2	mc	granular grungy high relief mc grains disseminated throughout and in highest concentration in massive chlorite seams	---
opagues (magnetite)	8-9	mc-vf	mc metamorphic magnetite found throughout, commonly found in small elongate clusters and locally rimming plagioclase grains; coarser grained magnetite of primary origin occurs in one fragment containing coarser grained plagioclase (intrusive?)	--- ---

Notes: Section contains lapilli sized fragments of amygdaloidal basalt, and one slightly coarser grained fragment that has a texture somewhere between intrusive and extrusive. The "semi-intrusive" looking clast contains a minor amount of quartz that could be polygonalized primary grains or amygdules(?).

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Sample #: RMC60895

Location: Mount Henry Clay prospect

Easting: 416622
Northing: 6584522

Drill hole: K85-5
Depth: 276.6 m (907.5 ft)

Rocktype: basalt

Hand Sample Description: strongly magnetic, moderately Fe-carbonate altered basalt

Thin section type: regular

Mineral	%	Size	Comment	Paragenesis
chlorite	30	mc	replaces groundmass interstitial to vf-f grained plagioclase	—
plagioclase (albite)	50	mc-f	laths of albitic composition; generally in fairly good shape with only minor chloritic alteration; fairly continuous gradation in grain size from mc to f grained.	—
calcite	7-8	mc-vf	disseminated throughout groundmass	—
opaques (magnetite > pyrite)	4	mc-f	mc-vf magnetite grains that appear to have both a primary magmatic, and a secondary (metamorphic?) origin; minor f. grained subhedral pyrite grains	— —
groundmass (feldspar +/- quartz)	8	cc-mc	occurs interstitial to coarser grained plagioclase disseminated amongst the chlorite and calcite that is replacing the matrix interstitial to the vf-f grained plagioclase	—
quartz	tr	mc-vf	rare grains, some of which may be filling small vesicles?	-?-

Notes: Section contains a fairly dense concentration of vf-f grained plagioclase, and vf grained primary magnetite, in a finer grained groundmass that is partially replaced by chlorite and calcite. Texture is similar to that seen in many thin sections of fragmental rock, which contain the occasional coarser grained clast that looks somewhere between an intrusive and extrusive.

cc cryptocrystalline (< 0.01 mm)
mc microcrystalline (0.01 – 0.1 mm)
vf very fine grained (0.1 – 0.3 mm)
f fine grained (0.3 – 1.0 mm)
m medium grained (1.0 – 3.3 mm)
c coarse grained (> 3.3 mm)

Appendix 6
X-RAY DIFFRACTION DATA

XRD Samples

Sample	Location	Minerals identified from X-ray diffraction data	Sample description
RMR31070	RW-Main zone	smithsonite and quartz	Cu-Zn oxide mineralization in calcareous sediments underlying leached baritic massive sulphide of the overturned RW horizon. Sample from continuous chip-line collected through unaltered sediments up into leached massive barite and QSP alteration. Sample assayed 1.7%Cu, 19% Zn.
RMR31073	RW-Main zone	barite and quartz	Fe-oxide stained, leached massive barite +/- quartz of the overturned RW horizon
RMR31080	RW-Main zone	muscovite and quartz	intensely deformed sericite(?) dominated QSP alteration; sample collected across the surface trace of the MZ thrust
RMR31089	RW-Main zone	muscovite (2M ₁ *) and quartz	QSP alteration collected above(?) the surface trace of the MZ thrust. Petrography indicates 50% v. fine-grained clay (sericite?), 45% quartz, 2-4% pyrite, and 1% chlorite.
MZ-01	RW-Main zone	no diffraction pattern produced – amorphous material??	blue and white oxide coating surface of tuffaceous carbonate in FW to overturned RW horizon (sample is of near pure oxide material)
MZ-02	RW-Main zone	smithsonite, quartz, actinolite, chlorite (ferroan clinocllore), langite?	pale blue-green and yellow-white oxide material coating surfaces of tuffaceous calcareous sediment in structural FW to overturned RW horizon (mixed sample of oxide material and sediment)
P94-02-366a	RW-Main zone	gypsum, tr. chlorite	from dyke x-cutting leached barite of the RW zone carrying 3-4% Zn over ~20' in DDH P94-02. Sample of recessive (water soluble?) gypsum like mineral that occurs in fracture filling veinlets that x-cut chalky, clay-rich(?) veinlets that carry a black mineral thought to be a zn-oxide?
P94-02-366b	RW-Main zone	gypsum, chlorite (clinocllore-1a, ferroan *), smithsonite	from dyke x-cutting leached barite of the RW zone carrying 3-4% Zn over ~20' in DDH P94-02. Sample of clay-rich(?) veinlets that carry a black mineral thought to be a zinc-oxide(?). Chalky veins also contain minor amounts of an unknown pale greenish mineral
RMR61425	Cap showing RMC98-01 (44 m)	muscovite, quartz and pyrite	highly QSP altered, extremely amygdaloidal rock from section containing numerous Ag-rich quartz-barite veins
RMR61435	Cap showing: DDH RMC98-01 (53 m)	muscovite, quartz and pyrite	extremely vesiculated, intensely QSP altered rock, w/ sections of >80% amygdules. Near complete silica-sericite replacement of protolith
RMR60057	Cap showing RMC98-01 (120 m)	muscovite (2M ₁ *) and quartz	intensely altered, strongly deformed, moderately amygdaloidal rock. Mineralogy appears to be sericite-quartz-pyrite

RMR60067	Cap showing RMC98-01 (129 m)	muscovite, quartz, calcite, and pyrite	sample from a zone of transition that marks the gradual decrease in sericite, an increase in calcite, and the introduction of chlorite
RMR60078	Cap showing RMC98-01 (143 m)	chlorite (clinochlore-IIb*), calcite, pyrite, quartz, epidote, muscovite/illite?	matrix of volcanic protolith totally replaced by chlorite, epidote, pyrite, and clay (possibly sericite). Amygdules composed of calcite, chlorite and clay, and much less commonly by quartz and pyrite.
RMR60096	Cap showing RMC98-01 (165 m)	muscovite, chlorite, epidote, quartz, and pyrite	moderately strongly altered mafic volcanic from low down in the CAP alteration system; rock although appearing only weakly altered in drill core, is in fact quite strongly altered based on petrography - 70% clay (sericite?), 20% epidote, 2-3% chlorite, 2-3% calcite, 4-5% pyrite, trace quartz
RMR60104	Cap showing RMC98-01 (176 m)	chlorite, quartz, calcite	sample from near the bottom of DDH RMC98-01 and it is clear that the rocks are still quite strongly hydrothermally altered. Chlorite content has increased significantly (metamorphic or hydrothermal?) - 41% chlorite, 2% calcite, 5-6% opaques, 15% epidote, 30% sericite(?), 8% quartz

* polymorph or mineral name that best fits measured XRD data (may not be exact match in d-spacing values)

Raw XRD data located on disk 1 in pocket.

Appendix 7**PHOTOGRAPHS AND PHOTOMICROGRAPHS**

View looking north at gossanous scars on the southeast flank of the informally named Mt. Morlan, Glacier Creek prospect area. Location of mineral occurrences are indicated.

Figure A7.2 (following page)

A. Overturned pillow basalt of the B5 basalt unit in the footwall to the MZ thrust fault at the Glacier Creek prospect. Topping direction of the pillows is down and to the SSW.

B. Recessive weathering surface trace of the MZ thrust fault in strongly quartz-sericite-pyrite altered host rocks near the Main occurrence, Glacier Creek prospect. The fault separates shallowly to moderately NNE dipping strata in the hanging wall from moderately to steeply NNE dipping overturned strata in the footwall. Person at right of photo for scale.

C. Photomicrograph of strongly deformed quartz-sericite-pyrite altered B6 basalt unit in the MZ thrust fault deformation zone. Note the quartz veinlets and the presence of a subtly developed foliation oriented at about 30° to the dominant foliation. Thin section 31082; crossed polars (width of view = about 3.5 mm).

Figure A7.3 (following page)

A. Surface exposure of highly oxidized Main Zone massive sulphide unit at the Glacier Creek prospect. The unit is leached of sulphides and consists of Fe-oxide stained, variably siliceous vuggy barite.

B. Feldspar porphyritic pillow basalt of the B6 basalt unit, Glacier Creek prospect.

C. Feldspar porphyritic agglomerate of the B6 basalt unit, Glacier Creek prospect.

Figure A7.4 (following page)

A. View up at massive, rounded, gossanous quartz-sericite-pyrite altered rhyolite exposed along the ice edge beneath the Little Jarvis occurrence, Glacier Creek prospect.

B. Rhyolite fragmental exposed along ridge southwest of Mt. Morlan at the Glacier Creek prospect. Fragmental zones occur along the flanks, and locally along the upper contact, of the otherwise massive rhyolite flow.

Figure A7.5 (following page)

A. Surface exposure of RW zone massive sulphide at the Little Jarvis occurrence, Glacier Creek prospect.

B. Close-up of massive chalcopyrite and sphalerite at the Little Jarvis occurrence, Glacier Creek prospect.

Figure A7.6 (following page)

A. Typical exposure of tuffaceous limestone beds that occur intercalated throughout the stratigraphic section at the Glacier Creek prospect

B. Conspicuous white spherules visible along chloritic pillow selvages of the B4 spherulitic basalt unit in the hanging wall to the RW zone. Photograph taken in the vicinity of the Little Jarvis occurrence, Glacier Creek prospect.

C. Distinctive siliceous lapilli occurring in narrow beds within the mafic tuff – lapilli tuff and limestone unit that occurs between the B4 basalt and B3 basalt units at the Glacier Creek prospect. This unit forms a good marker horizon in both the hanging wall and footwall of the MZ thrust fault.

Figure A7.7 (following page)

A. Typical pillow textures in the B3 pillow basalt unit at the Glacier Creek prospect.

B. Angular and rounded clasts of basalt, chert and/or rhyolite, and subordinate limestone of the debris flow conglomerate unit that occurs at the top of the stratigraphic section exposed in the Glacier Creek prospect area. Siliceous fragments are commonly well rounded and therefore were probably sourced in a subaerial environment. The carbonate-rich matrix weathers recessively, producing a distinctive knobby texture in outcrop.

C. Example of the range in clast size and poor sorting exhibited by the debris flow conglomerate unit.

Figure A7.8 (following page)

A. Rubbly, weathered, sphalerite-rich carbonate of the RW zone exposed at the UMP occurrence, Glacier Creek prospect. Grab samples from this locality assayed up to 18.75% Zn.

B. Photomicrograph of sphalerite engulfing and replacing pyrite euhedra from the RW zone, Glacier Creek prospect. Thin section RMC60370; reflected light (width of view = about 1.9 mm).

C. Photomicrograph of ragged looking sphalerite partially replaced by massive chalcopyrite from the RW zone, Glacier Creek prospect. Thin section RMR31205A; reflected light (width of view = about 0.9 mm).

Figure A7.9 (following page)

A. Disaggregated intensely leached vuggy barite and barite sand of the RW zone, Glacier Creek prospect. Formed during supergene oxidation of massive barite-sulphide.

B. Photomicrograph of vuggy barite rock of the RW zone, Glacier Creek prospect. Vugs, or voids, are areas that have been leached of sulphides during supergene oxidation. Thin section RMR31075; plane light (width of view = about 3.5 mm).

C. Photomicrograph of non-leached massive barite-sulphide of the RW zone, Glacier Creek prospect. Note the similarity in texture and percentage of sphalerite with the texture and percentage of vugs, or voids, in (B). Thin section RMC9911-622; plane light (width of view = about 3.5 mm)

Figure A7.10 (following page)

A. Blue supergene oxide precipitate coating rock surfaces below leached massive barite-sulphide at the Glacier Creek prospect. Precipitate does not have a crystalline structure as determined by X-ray diffraction analysis and is believed to be amorphous chrysocolla. Steel becomes coated with copper when dipped in a mixture of the powdered oxide and HCL.

B Photomicrograph of skeletal pyrite and hydrous Fe-oxides replacing pyrrhotite, evidence of incipient oxidation 150 m vertically below surface in drill hole RMC99-10, Glacier Creek prospect. Thin section RMC60280; reflected light (height of view = about 0.45 mm)

C Photomicrograph of skeletal pyrite and hydrous Fe-oxides in chalcopyrite-rich massive sulphide of the RW zone, Glacier Creek prospect. The skeletal pyrite and hydrous Fe-oxides are interpreted to have replaced pyrrhotite during oxidation. Thin section RMC60279; reflected light (width of view = about 0.90 mm)

Figure A7.11 (following page)

A. Strongly oxidized Main zone massive barite-sulphide, Glacier Creek prospect. The massive barite-sulphide body has been completely leached of sulphides, leaving behind a vuggy, porous, variably siliceous massive barite rock. Primary layering is clearly discernable.

B. Weakly oxidized enclave of Main zone massive barite-sulphide in which primary mineralogy is still preserved. The black shaley carbonate located above the massive sulphide would have buffered metal-leaching acids that were generated during oxidation of sulphide, and is likely responsible for the preservation of primary sulphide mineralogy at this locality.

Figure A7.12 (following page)

A. Rusty, yellow-orange weathering quartz-sericite-pyrite altered rocks in the vicinity of the Main occurrence, Glacier Creek prospect. Person in lower left-hand corner of image provides scale.

B. Photomicrograph of pervasive quartz-sericite-pyrite alteration in the stratigraphic footwall to the RW zone, Glacier Creek prospect. Thin section RMR31082; crossed polars (width of view = about 3.5 mm)

C. Photomicrograph of deformed, pervasively sericitized, feldspar phenocrysts of the B6 basalt unit in a zone of moderate to strong QSP alteration in the stratigraphic footwall to the RW zone, Glacier Creek prospect. Thin section RMC60390; plane light (width of view = about 3.5 mm).

Figure A7.13 (following page)

- A. Surface exposure of pervasively quartz-sericite-pyrite altered basalt and massive pyritic barite bed (white layer at top of gossanous zone) at the Cap occurrence, along the edge of the Saksia glacier. Drill rig in background.**
- B. Westerly dipping brittle fault exposed in the northwest corner of the Cap prospect map area.**

Figure A7.14 (following page)

- A. Massive, poorly sorted, matrix supported mafic volcanoclastic more than 100 m stratigraphically below bedded massive barite at the Cap occurrence. Unit contains lapilli and rare blocks of finely amygdaloidal basalt hyaloclastite in a relatively pure carbonate matrix.
- B. Drill core of pyritic massive barite at the Cap occurrence. From drill hole RMC98-01.
- C. Drill core of black shaley carbonate with pale gray to cream tuffaceous carbonate interbeds in the immediate hanging wall to bedded massive barite at the Cap occurrence. From drill hole RMC98-01.

Figure A7.15 (following page)

A. Poikilitic gabbro with pyroxene oikocrysts completely replaced by chlorite, from gabbro body exposed in hanging wall to Cap occurrence. Thin section RMR31051; crossed polars (width of view = about 3.5 mm).

B. Intrusive breccia around margin of Cretaceous-Tertiary biotite-hornblende granodiorite pluton, exposed along the eastern edge of the Cap prospect map area. Blocks are composed of meta-sedimentary and mafic meta-volcanic country rocks that are in various states of resorption.

Figure A7.16 (following page)

A. Drill core of Ag-rich, baritic, brecciated, pervasively quartz-sericite-pyrite altered highly vesicular basalt at the Cap occurrence. From drill hole RMC98-01.

B. Drill core of irregular, 'wormy', quartz-barite-pyrite veins in pervasively quartz-sericite-pyrite altered basalt at the Cap occurrence. Veins are zoned, with pyrite occurring along vein margins, and quartz-barite cores. From drill hole RMC98-01.

C. Close-up of drill core of extremely vesicular, pervasively quartz-sericite-pyrite altered basalt at the Cap occurrence. Note the pale, honey coloured sphalerite at the center of some amygdules. From drill hole RMC98-01.

Figure A7.17 (following page)

A. View northwest at the Mount Henry Clay prospect area. Massive sulphide boulders are distributed along the terminus of the small ice sheet that is at the center of the photo.

B. Strongly deformed quartz-sericite-pyrite-chlorite altered rocks at the Mount Henry Clay prospect that exhibit local mylonitic foliation.

C. Assortment of high-grade massive sulphide boulders collected along the terminus of the informally named Mount Henry Clay glacier.

Appendix 8
GEOCHEMICAL ANALYSES

(data located on disk in pocket)

NOTE TO USERS

Oversize maps and charts are microfilmed in sections in the following manner:

LEFT TO RIGHT, TOP TO BOTTOM, WITH SMALL OVERLAPS

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UMI[®]

420200

6585600

6585400

limit of mapping

X 3 m massive barite boulder

72
RMR30299

66-PA-62

RMR31817

RMR30289 RMR31815
RMR31816

RMR31814

2859
51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100

RMR31808
RMR31809
RMR31810

RMR31811
RMR31812

RMR30291

RMR30286

66-PA-56

X massive barite boulder

421200

421400

Scale: 1:2000

100

0

100

Contour Interval: 50 ft
Base Map: Skagway B4 Quadrangle

■ 98-PA-38

421600

Legend

Stratified Rocks:

Debris flow conglomerate unit: poorly sorted, heterolithic unit that contains angular to rounded granules to boulders of and/or rhyolite, and subordinate limestone. Unit has a texture due to recessive weathering nature of the carbonaceous material.

Tuffaceous limestone unit: thin, semi-continuous, finely massive beds of pale buff-tan or dark gray, silty tuffaceous limestone. Locally graphitic and in places contains narrow lenses of chert.

B1 basalt unit: black, non-magnetic, coarsely amygdaloidal pillowed basalt.

Feldspar porphyritic trachyandesite unit: massive, pale gray to dark gray, variably magnetic, feldspar porphyritic trachyandesite.

B2 and B3 basalt units: medium to dark green, massive basalt flows. Typically amygdaloidal and weakly to non-magnetic.

Mafic tuff - lapilli tuff, limestone, and chert unit: well bedded, coarse ash tuff, lapilli tuff and subordinate limestone (Pink). Mafic, but some layers contain rare, yet distinctive, siliceous nodules. Massive white chert (Pink).

B4 and B5 basalt units: massive and pillowed basalt flows. B4 is dark blue-green, moderately to strongly magnetic, and commonly exhibits a distinctive spherulitic texture. B5 is gray-green, weakly to strongly magnetic, and weakly to non-magnetic.

RW zone massive sulphide unit: stratiform base and massive baritic massive sulphide, and subordinate chert, and limestone (Red). Massive white chert (Pink).

Rhyolite unit: locally amygdaloidal, generally aphyric, flow with zones of breccia along its flanks and locally altered to an assemblage of quartz-sericite-pyrite +/- chlorite.

Legend

Stratified Rocks:

Debris flow conglomerate unit: poorly sorted, heterolithic conglomerate that contains angular to rounded granules to boulders of basalt, chert and/or rhyolite, and subordinate limestone. Unit has a distinctive knobby texture due to recessive weathering nature of the carbonate-rich matrix

Tuffaceous limestone unit: thin, semi-continuous, finely laminated to massive beds of pale buff-tan or dark gray, silty tuffaceous limestone. Locally graphitic and in places contains narrow lenses of chert

B1 basalt unit: black, non-magnetic, coarsely amygdaloidal, pillowed basalt

Feldspar porphyritic trachyandesite unit: massive, pale green to blue-gray, variably magnetic, feldspar porphyritic trachyandesite flow.

B2 and B3 basalt units: medium to dark green, massive to pillowed basalt flows. Typically amygdaloidal and weakly to non-magnetic

Mafic tuff - lapilli tuff, limestone, and chert unit: well bedded fine to coarse ash tuff, lapilli tuff and subordinate limestone (Green). Dominantly mafic, but some layers contain rare, yet distinctive, siliceous lapilli fragments. Massive white chert (Pink).

B4 and B5 basalt units: massive and pillowed basalt flows. B4 basalt unit is dark blue-green, moderately to strongly magnetic, amygdaloidal and commonly exhibits a distinctive spherulitic texture. B5 basalt unit is gray-green, weakly to strongly magnetic, and weakly to non-amygdaloidal

RW zone massive sulphide unit: stratiform base and precious metal-rich baritic massive sulphide, and subordinate chert, altered tuff and limestone (Red). Massive white chert (Pink).

Rhyolite unit: locally amygdaloidal, generally aphyric, massive rhyolite flow with zones of breccia along its flanks and locally near the upper contact. Locally hosts Cu- and Zn-rich stockwork and is pervasively

Main zone massive sulphide unit: stratiform massive sulphide, and subordinate chert and limestone (Red). Massive white chert (Pink).

Rhyolite unit: locally amygdaloidal, generally aphyric flow with zones of breccia along its flanks and local contact. Locally hosts Cu- and Zn-rich stockwork and is altered to an assemblage of quartz-sericite-pyrite + chlorite.

B6 basalt unit: aphyric and feldspar porphyritic, mainly basalt flows and minor volcanic breccia or agglomerate. Locally hosts Cu- and Zn-rich stockwork and is altered to an assemblage of quartz-sericite-pyrite +/- chlorite.

Main zone massive sulphide unit: stratiform massive sulphide, and rare black silty limestone.

B7 basalt unit: mafic flows and subordinate tuff, interpreted as an assemblage of quartz-sericite-pyrite.

Undivided basalt

Intrusive Rocks:

Hornblende diorite to gabbro: small plug of coarse-grained hornblende diorite to gabbro. Appears to post-date regional greenschist-facies metamorphism.

Gabbro: moderately to strongly magnetic, very fine-grained sill-like gabbro bodies, which pre-date regional greenschist-facies metamorphism.

Other:

Volcanic fragmental textures: consisting of tuff, lapilli breccia and agglomerate.

Zones of intense pervasive quartz-sericite-pyrite + chlorite.

Talus and overburden cover

Glacial ice

limestone (Red). Massive white chert (Pink).

Rhyolite unit: locally amygdaloidal, generally aphyric, massive rhyolite flow with zones of breccia along its flanks and locally near the upper contact. Locally hosts Cu- and Zn-rich stockwork and is pervasively altered to an assemblage of quartz-sericite-pyrite +/- chlorite

B6 basalt unit: aphyric and feldspar porphyritic, massive and pillowed basalt flows and minor volcanic breccia or agglomerate. Locally hosts Cu- and Zn- rich stockwork and is variably altered to an assemblage of quartz-sericite-pyrite +/- chlorite

Main zone massive sulphide unit: stratiform massive vuggy barite and sulphide, and rare black silty limestone

B7 basalt unit: mafic flows and subordinate tuff, intensely altered to an assemblage of quartz-sericite-pyrite

Undivided basalt

Intrusive Rocks:

Hornblende diorite to gabbro: small plug of coarse-grained hornblende diorite to gabbro. Appears to post-date regional greenschist-facies metamorphism.

Gabbro: moderately to strongly magnetic, very fine- to fine-grained, sill like gabbro bodies, which pre-date regional greenschist-facies metamorphism

Other:

Volcanic fragmental textures: consisting of tuff, lapilli tuff, volcanic breccia and agglomerate

Zones of intense pervasive quartz-sericite-pyrite +/- chlorite alteration

Talus and overburden cover

Glacial ice

ction through Glacier Creek map area

A'

3-11

420800

421000

5

76.1400

76.1700

Poles to S1 foliation

Equal Area
(Schmidt)

Poles to bedding

Occurrences

421400

421600

Talus and overburden cover

Glacial ice

Symbols and Linetypes:

	bedding (inclined)		RMR30352
	bedding (overturned)		U/Pb
	bedding (vertical)		C-304750
	S1 foliation		RMC98-02
	dyke		
	pillows		
	pillows (overturned)		
	fault surface or fabric		
	fold axis		
	vein		

Geology of Glacier Creek

Palmer Property,

Talus and overburden cover

Glacial ice

Symbols and Linetypes:

	bedding (inclined)		RMR30352	whole rock geochemistry sample
	bedding (overturned)			boulder of massive sulphide or barite
	bedding (vertical)		U/Pb	U-Pb geochronology sample
	S1 foliation		C-304750	microfossil sample
	dyke		RMC98-02	diamond drill hole collar
	pillows			geologic contact (known)
	pillows (overturned)			geologic contact (approximate)
	fault surface or fabric			MZ thrust fault (known)
	fold axis			MZ thrust fault (approximate)
	vein			high-angle fault
				slump fault scarp

421600

Geology of the Glacier Creek Prospect

Palmer Property, Alaska

420200

A

100 0 100 Meters

A horizontal scale bar with three segments. The left segment is labeled '100', the middle segment is labeled '0', and the right segment is labeled '100 Meters'.

MZ thrust fault

overturned RW zone
massive sulphide

420400

420600

Mount Morlan (5720 ft)

Section through Glacier Creek map area

A'

RMC99-11

thrust fault

RW zone massive sulphide

Main zone massive sulphide

420800

421000

A'

Poles to S1 foliation

Equal Area
(Schmidt)

Axial

to S1 foliation

N = 77

Poles to bedding

N = 95

Axial

421600

fault surface or fabric

fold axis

vein

MZ thrust fault

high-angle fault

slump fault

Geology of the Glacier Creek Pro

Palmer Property, Alaska

Plate #1

Geology based on mapping by Darwin Green during 1999
incorporation of geology from mapping by Jim Oliver (1998)

fault surface or fabric

fold axis

vein

MZ thrust fault (approximate)

high-angle fault

slump fault scarp

421600

Geology of the Glacier Creek Prospect

Palmer Property, Alaska

Plate #1

THS
M.S.C.
2001
G74

Geology based on mapping by Darwin Green during 1999 and 2000, with minor
correction of geology from mapping by Jim Oliver (1998).