BRITISH COLUMBIA

Ministry of Energy and Mines
Energy and Minerals Division
Geological Survey Branch

GEOLOGY OF THE FORREST KERR- MESS CREEK AREA, Northwestern British Columbia (NTS 104B/10, 15 & 104G/2 & 7W)

**By James M. Logan, P.Geo,
John R. Drobe and William C. McClelland**

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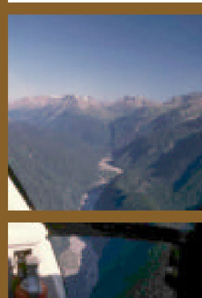

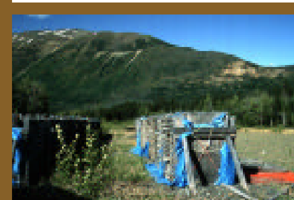

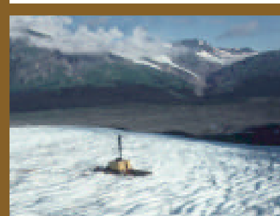

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GEOLOGY OF THE FORREST KERR-MESS CREEK AREA, NORTHWESTERN BRITISH COLUMBIA (NTS 104B/10, 15 & 104G/2 & 7W)

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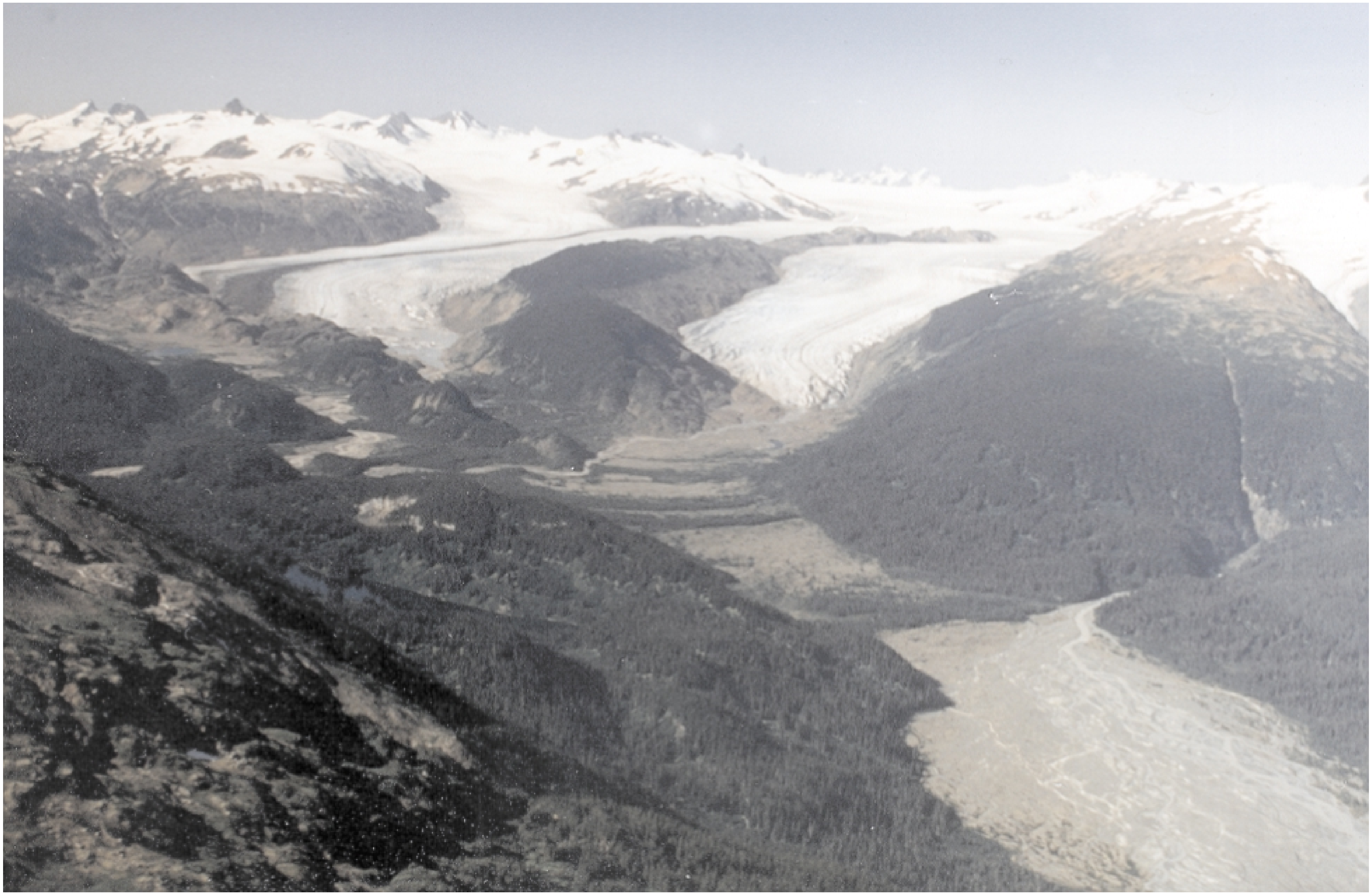

Frontispiece: View west up the Andrei Glacier.

SUMMARY

The Forrest Kerr-Mess Creek map area straddles the boundary between the Intermontane and the Coast belts in northwest British Columbia. This region is underlain by rocks comprising the western boundary of the Stikine Terrane(Stikinia). At this latitude Stikinia consists of well stratified, middle Paleozoic to Mesozoic sedimentary rocks and volcanic and comagmatic plutonic rocks of island-arc affinity which include: the Early Devonian to Permian Paleozoic Stikine assemblage, the Late Triassic Stuhini Group and the Early Jurassic Hazelton Group. These are overlapped by Middle Jurassic to early Tertiary successor-basin sediments of the Bowser Lake and Sustut Groups, Late Cretaceous to Tertiary continental volcanic rocks of the Sloko Group, and Late Tertiary to Recent bimodal shield volcanism of the Edziza and Spectrum ranges. Warm-spring, tufa deposits forming in the Mess Creek valley attest to areas of dynamic geological evolution in modern day.

Polyphase deformation affects rocks that are older than Late Cretaceous, and crustal scale faults affect rocks in the area as young as Tertiary. Early and middle Devonian rocks within the map area have been subjected to up to four phases of folding and deformation. Mid-Carboniferous to Early Permian rocks record as few as two phases of deformation, whereas the Late Triassic and Jurassic strata record no more than two phases of deformation in addition to a regionally important post-Norian unconformity. Mid-Devonian, northeast-verging D_1 structures correspond to a northern Cordilleran-wide event correlative with the Antler Orogeny of the southwest U.S. and Ellesmerian Orogeny in the arctic. Pre-Norian, Permo-Triassic (Tahltanian Orogeny) D_2 deformation was accompanied by upper greenschist facies metamorphism. Early Jurassic, D_3 (circa 185 Ma) deformation broadly warped and folded the rocks into upright, open structures. Late Jurassic to Tertiary contraction (D_4), produced northeast-verging structures related to development of the Skeena Fold and Thrust Belt. The youngest structures record east-west extension and northerly translation, thought to post date the Eocene.

The Late Paleozoic and Mesozoic volcanic and plutonic rocks within the map area are characterized by metal deposits related to island-arc volcanic centres. Mineral production is not recorded within the map area although large copper, gold and molybdenum mineral resources are defined for porphyry deposits at Schaft Creek (971 495 000 tonnes grading 0.298 %Cu, 0.033 % MoS_2, 0.14 g/t Au and 1.20 g/t Ag; Spilsbury, 1995) and Galore Creek (Central zone: 233 900 000 tonnes grading 0.67 %Cu, 0.35 g/t Au and 7.0 g/t Ag; Enns *et al*., 1995). Mineral occurrences and prospects in the Forrest Kerr - Mess Lake area can be grouped into four main categories: calcalkaline Cu-Mo-Au and alkaline Cu-Au porphyries; Cu and Cu-Au skarns; subvolcanic Cu-Ag-Au (As-Sb) fault and shear-hosted veins and carbonate hosted replacement; and, stratiform volcanogenic massive sulphide and carbonate hosted (?Irish-type) Zn-Pb-Ag deposits. Mineral occurrences, within the map area, display (except stratiform types) a direct correlation with north and northeast striking faults and Late Triassic to Early Jurassic intrusive rocks.

TABLE OF CONTENTS

APPENDICES

TABLES

MAP

FIGURES

PHOTOS

CHAPTER 1 INTRODUCTION AND REGIONAL GEOLOGY

LOCATION AND ACCESS

The Forrest Kerr Creek, More Creek and Mess Creek map areas comprise a 3 000 km^2 area, which is located east of the Coast Mountains, between Iskut River and Mess Lake, approximately 100 kilometres southeast of Telegraph Creek in northwestern British Columbia (Figure 1-1). The large tonnage Schaft Creek calcalkaline porphyry copper-gold-molybdenum deposit is located within the area mapped. The three map sheets, 104B/15 and part of 104B/10, 104G/2 and 104G/7W, lie between latitudes 56°40 and 57°30 north, and longitudes 130°30 and 131° 00 west. Results of regional mapping and sampling carried out between 1989 and 1992 are summarized here. This report and accompanying map incorporates new data and revisions to the 1:50 000 geology and mineral occurrence maps, Open File 1990-2, Open File 1992-1 and Open File 1993-6. The focus of the project was to produce detailed geological maps and a database to better understand the geological setting of the mineral deposits in the area between Forrest Kerr and Mess Creek areas and aid in making new discoveries.

The area mapped is located along the western margin of the Intermontane Belt, adjacent to the high-relief mountains of the Coast Belt. Topography is rugged, typical of mountainous and glaciated terrain with numerous snowfields and radiating glaciers. Elevations range from 100 metres on the Iskut River flood plain to over 2662 metres atop Hankin Peak in the More Creek area. Permanent icefields and alpine glaciers cover approximately one-third of the Forrest Kerr map area, less of the More Creek area, and only small isolated areas in the Mess Creek area. The map area covers two physiographic regions, the high, rugged Boundary Ranges, on the southwest and the more subdued Tahltan Highlands which cover the area east of Mess Creek and north of More Creek (Holland, 1976). West of the map area, the Coast Mountains are covered by large icefields, remnants of the Quaternary ice sheet, which feed glaciers descending north and eastward into the headwaters of the Forrest Kerr Creek (frontispiece). The Andrei Glacier is one of the larger, approximately 2 kilometres wide and terminates at an elevation of less than 600 metres. North in the More Creek area the More glacier carries both medial and lateral moraines which merge to cover the ice completely. Natavas and Alexander glaciers are somewhat smaller than Andrei Glacier; Matthew Glacier is a large ice sheet which covers the high peaks south and east of Hankin Peak.

The Iskut north project area is wholly contained within the drainage basin of the Stikine River. The south and eastern areas drain southward into the Iskut River; the west and northern areas drain northward into Schaft and Mess creeks. Both are tributaries of the Stikine River, the Iskut River is it's largest and forms the south boundary to the map area. The Iskut River occupies a broad, one to two kilometre wide steep-sided valley for the most part, which flows east crossing the structural grain of the Coast Belt and joins the Stikine approximately 50 kilometres upstream from it's mouth. Near the confluence of Forrest Kerr Creek the Iskut is confined to a narrow canyon for approximately 20 kilometres, where it has eroded through 10 metres of Recent basalt flows in the last 3600 to 3800 years (B.C. Hydro, 1985, *in* Hauksodottir *et al.*, 1994). Physiography of the Stikine valley varies from mature, broad steep-walled to youthful canyons over its length from its source on the Stikine Plateau to where it discharges into Frederick Strait near Wrangell, Alaska. Northeast of Telegraph Creek the steep-walled "Grand Canyon" is a post-Tertiary drainage feature. Pre-Quaternary, the river may have flowed southwesterly from the head of this canyon, rejoining the present lower Stikine valley near the mouth of Mess Creek, or have been diverted into the Iskut valley (Kerr, 1948a, Mathews, 1991). In the Flood Glacier area the river occupies a broad, mature valley 3 to 4 kilometres wide. During high water, material carried into the Stikine from tributary streams exceeds the river budget and the river aggrades its channel. The result is a sinuous braided river of constantly shifting bars and channels (Souther, 1972). The Sphaler Creek area drains northward through the valleys of Galore Creek and the South Scud River into the west-flowing Scud River, a tributary of the Stikine River and westward down Sphaler Creek into the Porcupine River which joins the Stikine 9 kilometres west of Mount Scotsimpson. The north-trending drainages occupy fault-controlled valleys. Similar structures control the Mess and Iskut valleys farther east.

Historically the Stikine River and its tributaries provided access through the Coast Mountains into the interior of the province. One of the main routes to the Klondike and Atlin Lake discoveries of 1896 and 1898 was up the Stikine to Telegraph Creek, then overland to Teslin or Atlin Lake (Kerr, 1948a). Paddle-wheel riverboats navigated between tidewater at Wrangell, Alaska as far upstream as the Stikine Canyon at Telegraph Creek until the late 1960s. Fixed-wing aircraft fly charters from Smithers, Dease Lake and Telegraph Creek to the Bronson airstrip located 25 kilometres west at the Snip Mine. A gravel airstrip is located at Schaft Creek and a third, though shorter gravel strip is located at the headwaters of Forrest Kerr Creek. Access to the remaining areas is by helicopter. During summer field seasons in the past, helicopters have been stationed at Galore Creek, Scud strip, Forrest Kerr strip and Bronson strip. A helicopter base is located 80 kilometres to the southwest at Bob Quinn Lake and 150 kilometres north at Dease Lake. With the development of the Eskay Creek deposit into one of the highest grade gold and silver producing mines in the country, an all weather gravel road was constructed in 1994 linking the

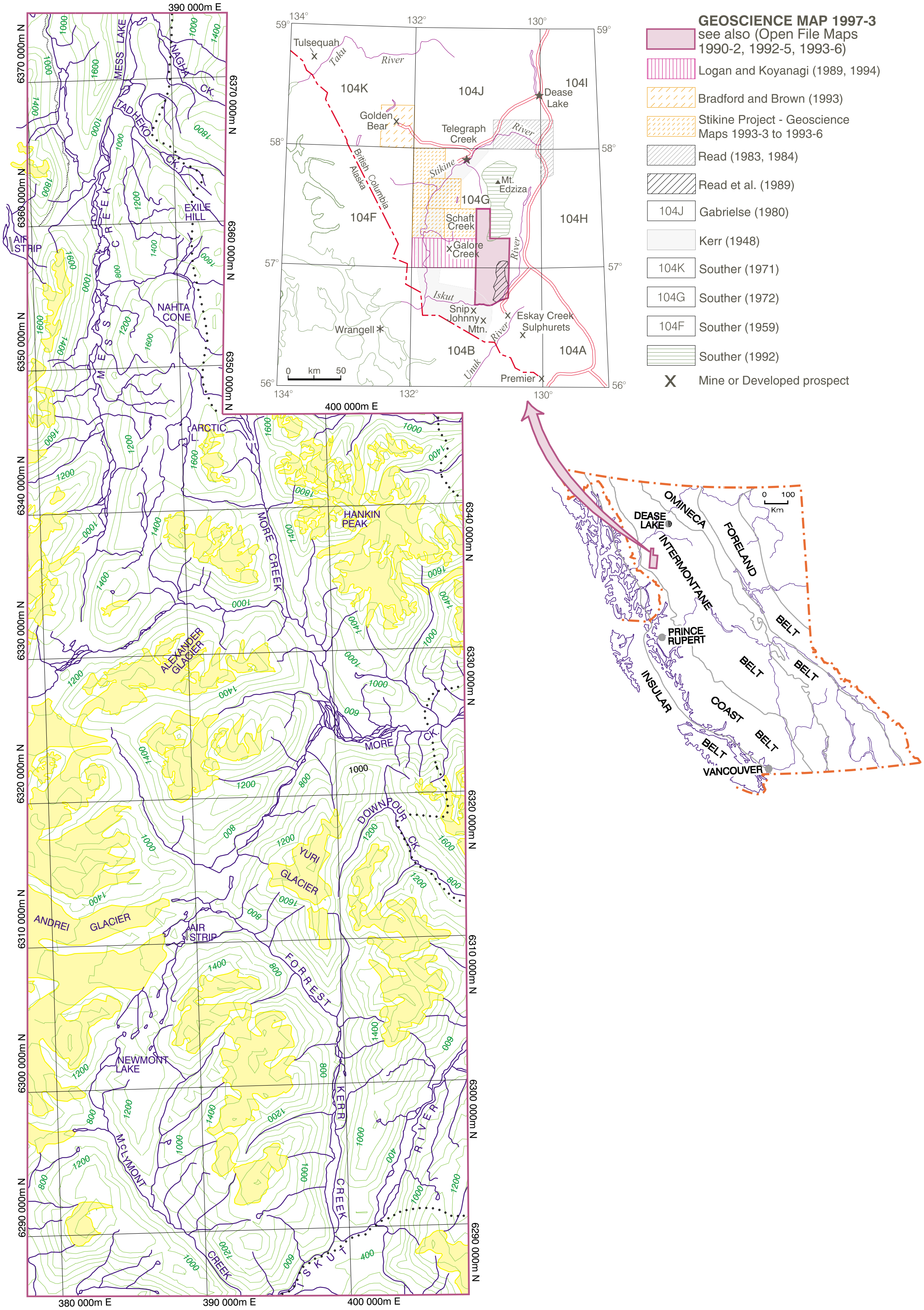

Figure 1-1. Location map showing compilation sources and previous work and the physiography of the map area.

mine to the highway and providing access to the southeastern corner of the study area.

Wrangell, Alaska located on tidewater 90 kilometres to the southwest, provides commercial air connections to Anchorage, Alaska or Seattle, Washington. Between 1991 and mid- 1996 Cominco Ltd. operated a hovercraft between Wrangell and the Bronson air strip on the Iskut River, 30 kilometres south of the map area.

HISTORY OF EXPLORATION

The first recorded mineral assessment of the area was conducted by a group of Russian geologists who explored along the Stikine River in 1863 (Alaska Geographic Society, 1979). Placer gold was mined from bars on the Stikine River a short distance south of Telegraph Creek and later production is recorded from the Barrington River, during the late 1800s and early 1900s. Exploration for lode deposits began in the 1900s along access corridors provided by the Stikine River and its tributaries. Hudson Bay Mining and Smelting Company Limited initiated prospecting in the more remote parts of the Galore Creek map area in 1955, using helicopter-supported field parties. Discovery of the Galore Creek porphyry copper deposit in 1955 was a direct result of this program and focused porphyry exploration activity on the area. The Schaft Creek (Liard Copper) deposits were staked in 1957. The recent resurgence of mineral exploration in the map area has been in response to its geological similarities with the Sulphurets, Iskut and Golden Bear gold camps. Mining and exploration companies active in the map area during the fieldwork included Pamicon Development Limited (Forrest claims), Cominco Ltd. (Foremore), Noranda Exploration Company Limited (GOZ/RDN and Lucifer), Gulf International Minerals Limited (McLymont-NW), Kestrel Resources (Tic-Arc-Mon) and Keewatin Engineering Ltd. (Little Les - Arctic claims).

PREVIOUS GEOLOGICAL WORK

Forrest Kerr carried out the first geological mapping along the Stikine and Iskut rivers from 1924 to 1929, but it was not until 1948 that his data were published (Kerr, 1948a, b). Kerr proposed the original Permian and pre-Permian subdivision of Paleozoic strata, and from his work in the Taku River valley of the Tulsequah map area, he defined the Late Triassic Stuhini Group, much of which underlies the current study area. In 1956, a helicopter-supported reconnaissance of the Telegraph Creek map area was conducted by the Geological Survey of Canada (1957, Operation Stikine). Other work by the Geological Survey of Canada (Figure 1-1) includes that of Souther (1971, 1972, 1988, 1992), Monger (1970, 1977a) and Anderson (1984, 1989). Jack Souther masterminded Operation Stikine and produced 1:250 000-scale geological maps of the Telegraph Creek sheet (104G), Tulsequah sheet (104K) and 1:50 000-scale detailed studies of Mount Edziza (1988, 1992). James Monger (1977a) further subdivided the late Paleozoic rocks and informally named them the Stikine assemblage. Robert Anderson's work includes studies to the north on the Hotailuh (1983) and Stikine batholiths (1984) and, more recently, a 1:250 000-scale geological map of the Iskut River area (Anderson, 1989). Peter Read has conducted regional mapping for the Geological Survey of Canada in the Stikine Canyon area (Read, 1983) and feasibility studies for B.C. Hydro in the Forrest Kerr Creek area (Read *et al.*, 1989).

Regional metallogeny studies and mapping by D.J. Alldrick, J.M. Britton and others of the British Columbia Geological Survey Branch have covered the Sulphurets, Unuk River and Snippaker areas to the south (Alldrick and Britton, 1988; Alldrick *et al.*, 1989, 1990). To the west, A. Panteleyev carried out mapping in the immediate area of Galore Creek, in conjunction with a study of the deposit between 1973 and 1975 (Panteleyev, 1973, 1974, 1975, 1976, 1983). Geological mapping was completed at 1:50 000 scale in the Galore Creek area (Sphaler Creek and Flood Glacier map sheets) in 1988 (Logan *et al.*, 1989; Logan and Koyanagi, 1995). Concurrent British Columbia Geological Survey projects have completed 1:50 000 scale map coverage north and west of the Iskut-north project area in the Scud River, Yehiniko Lake, Chutine River and Tahltan Lake map areas (Brown *et al.*, 1996).

Further descriptions of the geology and mineral prospects within the area can be found in various Annual Reports of the British Columbia Minister of Mines dating from the early 1900s and assessment reports on file with the Ministry of Energy, Mines and Petroleum Resources.

ACKNOWLEDGMENTS

We wish to acknowledge contributions from many people regarding various aspects of this study. Victor Koyanagi contributed a field season mapping in the Forrest Kerr area (1989) and two weeks reconnaissance mapping and sampling in 1990. He provided sound data and insights to the geology of the area and his contributions are gratefully acknowledged. Discussions with Dave Lefebure, Mitch Mihalynuk, Andre Panteleyev, Gerry Ray and Derek Brown of the British Columbia Geological Survey and Bob Anderson of the Geological Survey of Canada were important at the inception stage and ongoing phases of the study and are much appreciated. Capable and enthusiastic assistance throughout the 1989 field season was provided by Gabriel Viehweger, and by Darren Elsby and James Gough during the 1991 field season. The cooperation, logistical support and free discussion of geological ideas by various mineral exploration companies made this study possible from its earliest stage. These people and companies include: Ian Paterson and Mike Westcott of Cominco Ltd.; Wayne Spilsbury and Andy Betmanis of Teck Exploration Ltd.; Steve Todoruk and Mike Stammers of Pamicon Developments Limited; Mike Savell and Rob Berg of Noranda Exploration Company Limited; Henry Awmack and David Caulfield of Equity Engineering Ltd.; and David Blann of Coast Mountain Geological Ltd.

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W.J. McMillan reviewed an earlier version of this manuscript and suggested improvements. V. Vilkos of the Geological Survey Branch drafted many of the figures and facilitated production of the Geoscience Map.

REGIONAL GEOLOGY

TECTONIC SETTING

The study area (Figure 1-2) straddles the boundary between the Intermontane Belt and the Coast Belt and is underlain mainly by rocks of the Stikine Terrane (Stikinia), the westernmost terrane of the Intermontane Superterrane. Stikinia is the largest of the allochthonous terranes. Like other terranes of the North American Cordillera, its pre-Jurassic geological history, paleontological and paleomagnetic signatures are unique. They have been interpreted to indicate that it originated far removed from the margin of ancestral North America (Gabrielse *et al.*, 1991) and was amalgamated with the Cache Creek, Quesnel and Slide Mountain terranes prior to accretion to the North American craton (Figure 1-2). Recent studies suggest that the Stikine terrane developed adjacent to the ancestral margin of North America (McClelland, 1992; Mihalynuk *et al.*, 1994).

Stikinia's outboard (western) position relative to the Cache Creek Terrane in British Columbia is an enigma (Monger, 1977b). Wernicke and Klepacki (1988) proposed that Stikinia and Quesnellia are segments of a single arc generated by Mesozoic subduction of the Cache Creek Terrane, which through subsequent collision with Wrangellia and complex dextral movement, produced the present configuration. The result is a doubling up of the arc terranes, with Stikinia separated from Quesnellia, by the Cache Creek Terrane. Geological studies in southeastern Alaska (Gehrels *et al.*, 1990; Rubin and Saleeby, 1991) and northwestern British Columbia (Gareau, 1991; McClelland 1992) correlate metamorphic rocks west of and within the Coast Belt with rocks of the Yukon-Tanana Terrane. As well, McClelland and Mattinson (1991) and McClelland (1992) suggest that parts of the Paleozoic Stikine assemblage are correlative with and depositionally tied to Paleozoic rocks of the Yukon-Tanana Terrane. Depositional ties between the Quesnel and Yukon-Tanana terranes are also known and this together with the hook-like geometry of the

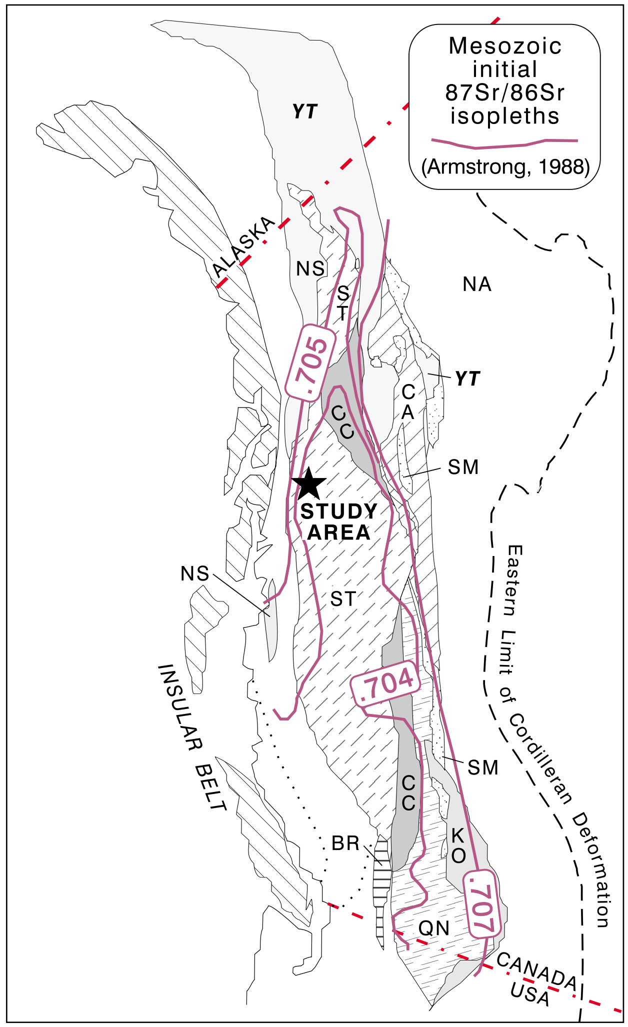

Figure 1-2. Terrane map showing tectonostratigraphic setting of the study area. Mesozoic initial strontium isopleths from Armstrong (1988). NA=Ancestral North America, CA=Cassiar, NS=Nisling, KO=Kootenay, SM=Slide Mountain, QN=Quesnellia, CC=Cache Creek, ST=Stikinia, BR=Bridge River, YT=Yukon Tanana (modified from Wheeler and McFeely, 1991).

0.706 initial 87Sr/86Sr line around the northern end of Stikinia (Figure 1-2) led Nelson and Mihalynuk (1993) to propose a single arc model consisting of the Quesnel, Yukon Tanana, Nisling and Stikine terranes. Neodymium isotope studies (Samson *et al.*, 1989) suggest the Stikine Terrane in the Iskut River area comprises juvenile (Phanerozoic) crustal material that evolved in an intra-oceanic environment with no continental detrital influences. Diverse isotopic signatures may reflect construction of a late Paleozoic arc that was transitional across continental slope deposits to distal intra-oceanic settings, a modern analog being the Aleutian arc of western Alaska.

Mihalynuk *et al.* (1994) envisage the Late Triassic arc to have subsequently been deformed into an orocline that encloses the Cache Creek Terrane. The orocline closed by

Middle Jurassic time, after which emplacement of Quesnellia onto North America began (Gabrielse and Yorath, 1991; Murphy *et al.,* 1995). These models use geological, faunal, isotopic and paleomagnetic data that are not always consistent but are compatible with each model.

The major tectonic elements of the northern Intermontane Belt include the Bowser Basin and the northeast-trending Stikine Arch. The Forrest Kerr - Mess Creek area is within the Stikine Arch. The Bowser Basin is confined between the Stikine and Skeena arches, rests on Stikinia and consists of marine and non marine clastic rocks. It is a Middle Jurassic to Middle Cretaceous successor basin, initiated during amalgamation of the Intermontane Superterrane (Ricketts *et al.*, 1992). Overlying all the older rocks, the Cretaceous to Tertiary Sustut Group records fluvial and alluvial fan deposition derived initially from the east (Omineca Belt) and later from the west (Stikinia and the Coast Belt). The Coast Plutonic Complex intrudes the western boundary of the Stikine Terrane. It is a long and narrow magmatic belt that extends the length of the Canadian Cordillera and is, comprised predominantly of calcalkaline granitoid rocks of Jurassic to Paleogene age. Cooling ages and uplift history are complex across the belt. Plutonic rocks of the Coast Belt are mid-Cretaceous and older on the west side of the belt and mainly Late Cretaceous and Tertiary on the east. In the study area, which is on the east (Figure 1-3), voluminous postorogenic Tertiary bodies obscure the western margin of Stikinia. Eocene Sloko Group continental volcanic rocks erupted from centres located north and northwest of the study area.

At this latitude Stikinia consists of well stratified middle Paleozoic to Mesozoic sedimentary rocks and volcanic and comagmatic plutonic rocks of probable island arc affinity which include: the Paleozoic Stikine assemblage, the Late Triassic Stuhini Group and the Early Jurassic Hazelton Group. These are overlapped by Middle Jurassic to early Tertiary successor-basin sediments of the Bowser Lake and Sustut Groups, Late Cretaceous to Tertiary continental volcanic rocks of the Sloko Group, and Late Tertiary to Recent bimodal shield volcanism of the Edziza and Spectrum ranges.

REGIONAL STRATIGRAPHY

Rocks of the Stikine assemblage are the structurally and stratigraphically lowest supracrustal rocks observed in the Forrest Kerr - Mess Creek area. Stikine assemblage rocks were informally named by Monger (1977b) to include all upper Paleozoic rocks (within Stikinia) which cropped out around the periphery of the Bowser Basin. The assemblage consists of Permian, Upper Carboniferous, Lower Carboniferous and Devonian age (using the geological time scale of, Harland *et al.*, 1990) rocks. The dominant lithologies are tholeiitic to calcalkaline, mafic and bimodal flows and volcaniclastics, interbedded carbonate, minor shale and chert (Table 1-1). The Permian carbonates and volcanics are a distinctive part of the Stikine assemblage, traceable for over 500 kilometres from north of the Stikine River to south of Terrace. Correlative Permian strata east of the Bowser Basin are assigned to the Asitka Group, a name

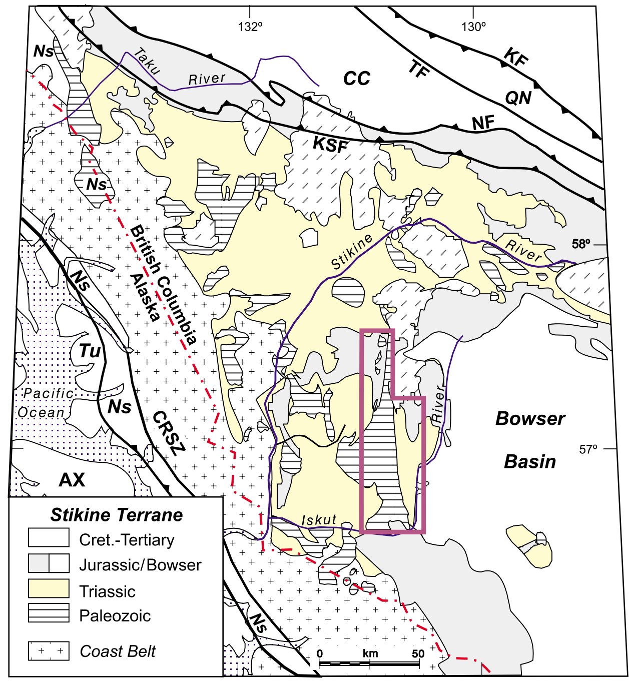

Figure 1-3. Location of study area relative to the major tectonostratigraphic features of the northwestern Cordillera and regional distribution of Paleozoic, Triassic, Jurassic and Cretaceous-Tertiary rocks of Stikinia (modified from Wheeler and McFeely, 1991). AX=Alexander Terrane, TU=Taku Terrane, Ns=Nisling Terrane, CC=Cache Creek Terrane, QN=Quesnellia, CRSZ=Coast Range Shear Zone, KSF=King Salmon Fault, NF=Nahlin Fault, TF=Thibert Fault, KF=Klinkit Fault.

applied to all Paleozoic strata in Stikinia (Wheeler and McFeely 1991).

Unconformably overlying the Stikine assemblage are Lower to Middle Triassic sedimentary and Upper Triassic volcanic rocks. Similar Upper Triassic volcanic rocks are exposed the length of the Canadian Cordillera. Across the northern end of the Intermontane Belt there is little difference in age, lithology or chemistry of the Triassic strata from one tectonostratigraphic terrane to the next (*i.e.*, between Takla and Stuhini). Unconformities separate the Upper Triassic Stuhini Group, which is mainly submarine volcanic rocks, from the Jurassic Hazelton Group which is mainly subaerial volcanic and sedimentary rocks in the map area. Rocks of the Hazelton Group encircle the northern Bowser Basin inboard (basinward) of the Upper Triassic Stuhini volcanic arc (Figure 1-3). The Hazelton Group consists of a lower sequence of intermediate flows and volcaniclastics, a middle felsic volcanic interval and an upper unit of sedimentary and submarine bimodal volcanic rocks.

The pre-amalgamation Paleozoic and Mesozoic volcanic archipelagos, carbonate platforms and related clastic basins are overlapped by Middle Jurassic to Upper Cretaceous and Lower Tertiary successor basin sediments of the Bowser Lake and Sustut groups respectively, and

TABLE 1-1
TABLE OF FORMATIONS

ERA	PERIOD	GROUP OR FORMATION	MAP UNIT	LITHOLOGY	THICKNESS (metres)		INTRUSIVE SUITES
QUAT	RECENT		Qt Qob Qal	tufa deposits olivine basalt unconsolidated glacial till	10-20		basaltic dikes
	PLEISTOCENE	BIG RAVEN FORMATION	Qb	olivine-plagioclase-augite basalt	10-20		basaltic dikes
TERT	PLIOCENE	SPECTRUM FORMATION	TSr	leucocratic peralkaline rhyolite	? ?		
		NIDO FORMATION	TNb	aphyric and olivine-phyric basalt subaerial flows, intercalated fluvial gravel			
MESOZOIC	LATE CRETACEOUS	**SUSTUT GROUP**	uKSs	conglomerate, quartzose sandstone, arkose	?		
	MIDDLE JURRASIC TO CRETACEOUS	**BOWSER LAKE GROUP**	JBp JBcg	greywacke, shale, minor cross bedded sandstone chert pebble to granule conglomerate	500	2000	diabasic-diorite (**MJdi**) Yehiniko Pluton monzonite (**MJmz**),
	EARLY TO MIDDLE JURASSIC	**HAZELTON GROUP**	Jw mJHsl mJHb lJHv lJHr lJHsn lJHsl	brecciated and fractured dark green siliceous siltstone siltstone, sandstone, minor tuff pillow basalt purple, maroon, and green andesite felsic welded ash-flow tuff, rhyolite flows tan sandstone, plagioclase-crystal tuffs, peperite graphitic siltstone	1000-2000		Monzonite (EJmz) and granite (EJg) stocks, augite-plagioclase diorite plugs and dikes
	LOWER JURASSIC		lJcg	thick well-bedded conglomerate	200-300		
	UPPER TRIASSIC	**STUHINI GROUP** NEWMONT LAKE facies	uTrS uTrSvt uTrvr uTrSl uTrSva uTrSpp	undivided volcanics plagioclase crystal tuff pink flow-layered rhyolite algal limestone hornblende-plagioclase phyric andesite thick plagioclase-pyroxene porphyry flows, interbedded tuff	400		Hornblende-plagioclase porphyry (**LTrmz**); Pyroxene diorite (**LTrpp**, **LTrpd**), syenite (**LTrs**), hornblende diorite (**LTrHd**) and periodotite (**LTrum**)
		MESS LAKE facies	uTrSvt uTrSvb uTrSmt uTrSv	massive pale weathering crystal tuff, lapilli tuff massive basalt flows and tuff serpentinized basaltic tuff pale green grey tuffs, minor basalt flows	800		
		MORE CREEK facies	uTrSs uTrSc uTrSsn uTrSsl	thick poorly bedded sandstone grey sparsely crinoidal limestone well bedded feldspathic sandstone thin laminated black siltstone	1500		
	EARLY - MIDDLE TRIASSIC		mTrs	thin bedded chert, siltstone	>15		
PALEOZOIC			PSu	undivided metavolcanic and metasedimentary rocks	?		
	EARLY PERMIAN	STIKINE	lPSc lPSdt	medium bedded to massive fossiliferous carbonate deformed tuff	<200		
	CARBONIFEROUS		CSst	phyllitic siltstone, graphitic argillite, tuffaceous phyllite			
	UPPER CARBONIFEROUS TO LOWER PERMIAN		uCSc uCSr uCSmv uCSb uCScg uCSss	massive and foliated limestone, chert, siltstone mauve to grey, flow-layered and spherulitic rhyolite maroon tuff and lapilli tuff, ash-flow tuff massive amygdaloidal basalt volcanic conglomerate siltstone, sandstone, tuffaceous wacke	500-1000		
	MID CARBONIFEROUS		mCSc	bioclastic limestone	200		
	DEVONIAN TO EARLY MISSISSIPPIAN		DMSv DMSvr	pillow basalt - andesite, hyaloclasite and breccia rhyodacite flow breccia, tuff and subvolcanic intrusives	>2000-3000		**More Creek Pluton:** **Forrest Kerr Pluton:**
	LOWER AND MIDDLE DEVONIAN		lmDSfv lmDSc lmDSs lmDSst lmDSqs lmDSgs	intermediate to felsic plagioclase-phyric tuffs deformed thin-bedded to massive limestone thin-bedded siltstone, sandstone and argillite green and purple schistose tuffs quartz sericite schist graphitic schist			biotite granite (LDg/EMg), hornblende diorite (LDd/EMd), gabbro, hornblendite, clino-pyroxenite (LDum) pyroxene diorite (EDd)

north-trending Late Cretaceous to Tertiary continental volcanic rocks of the Sloko Group. (Figure 1-3).

Neogene to Recent volcanic rocks comprise the 700 km^2 bimodal Mount Edziza volcanic complex that is situated north and east of the study area (Souther, 1992) and the volcanic centre located at Hoodoo Mountain, which is located to the southwest on the Iskut River (Edwards and Russell, 1994). Related Pliocene basalt flows also mantle the Iskut River valley bottom near the junction with Forrest Kerr Creek (Read *et al.*, 1989). The alkaline volcanic rocks are byproducts of continental rifting related to north-trending, deep-seated (lower crustal) structures which tapped mantle-derived magmas.

REGIONAL PLUTONISM

Workers in the area recognize at least seven discrete plutonic episodes: Late Devonian, Early Mississippian, Middle(?) to Late Triassic, Late Triassic to Early Jurassic, late Early Jurassic, Middle Jurassic and Eocene in the Stewart-Iskut-Stikine area of northwestern Stikinia (Figure 1-4). These distinctions are based on detailed work by Anderson (1989), Anderson and Bevier (1990), Brown and Gunning (1989a), Holbek (1988), McClelland *et al.* (1993) and others. In a gross sense these episodes young westward, suggesting the magmatic front migrated westward in time from the Forrest Kerr pluton to the Coast Belt. Missing from this part of northwestern Stikinia are the three episodes of plutonism that span 100 million years from late Jurassic (155 Ma) through Cretaceous (65 Ma). This report follows the informal terminology of Woodsworth *et al.* (1991) for the plutonic suites.

Late Devonian plutonism, unknown elsewhere in Stikinia, is represented by a composite body of tholeiitic hornblende diorite and younger calcalkaline granodiorite and tonalite to trondjhemite phases of the Forrest Kerr pluton in the Forrest Kerr area. The Early Mississippian More Creek pluton is a mineralogically similar, but younger body that intrudes Devonian rocks in the More Creek area (Figure 1-4). Both intrusions have primitive isotopic signatures and lack continental inheritance.

Middle(?) to Late Triassic plutonic rocks of the Polaris Ultramafic Suite and the Stikine suite intrude Stuhini Group volcanics and are considered to be comagmatic and coeval with them. The Polaris suite consists of numerous, small Alaskan-type ultramafic bodies; the Stikine suite, tholeiitic

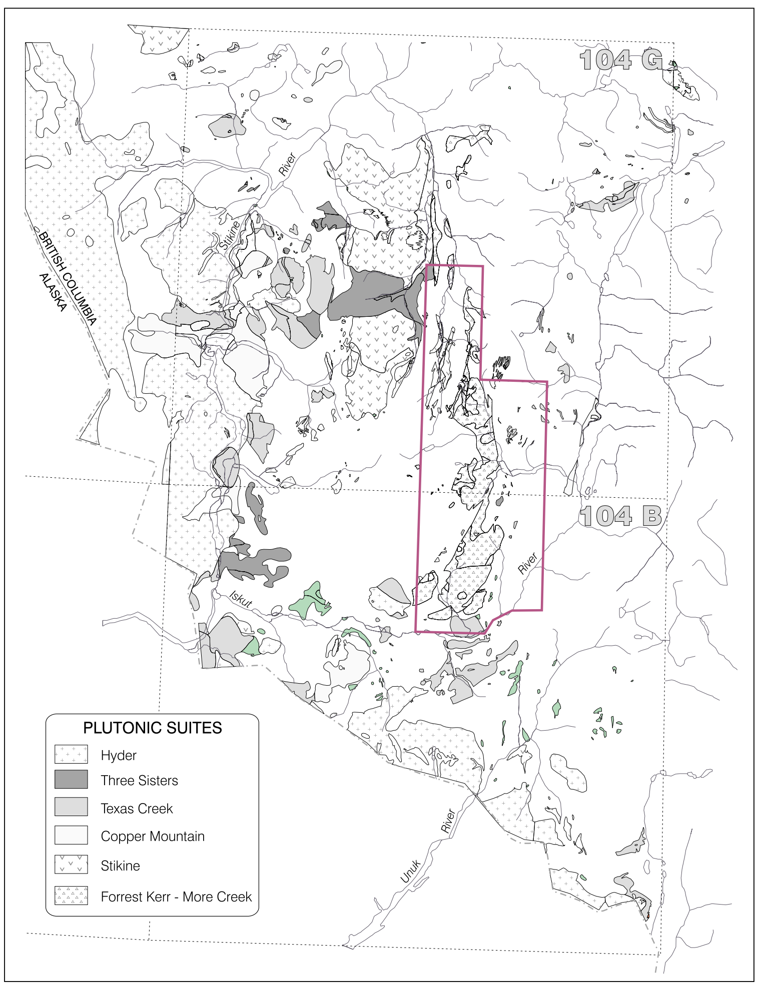

Figure 1-4. Location of map area relative to the six main plutonic suites in the Stikine-Iskut rivers area. Modified from the Map Place. Compiled sources include: Bevier and Anderson (1991), Brown and Gunning (1989), Holbek (1988), Logan and Koyanagi (1989), Logan *et al*. (1989), Macdonald *et al*. (1992) and McClelland (1992).

to calcalkaline granitoid plutons. The Hickman batholith, comprising the Nightout and Hickman I-type plutons and the Hickman Ultramafic Complex, contains both suites (Figure 1-4).

In northwestern British Columbia, the Late Triassic to Early Jurassic Copper Mountain Plutonic Suite consists of numerous small alkaline and associated ultramafic bodies that occupy a north-northwest-trending belt along the east side of the Coast Range. They lie within Stikinia, are hosted by Upper Triassic Stuhini Group volcanics and include the Bronson, Zippa Mountain and Galore Creek intrusions. These intrusives and their counterparts in Quesnellia host important alkaline porphyry copper-gold mineralization.

The Early Jurassic Texas Creek Plutonic Suite consists of calcalkaline, I-type bodies that are slightly younger than the Copper Mountain suite. These plutons crop out discontinuously between the Coast and Intermontane belts. Characteristically they are deformed, north-trending bodies that are metamorphosed to greenschist grade. They are cospatial and coeval with Hazelton Group volcanic rocks. Middle Jurassic plutons of the Three Sisters suite comprise calcalkaline, felsic intrusive phases of the Hotailuh batholith (Anderson, 1983) and Stikine batholith (Anderson, 1984) of the Stikine Arch. The Middle Jurassic Yehiniko pluton intrudes the centre of the Hickman batholith (Holbek, 1988) and two additional Middle Jurassic intrusions, the Warm Springs and Middle Mountain bodies (Bevier and Anderson, 1991) are exposed west of the map area (Figure 1-4).

Rocks of the Paleogene Hyder Plutonic Suite, which represent the last major magmatic episode of the northern Cordillera, form the core of the Coast Plutonic Complex. This mainly Eocene event is characterized by plutons that are relatively more siliceous, biotite rich and unaltered. They occupy a wide belt west of the Stikine River.

UNCONFORMITIES AND OROGENIC EVENTS

Three regionally important unconformities are exposed in the study area: a Late Devonian - Early Carboniferous disconformity and nonconformity, a Late Permian - Early Triassic disconformity, and a Late Triassic - Early Jurassic angular unconformity and nonconformity (Figure 1-5, 1-6). Each represents important hiatuses in the rock record and reflect episodes of contraction and/or extension and uplift which characterized the Paleozoic through Mesozoic evolution of Stikinia, prior to its amalgamation and accretion to ancestral North America. Unconformities that separate Mesozoic from Cretaceous rocks and Cretaceous from Tertiary record various episodes of tectonism and magmatism during the last 180 Ma that can be related to changes in the relative motions of North America, Pacific, Kula and Farallon Plates, in particular, the change from Mesozoic contraction to Eocene extension (Engelbretson, 1985). Cenozoic magmatism, extension and dextral strike-slip regimes re-

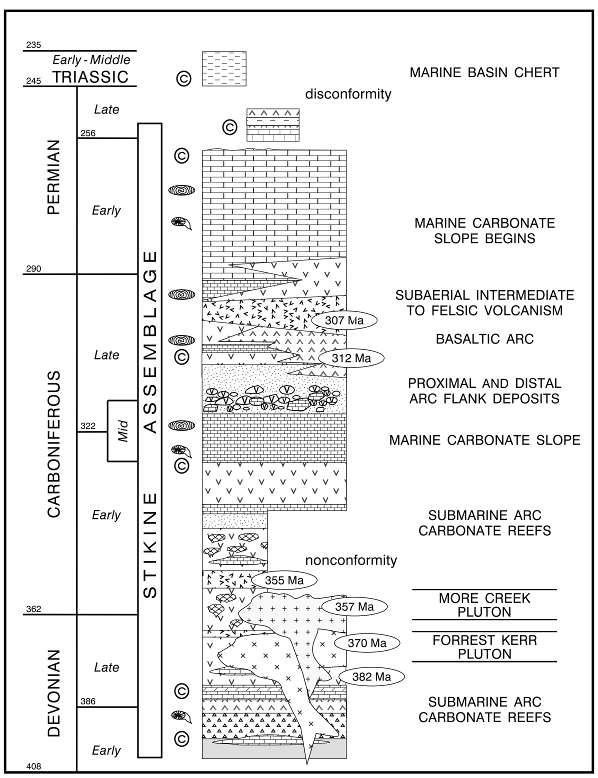

Figure 1-5. Schematic Paleozoic stratigraphic column, Forrest Kerr-Mess Lake area. Biostratigraphic and radiometric age constraints are discussed in the text.

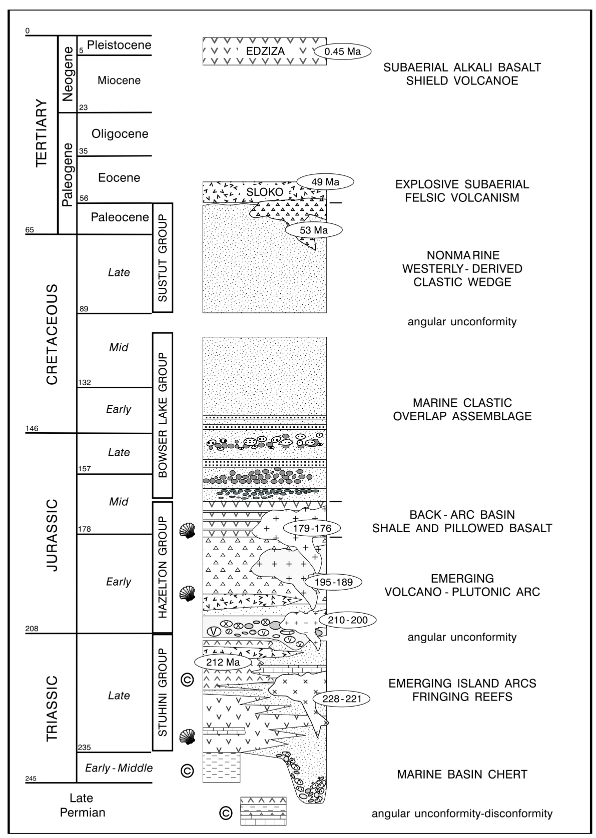

Figure 1-6. Schematic Mesozoic to Cenozoic stratigraphic column, Forrest Kerr-Mess Lake area.

sulted in numerous local unconformities within Tertiary to Recent volcanic rocks.

The Late Paleozoic and early Mesozoic history of Stikinia is interpreted to have encompassed an island arc setting similar to the modern day southwest Pacific. The oldest recognized unconformity places Visean to Bashkirian (Lower to mid-Carboniferous) carbonate on Lower Devonian volcanic and Late Devonian plutonic rocks. Carbonate deposition directly on an intrusive substrata implies significant uplift and unroofing of the intruded Lower Devonian arc by Early Carboniferous time. The timing of uplift coincides with the Antler Orogeny in the southwestern U.S. and a similar aged, but less well understood, event in the Kootenay Arc of Southeastern B.C. (unnamed) and the Ellesmerian Orogeny in northwestern Canada (Figure 1-5).

The disconformity at the top of the Early Permian carbonate is exposed in at least two areas east of Mess Creek. It corresponds to the Sonoma Orogeny of the western U.S. cordillera described by Wyld (1991) and the Tahltanian Orogeny of Souther (1971). This tectonic event affected Stikinia, Quesnellia, and Slide Mountain Terrane (Gabrielse and Yorath, 1991) and seems to have been a global phenomenon (Gabrielse, 1991). The earliest Triassic rocks deposited on the Permian carbonate are thin bedded marine sediments, followed by mafic, picritic tuffs, which mark the onset of Upper Triassic Stuhini volcanism (Figure 1-6).

Lower Jurassic marine sediments lie with angular unconformity on Late Triassic volcanic arc rocks and Lower Jurassic fluvial conglomerate also nonconformably overlies subvolcanic diorite in the study area. Both contacts are well-exposed and provide clear evidence for tectonism at the Triassic - Jurassic boundary (Figure 1-6). The same unconformity sharply separates flat-lying, homoclinal Toarcian volcanic rocks from folded, steeply inclined Late Triassic tuffaceous sediments to the north in the Yeheniko Lake area (Brown and Greig, 1990; Brown *et al.*,1992). A regionally significant unconformity preempted sub-Sinemurian, Early to Middle Jurassic Hazelton volcanism and sedimentation in the Iskut River area (Henderson *et al.*, 1992).

The Early Jurassic marked the transition from terrane-specific events in the northern Cordillera to the development of overlap assemblages in the Middle Jurassic. The main deformation of the Intermontane Belt occurred during collision of Stikinia, Quesnellia and the Cache Creek terrane and formation of the Omineca Belt during the Middle and Late Jurassic (Gabrielse, 1991). Development of the Bowser Lake overlap assemblage is attributed to initial collision of the Intermontane Superterrane with the craton in northern B.C. (Gabrielse and Yorath, 1991) and obduction and southwestward emplacement of the Cache Creek terrane onto Stikinia along the King Salmon Fault by Middle Jurassic, Aalenian time (Ricketts *et al.*, 1992).

Marine sedimentation in the Bowser Basin foreland ended when the Insular Superterrane collided with the Intermontane Superterrane, possibly in mid-Cretaceous time (Monger *et al.,* 1982) or as early as Late Jurassic time (McClelland *et al*., 1992; van der Heyden, 1992). Northeastward contraction of supracrustal rocks of the Bowser Basin (shortening has been estimated at 44 per cent) formed the Skeena fold belt in the Late Cretaceous (Evenchick, 1991a, b). The structural style of the Bowser Basin suggests a basal detachment surface(s) underlies the Mesozoic sedimentary sequence (Gabrielse, 1991) and roots to the west in the Coast Belt. Cretaceous terrigenoclastic sediments of the Sustut Group were deposited with angular unconformity on folded and uplifted Mesozoic and Paleozoic rocks. In the study area, Cretaceous sandstone overlies the Early Mississippian More Creek pluton.

Cretaceous to Early Cenozoic right lateral transform motions and regional extension (Gabrielse, 1985) resulted in volcanic activity that formed the older units of the Mount Edziza complex. These were erupted onto a peneplain of Mesozoic and Paleozoic rocks. Recent flows filled valleys after erupting through faults in the More Creek Pluton. Periods of volcanic quiescence are marked by paleosols and occur at levels in the volcanic stratigraphy (Souther, 1972, 1992).

CHAPTER 2 STRATIGRAPHY

STIKINE ASSEMBLAGE

The Late Paleozoic Stikine assemblage forms the structurally and stratigraphically lowest rocks exposed in the study area. Initial work in the Stikine River area was by Kerr (1948a,b) who suggested a two-fold division for the Paleozoic strata; a deformed unit of pre-Permian metasedimentary and metavolcanic rocks, and an overlying less-deformed unit of Permian limestone (Figure 2-1). Souther (1972) and Monger (1970) recognized Lower Carboniferous limestone in the Telegraph Creek area and divided the Permian limestone succession into a lower, thinly bedded argillaceous or tuffaceous limestone and an upper massive, white grainstone. Kerr inferred Devonian ages, and recent work by Read *et al*. (1989) and Anderson (1989) identified a Lower to Middle Devonian unit near Forrest Kerr Creek, about 20 kilometres to the southeast. In the same area, Logan *et al*. (1990a, 1993) and this study determined a Late Devonian (370 Ma) age for the Forrest Kerr Pluton. Quartz-rich, metasedimentary rocks have been recognized beneath Paleozoic rocks in the western part of the Iskut River area (McClelland, 1992) and while correlations with the Yukon-Tanana Terrane equivalent continental margin rocks in southeastern Alaska strengthen arguments for Paleozoic ties between the Stikine Terrane and Yukon-Tanana Terrane in this area (McClelland and Mattinson, 1991; McClelland *et al*., 1993) and further north

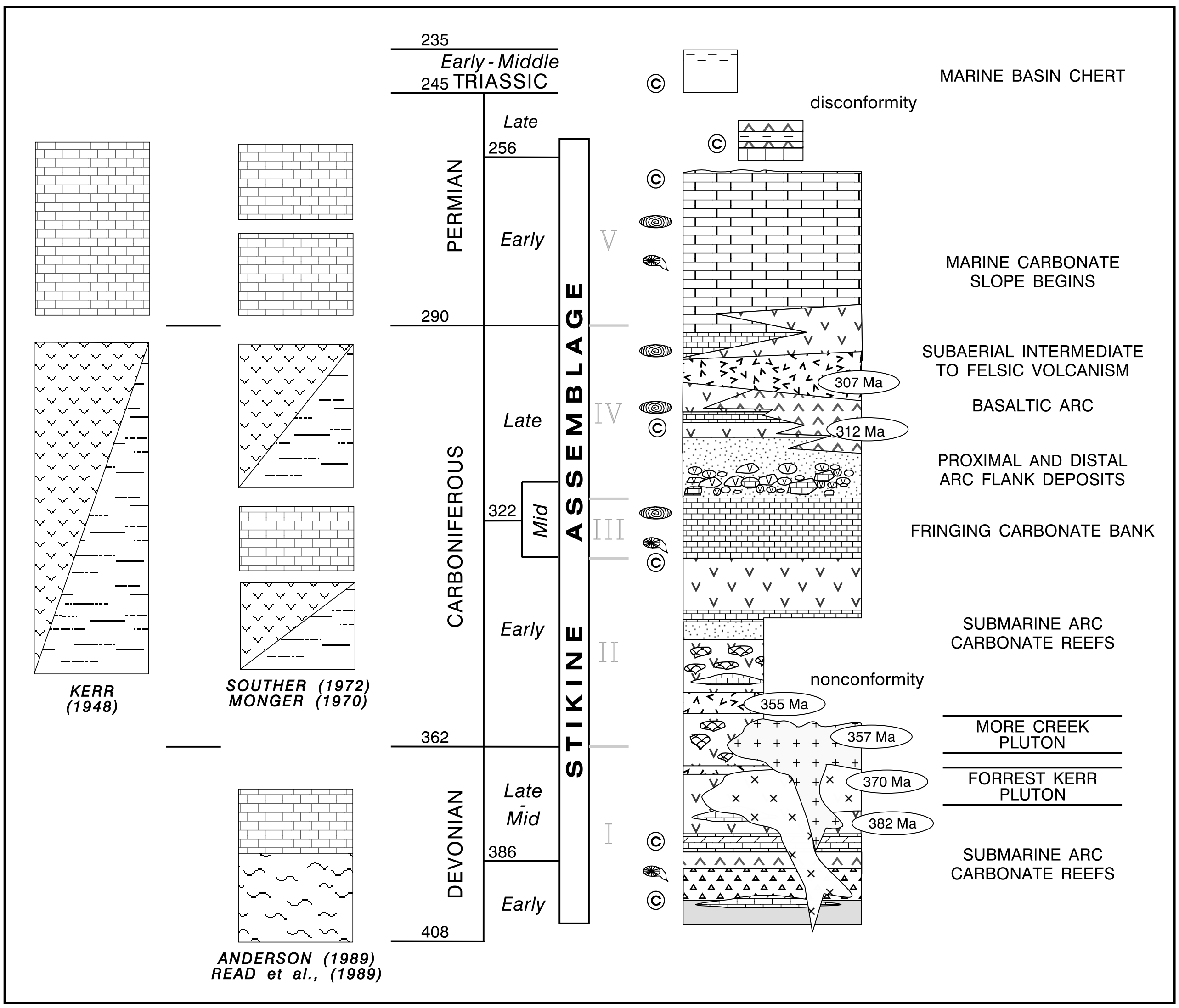

Figure 2-1. Evolution and current geological understanding of the Stikine assemblage stratigraphy, Stikine-Iskut area (modified from Logan and Koyanagi, 1994). Lithologies include; carbonate units = bricks, mafic volcanic rocks = v, sedimentary units = dash and dots and plutons = x and + patterns.

(Mihalynuk, 1999), primitive isotopic signatures and stratigraphy in this part of Stikinia suggest an oceanic setting. Schematic Figure 2-1 illustrates the evolution and current geological understanding of the Stikine assemblage in the Stikine River area. The much simplified stratigraphic column is a compilation incorporating stratigraphy, radiometric dates and fossil identifications of Anderson (1989), Read *et al*. (1989), Logan *et al*. (1990a,b, 1992a,b), Brown *et al*. (1996), Gunning (1990) and McClelland (1992) as well as ongoing work in the region by the authors. Of particular significance is the recognition of Lower Triassic clastic sediments; an Upper Carboniferous intermediate calcalkaline, and in part, subaerial volcanic sequence; Late Devonian and Early Mississippian tonalitic to trondjhemitic plutonism; and a Devono-Carboniferous unconformity. A rapidly growing database and understanding of the Paleozoic history of Stikinia is emerging from current studies of the Stikine assemblage in the Iskut-Stikine-Tulsequah areas. It is from these areas that Early Devonian strata and Late Devonian plutons, the oldest rocks known in Stikinia occur and unconformities and deformational events are recorded in the Carboniferous and Permian stratigraphy.

In this discussion the term Stikine assemblage is retained for this discussion rather than the Asitka Assemblage of Wheeler and McFeeley (1991). Division and definition of the Upper Carboniferous to Upper Permian section of Stikine assemblage rocks in the Scud River area into the Navo, Ambition and Scud Glacier formations (Gunning *et al*., 1994b; Brown *et al*., 1996), and separation of the mid-Carboniferous Round Lake Formation, may warrant redefinition of the Stikine assemblage to group status in this part of the Stikine Terrane.

The Stikine assemblage comprises a submarine succession of tholiietic island arc volcanic flow, breccia and epiclastic rocks, with several accumulations of carbonate, which mark periods of volcanic quiescence. In the map area the assemblage consists of five main subdivisions (Figure 2-1, I-V). From the oldest to the youngest, they are: (I) a Lower to Middle Devonian package of penetratively deformed, intermediate to mafic metavolcanic tuff, flows, diorite and gabbro, recrystallized limestone, graphitic schist and quartz sericite schist; (II) an Upper Devonian to Mississippian package of bimodal mafic and felsic volcanic flows and tuffs; (III) a mid Carboniferous echinoderm-rich limestone and cherty tuff unit, which overlies the Upper Devonian to Mississippian volcanic flows and clastic rocks along the northern edge of the Forrest Kerr map sheet; (IV) Late Carboniferous to Early Permian aphyric basalt, limestone and intermediate to felsic tuffs and flows; and (V) thick Early Permian carbonate. Volcanic rocks older than mid Carboniferous (*i.e*. Division I and II) are difficult to subdivide. Early and middle Devonian macro and micro fossils from the carbonates interlayered with the sedimentary and volcanic rocks constrain ages for Division I. The conformable lower contact of fossil-rich mid-Carboniferous carbonate (Division III) with a bimodal volcanic and epiclastic package implies a Lower Carboniferous volcanic sequence and the single, Early Mississippian U-Pb zircon date from a rhyolite located west of the map area substantiates it (Table 2-1). No obvious stratigraphic break was recognized between the two packages in the field. Coeval, in part comagmatic intrusive episodes include the Late Devonian Forrest Kerr and the Early Mississippian More Creek plutons.

Pre-Early Devonian to Early Permian rocks underlie the western third of the Forrest Kerr and More Creek map areas and the area east of Mess Creek in the Mess Lake area (Figure 2-2). East of the Forrest Kerr pluton, Paleozoic rocks are moderately to highly deformed, whereas west of it Carboniferous to Permian rocks are undeformed and Devono-Mississippian rocks vary from being schistose to

TABLE 2-1
U-Pb AND K-Ar ISOTOPIC DATES FOR STRATIFIED ROCKS

FIELD NO.	MAP UNIT	ROCK TYPE	GROUP/FM/ ASSEMBLAGE	SAMPLE LOCATION	DATING METHOD	MINERAL	AGE (Ma)
91JDR10-15	Qb	olivine basalt	Arctic Lake Fm	Arctic plateau	K-Ar	WR	0.45 ± 0.07
89JLO9-3-2	mJHb	pillow basalt	Salmon River Fm	Iskut River	K-Ar	WR	103 ± 3
89JLO24-7-2	u>Sva	Hb-plagioclase phyric andesite	Stuhini Group	Newmont Graben	K-Ar	WR	125 ± 5
92JLO 270	u>Svr	rhyolite	Stuhini Group	Newmont Graben	U-Pb	Zr	212.8 +4.2 -3.5
92JLO 266	uCSr	rhyolite	Stikine Assem.	Mess Creek	U-Pb	Zr	311.7 ± 2
89VKO29-2-3	DMSv	pillow basalt	Stikine Assem.	Verrett R.	K-Ar	WR	222 ± 7
91-203	DMSvr	dacite	Stikine Assem.	More Glacier	U-Pb	Zr	355.1 ± 3.7
91-238	lmDSfv	intermediate tuff	Stikine Assem.	Lime Lake	U-Pb	Zr	380 ± 5

One sigma errors for K-Ar dates, and two sigma errors for U-Pb dates are reported. K-Ar analysis completed by J. Harakal, U-Pb analysis completed by W. McClelland, *see* Appendices 11 and 13 for analytical data. WR = whole rock, Zr = zircon, Hb = hornblende.

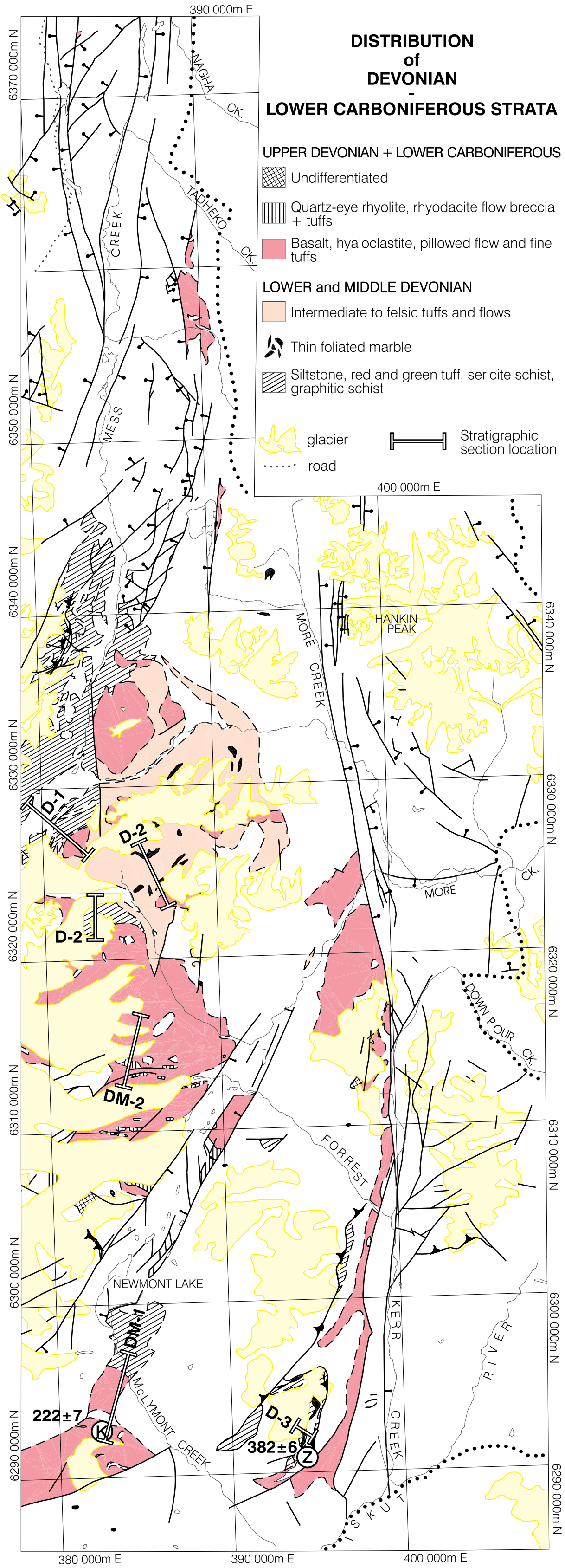

Figure 2-2. Distribution of Devonian to Lower Carboniferous strata of the Stikine assemblage. Lines show the locations of stratigraphic sections in Figure 2-3 and 2-4.

little deformed. Overall deformation of the Paleozoic rocks is variable. Despite structural and metamorphic disparities, stratigraphy in general can be correlated from one side of the pluton to the other, although much of the Paleozoic rock package east of the pluton remain undivided.

DIVISION I

LOWER AND MIDDLE DEVONIAN

A 3 to 5 kilometre-wide arcuate belt of polydeformed, penetratively foliated metavolcanic and metasedimentary rocks begins west and south of the headwaters of Mess Creek and extends west into the Galore Creek area (Logan and Koyanagi, 1994; Figure 2-2). These rocks comprise a structurally complex succession of schistose felsic and mafic volcaniclastics with interbedded sericite and chlorite schist, graphitic and siliceous phyllite and limestone (Holbek, 1988; Barnes, 1989; Logan and Koyanagi, 1989; Logan *et al*., 1992a). This package appears to be basement to all other rocks in the study area; a lower contact was not observed. Overlying these 'basement rocks' in uncertain stratigraphic relationship is a Lower to Middle Devonian package of mafic and intermediate volcaniclastic rocks and limestone at Bear valley, in the More Creek area. A package of limestone, siltstone and mafic-dominated bimodal volcaniclastic rocks of similar age is intruded by the Late Devonian Forrest Kerr Pluton in the Forrest Kerr area.

In the headwaters of Mess Creek (D-1, Figure 2-3), the structurally, and presumably stratigraphically lowest unit in the polydeformed package is a meta-sedimentary-metavolcanic sequence of intermixed chloritic, graphitic and maroon phyllites with quartz-sericite schist layers (units lmDSgs and lmDSqs, GS-Map). These are intruded by massive to variably schistose subvolcanic diorite sills which locally comprise as much as 25 per cent of the section (Photo 2-1). Intermediate to mafic, purple and green tuffs and flows (lmDSst) overlie the lower unit of metasediments. Contacts are structurally interleaved, but appear gradational. The upper section consists of felsic volcaniclastic rocks and undifferentiated volcanic flows and tuffs. All units are tightly folded, penetratively foliated and interleaved along foliation parallel structures; thicknesses are indeterminate. The stratigraphic sequence can be traced 5 kilometres to the southwest where it structurally underlies Lower to mid-Carboniferous carbonate at Round Lake; other age constraints are ubiquitous.

A thick package of variably deformed mafic to intermediate volcanics (lmDSfv) with numerous limestone members of variable thickness (lmDSc) underlies most of the western third of the More Creek and parts of the Forrest Kerr map areas (Figure 2-2). The strata is best exposed in Bear valley, a northeast trending valley located between Alexander and Natavas glaciers (D-2, Figure 2-3). The volcanic rocks are predominantly green plagioclase-phyric tuffs, amygdaloidal flows and volcaniclastic rocks, with subordinate purple and maroon tuff, black siltstone and felsic tuff. Interbedded recrystallized limestones contain the coral Favosites sp. so are at least as old as late Early Devonian (C-189406, 07, 08 and 189767; Appendix 1) and conodonts of Lochkovian age (C-189417). Exposed in the valley floor

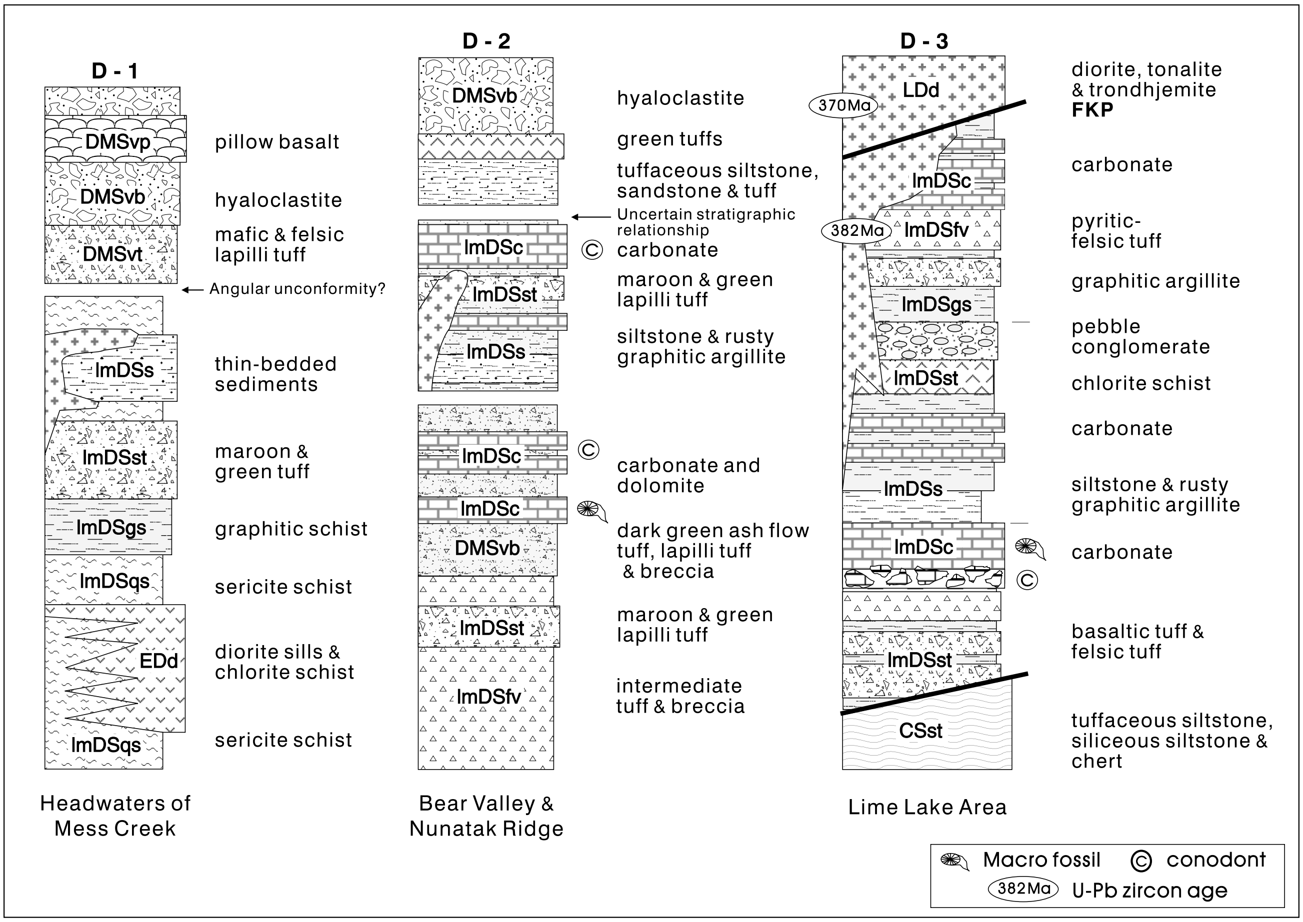

Figure 2-3. Schematic stratigraphic columns for the Lower to Middle Devonian Paleozoic Stikine assemblage. FKP= Forrest Kerr pluton. Section locations are shown on Figure 2-2.

Photo 2-1. Interlayered white-weathering quartz-sericite schists and massive green subvolcanic diorite sills exposed west of the headwaters of Mess Creek.

and presumably stratigraphically lowest are intermediate and felsic lapilli and ash flow tuffs. The tuffs are white to light green in colour and well stratified to thinly bedded. Lapilli consist of predominantly aphyric pink, grey and white fragments, less than 5 per cent of them are plagioclase phyric. Thin bedded, normally graded green dust and ash tuffs contain metre thick layers of white-weathering, compositionally stratified crystal and ash flow tuffs. Intercalated with the felsic tuffs are mottled maroon and green plagioclase phyric lapilli and ash tuffs and thin massive green andesite flows. The upper volcanic sequence is a mafic to intermediate package of green, plagioclase phyric volcaniclastic rocks intercalated with variably strained limestone layers (Photo 2-2). Dark green massive and amygdaloidal flows, breccias and tuffs predominate. Thin beds and lenses of carbonate (lmDSc) that are intercalated with the volcanics are white to light grey, penetratively foliated, and locally variegated and recrystallized. Interbeds of recrystallized black to dark grey micrite and green calcareous tuffaceous siltstone are common. Intraformational limestone conglomerates and breccias, buff and orange dolomite, and cherty siltstone horizons also occur. Thicker units of limestone, which are in part structurally thickened,

Photo 2-2. Polydeformed Early to Middle Devonian carbonate and mafic to intermediate volcaniclastic rocks intruded by subvolcanic feeder dikes, east of Bear valley.

are medium bedded, light grey and recrystallized. Thin interbedded siliceous layers weather in relief and outline folds and axial planar cleavage in otherwise massive, amorphous bone-white marble. Limestone units accommodated the majority of strain affecting these rocks, particularly unit lmDSfv, where the competency contrast between volcanics and carbonates is high.

Lower Devonian rocks underlie the northern end of Nunatak Ridge, approximately 3 kilometres southwest of Bear valley (D-2, Figure 2-2). The section comprises predominantly interlayered fine grained clastics, carbonates and volcaniclastics (Figure 2-3). These are overlain in uncertain stratigraphic relationship by mafic hyaloclastite, intermediate and felsic tuffs and epiclastics of the Devono-Mississippian unit. The Lower Devonian strata are polydeformed and structurally thickened so that stratigraphic thicknesses are indeterminate from this locale. Thinly foliated, tightly folded grey fossiliferous limestone, black pyritic siltstone and purple lapilli tuff contains Lower Devonian, Emsian conodonts (C-189443, Appendix 2). Structurally below the sedimentary package are intermediate to felsic pale green and pink well stratified lapilli and ash tuffs and lesser aphyric intermediate to mafic volcanic rocks. Aphyric pyritic felsic tuff, subvolcanic equivalent pyritic sills and quartz and potassium feldspar porphyritic units of either extrusive or intrusive origin comprise minor parts of the section. The degree of strain preserved in these rocks is often enough to distinguish them from the overlying Devono-Mississippian package, but the thin layers of carbonate, fine-grained black clastics and variegated nature of the volcanic rocks, is also substantially different from the mainly dark to light green volcanic and epiclastic rocks of the younger rock package.

Lower to middle Devonian rocks crops out in a north-trending belt between the Forrest Kerr fault and Forrest Kerr pluton in the Forrest Kerr area. The belt has been examined by various workers (Read *et al*., 1989; Anderson, 1989; Logan *et al*., 1990a; McClelland, 1992). The rocks are similar to strata at the headwaters of Mess Creek, but here, the strata contain at least four variably strained coralline carbonate members (lmDSc) of Pragian (Early to Middle Devonian) age (Anderson, 1989; Read *et al*., 1989), the oldest known ages from the Stikine assemblage. Interbedded with the carbonates are pebble conglomerates, siliceous and carbonaceous shales, thin bedded cherty siltstones and both mafic and felsic tuffs up to 400 metres thick (Brown *et al*., 1991). The rocks are polydeformed. They are characterized by a moderate west-northwest dipping schistosity that is overprinted by a gentle southwest plunging crenulation with an axial plane dipping steeply southeast. North of Lime Lake, the succession is intruded and in part overthrust by Late Devonian quartz diorite at the top of the section (D-3, Figure 2-3) and the base of the section forms the hangingwall of the West Lake fault, an east-directed thrust fault (Read *et al*., 1989). Recumbently folded, varicoloured, weakly foliated siliceous siltstone, tuff, and ribbon chert in the footwall (unit CSst, GS-Map) are lithologically similar to Upper Carboniferous rocks at Scud River (*see* following).

The Lower to middle Devonian hangingwall contains a three part, 50 m section. The lowest unit includes silicified siltstone and mafic lapilli tuff; pyritic, felsic tuff and calcareous siltstone; and 10 m of grainstone. The limestone consists of beds 1 to 2 m thick containing silicified corals, echinoderm ossicles and other bioclastic debris alternating with centimetre thick carbonaceous siltstone. Limestone of the lowest beds is characteristically brecciated and yields the conodonts *Eognathodus*, sulcatus kindlei, Lane and Ormiston and *Icriodus* steinachensis, Al Rawi of middle Early Devonian, Pragian age (C-087672, C-087673; Appendix 2). A tabulate coral, *Favosites* sp. of Silurian to Devonian age (C-158967) occurs within the coral-bearing grainstone. The section changes facies upwards to the second unit of rusty weathering graphitic and calcareous siltstone, chloritic schist and grainstone and the upper 4 m consists of conformable pebble conglomerate containing clasts of felsic volcanics and limestone. The upper unit comprises lower foliated and pyritic tuff and upper thinly bedded limestone with alternating white, pink and dark grey beds (D-3, Figure 2-3). Structurally and perhaps stratigraphically high in the sequence are varicoloured weakly foliated siliceous siltstones and 5 centimetre thick beds of ribbon chert interlayered with the carbonate. The top of the succession is intruded by foliated Late Devonian hornblende quartz diorite of the Forrest Kerr Pluton (Photo 2-3).

Chlorite and sericite-rich schistose rocks are common in the Forrest Kerr area, angular fragments are occasionally preserved and a mafic or intermediate to felsic tuff protolith can be discerned. Felsic rocks have potassium feldspar phenocrysts that are weakly altered to sericite. The groundmass consists of equigranular potassium feldspar and quartz, with minor subhedral plagioclase. Mafic to intermediate flows are weakly foliated, purple to dark green and either massive or brecciated. Amygdaloidal plagioclase ± augite phyric flows predominate. Mottled purple and green mafic to felsic lapilli tuffs are well foliated to phyllitic and clasts are flattened in the plane of foliation. Fine-grained crystal tuffs and tuffaceous sediments have

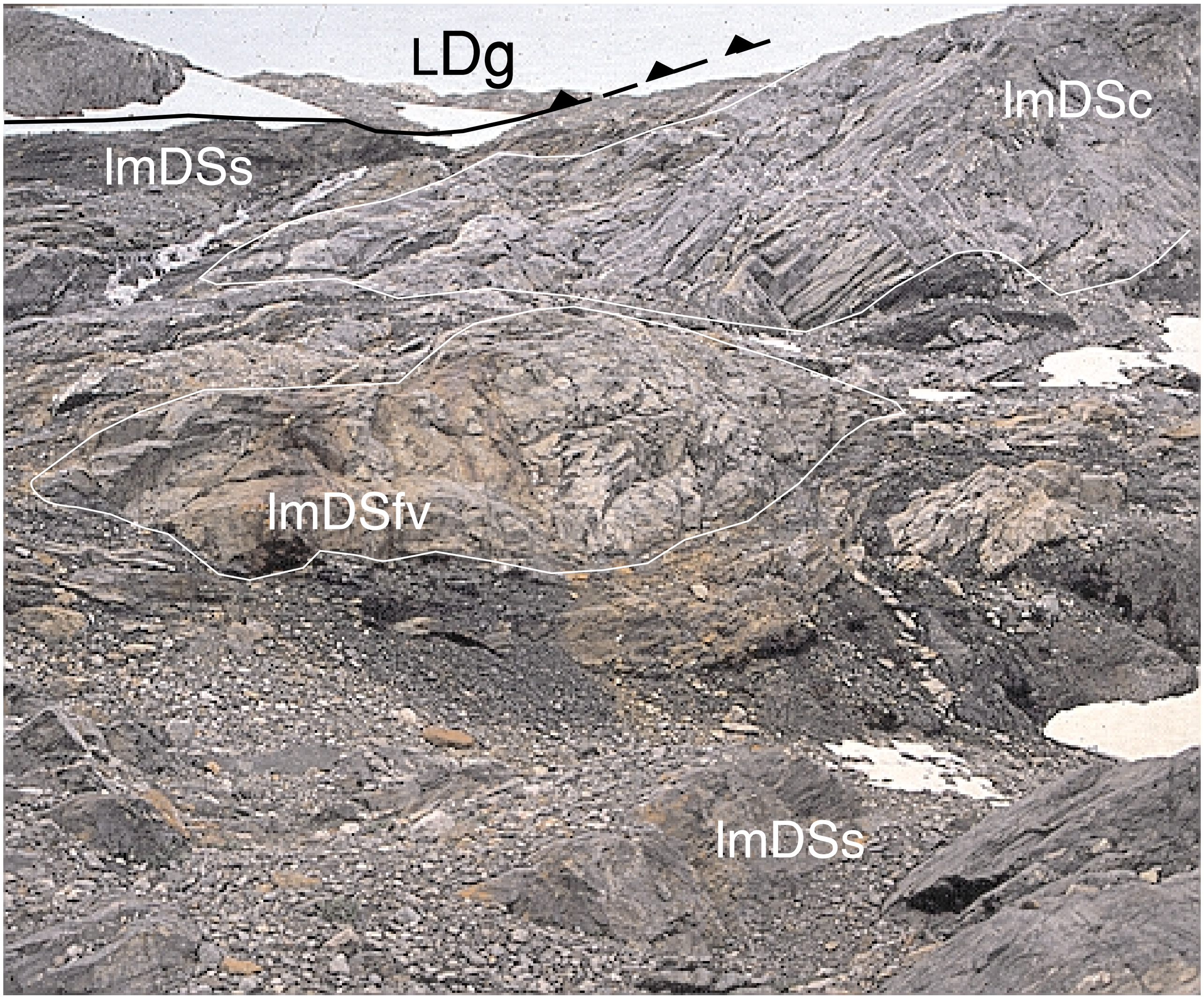

Photo 2-3. Carbonate, black carbonaceous phyllite and an augen of rusty weathering felsic tuff (centre of photo) comprise the third package of Lower to middle Devonian rocks north of Lime Lake. Late Devonian Forrest Kerr tonalite crops out above the phyllite.

been metamorphosed to greenschist grade chlorite schists and lesser quartz sericite schists. Interbedded with these metavolcanic rocks are subordinate phyllite, tuffaceous pyritic argillite and recrystallized limestone.

U-Pb age dates on zircons from intermediate tuff within a volcanic dominated section of well foliated rocks located northeast of Lime Lake gave a middle Devonian emplacement age of 380± 5 Ma (Table 2-1).

Southwest of the Forrest Kerr Pluton is a well-indurated, commonly bleached and pyritic, finely layered siltstone, conglomerate, and carbonate sequence (lmDSs). The epiclastic rocks appear to be thin pendants in the intrusion and are hornfelsed by the enclosing hornblende diorite and quartz-rich phases of the pluton (unit LDg, GS-Map) southeast of Newmont Lake, between McLymont Creek and Newmont Lake. The recrystallized carbonate lenses have a high silica content and contain only sparse, poorly preserved coral fossils of unknown age. Calcareous pendants of probable Lower to Middle Devonian carbonate occur within the Forrest Kerr and More Creek plutons. They are hornfelsed to calcsilicate assemblages of pale green diopside marble containing 1 to 2 per cent disseminated pyrite. Other calcareous pendants contain poorly formed spessartine garnets and, along the southwest end of the More Creek Pluton, copper-bearing magnetite skarns developed (cf. Mineralization chapter).

DIVISION II

DEVONIAN TO MISSISSIPPIAN

A sequence of variably foliated mainly basaltic and lesser rhyolitic volcanic rocks (unit DMSv) occupies the higher ridges and peaks south and east of the headwaters of Mess Creek, and forms ridges and nunataks in the northern half of the Forrest Kerr map area (Figure 2-2), where they are conformably overlain by a mid-Carboniferous carbonate (unit mCSc, GS-Map). West of McLymont Creek is another panel of predominantly mafic volcanic rocks and lesser felsic tuffs; these correlate with the rocks north of Andrei Glacier. The contact between this volcanic succession and the Lower to Middle Devonian volcanic succession may be conformable and gradational; it could not be defined by present 1:50 000 scale mapping. East of the Foremore Camp, this overall more mafic package rests with angular unconformity on the lowermost package of sericite and graphite schists (D-1, Figure 2-3).

Strata in both the northwestern (DM-1, Figure 2-4) and southwestern (DM-2, Figure 2-4) corners of the Forrest Kerr map area comprise southwest-dipping homoclinal mafic volcanic sequences conservatively estimated to exceed 2000 metres in thickness. Interbedded hyaloclastite and pillowed flows volumetrically exceed massive sheet flows of basalt. Fragmental rocks are dominated by heterolithic lapilli tuffs and block breccias. Less common are poorly sorted, immature volcanic conglomerate layers. A distinctive dark green heterolithic tuff crops out east of the headwaters of Mess Creek. It contains abundant medium grained diorite, distinctive coarse grained amphibolite blocks, and amphibole crystals (1-2 centimetre in size) in a green ash matrix. Intrusive phases similar to these clasts comprise the More Creek and Forrest Kerr plutons. Dark green to grey angular to subrounded densely amygdaloidal fragments typify tuffs interbedded with pillowed flows and scoriaceous hyaloclastites. Dominantly green, orange weathering ash flow and welded lapilli tuffs with pale grey, pink and purple aphyric lithic and crystal lapilli form another distinctive unit (Photo 2-4a). These felsic tuffs are spatially related to light purple to pink dacite flow breccias north of the headwaters of Forrest Kerr Creek. A third variety of tuff consists of thin, planar bedded siliceous dust tuffs that are interbedded with graded and cross bedded crystal and lapilli tuffs (Photo 2-4b). Felsic tuff and scattered rhyolitic lapilli appear to be localized in the area near the Andrei Glacier (Photo 2-4c). The mafic volcanic rocks consist of dark green, massive to pillowed flows, flow breccia and hyaloclastite (Photo 2-4d, 4e). Rare intercalated carbonate layers are up to a few metres thick and unfossiliferous. Flows are aphyric or weakly porphyritic and commonly amygdaloidal, with amygdules distributed parallel to borders of clasts and often concentrically zoned

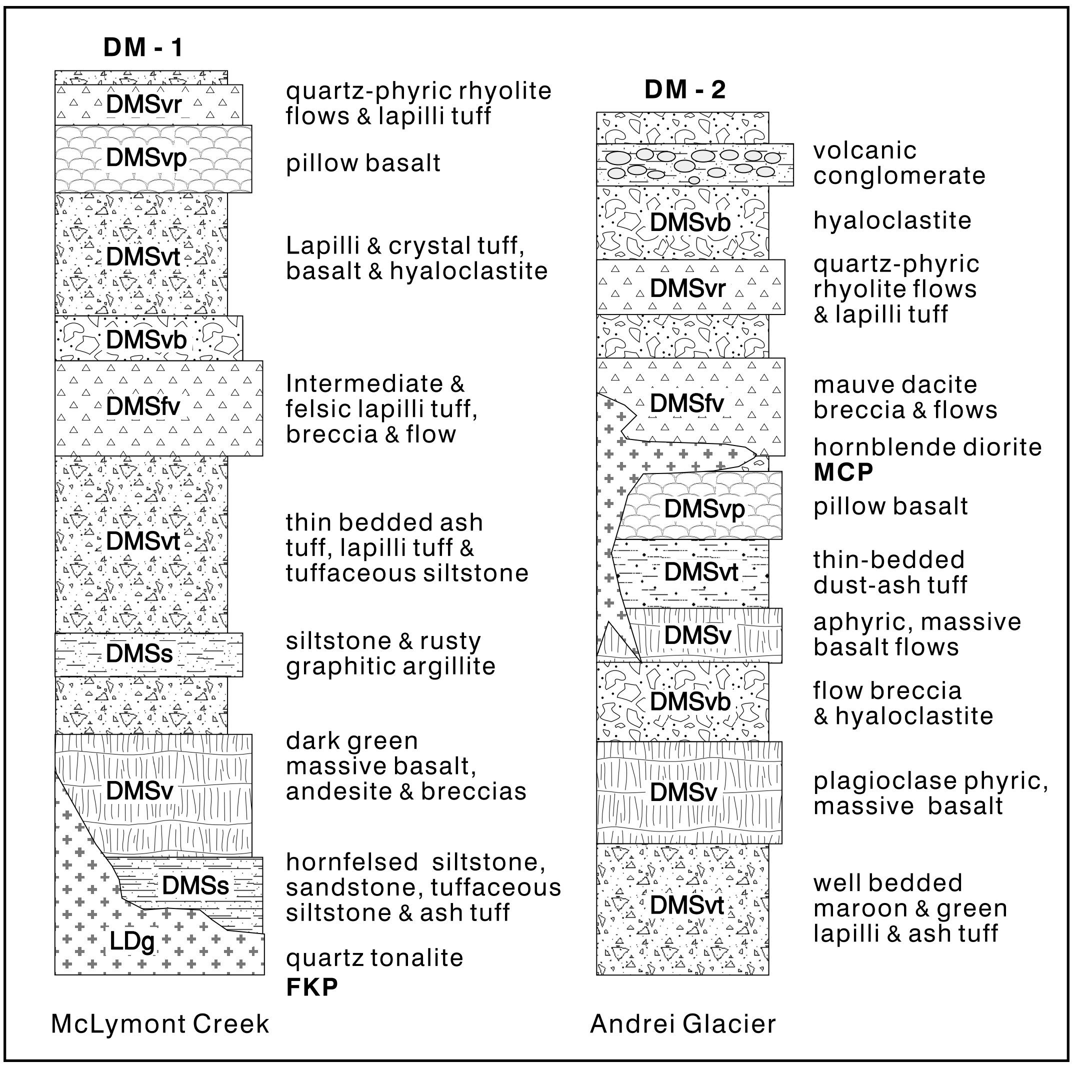

Figure 2-4. Schematic stratigraphic columns for Devonian to Mississippian strata of the Stikine assemblage. FKP= Forrest Kerr pluton, MCP= More Creek pluton. Section locations are shown on Figure 2-2.

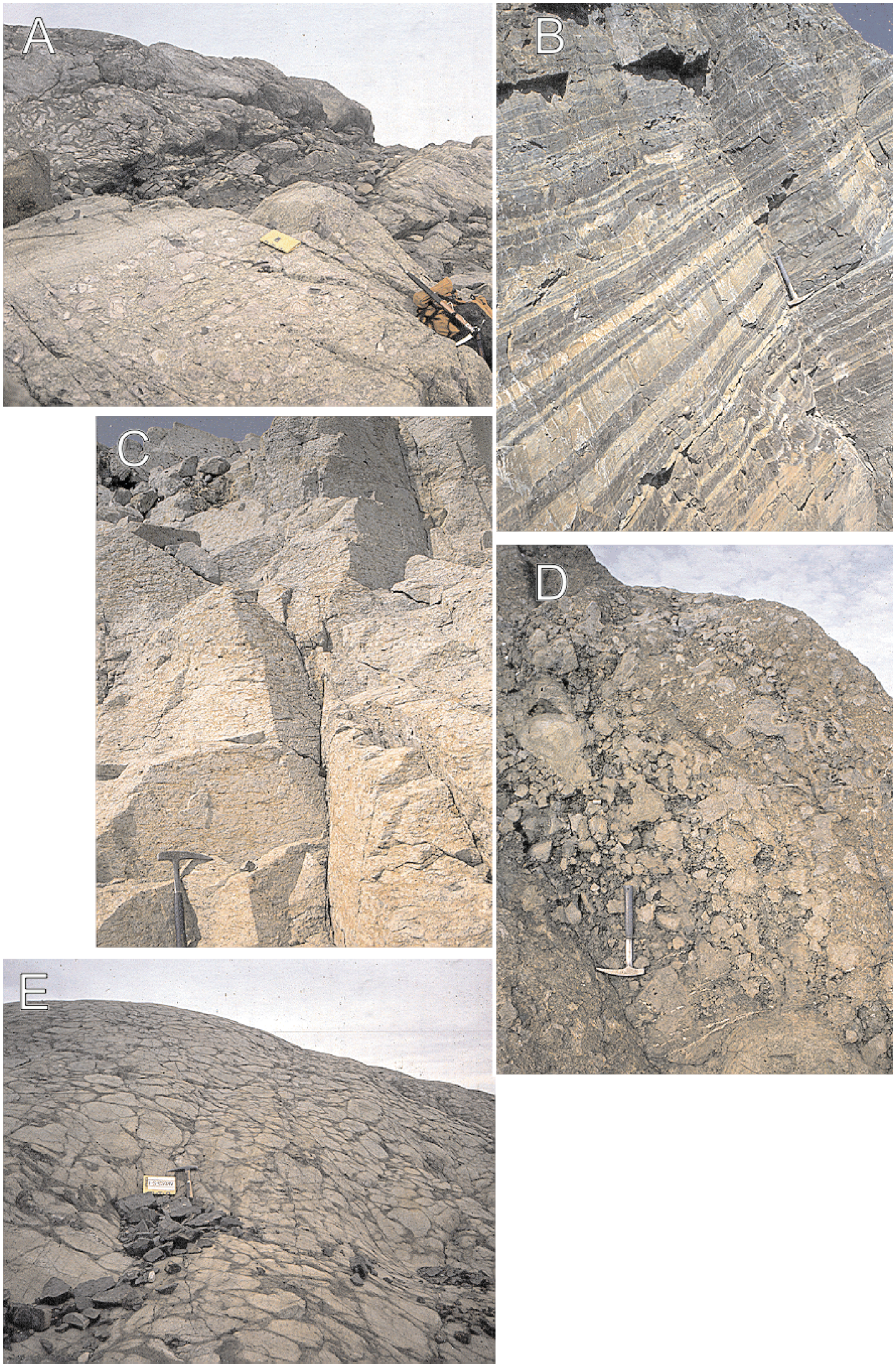

Photo 2-4. Devonian to Early Mississippian submarine volcanic rocks. 4a) interbedded hyaloclastite, pillowed flows, ash and welded lapilli tuffs. 4b) Variegated sharp-bedded, parallel laminated and normal-graded siliceous ash and dust tuffs. 4c)White-weathering felsic lapilli tuffs 4d) Scoriaceous hyaloclastite (a, b, c and d are exposed north of Andrei Glacier). 4e) Well-formed pillowed basalts cap the ridge southwest of McLymont Creek.

about the clasts. Hyaloclastite debris flows contain scattered pillows. Massive flows have brecciated tops and bottoms. Plagioclase microphenocrysts and fine augite grains are altered to chlorite, epidote, sericite and carbonate. These secondary minerals also form amygdules. Scoriaceous pillows and bombs occur within thick interbedded finely vesicular basalt lapilli tuff and hyaloclastite debris flows. The latter comprise pale green angular to globular-shaped fragments with narrow quench-alteration rims in a limy, green-grey matrix; they give the rock a distinctive mottled weathering pattern. Rare rhyolitic fragments also occur. The irregular distribution of quartz, epidote and chlorite amygdules indicates synvolcanic propylitic alteration rather than regional greenschist metamorphism.

Directly southwest of the map boundary on a nunatak in 'More glacier', is a Devonian to Early Mississippian and younger package of volcaniclastic rocks. The nunatak was mapped in detail (Westcott, 1991), drilled by Cominco Ltd. (Wagner, 1996) and sampled for radiometric age dating by one of us. In general, the strata comprise; 1) Devonian Favosites-bearing coralline limestone, 2) foliated intermediate to felsic tuff and flow breccia interbedded with argillite, chert, and crinoidal limestone, and 3) mafic breccia flows with interbeds of tuff and felsic quartz crystal tuff. U-Pb age dates on zircons from dacitic tuff in the lower part of the second stratigraphic member gave an Early Mississippian emplacement age of 355.1±3.7 Ma (Table 2-1). The contact between the first and second members is intruded by a felsic to intermediate sill and is either structural or unconformable (Westcott, 1991).

CHEMISTRY OF THE LOWER DEVONIAN AND EARLY MISSISSIPPIAN VOLCANIC ROCKS

Whole-rock major oxide and trace element analyses have been completed on twenty samples of Devonian and Early Mississippian Stikine assemblage volcanic rocks by the Ministry of Energy, Mines and Petroleum Resources analytical laboratory in Victoria. Results are presented in Appendix 8 and Appendix 9. The samples are from an area that was metamorphosed to lower greenschist metamorphic grade. As a result, loss on ignition (LOI) and CO_2 values are high for some samples and major element mobility may have occurred. The data were screened following the criteria discussed in Chapter 4 under "Geochemistry and Tectonic Discrimination of Intrusive rocks", to identify and remove altered samples prior to plotting.

On the alkalis versus silica plot of Irvine and Baragar (1971), the data forms three discrete clusters (Figure 2-5A); Lower Devonian Lime Lake basalt (inverted solid triangles), plot in the subalkaline field, Devono-Mississippian More Creek basalt and andesite (solid triangles), plot as transitional subalkaline to alkaline, and More Creek rhyodacite rocks (inverted triangles), plot in the subalkaline field. The average trace element values and ratio ranges for the Lime Lake and More Creek volcanics are listed in Table 2-2. Silica averages 47 and 52 per cent for the two basalt groups, but ranges from 69 to 75 per cent for the rhyodacites. Two samples of Devono-Mississippian felsic volcanic rocks have intermediate silica content (63 per cent). Volumetrically the intermediate and felsic rocks comprise equal amounts and together comprise about 15 per cent of the total volcanic pile. The intermediate volcanic rocks are fine grained porphyritic flows. The felsic volcanic rocks are coarse quartz porphyritic flows and tuffaceous rocks. On

TABLE 2-2
SILICA AND SELECT TRACE ELEMENT CONTENTS OF LATE PALEOZOIC VOLCANIC ROCKS

	Tholeiitic basalt Lime Lake (n=4)	Tholeiitic/Calcalkaline More Creek (n=6)	Andesite-Dacite More Creek (n=2)	Dacite More Creek (n=4)
SiO_2	45.9-47.9 (47.2)	50.2-55.4 (52.4)	62.7-63.4 (63.0)	69.5-75.6 (71.5)
K	166-2075 (2055)	747-26315 (10030)	12203-15523 (10543)	11705-13365 (12494)
Ba	na	36-731 (537)	699-859 (779)	724-1099 (911)
Rb	10 (10)	2.0-48 (16.5)	10.0-34.0 (22)	12.0-19.0 (17.3)
Sr	na	101-452 (205)	76.0-276.0 (176)	69.0-137.0 (109)
Ti	6774-11990 (10401)	5935-8033 (6854)	2698-3117 (2907)	1019-2758 (2113)
Nb	10-12 (11)	2.0-5.0 (4.0)	2.0-11.0 (6.5)	4.0-7.0 (5.0)
Zr	66-123 (98.5)	45.0-69.0 (57.2)	97.0-195.0 (146)	86.0-145.0 (109.5)
Y	19-32 (25.8)	18.0-36.0 (27.0)	18.0-47.0 (33.0)	27.0-47.0 (38.5)
Zr/Y	3.47-3.46 (3.80)	1.83-2.62 (2.17)	4.14-5.38 (4.76)	2.74-3.18 (2.86)
Y/Nb	1.90-2.67 (2.38)	5.25-9.0 (6.95)	4.27-9.0 (6.5)	5.4-11.75 (7.65)
Ti/Zr	96.3-112.1 (104.7)	95.9-144.8 (121.3)	16.0-27.8 (21.9)	11.8-22.6 (19.0)

Minimum, maximum and average values are presented. na = not available

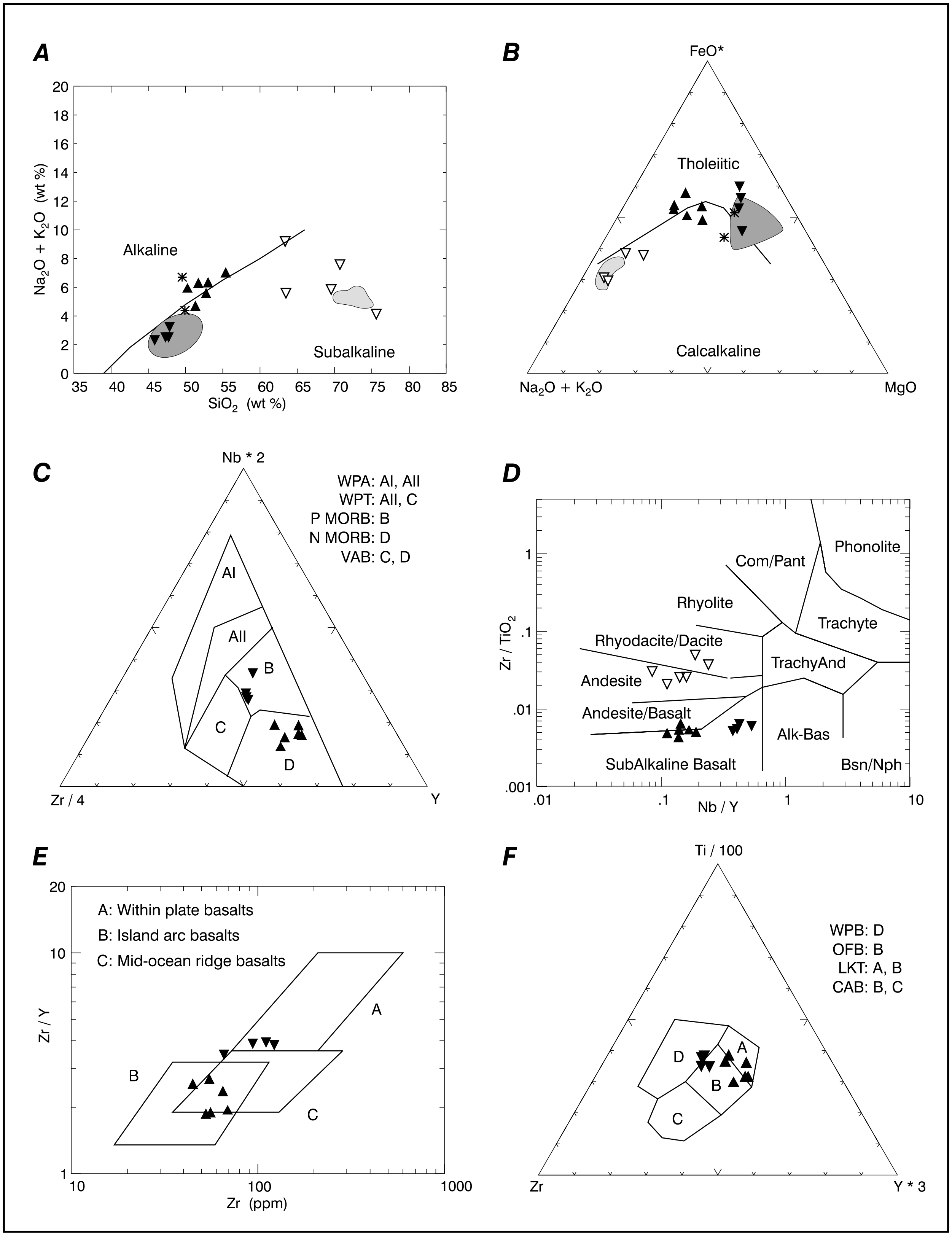

Figure 2-5. Major and trace element geochemical plots for Lime Lake basalts (inverted filled triangles), More Creek mafic (filled triangles) and felsic (inverted triangles) volcanic rocks. A) total alkali versus silica (after Irvine and Baragar, 1971); B) AFM plot (after Irvine and Baragar, 1971); C) ternary plot of Nbx2 - Zr/4 -Y (after Meschede, 1986); D) plot of Zr/TiO_2 versus Nb/Y (after Winchester and Floyd, 1977); E) plot of Zr/Y versus Zr (after Pearce and Norry, 1979); F) ternary plot of Ti/100 - Zr- Yx3 (after Pearce and Cann, 1973). A) and B) show mafic (dark) and felsic (light) fields of Forrest Kerr and More Creek plutons and Early(?) Devonian diorite sills (stars).

the AFM diagram (Figure 2-5B), Lime Lake basalts are tholeiitic, the More Creek basalts and andesites are transitional from tholeiitic to calcalkaline, and the rhyodacites are calcalkaline. The two shaded areas show the distribution of mafic and felsic intrusive rocks of the Late Devonian Forrest Kerr and Early Mississippian More Creek plutons.

On the Nb/Y vs Zr/TiO_2 diagram of Winchester and Floyd (1977) the volcanic rocks plot as two clusters in the subalkaline basalt field, and as a cluster of data plots transitional from andesite to dacite (Figure 2-5D). On the SiO_2 vs. Zr/TiO_2 diagram (not shown) the silica-rich samples plot in the rhyodacite to rhyolite fields and the compositions of mafic and felsic plutonic rocks overlap those of the volcanic samples. The trace element contents (Nb/Y) of the siliceous rocks indicate a less evolved rock than the silica content indicates. This may be an artifact of low trace element abundances and the detection limits for the method of analysis, in this case X-ray fluorescence (5 parts per million).

On the Zr-Nb-Y discrimination diagram of Meschede (1986), the basalts clearly define two clusters of data (Figure 2-5C). The Lower Devonian Lime Lake basalts are enriched in Nb relative to Zr and Y and plot in the P- MORB field. The More Creek basalts plot in the N- MORB and volcanic arc (VAB) field. On the Zr-Ti-Y tectonic discrimination diagram of Pearce and Cann (1973), Devono-Mississippian More Creek basalts and andesites (solid triangles) plot as low-potassium tholeiites (Figure 2-5F). The Lime Lake basalt samples (inverted solid triangles), plot on the division between lava with characteristics of within-plate basalt (WPB), and those with mid-ocean ridge and volcanic arc affinities (MORB and VAB). In the Zr-Ti-Sr diagram (not shown), the Devono-Mississippian basaltic rocks plot on the division between the ocean floor basalt (OFB) and island arc basalt (IAB) fields. The Lime Lake suite plot above the oceanic-arc field on the Zr/Y versus Zr plot (Figure 2-5E), with 3 samples in the within-plate field. The More Creek suite cluster within the overlap between mid-ocean ridge and island-arc fields. The trace element evidence suggests these rocks are best described as low-potassium, island arc, tholeiitic basalt/andesite. Other trace element ratios such as Rb/Zr (0.25-0.35) are closer to tholeiitic island arc basalts (0.20-0.30) than calcalkaline basalts (0.35-0.50; Gill and Whelan, 1989). Their high magnesium/iron ratios are typical of values for tholeiites and indicate fractionation of olivine, augite and possibly magnetite. The samples plotted were the least altered of those analysed and passed the screen for potassic and carbonate alteration, but the data apparently indicate an overall addition of alkalis.

The Devonian and Devono-Mississippian basalts, metabasalts and rhyodacites show various levels of trace element enrichment and depletion, which, in general, correspond to geochemical patterns of tholeiitic oceanic arc basalt and transitional (T-type) mid-ocean ridge basalts (Figure 2-6). The rhyodacite rocks have larger element variations for samples than either of the two basalt groups, and this may reflect tuffaceous components in some of the felsic samples. The Devono-Mississippian basalts have a relatively flat trend to the right of Nb, and are slightly depleted in Ce, Zr, Ti and Y relative to MORB. The lack of a significant negative Nb anomaly, which is so characteristic of volcanic arc basalts, is puzzling. The Devonian metabasalts are enriched in the incompatible elements La, Nb and to a lesser extent Ce. Zirconium and Yittrium are not enriched relative to MORB and define a pattern that most closely resembles the T-type MORB pattern. Similar patterns are also characteristic of transitional settings like plume-ridge interactions and these lavas are termed P-type MORB. The Lime Lake suite is slightly enriched in the incompatible elements Nb, Ce, Zr, and Ti relative to the More Creek suite (Figure 2-6). The negative titanium anomaly (with respect to Zr) for the felsic rocks indicates they are the product of extensive crystal fractionation. The basalt and metabasalt appear to be relatively primitive. The flat trend of the basalts is characteristic of tholeiitic rocks of newly established (immature) island arcs (Gill, 1981).

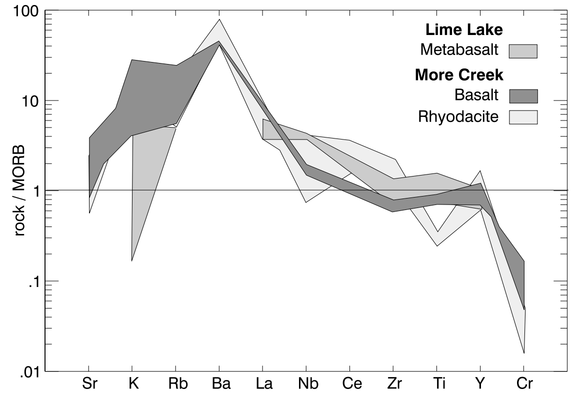

Figure 2-6. Multi-element geochemical patterns for Devonian and Devono-Mississippian volcanic rocks of the Stikine assemblage. Units normalized to an average tholeiitic (N-type) MORB. Normalizing values (in ppm unless indicated) are: Sr=120; K=955; Rb=2; Ba=14.5; La=3.96; Nb=2.7; Ce=10; Zr=90; TiO_2=1.45%; Y=30; Cr=250.

PALEOENVIRONMENTAL INTERPRETATIONS

The Devonian to Early Mississippian volcanic succession of Divisions I and II is interpreted to represent mainly submarine island arc deposition. Initial eruptions were basaltic andesite, dominated by pillow lavas and hyaloclastites upon which fringing carbonate mounds accumulated. The repetition of grainstone and siltstone indicates deposition from turbidity flows in a shelf slope or basinal setting. Graphitic and pyritic sediments indicate an euxinic environment that received periodic influxes of carbonate debris and tuffaceous material from distal sources. Periodically, the volcanic edifice became emergent, generating flows, subaerial welded pyroclastic and epiclastic rocks. Compositions evolved from basalt to rhyolite. The island arc tholeiitic chemistry of the suite is consistent with the above field interpretations. The succession likely represents the earliest stage of island arc formation, when relatively unevolved tholeiitic products were erupted, followed by more evolved rocks. By Late Devonian time the arc must have been mature and thick enough to allow formation and intrusion of the tonalitic to trondjhemitic Forrest Kerr and More Creek plutons.

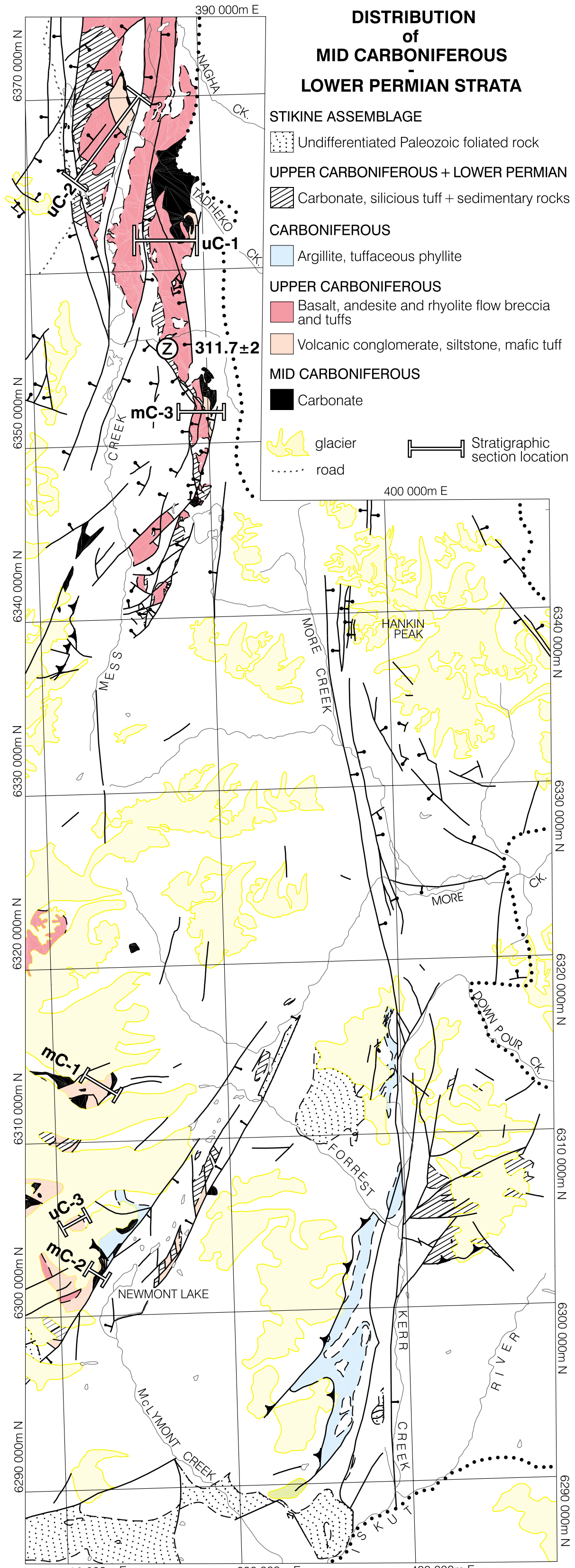

Figure 2-7. Distribution of Mid-Carboniferous to Lower Permian strata of the Stikine assemblage. Lines show the locations of stratigraphic sections in Figure 2-8 and 2-9.

DIVISION III
MID CARBONIFEROUS

Mid Carboniferous, Serpukhovian to Bashkirian limestone and minor chert (mCSc, GS-Map) crop out on ridges and underlie slopes around the edges of the Iskut icefield in the Forrest Kerr map area and north of Arctic Lake in the More Creek area, in north trending fault-bound panels which extend to Nahta cone in the Mess Lake area (Figure 2-7). The thickest and best studied exposures are located in the northwest corner of the Forrest Kerr area, where less than 200 metres of thick bedded, grey echinoderm grainstone with interbeds of amorphous chert are exposed north of Andrei Glacier, and west of Newmont Lake, where less than 50 metres of thin bedded, echinoderm wackestone and interbedded epiclastic rocks are exposed (Logan *et al.*, 1990b; Brown *et al.*, 1991; Gunning 1992). In both areas, and at Nahta cone, the carbonate is conformably overlain by a coarsening-upwards sequence that begins with siliceous siltstone or fine greywacke that grade upward into poorly sorted volcanic conglomerate (Figure 2-8). The carbonate overlies Upper Devonian to Lower Mississippian volcanic rocks (DMSv) in apparent conformity in the northwest corner of the Forrest Kerr area and north of Exhile Hill in the Mess Lake area (mC-1, Figure 2-8). West of Newmont Lake, the base is truncated by a thrust fault (mC-2, Figure 2-8). Discontinuous fault bound and interleaved carbonate blocks of late Early Carboniferous age occur adjacent to Early Permian carbonate along South More Creek and north of Newmont Lake; lower contacts are not clearly exposed, though it appears the carbonate was deposited nonconformably on the Late Devonian Forrest Kerr pluton. Ferruginous quartzitic carbonate nonconformably overlies Early Mississippian granite at Nahta cone and in small outcrops between Nahta cone and Arctic Lake (mC-3, Figure 2-8).

Middle Carboniferous carbonate rocks in the study area are folded but lack any associated cleavage or pre-folding fabric; they have low conodont alteration indices (CAI) relative to Early and middle Devonian and even the Early Permian carbonates. At Round Lake, about 20 kilometres northwest of Newmont Lake in the Galore Creek area (Logan and Koyanagi, 1994), the carbonate is penetratively deformed and structurally thickened to more than 500 metres; there conodonts possess high CAI numbers.

Two northwest trending belts of Early to middle Carboniferous carbonate are well exposed on a ridge north of Andrei Glacier (Photo 2-5). The carbonates occur in a southwest facing predominantly epiclastic sequence of maroon and green, thin bedded cherty siltstone, poorly bedded tuff, wacke, sandstone and volcanic conglomerates (unit uCSss, GS-Map), that overlies a predominantly mafic volcanic sequence of basalt breccia and pillowed flows, hyaloclastite and tuff and minor rhyodacite tuff and rhyolite flow rocks (unit DMSv, GS-Map). The strata are disrupted by northeast and east trending faults and east-trending plagioclase pyroxene porphyritic dikes. The eastern carbonate is the least deformed (mC-1, Figure 2-8). Relationships between the two carbonates is uncertain. A detailed stratigraphic and biostratigraphic sampling traverse was carried

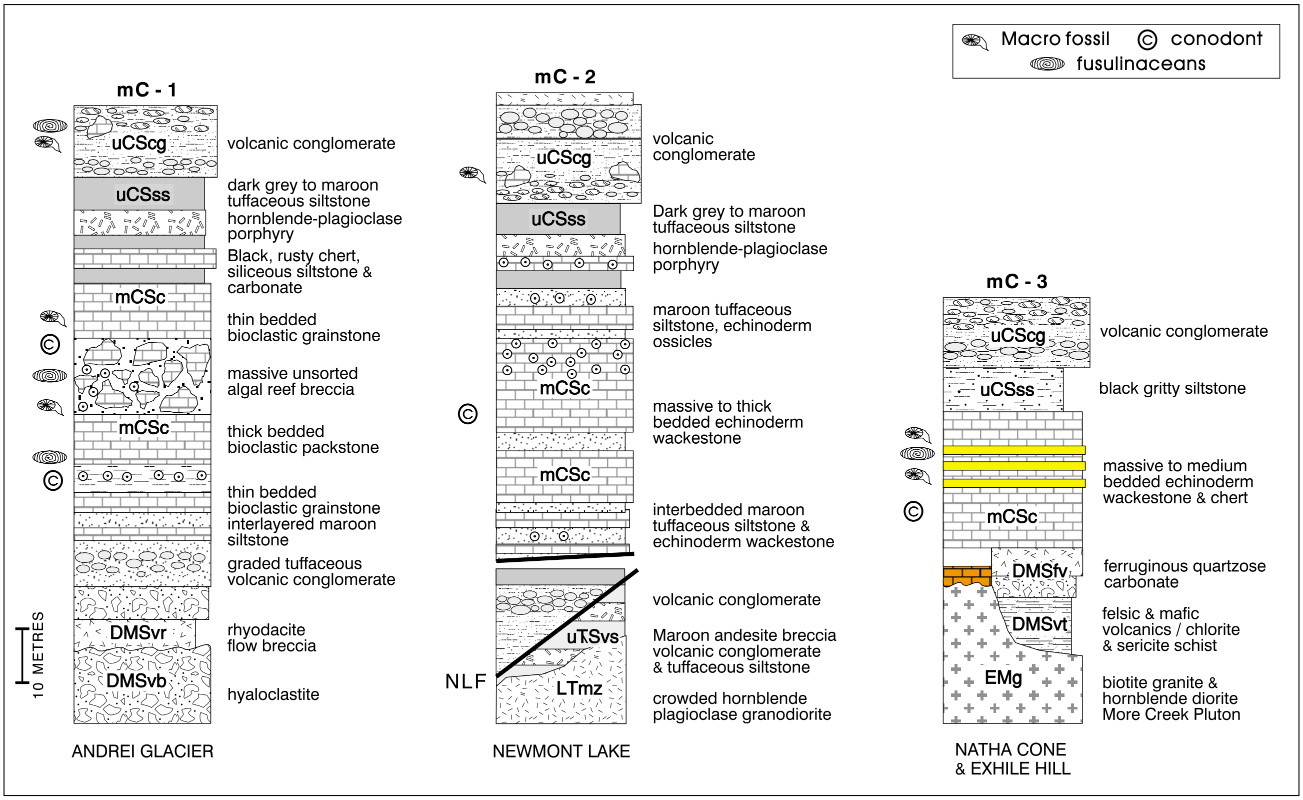

Figure 2-8. Generalized stratigraphic columns for mid-Carboniferous strata of the Stikine assemblage. NLF = Newmont Lake Fault. Section locations are shown on Figure 2-7.

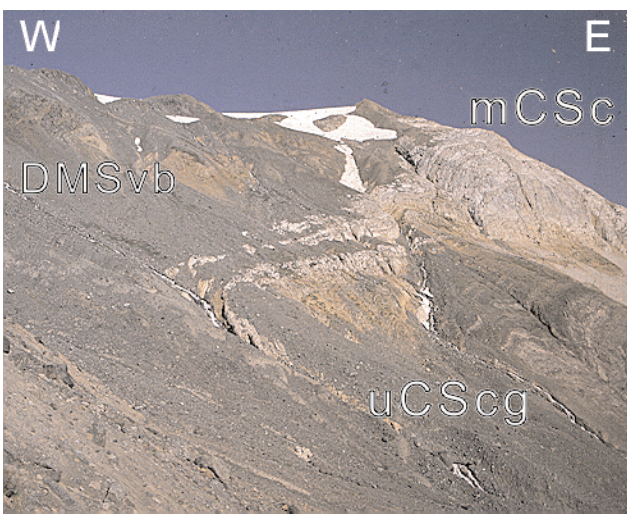

Photo 2-5. East-trending, steep south dipping Mid-Carboniferous carbonate exposed north of Andrei Glacier. Devonian to Early Mississippian submarine volcanic rocks underlie the carbonate to the north and well bedded cherty siltstone, maroon wacke and volcanic conglomerate interfinger with the echinoderm-rich packstone in the foreground.

out in 1990 on the eastern carbonate. It was systematically sampled along three separate traverses; 15 samples were collected. Mamet (1991a) carried out thin section studies of the carbonates at the University of Montreal (Appendix 5). The lower and upper parts of the section comprise thin bedded bryozoan-echinoderm grainstone, with packstone beds of reworked bioclasts and lithic clasts of different carbonate facies, including pelletoidal grainstone, foram-bryozoan wackestone and bryozoan packstone. The medial part is characterized by thick bedded packstone and an 11 metre section of chaotic unsorted algal reef breccia (Photo 2-6). The breccia is massive and contains blocks of foraminiferal grainstone, bryozoan wackestone, fragments of corals, echinoderm columnals, sponge megascleres and brachiopod spines. Stratified, coarse graded and well sorted grainstone beds are common in the upper sections of the carbonate. Conodonts, foraminiferers and algae indicate a mid-Carboniferous, Serpukhovian age throughout the section. Corals indicate a slightly broader range of Serpukhovian to Bashkirian.

The contact between the carbonate sequence and the underlying bimodal volcanic succession is not exposed. The lower carbonate is a thin bedded, graded grainstone-

Photo 2-6. Mid-Carboniferous echinoderm packstone, 1.5 km north of Andrei Glacier. Large, up to 3 cm in diameter, echinoderm columnals characterize the limestone unit.

packstone unit interbedded with maroon siltstone, and characterized by echinoderm columnals up to 2 centimetres in diameter. Buff weathering, medium bedded wackestone and thick bedded massive grey packstone overlie the lower carbonate. Block breccias and graded grainstone comprised of abundant reworked bioclasts and lithoclasts of a disarticulated algal reef. The upper carbonate resembles the lower thin bedded grainstone. It is interbedded with dark green siliceous siltstone near the top and grades conformably upward into maroon and purple wackes and volcanic conglomerate.

An Early to mid-Carboniferous age for this unit is indicated by the occurrence of Early Carboniferous conodonts (C-158953), the late Early Carboniferous (late Visean or Serpukhovian) coral *Chaetetes* sp., (C-158967) and the presence of the colonial coral, *Acrocyanthus* sp., which is associated with mid-Carboniferous (lower Bashkirian) foraminifers (C-158967).

Three km to the west, less than 200 m of thick bedded, grey echinoderm packstone with interbedded chert crop out (Figure 2-7). This limestone, contains small echinoderm stems and fossil fragments and is locally fetid. It contains a mid-Carboniferous (lower Bashkirian) foraminiferal fauna (C-167803). The lower contact of carbonate with basalt breccias and tuff is obscured by a 7 metre wide plagioclase porphyritic dike. The limestone and interbedded chert are gradationally overlain by a 300 m thick, coarsening-upwards sequence of thinly laminated, rusty weathering, cherty siltstone, that is conformably overlain by maroon volcanic sandstone and conglomerate.

Discontinuous lenses of mid-Carboniferous carbonate crop out on the northwest and southeast flanks of the northeast trending Newmont Lake Graben. Northwest of Newmont Lake the carbonate is folded and structurally thickened. Folds verge northeast and axes trend northwest. The carbonate is characteristically massive to medium bedded grey echinoderm wackestone to packstone. Interbedded are zones with chaotic breccia blocks of fine grained echinoderm wackestone with interstitial coarse echinoderm columnals up to 2 cm in diameter. Minor sections of the thin bedded wackestone contain thin chert interbeds. West of Newmont Lake the carbonate section is 56 metres thick, and consists of interbedded echinoderm fragment-rich limestone and dark purple and green volcanic sandstone and limy litharenites (Photo 2-7), with conformable upper and lower contacts (Gunning, 1992). A section across the northern end of the carbonate exposed west of Newmont Lake indicates gradational upper contacts with fine grained siltstone. The base of the section is sheared and probably faulted (mC-2, Figure 2-8). At the base of the carbonate is a 1 metre wide zone of sheared fine tuffaceous chloritic siltstone veined by iron carbonate fracture fillings. Below this gently dipping zone in angular discordance, are thickly bedded, thinly laminated cherty siltstone and massive, weakly stratified volcanic conglomerate. These Carboniferous sediments are faulted (Newmont Lake Fault) against Upper Triassic plagioclase phyric maroon andesite breccia, volcanic conglomerate, tuffs and subvolcanic intrusions of the Newmont Lake Graben.

An Early to mid-Carboniferous age for the carbonate is indicated by the occurrence of Early Carboniferous, Visean to Early Namurian conodonts (C-158971). A limestone clast

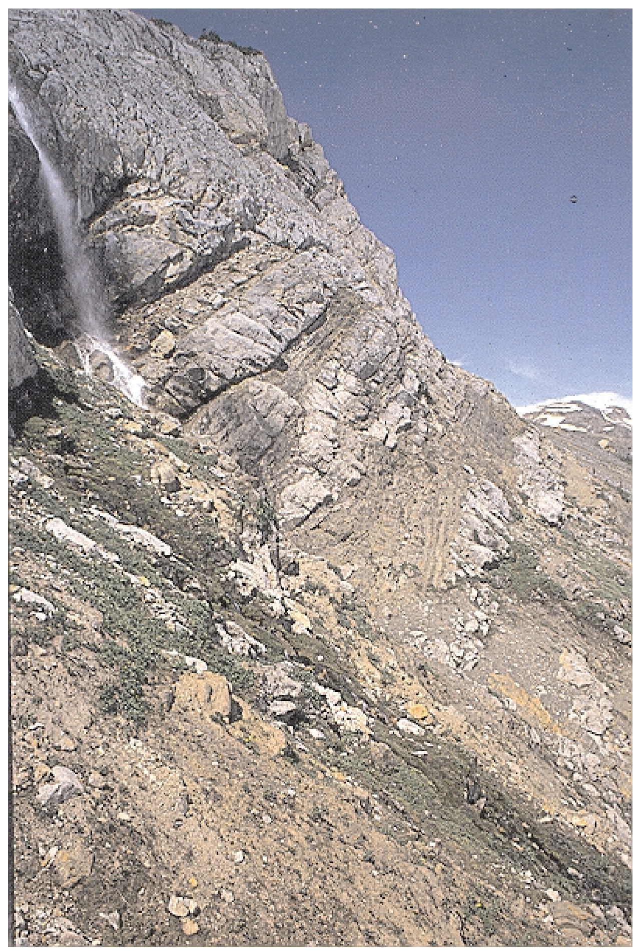

Photo 2-7. Interbedded echinoderm fragment-rich carbonate and siltstone near the base of the Mid-Carboniferous section west of Newmont Lake.

from polymictic volcanic conglomerate, located stratigraphically higher in the section, contains solitary corals of middle Carboniferous age, associated with Serpukhovian or Bashkirian foraminifers (C-158994, Appendix 1).

Small fault-bounded panels of mid-Carboniferous limestone occupy a narrow north trending belt which follows the western contact of the Early Mississippian More Creek Pluton from Arctic Lake north to Nahta cone in the Mess Lake area. At Nahta cone the carbonate rests with apparent disconformity on medium grained pink granite of the More Creek Pluton (mC-3, Figure 2-8). The contact is sharp, limestone is limonitic and contains feldspar, quartz grains and granitic grit, no basal conglomerate was observed. The contact appears to be depositional, although the overlying carbonate is only 4- 5 centimetres thick. Elsewhere, the limestone overlies penetratively foliated mafic volcanic rocks, tuff and chlorite and sericite schists of Devono-Mississippian age. A thin volcanic package comprised of green vesicular andesite, vesicular lapilli tuff, mauve and grey ash flow tuff containing fiamme and carbonate lenses underlies the carbonate unit north of Exhile Hill. The carbonate is a well bedded grey wackestone that is interlayered with chert and contains quartz and plagioclase crystal-rich horizons. The interdigitated character of volcanic and carbonate material suggests a conformable lower contact and coeval carbonate sedimentation and volcanism.

Early Carboniferous, Visean to Early Namurian conodonts (C-189428) indicate an Early Carboniferous age for the carbonate located north of Arctic Lake. Corals collected from carbonates south of Natha Cone (C-207963) and north of Exhile Hill (C-207965) are mid-Carboniferous, Serpukhovian or Bashkirian, and associated with mid-Carboniferous (probably Serpukhovian or Bashkirian) foraminifers (Appendices 1, 2 and 3).

Well bedded, pale green to khaki greywacke and cherty volcanic siltstone conformably overlie the carbonate at both locations. Macrofossils collected from these sediments south of Natha Cone are non-diagnostic (C-207964).

PALEOENVIRONMENTAL INTERPRETATIONS

Lens-like buildups and mounds of massive lime mudstone accumulated on and around the flanks of the volcanogenic highlands and/or centers. The morphology suggests carbonate mounds (Photo 2-5), but the composition and nature have not been fully investigated. Echinoderm grainstone is draped onto the flanks and interfingers with maroon volcaniclastic siltstone, sandstone and conglomerate. The mounds developed in an upper slope, shallow carbonate ramp environment of deposition. The carbonate and overlying cherty siltstone represent the accumulation of a distal facies and/or an eruptive hiatus during the mid Carboniferous.

DIVISION IV

UPPER CARBONIFEROUS

Upper Carboniferous rocks comprise; a package of calcalkaline volcanic rocks, carbonate and lesser sedimentary rocks (units uCSss, uCSb, uCSmv and uCSc; GS-Map), which lie between well dated carbonate units of mid-Carboniferous and Early Permian ages (mCSc and lPSc) in the Mess Lake area (uC-1 and -2, Figure 2-7); and a relatively undeformed package of epiclastic rocks (uCSss and uCScg), which overlie mid-Carboniferous carbonate in the Forrest Kerr area (uC-3, Figure 2-7). Biostratigraphic and geochronologic data provide good age constraints for the northern part of the map area, the controls in the Forrest Kerr area are equivocal. The Upper Carboniferous strata are distributed in fault bound areas, adjacent to the Forrest Kerr Pluton, around Newmont Lake and to the west where predominantly sedimentary rocks occupy topographic high areas west of the Newmont Lake Graben. Tuffaceous sedimentary rocks overlie mid-Carboniferous carbonate north of the Andrei Glacier and further north in the Mess Lake area, volcanic rocks predominate.

Carboniferous strata comprise undated epiclastics overlain by, and partly correlative with, a calcalkaline volcanic island arc succession, which in turn is conformably overlain by carbonate that in most places yields Early Permian (Asselian) fossils. Based on this upper contact the volcanic rocks are assigned a Late Carboniferous (*i.e.* Pennsylvanian) age. U-Pb zircon dating of flow banded rhyolite in the Mess Lake area returned a Late Carboniferous, Moscovian age of 311.7±2 Ma (Table 2-1). The epiclastic rocks, which in places conformably overlie mid Carboniferous carbonate, are probably also Moscovian but may be younger.

Upper Carboniferous strata are the oldest rocks exposed in the Scud River area (Brown *et al*., 1996) where they comprise a lower package of interdigitated sedimentary and mafic volcanic rocks with minor carbonate of the Devils Elbow and Butterfly units respectively, and felsic volcanic rocks of the overlying Navo Formation. A Moscovian U-Pb date of 311.1 + 6.2/ -10.4 Ma (J.K. Mortensen in Gunning, 1993a) from a mafic crystal tuff constrains the age of the Butterfly unit, conodonts from near the top of the Navo Formation are Late Carboniferous to Early Permian (Brown *et al*., 1996). An identical U-Pb date of 311.7±2 Ma (Table 2-1) from flow layered rhyolite constrains the calcalkaline volcanic package at Mess Lake. Other similar Upper Carboniferous U-Pb dates from Stikinia include 315±5 Ma from Delta Peak, Owegee Dome (Greig and Gehrels, 1995), and 307±2 Ma from a felsic unit at Tatsamenie Lake (Oliver and Gabites, 1993). The common occurrence of Upper Carboniferous intermediate to felsic volcanic rocks indicates consanguinity of arc volcanism during this time across northern Stikinia. The basic Upper Carboniferous stratigraphic sequence of epiclastic, volcanic and carbonate rocks, is consistent across the Scud River, Galore, Arctic Lake, and Newmont Lake areas.

MESS LAKE AREA

A moderately west-dipping, fault-duplicated section of characteristically maroon, in part subaerial, calcalkaline volcanics forms a north trending belt located between Mess Creek and the western contact of the More Creek Pluton. The most complete section of Late Carboniferous volcanic rocks in the study area is located west of Exile Hill (uC-1, Figure 2-9). Interbedded limestone horizons containing abundant Wolfcampian (late Asselian), fusulinacean foraminifers crop out near the top of the volcanic package (C-207976, Appendix 3) and the base of the package is conformable with fine clastic rocks (uCSss) and mid Carboniferous carbonate (mCSc), west of Nahta Cone. The western section is probably no more than 1000 metres thick and forms a dip slope down to Mess Creek. Aphyric purple and green amygdaloidal basalt, plagioclase and pyroxene-phyric andesite breccia flows and associated volcaniclastics form what appears to be the lowest volcanic unit (uCSb), but similar rocks also occur as subordinate members at various levels within the section (uC-1, Figure 2-9). Well-bedded, feldspar-phyric intermediate and felsic tuffs and epiclastic rocks comprise the characteristically pale maroon weathering medial unit, which contains both hornblende and pyroxene, as well as augite and hornblende-phyric fragments. Most lapilli are intermediate to felsic or andesitic; plagioclase crystals/grains are ubiquitous. Interbedded quartz-bearing polylithic epiclastic rocks and rare accretionary lapilli tuffs and ash flow tuffs record contemporaneous submarine and subaerial depositional environments. The uppermost volcanic unit (uCSr) consists mainly of maroon, mauve and brown flow-layered and spherulitic rhyolite, and quartz-feldspar-phyric rhyolite flows, autobreccia and ash-flow tuffs (Photo 2-8). These felsic rocks are resistant and form most of the prominent ridges and dip slopes east of Mess Creek. Most of the feldspar is orthoclase or microcline, and is weakly to moderately altered to sericite. Rare flows contain euhedral to subhedral quartz crystals 2 to 3 millimetres in diameter. Mafic minerals are generally absent except for rare biotite.

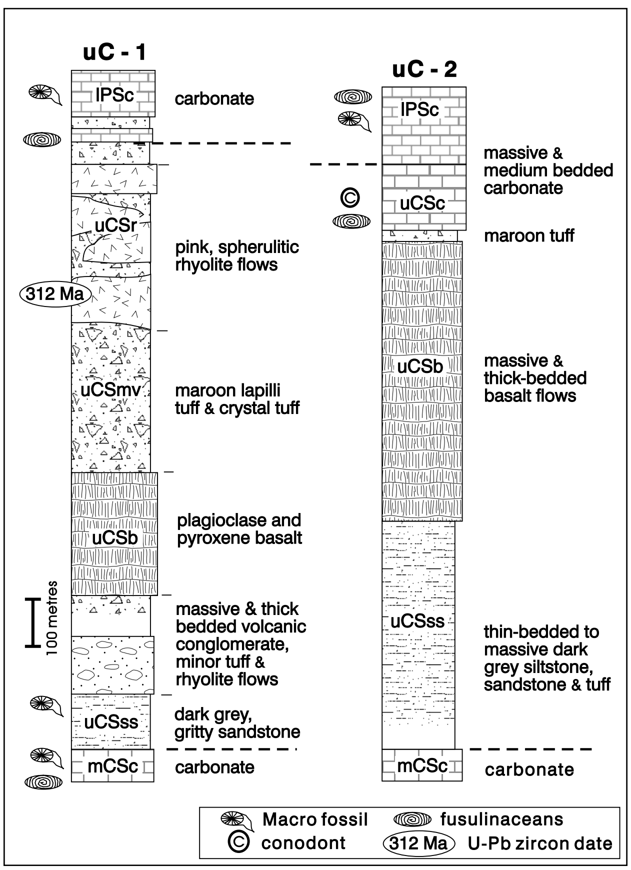

Figure 2-9. Generalized stratigraphic columns for Upper Carboniferous strata of the Stikine assemblage. Unit designation corresponds to legend on GS-Map 1997-3. Section locations are shown on Figure 2-7.

At least 10 to 15 metres of maroon ash-flow tuff and lapilli tuff underlie Early Permian carbonate west of Arctic Lake (Logan *et al*., 1992a). The silicic volcaniclastic rocks under the limestone are an extension of the much thicker rhyolite flows and tuffs to the north. Welded ash-flow tuff, about 5 metres thick, is conformably overlain by a maroon and green volcanic granule conglomerate and then well-bedded, grey, fossiliferous micritic limestone. Fault-bounded, massive maroon tuff occurs closer to the lake (GS-Map, in back pocket). In thin section, this tuff contains subhedral to anhedral quartz and feldspar grains in a devitrified matrix with a slight flattening fabric. A weak eutaxitic texture is defined by lenses of polycrystalline quartz, which wrap around crystals and fragments. Most of these lenses have euhedral, lath shaped crystals of possible zeolite projecting into them perpendicular to their walls.

A second, fault-bounded wedge of Upper Carboniferous volcanic rocks crops out between Mess and Skeeter lakes at the northern margin of the map (uC-2, Figure 2-7). The strata are intruded(?) by an undated coarse grained, pink hornblende granite above Mess Lake. Discontinuous lenses of massive recrystallized carbonate mark the contact of the granite with a southwest facing package of tuffaceous sediments (uCSss) comprised of khaki, green and brown coloured lapilli tuff and ash tuff, and thin bedded siltstone and sandstone with plagioclase crystal-rich epiclastic beds (uC-2, Figure 2-9). The sediments display normal grading and flame and load structures that indicate a younging direction to the southwest. Interlayered with the sediments are maroon and green, fine ash and lapilli basalt tuff and overlying them, although in fault contact are thick bedded amygdaloidal basalt flows and massive tuffs (uCSb). The

Photo 2-8. Pale weathering Upper Carboniferous (Moscovian) flow-layered spherulitic rhyolite.

volcanic rocks do not show any internal structure. The flows are mainly aphyric but some have coarse plagioclase phenocrysts. In places, quartz-carbonate-sericite amygdules delineate apparently planar flow tops, suggesting the basalt was erupted as sheets, and is not pillowed. Polydeformed, structurally thickened limestone, chert and siliceous tuff (uCSc) are exposed on Skeeter Ridge between Skeeter and Mess lakes (uC-2, Figure 2-7). This succession forms the eastern slope above Skeeter Lake and extends to the top of the plateau. Near its base the carbonate contains late Upper Carboniferous (Kasimovian to Gzhelian) fusulinacean foraminifers (C-207968, Appendix 3); there it is interbedded with maroon tuffs of the volcanic package. Higher in the section the carbonate yielded Early Permian fossils (C-207970, Appendix 2). The carbonate unit represents a period of tectonic stability in this area. There was a hiatus in volcanic activity and continuous deposition that spanned the Carboniferous-Permian boundary.

MORE CREEK AREA

A section of weakly foliated to unfoliated, well-stratified and graded volcaniclastics more than 400 metres thick is exposed on the flank of a nunatak in the southwestern corner of the More Creek area (Figure 2-7). The section includes maroon, hematitic and manganiferous lapilli and crystal tuffs, maroon pillow basalt flows and breccias, and also felsic dacitic to rhyolitic flows, ash-flows and lapilli tuffs. Similar ash-flow lapilli tuffs occur in the Mess Lake area, near Nahta cone. Thin-bedded ash tuff, tuffaceous sandstone and conglomerate are interspersed among the pillowed and brecciated flows; sedimentary structures indicate the strata are upright. Carbonate is absent from the section. Radiolarians from well bedded pale green cherty siltstone and dust tuff, located approximately in the middle of the section, indicate a possible late Mississippian to early Pennsylvania age (C-189790, Appendix 4).

FORREST KERR AREA

Upper Carboniferous sedimentary and epiclastic rocks predominate in the Forrest Kerr area. West of the Forrest Kerr Pluton, an upward coarsening package of volcaniclastic rocks conformably overlies middle Carboniferous carbonate at three locations; east and west of Newmont Lake, on a nunatak within the Andrei glacier, and on the slope immediately north of the glacier (uC-3, Figure 2-7).

Thin bedded cherty siltstone, poorly bedded tuff, wacke and sandstone and minor chert of unit uCSss comprise the basal unit which interfingers with middle Carboniferous (lower Bashkirian) limestone north of Andrei Glacier (Photo 2-5). It is gradationally overlain by a coarse clastic package of maroon volcanic sandstone, thick bedded polylithic volcanic conglomerate and tuff of unit uCScg. Dark purple and green pyroxene-porphyritic and hornblende- plagioclase-porphyritic andesite, scoriaceous basalt and grey fossiliferous limestone clasts form up to 70 per cent of the conglomerate. Up section the two units are interbedded and difficult to separate; both are tuffaceous, contain a substantial volcanic component and host blocks of the underlying middle Carboniferous carbonate up to several metres across. A limestone clast in the conglomerate contains solitary and rugose colonial corals and mid-Carboniferous (lower Bashkirian) foraminifers (C-158986, Appendix 1). Bedding top directions and conformable contacts indicate that the conglomerate is upright and either Late Carboniferous or Early Permian in age. This strata can be traced for ten kilometres northwest into the Galore Creek area where 200 metres of dominantly polymictic volcanic conglomerate, containing discontinuous limestone masses, well bedded siliceous epiclastics beds and intermediate volcanic flows are exposed (Logan and Koyanagi, 1994). They comprise a southwest-dipping homoclinal sequence which is overlain by Lower Permian limestone to the west. The conglomerate is medium bedded and locally fossiliferous. *Neospirifer* sp., ?*Spiriferella* sp., and productoid brachiopods of probable Early Permian age (C-189355, Appendix 1) are abundant in the conglomerate adjacent to limestone pods. Clasts of limestone in the conglomerate contain foraminifers of late Mississippian-Peratrovich facies and middle Carboniferous red algae facies (C-189355; Mamet,1991a). An Early Permian to no older than middle Late Carboniferous age is indicated for the conglomerate. The middle Bashkirian age of the clasts indicates the age of the source rock. The succession in general fines upward and high in the section consists of volcanic sandstone, siltstone and siliceous argillite with plagioclase crystal tuff horizons and occasional conglomerate beds. The fine-grained clastic layers display fining-upwards sequences, rip-up clasts and soft-sediment deformation features indicating a west-facing, right-way-up stratigraphic section. At this location, less than 100 metres of maroon plagioclase-porphyritic tuff caps the sequence and conformably underlies limestone containing Early Permian *Heritshiodes* sp. corals and *Pseudovidalena* sp. and *Clinacammina* sp. fusulinacean foraminifers (C-189356, Appendix 1 and Appendix 3) (Logan and Koyanagi, 1994).

The thickest and best exposed section of Upper Carboniferous epiclastic rocks (uCSss and uCScg, GS-Map) is west of Newmont Lake (uC-3, Figure 2-7). Interbedded conglomerate, sandstone, wacke and thinner layered siltstone and cherty siltstone comprise a structurally thickened section extending from the conformable contact with mid Carboniferous carbonate at 1350 metres to the top of Pyramid mountain at an elevation of 2041metres. A well-bedded section of epiclastic sediments and intercalated tuffs (unit uCSss) several hundred metres thick crops out on the north-facing ridge slope, five kilometres northwest of Newmont Lake (Figure 2-10). It conformably overlies mid Carboniferous carbonate west of Newmont Lake and comprises a thin to medium bedded succession of turbiditic, fine, siliceous siltstone and carbonaceous siltstone, interbedded sandstone and polymictic pebble to cobble conglomerate. Fining-upward sequences are common. Lenses of lapilli tuff and thick accumulations of coarse breccias and lahar at the base and top of the section attest to periodic influxes of volcanic materials (Figure 2-10). Lapilli are purple, equant, plagioclase crystal phyric basaltic andesite, in a plagioclase crystal rich matrix. Breccia fragments are commonly amygdaloidal basalt to dacite in composition. In one 10 metre section of tuff there are 4 fining upward sequences from lapilli to crystal to finely laminated ash (Photo 2-9). Epiclastic layers of fine sandstone and green laminated siltstone separate the tuffs and flow rocks. The middle of the section is comprised of black and white sandstone-siltstone 'DE' turbidite couplets, coarse sandstone, grit and conglomerate 'AB' beds. Flame structures and normal grading indicate upright facing bedding directions. Isoclinal folds in some of the black siliceous siltstone and chert layers are probable synsedimentary, slump features. Conglomerate beds are green or maroon and matrix supported. Clasts are augite and plagioclase phyric basaltic andesite, felsic volcanic rocks, green and black siltstone and fossiliferous carbonate. Large echinoderm ossicles characteristic of the middle Carboniferous carbonate in this area occur at one conglomerate horizon and conodonts from another indicate an Early Carboniferous, Visean-early Namurian age (C-159100, Appendix 2). The clasts are generally well rounded, moderately to well sorted and range from granule to boulder sizes. A single paleocurrent measurement indicates flow direction from the southwest. Structurally and presumably stratigraphically higher in the section are conglomerates. These are mainly dark grey to purple and only weakly bedded or graded. In places, near the lower contact with unit uCSss, they consist of maroon tuff with crinoid ossicles and thin bedded siltstone. The unit coarsens upwards into poorly sorted volcanic conglomerate with larger clasts averaging 20 to 40 centimetres in size. Clasts are mainly porphyritic andesite with plagioclase, hornblende, and pyroxene phenocrysts in a matrix of fine grained volcanic material (Photo 2-10). Carbonate clasts are an important feature which distinguish this conglomerate from stratigraphically equivalent? conglomerate units located east of Newmont Lake and north of Arctic Lake. Corals and foraminifers in a carbonate clast from conglomerate located 3 kilometres west of Newmont Lake are middle Carboniferous, Serpukhovian or Bashkirian (C-158994, Appendix 1 and Appendix 3). Topographically above this locale near the top of the peak is a large (20 by 50 metre) block of probable Carboniferous carbonate (Photo 2-11, C-168156, C-158996; Appendix 1 and Appendix 2).

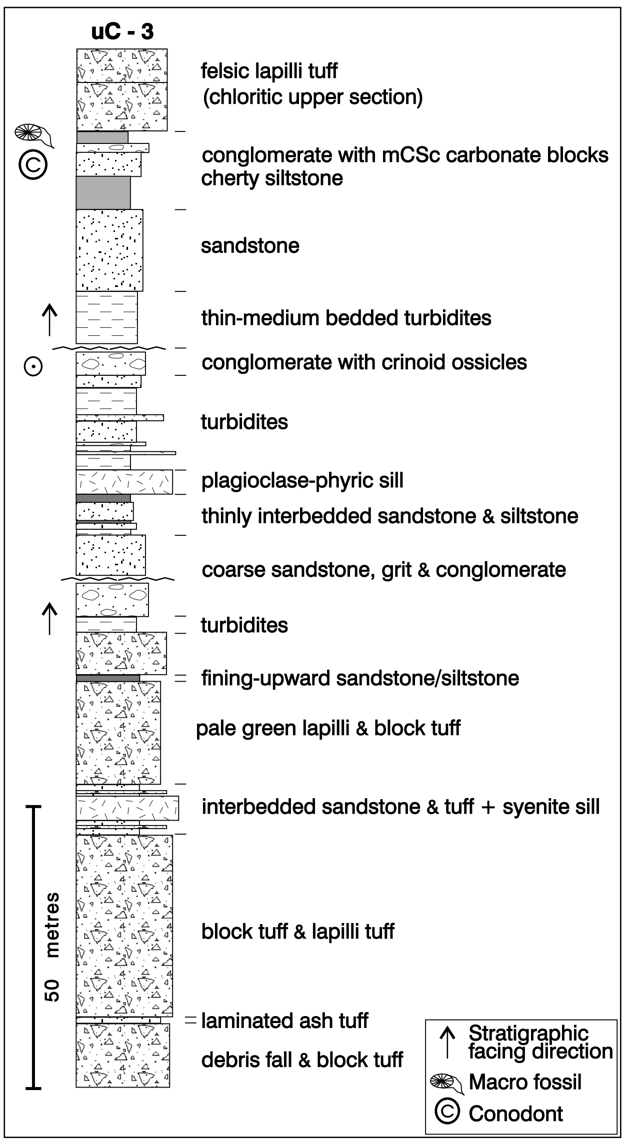

Figure 2-10. Measured section of Upper Carboniferous epiclastics and tuffaceous strata exposed northwest of Newmont Lake.

Photo 2-9. Fining-upward, normal graded series of epiclastic volcanic debris flows, cut by a high angle syn-diagenetic fault.

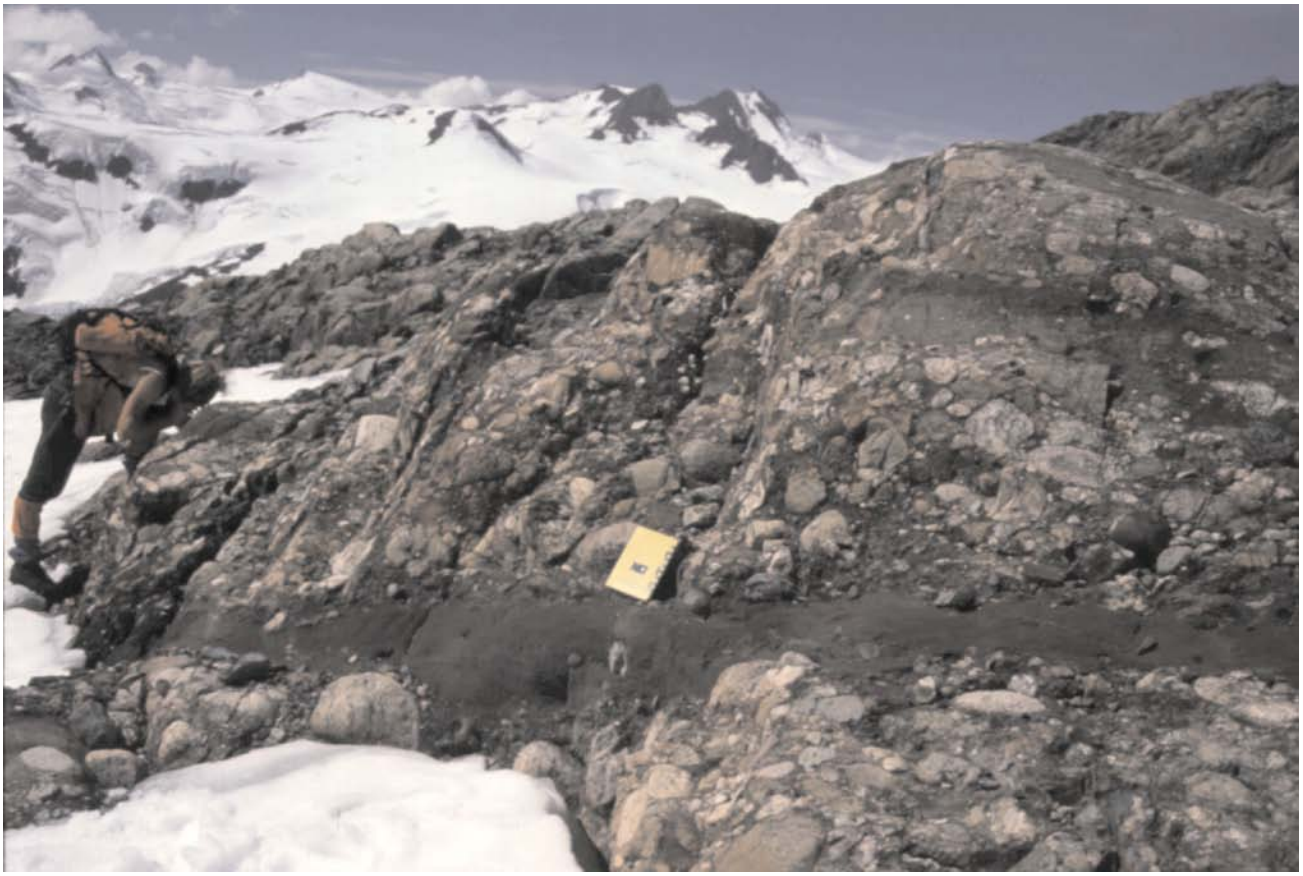

Photo 2-10. Poorly-sorted, thick bedded polylithic volcanic, plutonic and sedimentary clast conglomerate. Carbonate clasts contain mid-Carboniferous fossils and conodonts.

East of the Forrest Kerr Pluton, a north trending belt of interlayered metasedimentary and metatuffaceous rocks of probable Carboniferous age (CSst, GS-Map) crops out between the Forrest Kerr Pluton and the Forrest Kerr Fault. Strata include grey to light green phyllitic siltstone, graphitic argillite, siliceous phyllite, chlorite schist and tuff and thin lenses of dark brown limestone. Five kilometres northwest of the confluence of Iskut River and Forrest Kerr Creek the belt is intruded by small (1 kilometre) plugs of hornblende diorite and it is also from this location that Read *et al*. (1989) collected Early Permian conodonts from interlayered carbonate (C-102756, 7; Appendix 2). A unit of white and green, centimetre scale normally graded siliceous siltstone and argillite, less than 200 metres thick, is interbedded with, and overlain by dark green lenses of massive to plagioclase phyric mafic metavolcanic rocks and mottled purple and green breccias and lapilli tuff (lmDSst, GS-Map), south of the bend in Forrest Kerr Creek. Thin foliated marble, cherty grey schist, and green and grey siltstone (lmDSs, GS-Map) at the structural top of the section are intruded by biotite tonalite and hornblende diorite of the Late Devonian Forrest Kerr pluton. These rocks are

Photo 2-11. Large block of probable Carboniferous carbonate in a chaotic mix of mafic volcaniclastic sediments and coarse volcanic conglomerates, located near the top of "pyramid" peak.

polydeformed. They contain a well developed penetrative foliation, which locally is crenulated and overprinted by younger brittle fabrics; the fabrics make estimation of unit thickness difficult.

CHEMISTRY OF THE VOLCANIC ROCKS

The Upper Carboniferous tuffs and highly porphyritic and moderately altered flows have high LOI when analyzed (Appendix 8) and are not suitable for chemical interpretation or tectonic discrimination. Exceptions are the sparsely phyric rhyolite flows south of Mess Lake. A sample of massive, mauve rhyolite plots as calcalkaline, rhyodacite to dacite (not shown). The sample falls within the field of Lower Permian volcanics of the Asitka Group (Souther, 1977).

PALEOENVIRONMENTAL INTERPRETATIONS

The coarsening-upward volcanic sandstone and conglomerate sequence (unit uCSss and uCScg) is interpreted to represent a volcaniclastic/epiclastic dispersal apron shed from nearby volcanic island arc centers. The repetitive conglomerate-sandstone-siltstone sequences, normal grading and sharp, abrupt base to sandstone beds are common sedimentary features of submarine fans or turbidity flow deposits. The periodic influx of plagioclase crystal-rich volcanic rocks indicates volcanism coincided with deposition. The presence of well rounded volcanic and carbonate boulders requires a high energy system, probably reflecting substantial relief to transport and erode the clasts prior to incorporation into the turbidity flow. Tectonic instability and faulting along the margin of the arc may have calved off large blocks of the fringing middle Carboniferous carbonate, to be re-deposited outboard as melange blocks within the volcaniclastic turbidite. Limestone clasts of mid-Carboniferous (early Bashkirian) age in the upper conglomerates and the absence of younger Carboniferous strata suggest uplift and erosion. Overlying Lower Permian limestone accumulated in a shallow marine setting during a tectonically stable period following depostion of the epiclastics.

A middle Pennsylvania carbonate, volcanic conglomerate and sandstone and volcaniclastic unit containing large carbonate breccia blocks comprises the Mount Eaton block in Tulsequah River area (Mihalynuk *et al*., 1994). The similarities to the Upper Carboniferous package in the Forrest Kerr-Mess Creek area are strong.

DIVISION V

EARLY PERMIAN

Early Permian strata comprise two packages; a massive and thin bedded fossiliferous carbonate, and a poorly constrained package of siliceous tuff and sedimentary rocks interlayered with white carbonate. Distribution of the strata is largely controlled by north and northeast trending faults. Mainly carbonate, forms the prominent limonite- and hematite-stained bluffs that extend along the west side of the Forrest Kerr and More Creek plutons from Newmont Lake north to Mess Lake (Figure 2-7). In contrast with the area 45 kilometers to the northwest (Logan and Koyanagi, 1994; Brown *et al*., 1996) where 500 to 1000 metres of carbonates are present at the Scud River, less than 200 metres of carbonate are present here. Deformed equivalents of the carbonate and metavolcanic and metasedimentary rocks are exposed east of the Forrest Kerr Pluton in both hangingwall and footwall sections of the Forrest Kerr Fault (Figure 2-7). The Early Permian carbonate is recrystallized and variably deformed throughout the area but conodont alteration indices on average for the rocks west of the Forrest Kerr and More Creek plutons are much lower than those in the Forrest Kerr area to the east.

WEST OF THE FORREST KERR AND MORE CREEK PLUTONS

Medium-bedded to massive Lower Permian packstone (unit lPSc, GS-Map) forms knobs and discontinuous ridges in the Mess Lake area and west of Arctic Lake, extending as far north as Tadekho Creek. Six kilometres south and 2 kilometres northwest of Nahta Cone, respectively it overlies Upper Carboniferous epiclastic rocks of unit uCSmv and flow layered rhyolite of unit uCSr, with apparent conformity. The carbonate also disconformably overlies Early Mississippian granite and diorite of the More Creek Pluton in the same area. The upper contact with mafic tuff of probable Upper Triassic age is exposed in two creeks west of Nahta Cone. High angle listric extension faults offset and tilt the stratigraphy eastward. Thin-bedded layers in the packstone contain an abundant Early Permian fauna of rugose and tabulate corals, productoid and rhynchonellid brachiopods, pelecypods, bryozoa and fusulinacean foraminifers (C-207969 and C-207976, Appendix 1 and Appendix 3). Massive, pale grey marble and carbonate breccia members are generally barren of fossils. A large exposure of carbonate of unknown age straddles Tadekho Creek. At the southern end of the belt the carbonate contains mid Carboniferous tabulate corals and fusulinaceans, but further north it is medium bedded and interlayered with chert layers more diagnostic of the Early Permian carbonates.

Early Permian carbonate in the More Creek area comprises less than 200 metres of massive marble and medium to thin-bedded grey, fetid micritic limestone exposed in fault blocks along the east side of Mess Creek. Strata contain an abundant Early Permian fauna of rugose and tabulate corals, pelecypods, productoid and rhynchonellid brachiopods (C-189436, 7; Early Permian, probably Asselian or Sakmarian) and fusulinacean foraminifers. Biostratigraphic samples from the base of the carbonate near the basal contact with maroon Upper Carboniferous volcanic rocks contain latest Carboniferous, Gzhelian to earliest Permian, Asselian fusulinids (C-189783, 4; Appendix 3). Although the limestone is mainly medium to thick bedded, patch reefs occur where several types of corals are preserved in growth positions indicating small reef mounds were present (Photo 2-12). A major proportion of the limestone is massive, recrystallized and hematitic. Breccia textures are very common with an average fragment size of 2 to 4 centimetres; the colour is typically buff to rusty red. Except for small crinoidal pieces and the odd silicified brachiopod, this recrystallized limestone is barren of fossils.

Photo 2-12. Early Permian coralline limestone.

To the south, in Forrest Kerr area, Early Permian carbonate is exposed on an east trending nunatak at the western edge of the map area and in fault-bounded blocks on the eastern side of the Newmont Lake graben.

Early Permian, (probably lower Artinskian) based on fusulinacean foraminifers (C-158988, Appendix 3), carbonate is exposed along the edge of the Iskut icefield south of Andrei Glacier (Figure 2-7). The limestone comprises, less than 200 metres of primarily massive to thin-bedded grey bioclastic grainstone with minor buff silty dolomitic units. Interbedded in thinly-bedded sections are black to yellowish buff chert beds up to 20 cm thick which may constitute up to 50 per cent of the outcrop. These layers are probably diagenetic, representing silicified fossil-rich horizons. Locally, they contain abundant solitary corals, foraminifers, bryozoans, echinoderms and productoid and spiriferid brachiopods. Maroon volcanic conglomerates of probable uCScg are in faulted contact with the carbonate at this location.

Disrupted, fault-bounded blocks of Early Permian carbonate east of Newmont Lake consist primarily of massive to thin bedded grey bioclastic calcarenite and lesser buff silty dolomitic units. Thin-bedded sections are rhythmically interleaved with black to yellowish amorphous silica beds up to 10 centimeters thick (Photo 2-13). Solitary corals, foraminifers, bryozoans, conodonts and spiriferid brachiopods are locally abundant, in both carbonate and silicified beds (C-158969,158987; Appendix 2). Limonitic and hematitic limestone are coincident with fault structures and indicate fluid flow and attendant alteration. This alteration is selective and occurs predominantly in the massive limestone and dolomitic mudstone layers.

EAST OF THE FORREST KERR PLUTON

An Early Permian, Artinskian to Sakmarian (C-087669, 71 and C-158998; Appendix 2) carbonate lens crops out adjacent to the West Slope fault. The limestone is a massive, white to buff, sparsely crinoidal calcarenite which is locally completely recrystallized to coarse crystalline calcite. Structurally below the carbonate is a purple and green volcanic conglomerate containing limestone clasts, that is interpreted to be the basal Triassic Stuhini Group (Read *et al.*, 1989). In outcrop it resembles the Upper Carboniferous coarse volcaniclastic units located west of the Forrest Kerr Pluton.

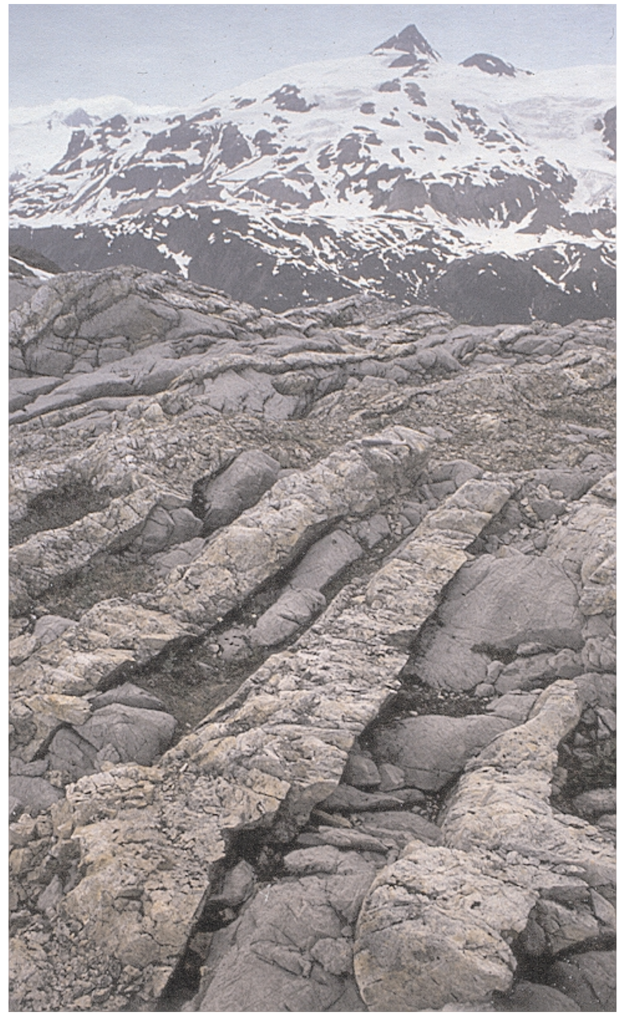

Photo 2-13. Early Permian limestone interlayered with yellow amorphous silica beds (~10 cm thick), east of Newmont Lake, view is to the west, "pyramid" peak forms the background.

East of the Forrest Kerr Fault deformed siliceous tuff and metasedimentary rocks of Paleozoic, probable Permian age, underlie a 25 square kilometre northeast trending structural culmination located east of the bend in Forrest Kerr Creek. Foliated and crenulated metavolcanic rocks of unit lPSdt consist of green interbedded chloritic tuff, tuffaceous and siliceous siltstone and numerous thin recrystallized Early Permian (C-102947, C-102855, Appendix 2) carbonate beds (lPSdc, GS-Map). Thinly laminated tuffs within the unit resemble siltstone, but in thin section are seen to contain laminae of angular, broken plagioclase, quartz, and potassium feldspar crystals. Crystal fragments are also scattered throughout the more abundant, finer grained layers. A weak planar foliation is visible. The strata resemble sections of Upper Carboniferous rocks and some parts of the Upper Triassic section.

PALEOENVIRONMENTAL INTERPRETATIONS

Early Permian, Asselian age fusulinacean-bearing limestone and interbedded maroon tuffaceous siltstone indicate that volcanism initiated in the Upper Carboniferous apparently continued into the Early Permian and was coeval with carbonate accumulation in the Mess Lake area. Latest Carboniferous, Gzhelian to Early Permian, Asselian age fusulinaceans suggest that carbonate deposition was initiated as early as late Carboniferous and continuous through into Early Permian time.

EARLY TO MIDDLE TRIASSIC

Black, carbonaceous siltstone (unit mTs, GS-Map) underlies the eastern edge of the map area in structurally low positions (Figure 2-11). It is bedded on a 10 centimetre or finer scale, with rhythmic normal graded beds rarely coarsening to very fine sandstone. The strata contains approximately 0.5 per cent finely disseminated pyrite and numerous elliptical carbonate concretions. Minor chert occurs with siliceous varieties of the siltstone. The majority of the unit is a distinctly carbonaceous, black weathering rock with stockworks of white calcite veinlets. The incompetent nature of these rocks accounts for their characteristically tight, disharmonic, parallel folding. Sedimentary structures indicate that this unit is stratigraphically upright and below the Late Triassic More Creek sedimentary facies rocks. The strata are correlated with Early to Middle Triassic silty argillite, limy dolomitic siltstone and cherty siltstone exposed at Copper Canyon, 50 kilometres west in the Galore Creek area (Souther, 1972; Logan and Koyanagi, 1994). There are no biostratigraphic age constraints for the siltstone package in the current map area. However, Middle Triassic and Middle to Late Triassic radiolarian have been identified by Cordey (1992) from thin bedded, black and brown chert interbedded with limestone in the More Creek area, northwest (C-167847, Appendix 4) and northeast of Hankin Peak (C-189401, Appendix 4). The strata are essentially indistinguishable in outcrop and hand specimen from similar Upper Triassic limestone and chert east of More Creek and in both localities they occur adjacent to limy sedimentary rocks which contain Late Triassic conodonts (C-167850 and C-189402, Appendix 2). One possibly important difference is that the Middle Triassic chert is generally more deformed, although the tight parallel folds may in part be due to soft-sediment deformation. The small and discontinuous nature of both these outcrops and the imbrication with younger rocks is fault related.

LATE TRIASSIC STUHINI GROUP

Rocks of the Upper Triassic Stuhini Group change across the study area from mainly volcanic flows and subaerial tuffs in the Mess Lake and Forrest Kerr areas, to predominantly volcanic sediments and limestone in the More Creek area (Figure 2-11). The Newmont Lake assemblage is a distinct package of volcanic rocks and carbonate which occupies the Newmont Lake Graben in the Forrest Kerr area. Across the map, the change from proximal volcanic facies in the west (Mess Lake facies), to more distal sedimentary facies in the east (More Creek facies), is

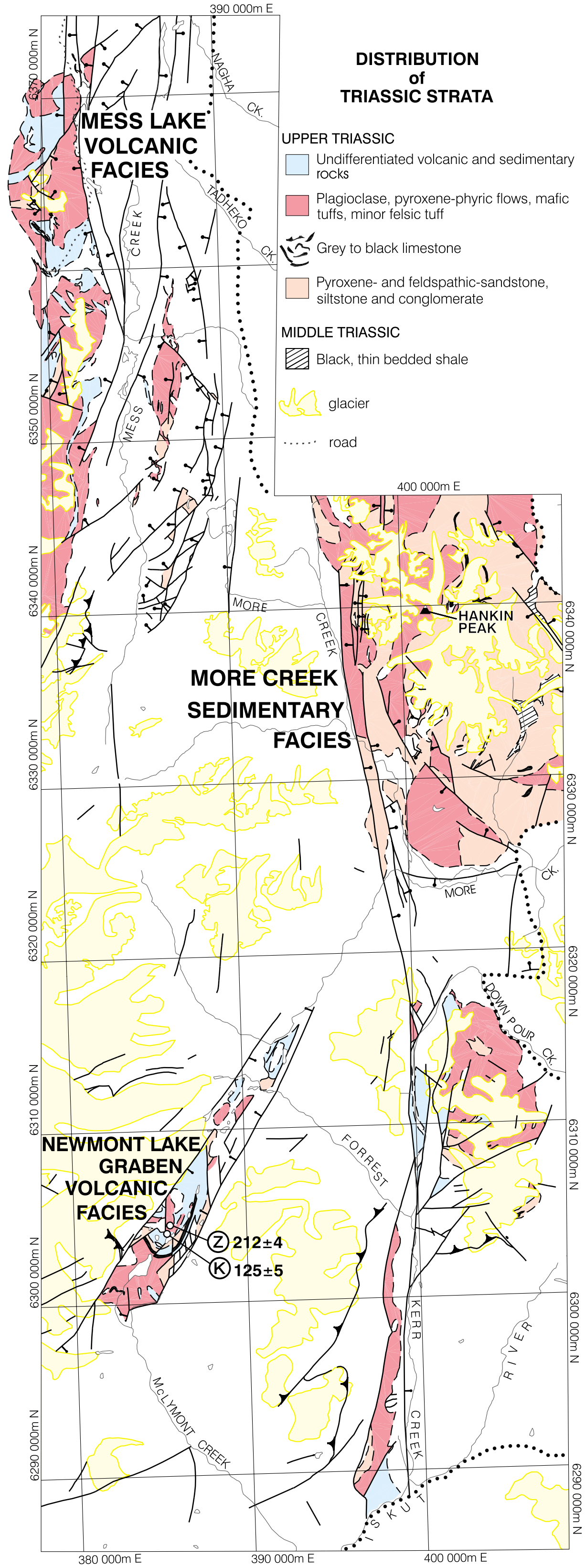

Figure 2-11. Distribution of Triassic strata, shows the locations of the three main subdivisions; Mess Lake volcanic facies, More Creek sedimentary facies and Newmont Lake Graben volcanic facies. Sample sites and results are shown for a K-Ar, whole rock and U-Pb, zircon age dates from the Newmont Lake Graben.

compatible with the Late Triassic to Early Jurassic arc being located west of the map area. The present distribution of Late Triassic to Early Jurassic extrusive and intrusive rocks defines a north-trending axis located probably between the present map area and the Stikine River (Hickman Pluton, volcanic edifice at Galore Creek, the Moosehorn Pluton).

Upper Triassic proximal deposits comprise pyroxene and/or plagioclase porphyritic lava flows, coarse volcanic breccias and lapilli and crystal tuffs. Substantial proportions of the volcanic pile are made up of massive subvolcanic rocks, that are considered to be parts of the volcanic feeder system. Pyroxene and potassium feldspar rich sediments are interbedded with carbonaceous shale, cherty siltstone and limestone in the More Creek area. The pyroxene and feldspar crystals were derived either from eruptions of crystal tuffs or were washed off the flanks of the volcanoes into the basin. Potassium feldspar megacrystic syenite dikes and less commonly mafic pyroxene porphyry flows are interspersed within the sedimentary rocks at More Creek area, indicating that the sediments were deposited proximal to the main arc. Due to the steep and variable inclinations of the strata, it is difficult to estimate thickness. However, the Upper Triassic strata are roughly estimated to be a maximum of 2 kilometres in most areas (Souther, 1972).

MESS LAKE/ARCTIC LAKE AREA

The Stuhini Group is dominated by volcanic rocks in the Mess and Arctic lakes areas (Mess Lake volcanic facies, GS-Map). Volcanic rocks underlie Mount LaCasse and most of the rugged mountainous area west of Mess Creek and also crop out in a narrow north-trending belt east of Mess Creek, where they are less well exposed (Figure 2-12). They lie unconformably on Lower Permian limestone 3 kilometres northwest of Nahta Cone and 4 kilometres southwest of Arctic Lake, and are unconformably overlain by Lower Jurassic conglomerate along their eastern margin southwest of Nahta Cone and at two localities west of Mess Creek. The volcanic rocks are truncated on the west side by the Hickman and Yehiniko plutons. To the south they are faulted against Paleozoic rocks. A generalized stratigraphy consists of a basal sedimentary succession (uꞆSsn) or mafic tuffaceous succession (uꞆSmt), a medial volcanic succession characterized by flows and breccias with a central tuff unit (uꞆSvb, uꞆSvt, uꞆSpp) and an upper tuffaceous sedimentary succession (uꞆSs, Figure 2-12).

West of Mess creek, maroon amygdaloidal plagioclase and pyroxene-phyric basalt flows, breccias and tuffs, and dun-weathering, olivine-rich basaltic tuffs at least 800 metres thick are intruded by trachytic sills of coarse-bladed plagioclase and pyroxene porphyry, probable feeders to overlying volcanics.

The lowermost stratigraphic unit consists of less than 100 metres of recessive, dun weathering, serpentinized mafic to ultramafic volcanic rocks. Lapilli tuffs predominate and together with minor flows are variably altered to serpentinite and ductily deformed. The lapilli are scoriaceous, green-blue and black and altered to serpentine, talc and chlorite (Photo 2-14). East of Mess Creek, serpentinized tuff overlies Lower Permian carbonate at two areas; the contact at one site is partly faulted. Volcanic rocks of unit uꞆSvb were not observed to directly overlie the mafic tuff unit, but they usually crop out nearby and consist of dark grey, massive, plagioclase phyric basalt and similarly textured subvolcanic rocks. They are best exposed north and south of the Schaft Creek porphyry copper deposit. Contact relationships of the basalt are poorly exposed, except where it is intruded by hornblende diorite to monzonite of the Hickman Pluton. The basalt is typically fine-grained, with 0.5 to 1 mm plagioclase phenocrysts to about 30 per cent and several per cent pyroxene phenocrysts. Outcrops are generally massive with few extrusive textures visible, but locally, breccia and amygdaloidal textures are recognized in talus blocks. Tuffs of the medial volcanic unit overlie these basaltic rocks 7 kilometres north of the Schaft Creek camp. Unit uꞆSvt comprises massive to weakly stratified, polylithic, grey to mauve lapilli tuffs and crystal tuffs that form thick sections underlying the east-facing slope above Mess Creek. Both plagioclase and augite crystal fragments are common, although augite is generally less than 5 per cent of the rock (Photo 2-15). Measurable bedding attitudes are rare; the few seen indicate steep dips. The same succession crops out further west, where it underlies the west-facing slopes above Schaft Creek. It consists of maroon and green fine ash and plagioclase-rich crystal tuff intermixed with purple monolithic augite phyric lapilli tuff and thin purple basalt flows (Figure 2-12). Epiclastic horizons include colorful, polylithic boulder to cobble conglomerates, containing clasts of green and black augite phyric basalt, maroon plagioclase porphyry, green, epidote-rich altered volcanic rock and purple aphyric basalt. The thickest

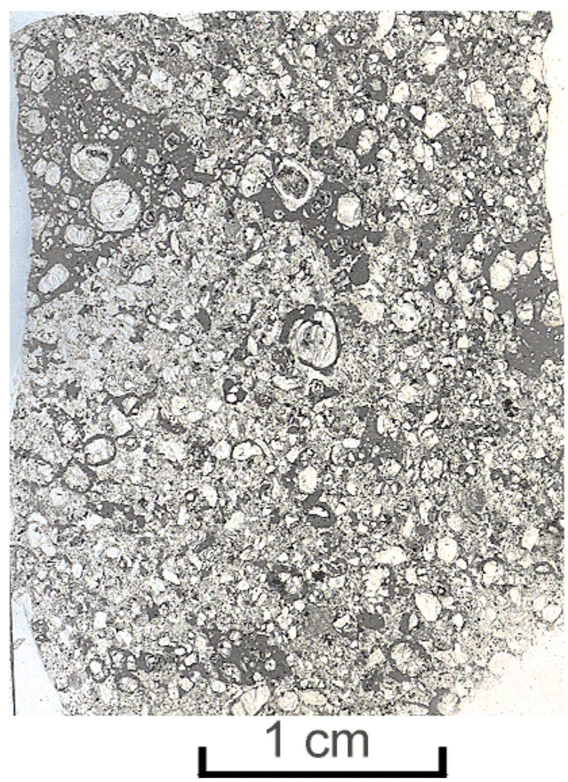

Photo 2-14. Thin-section of Upper Triassic serpentinized mafic tuff (?) or peperitic sill. Serpentine pseudomorphs euhedral to subhedral olivine crystals and replaces fine grained matrix.

volcanic unit comprises augite-phyric, plagioclase-phyric, augite and plagioclase-phyric, and aphyric basaltic andesite flows (uTSpp). It extends the full length of the western edge of the map area and is the host rock of the Schaft Creek deposit. Subvolcanic intrusive rocks are difficult to distinguish from the extrusive rocks in this area and are included with them. Tuffs and flows occur in subequal amounts and vary in colour from maroon to green; it is common for purple tuff to be interbedded with green tuff. The basaltic andesite is pillowed for 3 kilometres both northeast and southeast of Schaft Creek (Photo 2-16). All bedding attitudes observed in the intercalated tuffs were steeply inclined to the northeast or southwest. Locally the unit may be tightly folded, but the lack of good stratification makes the extent of this difficult to determine. Unit uTSs comprises about 150 metres of well-bedded green dust tuffs, tuffaceous siltstone-sandstones and wackes which crop out on the northwestern flank of Mount LaCasse, 5 kilometres north of the Schaft Creek deposit. Near its western margin, the well-bedded section thins considerably where it is faulted against unit uTSpp. The tuffs also apparently thin to the northeast, limiting their usefulness as a marker unit. A thin maroon quartz and limestone-bearing volcaniclastic unit (possibly Unit lJcg) apparently overlies these sediments conformably but is faulted against pyroxene-phyric volcanics of Unit uTSv farther east. Steeply dipping, tightly folded volcanic conglomerate, interbedded sandstone and siltstone, pyroxene crystal sandstone and limy siltstone (Unit uTSs) are exposed about 4 kilometres south of the Schaft Creek deposit (GS-Map, in pocket). Fossils from thin interbedded siltstone, sandstone and conglomerate layers are identified as the Late Triassic, Upper Norian brachiopod *Monotis Subcircularus* (C-207971, Appendix 1).

Photo 2-15. Epidote altered breccia fragments of subvolcanic and mafic volcanic rocks within massive thick bedded plagioclase crystal and lapilli tuffs, which comprise the western slopes above Mess Creek.

East of Mess Creek, Upper Triassic volcanic rocks comprise a north-trending belt, 10 by 2 kilometres wide which in part forms the eastern intrusive margin to the Late Triassic to Early Jurassic Loon Lake Stock (Figure 2-12). General stratigraphy, while similar to that west of Mess Creek, is more condensed. Rafts of hornfelsed mafic tuff, breccia and sedimentary rocks are hosted in the main body of plagioclase hornblende monzonite. Contact metamorphic and hydrothermal effects of the Loon Lake Pluton produced a large gossan in the volcanic and subvolcanic hostrocks as well as in the intrusive itself. In some cases this has made it impossible to distinguish the massive plagioclase phyric tuffs and flows from subvolcanic intrusive rocks.

Mafic tuffs of unit uTSmt are clearly visible in creek exposures where alteration and weathering have produced characteristic dun to bluish-green hues. The lapilli tuff is intruded along its western limit by the Loon Lake stock and probably overlain conformably by silicified dust tuff and turbiditic siltstone of Unit uTSs, which commonly crops out nearby. The same stratigraphic relationships are apparent west of Mess Creek (Logan *et al*., 1992a,b). Massive tuffs and flows of Unit uTSvb include associated subvolcanic intrusive rocks which could not be mapped separately. Both are predominantly dark green, plagioclase phyric rocks with lesser pyroxene. Pillowed and breccia flow textures occur locally in the massive sequence of plagioclase-phyric basaltic andesite. The volcanic and sedimentary strata are un-

Photo 2-16. Moderately-dipping pillowed basaltic andesite units overly massive flows and subvolcanic sills northeast of the Schaft Creek deposit.

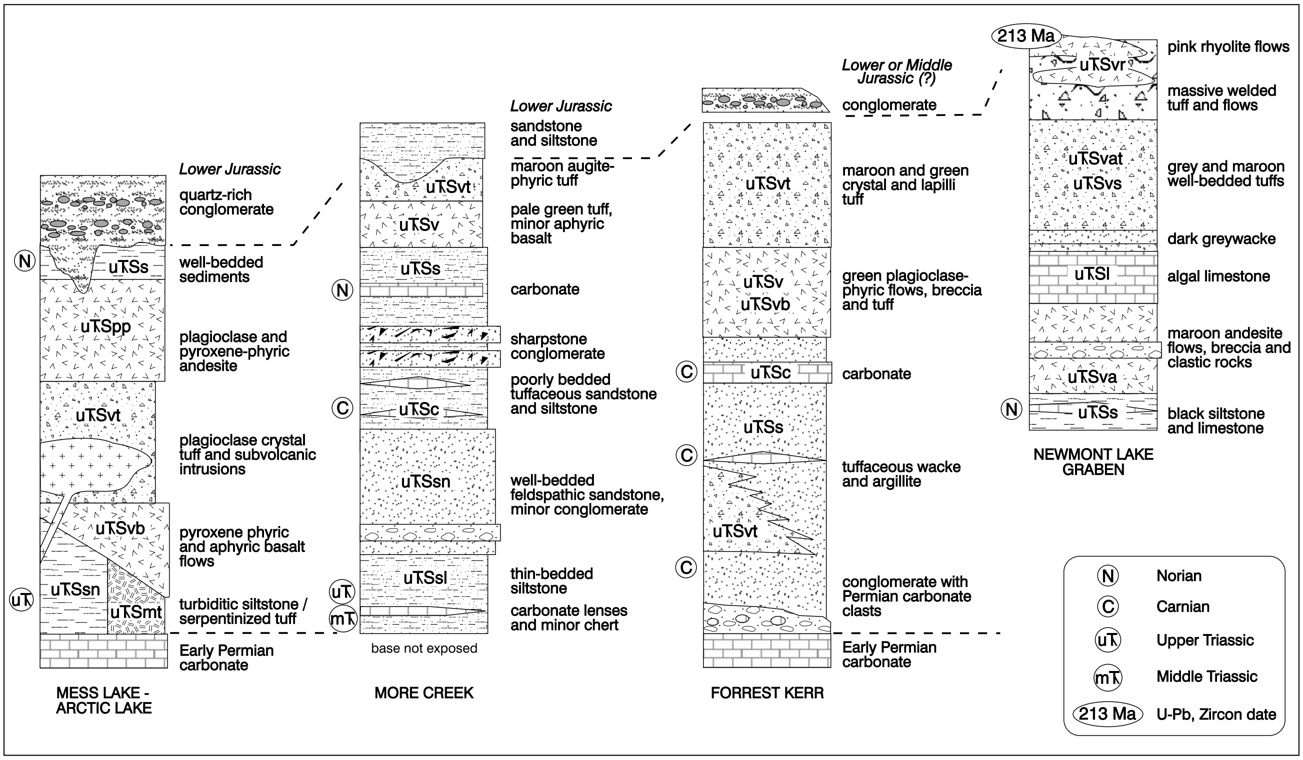

Figure 2-12. Schematic stratigraphic columns for Upper Triassic Stuhini Group, showing fossil and geochronological constraints and facies equivalent correlations for the Mess Lake, More Creek, Forrest Kerr and Newmont Lake areas. Unit designation corresponds to legend on GS-Map 1997-3. Section locations are shown on Figure 2-11.

conformably overlain by Lower Jurassic conglomerate along their eastern exposure.

MORE CREEK AREA

Upper Triassic Stuhini Group rocks in the More Creek area comprise a thick package of predominantly volcanic arc derived sediments, limestone and lesser intercalated intermediate to mafic volcanic rocks (More Creek sedimentary facies) which correspond, in part, to the eastern facies of Anderson (1989). Sedimentary rocks crop out mainly east of the Forrest Kerr fault, north of More Creek, and west of Arctic Lake (Figure 2-12). Volcanic rocks of the Mess Lake volcanic facies form the steep cliffs west of Mess Creek in the northwest corner of the map area. The best exposed stratigraphic sections in the More Creek area are on the northeast and southwest flanks of Hankin Peak, and approximately 10 kilometres south of Hankin Peak on the Lucifer claims. The base of the section is exposed near the eastern margin of the More Creek map area, where Upper Triassic siltstones lie conformably on black carbonaceous siltstone of probable Middle Triassic age. At a second location west of Arctic Lake, Late Triassic sediments paraconformably overlie Early Permian limestone.

The widespread Upper Triassic rocks in the More Creek area have been divided into five map units (Figure 2-12). From oldest to youngest, these are: massive, thin-bedded to laminated, black and brown siltstone (uTSsl); khaki feldspathic sandstone, limestone conglomerate and greywacke (uTSsn); grey recrystallized limestone and cherty and carbonaceous siltstone (uTSc); thick-bedded augite-bearing greywacke and sharpstone conglomerate (uTSs); and augite-phyric and aphyric flows, related tuffs and epiclastics (uTSv).

East of Forrest Kerr fault, the lowermost unit is a planar-laminated siltstone interbedded with undulose to wavy cross-stratified sandstone. It crops out as dark grey to black, massive or thickly bedded calcareous siltstone with light brown to orange-weathering sandstone interbeds. Common sedimentary structures include load and flame structures, soft-sediment slumping and trough crossbeds; graded bedding is less common. Interbedded with the siltstone are horizons of siliceous siltstone, limestone and ribbon chert (to 50 m thick). The siltstone and chert are variegated, black, green, yellow and grey, and contain Middle-Late Triassic, Ladinian-Carnian radiolarians (C-189401, Appendix 4). The siltstone unit is overlain by a well-bedded sequence of khaki coloured feldspathic sandstone, thin interbedded dark grey siltstone to fine sandstone, poorly sorted dark grey arkosic greywacke, and limestone-bearing conglomerate (uTSsn, Figure 2-12). Sandstone units commonly contain lithic clasts and laminated siltstone rip-up clasts. Interbedded with these rocks are planar-laminated, olive-grey, dark green and black, thin-bedded siliceous siltstones and fine sandstones (Photo 2-17). Limestone conglomerates and polymictic limestone-bearing conglomerates comprise distinctive green, yellow or maroon-weathering coarse clastic units. Angular to rounded light grey limestone clasts in a buff matrix of coarse, tuffaceous and limy sand comprise up to 85 per cent of some outcrops. Subordinate volcanic sandstone and siltstone make up the

Photo 2-17. Planar-laminated, normal graded grey siltstones and green volcanic-derived sandstone of Upper Triassic Stuhini Group. Flame structures and fining directions commonly show top directions.

remainder. Polymictic conglomerate layers of variable thickness contain mixed angular and rounded fragments up to 20 centimetres (average 5 centimetre) in diameter. Clasts include maroon and grey pyroxene-phyric and plagioclase-phyric andesite, black siltstone and limestone. Star-shaped (isocrinus?) crinoids, of Triassic or younger age, occur within limestone clasts. White-weathering, grey, recrystallized, massive to medium-bedded limestone crops out throughout the stratigraphy as discontinuous units that are less than 50 metres thick. The limestone is bioclastic, with sparse crinoids and various pelecypod and brachiopod fossil fragments and contains conodonts of Late Triassic, Late Carnian age (C-189760, 61; Appendix 2). Recessive dark grey and black silty limestone may represent basinward facies equivalents of the bioclastic limestone. Thick-bedded tuffaceous sandstones, sharpstone conglomerates, and thin-bedded black limestones comprise a succession 300 metres thick east of Hankin Peak (uŦSs, Figure 2-12). The sandstones are light green, augite-bearing, medium-grained, well-sorted epiclastics; in places, they texturally resemble pyroxene diorite intrusive bodies. These massive bedded green tuffaceous sandstones are interlayered with chaotic slump or debris flow deposits of poorly sorted greywacke or sharpstone conglomerate. The sharpstone conglomerate layers are thick and numerous within this unit. The matrix is most commonly arkosic, though east of Hankin Peak it is argillaceous. Clasts include laminated siltstone, bedded sandstone, chert, limestone and rare aphyric volcanics (Photo 2-18). Limestone clasts from the sharpstone conglomerates contain Middle Triassic (C-189800, Appendix 2) and Carnian, Late Triassic (C-207977, Appendix 2) conodonts and radiolarians. The clasts are angular to subangular; they average 2 centimetres in size, but are as large as 10 centimetres. Bivalves, possibly Upper Triassic *Monotis* or Middle Triassic *Daonella* are present in thin siltstone layers and in clasts from interbedded sharpstones north of the Lucifer claims. Light grey massive limestone from this same location yielded Late Triassic, Norian conodonts (C-189793, Appendix 2). Thin-bedded black to dark grey argillaceous limestone is interbedded with tuffaceous sandstones north of Twin glaciers. The limestone contains belemnites, ammonites and the Carnian conodont *Metapolygnathus* sp. (C-189450, Appendix 2); the siltstone and sandstone contain the Carnian bivalve ?*Halobia* (C-189755, Appendix 1).

Upper Triassic volcanic rocks are volumetrically subordinate to sedimentary rocks in the More Creek area. Intermediate volcaniclastics and epiclastics predominate, intermediate and mafic flows are subordinate. Maroon and dark green plagioclase-phyric lapilli tuff is interbedded with white to brown-weathering, medium-grained feldspathic volcanic sandstone north of More Creek. Subangular lapilli and reworked, well-rounded 1 to 2 centimetre fragments of plagioclase and hornblende phyric volcanics occur in a pyroxene crystal-rich matrix. The tuffs and epiclastics are stratified but thick bedded, and generally difficult to distinguish from one another. Coarse polylithic block tuffs containing plagioclase-phyric andesite, dacite and maroon hornblende plagioclase andesite clasts are distinctive within the thick package of interbedded ash and lapilli tuff and reworked epiclastic rocks. Maroon augite-phyric and plagioclase-hornblende-phyric flows and flow breccias are interlayered with pyroxene-rich crystal and lapilli tuff to the northwest and northeast of Hankin Peak (Photo 2-19). The flows contain augite phenocrysts up to 10 millimetres in size and stubby plagioclase phenocrysts to 3 millimetres in size in a purple and green mottled groundmass. East of Hankin Peak, interlayered maroon and green ash and lapilli tuff, massive plagioclase-phyric andesite, and scoriaceous flow breccias overlie thin bedded pyritic siltstone and sandstone.

Weak to variably foliated volcanic, tuffaceous and epiclastic rocks crop out in creek valleys north of Hankin Peak. Lithologically this package is identical to rocks of the Upper Triassic Stuhini Group. Chlorite phyllite and schists

Photo 2-18. Khaki to olive coloured volcanic debris flow, consisting of angular siltstone, chert, limestone and rare volcanic clasts in a feldspathic matrix (sharpstone conglomerate of unit uŦSs).

are locally developed, and these generally occur structurally below less-deformed pale green, fine-grained distal tuffs. This area may contain pre-Triassic rocks, but insufficient work has been completed to be certain.

A section of limy sediments 175 metres thick paraconformably overlies Lower Permian limestone west of Arctic Lake (Figure 2-12 and Photo 2-20). The sediments resemble Middle Triassic rocks and earlier work (Logan *et al*., 1992a,b) mistakenly correlated them with the Middle Triassic sediments present in the Galore Creek area (Souther, 1972; Logan and Koyanagi 1994). Subsequent identification of sparse brachiopod fossils indicates that the succession is, at least in part, Upper Triassic. The lowermost 100 metres consists primarily of black, medium-bedded, planar-laminated, fetid, limy siltstone and fine sandstone that are correlated with unit uTSsn. Elliptical concretions of coarsely crystalline siderite are common. A discontinuous thin-bedded, quartz-bearing tuffaceous sandstone/greywacke comprises the base of the section where it overlies Latest Carboniferous to earliest Permian limestone (C-189783, Appendix 3). The lower unit is interbedded with fetid black limestone at its upper contact. The clastic component increases in size and proportion up section; micrite and limy siltstone grade into thinly interbedded siltstone and sandstone. The upper package is 75 metres thick and consists of medium-bedded buff to orange sandstone with thin interbeds of black and grey siltstone. The sandstone weathers concentrically and contains carbonized wood fragments. In gradational contact above the siltstone-sandstone package is a discontinuous unit of finely laminated, pale green cherty siltstone 1 to 2 metres thick.

Overlying the siltstone is a dark green polymictic pebble to cobble conglomerate (uTSs). This unit crops out west and north of Arctic Lake (at the edge of the plateau) and also to the southeast, on the other side of the FKP; in an isolated occurrence 6 kilometres north of the confluence of More and South More creeks; on the west side of More Creek; and on the Lucifer property, north of More Creek. The contact of the conglomerate with the underlying siltstone is sharp, parallel to bedding and appears to be depositional. Clasts are well rounded to angular and include limestone, marble, augite and hornblende-phyric volcanics, basalts and chert. In contrast to the Lower Jurassic conglomerates that contain granite and free quartz, this conglomerate contains augite grains. Tuffaceous sections within the conglomerate contain coarse (0.5 to 2 centimetre) white and pink potassium feldspar laths, that comprise about 5 per cent of the rock.

Photo 2-19. Pyroxene-rich crystal and lapilli tuffs, north east of Hankin peak.

FORREST KERR AREA

The distribution of Upper Triassic rocks in the Forrest Kerr area is controlled by faults. These strata crop out between West Slope and Forrest Kerr faults, east of the Kerr fault in the area south of Downpour creek, and within the Newmont Lake Graben (Figure 2-11). A generalized stratigraphy for the eastern part of the map, after Read *et al*. (1989), consists of a lowermost predominantly sedimentary succession (uTSs), a medial mafic volcanic succession (uTSv) and an overlying tuffaceous sedimentary succession (uTSvt). Contacts between units are faulted or poorly exposed and, as a result, thickness and overall stratigraphic relations are uncertain. South of Newmont Lake, carbonaceous siltstone and limestone (probably correlative with uTSs) are overlain by volcaniclastic and sedimentary rocks of the Newmont Lake Graben volcanic facies (Figure 2-12). The stratigraphy at Newmont Lake consists of an intermediate to felsic volcanic and sedimentary succession characterized by a medial shallow water limestone. The section is at least 500 metres thick, but neither the base nor top are constrained.

The lowermost Upper Triassic unit consists of a thick package of fine-grained volcaniclastics and sediments that crop out east of the Forrest Kerr fault, in the eastern part of the map. Strata are green to grey massive volcanic wackes and arenites, interbedded black siltstone and argillite and lesser limestone and limy conglomerates. Massive to

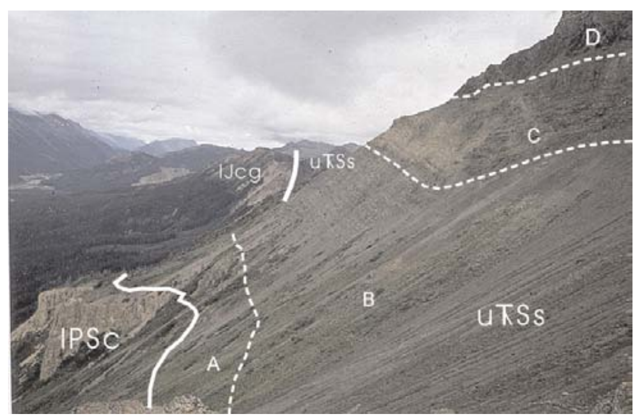

Photo 2-20. Well-bedded Upper Triassic section of sediments exposed southwest of Arctic Lake, in Mess Creek Valley (viewed north down Mess Creek). Sediments are kinked and gently warped about a northeast-trending axis. Normal faulting has down dropped Lower Jurassic conglomerate against Upper Triassic Stuhini Group sediments to the north. lPSc=Permian limestone; uTSs=Upper Triassic Stuhini Group sediments, A=quartzose sandstone, B=limy, fetid sandstone-siltstone, C= interbedded sandstone and siltstone, D=volcanic conglomerate with potassium feldspar crystal-tuff horizons, lJcg= polylithic quartz-rich volcanic boulder conglomerate.

thickly bedded volcanic sandstones and poorly sorted lithic wackes consist of up to 80 percent plagioclase, the remaining 10 to 30 per cent being 2 to 4 millimetre pyroxene grains and lithic clasts of plagioclase-pyroxene porphyry. Plagioclase crystal tuffs with lapilli to 5 centimetres are intercalated with the wackes east of Forrest Kerr Fault at the headwaters of Downpour Creek. The volcaniclastics are interbedded with thin planar bedded to crudely cross-bedded (locally), carbonaceous rusty weathering argillite. The fine-grained sediments contain fossiliferous limy horizons with abundant faunas of Late Triassic, Carnian age and local limy conglomerate beds that contain Late Triassic, Carnian conodonts (C-103682, Appendix 2). At the south end of the Forrest Kerr map area, east of the West Slope fault, a maroon volcanic conglomerate containing limestone clasts structurally underlies Lower Permian limestone (Figure 2-13). In general appearance and character it closely resembles the Upper Carboniferous conglomerate exposed further west and it has been interpreted by Read *et al*. (1989) to mark the base of the Stuhini Group. The unit passes structurally downward into an epiclastic unit of interbedded crystal and lapilli tuff, sandstone, volcanic conglomerate and rare amygdaloidal maroon and green plagioclase porphyritic flows. Correlative and interlayered carbonate and calcareous sediments yield Late Triassic, Carnian and Early Norian ages (Read *et al*.,1989, Appendix 2).

Purple, grey and dark green, massive and plagioclase porphyritic volcanic rocks of the medial volcanic unit (uŦSv) underlie the fault block, that is located between the West Slope and Forrest Kerr faults, 2 kilometres northwest of the confluence of the Iskut River and Forrest Kerr Creek. Intercalated with the plagioclase porphyry flows are massive light grey to dark green aphanitic lapilli tuffs and andesite breccias which make up minor though distinctive units. The tuff is massive to stratified with monolithic scoriaceous to aphyric andesite lapilli. Read *et al*. (1989) suggested a thickness of a few hundred to perhaps several thousand metres for unit uŦSv. Green and lesser maroon crowded to sparse-plagioclase porphyritic andesite breccia and flows underlie the area immediately west and east of the Forrest Kerr fault. Euhedral plagioclase phenocrysts range to 4 millimetres and comprise up to 30 per cent of the rock. Pyroxene is a fine-grained minor component of the lavas. The flows are generally massive; less common are breccia and amygdaloidal varieties. Massive fine to medium grained hornblende diorite sills and subvolcanic plagioclase porphyritic intrusive rocks are interlayered and probable feeders to the volcanic flows. Intraflow tuff and epiclastic deposits are mottled maroon and green; some consist of green lapilli in a maroon groundmass and vice versa. Alteration is characteristically hematite and chlorite with variable amounts of epidote, quartz and calcite as patches and veinlets.

Maroon to dark green tuffs and monolithic augite+/-plagioclase phyric fragmentals (uŦSvt) are best exposed adjacent to the Forrest Kerr linear, north of the bend in Forrest Kerr Creek. Lapilli tuffs containing varicoloured porphyritic volcanic and lesser scoriaceous fragments are interlayered with well-bedded purple to maroon and green, locally graded plagioclase crystal-ash tuffs and fine epiclastics. The tuffs are massive to weakly stratified. Coarse breccias and block tuffs of augite porphyry occur near the top(?) of the succession. Associated conglomerates and reworked volcaniclastics consist of angular to rounded green pyroxene porphyry clasts in a pyroxene-rich matrix. At the top of the exposed section green cherty siltstone, grey argillite and greywacke are interbedded with plagioclase and lesser augite crystal tuff horizons and epiclastic rocks.

NEWMONT LAKE GRABEN VOLCANIC FACIES

A maroon, hornblende porphyritic volcaniclastic succession with a medial 95 metre thick algal limestone is gently folded into an open, northeast-trending, doubly plunging syncline in the Newmont Lake area (Figure 2-12). These rocks form a distinctive fault-bounded succession, which was difficult to correlate with strata elsewhere. They are fresh in appearance and with the exception of the limestone member, resemble the volcanogenic rocks of the Lower Jurassic Hazelton Group. Previous workers correlated this package with Lower Permian volcanic strata of the Paleozoic Stikine assemblage (Anderson, 1989; Logan *et al*., 1990a). A U-Pb zircon date of 212.8+4.2/-3.5 Ma (Table 2-1) from felsic flow rocks located high in the stratigraphy of the graben rocks indicates a Late Triassic age for the succession (Figures 2-11 and 2-12).

The stratigraphically lowest rocks are maroon plagioclase, pyroxene, and hornblende-phyric andesite flows (uŦSva, uŦSvat). Brecciated and massive flows averaging 5 metres in thickness are interbedded with well-graded interflow clastic rocks west of Newmont Lake. The flows are locally amygdaloidal and generally contain 30 to 40 percent euhedral white plagioclase and 15 per cent chloritized acicular hornblende crystals. Larger euhedral plagioclase phenocrysts are moderately altered to sericite. Finer clinopyroxene grains are euhedral to subhedral, unaltered, and occur both as phenocrysts and in the groundmass. Opaque oxides are abundant as fine disseminations and larger isolated grains. Equant euhedral plagioclase grains have strongly sericitized cores and narrow clear rims. Light green to pink, block and lapilli tuff with lesser plagioclase crystal tuff crop out east of Newmont Lake. Maroon breccias, lahar and well-bedded graded conglomerates are exposed north of Forrest Kerr Creek (Photo 2-21). Near the base of the section black, locally calcareous, silty shale and argillite and silty limestone which contain bivalves and conodonts of Upper Triassic age are intercalated with the maroon volcanic breccias and conglomerate. A Late Triassic, latest Norian conodont (C-168200, Appendix 2) was recovered from limestone located south of Newmont Lake.

The medial limestone (uŦSl) is a good marker that can be traced around the Newmont Lake syncline (Figure 2-12). North of the lake, 95 metres of continuous limestone is exposed. The limestone pinches along strike and on the east limb is only 20 metres thick. It is dark grey to black on fresh surfaces and is not recrystallized. Weathered surfaces are buff and finely laminated; it is locally fetid and barren of fossils. Pisolite-rich beds and cuspate stacked concave algal structures are common. The upper part of the unit is interlayered with silica and variably silicified. (Photo 2-22).

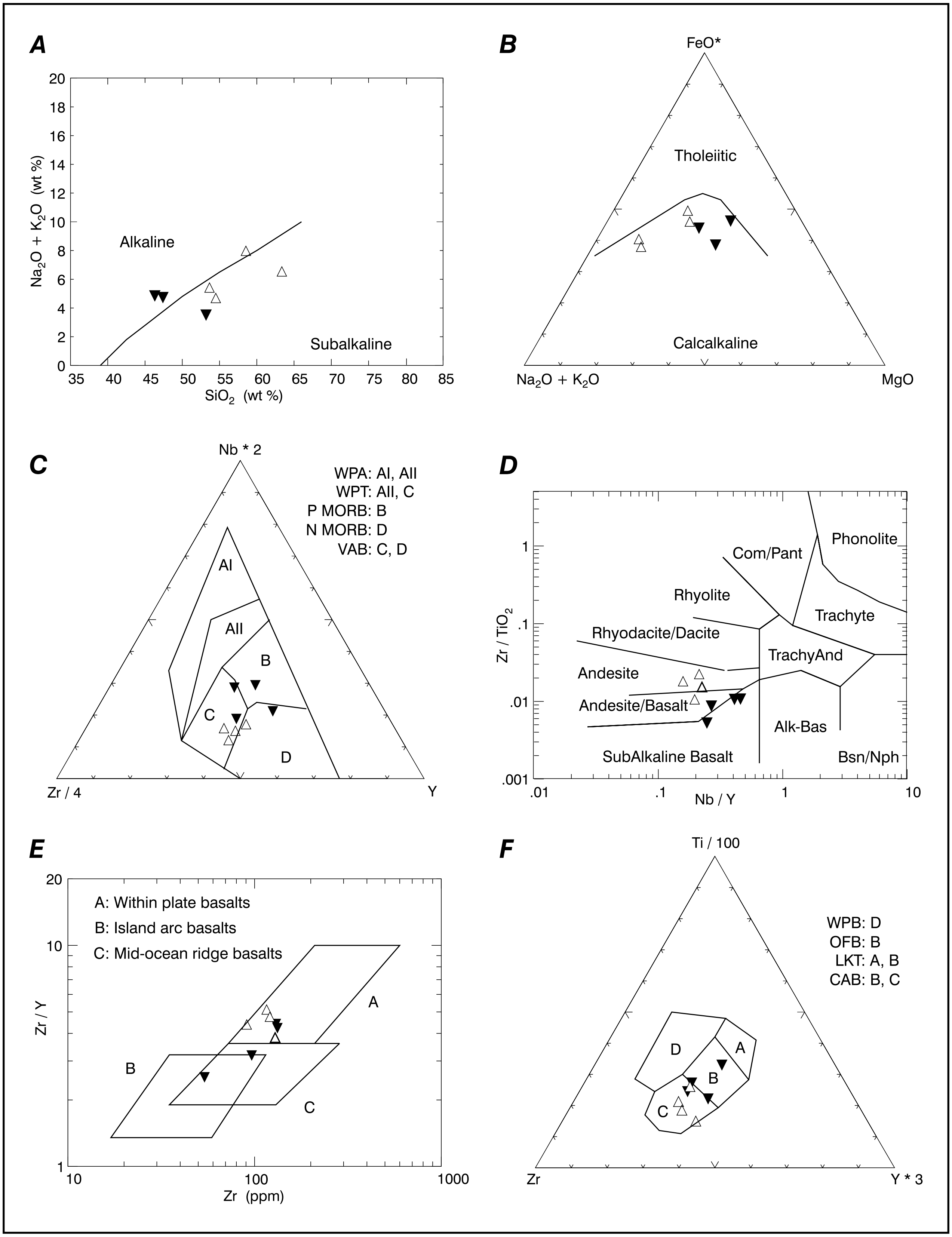

Figure 2-13. Major and trace element geochemical plots for Stuhini Group volcanic rocks. Mess Lake facies basalts (inverted filled triangles), Newmont Lake facies andesites mafic (triangles). A) total alkali versus silica (after Irvine and Baragar, 1971); B) AFM plot (after Irvine and Baragar, 1971); C) ternary plot of Nbx2 - Zr/4 -Y (after Meschede, 1986); D) plot of Zr/TiO_2 versus Nb/Y (after Winchester and Floyd, 1977); E) plot of Zr/Y versus Zr (after Pearce and Norry, 1979); F) ternary plot of Ti/100 - Zr- Yx3 (after Pearce and Cann, 1973).

Photo 2-21. Purple, plagioclase hornblende porphyritic andesite block breccia of Newmont Lake graben facies

Photo 2-22. Cuspate stacked concave algal structures of silicified limestone characteristic of the Upper Triassic limestone unit in the Newmont Lake.

The fine laminations are interpreted to be cryptalgal in origin (Aiken, 1967) indicative of algal mats and an intertidal zone of deposition for the limestone. We believe this unit is a supra tidal equivalent of the more common Upper Triassic carbonate slope deposits of unit uTSc. The variation is due primarily to the different environments in which the carbonate deposits formed.

The algal limestone unit is overlain by at least 230 metres of well bedded tuffaceous epiclastic rocks comprising maroon shallow water conglomerates, siltstone, lapilli and plagioclase crystal tuffs (uTSvs). Discontinuous beds of thinly bedded siliceous limestone up to 5 metres thick are interspersed throughout. These rocks are in turn overlain by more than 100 metres of brownish, grey massive to thick bedded welded andesitic to rhyolitic lapilli and ash tuff and lava flows (uTSvr). The tuffs exhibit good eutaxitic flow laminae and many are columnar jointed. Air-fall tuffs are well-stratified and contain 5 to 10 per cent angular lithic lapilli. Broken grains of otherwise euhedral, blocky plagioclase are moderately to strongly altered to sericite. Some grains are resorbed and have inclusions of devitrified glass. The matrix may either be very dark due to disseminated oxides, or have a eutaxitixic texture defined by chlorite lenses to 4 millimetres long. Lithic fragments present typically consist of fine plagioclase porphyries. In one thin section, a lithic fragment was seen with a slightly chloritic, devitrified glass matrix. Chlorite and carbonate are common in the groundmasses of most of the tuffs studied in thin section.

Pink to mauve, flow banded dacite, rhyolite and related ash flow and welded tuffs occur high in the section (Photo 2-23). Crowded fine plagioclase phenocrysts are euhedral, well-zoned, and altered to sericite. Hornblende occurs in some rocks as euhedral oxidized grains that are partially altered to carbonate and sericite. Quartz occurs as equigranular clots with fritted edges that may be secondary. The groundmass is typically fine grained; in places it consists essentially of devitrified glass, which is partly altered to chlorite and minor epidote. Pink, flow banded rhyolite from the core of the Newmont Lake Syncline gave an Upper Triassic, Norian U-Pb zircon date of 212.8+4.2/-3.5 Ma (Table 2-1).

CHEMISTRY OF UPPER TRIASSIC VOLCANIC ROCKS

Chemical analyses of the Late Triassic volcanic rocks was limited due to the preponderance of volcaniclastic rocks with significant epiclastic components. The lava flows are typically coarsely porphyritic and/or amygdaloidal; consequently, there are few that can be adequately sampled. Most of the samples collected are altered (LOI >5%). The Stuhini Group includes tholeiitic to calcalkaline basalts, basaltic andesite, trachybasalts and basaltic trachyandesites in the Stikine River area (Brown *et al*., 1996) and calcalkaline, high potassium to shoshonitic basalts and basaltic trachyandesites in the Galore Creek area (Logan and Koyanagi, 1994). Mafic alkaline to subalkaline augite phyric lavas and intermediate to felsic plagioclase-hornblende phyric calcalkaline lavas are distinguished in the Forrest Kerr-Mess Creek area.

The two volcanic suites are plotted separately (Figure 2-13). The plagioclase hornblende basalt samples from the Newmont Lake facies are subalkaline basaltic-andesite (SiO_2 contents between 53 and 55 per cent) and andesite

Photo 2-23. Angular block of andesite with bomb sag in planar bedded intermediate to felsic crystal ash tuff.

with SiO_2 contents less than 63 per cent. Pyroxene and plagioclase basalt samples from the Mess Lake volcanic facies are transitional subalkaline to calcalkaline basalt and basaltic-andesite. Both suites straddle the subalkaline-alkaline boundary on the alkalis vs. silica diagram, and plot in the calcalkaline field on the AFM diagram (Figure 2-13A and 13B).

Trace element plots provide a useful means of characterizing metamorphosed and hydrothermal altered rocks using relatively immobile trace elements. Volcanic rocks of Upper Triassic age plot as subalkaline, medium-K, calcalkaline basalt to basaltic andesite on the Nb/Y vs. Zr/TiO_2 trace element discrimination diagram (Figure 2-13D). The Newmont Lake suite is more evolved than the Mess Lake suite. The Ti-Zr-Y diagram (Pearce and Cann, 1973) in Figure 2-13F discriminates within-plate basalt from those extruded along plate margins. The Stuhini Group basalt samples plot in the calcalkaline island-arc basalt field on this diagram and on the Nb-Zr-Y diagram of Meschede (1986) in fields typical of subduction-generated lavas formed at plate margins. On the Zr/Y vs. Zr plot of Pearce and Norry (1979) the more evolved Newmont Lake rocks occupy the within plate basalt field (Figure 2-13E).

Eight samples, four from each of the two Late Triassic volcanic suites are plotted on a mid-ocean ridge basalt normalized discrimination diagram (Figure 2-14; after Pearce, 1996). The fields for both suites display patterns typical of volcanic arc lavas, with strong enrichment in lithophile elements (Sr, K, Rb and Ba) and a negative slope of the Nb, Ce and Zr trend. The elevated concentrations of Nb and Zr, but lower Ti and Y abundance's relative to N-MORB are characteristic of calcalkaline and high-potassium calcalkaline volcanic arc basalts. Missing from this pattern is the significant negative Nb anomaly with respect to Th (La) and Ce that is a key characteristic of all volcanic arc basalts (Pearce, 1996). The negative Ti anomaly (with respect to Zr and Y) in the Newmont Lake suite reflects the increased fractional crystallization and higher silica content of this suite. Alkaline plutons and syenite bodies are clearly comagmatic with the uppermost Late Triassic volcanics at Galore Creek. Coeval intrusive and subvolcanic bodies in the area range in composition from diorite through monzonite to granodiorite and the more highly fractionated extrusive phases like the Newmont Lake suite should be prevalent. Anderson (1993) describes bimodal and intermediate volcanic rocks in the younger, Norian assemblages of his western and eastern Stuhini facies in the Iskut River area.

PALEOENVIRONMENTAL INTERPRETATIONS

Triassic strata include; a rare package of thin-bedded siltstone and chert of Lower to Middle Triassic age, and a thick volcano-sedimentary succession of Upper Triassic Stuhini Group rocks. The Upper Triassic rock package consists of a Carnian to Norian predominantly sedimentary facies, east of More Creek and farther west, two Norian volcanogenic facies, at Mess Lake and Newmont Lake. Upper Triassic to Early Jurassic (Stikine and Copper Mountain plutonic suites, Woodsworth *et al*., 1991) volcano-plutonic centres are known at Zippa Mountain, Galore Creek and Mess Creek (Hickman and Nightout plutons), but the polarity of the arc is unknown.

The Lower Triassic record is poorly represented in the western Cordillera, and whether from non deposition or subsequent erosion, it remains uncertain. Early and Middle Triassic silty shale and cherty siltstone paraconformably overlie Early Permian limestone in the Galore Creek area (Logan and Koyanagi, 1994) and isolated Middle Triassic cherts are structurally interleaved with Upper Triassic sediments in the More Creek area. These cherts and fine-grained clastic rocks are deep-water slope deposits, indicating a slow sedimentation rate during the Early to Middle Triassic.

Upper Triassic fine grained clastic rocks and alternatively coarse conglomerates unconformably overlie Early Permian rocks east of Mess Creek and at Forrest Kerr Creek, suggesting a period of non deposition or uplift and erosion.

Fine grained clastic sedimentation continued in the eastern part of the map area where Carnian thin bedded

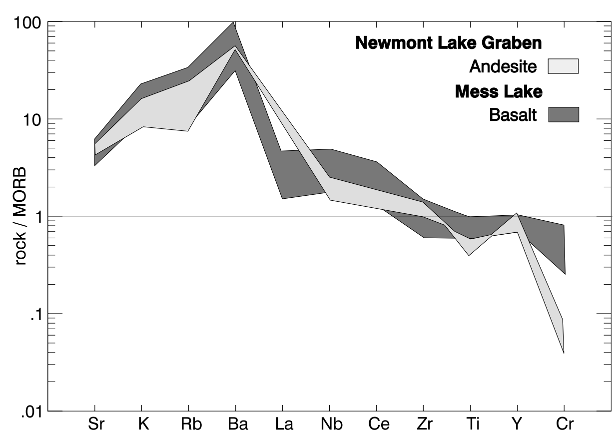

Figure 2-14. Multi-element geochemical patterns for Mess Lake and Newmont Lake facies volcanic rocks of the Stuhini Group.

black and green cherty siltstone and feldspathic sandstone with rare intraformational conglomerate characterize the lower sections of the More Creek sedimentary facies. They are interlayered with and overlain by thin limestone beds of Carnian and Norian ages. Pyroxene phyric volcaniclastics and well bedded epiclastics interbedded with Norian limestone occupy the highest stratigraphic position in both the Mess Creek volcanic facies and the More Creek sedimentary facies. Rare, but distinctive tuffaceous horizons containing coarse pink and white potassium feldspar laths are also present near the top of the stratigraphic section. The lithic and crystal content of these sedimentary and tuffaceous flank deposits reflect the same dominant phenocryst composition and stratigraphy as the volcanic pile at Galore Creek (Logan and Koyanagi, 1994), where hornblende-plagioclase andesite is overlain by sediments and pyroxene porphyritic lavas and an upper unit of orthoclase-rich flows and tuffs. Basaltic, calcalkaline volcanism began in the early Carnian and continued into the latest Rhaetian or Early Jurassic time. At Schaft Creek, the Mess Creek facies deposits are primarily submarine, massive augite and plagioclase phyric basalt and rare pillowed flows, breccias and coarse conglomerates that are intruded by subvolcanic plagioclase porphyry feeders and the coeval Hickman pluton. Volcanics are subalkaline to calcalkaline, basalt and andesite and possess a strong arc signature. Norian volcanic rocks of the Newmont Lake facies comprise a maroon succession of crowded hornblende plagioclase porphyry andesite breccia flows, lapilli tuff, welded rhyolite tuff, and conglomerate. The deposits are coarse 'proximal facies' breccia flows. The presence of shallow water carbonates and variable oxidizing states suggest a transgressive submarine to subareal volcanic centre. The more differentiated nature of these Norian rocks suggests that the Late Triassic arc developed over crust thickened in Late Paleozoic time by addition of the Stikine assemblage. Development of the Triassic arc is the culmination of various constructive and destructive tectonic and volcanic processes including intrusion, eruption, subsidence and uplift. The presence of interpreted-coeval plutonic clasts in coarse volcanic conglomerates requires not only uplift, and unroofing of the intrusion, but also substantial relief and a subareal environment in which to transport and round the clasts.

LOWER JURASSIC

Lower Jurassic sedimentary strata are exposed between Arctic Lake and Mess Creek (Souther, 1972) where they comprise a north-trending belt about 35 square kilometres in size. The strata are well-bedded granite and quartz clast-bearing conglomerates that are preserved in a series of listric fault blocks. North of Arctic Lake, the basal conglomerate of the Lower Jurassic succession rests on Upper Triassic Stuhini Group volcanic rocks in apparent conformity. Additionally, Lower Jurassic sedimentary rocks form small erosional remnants in the northeast corner of More Creek map area, above the Schaft Creek deposit and along the eastern edge of Mess Creek (Figure 2-15). At these locations Jurassic strata unconformably overlie Stuhini Group volcanic rocks. A similar angular unconformity between Upper Triassic Stuhini Group and Lower Jurassic strata is recognized in the Yehiniko Lakes area (Brown and Greig, 1990) and in the Sulphurets area (Henderson *et al*., 1992). Lower Jurassic sedimentary rocks of the Jack Formation also unconformably overlie the Upper Triassic Stuhini Group in the Sulphurets area. The Jack Formation is a fining upwards marine sequence, characterized by a granitoid-bearing basal conglomerate overlain by fossiliferous limy sandstone (Hettangian-Sinemurian age) and siltstone, in turn overlain by dark carbonaceous mudstone and lesser interbedded turbiditic sandstone (Henderson *et al*., 1992). In the Mess Creek area the Lower Jurassic unit consists entirely of coarse clastic and conglomerate beds.

The largest exposure of Lower Jurassic conglomerate crops out in a 2 to 2.5 kilometres wide belt east of Mess Creek that extends north from south of Arctic Lake to Nahta Cone (Figure 2-15). At the northern end of this exposure, conglomerate overlies volcanic rocks of the Stuhini Group with structural conformity, however, farther south they unconformably overlie Late Triassic plagioclase hornblende porphyritic monzodiorite of the Loon Lake Stock (unit LT̄mz, GS-Map). The conglomerate is at least 250 metres thick (Figure 2-16). In general, the lowermost sections are maroon, well-bedded, immature, volcanic-derived conglomerates. In places they are graded and consist almost entirely of maroon plagioclase-phyric andesite clasts in a plagioclase-rich groundmass; rare pyroxene-phyric andesite clasts also occur. Up section, quartz and potassium feldspar grains and granite clasts appear then increase in abundance. Granite clasts are more common in the conglomerate southwest of Arctic Lake (Photo 2-24). Coarse carbonate boulder layers are prominent within the unit in the Mess Lake area, as well as a 2 metre thick cobble and pebble carbonate conglomerate with a siliciclastic matrix. The 4 to 5 metre boulders are well- rounded and consist of Mesozoic reefoid limestone. Rare interbedded limestone and sandstone lenses up to a metre thick in the conglomerate unit were sampled for radiolarian. The conglomerate grades upward into poorly sorted, more juvenile conglomerate, then lapilli tuff. The top of the unit is cut off by a major north trending, west-dipping listric fault. Quartz-rich maroon breccia is found along the entire length of the fault and is probably crushed conglomerate.

West of Mess Creek, Lower Jurassic rocks rest with angular unconformity on volcanics of the Upper Triassic Stuhini Group. East of the Schaft Creek porphyry deposit, on Mount LaCasse (Figure 2-15), the Jurassic unit comprises conglomerate with equal proportions of well-rounded crowded plagioclase porphyritic andesite and aphyric basalt clasts, that is interbedded with coarse sandstone containing high proportions of quartz and potassium feldspar. The conglomerate overlies propylitically altered pyroxene phyric volcanics. The nature of the contact is uncertain, but the conglomerate appears to occupy a fault-bounded graben. The conglomerate itself is pervasively epidotized. Alteration is due in part to its permeability and probably related to dike swarms associated with the Middle Jurassic Yehiniko pluton.

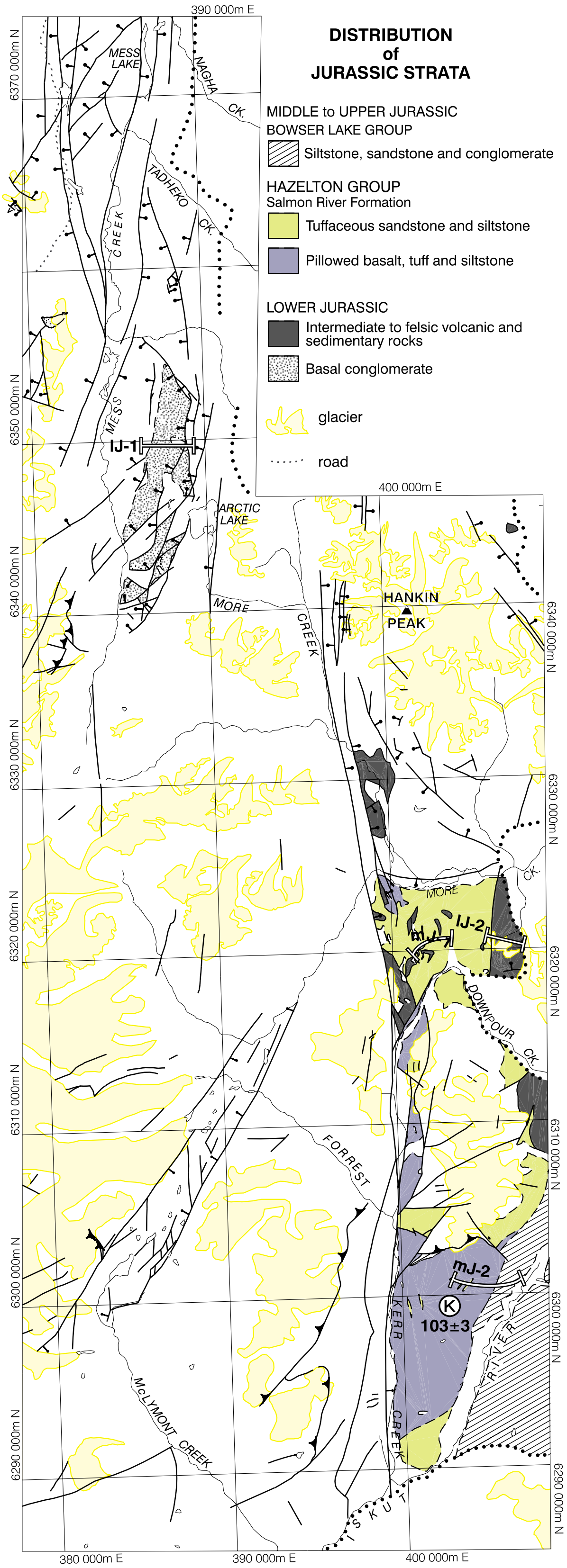

Figure 2-15. Distribution of Middle and Upper Jurassic strata. Lines show the locations of stratigraphic sections in Figure 2-16 and 2-17.

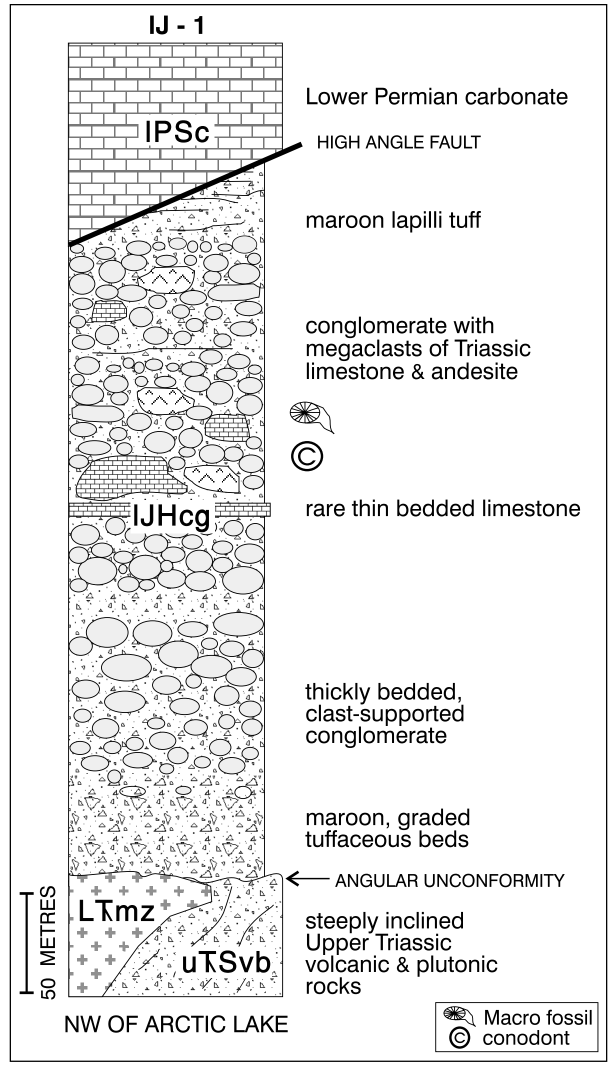

Figure 2-16. Schematic stratigraphic column for Lower Jurassic section northwest of Arctic Lake.

Moderately south-dipping Jurassic conglomerates rest unconformably on steeply dipping Upper Triassic pyroxene-phyric flows and volcaniclastics in a second exposure 3 kilometres south of the Schaft Creek deposit (Figure 2-15). The section consists of 20 metres of quartz and feldspar crystal and lithic tuff overlain by 90 metres of quartz-bearing polymictic volcanic conglomerate. The lower zone is a pale maroon, pink-weathering feldspar and quartz-eye crystal-lapilli tuff. Upper contacts are gradational and conformable with the conglomerate. The sediments are well-bedded granule or weakly stratified to massive boulder conglomerates and lesser sandstones. Clasts are generally subangular purple, maroon and green plagioclase and/or pyroxene-phyric andesite. Epidotized clasts are common and clasts of the underlying quartz feldspar crystal tuffs are most abundant near the base of the conglomerate.

Sedimentary rocks of probable Lower Jurassic age form an erosional outlier within Triassic rocks north of Hank Creek, about eight kilometres northeast of Hankin

Photo 2-24. Moderately east-dipping, well-bedded, maroon volcanic clast dominated, quartz-grain and granite-bearing Early Jurassic conglomerate, located west of Arctic Lake, viewed northwards.

Photo 2-25. Disconformable basal contact of (?)Lower Jurassic interbedded siltstone and cross-stratified sandstone located north of Hankin Peak. The sediments overlie maroon plagioclase and hornblende porphyritic andesitic basalt volcaniclastic rocks of probable Late Triassic age.

Peak (Souther, 1972). The strata consist of well-bedded grey siltstones interbedded with buff-weathering, cross-stratified sandstones and disconformably overlie Upper Triassic maroon, hornblende and plagioclase porphyritic andesitic-basalt volcaniclastic and epiclastic rocks (Photo 2-25). The sediments are flat-lying to gently inclined and unconformably overlie the moderately dipping, steeply foliated maroon volcaniclastic beds. The sandstones are arkosic, but also contain fine lithic volcanic rock fragments. Bed thickness varies from less than 0.5 metre up to 5 metres and comprises a general fining upward sequence from coarse sandstone to siltstone to carbonaceous shale.

LOWER TO MIDDLE JURASSIC HAZELTON GROUP

The Hazelton Group has been divided into four or five formations in the Iskut River area (Grove,1986; Alldrick and Britton, 1988; Anderson and Thorkelson, 1990), which include the Lower Jurassic volcanogenic rocks of the Unuk River, Betty Creek and Mount Dilworth formations and the Lower to Middle Jurassic sedimentary and volcanic rocks of the Salmon River Formation. Inadequate age-dating, abrupt facies changes and attempts to correlation volcanic and sedimentary stratigraphy over long distances from type sections has led to confusion and overlapping formational designations. A recently enlarged biostratigraphic and geochronological data base for the north-central Iskut River area indicates that there are five lithological units in the Hazelton Group ranging from early Lower Jurassic to mid Middle Jurassic time (Lewis *et al*., 1993; Macdonald *et al*., 1996). Regional mapping supported by geochronology has recognized Hazelton Group volcanic rocks as far north as Yehiniko Lake (Brown *et al*., 1996). Refinements to and redefinition of the Salmon River Formation (Anderson and Thorkelson, 1990; Anderson, 1993) to include only upper Lower Jurassic and lower Middle Jurassic strata and exclude younger Bowser Lake Group strata, focuses on the economic importance of the upper member (*viz.* Eskay Creek facies).

Hazelton Group rocks underlie most of the 300 square kilometre area south of More Creek and east of Forrest Kerr fault (Figure 2-15; Souther, 1972; Read *et al*., 1989). In general, the Lower to Middle Jurassic stratigraphic sequence comprises a lower package of dominantly siltstone and sandstone, a middle package of massive rhyolitic and intermediate volcanic rocks, and an upper package of siltstone, pillow basalt and related tuff and breccia. Strata of the lower and middle packages occur mainly north of Downpour Creek and on GS-Map (in back pocket) comprise the Unuk River, Betty Creek and Mount Dilworth formations. Sedimentary rocks of the upper package underlie the area located between Downpour and More creeks. The overlying volcanic rocks occupy fault-bound slivers extending south of Downpour Creek to the Iskut River. Sedimentary and volcanic strata southeast of Forrest Kerr Creek are assigned to the Salmon River Formation as defined by (Anderson and Thorkelson, 1990).

The stratigraphically lowest, but structurally highest Lower Jurassic rocks occur northeast of Downpour creek (Figure 2-15 and 2-17). There more than 200 metres of massive and thin-bedded black siltstone and minor sandstone (lJHsl) are conformably overlain by at least 50 metres of tan to rusty-weathering sandstone and minor pebble conglomerate (lJHsn). These sediments are conformably overlain by a resistant volcanic succession consisting of rhyolite (lJHr) and andesitic flows and tuffs (lJHv); (Photo 2-26). The rhyolitic rocks are about 120 metres thick and consist of a basal welded ash-flow tuff and an upper flow-layered, aphyric, white and rusty weathering rhyolite flow. The ash-flow tuff contains pale green aphanitic and finely flow-layered lapilli, which are generally 3 to 6 millimetres in size, in a white to pale grey siliceous matrix. In thin section, the ash-flow tuff is devitrified with an overall cherty texture in cross polarized light. In plane light, with the diaphragm nearly closed, relict glass shards and collapsed pumice are visible and impart a eutaxitic texture. The exact contact relationship of the ash-flow tuff with the overlying flow-layered rhyolite is not exposed, but it appears to be conformable. Pebble conglomerate adjacent to the rhyolite and up to 5 metres above is intensely silicified and has a characteristic pale bluish-green hue. The conglomerate is unaltered where it is in apparent fault contact with the rhyolitic rocks. Souther (1972) mapped these rhyolitic rocks as Late Cretaceous to Tertiary dikes. However, because they are pyroclastic at least in part, they are herein interpreted as a Jurassic extrusive unit. Silicification of adjacent sedimentary rocks may be due either to primary synvolcanic or secondary hydrothermal fluid circulation, or both.

About 10 to 20 metres of fossiliferous sandstone, conglomerate, and a variety of green, thin-bedded tuffs and tuffaceous sediments (included with lJHsn) overlie the rhyolitic rocks. The sediments and tuffs have rapidly changing inclinations, apparently due to faulting and folding. An ammonite from this horizon returned a mid-Lower Jurassic (Sinemurian) age (Poulton, 1991).

The rhyolite unit and adjacent sediments are overlain by andesitic, maroon, plagioclase phyric flows, breccias and tuffs (lJHv). These volcanic rocks were originally mapped by Souther (1972) as Late Triassic in age. However, their stratigraphic position indicates they are Lower Jurassic, unless contact relationships with the underlying sediments are structural. Poorly formed pillows occur in the andesite. The rocks weather maroon-grey and contain about 30 per cent euhedral, felted plagioclase phenocrysts. Debris flow deposits greater than 30 metres thick contain subrounded clasts of green-grey aphyric to plagioclase phyric andesite in a maroon matrix and overlie the pillowed and fragmental rocks. These grade upward into a thick sequence of massive to poorly bedded dark green-grey and reddish-grey andesitic tuffs. Most fragments have narrow rims that weather to a lighter shade of grey. The green-grey tuffs contain about 30 to 40 per cent euhedral, equant plagioclase crystals and lapilli-sized fragments containing plagioclase and chloritized augite phenocrysts. Plagioclase in both the matrix and the fragments is euhedral with resorbed margins and abundant devitrified glass inclusions. Larger lapilli have euhedral plagioclase set in chloritic devitrified glass with finer plagioclase microlites. Sparse augite phyric fragments contain 10 to 15 per cent completely chloritized clinopyroxene and 30 to 40 per cent, much finer, equant plagioclase phenocrysts. Similar tuffs and augite phyric flows crop out on the ridge between Carcass and Downpour

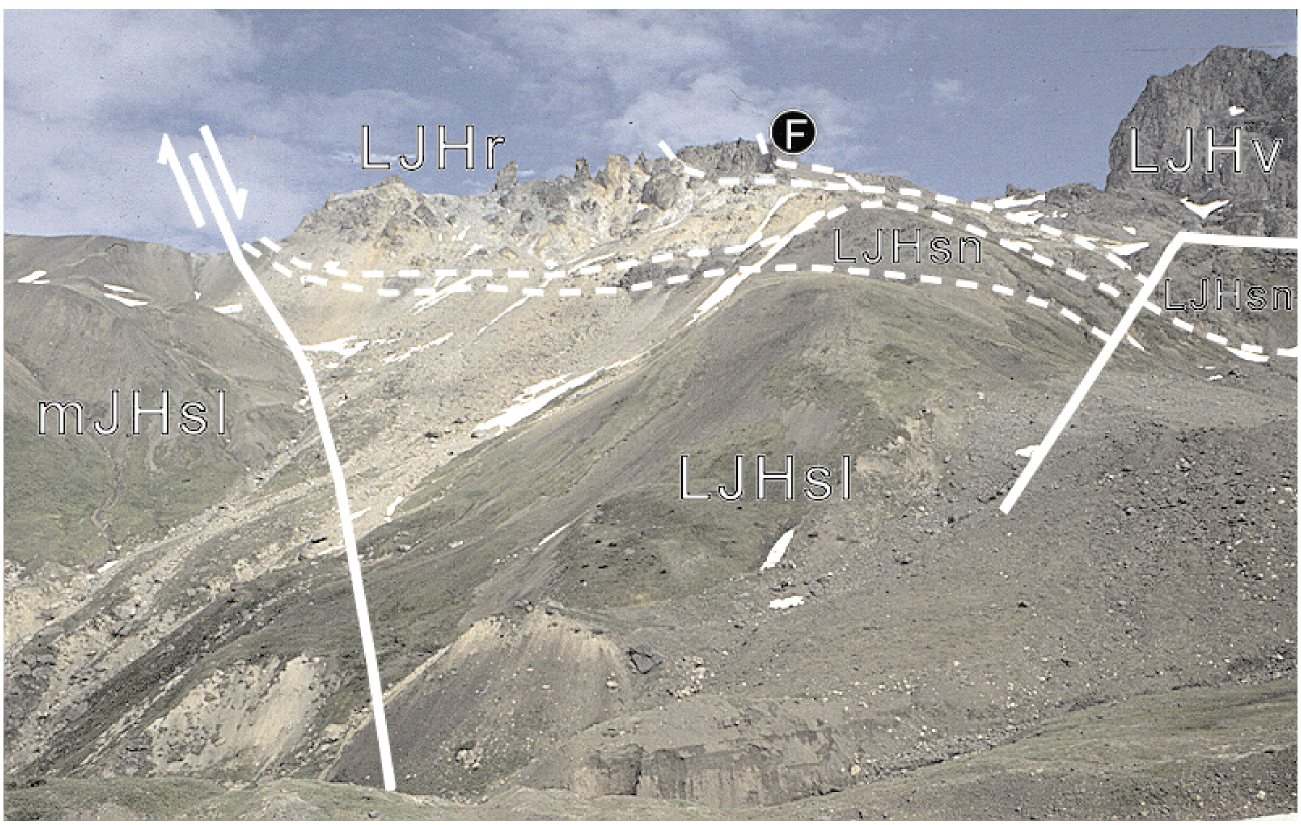

Photo 2-26. Jurassic stratigraphic section, 8 km southeast of the confluence of South More and More creeks, viewed northeastward. Early (?) to Middle Jurassic black siltstone and rusty sandstone (mJHsl) are faulted against a sequence beginning with thin-bedded black siltstone and sandstone (lJHsl) and conformably overlain by tan sandstones and minor conglomerate (lJHsn). Overlying these sediments is a white and rusty weathering, silicified rhyolite flow and tuff unit (lJHr). Maroon plagioclase-phyric andesite flow, breccia and tuff (lJHv) form the top of the section. Separating unit lJHr and unit lJHv is a sandstone and conglomerate unit, 10 to 20 m thick which contains Sinemurian fossils.

creeks (west-side of the syncline), in the vicinity of the Lower Jurassic fossil locality of Read *et al*. (1989).

Several isolated outcrops of thin-bedded siltstone and sandstone, conglomerate, felsic tuff, and flow-layered rhyolite occur on both the east and west sides of More Creek a few kilometres north of the confluence with the south fork (Figure 2-15). Lithology suggests that these rocks correlate with Units lJHsn and lJHr. On the west side, moderately west-dipping, white weathering, resistant rhyolite breccias and tuffs overlie thin-bedded deformed sediments. The felsic rocks are well-stratified and graded; tuffs contain pink, angular flow-layered fragments of rhyolite and grey, white and blue-green aphanitic fragments. On the east side of More Creek, about 30 metres of orange weathering felsic lapilli crystal tuff crop out and are, at least structurally, overlain by thinly interbedded carbonaceous siltstone and sandstone. The tuff contains about 1 per cent quartz grains and grey andesitic lapilli to 3 centimetres in size. Two 5 to 7 metre thick aphyric, sparsely amygdaloidal rhyolite or dacite flows occur within the tuffs. The carbonaceous black siltstone and tan, well-sorted feldspathic sandstone which overlie the tuffs are poorly indurated and deeply weathered. Carbonaceous plant stems and leaves are ubiquitous.

SALMON RIVER FORMATION

The Salmon River Formation of Anderson and Thorkelson (1990) includes strata of upper Lower Jurassic and lower Middle Jurassic ages. In the Iskut River area it comprises two members, an unnamed fossiliferous, calcareous sandstone of upper Lower Jurassic age and an upper tripartite subdivision including from west to east the Snippaker Mountain facies, Eskay Creek facies and Troy Ridge facies of lower Middle Jurassic age (Anderson and Thorkelson, 1990; Anderson, 1993). The unnamed lower member consists of a sandy, calcareous greywacke of Toarcian age (Gunning, 1986) east of Eskay Creek, which, to the north in the Downpour Creek area, has thickened to more than 1500 metres (Read *et al*., 1989). These upper member facies define north-trending belts and Eskay Creek facies strata underlie parts of the current map area and areas as far north as Kinaskan Lake (Souther, 1972). The Eskay Creek facies, which hosts the stratabound high-grade, precious and base metal volcanic massive sulphide-sulphosalt mineralization at the Eskay Creek mine (located about 15 kilometres southeast), is an important exploration target regionally. Aalenian, possibly Early Bajocian radiolarian (Nadaraju, 1993) from mudstone hosting the main 21 zone mineralization at Eskay Creek and from stratigraphically higher mudstone intercalated with pillowed and breccia flows constrains the age of mineralization and basalt volcanism at Eskay Creek.

Lower Sedimentary Member

East of the Forrest Kerr Fault, between More and Downpour creeks (Figure 2-15), is a thick succession of massive and thin-bedded siltstone (unit mJHsl, GS-Map). This area is bisected by a southerly flowing tributary of Downpour Creek and west of this tributary, Read *et al*. (1989) report fossils from atop the ridge of Early Jurassic (Late Toarcian) age. Fossils collected from the same general area (this study) have been interpreted to be of Middle Jurassic (Bathonian) age (Appendix 1; Poulton, 1991). East of this tributary, Souther (1972) reports fossils with Middle Jurassic (Middle Bajocian) ages from three localities along the lower slopes of the ridge. At the east end of this ridge is the fault-bound package of Lower Jurassic (Sinemurian) volcanic and sedimentary rocks described above. Structures and the distribution of fossils indicate a northerly trending syncline for the Jurassic strata south of More Creek. Souther (1972) shows the structure flanked by a volcanic dominated unit interpreted as Upper Triassic Stuhini Group, Read and others (1989) and this study, correlate these volcanic rocks with the Lower Jurassic Hazelton Group.

The core of the Downpour syncline is underlain by three packages of fine grained clastic rocks and subordinate interlayered volcanic rocks (Figure 2-17). All are inter-gradational. There is no continuously exposed section in which to measure thickness and the units are tightly folded and faulted. The structurally and presumably stratigraphically lowest rocks consist of black graphitic and pyritic shale and thin bedded, alternating grey siltstone and orange-weathering sandstone. The sandstone layers are often boudinaged and transposed along bedding parallel shear planes. Interlayered volcanic rocks include mafic pyroxene porphyry flow breccia and tuff, and felsic plagioclase crystal tuff and epiclastic rocks. A Late Aalenian or late Early Aalenian ammonite *Tmetoceras* sp. (C-189785, Appendix 1) was collected from a tuffaceous sandstone layer low in the sequence.

Vesicular, columnar-jointed, basaltic-andesite sills and breccia flows, tuffaceous layers and volcanogenic sandstone units characterize the medial package of rocks. Sill and flow margins have peperitic textures characteristic of intrusion into or extrusion over water saturated sediments. Individual sills and flows vary to as much as 10 metres in thickness. The sedimentary units include calcareous olive to buff sandstone and light grey siltstone; carbonaceous plant material is common in coarser-grained beds of the sandstone. Numerous lenses of crystal tuff and lapilli tuff from about 5 to 30 metres thick are interbedded with the sedimentary strata. The lapilli tuff contains mainly pale grey rhyolitic fragments that average 1 centimetre in diameter. The crystal tuffs are typically maroon weathering and contain up to 30 per cent plagioclase crystal fragments averaging 2 to 4 millimetres in size; finely vesicular basaltic lapilli to 7 millimetres in size are common. These intermediate volcaniclastic rocks are lithologically similar to Lower Jurassic volcanic units (lJHv and lJHr); they were included with them during mapping and are shown as such on the GS-Map (in back pocket). Aalenian to pre Bajocian ammonoid-bearing sediments constrain bimodal volcanism in the Treaty Glacier area (Lewis *et al*., 1993) and at Eskay Creek. U-Pb zircon ages ranging from 181 to 173 Ma attest to a distinct younger and separate volcanic episode post-dating Early Jurassic, Mount Dilworth eruption and predating deposition of the Bowser Lake Group sediments. In retrospect the volcaniclastic rocks of the medial package probably belong to this Middle Jurassic episode. Interbedded with the tuff and siltstone are rare sandy lime-

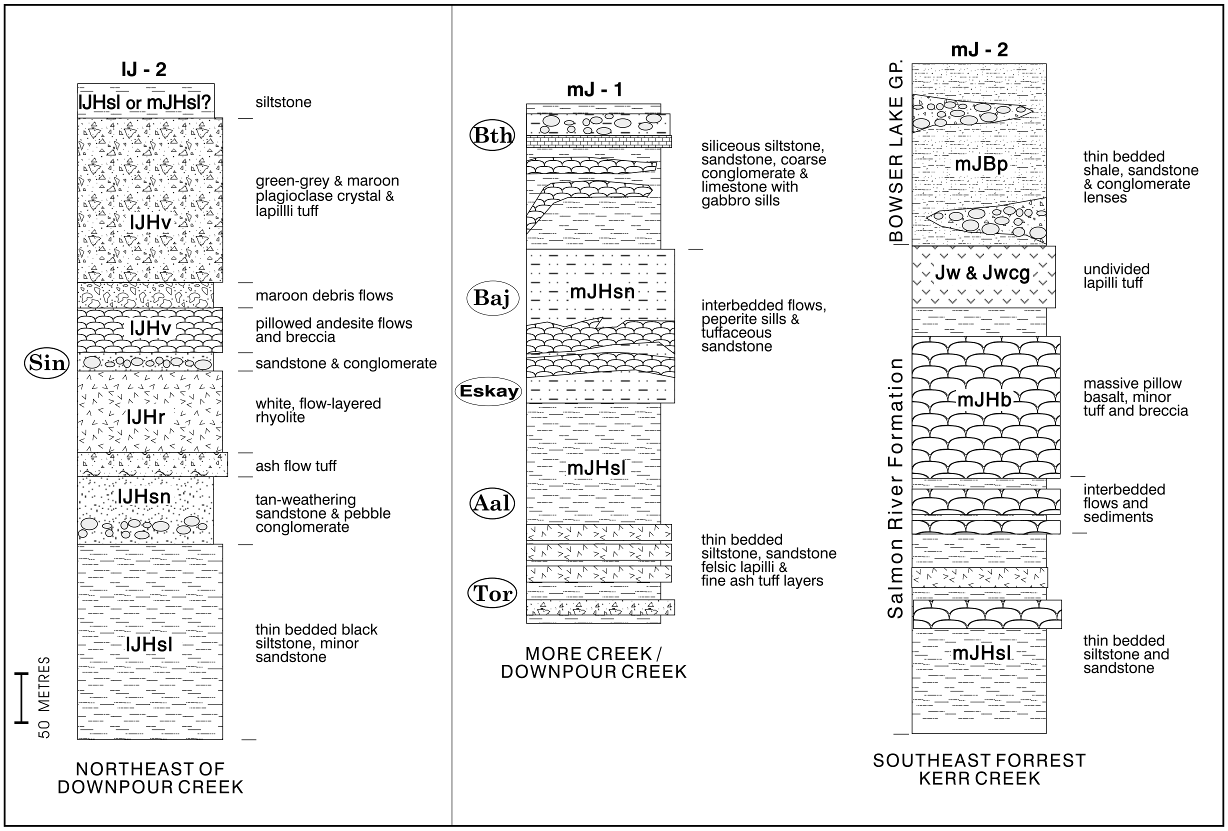

Figure 2-17. Schematic stratigraphic columns for the Lower to Middle Jurassic Hazelton Group strata. Lower volcanogenic stratigraphy exposed northeast of Downpour Creek and upper sedimentary and volcanic stratigraphy exposed southeast of Forrest Kerr and on ridge separating More and Downpour creeks. Jurassic stage names correspond to macro fossil ages, *see* Appendix 1.

stone units. Souther (1972) reports Middle Jurassic, Bajocian fossil ages for strata of this division.

The upper package of sediments includes dark green to olive coloured siliceous siltstone and sandstone interlayered with coarse granule conglomerate and fossiliferous limestone. Strata adjacent to the Forrest Kerr Fault are intruded by gabbro sills, which, in weathered-outcrop, have the concentric appearance of pillowed lava. A light grey, sandy, fossil-rich limestone contains belemnoid, pelecypod, gastropod and bivalve species indicative of a probable Bathonian age (C-189770, Appendix 1). Thin bedded, orange and grey weathering limy sandstone and pyritic siltstone of the lower and upper packages are similar in age and lithology to the Ashman Formation. However, intercalated volcanic rocks distinguish them from the basal unit of the Bowser Lake Group.

Upper Eskay Creek Facies

Middle Jurassic pillow and flow-breccia basalts of the upper member of the Salmon River Formation underlie a large area between Forrest Kerr Creek and the Iskut River, south of the bend in Forrest Kerr Creek (Figure 2-15). Smaller fault-bounded slices extend north to More Creek, where they conformably overlie and are intercalated with shale and siltstone of unit mJHsl.

Between Forrest Kerr Creek and the Iskut River, the volcanic succession comprises up to 2,000 metres (Read *et al*., 1989) of predominantly pillowed lava flows and scoriaceous lapilli-tuff breccia (Figure 2-17, Photo 2-27). Pillows average 30 to 100 centimetres in size and are well-preserved; flow tops and facing directions are easily recognized (Photo 2-28). Outcrops weather dark brown to

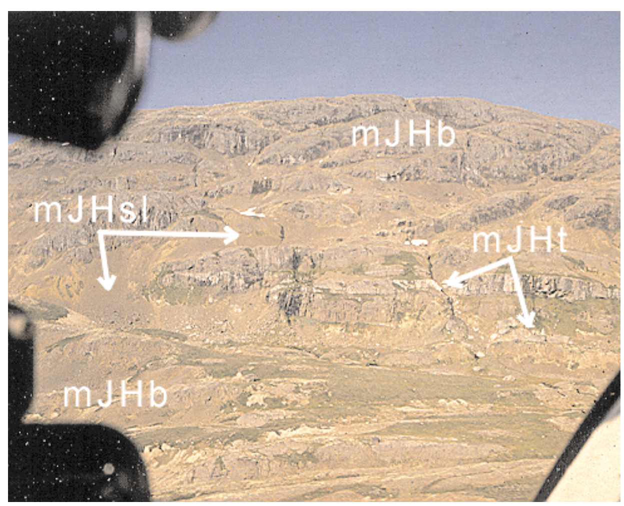

Photo 2-27. Thick accumulation of Middle Jurassic pillowed and flow breccia basalts exposed northeast of the confluence of Iskut River and Forrest Kerr Creek. Interbedded with the basalt, though comprising only 10 percent of the section are rusty pyritic siltstone and white-weathering dacitic tuffs which together comprise the Eskay Creek facies of the Salmon River Formation (photograph shows upper 300 m of 2 000 m section).

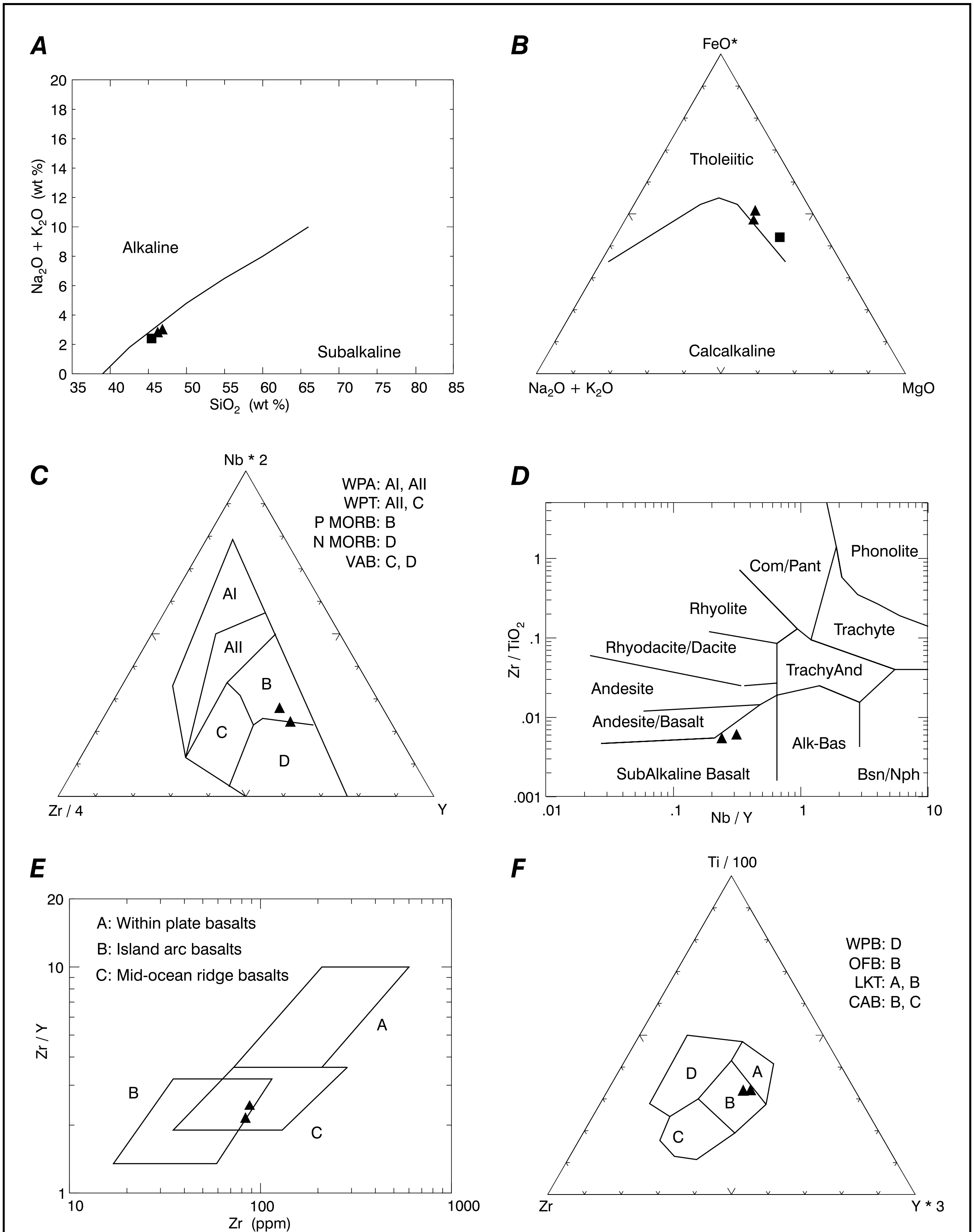

Figure 2-18. Major and trace element geochemical plots for Salmon River Formation pillowed basalts (filled triangles) and a subvolcanic diorite sill (filled square). A) total alkali versus silica (after Irvine and Baragar, 1971); B) AFM plot (after Irvine and Baragar, 1971); C) ternary plot of Nbx2 - Zr/4 -Y (after Meschede, 1986); D) plot of Zr/TiO_2 versus Nb/Y (after Winchester and Floyd, 1977); E) plot of Zr/Y versus Zr (after Pearce and Norry, 1979); F) ternary plot of Ti/100 - Zr- Yx3 (after Pearce and Cann, 1973).

Photo 2-28. Outcrop exposure of well preserved pillow-forms indicating bedding tops are upright, viewed northward.

orange. Flow breccias are interbedded with the pillowed flows and locally scour and disrupt interflow sediments. Pillow basalts and hyaloclastite-flow breccias comprise greater than 90 per cent, and fine-ash tuff and siltstone less than 10 per cent of this unit. White and grey siliceous argillite or tuff and pyritic siltstone are interbedded with the basalts. Grey and khaki siliceous siltstone, conglomerate and tuff (unit JHtw, GS-Map) overlie and interfinger with the pillow basalt. Subvolcanic gabbroic sills and dikes intrude the volcanic pile. Their mineralogy and textures are similar to those in pillows and clasts in brecciated extrusive rocks and likely represent feeders to them.

South of More Creek, at the confluence of its north and south forks, approximately 200 metres of mainly dark grey, fine-grained, aphyric basaltic rocks with minor interbedded graphitic and pyritic siltstone of the Salmon River Formation crop out. Although the basaltic volcanic rocks structurally underlie folded siltstone, they may overlie them stratigraphically. An ammonite was collected from interbedded tuffaceous sandstone near the stratigraphic top(?) of the volcanic sequence that yielded an early Middle Jurassic (Aalenian) age (Poulton, 1991). Flows dominate, but local coarse fragmental rocks, similar to basaltic hyaloclastite in the pillowed successions, also occurs. Fragments are mainly scoriaceous and lapilli to block-size. The volcanic rocks are generally dark grey but, where pyritized, are bleached to light grey. In the middle of the package a 10 metre thick sequence of thin, alternating black siltstone and white tuff is interbedded with massive to thick-bedded basaltic fragmentals. These tuffaceous sediments resemble the 'pajama bed' rocks of the Troy Ridge Facies of the Salmon River Formation (Anderson and Thorkelson, 1990). In thin section, the darker layers are finely laminated and finer grained than the lighter layers, which are granular and appear to consist of fine lithic fragments (basalt?) and rare angular, anhedral clinopyroxene grains.

The basalt is dense, amygdaloidal and consists almost entirely of fine-grained vitreous plagioclase crystals, rare pyroxene phenocrysts and abundant disseminated pyrite in a fine groundmass. In thin section, felty, acicular plagioclase laths form an open intersertal texture with dark iron oxide stained devitrified glass and variolitic intergrowths of clinopyroxene and plagioclase. In other thin sections, an intergranular texture with randomly oriented, interlocking, subhedral grains of plagioclase occurs and clinopyroxene is more common.

Alteration is mainly low grade. Calcite, chlorite, chalcedonitic quartz, and rare epidote line vesicles. Prehnite+quartz+chlorite±albite assemblages occur in thinly bedded, intraflow volcanic siltstones and tuffs. Radiating and "bow-tie" structures of prehnite (Photo 2-29) are similar to the "crystallites" described at Eskay Creek (Ettlinger,1991). Although, north of the Iskut River, these mineral assemblages are not associated with known mineralization. Locally, plagioclase laths and microlites in the groundmass are altered to sericite. Chlorite pseudomorphs clinopyroxene.

CHEMISTRY OF THE SALMON RIVER FORMATION BASALT

Two analyses of relatively unaltered Middle Jurassic pillow basalt from the Forrest Kerr area are plotted in Figure 2-18. Although the basalts are aphyric, they are typically

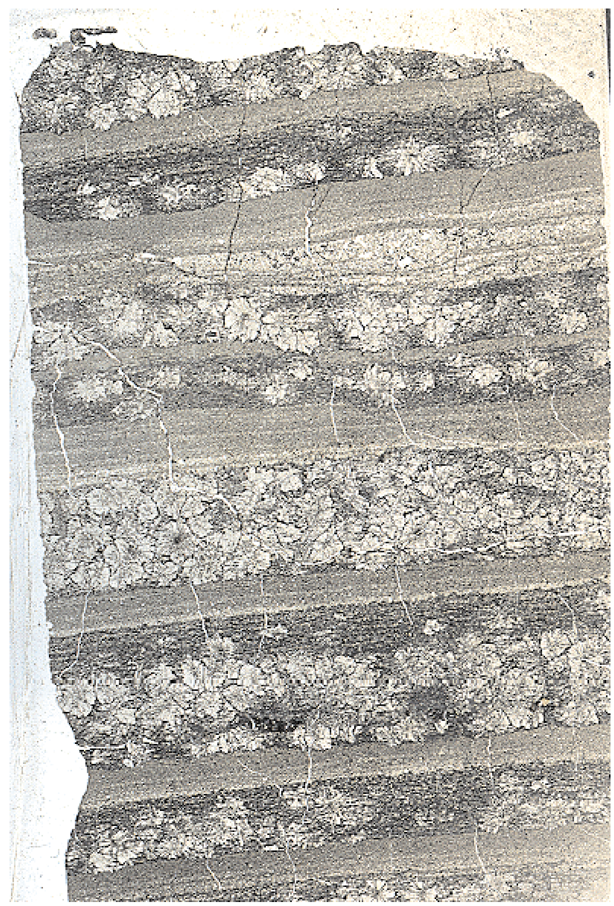

Photo 2-29. Thin-section showing prehnite as radiating and "bow-tie" structures, quartz and chlorite mineral assemblage characteristic of the low grade metamorphic alteration of this intraflow siltstone. Width of slide is approximately 2 centimeters.

strongly vesiculated, and this limited sampling. The rocks are relatively homogenous, at least in texture and mineralogy, and the two samples collected are probably sufficiently representative for the purposes of classification. The lavas are basaltic, with subalkaline tholeiitic compositions, and lie on an iron enrichment trend on the AFM diagram (Figure 2-18A and 18B). They plot as subalkaline basalts (Figure 2-18D) on the trace element plot of Winchester and Floyd (1977) and are transitional between N-MORB and P-MORB (Figure 2-18C) on the Nb-Zr-Y plot of Meschede (1986). In addition, they plot as mid ocean ridge basalts (Figure 2-18E) on the trace element discrimination diagram of Pearce and Norry (1979). On the ternary trace element plot of Pearce and Cann (1973) the two samples occupy either the ocean floor basalt or low potassium tholeiite or unlikely the calcalkaline arc basalt field (Figure 2-18F).

Trace elements other than Ba and the potassium group elements (K, Rb, Sr) are only slightly enriched relative to MORB (Figure 2-19). Their stratigraphic position and lithology corroborates a back-arc depositional environment. These rocks are comparable to back-arc rocks described by Donato (1991).

LOWER(?) AND MIDDLE JURASSIC

Unnamed Lower(?) and Middle Jurassic tuffs, siliceous wackes and conglomerates (Read *et al.*, 1989; unit Jw GS-Map) overlie Upper Triassic Stuhini Group rocks and Middle Jurassic rocks east of Forrest Kerr fault. There are rare limestone lenses but the paucity of datable fossils precludes assigning a more precise age to these rocks. The conglomerate horizons contain volcanic, plutonic and sedimentary clasts of apparent Jurassic age and local derivation.

Strata of this unit crop out at the southern edge of the map area between Iskut River and Forrest Kerr Creek, northwest of the Iskut River 18 kilometres upstream from its confluence with Forrest Kerr Creek, and as a fault-bounded wedge east of Forrest Kerr fault near the northern edge of the map area (Figure 2-15). The rocks are characteristically drab olive to grey in colour, unlike the maroon and dark green colours typical of Upper Triassic Stuhini Group rocks, and are commonly fractured and brecciated. Dark green and grey siliceous siltstones and pyritic cherts are crackled and brecciated in-situ, forming subangular to angular centimetre-scale fragments. Tuffaceous wackes are carbonaceous and variably sheared. Interbedded with the tuffaceous arenites are sedimentary conglomerates containing clasts of chert, black siltstone and intermediate to felsic volcanics. Volcaniclastics are characteristically brownish-grey lapilli and crystal tuffs comprised of euhedral plagioclase and green and grey scoriaceous fragments. The contact with the Middle Jurassic Bowser Lake Group is conformable, therefore parts of the section are upper Salmon River Formation, Eskay Facies.

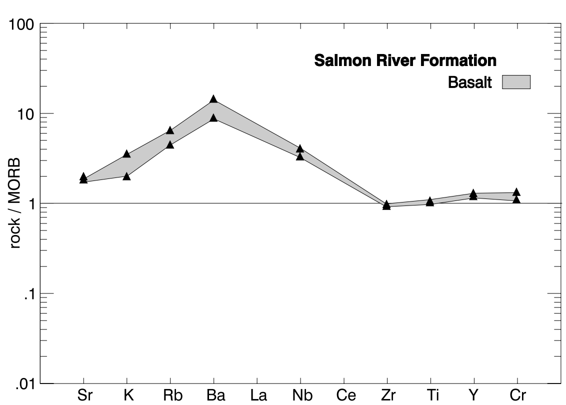

Figure 2-19. Multi-element geochemical patterns for Salmon River Formation basalts (n=2) of the Hazelton Group.

Paleoenvironmental Interpretations

The Lower to Middle Jurassic Hazelton Group is a volcano-sedimentary succession characterized by a variety of different facies and stratigraphic units (Tipper and Richards, 1976; Marsden and Thorkelson, 1992). Volcanic strata in the study area reflect proximal, distal, submarine and subaerial environments of deposition as well as arc and back-arc characteristics (Anderson, 1993). In the Telegraph Creek area, Lower Jurassic basal conglomerate overlies Upper Triassic volcanic and plutonic rocks with angular unconformity. The uplift and erosional event that led to conglomerate deposition preceded initiation of Hazelton volcanism. Basaltic to bimodal volcanism began in the lower Sinemurian and continued until Bajocian time. The deposits are widespread and consist predominately of subaerial flows and welded tuffs of basaltic to rhyolite compositions. The volcanism probably built stratovolcanoes (Alldrick, 1989). Interbedded with the volcanic breccia and subaerial welded tuffs north of Downpour Creek are marine deposits of greywacke and siltstone containing Sinemurian to Bajocian ammonites and bivalves. Volcanism and marine deposition were contemporaneous and reflect an emergent island-arc setting during this period. The volcanics are calcalkaline to tholeiitic, have a strong arc signature and show little evidence of continental influence. The youngest volcanic rocks, in the Eskay Creek facies of the Salmon River Formation, consist of a submarine package of fine clastic sediments and a pile of felsic and mafic pillow lava. These volcanic rocks are different, and are probably rift related lavas formed in either a back-arc or forearc setting. The facies variations from west to east of the Salmon River Formation suggest an west-facing arc in the Lower to Middle Jurassic (Anderson, 1993). The youngest volcanogenic rocks are conformably overlain by black siltstone of the basal Bowser Lake Group.

MIDDLE TO UPPER JURASSIC BOWSER LAKE GROUP

ASHMAN FORMATION

Middle Jurassic to mid-Cretaceous marine and nonmarine clastic rocks of the Bowser Basin comprise the Bowser Lake Group (Tipper and Richards, 1976; Cookenboo and Bustin, 1989). Sediments that form the northwestern edge of the Bowser Basin crop out along the eastern edge of the map area along the flanks of the Iskut River valley (Figure 2-15). Souther (1972) recognized shallow water facies-equivalent strata as far west as Mess Creek. Evenchick (1991c) mapped the Bowser Lake Group rocks in the east Telegraph Creek and southwest Spatsizi areas and concluded that the western exposures of the Bowser Lake Group in these areas were all Ashman Formation. They have the same marine character as the Ashman further east in the Spatsizi area, and she (Evenchick, 1991c) concluded that a western depositional margin to the Bowser Basin was not evident in this part of the Telegraph Creek area. The Ashman Formation is predominantly black siltstone and very fine grained sandstone and contains marine fossils. It includes thin orange weathering calcareous siltstone and claystone beds, and grey weathering lenses and discontinuous sheets of chert pebble conglomerate (Evenchick and Thorkelson, 1993).

South of the Iskut River, in the southeast corner of the map area, planar-bedded shale and locally cross-bedded sandstone couplets dominate but are interbedded with local granule conglomerate. The conglomerate beds are thin, lensoidal bodies containing quartz and siltstone clasts in a limonitic sandy feldspathic matrix. They weather grey to rarely rusty. The argillites have a well-developed pencil cleavage and locally contain pressure solution quartz veinlets. These grey shales and siltstone are of late Middle Jurassic (Callovian) age and are correlated with the Ashman Formation of the Bowser Lake Group (Read *et al*., 1989). West of the Iskut River the lithologies consist mainly of fine to medium-grained sandstones containing 10 to 15 per cent detrital quartz and fine siltstone.

In the area south of the east-flowing segment of More Creek and north of Downpour Creek, there is a package of Lower and Middle Jurassic black clastic sediments (unit 14 of Souther, 1972). The unit consists dominantly of black and brown planar laminated siltstone, siliceous siltstone, sandstone which resemble Ashman Formation strata, but include mafic, intermediate and felsic volcanic flows and tuffs. The strata range in age from Bajocian to Bathonian and are correlated with the Salmon River Formation of the Hazelton Group (see above).

PALEOENVIRONMENTAL INTERPRETATIONS

The middle Jurassic to Cretaceous Bowser Lake Group in the Telegraph Creek area is entirely marine (Evenchick, 1991c). The predominantly black siltstone and fine sandstone, thin orange weathering calcareous siltstone and pebble conglomerate of the basal Ashman Formation were probably deposited in submarine channel and slope environments (Green, 1991; Ricketts and Evenchick, 1991). The basin developed on Stikinia within the confines of the Stikine Arch and the Skeena Arch. Paleocurrent directions and structural trends indicate sediment sources from the north, east and south (Eisbacher, 1981).

UPPER CRETACEOUS TO TERTIARY SUSTUT GROUP

Small isolated remnants of Sustut Group sediments (Unit uKSs, GS-Map) are preserved in downfaulted blocks on Exile Hill and north of Nagha Creek (Figure 2-20; Souther, 1988). On Exile Hill, they consist of well-bedded,

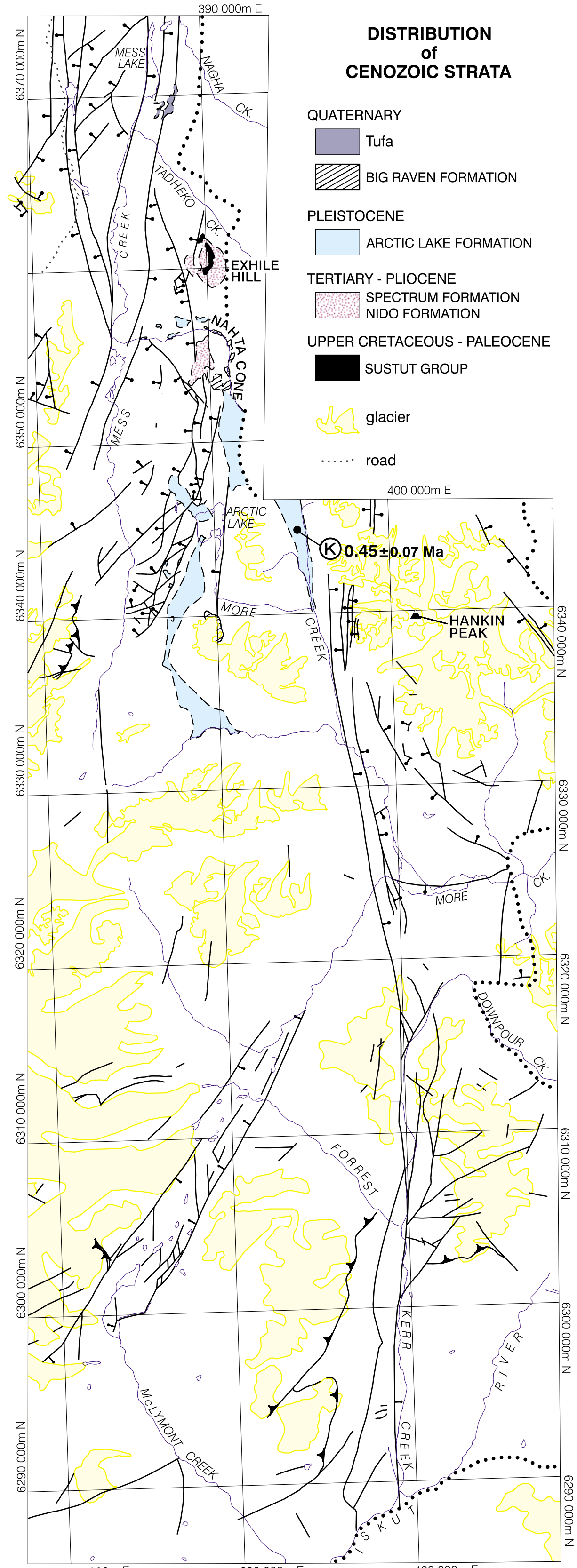

Figure 2-20. Distribution of Upper Cretaceous, Tertiary, Quaternary strata. Sample site and K-Ar, whole rock age date from basalt of Arctic Lake Formation.

pale green weathering and friable carbonaceous siltstone, quartzose sandstone and polylithic chert-granule conglomerate and rest unconformably on Early Mississippian diorite of the More Creek Pluton. The conglomerates are poorly sorted, well-bedded and matrix supported. Granitic, aphyric volcanic, chert and quartz clasts comprise roughly equal proportions of the conglomerate. Granitic clasts are hornblende biotite granodiorite, quartz eye porphyritic granite, hornblende diorite and potassium feldspar megacrystic monzonite. Volcanic clasts include pink flow banded rhyolite and pale green and grey intermediate and felsic flows. White vein quartz and light coloured chert and siltstone clasts are conspicuous components of the conglomerate. The sandstones are limonitic, well consolidated units. Weathering (exfoliation) produced bowling ball-sized sandstone spheres that lie at the base of the sandstone outcrops. All sediments of the unit are limonitic, closely fractured and veined by calcite at the north end of Exhile Hill.

PALEOENVIRONMENTAL INTERPRETATIONS

Nonmarine Upper Cretaceous to Tertiary conglomerate and sandstone units of the Sustut Group Strata accumulated in response to tectonism and uplift in the eastern Coast Belt. Strata were deposited in fluvial and alluvial fan type settings, which are preserved in a narrow northwest trending belt, that extends from the Stikine River south to Takla Lake. The basal Tango Creek Formation generally rests unconformably on Bowser Lake Group sediments. Sandstone, mudstone and conglomerate of the Tango Creek Formation are believed to have been deposited by two major river systems flowing south and southwestward (Eisbacher, 1981). It is overlain conformably by conglomerate and tuff of the Brothers Peak Formation in the Spatsizi River area (Evenchick and Thorkelson, 1993). Coarse thick conglomerate of the Brothers Peak Formation unconformably overlies Triassic rocks in the Stikine canyon area (Read, 1983), and rests with angular unconformity on Upper Triassic and Lower Jurassic volcanic rocks on Strata Mountain and Mount Helveker (Brown *et al*., 1996). The dominant clastic input in the northern part of the basin during deposition of the Brothers Peak Formation was from the west (Gabrielse *et al*., 1992). At Mess Creek, Kerr (1948a) recognized a progression from mainly foliated schist, slate and volcanic rock clasts in the lower beds to predominantly granitic rocks in the upper parts of the section and suggested the uplift and erosion, culminated in unroofing Paleozoic and Mesozoic plutonic rocks.

PLIOCENE

NIDO AND SPECTRUM FORMATIONS

Subaerial flows of aphyric and olivine-phyric basalt with intercalated fluvial gravel of the Nido Formation (unit TNb, GS-Map) and peralkaline rhyolite flows of the Spectrum Formation (unit TSr, GS-Map) underlie the Arctic Lake plateau area. These are Quaternary members of the Mt. Edziza Volcanic Complex on the eastern border of the map area (Figure 2-20). These Pliocene rocks were not examined in detail because they were mapped by Souther (1988, 1992) at a scale of 1:50 000. The reader is referred to 'The Late Cenozoic Mount Edziza Volcanic Complex' (Souther, 1992) for detailed stratigraphic, petrographic and chemical descriptions of these formations as well as the entire volcanic complex.

In the map area, the Nido Formation unconformably overlies carbonate, intrusive and volcanic rocks of the Paleozoic Stikine assemblage and also Upper Cretaceous sedimentary rocks. It is intruded by feeders to, and overlain by the Spectrum Formation at Exile Hill (Cross section E-F, GS Map; Figure 2-20). Exhile Hill is a small satellite eruptive centre of the main Spectrum cauldera, which is inferred to be centred on Yeda Peak, about 7 kilometres to the northwest. The Spectrum Formation rocks intrude flat-lying basalt of the Nido Formation and extrusive equivalents cap the top of Exile Hill. Flows in both formations are essentially flat lying. The two formations are separated by a thick layer of gravel that is composed almost entirely of Spectrum rhyolite and obsidian (Souther, 1992). At this same locality, an intraflow cobble conglomerate layer occurs between flows of the Nido Formation.

QUATERNARY

ARCTIC LAKE FORMATION

Flat-lying, columnar jointed basaltic flows (unit Qb, GS-Map) underlie the plateau north and south of Arctic Lake and crop out at the north end of More Creek. The flows occupy north-trending valleys in the area and extends for about 10 kilometres south from Arctic Lake. Small outliers cap ridges in the Mess Lake area and one flow crops out on the floor of Mess Creek valley (Figure 2-20). The distribution of flows indicates that the paleosurface was similar to the present topography. They unconformably overlie Late Paleozoic diorite of the FKP, polydeformed layered rocks of unknown age and poorly consolidated glacial-fluvial sediments of uncertain age. Souther (1972) assigned an Upper Tertiary to Pleistocene age to the basalts based on correlation with similar rocks to the north, near Mount Edziza.

Flows are vesicular near their tops and bases, so individual flows are identifiable where they are dissected by More Creek. Fragmental aphyric rocks only occur in one outcrop at the south edge of Arctic Lake. Dark grey basalt with a maximum of 2 to 3 per cent plagioclase, 1 per cent clinopyroxene, less than 1 per cent magnetite and rare olivine phenocrysts is the most common rock type. The mineralogy varies little in all the exposures examined. Phenocrysts are vitreous and unaltered. In thin section, phenocrysts in the basalt consist of euhedral, oscillatory zoned plagioclase and subhedral to anhedral olivine and sparse clinopyroxene. In each section several plagioclase grains, probably xenocrysts, have thick resorption zones, with a sponge-like texture of fine glass inclusions; plagioclase overgrowths (coronas) are typical on these grains. Olivine crystals frequently have embayed margins. The groundmass consists of fine plagioclase microlites, intergranular olivine and pyroxene, and abundant (about 30-40 per cent) grainy opaques.

A K/Ar whole rock analysis of a sample of Arctic Lake Formation alkali olivine basalt collected east of Exhile Hill gave a date of 0.71±0.05 Ma (Souther *et al*., 1984). A younger Pleistocene date of 0.45±0.07 Ma was obtained by Joe Harakal (UBC geochronology Lab) from K/Ar whole rock analysis of a flow at the north end of More Creek (Figure 2-20, Table 2-1). Klastline Formation volcanism is slightly younger (0.62±0.04 Ma; Souther *et al*., 1984) than Arctic Lake Formation alkali basalt but still older than our date. Deposition of Arctic Lake Formation basalt occurred from at least seven separate vents, located between Tadekho Creek and Arctic Lake. Volcanic activity was episodic and progressed from north to south (Souther, 1992), but whether the apparent time span, between 0.71±0.05 and 0.45±0.07 Ma, reflects its longevity, a separate igneous pulse or the limitations of the K-Ar dating technique is not certain.

BIG RAVEN FORMATION

South of Arctic Lake, post-glacial basaltic scoria, angular debris deposits and lava flows (unit Qob, GS-Map) form a small knob built on the FKP (Figure 2-20). Several small dikes, all less than a metre wide, cut the scoria deposits. Along the flanks of the knob, the scoria are weakly cemented, forming rough beds about 30 centimetres thick. The north side of the knob comprises mainly thin lava flows, underlain by weakly indurated, till-like sediments (diamictite) with rounded cobbles of granite and diorite to 10 centimetres in diameter. Minor stratified tuff is also present. The basalt contains an average of 5 per cent vitreous olivine and less than 1 per cent each of clinopyroxene and plagioclase; the phenocrysts range up to 5 millimetres in size. In thin section, plagioclase forms euhedral, normally zoned crystals. A few larger, anhedral, rounded plagioclase xenocrysts have distinguishing sponge-textured resorption zones and plagioclase overgrowths on the rims, similar to those in Arctic Lake Formation basalt. Olivine forms both euhedral and anhedral grains, the latter with resorbed margins; they were determined to be fayalitic in composition from their negative optic sign. The groundmass is darkened by very finely disseminated opaques. Vesicles walls are free of secondary minerals.

Similar olivine basalt scoria and flows form Nahta cone, located about 7 kilometres north of Arctic Lake. The cone is approximately 70 metres high and consists mainly of black and brick-red scoria blocks (Photo 2-30). The circular crater rim is breached on its east side where at least two highly fluid lavas flowed to the north along a drainage in which they are still preserved. Levees of flow breccia mark the path of the flows down the creek. The cone is situated at the contact between the mid Carboniferous carbonate rocks of unit mCSc and granitic rocks of unit EMg. A thin, V-shaped apron of lapilli and ash-sized tephra covers these units for a distance of about 700 metres north and 500 metres west of the main cone. The apron is good evidence that the cone erupted on two occasions with differing wind directions.

Souther (1972, 1992) correlated these olivine-bearing scoria and basalt flows with olivine basalt and related pyroclastic rocks of the Holocene Big Raven Formation (radio-carbon dated at 1340 years B.P.; Souther, 1970). The Big Raven Formation contains more olivine and fewer plagioclase phenocrysts than the Tertiary basalt flows around Arctic Lake and in More Creek valley.

CHEMISTRY OF THE QUATERNARY ARCTIC LAKE FORMATION

Quaternary volcanism in the Canadian Cordillera is localized along distinct linear belts that appear to be related to the same tectonic regime as the present, that of right lateral translation along the Queen Charlotte Fault. This produced extension and subsequent deep fracturing of newly accreted continental crust. Basalts which erupt in such settings are typically alkaline and often bimodal in composition; examples include the east-trending Anaheim Belt in southern British Columbia (Souther, 1977, 1986) and the north-trending Stikine Belt (Souther, 1992). Four samples of olivine-pyroxene basalt of the Arctic Lake Formation analysed are basic alkaline basalt with less than 49 per cent SiO_2 (Figure 2-21A and 21D). They all plot in the tholeiitic field on the AFM diagram (Figure 2-21B). The Ti-Zr-Y diagram (Pearce and Cann, 1973) in Figure 2-21F discriminates within-plate basalt from those extruded along plate margins. The Arctic Lake basalt samples plot in the within-plate field typical of alkaline continental rift lavas on this diagram, the Zr/Y vs. Zr of Pearce and Norry (1979) and the Nb-Zr-Y diagram of Meschede (1986). They show a pattern with a negative slope, characterized by enrichment of Zr and Ti with respect to N-MORB (Figure 2-22). Enrichment increases from Yittrium (no enrichment) to the lithophile elements (substantial enrichment) which is characteristic of within plate basalts (Pearce, 1996).

HOT SPRING DEPOSITS

Hot spring deposits of tufa (unit Qt, GS-Map) occupy an elongate area of about 100 hectares southeast of Mess Lake (Figure 2-20). The warm-springs are located along north-trending faults of the Mess Creek system. They are discharging and depositing tufa into a connected series of

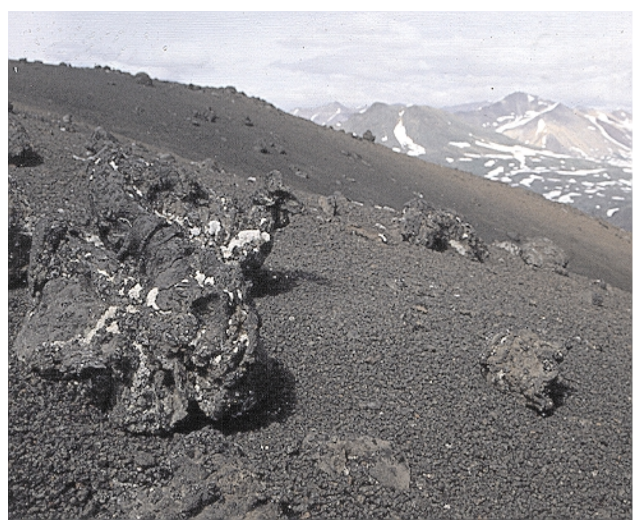

Photo 2-30. Black and red scoria blocks and lapilli-sized Quaternary basalt comprise the eastern flank of Nahta Cone, viewed northeastward.

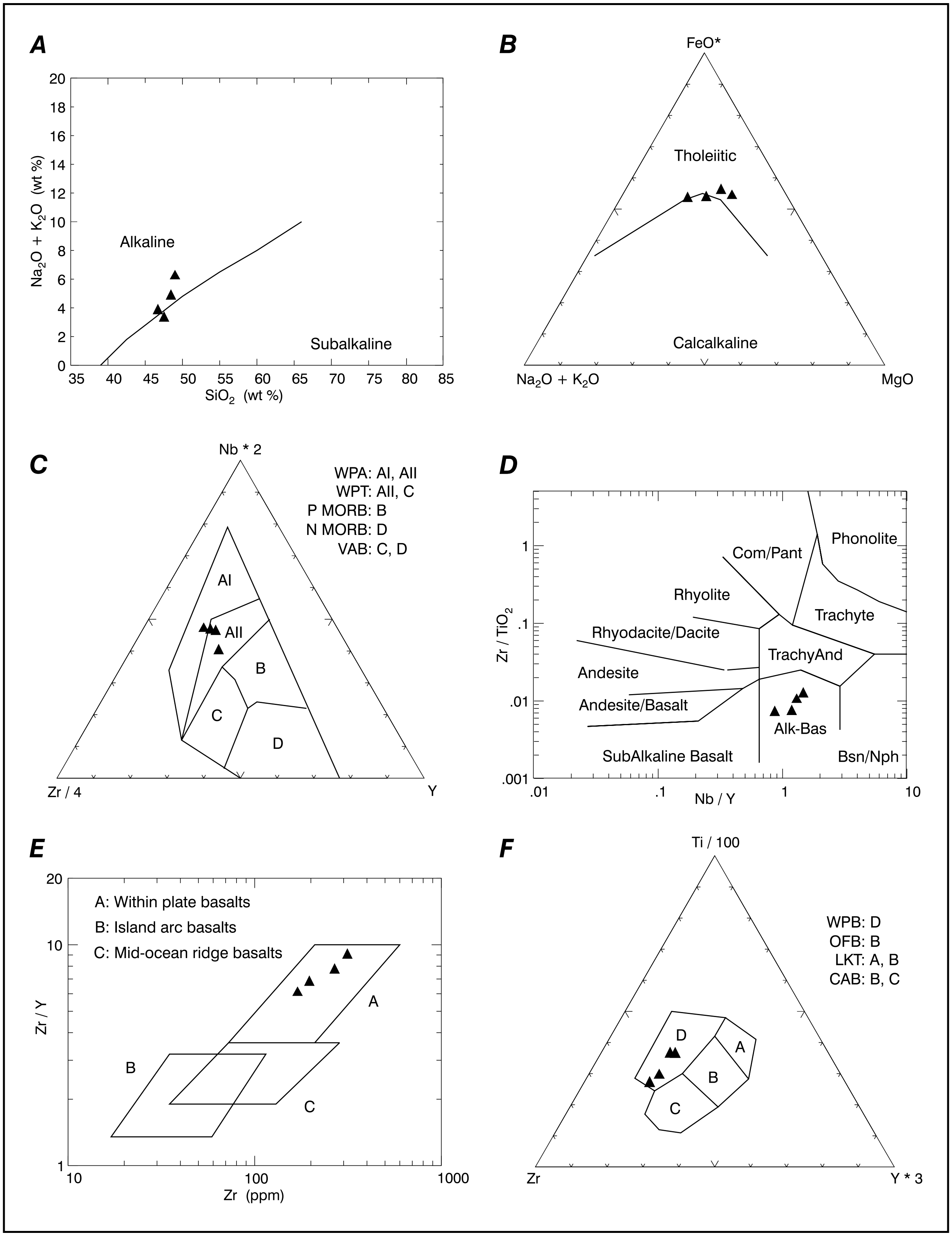

Figure 2-21. Major and trace element geochemical plots for Arctic Lake Formation basalts (filled triangles). A) total alkali versus silica (after Irvine and Baragar, 1971); B) AFM plot (after Irvine and Baragar, 1971); C) ternary plot of Nbx2 - Zr/4 -Y (after Meschede, 1986); D) plot of Zr/TiO_2 versus Nb/Y (after Winchester and Floyd, 1977); E) plot of Zr/Y versus Zr (after Pearce and Norry, 1979); F) ternary plot of Ti/100 - Zr- Yx3 (after Pearce and Cann, 1973).

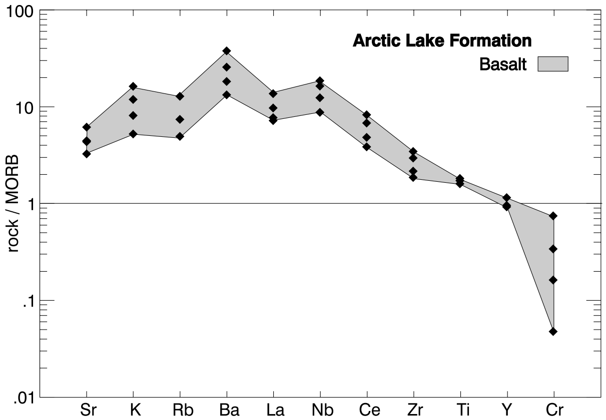

Figure 2-22. Multi-element geochemical patterns for Arctic Lake Formation basalts of the Edziza Complex.

poorly drained flat-bottomed valleys. Water percolating in the active springs is about 8-15 degrees Celsius, temperatures measured in 1984 were 13.0 degrees Celsius (Piteau and Associates, 1984). Most of the deposits are of the low-hill, terraced type (Photo 2-31), but six small circular cones 1 to 4 metres high and a hill of travertine up to 10 metres high are also present. Many of the tufa terraces have raised pressure ridges, with relief on the order of 10 to 40 centimetres and are from 50 to100 metres in length. It is not known whether these resulted from recent fault movement or seasonal freezing.


Photo 2-31. Low-hill, terraced tufa deposits east of Mess Creek, near the south end of Mess Lake.

Quaternary volcanism probably provided heat for the springs; as the lava cooled so did the springs and slowed deposition of calcareous tufa (Woodsworth, 1997). The nearby, large exposures of Paleozoic limestone are probably responsible for the high levels of dissolved solids in the groundwater which resulted in large volumes of calcareous tufa being deposited.

CHAPTER 3 INTRUSIVE ROCKS

INTRODUCTION

Plutonic rocks of northern British Columbia represent at least seven intrusive episodes: Late Devonian, Early Mississippian, Middle(?) to Late Triassic, Late Triassic to Early Jurassic, Early Jurassic, Middle Jurassic and Eocene (Drobe *et al*., 1992; Anderson, 1993; Bevier and Anderson, 1991; Woodsworth *et al*., 1991; Figure 3-1). Recent U-Pb dating of plutonic rocks has identified additional episodes of intrusive activity, for example; a late Early Jurassic episode in the Scud River area (Brown *et al*., 1996) and geochronological dating in the Iskut River area demonstrates that intrusive activity is nearly continuous for the entire period from Sinemurian to Bajocian, 195 to 175 Ma (Macdonald *et al*., 1996). Missing in this part of Stikinia are the mid and Late Cretaceous plutons found further north and in central British Columbia (Armstrong, 1988).

Isotopic dating completed for plutonic and volcanic rocks in the map area has allowed accurate age determination and "suite" classification for several of the larger intrusions. The intrusive episodes are characterized by distinctive suites of plutonic rocks and associated mineral deposits (Barr *et al*., 1976; Sinclair, 1986; Alldrick *et al*., 1987). For intrusions in the map area with no isotopic age data, classification is based on intrusive relationships, chemical and mineralogical composition and mineral deposit associations. For example, potassium feldspar megacrystic syenite intrusives that cut Upper Triassic Stuhini Group rocks and have associated minor copper mineralization, even if it is apparently minor, are assigned a Late Triassic and younger age and grouped into the Copper Mountain plutonic suite.

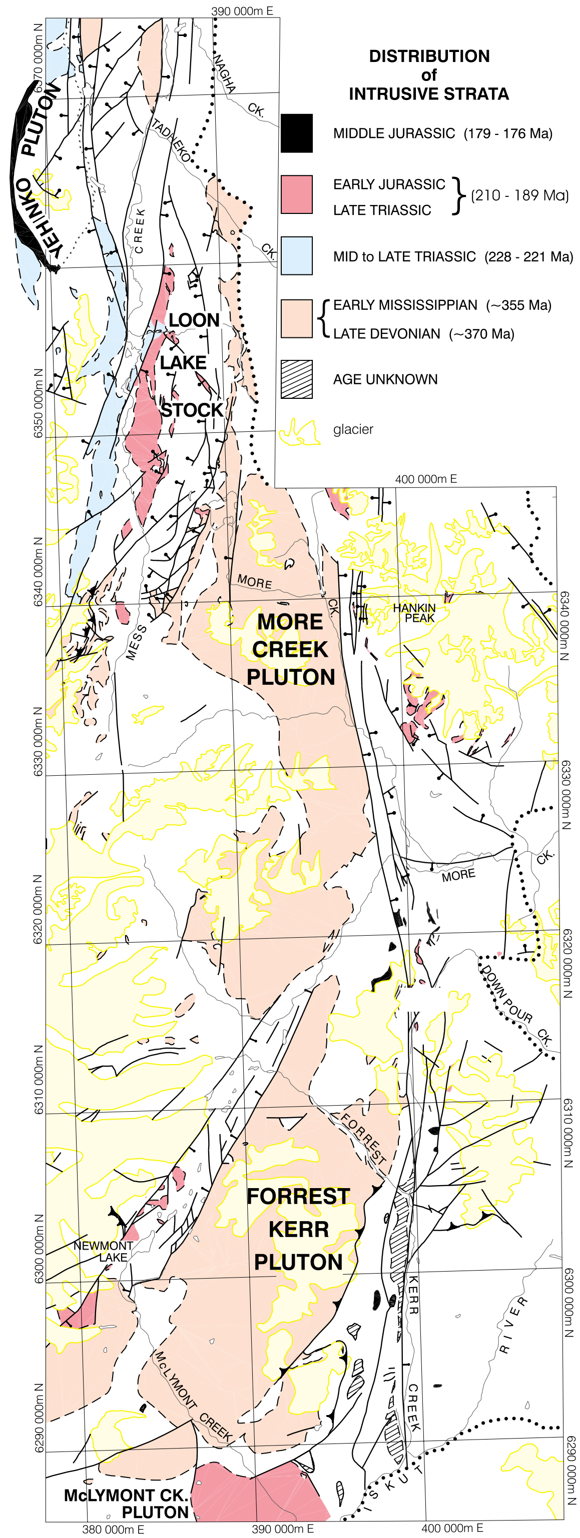

Figure 3-1. Distribution of the six main intrusive suites within the study area.

EARLY(?) DEVONIAN

Weakly foliated to schistose diorite sills and stocks intrude schistose Devonian rocks west of and at the headwaters of Mess Creek (Figure 3-2, Photo 2-1). Where the intrusions are less deformed equigranular, medium-grained textures are preserved. These chloritic metadiorites grade into penetratively foliated, pervasively deformed chlorite schist in which intrusive textures have been completely destroyed. The massive, textureless nature of these rocks are distinctive and distinguishes them from similar chloritic, schistose mafic tuffs and flows in which primary textures are generally preserved.

In thin section, less deformed diorites contain subhedral to anhedral clinopyroxene that is variably chloritized and replaced by actinolite. Plagioclase is slightly finer grained and moderately sericitized. In schistose rock, actinolite pseudomorphs pyroxene and forms scattered needles of variable size throughout the groundmass. In these same rocks, quartz locally forms over 50 per cent of the groundmass as fine equigranular grains; it also occurs

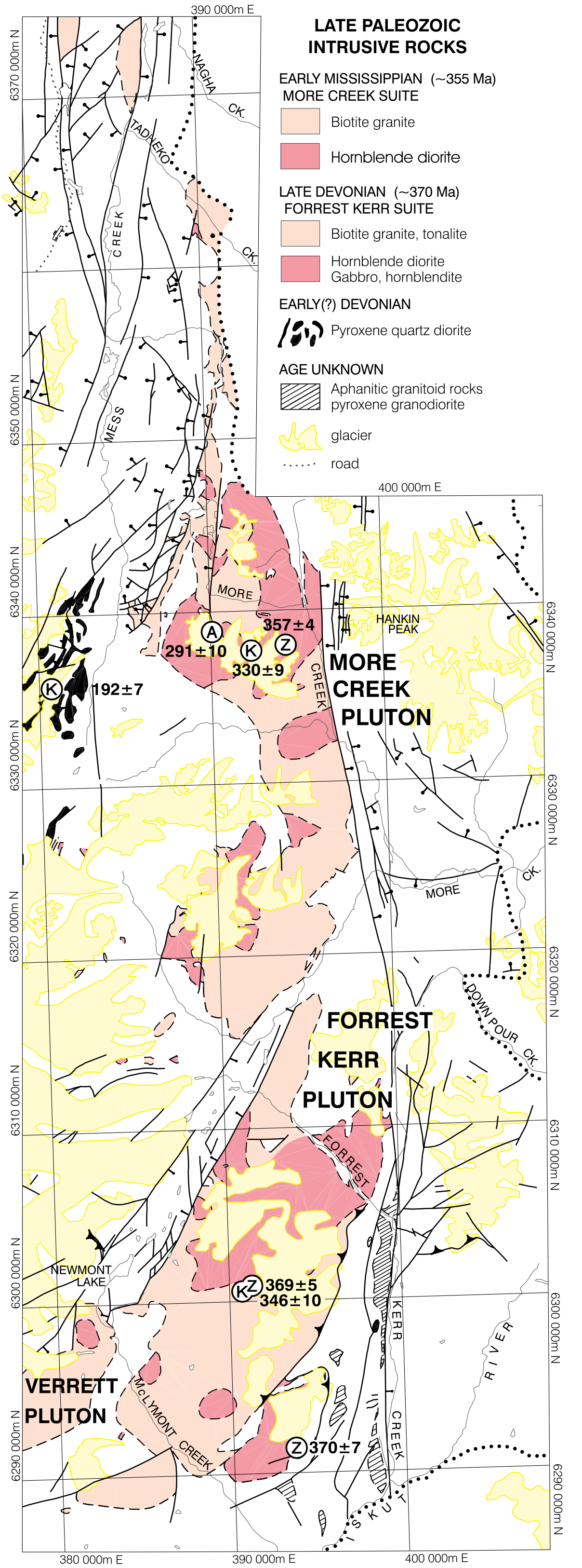

Figure 3-2. Distribution of Late Paleozoic Forrest Kerr, More Creek and Early(?) Devonian intrusive suites in the study area. Sample sites, method and results are shown for K-Ar, Ar-Ar and U-Pb age dating of these suites. Numbers correspond with data in Table 3-1.

sparsely as larger anhedral grains. Chlorite is abundant, and the rock is cut by deformed sericite and quartz veinlets.

The metadiorite intrusions may be subvolcanic equivalents of or feeders to mafic metavolcanic rocks of the same age. Alternatively, they may be the diorite phase of the Late Devonian Forrest Kerr pluton. The rocks are interpreted to be the oldest intrusions mapped in the area, but are not constrained by age dating.

LATE DEVONIAN TO EARLY MISSISSIPPIAN FORREST KERR AND MORE CREEK PLUTONIC SUITES (370-355 Ma)

An elongate, north-trending composite intrusion of monzodioritic to tonalitic composition straddles 57° 00' latitude. It extends more than 30 km north into the Telegraph Creek and south into the Iskut River map areas (Figure 3-1). It is bounded to the east by the Forrest Kerr fault, which lies within the Forrest Kerr and More Creek valleys, and to the south by the Iskut River. The intrusive can be subdivided into two plutons, the Late Devonian - Forrest Kerr pluton (FKP) - in the south, and the younger, Early Mississippian - More Creek pluton (MCP) - to the north (Drobe *et al.*, 1992). They are roughly the same size; each underlies an area of about 250 square km. Mineralogically, texturally and chemically both plutons are remarkably similar. They are probably subvolcanic plutons since Late Devonian and Early Mississippian extrusive rocks are well documented for this part of northern Stikinia (Greig and Gehrels, 1995; Mortensen in Sherlock *et al.*, 1994), although intrusive rocks of this same age were not recognized until recently (McClelland *et al.*, 1993; Friedman in Ash *et al.*, 1997).

Contact relationships with the country rocks varies along the length of these plutons. Dikes and sills of foliated tonalite and trondjhemite intrude Early and middle Devonian rocks along the west and south margins of the MCP. Along this same contact, mid Carboniferous and Permian carbonates nonconformably overlie the pluton in the vicinity of Arctic Lake. Nowhere was the MCP observed to intrude rocks younger than mid Carboniferous. The eastern margin of the MCP is faulted against Late Triassic rocks of the Stuhini Group. It is nonconformably overlain by Quaternary basalts north of Tadehko Creek.

To the south, in the Forrest Kerr area, the FKP is thrust eastward over Early Devonian limestone along its eastern margin. The lateral extent and exact timing relationship of this contact, however, is uncertain. Roof pendants of Devonian or older sedimentary rocks, including carbonate, occur at its north and south margin, and the western margin is faulted against a series of steep, northeast-trending fault slices of Late Triassic, Carboniferous and Devonian to Mississippian rocks. At the northern margin, the pluton is cut by flat lying sill-like bodies and dike swarms of dark green diabase of probable Jurassic age.

FORREST KERR PLUTON

The FKP is a 10 km wide composite body extending approximately 25 km north from McLymont Creek to north of Forrest Kerr Creek (Figure 3-2). It is a texturally heterogeneous pluton and consists of a mafic phase of hornblende monzodiorite, diorite and tonalite and a leucocratic phase of granodiorite and biotite trondhjemite. The mafic phase is thought to be the earliest; it forms roughly the northern half of the pluton and the thrust faulted satellite body at its southeast margin. The tonalite and trondhjemite form an inclusion-rich phase which appears to be localized near the margins of the pluton. Granodiorite forms the northwestern margin and leucocratic biotite trondhjemite the majority of the southern part of the pluton. The contacts between phases are abrupt to gradational over short distances, often with conflicting intrusive age relationships. In general the mafic phases occur as inclusions within, or are brecciated and veined by the more felsic phases.

The northern half of the FKP is a mafic, heterogeneous mix of porphyritic to fine grained equigranular hornblende monzodiorite with more mafic hornblendite phases. Hornblende is chloritic and comprises more than 40 percent of the rock; quartz is generally less than 5 percent, but varies to greater than 10 per cent so the rock becomes quartz monzodiorite. The remainder is subhedral plagioclase. Contacts with the leucocratic phase are gradational over short distances of complex intrusive mixing. Intrusive breccias, gneissic sills and pendants of metavolcanic and metasedimentary rocks are common. North of Forrest Kerr Creek, the mafic phase encloses a 9 square km pendant of contact metamorphosed Paleozoic rock. It separates hornblende monzodiorite in the east from granodiorite of the felsic phase.

The satellite intrusion north of Lime Lake is also compositionally heterogeneous. The inclusion-rich phase along the margins of this body consist of trondhjemite containing numerous inclusions of mafic diorite to hornblende tonalite. The inclusions are well rounded to irregularly shaped and vary in size from 2 up to 100 centimetres. They are always finer grained, seriate textured amphibolites and comprise up to 65 percent (by volume) of the intrusive (Photo 3-1). Margins of the smaller inclusions are characteristically sharp and chilled. The larger inclusions generally have more diffuse, gradational or irregular boundaries. The proportion of inclusions to groundmass is variable, but local zones within the trondhjemite contain rounded mafic inclusions of roughly the same size. The chilled margins suggest they represent inter-mixing of two magmas with higher temperature magma injected into the host trondhjemite.

An intermediate phase of granodiorite forms the fault-bound, northwestern margin of the FKP. It is composed of coarse to medium-grained hornblende quartz monzodiorite to granodiorite. Hornblende, which averages 20 percent, forms 5 millimetre crystal laths and poikilitic clots; biotite, where present, is fine-grained and less than 5 percent. Quartz averages 10 to 20 percent. Feldspars comprise the remainder, with a 60:40 ratio of plagioclase to potassium feldspar.

Photo 3-1. Angular to subrounded inclusions of mafic diorite and amphibolite in light coloured medium grained tonalite to trondhjemite of the marginal phase of the Forrest Kerr pluton, located north of Lime Lake.

A quartz rich granitoid suite consisting of principally biotite trondhjemite and hornblende biotite tonalite occupies the southern half of the FKP. Leucocratic tonalite or trondhjemite of the FKP is coarse to medium grained. In places it is deeply weathered producing a sandy to rubbly outcrop surface. It is pink on fresh surfaces and contains about 30 to 40 per cent quartz and 5 to 7 per cent biotite, the remainder being euhedral, light grey, white and pink feldspars. Potassium feldspar is present but rarely exceeds 5 per cent. Hornblende is less common. As in the More Creek area, the granite varies from equigranular to “quartz-eye” porphyritic. Coarse grained quartz-rich phases with up to 50 per cent quartz occur north of McLymont Creek at its headwaters and east of the Newmont Lake syncline. Flat and steeply-dipping, primarily north and east-trending diabase dikes, one to several metres wide cut the pluton. Epidote, chlorite, quartz, pyrite and iron carbonate occupy fractures in both the host and dike rocks.

A similar suite of rocks comprise a second intrusion centered on the Verrett River and southwest of McLymont Creek. The age of the Verrett pluton is not well constrained, but its northern margin is nonconformably overlain by Late Triassic andesitic lahar deposits of the McLymont Graben (Kowalchuck, 1982) and we tentatively correlate it with the FKP suite.

MORE CREEK PLUTON

The MCP extends approximately 25 km north from the south fork of More Creek to north of Arctic Lake (Figure 3-2). It is approximately 10 km wide at its north and south margins, pinching to only 5 km across the middle. Like the FKP, this heterogeneous pluton consists of hornblende monzodiorite, diorite, tonalite and leucocratic phases of granodiorite and biotite trondhjemite. Fault-bound bodies of these rocks caught up in the Mess Creek fault zone can be traced 15 km to the north into the Mess Lake map area.

The earliest phase of the MCP is an equigranular medium-grained hornblende diorite. Hornblende and plagioclase are the dominant constituents, although, in places, 1 to 2 per cent biotite or minor clinopyroxene coexist with the hornblende. In some outcrops, quartz is present to as much as 5 per cent; it forms "eyes" averaging 4 millimetres in size, which often have a distinctive blue colour. Parts of the intrusion are compositionally layered, with variations in hornblende to plagioclase ratios and crystal size. There are also alternating zones of homogeneous diorite and intrusive breccia tens of metres thick (Photo 3-2). The layering in general trends northerly and dips west. Amphibolite forms irregular lenses and pods with diffuse margins grading into more typical hornblende diorite. Coarse grained plagioclase and hornblende pegmatitic segregations derived from residual fluids during crystallization vein the early more mafic phases. Hornblende in these segregations forms coarse clusters and rows of elongate crystals up to 20 centimetres long (Photo 3-3). Gneissic and foliated zones within the intrusion are for the most part magmatic in origin. They are characterized by lenticular-shaped enclaves of one phase within the other and vice versa. Minerals in the diorite are altered to chlorite, epidote, sericite and, locally, actinolite. The crystallization sequence, evident in one thin-section is clinopyroxene, hornblende, then plagioclase, with an alteration overprint of actinolite±epidote±chlorite.

Photo 3-2. Medium to coarse grained hornblende diorite cut by pegmatitic apophyses of felsic biotite tonalite, at northeastern corner of Forrest Kerr pluton. Where the felsic layers and dikes coalesce, intrusive breccia zones consisting of both felsic and mafic phases occur.

Photo 3-3. Hornblende plagioclase pegmatite segregation in gneissic layered gabbroic phase of the More Creek pluton.

Fresh, unaltered hornblende is common and displays strong brown-green to yellow pleochroism.

A pendant of ultramafic rocks, about 200 square metres in area, crops out six km south of Arctic Lake. The ultramafic rocks are intruded and surrounded by granite, and nonconformably overlain by a small Quaternary scoria cone. Lithologies include; massive, coarse-grained hornblende gabbro, hornblendite and equigranular clinopyroxene hornblendite, clinopyroxenite and biotite hornblendite. Layering within the hornblende gabbro is defined by zones that are slightly more enriched in plagioclase. They average 10 to 50 centimetres in width, and typically 3 to 5 metres in length. Hornblende crystals are aligned perpendicular to the compositional layering (Photo 3-4). The boundaries are usually diffuse with hornblende crystals protruding into the plagioclase matrix from the adjacent hornblendite. Hornblende is mainly fresh and unaltered, but epidote veins are common and disseminated epidote occurs in places. Poikilitic hornblende encloses

Photo 3-4. Coarse intergrowths of hornblende and plagioclase in a layered hornblende gabbro forming part of the ultramafic pendant situated 6 km south of Arctic Lake within the More Creek pluton.

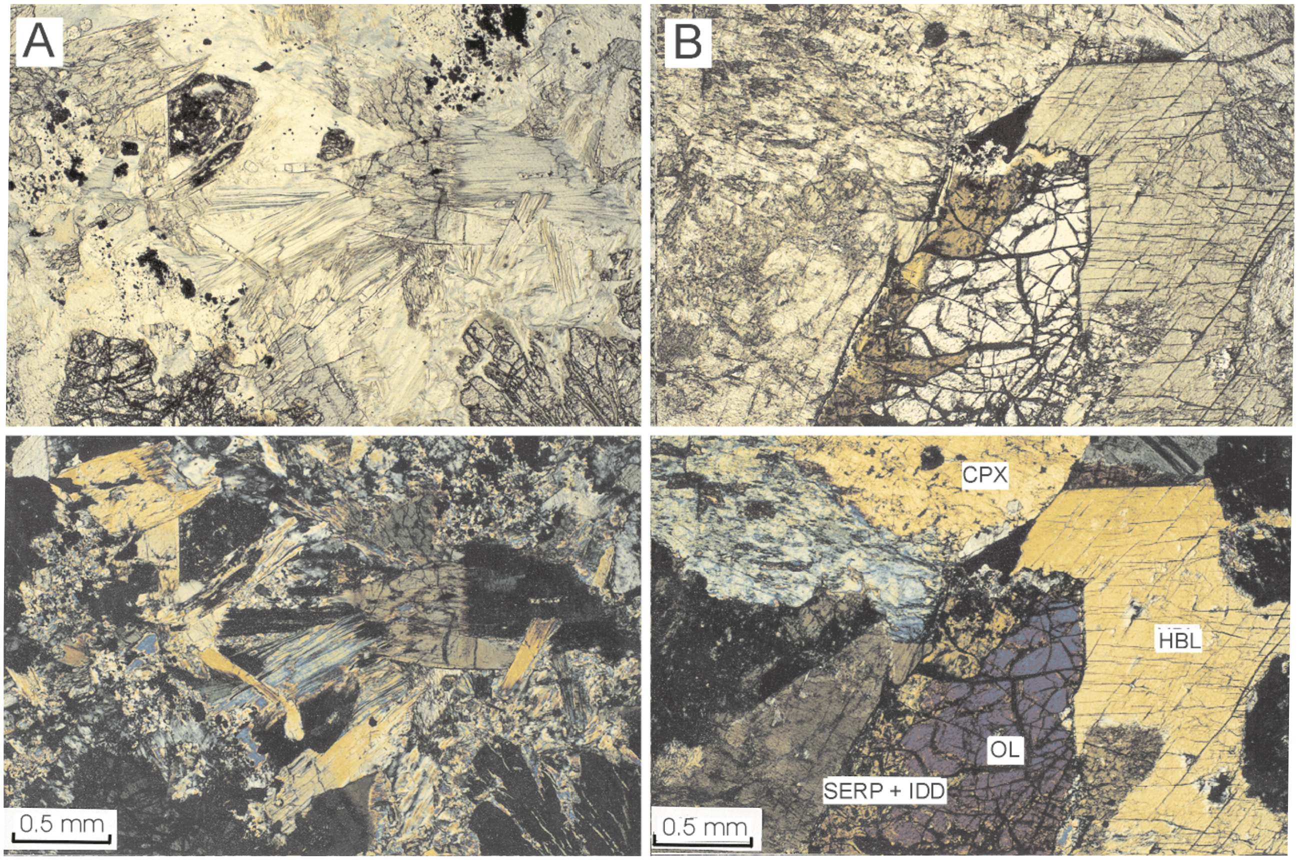

Photo 3-5. Photomicrograph of two rocks from the Early Mississippian ultramafic pendant. A) Biotite hornblendite, plane polarized (above) and x-nicols (below). B) Clinopyroxene hornblendite, plane polarized (above) and x-nicols (below). Mineral assemblages of clinopyroxene, olivine, hornblende and green pleochroic biotite are characteristic of Alaskan-type ultramafic rocks.

Photo 3-6. Lenticular, flattened mafic inclusion-rich gneissic tonalite of probable magmatic origin occur locally along the eastern margin of the More Creek pluton.

clinopyroxene in the clinopyroxene hornblendite and magnetite in the biotite hornblendite. Biotite books in the latter are up to 2 centimetres in size and green in colour, but are not chloritized. Olivine is common in the hornblendite and is weakly altered to serpentinite and iddingsite (Photo 3-5). Massive medium grained, cumulate-textured clinopyroxenite with minor olivine also occurs. The above textures and mineralogy are consistent with Alaskan-type (zoned) ultramafic bodies (G.T. Nixon, personal communication, 1991). Thus, the MCP encloses remnants of a pre-Early Mississippian Alaskan ultramafic complex.

Tonalite and trondhjemite comprise the granitoid phase of the pluton. Textures are typically medium to coarse-grained and equigranular. Quartz is usually the coarsest mineral, and forms elliptical “eyes” that make up between 10 and 30 per cent of the rock. In thin section quartz grains invariably display undulose extinction and some have pressure shadows. Potassium feldspar occurs as anhedral, slightly finer grains between subhedral plagioclase crystals. Both feldspars are weakly altered to sericite. Biotite, which is chloritized (with minor epidote) or rarely pristine, forms from 2 to 10 per cent of the rock. Hornblende is uncommon, but where present occurs as weakly altered crystals to 0.5 millimetres in size.

Magmatic foliation and gneissic zones are common, particularly around the margins of the intrusion (Photo 3-6). The fabric is developed at various scales from metre thick zones of lenticular, flattened inclusion-rich tonalite to a weak mineral foliation in biotite hornblende tonalite. At one locality, the mineral foliation appears to be folded into tight isoclinal folds of probable tectonic origin. Structural fabrics are uncommon within the intrusion, but apophyses and finer grained phases of the tonalite are tectonically foliated and locally mylonitic. Quartz often forms larger grains within equigranular fine quartz-feldspar trains (Photo 3-7). Albite and pericline twin planes within feldspar and cleavage traces within biotite are kinked. Actinolite and secondary sericite are aligned and deflect around the larger quartz and feldspar grains. The rock is weakly schistose where micaceous minerals form more than 30 per cent of the rock.

Contacts with the diorite are commonly irregular and curviplanar, with complex interfingering. Intrusive breccia with angular blocks of amphibolite suspended in diorite and diorite suspended in granite can be followed into areas where the granite clearly crosscuts the diorite. The contact between granitic rocks and diorite has been drawn as close to such transition zones as possible. Where the diorite appears to be suspended as blocks within the granitic phase (*i.e.* an intrusive breccia), the outcrop was mapped as granite.

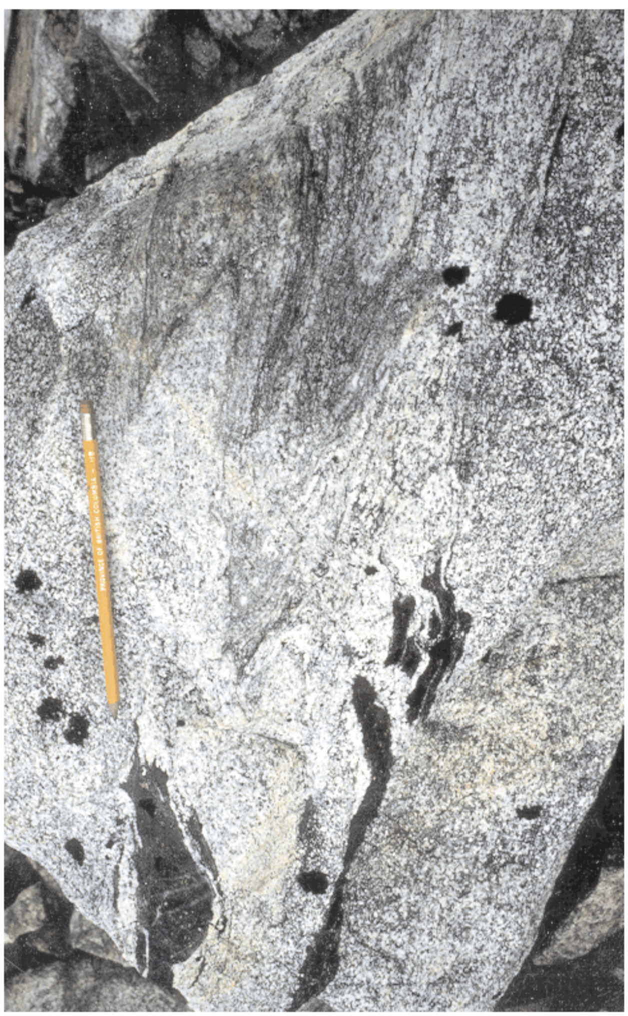

Photo 3-7. Rare isoclinal folds and weak foliation developed in hornblende quartz diorite of the More Creek pluton. Mafic inclusions are fine grained amphibolite restite.

Numerous fine-grained aphyric and aphanitic dikes and several types of plagioclase porphyry diorite dikes cut the main Mississippian diorite-granite pluton. Most of them are less than 3 metres wide, but a few larger dikes are exposed above the south fork of More Creek and east of Arctic Lake; they are discussed below.

GEOCHRONOLOGY

The FKP and MCP are composite bodies comprising a felsic phase, which ranges from biotite granodiorite to biotite tonalite and trondhjemite, and an older mafic phase of mainly hornblende monzodiorite and gabbro composition.

The Late Paleozoic age of the Forrest Kerr Pluton was first established with potassium-argon radiometric dating techniques carried out by J. Harakal and D. Runkle (1989), at The University of British Columbia. Potassium-argon isotopic dates of 346±10 Ma and 343±12 Ma (K-Ar, biotite) from biotite granite, suggested an Early Mississippian age for the felsic phase of the pluton (Table 3-1). Subsequent age dating of samples from the MCP gave cooling ages of 330±9 Ma (K-Ar, hornblende) for the diorite phase, from a sample collected eight km southeast of Arctic Lake. Pyroxene hornblendite from the ultramafic raft located six km south of Arctic Lake, in the MCP has a minimum K/Ar age of 291±10 Ma (K-Ar, hornblende); this may be a partially reset age, reset during intrusion of the felsic phases of the MCP.

To better constrain the age the argon^{40}-argon^{39} method of radiometric dating was employed on hornblende mineral separates of two diorite samples, one from the Forrest Kerr Pluton (90JLO13-10) and the other from the More Creek Pluton (91JDR9-4). Incremental heating techniques were carried out and the 40Ar-39Ar spectra generated at Dalhousie University (P. Reynolds, 1993). Hornblende mineral separates from the diorite phase of the More Creek pluton yielded broad U-shaped spectra suggestive of excess argon, and an 40Ar-39Ar plateau age of approximately 350 Ma (Figure 3-3). The 40Ar-39Ar spectra from hornblende separates of the FKP sample are discordant, indicate excess argon and a minimum apparent cooling age of early Permian.

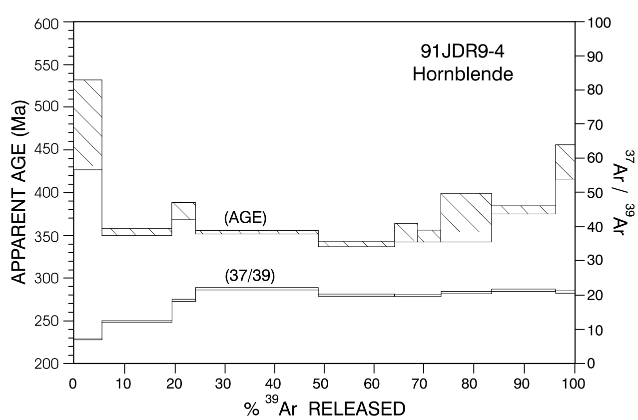

Figure 3-3. Hornblende ^{37}Ar/^{39}Ar plateau date for diorite of the More Creek pluton.

TABLE 3-1
U-Pb AND K-Ar ISOTOPIC DATES FOR IGNEOUS ROCKS

FIELD NO.	MAP UNIT	ROCK TYPE	PLUTONIC SUITE	PLUTON	DATING METHOD	MINERAL	AGE (Ma)	REF.
81-HA19a	MJMZ	Quartz monzonite	Three Sisters	Yehiniko	Rb-Sr	Bi	170±16	2
81-HA19a	MJMZ	Quartz monzonite	Three Sisters	Yehiniko	K-Ar	Bi	172±6	2
81-HA19a	MJMZ	Quartz monzonite	Three Sisters	Yehiniko	Rb-Sr	WR	178±11	2
89VKO28-15	EJg	Bi-Hb monzogranite	Texas Creek	McLymont Ck.	K-Ar	Hb	203±7	1a
AT-86-137-1	EJg	Bi-Hb monzogranite	Texas Creek	McLymont Ck.	K-Ar	Hb	189±3	4
91-GC-1395 -1433	LŦs	K-spar porphyry	Copper Mtn.	Galore Ck.	U-Pb	ZrTt	205.1±2.3200.1 ±2.2	33
91-GC-1396	LŦs	K-spar porphyry	Copper Mtn.	Galore Ck.	U-Pb	Tt	205±1.8	3
91-GC-1398	LŦs	Syenite porphyry	Copper Mtn.	Galore Ck.	U-Pb	Tt	210±1	3
91-GC-1399	LŦs	K-spar porphyry	Copper Mtn.	Galore Ck.	U-Pb	Tt	197.2±1.2	3
T-169-504-557	LŦHd	Qtz-feldspar porphyry	Stikine	Hickman	U-Pb	Zr	216.6±2	1d
81-HA10a	LŦHd	Bi-Hb granodiorite	Stikine	Hickman	K-Ar	Bi	209±15	2
81-HA10a	LŦHd	Bi-Hb granodiorite	Stikine	Hickman	Rb-Sr	Bi	216±4	2
81-HA10a	LŦHd	Bi-Hb granodiorite	Stikine	Hickman	K-Ar	Hb	221±8	2
81-HA10a	LŦHd	Bi-Hb granodiorite	Stikine	Hickman	Rb-Sr	WR	233±23	2
91-305	EMg	Bi-Hb granite	More Creek	More Ck.	U-Pb	Zr	356.9+4.3/-3.8	1c
91JDR9-4	EMd	Hornblende diorite	More Creek	More Ck.	K-Ar	Hb	330±9	1a
91JDR33-4-1	LDum	Hornblendite	Forrest Kerr	Umafic raft	Ar-Ar	Hb	291±10	1b
89-JDR6-3	LDg	Bi-Hb granite	Forrest Kerr	Forrest Kerr	K-Ar	Bi	343±12346±10	1a1a
91-246	LDg	Bi-Hb granite	Forrest Kerr	Forrest Kerr	U-Pb	Zr	369.4 ±5.1	1c
91-226	LDg	Bi-Hb granite	Forrest Kerr	Forrest Kerr	U-Pb	Zr	370.7±6.7	1c

One sigma errors for K-Ar and Rb-Sr dates, two sigma errors for U-Pb dates are reported, see Appendices 11, 12 and 13 for analytical data. References: 1 = this report, a = Harakal, b= Reynolds, c = McClelland, d = Gabites; 2 = Holbek (1988); 3 = Mortenson *et al.* , (1995); 4= Anderson and Bevier (1990). Bi = biotite, WR = whole rock, Hb = hornblende, Tt = titanite, Zr = zircon, K-spar

To improve on these, uranium-lead zircon geochronology was completed on a number of intrusive samples and country rocks to constrain the age of emplacement of the FK and MC plutons (Table 3-1). This work was carried out at the University of California, Santa Barbara by one of the authors. Plutons were sampled from two localities in the Forrest Kerr map area and one in the More Creek map area. The presence of inherited zircon components was not detected in any of the Devonian and Mississippian plutonic and volcanic samples analyzed during this study. Tonalite from the centre of the FKP yielded a U-Pb zircon date of 369.4±5.1 Ma for the felsic phase of the pluton (Table 3-1, Appendix 13). This is interpreted to represent the age of crystallization and emplacement of the felsic phase. The K-Ar date of 346±10 Ma from the same outcrop is re-interpreted to be a cooling age. Hornblende monzodiorite from the satellite-intrusion north of Lime Lake yielded a U-Pb zircon date of 370.7±6.7 Ma (Table 3-1, Appendix 13). This body intrudes Early Devonian carbonate, phyllite and intermediate tuffaceous metavolcanic rocks (380±5 Ma; U-Pb, zircon, Table 3-1, Appendix 13). The MCP was sampled approximately 7 km west of Hankin Peak. Heterogeneous, foliated biotite granodiorite was collected and returned a U-Pb zircon date of 356.9 +4.3/-3.8 Ma for the felsic phase of the MCP (Table 3-1, Appendix 13). Concordia diagrams for the Forrest Kerr and More Creek plutons are shown in Appendix 13.

INITIAL STRONTIUM

Strontium and rubidium isotopes were analysed for diorite and granite samples from the Forrest Kerr pluton (91JDR9-4 and 91JLO37-451) and from the More Creek pluton (91JLO31-1 and 91JLO31-2) at The University of British Columbia Geochronology Laboratory. The isotopes are plotted on a $^{87}Rb/^{86}Sr$ vs. $^{87}Sr/^{86}Sr$ diagram (Figure 3-4) together with 3 Stikine Assemblage metavolcanic rocks from Holbek (1988).

The plot shows the data and the 370 Ma isochron line drawn twice, through the diorite and granite samples of the FKP. The initial strontium ratio calculations (Appendix 13) for all four samples are based on a U-Pb zircon age of 370±3 Ma. At the time of the analyses these were assumed to represent four widely-spaced samples from coeval plutons. The data set did not form a satisfactory isochron, and a regression on 3 points gave an age of 208±45 Ma, much younger than the U-Pb age of 370.7±6.7 Ma, determined from sample 91JLO31-2. Subsequent U-Pb dating, recognized an Early Mississippian age for the felsic phase of the More Creek pluton.

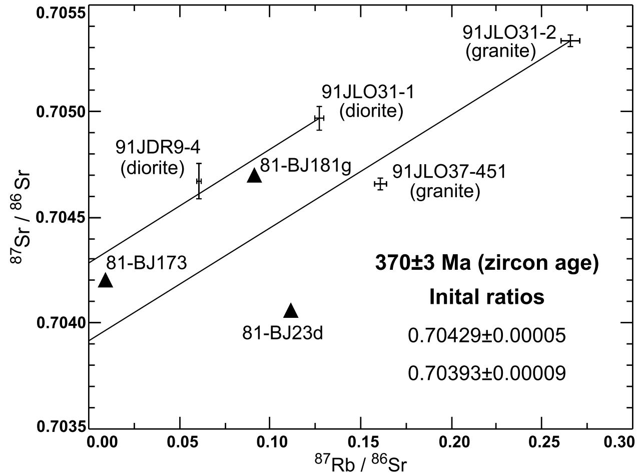

Figure 3-4. Feldspar $^{87}Sr/^{86}Sr$ versus $^{87}Rb/^{86}Sr$ plot for diorite and tonalite of the More Creek and Forrest Kerr plutons. Triangles are Paleozoic Stikine assemblage metavolcanic rocks from Holbek (1988).

The measured $^{87}Sr/^{86}Sr$ value for the foliated granite of the MCP (91JLO37-451) is marginally lower than the 87Sr/86Sr value of the diorites (Appendix 14), and may reflect a low-grade alteration which accompanied deformation. The two hornblende diorite samples, albeit from separate bodies (FKP and MCP), lie within the 1 sigma error along the 370 Ma isochron with whole rock initial $^{87}Sr/^{86}Sr$ value of 0.70429. The initial $^{87}Sr/^{86}Sr$ value for the felsic sample of the FKP is 0.70393, remarkably lower than the mineralogically more primitive mafic phase. Initial $^{87}Sr/^{86}Sr$ values from all four samples range between 0.7039 and 0.7043 and suggest a relatively primitive magma source region; consistent with the juvenile Nd-isotopic signature observed from the granitic phase of the FKP (McClelland, unpublished data].

MIDDLE (?) TO LATE TRIASSIC STIKINE PLUTONIC SUITE (228-221 Ma)

Triassic plutons of northern British Columbia include two main types: small Alaskan-type ultramafic bodies and larger calcalkaline plutons; these correspond to the Polaris and Stikine suites of Woodsworth *et al*. (1991). These plutons are associated with, and locally crosscut, thick successions of Upper Triassic Stuhini Group volcanic rocks. In the Iskut River area they form small, northwest trending bodies (Anderson, 1993); in the Telegraph Creek area plutons are larger and trend northerly (Souther, 1972; Brown *et al*., 1996)(Figure 3-1). Intrusive rocks of the Stikine suite are restricted to the northern part of the study area, where they intrude Upper Triassic volcanic rocks of the Mess Lake Facies. With the exception of several small isolated bodies, they comprise a single 2 km wide north-trending pluton that extends from the headwaters of Mess Creek 20 km north to the Schaft Creek deposit (Figure 3-5). The intrusion includes three main phases: plagioclase porphyritic diorite, augite monzodiorite and hornblende biotite granodiorite to quartz monzonite.

HICKMAN PLUTON

A medium to fine grained, pink or grey hornblende biotite granodiorite to quartz monzonite forms the western and southern margins of the intrusion (Unit lT̄Hd, GS-Map). It crops out on the east-facing slope above Mess Creek and is probably an eastern extension of the main phase of the Hickman pluton (Souther, 1972). Along its western margin, numerous aplitic dikes that extend outward from the main stock cut Upper Triassic volcanic rocks of the Stuhini Group. The western margin or top of the stock is monzonite where it intrudes Upper Triassic rocks, but east and downward grades into hornblende diorite, commonly with enclaves of dark grey hornblendite. The eastern contact is poorly exposed and relationships are equivocal. The northern margin is faulted against grey plagioclase-porphyritic diorite. The monzonite portion of the stock is pink and equigranular with up to 15 per cent hornblende. Where the percentage of hornblende is higher, pink, fine-grained, equigranular dikes to about 30 centimetres wide are common. The hornblende is subhedral and moderately altered to chlorite and epidote. Plagioclase is weakly altered to sericite. The mafic content of the stock locally increases until the rock is fine to coarse-grained hornblendite with hornblende crystals up to one centimetre in length. The crystals are mostly weakly chloritized, though vitreous hornblende is locally present. Narrow fracture-fillings commonly contain carbonate, epidote and zeolite mineral assemblages.

At the Schaft Creek deposit, the intrusion associated with mineralization is a white, argillically altered, equigranular monzonite to quartz monzonite. Quartz and feldspar porphyritic apophyses intruded and altered the volcanic country rock. Several small outcrops of the monzonite at the north edge of the Schaft Creek deposit are mineralized along with adjacent volcanic rocks. Drill core intersections of a porphyritic monzonite dike from the Liard zone were collected and zircons extracted for U-Pb age dating. Sample preparation and U-Pb analyses were carried out at the Geochronology Laboratory of the University of British Columbia by Janet Gabites (Appendix I2). A Late Triassic date of 220 +15/-2 Ma (U-Pb zircon) from mineralized quartz-feldspar porphyry is interpreted to be the age of dike emplacement (Figure, Appendix 12). The Late Triassic date indicates the leucocratic porphyry dikes at Schaft Creek are comagmatic with the Hickman pluton and, because the dikes are mineralized, mineralization has a minimum age of circa 220 Ma.

OTHER STIKINE SUITE INTRUSIONS

Hypabyssal plagioclase porphyritic diorite (Unit LT̄pp, GS-Map), crops out along the lower slopes of the Mess Creek valley mainly west of the creek. It separates orange-weathering monzonite of the Loon Lake stock from the Hickman granodiorite to monzodiorite intrusive It was mapped as a separate body, but may be a border phase of the equigranular Hickman phase or related to the Loon Lake stock. The monzodiorite is typically pale green; it contains stubby plagioclase phenocrysts and rare chloritic hornblende or pyroxene. The plagioclase is moderately to highly sericitized, euhedral to anhedral phenocrysts to 4

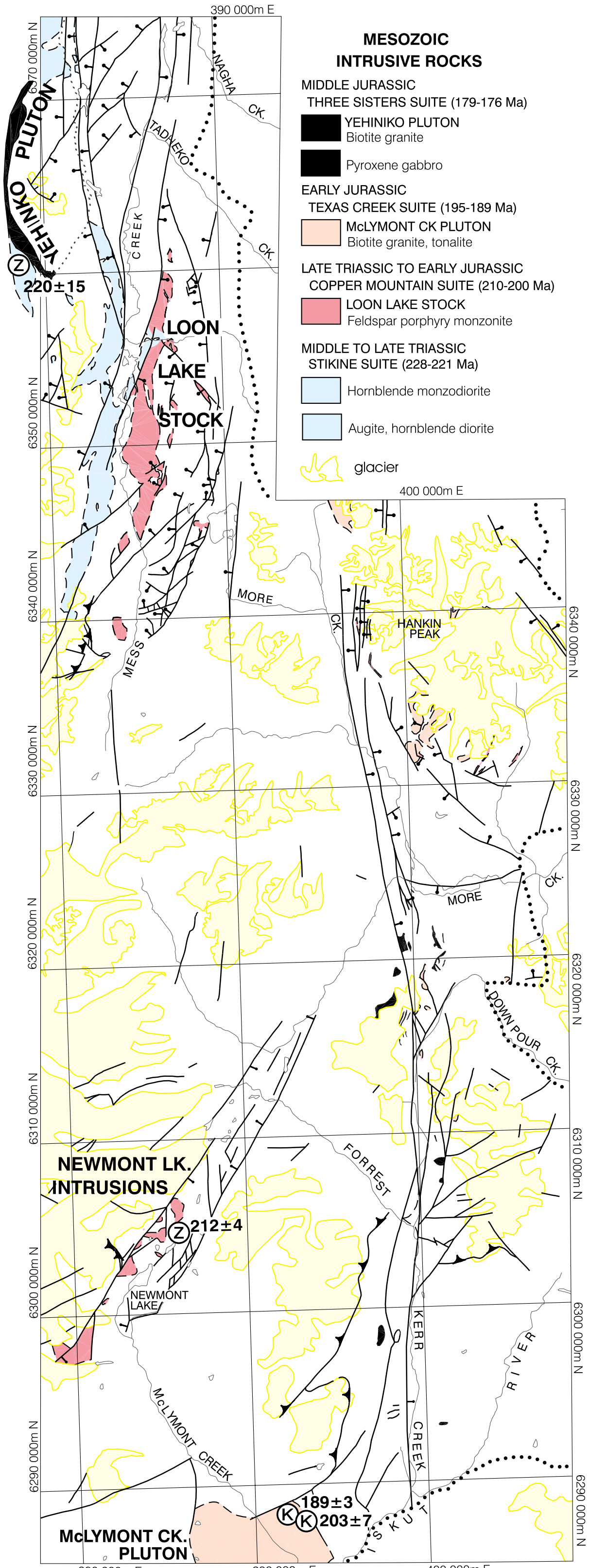

Figure 3-5. Distribution of the Middle to Late Triassic Stikine, Late Triassic to Early Jurassic Copper Mountain, Early Jurassic Texas Creek and Middle Jurassic Three Sisters Plutonic Suites in the map area. Sample sites, method and age date results correspond with data in Table 3-1.

millimetres in length. Scarce pyroxene forms anhedral grains with rounded dusty margins. The groundmass is highly altered to chlorite and epidote.

Plugs of pyroxene diorite crop out in several areas west of Mess Creek (Unit LT̄pd, GS-Map). About 5 km south of the Schaft Creek deposit, a small plug intrudes Upper Triassic sediments. About 2 km south of the deposit, and also about 5 km north of it, similar plugs intrude Upper Triassic volcanic rocks, and a larger stock intrudes Upper Triassic volcanic rocks in the northwest corner of the map area. The plugs are mainly medium-grained, green-grey augite-plagioclase diorite. They are generally associated with plagioclase-phyric and coarse pyroxene-phyric dikes and are probably genetically linked to them.

The three undated intrusions are tentatively correlated with the Stikine suite based on intrusive relationships, geochemistry and mineralogy. Late Triassic dates of 209±15 Ma (K-Ar biotite), 221±8 Ma (K-Ar hornblende), 216±4 Ma (Rb-Sr biotite) and 233±23 Ma (Rb-Sr whole rock) from the centre of the body, constrain the main phase of the Hickman Pluton (Holbek, 1988; Table 3-1). The Late Triassic age of mineralized porphyritic monzonite sills at Schaft Creek places a lower limit to the age of the porphyry Cu-Mo-Au mineralization (*cf*. Chapter 6: Mineralization).

LATE TRIASSIC TO EARLY JURASSIC COPPER MOUNTAIN PLUTONIC SUITE (210-195 Ma)

Late Triassic to Early Jurassic intrusive rocks of the Copper Mountain Plutonic Suite (Woodsworth *et al*., 1991) characteristically comprise small alkaline bodies, varying from monzodiorite to monzonite to syenite. The intrusions are lithologically complex with multiple intrusive phases, and are metalogenically important because they are copper and gold mineralizers in both Stikinia and Quesnellia. U-Pb ages are similar (circa 200 to 210 Ma) for intrusions associated with porphyry Cu-Au deposits in both terranes. In the Iskut River area, the Zippa Mountain intrusive complex comprises at least four phases: gabbro and pyroxenite, biotite syenite, quartz monzonite and hornblende plagioclase porphyry dikes (Anderson, 1993; Lueck and Russell, 1994). Multiple alkaline intrusions and associated ultramafic phases are also present at Galore Creek (Barr, 1966; Allen *et al*., 1976; Enns *et al*., 1995), in the Ten Mile Creek body (Morgan, 1976) and in the Rugged Mountain pluton (Neil, 1992) in the Telegraph Creek area (Figure 3-1). U-Pb dates of 205.1 ±2.3 (zircon) and 200.1±2.2 (titanite) for the potassium feldspar megacrystic syenite porphyry at Galore Creek (Mortensen *et al*., 1995) constrain emplacement ages and brackets Cu-Au mineralization. Compatible Late Triassic to Early Jurassic dates have been obtained from the syenite phase (~210 Ma, M.L. Bevier, unpublished data) and monzonite phase (213 ±4 Ma, K-Ar, hornblende; R.G. Anderson in Hunt and Roddick, 1991) of Zippa Mountain, and from the clinopyroxenite (209 ±7 Ma, K-Ar, hornblende; Morgan, 1976) of the Ten Mile Creek body. The Loon Lake stock (Figure 3-5) is tentatively included in this suite on the basis of its composition and associated copper mineralization. Narrow dikes and sills of trachytic potassium feldspar syenite and small isolated plugs of monzonite, are also included in this suite. The post mineralization potassium feldspar porphyry at Galore Creek contains a minor amount of older inherited zircon (J.K. Mortensen, unpublished data); consistent with the presence of Proterozoic inherited components in the Zippa Mountain syenite (M.L. Bevier , unpublished data). However, the Galore Creek intrusive rocks have juvenile Sr and Nd isotopic signatures (J.K. Mortensen, unpublished data).

LOON LAKE STOCK

A north-trending hypabyssal stock of plagioclase-hornblende monzonite porphyry (unit lƬmz, GS-Map) forms the eastern slope above Mess Creek (Figure 3-5). On its eastern side it intrudes Upper Triassic sediments and volcanic rocks and, farther north, Late Carboniferous and Early Permian rocks. The intrusion is nonconformably overlain by Lower Jurassic conglomerate in a creek exposure about 4 km west of Arctic Lake. The western limit of the Loon Lake stock appears to be faulted against intrusive (unit lƬpp) but the contact may in part be intrusive. A large coincident alteration zone has coloured the intrusion and immediate country rock various shades of pink and salmon red which makes it difficult to distinguish intrusive from volcanic rocks in outcrop. As a result, altered porphyritic volcanic rocks may inadvertently have been mapped as intrusion. The typical texture of the stock is crowded porphyry with 20 to 40 per cent euhedral plagioclase laths to 7 millimetres in length and up to 10 per cent hornblende to 3 millimetres in length. The rock is mostly salmon pink to mauve grey. Common variations in the texture include darker grey, less crowded plagioclase porphyry and fine to medium-grained, equigranular grey diorite.

Panteleyev (1973) recognized two stages of feldspar porphyry at the Run showing, located at the western margin of the stock. The older, subordinate phase is a pervasively altered sericite and pyrite-rich rock. He described the main phase as a mafic-poor, sparsely porphyritic rock containing about 25 per cent seriate, fine to medium-grained pink plagioclase phenocrysts in a brown aphanitic matrix. Chemical analyses indicate a syenite or trachyte classification for the feldspar porphyries.

Several small monzonite bodies, less than 1 square km, are exposed northwest of Arctic Lake and in the lower reaches of a small creek that drains west into Mess Creek. Sharp intrusive contacts with Lower Permian limestone are exposed west of Arctic Lake, where a small plug lies and appears to intrude along the contact between the limestone and Early Mississippian granite. The contact relationship with the granite along the eastern margin of the plug is not exposed. In outcrop, the monzonite weathers light pink and is brown or greenish purple on fresh surfaces. It is characterized by about 10 per cent plagioclase and 15 to 20 per cent oxidized hornblende phenocrysts in an aphanitic hematized potassium feldspar matrix.

NEWMONT LAKE PLUGS

Sills and plugs of plagioclase-hornblende porphyritic monzonite to monzodiorite crop out around Newmont Lake. The rocks are identical in appearance to the Loon Lake Stock. They closely resemble the Newmont Lake Graben Facies andesitic volcanic rocks and because they are distributed along the trace of the McLymont Fault there may be a direct structural link for their emplacement. The rocks are porphyritic and characterized by a hematitic groundmass that is commonly purple to grey. Phenocrysts are pink subhedral to euhedral plagioclase crystals (up to 50 per cent) and hornblende crystals. Numerous round, recessively weathered mafic xenomelts (melt inclusions) average 5 to 10 centimetres in diameter. Centimetre scale flow laminae are common in some areas.

Seriate to porphyritic textures suggest a subvolcanic environment of intrusion. In thin section plagioclase and lesser anorthoclase phenocrysts are euhedral and generally zoned. Most grains are moderately altered to sericite, typically with dusty cores and clear rims. Hornblende is clouded with opaque oxides or chloritized. Potassium feldspar is interstitial to plagioclase and hornblende. Quartz is a minor phase and apatite is an accessory mineral. Carbonate is another minor alteration product. The groundmass is very fine grained with a trachytic texture; staining for potassium indicates that more than 80 per cent of it is potassium feldspar.

SYENITE PORPHYRY

Dikes of coarsely porphyritic syenite (unit LƬs, GS-Map) crosscutting Upper Triassic rocks are common between Hankin Peak and More Creek, where they form a diffuse northerly trending dike swarm. Scattered dikes crop out to the east and south of Hankin Peak as well. They range from a metre to over 20 metres in width. Tabular, euhedral phenocrysts of potassic feldspar in the syenite range from 2 to over 30 millimetres in size and average 20 per cent of the rock (Photo 3-8). They are grey, pink or, where chloritized, green. In thin section, they are generally only lightly dusted with sericite. Anorthoclase phenocrysts are generally finer but also euhedral and weakly altered. The phenocrysts often impart a trachytic texture to the rock. Weakly oxidized, dark green to yellow pleochroic hornblende occurs to about 5 per cent of the rock. The grains are mostly euhedral, up to 4 millimetres in size and show diffuse zoning. The groundmass is grey or pink and consists of very fine grained, equigranular quartz and feldspar. Accessory apatite occurs as euhedral microphenocrysts to 1 millimetre in size, minor secondary carbonate and epidote are also present. Host rocks are hydrothermally altered adjacent to the syenite dikes and copper mineralization commonly occurs within and adjacent to the dikes, although it is more abundant in the volcanic host rocks. These dikes have textures and mineralogy similar to those in the Loon Lake Stock.

EARLY JURASSIC TEXAS CREEK PLUTONIC SUITE (189-195 Ma)

Plutons of the Early Jurassic Texas Creek plutonic suite consist of calcalkaline, hornblende granodiorite and quartz monzonite to alkaline, potassium feldspar megacrystic monzogranite (Kerr, 1948a; Alldrick *et al*., 1987; Anderson, 1993; Woodsworth *et al*., 1991). These plutons define a northwest trending belt parallel to the international boundary, with igneous centres localized near Stewart, at the Iskut

Photo 3-8. Weakly aligned, trachytic porphyry syenite sill, comprised of zoned potassium feldspar megacrysts in a massive grey coloured chloritic feldspar groundmass.

River and at the confluence of the Scud and Stikine rivers (Figure 3-1). The Texas Creek pluton, in the Stewart area, is a granodiorite with characteristic comagmatic potassic feldspar megacrystic dikes (Premier porphyry; Grove, 1971; Brown, 1987). Mesothermal and epithermal precious and base metal veins are spatially associated with Early Jurassic potassium feldspar porphyries at the Premier, Johnny Mountain and Snip mines and at Sulphurets in the Iskut-Stewart area (Grove, 1971; Alldrick, 1991; Rhys, 1993).

The McLymont Creek pluton is coeval with the alkaline variety of the Texas Creek plutonic suite (Anderson and Bevier, 1990). Small porphyritic monzonitic plugs located south of Hankin Peak at the Little Les and Biskut mineral prospects and south of More Creek on the GOZ/RDN property (Figure 3-5) are also included, based on composition and associated mineralization.

McLYMONT CREEK PLUTON

The McLymont Creek pluton is a roughly circular body, centered on McLymont Creek. It underlies a 36 square km area situated north of the Iskut River. Coeval magmatic rocks located south of the Iskut River are part of the Lehto batholith (Read *et al*., 1989). The McLymont Creek pluton is probably a satellite intrusion of the Lehto batholith and therefore constrains any post-intrusion substantial east-west motion along the Iskut River linear. The pluton is a heterogeneous two-phase intrusion consisting of equigranular biotite-hornblende granodiorite and porphyritic potassium feldspar and hornblende monzonite. It is variably altered from pink to a characteristic green colour that reflects chlorite and epidote alteration assemblages. The equigranular variety consists of medium to fine grained intergrown plagioclase, potassium feldspar, hornblende and quartz. Potassium feldspar porphyroblasts in the megacrystic porphyries are commonly zoned and rimmed by albite. They vary to 3 centimetres, but average 1 centimetre in size. Euhedral to subhedral hornblende ranges up to 1 centimetre in length. Quartz varies to as high as 15 per cent and is interstitial to the feldspars. Magnetite is an accessory mineral and hand samples are moderately magnetic. The outcrop area of the pluton corresponds to a prominent aeromagnetic anomaly on the 1:1000 000 aeromagnetic survey map for Dease Lake (Map No-9).

Age controls for the McLymont Creek pluton (Table 3-1) include a potassium-argon isotopic dates of 203±7 Ma (K-Ar, hornblende) for potassium feldspar megacrystic granodiorite (this study) and 189±3 Ma (K-Ar, hornblende) for a hornblende-biotite monzogranite containing alkali feldspar megacrysts (Anderson and Bevier, 1990). These and a U-Pb zircon date of circa 193 Ma (M.L. Bevier, unpublished data, in Anderson, 1993) indicate that this body is coeval with the Texas Creek plutonic suite.

OTHER TEXAS CREEK PLUTONIC SUITE INTRUSIONS

Stocks, sills and dikes of intermediate to felsic composition intrude Lower Jurassic rocks south of More Creek and Upper Triassic rocks south of Hankin Peak. These are tentatively included in the Texas Creek suite.

Small plugs and dikes of quartz feldspar porphyritic monzonite are intruded along north-trending faults in Forrest Kerr Creek valley north to the headwaters of Downpour Creek (Figure 3-5). The plugs intrude Early Jurassic felsic volcanic rocks adjacent to the Forrest Kerr fault on the GOZ/RDN. Read *et al*. (1989) interpreted these to be subvolcanic feeders to the felsic volcanic rocks that they intrude. The intrusion contains phenocrysts of potassium feldspar, up to 10 per cent, and lesser quartz, hornblende and biotite, in a fine-grained potassium feldspar-rich groundmass of quartz and plagioclase. They are commonly potassically altered, contain finely disseminated pyrite, sericite and quartz, and become oxidized so outcrops have yellow and red colors that are easily visible from a distance. Similar rocks intrude Late Triassic rocks north of More Creek.

An unnamed stock of monzonite and several smaller apophyses of monzonite to syenite (unit eJmz, GS-Map) intrude Late Triassic siltstone and volcanic rocks 6 km south of Hankin Peak (Figure 3-5). The intrusion trends northerly and is spatially associated with a series of thick, north-trending diorite dikes. It is mainly a light grey to pink-weathering, equigranular, medium-grained monzonite, but grades into medium grey weathering, seriate-textured syenite. Phenocrysts of potassium feldspar range up to 1 centimetre in size and comprise 30 per cent of the rock. Potassium feldspars are moderately altered to sericite; plagioclase is completely sericitized. The altered plagioclase phenocrysts comprise from 10-20 per cent of the rock. Fine, chloritized hornblende and biotite make up about 2 per cent. Veinlets and fracture coatings of quartz, pyrite, minor epidote, calcite and actinolite are common byproducts of the secondary alteration.

A northeast-trending, isolated plug of feldspar porphyritic monzonite (unit EJmz, GS-Map) intrudes Late Triassic sedimentary rocks seven km north of the east-west flowing segment of More Creek (Figure 3-5). A large gossan is centred on the intrusion and attracted early exploration work in the area (Biskut, Voigtberg showing). The monzonite weathers pink and contains 2 to 5 per cent fine disseminated pyrite. It is strongly altered to potassic and argillic alteration assemblages and most of the original textures and minerals have been obliterated. In thin section, felty plagioclase, anhedral potassium feldspar and quartz form the groundmass. Biotite occurs as fresh euhedral grains and as finer, subhedral, weakly chloritized grains. Quartz comprises up to several per cent of the groundmass as scattered fine grains. Clots of coarsely crystalline sericite and carbonate up to 2 centimetres in size are common. Quartz, sericite, carbonate, unknown clay minerals and pyrite comprise the hydrothermal alteration minerals. The fresh euhedral biotite is probably primary. Apatite is an accessory phase.

EARLY JURASSIC AND YOUNGER INTRUSIONS

Three monzodiorite intrusions located northwest, east and south of Hankin Peak are tentatively assigned an Early Jurassic or younger age (Figure 3-5). These are all medium-grained, equigranular augite-plagioclase diorite plugs with associated dike swarms and intrude Late Triassic volcanic and sedimentary rocks.

About 6 km south of Hankin Peak, a series of diorite sills up to 100 metres wide intrude Upper Triassic siltstones and sandstones. They are fine to medium grained and equigranular with subequal amounts of plagioclase and pyroxene. Contacts with the enclosing sedimentary rocks are knife sharp. Hornfelsing adjacent to contacts has increased induration of the sediments and resulted in a minor addition of epidote and chlorite. Some of the sills have poorly developed columnar joints. A similar diorite sill intrudes both siltstone and green andesitic tuffs 2 km east of Hankin Peak. Parts of this diorite have a distinct felty texture imparted by 40 to 50 per cent plagioclase laths to 4 millimetres in length, equigranular textures are also common. The third body, north of Hankin Peak, consists of propylitized, equigranular diorite. It apparently intrudes Upper Triassic volcanic rocks, but relationships with the volcanic rocks are confusing because intrusive textures repeatedly grade in and out of pyroclastic textures. The pyroclastic rocks have been hornfelsed and partially assimilated into the diorite intrusion.

MIDDLE JURASSIC THREE SISTERS PLUTONIC SUITE (179-176 Ma)

Middle Jurassic plutons of the Three Sisters plutonic suite (Woodsworth *et al*., 1991) consist of large, north and easterly trending calcalkaline, quartz monzonite to granite plutons in the western part of the Iskut River and Telegraph Creek areas (Anderson, 1993; Souther, 1972; Brown *et al*., 1996)(Figure 3-1). As well, in the eastern part of these map sheets small plugs and northerly trending dike swarms of bladed plagioclase-pyroxene diorite and gabbro (Logan *et al*., 1990a) occur adjacent to north-trending regional faults (South Unuk-Harrymel, Forrest Kerr, Mess Creek). The western plutons are interpreted to have been in the root zone of the Middle Jurassic arc (Anderson, 1993), and the mafic dikes and plugs are feeders to Middle Jurassic (Aalenian to Middle Bajocian) back-arc pillow basalts. Granite of the Yehiniko pluton and the coeval diorite plugs and dikes are included in the Three Sisters suite.

YEHINIKO PLUTON

Most of the Middle Jurassic Yehiniko pluton crops out east of the map area (*cf.* Brown *et al*., 1996). Granite to quartz monzonite of the eastern margin of the pluton intrudes Late Triassic volcanic rocks of the Stuhini Group east of Schaft Creek and north of the Schaft Creek deposit in the northwest corner of the map area (Figure 3-5). Much of the contact is gradational across a zone of numerous aplite and rhyolite dikes in the country rock (GS-Map, in back pocket). Locally the contact is a simple curviplanar surface. The southern contact with the Late Triassic Hickman batholith is covered by overburden in the map area.

The main phase of the Yehiniko pluton is pink, medium to coarse-grained biotite granite (Brown and Gunning, 1989a). Near its contacts with Upper Triassic volcanic rocks, the texture is finer, the granite more fractured and the colour grey to orange. North of the Schaft Creek deposit, the apophyses of the intrusion consist of both aphanitic to fine-grained, flow-layered pink rhyolite dikes and sills of quartz-eye feldspar porphyry that may be younger. These alter the country rock locally.

Middle Jurassic potassium-argon cooling dates of 172±6 Ma (K-Ar, biotite) and rubidium-strontium ages of 170±16 Ma (Rb-Sr, biotite) and 178±11 Ma (Rb-Sr, whole rock) from a quartz monzonite phase are interpreted to be the minimum age of emplacement (Holbek, 1988).

MIDDLE JURASSIC DIORITE AND GABBRO INTRUSIONS

Coarse-grained pyroxene gabbro and diorite plugs and sills are interpreted to be Middle Jurassic age on the basis of similar mineralogy, texture and chemical composition as the Aalenian to Middle Bajocian pillowed basalts (Unit mJHvb, GS-Map) which they intrude. They crop out mainly within and west of the Forrest Kerr fault zone and on ridges south of More Creek, where numerous dikes and sills of dark green-grey, fine to coarse-grained gabbro (Read *et al*., 1989) intrude Lower and Middle Jurassic siltstone and sandstone (Figure 3-5). Scattered dikes and sills intrude Upper Triassic rocks around Hankin Peak and west of Mess Creek.

Dikes less than about 2 metres in width are fine grained and equigranular. Larger dikes and stocks, though mainly equigranular, are locally felty textured with slender laths of plagioclase to 4 millimetres in length. Anhedral interstitial pyroxene is moderately to strongly replaced by chlorite. Disseminated pyrite, up to 1 per cent, is commonly present. Apatite is a minor accessory mineral and local alteration patches and veinlets of carbonate and quartz. A small plug of coarse grained gabbro intrudes basalts north of the confluence of Forrest Kerr Creek and the Iskut River. It weathers light grey and consists of 10 to 20 per cent dark green chloritized clinopyroxene to 5 millimetres in size. West of Forrest Kerr fault, the dikes are weakly deformed, fractured and altered to chlorite and sericite.

In thin section, subhedral plagioclase laths form a felty, tightly intergrown mass. Unaltered to strongly chloritized anhedral clinopyroxene is interstitial to the plagioclase, and usually contains small plagioclase inclusions. Minor zeolite is interstitial to the plagioclase and pyroxene in the least altered material, in more altered material, chlorite, carbonate, sericite, and epidote occur.

AGE UNKNOWN

HORNBLENDE BIOTITE MONZODIORITE

Discrete north-south elongate monzodiorite plugs of unknown age intrude Late Paleozoic strata west of Forrest Kerr Creek (Figure 3-5). Where the intrusions are locally heterogeneous due to abundant xenoliths of hornblende, pyroxene and/or plagioclase porphyritic phases and younger felsic intrusive breccias, they resemble parts of the Late Devonian Forrest Kerr pluton. Commonly the intrusions are fine grained hornblende monzodiorite, that is locally foliated, deformed and metamorphosed to a pale green colour.

The plugs are massive, medium grained bodies which locally contain quartz proportions of quartz diorite and quartz monzodiorite. Mafic porphyritic phases are common south of Lime Lake. Quartz and plagioclase in these intrusions occur as glomeroporphyritic patches. Most feldspar grains are deformed and moderately altered to sericite and chlorite. They lie in a foliated groundmass of opaque-rich actinolite with many opaque inclusions and chlorite. Actinolite also occurs with quartz as glomeroporphyritic patches. Epidote is common and zeolite fills microfractures.

Constraints on the age of these intrusions is limited. Early Permian conodonts (M.J. Orchard, in Read *et al*., 1989) have been recovered from a polydeformed sequence of carbonate, siliceous phyllite, siltstone, tuff and graphitic siltstone, that is intruded by two of these diorite bodies (GS-Map); provides a lower age constraint.

ALTERED GRANITOID INTRUSIONS

Massive, silicified and propylitically altered intrusive rocks are exposed along the western slopes of Forrest Kerr Creek, south of the main bend (Figure 3-5). They are distributed along major north-northeasterly fault structures west of Forrest Kerr fault (unit gd, GS-Map). Primary textures and mineralogy have been obliterated. The rocks are aphanitic, vitreous to dull green and thoroughly fractured. Pyrite is ubiquitous as disseminations and in quartz-carbonate veinlets. The rocks are cliff formers which weather white to light green. Read and others (1989) mapped them as Jurassic feldspar porphyry and postulated they were subvolcanic feeders for Early Jurassic volcanic rocks.

DIKES

In the centre of the map sheet, a large area is characterized by a complex series of mainly plagioclase-phyric andesite dikes which intrude both Devonian to Mississippian volcanic rocks and the southern half of the Early Mississippian More Creek pluton. In the dikes, plagioclase phenocrysts are from 2 to 5 millimetres in size. Some dikes have seriate and some equigranular textures. Pyroxene is the only mafic mineral. It is usually interstitial to plagioclase but also forms less abundant , 1 to 2 millimetre phenocrysts locally. Most dikes are weakly propylitized. Similar dikes, and dikes which are pyroxene phyric, also cut the Late Devonian Forrest Kerr pluton and Early to Late Devonian rocks east of the FKP; their orientation is apparently random. In all of the dikes clinopyroxene is moderately altered to chlorite and epidote, and plagioclase is altered to sericite and epidote. Crosscutting these porphyritic dikes are swarms of one metre wide, aphyric, green to grey dikes (Photo 3-9). Several of these plagioclase porphyritic dike swarms are observable in east-west creek valleys along the eastern margin of the MCP. Similar plagioclase porphyry diorite dikes comprise an extensive northerly trending dike swarm along the eastern margin of the Forrest Kerr pluton. The intrusions cross cut one another at right angles but in general conform to the regional west dipping foliation of the country rocks and pluton margin (Photo 3-10).

Aphyric to sparsely feldspar phyric felsic dikes intrude Late Triassic volcanic rocks in the More Creek area, 1 km east of Hankin Peak. The dikes are up to 50 metres wide. They are white to pale green in colour, flow layered and spherulitic on millimetre scale. Mineralogically they correlate with Early Jurassic monzonite of the Texas Creek suite.

Lamprophyre dikes intrude Upper Triassic rocks east of Forrest Kerr fault. A 2 metre dike also intrudes Upper Triassic (?) rocks southwest of Arctic Lake, and another 1 metre dike intrudes an andesitic dike complex of probable Mississippian age or younger near the south edge of the map area. The dikes are up to 10 metres wide and have conspicuous biotite phenocrysts up to 2 centimetres in size. The matrix grain size averages 2 to 4 millimetres.

A basaltic dike, 1.5 metres wide, with 2 to 5 per cent vitreous plagioclase and a pristine grey groundmass, intrudes schists along the east side of the headwaters of Mess Creek. Mineralogically it is identical to the Arctic Lake basalts, and was probable a feeder to these Pleistocene flows.

Photo 3-9. Gneissic-textured hornblende diorite of the More Creek pluton, crosscut by medium grained tonalitic dikes and younger aphanitic to plagioclase porphyritic mafic dikes.

Photo 3-10. Fine-grained green, diorite dike swarm from eastern flank of the Forrest Kerr pluton, showing sharp, crosscutting and complex contacts with the tonalite phase.

GEOCHEMISTRY AND TECTONIC DISCRIMINATION OF INTRUSIVE ROCKS

Major and trace element analyses of 39 samples of intrusive rocks from the map area are summarized in Appendix 8. Analyses of 35 of the samples were completed at the Ministry of Energy, Mines and Petroleum Resources analytical laboratory in Victoria. The data reflects the range in composition of intrusions from the six plutonic suites recognized in the map area; the Forrest Kerr, More Creek, Stikine, Copper Mountain, Texas Creek and Three Sisters suites. Four additional samples of metadiorite from the Mess Creek area (Holbek, 1988) are included. These samples are believed to be the earliest plutonic rocks in the map area.

The data is presented using established chemical classification schemes to distinguish rock type and as well as to establish tectonic affinities. The least altered rocks available were collected in the field. The data were further screened for alteration petrographically and geochemically using K_20/Na_2O ratios and loss on ignition (LOI) values. Samples with high loss on ignition values (5% or greater), and those with anomalous ratios of the mobile elements sodium, potassium, rubidium, calcium, strontium and barium are appended but were not used in classification or discrimination plots. All intrusive rocks are classified according to modal mineral contents using the QAP diagram (LeMaitre, 1989), which uses the same classification nomenclature as Streckeisen (1976). With consideration to the small size or this data set, regional geochemical data from Logan and Koyanagi (1994) and Brown *et al*., (1996) are considered for the following general summary of the range in compositions for each plutonic suite.

EARLY(?)DEVONIAN UNNAMED SUITE

Chemically, these rocks have subalkaline tholeiitic affinities and plot as quartz diorites and tonalite on the normative QAP diagram (Figure 3-8a,b,d). The intrusions are peraluminous and straddle the line between volcanic-arc granites and ocean-ridge granites (Figure 3-8c,e).

FORREST KERR-MORE CREEK PLUTONIC SUITE

The Forrest Kerr and More Creek plutons are subalkaline intrusions. The leucocratic phases are calcalkaline while the mafic to ultramafic rocks plot as tholeiitic on the AFM diagram (Figure 3-6a,b). A single sample of granodiorite from the northwestern margin of the FKP plots in the calcalkaline field midway between the mafic and felsic rocks, suggestive of a continuum between the two end member groups. The dashed line on the AFM diagram is the differentiation trend of a high-Al_2O_3, gabbro-trondhjemite suite located in southwest Finland (Barker and Arth, 1976). The granodiorite sample from the FKP lies along this trend (Figure 3-6b). Mafic rock samples from MCP are scattered across quartz monzodiorite and tonalite fields on the normative QAP diagram (Figure 3-6d), two samples from the FKP plot in the monzonite field (not shown). These hornblende diorite and hornblendite samples from the FKP have low K_2O contents and their modal classification as monzonite is inconsistent with their mineral assemblage. The leucocratic phases of both FK and MC plutons cluster in the tonalite field on the normative QAP diagram (Figure 3-6a,b,d). The single sample from the northern margin of the FKP lies within the granodiorite field on the normative QAP diagram and the An-Ab-Or diagram (Figure 3-6c,d). The majority of the samples on the An-Ab-Or diagram (O'Connor, 1965) lie within the tonalite field, a single sample from the FKP lies in the trondhjemite field. The clustering of felsic data points indicates similar compositions for the two different aged plutons.

Major element variation plots of FKP and MCP rocks illustrate the bimodal nature of these two suites (Figure 3-7a-f). However, the small data set (n=12) and possible sampling biases could account for the apparent lack of intrusive phases with intermediate SiO_2 contents. The increase of Na_2O and decrease in K_2O from the mafic to felsic rocks is clearly different from "normal" calcalkaline suites. In general, in these samples, MgO, FeO total and CaO show a decrease with increasing SiO_2 . Na_2O increases from about 2 per cent for the diorite-hornblendite to greater than 4 per cent for the felsic rocks, which are interpreted to be tonalite-trondhjemites. Al_2O_3 increases from about 14 up to 17 per cent for intermediate SiO_2 values and then decreases to about 13.5 to 14.5 per cent for samples with greater than 70 percent SiO_2 . K_2O increases from less than 1 up to 3 per cent for intermediate SiO_2 values and then decreases to about 1.5 per cent for the trondhjemitic rocks. The strong Na_2O enrichment and K_2O depletion is the distinguishing chemical feature of the trondhjemitic suite. A comparison with published data (Figure 3-7) shows that the major element variation trends for the Forrest Kerr and More Creek plutons resemble those for the classic gabbro-diorite-tonalite-trondhjemite suite of the Uusikaupunki-Kalanti area, southwest Finland (*cf*. Arth *et al*., 1978).

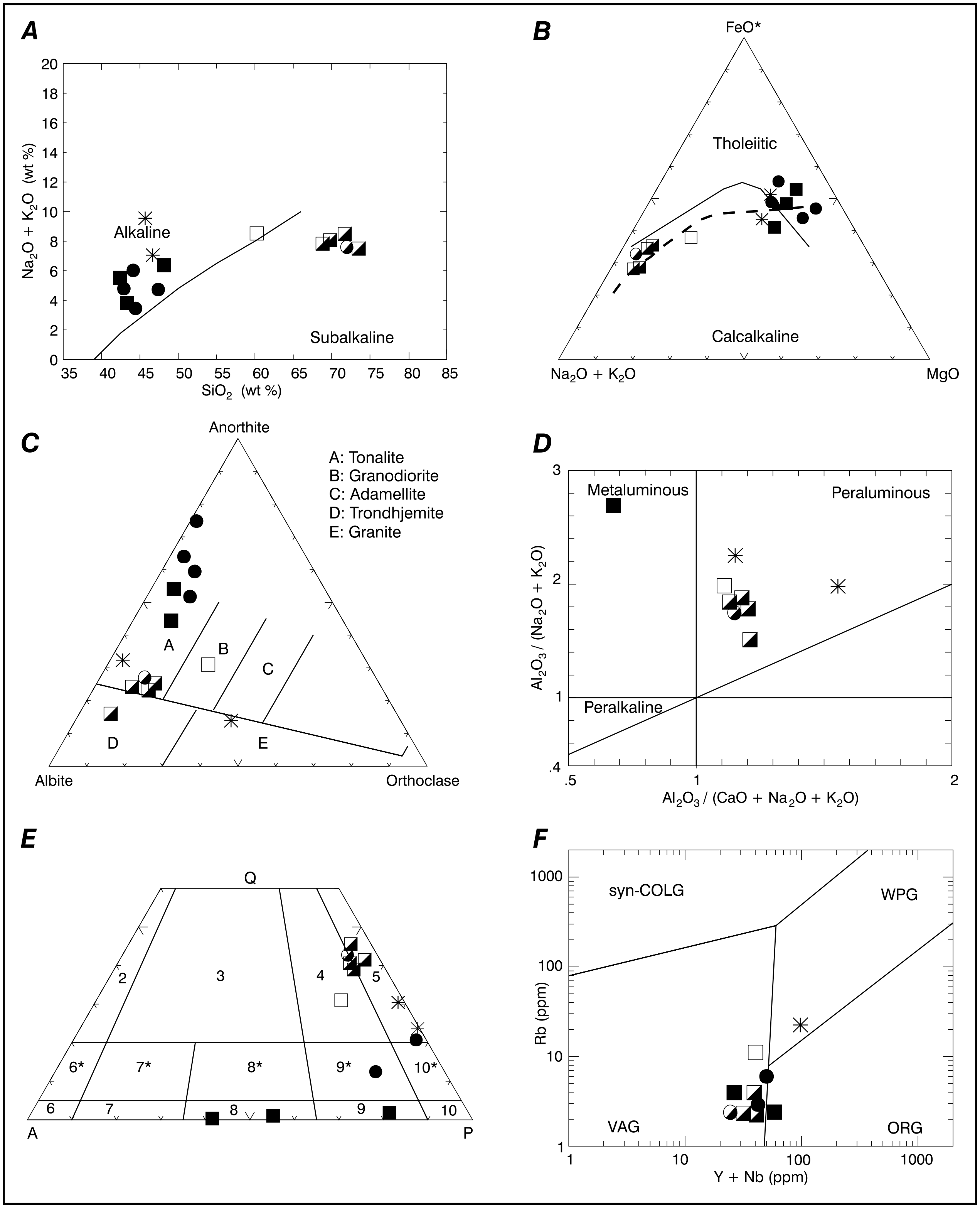

Figure 3-6. Major and trace element geochemical plots for Early Devonian diorite (asterisk), Late Devonian Forrest Kerr diorite (filled square), granodiorite (square), and trondhjemite-tonalite (half-filled square) and Early Mississippian More Creek diorite (filled circle) and tonalite (half-filled circle); A) total alkali versus silica (after Irvine and Baragar, 1971); B) AFM plot (after Irvine and Baragar, 1971), dashed line is differentiation trend of gabbro-trondhjemite suite of southwest Finland (Barker and Arth, 1976); C) normative plot of albite-orthoclase-anorthite (after O'Connor, 1965); D) Shand's index diagram showing relative alumina saturation (after Shand, 1951); E) plot of quartz-alkali feldspar-plagioclase, based on modal mineralogy (after Streckeisen, 1976); F) ternary plot of Y+Nb versus Rb (after Pearce *et al*., 1984).

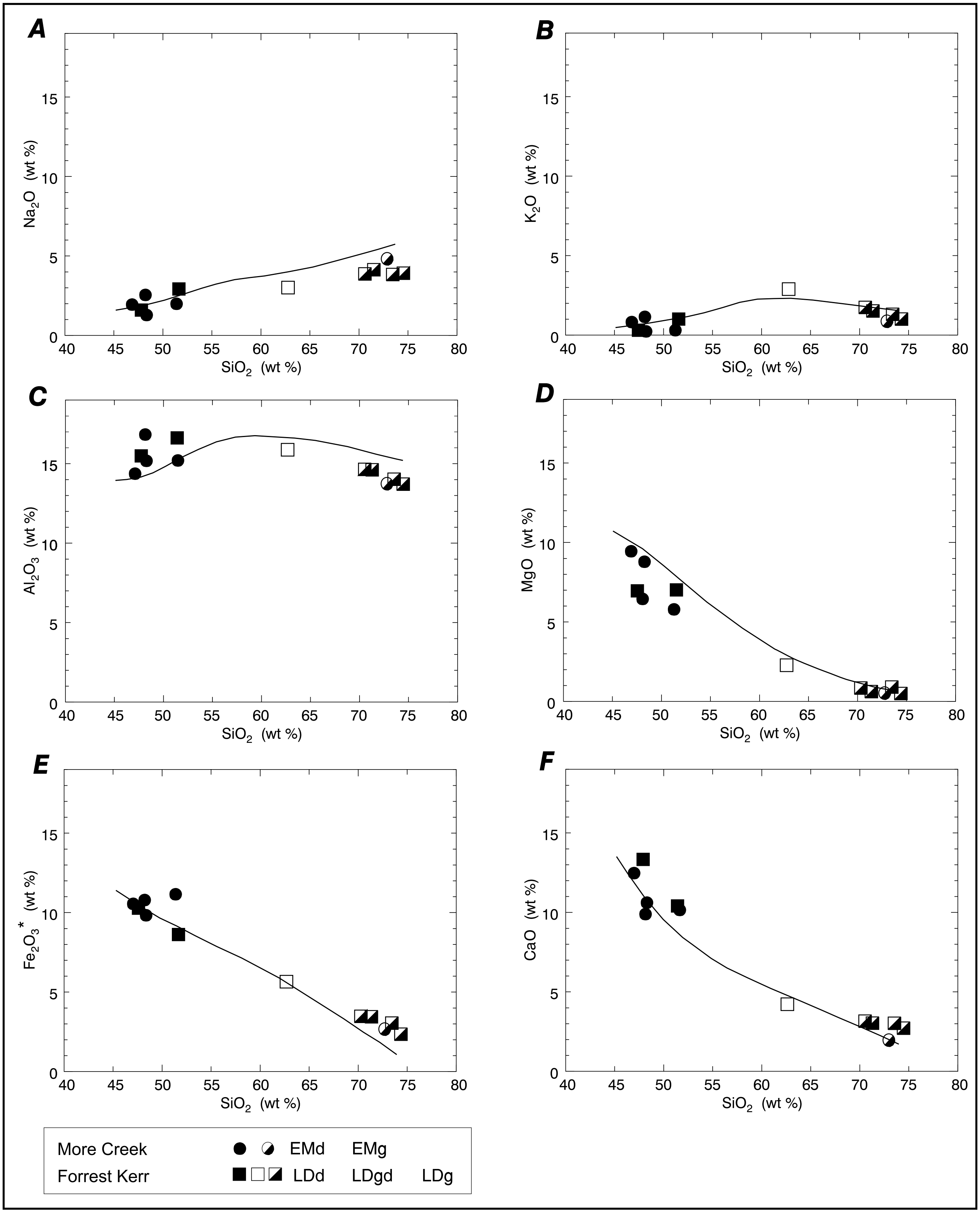

Figure 3-7. Harker variation diagram for the Late Devonian to Early Mississippian Forrest Kerr and More Creek diorite-tonalite-trondhjemite suite. Major element variation trend line from gabbro-diorite-tonalite- trondhjemite of southwest Finland (Arth *et al*., 1978).

The felsic rocks are also peraluminous, as indicated by their $Al_2O_3/(CaO + Na_2O+K_2O)$ ratios of 1.0 to 1.1 (Shand, 1951), a single sample of hornblende diorite from the Forrest Kerr pluton plots as highly metaluminous (Figure 3-8e). The relatively high concentrations of CaO (9.92 to 13.28 wt. %, Appendix 8) for all of the mafic phases results in ratios which plot to the left of the diagram. Trace elements show volcanic arc signatures for both mafic and felsic suites (Figure 3-6f).

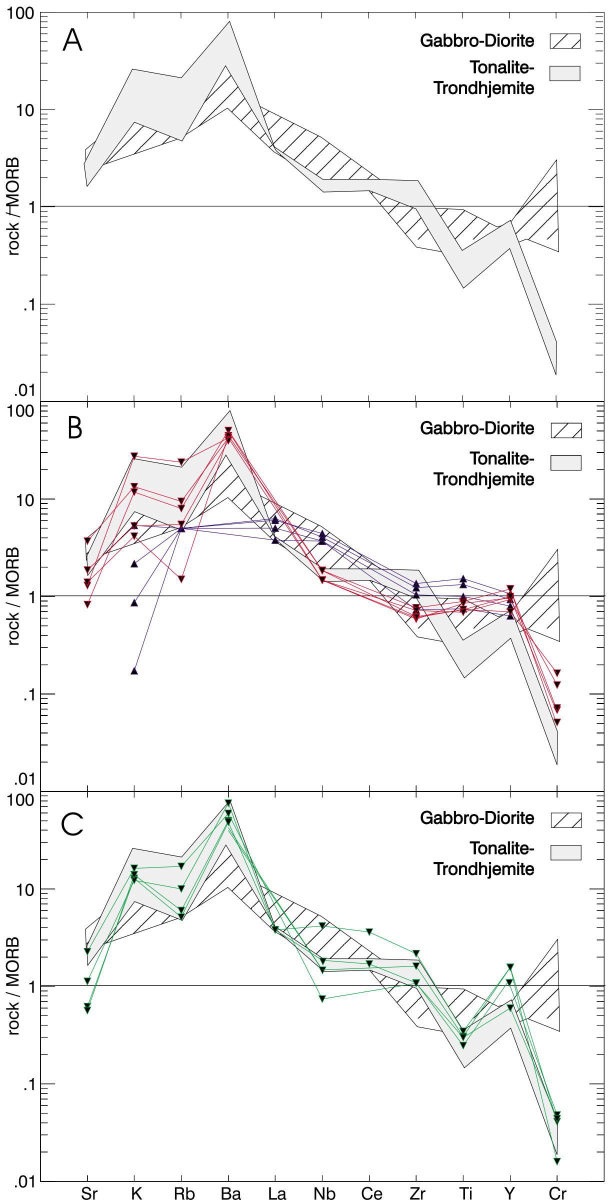

Figure 3-8. Multi-element geochemical patterns for gabbro-diorite and tonalite-trondhjemite rocks of the Late Devonian Forrest Kerr and Early Mississippian More Creek plutons. A) combined gabbro-diorite and tonalite fields of both Forrest Kerr and More Creek plutons; B) Lime Lake (triangle) and More Creek (inverted triangle) basaltic units; C) More Creek rhyodacite units. Normalizing values (in ppm unless indicated) are: Sr=120; K=955;Rb=2; Ba=14.5; La=3.96; Nb=2.7; Ce=10; Zr=90; TiO_2=1.45%; Y=30; Cr=250.

The fields from, five gabbro-diorite and four tonalite from the Late Devonian to Early Mississippian Suite are plotted on a mid-ocean ridge basalt normalized discrimination diagram (Figure 3-8, after Pearce, 1996). The fields for both suites display patterns typical of volcanic arc lavas, with strong enrichment in lithophile elements (Sr, K, Rb and Ba) and a negative slope of the Nb, Ce and Zr trend. The elevated concentrations of Nb and Zr, but lower Ti and Y abundance's relative to N-MORB are characteristic of calcalkaline and high-potassium calcalkaline volcanic arc basalts. Missing from this pattern is the significant negative Nb anomaly with respect to Th (La) and Ce that is a key characteristic of all volcanic arc basalts (Pearce, 1996). The large negative Ti anomaly (with respect to Zr) of the More Creek rhyodacite units (Figure 3-8c) versus the more basic Lime Lake and More Creek basalts reflects the higher degree of fractionation and accompanying crystallization of Ti-bearing oxides in the more felsic units.

Tonalites and trondhjemites are plagioclase-quartz-rich intrusive rocks containing less than 20 per cent Fe-Mg minerals and 2/3 or more of the feldspars being plagioclase. O'Connor (1965) defines the boundaries between tonalite and trondhjemite on the amount of albite present (Figure 3-6c). Trondhjemitic-tonalitic suites are of two general types; a low-Al_2O_3 type contains less than 15 weight per cent, and a high-Al_2O_3 type contains 15 weight per cent or more Al_2O_3 (Barker and Arth, 1976). The low-Al_2O_3 suites are characteristic of subvolcanic oceanic arc environments and usually have low abundances of Rb and Sr, slight enrichments in LREE, negative Eu anomalies and flat HREE patterns. Plagioclase-pyroxene-magnetite fractionation during the formation of these intrusive suites (Arth and Barker, 1976). Geochemical studies and experimental work indicate that trondhjemitic magmas are derived either from fractional crystallization of mafic magmas or by partial melting of mafic source rocks (Barker and Arth, 1976; Arth *et al.*, 1978; Johnston, 1986). The Forrest Kerr and More Creek plutons may have been derived from differentiation of mafic magmas that were generated by subduction beneath a middle Paleozoic island-arc or may have been generated by partial melting of mafic material (arc roots) at depth. Partial melting has been suggested as a source of trondhjemitic plutons in other island-arc settings (Gill and Stork, 1979).

STIKINE SUITE

The Late Triassic Stikine suite is represented by 3 samples; one from each of Unit L$\overline{T}$Hd, L$\overline{T}$pp, and L$\overline{T}$pd, and all from the Mess Creek intrusive body. They range in composition from monzodiorite to granodiorite, with subalkaline, calcalkaline to tholeiitic affinities (Figure 3-9a,b,d). The hornblende diorite correlative of the Hickman pluton plots in the tholeiitic field, similar to diorite from the Late Triassic Tahltan Lake pluton (Brown *et al.*, 1996). One sample plots outside the main trend due to its very high iron content. This is considered to be the result of magnetite accumulation, and not sample contamination, because the sample also has high P_2O_5 and low Cr relative to the other samples. The three phases are characteristically I-type intrusions (Chappell and White, 1974), metaluminous (Shand's index less than 1.1;

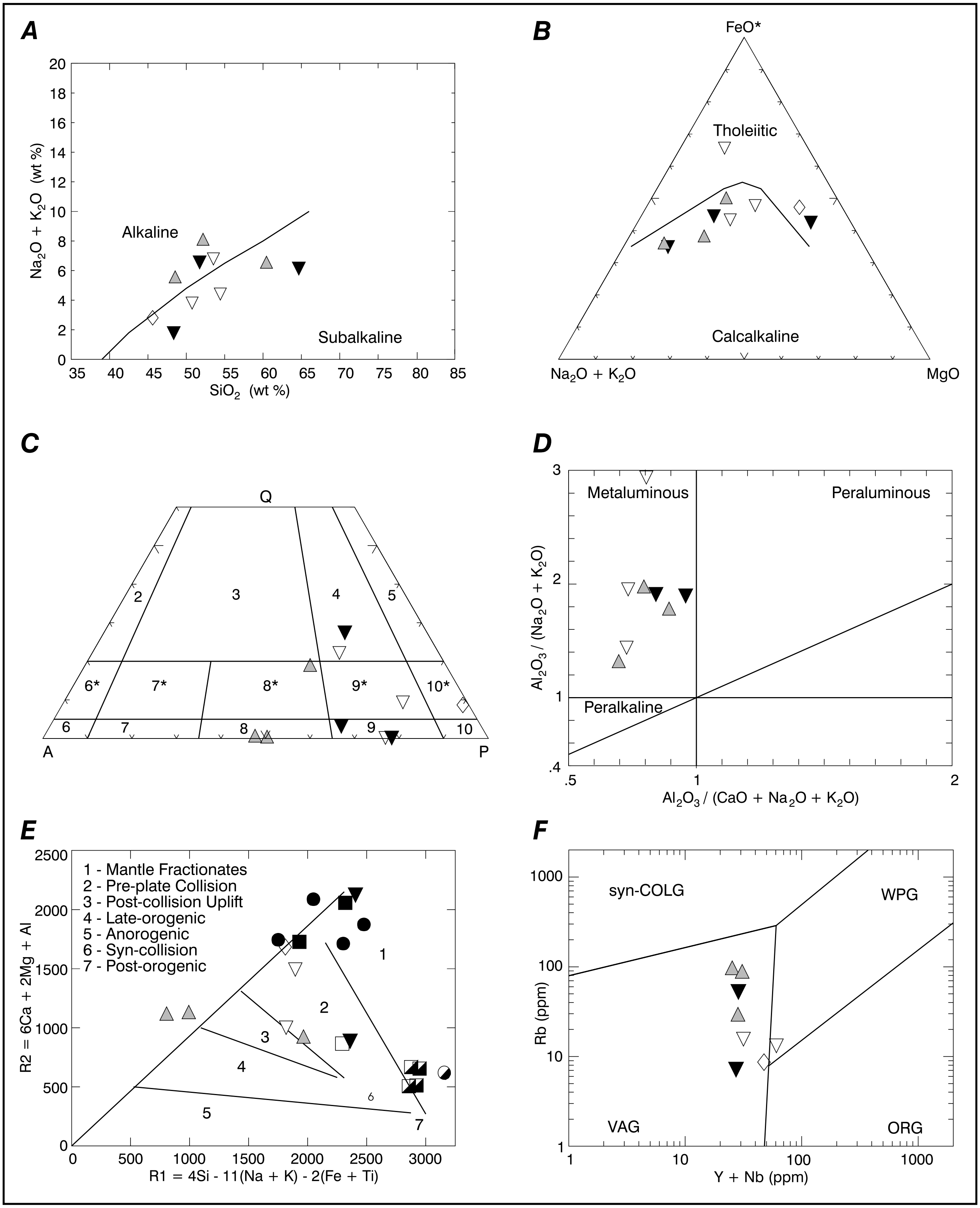

Figure 3-9. Whole-rock major oxide classification and trace element discriminant diagrams for the Middle to Late Triassic Stikine, Late Triassic to Early Jurassic Copper Mountain, Early Jurassic Texas Creek and Middle Jurassic Three Sisters Plutonic Suites.

Shand, 1951) and show volcanic arc signatures (Figure 3-9c,e).

COPPER MOUNTAIN SUITE

The Late Triassic to Early Jurassic Copper Mountain suite is represented by two samples from the Loon Lake stock and a sample of quartz monzonite from one of the Newmont Lake plugs. The Loon Lake samples include a dark grey, sparsely plagioclase-phyric variety and an equigranular pink variety; both are chemically equivalent to basaltic andesite. The Newmont Lake sample is a pink, crowded plagioclase-hornblende porphyry chemically equivalent to a high-potassium dacite. On the normative QAP diagram of LeMaitre (1989), the Newmont Lake sample plots on the boundary between granite and quartz monzonite, the Loon Lake samples plot in the monzonite field (Figure 3-9d). The sample from the Newmont Lake plug is subalkaline, the Loon Lake stock samples are alkaline. Both have elevated potassium values relative to the Stikine suite, but these are intermediate values in comparison to some end member syenites and shoshonitic rocks at Galore Creek (Logan and Koyanagi, 1994). The intrusions are metaluminous and show volcanic arc signatures (Figure 3-9c,e).

TEXAS CREEK SUITE

The Early Jurassic Texas Creek suite is characteristically altered and therefore poorly represented. A single sample from the McLymont pluton and one from an isolated pyroxene diorite body represent the suite. The McLymont pluton plots in the granodiorite field and the small plug located east of Hankin Peak plots in the monzodiorite field on the normative QAP diagram (Figure 3-9d). Both samples are subalkaline; the McLymont pluton has calcalkaline affinities and the monzodiorite has tholiietic affinities (Figure 3-9a,b). They are metaluminous (Figure 3-9c), and both show volcanic arc signatures (Figure 3-9c,e).

THREE SISTERS SUITE

A single, unaltered diorite sample from the eastern belt of Middle Jurassic intrusions provides the only chemical data for Three Sisters suite of rocks in the map area. Chemistry of the Yehiniko pluton indicates it is a subalkaline, calcalkaline granite with peraluminous characteristics (Brown *et al*., 1996). In the Forrest Kerr area the gabbroic to dioritic intrusions of unit mJHb are a subalkaline, tholeiitic suite, showing a strong iron enrichment trend. On the normative QAP diagram of LeMaitre (1989), it plots as quartz diorite to quartz gabbro (Figure 3-9a, b, d). On the plot, the intrusion composition lies very close to that of the extrusive rocks which are spatially related in the field. The gabbro and diorites are thought to be feeders to the pillow and breccia flow basalts.

CHAPTER 4 STRUCTURE

INTRODUCTION

The Forrest Kerr-Mess Creek area provides a unique opportunity to document ductile deformation of the oldest rocks of Stikinia and young brittle transtensional strain of the region. The variety of structural styles evident across the map area reflect the different structural histories of the four tectonostratigraphic packages which comprise this part of Stikinia. The central portion of the map area is dominated by a polydeformed volcano-plutonic arc assemblage of Late Paleozoic age. These are the oldest known rocks of Stikinia and record a Late Paleozoic history of volcanic arc development and tectonism. Unconformably overlying this succession in both the west and east parts of the map area are less deformed Mesozoic volcanic and sedimentary rocks of the Stuhini and Hazelton arc assemblages and sedimentary rocks of the Bowser Lake overlap assemblage. These rocks are separated by and interleaved with the older strata along the Forrest Kerr fault and the Mess Creek fault systems, two north-trending regional fault systems which control the structural grain of the area. They are probably at least as old as Jurassic and remained active into the Holocene. The Mess Creek fault system is a 4-5 km wide major structure that bounds and possibly controlled eruption of the Pliocene Mount Edziza volcanic complex (Souther, 1992). The Forrest Kerr fault zone is confined to a narrow zone which at its northern extent either steps in en echelon fashion, westward into the Mess Creek fault system at Arctic Lake (Read et al., 1989) or continues northward beneath the recent Edziza lavas. Both sinistral and dextral senses of shear are documented for parts of these north-trending structures. Northeast- and northwest-trending faults either merge with similar aged, or are crosscut by, younger north-trending fault segments along both of these fault systems. A northeast-trending graben at Newmont Lake and half-graben listric structures preserved along the east side of the Mess Creek fault attest to phases of extensional deformation in the area. It is unclear whether they are related to the Cordilleran-wide post-Cretaceous dextral translation or to earlier events.

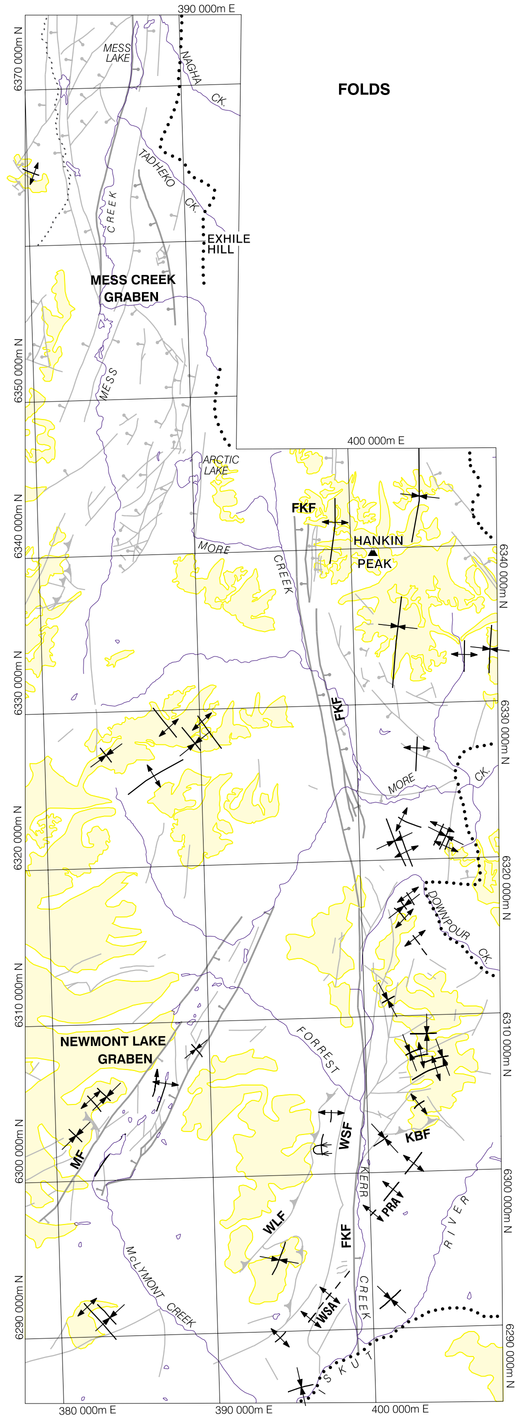

Figure 4-1. Structural elements of the Forrest Kerr Mess Creek area, illustrating faults and fold axes. Dominant fault and graben structures are bold. FKF= Forrest Kerr Fault, MF= McLymont Fault, WLF= West Lake Fault, WSF= West Slope Fault, KF= Kerr Bend Fault, WSA= West Slope anticline, PRA= Pillow Ridge anticline.

DEFORMATIONAL HISTORY OF LATE PALEOZOIC STRATA

Devonian rocks east of the Forrest Kerr pluton and at the headwaters of Mess Creek (Figure 4-1) show up to four phases of folding and deformation. Two early subparallel penetrative foliations are kinked by a third crenulation event, and the crenulations in turn appear to be gently folded by a fourth event.

PALEOZOIC DEFORMATION

D_1

The earliest deformation (D_1) is characterized by a prominent, northeast-striking, moderately northwest-dipping compositional layer-parallel penetrative foliation within volcanic and sedimentary rocks of Early and Middle Devonian age. This foliation is axial planar to ?northwest-trending, mesoscopic, recumbent isoclinal folds, which have an overall northeast vergence. Development of axial planar foliation (S_1) is prominent in schists west of Mess Creek and coincident with lower greenschist grade metamorphism. Here, foliation is bedding parallel. Mid-Carboniferous and younger rocks lack these first-phase folds and foliations. During D_1 and/or D_2 numerous discrete west-dipping layer parallel ductile shear zones developed which separate packages of deformed and largely undeformed rocks. Shearing along these zones is top plate to the east.

D$_2$

The second phase (D_2) deforms and transposes S_1 in Devonian rocks and isoclinally folds bedding (S_0) in Late Carboniferous and Early Permian rocks (Photo 4-1). The S_2 fabric is superposed on S_1 in thin layered tuffaceous sedimentary and volcanic rocks of Unit lmDSst, but S_2 in general is the dominant fabric throughout the Paleozoic strata. It developed under lower greenschist grade metamorphic conditions. Second phase cleavage (S_2) is, in most places, a southwest dipping, penetrative axial planar cleavage. No map scale folds of phase 1or phase 2 were observed and it is difficult to distinguish phase 1 and phase 2 minor folds, both are flattened, rootless isoclinal folds (Photo 4-2). Where a second phase fold refolds a first phase fold, the two appear to be coaxial (Holbek, 1988). Second phase structures are northwest-trending recumbent to moderately inclined, southeast plunging folds. Folds in the sericite-schist are tight to isoclinal, recumbent structures. Limbs are tightly appressed and contain layer parallel sub-horizontal to west-dipping shear zones and thrust faults (Photo 4-3). Northerly trending, shallowly-dipping ductile thrust faults are exposed west of Mess Creek, on the BJ property (Holbek, 1988 and this study). These zones occur within quartz sericite and chlorite sericite schists where these relatively incompetent units are in contact with greenstone and metadiorite. Easterly-directed thrusting was localized along these contacts. Timing of shearing and faulting are not well constrained.

Photo 4-1. Recumbent F_1 or F_2 folds in Early Devonian carbonate showing good axial planar cleavage which transposes bedding.

MESOZOIC(?) DEFORMATION

D$_3$

The third phase (D_3) is characterized by mesoscopic, disharmonic, upright, open to tight crenulation folds and kink bands which deform all earlier structures (Photo 4-4). Fold amplitudes vary from millimetres to several metres.

Photo 4-2. Intrafolial isoclinal F_1 folds in green and purple schistose chlorite tuffs of Early to Middle Devonian age.

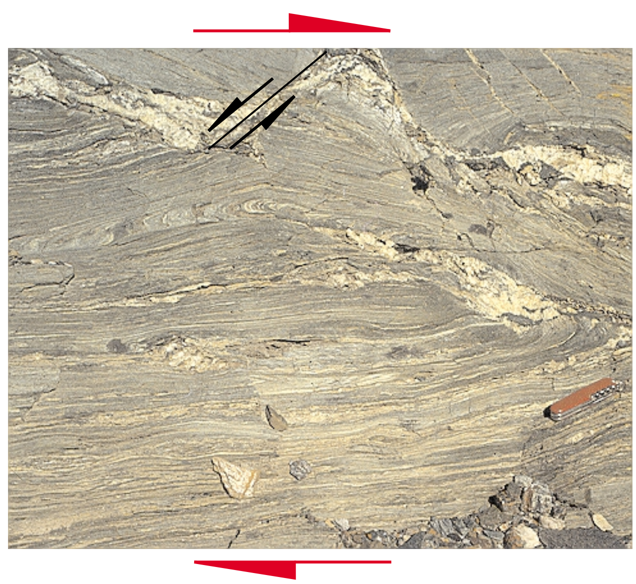

Photo 4-3. Tightly appressed and transposed intrafolial isoclinal folds and quartz veins illustrate the high degree of shear strain present in the Early to Middle Devonian chlorite schists at Mess Creek.

Photo 4-4. West-trending, upright F_3 kinks and crenulation cleavage developed in quartz sericite and chlorite schists in the headwaters of Mess Creek.

Fold axes plunge shallowly eastward and less commonly westward, axial surfaces dip steeply south to southwest. Third phase deformation commonly produces a strong crenulation cleavage in Paleozoic rocks and is interpreted to correspond to upright northwest-trending open, sometimes overturned, folds in Mesozoic rocks. No significant, large-scale (D_3) folds are recognized in the Paleozoic rocks. D_3 folds do not significantly alter the map pattern of the rock units.

D_4

The fourth phase (D_4) folds are moderate to open, north-trending upright mesoscopic to macroscopic structures with fold wavelengths of several metres to several km. Folds plunge mainly north or south. Styles include open cylindrical (in Paleozoic rocks) to chevron or open box-folds and minor kink bands (in Mesozoic rocks). Everywhere S_4 is a spaced fracture cleavage. This phase folds Late Triassic and Middle Jurassic rocks and is correlated with Skeena Fold belt deformation. It accommodates most of the shortening seen in the Mesozoic rocks.

SELECTED AREAS OF PALEOZOIC STRATA

MESS CREEK

Southeast of the headwaters of Mess Creek a package consisting of Early to Middle Devonian intermediate to felsic volcaniclastic rocks, flows and limestones forms a northeast-trending re-entrant in the More Creek pluton. The strata are tightly folded and penetratively foliated about northeasterly-trending isoclinal, recumbent structures (D_2). Ductile fabrics indicate layer-parallel shears with top-to-the-southeast sense of shearing. Rarely, a second foliation, subparallel to the first, is developed in these rocks, suggestive of a second early phase of deformation. Thin foliated limestone lenses and pods exposed on either side of Bear valley outline the northeast trace of an early fold limb (Section M-M', GS-Map, back pocket). Upright, moderately tight northwest-trending, anticline-syncline pairs refold the earlier foliation and bedding. Crenulation of the early foliation is well developed in phyllitic limestone and sericite-schist members. East to southeast trending and variably plunging kink bands and chevron folds characterize the third phase of deformation. Rarely, north-trending spaced fracture cleavage is present and presumed to represent the last contractional phase of deformation.

EAST OF FORREST KERR PLUTON

Early Devonian to Early Permian rocks located west of the Forrest Kerr fault and east of the FKP were termed "eastern" Stikine assemblage rocks by Logan *et al*. (1990a). The rocks in this area (Lime Lake and vicinity) have been well studied by various workers (Table 4-1). Read *et al*. (1989) recognized three phases of deformation in the Forrest Kerr Creek and southern More Creek areas. They limited the first phase of folding to a post-Permian and pre-Middle Triassic interval, and because the second and third phases affected the Middle to Late Jurassic Bowser Lake Group, suggested these phases were probably Early Cretaceous in age. Elsby (1992) recognized four phases of deformation in the southern Forrest Kerr area. These comprise an early pre-Late Triassic phase, a second phase that accompanied progressively higher metamorphism and strain that is of probable Triassic to Jurassic age, and two subsequent phases. Elsby thought the youngest phase may be associated with movement along regional scale faults such as the Forrest Kerr fault zone. McClelland *et al*. (1993) recognized that the early schistosity in the country rock was cut by nonfoliated dikes of the Late Devonian, Forrest Kerr pluton, implying a pre-Late Devonian timing for the formation of the earliest foliation. Gunning (1993) working in the same area, recognized at least three, and perhaps four contractional deformational events that folded Late Paleozoic strata at the south end of Forrest Kerr Creek. All four events affected Paleozoic rocks; therefore he concluded the folding was post-Paleozoic. These various workers agree in general on the fundamental structural relationships in the area. On the other hand, interpretation and explanation of the overall structurally complex, faulted and stratigraphically inverted section above Lime Lake remains controversial.

Our "cross-section" (Figure 4-2) shows the area to comprise up to four structural panels of fault-bounded and interleaved Paleozoic and Mesozoic rocks. The upper (western) thrust panel consists of carbonate and volcanic rocks intruded at the top of the section by Late Devonian quartz diorite of the Forrest Kerr pluton. Structurally below is a panel of polydeformed thinly layered siliciclastic rocks of Carboniferous and younger age. Massive green plagioclase phyric metabasalt, breccias and volcaniclastic rocks of Late Devonian to Early Carboniferous age underlie the Carboniferous and younger strata and occupy the footwall of the West Slope fault. East of the West Slope fault (Read *et al*., 1989) are Permian limestone and Late Triassic volcanic rocks. The Paleozoic strata west of West Slope fault (Figure 4-2) are affected by a moderate, west- northwest-dipping schistosity comprising transposed subparallel foliation S_1 and S_2 planes. The schistosity is axial planar to

TABLE 4-1

COMPILATION AND COMPARISION OF STRUCTURAL FEATURES FOR THE FORREST KERR-MESS CREEK AREA

MESS CREEK AREA

Deformation	this study*	Fold Orientation	Characteristics	Timing	Reference
1st phase	D_1	isoclinal, rootless minor folds	syn-metamorphism	post-Permian but pre-Middle Triassic	Holbek, 1988
2nd phase	D_2	isoclinal, rootless minor folds, NW-trending		post-Permian but pre-Middle Triassic	
3rd phase	D_3	chevron kink band folds, upright E-trending		post-Late Triassic	
4th phase	D_{4A}	Parallel upright, N-trending		post-Late Triassic	

FORREST KERR AND MORE CREEK AREAS

Deformation	this study*	Fold Orientation	Characteristics	Timing	Reference
1st phase	D_1 & D_2	mesoscopic isoclinal folds	syn-metamorphism	post-Permian but pre-Late Triassic	Read *et al*., 1989
2nd phase	D4A	upright, N and NE macroscopic folds		post-Jurassic, probably Early Cretaceous	
3rd phase	D_{4B}	upright, NW-trending		post-Jurassic, probably Early Cretaceous	

SOUTH FORREST KERR AREA

Deformation	this study*	Fold Orientation	Characteristics	Timing	Reference
1st phase	D_1	mesoscopic, NE-trending, SE-verging isoclinal folds	syn-metamorphism	pre-Late Triassic	Elsby, 1992
2nd phase	D_2	mesoscopic, NE-trending, SE-verging isoclinal folds	syn-metamorphism	post-Paleozoic	
3rd phase	D_3	upright, west to northwest		?	
4th phase	D_4	macroscopic, NE to NW		?	

SOUTH FORREST KERR AREA

Deformation	this study*	Fold Orientation	Characteristics	Timing	Reference
1st phase	D_1 & D_2	mesoscopic east-verging, north plunging		post-Paleozoic	Gunning, 1993
2nd phase	D_3	west-plunging folds		post-Paleozoic	
3rd phase	D_{4A}	upright, NE-trending large scale antiforms		post- Late Triassic	
4th phase	D_{4B}	upright, N-trending		post- Late Triassic	

This study*: equivalent event correlated to deformational event in Table 4-2.

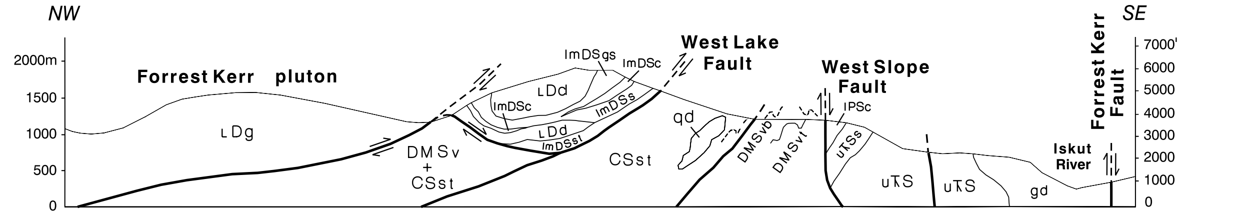

Figure 4-2. Schematic cross-section of the structurally interleaved and inverted Early Devonian to Late Triassic strata exposed west of the Forrest Kerr Fault and east of the Late Devonian Forrest Kerr pluton. Unit designators and section line corresponds in part to Section U-V, on GS-Map, in back pocket.

tight recumbent, rootless isoclinal folds that are overprinted by a gently southwest-plunging crenulation (S_3) with its axial plane dipping steeply southeast. F_3 fold axes are gently folded about roughly perpendicular fold axes. Deformational styles, therefore, appear to be identical with those present in the Late Paleozoic rocks west of Mess Creek.

Read *et al*. (1989) and Logan *et al*. (1990b) suggest that the upper limestone-volcanic section structurally overlies the lower siliciclastic section along the west-dipping West Lake thrust fault. McClelland (1992) interpreted the contacts between these two divisions as gradational and concluded that the Forrest Kerr section was an overturned but otherwise intact section. Elsby (1992) recognized discrete mylonitic shear zones in the West Lake fault zone and parallel splays that are developed in the footwall stratigraphy. He showed that these northwest-dipping structures coalesce and root into subhorizontal, east-verging thrust faults (Figure 1-16-3, Elsby, 1992). Southeast-directed thrusting along the West Lake fault predated development of the north-trending syncline which deforms the thrust. The displacement and timing on these southeasterly-directed structures is not constrained.

DEVONO-MISSISSIPPIAN CONTRACTION (D_1)

There is good evidence in the map area for a Late Devonian phase of deformation. With the exception of some massive volcanic units, Early and Middle Devonian strata are everywhere penetratively foliated and polydeformed. In contrast, Late Devonian and Early Carboniferous volcanic strata and in particular the mid-Carboniferous carbonate are for the most part little deformed. The volcanic strata contain primary volcanic-depositional features, the carbonate in most cases have low conodont alteration indices (*c.f.* metamorphism), and there is at least one less phase of penetrative deformation. The heterogeneity and competency contrasts between the Late Paleozoic plutons and the volcanic and carbonate units has contributed to strong strain partitioning, although the preservation of little-deformed post mid-Carboniferous age strata in this part of Stikinia during subsequent Mesozoic and? younger deformations is intriguing.

Small pendants of foliated and non foliated metasedimentary and metavolcanic rocks occur within both the Late Devonian and Early Mississippian plutons. The satellite-border phase of the Forrest Kerr pluton (370.7±6.7 Ma) intrudes foliated Early to Middle Devonian metasedimentary and metavolcanic (380±5 Ma) strata north of Lime Lake. The pluton is multi-phased, equigranular to sparsely porphyritic and not foliated. The intrusion does not crosscut the foliation, so does not provide conclusive evidence for a pre-Late Devonian deformation. However, south of Lime Lake, McClelland *et al*. (1993) recognized that the early schistosity in the country rock was cut by nonfoliated apophyses of the Late Devonian Forrest Kerr pluton, implying a pre-Late Devonian timing for the formation of the earliest foliation.

Foliated Paleozoic rocks are also intruded and crosscut by non-foliated Early Jurassic monzogranite of the McLymont Creek pluton, south of Lime Lake (Photo 4-5). Gunning (1993) included this intrusion with the Late Devonian Forrest Kerr suite, thus some of the structural relationships he interpreted as post Devonian are actually younger (*i.e.* post Early Jurassic).

West of the main body and south of Arctic Lake, apophyses of the Early Mississippian More Creek pluton (356.9+4.3-3.8 Ma), appear to be equally as penetratively deformed as the country rocks which they intrude (Logan *et al*., 1992a). At its' southern end, Devonian and Early Carboniferous volcaniclastic and interbedded tuffs are skarnified by quartz-rich tonalite intrusions of the More Creek pluton. These apophyses are injected parallel to

Photo 4-5. Intrusive contact relationships at the northeast margin of the McLymont Creek Pluton, between Early Jurassic medium grained hornblende, biotite monzogranite and undivided Paleozoic meta-tuffaceous sediments.

compositional layering and provide no constraints on the timing of this deformation. The ~330 Ma cooling ages for the More Creek pluton may reflect the uplift and unroofing required for the nonconformable deposition of Mid-Carboniferous carbonate rocks on the pluton east of Mess Creek.

PERMO-TRIASSIC DEFORMATION (CIRCA 240 Ma)

Mesozoic rocks in this part of Stikinia developed on a basement of deformed and uplifted Paleozoic rocks of the Stikine assemblage. The Tahltanian orogeny represents a Permian to pre-Late Triassic episode of deformation, metamorphism and uplift first recognized in the Tulsequah and Telegraph Creek areas (Souther, 1971, 1972). Read (1983, 1984) and Read et al. (1983) suggested an older, Late Permian to Early Triassic interval for this event on the basis that the Middle Triassic rocks in the Iskut and Stikine areas do not contain the first phase fabrics that are present in Early Triassic and older rocks. In the Iskut River area the regionally extensive Permo-Triassic disconformity is marked by local polymictic conglomerate, a regional decrease in conodont colour alteration index with younger strata, and an angular unconformity between recumbently folded Early Permian limestone and overlying Late Triassic(?) mafic volcanics (Anderson, 1989, 1993). Evidence for a Permo-Triassic metamorphic event in the Telegraph Creek area is based on the conodont colour alteration index and is equivocal (Brown et al., 1991; Logan and Koyanagi, 1994; this study). In fact, it could be argued (Figure 4-7) that the data preclude a metamorphic event, and therefore this type of data must be interpreted with care in areas with complicated structural and thermal histories.

A variety of lithologies and ages of strata mark the Paleozoic to Mesozoic transition for this part of northwestern Stikinia. With the exception of the single condensed section of Upper Permian strata exposed at the Scud glacier, it is generally Early Permian limestone which are disconformably overlain by Early, Middle or Late Triassic units. The sections are paraconformable but disconformities of varying duration occur in different areas, generally with a hiatus from the Late Permian to various parts of the Triassic. Angular unconformities are rare, the basal “Stuhini” conglomerate which overlies deformed Paleozoic rocks in Sittakany valley (Souther, 1971) has yielded Tertiary, U-Pb dates and is correlative with the Sloko Group (Mihalynuk *et al*., 1994).

Early Permian, Artinskian limestones are overlain by a coarse polylithic basal conglomerate of Late Triassic Carnian age in the Galore Creek area. Angular limestone clasts and chert fragments similar to chert interbedded with the Permian limestone suggest a local erosional source at this location (Logan and Koyanagi, 1994). Further east, in the Mess Lake area, Late Triassic mafic tuff and/or fine sandstone and siltstone overlie Early Permian limestone (Photo 2-20). Either restricted sedimentation and/or non sedimentation during the Late Permian to Middle Triassic (Read and Okulitch, 1977) or post-Early Triassic uplift, deformation(?) and erosion are possible scenarios for the Tahltanian interval in this area. The appreciable difference in deformational style between Paleozoic and Triassic strata suggests that the Tahltanian Orogeny was a compressive deformational event in this part of Stikinia. It probably followed a period of restricted sedimentation during the Late Permian to Middle Triassic (chert and black clastic rocks at Galore Creek, Logan and Koyanagi, 1994), it affected rocks older than Carnian, but did not coincide with a regional Barrovian metamorphic event.

PRE-LATE TRIASSIC CONTRACTION (D_2)

In the northern part of the map area, Late Carboniferous rocks that underlie the plateau between Skeeter and Mess lakes show the same basic fold geometries and relationships as the Devono-Mississippian rocks located east of Mess Creek. These rocks are penetratively foliated and schistose just like those to the south, in the Mess Creek area. Only S_1 appears to be absent in the Late Carboniferous rocks. Foliated, thin-bedded tuff and carbonate display both recumbent isoclinal and tight parallel folds in cliff exposures on both sides of the plateau. Most folds have amplitudes on a scale of several metres. Fold axes plunge gently either northwest or southeast, and vergence appears to be to the northeast; axial surfaces dip gently to the southwest. Schistose and slaty beds also display millimetre and centimetre-scale crenulation folds. Foliation is typically subparallel to bedding, except in apparent fold closures. The massive basalt of Unit uCSb is weakly foliated in places but shows no evidence of folding. The poor correlation between stratigraphic age and degree of deformation across the map area suggests that strata forming the ridge between Skeeter and Mess lakes have undergone one fewer deformational event, and that most of the strain was taken up in the carbonate and fine grained sedimentary rocks, possibly during thrust faulting. The only other place that this level of deformation was seen in Early to mid-Carboniferous rocks is four km west of the headwaters of Mess Creek, in the Galore Creek area (Logan and Koyanagi, 1994).

Mid-Carboniferous carbonate rocks east of Mess Creek unconformably overlie the Early Mississippian More Creek pluton and Late Devonian to Early Mississippian volcaniclastic rocks, and are unaffected by penetrative deformation. The rocks are deformed into open, gentle folds on a scale of hundreds of metres. The folds are the only deformation recognized in the carbonate and may reflect movement in the underlying rocks.

Late Carboniferous volcanic rocks and Early Permian carbonate east of Mess Creek are homoclinal; minor deviations in attitude are due to brittle faulting and disruption by intrusion of the Loon Lake stock. On the south slope of Tadekho Creek, the carbonate is deformed into large open folds. It is also drag folded adjacent to a minor, north-trending fault about 4 km southwest of Exile Hill. The most extensive deformation is adjacent to a well-exposed listric fault that places Early Jurassic conglomerate against Early Permian limestone. Approaching the fault from the east, bedding dips in the carbonate steepen from shallow to vertical, and become east-dipping adjacent to the fault. Either the east-dipping beds are overturned or the carbonate is tightly folded into an upright syncline in which the closure is not exposed.

Similar mid-Carboniferous carbonate and Late Carboniferous coarse clastics with lesser Early Permian carbonate and volcanic conglomerate (Stikine "western" assemblage of Logan *et al*., 1990a) comprise for the most part southwest-dipping and facing (?) homoclinal panels west of the Newmont Lake graben. Folds and low-angle thrusts are disrupted by numerous high-angle faults.

DEFORMATIONAL HISTORY OF MESOZOIC STRATA

EARLY JURASSIC CONTRACTION (D_3) (CIRCA 185 Ma)

Third phase structures in the Paleozoic rocks are characterized by upright, open to tight, crenulation folds and kink bands. Fold axes generally plunge easterly, axial surfaces dip steeply south (Photo 4-6). Similar upright folds with chevron cores affect the Late Triassic Stuhini Group sedimentary rocks in the area, do not offset the map pattern of the rock units. Folds are sparse within the Stuhini Group; bedding commonly dips steeply but closures are rarely seen. Large-scale warps with km-scale wavelengths are common. Small-scale folds are brittle features, typically upright box folds with chevron cores.

Late Triassic rocks east of Mess Creek have steep westerly dips. Most of the variation in bedding attitudes in these rocks probably resulted from intrusion of the Loon Lake stock. Later high-angle listric faulting has further back-rotated the strata. Outcrop exposures are too poor to recognize large-scale folds but minor folds were observed in a small creek about 7 km southwest of Nahta Cone. Gently-dipping Early Jurassic conglomerate overlie the Late Triassic volcanic and intrusive rocks with angular unconformity northwest of Arctic Lake. The unconformity is also exposed at two locations east of Mess Creek; 5 km north and 2.5 km south of the Schaft Creek porphyry deposit (GS-Map, in back pocket). The angular unconformity suggests a period of post-Late Triassic tectonism, either block faulting or folding. A post-Late Triassic and pre-Hettangian angular unconformity, marked by a basal conglomerate, is located south of the map area in the Sulphurets area (Henderson *et al*., 1992). The presence of a basal conglomerate and the older age of the unconformity located at Sulphurets more closely corresponds to the relationships in the Mess Creek area. Brown and Greig (1990) describe folding in Triassic rocks beneath an angular unconformity with homoclinal Early Jurassic volcanic rocks to the north. The Toarcian age of the overlying volcanics constrains the upper limit of this contractional event (Brown *et al*., 1996).

Stuhini Group strata are folded about northerly trending structures interpreted to be Late Jurassic to Cretaceous in age, and therefore pre-date the development of the Skeena Fold and Thrust belt. These structures are tentatively correlated with the late Early Jurassic event recognized to the north (Brown *et al*., 1996).

Photo 4-6. West-trending, upright F_3 chevron folds developed in Early to Middle Devonian interlayered calcareous phyllite and chlorite sericite schists northeast of the Foremore property.

LATE JURASSIC TO TERTIARY CONTRACTION (D4A & D4B)

Mesozoic rocks underlie the majority of the area east of the Forrest Kerr fault. They comprise mainly fine grained tuff and sedimentary rocks of the Late Triassic Stuhini, Early Jurassic Hazelton and Middle Jurassic Bowser Lake groups. In most locations Mesozoic rocks contain variably developed cleavage. In general these fabrics strike northerly to northeasterly and have steep dips (Photo 4-7). Well-bedded sections are conspicuously folded. Open, upright folds with wavelengths up to several km vary from mainly north trending in the area north of More Creek to northwest and northerly trending south of More Creek. Folds are generally chevron or open box-folds and locally there are minor kink bands. Rarely minor folds are isoclinal. Most folds appear to be disharmonic with varying ax-

Photo 4-7. Well developed axial planar cleavage developed in Upper Triassic thin bedded siltstones and shales. The pencil (15 cm) is oriented parallel to cleavage.

ial-plane orientations and many are disrupted by high-angle faulting.

Paleozoic rocks east of the Forrest Kerr fault are restricted to a northeast-trending structural culmination located between the Iskut River and Forrest Kerr Creek. The rocks consist of thin bedded tuffaceous green and grey siltstone interbedded with lenses of grey Early Permian carbonate. These strata together with the overlying Triassic rocks are folded into large, upright, tight, east-trending structures. A south directed thrust fault (Kerr Bend fault, Read *et al*., 1989) defines the southern boundary of the culmination. If the north-south contraction responsible for folding also juxtaposed the Paleozoic and Triassic rocks on top of the Middle Jurassic pillowed basalts, then this phase of deformation postdates the Middle Jurassic. Alternatively if the thrusting reactivated older structures, the east-trending folds may be substantially older and correlative with east-trending structures in Paleozoic rocks in the Mess Creek area (D_3) .

SELECTED AREAS OF MESOZOIC STRATA

West of Mess Creek, Late Triassic rocks dip steeply to the southwest and northeast, suggesting either tight folding or large fault rotations. The paucity of bedding attitudes in much of the section hinders recognition of folding. No minor structures were observed in volcanic rocks, suggesting mainly brittle deformation. Tight noncylindrical folds do occur in well-bedded sandstone and tuff. Well-bedded tuff is drag folded into a shallow, open northwest-trending anticline against a normal fault, 5 km north of the Schaft Creek deposit.

In the More Creek area, folding close to the Forrest Kerr fault is tight, disharmonic and asymmetric; eastward it becomes progressively more open, away from the fault. Westerly trending chevron folds with decimetre amplitudes affect Late Triassic siltstone and sandstone north of More Creek. Orthogonal, north-trending km scale open, upright syncline and anticline pairs affect the Late Triassic strata underlying the area east of the Forrest Kerr fault and north of More Creek (Photo 4-8).

In the area between More and Downpour creeks, Early and Middle Jurassic tuffaceous siltstone, sandstone and volcanic rocks are folded into upright to inclined, open, chevron folds (Figure 4-3). Thinly layered, black and orange sandy phyllite is variably folded into southeasterly inclined folds. The bedding-cleavage relationships on the east limb suggest the beds are moderately to tightly folded indicating a syncline to the west. This synclinal structure is bounded on the west by the Forrest Kerr fault and a steep to easterly dipping fault structure on the east (Photo 4-9).

Pillowed basalt flows of the Salmon River Formation have no penetrative fabric, and pillow forms preserve their primary depositional forms. Interbedded siltstone is disharmonically folded. North of the confluence of Forrest Kerr Creek and Iskut River a large competent block of primarily pillowed flows and breccias is folded into a northeast-trending anticline, the Pillow Ridge anticline (Read *et al*., 1989).

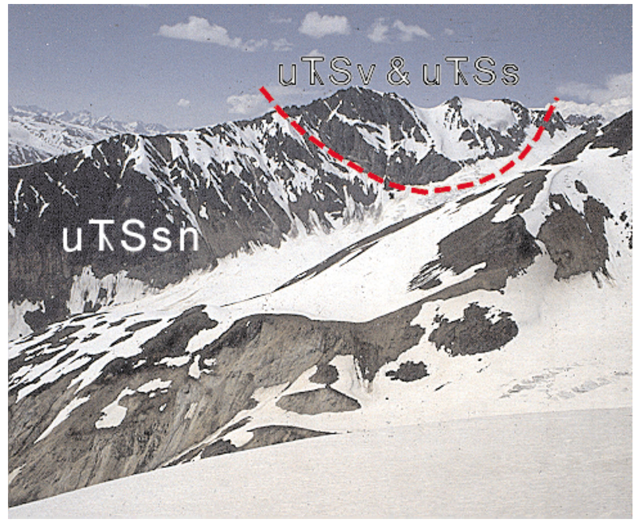

Photo 4-8. Upright, open north-trending syncline in Upper Triassic augite and feldspar-rich volcaniclastic sandstones, siltstones and limestone conglomerates north of More Creek, viewed north northwest. Gossan in foreground is developed adjacent to Early Jurassic or younger subvolcanic plugs at the Biskut showing.

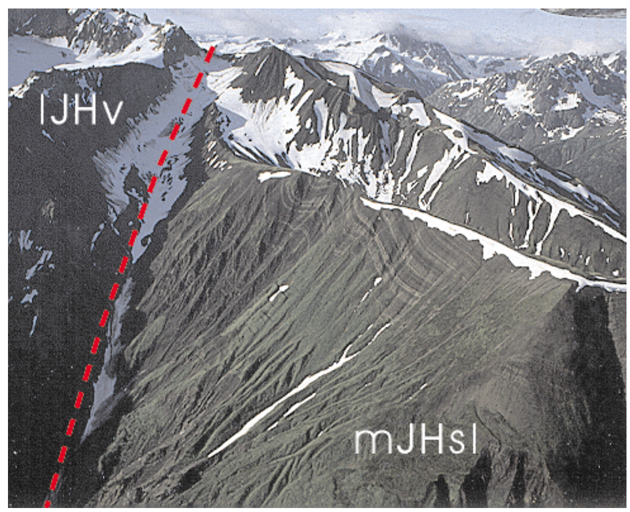

Photo 4-9. Gentle, upright north trending D_4 folds on east limb of the Downpour syncline. The syncline is cut by a steep north trending fault, viewed to the south.

South of the Iskut River, Bowser Lake Group shale and siltstone have a well-developed slaty cleavage. The cleavage is axial planar to north northeast-trending upright folds. The cleavage is refracted across interbedded sandstone beds. A second, west northwest-trending cleavage, orthogonal to the first is present in the shale and siltstone units southeast of the Iskut River. Bedding cleavage intersections have produced good pencil cleavage lineation in the shale beds.

AGE CONSTRAINTS (D_3 & D_4)

Placing age constraints on the post-Late Triassic and post-Jurassic folding and faulting is difficult. Late Triassic strata, and older rocks, in the Galore Creek area are folded about two virtually orthogonal axes. The earlier event is

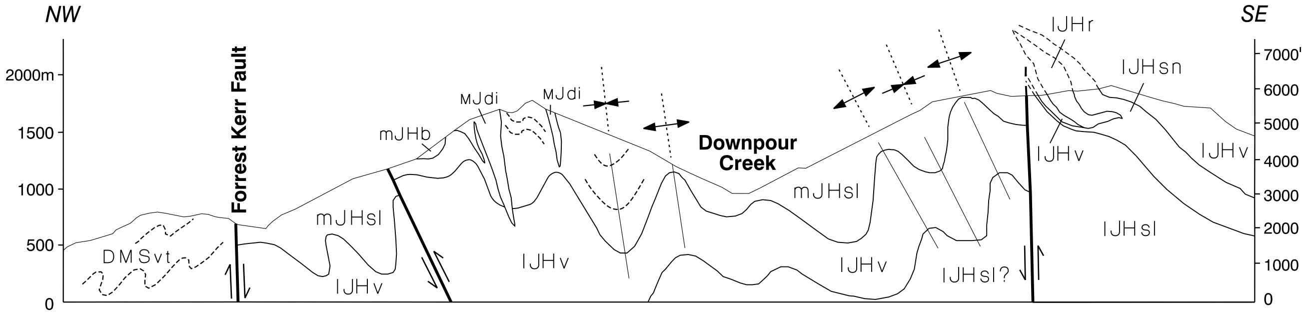

Figure 4-3. Schematic cross-section of the Lower to Middle Jurassic sedimentary and volcanic strata of the Hazelton Group, illustrating the synclinal form in the area between Downpour and More creeks. Folds are northerly trending, west-verging phase four structures. Unit designators and section line corresponds in part to Section O-P, on GS-Map, *in* back pocket.

characterized by northeast-trending folds, the later by north to northwest axial trends. Although these are apparently two phases of folding, no folded cleavages or folded folds have been observed (Logan and Koyanagi, 1994). Locally, north-trending folds progressively tighten westward into southwest-verging folds and thrust panels. The southwest-verging structures may represent back thrusting related to the overall northeast-directed compression recorded by the northeasterly vergent folds and faults in the northern Bowser Basin that are related to Late Jurassic to Early Cretaceous development of the Skeena Fold and Thrust Belt (Evenchick, 1991a,b).

Westerly trending chevron and kink band folds affect rocks as young as Late Triassic, their age is difficult to constrain, although they are older than north-trending open, upright folds and faults in the More Creek area. These phase 3 structures may have formed in response to Middle Jurassic deformation accompanying southward thrusting of Cache Creek Terrane onto Stikinia along the King Salmon fault (Souther, 1972).

Two orthogonal fold sets deform Middle to Late Jurassic Bowser Lake Group sedimentary rocks in the Forrest Kerr area; an early north to northeasterly trending set, and a later set trending west to northwesterly. Two main phases of contractional deformation affect the same overlap assemblage rocks northeast of the map area and caused development of the Late Jurassic to latest Cretaceous Skeena Fold Belt (Evenchick, 1991a,b). The first, an east-west compressional event of Late Jurassic to Early Cretaceous age resulted in east-directed thrusting. This was followed by deposition, derived from the east, of the lower Sustut Group. The second event, of Late Cretaceous to Tertiary age, developed east-verging thrusts and folds and was followed by deposition of the upper Sustut Group in the foreland of the eastward propagating Skeena Fold and Thrust Belt.

LATE TERTIARY STRUCTURES

The only Late Tertiary structures recognized in the area are north-trending extensional faults and possibly northeast-trending horst and graben structures. Many of these acted as conduits for eruption of Pliocene and younger tephra cones and basalt flows. These Tertiary structures are related to east-west extension and probably dextral translation on major north and northwesterly trending structures in the area (Figure 4-4).

FAULTS

Regional scale faults cross the study area and control the distribution and structural level of lithostratigraphic packages. The two main fault systems: the Forrest Kerr and Mess Creek fault zones, trend northerly (Figure 4-1). A conjugate set of near vertical northwest and northeast trending faults is also prominent. Some of the conjugate faults are cut by the younger north-trending faults, whereas others change direction and merge with the north-trending structures, thus relative timing of movement on these fault sets is not clear. Northeasterly faults form two complex, broad, but relatively restricted zones: on the west flank of the FKP, north of Newmont Lake and on the western flank of the MCP, west of Arctic Lake; they are important controls for mineralization. The current orientation of north-trending fault systems and northeast-trending extension structures is compatible with a dextral strike slip regime, a Cordilleran wide phenomena during the Cenozoic (Figure 4-4).

NORTH-TRENDING CONTRACTIONAL FAULTS

North-trending, west-dipping thrust faults with top-to-the east or southeast sense of motion were mapped west of Mess Creek (Holbek, 1988), and east of Forrest Kerr Creek (Read *et al*., 1989). A thrust fault which duplicates Carboniferous marble and sediments above Late Carboniferous conglomerate is tentatively interpreted for the area west of Newmont Lake. The thrust is marked by about 1 metre of sheared chloritic breccia at the base of thick mid-Carboniferous carbonate. Across the map area, interleaving of polydeformed with less deformed Paleozoic strata suggests the presence of other unrecognized thrust faults. This is probably the case in the area between the Forrest Kerr Pluton and Forrest Kerr fault and in the Mess Creek area.

The northerly trending West Lake and West Slope faults (Read *et al*., 1989), occur west of the Forrest Kerr fault in the southern part of the map area. They are folded, regional-scale structures characterized by low angle easterly-directed movement. Read *et al*. (1989) correlate the West Slope fault with similar low angle fault structures to the north in the Stikine Canyon area (Read, 1983, 1984). There the structures do not cut, and therefore predate, the Cretaceous Sustut Group rocks.

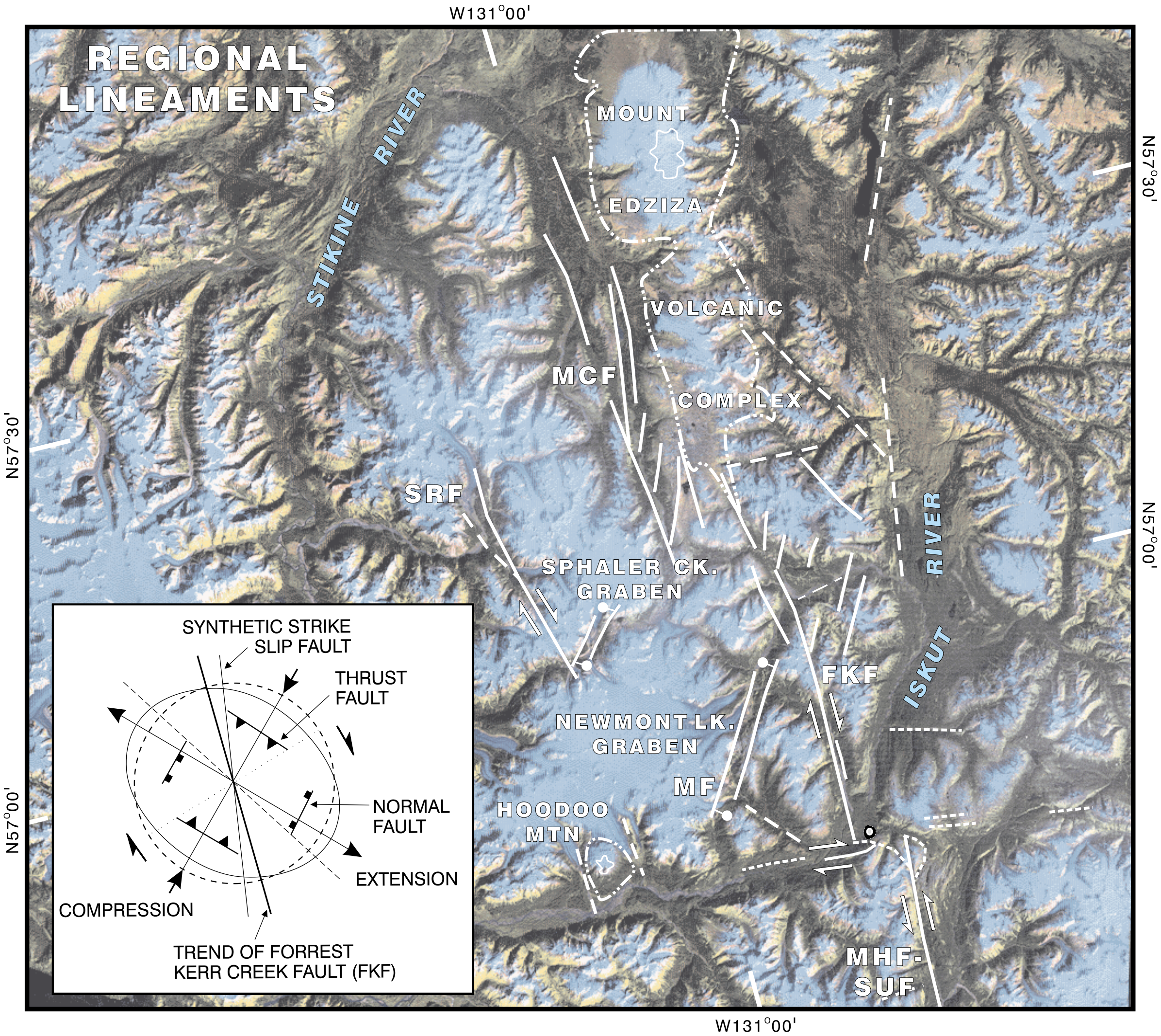

Figure 4-4. False colour enhanced, 1985-Landsat image (bands 3, 4 and 5) of the Stikine-Iskut rivers area with the dominant geographical and structural features added. Insert shows the structures formed after infinitesimal simple shear in a dextral strike slip fault zone. North-east-trending extensional features include the Newmont Lake and Sphaler Creek grabens. MHF-SUF = Harrymel/Melville South Unuk Fault, FKF= Forrest Kerr Fault, MF= McLymont Fault, SRF= Scud River Fault, MF= Mess Creek Fault.

WEST LAKE FAULT

The West Lake thrust fault, which extends north north-eastward for about 15 km from Lime Lake to Forrest Kerr Creek, dips moderately to the west (Figure 4-1). Early Devonian layered rocks and Late Devonian intrusive rocks in the hangingwall at the south and north end of the fault respectively, have moved southeast and east over Carboniferous rocks of the footwall (Figure 4-2, Photo 4-10). Discrete, narrow ductile strain zones define the thrust zone. Studies of deformed L_1 linear structures within F_2 folds indicate that the shear direction trends to the southeast at a high angle to the northeast-trending F_2 folds. Elsby (1992) interpreted this data, together with work by Read *et al*. (1989), and concluded that the latest movement on the West Lake thrust was directed toward the southeast.

WEST SLOPE FAULT

The West Slope fault extends for over 25 km from north of Forrest Kerr Creek to the Iskut River. It is a moderately steep, easterly dipping fault which trends northerly merging with the Forrest Kerr fault trace north of Forrest Kerr Creek (Figure 4-1). At its southern extent, in the Iskut River Canyon, Read *et al*. (1989) show the fault folded about the northeast-trending Canyon syncline. The fault juxtaposes Late Paleozoic rocks west of the fault with Early Permian carbonate and Late Triassic Stuhini Group volcanic and sedimentary rocks of the footwall, east of the fault. Strata west of the fault are thin bedded, well foliated siliceous siltstone and tuff which dip westerly. A near vertical, north-trending spaced fracture set cuts carbonate adjacent and east of the linear. The fault zone is marked by a several metre wide limonitic alteration zone. Alteration overprints and for the most part obliterates the zone but the fabrics developed along its length are brittle, sub-vertical spaced fractures.

EAST-TRENDING CONTRACTIONAL FAULTS

East-trending linears, faults and fractures traverse the map area, but are particularly abundant in the Iskut River

Photo 4-10. Deformed, intrusive contact between Late Devonian Forrest Kerr pluton (diorite phase) and Early to Middle Devonian carbonates, located west and above Forrest Kerr Creek. The top to the east-southeast sense of shear characterize the West Lake thrust zone in this area. Viewed to the north.

Valley where previous workers speculated on the presence of an Iskut River Fault zone (Figure 4-4). Possible post-Early Jurassic strike-slip displacement on this inferred fault is limited to less than 10 km by the Early Jurassic plutonic rocks which straddle the Iskut River at its junction with Forrest Kerr and McLymont creeks. The McLymont Creek pluton on the north side of the Iskut River is the same composition and age as the Lehto batholith located south of the Iskut River. The aeromagnetic survey map for the Dease Lake area shows a single anomaly encompassing both bodies.

The Kerr Bend thrust fault is an early, easterly trending fault that was later folded (Read *et al*., 1989). It extends easterly from the Iskut River to Forrest Kerr Creek (Figure 4-1). It carries Late Triassic and Paleozoic strata southward over pillowed basalts of the Middle Jurassic Salmon River Formation and shale of the Bowser Lake Group. A penetrative foliation is present in tuff of the hangingwall for up to 100 metres above the lower thrust contact with Middle Jurassic pillow basalt of the footwall. The fault predates formation of the northeast-trending Kerr Bend anticline, a second phase post-Jurassic, probable Early Cretaceous structure (Read *et al*., 1989), which deforms the eastern end of the thrust fault.

Another east-trending structure is interpreted to lie in the valley of More Creek. The structure extends east from Forrest Kerr fault and accommodates juxtaposition of Early to Middle Jurassic sedimentary and volcanic strata, which occur south of the river, with Late Triassic volcaniclastic and sedimentary rocks which underlie the area north of More Creek (Figure 4-1).

NORTH-TRENDING REGIONAL STRUCTURES

The north-trending valleys of the Iskut River and Mess Creek are believed to have been controlled by major fault zones that have undergone repeated movement (Souther 1972). The majority of north-trending normal faults probably developed during the Early Tertiary, when east-west extension controlled faulting, dike swarms and eruption of Sloko Group volcanic rocks in the Telegraph Creek area (Souther 1972, 1992; Brown *et al*., 1996). Extension continued after deposition of the Eocene strata with development of north-trending normal faults that bound horst and graben structures (*i.e.* Mess Creek graben). The main north-trending regional structures are probably crustal scale features which controlled the location of Neogene eruptive centres (Souther, 1992). However, some north-trending regional structures in the area were active in the Mesozoic. South of the Iskut River, U-Pb dating of syntectonic intrusions indicate that the South Unuk-Harrymel shear zone was active in the Middle Jurassic (J. Mortensen, personal communication, 1995, in Macdonald *et al*., 1996).

MESS CREEK FAULT

The north-trending Mess Creek fault zone lies along an abrupt topographic contrast between the rugged high peaks of Late Triassic volcanic and plutonic rocks on the west from the flat-lying Pliocene Edziza volcanic complex and Paleozoic basement rocks of the Arctic Lake plateau on the east. Unlike the relatively narrow Forrest Kerr fault zone, the Mess Creek fault comprises a zone up to 7 km wide that consists of a series of curvilinear north-trending faults that end near the headwaters of Mess Creek. Northeast-trending splays cross the ridge between Skeeter and Mess Lake valleys. The Mess Creek fault system has undergone repeated movement, beginning at least in the Late Jurassic and continuing into the Quaternary (Souther and Symons, 1974).

Motion along the north-trending fault zones has been complex and repetitive and this is borne out by the apparently contradictory sense of movement on many of these structures. The youngest motions recognized are normal. Net relative motion across the Mess Creek fault zone indicates two separate episodes of opposite-sense, normal movement in the Tertiary. The first episode uplifted rocks east of Mess Creek and the Skeeter Lake block relative to rocks to the west, the second had the opposite sense of displacement and rocks west of Mess Creek were uplifted relative to rocks to the east. Souther (1972) inferred substantial west-side-up motion on the Mess Creek fault system to explain the abrupt termination of the early Tertiary erosion surface. He recognized the gently west-dipping erosion surface on the east side of Mess Creek valley but not on the west side and concluded that the western side had been uplifted and eroded off. The youngest dated rock that the Early Tertiary erosion surface affects is the Elwyn Creek Pluton (53.1±2.4 Ma, K-Ar, biotite; Souther, 1992) and the oldest dated lavas of the Edziza volcanic complex that flowed over it are Late Miocene Raspberry Formation lavas. Thus the erosion surface developed between Early Tertiary and Late Miocene time. Uplift west of the Mess Creek fault, and ultimately erosion of this surface probably post-dates the Early Miocene. The present juxtaposition of Paleozoic rocks east of the fault zone with Late Triassic rocks to the west suggests an earlier east-side-up sense of motion. This episode brought rocks as old as Devonian to the surface prior to eruption of the Mount Edziza volcanic complex in the Late Miocene. Most of the movement was probably accommodated along faults presently lying in the Mess Creek and Schaft Creek-Skeeter Lake valleys. If the east-side-down motion on the Forrest Kerr fault coincided with early east-side-up motion on the Mess Creek Fault, the intervening fault blocks of Paleozoic plutons and layered rocks would have been positive horst structures in the Tertiary.

West of Arctic Lake the eastern margin of the Mess Creek fault zone is characterized by an anastamosing system of young listric fault blocks in which Early Jurassic rocks are preserved. The trace of the main listric fault is well exposed and runs along the edge of the Arctic Lake plateau from just south of Nahta Cone to west of Arctic Lake in the More Creek map area (Figure 4-1). The hangingwall has moved down and westward, tilting strata to the east. Hangingwall rocks comprise east-dipping Early Jurassic conglomerate, which unconformably overly an Late Triassic sequence of west-dipping (overturned) volcanic, sedimentary and intrusive rocks. Hangingwall rocks include west-dipping Early Permian carbonate north of Arctic Lake, and Early Mississippian tonalite of the More Creek pluton south of the lake. A maroon, quartz-porphyroclastic breccia unit is exposed along the entire length of the listric fault. It is an altered fault breccia unit developed variably in the footwall quartz tonalite and hangingwall conglomerate units.

The post-Early Miocene extensional episode uplifted rocks west of Mess Creek and Skeeter Lake along numerous faults located east of the creek. Uplift was young enough to affect the distribution of Eocene and younger rocks to the east, and to cause the dramatic difference in topography across Mess Creek. Souther (1970) concluded that movement occurred in at least three episodes between post-Pliocene time and 1340 years B.P. Normal faults which cut the volcanic rocks show progressively greater offset of the older flows, suggesting that they are syn-volcanic growth faults (Souther, 1992). East of Mess Creek, west-side-up faults repeat Early Permian stratigraphy south of Tadekho Creek. Drag folds in Early Permian limestone clearly indicate west-side-up movement along a north-trending structure in a creek bed, 4 km southwest of Exile Hill.

FORREST KERR FAULT ZONE

The north-trending Forrest Kerr fault system and corresponding regional lineament extends from the Iskut River to the north edge of the More Creek map area. It is a vertical to steep easterly dipping structure, on which the most recent fabrics (slickensides) indicate strike-slip displacement. In the south, north of the Iskut River, it follows Forrest Kerr Creek, where it separates Mesozoic volcanic and sedimentary rocks on the east from Paleozoic metavolcanic and metasedimentary rocks and Devonian granitic plutons on the west (Figure 4-1, 4-4, Photo 4-11). To the north, the fault zone bends northwesterly, crosses into the More Creek drainage and can be traced for another ten km after which it disappears beneath Pleistocene basalts of the Arctic Lake Formation in the valley of More Creek. From this point, the fault probably continues northward, although, Read *et al.* (1989) suggest the fault steps, en echelon, westward to the northerly trending faults in the Mess Creek Graben (Figure 4-4). The northern portion of the fault, in the More Creek area, separates similar stratigraphic packages; older rocks to the west, younger to the east. The stratigraphic distribution supports east-side-down movement for the fault in the Forrest Kerr and More Creek areas. Near the junction of Forrest Kerr Creek and the Iskut River, the presence of 2000 metres of Middle Jurassic pillow basalts east of the fault and none west of the fault suggests a minimum vertical displacement of 2000 metres east-side-down for the FKF (Read *et al.*, 1989).

The Forrest Kerr fault system (FKF) and the north-trending Harrymel/Melville fault (HMF), situated south of the Iskut River, were first mapped by Read *et al.* (1989). They discarded the possibility that the FKF is the offset northern extension of the HMF because they recognized opposite movement histories for each structure. They postulated at least a 2.5 km component of sinistral, oblique-slip motion on the FKF based on offset of the Pillow Ridge anticline and the West Slope anticline, its assumed extension west of the fault (Figure 4-1). South of the Iskut River, there are subhorizontal slickensides on the HMF, and an apparent 2.5 km offset of an intrusive contact indicates

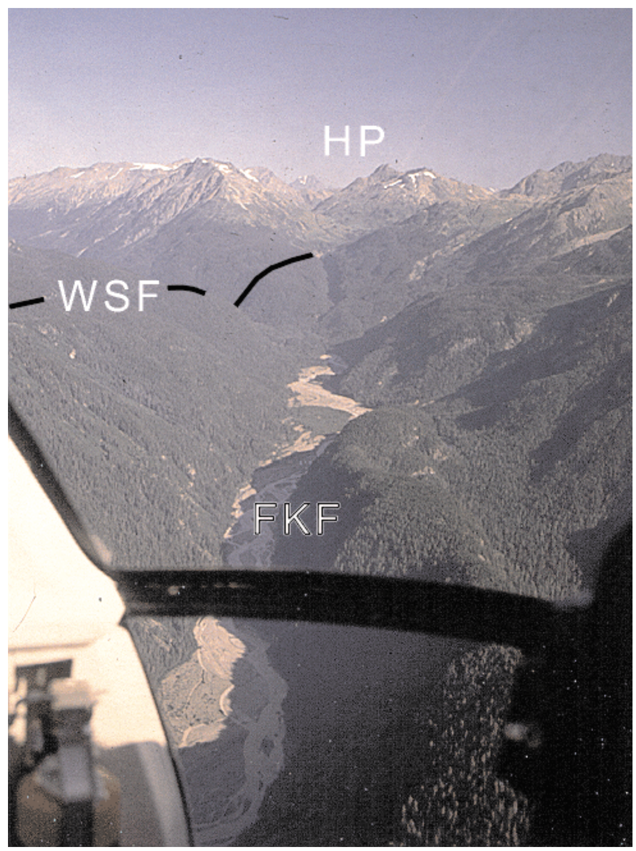

Photo 4-11. Looking north, from the confluence of Forrest Kerr Creek and the Iskut River along the trace of the Forrest Kerr Fault (FKF). The fault continues past the northwest bend of Forrest Kerr Creek, up into the hanging valley (area of Foregold showing) and northwards into the More Creek map-area where Hankin peak dominates the horizon. A narrowly defined linear converging northwards into the FKF from the west is the trace of the West Slope Fault.

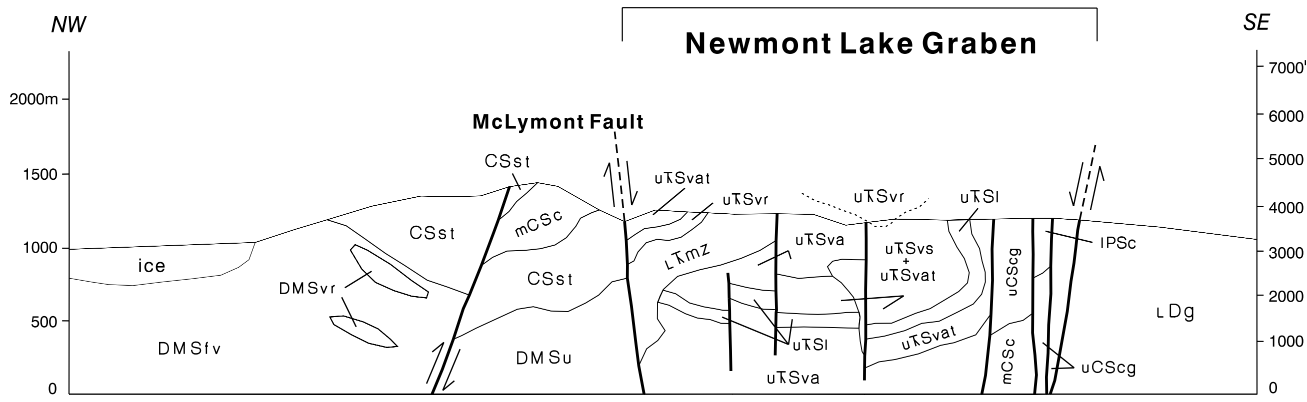

Figure 4-5. Schematic cross-section of the post-Upper Triassic Newmont Lake graben, illustrating the simple sharp western boundary defined by the McLymont Creek fault and the complex multiply-faulted eastern boundary which abuts the Forrest Kerr pluton. Folds in the graben are northeasterly trending, open warps. Unit designators and section line corresponds in part to Section U-V, on GS-Map, *in* back pocket.

that the fault had a dextral strike-slip component of motion (Read *et al*., 1989). Other workers have traced the HMF structure south along the Unuk River where it is referred to as the South Unuk-Harrymel fault system. Near Lee Brant Creek, along the east flank of the South Unuk River valley, Lewis (1992) mapped mesoscopic kinematic indicators associated with sub-horizontal stretching lineations which consistently show a component of sinistral shear. At its north end the structure is a narrow brittle shear zone, but it widens to more than 2 km in the south, where it accommodates up to 20 km or more of sinistral strike-slip displacement. The South Unuk-Harrymel shear zone was active in the Middle-Jurassic (Macdonald *et al*., 1996).

Mapping along the Forrest Kerr fault system is, for the most part, hampered by poor exposure. The southern trace of the FKF occupies the valley of Forrest Kerr Creek, where it is covered by overburden. North of Forrest Kerr Creek the fault is not a discrete structure, but a zone from 500 up to 1000 metres wide containing numerous fault planes. In the vicinity of the headwaters of Downpour Creek, where the faults are narrow to metre-wide brittle limonitic fault zones they controlled fluid flow and rock alteration. Air-photo linears and north-trending parallel features mark the trace of individual structures. Slickensides measured on a fault plane south of More Creek plunge gently to the south and indicate a dextral strike-slip component to latest movement. Further north and east of More Creek, the fault zone is marked by a highly fractured zone extending over 200 metres west into the hangingwall granite of the More Creek pluton and possibly a greater distance eastward into black siliceous clastics of the footwall rocks. Both fracture surfaces and the faulted contact dip steeply west and strike northerly to northwesterly. Anastamosing brittle chlorite filled fractures pervade the intrusion. Chlorite, serpentine and calcite coat bedding parallel slip planes and fracture surfaces in siltstone and sandstone east of the fault. No consistent sense of motion could be established for the structure at this location. At the headwaters of More Creek (Figure 4-1), in hangingwall rocks east of the main fault trace is a 2.5 km wide zone of discrete narrow brittle faults and north-trending zones of fractured rock. The faults crosscut north northeast-trending folds and therefore are late syn- to post-folding. Displacements range from 10's to less than 100 metres. The relationship of these faults to the Forrest Kerr structure is not clear.

AGE CONSTRAINTS

Recent lava flows in the Iskut River canyon are dated at about 70 000 years old (K-Ar), near the base and overlying basalts are dated at 8730 years old by carbon 14 methods (Hauksdottir *et al*., 1994). The FKF does not apparently displace these lavas. Further north, normal faulting on different structures has displaced Edziza flows as young as 20 000 years old but do not offset basalt flows erupted 1340 years ago (Souther, 1970). The spatial association of Recent volcanic centres with north-trending structures is well documented and the deep-rooted nature of these structures is evidenced by the peralkaline nature of the Mount Edziza volcanic complex (Souther and Symons, 1974), which is typical of melts produced by crustal rifting.

EXTENSIONAL FAULTS: GRABEN STRUCTURES

NEWMONT LAKE GRABEN

The Newmont Lake graben is a 3 km wide northeast-trending post-Late Triassic structure (Figure 4-1). It extends 20 km northeastward from McLymont Creek and demarcates the faulted northwestern contact of the Forrest Kerr Pluton. The structure appears to separate the Forrest Kerr pluton from the More Creek pluton at its northern extent, then apparently ends 5 km east of the Forrest Kerr Fault system. The eastern boundary of the graben consists of a one km wide zone of intersecting northeast and north-trending high-angle faults (Figure 4-5). Faulted slivers of Early Permian carbonate, Late Carboniferous conglomerate and Devonian to Early Carboniferous volcanic rocks are caught up in this zone which separates the FKP from Late Triassic rocks of the graben. In addition, east of the major graben-bounding fault is a small panel of mid-Carboniferous carbonate. It lies either in unconformable contact with the Late Devonian FKP or more likely in faulted contact. Early Permian carbonate and volcanic rocks at the south end of the graben are mainly homoclinal and compose southwest-dipping fault blocks. The McLymont Fault bounds the structure to the west. It is a single, strong, 040 degree trending structure that separates middle and Late Carboniferous strata (to the west) from Late Triassic strata within the graben. The dip of the fault is steep, but the direction is unknown.

The McLymont fault truncates northwesterly-trending folds in older rocks to the west. The same northwest-trending folds and strata are present on the eastern edge of the graben. Late Triassic rocks in the graben are folded about northeast-trending axes, parallel to the length of the graben, but orthogonal to folds in the adjacent older rocks. The northeast-trending folds and faults are cut by northerly-trending structures. Ray *et al*. (1991) interpreted these to be second-order splay faults off the main northeast-trending structure. Slickensides on one of these north-striking, steep east-dipping structures plunge steeply east. Subhorizontal slickensides and the progressive northward displacement of segments of an east-trending, undated

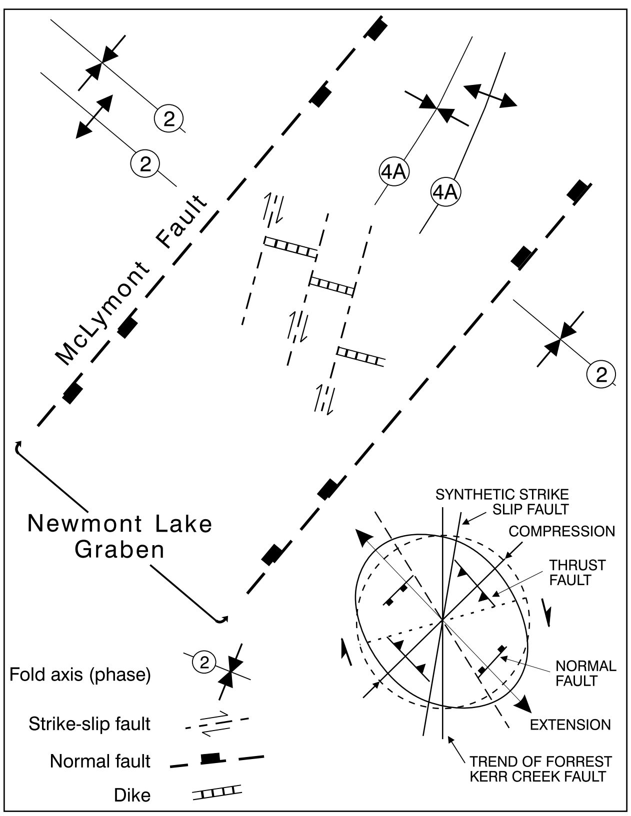

Figure 4-6. Schematic plan of the Newmont Lake graben, bounded on the northwest by the McLymont Creek fault and the southeast by an unnamed structure. The orientation of pre-Mesozoic (2) and post Late Jurassic (4) fold axes are shown and a late lamprophyre dike which illustrates dextral displacement along north-trending faults within the graben. Insert shows the structures formed after infinitesimal simple shear in a dextral strike slip fault zone.

lamprophyre dike indicate a dextral sense of motion on north-trending structures in the graben (Figure 4-6).

Ray *et al*. (1991) also recognized a series of younger east-trending faults which offset the north-trending structures. Slickensides indicate subhorizontal dextral motion. If these are the same generation as the east-trending fracture zones and linears exposed in the Iskut River valley then a dextral sense of motion is indicated for these features also. Read *et al*. (1989) documented right lateral motion in excess of 4 km on the east to northeast trending Lehto Creek shear zone, located south of the Iskut River.

The McLymont Graben structure is an extensional feature, that contains deformed strata as young as Late Triassic in age. It trends northeasterly, and is cut by a series of north-trending dextral shear faults (synthetic Reidel shears) that crosscut the graben. Dip and strike-slip motion is evident along these later structures, with offsets of no more than tens of metres.

SPHALER CREEK GRABEN

A second northeast trending graben structure occupies the headwaters of Sphaler Creek, 10 km west of the More Creek Sheet (Figure 4-4). The Sphaler Creek graben is 1.5 to 2 km wide at its southern terminus adjacent to the South Scud River fault (Logan and Koyanagi, 1994), but its northeastern extension is poorly constrained. Bounding structures are subvertical to northwest dipping and cut Late Carboniferous and older metavolcanic and metasedimentary rocks, Mid- to Lower Carboniferous carbonates and Devonian to Early Carboniferous metavolcanic and metasedimentary rocks. Strata preserved within the graben include little deformed, well-bedded maroon potassium feldspar tuff, accretionary lapilli tuff, rhyolite, volcanic conglomerate, shale and sandstone of Triassic and (?)Early Jurassic age, resting on a basement of polydeformed carbonate of probable Early Permian age. Northwest-trending, northeast verging folds affect rocks in both the graben and the surrounding area, indicating that graben formation postdated Late Jurassic to Cretaceous northeast-directed compression.

MESS CREEK GRABEN

The Mess Creek Graben comprises a mosaic of fault-bounded blocks which underlie the Mess and Schaft creek valleys (Figure 4-1). It is controlled by north and northeast trending sets of faults. A zone 1 to 3 km wide of north-northeast-trending listric normal faults exposed along the east side of Mess Creek have produced a sharp, abrupt escarpment on the east side of the creek and apparently controlled alteration and copper-gold mineralization on the Bam 8 and Bam 10 properties, southwest of Arctic Lake. This graben is identical in setting to the graben structure at Newmont Lake. The faults cut rocks as young as Jurassic and in both areas they contain mineral prospects characterized by Early Jurassic mineral assemblages (Au-Cu-Ag-As±Pb-Zn).

METAMORPHISM

The majority of rocks in the map area have undergone sub-greenschist grade metamorphism. Primary textures are preserved in the Mesozoic and younger rocks but early structures and related penetrative foliations (S_1 and S_2) have obliterated primary textures in most of the Paleozoic strata. Panels of undeformed, weakly metamorphosed Paleozoic volcanic rocks occur in an area located south of Mess Creek, north of Newmont Lake and west of the two main Paleozoic plutons.

The sub-greenschist to greenschist-grade metamorphism is synchronous with the earliest deformation in the area and metamorphism peaked during D_1 deformation. Fine grained schists contain synkinematic mineral assemblages of sericite-muscovite-chlorite-calcite and epidote. Early formed quartz veins are deformed and recrystallized. Phyllitic argillite west of Round Lake contains a muscovite-chlorite-albite-epidote metamorphic assemblage, mafic tuff contain a chlorite-tremolite-albite-carbonate assemblage. Micaceous minerals define cleavage planes and are synkinematic. The crenulation cleavage (S_3) is a brittle feature which deforms the earlier fabric and postdates metamorphism.

CONODONT COLOUR ALTERATION INDICES

Colour alteration indices (CAI) for 67 Devonian to Late Triassic conodont samples collected from the area were determined by M. J. Orchard, in the course of microfauna identification. Results from the Forrest Kerr map area were published, together with data from the Galore Creek, Scud River and Chutine River areas in Brown *et al*. (1991). Conodont colour alteration indices provide a thermal history of the strata and an index to thermal maturation in the region. Results indicate that conodonts and host strata have experienced a wide range of temperature conditions (Figure 4-7). There is no simple correlation between age and CAI values, and therefore no evidence for a single thermal event, although the Early to Middle Devonian conodonts show consistently higher CAI values than the mid-Carboniferous samples. However, the higher temperatures experienced by these older rocks is probably related to high heat flow linked to emplacement and cooling of the Forrest Kerr and More Creek plutons not to a regional thermal event. Anomalously low CAI values were obtained from Mid-Carboniferous and Early Permian limestone from the Newmont Lake and Forrest Kerr glacier areas. The values are substantially lower than those from correlative polydeformed strata located at Round Lake which have been subjected to temperatures 100 to 150°C higher (Brown *et al.*, 1991). Isolated, high CAI values for Permian and Triassic strata occur adjacent to intrusive bodies.

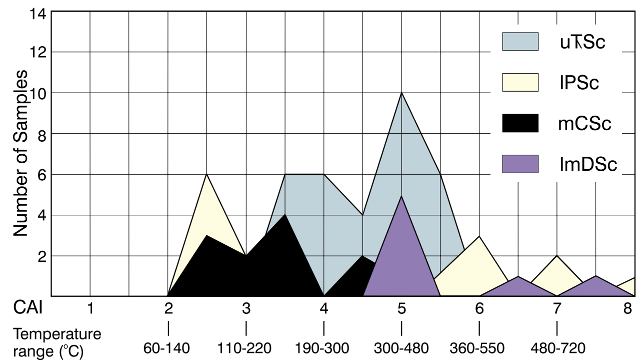

Figure 4-7. Histogram showing the distribution of CAI values relative to age. Temperature ranges are from Epstein *et al*. (1977) and Rejebian *et al*. (1987).

SUMMARY

Polyphase deformation affects rocks in the study area that are older than Late Cretaceous. The complex structures that resulted, reflect not only polyform deformation, but also competency contrasts between the volcanic and sedimentary units. Penetrative planar fabrics are ubiquitous in Paleozoic strata, are rare in Late Triassic rocks and often only a single phase of brittle deformation is recorded in the younger rocks. Deformation intensity and styles vary across the study area, for example, on one side of the Forrest Kerr (FKP) and More Creek (MCP) plutons to the other, and on either side of the Forrest Kerr and Mess Creek fault zones; reflecting changes in stratigraphy and structural depth across these features. East of the FKP all Paleozoic rocks are penetratively deformed. Generally, Early and Middle Devonian rocks west of the Forrest Kerr fault are affected by two earlier penetrative cleavages that are not present in Mesozoic rocks east of the fault. The overall intensity of deforma-

TABLE 4-2

STRUCTURAL FEATURES IN THE FORREST KERR-MESS CREEK AREA

Timing	Event	Regional Tectonic Events	Structural Regime	Fold Styles	Planar Structures	Orientation Fold Planes	Area
Devono-Mississippian	D1	Antler -Ellesmerian	Compression	Isoclinal rootless minor folds	axial planar foliation (S1)	Variable	West of Forrest Kerr and Mess creeks
pre-Late Triassic	D2	Tahltanian - Sonoman	Compression	Similar, isoclinal folds	axial planar foliation (S2)	Northwest	West of Forrest Kerr and Mess creeks
Early Jurassic	D3		Compression & Uplift?	Upright chevron to kink band	crenulation cleavage (S3)	West	Northwest Iskut River, Mess Creek
Late Jurassic to Tertiary	D4A	Skeena Fold	Compression	Upright, open folds	axial planar cleavage (S4)	Northeast to north	East of Forrest Kerr fault
	D4B	Belt		Upright chevron	crenulation cleavage	Northwest	Southeast Iskut River
Late Tertiary / Post-Eocene			Transpression	?	crenulations	East	

tion west of FKP increases northward from Newmont Lake to the headwaters of Mess Creek. Carboniferous and Permian rocks in the southern Forrest Kerr area are only weakly deformed whereas Devonian and Early Carboniferous rocks around Mess Creek show up to four phases of deformation. The variable degrees of strain in the Devonian to Carboniferous rocks reflect: an early pre-middle Carboniferous phase of deformation; strain partioning due to lithological heterogeneity throughout the succession; and probable unrecognized thrust faults which have interleaved undeformed rocks with more deformed rocks. Mesozoic rocks east and west of the Forrest Kerr fault show at least two phases of macroscopic folding. The anisotropic deformation of Mesozoic rocks reflects contrasts between the competent volcanic and the less competent folded sedimentary units.

Macroscopic folds in the area comprise an early westerly trend, a northerly trend, and a late northwesterly trend. These structures deform earlier synmetamorphic, Paleozoic structures and related northwest-dipping penetrative foliations. Early and middle Devonian rocks in the map area display up to four phases of folding and deformation. Mid-Carboniferous to Early Permian rocks record as few as two phases of deformation, whereas the Late Triassic and Jurassic strata record no more than two phases of deformation in addition to a regionally important post-Norian unconformity. From these relationships, four possibly five episodes of deformation are interpreted in the study area (Table 4-1): pre-middle Carboniferous contraction? (D_1), pre-Late Triassic contraction (D_2), Early Jurassic contraction(?) event (D_3), Late Jurassic to Tertiary contraction (D_{4A} & D_{4B}), and Late Tertiary transpression. The timing of many structural features and their inter-relationships are poorly constrained. It is likely that some structures, albeit with different orientations, may have formed during a single episode and do not necessarily represent two separate events. In addition, it may be erroneous to correlate regional unconformities with periods of contractional tectonism.

McClelland *et al*. (1993) interpret the earliest deformation event and structures to be mid-Devonian in age, based on observations of schistose rocks around Lime Lake. This event would correspond to the Antler Orogeny of the southwest U.S. and Ellesmerian Orogeny to the north in the arctic. The second phase is post Early Carboniferous and pre-Middle Triassic. It is uncertain whether the second phase of deformation precedes or corresponds to the Tahltanian or Sonoman Orogeny (Souther, 1971; Wyld, 1991) at the Permo-Triassic boundary. The angular unconformity recognized in the Mess Creek area and brittle structures developed predominantly in the Paleozoic strata (D3) may correspond to an Early Jurassic phase of contractional? deformation recognized to the north (Brown *et al*., 1996) and south (Henderson *et al*., 1992) of the map area. Two additional phases (D_4) are evident in the Middle Jurassic to Cretaceous Bowser Lake sedimentary rocks. These two events are thought to be Late Jurassic to Early Cretaceous and Late Cretaceous to Tertiary, respectively, and to correspond with deformation related to development of the Skeena Fold and Thrust Belt (Evenchick, 1991a). A final period of east-west extension and northerly translation is interpreted to post date the Eocene.

CHAPTER 5 ECONOMIC GEOLOGY

INTRODUCTION

The Forrest Kerr - Mess Lake area lies within an important base and precious metal-rich part of Northwestern British Columbia, termed the "Golden Horseshoe" (Lefebure, 1991). The Horseshoe extends north from Alice Arm to the Taku River, east of the Coast Belt, and wraps back around the northwestern edge of the Bowser basin as far east as the Toodoggone River (Figure 5-1). This metallotect is underlain predominantly by Late Paleozoic and Mesozoic volcanic and plutonic rocks of the Stikine terrane and is characterized by metal deposits related to island-arc volcanic centres. Mineral deposits commonly found in island arc settings include porphyry, intrusion-related (*i.e.* mesothermal) vein, metasomatic skarn, epithermal vein and volcanogenic massive sulphide deposits of the Kuroko type. Regional examples of these deposit types are found in northwestern Stikinia (Figure 5-1). Porphyry copper deposits in the area include both the alkaline copper-gold-silver (Galore Creek) and calcalkaline copper-molybdenum-gold (Schaft Creek) types. Early Jurassic intrusion-related, gold-silver quartz veins are shear-hosted at the Snip gold mine and extensional vein structures at the past producing Stonehouse deposit (Johnny Mountain Gold Mine). The largest epithermal silver-gold deposit in the province is the Premier mine, formerly the Silbak Premier mine in the Stewart area. Tulsequah Chief is a Kuroko type volcanogenic gold-silver-zinc-copper-lead massive sulphide deposit located in the Tulsequah area of northwestern Stikinia. In 1996, the volcanogenic massive sulphide Eskay Creek mine was the sixth largest silver producer in the world, and one of the highest grade gold and silver deposits ever discovered in North America (Schroeter, 1997). At the Golden Bear property (Carlin-type deposit) 6780 kg of gold was recovered from underground and open-pit mining between 1989 and 1994; and in 1997 began producing gold from heap leach pads on site 75 km northwest of Telegraph Creek.

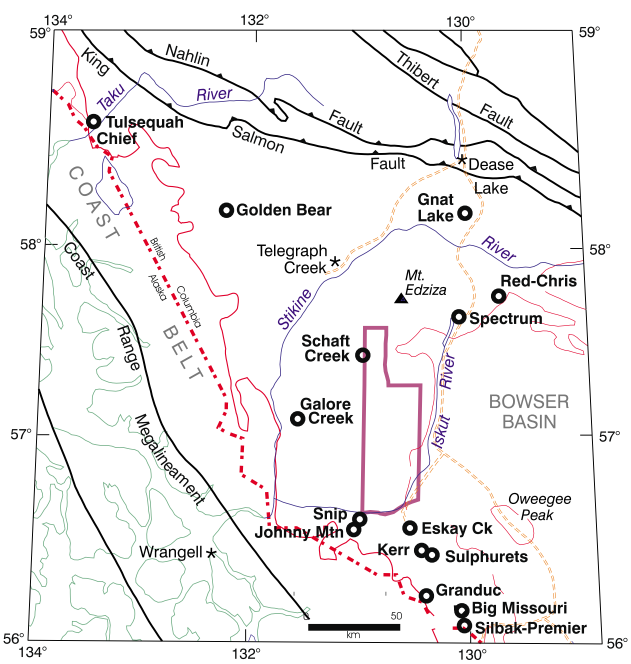

Figure 5-1. Location of map area relative to the major tectonostratigraphic features of the northwestern Cordillera (modified from Wheeler and McFeely 1991), showing regionally significant mineral occurrences.

No past production is recorded for the map area although large copper, gold and molybdenum mineral inventories are defined at Schaft Creek (971 495 000 tonnes grading 0.298 %Cu, 0.033 % MoS_2, 0.14 g/t Au and 1.20 g/t Ag; Spilsbury, 1995) and Galore Creek (Central zone: 233 900 000 tonnes grading 0.67 %Cu, 0.35 g/t Au and 7.0 g/t Ag; Enns *et al*., 1995) porphyry deposits.

Mineral deposits and prospects in the Forrest Kerr - Mess Lake area can be grouped into four main categories: calcalkaline Cu-Mo-Au and alkaline Cu-Au porphyries; Cu- and Cu-Au skarns; subvolcanic Cu-Ag-Au (As-Sb) fault and shear-hosted veins and carbonate hosted replacement; and stratiform volcanogenic massive sulphide and carbonate hosted (?Irish-type) Zn-Pb-Ag deposits. The distribution of mineral occurrences in the map area (except stratiform types) shows a direct correlation with north and northeast striking faults and Late Triassic to Early Jurassic intrusive rocks (Figure 5-2). Porphyry deposits, subvolcanic veins and carbonate hosted replacements are centered around the Loon Lake Stock, in the Schaft and Mess creeks area, and north of More Creek. Skarn occurrences are distributed along northeast trending faults west of the Forrest Kerr Pluton (FKP). Fault and shear hosted vein showings are localized along the prominent, north-trending Forrest Kerr Fault zone between More and Forrest Kerr creeks, and northeast of McLymont Creek east of the FKP, and along the northeast-trending bounding structures of the Newmont Lake Graben, west of the FKP. The stratiform massive sulphide deposits are hosted in Devonian to Mississippian volcanic rocks located near the headwaters of Mess Creek. These types of deposits can be modeled into one generalized hydrothermal system; each represent different sites (from deep, intermediate to near surface) and ore-forming environments within it.

Mineral occurrences from the map area are classifed according to these four main deposit types: porphyry, skarn, subvolcanic vein and stratiform. Important subgroups are described below and individual occurrences are summarized in Table 5-1.

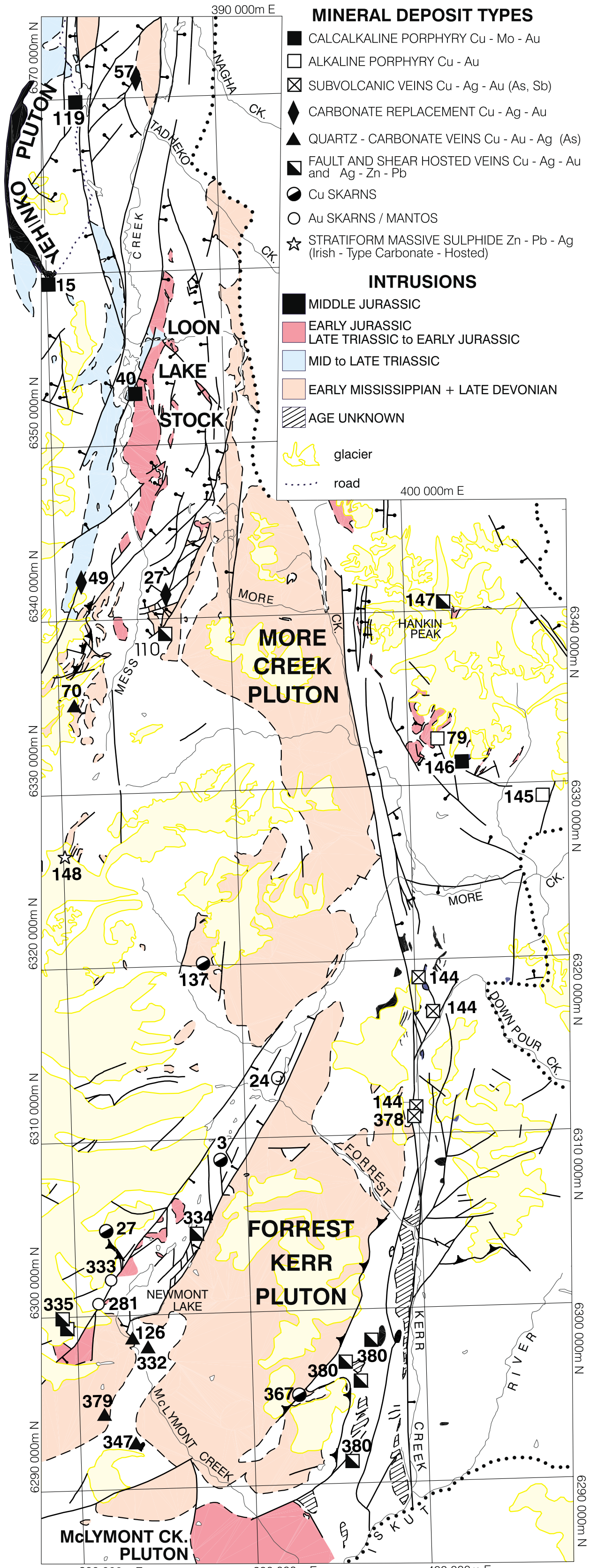

Figure 5-2. Distribution of mineral occurrences recorded in the MINFILE database and the spatial relationship to intrusive rocks in the project area. Numbers and symbols correspond to Table 5-1.

COPPER-GOLD PORPHYRY DEPOSITS

Alkalic porphyry copper-gold deposits occur throughout the length of the Intermontane Belt in both Stikinia and Quesnellia. They are restricted to Late Triassic and Early Jurassic volcanic island arc assemblages of the Nicola, Takla and Stuhini groups and form a class distinct from the calcalkaline porphyry deposits with which they are interspersed. The alkalic-suite deposits are copper-gold resources enriched in silver and deficient in molybdenum (Sinclair *et al.*, 1982; McMillan *et al.*, 1995). In contrast, calcalkaline porphyry deposits are copper-molybdenum with generally low gold. However, both types may carry significant gold values (Sillitoe, 1989a,b). Schaft Creek with reserves of almost 1 billion tonnes, contains 120 tonnes gold and is one of these gold-rich calcalkaline porphyry deposits.

The alkalic-suite deposits are associated with subalkaline to alkaline and shoshonitic volcanic rocks and comagmatic, high-level alkaline intrusions (Barr *et al.*, 1976; Panteleyev, 1976). Crowded feldspar porphyritic textures are characteristic of both the intrusives and the volcanics; pyroxene-phyric basalts are typical. The calcalkaline suite deposits are associated with deep-seated to high-level felsic intrusions of calcalkaline affinities.

Porphyry deposits in the map area include both the calcalkaline Cu-Mo-Au (Schaft Creek) and alkaline Cu-Au-Ag (Galore Creek) types. To the east, in the Coast belt, the Ben deposit is a calcalkaline Mo-only type (Brown *et al.*, 1996). These deposits are hosted in the Late Triassic, Stikine Plutonic Suite; the Late Triassic to Early Jurassic, Copper Mountain Suite; and the Eocene, Hyder Plutonic Suite respectively (Woodsworth *et al.*, 1991; Anderson, 1993). Schaft Creek and Galore Creek deposits have characteristics of the Volcanic-type porphyry copper deposit classification of Sutherland Brown (1976); the Ben is a Classic (stock-related) type.

CALCALKALINE PORPHYRY Cu-Mo-Au

SCHAFT CREEK (MINFILE 104G/15)

The Schaft Creek porphyry copper-molybdenum deposit is situated at the western edge of the map area, at an elevation of 1000 metres on the west-facing slope above Schaft Creek (Figure 5-2, Photo 5-1). Access is by fixed wing aircraft to a 1000 metre long gravel airstrip in Schaft Creek valley. Since its discovery in 1957, successive drill programs by Silver Standard Mines Ltd., American Smelting and Refining Company, Hecla Mining Company and Teck Corporation, the present owner, have tested the property. The deposit is classified as a high-level calcalkaline volcanic porphyry (Linder, 1975; Fox *et al.*, 1976). Reserves are 971 495 000 tonnes grading 0.298 %Cu, 0.033 % MoS_2, 0.14 g/t Au and 1.20 g/t Ag (Spilsbury, 1995).

The geology of the deposit is complex and it is poorly exposed. Regional mapping enabled us to trace stratigraphy along ridges from the north and south into the deposit area, but the reader is directed to Linder (1975) and Fox *et al.* (1976) for detailed discussions of the stratigraphy and gene-

TABLE 5-1
SUMMARY OF MINERAL OCCURRENCES

MINFILE 104G/B	NAME	NTS MAP	UTM EAST	Zone 09 NORTH	HOST ROCKS	COMMODITY	DESCRIPTION	REFERENCES
CALCALKALINE PORPHYRY Cu-Mo-Au								
15	SCHAFT CREEK	104G/06	378130	6359530	uTrSvb, uTrSvt uTrSpp, LTrmz	Cu, Mo, Au, Ag	Disseminated and fracture-controlled chalcopyrite, molybdenite, gold and silver mineralization is related to a high-level intrusive complex of felsic to intermediate dike swarms and a breccia pipe. Mineralization is discordant to volcanic stratigraphy. Mineable reserves of 971 million tonnes grading 0.298% Cu, 0.033% Mo, 0.14 g/t Au and 1.20 g/t Ag.	Linder (1975), Fox *et al* . (1976) Spilsbury (1995)
040, 041	RUN MIX, RUN NORTH	104G/07	382914	6353186	uTrSvt, LTrmz	Cu, Au, Mo	Chalcopyrite, magnetite and pyrite disseminations and molybdenum in fractures, selvages and in quartz veinlets and cut crowded plagioclase porphyries and mafic volcanic rocks. Steep fracture and breccia zones control mineralization.	EMPR ASS RPT # 3,093 (Gutrath 1971) EMPR ASS RPT # 6,162 (Cloutier 1976) Panteleyev (1973)
118,119	BB 5, BB 37	104G/07	379476	6369955	uTrSvb, LTrpd uTrSvt, uTrSpp	Cu	Trace amounts of disseminated chalcopyrite, magnetite, pyrite and bornite occur in fractured and sheared propylitic andesite, augite porphyritic diorite and monzodiorite.	EMPR ASS RPT # 3,640 (House 1971)
146	BISKUT, VOIGTBERG	104G/02	401665	6332020	uTrSsn, lTrs EJmz	Au, Au, Cu Pb, Zn	NE-trending quartz-sericite-pyrite-clay alteration zone (300m x 50-100m wide) associated with feldspar porphyritic stocks and feldspar megacrystic dikes. Original textures obliterated by supergene leaching. Contains up to 5% pyrite, minor galena and arsenopyrite. Narrow, quartz-carbonate breccia veins containing Ag-Cu with Zn and Pb occur peripheral to the main gossan. 1996 Drilling (3 holes, 456m) intersected potassium feldspar-carbonate-sericite-pyrite altered volcanic rocks containing an average of 0.26 g/t Au.	EMPR ASS RPT # 19,605 (Brown, 1990) EMPR ASS RPT # 23,117 (Smith, 1993) EMPR ASS RPT # 24,189 (Kemp, 1995) EMPR ASS RPT # 24,937 (Gunning, 1996) Wojdak (1997)
ALKALINE PORPHYRY Cu-Au								
79	LITTLE LES, TWO MORE	104G/02	399978	6333215	uTrSs. lTrs Ejmz, Ejd	Cu, Au, Ag	Disseminated and fracture-controlled chalcopyrite mineralization in a pyritic-propylitic alteration zone (300m x 25m) associated with potassium feldspar porphyry syenite dikes. Grab sample; 13.1 g/t Au and 5.9 % Cu. Chip sample over 5.4m; averaged 2.57 g/t Au 1.65 % Cu.	EMPR ASS RPT # 9,041 (Folk, 1981) EMPR ASS RPT # 20,667 (Bobyn, 1990) EMPR ASS RPT # 21,529 (Bobyn, 1991)
145	LUCIFER	104G/02	406350	6330115	uTrSv. lTrs uTrSs	Cu, Au	Structurally controlled propylitic alteration zone (1 x 2 km) coincident with potassium feldspar porphyry syenite dIke swarm. Mineralization includes chalcopyrite, galena and gold in quartz-carbonate pyrite veins.	EMPR ASS RPT # 21,091 (Baerg and Wong, 1991)

TABLE 5-1 CONTINUED
SUMMARY OF MINERAL OCCURRENCES

MINFILE 104G/B	NAME	NTS MAP	UTM EAST	Zone 09 NORTH	HOST ROCKS	COMMODITY	DESCRIPTION	REFERENCES
Cu SKARNS								
3	DON, DON 12, DON 40	`	388330	6309900	lPSc, LDd	Cu,Ag	Skarn mineralization occurs near the contact between Lower Permian carbonate and a Late Devonian diorite intrusion mineralization includes disseminated pyrite, chalcopyrite,and tetrahedrite.	EMPR ASS RPT # 443 (Gutrath, 1962) EMPR ANNUAL RPT 1963 (Bapty, 1964)
24	MAG	104B/15	391142	6313807	lPSc, LDd	Cu	Magnetite skarn occurs near the contact between Lower Permian carbonate and a Late Devonian diorite intrusion; mineralization consists of massive magnetite with minor pyrite and chalcopyrite.	
27	KEN, DIRK, GLACIER, ROPE	104B/15	381254	6305008	uCScg, mCSc	Cu, Ag, Au	A 1m up to 9m wide, NE-trending, SE-dipping conformable skarn zone developed in upper Carboniferous volcanic rocks. Skarn is comprised of alternating garnet and epidote-rich layers mineralized with massive magnetite, chalcopyrite and pyrite. A north-trending, crosscutting garnetite zone structurally below the main skarn may represent a feeder zone. Drilling in 1972 (Ken), intersected 15.2 m assaying 1.5% Cu and 1.5m assaying 7.5 g/t Au. 1988 Drilling (6 holes, 456m) Ken: intersected 5.4m averaging 2.81 g/t Au and 0.83% Cu. 1988 Drilling (2 holes, 171m) Glacier: intersected 1.5m of skarn averaging 0.48 g/t Au.	EMPR ASS RPT # 4,150 (Costin, 1973) EMPR ASS RPT # 18,506 (Kiesman and Ikona, 1989) Ray and Webster (1997)
137	DUNDEE,GLA	104G/02	386818	6320417	DSst, EMg, PP	Fe, Cu, Zn, Au	Iron-copper skarns developed where feldspar-porphyritic andesite dikes intrude Early Mississippian granite and carbonate pendant rocks. Mineralization comprises magnetite and lesser pyrite, pyrrhotite, chalcopyrite, sphalerite and gold.	Webster and Ray (1991) EMPR ASS RPT # 20 625 (Tennant and Buchholz, 1990)
Cu (AU) SKARN								
367	TIC	104B/15	392409	6295546	lmDSc, LDd	Au, Ag, Cu, Fe	A zone of magnetite up to 7 m thick occurs along the contact between Devonian marble and mafic tuff, and a Late Devonian quartz diorite. Maximum assays from two grab samples are 0.98% As, 0.31% Cu, 2.9 g/t Au and 1.6 g/t Ag.	Ray and Webster (1997)
AU SKARNS / MANTOS								
281	NORTHWEST, MYCLYMONT, WARRIOR 4	104B/15	380820	6300800	uCSss, mCSc uCScg, UCSb	Au, Ag, Cu, Ba	Retrograde-altered garnet-magnetite skarn. Host rocks are mid Carboniferous marbles, cherty siltstone and younger(?) volcanic conglomerates. Flat-lying and steeply dipping mineralized zones consist of pyrite and magnetite with subordinate chalcopyrite and trace galena, sphalerite and gold in carbonate-quartz-chlorite gangue. Silicic and dolomitic alteration envelop the skarn. The zone strikes ~025 and dips 65 degrees east toward the McLymont fault.	EMPR ASS RPT # 16 932 (Grove, 1987) Ray *et al* . (1991)

TABLE 5-1 CONTINUED
SUMMARY OF MINERAL OCCURRENCES

MINFILE 104G/B	NAME	NTS MAP	UTM EAST	Zone 09 NORTH	HOST ROCKS	COMMODITY	DESCRIPTION	REFERENCES
282, 333	GAB NW GAB 9,GAB7	104B/15	381534	6302175	uCSss, mCSc, uCScg	Au	Adjoins McLymont NW zone. Drilling in 1988 (5 holes, 854m) and 1990 (5 holes, 2523m) intersected the same mid Carboniferous stratigraphy that is mineralized on the NW zone, 500m to the southwest. Best gold values intersected in 1990 drilling include 11.0 g/t and 4.0 g/t, over 1m. Higher values are associated with pyrite below a 200 m-thick stratabound, silica-dolomite-sericite alteration zone.	EMPR ASS RPT # 17210 (Todoruk and Ikona, 1988); EMPR ASS RPT # 21 152 (Montgomery *et al* ., 1991)
SUBVOLCANIC VEINS Cu-Ag-Au (As,Sb)								
144	GOZ/RDN Carcass Creek	104G/02 104B/15	399225	6319617	lJHv, lJHr mJHsl, eJmz	Au, Ag, Zn, Cu, Pb	Au- and Ag-enriched chalcopyrite, sphalerite, galena, pyrite and arsenopyrite-bearing veins hosted in silicified and pyritized Lower-Middle Jurassic rocks. Mineralization and alteration are related to coeval subvolcanic feldspar porphyritic monzonite intrusives. Potential for exhalative deposits. 1990 Drilling (15 holes, 1545m); 1991 Drilling (15 holes, 2087m) Carcass Creek zone: narrow high-grade quartz-sulphide breccia veins; assays up to 137.8 g/t Au over 0.85m and 101 g/t Au over 0.95m. Gossan Creek/Main Gossan zone: Sericite and pyritic-argillically altered subvolcanic feldspar porphyry. Mineralization is sporatic: one 10m zone of fracture-fillings assayed 0.18% Cu, 0.135% Pb, 0.429% Zn, 1.17 g/t Ag and 0.07 g/t Au; another, drill hole RG-91-19 returned only background values. South Boundary zone: 23.9 g/t Au over 11.6 m (hole RG-91-16)	EMPR ASS RPT # 20,769 (Savelle, 1990) EMPR ASS RPT # 22,003 (Savelle and Grill, 1991) The Northern Miner, Vol. 77- No. 28, Sept. 1991
	Gossan Creek		400064	6317671				
	South Boundary		399089	6312074				
378	FORGOLD	104B/15	398979	6311721	uTSvt	Au, Cu	Mineralization includes; podiform, Ag-bearing massive chalcopyrite veins (up to 0.5m wide) and Au-bearing, base metal quartz-carbonte and/or calcite veinlets (generally less than 5cm wide). Grades of 112.4 g/t Au and 9.58% Cu are reported from a 5cm wide quartz-carbonate veinlet. 1991 Drilling (5 holes, 936m) outlined two narrow and discontinuous zones:one returned 3.9 g/t Au over 1.58m and the other 19.2 g/t Au over 0.82m.	EMPR ASS RPT # 20,540 (Termeunde and Termeunde, 1990) EMPR ASS RPT #21,868 (Ronning, 1991) EMPR ASS RPT # 22,623 (Bond, 1992)
QUARTZ-CARBONATE VEINS Cu-Au-Ag (As)								
70	BJ	104G/02	379644	6335126	lmDSqs, EDd	Au, Cu, Pb, Zn, Ag	Mineralization occurs within mesothermal quartz veins and an iron carbonate breccia zone. Veins contain pyrite, tetrahedrite, chalcopyrite, sphalerite, trace arsenopyrite, galena, gold and have prominent iron-carbonate alteration envelopes. Northeast-trending quartz veins crosscut strata, iron carbonate breccia is stratiform. Placer gold occurs in creeks below the showing.	Holbek (1988) EMPR ASS RPT # 14,982 (Folk, 1986) EMPR ASS RPT # 9,692 (Holbek, 1982)

TABLE 5-1 CONTINUED
SUMMARY OF MINERAL OCCURRENCES

MINFILE 104G/B	NAME	NTS MAP	UTM EAST	Zone 09 NORTH	HOST ROCKS	COMMODITY	DESCRIPTION	REFERENCES
379	NEW	104B/15	378655	6299828	LDg	Au, Ag	Narrow, irregular quartz-carbonate veins cut quartz-carbonate-chlorite altered quartz monzonite. The veins pinch and swell. They contain pyrite, chalcopyrite and sporadic gold and silver values. Diamond drilling in 1990 (447m in 10 holes) showed poor continuity of veins and metal grade.	EMPR ASS RPT # 20,666 (Toduruk and Ikona, 1990a); EMPRASS RPT # 21,340 (Toduruk and Ikona, 1991)
126	McLYMONT CAMP ZONE	104B/15	382784	6298756	LDg	Au,Ag,Cu	1) Narrow (<30cm), NW-trending en echelon, Au-bearing pyrite-chalcopyrite-quartz veins cut quartz-rich Late Devonian granite and 2) NW- and NE-trending pyritic quartz-ferrocarbonate veins 1988 Drilling results include 6.9 g/t Au over 1.5 m; trench samples assay 15.6-57.9 g/t Au.	EMPR ASS RPT # 16,932 (Grove, 1987) Grove (1989)
332	McLYMONT NE ZONE	104B/15	383603	6298289	LDd, lmDSs	Au,Zn	Au-bearing massive pyrite and sphalerite hosted in a hornfelsed, pyritic altered graphitic siltstone pendant in Late Devonian diorite.	EMPR ASS RPT # 16,932 (Grove, 1987)
347	EGG, VERJOY RET 7	104B/15	382961	6292896	DSv, LDg	Au	Quartz-barite veins infilling shear or fracture systems are mineralized with pyrite, chalcopyrite, galena, hematite, magnetite and malachite; gold values are low but silver, cobalt and copper values are elevated above background. Assays from massive pyrite veins up to 5.0cm wide containing chalcopyrite, hematite and magnetite returned 4.15% Cu.	EMPR ASS RPT # 17,469 (Ikona, 1988) EMPR ASS RPT # 18,515 (Dewonck and Raven, 1988)
350*	ADRIAN	104B/15	377605	6292280	DSv, LDg	Au,Ag,Cu,	Nine grab samples from the property returned gold values ranging from 2.7 g/t to 30.0 g/t.	George Cross Newsletter, #165, 1988 (p.3)
FAULT AND SHEAR HOSTED VEINS Cu-Ag-Au and Ag-Zn-Pb								
110	BAM 10	104G/02	384705	6339447	Emg, Emd,lmDSst	Au, Ag, Bi	Gold and fine-grained pyrite occupy quartz and carbonate veinlets in fractured Early-Mississippian in the granite. Discontinuous mineralization occupies NE-trending silicified and sericitized shear zones in the granite. Gold values range from 8.57 g/t over 18.9m in trench 86-1 to 1.72 g/t over 2.43m in DDH 87-1, drilled in 1987 to test the ground beneath Trench 86-1. 1997 Drilling intersected no significant Au values in 6 holes.	EMPR ASS RPT # 17,570 (Diner, 1987) EMPR ASS RPT # 15,827 (Hewgill and Walton, 1986a) EMPR ASS RPT # 14,859 (Walton, 1986) Wojdak (1997)
334	CUBA,GAB 8	104B/15	386457	6304855	lPSc, uCscg, uTrSvat	Ag,Pb,Zn,Ba,Cu	Silver-rich mineralization occurs as quartz-barite-sulphide fractures (1-2cm wide) and as matrix to crackle-breccia zones (up to 4m wide) in fault dissected and brecciated Permian limestone adjacent to the east bounding fault of the Newmont graben. Mineralization consists of sphalerite galena and tetrahedrite interstitial to calcite and coarse crystalline barite. 1988 Drilling (2 holes, 133m) intersected 7.5m averaging 56.2 g/t Ag and 0.488% Zn. A grab sample from surface trenchs returned 125 g/t Ag, 5.88% Zn and .05% Cu.	EMPR ASS RPT # 18,506 (Kiesman and Ikona, 1989) Logan *et al*. (1990b)

TABLE 5-1 CONTINUED
SUMMARY OF MINERAL OCCURRENCES

MINFILE 104G/B	NAME	NTS MAP	UTM EAST	Zone 09 NORTH	HOST ROCKS	COMMODITY	DESCRIPTION	REFERENCES
335	GAB 12, SW	104B/15			LTRmz, Psu	Ag,Zn,Pb,	Arseno/sulphide zone: consists of 2 vertical, subparallel mineralized fault zones which strike	EMPR ASS RPT # 18,517 (Todoruk and Ikona, 1989)
	Arseno/sulphide		378663	6299833		Cu, As, Au	030. Ferrocarbonate alteration extends 10-15m beyond the shear zones. Mineralized quartz	EMPR ASS RPT # 20,928 (Game and Sampson, 1990)
	Rusty shear		379253	6299377			veins varying from a few cm up to 1.5m in width, contain pyrite, arsenopyrite and chalcopyrite. Rusty shear zone: Ferrocarbonate alteration zone developed along a 040 trending fault structure. Mineralization consists of fine pyrite and arsenopyrite in 090 trending vertical ferrocarbonate veins (several cm to 0.5m wide) that cut the alteration zone. 1988 Drilling (7 holes, 856m) Arseno: 74.0 g/t Au over 0.65 m; Rusty shear: 2.4g/t Au over 0.5m. 1990 Drilling (7 holes, 638m) Arseno: 3.6 g/t Au over 0.5m; Sulphide: 5.0 g/t Au over 2.2m.	
336*	GAB 11,SE	104B/15	380487	6298490	uCScg	Au,As,Fe,Cu,Ag	Massive fine-grained pyrite occurs within sedimentary rocks of upper Carboniferous to Early Permian age; grab samples of talus from a pyritized zone returned values of 23.5 g/t Au and 16.9 g/t Ag.	EMPR ASS RPT # 17,131 (Todoruk, 1988)
337*	GAB 12 NE	104B/15	38005	6300541	uCScg, uCSb	Au,Cu,Pb,Zn	A gossanous zone several hundred meters wide in upper Carboniferous volcanic and sedimentary rocks. Adjoins McLymont NW zone. Talus samples contain massive and disseminated magnetite, chalcopyrite, sphalerite and galena; with gold values as high as 26.7 g/t Au.	EMPR ASS RPT # 17,131 (Todoruk, 1988)
380	FORREST 1-15	104B/15				Au,Ag,Cu,	Triple Creek/Creek/Canyon Shear zones: NE-trending, en echelon shear zones,	EMPR ASS RPT # 20,562 (Stammers and Ikona, 1990)
	Creek/Canyon		395021	6297511	DSvb, Csst	Pb, Zn	characterised by pervasive ferrocarbonate alteration, mineralized with chalcopyrite and contain Ag>Au values. The shears cut N-	EMPR ASS RPT # 24,156 (Scott and Ikona, 1995)
	Crooked Creek		396558	6298839	DSvb, Csst		trending auriferous arsenopyrite quartz	
	Forrest		395897	6296424	DSvb, Csst		veins 1990 Drilling (14 holes, 1214m), 1995 Drilling (8 holes, 995m).	
	Gold Pan/Falls		395414	6291764	DSvb, Csst		Crooked Creek: NE-trending shear zone which contains chalcopyrite with Ag>Au values in mineralized quartz-carbonate veins. 1995 Drilling (2 holes, 308m). Forrest: 250 X 250m, weakly to unmineralized quartz stockwork, hosted in meta-andesite. Gold Pan/Falls: E-trending, narrow (5-50cm wide) quartz veins; contain pyrite, arsenopyrite, chalcopyrite , and locally visible Au.	
147	MAL	104G/02	400727	6341284	uTRSs, uTRSv	Au, Ag	Gold and silver mineralization occurs in silicified and pyritized shears in volcanics and sediments.	EMPR ASS RPT # 18,722 (Westcott, 1989)
							Gold and silver soil anomolies define a 200 metre wide zone below the sediment hosted gossan.	EMPR ASS RPT # 20,412 (Pegg, 1990)
							Known mineralization is discontinuous and low grade.	

TABLE 5-1 CONTINUED
SUMMARY OF MINERAL OCCURRENCES

MINFILE 104G/B	NAME	NTS MAP	UTM EAST	Zone 09 NORTH	HOST ROCKS	COMMODITY	DESCRIPTION	REFERENCES
CARBONATE REPLACEMENT Ag-Cu-Au								
57	COT & BULL	104G/07	383075	6371290	mCSc	Ag, Cu, Au	Disseminated blebs of tetrahedrite, chalcopyrite and pyrite occupy fractures and breccia zones in a bedding-parallel, east-trending fault cutting limestone. Mineralization either predates or is synchronous with a north-trending basalt dike swarm.	EMPR ASS RPT # 9,479 (Betmanis 1981), EMPR ASS RPT #15,828 (Hewgill and Walton, 1986b)
27	BAM 8 ARCTIC	104G/02	384815	6341514	PSlm, lJHcg	Cu, Ag, Zn	Disseminated blebs and veinlets of tetrahedrite, minor chalcopyrite, pyrite, sphalerite and galena occupy fractures and breccia zones in limestone, sandstone and conglomerate. Mineralization and carbonate alteration follow NE-trending splay faults related to N-trending regional structures. INVENTORY** Tonnes Cu% Ag g/t Southwest Zone 299 400 0.76 - East Zone 4 540 2.45 17.83	Souther (1972) EMPR ASS RPT # 11,515 (Dearin, 1983) EMPR ASS RPT # 12,561 (Gillen *et al* .,1984) EMPR ASS RPT # 695 (Rayner, 1965) ** 1967 drilling (Shawinigan Mining and Smelting Co. Ltd.)
49	BIK	104G/02	379840	6342134	mCSc, ?PSlm	Cu, Ag, Zn, Pb	Disseminated replacements and thin fracture-fillings of tetrahedrite occupy fractured and silicified limestone. Mineralization is controlled by subvertical and flat north-trending joints. A grab sample of mineralization returned 819.0 g/t silver, 13.0% copper, 2.8% zinc and 0.2% lead.	EMPR ASS RPT # 590 (Lammle, 1964)
STRATIFORM MASSIVE SULPHIDE Zn-Pb-Ag (Kuroko and Irish-Type?)								
148	FOREMORE	104G/02	378966	6326593	lmDSst,lmDSc,lmDSgs	Zn, Pb, Cu, Ag	Laminated sphalerite and galena occur in felsic volcanic horizons within a foliated package of graphitic schist, argillite and intermediate to mafic volcanics of Lower Devonian age. Mineralized boulders include pyrite, sphalerite and chalcopyrite-rich varieties. Assay data from company reports show the following average values:	EMPR ASS RPT # 18,105 (Mawer, 1988) EMPR ASS RPT # 19,379 (Barnes,1989)
							Boulder Type Cu % Pb% chalcopyrite-rich (n=12) 2.3 0.5 sphalerite-rich (n=29) 0.22 3.5 pyrite-rich (n=112) trace 1	Zn% Ag g/t Au g/t Fe% 6.2 186 1.5 16 10.2 96 1 16 6.2 78 nil 23
							Diamond drilling of geophysical conductors in 1990 (5 holes, collared on the glacier) and one hole in 1996 (663.9m) intersected several horizons of variably graphitic mudstone. The source of the boulders remains undiscovered and presumably under the glacier.	EMPR ASS RPT # 24,796 (Wagner, 1996)

* mineral occurrence not plotted on map

Photo 5-1. The Schaft Creek Cu-Mo-Au porphyry deposit consists of three zones, the Liard or Main zone, the West Breccia zone and the Paramount zone and lies east of Schaft Creek on the lower slopes of Mount La Crasse. View is to the north.

sis of the deposit. Spilsbury (1995) provides a detailed description of mineral paragenesis, zonation patterns and a synopsis of the current knowledge of the deposit.

Our observations of the Upper Triassic stratigraphy in the area of the deposit agree with those of Fox *et al*. (1976). They note that 90 per cent of the deposit is hosted by plagioclase-phyric and aphyric basalt flows (uTrSvb) and associated subvolcanic intrusions, massive tuffs, and bedded green and purple epiclastics (uTrSvt). The epiclastic rocks are overlain by weakly mineralized mixed purple and green flow breccias and tuff (uTrSpp). Dike swarms of plagioclase porphyry, pyroxene plagioclase porphyritic diorite, felsite (aplite and quartz-eye feldspar porphyry) and hornblende porphyry, in order of abundance, cut the Upper Triassic volcanic rocks (GS-Map). The aplite and quartz-eye feldspar porphyry intrusives are bleached, altered and mineralized with disseminated and fracture-controlled sulphides.

Early workers distinguished between the purple volcanics and mineralized green andesitic volcanic rocks, and postulated the presence of an unconformity or disconformity separating the two units (Fox *et al*., 1976). No simple lithologic or stratigraphic difference was recognized during the current mapping. The colour difference may reflect alteration related to the Hickman or Yehiniko plutons, or proximity to the north-trending mineralizing and alteration system which produced the deposit. Clasts of probable mafic pumice that have been completely replaced by epidote, and volcanic and intrusive fragments that are variably replaced by epidote occur within purple volcanic flow and tuff of units uTrSvt and uTrSpp. Epidote alteration occurs within the propylitic alteration zone marginal to mineralization. South of the deposit, this stratigraphic package is unconformably overlain by quartz-eye felsic tuffs and quartz-bearing Lower Jurassic conglomerates that contain epidotite clasts and clasts of epidotized volcanic rocks.

In the areas south and east of the deposit, the overall strike of bedding is north-northwesterly with easterly and westerly dips that average 70 degrees. Locally strikes vary to northeasterly, also with steep dips, suggesting tight folds. Other workers describe gentle east dips for bedding in the western part of the deposit, suggesting a simple synclinal structure (Fox *et al*., 1976; Linder, 1975).

A prominent north-striking fault truncates the Main zone on its western side. The West Breccia and Paramount zones occupy other northerly-striking faults. Northeast-trending and northwest-dipping normal faults truncate the deposit and produced a mosaic of fault blocks with varying internal structure and stratigraphy.

The deposit consists of three distinct zones: the Liard or Main zone, a fracture-controlled zone of mineralization; the West Breccia zone, which is a fault-bounded breccia characterized by a tourmaline sulphide matrix; and a linear intrusive breccia, the Paramount zone (Spilsbury, 1995). The Liard zone is hosted in andesite flows and epiclastic rocks. The volcanic rocks at the Paramount zone are intruded by granodiorite to quartz monzonite bodies, possibly non-porphyritic equivalents of the quartz-feldspar porphyry dikes that cut the Liard zone.

Mineralization includes chalcopyrite, pyrite, bornite and molybdenite. Alteration assemblages in the Main zone define a well-developed central potassic zone (biotite and potassium feldspar) which is bounded by a broad propylitic zone, characterized by epidote, chlorite and pyrite . Silica alteration is limited to breccia zones, and phyllic (sericite-rich) zones are confined mainly to felsic porphyry dike swarms. Spilsbury (1995) provides a succinct discussion of mineral zonation and paragenesis for the Liard zone.

The deposit is hosted by Upper Triassic volcanic rocks of the Stuhini Group adjacent to the eastern contact of the coeval Hickman pluton, and the east-trending Middle Jurassic Yehiniko pluton. The ages of intrusive bodies are approximately constrained by K-Ar and Rb-Sr dating methods (Holbek, 1988) and in addition the host volcanic rocks have sedimentary interbeds which contain the Late Triassic (Norian) bivalve *Monotis Subcircularis* (C-207971, Appendix 1). However, the timing of copper-molybdenum mineralization at Schaft Creek is not tightly constrained.

A whole-rock K-Ar date of 185±5 Ma (Panteleyev and Dudas, 1973) for hydrothermal biotites falls within the range of dates for the Middle Jurassic Yehiniko pluton and in addition, leucocratic syn-mineralization dikes were thought to be derived from the quartz monzonite to granite phases of the Yehiniko pluton. A lower limit on the age of mineralization is provided by a Late Triassic (216.6 ± 2 Ma) U-Pb date obtained from an altered and mineralized quartz-feldspar porphyry dike from the Liard zone (Table 5-1). This new age constraint suggests that these dikes are comagmatic with the Hickman pluton. These leucocratic, porphyritic dikes are spatially and apparently temporally associated with the mineralizing event. The whole-rock K-Ar date of 185±5 Ma (Panteleyev and Dudas, 1973) for hydrothermal biotites probably reflects argon loss related to intrusion of the Yehiniko pluton.

RUN (MINFILE 104G/40)

The Run property is located approximately 10 kilometres southeast of the Schaft Creek deposit. It is within a large iron-stained alteration zone that outcrops for over 15 km along the east side of Mess Creek (Figure 5-2). Access to the property is by helicopter; small float planes have landed on Loon Lake, but the lake is too short to take-off with heavy loads. Diamond drilling in 1972 (4 holes, 563m), tested a low-lying area located approximately 800 m north of Loon Lake (Panteleyev, 1972). Drill results are unknown. The last active exploration carried out on the Run claims was in 1976, when Utah Mines Ltd. conducted a limited program of geological mapping and soil geochemical sampling.

The claims are underlain by a salmon-pink weathering plagioclase hornblende porphyritic monzonitic intrusion (LŦmz). Rafts of hornfelsed lapilli and crystal tuff are exposed where creeks are incised into the main intrusive body. Farther upslope, dikes of pink monzonite intrude a thick package of plagioclase-phyric basalt flows, tuffs and subvolcanic gabbro dikes and plugs of Upper Triassic age (Figure 5-2). The Upper Triassic rocks are overlain unconformably(?) by a Lower Jurassic quartz-rich polymictic conglomerate dominated by maroon hornblende-plagioclase porphyry volcanic and granitoid clasts.

The monzonite texture varies from weakly porphyritic to a crowded plagioclase-porphyry, characterized by salmon red plagioclase phenocrysts, often zoned with pink potassium feldspar rims. Aligned feldspars locally define trachytic texture; they lie in a brown aphanitic matrix. The intrusion contains up to several per cent magnetite that is partly altered to hematite. West of the monzonite is a subvolcanic plagioclase porphyritic diorite. The diorite is typically massive, pale green to grey and texturally similar to the flows and tuffs which crop out to the east. It may be comagmatic with these flows or may represent a border phase to the Loon Lake stock.

The distribution of strata and mineralization is controlled by north-, northeast- and east-trending structures related to the Mess Lake fault zone. Limited bedding attitudes show northerly, and steep west dips.

The large gossan represents two main types of alteration: propylitic, characterized by chlorite, sericite, epidote, iron oxides and pyrite assemblages; and a carbonate-rich subfacies , in which the rock is bleached with a ferroan dolomite or ankerite and sericite mineral assemblage (Panteleyev, 1972). Further alteration through surface oxidation of magnetite to hematite produced the characteristic red staining of the monzonite. Oxidation of ankerite to limonite produced a light orange to brown gossan locally.

Fractures, faults and intrusive breccias localize alteration and stockwork mineralization. Pyrite and chalcopyrite occur commonly as fracture-fillings adjacent to the intrusions in the volcanic rocks, but also as disseminations in the feldspar porphyries. Molybdenite occur as fracture fillings and in quartz veinlets in both rock types. Panteleyev (1973) reports that the best copper and molybdenum mineralization is developed in steeply dipping fractures and breccia zones, possibly related to faults of the Mess Creek fault system, in an area of feldspar porphyry intrusion. A grab sample collected from a northeast-trending quartz-carbonate altered breccia zone located 2 km east of Loon Lake returned 155ppb Au, 165 g/t Ag, 1.07% Cu, 0.18% Zn, 0.10 % As and 0.66% Sb.

BISKUT, VOIGTBERG (MINFILE 104G/146)

Midway between the Lucifer and Little Les showings, about 8.5 km south of Hankin peak, is a substantial limonitic gossan that is clearly visible from the air. This alteration zone lies at the centre of the Biskut - Voigtberg property (Figure 5-2). Lac Minerals Ltd. recorded the first prospecting and rock sampling work in 1988 and assessment by various companies continued unabated until 1996, when Hayden Resources Ltd. conducted a 456 m drilling program.

The property is underlain by a thick succession of Upper Triassic Stuhini Group rocks belonging to the More Creek sedimentary facies. These include well bedded feldspathic sandstone, limestone-bearing conglomerate with thin bedded siltstone layers, interbedded volcanic flow and augite-bearing volcaniclastic rocks, and argillaceous limestone. The layered rocks are intruded by northeast-trending megacrystic orthoclase porphyry syenite dikes and a mafic-poor biotite monzonite stock. The latter is believed to underlie much of the gossan. The gossan area was mapped by Souther (1972) as a Late Cretaceous to Tertiary felsite dike. Bobyn (1990) interpreted the felsite as Early Jurassic, and correlative with the Mount Dilworth Formation. The monzonite is probably Early Jurassic or older in age, and part of either the Copper Mountain or Texas Creek plutonic suites.

Bedding measurements show the rocks strike northwesterly on the property, but regional scale north-trending, upright open folds and faults and younger east-trending chevron folds are known to occur in the vicinity.

The northeast-trending gossan, 300 metres long by 50 to 100 metres wide, consists of an argillic alteration assemblage of predominantly limonite, clay, sericite, pyrite and quartz. Oxidation of sulphides and acid generation has obliterated all the original textures. Epidote-chlorite-carbonate alteration assemblages are present in volcanic rocks peripheral to the main zone. The gossan contains up to 5 per cent disseminated pyrite and traces of arsenopyrite and galena. Rock geochemical results (Kemp, 1995) suggest metal zoning peripheral to the main intrusion/alteration zone. Silicified, pyritic argillic zones in volcanic rocks adjacent to the porphyry intrusions carried anomalous values only in gold (1.38 g/t and 1.43 g/t from 2.0m and 1.6m chip samples), while sedimentary-hosted carbonate breccia veins, located upslope from these, are characterized by silver-rich base metal mineralization containing anomalous values of gold, arsenic and antimony.

Two grab samples collected from the gossan and one from a pyritic tuff located upslope are listed below (Table 5-2). Samples of the pyritic feldspar porphyry contain only slightly elevated copper values. A single grab sample from the gossan returned 16.1 grams per tonne gold (Bobyn, 1990).

Diamond drilling in 1996 cut a total of 456 m in 3 holes. Drilling was conducted from a single setup located in altered volcanic rocks, approximately 500 m north of the main gossan. All 3 holes intersected potassium-feldspar-carbonate-sericite-pyrite altered volcanic rocks. The rocks contain anomalous values of gold over the entire 456 m drilled, averaging 0.26 g/t Au (Gunning, 1996). The best intersection was 2.01 g/t Au over 2.43 m at the bottom of hole 96-3. Arsenic values show a weak correlation with gold values. Copper, molybdenum, antimony, lead and zinc show no enrichment or correlation with higher gold values.

ALKALINE PORPHYRY Cu-Au

LUCIFER (MINFILE 104G/145)

The Lucifer property is located 2 km north of More Creek, on the eastern side of the map area (Figure 5-2). The first work recorded was conducted by Noranda Exploration Company Limited (NPL) in 1990. This comprised airborne EM-Mag surveys and on-the-ground follow-up mapping, and soil, rock and heavy mineral sampling. Limited drilling is reported to have been completed later that same year.

Upper Triassic tuffaceous sediments, reworked tuffs and minor limestones of the More Creek sedimentary facies underlie the claims. Further north green tuff and epiclastic rocks are interlayered with augite-phyric basalt flows and sills. Maroon ash tuffs and tuffaceous conglomerates containing coarse potassium feldspar crystal fragments crop out high on the ridge west of the alteration zone. These lithologies are intruded by northerly trending megacrystic potassium feldspar porphyry dikes.

The area of interest occupies the headwall and steep upper reaches of a south-draining tributary of More Creek. It consists of a large (1000 x 2000 m) northerly trending limonite-carbonate-pyrite alteration zone. Narrow quartz stringer zones and veinlets crosscut this chiefly propyllitic alteration zone. The alteration zone lies west of a northeast-trending fault and coincides with a northeast-striking swarm of megacrystic potassium feldspar porphyry dikes. Pyritic and propylitically altered and unaltered dikes crosscut the zone and indicate complex and episodic intrusive and mineralizing events. Mineralization consists of quartz-carbonate-pyrite veins containing chalcopyrite and galena. Results from the two 1991 diamond drill holes do not explain the anomalous gold soil geochemistry of the alteration zone (R. Baerg, personal communication, 1991).

LITTLE LES (MINFILE 104G/179)

The Little Les-Two More showing is situated on a limonitic gossan located 9 km north of the confluence of More and South More creeks and about 7 km south of Hankin peak, on the Arctic claims (Figure 5-2). The property has received limited exploration work. Newmont Mining Corporation conducted geological mapping and drilled 2 holes totaling 52 m in 1970 and Teck Exploration Ltd. continued mapping and completed a rock and soil sampling program over the area in 1980. More recently, Keewatin Engineering Inc. carried out mapping and sampling of the area (Bobyn, 1991).

TABLE 5-2
SELECTED GEOCHEMICAL ANALYSES AND ASSAYS FROM THE BISKUT PROPERTY

Map Number	Au ppb	Ag ppm	Cu ppm	Pb ppm	Zn ppm	As ppm	Sb ppm	Mo ppm	Ni ppm	Fe %	SAMPLE DESCRIPTION
91JLO3-27	30	5	127	84	68	136	12	5	18	9.21%	pyritic feldspar porphyry, 1-2 % py
91JLO3-28	<5	1	550	28	45	17	1	47	12	3.80%	pyritic feldspar porphyry, 1-2 % py
91JLO3-21	40	1	65	36	38	81	5	30	13	5.21%	grab pyritic limy tuff

Upper Triassic volcaniclastic rocks of the More Creek Sedimentary facies underlie the area. Coarse grained to cobble sized, polymictic intraformational conglomerates, green feldspathic sandstone and thin bedded black shales and limestone dominate the succession, but there are also plagioclase phyric and aphyric basalt flows, and lithic tuff horizons; and the flows and tuffs host the copper mineralization. Intruding these rocks are a series of medium grained, equigranular, green, chloritic diorite sills, megacrystic orthoclase porphyry syenite dikes and a larger body of medium grained chloritized monzonite. Younger biotite lamprophyre and biotite feldspar porphyry dikes cross-cut all the other rocks.

The dominant trend of the strata is north-northwest with moderate northeasterly dips. Sedimentary structures indicate upright-facing stratigraphy, but isoclinal folding and faulting is recognized on the property. Some of this may be linked to intrusion of the diorite and monzonite bodies, but regional scale north-trending, upright open folds and faults and younger east-trending chevron folds deform Upper Triassic rocks elsewhere in the area.

The gossan mantles a pyrite-rich alteration envelope which flanks a 200 by 50 metre zone of propylitically altered andesite flows and tuffs. Alteration minerals include chlorite, biotite, pyrite and carbonate. Mineralization consists of 2 to 5 per cent disseminated and fracture-filling chalcopyrite and traces of galena and molybdenite (Folk,1981). A chip sample across 5.4 m averaged 2.57 g/t Au, 10.2 g/t Ag and 1.65% Cu (Bobyn,1991). A grab sample of disseminated and fracture-controlled chalcopyrite and pyrite-mineralized tuffaceous siltstone returned 1.12 g/t Au, 4 g/t Ag and 0.95% Cu (Logan *et al*., 1992b).

Alteration and mineralization are related to syenite porphyry dikes. Alteration and the best mineralization is developed within volcanic and volcaniclastic rocks. The variety and number of intrusive bodies indicate that the area was a focus of igneous activity; the preponderance of sedimentary strata over volcanic and lack of coarse volcanic breccia suggests a volcanic flank-setting rather than a vent-proximal position.

SKARN DEPOSITS

Skarns in the Iskut River area typically fall into either the copper or iron-copper skarn classification, but they are sporadically enriched in gold. The Ken and Dundee occurrences are typical copper skarns. Another potentially important type in the area are gold-skarns. Mineralization of this type is present at the Northwest zone on the McLymont property and on the Gab-NW occurrence (Figure 5-2). Copper and iron-copper skarns are more typical of other skarns in the Iskut River area, while the gold skarns are unique. Another difference between the two groups is the age of mineralization. The Dundee Skarn is probably Late Devonian to Early Mississippian in age and related to one or more intrusive phases of the More Creek pluton into a mixed sequence of volcaniclastic and carbonate rocks. In contrast, the skarns in the Newmont Lake area are related to structurally controlled intrusions of relatively small, felsic to potassic bodies of probable Late Triassic to Early Jurassic age which altered and mineralized mid-Carboniferous carbonate rocks.

Many of the skarns in the Iskut River area have recently been studied by Gerry Ray. He described, classified and tabulated them in Ray and Webster (1997). The skarn deposits described below are therefore only briefly summarized, the property descriptions taken primarily from Webster and Ray (1991) or Ray and Webster (op.cit).

COPPER SKARNS

KEN (MINFILE 104B/27)

The Ken showing is exposed on several nunataks approximately 3 km northwest of Newmont Lake (Figure 5-2). Well-bedded siltstone, sandstone and polymictic conglomerate with interbedded mafic lapilli tuff and coarse breccia horizons of probable Upper Carboniferous age underlie the area. A quartz diorite of unknown age intrudes the package. The showing consists of at least 4 separate easterly to northeast-trending, southeast-dipping conformable skarn horizons developed in carbonate and volcaniclastic rocks. A north-trending, crosscutting garnetite zone, located structurally below the main skarn, may be a structurally controlled feeder zone (G. Ray, personal communication, 1997).

The skarned horizons vary from 1m up to 9 m in thickness and comprise alternating garnet and epidote-rich layers mineralized with massive magnetite, chalcopyrite and pyrite. Skarn minerals are coarsely crystalline garnet, epidote and calcite and the zones contain pods of massive magnetite with veins and disseminations of chalcopyrite and coarse pyrite. The rocks are overprinted by later ferrocarbonate alteration which occupies northeast-trending fractures.

Drilling below the surface trenches in 1988 (6 holes, 456 m) intersected an unaltered augite porphyry sill and a weakly altered syenite dike (Kiesman and Ikona, 1989). The skarn intersections and most of the better Cu-Au values occur in strata above the augite porphyry sill. Intersections include 5.4m of 2.81 g/t Au and 0.832% Cu in hole 88PG1 and 6.0m of 2.61 g/t Au and 0.94% Cu in hole 88PG-5 (Kiesman and Ikona, 1989).

DUNDEE (MINFILE 104G/137)

The Dundee showing straddles the south fork of More Creek 13 kilometres southwest of its confluence with More Creek (Figure 5-2). The property is underlain by hornfelsed and silicified Lower Devonian rocks and monzonite to biotite granite of the Early Mississippian More Creek Pluton (MCP). Mineralization is concentrated along the northwest trending intrusive contact and in pendant rocks within the MCP. Three types of mineralization occur: quartz- carbonate-pyrite veins; silicified and pyritized structural zones; and at least two stages of skarn alteration, one related to the main intrusion in which the pendant occurs and a second related to the later dikes. Skarn mineralization is apparently the only type with economic potential. Mineralized skarns are developed where younger feldspar-porphyritic andesite dikes crosscut limestone bodies and the main intrusive body.

The following is a summary from Webster and Ray (1991). Four zones of skarn alteration occur within or near the southwestern margin of the More Creek Pluton. Three of the four zones occur east of More Creek at between 1220m and 1520m elevation along the contact of the main pluton (Figure 2-10-2, op. cit). These zones consist of massive garnetite, garnetite-epidote or banded garnet-epidote skarn assemblages. They are variably crosscut by veins of magnetite and pyrite, and epidotized diorite sills and/or veins of garnetite, illustrating prograding fluid interactions with country rock (Photo 5-2). Mineralization comprises massive and veined magnetite with variable amounts of pyrite, pyrrhotite, chalcopyrite, sphalerite and gold.

Webster and Ray (1991) report assays of samples from a chalcopyrite and pyrite mineralized sheared contact zone between the MCP monzonite and an andesite dike enriched in Au, Ag, Cu and Zn. A grab sample of magnetite-epidote-diopside-pyrite rock collected during regional mapping returned very low base and precious metal values (Appendix 10).

The fourth zone occurs in intermediate tuffaceous and volcaniclastic rocks of Devono-Mississippian age, at 760m elevation. Mineralization consists of semimassive pods and lenses of pyrrhotite up to 5m long in silicifed and epidotized andesite. Garnetite zones are characterized by reddish-brown garnet, and contain coarse radiating magnetite crystals intergrown with minor pyrite, and semimassive pods of pyrite.

The local pyrrhotite-rich mineralization in the Dundee skarns distinguishes them from other skarns in the area. However, similar coarse radiating magnetite crystals are present in the McLymont skarn.

COPPER (GOLD) SKARN

TIC (MINFILE 104B367)

The Tic showing (Figure 5-2) is a zone of magnetite up to 7m thick developed along the intrusive contact between

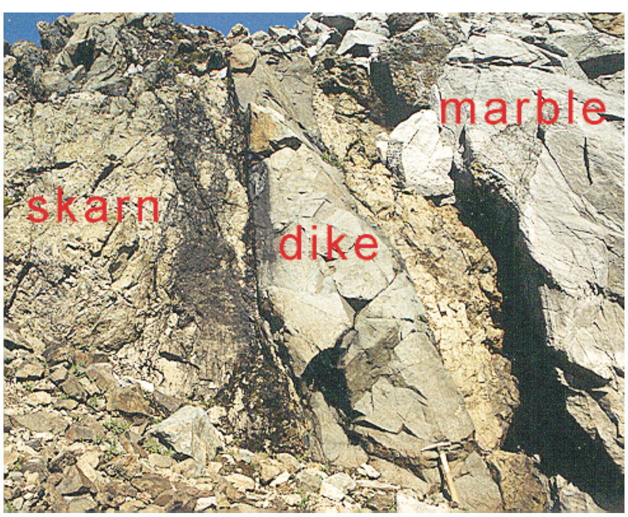

Photo 5-2. Epidote, diopside and magnetite skarn envelopes mafic dike crosscutting marble pendant in the Early Mississippian More Creek pluton at the Dundee showing.

interlayered Lower Devonian marble and metavolcanic rocks and a mafic quartz diorite border-phase of the Late Devonian Forrest Kerr pluton. The massive magnetite zone, trends northeast and dips steeply southeast, it follows a sharp footwall contact in the marble. The lower contact zone of the magnetite is marked by either a 1m zone of ferrocarbonate alteration or irregular pods of pyrite in the marble. Endoskarn alteration comprised of epidote, garnet, pyrite and potassium feldspar is developed within the diorite proximal to its margins and forms the hangingwall. Lenses and veinlets of pyrite, carbonate and locally euhedral quartz occur within the magnetite unit. Ray and Webster (1997) report the highest assays from two grab samples to be 0.98% As, 0.31% Cu 2.9g/t Au and 1.6 g/t Ag.

GOLD SKARN / MANTOS

MCLYMONT (NW zone) (MINFILE 104B/281)

The McLymont Creek property straddles the headwaters of McLymont Creek, about 2 kilometres south of Newmont Lake (Figure 5-2). Gold-enriched skarns were discovered by Gulf International Minerals Limited at the northwest corner of the property (NW zone) in 1987. The NW zone contains stratabound chimney and manto-type skarn mineralization hosted in a mid Carboniferous and younger volcaniclastic sequence consisting of green tuffaceous siltstone, sandstone, polylithic conglomerate and volcanic breccia with lesser interbedded marble beds.

Mineralization is developed in marble beds and along contacts between tuffaceous sandstones and marble where faults and fractures have provided permeability for the hydrothermal solutions.

The deposit plunges north and has been traced by drilling for over 300 m in a northeast direction. It lies immediately west of and parallels the trend of the McLymont Fault. The dip of the fault is steep, but the direction is unknown. It truncates easterly-trending structures in the older rocks to the west, with bedding dips generally rotated down into the fault plane. East of the fault, bedding in the younger rocks is rotated up relative to the fault. The fault is itself cut by northerly-trending splay structures and steep east-dipping fractures. Dikes displaced along these structures indicate subhorizontal dextral movement (progressive northward displacement). Bedding attitudes in the vicinity of the mineralized zone suggest the presence of a north striking and plunging fold (Figure 2-11-3, Ray *et al*., 1991). The 1989 drilling tested mineralization to a depth of 200 metres below the surface. Mineralization is in semi-conformable replacement zones in crinoidal marble and calcareous tuffaceous sediments and also in steep, fracture controlled zones. The shallow southeast dipping mineralized strata are truncated at depth by the McLymont fault. If this regional structure was open during the Early Jurassic it could have acted as a conduit for mineralizing solutions to travel upward and outward into the permeable and chemically reactive carbonates.

Ray *et al*. (1991) classify the skarn as a retrograde-altered gold-rich skarn. Sulphides include pyrite, chalcopyrite, sphalerite and galena with a gangue of barite, calcite and gypsum. Oxides are coarse-grained magnetite and specular hematite. Other skarn minerals include dolomite, siderite, jasper and potassium feldspar. The best gold mineralization is associated with coarse euhedral pyrite (E.W. Grove, personnel communication, 1989). Polished section studies show that most of the gold is fine grained (<15 micrometres) and occurs within chlorite, coarse pyrite and late stage fine grained pyrite (Ray *et al*., 1991). The mineralized zones are surrounded by irregular envelopes of silicification and later ankerite-dolomite alteration envelopes up to 25 metres wide. Both these stages of mineral deposition/alteration appear to post date mineralization.

The gold occurs together with silver and copper and trace amounts of antimony and arsenic. Drill intersections show high-grade but erratic gold values over the entire deposit. Drillhole 87-29 returned values of 55.05 g/t Au, 39.78 g/t Ag and 0.97 % Cu over an 11.1metre intersection (Grove, 1989).

Well developed structures, proximity to intrusive bodies and the chemically reactive stratigraphy have all contributed to localizing this deposit. Galena-lead from galena and sphalerite veins located peripheral to the NW zone give Pb-Pb model ages of Early Jurassic or older. These veins are interpreted to represent a distal part of the hydrothermal system that is responsible for deposition of the NW zone.

GAB 9 (MINFILE 104B333)

The Gab 9 occurrence adjoins the McLymont NW zone (Figure 5-2). The property is bisected by the northeast-trending extensional McLymont fault. West of the fault are mid-Carboniferous carbonate and younger sedimentary and volcaniclastic rocks. East of the fault, within the Newmont Lake Graben, are Upper Triassic Stuhini Group volcanic and sedimentary rocks and coeval to probably younger Newmont Lake intrusive bodies. The latter are maroon hornblende-plagioclase porphyritic andesite breccia flows, lapilli tuff and epiclastic rocks, with lesser rhyolite and limestone beds. West of the fault is a thick (>500m) epiclastic sequence dominated by polymictic volcanic conglomerate, sandstone, lesser cherty siltstone and interlayered mafic lapilli tuff and coarse breccia. This succession conformably overlies approximately 30 m of Early(?) to mid Carboniferous limestone. The limestone is massive to thickly bedded, locally interlayered with maroon and green tuffaceous sandstone and irregularly bleached and stained by oxidized ferrocarbonate-altered breccia zones. Large angular blocks of carbonate (up to 5 X 10m) as well as carbonate-clast dominated beds are common at various horizons within the conglomerate. The unit resembles Upper Triassic conglomerates described above Forrest Kerr Creek (Read *et al*., 1989), and north of the Chutine River (Brown *et al*., 1992b), but bedding-top directions, conformable contacts, and the mid Carboniferous age of the limestone clasts suggest a Late Paleozoic age for this unit.

Exploration to date has been focused west of the fault in the older rocks. The intended target being extensions to the carbonate-hosted gold mineralization present on the McLymont NW zone. Mineralization at the NW zone lies immediately west of the McLymont fault in green, thin bedded ash and crystal tuff, tuffaceous siltstone and grey crinoid-bearing marble.

West of the fault, the northeast-trending McLymont fault truncates easterly-trending structures in the older rocks. Mineralization, alteration and monzonite bodies that are either potassium feldspar porphyritic or equigranular that lie along the structure suggest it acted as a locus for intrusion and mineralization.

Diamond drilling in 1988 (5 holes, 854m) and in 1990 (5 holes, 2523m) tested a small area, in the southwestern corner of the property, located immediately adjacent to the projected extension of the McLymont NW zone. All holes intersected interbedded coarse and fine grained epiclastic rocks and a crinoidal limestone unit. The strata dip gently southeast. Below the limestone unit intersected in the 1990 drilling is a semi-concordant pervasive alteration zone up to 200 m thick (Montgomery *et al*., 1991). The alteration consists of a quartz-sericite-dolomite mineral assemblage containing disseminated and stringer pyrite, with minor chalcopyrite and magnetite. This overprints well bedded tuffaceous sandstone, siltstone and volcanic conglomerate units. Widely-spaced, anomalous gold values occur in hole J90-2; these include, 11.35 g/t, 4.66 g/t and 4.04 g/t from 1.0 m samples (Montgomery *et al*., 1991). These occur within or below the alteration zone.

SUBVOLCANIC (INTRUSION-RELATED) VEIN DEPOSITS Cu-Ag-Au (As, Sb)

Vein mineralization occupies brittle to semi-brittle fracture, fault and shear zones crosscutting all but the most recent Pleistocene age rocks in the map area. The veins are commonly less than 1 m wide and vary in morphology, mineralogy and precious metal content. They can be divided into two main groups: foliation-parallel, metamorphogenic veins and discordant, subvolcanic veins. Pre-Mesozoic rocks host foliation-parallel, chiefly barren quartz veins related to an early greenschist metamorphism. These veins are deformed, often recumbently folded and predate the main regional Late Triassic to Early Jurassic precious metal mineralizing event.

Crosscutting structures host veins characterized by Cu-Au-Ag (As-Sb) metal assemblages. The mineralization reflects a transition from porphyry copper to epithermal conditions and typifies the subvolcanic classification of Panteleyev (1995). Mineralization occurs as stockworks (Forrest), vein sets (Run), breccia bodies and replacements (Bam), in fault structures (Photo 5-3) and adjacent to porphyritic subvolcanic intrusive bodies (Table 5-3). Subvolcanic veins can be sub-divided into five groups based on the predominant sulphide mineral and metal assemblage. They consist of: (I) chalcopyrite only; (II) tetrahedrite with minor chalcopyrite and sphalerite; (III) pyrite only; (IV) arsenopyrite and chalcopyrite; and (V) chalcopyrite, sphalerite, galena, pyrite and minor arsenopyrite. Associated with each vein group are different metal and gangue assemblages, which seem to be primarily controlled by the lithology hosting the structure (Table 5-3). Distinction between groups is not always clear.

TABLE 5-3
SUBVOLCANIC VEINS GROUPED BY DOMINANT SULPHIDE

Group	Sulphide Mineral	Gangue Minerals	Anomalous Metals
I	Chalcopyrite	Epidote, calcite, quartz	Cu (locally Ag)
II	Tetrahedrite	Quartz, specular hematite	Cu-Sb-As-Zn-Ag±Pb
III	Pyrite	Quartz, sericite, chlorite	Au
IV	Arsenopyrite & Chalcopyrite	Quartz, pyrite, chlorite, ferrocarbonate	As-Cu-Au-Ag
V	Polymetallic	Quartz, sericite, chlorite, ferrocarbonate	Au-Ag-Cu-Zn-As-Sb-Pb

Photo 5-3. Characteristic ferrocarbonate altered north-east-trending, shear zone. The 1 meter wide shear crosscuts Late Devonian hornblende diorite and granite, approximately 3 kilometers south of Forrest Kerr airstrip. The zone is comprised of a ferrocarbonate replacement and pyrite-quartz-chlorite-calcite veinlets which contain in the order of 100 ppb gold (two grab samples).

The chalcopyrite-only veins occupy narrow zones following fractures and joint planes primarily in massive tuff or basalt of the Upper Triassic volcanic rocks. Gangue minerals include chlorite, epidote, calcite and quartz and rarely pyrite. Assays generally detect only copper and no precious metals. Massive chalcopyrite veins from the Forgold property show typical low gold and base metal values but substantial silver enrichment (Malensek *et al*., 1990).

Tetrahedrite occupies quartz veins and siliceous breccia zones in mid Carboniferous and Early Permian carbonate rocks at the Bam 8, Bik and Cot and Bull mineral occurrences. Tetrahedrite in these veins is accompanied by minor chalcopyrite, pyrite, sphalerite and galena. Analyses give anomalous values for Cu-Sb-As-Zn±Pb and appreciable silver, but gold values are rare.

Group III, auriferous quartz and quartz-carbonate veins occur at the Bam 10, Camp Zone (McLymont) and BJ mineral occurrences. Pyrite is typically the only sulphide present. At the Bam 10 and Camp zone the veins cut sericite altered, silicifed and pyritized granite, at BJ the veins are hosted by diorite. Argillic alteration envelops the vein/stockwork zones. Ferrocarbonate alteration locally overprints the argillic alteration zones. Assay results from these veins return anomalous values for gold only.

Arsenopyrite and chalcopyrite mineralized quartz veins and quartz-carbonate veins occupy shear zones on the Gab 12 and Forgold mineral occurrences. Ferrocarbonate alteration envelopes extend beyond the shear zone into the country rock, but may reflect later fluids than the vein mineralizers. The veins contain pyrite, arsenopyrite and chalcopyrite. Assays return anomalous values for gold, silver, arsenic and copper. Arsenopyrite is generally an indicator of gold enrichment in these veins.

Polymetallic Ag- and Au-enriched quartz veins are hosted in Early Jurassic volcanic rocks at the GOZ/RDN and quartz-carbonate veins occur in Paleozoic rocks at the BJ. Host lithologies control alteration assemblages. At the GOZ/RDN, felsic volcanics and intrusives are altered to sericite and argillite assemblages, at the BJ greenstones are ferrocarbonate altered.

Analyzing the strike and dip of 42 veins selected from throughout the map area showed a wide variation and no preferred orientations. Figure 5-3 shows the strike and dip measurements and distribution of the veins. Also shown are equal-area projections of poles to vein orientations for the Forrest Kerr map area, and the More Creek and Mess Lake map areas. After, separating the data into mineralized (n=23) and barren (n=19) subsets and two domains, the Forrest Kerr map area, and the More Creek and Mess Lake map areas, some general trends become apparent. First, there is no simple correlation between vein orientation and mineralization. In the Forrest Kerr map area mineralized veins strike northeasterly and northwesterly, barren veins strike easterly and northeasterly. In the More Creek and Mess Lake map areas mineralized veins strike northerly, easterly and northwesterly, but equally as many barren veins strike northerly and easterly. In general barren bull quartz veins trend easterly but exceptions are common. Visible gold is reported from east-trending veins at the Gold Pan and Falls showings on the Forrest property (*see* below) and auriferous veins occupy east-trending tension gashes in a north-east-trending shear zone at the Gab 12 mineral occurrence. In addition, no correlation could be made between vein orientation and the different metal assemblages described above.

In most cases the relative ages from crosscutting relationships show an early silica±sulphide±precious metal event followed by a ferrocarbonate±silica±sulphide±precious metal vein mineralizing event. These relationships are consistent at a local scale and probably represents single

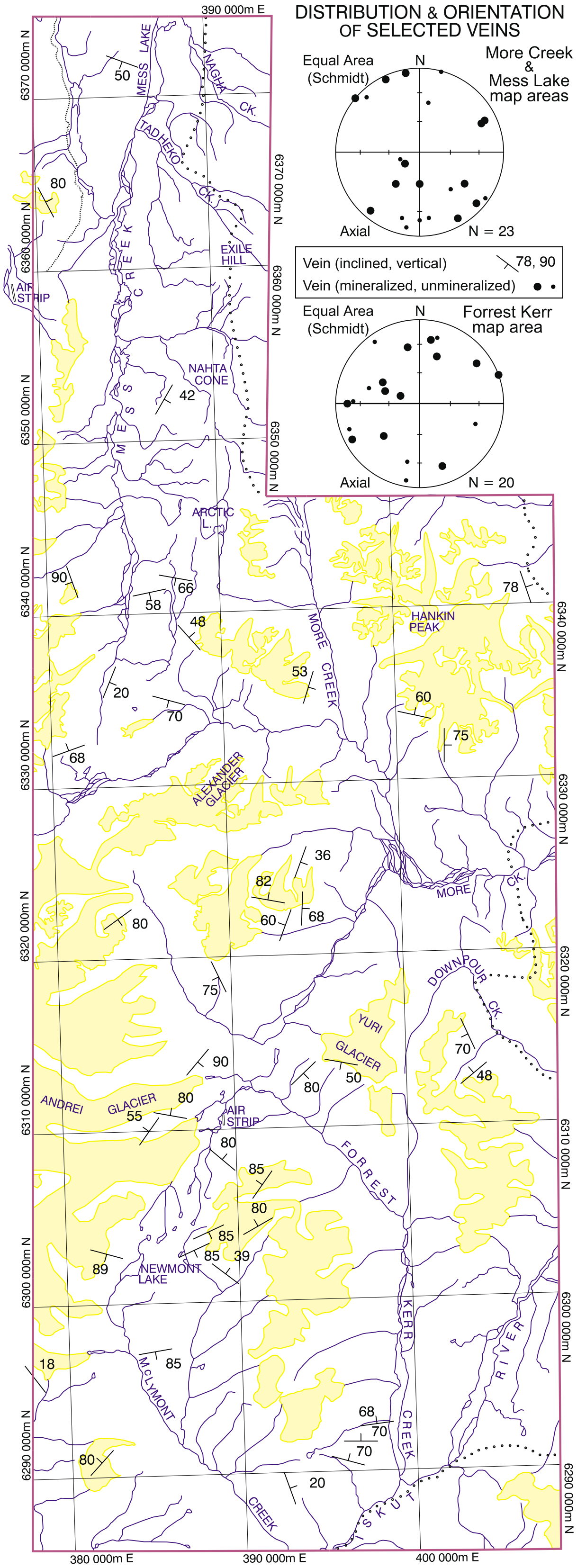

Figure 5-3. Distribution and orientation of selected veins in the study area. Equal area projections of poles to mineralized and barren veins in the Forrest Kerr map, and the More Creek and Mess Lake map areas .

evolving and cooling fluids which deposited silica early from higher temperature fluids, and carbonate-silica later from lower temperature fluids.

GOZ/RDN (MINFILE 104G/144)

The GOZ/RDN property is located about 5 kilometres south of the confluence of South More and More creeks, in the headwaters of Downpour Creek (Figure 5-2). The RDN claims were staked in 1987 to cover a prominent gossan in Downpour Creek (Photo 5-4). Noranda Exploration optioned the claims and explored them together with the GOZ claims from 1989 through to 1991. Extensive soil and rock geochemical surveys, mapping and geophysical surveys were completed on the property. Diamond drilling in 1990 consisted of 1545 m in 15 holes. A second program in 1991 totaled 1519 m of drilling in 10 holes. The exploration target was a precious metal enriched polymetallic massive sulphide deposit similar to Eskay Creek. Noranda concluded the claims had been adequately tested and allowed them to lapse in 1994.

The property lies predominantly east of the Forrest Kerr Fault, within fault-bound panels of Upper Triassic volcanic and clastic rocks and Lower to Middle Jurassic volcanic and sedimentary rocks. The layered rocks are intruded

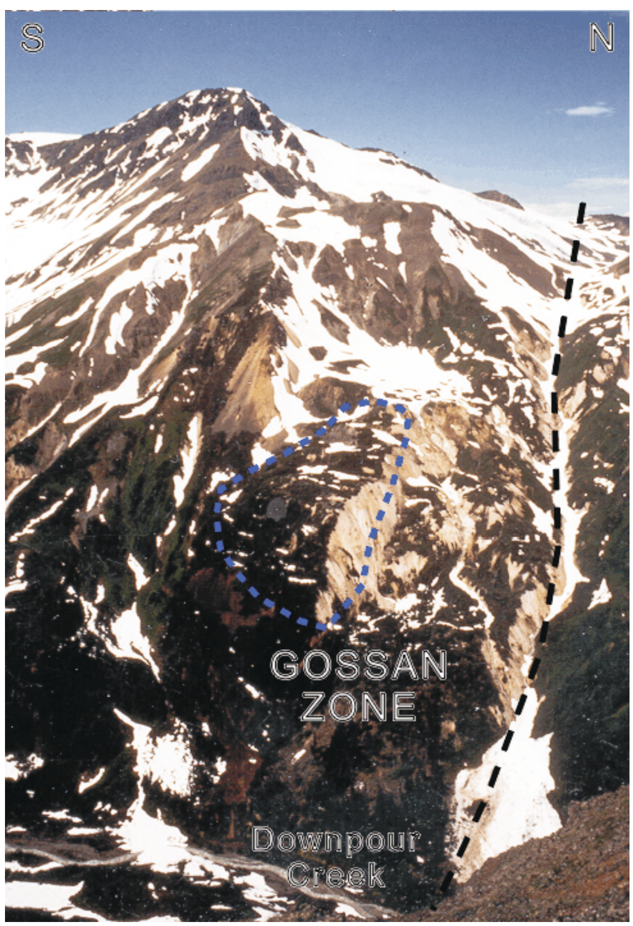

Photo 5-4. Dark ferricrete gossan and surrounding light coloured argillic alteration at the main Gossan Zone on the GOZ/RDN. Zone is located on southeast-facing slopes of Downpour Creek, view is to the west.

by Early and Middle Jurassic sills, stocks and plugs. The Upper Triassic rocks are massive green volcanic flows and maroon feldspar and hornblende crystal tuffs and volcaniclastic rocks. Structurally above is a Lower Jurassic succession of siltstone and sandstone, and grey and pink felsic to intermediate flows and crystal tuffs, which is either overlain or interlayered with a Middle Jurassic succession of thin-bedded siltstone, basalt flow breccia and tuff. The host rocks are age equivalents of the Mount Dilworth Formation and the Eskay Creek facies of the Salmon River Formation. Mineralization consists of gold-enriched polymetallic quartz veins hosted in silicified and pyritized rhyolite, felsic tuff, and subvolcanic porphyritic monzonite intrusive rocks.

Three areas of mineralization received the most attention on the claims; the Wedge zone, the main Gossan zone and the South Boundary zone (Figure 5-4).

Although less important, the Marcasite zone was the main reason the original RDN claims were staked. It is situated in the valley of Downpour Creek midway between the Wedge and South Boundary zones (Figure 5-4). The gossan consists of silicified porphyritic rhyolite containing 10 to 20% marcasite (after pyrite) in stringers of chalcedonic quartz and minor pyrobitumen (Savell, 1990). Gold and base metal values are negligible but erratic silver values up to 208 g/t have been reported.

The South Boundary zone was described as a narrow silicified zone containing chalcopyrite and significant gold values (Savell, 1990). It was drilled in 1991and the results released in the Northern Miner (September 16, 1991) reported an 11.6-metre drill intersection grading 23.9 g/t Au and minor amounts of base metals. The drill hole (RG-91-16) was collared in Upper Triassic plagioclase porphyritic andesitic rocks that are intruded by porphyritic syenite dikes at the south end of the property.

The wedge of felsic volcanics and subvolcanic intrusives in the centre of the property host the Wedge and Gossan zones respectively. The Wedge zone is located in the steep cliffs above where the highest-grade auriferous polymetallic boulders are located in Carcass Creek. Stratabound mineralization consists of massive to brecciated quartz veins and stringer zones hosted in silicified felsic volcanics. The gold-enriched quartz veins strike north and generally dip easterly parallel to the stratigraphy. The veins are chiefly narrow (about 1 metre) and contain from 5 to 10 per cent sulphides of copper, zinc, lead and arsenic in a quartz gangue. Drilling indicates the felsic succession is underlain by maroon, feldspar-porphyritic volcaniclastics and black siltstones. Alteration and mineralization are related to coeval(?) subvolcanic porphyritic monzonite intrusions. Drilling in the Carcass creek area in 1991 followed up a 1990 intersection of 11.8 g/t Au over 4.4m (Hole RG90-7) and a soil geochemical anomaly. Drilling the former revealed several narrow high-grade, quartz-sulphide breccia mineralization structures. Hole RG91-21 intersected two veins which assayed 137.8 g/t Au over 0.85 m and 101g/t Au over 0.95 m (Savell and Grill, 1991). Testing these structures along strike and down dip did not show appreciable continuity of grades or structure.

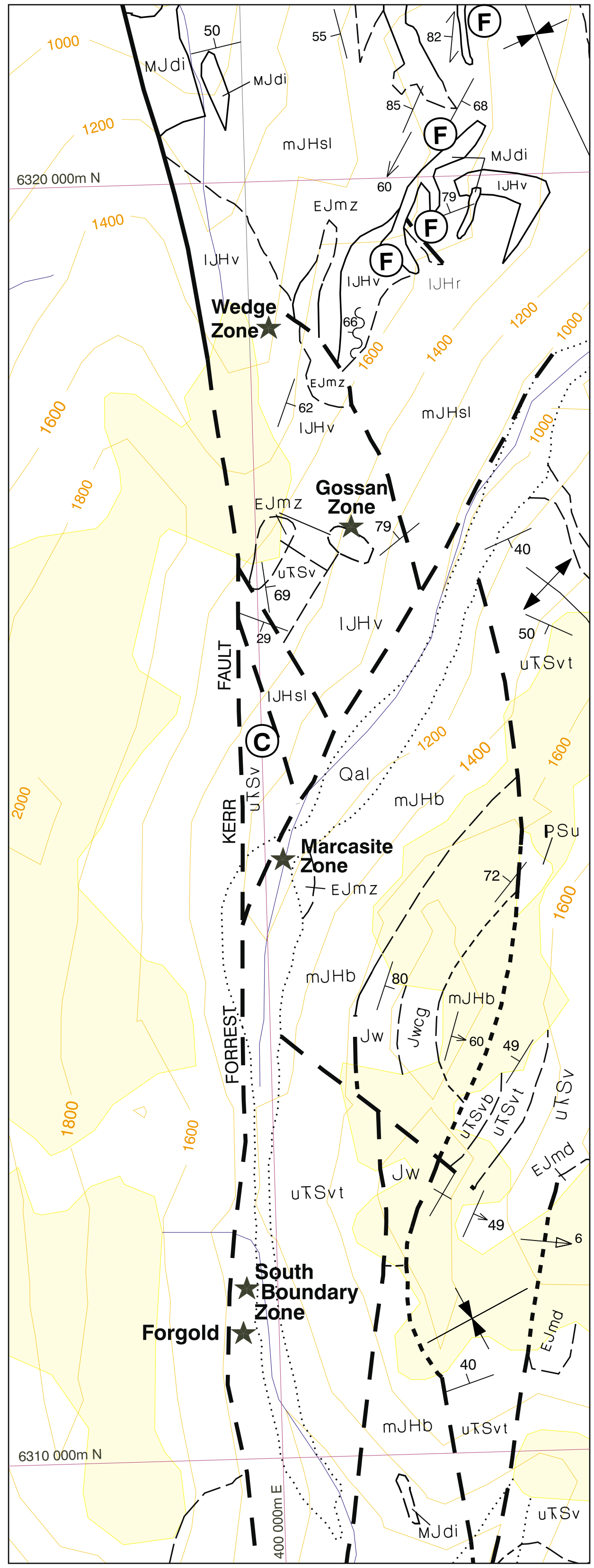

Figure 5-4. Generalized geology of the GOZ/RDN area, showing the locations of the Wedge, Gossan, Marcasite and South Boundary zones and the Forgold mineral occurrence. Unit designation corresponds to legend on GS-Map 1997-3.

Two holes tested the multi-element soil anomaly located 500m north of the Carcass Creek zone. Narrow quartz-sulphide breccia veins were intersected within variably altered felsic volcanic rocks.

The Gossan zone is located 2 km south of the Wedge zone on the south facing slopes of Downpour Creek. It is a large, spectacular ferricrete gossan and argillic alteration zone associated with a subvolcanic monzonite intrusion. Drilling in 1991 tested 2 geophysical targets on the zone (Savell and Grill, 1991). The first, RG91-18 intersected argillic altered pyritic feldspar porphyry, with a 9.9 m zone which assayed 0.18% Cu, 0.135% Pb, 0.429% Zn, 1.17 g/t Ag and 0.07 g/t Au. Hole RG91-19 intersected 125m of alternating quartz-sericite and argillic altered feldspar porphyry containing 5 to 25% pyrite. No significant assays were returned.

Regionally, gold and copper porphyry and subvolcanic vein deposits are spatially and genetically associated with Late Triassic to Early Jurassic volcanic centres and porphyritic monzo-syenitic intrusions. The Wedge and Gossan zones contain gold and silver enriched polymetallic vein and disseminated mineralization in Lower Jurassic felsic volcanic rocks and subvolcanic intrusions. The extensive hydrothermal alteration and presence of porphyritic intrusions suggests this area may be an exposed root system of a volcanic centre (Savell and Grill, 1991). Mineralization discovered to date on The GOZ/RDN appears to represent a synvolcanic Early Jurassic event. The Middle Jurassic rocks to the east and south may have potential to host exhalative deposits (*i.e.* Eskay-type).

FORGOLD (MINFILE 104B/378)

The Forgold claims are located approximately 20 km north of the confluence of Forrest Kerr Creek and the Iskut River, immediately south of the GOZ/RDN property (Figure 5-2). The claims were staked in 1989. Prospecting and rock chip sampling was carried out in 1990; mapping, soil sampling and diamond drilling in 1991. The drill program cut a total of 935.7m in five holes (Bond, 1992).

The property is divided into eastern and western halves by the north-trending Forrest Kerr Fault zone. The west side is underlain by penetratively polydeformed Paleozoic Stikine assemblage metavolcanic and metasedimentary rocks and the Late Devonian Forrest Kerr Pluton, the east side by fault-bounded panels of Upper Triassic volcanic and sedimentary rocks and Lower(?) to Middle Jurassic volcanic rocks. The Mesozoic rocks are intruded by Early and Middle Jurassic sills, stocks and plugs and host the known vein-style mineralization.

Rock and silt geochemical sampling discovered base and precious metal mineralization in highly leached, sericite altered lapilli tuff and crystal tuff west of Downpour Creek, just south of the GOZ/RDN claims (Termeunde and Termeunde, 1990). The mineralization is hosted in maroon lapilli and tuffaceous feldspar crystal-rich rocks. Proximal stocks of monzonite may be associated with the quartz-sericite and carbonate alteration, as it appears to be to the north on the GOZ/RDN claims.

Malensek *et al*. (1990) divided the vein mineralization into three types; all appear to be structurally controlled by the Forrest Kerr fault. The vein types are: steeply dipping chalcopyrite veins containing minor galena and sphalerite; quartz-carbonate stockwork veins containing sphalerite, galena and chalcopyrite; and silicified zones containing disseminated chalcopyrite. All the significant mineralization is hosted in Triassic rocks and only the first two types of veins are well mineralized. The majority of the veins trend northeastward and have steep dips.

The massive chalcopyrite veins are typically podiform. They pinch and swell from 0 to 50 cm over a few metres of strike length. While the chalcopyrite veins are silver-rich and generally low in gold and base metal values, the quartz-carbonate veins contain chalcopyrite, variable amounts of sphalerite and galena and are gold-bearing. These veins are typically narrow veinlets or stockworks. Grades of 112 g/t Au and 9.8% Cu are reported from a 5 cm wide veinlet (Malensek *et al*., 1990).

Five holes were drilled in 1992 on the northern portion of the Forgold 1 claim. Drill holes FG1 to FG4 were laid out to test the possible extension of the 1991, high-grade drill intersection made by High Frontier Resources Ltd. on the southern boundary of the GOZ/RDN. That intersection included 73.74 g/t Au over 3.7 m in a 11.6 m zone averaging 23.9 g/t Au (The Northern Miner, Sept. 1991). On the Forgold, two significant zones of gold mineralization were outlined; 3.9 g/t Au over 1.58 metres in drill hole FG-2 and 19.2 g/t Au over 0.82 metres in drill hole FG-3 (Bond, 1992). The drilling also encountered wide sections of alteration and sulphide mineralization. Drill hole FG-4 intersected extensive graphitic fault gouge and breccia zones (components of the FKF zone). Two narrow zones of copper mineralization were intersected in hole FG-5, located about 1 km south of the other 4 holes. Based on this drilling Bond (1992) concluded that the gold mineralization is narrow and discontinuous.

QUARTZ-CARBONATE VEINS Cu-Au-Ag (As)

BJ CLAIM GROUP (MINFILE 104G/70)

The BJ claim group is located at the headwaters of Mess Creek (Figure 5-2). The property was staked in 1980 on the basis of anomalous stream sediment geochemistry. Geological mapping, rock and soil sampling was carried out in 1980, 1981 and 1982 by Teck Explorations. Follow-up mapping and detailed sampling was completed over two areas; an iron carbonate breccia zone and an area containing anomalous gold values in soils (Folk,1986).

The claims are underlain by a polydeformed and metamorphosed volcanic and sedimentary succession of Paleozoic, probable Lower to middle Devonian age rocks consisting of quartz sericite schists, intercalated mafic flows and tuffaceous rocks, and a lower unit of graphitic schist and siltstone. Foliated to equigranular Early Devonian diorite intrudes these units. Farther west, Upper Triassic volcanic and sedimentary rocks are in faulted contact with these penetratively deformed Paleozoic rocks.

The area has undergone four phases of folding (Holbek, 1988). Dominant foliation, is bedding parallel and axial planar to regional phase 2 folds. It is north to northwest-trending. East-trending third phase structures crenulate the dominant foliation and younger open, upright, north-trending folds deform all the earlier structures.

Mineralized structures on the BJ claims include; concordant, foliation-parallel quartz veins and discordant, fault-hosted quartz veins and iron-carbonate breccia zones. Foliation parallel bull quartz and pyritiferous quartz veins are common throughout the Paleozoic strata. They contain minor pyrite but no precious metals, are often recumbently folded, and predate or are synchronous with early deformation. These are metamorphogenic veins and formed during the greenschist metamorphism which accompanied early deformation.

Younger discordant mineralized structures trend northeast to east across the dominant early foliation. These are chiefly quartz and quartz-carbonate breccia veins. Brown, limonitic-weathering ferrocarbonate alteration envelopes are associated with these structures. The veins contain disseminated to locally massive pyrite, arsenopyrite, less tetrahedrite, chalcopyrite, and sphalerite and traces of galena, hematite and gold. Potassium-argon determinations on chromium-bearing muscovite associated with quartz-carbonate sulphide vein mineralization gave a date of 194±6 Ma, an Early Jurassic age (Holbek, 1988). It is this second vein-type, with its precious metal potential, that has received the most exploration attention. A zone of easterly-trending quartz veins is localized along the faulted contact between metadiorite and chlorite sericite schist on the Windy claim. The main vein has a strike length of 500m and widths to 6m. Gold values from the main vein average 0.034 g/t with a single sample assaying 0.136 g/t (Folk, 1986). Gold values from a second vein, located near line 6+00 S on the Windy grid, range from 3.43 to 10.29 g/t, with a parallel structure returning 24.35 g/t Au from a 0.4m chip sample (Folk, 1986). A grab sample collected during regional mapping from a sloughed trench returned; 32.9 g/t Au, 55 g/t Ag, 2.57% Pb, 1.80% Zn and 30.0% As (Appendix 10).

Approximately 4 km south is an extensive northeast-trending ferrocarbonate breccia zone on the BJ claim. The zone is 175m wide and has a strike length of over 1000m. At least two stages of quartz and carbonate veins are indicated by crosscutting relationships (Holbek, 1988). Gold values are associated with pyrite-rich sections, and range from 0.34 to 1.78 g/t Au, (Folk, 1986).

NEW (MINFILE 104B/379)

The New 1, 5 and 6 claims are located approximately 8 kilometres south of Newmont Lake and cover the area between McLymont Creek and the Verrett River (Figure 5-2). Diamond drilling on the claims in 1990 totaled 447 m in 10 holes (Todoruk and Ikona, 1990, 1991).

The claims are underlain by a homoclinal panel of moderately south-dipping mafic pillowed basalt flows, breccia and tuff, quartz-phyric rhyolite and intermediate to felsic tuffaceous and epiclastic rocks of Upper Devonian and Lower Carboniferous age. These volcanic and subvolcanic rocks overlie complexly folded and faulted intermediate volcanic and sedimentary rocks. The Late Devonian Forrest Kerr Pluton (FKP) intrudes these rocks in the eastern part of the property. A compositionally similar granitoid body centered on the Verrett River, underlies the western portion of the claims. It is interpreted to be a Late Paleozoic intrusive, possibly a temporal satellite body to the FKP. Compositions vary from diorite through quartz monzonite to granite. The intrusion is medium to fine grained, equigranular, and contains 20 to 35% quartz, 20 to 30% potassium feldspar, 40% plagioclase and 15% fine grained hornblende and/or biotite. Alteration is localized along fractures and fault zones in the granite and has deposited any combination of the following; chlorite, quartz, potassium feldspar, epidote and/or carbonate minerals . These permeable zones are later oxidized by surface solutions.

Precious metal mineralization is contained within sulphide-bearing quartz and quartz-carbonate veins in the intrusion. The veins pinch and swell from less than one centimetre to greater than one metre widths. They contain variable amounts of pyrite and chalcopyrite, and gold values tend to follow the sulphides. Quartz-carbonate-chlorite alteration zones within the granite, envelop the better mineralized veins (Todoruk and Ikona, 1990, 1991). Drilling below the surface exposures showed poor continuity of the vein structures and metal grade. The en echelon, pinch and swell, arcuate and anastamosing character of the veins seen on surface suggests they occupy irregular and discontinuous structures. Later faults and shearing have further complicated their distribution.

MCLYMONT (Camp Zone) (MINFILE 104B/126)

The McLymont Creek property straddles the headwaters of McLymont Creek, about 2 kilometres south of Newmont Lake (Figure 5-2). Early exploration on the McLymont property tested the base metal potential of the copper-iron skarn deposits in the area. It was not until the early 1980's that Du Pont of Canada Exploration Limited located and explored precious metal-bearing quartz veins present in the area (Kowalchuk, 1982). The property was restaked in 1986 by Gulf International Minerals Ltd. and drill tested. Diamond drilling continued in 1987, with a total of 2185m drilled in 11 holes (Grove, 1987) and in 1988 with 721m drilled in 9 holes (Grove, 1989).

The Camp zone is located at the 90° bend in McLymont Creek, 3 km south of Newmont Lake. Veins crop out on both the north and south sides of the creek. Mineralization occurs in auriferous quartz veins that fill fractures in a quartz-rich granite (quartz porphyry). The host unit is tentatively correlated with the Late Devonian FKP. Feldspar porphyritic monzonite intrusions crop out nearby to the north and may have generated the mineralization.

Two types of veins were recognized. The first is an early quartz-pyrite-chalcopyrite vein set that trends 120 to 140 degrees. The veins are narrow, generally less than 30cm. Mineralization comprises minor sphalerite, galena, and free gold (Grove, 1987). Grove (1989) shows a vertical section at 030° azimuth containing drill holes 88-1, 5 and 6

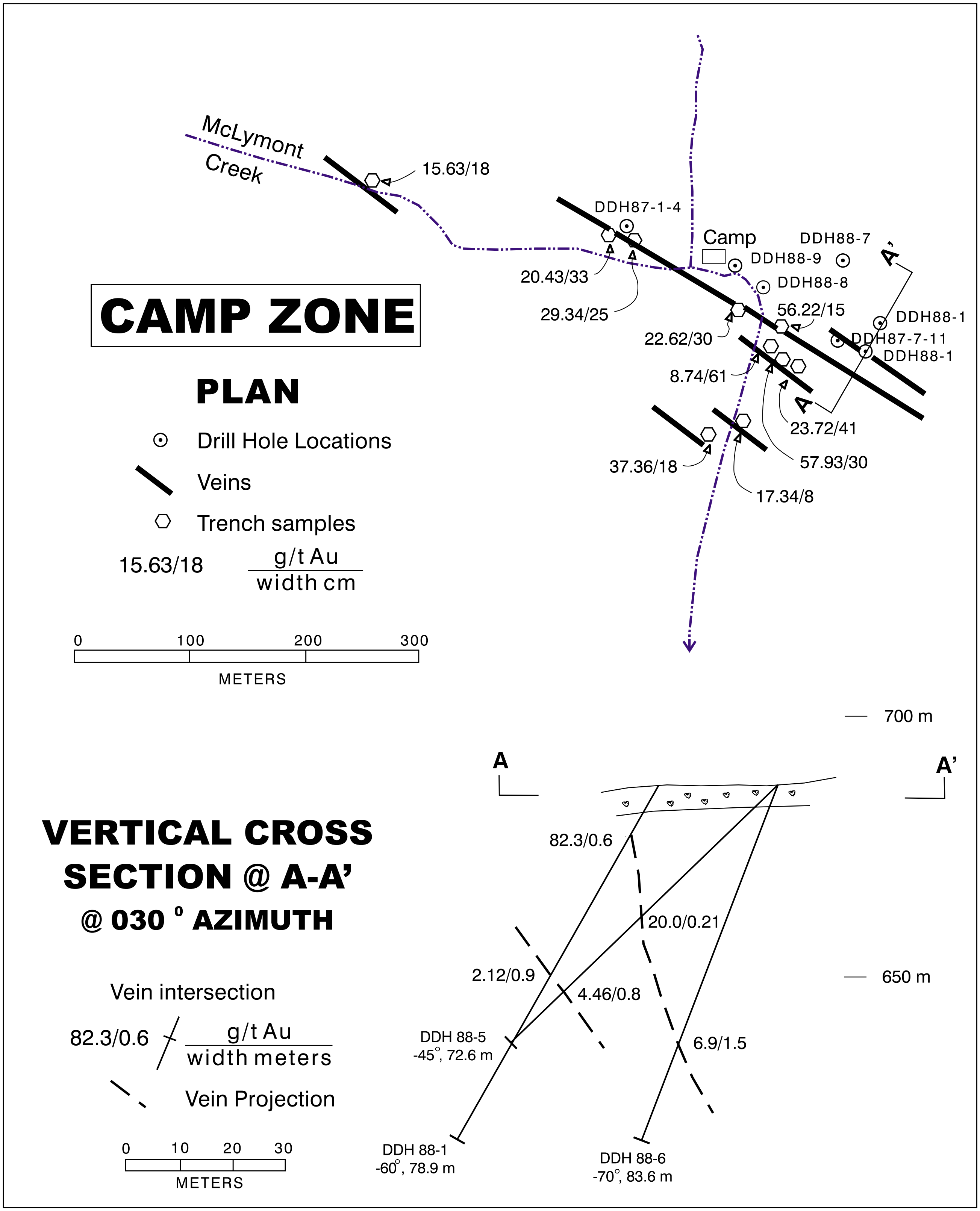

Figure 5-5. Generalized plan and longitudinal section through the Camp zone, McLymont Creek property (after Grove, 1989). Assay values are from trench samples and drill intersections of northwest trending quartz-pyrite-chalcopyrite veins hosted in Late Devonian(?) granite.

(Figure 5-5). It shows the variation in width, grade and orientation of one of these quartz veins over a vertical distance of 40 m. The vein dips 70 degrees northeast. Diamond drill hole 88-1 cut 0.61m of 82.32 g/t Au, the vein had narrowed to 0.21m with values of 20.0g/t Au in hole 88-5, and in 88-6 the structure widened to 1.5 m but the grade dropped to 6.9 g/t Au. Samples from trenches assayed from 15.6 up to 57.9 g/t Au.

The second vein type consists of northwest or northeast-trending en echelon vein swarms that postdate the earlier quartz veins. These are ankerite-quartz-pyrite replacement veins and contain sparse chalcopyrite and erratic gold values.

FAULT AND SHEAR HOSTED VEINS Cu-Ag-Au and Ag-Zn-Pb

BAM 10 (MINFILE 104G/110)

The Bam 10 occurrence is located 1 kilometre southwest of Bam 8, at the southwest end of the Arctic Plateau (Figure 5-2). The potential for gold-bearing quartz veins was recognized by Chevron Canada Resources Ltd. during mapping and sampling in 1985. Follow-up work in 1986 included detailed mapping, soil sampling, VLF-EM16 geophysical survey and trenching (Hewgill and Walton, 1986a). Radcliffe Resources Ltd. drilled 837 metres in 9 holes the following year (Diner,1987). Diamond drilling in 1997 intersected no significant gold values in the 6 holes drilled (Wojdak, 1997).

Strongly schistose flows, tuffs and subordinate carbonates of probable Devonian age underlie the claims. Early Mississippian granite and diorite intrude these metavolcanic rocks. The contact, which is in part structural, dips moderately westward. Auriferous quartz veins are hosted in the Upper Paleozoic granite. North, northeast and northwest striking structures cross the property. Northerly-trending structures, generally west side-down listric normal faults, produced the Mess Creek valley and are part of the Mess Creek Fault zone. Northwest -trending fractures were identified as the pyrite-gold bearing structures (Hewgill and Walton, 1986a). Northeast-trending structures are dominant on the property. They offset the northwest fractures and are probable splays from the main northerly-trending faults.

Sericite-silica-sulphide alteration of the granite is variably developed adjacent to fracture zones and is overprinted, locally pervasively, by younger ferrocarbonate alteration. Mineralized zones are podiform and associated with carbonate and sericite alteration and zones of silicification developed along north and northeast-trending faults in the granite (Diner, 1987). Mineralization consists of native gold and fine-grained blebs of pyrite, with lesser chalcopyrite, galena, and rare molybdenite in quartz and carbonate veinlets hosted within fractured, sericitized and silicified granite. Rock geochemical results indicate samples anomalous in gold also contain anomalous amounts of silver, bismuth and antimony, and, in the vicinity of Bam 8, copper as well (Hewgill and Walton, 1986a). In contrast, the Bam 8 deposit, although characterized by the same suite of elements, contains very low gold values.

From the 1987 drilling, predictable and mappable alteration halos were recognized peripheral to mineralization, and most mineralization is located within 50 metres of the granite-metavolcanic contacts.

Mineralized zones are irregular and gold values highly variable up to multi-gram grades (Trench 86-1). Resampling the discovery showing returned an assay of 200.8 g/t Au (Hewgill and Walton, 1986a). Gold values range from 8.57 g/t over 18.9 m in trench 86-1 to 1.72 g/t over 2.43 m in diamond drill hole 87-1, drilled to test the ground beneath this Trench (Diner, 1987). Mineralization is hosted in Lower Jurassic conglomerates and Early Mississippian granite. The spatial distribution of mineralized zones along intersecting north and northeast-trending structures indicate these structures were open to mineralizing fluids in post-Lower Jurassic (?Sinemurian) time.

CUBA (MINFILE 104B/334)

The silver-rich Cuba showing is located 3 kilometres northeast of Newmont Lake (Figure 5-2). Mineralization is hosted in fault dissected and brecciated blocks of northeast-trending Lower Permian carbonate. In outcrop the carbonate forms spectacular crumbling varicoloured pinnacles that weather various hues of white, yellow, orange and brown. The unaltered carbonate is a medium grey, echinoderm skeletal wackestone containing interbedded chert horizons. In the vicinity of mineralization the carbonate is crackle-brecciated, dolomitized and ferrocarbonate altered.

Mineralization occurs in two zones located approximately 600m apart (Kiesman and Ikona, 1989). The showings lie adjacent to the east-bounding fault of the Newmont Lake Graben, a northeast-trending regional extensional structure. The McLymont, Gab NW and Gab SE occurrences are situated along a parallel structure to the southwest. Mineralization at the Cuba showings occurs as narrow cm wide fracture fillings, as matrix to crackle-breccia zones and as replacements up to 4m wide in easterly-trending shear zones (Kiesman and Ikona, 1989). Sulphide minerals include galena, sphalerite and tetrahedrite in a gangue of calcite and locally coarse crystalline barite. A grab sample taken from a trench in the south zone returned values of 125 g/t Ag, 5.88% Zn and 0.05% Cu.

Drilling in 1988 tested the southern zone with 2 holes, totaling 133 m. The holes were drilled at 160° azimuth from the same setup, 88PG-9 at -45° and 88PG-10 at -60°. Hole 88PG-10 intersected 7.5m averaging 56.2 g/t Ag and 0.488% Zn; hole 88PG-9 intersected ferrocarbonate altered and oxidized carbonates with sporadic silver values (Kiesman and Ikona, 1989). The mineralization intersected in the lower hole (88PG-10) lies nearly vertically below the trench exposures, suggesting a steeper dip than exposed at surface, if these are the same structures.

GAB 12-SW (MINFILE 104B/335)

The Gab 12 property is located east of the headwaters of McLymont Creek, approximately 4 kilometres southwest of Newont Lake (Figure 5-2). The claims were staked in 1986 and airborne magnetic and electromagnetic-VLF surveys covering the claims were completed between 1987 and 1988. Geological mapping, prospecting and soil sampling in 1987 identified 3 zones of alteration and mineralization; Gab11-SE, Gab12-NE and Gab12-SW (Todoruk, 1988). Diamond drilling in 1988 tested the Gab12-SW zone with 856 m in 7 holes. A second phase of drilling was completed in 1990 totaling 638m in 7 holes (Game and Sampson, 1990).

The property is bisected by the northwest trending McLymont Fault and subsidiary parallel and north-trending fault structures. West of the main fault zone, and host to the mineralization is a thick sequence dominated by polymictic volcanic conglomerate, sandstone and cherty siltstone. This same succession conformably overlies Early(?) to mid Carboniferous limestone at the McLymont NW zone and the Gab 9 to the north. East of the fault is a Late Triassic to Early Jurassic hornblende, potassium feldspar porphyritic monzonite. It occupies a fault zone separating Late Devonian(?) Verrett River quartz-diorite to granite intrusion from the Carboniferous conglomerate unit. Detailed mapping along the faulted western margin of the monzonite (Game and Sampson, 1990) shows offset along the McLymont fault indicating at least some post-intrusion fault motion. A 30 m wide east-trending feldspar porphyry dike crosscuts sediments in the conglomerate unit adjacent to the faulted contact with the monzonite.

Mineralization includes the Arseno/sulphide zone, the Rusty shear zone and an auriferous sulphide boulder train (Figure 5-6). The Arseno zone consists of two subparallel auriferous arsenopyrite-pyrite mineralized shear zones which strike 030° and dip vertically. Mineralized quartz veins vary from a few centimetres up to 1.5 metres in width. Sulphide minerals include pyrite, arsenopyrite and chalcopyrite. Ferrocarbonate alteration extends 10 to15m beyond the shear zone into the country rock. Four drill holes tested the Arseno zone in 1988. Only 88-1 intersected mineralization, returning 74.0 g/t Au over 0.60 m from a well mineralized section of quartz-veins containing pyrite, arsenopyrite and chalcopyrite (Todoruk and Ikona, 1989). Drilling in 1990 totaled 638 m in 7 holes. Holes BRY 90-1 and 2 tested the Arseno zone and the remaining five holes (BRY 90-3 to 7) the Sulphide zone. Results from the 1990 drilling were not encouraging. From the Arseno zone; Hole 90-1 inter-

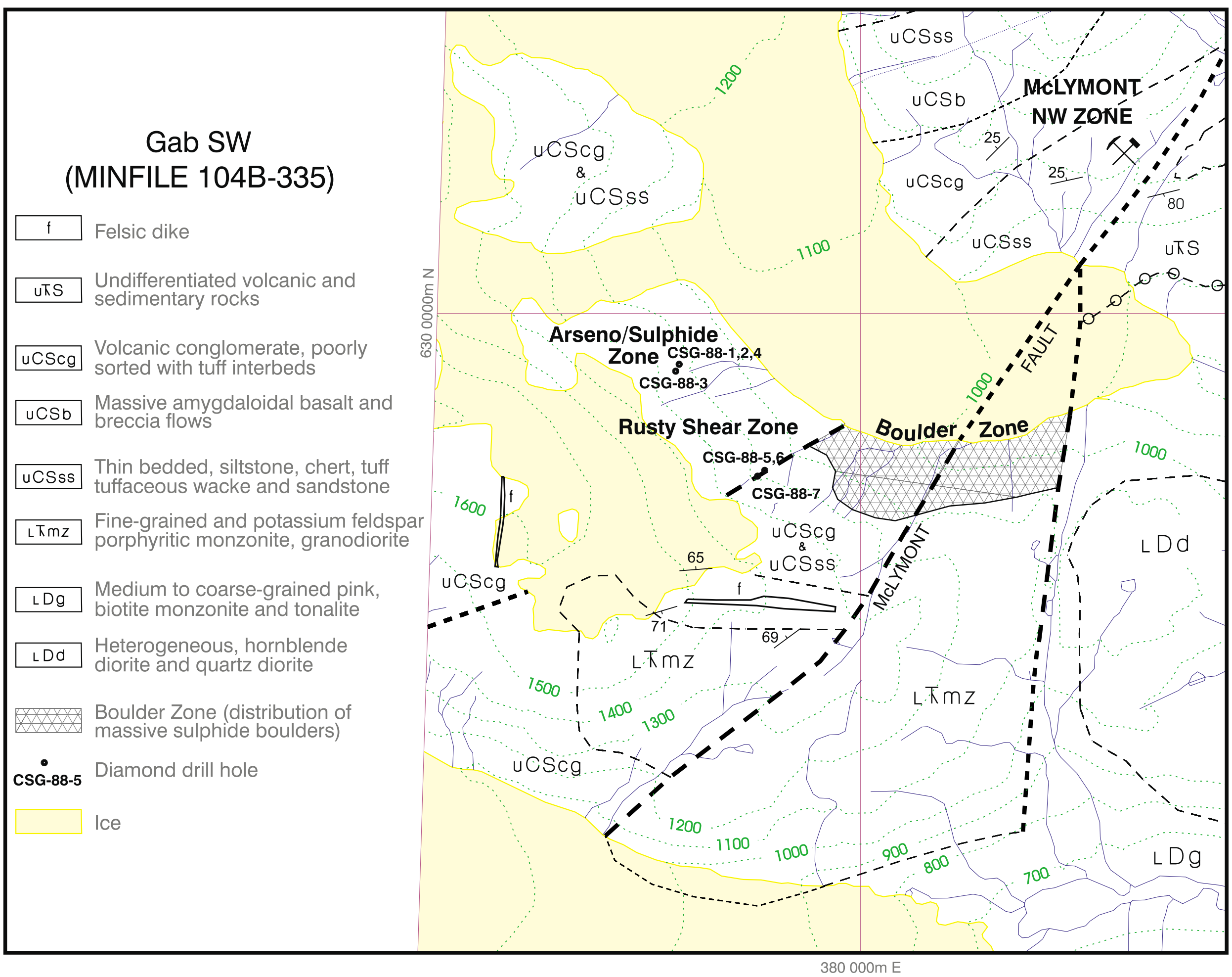

Figure 5-6. Generalized geology of the Gab SW area, showing the locations of the Arseno/Sulphide, Rusty Shear and Boulder zones and the McLymont NW Zone. Location of the 1988 drill holes from Todoruk and Ikona (1989). Unit designation corresponds to legend on GS-Map 1997-3.

sected 0.5 m assaying 3.6 g/t Au and 90-2 did not intersect significant mineralization. The Sulphide zone is offset by easterly-trending cross faults along its length and truncated by the McGillivray fault at its southern end (Game and Sampson, 1990). Incompetent and open zones in the bedrock caused problems drilling the structure. Intersections of note include an 8.6m wide zone of fractured and weak to moderately carbonate altered siltstone in hole 90-6. The top of the zone contains a 0.20 m quartz vein with massive pyrite, arsenopyrite and trace chalcopyrite. It assayed 3.08 g/t Au. The lower 2.2 m is locally silicified, and cut by carbonate stringers and 1 to 5 cm wide massive pyrite and arsenopyrite veinlets. This mineralized zone averaged 5.07 g/t Au. The intervening section (6.2 m) returned low gold values.

The Rusty Shear zone is located 500 m east of the Arseno zone. It comprises a ferrocarbonate alteration zone developed along a 040° trending fault structure. Mineralization consists of fine pyrite and arsenopyrite hosted in vertical ferrocarbonate veins that strike 090° within the northwest-trending altered structure. The veins vary from several centimetres to 0.5 metre in width. The zone was drill tested in 1988 with three holes totaling 460m. Gold values were generally low; the best value, 2.4 g/t Au over 0.5 m was returned from hole 88-5 where it intersected a 1 to 2 cm wide quartz veinlet containing pyrite (Todoruk and Ikona, 1989). Surface trenching and rock sampling was carried out in 1990. The alteration zone is auriferous and also anomalous in arsenic and zinc (Game and Sampson, 1990).

The boulder train contains three types of auriferous sulphide boulders; massive sulphide, pyrite -arsenopyrite-chalcopyrite-quartz vein material and arsenopyrite-pyrite-quartz-carbonate vein material. Gold values vary from nil to as high as 100 g/t (Game and Sampson, 1990). The boulders are dispersed along the southern lateral moraine of the glacier and can be traced west and then southwest up the Rusty Shear zone structure. The mineral assemblages are similar to the vein-type mineralization in the area and suggest the source is beneath the ice field to the west.

FORREST (MINFILE 104B/380)

The Forrest claims extend approximately 10 kilometres north from the Iskut River along the west side of Forrest Kerr Creek (Figure 5-2). The claims were first staked in 1987, with more added in 1988. Prospecting in 1988 discovered shear-hosted quartz vein mineralization and in 1989 an extensive program of exploration was undertaken. This included; detailed mapping, trenching, and soil geochemical and geophysical surveys. Several targets were defined and trenched and drilled in 1990 (Stammers and Ikona, 1990). Diamond drilling in 1995 totaled 995 m in 8 holes.

The claims are underlain by a structurally inverted succession of variably deformed, fault-bounded panels of Upper Paleozoic rocks. The oldest rocks (Lower Devonian), crop out on the western part of the claims and occupy the highest elevations; the youngest rocks (Upper Triassic) are exposed in Forrest Kerr Creek. The Late Devonian Forrest Kerr Pluton underlies the western part of the claims. It intrudes Devonian rocks and is thrust imbricated with younger (?) metasedimentary rocks. Mineralization is hosted by penetratively deformed Lower and Middle Devonian metavolcanic and metasedimentary rocks, Upper Devonian and Mississippian volcanic rocks and Upper Carboniferous tuffaceous sedimentary rocks. One to two kilometre diameter plagioclase porphyritic diorite stocks intrude a panel of Carboniferous rocks in the center of the property. Another small diorite stock, of probable middle Jurassic age, crops out further north.

More than thirty small, high-grade precious metal mineral occurrences have been discovered on the claims since 1987. These are described in detail in various reports (Ikona and Todoruk, 1988; Stammers and Ikona, 1990 and Todoruk, 1994). Exploration and development of the claims has focused on four main mineralized zones. These are the Creek/Canyon shear, and the Crooked Creek, Forrest and Gold Pan/ Falls zones (Figure 5-7).

The Creek shear, Triple Creek and Canyon shear occurrences occupy the steep cliffs on the south side of Gossan Creek (Figure 5-7). They comprise mineralized northeast striking, subvertical shear zones hosted in massive greenstone, interlayered with cherty tuff, phyllite and siltstone. Alteration mineral assemblages include chlorite, sericite and carbonate. The fault structures are pervasively ferrocarbonate altered and oxidized and variably mineralized with auriferous arsenopyrite-bearing quartz veins, stockwork and breccia zones; massive pyrite and chalcopyrite ± gold and silver-rich chalcopyrite-bearing ferrocarbonate-quartz veins. Scott and Ikona (1995) interpret the northerly striking and variably dipping auriferous arsenopyrite quartz veins to be early structures that are cut by the northeast striking, subvertical shear zones, and concluded that the pervasive ferrocarbonate alteration and chalcopyrite± gold mineralization was introduced late in the paragenesis of the shear zones.

Diamond drilling in 1990 tested the Creek shear with nine holes (totaling 813 m) from 3 setups; the Canyon shear with two holes totaling 240 m, and the Triple creek showing with 3 holes from a single setup (Stammers and Ikona, 1990). Results for the Creek shear include; 16.0 m of 4.49 g/t Au and 0.64% Cu from a quartz-breccia intersected in AVD-90-13; and 7.0 m of 3.56 g/t Au, 60.36 g/t Ag and 3.76% Cu in hole AVD-90-5. Results from the Triple Creek were discouraging. In 1995, drilling tested the Creek shear with six holes, and Triple Creek with 2 holes (Scott and Ikona, 1995). Drilling at the projected northeast extensions of the Creek zone, and, the mineralization intersected in AVD-90-13 did not intersect significant gold mineralization. Results from drilling on the Triple creek zone include: hole F95-9, abandoned; F95-10, no significant intersections; and F95-11, an eleven metre zone of narrow (1 to 6 cm) arsenopyrite-bearing quartz carbonate veinlets. Assays from the latter returned 3.01 g/t Au with low silver and copper values over a 3.15 m interval.

The Crooked Creek showing is located on the north side of Gossan Creek, about 2 km northeast of the Creek Shear showing (Figure 5-7). Mineralization is hosted within a northeast-trending shear zone crosscutting phyllite and cherty tuff. The structure is on strike with the Creek shear.

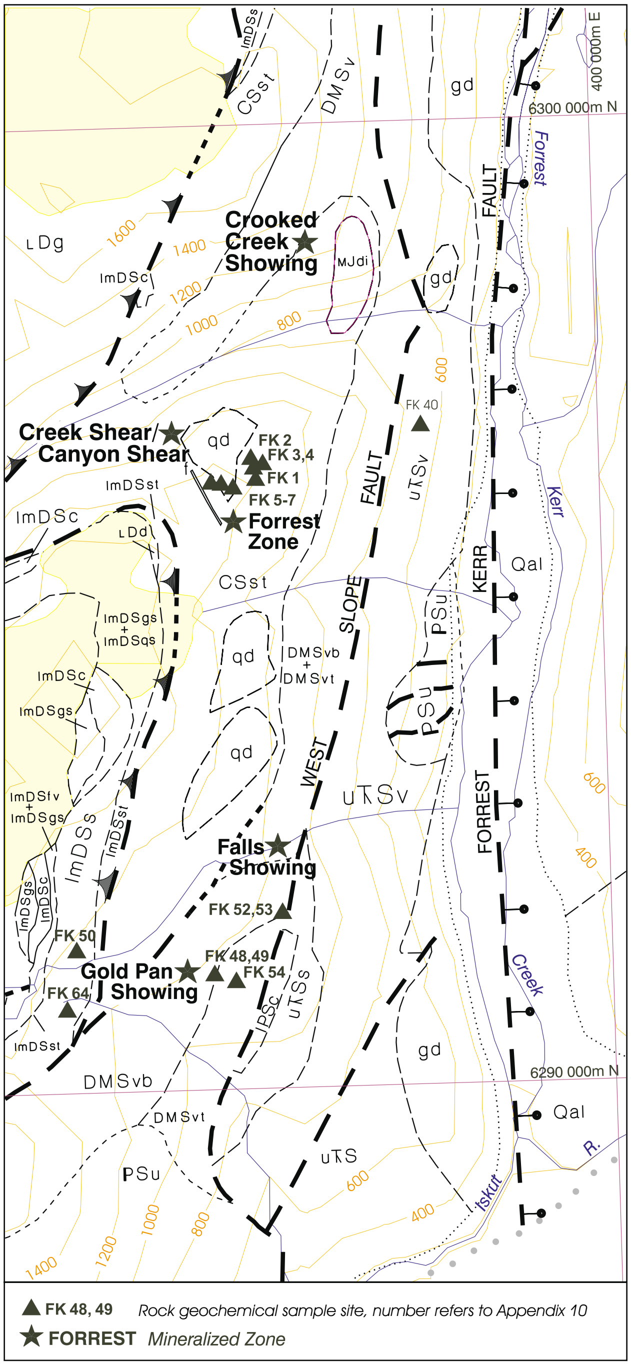

Figure 5-7. Generalized geology of the Forrest claims, showing the locations of the Cooked Creek Showing, Creek Shear and Canyon Shear, Forrest Zone and the Gold Pan and Falls showings. Symbology and line types correspond to GS-Map, in the pocket.

Mineralization consists of two assemblages; auriferous arsenopyrite-bearing quartz veins and silver-rich chalcopyrite± gold mineralized quartz-carbonate veins (Todoruk, 1994). Disseminated chalcopyrite hosted in a northeast trending axial planar shear zone was drill tested with two holes (Scott and Ikona, 1995). Assay results from drill core were low in gold and copper values.

The Forrest zone is a 250 x 250m area of weakly to unmineralized quartz stockwork hosted in massive meta-andesite. It is located about one km south of the Creek Shear. The quartz veins have a dominant trend of 130° and moderate southwest dips (Photo 5-5). The stockwork zone was drilled in 1990 with a single 223 m hole. The drill hole did not intersect any significant mineralization.

The Gold Pan/ Falls zone is located approximately 5.5 km south of the Creek Shear zone. The two occurrences consist of east-trending quartz veins. The veins range in width from 5 to 50 cm and contain pyrite, arsenopyrite, chalcopyrite and locally visible gold. The veins are narrow and generally discontinuous, but their orientation and gold content constrain orientation of the local stress field during at least some gold deposition.

CARBONATE HOSTED Cu-Ag-Au

BAM 8 (MINFILE 104G/27)

The Bam 8 prospect is located 4 kilometres southwest of Arctic Lake on top of the eastern escarpment of Mess Creek valley (Figure 5-2). In 1967, diamond drilling defined the Southwest zone, containing 299 400 tonnes grading 0.76 per cent copper, and the East zone, containing 4 540 tonnes grading 2.45 per cent copper and 17.83 grams per tonne silver.

The property is underlain by green chlorite schist, purple schistose tuff and flow rocks of the Upper Paleozoic Stikine assemblage. These are intruded by Early Mississippian granite and diorite of the More Creek Pluton and overlain paraconformably by thick-bedded Lower Permian carbonate and limonitic brecciated dolomitic carbonate; the latter hosts most of the copper and silver mineralization. Overlying the carbonates are variably altered and mineralized, Upper Triassic, thin-bedded limy fetid sandstone, siltstone and conglomerate units. These in turn are unconformably overlain by Lower Jurassic maroon polymictic granite-bearing cobble conglomerate. Fine-grained and porphyritic plagioclase-hornblende monzonite dikes cut the

Photo 5-5. Quartz stockwork crosscuts chloritic hornblende metadiorite and enclosing phyllite and tuff at the Forrest zone. Mineralization consists of pyrite, minor chalcopyrite and malachite with trace precious metal values.

granite and limestone and are probably related to mineralization. Small, highly fractured serpentinized peridotite bodies occur along northeast-trending fault zones.

Mineralization consists of disseminations, stringers and east-northeast-trending veinlets of tetrahedrite, with minor chalcopyrite, pyrite, sphalerite and galena. Secondary minerals include azurite and malachite. Alteration includes dolomitization of limestone, carbonitization of volcanic rocks, sandstone and conglomerate, and hydrothermal alteration and associated quartz veining in the granitic rocks (Gillan *et al*., 1984). Alteration (limonitic orange cliffs) and mineralization are spatially related to north-trending regional faults and northeast-trending splays off them.

It was previously thought that granitic rocks on the property were responsible for the mineralization, as they were interpreted to intrude the mineralized carbonate rocks. However, subsequent age constraints on the granite (Early Mississippian) and the carbonate (mid Carboniferous) indicate that the contact must be a fault or a disconformity. Probable heat sources for the mineralization are the subvolcanic monzonite plugs associated with Au-Ag mineralization on the Run claim group, a stock of which crops out a few kilometres north of the property.

STRATIFORM MASSIVE SULPHIDE DEPOSITS

VOLCANOGENIC Cu-Zn-Pb (Kuroko) and CARBONATE-HOSTED Zn-Pb-Ag (Irish-Type)

FOREMORE (MINFILE 104G/148)

The Foremore claims are located at the headwaters of the south tributary of More Creek, about 10 kilometres north of Forrest Kerr airstrip (Figure 5-2). The first claims were staked in 1987 by Cominco Ltd. in an area containing auriferous vein quartz boulders. Prospecting and mapping located quartz veins with gold values up to 9 g/t and copper skarn mineralization, but more importantly several hundred cobble to boulder sized clasts consisting of very fine grained pyrite, barite, sphalerite, with minor galena and tetrahedrite (Mawer, 1988). Additional staking was completed that year and the exploration target became the source of the massive sulphide boulders. Mapping, rock sampling and UTEM and Electromagnetic geophysical surveys were successful in locating laminated galena and sphalerite with coincident UTEM conductors in felsic volcanic rock (Barnes, 1989). Electromagnetic conductors located below 120 metres of glacier ice were drill tested in 1990 (Photo 5-6). Four holes were collared, three reached bedrock. Drilling intersected graphitic shear zones interpreted to represent the conductive horizons. A single hole was drilled in 1996 (664 m) from a nunatak located southwest of the 1990 drilling. The two electromagnetic conductors targeted in the 1996 drilling correspond to intersections of graphitic mudstone.

The property is underlain by Stikine assemblage rocks. These comprise a Lower and middle Devonian sequence of intermediate to felsic volcanic rocks, carbonate and graphitic and sericitic schistose sedimentary rocks and an Upper Devonian and Lower Mississippian sequence of primarily volcanic rocks. These sequences are intruded by the Early Mississippian More Creek Pluton and smaller satellite intrusions of quartz-porphyritic biotite granite.

Photo 5-6. Diamond drilling on Cominco Ltd. - Foremore claims, 1990. The 1990 program targeted UTEM conductors located below 120 metres of glacier ice.

Polyphase deformation has affected all rocks on the property. Strain partitioning led to formation of panels of more deformed rocks interleaved with largely undeformed rocks of the same age. Bedding and dominant foliation planes trend northeastward. Early recumbent folds in carbonate layers plunge shallowly to the northwest and southeast, deformed by later northeast-trending folds. East and northwest-trending crenulation cleavage overprints the dominant foliation. Several thousand mineralized boulders have been found on the Foremore claims. These occur in outwash plains at the eastern and northern lobes of the More glacier. The distribution of polymetallic massive sulphide float suggests the source is beneath the main ice sheet of More glacier. Boulders vary mineralogically, with pyrite-rich, zinc-rich, and copper-rich samples (Table 5-4) and texturally from massive to laminated.

TABLE 5-4
ASSAY RESULTS FOR MINERALOGICALLY DISTINCT BOULDERS, FOREMORE PROPERTY

	Cu %	Pb %	Zn %	Ag g/t	Au g/t	Fe %
North Zone						
chalcopyrite-rich (n=12)*	2.3	0.5	6.2	186	1.5	16
sphalerite-rich (n=29)*	0.22	3.5	10.2	96	1	16
South Zone						
pyrite-rich (n=112)*	trace	1	6.2	78	nil	23

*n= number of samples analysed
data from Barnes (1989)

The mineral and textural variation suggests the boulders from the north and south fields represent two or more distinct styles of mineralization, and those from the north, may indicate a single, zoned occurrence. Pb-isotope values also distinguish between the north and south boulder fields (Godwin, 1993). Boulders from the north field contain metal values comparable with those from 'in-place' volcanic hosted laminated sulphides. The boulders are mineralized with pyrite, sphalerite, chalcopyrite, galena and minor tetrahedrite and bornite (Barnes,1989). In the North Zone, pyritic felsic volcanic horizons host finely laminated and disseminated galena, sphalerite and pyrite mineralization. These felsic (quartz-eye) volcanics occur within a penetratively foliated sequence of graphitic schists, argillites and intermediate to mafic volcanics. Assay results from outcrop sampling average 87 ppb Au, 8 g/t Ag, 0.1% Cu, 0.3% Pb, and 2.7% Zn over an average sample width of 0.4 metres (Barnes, 1989). Boulders from the south field contain very fine grained pyrite and sphalerite with minor galena, chalcopyrite and tetrahedrite. Sulphide textures include massive, laminated, and blebby disseminations replacing carbonate and siliceous fragments. Limestone boulders host massive sulphide replacements. One such boulder contains probable algal laminations or stromatoporoid Favosites sp. of Late Ordovician to Middle Devonian age (B.S. Norford, personal communication, 1988; Logan *et al*., 1990a).

Foremore mineralization includes: laminated galena and sphalerite in felsic volcanics that resemble samples of Kuroko volcanic massive sulphide deposit ore, and massive to laminated sulphide replacements in Early Devonian carbonates that are similar to Irish-type carbonate-hosted deposit ore. These data indicate that similar Devonian-Mississippian Stikine assemblage rocks elsewhere are potential VMS exploration targets.

ANTLER PROPERTY (MINFILE 104G/?)

Pyrite veins, quartz veins and silicified stockwork zones are hosted in a mafic dominated, bimodal volcanic sequence of Devono-Mississippian age rocks north of the terminus of Alexander Glacier (Figure 5-2). This occurrence was first described by Gunning *et al*. (1994a) as a zone more than 100 metres long containing low base metal and variable precious and trace element abundances. It trends northwesterly, concordant with the volcanic host rocks. Follow-up mapping and rock, soil and stream sediment sampling indicated the zone is barren at surface (Gunning, 1995). The trace element association -elevated Cu, As and Sb- resembles some of the Mesozoic subvolcanic/intrusion-related veins and stockworks elsewhere in the area, but the potential for a Noranda/Kuroko-type base metal massive sulphide deposit in these rocks remains high.

NEW PROSPECTIVE HORIZONS

Stratabound pyritic horizons associated with dacitic(?) pyroclastics or altered mafic hyaloclastite horizons crop out discontinuously within cherty siltstones and black carbonaceous argillites in a thick succession of basic pillow and breccia flows north of the Iskut River, 12 kilometres upstream from the mouth of Forrest Kerr Creek (Figure 5-2). Massive fine-grained pyrite and pyrrhotite form bedding parallel layers several centimetres thick and occur as disseminations. Rusty limonitic gossans and white weathering felsic rocks can be traced along the ridge for 1.5 kilometres. These horizons occupy a higher stratigraphic position than the ore horizon at Eskay Creek deposit, nevertheless follow-up is considered to be worthwhile.

GALENA LEAD ISOTOPE RESULTS

Pb-isotope measurements of galena from selected stratabound massive sulphide boulders, skarn and subvolcanic vein deposits, together with feldspar-leads measured from a Late Devonian pluton, provide an exploration framework in which to define newly discovered mineral occurrences in the map area. The data also characterizes the basement and the metallogenic evolution of the Stikine terrane. The isotopic composition of Pb changes systematically over time because of the radiogenic decay of ^{238}U, ^{235}U and ^{232}Th to ^{206}Pb, ^{207}Pb and ^{208}Pb, respectively. At the time galena is formed it freezes the ambient Pb-isotope composition, thus lead in younger deposits is more evolved and lies at progressively more radiogenic positions along the growth curves. The different sources of Pb (mantle, upper crust and lower crust), the heterogeneity of Pb-isotopes in these source areas and mixing of more than one source, make absolute dating of the deposits using Pb-isotopes impossible. Relative ages can be inferred using different growth curves which model the evolution of Pb in various reservoirs (Stacey and Kramers, 1975; Zartman and Doe, 1981; Godwin and Sinclair, 1982). Absolute constraints on the timing of mineralizing events is provided by U-Pb ages and sometimes by biostratigraphic ages in nearby rocks.

Jurassic and Tertiary clusters of galena lead isotope ratios in the Stewart area were first recognized by Godwin *et al*. (1980). Subsequent work by Alldrick *et al*. (1987; 1990) and Godwin *et al*. (1991) showed that these clusters define two separate, relatively short-lived metallogenic events. Stratigraphic information and other radiogenic dates are consistent with the interpretation that these were Early Jurassic and Tertiary Events. Radiogenic isotopic studies by Godwin (1993) and geochronological and radiogenic isotopic studies by Childe (1995, 1996) of selected VMS deposits within accreted terranes of the Canadian Cordillera provide a means of characterizing the metallogenic sources for this part of the Stikine terrane in Late Devonian time. The Stikine terrane is a product of primitive island arc magmatism, beginning in the Early Devonian and developed in a location removed from continental (evolved) detrital influences.

Pb-isotopes from 5 occurrences in the map area are presented in Figure 5-8, together with the Tertiary and Jurassic clusters of Godwin *et al*. (1991) and the Middle Jurassic - Eskay Creek, Triassic - Granduc, Mississippian - Tulsequah and the Late Devonian - Ecstall and Forrest Kerr Pluton clusters of Childe (1996). The Jurassic cluster represents synvolcanic gold-silver-copper-zinc-lead mineralization related to Hazelton Group magmatism. There is insufficient resolution to discriminate between Early and Middle Juras-

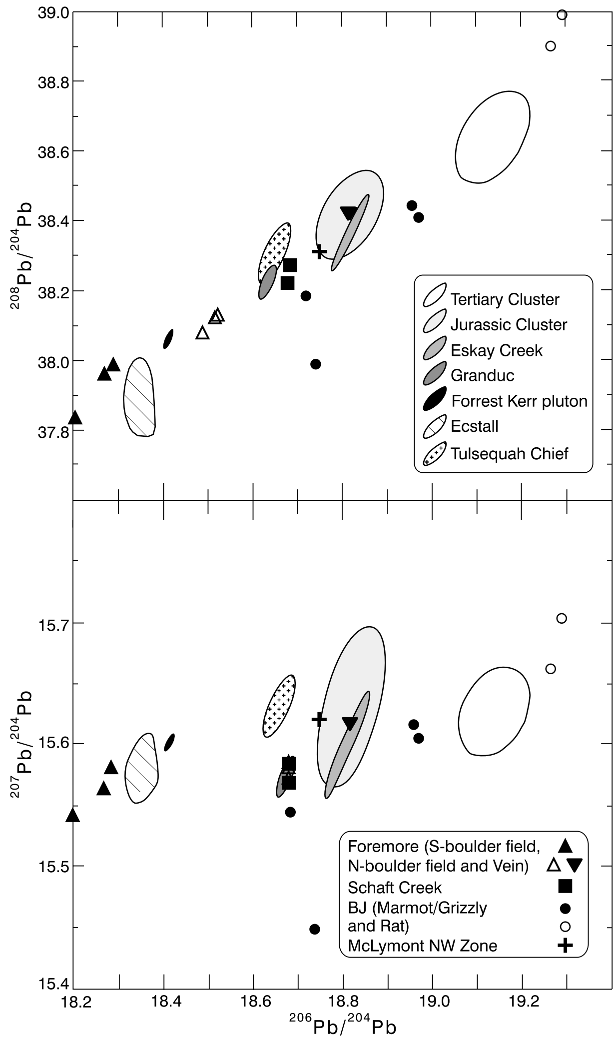

Figure 5-8. $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$ for mineral occurrences in the study area. Data compiled from Godwin *et al*. (1988) and presented with Tertiary and Jurassic clusters of Godwin *et al*. (1991) and Middle Jurassic, Triassic, Mississippian and Devonian data of Childe (1996).

sic events. The second cluster is silver-zinc-lead±molybdenum occurrences related to Tertiary plutons.

Galena from the Foremore property (Godwin, 1993) posses some of the most primitive lead ratios found (Figure 5-8). There, the stratabound, volcanic hosted zinc-lead-silver±copper mineralization occurs in Devonian to Mississippian volcanic and volcaniclastic rocks. These underlie much of the Foremore property and have discontinuous interlayers of carbonate. A limestone boulder partially replaced by massive sulphide contains probable algal laminations or stromatoporoid Favosites sp. of Late Ordovician to Middle Devonian age (B.S. Norford, personal communication, 1988). The analyses from sulphide boulders, those with probable felsic volcanogenic affinities are more radiogenic and are from the north boulder field (‘fn’). Less radiogenic samples are associated with Devonian carbonate from the south boulder field (‘fs’). All the analyses plot in and around the cluster of values from the Ecstall VMS deposit and that for feldspars from the Forrest Kerr Pluton. At the Ecstall deposit, a 377 +9/-4 Ma diorite sill crosscuts strata hosting the massive sulphide lenses and constrains mineralization to the Late Devonian or earlier (Childe, 1996). The Forrest Kerr Pluton is Late Devonian (U-Pb zircon dates returned 369±5 Ma and 371±6.5 Ma respectively, Table I-1). The primitive Pb-isotopes, their similarity to those from the Ecstall VMS deposit and from the Late Devonian Forrest Kerr Pluton, and the stratabound nature of the mineralization suggests mineralization is Late Devonian, not Middle Jurassic as suggested by Godwin (1993). Pb-isotopes from a sample of auriferous quartz vein cutting granodiorite on the east side of the Foremore property plot in the Jurassic field of Godwin *et al*. (1980) and probably represent a younger mineralizing event than the stratabound mineralization.

Schaft Creek lead isotopes (Godwin *et al*., 1991) plot between the Triassic Granduc cluster and the Jurassic cluster (Figure 5-8). The Granduc Cu-Zn besshi-type VMS deposit is hosted in well-dated Upper Triassic Stuhini Group basaltic andesites (223±5 Ma and 223±1 Ma; Childe, 1995). A previous interpretation, based on a Middle Jurassic age for Schaft Creek deposit, was problematic, but these isotopic ratios are explicable; if the crystallization age of the syn-mineralization felsic dikes (216.6±2 Ma) is close to the age of mineralization.

Galena from a sphalerite-galena vein in Drillhole 88-20, located at the north end of the McLymont Northwest zone was analyzed at The University of British Columbia for its isotope ratios (Ray *et al*., 1991). The measured ratios plot within the Jurassic cluster, suggesting an Early Jurassic or older age for this mineralization.

Lead isotope ratios of galena samples from the GOZ/RDN property and a gold-bearing vein on the Foremore properties both plot in the Jurassic cluster (Godwin *et al*., 1991).

Mineralization on the BJ property contains Pb-isotope ratios which lie outside both the Jurassic and Tertiary clusters (Godwin *et al*., 1988). The least radiogenic samples, plotted as the average of two vein samples from the Marmot and Grizzly showings, lie between, but well below the Jurassic and Granduc clusters. The highly anomalous sample from the Rat vein plots right of the Tertiary cluster. It was muscovite-fuchsite from this quartz-carbonate sulphide vein that yielded an Early Jurassic potassium-argon date of 194±5 Ma (Holbek, 1988). The vein contains a mixed mineralogy of pyrite, sphalerite, chalcopyrite, tetrahedrite with trace amounts of galena, arsenopyrite and gold, which is characteristic of deposits within the Jurassic cluster. Tertiary age mineralization is widespread to the west in and adjacent to plutonic rocks of the Coast belt. Twenty kilometres west of the BJ property Tertiary mineralization is associated with felsic Eocene plugs at the Trophy property where it forms the Ptarmigan and Hummingbird zones. Galena lead from the Ptarmigan zone has isotopic ratios similar to Tertiary model ages (Logan and Koyanagi, 1994). Tertiary fluids can utilize older structures and may overprint earlier isotopic signatures.

REGIONAL METALLOGENIC EVENTS

The general stratigraphic sequence, intrusive episodes and mineral deposit types are illustrated on Figure 5-9 for the Forrest Kerr - Mess Creek map area. Metallogenic activity occurred throughout the nearly continuous magmatic activity that spans an approximately 50 Ma period from the Late Triassic (228 Ma) to the Middle Jurassic (175 Ma). The intrusive activity has been divided into the distinctive: Late Triassic Stikine Plutonic Suite; the Late Triassic to Early Jurassic Copper Mountain Suite; the Early Jurassic Texas Creek Suite and the Middle Jurassic Three Sisters Plutonic Suite respectively (Woodsworth *et al.*, 1991; Anderson, 1993).

The potential for separate episodes of mineralization coincided with development of each of the volcano-plutonic arcs, beginning in Late Devonian to Early Mississippian, and including Pennsylvanian, Late Triassic to Early Jurassic, Middle Jurassic and Tertiary events. Mineral occurrences are known for all but the Pennsylvanian episode of volcanism and this maybe due to the fact that no intrusive rocks of this age are recognized in the map area. Early Devonian carbonate and volcanic rocks host conformable, massive polymetallic sulphide occurrences and copper skarns are developed adjacent to the Late Devonian Forrest Kerr and Early Mississippian More Creek plutons. High-level calcalkaline and alkaline synvolcanic porphyry, vein and replacement deposits are hosted in Late Triassic-Early Jurassic volcanic and subvolcanic rocks of the Stuhini and Hazelton groups. The Middle Jurassic back-arc facies rocks (Anderson, 1993), that host the submarine exhalative base and precious metal Eskay Creek deposit, crop out south of the Iskut River, hence the arc axis lay to the west of the map in the Middle Jurassic. Early Tertiary plutonism in the Coast Belt marks the position of the arc axis through the Early part of the Cenozoic and hosts calcalkaline porphyry Mo and silver-lead-zinc-rich vein deposits. Most precious metal mineralization is related to the latest Triassic and earliest Jurassic island arc, and to early accretion-related magmatic activity. Tertiary, post-accretionary mineralization is related to continental volcanism and epizonal plutonism.

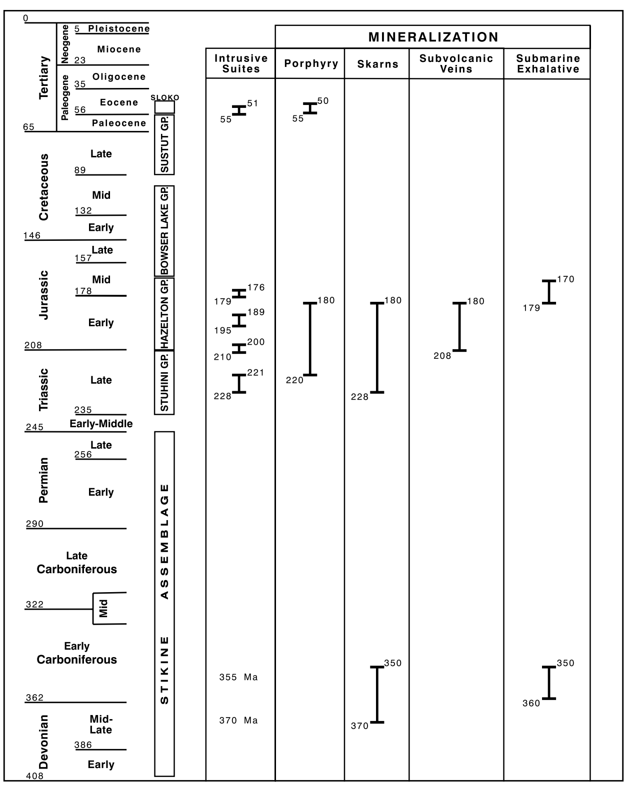

Figure 5-9. Summary of stratigraphy, intrusive events and mineralizing episodes by deposit type for the Forrest Kerr-Mess Creek area.

AGES OF MINERALIZATION

Two discrete, and a possible third mineralizing event are evident in the Forrest Kerr and Mess creek area; in the Devonian to Early Mississippian, the latest Triassic to Early Jurassic, and later in the Early Jurassic. Important deposits related to the regionally important Middle Jurassic and Tertiary metallogenic events are postulated but not known to occur in the map area.

The age of the volcanic hosted massive sulphide boulders on the Foremore property is probably close to the age of the host rocks (Lower to Upper Devonian, from fossils and U-Pb constraints). The host metavolcanic rocks are intruded by the Early Mississippian More Creek Pluton. Pb-isotopes from the massive sulphides are primitive and cluster together with the Late Devonian Ecstall massive sulphide deposit and feldspar leads from the Late Devonian FKP.

The age of Cu-Mo-Au porphyry mineralization at Schaft Creek has a 220 +15/-2 Ma lower age constrained by U-Pb dating of synmineralization porphyritic felsic dikes. It also has Pb-isotope ratios which are similar to those of the Late Triassic Granduc copper-zinc deposit.

Metasomatic gold skarn mineralization at McLymont Creek is hosted in mid-Carboniferous to Upper Carboniferous sedimentary and volcaniclastic rocks, but related to Late Triassic or younger structures and intrusions. Alkaline to calcalkaline porphyry copper-gold mineralization south of Hankin Peak and east of Mess Creek are hosted by Upper Triassic volcanics and subvolcanic intrusives. Mineralization is generally believed to be latest Triassic to Early Jurassic in age for both these occurrences. Copper-silver mineralization at the Bam is hosted in Early Mississippian granite, Lower Permian carbonate and Lower Jurassic conglomerates. The epigenetic nature of the mineralization indicates it must postdate the youngest strata. A Late Triassic to earliest Early Jurassic age is also inferred for mineralization on the Run claim group. Vein mineralization appears to be marginally younger than the Triassic-Jurassic porphyry mineralizing event. Lead isotope studies of galena samples from the GOZ/RDN property and a gold-bearing vein on the Foremore properties both plot in the Jurassic cluster (Godwin *et al.*, 1991). An Early Jurassic (194+6 Ma; Holbek, 1988) age for auriferous mineralization is inferred from K-Ar dating of chrome-bearing muscovite from a carbonate-sulphide vein on the BJ property.

The Middle Jurassic Eskay Creek submarine exhalative base and precious metal sulphide deposit is located approximately 15 kilometers southeast of the map area. Correlative rocks are present in the Forrest Kerr - Mess Lake map area and the potential for exhalative deposits in this area has not been sufficiently tested.

Silver-rich base metal mineralization of Tertiary age is widespread to the east and elsewhere in northwestern British Columbia, but to date none has been recognized in the Forrest Kerr - Mess Creek map area.

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APPENDICES

APPENDIX 1
MACROFOSSIL LOCATIONS, IDENTIFICATIONS AND AGES

FORREST KERR CREEK/ISKUT RIVER MAP AREA (104B/15 AND PART OF 104B/10)

GSC Loc. Number	Sample Number	UTM Zone 9 Easting Northing	Strat Unit	Fauna-Description	Age	Ref.
C-116288	PR15	404130 6309970	uTSv	macro	Late Triassic	5
C-158956	JLO6-4	383401 6314796	mCSc	colonial coral, (?)*Fomichevella* sp., foraminifers	mid-Carboniferous, Serpukhovian or Bashkirian, possibly reworked fauna	1a
C-158957	VKO4-1	396530 6300846	lPSdt	echinoderm columnals, solitary coral	indeterminate	1a
C-158958	VKO14-11	387830 6305396	uTSs	*Halobia* sp., indet.crushed belemnoids	Late Triassic, probably Carnian	8a
C-158959	VKO14-14	387780 6305796	uTSs	*Halobia* sp. indeterminate	Late Triassic, probably Carnian	8a
C-158967	JLO6-2	383301 6314036	mCSc	rhynconellid brachiopod, *Chaetetes* sp., colonial coral *Cystolonsdaleia* sp.	mid-Carboniferous, Serpukhovian or Bashkirian	1a
C-158968	JLO11-17	401690 6307445	lPSc	brachiopods (?)	indeterminate	1a
C-158986	JDR13-8	382071 6312657	clast in uCScg	hexaphyllid coral, probably *Hexaphyllia* sp., clisiophyllid colonial coral, foraminifers	mid-Carboniferous, Serpukhovian or Bashkirian	1a
C-158987	JDR14-5	385607 6302006	lPSc	productoid and spiriferid brachiopods	Early (?) Permian	1a
C-158991	VKO16-13	381180 6305577	CSst	burrows	indeterminate	1a
C-158992	VKO22-4.3	394600 6295636	lmDSc	*Favosites* sp. tabulate coral	Silurian or Devonian	1a
C-158994	JLO23-5	380850 6302206	clast in uCScg	clisiophyllid coral indet., foraminifers	mid Carboniferous, Serpukhovian or Bashkirian	1a
C-158996	JLO23-2	380840 6303036	mCSc	zaphrentid (?) and lophophyllid (?) corals indeterminate	(?)Late Carboniferous or Permian	1a
C-167801	JDR32-2.3	403161 6310386	uTSvt	bivalve casts *Palaeocardita* ? sp.	probably Upper Triassic	8a
C-167802	VKO36-5	378016 6306606	mCSc	*Cystolonsdaleia* sp. colonial coral	mid-Carboniferous, Serpukhovian or Bashkirian	1a
C-167803	JLO30-9	378807 6314095	mCSc	lithostrotionid coral, indeterminate, foraminifers	middle Carboniferous, Serpukhovian or Bashkirian	1a
C-168157	JLO24-11.3	386600 6303916	lPSc	echinoderm columnals, rare foraminifers	mid-Carboniferous to Early Permian	1a
C-168158	JLO25-14	388971 6309026	uTSvs	trace fossils	indeterminate	1a
C-168159	JLO24-8	386200 6303946	uTSl	(?)hydrozoans	indeterminate	1a
C-168160	JLO25-2.3	383421 6313476	mCSc	spiriferid brachiopods, indeterminate, foraminifers	prob. Carboniferous, Visean to Bashkirian	1a
C-168161	GVI3-5	387830 6308396	uTSs	*belemnoids* sp. indeterminate	indeterminate	8a
C-168162	JLO25-11	388750 6308586	lPSc	pyritized fasciculate colonial coral	mid-Carboniferous(?) to Early Permian	1a
C-168163	JLO24-14	384281 6324256	lmDSc	stromatoporoid, Favosites coral	Ordovician - middle Devonian	2
C-168179	VKO31-6.1	388060 6306666	lPSc	bothrophyllid coral, brachiopods, fusulinaceans	Permian	1a
C-168180	VKO31-6.2	388060 6306696	lPSc	*Neospirifer* sp., fusulinacean and other foraminifers	prob. Late Carboniferous, possibly Moscovian	1a
C-189358	90JLO11-4	383401 6313796	mCSc	*Heintzella* sp., algae	probably mid-Carboniferous	1b
C-189359	90JLO11-9	381451 6312647	mCSc	small lophophyllid coral	probably mid-Carboniferous	1b
C-189361	90JLO11-10	381631 6312547	mCSc	?*Fomichevella* sp. coral	prob. mid-Carboniferous, Serpukhovian or Bashkirian	1b

MORE CREEK MAP AREA (104G/ 2)

GSC Loc. Number	Sample Number	UTM Zone 9 Easting Northing	Strat Unit	Fauna-Description	Age	Ref.
-0005489	NA	unknown unknown	mJHsl	Conifer imprints resembling species *Elatides Sequoia* and *Geinitzia*	Jurassic and Cretaceous	6
-0028945	NA	405133 6342496	uTSsl	*Halobia* sp., *Juvavites* sp., *Arcestes* sp.	Late Triassic, prob. Carnian, pos. early Norian	6
-0032780	NA	unknown unknown	uTSsn	*Halobia* sp. indet.	Late Triassic	6
-0037110	NA	unknown unknown	mJHsl	*Sonniniids* gen. et sp. indet.	Middle Bajocian	6
-0040481	NA	unknown unknown	mJHsl	*Trigonia* sp. *Pecten* spp. pelecypods	Middle Jurassic?	6
C007942	NA	408781 6330496	uTSl	macro	Prob. Late Triassic	5
C116289	NA	401307 6319496	lJHsl	macro	Early Jurassic, probably Late Toarcian	5
C116290	NA	401607 6320296	lJHsl	macro	Early Jurassic, probably Late Toarcian	5
C167835	91JDR02-07	404182 6330145	uTSs	?*Spondylospira*	Upper Triassic, probably Norian	8a
C167836	91JDR04-03	402232 6334146	uTSsn	Bivalve, indet.		8a
C167837	91JDR06-04	409132 6338845	uTSsn	*Halobia* sp. indet.	Late Triassic, probably Carnian	8a
C167838	91JDR07-13-2	404082 6340146	uTSsn	*Halobia* sp. indet.	Late Triassic, probably Carnian	8a
C189406	91JLO01-04	385982 6326671	lmDSc	*Favosites* sp., stromatoporoid, rugose corals	Early mid- Devonian	3
C189407	91JLO01-03	385982 6326671	lmDSc	*Favosites* sp., stromatoporoid, rugose corals	Early mid- Devonian	3
C189408	91JLO01-05	385982 6326671	lmDSc	*Favosites* sp., stromatoporoid, rugose corals	Early mid- Devonian	3
C189434	91JLO12-153	386282 6342196	lPSc	indeterminate		1c
C189435	91DEL12-6	388133 6344946	lPSc	?*Spiriferella* sp.	probably Permian, possibly latest Carboniferous	1c
C189436	91JDR12-07	388413 6344816	lPSc	*Neospirifer* sp., *Yakovlevia* sp., productoid brachiopods, indeterminate	Permian, probably Early Permian	1c
C189437	91JDR12-08	388385 6344896	lPSc	*Neospirifer* sp., tabulate coral, indet., bothrophyllid coral, indet., *Paraheritschiodes* sp.	Early Permian, probably Asselian or Sakmarian	1c
C189754	91JLO18-246	409182 6338895	uTSsn	*Pecten* sp. bivalves, indet., gastropod, indet.	Not determinable	4
C189755	91DEL18-01	405232 6337345	uTSsn	?*Halobia*	Probably Carnian	8a
C189764	91DEL16-13	386633 6344796	lPSc	clisiophyllid coral, indeterminate, foraminifera	Late Carboniferous or Permian	1c
C189766	91JDR24-02	399732 6329996	lJHsl	plant (?) fragments	Not determinable	4
C189767	91JDR22-13	386532 6326296	lmDSc	*Favosites* sp., stromatoporoid, rugose corals	Early-middle Devonian	3
C189768	91JLO25-351	401831 6321295	mJHsl	ammonites, indet.	Not determinable	1
C189769	91JDR25-07	401031 6319296	mJHsl	*Astarte* sp. bivalves, indet. gastropod,indet.	Probably Jurassic	4
C189770	91JLO25-343	401632 6320295	mJHsl	*Myophorella* sp. *Trigonia* sp. bivalves, indet., *Mclearnia* (?) sp. gastropod,indet., corals, indet.	Probably Bathonian	4
C189772	91JDR26-2-2	406231 6319545	lJHsl	*Asteroceras* (?) sp.	Early Jurassic, Late Sinemurian	4
C189785	91JLO34-429	400531 6322496	mJHsl	*Tmetoceras* sp.	Late Aalenian or late Early Aalenian	4

APPENDIX 1 CONTINUED
MACROFOSSIL LOCATIONS, IDENTIFICATIONS AND AGES

MESS LAKE MAP AREA (104G/07W)

GSC Loc. Number	Sample Number	UTM Zone 9 Easting Northing	Strat Unit	Fauna-Description	Age	Ref.
0028948	-	389883 6351196	lTSsn	*Monotis Subcircularis* brachiopod	Upper Norian (Late Triassic)	6
C207976	92JDR3-8-4	387683 6355191	lPSc	?*Yakovlevia* sp., fusulinaceans	Early Permian, late Asselian	1d
C207974	92JDR12-6	383664 6373534	uCSc	deformed solitary coral, indet.	Devonian to Permian	1d
C207975	92JLO4-56	388895 6350817	lJHcg	scleractinian corals from limestone cobbles	Middle Triassic or younger	1d
C207963	92JLO7-91	390256 6352717	mCSc	?*Fedorowskiella* sp., *Siphonophyllia* sp., ?chaetetid sponge	Serpukhovian or Bashkirian (mid- Carboniferous)	1d
C207964	92JLO7-93	390029 6352321	uCSss	bivalves and gastropods, indeterminate	Indeterminate	1d,6,8b
C207965	92JLO11-131	389451 6362207	mCSc	*Fedorowskiella* spp., ?*Fomichevella* sp., tabulate coral, indet., *Chaetetes* sp.	mid-Carboniferous, probably Serpukhovian or Bashkirian	1d
C207966	92JLO11-134	389178 6362973	lPSc?MCSc?	productid brachiopod, indet., solitary coral, indet. - immature	Carboniferous or Permian	1d
C207967	92JLO20-215	384817 6370006	uCSc	?*Neospirifer* sp., syringoporid coral, indet., fusulinaceans	latest Carboniferous or Early Permian, probably Gzhelian	1d
C207968	92JLO22-226	383915 6366411	uCSc	?*Bothrophyllum* sp. - incomplete specimen, fusulinaceans	latest Carboniferous, Gzhelian	1d
C207970	92JLO22-229	384171 6364363	uCSc/ lPsc	indeterminate bryozoans and rhynchonellid brachiopod, fusulinaceans	Early Permian, late Asselian	1d
C207971	92JLO26-250	380747 6354773	uTSsn	*Monotis Subcircularis* brachiopod	Late Triassic, Upper Norian	8b
C207969	92JLO28-267	389533 6348996	lPSc	spiriferid and productid brachiopods, indetbellerophontid gastropod, indet., *Bothrophyllum* sp., syringoporid coral, indet., fusulinaceans	Early Permian, Asselian (Wolfcampian)	1d
C207973	92JLO28-269	389434 6346996	lPSc	syringoporid coral, indet., fusulinaceans	Early Permian, late Asselian	1d

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APPENDIX 2
CONODONT LOCATIONS, IDENTIFICATIONS, AGES AND COLOUR ALTERATION INDICES

FORREST KERR CREEK/ISKUT RIVER MAP AREA 104B/15 AND PART OF 104B/10

GSC Number	Sample Number	UTM Zone 9 East	North	Strat. Unit	Fauna Description	Age	CAI VALUE	REF.
C-087668	H-81-66F*	402009	6291115	Jw	Cypridodelliform element	Permo-Triassic, probably Late Triassic?	2.0-3.0	1
C-087669	H-81-68F*	396559	6291505	lPSc	Neostreptognathodus sp. B Wardlaw & Collinson	Late Early Permian, late Artinskian	6?	1
C-087670	H-81-70F*	400639	6291345	Jw	Conical ichthyoliths	prob no older than late Paleozoic	-	1
C-087671	H-81-71F*	396279	6290795	lPSc	Neogondolella sp. indet., Sweetognathus cf. S. whitei(Rhodes), Sweetognathus cf. S. merrilli Kozur, ramiform elements	Early Permian, late Sakmarian	6	1
C-087672	PRH-81-72Fa**	394104	6291816	lmDSc	Eognathodus sp. cf. E. sulcatus kindlei Lane & Ormiston, Pandorinellina steinhornensis	Middle Early Devonian, Pragian (Ziegler)	5	1
C-087673	H-81-73F*	393479	6290546	lmDSc	Eognathodus sp. cf. E. sulcatus kindlei Lane & Ormiston, Panderodus sp.	Early Devonian, Pragian	4.5-5.5	1, 2
C-102755	P-82-12F*	400730	6292595	lPSc	Neogondolella cf. N. bisselli (Clark & Behnken), treptognathodus elongatus, Gen. et sp. nov.	Early Permian, early Sakmarian	5	1
C-102756	P-82-14F*	400730	6292595	lPSdt	Neogondolella sp. indet.	Early Permian	7	1
C-102757	P-82-15F*	396130	6293895	lPSdt	Neostreptognathodus pequopensis Behnken 1975	Early Permian	7	1
C-102759	P-82-17F*	398030	6293395	uTRSv	Epigondolella? sp. indet	Late Triassic, probably Early Norian	7	1
C-102760	P-82-18F*	398029	6293115	uTRSv	Neogondolella sp. indet.	Probably Triassic	4.5	1
C-102853	P-82-7F*	402280	6307095	uTRSs	Paragondolella ex gr. polygnathiformis (Budurov & Stefanov), Metapolygnathus nodosus Hayashi, Metapolygnathus primitius Mosher	Late Triassic, Late Carnian	4	1
C-102855	H-82-9F*	403380	6302795	lPSc	Neogondolella sp., ramiform elements	Early Permian	5	1
C-102857	B-82-6F*	399580	6309145	DMSvt	Polygnathus or Pseudopolygnathus sp. indet., Hindeodus ? sp.	Middle Devonian or Early Mississippian	6.0-7.0	1
C-102947	P-83-16F*	399580	6309145	lPSc	Neogondolella sp. indet.	Probably Permian (?Early)	6	1
C-102948	P-83-17F*	400006	6315621	uTSv	ichthyoliths	late Paleozoic or younger	-	1
C-103652	83-MJO-P21F*	398581	6314396	uCSc	Idiognathodus ? sp.	Pennsylvanian or Early Permian	~6	1
C-103682	R-83-16F**	403780	6307895	uTRSs	Metapolygnathus ex gr. polygnathiformis (Budurov & Stefanov 1965)	Late Triassic, Carnian	4-4.5	1
C-103688	R83-17F*	402780	6308995	uTRSs	ichthyoliths	late Paleozoic or younger	-	1
C-103686	R-83-21F**	403930	6310245	uTRSs	Epigondolella Huckriede, ramiform elements	Late Triassic, Early Norian	5	1
C-158953	89JLO6-2.3	383301	6315046	mCSc	Cavusgnathus sp., Gnathodus aff. bilineatus (Roundy), Idioprioniodus sp.	Early Carboniferous, Visean - early Namurian	3	2
C-158963	89VKO14-18	387930	6306696	lPSc	Neostreptognathodus pequopensis Behnken 1975, ramiform elements	Early Permian, Artinskian	2.0-3.0	2
C-158969	89JDR14-5	385475	6302626	lPSc	Diplognathodus? sp., Ellisonia sp., Neostreptognathodus ruzhencevi Kozur 1976, Neogondolella sp., Hindeodus sp., ramiform elements	Early Permian, Artinskian	2.0-3.0	2
C-158971	89JDR16-6	382420	6303096	mCSc	Lochriea homopunctata (Ziegler), Gnathodus sp. indet., Geniculatus sp.	Early Carboniferous, Visean-early Namurian	3.0-4.0	2
C-158998	89JLO21-8	396489	6291405	lPSc	Sweetognathus sp.	Permian	8	2
C-158999	89JLO25-2.2	383421	6313496	mCSc	Gnathodus sp., M element	Carboniferous, probably Early	2.0-4.0	2
C-159100	89VKO16-18	381838	6305616	clast of lCSc	Idioprioniodus sp., Gnathodus sp., ramiform elements	Early Carboniferous; Visean-early Namurian	3.0-4.0	2
C-168155	89GVI2-1	383381	6313886	mCSc	Idioprioniodus sp., Protognathodus sp., Gnathodus sp., Cavusgnathoid	Early Carboniferous, Visean	3.0-4.0	2
C-168156	89JLO23-2	380840	6303036	mCSc	Idioprioniodus? sp., Gnathodus? sp., ramiform elements	Probably Carboniferous	4.5-5.5	2
C-168164	89VKO31-6.1	388060	6306666	lPSc	Cavusgnathoid, ramiform elements	Early Carboniferous - Early Permian	2.0-3.0	2
C-168165	89VKO30-16	380031	6313547	mCSc	ramiform elements	Ordovician - Triassic	2.0-3.0	2
C-168166	89VKO31-5	388030	6307006	lPSc	Ellisonia sp., Neostreptognathodus pequopensis Behnken 1975, ramiform elements	Early Permian, Artinskian	2.0-3.0	2
C-168168	89VKO31-9	387720	6307356	lPSc	Neostreptognathodus pequopensis Behnken 1975, Neogondolella sp.	Early Permian, Artinskian	2.0-3.0	2
C-168169	89VKO31-2.2	389100	6307066	mCSc	Gnathodus cf. bilineatus (Roundy), ramiform elements	Early Carboniferous, Visean - early Namurian	3.0-4.0	2
C-168171	89VKO31-3	388830	6307066	mCSc	Idioprioniodus sp., Gnathodus girtyi Hass, Lochriea comutata (Branson & Mehl)	Early Carboniferous, Visean - early Namurian	2.0-3.0	2

APPENDIX 2 CONTINUED
CONODONT LOCATIONS, IDENTIFICATIONS, AGES AND COLOUR ALTERATION INDICES

GSC Number	Sample Number	UTM Zone 9 East	North	Strat. Unit	Fauna Description	Age	CAI VALUE	REF.
C-168173	89GVI3-1	388301	6308916	lPSc	Neostreptognathodus pequopensis Behnken 1975, Neogondolella sp., Hindeodus sp., ramiform elements	Early Permian, Artinskian	2.0-3.0	2
C-168174	89VKO30-10	380281	6313886	mCSc	Gnathodus cf., bilineatus (Roundy), Geniculatus sp., ramiform elements	Early Carboniferous, Visean-early Namurian	2.0-3.0	2
C-168188	89JLO31-1.2	402001	6314595	uTSs	Hindeodus sp.	Carboniferous - Permian	5.5	2
C-168199	89JLO32-10	382630	6300916	clast in uTSvat	Neogondolella sp., ramiform elements	Probably Permian	5.0-6.0	2
C-168200	89JLO32-11	382710	6300956	uTSl	Epigondolella ex gr. bidentata Mosher, ramiform elements	Late Triassic, Late Norian	2.0-3.0	2
C-189398	90-JLO-11-9	381693	6312612	uCSc?	Sweetognathus? sp. indet.	Probably Carboniferous-Permian	2.0-3.0	3
C-189400	90JLO-12-15	405889	6304180	uTSc	Neogondolella sp. indet	Late Carboniferous to Triassic	5.0-6.0	3
Mine Creek Map Area 104G/2								
C167840	91JDR2-2	403957	6331045	uTSc	Epigondolella triangularis	late Early Norian	7	4
C167841	91JDR5-12	398733	6345096	uTSc	Metapolygnathus sp.	Late Triassic, Carnian	5	4
C167842	91JDR7-14	404282	6340196	uTSc	Metapolygnathus sp., Mosherella? sp., Neogondolella sp. cf. N. inclinata	Late Triassic, Early? Carnian	4.5-5.5	4
C167843	91DEL7-10	404282	6340196	uTSc	Metapolygnathus sp.	Late Triassic, Late? Carnian	5.5	4
C167844	91DEL7-10-1	404282	6340187	uTSc	Metapolygnathus sp.	Late Triassic, Carnian	5.5	4
C167849	91JLO3-13	404082	6332795	uTSc	ichthyoliths, formanifers	Late Paleozoic-Mesozoic	-	4
C167850	91JLO5-49	397808	6342096	uTSc	Metapolygnathus sp., ramiform elements	Triassic, probably Carnian	5	4
C189402	91JLO6-66	406583	6343370	uTSc	Metapolygnathus nodosus	Late Triassic, Late Carnian	5	4
C189404	91JLO7-78	402882	6340071	uTSc	Ramiform elements, Epigondolella sp. cf. E. quadrata	Late Triassic, Early? Norian	4.5-6	4
C189405	91JLO7-82	403283	6340971	uTSc	Hindeodus sp., Metapolygnathus ex gr. polygnathiformis, Neospathodus sp.	Late Triassic, Late? Carnian	4.5-5.5	4
C189411	91DEL11-13	387882	6330996	lmDSc	Neogondolella sp.	prob. Permian	7-8	4
C189417	91JLO11-132	389631	6328346	lmDSc	Erika sp., Pedavis? sp.	Early Devonian, ?Lochkovian	5	4
C189420	91DEL12-14	387883	6345196	lPSc	Neogondolella intermedia, Sweetognathus whitei	Early Permian, early-middle Artinskian	2.5-3.0	4
C189422	91DEL12-4	388083	6344696	lPSc	Neostreptognathodus sp. aff. N. pequopensis	Early Permian, middle-late Artinskian	2.5-3.5	4
C189426	91JDR12-8	388383	6344896	lPSc	Neostreptognathodus sp., Streptognathodus ex gr. elongatus	Late Carboniferous - Early Permian, Gzhelian-Sakmarian	3-4	4
C189428	91JDR12-20	389283	6346696	mCSc	Gnathodus? sp., ramiform elements	Early-Late Carboniferous, ?Visean-Namurian	4-4.5	4
C189439	91JLO18-257	407983	6340196	uTSc	Ichtyoliths, tubes	Phanerozoic	-	4
C189445	91DEL16-12	386633	6344445	lPSc	Ichtyoliths	Phanerozoic	-	4
C189443	91DEL17-6-2	382431	6322246	lmDSc	Belodella sp., Polygnathus inversus, P. laticostatus	Early Devonian-Emsian	5	4
C189448	91DEL18-3	405282	6337070	uTSc	Metapolygnathus spp., Neogondolella sp. cf. N. inclinata	Late Triassic, Carnian	4.5-5	4
C189450	91DEL18-10	405932	6336195	uTSc	Metapolygnathus sp.	Late Triassic, Carnian	5	4
C189751	91JDR18-1	408232	6336695	uTSc	Metapolygnathus communisti	Late Triassic	5	4
C189752	91JDR18-8	406882	6337795	uTSc	Metapolygnathus sp.	Late Triassic, Carnian	5	4
C189760	91JLO21-308-2	404582	6340646	uTSc	Metapolygnathus spp., Neogondolella? sp.	Late Triassic, Carnian	5	4
C189761	91JLO21-306-2	404582	6340346	uTSc	Metapolygnathus nodosus,	Late Triassic, Late Carnian	4.5-5	4
C189763	91JDR21-3	404883	6343296	uTSc	Metapolygnathus sp.	Late Triassic, Late?Carnian	5-6	4
C189775	91JDR22-5-2	387931	6325396	lmDSc	Ramiform elements	Ordivian-Triassic	5	4
C189787	91DEL32-07	398681	6320196	lPSc	Ichtyoliths	Late Paleozoic-Mesozoic	-	4
C189791	91DEL35-04	404682	6331785	uTSc	Epigondolella sp., Neogondolella sp.	Late Triassic, possibly early Norian	4-4.5	4
C189792	91DEL35-09-02	405352	6331635	uTSc	Metapolygnathus nodosus	Late Triassic, Late Carnian	4.5-6	4
C189793	91JLO36-450	407143	6330396	uTSc	Epigondolella quadrata, Epigondolella triangularis	Late Triassic, late Early Norian	3.5-4	4
C189800	91JLO36-441	407883	6331445	mTs	Metapolygnathus? spp., Neogondolella inclinata, good radiolarians	Middle Triassic	3-4	4
C207977	91JLO36-440	408683	6331945	uTSs	Metapolygnathusm polygnathiformis	Late Triassic, Carnian	3-4	4

APPENDIX 2 CONTINUED
CONODONT LOCATIONS, IDENTIFICATIONS, AGES AND COLOUR ALTERATION INDICES

MESS CREEK MAP AREA 104G/7

GSC Number	Sample Number	UTM Zone 9 East	UTM Zone 9 North	Strat. Unit	Fauna Description	Age	CAI VALUE	REF.
C207952	92JLO11-131	389462	6331945	mCSc	Ramiform elements, Hindeodus sp.	Carboniferous-Permian	4.5	5
C207956	92JLO22-226	383883	6366397	uCSc	Ramiform elements, Adetognathus sp.	Late Carboniferous- Early Permian	4.5	5
C207962	92JDR4-3	388024	6353657	clast in lJHcg	Epigondolella sp. cf. E. quadrata (Orchard 1991)	Late Triassic, Early ? Norian clast	3.5	5

References:
Conodont identifications by M.J. Orchard:
1= Report OF-1993-3, 2= Report OF-1992-2, 3= Report OF-1991-13, 4= Report OF-1992-27, 5= Report OF-1993-40.
* Read, P.B., Brown, R.L., Psutka, J.F., Moore, J.M., Journeay, M., Lane, L.S. and Orchard, M.J. (1989): Geology of Parts of Snippaker Creek (104B/10), Forrest Kerr (104B/15), Bob Quinn Lake (104B/16), Iskut River (104G/1), and More Creek (104G/2); Geological Survey of Canada, Open File 2094.
**Sample collected by R.G. Anderson, data from M.J. Orchard, written communication, 1990.

APPENDIX 3
BARREN CONODONT COLLECTION LOCATIONS

GSC Loc. Number	Sample Number	UTM Zone 9 East	North	Strat Unit
Forrest Kerr/Iskut River Map area (104B/15,10)				
C-158966	89JDR13-6	381631	6312697	mCsc
C-158972	89VKO18-12	385805	6304315	uTSl
C-158973	89VKO18-13	385805	6304315	uTSl
C-158975	89JLO16-10	384000	6303950	uTSl
C-158976	89JLO16-8	384000	6303950	uTSl
C-158977	89JLO13-19	386580	6304276	uTSl
C-158978	89JLO15-6	384460	6305456	mCSc
C-158980	89JLO17-4	394079	6292116	lmDSs
C-158981	89VKO22-4	394226	6295626	lmDSc
C-158983	89VKO25-3.1	400310	6313900	Jwcg
C-158984	89VKO25-3.2	400310	6313900	Jwcg
C-158985	89VKO22-4.3	394226	6295626	lmDSc
C-158997	89JLO23-13	382200	6302036	mCSc
C-159000	89JLO24-8	386200	6303956	uTSl
C-168151	89JLO25-2.1	382500	6313496	uCSss
C-168152	89JLO25-12	388831	6308706	lPSc
C-168153	89JLO25-7	396490	6302126	CSst
C-168154	89JLO24-11.2	386600	6303916	lPSc
C-168167	89VKO31-2	389100	6307066	mCSc
C-168175	89JDR25-5B	393459	6290716	lmDSs
C-168176	89VKO27-10	380810	6288316	lmDSc
C-168177	89VKO28-9	392279	6289316	lmDSc
C-168178	89JLO24-8.3	386200	6303956	lPSc
C-168182	89JLO29-8	398751	6314496	mCSc
C-168183	89VKO37-11	404090	6308405	lPSdt
C-168184	89VKO36-13	378821	6307376	mCSc
C-168185	89VKO36-5	378030	6306617	mCSc
C-168186	89JLO29-13	398481	6314826	CSst
C-168187	89VKO33-11	399961	6316865	lJHsl
C-168189	89JLO32-7.3	382080	6300896	uTSvs
C-168190	89JLO33-14	405920	6309895	Jwcg
C-168191	89JLO32-7.4	382080	6300896	uTSvs
C-168192	89GVI4-4	383940	6304296	lPSc
C-168193	89JLO30-9	378821	6314107	mCS c
C-168194	89JDR32-2	403141	6310365	uTSvs
C-168195	89JDR32-9.2	402381	6310865	uTSvs
C-168196	89JDR32-3	403261	6310355	uTSvs
C-168197	89JDR34-2.4	407180	6307155	lPSdt
C-168198	89JDR33-3.2	384460	6303196	uTSl

GSC Loc. Number	Sample Number	UTM Zone 9 East	North	Strat Unit
More Creek Map area (104G/2)				
C167839	91JLO1-6	385982	6326671	lmDSc
C167848	91JLO3-24	403582	6332295	uTSc
C189403	91JLO6-62	406008	6343320	uTSc
C189409	91JDR10-2	390633	6345646	mCS c
C189410	91JLO10-123	393283	6341996	lmDSc
C189412	91DEL11-10	387533	6330496	lmDSc
C189413	91DEL11-7	387532	6329996	lmDSc
C189414	91DEL11-11	387882	6330996	lmDSc
C189415	91DEL11-8	387532	6330096	lmDSc
C189416	91DEL11-6	387682	6329846	lmDSc
C189418	91JLO11-138	390183	6328896	lmDSc
C189419	91DEL12-9	387683	6344496	lPSc
C189423	91JDR12-6-2	388383	6344696	lPSc
C189424	91DEL12-18	387284	6345846	uTSc
C189425	91JLO12-152	386083	6342246	uTSsn
C189427	91JDR9-11	394550	6339746	lmDSc
C189429	91DEL13-18	382533	6345196	mCS c
C189430	91DEL14-12	391133	6331796	lmDSc
C189431	91DEL14-5	389482	6331446	lmDSc
C189432	91JDR14-13	390800	6333600	lPSc
C189433	91JLO11-147	391083	6330896	lmDSc
C189438	91JLO17-234	385031	6326046	lmDSc
C189440	91JLO16-224	385982	6339746	lPSc
C189441	91JLO15-205	405432	6335295	uTSsn
C189442	91DEL16-13	386633	6344796	uTSsn
C189444	91DEL17-5-1	382417	6322062	lmDSs
C189446	91DEL17-5	382417	6322062	lmDSs
C189447	91DEL18-1	405232	6337345	uTSs
C189449	91DEL18-4	405332	6336995	uTSs
C189753	91JDR17-18	384658	6321096	mCSc
C189757	91JDR16-12	387363	6346096	uTSsn
C189758	91JDR19-6-2	397982	6330046	uTSlm
C189759	91JLO21-291	407132	6340846	uTSsn
C189762	91DEL21-1-2	405283	6344596	uTSc
C189774	91JDR22-7-1	387756	6325596	lmDSs
C189776	91DEL23-10-2	388132	6327546	lmDSs
C189777	91DEL23-15	388983	6326195	lmDSs
C189778	91JDR29-5	388281	6322846	DMSv
C189779	91JDR29-14	386331	6321496	mCS c
C189780	91DEL29-12	392982	6327646	DMSv
C189781	91DEL30-10	385282	6335996	DMSv
C189789	91JLO35-437	386332	6341596	uTSsn
C189794	91JDR36-2.2	385832	6340126	PSlm

GSC Loc. Number	Sample Number	UTM Zone 9 East	North	Strat Unit
Mess Lake Map area (104G/7W)				
C207959	92JDR1-7	388573	6348469	lJHcg
C207960	92JDR1-14	389214	6348639	lPSc
C207961	92JDR3-8-4	387683	6355191	lPSc
C207951	92JLO4-56	388895	6350817	lJHcg
C207953	92JLO11-134	389199	6362951	lPSc
C207954	92JLO18-196	383673	6369686	uCSc
C207955	92JLO19-206	385207	6372980	uCSc
C207957	92JLO20-215	384795	6370027	uCSc
C207958	92JLO26-251	380747	6354773	uTSsn

APPENDIX 4
FUSULINID LOCATIONS, INDENTIFICATIONS AND AGES

GSC Loc. Number	Sample Number	UTM Zone 9 Easting	Northing	Strat Unit	Fauna-Description	Age	Ref.
C-158987	89JDR14-5	385475	6302626	lPSc	*Schwagerina* sp. cf. S. callosa (Rauser), *Schwagerina* sp. indet.	Early Permian; Late Wolfcampian (Sakmarian)	4
C-158988	89VKO1-1.1	380441	6309997	lPSc	*Parafusulina* sp. indet.	Early Permian, early Leonardian (Artinskian)	4
C-158995	89JLO23-13	382200	6302036	lPSc	*Parafusulina* (*Skinnerella*) sp. cf. P. (S.) megagrandis Ross, *Pseudofusulinella* sp. indeterminate	Early Leonardian (Artinskian)	4
C-168170	89VKO30-11	380131	6342456	mCSc	fusulinacean foraminifers	Carboniferous-Permian	1
C-168179	89VKO31-6.1	388060	6306666	lPSc	*Schwagerina* sp. cf. S. mccloudensis Skinner and Wilde, *Pseudofusulinella* sp. indeterminate	Late Wolfcampian - Early Leonardian (Sakmarian)	4
C-168180	89VKO31-6.2	388060	6306666	lPSc	*Pseudofusulinella* sp., Schubertella spp.	?Late Wolfcampian - Early Leonardian (Sakmarian)	4
C189764	91DEL16-13	386633	6344796	lPSc	*Globivalvulina* sp., ?Syzrania bella Reitlinger, ?"*Nodosaria*" sp. fragment, ?*Protonodosaria* sp. fragment	probably Permian, possibly Sakmarian	2
C189783	91JLO35-433	385981	6342346	lPSc	*Triticites* sp.	Gzhelian to Asselian	3
C189784	91JLO35-343-2	385981	6342346	lPSc	*Triticites* sp., ?*Schwagerina* sp.	latest Carboniferous (Gzhelian) to earliest Permian (Asselian)	3
C207963	92JLO7-91	390256	6352717	mCSc	small foraminifers, unstudied	Serpukhovian or Bashkirian (mid-Carboniferous)	3
C207965	92JLO11-131	389451	6362207	mCSc	small foraminifers, unstudied	probably Serpukhovian or Bashkirian	3
C207967	92JLO20-215	384814	6370006	uCSc	?*Pseudofusulinella* sp. indet., ?*Thompsonella* sp. indet.	probably Gzhelian (Virgilian = latest Carboniferous)	5
C207968	92JLO22-226	383915	6366411	uCSc	*Thompsonella* sp. cf. T. rugosa Skinner and Wilde	latest Carboniferous, Gzhelian	5
C207969	92JLO28-267	389533	6348996	lPSc	*Schubertella* sp. cf. S. sphaerica Suleimanov; *Pseudofusulinella* sp. indet.; *Schwagerina* sp.; ?*Oketaella* sp.	Early Permian, Asselian (Wolfcampian)	5
C207970	92JLO22-229	383939	6364363	uCSc/lPSc	*Schubertella* sp. indet.; *Pseudofusulinella* sp. indet.; ?*Cuniculinella* sp. indet.; ?*Oketaella* sp. indet.	Early Permian, late Asselian	5
C207976	92JDR3-8-4	387683	6355191	lPSc	*Pseudofusulinella* sp. cf. P. munda Sinner and Wilde	Early Permian, late Asselian	5
C207973	92JLO28-269	389433	6346996	lPSc	*Schubertella* sp. cf. S. sphaerica Suleimanov; ?*Pseudofusulinella* sp. indet. (fragment)	Early Permian, late Asselian	5

REFERENCES

1. Orchard (1991). Report No. MJO-1991-13
2. S. Pinard in Bamber (1991)
3. L. Rui in Bamber (1991)
4. Rui (1991). Report No. RUI-2-1991
5. Rui (1993). Report No. RUI-4-1993

APPENDIX 5

MICROFAUNA AND MICROFLORA LOCATIONS, IDENTIFICATIONS AND AGES

GSC Loc. Number	Sample Number	UTM Zone 9 East	North	Fauna-Description	Age	Ref.
C158994	89JLO23-5	380850	6302206	Fossil wackestone-packstone, with echinoderms, bryozoan, clams and abundant algae, in particular the rare *Pseudokomia*; *Asphaltina* sp., *Asteroarchaediscus* sp., *Bradyina* sp., *Calcisphaera* sp., *Climacammina* sp., *Donezella* sp. (abundant), *Endothyra* sp., *Eostaffella* sp., *Fasciella* sp., *Globoendothyra?* sp., *Insolentitheca* sp., *Millerella* sp., *Neoarchaediscus* sp., *Planoendothyra* sp., *Pseudoendothyra* sp., *Pseudoglomospira* sp., *Planospirodiscus* sp., *Pseudostaffella* sp., *Pseudokomia* sp. (abundant), *Tetrataxis* sp.	Zone 21, middle Bashkirian Facies comparable to Klawak-Soda Bay formations; Alexander Terrane	1c
C167302	89VKO36-5	378030	6306605	Lump, bioclast, microbreccia-packstone (abundant corals); *Aphralysia* sp., *Archaediscus krestovnikovi* Rauzer-Chernoussova, *Archaediscus koktjubensis* Rauzer-Chernoussova, *Apterrinella* sp., *Asteroarchaediscus* sp., *Asphaltina codillerensis* Mamet, *Calcisphaera* sp., *Climacammina* sp., *Consobrinella?* sp., *Earliandia vulgaris* (Rauzer-Chernoussova and Reitlinger)., *Endothyra* sp., *Globivalvulina?* sp., *Janichewskina* sp., *Janichewskina typica* Mikhailov, *Millerella sp., Neoarchaediscus* sp., *Neoarchaediscus grandis* (Reitlinger), *Planospirodiscus* sp., *Priscella sp*., *Pseudoendothyra* sp., *Stacheoides* sp., *Tetrataxis* sp.	Zone 18, latest Early Carboniferous Facies similar to C158956	1c
C167803	89JLO30-9	378821	6314100	Silicified-dolomitized reef breccia packstone (abundant red algae); *Archaediscus* sp., *Calcisphaera* sp., *Earlandia* sp*., Fasciella* sp., *Komia* sp., *Ungdarella* sp., *Stacheoides* sp., *Tetrataxis* sp.	Insufficient microfauna Facies full of *Ungdarella* and probably equivalent to top of Peratrovich Formation	1c
C168157	89JLO24-11.3	386600	6303916	Recrystallized echinoderm-bryozoan packstone-grainstone, broken fenestellid fronds; *Earlandia* sp., *Endothyra* ghosts, *Globoendothyra* sp.	Insufficient microfauna Facies similiar to C158994 probably equivalent of the Klawak Formation	1c
C168160	89JLO25-2.3	383421	6313476	Coarse-grained, silicified reef breccia packstone containing reworked brachiopods, echinoderms, bryozoan and sponge megascleres; *Asphaltina cordillerensis* Mamet, *Asteroarchaediscus* sp., *Climacammina* sp., *Earlandia vulgaris* (Rauzer-Chernoussova and Reitlinger), *Endothyra* sp., *Eostaffella* sp., *Globoendothyra* sp., *Fasciella* sp., *Neoarchaediscus* sp., *Planoendothyra* sp., *Pseudokomia* sp., *Stacheoides* sp.	Insufficient microfauna Anywhere between Zone 18 and 20, Uppermost Mississippian to lowermost Pennsylvanian	1c
C168162	89JLO25-11	388751	6308193	Breccia: reworked blocks of dolomite, bryozoan wackstone, fossil grainstone; no forams between blocks, but fossil grainstone contains foraminiferal ghosts of apterinellids, *Calcivertella* sp., and other mid-Carboniferous sessile forams.	Mid-Carboniferous	1c
C168181	89VKO30-13	380031	6313766	Fossil packstone (abundant forams and algae); *Archaediscus koktjubensis* Rauzer-Chernoussova, *Archaediscus krestovnikovi* Rauzer-Chernoussova, *Archaeolithophyllum* sp., *Asteroarchaediscus* sp., *Asteroarchaediscus baschkiricus* (Krestovnikov and Teodorovitsh), *Asteroarchaediscus ovoides (*Rauzer-Chernoussova), *Calisphaera* sp., *Biseriella* sp., *Cuneiphycus* sp., *Earlandia* vulgaris (Rauzer-Chernoussova and Reitlinger), *Eostaffella* sp., *Masloviporidium* sp., *Millerella* sp., *Monotaxinoides?* sp., *Hemidiscus* sp., *Neoarchaediscus* sp., *Neoarchaediscus grandis* (Reitlinger), *Pseudokomia* sp., *Stacheoides* sp., *Tetrataxis* sp., *Ungdarella* sp., *Zellerinella* sp.	Zone 20, early Bashkirian contains typical *Masloviporidium* microflora	1c
	89VKO30-13	380031	6313766	Fossil packstone (abundant forams and algae); A*mmovertella* sp., *Apterrinella sp., Archaediscus* sp., *Asteroarchaediscus* sp., *Biseriella* sp., *Bradyina* sp., *Calcivertella* sp., *Climacammina* sp., *Cribrostomum* sp., *Consobrinella*? sp., *Earlandia sp*., *Endothyra* sp., *Eostaffella* sp., *Eostaffellina* sp., *Globivalvulina* sp., *Globoendothyra* sp., *Glomospiroides* sp., *Hemidiscus* sp., *Haplophragmina*? sp., *Howchinia* sp., *Janichewskina* sp., *Mediocris*? sp., *Millerella* sp., *Monotaxinoides* sp., *Neoarchaediscus* sp., cf. *Omphalotis?* sp., *Planoendothyra* sp., *Planospirodiscus* sp., *Priscella sp*., *Pseudoammodiscus sp.*, *Pseudoendothyra* sp., *Pseudoglomospira* sp., *Pseudo*staffella sp., *Tetrataxis* sp., *Zellerinella* sp.	Foraminifers of Zones 18 and 20 Mid-Carboniferous	1c
	89VKO30-13	380031	6313766	*Aphralysia* sp., *Archaeolithophyllum* sp., *Asphaltina* sp., *Calcisphaera* sp., *Cuneiphycus* sp., *Donezella* sp., *Fasciella* sp., *Komia* sp., *Mametella* sp., *Masloviporidium* sp., *Pseudokomia* sp., *Renalcis* sp., *Stacheodies* sp., *Ungardella* sp.	Microflora of Zones 18 and 20 Mid-Carboniferous	1c

REFERENCE

1c = Mamet (1991c). Report No. 02-BLM-91

APPENDIX 6

MICROFAUNA AND MICROFLORA OF THE CARBONIFEROUS CARBONATE NORTH OF FORREST KERR GLACIER

GSC Loc. Number	Sample Number	UTM Zone 9 East	North	Fauna-Description	Age	Ref.
C188227	90VKO5-1	383881	6313196	Coarse-grained bryozoan-echinoderm grainstone, some microbreccia fragments; *Tetrataxis* sp.	Insufficient microfauna	1a
C188229	90VKO5-1	383881	6313196	Coarse-grained echinoderm-bryozoan grainstone, dissolved red algae; *Endothyra* sp., *Tetrataxis* sp.	Insufficient microfauna	1a
C188232	90VKO5-1	383881	6313196	Breccia of different carbonate facies; pelletoidal grainstone, foram-bryozoan wackestone, bryozoan packstone; *Calcisphaera* sp., *Earlandia* sp., *Endothyra* sp.	Insufficient microfauna	1a
C188233	90VKO5-1	383881	6313196	Fenestellid, algal pellet grainstone/packestone; *Calcisphaera* sp., *Earlandia* sp., *Endothyra* sp., *Tetrataxis* sp., *Tubertina* sp.	Insufficient microfauna	1a
C188234	90VKO5-1	383881	6313196	Reworked bioclasts, echinoderms, bryozoans, packstone with extensive pressure solution (rock fragments include; oolitic grainstone, mudstone, bryozoan wackestone); *Calcisphaera* sp., *Earlandia* sp., *Endothyra* sp., *Koskinotextulairia* sp., *Valvulinellia* sp. (exceptional record of *Valvulinella* in North America)	Insufficient microfauna	1a
C188235	90VKO5-1	383881	6313196	Organoclastic, bioclastic, oolitic "grainstone", big microbreccia from a sponge-algal reef (see C189358 - a *Renalcis-Fasciella-Sphaeroporella-Aphralysia*-sponge association); Archaediscus ex gr. *krestovnikovi* Rauzer-Chernoussova, *Archaediscus* ex gr. *moelleri* Rauzer-Chernoussova, *Archaediscus* sp., *Calcisphaera* sp., *Consobrinella* sp., *Endothyranopsis* ex. gr. *crassa* (Brady)., *Globoendothyra* sp., *Mediocris* sp., *Neoarchaediscus* sp., *Ortonella* sp., *Palaeotextularia* sp., *Priscella* sp., *Stacheoides* sp., *Tetrataxis* sp., *Ungdarella* sp.	Approximate zone 18, Serpukhovian abundant reworked fragments	1a
C188236	90VKO5-1	383881	6313196	Very coarse crinoidal lump pelletoidal "grainstone", reworked microbreccia and bioclasts; *Archaediscus* sp., *Calcisphaera* sp., *Consobrinella* sp., *Endothyra* sp., *Koskinobigenerina* sp., *Mediocris* sp., *Parathurammina* sp., *Priscella* sp., *Pseudotaxis* sp., Stacheoides sp., *Tetrataxis* sp., and sponges.	Approximate zone 18, Serpukhovian abundant reworked fragments	1a
C188237	90VKO5-1	383881	6313196	Coarse-grained microbreccia of sponge baffelstone/crinoids/bryozoans/bioclasts as reworked fragments; *Archaediscus* sp., *Calcisphaera* sp., *Endothyra* sp., *Endothyranopsis crassa* (Brady)., *Eostaffella* sp., *Koskinotextularia* sp., *Omphalotis* sp., *Pseudoendothyra* sp. solenoporid algae., *Tetrataxis* sp., *Ungdarella* sp.	Approximate zone 18, Serpukhovian with other older levels	1a
C188238	90VKO5-1	383881	6313196	Coarse-grained breccia, bioclasts, oolite grainstone, various microfacies; *Archaediscus* ex gr. *krestovnikovi* Rauzer-Chernoussova, *Calcisphaera* sp., *Earlandia* sp., *Endothyra similis* Rauzer-Chernoussova and Reitlinger., *Eotuberitina* sp., *Girvanella* sp., *Koskinotextularia* sp., *Insolenthiteca* sp., *Stacheodies* sp., *Tuberitina* sp., *Valvulinella* sp.	Approximate zone 18, Serpukhovian abundant reworked fragments	1a
C188239	90VKO5-1	383881	6313196	Coral-bioclast-microbreccia-oolite-lithic fragment grainstone, with sponge lumps; *Calcisphaera* sp., *Earlandia* sp., *Endothyra* sp., *Endothyranopsis crassa* (Brady)., *Neoarchaediscus* sp., *Priscella* sp., *Stacheoides* sp., *Tetrataxis* sp., *Ungdarella* sp.	Approximate zone 18, Serpukhovian abundant reworked fragments	1a
C188240	90VKO5-1	383881	6313196	Bioclast-microbreccia-oolite-lithic fragment grainstone; *Archaediscus moelleri* Rauzer-Chernoussova, *Calcisphaera* sp., *Earlandia* sp., *Endothyra sp.*, *Endothyranopsis crassa* (Brady)., *Climacammina* sp., *Koskinotextularia* sp., *Neoarchaediscus* sp., *Priscella* sp., *Pseudoendothyra* sp., *Tetrataxis* sp., *Ungdarella* sp.	Approximate zone 18, Serpukhovian abundant reworked fragments	1a
C189358	90JLO11-4	383401	6313796	Pellet-fossil grainstone-packstone, algal-sponge encrustations (Coral-*Renalcis-Fasciella-Sphaeroporella*-sponge bindstone); *Endothyra sp.*, *Endothyranopsis* sp., *Climacammina* sp., *Koskinotextularia* sp., *Priscella* sp., *Ungdarella peratrovichensis* Mamet and Rudloff.	Typical Peratrovich "reef" construction, around Zone 18, Serpukhovian	1b
C189359	90JLO11-9	381451	6312647	Pellet-fossil grainstone-packstone with algal (*Aphralysia*) encrustations on sponges and corals; *Cribroendothyra*? *sp.*, *Climacammina* sp., *Janichewskina* sp., *Koskinotextularia* sp., *Mikhailovella* sp., *Priscella* sp., *Ungdarella sp.*	Typical Peratrovich , approximate Zone 18, same as C189358	1b
C189360	90JLO11-8.2	381706	6312697	Fossil pellet packstone; echinoderm, bryozoan, pelecypod, sponge-algal encrusted sponge fragments; *Archaediscus* sp., *Calcisphaera* sp., *Climacammina* sp., *Earlandia* sp., *Endothyra* sp., *Koskinotextularia* sp., *Priscella* sp., *Ungdarella sp., Tetrataxis* sp.	Typical Peratrovich , approximate Zone 18, same as C189358	1b
C189361	90JLO11-10	381631	6312547	Coral in pelletoidal fossil packstone; *Calcisphaera* sp., *Earlandia* sp., *Endothyra* of the group *E. bowmani* Philips *in* Brown *emend* Brady., *Eostaffella* sp., *Koskinotextularia* sp., *Mediocris* sp., *Planoendothyra* sp., *Priscella* sp., *Tetrataxis* sp.	Typical Peratrovich , approximate Zone 18, same as C189358	1b
C158956	89JLO6-4	383401	6314796	Unsorted algal reef breccia, fragments of corals, spongiostromid algae, sponge-algal balls, echinoderm, brachiopod spines, extensive *Aphralysia* coating on corals; *Ammovertella* sp., *Aphralysia* sp., *Archaediscus* sp., Archaediscidae, *Asteroarchaediscus* sp., *Berestovia* sp., *Calcisphaera laevis* Williamson., *Calcisphaera pachysphaerica* (Pronina)., *Calcivertella* sp., *Climacammina* sp., *Earlandia vulgaris* (Rauzer-Chernoussova and Reitlinger)., *Endothyra* sp., *Eostaffella* sp., *Fasciella* sp., *Haplophragmina?* sp., *Insolentitheca* sp., cf. *Mediocris?* sp., *Neoarchaediscus* sp., cf. *Omphalotis?* sp., *Priscella sp*., *Pseudoendothyra* sp., *Pseudo taxis* sp., *Pseudoglomospira* sp., *Renalcis* sp. (youngest recorded *Renalcis* in Paleozoic), *Stacheoides* sp., *Tetrataxis* sp., *Tuberitina* sp.	Zone 18, Early Carboniferous, latest Serpukhovian Equivalent to Upper Limestone member of Peratrovich Formation in Alaska. lots of reworked material	1c
C158957	89JLO6-2	383301	6314036	Unsorted blocks of foraminiferal grainstone, coarse-grained encrinite, algal spongiostromids of a disarticulated reef; *Ammovertella* sp., *Archaediscus* sp., Archaediscidae, *Asteroarchaediscus* sp., *Asteroarchaediscus baschkiricus* (Kresovnikov and Teodorovitch), *Asteroarchaediscus ovoides* (Reitlinger), *Calcisphaera laevis* Williamson., *Calcisphaera pachysphaerica* (Pronina)., *Calcitornella* sp., *Climacammina* sp., *Cribrostomum* sp., *Donezella* sp., *Earliandia vulgaris* (Rauzer-Chernoussova and Reitlinger)., *Endothyra* sp., *Eostaffella* sp., *Fasciella* sp., *Globivalvulina?* sp., *Monotaxinoides?* sp., *Neoarchaediscus* sp., *Neoarchaediscus grandis* (Reitlinger), cf. *Omphalotis?* sp., *Priscella sp*., *Pseudoammodiscus sp., Pseudoendothyra* sp., *Pseudoglomospira* sp., *Pseudotaxis* sp., *Stacheoides meandriformis* Mamet et Rudloff, *Tetrataxis* sp., *Tuberitina* sp.	Zone 18, Serpukhovian similar to C158956 Equivalent to Upper Limestone member of Peratrovich Formation in Alaska. abundant reworked material	1c
C158986	89JDR13-8	385475	6302626	Algal foraminiferal grainstone-algal encrusted foraminiferal packstone; *Ammovertella* sp., *Apterrinella* sp., *Archaediscus* sp., *Archaediscus krestovnikovi* Rauzer-Chernoussova, *Asteroarchaediscus* sp., *Asteroarchaediscus baschkiricus* (Krestovnikov and Teodorovitsh), *Calisphaera* sp., *Calcitornella* sp., *Calcivertella* sp., *Biseriella* sp., Beadyinidae, *Climacammina* sp., *Earlandia* sp., *Endothyra* sp., *Eostaffella* sp., cf. *Eostaffellina* sp., *Globivalvulina* of the group *G. moderata* (Reitlinger), *Hochinia* sp., *Janichewskina* sp., *Janichewskina typica* Mikhailov, *Komia* sp., "*Lipinella*" sp., *Mediocris?* sp., *Millerella* sp., *Mametella*? sp., *Neoarchaediscus grandis* (Reitlinger), *Planoendothyra* sp., *Pseudoendothyra* sp., *Tetrataxis* sp., *Ungdarella peratrovichensis* Mamet and Rudloff.	Zone 20, early Bashkirian	1c

REFERENCES
1a = Mamet (1991a). Report No. 08-BLM-91
1b = Mamet (1991b). Report No. 07-BLM-91
1c = Mamet (1991c). Report No. 02-BLM-91

APPENDIX 7

RADIOLARIAN LOCATIONS, IDENTIFICATIONS AND AGES

GSC Loc. Number	Sample Number	UTM Zone 9 Easting	UTM Zone 9 Northing	Strat Unit	Fauna-Description	Age
C-167847	91JLO5-48	397783	6342021	mTRs	*Eptingium manfredi* Dumitrica, *Hozmadia* cf. *reticulata*, *Silicarmiger*(?) sp., *Triassocampe* cf. sp.	Middle Triassic, late Ansian to late Ladin
C-189401	91JLO6-65	406533	6343370	mTRs	*Pseudostylospharea* sp., *Triassocampe* sp., *Yeharaia* sp.	Middle-Late Triassic, Ladinian-Carnian
C-189421	91JLO12-153	386283	6342195	lPSc	Radiolarians	Phanerzoic
C-189788	91DEL33-06	405031	6321345	mJHsl	Radiolarians	Phanerzoic
C-189790	91JLO32-405	380883	6323146	DMSvt	?*Scharfenbergia ruestae*	possibly late Mississippian-early Pennsylv

Identifications by F. Cordey (1992), Report No. FC-1992-1

APPENDIX 8
WHOLE-ROCK AND TRACE ELEMENT CHEMISTRY OF VOLCANIC ROCKS

Sample	89JDR29-6	90VKO6-2	90JLO11-12	90VKO6-7	89JDR29-3	89VKO-29-2.	89VKO-29-2.	89JDR31-3	89JLO14-1	89JLO30-1.2	90VKO6-1	90JLO12-4	90JLO12-3
UTM East	384175	395535	381909	395684	384324	382615	382615	388782	384089	378689	395638	395704	395606
UTM North	6317262	6292054	6293576	6292549	6317026	6292744	6292744	6315048	6310830	6315850	6291845	6291685	6291653
Rock Type	DMSfv	DMSfv	**DMSv	**DMSv	DMSvb	DMSvb	**DMSvb	DMSvb	DMSvb	DMSvb	DSvb	DSvb	DSvb
SiO_2	51.29	67.80	47.31	42.37	50.24	51.79	45.75	52.81	53.02	55.43	47.42	47.89	47.56
TiO_2	1.04	0.68	0.92	1.12	1.11	0.99	0.67	1.28	1.10	1.34	1.51	1.13	2.00
Al_2O_3	16.00	13.72	16.90	12.54	15.49	14.88	13.52	14.95	15.36	14.55	14.92	15.41	13.08
Fe_2O_3*	10.97	6.80	10.73	12.21	11.68	11.27	8.55	12.75	11.23	12.65	10.90	9.81	13.49
MnO	0.18	0.20	0.21	0.23	0.16	0.11	0.16	0.23	0.21	0.26	0.18	0.16	0.21
MgO	4.05	2.14	2.87	10.75	5.31	3.89	5.48	3.04	2.76	2.98	5.91	7.01	6.72
CaO	6.38	0.92	5.58	10.40	4.61	4.52	9.79	4.53	3.31	3.34	10.73	10.61	9.47
Na_2O	3.07	3.94	4.80	1.35	2.68	6.12	3.14	4.89	5.74	5.60	2.41	2.68	2.57
K_2O	1.54	1.07	1.07	0.19	3.17	0.09	0.45	0.61	0.48	1.36	0.25	0.62	0.10
P_2O_5	0.21	0.09	0.13	0.42	0.18	0.13	0.09	0.16	0.21	0.26	0.12	0.09	0.15
Total	94.73	97.36	90.52	91.58	94.63	93.79	87.60	95.25	93.42	97.77	94.35	95.41	95.35
CO_2	-	1.00	-	3.00	-	-	-	-	-	-	1.84	1.00	1.00
LOI	5.00	2.59	8.38	7.70	4.53	5.31	-	4.47	5.71	1.80	3.80	3.27	3.69
Mg #	42.23	38.40	34.63	63.55	47.38	40.60	55.93	32.07	32.74	31.81	51.78	58.59	49.66
Cr	31	-	-	-	41	31	164	16	12	17	**98**	**280**	**93**
Ni	6	-	-	-	10	11	54	2	2	2	**68**	**133**	**73**
Sc	-	-	-	-	-	-	-	-	-	-	**32.70**	**34.80**	**37.10**
V	280	98	292	330	382	355	233	207	181	214	298	260	377
Mo	6	-	-	-	10	11	54	2	2	2	-	-	-
K	12784	8882	8882	1577	26315	747	3736	5064	3985	11290	2075	5147	830
Rb	19	16	10	10	48	2	9	11	3	16	10	10	10
Cs	-	-	-	-	-	-	-	-	-	-	**1**	**1**	**<1**
Ba	616	-	-	-	617	36	35	577	648	731	**207**	**259**	**178**
Sr	452	-	-	-	159	124	82	228	171	101	-	-	-
Ta	-	-	-	-	-	-	-	0.00	-	-	-	-	-
Nb	4	10	5	5	4	2	4	4	5	5	10	10	11
Hf	-	-	-	-	-	-	-	-	-	-	-	-	-
Zr	65	179	39	68	55	45	27	53	56	69	94	66	111
Ti	6235	4077	5515	6714	6654	5935	4017	7674	6595	8033	9052	6774	11990
Y	28	48	20	23	21	18	17	29	30	36	24	19	28
Th	-	-	-	-	-	-	-	-	-	-	-	-	-
U	-	-	-	-	-	-	-	-	-	-	-	-	-
La	-	15.00	15.00	28.00	-	-	-	-	-	-	20.00	15.00	25.00
Ce	-	-	-	-	-	-	-	-	-	-	**15.70**	**11.80**	**20.90**
Nd	-	-	-	-	-	-	-	-	-	-	**12.20**	**8.70**	**16.50**
Tb	-	-	-	-	-	-	-	-	-	-	**0.60**	**0.40**	**0.70**
Yb	-	-	-	-	-	-	-	-	-	-	**1.60**	**1.30**	**2.00**
K_2O/Na_2O	0.50	0.27	0.22	0.14	1.18	0.01	0.14	0.12	0.08	0.24	0.10	0.23	0.04
K/Rb	673	555	888	158	548	374	415	460	1328	706	208	515	83

** Samples with high loss on ignition values

Numbers in bold type are ICP-MS analyses performed by X-Ray Assay Laboratories and provided by James Macdonald

APPENDIX 8 CONTINUED
WHOLE-ROCK AND TRACE ELEMENT CHEMISTRY OF VOLCANIC ROCKS

90JLO12-5	91JDR17-3	91JLO38-452	89JLO14-1.2	89JLO30-3	90JLO11-14	89JDR29-10	89JLO9-3.2	89VKO11-4	91JLO5-58	91JDR10-15	91JDR11-16	91JLO12-162
396126	381277	384981	384092	378600	382071	384622	402955	401851	395361	394841	388037	387185
6292234	6319778	6314096	6310829	6315699	6293715	6317878	6301149	6300709	6343586	6345099	6335466	6339962
DSvb	DMSvr	**DMSvr	DMSvr	DMSvr	DMSvr	DMSvr	mJHb	mJHb	Qb	Qb	Qb	Qb
45.91	63.44	70.11	69.55	70.79	75.58	62.71	46.52	46.21	47.49	48.92	48.41	46.62
2.30	0.52	0.37	0.41	0.46	0.17	0.45	1.54	1.60	2.44	2.59	2.62	2.76
13.28	17.29	10.90	13.22	13.53	10.36	15.79	14.84	14.93	14.93	16.11	15.67	15.59
14.77	4.89	3.89	4.75	4.27	2.24	5.31	11.57	12.90	13.75	13.40	13.03	14.05
0.22	0.25	0.21	0.04	0.12	0.08	0.12	0.18	0.19	0.19	0.18	0.19	0.20
6.34	1.09	1.22	0.87	0.76	0.40	1.81	6.30	6.49	6.93	4.19	5.15	6.04
9.44	0.87	2.50	0.86	0.75	3.03	3.91	11.07	10.59	10.21	7.29	8.99	10.12
2.38	7.77	3.08	4.35	6.02	2.68	3.86	2.65	2.63	2.75	4.34	3.52	2.92
0.02	1.47	1.41	1.53	1.61	1.47	1.87	0.41	0.23	0.61	1.90	1.39	0.95
0.18	0.08	0.06	0.07	0.09	0.03	0.10	0.20	0.19	0.38	0.76	0.52	0.40
94.84	97.67	93.75	95.65	98.40	96.04	95.93	95.28	95.96	99.68	99.68	99.49	99.65
1.00	-	-	-	-	2.00	-	-	-	-	-	-	-
3.89	1.53	5.74	4.20	1.32	3.82	3.96	3.93	3.36	0.48	0.32	0.32	0.35
45.95	30.63	38.31	26.62	26.06	26.13	40.30	51.89	49.91	49.95	38.24	43.91	45.99
120	10	12	3	4	-	11	334	277	189	12	86	41
99	-	-	2	2	-	2	103	93	-	-	-	-
40.30	12.00	10.00	0.00	-	-	-	**38.40**	**40.80**	31.00	20.00	27.00	32.00
428	5	7	6	14	10	92	312	338	223	132	212	264
-	-	-	2	2	-	2	103	93	-	-	-	-
166	12203	11705	12701	13365	12203	15523	3404	1909	5064	15772	11539	7886
10	10	20	19	12	18	34	13	9	10	26	15	10
<1	-	-	-	-	-	-	**2**	**1**	-	-	-	-
275	699	1099	75	724	-	859	211	130	196	557	378	269
-	76	137	27	69	-	276	225	243	404	764	550	540
-	15.36	15.00	-	-	-	-	-	-	15.00	15.00	15.00	15.00
12	11	5	7	4	5	2	11	9	24	51	45	34
-	-	-	-	-	-	-	-	-	-	-	-	-
123	195	98	109	145	86	97	88	84	170	315	269	197
13789	3117	2218	2458	2758	1019	2698	9232	9592	14628	15527	15707	16546
32	47	36	44	47	27	18	36	39	28	35	35	29
-	15.36	15.00	-	-	-	-	-	-	15.00	15.00	15.00	15.00
-	15.36	15.00	-	-	-	-	-	-	15.00	15.00	15.00	15.00
24.00	15.00	15.00	-	-	15.00	-	**6.10**	**3.80**	31.00	55.00	39.00	29.00
22.50	36.00	17.00	-	-	-	-	**14.80**	**10.20**	39.00	84.00	69.00	49.00
18.10	-	-	-	-	-	-	**13.00**	**10.50**	-	-	-	-
0.80	-	-	-	-	-	-	**0.80**	**0.80**	-	-	-	-
2.20	-	-	-	-	-	-	**3.50**	**3.60**	-	-	-	-
0.01	0.19	0.46	0.35	0.27	0.55	0.48	0.15	0.09	0.22	0.44	0.39	0.33
17	1192	585	668	1114	678	457	262	212	506	607	769	789

APPENDIX 8 CONTINUED
WHOLE-ROCK AND TRACE ELEMENT CHEMISTRY OF VOLCANIC ROCKS

92JDR7-7	89JLO22-2	90JLO11-6	89JLO32-6.2	89JLO24-7.1	89JLO27-13	89JLO27-15	92JDR2-3	91JLO13-168	91JDR7-8	89JLO33-7
386236	379015	383332	381795	386095	386937	387024	386767	380465	402857	407260
6362315	6303510	6313522	6300889	6303985	6306627	6306980	6349974	6346067	6339721	6309996
uCSr	**uCSv	**uCSv	uTrSva	uTrSva	uTrSva	uTrSvat	**uTrSvb	uTrSvb	**uTrSvb	uTrSvb
68.98	51.16	48.26	63.31	58.44	53.57	54.37	47.59	53.13	46.24	47.33
0.52	0.68	0.96	0.60	0.71	0.89	0.79	0.99	0.89	1.17	1.46
15.52	15.92	17.79	16.32	16.75	16.71	17.36	16.77	14.09	15.93	17.29
3.48	9.48	10.13	6.04	6.81	8.79	8.49	7.59	10.08	8.50	7.80
0.05	0.15	0.12	0.16	0.18	0.15	0.09	0.25	0.17	0.15	0.17
0.14	5.66	3.62	1.60	2.24	4.00	3.25	2.71	6.56	4.50	5.99
1.58	3.98	7.68	2.52	2.57	7.16	6.14	9.66	8.37	8.63	8.78
5.33	5.25	3.72	4.58	6.95	3.46	3.47	4.23	2.21	3.32	3.78
3.12	1.33	1.82	1.92	0.99	1.89	1.18	2.65	1.49	1.66	1.07
0.12	0.17	0.33	0.12	0.27	0.20	0.22	0.22	0.24	0.36	0.33
98.84	93.78	94.43	97.17	95.91	96.82	95.36	92.66	97.23	90.46	94.00
-	-	2.00	-	-	-	-	-	-	-	-
1.14	5.70	4.39	2.33	3.27	2.30	4.19	6.84	2.24	9.02	5.19
7.38	54.18	41.44	34.41	39.45	47.40	43.12	41.42	56.31	51.18	60.33
10	110	-	10	15	22	18	86	192	67	201
32	15	-	2	2	2	2	28	-	-	126
6.40	-	-	-	-	-	-	26.00	29.00	30.00	-
37	223	277	81	139	236	186	358	262	251	216
1	15	-	2	2	2	2	1	-	-	126
25900	11041	15108	15938	8218	15689	9796	21998	12369	13780	8882
51	29	15	50	15	41	31	66	21	33	16
2	-	-	-	-	-	-	1	-	-	-
1300	617	-	812	840	-	-	650	448	1451	**2620**
309	563	-	551	581	705	663	595	398	543	731
15.00	-	-	-	-	-	-	15.00	15.00	15.00	-
10	1	5	7	4	4	5	5	12	13	8
7	-	-	-	-	-	-	2	-	-	-
235	52	52	129	122	91	116	54	97	130	133
3117	4077	5755	3597	4256	5336	4736	5935	5336	7014	8753
36	14	19	34	26	21	23	21	30	29	31
15.00	-	-	-	-	-	-	15.00	15.00	15.00	-
15.00	-	-	-	-	-	-	15.00	15.00	15.00	-
33.00	-	20.00	-	-	-	-	6.00	18.00	15.00	**16.40**
66.00	-	-	-	-	-	-	13.00	25.00	37.00	**35.50**
28.00	-	-	-	-	-	-	8.00	-	-	**22.20**
0.70	-	-	-	-	-	-	0.60	-	-	**0.60**
4.70	-	-	-	-	-	-	2.00	-	-	**1.90**
0.59	0.25	0.49	0.42	0.14	0.55	0.34	0.63	0.67	0.50	0.28
508	381	1007	319	548	383	316	333	589	418	555

APPENDIX 9
WHOLE-ROCK AND TRACE ELEMENT OF PLUTONIC ROCKS

Sample	91JLO18-247	91JLO10-117	R81-126E+	R81-136B+	R81-173+	R81-188+	91JLO7-76	89VKO28-15	90JLO12-1
UTM East	409186	391566					402785	392789	394343
UTM North	6339066	6342893					6339812	6288367	6293609
Rock Type	**dike	dike	EDd	EDd	**EDd	**EDd	EJdi	EJg	EJg
SiO_2	48.19	48.25	50.47	49.64	39.04	50.32	48.27	64.67	51.93
TiO_2	0.97	0.80	2.36	1.04	6.68	3.66	0.59	0.42	0.86
Al_2O_3	16.33	15.15	15.68	17.45	15.82	14.09	16.20	16.18	17.28
Fe_2O_3*	9.93	9.94	14.83	14.21	20.96	16.10	7.80	4.61	9.15
MnO	0.27	0.17	0.17	0.17	0.16	0.29	0.14	0.12	0.23
MgO	4.04	8.86	8.30	9.59	11.97	7.41	7.69	1.42	3.72
CaO	5.88	10.56	4.24	1.85	4.58	3.76	13.48	4.69	6.49
Na_2O	4.90	1.22	4.11	2.83	2.88	4.17	1.60	3.19	3.25
K_2O	1.84	0.14	0.33	3.93	0.10	0.32	0.12	2.99	3.38
P_2O_5	0.35	0.16	0.38	0.23	0.61	0.53	0.06	0.17	0.33
Total	92.70	95.25	100.87	100.94	102.80	100.65	95.95	98.46	96.62
CO_2	-	-	-	-	-	-	-	-	-
LOI	6.77	3.86	4.33	4.74	5.57	5.17	3.72	0.57	2.26
Mg #	44.62	63.84	52.57	57.20	53.07	47.68	66.13	37.89	44.60
Cr	10	415	77	13	15	10	699	0	-
Ni	-	-	20	3	4	-	-	-	-
Sc	15.00	37.00	-	-	-	-	46.00	-	-
V	258	240	355	205	401	421	233	-	256
Sn	15.00	15.00	-	-	-	-	15.00	-	-
W	-	-	-	-	-	-	-	-	-
Mo	-	-	-	-	-	-	-	-	-
K	15274	1162	2739	32624	830	2656	996	24821	28058
Rb	27	10	4	77	1	2	10	-	49
Cs	-	-	-	-	-	-	-	-	-
Ba	1285	154	-	-	-	-	138	-	-
Sr	329	336	101	80	245	188	147	-	-
Ta	15.00	15.00	-	-	-	-	15.00	-	-
Nb	13	6	20	20	20	22	8	-	5
Hf	-	-	-	-	-	-	-	-	-
Zr	115	47	137	121	193	186	33	-	80
Ti	5815	4796	14148	6235	40047	21942	3537	2518	5156
Y	24	19	38	32	26	43	18	-	22
Th	15.00	15.00	-	-	-	-	15.00	-	-
U	15.00	15.00	-	-	-	-	15.00	-	-
La	34.00	15.00	-	-	-	-	16.00	-	-
Ce	57.00	22.00	35.69	34.67	29.18	32.56	15.00	-	-
Nd	-	-	8.92	6.93	46.69	13.41	-	-	-
Tb	-	-	-	-	-	-	-	-	-
Yb	-	-	-	-	-	-	-	-	-
K_2O/Na_2O	0.38	0.11	0.08	1.39	0.03	0.08	0.07	0.94	1.04
K/Rb	566	116	690	422	856	13883	100	-	573

* Data from Holbek (1988)

** Samples with high loss on ignition values

APPENDIX 9 CONTINUED
WHOLE-ROCK AND TRACE ELEMENT OF PLUTONIC ROCKS

Sample	91JDR9-4	91DEL19-10	91JLO9-105	91JLO10-117	91JLO37-451	91JLO33-416	91JLO31-1	89JDR20-11.	90JLO12-2
UTM East	392299	394885	393649	391566	394081	387725	391062	393514	391949
UTM North	6337820	6331542	6337148	6342893	6337696	6344028	6300956	6297494	6288344
Rock Type	EMd	EMd	EMd	EMd	EMg	grnt clast	LDd	LDd	LDd
SiO_2	51.19	48.16	47.02	48.25	73.38	64.65	51.46	46.53	56.27
TiO_2	0.80	1.43	1.13	0.80	0.28	0.28	0.48	1.05	0.51
Al_2O_3	16.70	16.93	14.41	15.15	13.81	14.65	15.30	16.31	18.50
Fe_2O_3*	11.14	10.69	10.55	9.94	2.96	2.45	8.47	11.06	3.93
MnO	0.20	0.18	0.17	0.17	0.04	0.06	0.19	0.20	0.08
MgO	5.83	6.50	9.46	8.86	0.45	0.81	6.98	8.10	2.20
CaO	10.27	9.92	12.39	10.56	2.97	5.25	10.10	10.27	4.21
Na_2O	2.03	2.49	1.76	1.22	3.87	4.94	2.95	2.04	8.47
K_2O	0.36	1.14	0.70	0.14	1.18	2.67	0.98	0.82	0.33
P_2O_5	0.07	0.21	0.12	0.16	0.05	0.10	0.05	0.12	0.17
Total	98.59	97.65	97.71	95.25	98.99	95.86	96.96	96.50	94.67
CO_2	-	-	-	-	-	-	-	-	3.00
LOI	1.22	2.07	1.92	3.86	0.71	3.78	2.33	2.96	4.45
Mg #	50.89	54.63	63.97	63.84	23.14	39.57	62.01	59.19	52.58
Cr	90	111	758	436	10	16	182	206	0
Ni	-	-	-	-	-	-	-	118	-
Sc	45.00	30.00	47.00	37.00	5.00	5.00	42.00	-	-
V	344	215	278	240	16	53	250	244	82
Sn	15.00	15.00	15.39	15.75	15.00	15.65	15.00	-	-
W	-	-	-	-	-	-	-	-	-
Mo	-	-	-	-	-	-	-	118	-
K	2988	9463	5811	1162	9796	22164	8135	6807	2739
Rb	10	24	12	11	10	37	16	12	10
Cs	5	-	-	-	-	-	5	-	-
Ba	239	312	251	154	1099	1417	516	405	-
Sr	298	474	300	353	293	1088	342	217	-
Ta	15.00	15.00	15.39	15.75	15.00	15.65	15.00	-	-
Nb	5	14	12	6	5	5	5	5	5
Hf	-	-	-	-	-	-	-	-	-
Zr	46	88	71	49	171	94	36	52	112
Ti	4796	8573	6774	4796	1679	1679	2878	6295	3057
Y	20	15	17	20	12	14	12	25	36
Th	15.00	15.00	15.39	15.75	15.00	15.65	15.00	-	-
U	15.00	15.00	15.39	15.75	-	15.65	15.00	-	-
La	16.00	16.00	-	15.00	15.00	15.00	15.00	-	15.00
Ce	15.00	26.00	23.00	22.00	19.00	16.00	15.00	-	-
Nd	-	-	-	-	-	-	-	-	-
Tb	-	-	-	-	-	-	-	-	-
Yb	-	-	-	-	-	-	-	-	-
K_2O/Na_2O	0.18	0.46	0.40	0.11	0.30	0.54	0.33	0.40	0.04
K/Rb	299	394	472	111	980	607	508	567	274

APPENDIX 9 CONTINUED
WHOLE-ROCK AND TRACE ELEMENT OF PLUTONIC ROCKS

Sample	90JLO12-2DU	90JLO12-6.2	89JDR-6-3	90JLO13-8	89JLO7-2	89JLO7-2DUP	90JLO13-9	91JLO31-2	89JLO29-10	91JDR33-4-1
UTM East	391949	396226	391062	393747	391979	391979	387735	391381	398640	390193
UTM North	6288344	6293195	6301013	6313748	6297566	6297566	6303401	6301696	6314503	6338516
Rock Type	LDd	LDd	LDg	LDg	LDg	LDg	LDg	LDg	**LDg	LDum
SiO_2	55.93	47.81	71.16	62.76	72.94	73.28	74.34	70.62	50.01	47.00
TiO_2	0.52	1.38	0.29	0.54	0.25	0.25	0.24	0.29	1.51	1.12
Al_2O_3	18.37	15.30	14.53	15.85	13.69	13.77	13.59	14.50	15.03	14.40
Fe_2O_3*	3.92	10.27	3.56	5.59	2.82	2.87	2.39	3.57	5.31	18.15
MnO	0.08	0.18	0.12	0.13	0.06	0.06	0.06	0.10	0.22	0.17
MgO	2.19	6.67	0.66	2.23	0.65	0.65	0.50	0.70	4.67	9.17
CaO	4.19	13.28	3.15	4.13	1.88	1.87	2.70	3.08	7.48	12.28
Na_2O	8.65	1.59	3.93	3.01	4.86	4.84	3.97	3.85	3.70	1.84
K_2O	0.35	0.02	1.41	2.87	0.83	0.85	0.96	1.40	1.06	0.70
P_2O_5	0.17	0.11	0.08	0.09	0.05	0.04	0.04	0.08	0.24	0.12
Total	94.37	96.61	98.89	97.20	98.03	98.48	98.79	98.19	89.23	104.95
CO_2	3.00	-	-	-	-	-	-	-	-	-
LOI	4.45	2.18	0.82	1.91	1.38	1.36	0.82	1.43	2.22	5.02
Mg #	52.53	56.26	26.86	44.14	31.34	30.96	29.29	27.97	63.53	50.01
Cr	-	-	-	-	5	5	-	10	36	11
Ni	-	-	-	-	2	2	-	-	2	-
Sc	-	-	-	-	-	-	-	5.00	-	6.00
V	82	300	-	127	21	19	18	23	387	45
Sn	-	-	-	-	-	-	-	15.00	-	15.79
W	-	-	-	-	-	-	-	-	-	-
Mo	-	-	-	-	2	2	-	-	2	-
K	2905	166	11705	23825	6890	7056	7969	11622	8799	5811
Rb	10	10	0	41	9	9	10	16	20	14
Cs	-	-	-	-	-	-	-	5	-	-
Ba	-	-	-	-	434	437	-	1090	408	131
Sr	-	-	-	-	206	211	-	257	283	224
Ta	-	-	-	-	-	-	-	15.00	-	15.79
Nb	10	11	-	5	4	1	5	5	5	5
Hf	-	-	-	-	-	-	-	-	-	-
Zr	122	76	-	91	106	105	89	96	60	21
Ti	3117	8273	1739	3237	1499	1499	1439	1739	9052	6714
Y	41	22	-	20	21	21	13	19	25	11
Th	-	-	-	-	-	-	-	15.00	-	15.79
U	-	-	-	-	-	-	-	15.00	-	15.79
La	15.00	15.00	-	15.00	-	-	-	15.00	-	18.00
Ce	-	-	-	-	-	-	-	15.00	-	15.00
Nd	-	-	-	-	-	-	-	-	-	-
Tb	-	-	-	-	-	-	-	-	-	-
Yb	-	-	-	-	-	-	-	-	-	-
K_2O/Na_2O	0.04	0.01	0.36	0.95	0.17	0.18	0.24	0.36	0.29	0.38
K/Rb	291	17	0	581	766	784	797	726	440	425

APPENDIX 9 CONTINUED
WHOLE-ROCK AND TRACE ELEMENT OF PLUTONIC ROCKS

Sample	91JLO13-171	92JLO3-27	92JL01-6	92JLO1-4	89JDR28-7	92JLO16-186	JLO16-186D	92JDR10-4	89JDR10-1	89JLO9-6.2
UTM East	381157	386097	385513	386443	384898	381233	381233	382583	398919	403052
UTM North	6346207	6352193	6349976	6350490	6304676	6358511	6358511	6355211	6317415	6300989
Rock Type	LTrHd	LTrmz	LTrmz	LTrmz	LTrmz	LTrpd	LTrpd	LTrpp	MJdi	MJdi
SiO_2	54.51	48.67	52.23	49.90	60.43	50.89	50.87	53.67	47.50	45.78
TiO_2	1.57	1.05	1.03	1.16	0.41	0.84	0.84	0.89	2.49	1.47
Al_2O_3	12.90	16.53	15.07	15.16	15.89	17.20	17.04	15.18	13.35	13.72
Fe_2O_3*	14.57	10.85	8.60	11.52	5.17	9.07	9.02	10.39	13.06	12.27
MnO	0.28	0.17	0.13	0.21	0.09	0.16	0.15	0.18	0.23	0.23
MgO	2.44	3.78	3.94	2.33	1.29	4.96	5.02	5.23	6.41	9.83
CaO	6.14	6.90	5.79	6.57	4.99	8.68	8.68	5.78	4.82	8.71
Na_2O	3.11	3.98	4.28	3.88	3.01	2.80	3.00	5.69	2.62	2.16
K_2O	1.32	1.63	3.90	2.71	3.61	1.09	1.10	1.11	1.12	0.52
P_2O_5	0.55	0.26	0.63	0.33	0.16	0.22	0.21	0.25	0.41	0.19
Total	97.39	93.82	95.60	93.77	95.05	95.91	95.93	98.37	92.01	94.88
CO_2	-	-	-	-	-	-	-	-	-	-
LOI	1.93	4.27	3.50	5.25	4.61	3.38	3.37	1.39	7.23	4.22
Mg #	24.91	40.83	47.57	28.60	33.07	51.99	52.43	49.92	49.29	61.34
Cr	10	23	49	22	19	75	73	101	43	466
Ni	-	30	36	28	5	30	32	38	11	179
Sc	27.00	28.00	24.00	25.00	-	30.00	31.00	33.00	-	-
V	169	332	213	279	81	199	210	256	390	317
Sn	15.00	15.00	15.00	15.00	-	15.00	15.00	15.00	-	-
W	-	24.00	41.00	19.00	-	46.00	48.00	74.00	-	-
Mo	-	1	2	1	5	2	1	1	11	179
K	10958	13531	32375	22497	29968	9048	9131	9214	9297	4317
Rb	13	30	85	46	93	15	14	10	19	9
Cs	-	1	2	2	-	1	1	2	-	-
Ba	847	580	1600	600	-	590	520	860	823	604
Sr	312	524	1036	289	329	492	490	314	298	219
Ta	15.00	15.00	15.00	15.00	-	15.00	15.00	15.00	-	-
Nb	12	5	7	5	5	6	6	5	13	12
Hf	-	2	5	3	-	3	4	3	-	-
Zr	134	70	148	94	101	108	108	74	147	79
Ti	9412	6295	6175	6954	2458	5036	5036	5336	14928	8813
Y	48	23	24	30	20	23	22	22	36	35
Th	15.00	15.00	15.00	15.00	-	15.00	15.00	15.00	-	-
U	15.00	15.00	15.00	15.00	-	15.00	15.00	15.00	-	-
La	25.00	6.00	43.00	11.00	-	17.00	18.00	8.00	-	-
Ce	32.00	14.00	82.00	24.00	-	34.00	38.00	20.00	-	-
Nd	-	7.00	34.00	16.00	-	17.00	17.00	11.00	-	-
Tb	-	0.70	0.50	0.50	-	0.50	0.60	0.50	-	-
Yb	-	2.60	2.50	3.40	-	2.50	2.80	2.40	-	-
K_2O/Na_2O	0.42	0.41	0.91	0.70	1.20	0.39	0.37	0.20	0.43	0.24
K/Rb	843	451	381	489	322	603	652	921	489	480

APPENDIX 10
LITHOGEOCHEMICAL ANALYSES
FORREST KERR CREEK AND ISKUT RIVER MAP AREAS
(104B/15 AND PART OF 104B/10)

Map Number	Sample Number	UTM EAST	ZN 09 NORTH	Au (ppb)	Ag (ppm)	Cu (ppm)*	Pb (ppm)*	Zn (ppm)*	As (ppm)*	Sb (ppm)	Mo (ppm)*	Ni (ppm)*	Fe (ppm)*	SAMPLE DESCRIPTION
FK 1	89GVI01-1	395880	6296816	<2	<0.3	349	<3	36	5	2	-	-	-	grab, 15 cm qtz vein, tr. ml
FK 2	89GVI01-2	396070	6297165	34	<0.3	166	<3	20	14	0.6	-	-	-	grab, 100 m qtz stwk
FK 3	89GVI01-3.1	396180	6297065	16	3	0.14%	<3	74	19	0.7	-	-	-	grab, qtz vein with ml
FK 4	89GVI01-3.2	396180	6297065	6	<0.3	352	<3	17	20	<0.5	-	-	-	20 m chip, qtz stwk tr. cpy
FK 5	89GVI01-4.2	396100	6296865	<2	<0.3	10	<3	37	7	0.6	-	-	-	grab, qtz-py stwk
FK 6	89GVI01-5	395760	6296795	67	<0.3	10	<3	9	2	1	-	-	-	grab, 3 m qtz-carb stwk
FK 7	89GVI01-6	395560	6296856	436	<0.3	289	<3	36	6	0.6	-	-	-	grab, veinlets with ml+cpy+mgnt
FK 8	89GVI04-10	385205	6305910	34	32	200	0.30%	0.57%	0.55%	169	-	-	-	grab, diss sulphides in lmst
FK 9	89GVI04-8	385081	6305697	<2	<0.5	6	<2	57	9	1	-	-	-	qtz-carb veinlets
FK 10	89JDR01-11	392631	6309716	<2	<0.5	8	<4	27	15	2	-	-	-	diss py grnt
FK 11	89JDR01-15	393940	6310496	<2	<0.5	9	<4	29	3	1	-	-	-	grab, qtz-carb veinlets with py
FK 12	89JDR01-2	391280	6307806	5	<0.5	7	<4	38	2	1	-	-	-	grab, qtz-carb veinlets with py
FK 13	89JDR02-2	398880	6308845	<2	<0.5	135	<4	43	<1	0.6	-	-	-	qtz-carb veins
FK 14	89JDR02-4	398760	6308495	9	<0.5	8	<4	11	<1	1	-	-	-	oxidized pyritic aplite dyke
FK 15	89JDR02-5	398799	6308396	9	<0.5	0.46%	<4	57	6	0.8	-	-	-	qtz-carb vein w/cpy+py+ml
FK 16	89JDR06-10	388880	6299196	32	<0.5	17	10	50	3	1	-	-	-	hematized grnt
FK 17	89JDR10-3	398668	6317316	1395	<0.5	0.41%	<4	16	<1	0.6	-	-	-	grab, 1-10 cm qtz veinlets, tr. cpy+ml
FK 18	89JDR12-4	388875	6302948	997	3	0.48%	<4	59	4	1	-	-	-	grab, 2 cm qtz veinlets, diss cpy+ml+az
FK 19	89JDR16-4	382160	6303296	72	<0.5	22	<4	16	6	<0.5	-	-	-	qtz-carb-py vein
FK 20	89JDR18-2.1	376679	6295596	<2	5	9	104	126	210	37	-	-	-	grab, narrow oxidized qtz veinlets
FK 21	89JDR18-2.2	376679	6295596	<2	2	3	457	450	20	163	-	-	-	grab, mg-skarn
FK 22	89JDR18-3	376879	6295596	<2	18	59	0.28%	0.27%	337	122	-	-	-	grab, oxidized mg-skarn
FK 23	89JDR18-4	376879	6295376	2360	<0.5	9	<4	10	14	4	-	-	-	massive and drusy qtz veins + py
FK 24	89JDR20-12	393020	6297256	<2	<0.5	10	<3	85	5	5	-	-	-	qtz+py stwk, cross cuts dyke swarm
FK 25	89JDR20-6	394250	6297546	5	<0.5	4	<3	10	<1	0.9	-	-	-	chl-altered, sheared grnt
FK 26	89JDR22-12	386491	6313256	<2	<0.5	19	<3	35	3	1	-	-	-	oxidized rhyolite
FK 27	89JDR22-4.3	388131	6314896	<2	<0.5	22	19	404	3	3	-	-	-	oxidized, silicified-pyritic flow brcc
FK 28	89JDR23-6	398061	6312756	<2	<0.5	720	<3	14	3	2	-	-	-	grab, qtz stwk+py+cpy+ml
FK 29	89JDR24-2	380469	6290326	592	1.1	0.12%	6	70	2	1	-	-	-	qtz-epid-py veinlets
FK 30	89JDR25-11	393639	6289856	4	<0.3	7	<3	17	9	2	-	-	-	silicified and oxidized slsn
FK 31	89JDR26-13	383179	6290396	<2	<0.3	74	<3	57	2	0.6	-	-	-	grab, silicified-pyritized tuff
FK 32	89JDR30-1	400998	6317261	<2	<0.5	8	19	4	8	2	-	-	-	silic and argillic alt, py to 5%
FK 33	89JDR30-2	400821	6317390	6	<0.5	4	62	1	14	2	-	-	-	oxidized, argillic and silic alt
FK 34	89JDR30-4	400314	6317531	<2	73	0.20%	730	557	441	250	-	-	-	silicified, ml+az+ tr. gln
FK 35	89JDR31-4	388821	6314968	<2	<0.5	32	<2	66	6	2	-	-	-	qtz-carb-barite veins
FK 36	89JLO01-1.1	394161	6313996	15	<0.5	4	<4	78	<1	0.8	-	-	-	grab, qtz-carb-py vein
FK 37	89JLO01-10	391870	6312185	<2	<0.5	120	10	62	8	1	-	-	-	pyritic felsic volcanic
FK 38	89JLO01-4.2	393921	6313636	62	<0.5	73	<4	77	5	7	-	-	-	chip, 1 m, qtz-ankerite vein
FK 39	89JLO03-9	397990	6303555	<2	<0.5	21	<4	20	3	1	-	-	-	qtz-carb alt dort, cpy+py
FK 40	89JLO04-17.2	397830	6297455	<2	<0.5	0.28%	<4	95	3	2	-	-	-	alt andt, 1% diss py
FK 41	89JLO07-4.2	391680	6297136	<2	2	0.33%	<4	58	<1	<0.5	-	-	-	qtz stwk diss cpy+py
FK 42	89JLO08-14	388751	6318506	191	2	140	16	38	120	2	-	-	-	qtz-carb alt qtz vein
FK 43	89JLO08-4.2	388851	6319406	<2	2	71	10	119	12	1	-	-	-	pyritic tuff
FK 44	89JLO08-4.3	388851	6319406	9	3	84	6	74	63	3	-	-	-	pyritic tuff
FK 45	89JLO13-6	387760	6303296	<2	1	380	22	64	4	1	-	-	-	pyritic sheared dort
FK 46	89JLO14-11	385501	6311176	72	<0.5	81	<4	282	2	3	-	-	-	carb veinlet
FK 47	89JLO14-8.2	385071	6311076	1152	<0.5	43	10	338	5	7	-	-	-	oxidized, carb-alt fault zone
FK 48	89JLO17-14	395609	6291775	<2	<0.5	2	<3	2	<1	<0.5	-	-	-	1 m chip, massive-bull qtz veins
FK 49	89JLO17-15	395690	6291746	300	3	0.82%	<3	13	158	4	-	-	-	fault brcc, cpy+py+po
FK 50	89JLO17-6.2	394269	6292036	4	<0.5	98	31	108	<1	9	-	-	-	pyritic slsn/tuff
FK 51	89JLO19-21	389541	6310626	<2	24	0.98%	6	50	21	5	-	-	-	grab, py+cpy in calcareous shear
FK 52	89JLO21-17.1	396449	6292395	36	0.6	810	<3	10	7	1	-	-	-	chip, 0.35 m qtz vein tr. ml
FK 53	89JLO21-17.2	396449	6292395	<2	<0.5	373	<3	5	2	0.7	-	-	-	chip, 1.0 m qtz vein tr. ml
FK 54	89JLO21-3	395979	6291665	<2	<0.3	66	<4	58	63	6	-	-	-	oxid fractured py tuff
FK 55	89JLO22-16	380450	6300896	<2	<0.3	38	<3	53	10	2	-	-	-	qtz-carb-py alt bslt
FK 56	89JLO24-11	386600	6303916	<2	125	510	24	5.88%	49	456	-	-	-	grab sph+barite vein filling lmst
FK 57	89JLO25-10	388740	6308776	5	6	0.35%	162	660	0.13%	680	-	-	-	ankerite alt lmst, cpy+aspy
FK 58	89JLO25-11	388751	6308586	<2	0.8	86	18	161	47	12	-	-	-	ankerite alt lmst
FK 59	89JLO25-15	388740	6308776	16	0.8	164	96	0.14%	81	16	-	-	-	grab, silic fault brcc diss sph+py
FK 60	89JLO25-16	388740	6308776	9	0.866	183	42	133	129	40	-	-	-	grab, silic fault brcc
FK 61	89JLO25-6	396640	6302056	<2	0.8	72	6	74	2	0.9	-	-	-	carb- and sericite-alt, parallels S1
FK 62	89JLO31-6	402450	6314442	91	1.1	0.40%	33	161	15	2	-	-	-	py felsic dykes, diss cpy+ml
FK 63	89JLO31-8	402793	6314263	4	0.5	5	<2	80	7	2	-	-	-	8 m wide argillic alt zone
FK 64	89JLO34-1	394179	6291370	<2	<0.3	109	30	114	33	8	-	-	-	pyritic felsic tuff
FK 65	89JLO34-2	406131	6317345	<2	<0.3	2	7	10	59	3	-	-	-	pyritic qtz-feldspar porphyry

APPENDIX 10 CONTINUED
LITHOGEOCHEMICAL ANALYSES
FORREST KERR CREEK AND ISKUT RIVER MAP AREAS
(104B/15 AND PART OF 104B/10)

Map Number	Sample Number	UTM EAST	ZN 09 NORTH	Au (ppb)	Ag (ppm)	Cu (ppm)*	Pb (ppm)*	Zn (ppm)*	As (ppm)*	Sb (ppm)	Mo (ppm)*	Ni (ppm)*	Fe (ppm)*	SAMPLE DESCRIPTION
FK 66	89VKO02-5	393881	6310536	<2	<0.5	6	<4	27	11	6	-	-	-	hematized, fractured tuff
FK 67	89VKO07-9	387731	6311096	<2	<0.5	3	16	28	<1	<0.5	-	-	-	oxidized qtz-carb-alt andt
FK 68	89VKO10-6	305083	6303695	<2	<0.5	169	28	269	8	3	-	-	-	pyritic shale 1-2% diss py
FK 69	89VKO13-5	303873	6315546	78	<0.5	58	12	72	15	2	-	-	-	oxidized shear zone, grab
FK 70	89VKO14-3	389330	6305496	118	<0.5	66	<4	49	9	2	-	-	-	oxidized qtz-carb vein, grab
FK 71	89VKO14-4	389130	6305646	102	2	208	<4	33	19	153	-	-	-	qtz vein w/ pyritic alt envelope
FK 72	89VKO17-3	379240	6298666	15	7	720	0.34%	700	200	7	-	-	-	hornfelsed slsn, py
FK 73	89VKO18-2.1	388230	6304596	619	3	61	<4	22	5	3	-	-	-	0.3 m qtz-carb vein, grab
FK 74	89VKO18-2.2	388230	6304596	<2	<0.5	13	<4	35	5	7	-	-	-	0.4 m qtz-carb vein, grab
FK 75	89VKO19-11	384320	6297426	<2	<0.5	110	12	72	9	2	-	-	-	massive pyrite lenses in tuff
FK 76	89VKO19-16	383780	6296735	<2	<0.5	0.14%	16	73	93	7	-	-	-	qtz vein massive mgnt+cpy+po
FK 77	89VKO22-13	393142	6295263	6	2	30	11	47	233	80	-	-	-	limonitic py stwk
FK 78	89VKO22-4	394620	6295626	11	<0.5	139	14	98	195	13	-	-	-	grab, hornfelsed slsn, py
FK 79	89VKO27-11	380799	6288156	18	<0.3	150	6	54	25	2	-	-	-	grab, oxidized 5cm shear zone
FK 80	89VKO28-4	392529	6289816	<2	0.4	246	9	320	<1	0.6	-	-	-	oxidized qtz-carb veins
FK 81	89VKO28-7	392529	6289516	<2	<0.3	170	<3	110	3	1	-	-	-	pyritic dort dyke, 5% py
FK 82	89VKO29-16	384369	6290746	<2	<0.3	71	7	47	3	0.8	-	-	-	grab, oxidized pyritic andt
FK 83	89VKO30-8	380161	6314107	4	<0.5	33	<4	111	21	3	-	-	-	grab, qtz-carb veinlets
FK 84	89VKO31-1	389340	6307106	37	1	194	<2	82	77	36	-	-	-	qtz-chl-carb veins + stwk
FK 85	89VKO31-2.2	389100	6307066	<2	<0.5	26	<2	32	4	6	-	-	-	grab, barite-carb veins
FK 86	89VKO33-11	399948	6316874	<2	<0.5	63	<4	81	85	4	-	-	-	oxidized fault zone, no vis. sulphides
FK 87	89VKO33-3	399088	6316032	<2	<0.5	11	<2	25	<1	2	-	-	-	grab, qtz-carb vein, sericite alt
FK 88	89VKO34-2	387140	6314300	126	11	0.27%	19	50	6	1	-	-	-	grab, narrow oxidized pyritic shear
FK 89	89VKO35-13	402185	6312782	<2	<0.5	135	19	84	21	15	-	-	-	pyritic sheared andt
FK 90	89VKO35-2	401598	6312697	<2	<0.5	75	17	107	25	3	-	-	-	pyritic silicified andt
FK 91	89VKO36-1	377399	6306163	<2	208	2.50%	12	0.37%	0.32%	1.01	-	-	-	grab, qtz-carb stwk cpy+sph+py+ml

MORE CREEK MAP AREA (104G/02)

Map Number	Sample Number	UTM EAST	ZN 09 NORTH	Au (ppb)	Ag (ppm)	Cu (ppm)*	Pb (ppm)*	Zn (ppm)*	As (ppm)*	Sb (ppm)	Mo (ppm)*	Ni (ppm)*	Fe (ppm)*	SAMPLE DESCRIPTION
M 1	91DEL13-1	378963	6343528	<5	8	0.74%	4	78	5	2	<3	30	4.04%	ml stained fracture surfaces
M 2	91DEL13-2	379124	6343527	<5	7	1.85%	34	84	22	9	<3	15	4.73%	ml + carb alteration
M 3	91JLO12-159	386548	6341351	10	14	1.65%	52	0.25%	0.33%	0.53%	<3	39	3.52%	diss + fract tt, mal + az, grab from trench
M 4	91JLO21-290	407376	6340918	770	3.2	820	16	135	124	2	<3	5	14.70%	grab diss + fract controlled po + py
M 5	91JLO21-293	406938	6340858	<5	0.6	37	8	42	59	2	26	52	4.38%	75 cm wide chip qtz-carb alteration
M 6	91JLO16-228	386279	6339267	462	5	45	162	28	30	4	32	2	3.32%	grab ser + py + sil altered grnt
M 7	91DEL20-14	382719	6339157	32996	55	245	2.57%	1.80%	30.00%	310	<3	<2	23.60%	massive py + aspy + gl + qtz from trench, BJ claims
M 8	91DEL10-17	388755	6338027	<5	0.6	18	36	34	5	0.5	<3	4	6.53%	hem altered volcanics w/ diss. py
M 9	91JLO8-89	397941	6337406	<5	0.6	41	30	108	18	<0.5	12	6	3.73%	qtz-carb altered fault zone
M 10	91JDR20-9DUP	381722	6336101	795	<0.5	7	7	13	17	0.5	<3	5	1.60%	qtz stwk, minor diss. py, veins 20-40cm wide
M 10	91JDR20-9	381722	6336101	865	0.6	6	6	13	13	0.5	<3	5	1.53%	qtz stwk, minor diss. py, veins 20-40cm wide
M 11	91DEL9-17	386024	6335900	<5	0.6	4	26	185	51	3	<3	16	6.62%	clay altered granite
M 12	91DEL9-17-1	395087	6335753	<5	0.6	22	18	119	23	5	<3	13	5.66%	clay altered granite
M 13	91DEL9-16	395087	6335753	<5	0.6	70	12	183	73	11	7	110	6.31%	clay altered granite
M 14	91JDR20-2	394901	6335690	100	<0.5	8	4	12	0.11%	4	<3	4	1.26%	qtz veins w/ 1-2mm wide aspy selvages
M 15	91JDR8-10	380604	6335589	<5	1	16	22	69	31	1	8	11	5.93%	carb veining, diss. py, + hem-alteration
M 16	91JLO14-195	399199	6334942	<5	1.4	33	30	132	13	1	4	3	2.22%	qtz-carb alteration zone, diss. py
M 17	91JDR15-2	385614	6334846	<5	0.5	137	10	43	9	1	<3	11	4.69%	qtz-carb veining, common diss. py
M 18	91JLO20-275	408877	6334836	1660	1.2	84	20	32	155	2	<3	9	5.14%	qtz-carb-py veinlets in argillic alt. brcc zone
M 19	91JLO3-21	381326	6334489	40	1	65	36	38	81	5	30	13	5.21%	grab pyritic limy tuff
M 20	91JDR3-13	403510	6332690	1120	4	0.95%	22	85	10	2	4	14	4.69%	fracture-controlled diss.+ blebby py+cpy+ml
M 21	91DEL28-1	401326	6332624	120	1.2	30	56	97	845	3	4	23	9.82%	py veining along foliation
M 22	91DEL15-7	379037	6332060	15	1.0	50	35	73	110	5	3	9	10.96%	diss. py + cp, abundant hem
M 23	91JLO3-27	406696	6331589	30	5	127	84	68	136	12	5	18	9.21%	pyritic feldspar porphyry, 1-2 % py
M 23	91JLO3-27DUP	403436	6331563	60	6	124	88	69	120	12	5	17	9.10%	pyritic feldspar porphyry, 1-2 % py
M 24	91DEL14-16	403436	6331563	<5	0.6	14	4	75	9	3	4	13	2.35%	hem altered boulder
M 25	91JLO3-28	391971	6331470	<5	1	550	28	45	17	1	47	12	3.80%	pyritic feldspar porphyry, 1-2 % py
M 26	91JLO36-443-2	403255	6331409	-	<0.5	11	7	108	-	-	<3	6	6.22%	pyritic syenite porphyry, 2 % finely diss py
M 27	91JLO11-144	408236	6331293	<5	<0.5	5	8	10	2	0.5	<3	<2	1.43%	sil. brcc. rhyolite, with 2% specular hem
M 28	91JLO2-7	390779	6329904	<5	8	420	426	158	112	5	49	3	0.60%	qtz vein stwk, trace py + ml
M 29	91JDR19-9	398750	6329403	<5	<0.5	7	9	4	6	2	<3	<2	0.53%	diss. py + hm in flow-layered rhyolite
M 30	91DEL23-2-2	389562	6328361	<5	1.8	900	464	236	7	3	<3	<2	1.01%	qtz-hem altered tuff w/ minor ml+cpy
M 31	91JLO19-271-2	397674	6327132	<5	0.8	0.17%	12	80	22	2	<3	10	4.80%	sheared chloritic volcs, with trace diss py + cpy

APPENDIX 10 CONTINUED
LITHOGEOCHEMICAL ANALYSES
FORREST KERR CREEK AND ISKUT RIVER MAP AREAS
(104B/15 AND PART OF 104B/10)

Map Number	Sample Number	UTM EAST	ZN 09 NORTH	Au (ppb)	Ag (ppm)	Cu (ppm)*	Pb (ppm)*	Zn (ppm)*	As (ppm)*	Sb (ppm)	Mo (ppm)*	Ni (ppm)*	Fe (ppm)*	SAMPLE DESCRIPTION
M 32	JLO29-395-2	393137	6325948	380	10	193	38	18	750	5	11	3	13.70%	qtz vein, py to 7% as bleb + fract-fillings
M 33	91JDR23-4	395710	6324852	<5	0.5	16	6	31	5	2	<3	6	4.97%	altered breccia w/ specular hem veinlets
M 34	91JLO32-409	380564	6323004	<5	1.6	65	22	62	11	5	<3	16	5.17%	oxidized pyritic schistose tuff
M 35	91DEL17-8	382467	6322518	<5	0.8	126	13	107	20	2	3	10	6.14%	iron-carb alt along joints
M 36	91JLO23-320	393065	6322510	<5	0.5	7	6	5	2	2	8	4	1.66%	hem + manganese gossan zone in grnt
M 37	JLO23-320-2	393064	6322507	<5	0.5	4	4	14	2	<0.5	8	3	1.70%	sericite-qtz-py filled fract, grnt
M 38	91DEL17-5-3	382417	6322062	35	2.8	610	102	125	60	4	13	10	14.34%	pyritic qtz vein
M 39	JLO23-328-2	391752	6321354	<5	<0.5	129	6	13	3	1	<3	13	2.08%	narrow qtz veinlets, 1-2% coarse py + aspy
M 40	91JDR35-2-3	401007	6321146	<5	<0.5	4	6	14	1	<0.5	<3	29	0.73%	silicified siltstone
M 41	91JDR17-14	383708	6320783	<5	0.6	2	5	52	7	<0.5	<3	<2	2.73%	sil. tuff w/ <0.5% diss. py ; fine qtz vein stwk
M 42	JLO27-371-2	388592	6319817	<5	0.6	133	14	39	11	3	<3	<2	12.80%	grab, magnetite-epidote-diopside skarn
M 43	91JDR27-3	400011	6318466	75	18	0.44%	276	0.44%	600	6	<3	<2	4.00%	grab of qtz+cpy+sph veins; ml+az stained

MESS LAKE MAP AREA (104G/07W)

Map Number	Sample Number	UTM EAST	ZN 09 NORTH	Au (ppb)	Ag (ppm)	Cu (ppm)*	Pb (ppm)*	Zn (ppm)*	As (ppm)*	Sb (ppm)	Mo (ppm)*	Ni (ppm)*	Fe (ppm)*	SAMPLE DESCRIPTION
ML 1	92JLO20-212	385609	6371200	<5	3	0.66%	18	43	1	0.90%	5	6	1.87%	silicified fracture zone with disseminated cpy+py+tt
ML 2	92JLO24-242-2	387457	6369996	<5	37	0.17%	262	260	31	450	5	4	2.67%	ml stained qtz veining in augite-phyric basalt
ML 3	92JLO24-242-3	387457	6369996	<5	5	450	7	40	3	0.60%	5	<2	0.98%	ep+carb altered basalt with traces of disseminated py
ML 4	92JDR9-1	387017	6365700	<5	5	1.17%	9	14	4	1	5	<2	5.24%	tuff hosted ml stained ep+carb veins with cpy
ML 5	92JDR11-5	382198	6358005	<5	19	3.69%	11	59	20	0.70%	5	51	4.56%	ml stained fractures in andesite flows
ML 6	92JDR11-2	382083	6357548	10	20	4.02%	15	100	7	0.60%	5	17	5.22%	tuff hosted ml+az stained carb veins with tt+cpy
ML 7	92JLO15-178	383254	6357310	<5	<0.4	45	16	130	23	3	5	6	3.85%	disseminated py+hem and ep veins in felsic intrusion
ML 8	92JLO3-48	387236	6351717	155	165	1.07%	17	0.18%	0.10%	0.66%	9	20	8.19%	ml stained tt veinlets with disseminated py
ML 9	92JLO1-9	385767	6350573	<5	0.3	27	8	31	5	2	5	3	5.66%	qtz stwk with disseminated specular hem

* values in ppm or percent where indicated

Abbreviations:
qtz= quartz, carb= carbonate, py= pyrite, cpy= chalcopyrite, sph= sphalerite, po= pyrrhotite, mgnt= magnetite, ml= malachite,
az= azurite, aspy= arsenopyrite, gl= galena, stwk= stockwork, alt= alteration, brcc= breccia, dort= diorite, bsl=basalt, andt= andesite
lmst= limestone, sil= silicification, hem= hematite, ser= sericite, tt= tetrahedrite

Analytical Procedures:

Sample Preparation:

Samples are pulverized to approximately 200 mesh using tungsten carbide equipment.

Trace Element Analysis: Ag, Cu, Pb, Zn, As, Sb

Samples (usually 0.5 grams) are digested in Teflon beakers using a mixed acid attack which includes HF. A dilute dissolution of the residue is then diluted to a specific volume and the elements measured using atomic absorption spectroscopy. As and Sb were determined by atomic absorption using a hydride evolution method wherein the hydride (AsH_3 or SbH_3) is evolved, passed through a heated quartz tube in the light path of an atomic absorption spectrometer. Background corrections were made for Pb, As and Sb.

Trace Element Analysis: Au

A 20 gram sample is concentrated into a silver bead by the classical fire assay method. The bead is dissolved by aqua regia and gold determined by graphite furnace atomic absorption spectroscopy.

APPENDIX 11
POTASSIUM-ARGON ANALYTICAL DATA AND DATES FROM MORE CREEK AND FORREST KERR MAP AREAS

Sample No.	Unit	UTM Easting	Zone 09 Northing	RockType	Mineral	% K	^{40}Ar 10-10 mole/g	^{40}Ar*	Apparent Age (Ma)
91JDR10-15	Qb	394950	6344900	Basalt	WRx	1.53±0.04	0.0118	16.8	0.45±0.07
91JDR33-4-1	LDum	390300	6338350	Hornblendite	Hbl	0.555±0.003	3.034	84.9	291±10
91JDR9-4	LDd	392450	6337650	Diorite	Hbl	0.188	1.18	81	330±9
89JLO9-3-2	mJHb	403074	6300953	Basalt	WRx	0.419±0.007	0.772	68.7	103±3
89VKO29-2-3	DMSvb	382650	6292500	Basalt	WRx	0.374±0.001	1.532	84.2	222±7
89-JDR6-3	LDg	391250	6300750	Tonalite	Bi	5.73±0.04	37.521	97.8	343±12
							37.956	95.2	346±10
89JLO24-7-2	u>Sva	386200	6303700	Andesite	WRx	0.793±0.017	1.774	86	125±5
81-HRC4**	VEIN	381000	6335750	Quartz vein	Ms				192±7
89VKO28-15	EJg	392850	6288200	Monzogranite	Hbl	0.794±0.002	2.963	82.4	203±7
AT-86-137-1***	EJg	392500	6288000	Monzogranite	Hbl	0.781±.005	5.4	60.54	189±3

* radiogenic argon
**sample from Holbek (1989), ***sample from Anderson and Bevier (1990).
Abbreviations: WRx = whole rock, Hbl = hornblende, Bi = biotite, Ms = muscovite.
Constants: l 40Ke = 0.581 x 10-10 yr-1; l 40Kb = 4.96 x 10-10 yr-1; 40K/K = 1.167 x 10-4
% K determined by the Analytical Labratory, British Columbia Ministry of Energy, Mines, and Petroleum Resources, Victoria.
Ar analysis and age calculation by J.E. Harakal and D. Runkle, The University of British Columbia.

APPENDIX 12
U-PB ZIRCON DATE FOR A SAMPLE FROM SCHAFT CREEK

The Schaft Creek porphyry molybdenum deposit is hosted by upper Triassic volcanic rocks adjacent to the eastern contact of the coeval Hickman pluton. The Jurassic Yehiniko pluton cuts the sequence. The sample from Schaft Creek submitted for U-Pb geochronometry is an equigranular, medium-grained to rarely porphyritic argillic altered quartz monzonite porphyry which is spatially and temporally related to the mineralization. It is veined by quartz and locally mineralized by chalcopyrite +/- molybdenum. The sample was collected from the 504 – 557 ft interval of D. D. Hole T-169.

Nine zircon fractions have been analysed. The data are presented in Table 1, and the analyses have been plotted on a concordia diagram in Figure 1. The zircons are clear and pale pink, but contain many fluid inclusions. The best available crystals were chosen for each picked fraction. Two morphologies are present; long, doubly terminated prisms with aspect ratios of 1:3-4, and nearly equant multifaceted tabular crystals with aspect ratios of 1:1.5-2. Fractions A, C, D, G, and I are long crystals, and E, H, J, and K are equant crystals.

Four of the fractions (A, C, D, I) plot on or near concordia but not overlapping each other, and four (E, G, H, K) have a component of inherited old zircon Fraction J plots very close to concordia at a much younger age than that indicated by the other fractions, suggesting that those zircons have lost a significant amount of lead. The cause of this lead loss is not apparent, though tabular crystals are notoriously hard to abrade properly. A damaged surface layer might have remained on the crystals. Because of the possibility that there has been both lead loss and incorporation of inherited old lead in the various fractions, the $^{206}Pb/^{238}U$ ages are more reliable than the $^{207}Pb/^{206}Pb$ ages. The best estimate of the age of the rock is given by the median of the range of $^{206}Pb/^{238}U$ ages of the younger three of the four fractions that overlap concordia between 214 and 221 Ma. The errors are defined by the range. Fraction A has not been included because there is a strong possibility that the zircons contain old zircon. The date obtained for the rock is therefore 216.6 $\pm$ 2 Ma.

U-Pb Geochronology: Analytical Techniques and Data Interpretation

Zircon and titanite were separated from ~25 kg samples using conventional crushing, grinding, and Wilfley table techniques, followed by final concentration using heavy liquids and magnetic separations. Mineral fractions for analysis were selected based on grain morphology, quality, size and magnetic susceptibility. All zircon fractions were abraded prior to dissolution to minimize the effects of post-crystallization Pb-loss, using the technique of Krogh (1982). All geochemical separations and mass spectrometry were done in the Geochronology Laboratory at The University of British Columbia. Samples were dissolved in concentrated HF and HNO_3 in the presence of a mixed $^{233-235}U$-^{205}Pb tracer. Separation and purification of Pb and U employed ion exchange column techniques modified slightly from those described by Parrish *et al.* (1987). Pb and U were eluted separately and loaded together on a single Re filament using a phosphoric acid-silica gel emitter. Isotopic ratios were measured using a modified single collector VG-54R thermal ionization mass spectrometer equipped with a Daly photomultiplier. Most measurements were done in peak-switching mode on the Daly detector. U and Pb analytical blanks were in the range of 1-3 pg and 7-15 pg, respectively, during the course of this study. The compositions are listed below Table 1. U fractionation was determined directly on individual runs using the $^{233-235}U$ tracer, and Pb isotopic ratios were corrected for a fractionation of 0.12%/amu and 0.43%/amu for Faraday and Daly runs, respectively, based on replicate analyses of the NBS-981 Pb standard and the values recommended by Todt *et al.* (1984). All analytical errors were numerically propagated through the entire age calculation using the technique of Roddick (1987). Analytical data are reported in Table 1. Concordia intercept ages and associated errors were calculated using a modified version of the York-II regression model (wherein the York-II errors are multiplied by the MSWD) and the algorithm of Ludwig (1980). All errors are quoted at the 2σ level. Age assignments follow the time scale of Harland *et al.* (1990).

APPENDIX 12 CONTINUED
U-PB ZIRCON DATE FOR A SAMPLE FROM SCHAFT CREEK

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TABLE 1
U-PB ZIRCON DATA

Fraction:[1,2]	wt mg	U^3 ppm	Pb^3 ppm	^{208}Pb %4	Pb pg	^{206}Pb/^{204}Pb5	Isotopic Ratios (±%1s) ^{206}Pb/^{238}U	^{207}Pb/^{235}U	^{207}Pb/^{206}Pb	Isotopic Dates (Ma,±2s) ^{206}Pb/^{238}U	^{207}Pb/^{235}U	^{207}Pb/^{206}Pb
Schaft Creek Quartz Monzonite Porphyry												
a N2, +a na	0.384	157	5	10.2	94	1358	0.03474 (.14)	0.2426 (.30)	0.05065 (.26)	220.1±0.6	220.5±1.2	225±12
c M2,-a+b	0.174	212	7	10.6	180	446	0.03435 (.11)	0.2394 (0.75)	0.05056 (.70)	217.7±0.5	218.0±2.9	221±33
d M2,-b+c	0.129	310	11	12	178	483	0.03402 (.14)	0.2376 (.73)	0.05065 (.68)	215.6±0.6	216.4±2.9	225±32
e N2,-a+b	0.042	733	25	10.1	28	2285	0.03422 (.07)	0.2433 (.16)	0.05155 (.13)	216.9±0.3	221.1±0.6	265.5±5.9
g N2, +a	0.372	146	5	9.8	21	5602	0.03488 (.08)	0.2446 (.10)	0.05085 (.05)	221.0±0.4	222.2±0.4	234.1±2.3
h M2,-a+b	0.113	193	7	10.1	17	2687	0.03448 (.13)	0.2426 (.18)	0.05103 (.12)	218.6±0.5	220.6±0.7	242.0±5.4
i N2,-b+c	0.08	188	6	10.9	12	2552	0.03386 (.11)	0.2356 (.23)	0.05047 (.15)	214.6±0.5	214.5±1.0	216.5±7
j N2,-b+c e	0.042	257	8	10.7	15	1352	0.03080 (.08)	0.2131 (.27)	0.05019 (.25)	195.5±0.3	196.1±1.0	204±11
k N2,-b+c	0.009	274	10	11.9	8	703	0.03699 (.17)	0.2964 (.44)	0.05812 (.36)	234.4±0.8	263.6±2.0	534.5±16

Notes: Analyses by J.E. Gabites, 1989 - 95, in the geochronology laboratory, Department of Geological Sciences, U.B.C.
IUGS conventional decay constants (Steiger and Jäger, 1977) are: ^{238}U: λ=1.55125x10^{-10}a^{-1}, ^{235}U: λ=9.8485x10^{-10}a^{-1}, ^{238}U/^{235}U=137.88 atom ratio.

1. Column one gives the label used in the Figure.
2. Zircon fractions are labeled according to magnetic susceptibility and size. NM = non-magnetic at given amperes on magnetic separator, M = magnetic.
   Side slope is given in degrees. The - indicates zircons are smaller than, + larger than the stated mesh (μm), e = equant crystals. All fractions are air abraded except where labeled na. Size fractions are: a 134, b 74, c 44μm. Magnetic fractions : N2 = NM2a/0.5° ,M2 = M2a/0.5°, M1.5 = M1.5a/3°
3. U and Pb concentrations in mineral are corrected for blank U and Pb. Isotopic composition of Pb blank is 206:207:208:204 = 17.299:15.22:35.673:1.00, based on ongoing analyses of total procedural blanks of 37 ±1 pg (Pb) and 6 ± 0.5 pg (U) during the time of this study. 1995 values are
   206:207:208:204 = 17.6:15.22:34.62:1.00, 10 ±1 pg (Pb) and 3 ± 0.5 pg (U).
4. Total common lead in analysis.
5. Initial common Pb is assumed to be Stacey and Kramers (1975) model Pb at the ^{207}Pb/^{206}Pb age for each fraction.

APPENDIX 12 CONTINUED
U-PB ZIRCON DATE FOR A SAMPLE FROM SCHAFT CREEK

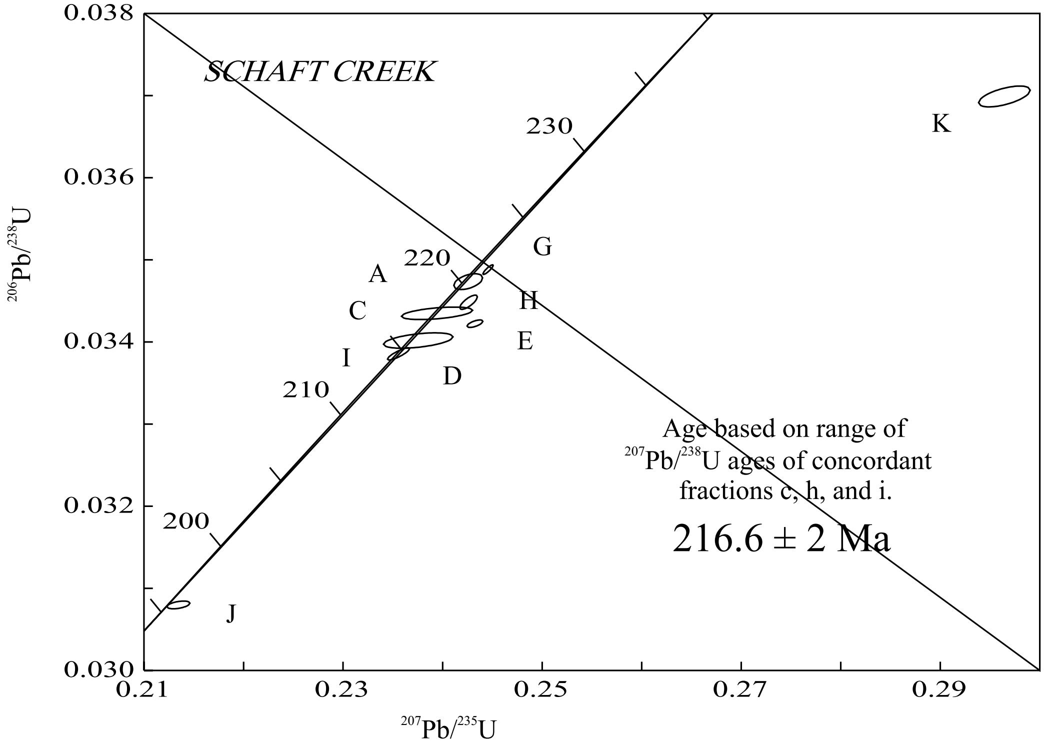

Figure 1.

APPENDIX 13
U-Pb AGE DATA FOR SAMPLES OF THE STIKINE ASSEMBLAGE AND STUHINI GROUP

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U-Pb zircon data and age interpretations are presented below for three samples of Paleozoic intrusions within the Stikine Assemblage and four samples from volcanic sections within Paleozoic Stikine Assemblage and Triassic Stuhini Group (Table 1, Fig. 1). The samples were collected during regional field studies conducted by McClelland, R.G. Anderson, Geological Survey of Canada, and J.M. Logan, Geological Survey Branch, British Columbia Ministry of Energy and Mines. All samples were analyzed at the University of California, Santa Barbara. Analytical procedures for conventional and partial dissolution analyses are described in McClelland and Mattinson (1996).

Each of the samples produced discordant zircon results that define lines with lower concordia intercepts of approximately 90-100 Ma. There was no indication in any of the samples of inherited components within the zircon fractions analyzed. The observed discordance is attributed Pb-loss during a regional mid-Cretaceous thermal or hydrothermal event.

Age interpretations

A. Stikine Assemblage intermediate tuff; Lime Lake (91-238).

Analyses from six fractions consisting of clear euhedral zircons with aspect ratios of 1:1:3-5 define a chord with upper and lower intercepts of 380 ± 5 Ma and 97 ± 16 Ma, respectively. A crystallization age of 380 ± 5 Ma is interpreted for this unit.

B. Stikine Assemblage dacite, More glacier (91-203).

Five discordant analyses from fractions of clear, euhedral zircons with aspect ratios of 1:1:3-5 define a define a chord with upper and lower intercepts of 355.1 ± 3.7 Ma and 120 ± 39 Ma, respectively. A crystallization age of 355.1 ± 3.7 Ma is interpreted for this unit.

C. Forrest Kerr granite (91-246).

A sample collected from a granitic phase in the interior of the Forrest Kerr intrusive complex yielded a population of euhedral clear to red and white opaque zircon with aspect ratios of 1:1:3-4. Analysis of six fractions of clear, inclusion free grains produced discordant analyses that fit a line with upper and lower intercepts of 369.4 ± 5.1 Ma and 95 ± 20 Ma, respectively. An emplacement age of 369.4 ± 5.1 Ma is interpreted for granite within the interior of the Forrest Kerr intrusive complex.

D. Forrest Kerr granite (91-226).

A sample collected from the granitic marginal phase of the Forrest Kerr intrusive complex where it intrudes the volcanic sequence dated by sample A yielded euhedral, white to red opaque zircons with aspect ratios of 1:1:2-3. Six analyses are highly discordant and define a line with upper and lower intercepts of 370.7 ± 6.7 Ma and 90 ± 19 Ma, respectively. The higher degree of Pb-loss relative to that observed for sample C is consistent with the relatively high U concentrations determined for this sample. An emplacement age of 370.7 ± 6.7 Ma is interpreted for margin granite phase of the Forrest Kerr intrusive complex.

E. More Creek granite (91-305).

Analyses from five fractions of clear to cloudy euhedral zircons with aspect ratios of 1:1:2-4 are discordant and fit a chord with upper and lower intercepts of 356.9 + 4.3/- 3.8 and 104 ± 22 Ma, respectively. An emplacement age of 356.9 + 4.3/- 3.8 Ma is interpreted for granitic phase of the More Creek intrusive complex.

F. Stikine Assemblage rhyolite; Mess Creek (92JLO266).

Three fractions of euhedral clear zircons with aspect ratios of 1:1:3 and abundant dark inclusions yielded discordant to concordant conventional analyses. The observed $^{206}Pb/^{204}Pb$ ratios are relatively low due to common Pb most likely derived from the unavoidable presence of inclusions. A three-step partial dissolution experiment effectively removed the effects of Pb-loss and high common Pb and produced a concordant residue. A crystallization age of 311.7 ± 2.0 is interpreted for this sample based on the concordant residue age.

G. Stuhini Group rhyolite; Newmont graben (92JLO270).

Discordant results from five fractions of clear euhedral zircons with aspect ratios of 1:1:3-5 define a chord with upper and lower intercepts of 212.8 + 4.2/- 3.5 Ma and 87 ± 12 Ma, respectively. A crystallization age of 212.8 + 4.2/- 3.5 Ma is interpreted for this unit.

APPENDIX 13 CONTINUED
U-Pb AGE DATA FOR SAMPLES OF THE STIKINE ASSEMBLAGE AND STUHINI GROUP

Acknowledgments

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TABLE 1
U-Pb ISOTOPIC DATA AND APPARENT AGES

	Fraction-Size[a] (µm)	Wt (mg)	Concentration[b]		Isotopic Composition[c]			Apparent Ages (Ma)[d]		
			U	Pb*	$^{206}Pb/^{204}Pb$	$^{206}Pb/^{207}Pb$	$^{206}Pb/^{208}Pb$	$^{206}Pb^*/^{238}U$	$^{207}Pb^*/^{235}U$	$^{207}Pb^*/^{206}Pb^*$
Sample A: Stikine Assemblage intermediate tuff; Lime Lake; 91-238										
a	30-63	0.1	619	30.9	1,349 ± 4	15.524	5.084	298.6 ± 0.6	304.9 ± 0.8	353 ± 4
b	63-350	0.01	469	20.7	862 ± 1	14.224	5.511	271.7 ± 0.8	279.6 ± 0.9	347 ± 4
c	63-350	0.02	524	25.8	1,033 ± 3	14.776	5.279	298.9 ± 0.9	305.1 ± 1.2	353 ± 5
d	63-350A	0.04	183	10.7	287 ± 0	9.526	3.706	354.9 ± 1.1	357.6 ± 2.5	375 ± 14
e	63-350A	0.1	142	7.6	5,414 ± 30	17.693	5.752	320.3 ± 0.6	325.7 ± 0.7	364 ± 1
f	63-350A	0.05	210	11.4	2,309 ± 8	16.623	5.452	325.1 ± 1	330 ± 1.2	365 ± 4
Sample B: Stikine Assemblage dacite; More glacier; 91-203										
a	30-63	0.2	351	18.3	7,689 ± 16	18.089	8.913	327.9 ± 0.7	330 ± 0.7	345 ± 2
b	63-100	0.2	303	16.1	3,859 ± 4	17.459	9.198	337.3 ± 0.7	338.8 ± 0.7	350 ± 1
c	63-350	0.2	504	26	2,420 ± 5	16.829	8.42	325.6 ± 0.7	328 ± 0.7	345 ± 2
d	120-350A	0.2	326	17.3	5,812 ± 11	17.86	9.902	338.2 ± 0.7	339.6 ± 0.7	349 ± 1
e	63-350A	0.2	353	19	3,175 ± 5	17.205	9.451	341.8 ± 0.7	343 ± 0.7	351 ± 2
Sample C: Forrest Kerr granite – interior; 91-246										
a	30-45	0.3	751	37.9	3,887 ± 52	17.442	8.66	318.2 ± 0.6	322.5 ± 0.7	353 ± 2
b	45-80	1.1	602	26.6	7,424 ± 56	18.01	9.779	308.4 ± 0.6	313.7 ± 0.7	353 ± 2
c	45-80	0.7	930	44.6	7,596 ± 12	18.039	9.373	303.7 ± 0.6	309.1 ± 0.6	351 ± 1
d	80-100A	0.3	580	29.4	1,504 ± 2	15.77	8.381	322.7 ± 0.6	327.1 ± 0.8	358 ± 3
e	80-350A	0.1	370	16.2	2,416 ± 11	16.759	8.592	317.5 ± 1	322.2 ± 1	356 ± 2
f	80-350A	0.1	505	23.2	3,805 ± 33	17.37	8.949	334.2 ± 1	337.5 ± 1.1	360 ± 2

APPENDIX 13 CONTINUED
U-Pb AGE DATA FOR SAMPLES OF THE STIKINE ASSEMBLAGE AND STUHINI GROUP

	Fraction-Size[a] (µm)	Wt (mg)	Concentration[b]		Isotopic Composition[c]				Apparent Ages (Ma)[d]					
			U	Pb*	$^{206}Pb/^{204}Pb$		$^{206}Pb/^{207}Pb$	$^{206}Pb/^{208}Pb$	$^{206}Pb^{*}/^{238}U$		$^{207}Pb^{*}/^{235}U$		$^{207}Pb^{*}/^{206}Pb^{*}$	
Sample D: Forrest Kerr granite – margin; 91-226														
a	45-63	0.1	2,094	119.0	3,130 ±	6	17.179	3.088	304.1 ±	1	309.7 ±	0.7	192 ±	2
b	45-63	0.1	8,039	434.6	2,118 ±	2	16.544	3.54	299.6 ±	1	305.6 ±	0.7	192 ±	2
c	80-100	0.7	5,137	278.1	1,935 ±	4	16.373	3.258	295 ±	1	301.3 ±	1.0	192 ±	2
d	100-350A	1	3,275	169.8	930 ±	1	14.46	3.078	282.9 ±	1	289.9 ±	1.1	192 ±	2
e	100-350	0.9	7,104	364.1	1,517 ±	3	15.885	3.069	276.7 ±	1	283.8 ±	0.9	192 ±	2
f	100-350A	0.3	2,983	157.6	1,685 ±	2	16.126	2.888	280.5 ±	1	287.2 ±	0.9	192 ±	2
Sample E: More Creek granite; 91-305														
a	63-80	1.4	266	13.1	19,911 ±	37	18.486	11.91	316.1 ±	1	319.4 ±	0.6	344 ±	1
b	100-125	0.3	168	8.5	8,431 ±	21	18.123	11.41	323.1 ±	1	326.2 ±	0.7	348 ±	1
c	100-125	0.4	277	14.1	7,451 ±	15	18.053	10.33	323.4 ±	1	326.3 ±	0.7	347 ±	1
d	100-125A	0.1	250	13	4,150 ±	17	17.549	10.24	333.5 ±	1	335.4 ±	0.7	349 ±	2
e	100-350A	0.1	273	14.6	1,529 ±	4	15.98	2.725	279.7 ±	1	285.1 ±	0.7	330 ±	3
Sample F: Stikine Assemblage rhyolite; Mess Creek; 92JLO-266														
a	63-100A	0.7	77	3.8	503 ±	0.4	12.245	5.188	304.4 ±	1	304.9 ±	1.3	309 ±	9
b	100-125A	0.2	75	3.5	248 ±	0.2	8.958	3.66	285.5 ±	1	288.1 ±	2.4	309 ±	18
c	100-350A	0.3	119	5.4	346 ±	0.2	10.559	3.939	271.6 ±	1	275.1 ±	1.8	304 ±	13
Partial dissolution	%U													
L1		14%	10	0.3	48 ±	0.1	2.822	1.12	199.6 ±	0	206.6 ±	13	287 ±	137
L2		18%	13	0.6	744 ±	2	13.886	5.042	289.3 ±	1	290.6 ±	1.0	301 ±	6
R		68%	50	2.5	5,555 ±	11	18.102	8.525	311.7 ±	1	311.7 ±	0.7	312 ±	2
T	45-63	0.6	121	5.7	307 ±	0.7	9.972	4.16	292.3 ±	1	294.1 ±	2.2	308 ±	16
Sample G: Stuhini Group rhyolite; Newmont graben; 92JLO-270														
a	30-63	0.6	1,480	39.4	2,916 ±	8	18.193	7.728	168.7 ±	0	170.2 ±	0.4	192 ±	2
b	30-63	0.1	1,413	39.8	2,261 ±	4	17.696	7.135	177.4 ±	0	178.6 ±	0.4	196 ±	2
c	63-100	0.3	1,530	43.1	5,795 ±	29	19.018	8.612	179.7 ±	0	181 ±	0.4	197 ±	2
d	80-100A	0.1	895	27.4	11,276 ±	133	19.406	9.472	196.1 ±	0	196.9 ±	0.4	206 ±	2
e	100-350A	0.2	454	13.1	840 ±	1	14.777	7.211	185.5 ±	0	186.9 ±	0.6	204 ±	6

[a] a, b, etc. designate conventional multigrain fractions; A designates fractions abraded to 30 to 60% of original diameter. L1, L2 designate leachate steps; R designates digestion of final residue; T designates mathematically recombined steps and residue. Dissolution schedule for sample F: 1= 3 hours at 80ºC; 2 = 24 hours at 120ºC; R = 30 hours at 245ºC. Zircon fractions are non-magnetic on Frantz magnetic separator at 1.8 amps, 15° forward slope, and side slope of 5°.

[b] Pb* is radiogenic Pb. Pb and U are expressed as ppm for conventional analyses and mathematically recombined partial dissolution totals. For partial dissolution steps, Pb and U are expressed as nanograms and % of total U.

[c] Reported ratios corrected for fractionation (0.125 ± 0.038%/AMU) and spike Pb. Ratios used in age calculation were adjusted for 4 to 10 pg of blank Pb with isotopic composition of $^{206}Pb/^{204}Pb$ = 18.6, $^{207}Pb/^{204}Pb$ = 15.5, and $^{208}Pb/^{204}Pb$ = 38.4, 2 pg of blank U, 0.25 ± 0.049%/AMU fractionation for UO_2, and initial common Pb with isotopic composition approximated from Stacey and Kramers (1975) with an assigned uncertainty of 0.1 to initial $^{207}Pb/^{204}Pb$ ratio.

[d] Uncertainties reported as 2 sigma. Error assignment for individual analyses follows Mattinson (1987) and is consistent with Ludwig (1991). An uncertainty of 0.2% is assigned to the $^{206}Pb/^{238}U$ ratio based on our estimated reproducibility unless this value is exceeded by analytical uncertainties. Calculated uncertainty in the $^{207}Pb/^{206}Pb$ ratio incorporates uncertainty due to measured $^{204}Pb/^{206}Pb$ and $^{207}Pb/^{206}Pb$ ratios, initial $^{207}Pb/^{204}Pb$ ratio, and composition and amount of blank. Linear regression of discordant data utilized Ludwig (1992). Decay constants used: ^{238}U = 1.5513 E-10, ^{235}U = 9.8485 E-10. $^{238}U/^{235}U$ = 137.88.

APPENDIX 13 CONTINUED
U-Pb AGE DATA FOR SAMPLES OF THE STIKINE ASSEMBLAGE AND STUHINI GROUP

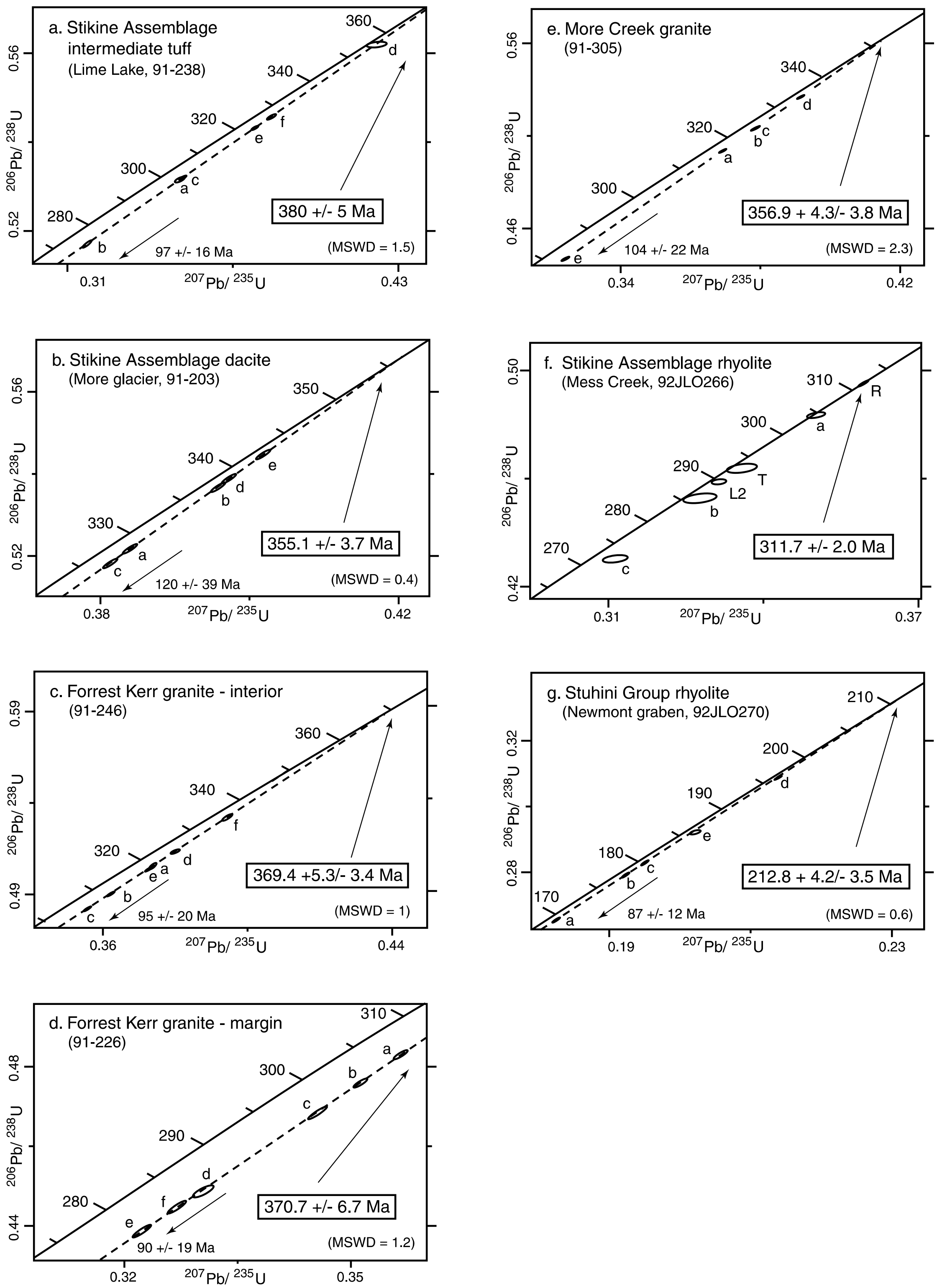


Figure 1. U-Pb concordia plots of zircon data from intrusive and volcanic rocks from the Paleozoic Stikine Assemblage and Triassic Stuhini Group.

APPENDIX 14
RUBIDIUM AND STRONTIUM ANALYTICAL DATA

Sample No.	Rock Description	Sr (ppm)	Rb (ppm)	Rb/Sr	$^{87}Rb/^{86}Sr$ measured	$^{87}Sr/^{86}S$ rmeasured	$^{87}Sr/^{86}Sr$ initial
91JDR 9-4	hornblende diorite	301	6.36	0.021	0.061	0.70467± 0.00008	0.70435± 0.00008
91JLO 31-1	hornblende diorite	340	14.9	0.044	0.127	0.70496± 0.00005	0.70429± 0.00005
91JLO 31-2	biotite granite	251	23.2	0.092	0.266	0.70533± 0.00003	0.70393± 0.00009
91JLO 37-451	foliated granite	329	18.3	0.056	0.162	0.70466± 0.00003	0.70381± 0.00007

Notes: Analytical procedures are described below. Measured ratios (with 2 sigma errors). Initial $^{87}Sr/^{86}Sr$ based on U-Pb zircon age of 370±3 Ma. Sr analyses and Rb/Sr analyses by D. Runkle (1992).

Analytical Procedures:

Rb and Sr concentrations were determined by replicate analysis of pressed powder pellets using X-ray fluorescence. U.S. Geological Survey rock standards were used for calibration; mass absorption coefficients were obtained from Mo K-alpha Compton scattering measurements. Rb/Sr ratios have a precision of 2% (1 sigma) and concentrations a precision of 5% (1 sigma). Sr isotopic composition was measured on unspiked samples prepared using standard ion exchange techniques. A modified V.G. Isomass 54R mass spectrometer with digitized and automatic data acquisition was used. A value of 0.1194 for $^{86}Sr/^{88}Sr$ was used for normalization and the ratios were adjusted so that the mean $^{87}Sr/^{86}Sr$ of NBS = 0.71019±2 (1 sigma). The precision of a single $^{87}Sr/^{86}Sr$ ratio is better than 0.00013 (one sigma). Rb-Sr dates are based on a decay constant of 1.42 x 10-11/yr. The regressions are calculated according to York (1969).

British Columbia
Ministry of Energy and Mines
Minerals Division
Geological Survey Branch

Geological Survey Branch

FIGURE GM97-3

To Accompany Bulletin 104

(Updated from Geoscience Map 1997-3)

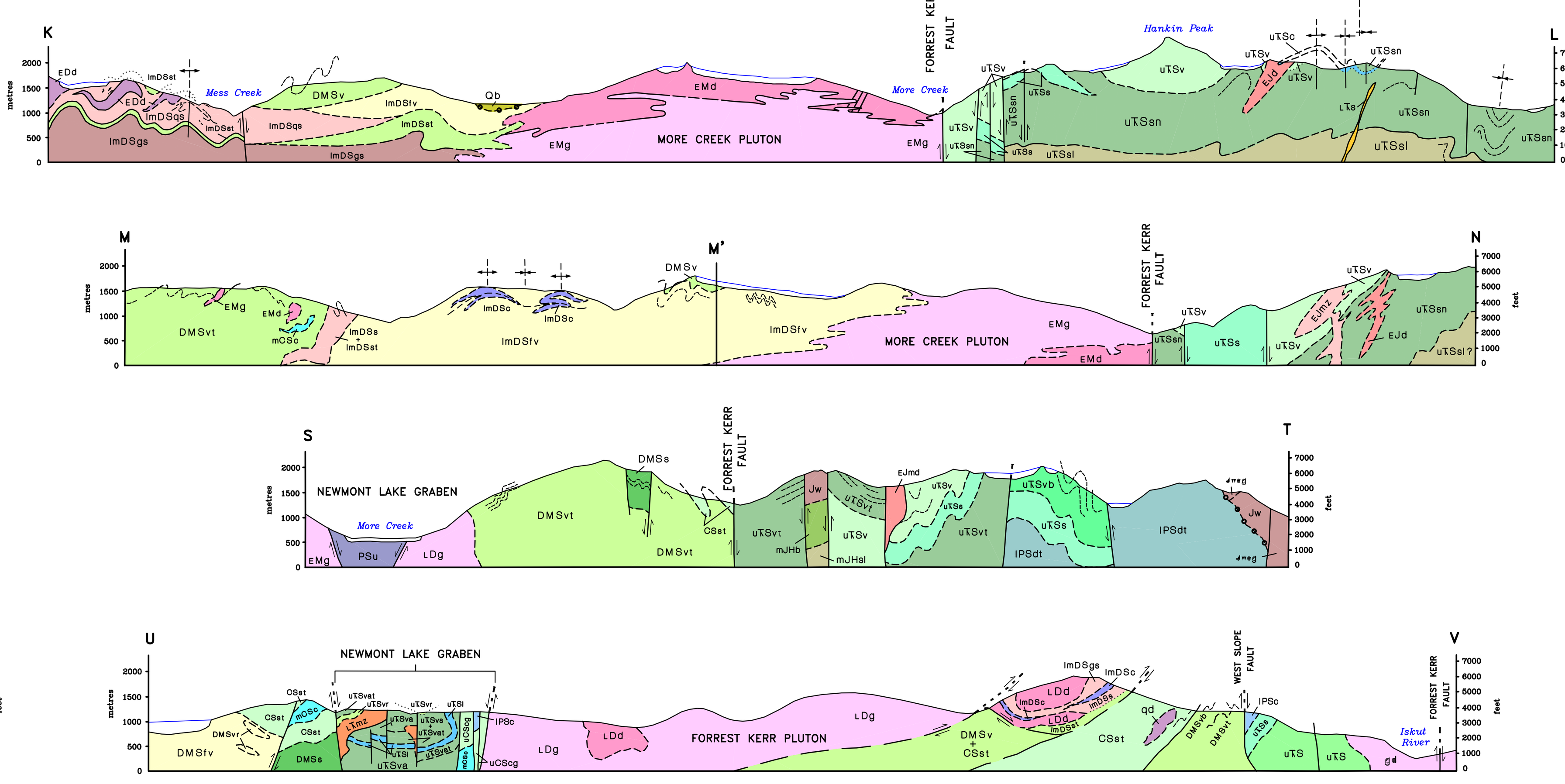
GEOLOGY OF THE FORREST KERR-MESS CREEK AREA, NORTHWESTERN BRITISH COLUMBIA

NTS (104B/10, 15 & 104G/2 & 7W)

Compiled by: J.M. Logan

Geology by: J.M. Logan, J.R. Drobe, V.M. Koyanagi and D.C. Elsby

SCALE 1:100 000



LEGEND

LAYERED ROCKS

QUATERNARY
- Qt — *Active hotspring, calcareous tufa deposits*

BIG RAVEN FORMATION
- Qob — Nahta Cone: *Plagioclase-olivine phyric basalt, pyroclastic cone, tephra and lava flows*
- Qal — *Unconsolidated glacial till and poorly sorted alluvium*

PLEISTOCENE
ARCTIC LAKE FORMATION
- Qb — *Olivine-plagioclase-augite basalt, subaerial lava flows, pyroclastic breccia and lenses of alluvium*

TERTIARY- PLIOCENE
SPECTRUM FORMATION
- TSr — Exhile Hill Vent: *Leucocratic peralkaline rhyolite and dark grey trachyte flows and subvolcanic intrusions*

NIDO FORMATION (KOUNUGU MEMBER)
- TNb — *Dark grey, aphyric and microporhyritic olivine basalt, subaerial flows, flow breccia and intercalated fluvial gravel*

UPPER CRETACEOUS TO PALEOCENE
SUSTUT GROUP
- uKSs — *Chert-pebble conglomerate, quartzose sandstone, siltstone and carbonaceous shale, coaly layers and carbonaceous plant fragments*

MIDDLE TO UPPER JURASSIC
BOWSER LAKE GROUP
ASHMAN FORMATION
- JBp — *Greywacke, planar-bedded shale and minor crossbedded sandstone, local chert-pebble conglomerate and granule conglomerate lenses*

LOWER TO MIDDLE JURASSIC
HAZELTON GROUP
- JHu — *Undifferentiated volcanic and associated sedimentary rocks*

SALMON RIVER FORMATION
- Jw — *Brecciated and fractured dark green and grey siliceous siltstone*
- Jwcg — *Polylithic conglomerate containing sedimentary, intermediate and felsic volcanic and subvolcanic clasts*
- mJHsl — *Dark grey to black, thin bedded carbonaceous siltstone and fine, rusty-brown bioclastic sandstone, minor intermediate to felsic crystal tuff*
- mJHb — *Pillow basalt, breccia and tuff, interbedded white and grey, thin-laminated siliceous siltstone and tuff*

LOWER JURASSIC
UNUK RIVER - BETTY CREEK - MOUNT DILLWORTH FORMATIONS
- lJHv — *Purple, maroon and green, plagioclase and augite phyric andesite, lapilli tuff, crystal tuff and pillowed lava flows*
- lJHr — *Felsic welded-ash tuff, rhyolite lava and ashflow tuff*
- lJHsn — *Tan-weathering sandstone, plagioclase crystal tuff, peperite flows, siltstone, carbonaceous plant fragments common*
- lJHsl — *Black, graphitic siltstone, stratiform diagenetic pyrite to several percent*
- lJcg — *Maroon-weathering, polylithic cobble to boulder conglomerate and coarse sandstone, well bedded, poorly-graded and quartz-rich, contains granitoid, volcanic and sedimentary clasts of Stikine assemblage and Stuhini Group strata*

UPPER TRIASSIC
STUHINI GROUP
- u>S — *Undifferentiated volcanic and arc-derived sedimentary rocks*

NEWMONT LAKE GRABEN
- u>Svr — *Felsic and intermediate lapilli and plagioclase crystal tuff and pink flow-layered rhyolite*
- u>Svs — *Intermediate volcanic conglomerate, sandstone and minor thin bedded siliceous limestone lenses*
- u>Sl — *Algal limestone, laminated, dark grey to black*
- u>Sva — *Maroon hornblende-plagioclase porphyritic andesite breccia flows*
- u>Svat — *Maroon lapilli and plagioclase crystal tuff and epiclastic rocks*

MESS LAKE VOLCANIC FACIES
- u>Spp — *Maroon and dark green pyroxene porphyritic, plagioclase porphyritic and aphyric-basalt flows and fragmental rocks*
- u>Svt — *Massive to weakly stratified, grey and mauve lapilli and crystal tuff*
- u>Svb — *Dark grey, massive plagioclase porphyritic basalt flows and coarse-bladed plagioclase and pyroxene porphyry dikes*
- u>Smt — *Dun-weathering mafic olivine lapilli tuff, includes some serpentinized peridotite*

MORE CREEK SEDIMENTARY FACIES
- u>Sv — *Medium bedded, pale green tuff and epiclastic rocks, orange-weathering augite phyric and aphyric basalt flows and sills*
- u>Ss — *Thick bedded augite-bearing volcaniclastic sandstone, interbeds of sharpstone conglomerate*
- u>Sc — *Limestone, grey to black, sparse crinoid fragments, minor argillaceous limestone and silty shale*
- u>Ssn — *Khaki, well bedded feldspathic sandstone, limestone-bearing conglomerate and thin bedded siltstone*
- u>Ssl — *Massive, thin laminated black and brown calcareous siltstone, interbedded with fine grained orange sandstone*

MIDDLE TRIASSIC
- m>s — *Black, thin bedded carbonaceous and pyritic silty shale, grey sandstone and siliceous siltstone*

STIKINE ASSEMBLAGE
- $Su — *Undifferentiated Paleozoic foliated volcanic and associated sedimentary rock*

LOWER PERMIAN
- lPSc — *Medium bedded to massive fossiliferous carbonate; deformed, thin layered carbonate of probable Permian age (lPSdc)*
- lPSdt — *Deformed, interlayered intermediate siliceous tuff and sedimentary rocks*

CARBONIFEROUS
- CSst — *Grey to light green phyllitic siltstone, graphitic argillite, siliceous phyllite/tuff and thin lenses of dark brown limestone*

UPPER CARBONIFEROUS
- uCSc — *Grey, thin bedded, fetid and dolomitic limestone, minor interbeds of maroon and green tuff and cherty siltstone*
- uCSr — *Pink flow-layered and spherulitic rhyolite, sparsely feldspar porphyritic lava and quartz feldspar-phyric flow breccia*
- uCSmv — *Maroon andesitic feldspar-phyric lapilli and crystal tuff, includes unwelded to weakly welded ash-flow tuff beds*
- uCSb — *Massive amygdaloidal, aphyric to plagioclase and pyroxene-phyric basalt and breccia flows*
- uCScg — *Thick bedded, maroon volcanic conglomerate, clasts are augite and plagioclase-phyric mafic and intermediate volcanic and subvolcanic rocks and limestone, poorly sorted with tuff interbeds*
- uCSss — *Thin bedded, siltstone, poorly bedded tuff, tuffaceous wacke and sandstone, lesser chert*

MID CARBONIFEROUS (SERPUKHOVIAN - BASHKIRIAN)
- mCSc — *Grey, medium bedded to massive bioclastic limestone, locally with buff, silty dolomitic layers*

UPPER DEVONIAN AND LOWER CARBONIFEROUS (MISSISSIPPIAN)
- DMSs — *Undifferentiated foliated sedimentary rocks*
- DMSv — *Undifferentiated basalt and andesite, hyaloclastite, pillowed and flow breccia rocks*
- DMSvb — *Massive to weakly foliated, dark green amygdaloidal basalt and related hyaloclastite, pillowed flows (p) and scoriaceous tephra*
- DMSvr — *Pale pink, quartz-eye rhyolite and aphyric to weakly porphyritic rhyodacite flows and flow breccias, includes orange-weathering, pyritic plagioclase porphyritic subvolcanic bodies*
- DMSfv — *Pale grey and green, intermediate to felsic, fine tuff, aphyric-dacite flows and volcaniclastic rocks*
- DMSvt — *Pale to dark green, well bedded siliceous dust and ash tuff, scoriaceous mafic tuff and minor pyritic felsic welded tuff*

LOWER AND MIDDLE DEVONIAN
- lmDSfv — *Green and grey intermediate to felsic plagioclase crystal tuff, breccia and flow rocks*
- lmDSc — *Deformed grey and buff thin layered to massive coralline marble and limestone*
- lmDSs — *Pale green and grey thin bedded siltstone, sandstone and cherty tuff*
- lmDSst — *Bright green chlorite and red-purple schistose tuff and minor basalt flows, interbedded dust tuff and thin layered recrystallized limestone*
- lmDSqs — *White and pale green quartz sericite schist, well foliated and tightly crenulated*
- lmDSgs — *Graphitic schist, black siliceous phyllite and chert*

INTRUSIVE ROCKS

TERTIARY AND OLDER DIKES
- sy — *Aphyric andesite and basalt, (a); mafic plagioclase ± pyroxene porphyry, (pp); lamprophyre, (l); felsic, (f); porphyritic syenite, (sy); basalt, (b)*

MIDDLE JURASSIC
THREE SISTERS PLUTONIC SUITE (179 - 176 Ma)
- MJmz — Yehiniko Pluton: *Pink, medium to coarse-grained, equigranular hornblende-biotite monzonite to granite*
- MJdi — *Dark green, medium-grained seriate-textured diorite, pyroxene gabbro*

EARLY JURASSIC AND YOUNGER
- EJd — *Medium-grained equigranular augite-plagioclase diorite and gabbro*

EARLY JURASSIC
TEXAS CREEK PLUTONIC SUITE (195 - 189 Ma)
- EJmz — *Equigranular, pink, medium grained monzonite, grading to syenite at base*
- EJg — *Hornblende-biotite potassium feldspar megacrystic monzogranite and syenite*

LATE TRIASSIC TO EARLY JURASSIC
COPPER MOUNTAIN PLUTONIC SUITE (210 - 200 Ma)
- L>s — *Grey and pink, hornblende biotite syenite, orthoclase porphyry with large zoned phenocrysts*
- L>mz — Loon Lake Stock: *Salmon-orange, crowded plagioclase-pyroxene monzonite porphyry, trachytic and equigranular phases*; Newmont Lake plugs: *Fine-grained and potassium feldspar porphyritic monzonite, granodiorite*

MIDDLE TO LATE TRIASSIC
STIKINE PLUTONIC SUITE (228 - 221 Ma)
- L>Hd — Hickman Pluton: *Medium to fine-grained, equigranular hornblende diorite, hornblende monzonite*
- L>pd — *Medium-grained equigranular augite diorite and gabbro*
- L>pp — *Pale green, stubby-plagioclase porphyritic hornblende-pyroxene diorite*

EARLY MISSISSIPPIAN
MORE CREEK PLUTONIC SUITE (~ 355 Ma)
- EMg — *Equigranular to quartz-porphyritic biotite granite*
- EMd — *Coarse to medium-grained, hornblende diorite, hornblende quartz monzonite*

LATE DEVONIAN
FORREST KERR PLUTONIC SUITE (~ 370 Ma)
- LDg — *Medium to coarse-grained pink, biotite granite, monzonite and tonalite*
- LDd — *Heterogeneous, medium-grained hornblende diorite, quartz diorite mainly equigranular, gneissic in places*
- LDum — *Coarse-grained gabbro, hornblendite, clinopyroxenite*

DEVONIAN
- EDd — *Foliated to equigranular, green pyroxene quartz diorite, locally chlorite schist*

AGE UNKNOWN
- qd — *Pink, equigranular biotite granite, monzonite, monzodiorite*
- gd — *Aphanitic altered, granitoid rocks west of Forrest Kerr Creek and small isolated granodiorite plugs*

SYMBOLS

- Geological boundary (defined, approximate, assumed)
- Unconformity (defined, assumed)
- Bedding; tops unknown (inclined, vertical) — 58
- Bedding; tops observed (inclined, overturned) — 50, 79
- Igneous flow layering (inclined, vertical) — 75
- Dominant foliation (inclined, vertical) — 45
- Foliation; generation indicated by number of ticks — 60
- Lineation; bedding-cleavage intersection, m=mineral, s=stretching, ss=slickensides — 26, 26
- Crenulation lineation; ages indicated by number of ticks (plunge indicated) — 20
- Joint (inclined, vertical) — 84
- Dike (inclined, vertical) — 70
- Vein (inclined, vertical) — 58
- Axial trace of overturned antiform, synform (arrow indicates plunge)
- Axial trace of upright antiform, synform (arrow indicates plunge)
- Fold axis of minor fold (arrow indicates plunge) m, s and z asymmetry — 20
- Brittle fault zone (inclined, vertical) — 75
- Extension fault; downthrown side indicated (defined, approximate, assumed)
- Contraction fault; teeth indicate upthrust side (defined, approximate, assumed)
- Cross-section line — O P
- Limit of mapped area
- Fossil locality (macrofossil, conodont, foraminifera, radiolarian) — Ⓕ Ⓒ ⓕ Ⓡ
- Isotopic age locality (U/Pb, Ar/Ar, K/Ar, Rb/Sr) — Ⓩ Ar Ⓚ Sr
- MINFILE occurrence; developed prospect, prospect, showing, number — 104G378
- Surface work; adit, trench
- Topographic contour (200 metre interval) — 1200
- Cart track

Fossil Identifications:

Mike J. Orchard, E. Wayne Bamber, Tim E. Tozer and Terry P. Poulton of the Geological Survey of Canada; Bernard L. Mamet of the University of Montreal and Fabrice Cordey.

Age Determinations:

Uranium-lead geochronology by Bill C. McClelland at University of California, Santa Barbara; potassium-argon determinations by Joe Harakal at The University of British Columbia; argon-argon dating by Peter Reynolds at Dalhousie University.

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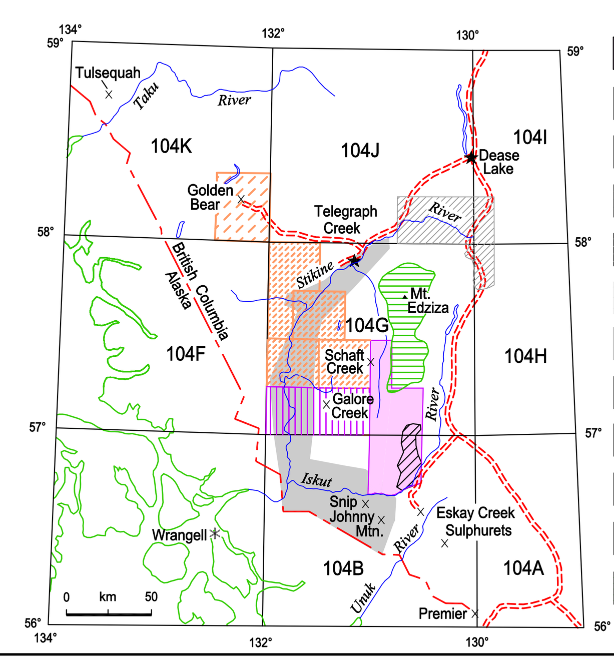
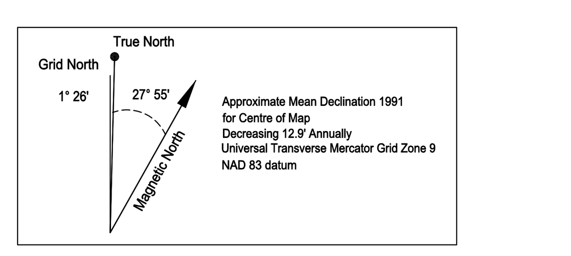


- GEOSCIENCE MAP 1997-3 see also (Open File Maps 1990-2, 1992-5, 1993-6)
- Logan and Koyanagi (1989, 1994)
- Bradford and Brown (1993)
- Stikine Project - Geoscience Maps 1993-3 to 1993-6
- Read (1983, 1984)
- Read et al. (1989)
- 104J — Gabrielse (1980)
- Kerr (1948)
- 104K — Souther (1971)
- 104G — Souther (1972)
- 104F — Souther (1959)
- Souther (1992)
- Mine or Developed prospect



Approximate Mean Declination 1991
for Centre of Map
Decreasing 12.9' Annually
Universal Transverse Mercator Grid Zone 9
NAD 83 datum

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This map can be viewed over the internet through the website:
http://www.em.gov.bc.ca/mining/geolsurv/bedrock/mapsonline/

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