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# The Mid-Cretaceous Rocky Ridge Formation - A New Target for Subaqueous Hot-Spring Deposits (Eskay Creek-Type) in Central British Columbia?

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*KEYWORDS:* Skeena Arch, Skeena Group, Rocky Ridge Formation, volcanogenic massive sulphide potential, Eskay Creek potential, shallow marine, rhyolite domes, geochronology, lithogeochemistry, U/Pb age dating, Ar/Ar age dating.

## INTRODUCTION

The Skeena Arch project was initiated in the 2000 field season as a follow up to work completed as part of the Nechako NATMAP project (MacIntyre and Struik, 1999). The main objective of this project is to define areas that have a high potential for the discovery of volcanogenic massive sulphide and/or subaqueous hot spring deposits (Eskay Creek type) along the trend of the Skeena Arch, in central British Columbia. In this area favourable host rocks for these deposit types occur in two separate geologic units - Lower to Middle Jurassic submarine volcanic rocks of the Hazelton Group and the mid-Cretaceous Rocky Ridge Formation of the Skeena Group. The latter represents a stratigraphic package whose potential was only identified during the recently completed Nechako NATMAP project.

In order to demonstrate the occurrence of favourable volcanic stratigraphy and associated vein and massive sulphide mineralization within the Rocky Ridge Formation, several key areas were visited and sampled in the 2000 field season. These include Nilkitkwa River, French Peak, Fort Babine, Fireweed, Suskwa River, Mt. Cronin, Beament , Rocky Ridge, Mt. Ney and Troitsa Lake (Figure 1). Samples for geochronology and litho geochemistry were collected at all of these sites.

## GEOLOGIC SETTING

The study area is within the Stikine Terrane of the Intermontane geomorphological belt (Figure 1). The Stikine Terrane includes Carboniferous to Middle Jurassic arc volcanic and plutonic rocks. East of the study area, oceanic rocks of the Carboniferous to Early Jurassic Cache Creek Terrane are structurally imbricated with the Stikine Terrane. Remnants of Late Cretaceous to Early Eocene continental volcanic arc rocks cover the Stikine and Cache Creek terranes and their Late Jurassic to Late Cretaceous sedimentary overlap successions.

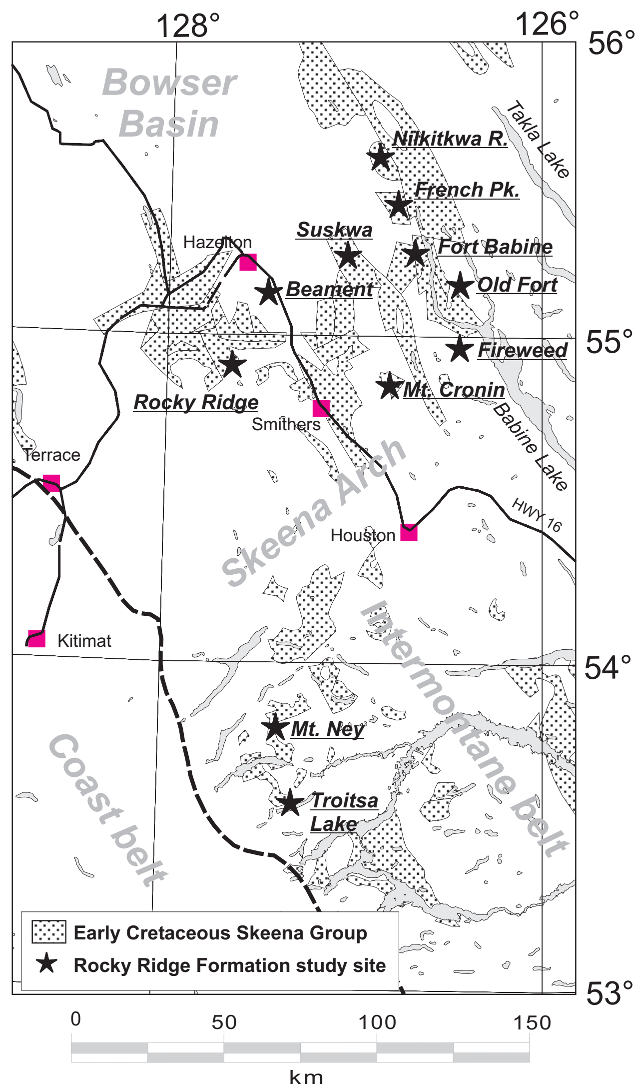


Figure 1. Map showing the areal extent of the Skeena Group (stippled pattern) in west central British Columbia relative to major tectonic elements. Stars mark sites where Rocky Ridge volcanic rocks of the Skeena Group were sampled as part of this study.

The best exposures of the Stikine Terrane occur along the Skeena Arch, a northeast trending uplift that forms the southern margin of the Bowser Basin. This uplift began to evolve in the early Jurassic as indicated by sedimentary and volcanic facies relationships in the area (MacIntyre *et al.*, in press). The core of the uplift exposes volcanic arc assemblages of the Early Permian Asitka, Late Triassic Takla and Early to Middle Jurassic Hazelton groups. Coeval plutonic rocks include the Late Triassic to Early Jurassic Topley and the newly recognized Early to Middle Jurassic Spike Peak intrusive suites (MacIntyre *et al.* 1998; in press). North of the Skeena Arch, the older volcanic arc rocks are onlapped by marine to non-marine sedimentary strata of the Late Jurassic Bowser Lake and Early Cretaceous Skeena groups; to the south the arch is covered by Tertiary volcanic rocks.

## SKEENA GROUP STRATIGRAPHY

The Skeena Group is comprised of marine and non-marine sedimentary rocks that overlap Jurassic and older rocks along the southern margin of the Bowser Basin. Although the base of the Skeena Group is rarely seen, where it is exposed it is an angular unconformity with the underlying Hazelton or Bowser Lake group. The Skeena Group is unconformably overlain by continental volcanic arc rocks of the Late Cretaceous Kasalka and Early Eocene Ootsa Lake groups. In general the lower Skeena Group is fluvial to fluvial-deltaic mudstone, siltstone, and sandstone. Higher in the stratigraphy are the volcanic rocks of the Rocky Ridge Formation (Figure 2) as first recognized by Tipper and Richards (1976). Overlying these rocks, and in part interbedded with them, are chert-quartz bearing conglomerates, quartzo-feldspathic wackes and siltstones that were deposited in a fluvial-deltaic environment (Tipper and Ricahrds, 1976; Richards, 1980; 1990; Bassett 1991).

The main Skeena lithologies are dark grey shaly siltstone, greywacke, carbonaceous mudstone and chert-pebble conglomerate These sedimentary rocks were deposited in a fluviodeltaic, near-shore to shallow marine environment (Basset, 1991). Although fossils are rare, the Skeena Group appears to range from Hauterivian to late Albian or early Cenomanian in age. Paleocurrent measurements indicate north, west and southwest sediment transport with the source area located in the Omineca belt. Bassett and Kleinspehn (1996) suggest that this belt was the main axis of a mid-Cretaceous continental arc and that the Skeena Group is a forearc succession (Figure 3). The Skeena rocks were folded, uplifted and eroded during a mid to late Cretaceous contractional event related to evolution of the Skeena Fold Belt (Evenchick, 1999).

Richards (1990) subdivides Skeena Group rocks in the Hazelton map area (93M) into six formations or mappable units. These are, from oldest to youngest, the Kitsumkalum shale, Kitsuns Creek Formation, the Rocky Ridge Formation, the Hanawald conglomerate and the

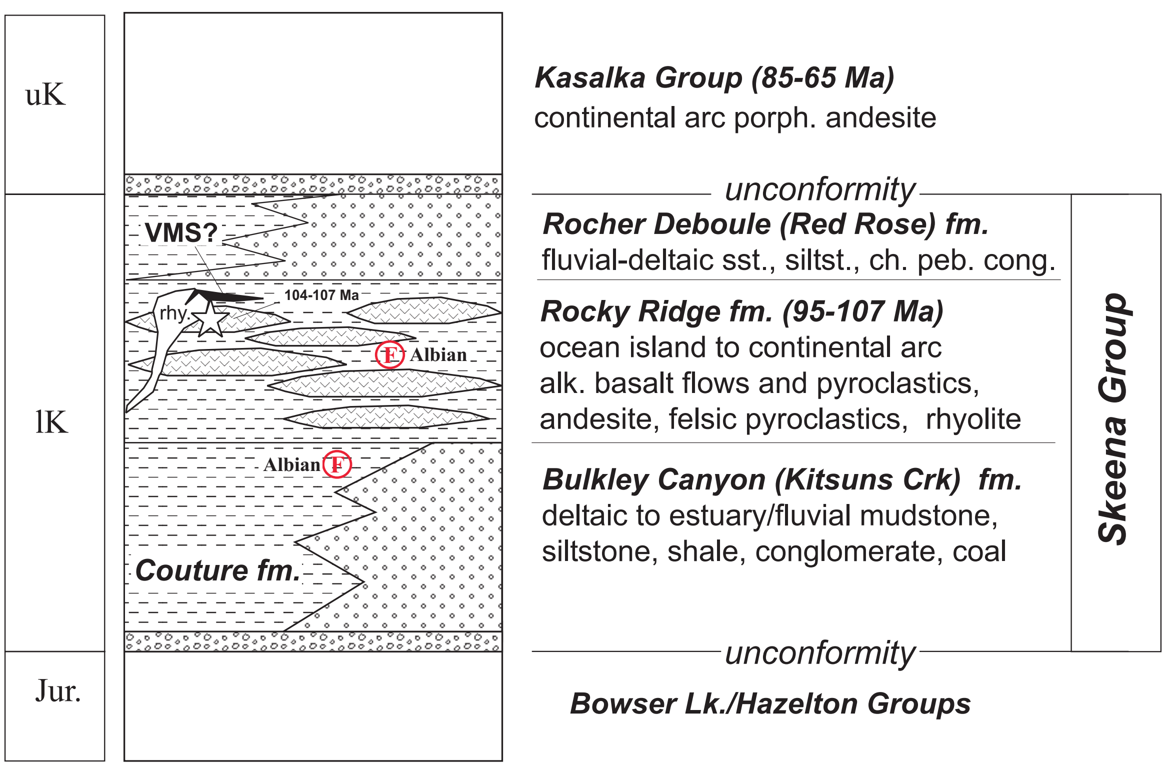


Figure 2. Schematic stratigraphy for the Skeena Group showing stratigraphic position of rhyolite domes and Rocky Ridge volcanic rocks discussed in this report.

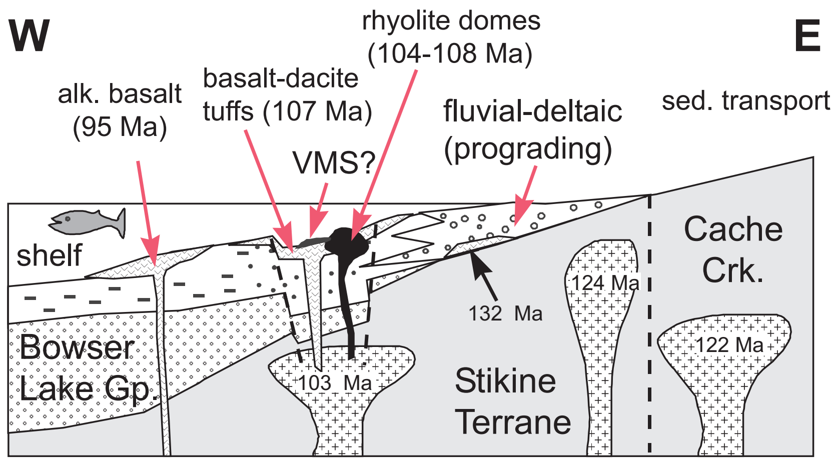


Figure 3. Schematic diagram illustrating the postulated depositional environment for the Skeena Group as suggested by Bassett and Kleinspehn (1996). Also shown are geochronologic controls determined during the Nechako Natmap project.

Red Rose Formation. In a recent paper, Bassett and Kleinspehn (1996) proposed a new stratigraphic nomenclature based on lithofacies. In their stratigraphy the lowest unit of the Skeena Group succession is the predominantly deltaic Bulkley Canyon Formation which includes, in the east, the fluvial Kitsuns Creek Member and to the west the subtidal, turbiditic Couture Formation. Locally these rocks are overlain by and in part interbedded with the volcanic arc rocks of the Rocky Ridge Formation, the main subject of this paper. The fluvial to deltaic Rocher Deboule Formation which would include the former Red Rose Formation and Hanawald conglomerate comprises the upper part of the Skeena Group succession. Table 1 compares this new stratigraphic nomenclature with that of Richards (1990).

## Rocky Ridge Formation

The Rocky Ridge Formation is comprised of submarine alkali basalt flows, breccias, and lapilli tuffs that were erupted along the southern margin of the Bowser Basin (Bassett and Kleinspehn, 1996) as part of a primitive volcanic arc assemblage. Interbedded with the volcanic rocks are marine shales and siltstones that contain Early Albian to Early Cenomanian macrofossils. The thickness and lateral continuity of the Rocky Ridge Formation is variable. For example, at Rocky Ridge, the type locality, the volcanic succession is up to 1000 metres thick whereas in the next range to the west if is thin or absent. These variations probably reflect proximity to major eruptive centers.

One of the key results of the geochronologic dating completed as part of the Nechako NATMAP project was the recognition of mid-Cretaceous rhyolite domes in the Rocky Ridge succession (MacIntyre and Villeneuve, in press). The rhyolite domes occur as an arcuate belt of topographic highs north of Old Fort Mountain in the Babine Lake area (Figure 4). These domes may be the remnants of a submarine caldera complex (MacIntyre *et al.*, 1997; Tackaberry, 1998). Similar flow-banded rhyolites crop

**TABLE 1**
**COMPARISON OF SKEENA GROUP STRATIGRAPHIC NOMENCLATURE**

| Richards (1990) | Bassett & Kleinspehn (1996) | Facies | Age Range |
|---|---|---|---|
| Red Rose Fm. | Rocher Deboule Fm. | fluvial, deltaic | Albian-Cenomanian |
| Hanawald conglomerate | | | |
| Rocky Ridge volcanics | Rocky Ridge Fm. | volcanic arc | |
| Kitsuns Creek Fm | Bulkley Canyon Fm. | deltaic | Hauterivian-Albian |
| | (Kitsuns Creek Mbr.) | fluvial, estuary | |
| Kitsumkalum shale | Couture Fm. | subtidal, turbiditic | |

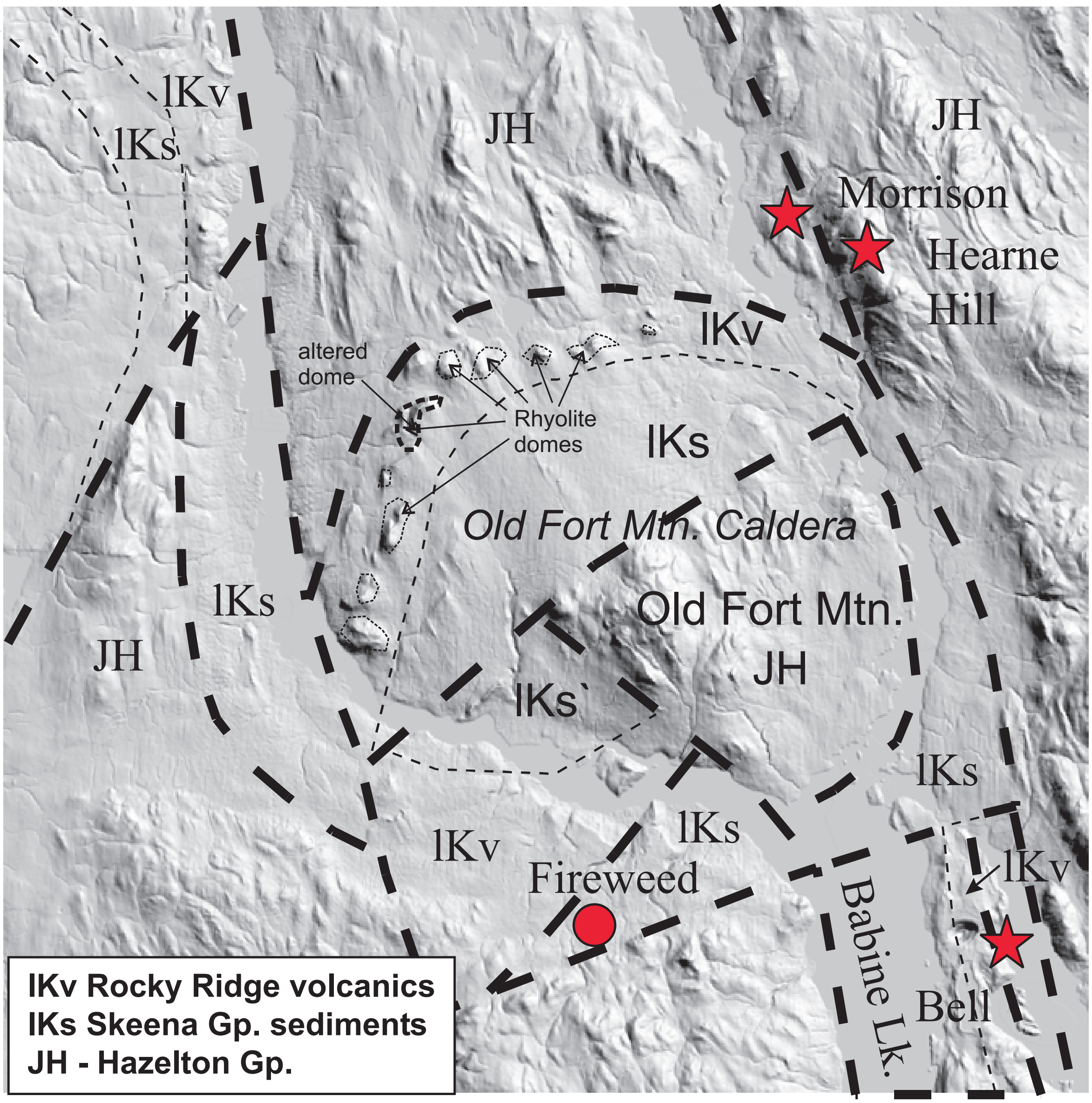


Figure 4. Shaded relief image derived from 20 metre digital elevation model data showing an arcuate belt of rhyolite domes north of Old Fort Mountain. The rhyolite domes are interpreted to be a ring dike structure bounding a resurgent caldera. Stars mark major Eocene age porphyry copper deposits; solid circles are massive sulphide prospects.

out in the vicinity of the Bell Mine on the Newman Peninsula. All of these rhyolites were previously mapped as part of the Eocene Babine intrusions (Richards, 1990), but are now mapped as Rocky Ridge Formation because they yield U/Pb and Ar/Ar isotopic ages between 104 and 108 Ma (MacIntyre and Villeneuve, in press). These ages suggest eruption of the domes occurred during Albian time. Marine sedimentary rocks that are intruded by the rhyolite domes contain Albian macrofossils suggesting the domes and sedimentary rocks are roughly coeval.

## THE ESKAY CREEK DEPOSIT MODEL

The Eskay Creek property, which is located 80 km north of Stewart, includes several deposits of polymetallic sulphide and sulphosalt mineralization as both exhalative massive sulphides and discordant veins. These deposits are economically important because of their precious metal contents and polymetallic nature. As of December 31, 1998, Eskay Creek had proven and probable reserves of 1.9 Mt grading 60.2 g/t Au and 2652 g/t Ag, 3.2% Pb, 5.2% Zn and 0.7%Cu (Sherlock *et al.*, 1999).

The Eskay Creek deposit is classified as a subaqueous hot spring deposit (Alldrick, 1995), an important new class of mineral deposit that has only recently been recognized in modern geological environments (Hannington, 1999). This deposit type shares mineralogical, geochemical and other characteristics of both subaerial epithermal Au-Ag hot spring deposits and deeper water Kuroko and

Besshi type volcanogenic massive sulphide deposits. Many deposits appear to be associated with bimodal (basalt-rhyolite) submarine volcanic centers, including sea-flooded, breached calderas in an active volcanic arc setting.

## Target Areas for Eskay Creek Type Deposits

The main focus of this study is to identify areas that may have potential for the discovery of Eskay Creek type shallow, subaqueous hot spring Au-Ag deposits along the trend of the Skeena Arch (Figure 1). A preliminary assessment of this area identified several areas with high potential for this type of deposit (Massey, 1999; Massey *et al.*, 1999) and four occurrences were classified as Eskay Creek type - French Peak, Fireweed, Mt. Cronin and the Knoll. The Fireweed, Mt. Cronin and Knoll properties all have massive Pb-Zn-Ag mineralization hosted in rhyolitic intrusions that are emplaced into marine sedimentary strata of the Lower Cretaceous Skeena Group. The rhyolitic intrusions were previously mapped as Eocene or Late Cretaceous but detailed mapping and isotopic age-dating of rhyolite domes in the Babine Lake area has shown that these rhyolites are part of the mid-Cretaceous Rocky Ridge Formation of the Skeena Group (MacIntyre and Villeneuve, in press) and are therefore coeval with surrounding sedimentary rocks.

## Nilkitkwa River

Richards (1980, 1990) suggests rocks of the Rocky Ridge Formation underlie a series of ridges west of the Nilkitkwa River. This site was visited via helicopter and a grab sample was collected for Ar/Ar isotopic dating and lithogeochemistry. A brief examination of outcrops at the sample site suggests the volcanic succession is predominantly alkali basalt, typical of much of the Rocky Ridge Formaiton. No evidence for a felsic component to the volcanism was observed.

## French Peak

Volcanic rocks on the east flank of French Peak have been mapped as part of the Late Cretaceous Kasalka Group (Richards, 1980, 1990). The stratigraphic succession is described as including subaerial and submarine dacite, andesite and rhyolite. These rocks were targeted for study because of the possibility that they may actually be Rocky Ridge Formation. The main exploration targets on the property are the UTE and Rio veins (Minfile 093M 015) both of which have been identified as having characteristics common to the Eskay Creek model (Massey, 1999). The UTE showing is a steep dipping, northeast-trending quartz-siderite vein system containing coarse argentiferous galena and tetrahedrite. Host rocks are sheared purple to orange weathering crystal-ash tuffs. The Rio vein is located 122 metres south and is comprised of massive, banded chalcopyrite, tetrahedrite, and pyrite hosted by andesitic to dacitic tuffs. The vein dips moderately to the northwest and appears to be conformable to bedding.

A total of 1.5 days was spent on the French Peak property. Based on examination of outcrop and core, it would appear that the host rocks for the UTE and Rio veins are not Late Cretaceous Kasaka Group or mid-Cretaceous Rocky Ridge Formation but rather the Lower to Middle Jurassic Saddle Hill Formation. This conclusion is supported by the occurrence of marine sedimentary rocks containing Middle Jurassic macrofossils within or overlying the volcanic succession (Robin Day, personal communication). The Saddle Hill Formation is the same age as host rocks for the Eskay Creek deposit and therefore, the French Peak area should be considered prospective for this type of deposit.

## Fort Babine

An east trending, fault-bounded panel of Rocky Ridge volcanic rocks is sporadically exposed in clearcuts west of the northern tip of Babine Lake near Fort Babine (Figure 1). Mapping in this area in 1997 and 1998 suggests a number of rhyolite domes and rhyolite breccia bodies occur within a mixed mafic volcanic and marine sedimentary succession (Richards, 1980, 1990; MacIntyre, in press). Locally the sedimentary rocks contain Albian macrofossils. These rocks trend easterly and dip steeply to both the north and south. As part of the current study, one day was spent examining exposures of mafic flows in a borrow pit near the 4039 marker on the 4000 (Fort Babine) road. This site was also drilled for a regional paleomagnetic study being conducted by Randy Enkin of the Geological Survey of Canada. Although there are no known mineral occurrences associated with the Rocky Ridge volcanic rocks at this locality, the occurrence of a felsic component within the volcanic succession is considered evidence for a favourable environment for Eskay Creek type deposits.

## Old Fort

An arcuate belt of resistant, rhyolite domes previously dated as mid-Cretaceous (MacIntyre and Villeneuve, in press) and interpreted to be a ring dike structure related to development of a submarine caldera crop out north of Old Fort Mountain in the Babine Lake area (Figure 4). These rhyolites are emplaced into mafic lapilli tuffs typical of the Rocky Ridge Formation. The volcanic succession is overlain and underlain by marine and non-marine clastic sedimentary rocks of the Skeena Group. Near the rhyolite domes, the sedimentary strata contain numerous angular clasts of rhyolite suggesting explosive volcanism accompanied emplacement of the domes (Photo 1a). One of these rhyolite domes has pervasive sericitic alteration accompanied by 1 to 2% finely disseminated pyrite (Figure 4). However, samples collected for assay in 1997 failed to detect anomalous metal concentrations in the rhyolite. Away from the domes, the area is heavily drift covered and has virtually no outcrop making exploration for massive sulphide lenses difficult.

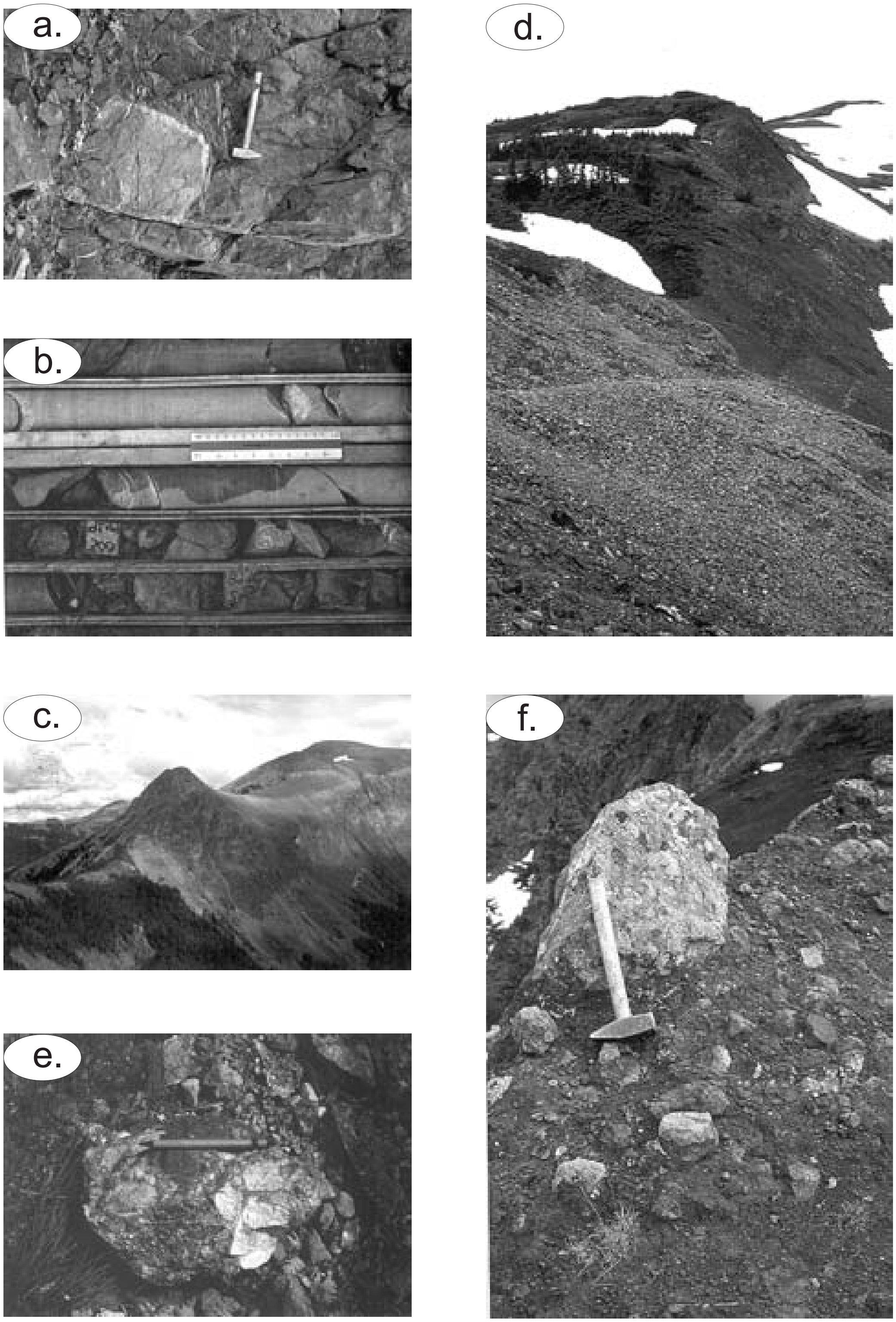


Photo 1. a. Large angular block of rhyolite in a tuffaceous siltstone. Photo taken in a borrow pit just north of a chain of rhyolite domes; b. Drill core from the Fireweed property showing rhyolite injected into graphitic mudstone. High grade Pb-Zn-Ag veins occur within the rhyolite; c. Prominent rhyolite dome intruding Skeena Group sedimentary rocks north of Mt. Cronin; d. Contact between rhyolite (light coloured talus) and siltstone at the Mt. Cronin property. Samples of rhyolite were collected near the contact for lithogeochemistry and U/Pb geochronology; e. Angular rhyolite clasts in Skeena Group conglomerate exposed in road cuts near Beament on Highway 16; f. Steeply dipping debris flow containing large, subangular to subrounded blocks of augite phyric basalt typical of the Rocky Ridge Formation. Photo taken on the crest of Rocky Ridge.

## Fireweed

The Fireweed Ag-Pb-Zn-Cu-Au prospect (Minfile 093M 151) is located south of Old Fort Mountain (Figure 4), in a fault-bounded, poorly exposed, east-trending panel of Skeena Group clastic sedimentary rocks (Malott, 1988). This property has been classified as a subaqueous hot-spring deposit of the Eskay Creek type (Massey, 1999). Mineralization occurs as breccia zones and vein stockworks containing massive pyrite-pyrrhotite and lesser sphalerite, chalcopyrite and galena in both the sedimentary rocks and altered rhyolite dikes, as fine to coarse-grained interstitial pyrite, marcasite, sphalerite, galena and tetrahedrite in coarse sandstone and granule conglomerate beds and as conformable, fine-grained pyrite/pyrrhotite and sphalerite/galena bands in fine-grained carbonaceous, marine sedimentary rocks. Massive sulphide is spatially associated with both the breccia/stockwork zones and altered rhyolite (quartz latite) dikes. Porous sandstone beds contain quartz, ankerite, sericite, chlorite and kaolinite alteration minerals.

The Fireweed property was discovered in 1987 and drill tested in 1988, 1989 and 1990. Indicated reserves on the West zone are 584,500 tonnes grading 341.77 grams per tonne silver, 2.22 per cent zinc and 1.34 per cent lead (George Cross Newsletter No.66, 1989). In 1999 Mansfield Minerals Inc. completed an additional 1250 metres of diamond drilling in six holes. Numerous rhyolite dikes, lithologically identical to the rhyolite domes observed north of Old Fort Mountain, occur in the drill core and some of these host high grade sphalerite vein stockworks (Photo 1b).

## Mt. Cronin

A number of rhyolite domes intrude Skeena Group sedimentary rocks in the vicinity of Mt. Cronin, in the Babine Range (Photo 1c). Two of these were sampled by helicopter during the current study - one on the northwest flank of the mountain and the other to the southwest. The latter hosts the Cronin past producing mine (Minfile 093L 127). From 1917 to 1974 sporadic production from this mine yielded 25,838 tonnes containing 8.17 million grams of silver, 8,772 grams of gold, 10,394 kilograms of copper, 1.37 million kilograms of lead and 1.52 million kilograms of zinc. Mineralization occurs as quartz veins and massive sulphide lenses containing high grade concentrations of argentiferous galena and sphalerite with minor pyrite and chalcopyrite. Boulangerite, freibergite and arsenopyrite have also been identified. The Cronin deposit was classified as a subaqueous hot-spring deposit by Massey (1999).

The rhyolite at the Cronin Mine (Photo 1d), which has at least two intrusive phases, is feldspar phyric and has pervasive sericite alteration. Mineralized quartz veins occur within the rhyolite and surrounding graphitic argillites and siltstones of the Skeena and Bowser Lake groups. These sedimentary rocks are strongly folded near the contact with the rhyolite. Some of this deformation is interpreted to be soft-sediment and related to emplacement of the rhyolite into weakly lithified strata. The rhyolite, which is lithologically identical to those in the Babine Lake area, has been mapped as Late Cretaceous or Tertiary in the past (Tipper and Richards, 1978) but may be coeval with surrounding mid-Cretaceous Skeena Group sedimentary rocks.

## Suskwa (Knoll Property)

A resistant steep-sided rhyolite dome, approximately 600 metres long, 300 metres wide and 60 metres high, intrudes Skeena Group sedimentary strata within a fault-bounded, north-trending panel in the Harold Price Creek valley north of the Suskwa River (Figure 1). Rocks exposed on the knoll are massive to flow-banded, or spherulitic rhyolite, rhyolite breccia and volcaniclastic conglomerate with variable degrees of sericitic alteration (Wojdak *et al.*, 1999). The presence of rhyolite breccia suggests volcanism was locally explosive. The rocks intruded by the rhyolite are recessive and poorly exposed graphitic black mudstone and argillite of probable Albian age.

Dan Ethier discovered disseminations and veinlets of pyrite, sphalerite and galena in rhyolite breccia and lapilli tuff within and adjacent to the rhyolite dome, in 1983. He named the property the Knoll occurrence (Minfile 093M 100). Disseminated pyrite and manganese staining are also widespread in the rhyolite. The Knoll property has been classified as an epithermal massive sulphide (Wojdak *et al.*, 1999) and as a subaqueous hot-spring deposit (Massey, 1999).

Goldpac Investments Ltd. optioned the property in 1987 and drilled seven holes, totaling 978 metres (Figure 5). These were collared to test induced polarization anomalies. Mineralization intersected by these drill holes is mainly fracture-controlled pyrite, pyrrhotite and arsenopyrite with associated quartz and calcite. The best intersection was hole 88-3 with over 1 metre grading 0.51% Pb, 1.32% Zn, 9.58% As, 30 ppm Ag and 1610 ppb Au.

The rhyolite at the Knoll property is lithologically identical to the flow-banded rhyolite domes located north of Old Fort Mountain and dated as mid-Cretaceous. A similar age is inferred for the Knoll rhyolite.

## Beament

A south-dipping section of feldspar phyric mafic volcanic rocks that overlie and are in part interbedded with quartzo-feldspathic wacke and chert-bearing heterolithic conglomerate is exposed in a 2 kilometre long road cut north of Beament station on Highway 16 (Figure 1). The volcanic rocks have been mapped as Late Cretaceous Kasalka Group (Richards 1980, 1990) but are lithologically identical to mid Cretaceous Rocky Ridge volcanic rocks elsewhere in the area. Sedimentary strata exposed at the north end of the road cut dip to the south and have been mapped as Lower Cretaceous Skeena Group. The contact with the overlying volcanic rocks appears to be conformable. Although no felsic component

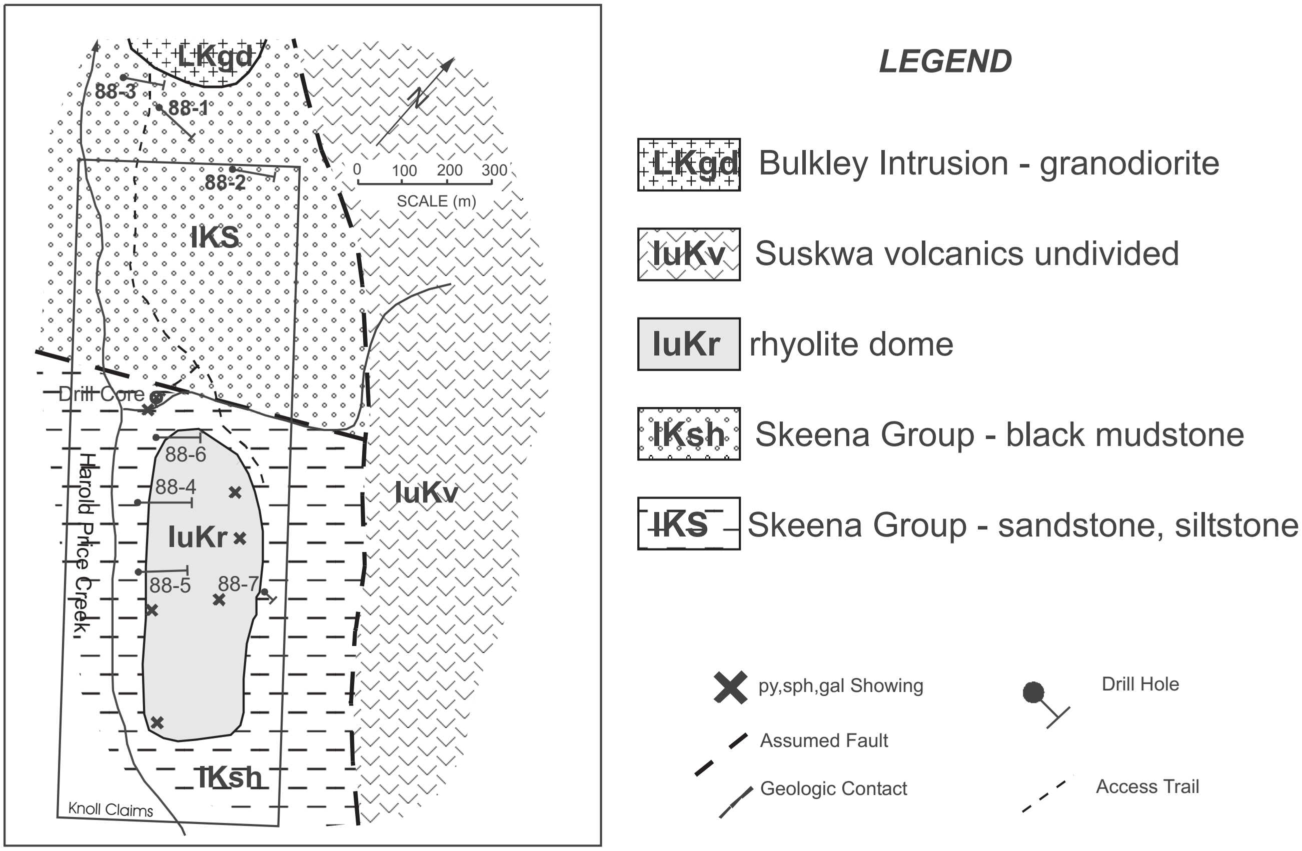


Figure 5. General geology and drill hole locations, Knoll property, Suskwa River area. Modified from Wojdak *et al.*, 1999.

was observed in the volcanic succession, coarse conglomerate beds underlying the volcanic rocks contain angular rhyolite clasts (Photo 1e) similar to those described in sedimentary rocks near rhyolite domes in the Babine Lake area (Photo 1a). This is indirect evidence for explosive rhyolite volcanism in the area prior to eruption of thick piles of mafic flows. This inferred bimodal volcanic style suggests rocks in the vicinity of Beament may have potential for subaqueous hot spring deposits associated with rhyolite eruptive centers.

## Rocky Ridge

The type area for the Rocky Ridge Formation is at Rocky Ridge, a prominent, serrated, east-trending ridge at the southern limit of the Rocher Deboule Range (Figure 1). The ridge is underlain by a steeply-dipping, east-trending succession of feldspar phyric alkali basalt flows, lahar and volcanic conglomerate. Clasts in the lahar are subrounded to subangular, up to a metre in diameter and are compositionally the same as volcanic flows in the section (Photo 1f). No felsic clasts were observed in the lahar units. The coarse, poorly sorted nature of the lahars on Rocky Ridge suggests proximity to a major eruptive center with steep, unstable slopes, possibly a major collapse structure (Rocher Deboule caldera?).

A thick, poorly exposed section of Skeena Group sedimentary rocks underlies the broad valley south of Rocky Ridge. These sedimentary rocks are intruded by a large, elongate, east-trending rhyolite body that forms a prominent east-trending ridge. This rhyolite, which has previously been mapped as an Eocene Nanika intrusion (Tipper and Richards, 1976) is lithologically identical to mid-Cretaceous rhyolite intrusions in the Babine Lake area.

## Mt. Ney

A thick succession of amygdaloidal, locally pillowed basaltic rocks underlies marine sedimentary rocks of the Skeena Group on the east flank of Mt. Ney (Figure 1) and elsewhere in the Tahtsa Lake area (Woodsworth, 1980; MacIntyre, 1985). These rocks, which were previously mapped as the Mt. Ney volcanics, are probably correlative with the Rocky Ridge Formation.

## Troitsa Lake

A prominent, white weathering rhyolite dike crops out along the north shore of Troitsa Lake (Figure 1). This rhyolite appears to be emplaced into amygdaloidal flows of the Mt. Ney volcanics and sedimentary strata of the Skeena Group. The rhyolite has been interpreted as a ring dike bounding the Tahtsa Lake caldera (MacIntyre, 1985).

## GEOCHRONOLOGY

U/Pb and $^{40}Ar/^{39}Ar$ isotopic dating in the Babine Lake area of central British Columbia documents a distinct magmatic event at 107-104 Ma (MacIntyre and Villeneuve, in press). This event involved emplacement of rhyolite domes into submarine volcanic rocks of the Rocky Ridge Formation. The volcanic rocks have yielded a U/Pb age of 107.9±0.2 Ma and an $^{40}Ar/^{39}Ar$ age of 104.8±1.2 Ma. Several samples of rhyolite were also dated but these did not give publishable ages. However, the data that was obtained is consistent with isotopic ages in the 104-108 Ma range (Mike Villeneuve, personal communication). The rhyolites, which were previously mapped as Eocene, are re-interpreted to be part of a previously unrecognized mid-Cretaceous cauldron subsidence complex (Figure 4).

Rhyolite at the Fireweed, Knoll, Mt. Cronin, Rocky Ridge and Troitsa Lake localities were sampled for U/Pb geochronology (Table 2). Mafic volcanic rocks of the Rocky Ridge Formation at the French Peak, Nilkitkwa River, Fort Babine, Rocky Ridge and Mt. Ney localities were also sampled for Ar/Ar geochronology (Table 2). All of the U/Pb and $^{40}Ar/^{39}Ar$ age determinations will be done at the GSC geochronology laboratory in Ottawa, Ontario, Canada under the supervision of Dr. Mike Villeneuve.

## LITHOGEOCHEMISTRY

A total of 19 samples were collected for major oxide, trace and rare earth element analyses and most of these have also been submitted for isotopic age dating (Table 2). Seven of these samples are from suspected mid-Cretaceous rhyolite emplaced into Skeena Group sedimentary strata and seven samples are from mafic flows within the Rocky Ridge volcanic succession. For comparison pur-

**TABLE 2**
**LITHOGEOCHEMICAL AND GEOCHRONOLOGICAL SAMPLES COLLECTED IN 2000**

| No. | Station | Map | Easting | Northing | Area | Unit | Lithology | Geochron | Comment |
|---|---|---|---|---|---|---|---|---|---|
| 1 | DMA00-001 | 93M3 | 602539 | 6116265 | Rocky Ridge | Rocky Ridge | green aphyric basalt | Ar/Ar | from top of ridge |
| 2 | DMA00-002 | 93L13 | 594585 | 6093062 | Rocky Ridge | Rocky Ridge | augite phyric basalt | Ar/Ar | from top of ridge |
| 3 | DMA00-003 | 93L13 | 594932 | 6093002 | Rocky Ridge | Rocky Ridge | amygdaloidal basalt | Ar/Ar | from top of ridge |
| 4 | DMA00-007 | 93L15 | 640023 | 6088597 | Mt. Cronin | Rhyolite dome | rhyolite | U/Pb | dome at Cronin Mine |
| 5 | DMA00-008 | 93L15 | 633729 | 6094767 | Mt. Cronin | Kasalka | feldspar phyric andesite | U/Pb | north of Mt. Cronin |
| 6 | DMA00-009 | 93L15 | 628538 | 6088436 | Mt. Cronin | Rhyolite dome | rhyolite | U/Pb | dome on ridge north of Lagopus Mtn. |
| 7 | DMA00-012 | 93M7 | 640334 | 6134053 | French Peak | Saddle Hill | basalt | Ar/Ar | basalt at UTE vein |
| 8 | DMA00-015 | 93M7 | 649605 | 6128284 | Fort Babine | Rocky Ridge | feldspar phyric andesite | Ar/Ar | quarry at km 39 on 4000 road |
| 9 | DMA00-016 | 93M7 | 649605 | 6128272 | Fort Babine | Rocky Ridge | augite phyric basalt | Ar/Ar | quarry at km 39 on 4000 road |
| 10 | DMA00-017 | 93M7 | 618251 | 6125954 | Sukwa River | Rhyolite dome | rhyolite | U/Pb | rhyolite dome on Knoll property |
| 11 | DMA00-018 | 93M7 | 618304 | 6125533 | Sukwa River | Rhyolite dome | banded rhyolite | | drill core from Knoll property |
| 12 | DMA00-020 | 93M7 | 637778 | 6138158 | French Peak | Kasalka | feldspar phyric andesite | | ridge E. of French Peak |
| 13 | DMA00-021 | 93M7 | 634262 | 6142600 | French Peak | Kasalka | feldspar phyric andesite | | ridge N. of French Peak |
| 14 | DMA00-022 | 93M7 | 633211 | 6154815 | Nilkitkwa R. | Rocky Ridge | feldspar phyric andesite | Ar/Ar | ridge W. of Nilkitkwa River |
| 15 | DMA00-042 | 93E11 | 607034 | 5935011 | Troitsa Lake | Rhyolite dome | rhyolite | U/Pb | dike along shores of Troitsa Lake |
| 16 | DMA00-043 | 93E11 | 612347 | 5943798 | Swing Peak | Kasalka | feldspar phyric andesite | U/Pb | south slope of Swing Peak |
| 17 | DMA00-045 | 93E13 | 605138 | 5963620 | Mt. Ney | Rocky Ridge | amygdaloidal basalt | Ar/Ar | volcanics south of Mt. Ney |
| 18 | DMA00-050 | 93L13 | 596691 | 6090754 | Rocky Ridge | Rhyolite dome | rhyolite | U/Pb | large intrusion south of Rocky Ridge |
| 19 | DMA00-055 | 93M1 | 663294 | 6098762 | Fireweed | Rhyolite dome | rhyolite | U/Pb | dike cutting Skeena seds (drill core) |

N.B. Easting and Northing coordinates are in NAD83; all samples are in UTM zone 9

**TABLE 3**
**MAJOR OXIDE AND TRACE ELEMENT ANALYSES**

| Element | Units | Limit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SiO2 | % | | 51.63 | 47.74 | 48.04 | 76.5 | 62.54 | 74.01 | 44.93 | 49.47 | 48.59 |
| TiO2 | % | | 1.01 | 0.61 | 0.56 | 0.05 | 0.68 | 0.18 | 0.82 | 1.73 | 1.65 |
| Al2O3 | % | | 16.64 | 19.19 | 19.54 | 14.81 | 16.09 | 14.96 | 16.29 | 17.69 | 17.87 |
| Fe2O3 | % | | 8 | 9.63 | 7.98 | 0.95 | 5.5 | 1.32 | 11.48 | 8.93 | 9.14 |
| MnO | % | | 0.17 | 0.15 | 0.18 | 0.01 | 0.03 | 0.07 | 0.2 | 0.18 | 0.18 |
| MgO | % | | 3.39 | 3.5 | 2.53 | 0.14 | 2.25 | 0.15 | 8.38 | 5.28 | 5.19 |
| CaO | % | | 5.8 | 10.27 | 8.18 | 0.03 | 3.17 | 0.38 | 7.36 | 5.96 | 7.51 |
| Na2O | % | | 2.33 | 2.78 | 3.53 | 0.07 | 4.09 | 3.16 | 2.5 | 4.03 | 4.03 |
| K2O | % | | 2.16 | 2.3 | 2.73 | 3.73 | 2.7 | 3.43 | 0.3 | 2.11 | 0.93 |
| P2O5 | % | | 0.38 | 0.43 | 0.62 | 0.01 | 0.31 | 0.01 | 0.07 | 0.51 | 0.47 |
| Ba | % | | 0.03 | 0.16 | 0.23 | 0.06 | 0.13 | 0.12 | 0.05 | 0.16 | 0.03 |
| LOI | % | | 8.3 | 2.57 | 5.32 | 2.81 | 2.34 | 1.96 | 7.36 | 3.73 | 3.95 |
| SUM | % | | 99.84 | 99.33 | 99.44 | 99.17 | 99.83 | 99.75 | 99.74 | 99.78 | 99.54 |
| Mo | ppm | 0.01 | 0.32 | 0.77 | 0.97 | 0.03 | 1.05 | 0.39 | 0.06 | 0.21 | 1.13 |
| Cu | ppm | 0.01 | 1.82 | 29.2 | 23.75 | 24.3 | 24.27 | 0.69 | 52.45 | 37.95 | 36.59 |
| Pb | ppm | 0.01 | 1.79 | 10.15 | 17.37 | 1298.4 | 7.14 | 21.06 | 1.04 | 2.24 | 1.88 |
| Zn | ppm | 0.1 | 62.9 | 48.2 | 47 | 220.8 | 50.5 | 79.2 | 74.3 | 64.1 | 55.3 |
| Ag | ppb | 2 | 16 | 25 | 52 | 16468 | 68 | 62 | 74 | 30 | 49 |
| Ni | ppm | 0.1 | 6.1 | 8.3 | 0.9 | 0.9 | 36.5 | 0.7 | 102.6 | 39.2 | 39.8 |
| Co | ppm | 0.1 | 12.9 | 24 | 12.7 | 0.1 | 13.3 | 0.2 | 47.8 | 25.1 | 25.6 |
| Mn | ppm | 1 | 1344 | 738 | 1121 | 20 | 362 | 592 | 1233 | 828 | 795 |
| Fe | % | 0.01 | 4.63 | 5.11 | 4.03 | 0.27 | 2.69 | 0.51 | 5.7 | 4.95 | 4.54 |
| As | ppm | 0.1 | < .1 | < .1 | 0.2 | 794.7 | 4.5 | 0.4 | 42.5 | < .1 | < .1 |
| U | ppm | 0.1 | 0.2 | 1.6 | 2.7 | 1.3 | 1.2 | 1.7 | < .1 | 0.3 | 0.3 |
| Au | ppb | 0.2 | < .2 | 1.4 | < .2 | 16.7 | 1 | 1.6 | 1.2 | 0.8 | 0.7 |
| Th | ppm | 0.1 | 1.6 | 5.6 | 10 | 2.2 | 2.8 | 13.7 | < .1 | 0.7 | 0.8 |
| Sr | ppm | 0.5 | 70.8 | 460 | 673.9 | 1.8 | 67.5 | 43.1 | 70.1 | 55.3 | 73.8 |
| Cd | ppm | 0.01 | 0.01 | 0.03 | 0.09 | 3.02 | 0.05 | 0.36 | 0.05 | 0.04 | 0.05 |
| Sb | ppm | 0.02 | 0.18 | 0.11 | 0.13 | 5.35 | 0.23 | 0.27 | 0.66 | 0.03 | 0.07 |
| Bi | ppm | 0.02 | 0.02 | 0.03 | < .02 | 0.07 | 0.03 | 0.02 | 0.18 | < .02 | < .02 |
| V | ppm | 2 | 67 | 179 | 110 | < 2 | 81 | < 2 | 147 | 65 | 86 |
| Ca | % | 0.01 | 3.5 | 3.95 | 3.43 | 0.01 | 0.87 | 0.25 | 2.87 | 1.35 | 1.28 |
| P | % | 0.001 | 0.159 | 0.178 | 0.252 | 0.001 | 0.122 | 0.015 | 0.035 | 0.23 | 0.197 |
| La | ppm | 0.5 | 18.8 | 16 | 27.5 | 1.7 | 15.8 | 24.6 | 1 | 16.3 | 14.6 |
| Cr | ppm | 0.5 | 9.2 | 26.5 | 10.3 | 46.7 | 104.4 | 27.4 | 138.7 | 53 | 51.1 |
| Mg | % | 0.01 | 1.94 | 0.95 | 0.57 | 0.01 | 1.33 | 0.02 | 3.98 | 2.67 | 2.39 |
| Ba | ppm | 0.5 | 49.6 | 214.1 | 219.5 | 80 | 145.8 | 120.2 | 386.7 | 82.9 | 37.9 |
| Ti | % | 0.001 | 0.001 | 0.133 | 0.145 | 0.001 | 0.052 | < .001 | 0.075 | 0.448 | 0.303 |
| B | ppm | 1 | 5 | 4 | 13 | 8 | 6 | 14 | 6 | 8 | 8 |
| Al | % | 0.01 | 2.61 | 5.15 | 4.99 | 0.58 | 1.32 | 0.34 | 4.21 | 2.8 | 2.41 |
| Na | % | 0.001 | 0.017 | 0.403 | 0.685 | 0.009 | 0.115 | 0.026 | 0.204 | 0.159 | 0.29 |
| K | % | 0.01 | 0.24 | 0.13 | 0.4 | 0.44 | 0.12 | 0.23 | 0.07 | 0.06 | 0.03 |
| W | ppm | 0.2 | < .2 | 0.3 | 0.5 | < .2 | < .2 | < .2 | < .2 | < .2 | < .2 |
| Sc | ppm | 0.1 | 4 | 2.5 | 0.9 | 0.3 | 5.1 | 0.5 | 9.8 | 4.2 | 3.2 |
| Tl | ppm | 0.02 | 0.13 | < .02 | 0.05 | 0.16 | 0.02 | 0.05 | 0.11 | < .02 | < .02 |
| S | % | 0.01 | 0.05 | < .01 | < .01 | 0.07 | < .01 | < .01 | 0.1 | 0.01 | 0.01 |
| Hg | ppb | 5 | < 5 | < 5 | < 5 | 112 | 10 | 9 | < 5 | < 5 | < 5 |
| Se | ppm | 0.2 | 0.2 | 0.2 | 0.3 | < .1 | 0.1 | < .1 | 0.4 | 0.3 | 0.2 |
| Te | ppm | 0.02 | < .02 | 0.04 | 0.05 | < .02 | < .02 | < .02 | 0.02 | < .02 | < .02 |
| Ga | ppm | 0.02 | 9.5 | 9.6 | 8.9 | 1.6 | 6.2 | 0.7 | 12.2 | 11.9 | 6 |

TABLE 3
MAJOR OXIDE AND TRACE ELEMENT ANALYSES CONTINUED

| Element | Units | Limit | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SiO2 | % | | 74.84 | 70.61 | 59.5 | 60.15 | 54.61 | 73.37 | 62.18 | 48.54 | 75.06 | 72.41 |
| TiO2 | % | | 0.1 | 0.11 | 0.51 | 0.43 | 0.56 | 0.1 | 0.54 | 0.89 | 0.05 | 0.17 |
| Al2O3 | % | | 11.94 | 13.82 | 16.61 | 17.12 | 18.01 | 14.52 | 16.17 | 16.55 | 14.47 | 13.35 |
| Fe2O3 | % | | 2 | 3.39 | 5.82 | 4.86 | 7.32 | 1.3 | 4.65 | 6.76 | 1.09 | 1.69 |
| MnO | % | | 0.01 | 0.52 | 0.12 | 0.18 | 0.1 | 0.02 | 0.11 | 0.1 | 0.02 | 0.33 |
| MgO | % | | 0.05 | 0.09 | 1.9 | 1.36 | 2.32 | 0.25 | 1.12 | 6.94 | 0.05 | 0.34 |
| CaO | % | | 0.02 | 0.07 | 4.48 | 4.78 | 4.63 | 1.57 | 4.63 | 9.47 | 0.03 | 2.51 |
| Na2O | % | | 0.15 | 0.12 | 5.05 | 4.23 | 5.25 | 2.89 | 3.76 | 2.48 | 2.78 | 0.46 |
| K2O | % | | 7.78 | 6.86 | 1.24 | 2.5 | 3.27 | 3.6 | 2.21 | 0.28 | 3.85 | 2.93 |
| P2O5 | % | | 0.01 | 0.01 | 0.28 | 0.25 | 0.49 | 0.02 | 0.18 | 0.23 | 0.01 | 0.01 |
| Ba | % | | 0.25 | 0.15 | 0.08 | 0.15 | 0.36 | 0.15 | 0.11 | 0.04 | 0.09 | 0.08 |
| LOI | % | | 2.02 | 3.39 | 4.01 | 3.27 | 2.22 | 1.57 | 3.77 | 7.28 | 2.25 | 5.32 |
| SUM | % | | 99.17 | 99.14 | 99.6 | 99.28 | 99.14 | 99.36 | 99.43 | 99.56 | 99.75 | 99.6 |
| Mo | ppm | 0.01 | 1.28 | 1.24 | 0.77 | 0.68 | 0.18 | 0.25 | 0.46 | 0.41 | 0.12 | 3.58 |
| Cu | ppm | 0.01 | 1.45 | 1.39 | 179.33 | 13.32 | 9.38 | 69.07 | 4.05 | 10.06 | 0.63 | 2.01 |
| Pb | ppm | 0.01 | 225.29 | 228.28 | 230.09 | 10.25 | 3.59 | 7.23 | 5.04 | 3.79 | 6.51 | 110.51 |
| Zn | ppm | 0.1 | 39.7 | 38.8 | 341.4 | 94.7 | 92.3 | 7.7 | 55.1 | 83.8 | 31.5 | 232.9 |
| Ag | ppb | 2 | 878 | 840 | 1301 | 49 | 30 | 350 | 20 | 16 | 14 | 155 |
| Ni | ppm | 0.1 | 1.8 | 1.6 | 211.6 | 1.9 | 1.6 | 1.2 | 6.2 | 201.9 | 1 | 1.1 |
| Co | ppm | 0.1 | 0.3 | 0.2 | 50.1 | 10.6 | 8.5 | 1 | 8.1 | 33.8 | 0.3 | < .1 |
| Mn | ppm | 1 | 21 | 23 | 1604 | 1107 | 1205 | 87 | 867 | 835 | 199 | 2583 |
| Fe | % | 0.01 | 1.11 | 1.1 | 6.77 | 3.18 | 2.82 | 0.29 | 2.29 | 3.9 | 0.54 | 0.76 |
| As | ppm | 0.1 | 113.2 | 111 | 61.3 | 1.1 | 6.5 | 0.7 | 1 | 0.8 | 0.7 | < .1 |
| U | ppm | 0.1 | 4.9 | 4.9 | 0.4 | 1 | 1.1 | 0.5 | 0.6 | 0.7 | 3.5 | 0.4 |
| Au | ppb | 0.2 | 0.3 | 2.8 | 29.8 | < .2 | < .2 | 2.3 | 0.8 | 0.6 | < .2 | 0.4 |
| Th | ppm | 0.1 | 16.7 | 16.3 | 3.7 | 2.8 | 2.2 | 3.3 | 1 | 1.6 | 10 | 2.3 |
| Sr | ppm | 0.5 | 6.3 | 6.1 | 18 | 61.3 | 97.7 | 33.1 | 196.5 | 86.8 | 44 | 28.7 |
| Cd | ppm | 0.01 | 0.1 | 0.09 | 0.62 | 0.06 | 0.17 | 0.03 | 0.03 | 0.04 | < .01 | 1.02 |
| Sb | ppm | 0.02 | 5.46 | 5.2 | 11.82 | 0.06 | 0.1 | 0.23 | 0.08 | 0.2 | 0.3 | 0.08 |
| Bi | ppm | 0.02 | 0.47 | 0.47 | 0.27 | 0.05 | < .02 | 0.38 | < .02 | 0.02 | < .02 | 0.02 |
| V | ppm | 2 | < 2 | < 2 | 105 | 70 | 45 | < 2 | 58 | 130 | 2 | 2 |
| Ca | % | 0.01 | < .01 | < .01 | 0.32 | 1.67 | 1.84 | 0.28 | 1.51 | 4.01 | 0.03 | 1.68 |
| P | % | 0.001 | 0.005 | 0.005 | 0.115 | 0.123 | 0.12 | 0.011 | 0.085 | 0.103 | 0.009 | 0.011 |
| La | ppm | 0.5 | 22.3 | 22 | 14.5 | 15.5 | 9.1 | 4.8 | 9.5 | 14 | 16.2 | 19.6 |
| Cr | ppm | 0.5 | 67.2 | 65.9 | 257.9 | 13.8 | 23.4 | 66.8 | 41.5 | 253.9 | 29.9 | 48.8 |
| Mg | % | 0.01 | 0.01 | 0.01 | 2.82 | 1.13 | 0.77 | 0.09 | 0.62 | 3.95 | 0.02 | 0.15 |
| Ba | ppm | 0.5 | 275.1 | 272.8 | 287 | 58.3 | 97.7 | 184.3 | 165.4 | 39.6 | 96.8 | 161.1 |
| Ti | % | 0.001 | < .001 | 0.001 | 0.072 | 0.062 | 0.113 | 0.012 | 0.155 | 0.287 | < .001 | < .001 |
| B | ppm | 1 | 11 | 11 | < 1 | 6 | 13 | 1 | 2 | 1 | 10 | < 1 |
| Al | % | 0.01 | 0.31 | 0.3 | 2.76 | 1.4 | 2.06 | 0.9 | 1.63 | 3.07 | 0.63 | 0.75 |
| Na | % | 0.001 | 0.005 | 0.005 | 0.006 | 0.108 | 0.097 | 0.063 | 0.116 | 0.185 | 0.04 | 0.013 |
| K | % | 0.01 | 0.4 | 0.39 | 0.04 | 0.1 | 0.1 | 0.37 | 0.1 | 0.03 | 0.29 | 0.41 |
| W | ppm | 0.2 | 1.6 | 1.6 | < .2 | < .2 | 0.3 | < .2 | < .2 | < .2 | < .2 | < .2 |
| Sc | ppm | 0.1 | 0.2 | 0.2 | 11.7 | 2.9 | 1.9 | 0.5 | 2.7 | 12.6 | 0.7 | 0.8 |
| Tl | ppm | 0.02 | 0.35 | 0.36 | 0.1 | 0.05 | 0.05 | 0.1 | 0.03 | 0.02 | 0.07 | 0.16 |
| S | % | 0.01 | 0.28 | 0.27 | 0.02 | 0.11 | 0.01 | 0.05 | 0.03 | 0.04 | 0.02 | 0.08 |
| Hg | ppb | 5 | 13 | 19 | 321 | 12 | < 5 | 9 | < 5 | < 5 | 94 | 35 |
| Se | ppm | 0.2 | < .1 | < .1 | 0.8 | < .1 | 0.1 | < .1 | < .1 | 0.1 | < .1 | < .1 |
| Te | ppm | 0.02 | < .02 | < .02 | 0.3 | < .02 | < .02 | 0.08 | 0.02 | < .02 | < .02 | < .02 |
| Ga | ppm | 0.02 | 0.6 | 0.6 | 9.1 | 7.1 | 9.4 | 3 | 6.6 | 8.1 | 1.7 | 1.5 |

Note: *See* Table 2 for sample descriptions; major oxide analyses done by XRF at Cominco; trace element analyses by aqua regia digestion ICPMS at Acme Analytical Laboratories

## TABLE 4
## TRACE AND RARE EARTH ELEMENT ANALYSES

| Element | Det. limit | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Y | 0.003 | 22.414 | 14.992 | 17.845 | 7.905 | 13.413 | 11.452 | 14.992 | 27.374 | 24.681 | 5.426 |
| Zr | 0.02 | 166.175 | 56.825 | 79.006 | 43.844 | 148.242 | 138.728 | 40.349 | 231.687 | 201.407 | 65.849 |
| Nb | 0.001 | 19.173 | 5.174 | 9.404 | 2.933 | 16.795 | 10.486 | 2.136 | 13.737 | 12.495 | 4.013 |
| Ba | 0.167 | 286.891 | 1516.915 | 2175.825 | 452.42 | 1219.38 | 972.947 | 418.986 | 1571.631 | 287.064 | 1856.938 |
| La | 0.003 | 20.699 | 16.57 | 27.153 | 1.902 | 22.861 | 23.917 | 1.904 | 15.793 | 14.555 | 24.775 |
| Ce | 0.002 | 43.271 | 30.894 | 48.29 | 3.912 | 41.663 | 41.266 | 5.533 | 39.053 | 35.415 | 33.068 |
| Pr | 0.001 | 5.402 | 3.665 | 5.569 | 0.526 | 4.768 | 4.33 | 0.912 | 5.292 | 4.751 | 2.666 |
| Nd | 0.002 | 22.313 | 15.154 | 22.042 | 2.282 | 18.165 | 15.083 | 4.861 | 22.91 | 20.726 | 7.738 |
| Sm | 0.006 | 4.931 | 3.573 | 4.851 | 0.833 | 3.605 | 2.582 | 1.737 | 5.412 | 4.979 | 1.152 |
| Eu | 0.002 | 1.427 | 1.153 | 1.523 | 0.185 | 1.025 | 0.568 | 0.747 | 1.943 | 1.815 | 0.256 |
| Gd | 0.004 | 4.444 | 3.419 | 4.354 | 1.028 | 3.026 | 1.99 | 2.382 | 5.655 | 5.154 | 0.701 |
| Tb | 0.002 | 0.684 | 0.487 | 0.61 | 0.192 | 0.433 | 0.303 | 0.408 | 0.853 | 0.782 | 0.103 |
| Dy | 0.007 | 4.441 | 2.954 | 3.567 | 1.283 | 2.58 | 1.917 | 2.745 | 5.248 | 4.795 | 0.672 |
| Ho | 0 | 0.931 | 0.599 | 0.723 | 0.264 | 0.52 | 0.405 | 0.598 | 1.091 | 0.993 | 0.166 |
| Er | 0.001 | 2.956 | 1.87 | 2.226 | 0.851 | 1.622 | 1.422 | 1.882 | 3.31 | 3.01 | 0.672 |
| Tm | 0 | 0.4 | 0.25 | 0.295 | 0.123 | 0.219 | 0.215 | 0.259 | 0.441 | 0.397 | 0.12 |
| Yb | 0.002 | 2.611 | 1.598 | 1.9 | 0.848 | 1.438 | 1.554 | 1.625 | 2.793 | 2.557 | 0.981 |
| Lu | 0.001 | 0.395 | 0.244 | 0.289 | 0.125 | 0.224 | 0.252 | 0.24 | 0.417 | 0.375 | 0.173 |
| Hf | 0.003 | 4.263 | 1.582 | 2.075 | 2.327 | 3.938 | 3.795 | 1.175 | 4.642 | 4.131 | 2.078 |
| Ta | 0.001 | 1.079 | 0.237 | 0.403 | 0.858 | 1.105 | 1.259 | 0.045 | 0.774 | 0.671 | 0.631 |
| Th | 0.01 | 4.919 | 6.002 | 10.131 | 2.376 | 9.083 | 14.039 | 0.175 | 1.167 | 1.1 | 25.876 |

| Element | Det. limit | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|
| Y | 0.003 | 9.803 | 13.986 | 14.995 | 20.091 | 7.765 | 8.473 | 19.414 | 9.646 | 16.76 |
| Zr | 0.02 | 80.152 | 127.288 | 140.022 | 162.9 | 78.382 | 99.886 | 145.146 | 41.206 | 164.118 |
| Nb | 0.001 | 15.292 | 13.816 | 20.728 | 21.032 | 8.064 | 5.982 | 7.603 | 18.683 | 16.667 |
| Ba | 0.167 | 1236.67 | 723.096 | 1400.019 | 3369.9 | 1349.38 | 1105.9 | 371.872 | 826.005 | 758.616 |
| La | 0.003 | 36.942 | 18.432 | 24.217 | 53.212 | 21.074 | 15.018 | 17.363 | 16.711 | 23.804 |
| Ce | 0.002 | 49.581 | 35.236 | 45.759 | 91.813 | 38.729 | 30.027 | 35.677 | 28.64 | 42.794 |
| Pr | 0.001 | 4.029 | 4.297 | 5.405 | 9.901 | 4.271 | 3.641 | 4.398 | 3.214 | 4.522 |
| Nd | 0.002 | 11.467 | 17.513 | 21.313 | 36.554 | 15.214 | 14.526 | 17.792 | 11.831 | 15.656 |
| Sm | 0.006 | 1.631 | 3.601 | 4.133 | 7.049 | 2.51 | 2.788 | 3.843 | 2.351 | 2.825 |
| Eu | 0.002 | 0.395 | 1.143 | 1.213 | 2.06 | 0.603 | 0.835 | 1.18 | 0.368 | 0.557 |
| Gd | 0.004 | 1.278 | 2.883 | 3.246 | 5.554 | 1.89 | 2.348 | 3.87 | 1.928 | 2.608 |
| Tb | 0.002 | 0.199 | 0.414 | 0.445 | 0.715 | 0.261 | 0.318 | 0.597 | 0.285 | 0.44 |
| Dy | 0.007 | 1.273 | 2.487 | 2.667 | 3.889 | 1.439 | 1.764 | 3.769 | 1.688 | 2.85 |
| Ho | 0 | 0.294 | 0.532 | 0.558 | 0.761 | 0.272 | 0.327 | 0.778 | 0.344 | 0.617 |
| Er | 0.001 | 1.107 | 1.706 | 1.79 | 2.218 | 0.837 | 0.955 | 2.363 | 1.111 | 2.094 |
| Tm | 0 | 0.193 | 0.237 | 0.252 | 0.294 | 0.123 | 0.128 | 0.323 | 0.166 | 0.315 |
| Yb | 0.002 | 1.528 | 1.631 | 1.685 | 1.878 | 0.846 | 0.811 | 2.133 | 1.15 | 2.231 |
| Lu | 0.001 | 0.272 | 0.254 | 0.27 | 0.281 | 0.126 | 0.12 | 0.309 | 0.17 | 0.335 |
| Hf | 0.003 | 2.633 | 3.371 | 3.701 | 3.987 | 2.495 | 2.653 | 3.451 | 1.89 | 4.149 |
| Ta | 0.001 | 1.091 | 0.791 | 1.213 | 1 | 0.589 | 0.323 | 0.415 | 1.645 | 1.303 |
| Th | 0.01 | 42.461 | 4.882 | 5.864 | 15.9 | 6.178 | 2.801 | 2.989 | 11.412 | 7.614 |

Note: *See* Table 2 for sample descriptions; all analyses done by peroxide fusion ICPMS at Memorial University of Newfoundland; values in ppm poses four samples were collected from the Late Cretaceous Kasalka Group and one sample was collected from the Early to Middle Jurassic Saddle Hill Formation at French Peak. Major oxides were determined by XRF at the Cominco laboratory and trace element determinations were done by aqua regia ICPMS at the Acme Analytical laboratory (Table 3). Additional trace and rare earth element analyses were done by peroxide fusion ICPMS at Memorial University, Newfoundland (Table 4). This data can be compared to the earlier study of Tackaberry (1998) who did detailed petrography and lithogeochemistry of the mid-Cretaceous rhyolite domes north of Old Fort Mountain.

Major oxide analyses indicate that the suspected mid-Cretaceous rhyolites have $SiO_2$ values ranging from 70.61 to 76.5 weight percent. By contrast interbedded Rocky Ridge basaltic flows contain between 47.74 to 54.61 weight percent $SiO_2$ and 0.56 to 0.89 weight percent $TiO_2$. Kasalka Group volcanics are more intermediate in composition with $SiO_2$ values ranging from 59.5 to 62.18 weight percent. A standard AFM ternary plot (Figure 6a) shows the bimodal, calc-alkaline nature of Rocky Ridge basalts and suspected coeval rhyolite domes. On an alkali-silica plot these samples range from alkaline to subalkaline in composition (Figure 6b) and plot in the rhyolite and sub-alkaline basalt to andesite fields of a $Zr/TiO_2$ versus $SiO_2$ diagram (Figure 6c). The major oxide compositions of Rocky Ridge basalts analyzed in this study are similar to those presented in Bassett and Kleinspehn (1996). Likewise, the rhyolite domes analyzed in this study have a similar composition to those analyzed by Tackaberry (1998) north of Old Fort Mountain (Figure 4).

Rhyolite that hosts Ag-Zn-Pb veins at the Cronin and Knoll properties appears to be strongly altered with nearly total removal of Na and Ca (samples 4, 10, 11, Table 3). Likewise, rhyolite dikes at the Fireweed property also appear to be depleted in Na but not Ca (sample 19, Table 3). Previous work by Tackaberry (1998) has also shown that one of the rhyolite domes north of Old Fort Mountain (Figure 4) is strongly quartz-sericite altered with very low Na and Ca concentrations. Interestingly, samples from adjacent domes in this chain do not show evidence of Na or Ca depletion, suggesting alteration intensity varies from dome to dome. Altered rhyolites can also have anomalous concentrations of Pb, Zn, Ag and As (Table 3).

A plot of $K_2O$ versus $Na_2O$ (Figure 6d) clearly distinguishes altered from unaltered rhyolite, with altered samples having very low $Na_2O$ and relatively high $K_2O$ values. K enrichment is interpreted to reflect the presence of sericitic alteration at the expense of Na-rich plagioclase feldspar.

Rare earth element concentrations for basalt and rhyolite were also determined as part of the current study. Chondrite normalized values are plotted in Figure 6e as are those previously determined by Tackaberry (1998). Both basalts and rhyolites, regardless of their degree of alteration, have light rare earth element enrichment whereas rhyolites are also moderately to strongly enriched in heavy rare earth elements relative to the basalts. A notable exception is the rhyolite from Cronin which has a much lower level of light rare earths compared to other rhyolites in this study. The significance of this difference is not known. All of the rhyolites, including the Cronin sample, have moderate to strong Eu depletion consistent with plagioclase fractionation (Tackaberry 1998). The rare earth patterns determined for Rocky Ridge basalts in this study are very similar to those presented in Bassett and Kleinspehn (1996) for compositionally similar rocks.

## DISCUSSION

The focus of the current study was to demonstrate that rhyolite domes similar to those dated in the Babine Lake area occur elsewhere in the Rocky Ridge succession and that these represent local, felsic volcanic centers in a bimodal, submarine volcanic environment that is favourable for the formation of VMS and/or Eskay Creek type subaqueous hotspring deposits. Based on the presence of strong alteration in the host rhyolites as determined by lithogeochemical analyses and the presence of known mineral occurrences, the most favourable areas identified in this study are at the Fireweed, Cronin and Knoll properties (Table 5). Other, less well explored areas such as south of Rocky Ridge and at Troitsa Lake may also prove to be favourable. In all of these areas the rhyolite intrusions appear to be emplaced along ring structures related to the development of large submarine cauldron subsidence complexes. Isotopic dating of the rhyolitic intrusions will help constrain the timing of cauldron subsidence and thus demonstrate or repudiate correlation with Rocky Ridge volcanic rocks elsewhere in the study area.

Several polymetallic Ag-Au bearing mineral occurrences, including the Fireweed, Knoll and Cronin, appear to be spatially and temporally associated with rhyolite intrusions of probable mid-Cretaceous age. These properties have some of the characteristics of subaqueous hotspring deposits of the Eskay Creek type. If these deposits prove to be related to emplacement of rhyolite domes during bimodal Rocky Ridge volcanism then areas underlain by these rocks represent a new and exciting exploration target for this type of deposit in central British Columbia.

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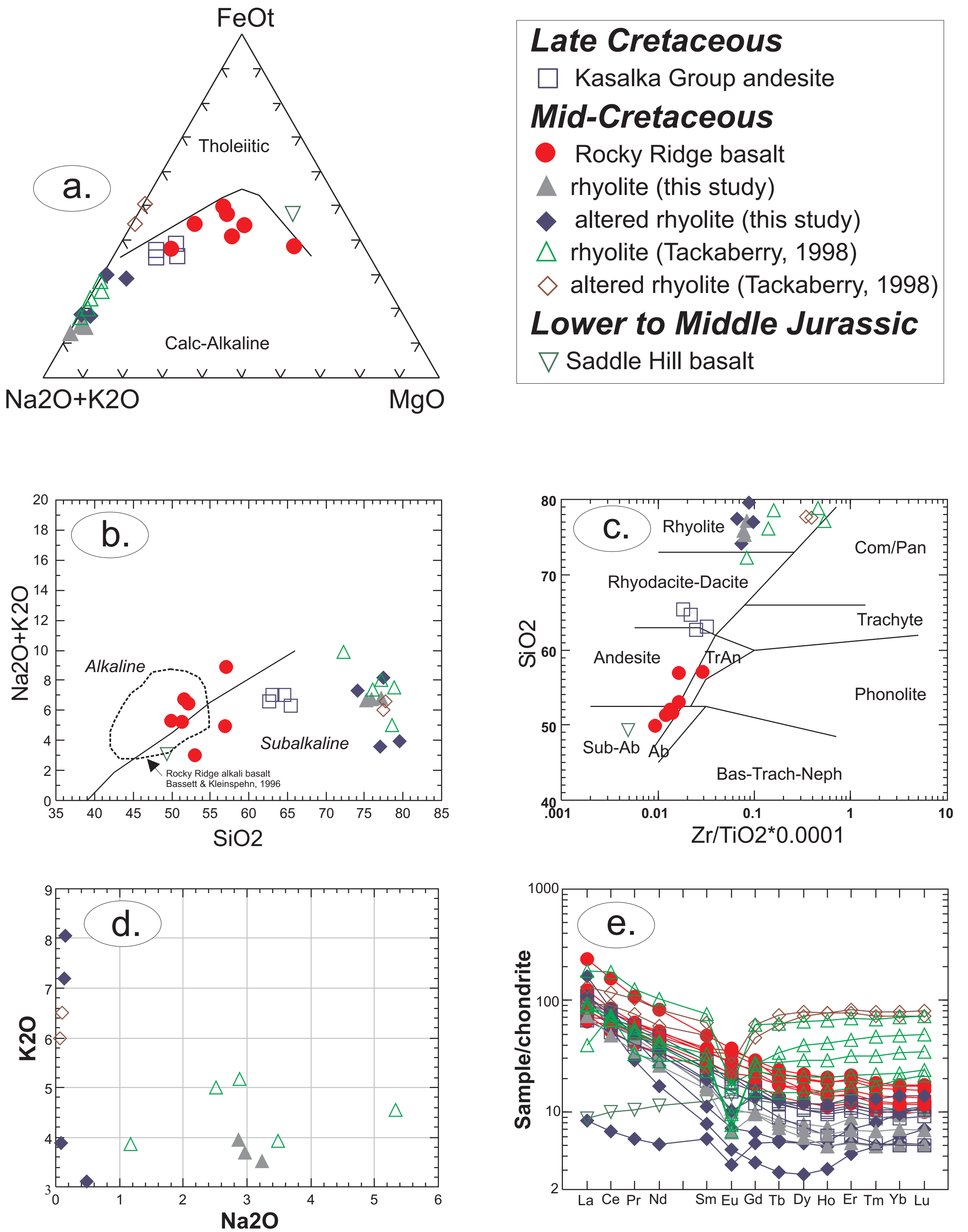


Figure 6. a. AFM ternary plot showing calc-alkaline nature of Rocky Ridge and Kasalka volcanic rocks; b. alkali-silica plot showing subalkaline to alkaline compositional trend; c. SiO2 versus Zr/TiO2 plot showing compositional range and classification of Rocky Ridge volcanic rocks and rhyolite domes; d. K20 versus Na2O plot showing Na depletion of altered rhyolite samples; e. plot of chondrite normalized rare earth element abundances for Rocky Ridge basalts and rhyolites.

**TABLE 5**
**SUMMARY OF TARGET AREAS EXAMINED IN 2000**

| Rank | Area | Description | Mineralization | Alteration | Commodities | Exploration |
|---|---|---|---|---|---|---|
| 1 | Fireweed property (093M 151) | Rhyolite dikes intrude conglomerate, sandstone and siltstone of the Skeena Group; probable age of dikes is mid-Cretaceous; volcanics in area are probably part of Rocky Ridge formation | c.gr., massive py-po and lesser sph, gn, cpy in breccias zones; f.gr. py, marcasite, sph, gn and tetrahedrite as interstitial dissem. in coarse sediments; massive, f.gr. banded py, po, sph, gn in sediments; massive stockwork veins in rhyolite dikes | Rhyolite dikes are altered. Lithogeochemistry shows Na depletion but not Ca depletion. Strong Mn oxide staining in sedimentary rocks. Alteration minerals include quartz, ankerite, sericite, chlorite and kaolinite. | Zn, Pb, Cu, Ag; anomalous Au | Extensively drilled but still much untested ground |
| 2 | Suskwa R. Knoll property (093M 100) | Rhyolite dome intrudes graphitic black mudstone and argillite of the Skeena Group; rhyolite is probably mid-Cretaceous in age | Disseminations and veinlets of py, sph and gn in rhyolite breccia and lapilli tuff; fracture controlled py, pyrrhotite and arsenopyrite associated with quartz and calcite. | Rhyolite is extensively altered to sericite with disseminated pyrite and manganese staining; lithogeochemistry shows strong Na and Ca depletion in rhyolite. | Pb, Zn, As with anomalous Ag and Au | 7 holes totaling 978 metres. |
| 3 | Mt. Cronin (093L 127) | Multi-phase rhyolite dome intrudes graphitic argillite, siltstone and conglomerate of the Skeena Group; rhyolite is probably mid-Cretaceous in age | Massive sulphide lenses and quartz vein stockworks containing argentiferous gn, sph, tetrahedrite, minor py and cpy; boulangerite, freibergite and arsenopyrite also present; mineralization occurs in rhyolite and to lesser extent surrounding sediments. | Rhyolite is extensively altered to sericite, calcite, zoisite and chlorite; lithogeochemistry indicates strong Na and Ca depletion near contact with sediments. | Ag, Pb, Zn, Au, Cu, Cadmium | Past producer; extensive underground workings |
| 4 | French Peak (093M 015) | Dacite, andesite and rhyolite of probable Lower to Middle Jurassic age cut by mineralized shear zones; near top of Saddle Hill stratigraphic succession. | quartz-siderite veins with tetrahedrite, argentiferous gn, cpy, sph and py in shear zones; banded cpy, tetrahedrite and pyrite in bedded rhyolite tuff | Carbonate and sericite alteration in rhyolitic rocks; manganese, clay and silica alteration associated with veins in shear zones; local strong K alteration in tuff. | Ag, Cu, Au, Pb, Zn; anomalous As, Sb | Developed prospect with open cuts, some drilling |
| 5 | Old Fort | Arcuate chain of rhyolite domes emplaced into graphitic tuffaceous sediments of the Skeena Gp. | non known | One rhyolite dome in chain has strong sericite-pyrite alteration; lithogeochemistry indicates strong Na and Ca depletion | | No significant exploration |
| 6 | Fort Babine | Rhyolite domes and breccia bodies emplaced into mudstone and siltstone containing Albian fossils | non known | unknown | | Some exploration in past |
| 7 | Rocky Ridge | Large rhyolite dike intrudes Skeena Group sedimentary rocks | non known | Lithogeochemistry at one site does not show evidence of alteration | | No significant exploration |
| 8 | Beament | Angular rhyolite clasts in Skeena Group conglomerate | non known | some strong clay alteration associated with fault zones | | Some exploration in past |
| 9 | Troitsa Lake | Large rhyolite dike along shores of Troitsa Lake; dike possibly mid-Cretaceous in age. | non known | Lithogeochemistry at one site does not show evidence of alteration | | No significant exploration |
| 10 | Mt. Ney | Predominantly basalt. No felsic component observed | some interstitial gn and sph in conglomerate higher in section | Chlorite alteration of basalt | | Some exploration in past |
| 11 | Nilkitkwa River | Predominantly basalt. No felsic component observed | | Chlorite alteration of basalt | | No significant exploration |

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