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By N.W.D. Massey, P.Geo.

PAPER 1992-3

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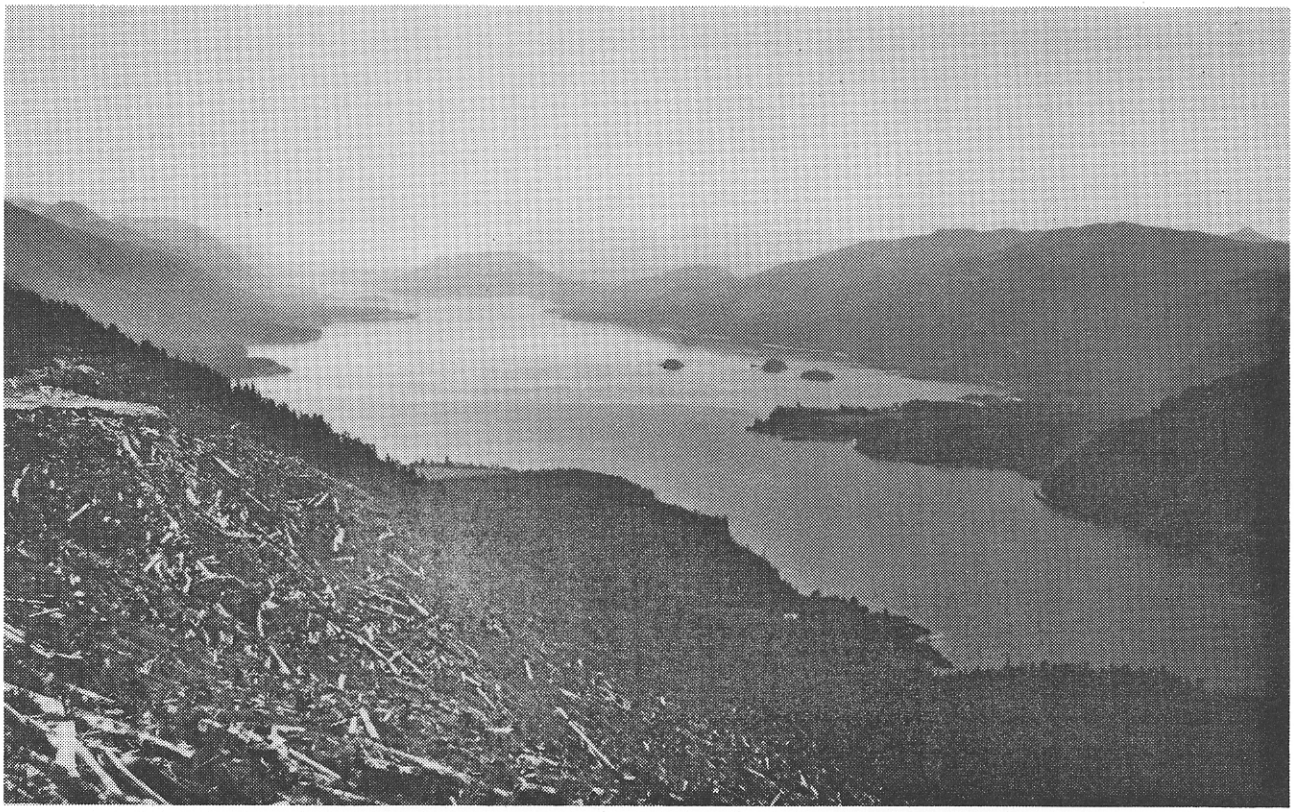
*Field work for this project was carried out during the period of 1986 through 1989.*



Frontispiece: View east-southeast down Cowichan Lake from the Little Shaw Creek area. The steep scarp face on the north shore marks the trace of the Cowichan fault separating the Paleozoic Sicker Group to the north from the Mesozoic volcanics and sediments to the south. Upper Cretaceous Nanaimo Group sediments are typically found in the footwall of this and other Eocene contractional faults.

# SUMMARY


The Cowichan Lake map area is centred on the north-northwest trending Cowichan Lake, 27 kilometres west of Duncan, on Vancouver Island. The area lies at the southeastern end of the Vancouver Island Ranges and is characterized by fairly rugged topography with fault-line scarps and fault-controlled valleys, accentuated by glaciation. The area is divided into two regions of differing structural style by a major thrust fault running along the north side of Cowichan Lake. The northern region is underlain by Paleozoic rocks forming the southwest limb of the Cowichan uplift, one of a series of major geanti-clinal structures constituting the structural fabric of the Wrangellia terrane of Vancouver Island. South of Cowichan Lake, Mesozoic sequences form a syncline-anticline pair that parallels the Cowichan uplift and plunges to the northwest.

The oldest rocks in the Cowichan Lake area belong to the Paleozoic Sicker and Buttle Lake groups which contain volcanic and sedimentary units ranging from Middle Devonian to Lower Permian age. The Devonian Sicker Group is a thick package of lower greenschist facies, metavolcanic and volcaniclastic rocks that formed in an oceanic island-arc environment. The lowest unit is the Duck Lake Formation which, in the Alberni - Nanaimo Lakes, area comprises a suite of grey to maroon and green pillowed basalts and basaltic breccias with chert, jasper and cherty tuff interbeds near the top of the sequence. This unit has not been positively identified in the Cowichan Lake area, although a narrow band of green-grey pillowed basalt, about 1 kilometre southwest of Heather Lake, is tentatively assigned to the Duck Lake Formation.

Overlying the Duck Lake Formation is the Nitinat Formation, characterized by pyroxene-feldspar-porphyritic basalts and basaltic andesites. These typically occur as agglomerates, breccias, lapilli tuffs and crystal tuffs that formed as pyroclastic flows, debris flows and lahars. Pyroxene-phyric, amygdaloidal, pillowed and massive flows are also developed.

South of the Chemainus River fault in the Cowichan Lake map area, the Nitinat Formation is overlain by a sequence of interbedded volcaniclastic sediments and pyroclastic rocks of the McLaughlin Ridge Formation. A variety of lithologies are developed including thickly bedded, massive tuffite and lithic tuffite; interbedded, laminated sandstones, siltstones and argillites; heterolithic volcanic breccias and lapilli tuffs, commonly mafic to intermediate in composition; and feldspar crystal tuffs and lapilli tuffs. The sequence probably formed in the transition between the proximal volcanic-dominated facies and distal volcaniclastic apron facies around a volcanic island. North of the Chemainus River fault, the mafic to felsic volcanics of the proximal volcanic facies dominate the McLaughlin Ridge Formation. The volcanics are predominantly intermediate pyroclastics, commonly feldspar crystal-lapilli tuffs, heterolithic lapilli tuffs and breccias and minor pyroxene-phyric lapilli tuffs. Felsic crystal and dust-tuffs interfinger with andesitic lapilli tuffs and breccias at the eastern edge of the map. The felsic rocks appear to be stratigraphically high within the formation.

A distinctive maroon, schistose heterolithic breccia and lapilli tuff with minor jasper is the uppermost unit and is overlain conformably by thinly bedded cherty sediments of the Fourth Lake Formation of the Buttle Lake Group. A suite of greenstone dikes, informally called the "older dikes", intrudes the felsic volcanics and maroon breccia. The age of these dikes is unknown, but may be contemporaneous with minor volcanics in the lower Fourth Lake Formation. The Nitinat and McLaughlin Ridge formations form a coherent suite of medium-potassium calcalkaline chemistry typical of island arcs. In contrast, the older dikes are high iron-titanium tholeiites with an affinity to transitional or enriched ocean-floor basalts.

The Buttle Lake Group is made up of a dominantly epiclastic and bioclastic limestone sedimentary sequence ranging from Mississippian to Early Permian in age. Within the Cowichan Lake area, the Buttle Lake Group is either in fault contact with, or rests unconformably on the Sicker Group. The Fourth Lake Formation comprises mostly thin-bedded, often cherty sediments. South of the Chemainus River, the base of the formation is marked by a sequence of radiolarian ribbon cherts and cherty siltstones 100 to 200 metres thick, informally called the Shaw Creek member. This passes upwards into monotonous thinly bedded, sometimes cherty, turbiditic sandstone-siltstone-argillite intercalations. Thicker beds of sandstone, granule sandstone, breccia and conglomerate are exposed to the south of the Chemainus River. The ribbon cherts of the Shaw Creek member are absent north of the river, where thinly bedded turbiditic clastic sediments conformably overlie the McLaughlin Ridge volcanics and dominate the sequence. Minor volcanism was synchronous with early Fourth Lake Formation sedimentation in the Mount Whymper - Rheinhart Creek area. This "Mount Whymper suite" consists of aphyric amygdaloidal basalt flows, interbedded with cherts and cherty sedi-

ments and olive-green, amygdaloidal, aphyric dacitic flows interbedded with maroon and green chert, jasper, magnetite-jasper and cherty sediments. The basalts are undersaturated and enriched in both compatible and incompatible trace elements, with a within-plate petrotectonic affinity.

The Mount Mark Formation conformably overlies the Fourth Lake Formation, although outcrops of the formation are not common in the Cowichan Lake area. It consists of well bedded bioclastic calcarenite with porcellaneous micrite and tuffaceous limestone interbeds and thinly bedded black cherts.

Rocks of the Upper Triassic Vancouver Group outcrop both north and south of Cowichan Lake. They form the core of the Seymour Range anticline in the south and Karmutsen Formation basalts unconformably overlie the Paleozoic sequences north of Cowichan Lake. The group is subdivided into a thick lower basaltic volcanic package (Karmutsen Formation) and a thin upper sedimentary package (Quatsino and Parson Bay formations). The lower Karmutsen Formation basalts rest unconformably on the underlying Paleozoic rocks. The basalts form pillowed flows, pillow breccias and hyaloclastite breccias interbedded with massive flows and sills. There is a tendency for the massive flows to dominate the sequence towards the top and the pillowed flows in the lower parts. Lithologically the flows are dark grey, variably feldsparphyric basalts. Glomeroporphyritic flows and hyaloclastite breccia are commonly seen at the top of the pile. The Karmutsen basalts show amygdule infillings and alteration assemblages typical of the prehnite-pumpellyite facies. The mafic bodies of the Mount Hall gabbro, intrusive into the Paleozoic rocks, are coeval and consanguineous with the Karmutsen basalts. The basalts formed from an iron-titanium enriched tholeiitic magma, similar to continental tholeiite or enriched mid-ocean ridge basalt, probably in an oceanic flood-basalt province.

The Quatsino Formation is characterized by massive, thickly bedded, black micritic limestone, essentially unfossiliferous, though bioclastic micrite, oolitic limestone, calcirudite and calcarenite may occur locally. The formation is conformably overlain by thinly bedded sediments and tuffs, provisionally correlated with the Parson Bay Formation. This sequence comprises tuff and tuffaceous sandstone overlain by flaggy limestones and black limy argillites, which grade vertically into thinly bedded argillites with minor fossiliferous limestone interbeds. Flaggy, sandy limestone and biohermal limestone ascribed to the Sutton limestone member of the Parson Bay Formation outcrop on the south shore of Cowichan Lake.

The Bonanza Group overlies the Vancouver Group sediments with a slight angular unconformity, only readily detectable from the regional distribution of rock units. The unconformity cuts down section and may result in the thinning or elimination of the Parson Bay Formation. The bulk of the Bonanza Group consists of maroon to green-grey, feldspar-phyric basalt and andesite flows, lapilli and crystal tuffs, feldspar-hornblende andesite flows, dacite and felsic lapilli tuff, and various minor basalt, andesite and dacite dikes. Tuffaceous and epiclastic sediments are found interbedded with lapilli and crystal tuffs, within the basal part of the sequence. The Bonanza Group evolved in a convergent-margin setting as an arc on the Paleozoic and Triassic transitional crust.

All of the Paleozoic and Triassic sequences have been intruded by granodioritic stocks of the Early to Middle Jurassic Island Plutonic Suite. Stocks north of Cowichan Lake have an elongate outcrop pattern, often with different stratigraphic units on either side, as with the Mount Buttle - Meade Creek stock. Stocks intruded into the Mesozoic sequences to the south of Cowichan Lake are more rounded in outcrop shape. The intrusions are dominantly equigranular quartz diorite to granodiorite but show considerable lithological variation. Most of the large intrusive bodies are rich in mafic inclusions, especially in marginal agmatitic intrusive breccias. Contact metamorphic aureoles are developed around the intrusions, causing hornfelsing and skarning in Paleozoic rocks. A variety of dikes and small irregular intrusions, that are probably coeval with the Island Plutonic Suite, occur throughout the area. Lithologically they include intermediate feldspar porphyry, feldspar pyroxene porphyry, hornblende feldspar porphyry and minor diabase. The Jurassic intrusions are coeval with the Bonanza volcanics and form a metaluminous, medium to high-potassium calcalkaline suite typical of a convergent-margin environment.

Clastic sediments of the Upper Cretaceous Nanaimo Group lie unconformably on the older rocks. They outcrop mainly around the shores of Cowichan Lake, but are also preserved in fault-controlled valleys to the north of the lake. The lower Benson Formation comprises basal cobble and boulder conglomerates and overlying medium to coarse-grained sandstones. These are succeeded by the black argillites and siltsones of the Haslam Formation. Younger formations of the Nanaimo Group are absent.

Southern Vancouver Island has a complex structural history with frequent rejuvenation of pre-existing structures. All Paleozoic rocks are affected by a series of southeast-trending, upright to overturned, southwest-verging folds. Penetrative axial planar foliation is absent throughout most of the area, except to the west of Mount Whymper and north of the Chemainus River fault, where foliation (schistosity in volcanics and cleavage in sediments) is well developed, trending north-northwest with generally steep northeasterly dips. Lineations plunge gently, up to 15, and may be to the west-northwest or east-southeast. Regional-scale warping of Vancouver Island occurred during the Early to Middle Jurassic, facilitating the emplacement of the Island Plutonic Suite intrusions and producing the geanticlinal Cowichan uplift. North of Cowichan Lake, the present map pattern is dominated by the northwestly trending contractional faults of the Tertiary Cowichan fold and thrust system. These are high-angle reverse faults which become listric at mid-crustal levels. They generally place older rocks over younger. A footwall syncline is developed in the thicker Nanaimo Group section beneath the Cowichan fault at the east end of Cowichan Lake. The deformation probably took place during the crustal shortening accompanying the formation and emplacement of the Pacific Rim and Crescent terranes outboard of Wrangellia.

The Cowichan Lake area has had a somewhat intermittent history of mineral exploration since about 1900. Production has been limited to small quantities of copper from the Blue Grouse mine and manganese and rhodonite from Hill 60. The localization of metal deposits in the area is controlled by the interplay of stratigraphy and spatial association with later intrusions and structures. Three major metallogenic epochs are recognised. Syngenetic mineralization occurred during the building of the Sicker arc. Oxide facies exhalites, such as the "900 zone" of the Mineral Creek area, are found in the uppermost Duck Lake Formation in the adjacent Alberni - Nanaimo Lakes area. Sulphide facies equivalents are also found, though less commonly. Thin syngenetic manganese oxide beds and sulphidic argillites occur within the radiolarian cherts of the basal Fourth Lake Formation in the upper Shaw Creek area.

The Early to Middle Jurassic arc was characterized by epigenetic mineralization of various types and styles, spatially related to the Island Plutonic Suite intrusions. Copper-molybdenum veins and stockworks occur within intrusions and volcanic country rocks. Rhodonite forms by contact metamorphism of manganiferous chert. Iron-copper-gold skarns are developed in calcareous tuffs and limestones of the Karmutsen and Quatsino formations, though are rare in Mount Mark lithologies.

Mesothermal gold-bearing quartz-carbonate veins are located along Tertiary structures and have been one of the main exploration targets in the area.

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# INTRODUCTION

A 4-year program of 1:50 000-scale regional mapping was initiated by the British Columbia Geological Survey Branch on southern Vancouver Island in 1986, under the Canada - British Columbia Mineral Development Agreement. The program was planned to cover three 1:50 000 NTS sheets centred on the Paleozoic rocks that occur in the core of the Cowichan uplift (Figure 1). These units are the host to several types of mineral deposits including polymetallic Kuroko-style massive sulphides, for example, the Mount Sicker camp, and mesothermal gold-bearing quartz-carbonate veins, for example, the Mineral Creek zone. Preliminary results of mapping have been described by Massey and Friday (1987, 1988, 1989) and released as Open File maps (Massey *et al.*, 1987, 1988, 1989).

## LOCATION AND ACCESS

The Cowichan Lake map area is located 25 to 30 kilometres west of Duncan, centred on the north-northwest-trending Cowichan Lake. The area lies at the southeastern end of the Vancouver Island Ranges (Holland, 1976) and is characterized by moderately rugged topography with steep slopes. Fault-line scarps and fault-controlled valleys are common throughout the area, with slopes steepened further by glaciation. Elevations rise from 159 metres on the surface of Cowichan Lake to over 1250 metres on many of the peaks north of the lake. Mount Whymper is the highest point in the area, at 1541 metres, followed closely by Mount Landale, 1537 metres, and Mount Service, 1490 metres. Elevations are somewhat lower to the south of the lake, though Towincut Mountain reaches 1249 metres and Mount Sutton 1170 metres.

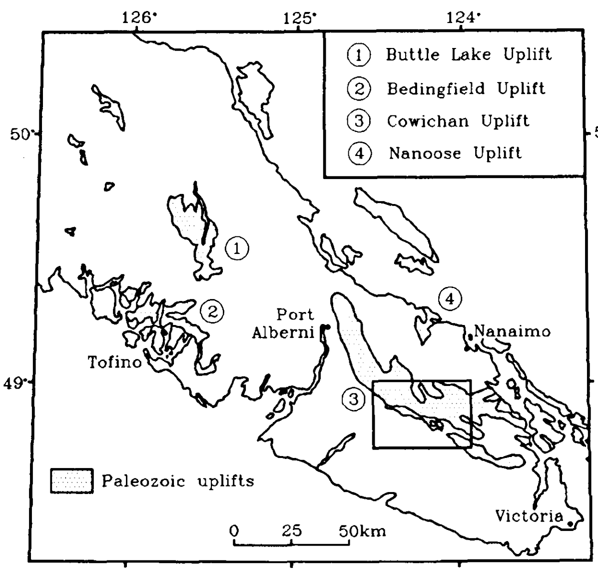


Figure 1. Location of the Sicker Project area, southern Vancouver Island. The four major uplifts cored by Paleozoic rocks are indicated. The Cowichan Lake map area is outlined.

The principal communities in the area are Lake Cowichan, Youbou, Mesachie Lake and Honeymoon Bay. A main highway connects Youbou and Lake Cowichan to Duncan and a good all-weather gravel road encircles Cowichan Lake, continuing westwards through Franklin Camp to Port Alberni. An extensive network of logging roads, in varying states of maintenance, provides access throughout most of the area. These roads generally radiate outwards from Cowichan Lake, although the Chemainus River and Haslam Creek areas in the northeast of the map area are accessed from the Island Highway, near Chemainus and Ladysmith respectively.

Rock outcrops are numerous in roadcuts along the logging roads, and are plentiful in creek beds and on hillsides, although the latter may be under thick forest cover.

## REGIONAL SETTING

The Cowichan Lake area lies on the southern flank of the Cowichan uplift, one of a series of major geanti-clinal structures constituting the structural fabric of Vancouver Island (Figure 1). It lies within the Wrangellia terrane, which on Vancouver Island comprises three thick volcano-sedimentary cycles - the Paleozoic Sicker and Buttle Lake Groups, the Upper Triassic Vancouver Group and the Lower Jurassic Bonanza Group. These are overlapped by Upper Cretaceous sediments of the Nanaimo Group. The area is involved in the Tertiary Cowichan fold and thrust system (England and Calon, 1991).

## PREVIOUS WORK

The first major examination of the rocks of the area was undertaken by Clapp as part of a reconnaissance of southern Vancouver Island (Clapp, 1912). He undertook more detailed mapping to the east (Clapp, 1913, 1914; Clapp and Cooke, 1917) but no further work was carried out in the Cowichan Lake area. Fyles (1955) reported on detailed mapping in the northern part of the map area and described several of the important mineral showings. Limestone deposits of the area were briefly described by Mathews and McCammon (1957) and the Permian Mount Mark Formation was studied in detail by Yole (1964). Muller and colleagues mapped large portions of

Vancouver Island including the Cowichan Lake area (Muller, 1982). Geological and geophysical studies were undertaken by the Geological Survey of Canada in support of the LITHOPROBE 1 Project to the west and southeast of the map area (Sutherland Brown and Yorath, 1986; Sutherland Brown *et al.*, 1985: Yorath, in preparation). Biostratigraphic and radiometric dating of the rocks of southern Vancouver Island, including the map area, have been summarized by Muller and Jeletzky (1970), Brandon *et al.*, (1986) and Armstrong *et al.*, (1986). Regional geochemical data have been released by Matysek *et al.* (1990), and mineral occurrences are described in the B.C. Ministry of Energy, Mines and Petroleum Resources mineral inventory database (MINFILE, 1990).

## ACKNOWLEDGMENTS

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# LITHOLOGY AND STRATIGRAPHY

The oldest rocks in the Cowichan Lake area belong to the Paleozoic Sicker and Buttle Lake Groups (Figure 2), which contain volcanic and sedimentary units ranging from Middle Devonian to Early Permian age. These are intruded by mafic sills of the Mount Hall gabbro, and overlain unconformably by basaltic volcanics of the Upper Triassic Karmutsen Formation. Succeeding limestones, argillites and tuffaceous sediments of the Quatsino and Parson Bay formations (which with the Karmutsen Formation make up the Vancouver Group) are conformably to disconformably overlain by marine sediments and marine to subaerial volcanics of the Lower Jurassic Bonanza Group. All of these sequences have been intruded by granodioritic stocks of the Early to Middle Jurassic Island Plutonic Suite. Upper Cretaceous sediments of the Nanaimo Group lie unconformably on the older sequences.

There have been several attempts to formally subdivide the Paleozoic rocks of Vancouver Island. Clapp (Clapp, 1912: Clapp and Cooke, 1917) first mapped these rocks in the Duncan area, naming them the "Mount Sicker Series". However, he incorrectly interpreted them as younger than the Triassic Karmutsen Formation (Vancouver Series). Later workers in the Buttle Lake and Cowichan Lake areas recognized them as indeed Paleozoic in age and referred to them as the Sicker Group (Gunning, 1931: Fyles, 1955; Yole 1964, 1969). In the first major synthesis of data on the Paleozoic rocks of Vancouver Island, Muller (1980) continued the use of the term "Sicker Group" and proposed four subdivisions which, in ascending stratigraphic order, are the Nitinat Formation, the Myra Formation, an informal sediment-sill unit and the Buttle Lake Formation. Recent paleontological and radiochronological studies (Brandon *et al.*, 1986), coupled with newer mapping (Sutherland Brown *et al.*, 1986; Sutherland Brown and Yorath, 1985), have thrown some doubt on these subdivisions and their applicability in the Cowichan uplift. Revised stratigraphic subdivisions have been proposed by Sutherland Brown (*in* Yorath, in preparation) based on work in the Alberni area, and a similar revision has also been made independently by Juras (1987) in the Buttle Lake uplift. The major contribution of these studies has been the formal recognition that the Paleozoic rocks can be separated into an older volcanic-dominated sequence of Devonian age, renamed the Sicker Group *sensu stricto*, and a younger Mississippian to Permian sedimentary sequence renamed the Buttle Lake Group (Figure 3). The revised stratigraphic nomenclature of Sutherland Brown, with some revision by Massey and Friday (1989), has proven to be applicable and useful throughout the entire Cowichan uplift and has been adopted for this project. However, the previously proposed name of "Cameron River Formation" for the lower unit in the Buttle Lake Group (Massey *et al.*, 1987, 1988, 1989; Massey and Friday, 1988, 1989) has been abandoned and the term "Fourth Lake Formation" introduced to avoid conflict with an already extant Cameron River Formation elsewhere in Canada.

## SICKER GROUP

The Sicker Group is a thick package of volcanic and volcaniclastic rocks that forms the exposed basement on Vancouver Island. Biostratigraphic age control is lacking due to the paucity of fossils within the sequence; only scarce, unidentified plant debris and trace fossils have been found to date in tuffaceous sandstone of the McLaughlin Ridge Formation. Whole-rock and mineral K-Ar radiometric dating of the volcanics are inconclusive, yielding ages ranging from the Silurian to the early Jurassic, due to the mobility of both potassium and argon during metamorphism. Zircons from rocks of the Saltspring Intrusive Suite, believed to be cogenetic with the felsic volcanics in the upper part of the McLaughlin Ridge Formation, have yielded concordant U-Pb ages of 362 and 366 Ma (Parrish, 1991). These data point to a Late Devonian age for McLaughlin Ridge volcanism, in agreement with correlative rocks in the Buttle Lake uplift (Juras, 1987). The age of the older Duck Lake and Nitinat volcanic rocks is unknown, but not expected to be older than Middle Devonian.

### DUCK LAKE FORMATION

The lowermost exposed unit in the Sicker Group comprises dominantly pillowed, amygdaloidal basalts with minor cherts and cherty tuffs (Massey and Friday, 1989). This unit has not been positively identified in the Cowichan Lake area. However, a small band of outcrop about 1 kilometre southwest of Heather Lake comprises green-grey, epidotized, aphyric to variolitic, tightly packed pillowed basalt, with pillows averaging 50 to 70 centimetres in diameter, and diabasic massive flows (Plate 1). The flows are intruded by a Jurassic diorite to the southwest, and are in fault contact with McLaughlin

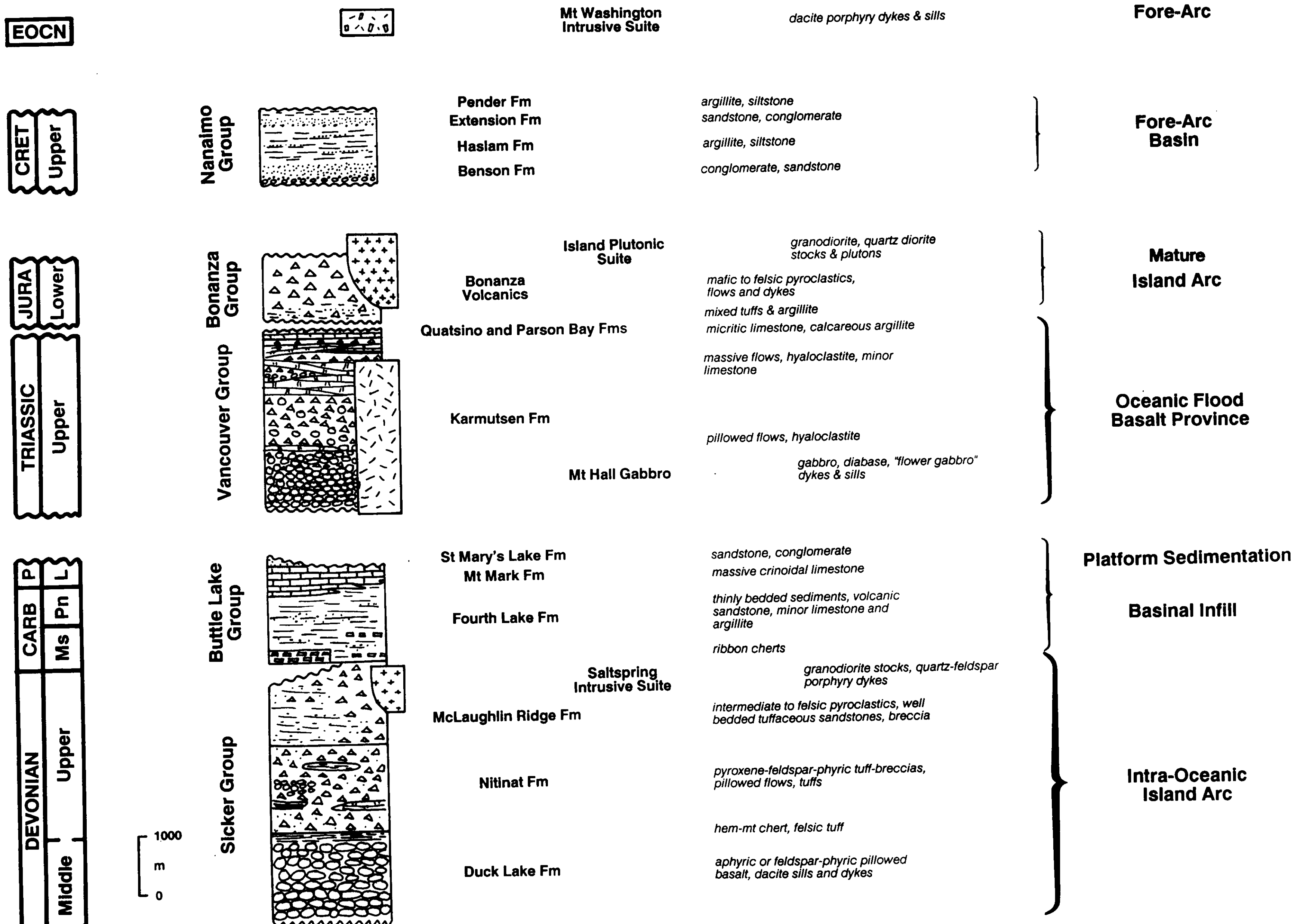


Figure 2. Stratigraphy and tectonic setting of rock units in the Cowichan uplift.

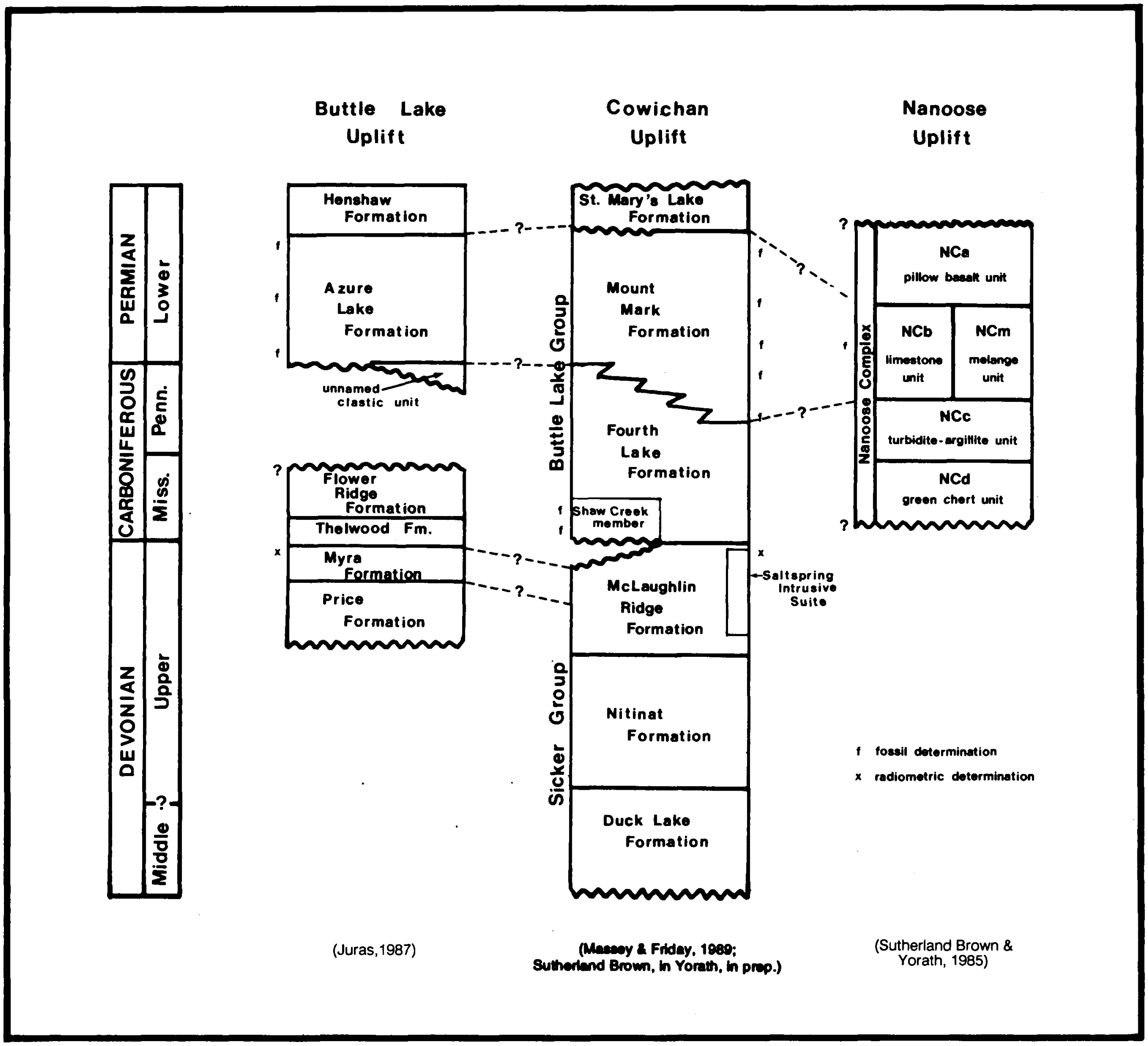


Figure 3. Comparative stratigraphy of the Paleozoic rocks of Vancouver Island. Stratigraphic columns are not drawn to scale. Note that stratigraphic divisions of the Nanoose Complex are informal and have been designated by letter only.

Ridge volcaniclastics to the northeast. They are tentatively assigned to the Duck Lake Formation.

Aphyric, amygdaloidal pillow lavas with jasper interpillow infillings were noted by Fyles (1955) on the north side of east Shaw Creek, but were not seen during present investigations. Although their description is similar to the Duck Lake Formation lavas, their stratigraphic assignation must remain uncertain at the moment.

## NITINAT FORMATION

The Nitinat Formation is generally the lowermost unit recognized in the Sicker Group in the Cowichan Lake map area. It is a volcanic package characterized by pyroxene-feldspar-porphyritic basalts and basaltic andesites. They typically occur as agglomerates (Plate 2), breccias (Plate 3), lapilli tuffs (Plate 4) and crystal tuffs that formed as pyroclastic flows, debris flows and lahars. Porphyritic pillowed and massive flows are also found (Plate 5), as well as dikes. Pyroxenes are large, up to 3 centimetres in diameter, euhedral to subhedral, and comprise 5 to 20 per cent of the rock. Plagioclase is equally abundant, but phenocrysts are usually smaller, ranging up to 1 centimetre in diameter. Amygdules present in flows and clasts in coarser pyroclastics are filled with chlorite, quartz, epidote or calcite. Minor laminated tuff and tuffaceous sandstone are present locally, although a 100-metre section of tuffaceous sandstone, laminated cherty tuffs

Plate 1. Pillowed aphyric basalt, ?Duck Lake Formation. Note only minor interpillow hyaloclastite, thin chill zones and rims of pillows are epidotized (southwest of Heather Lake; NMA86-07-11-2: 5424421N; 391250E).

and chert is developed on the hillside just west of the confluence of the north and east branches of Shaw Creek.

## McLaughlin Ridge Formation

The McLaughlin Ridge Formation shows gross lithofacies variation along the length of the Cowichan uplift, reflecting changes from the proximal environment around a volcanic centre located in the present-day Saltspring Island - Mount Sicker area, to the more distal volcaniclastic apron to the northwest (Figure 4). South of the Chemainus River fault within the Cowichan Lake map area, the Nitinat Formation is overlain by a sequence of interbedded volcaniclastic sediments and pyroclastic rocks that forms the transition between the proximal and distal facies. A variety of lithologies are developed including thickly bedded, massive tuffaceous sandstones and lithic sandstones with interbedded, laminated sandstones, siltstones and argillites (Plate 6). Volcanic breccias and lapilli tuffs are usually heterolithic and include aphyric and hornblende-plagioclase-porphyritic lithologies, commonly mafic to intermediate in composition (Plates 7 and 8). Feldspar crystal tuffs and lapilli tuffs are also common. Some minor felsic tuffs and breccias occur in the Sherk Lake area. Polymictic volcanic conglomerate is developed in several areas and sometimes bears occasional intrusive clasts (Plates 9 and 10). White to grey, aphyric dacitic dikes and sills are intrusive into other lithologies. Pyroxene-bearing breccias are sometimes interbedded with tuffaceous sandstone in the lower part of the sequence, forming a transition zone into the underlying Nitinat Formation.

North of the Chemainus River fault, the mafic to felsic volcanics of the proximal facies dominate the formation. The volcanics are predominantly intermediate pyroclastics, commonly feldspar crystal-lapilli tuffs, heterolithic lapilli tuffs and breccias and minor pyroxene-phyric lapilli tuffs. Felsic quartz-crystal, quartz-feldspar-crystal and fine dust-tuffs interfinger with andesitic lapilli tuffs and breccias at the eastern edge of the map (Plate 11). The felsic package thickens eastwards in the Chipman Creek - Mount Sicker area where it is host to polymetallic sulphide showings (Massey, 1993a). The felsic rocks appear to be stratigraphically high within the formation. A distinctive maroon, schistose heterolithic breccia and lapilli tuff (Plate 12) with minor jasper, exposed in the Rheinhart Creek area, is the uppermost unit within the McLaughlin Ridge Formation and is overlain conformably by thinly bedded cherty sediments of the Fourth Lake Formation (Plate 13).

A suite of greenstone dikes, informally called the "older dikes", intrudes the felsic volcanics and maroon breccia. The dikes are too thin and scattered to be mapped and designated separately on the 1:50 000-scale maps of this project. However, they occur throughout the belt of McLaughlin Ridge volcanics from Rheinhart Creek eastwards to Maple Mountain. They differ markedly from Late Triassic diabase dikes, also found in this area, in being generally aphyric, weakly to moderately foliated and strongly altered to epidote-chlorite-actinolite-calcite assemblages. The significance of their recognition lies in their differing tholeiitic chemistry compared to the calcalkaline nature of the McLaughlin Ridge vol-

Plate 2. Maroon and green-coloured, clast-supported agglomerate, Nitinat Formation. Clasts of pyroxene-feldspar basalt, matrix tuffaceous (Shaw Lake; NMA86-03-02: 5430321N; 394101E).

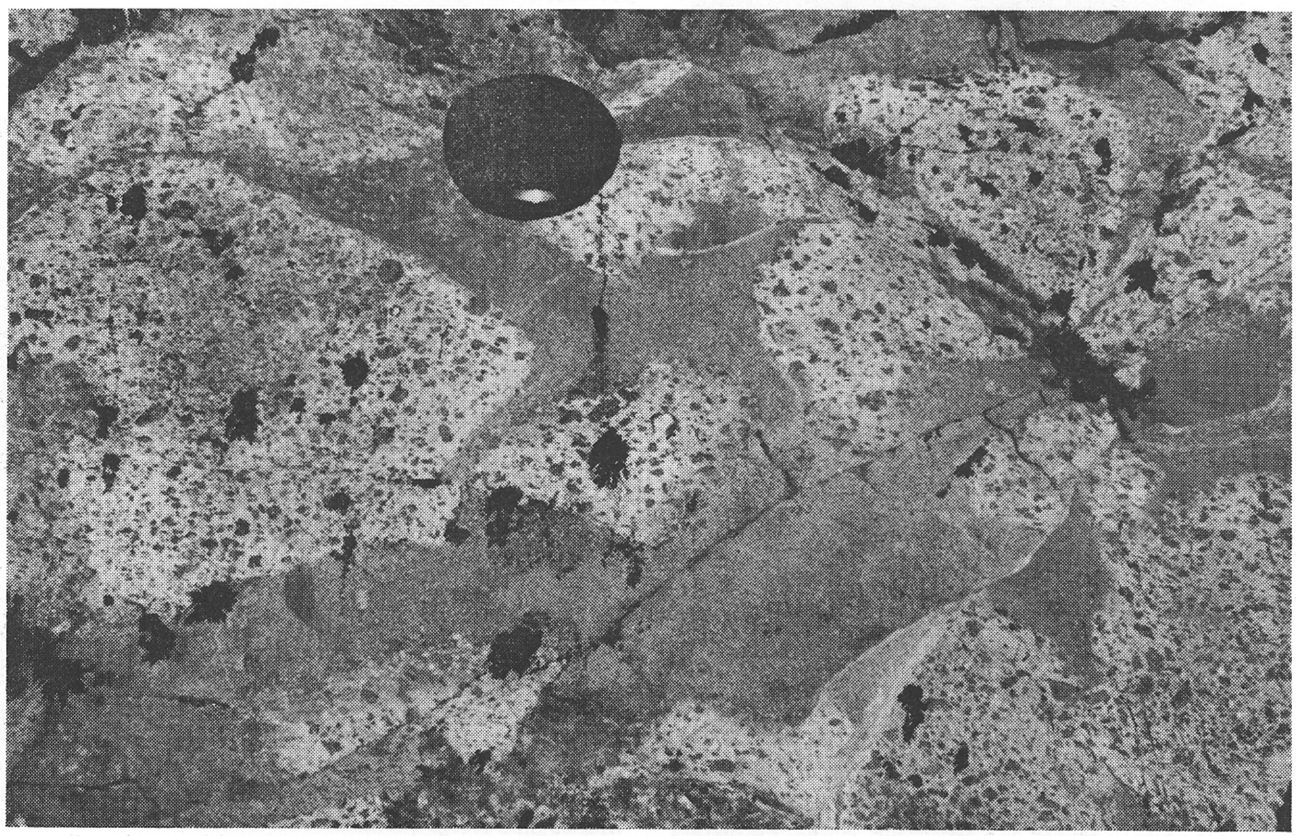

Plate 3. Matrix-supported, pyroxene-phyric tuff-breccia, Nitinat Formation (logging road S10G, west Shaw Creek; 5426300N; 395600E).

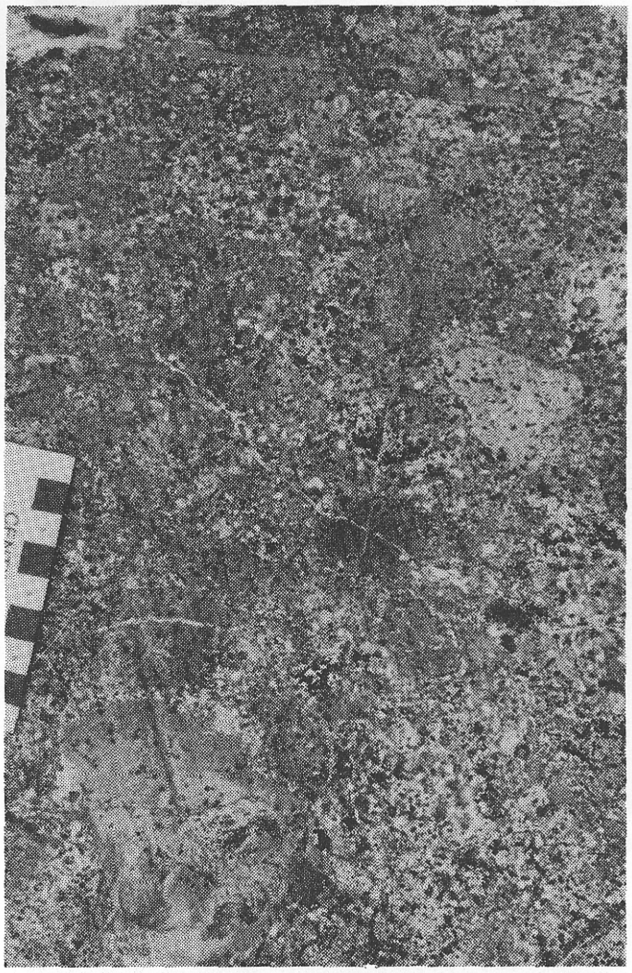

Plate 4. Heterolithic pyroxene-feldspar-phyric lapilli tuff, Nitinat Formation (east Shaw Creek; NMA86-17-04: 5424633N; 401243E).

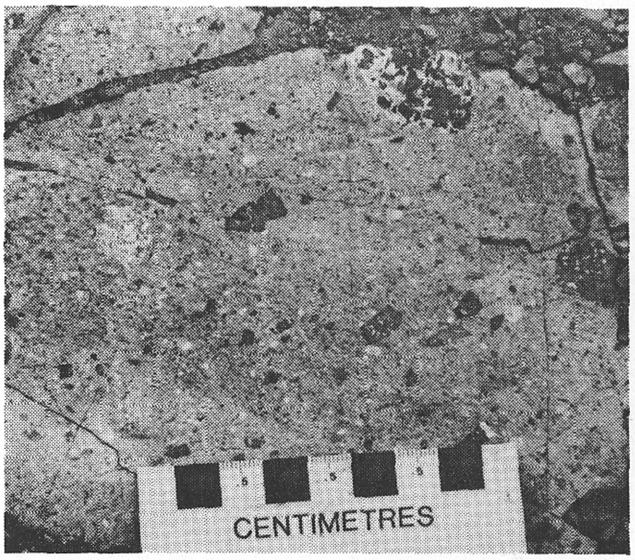


Plate 5. Amygdaloidal pyroxene basalt flow with cognate(?) xenoliths of gabbro and pyroxenite, Nitinat Formation (west end of Meade Creek, about 2 km south of Mount Franklin; NMA86-48-16: 5416227N; 414937E).

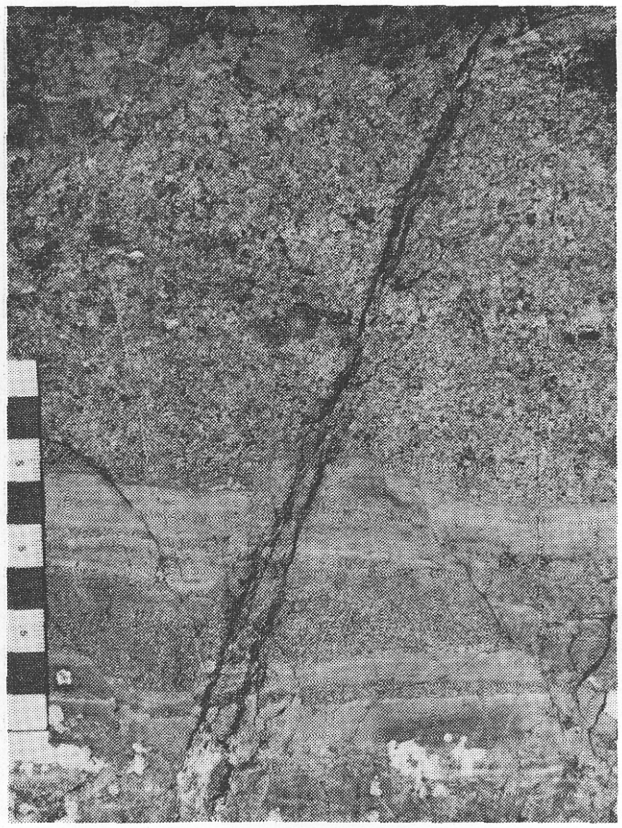

Plate 6. Tuffaceous sandstone with silty tuffite interbeds, McLaughlin Ridge Formation. (Widow Creek; NMA86-37-13: 5417608N; 413889E).

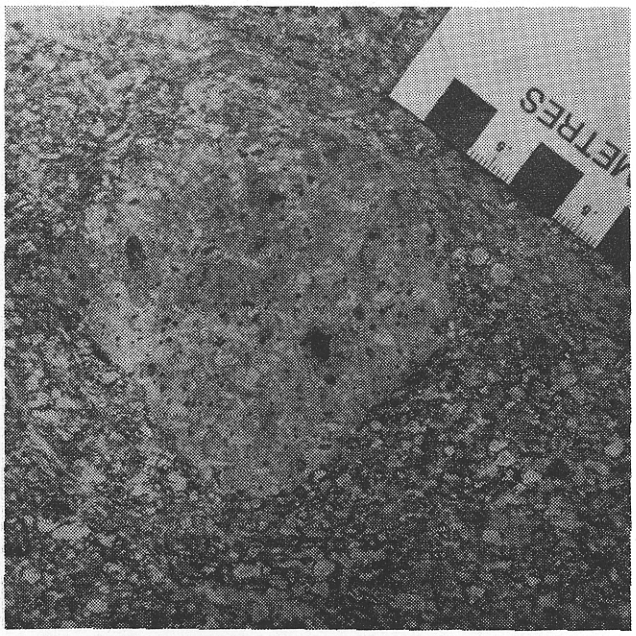

Plate 7. Amygdaloidal feldspar-pyroxene-phyric bomb in intermediate to felsic, feldspar crystal, lithic-lapilli tuff, McLaughlin Ridge Formation. Note deflection of crude lamination beneath bomb and draping of lamination over the top (east of Dixie Lake; NMA86-15-09-1: 5425409N; 400426E).

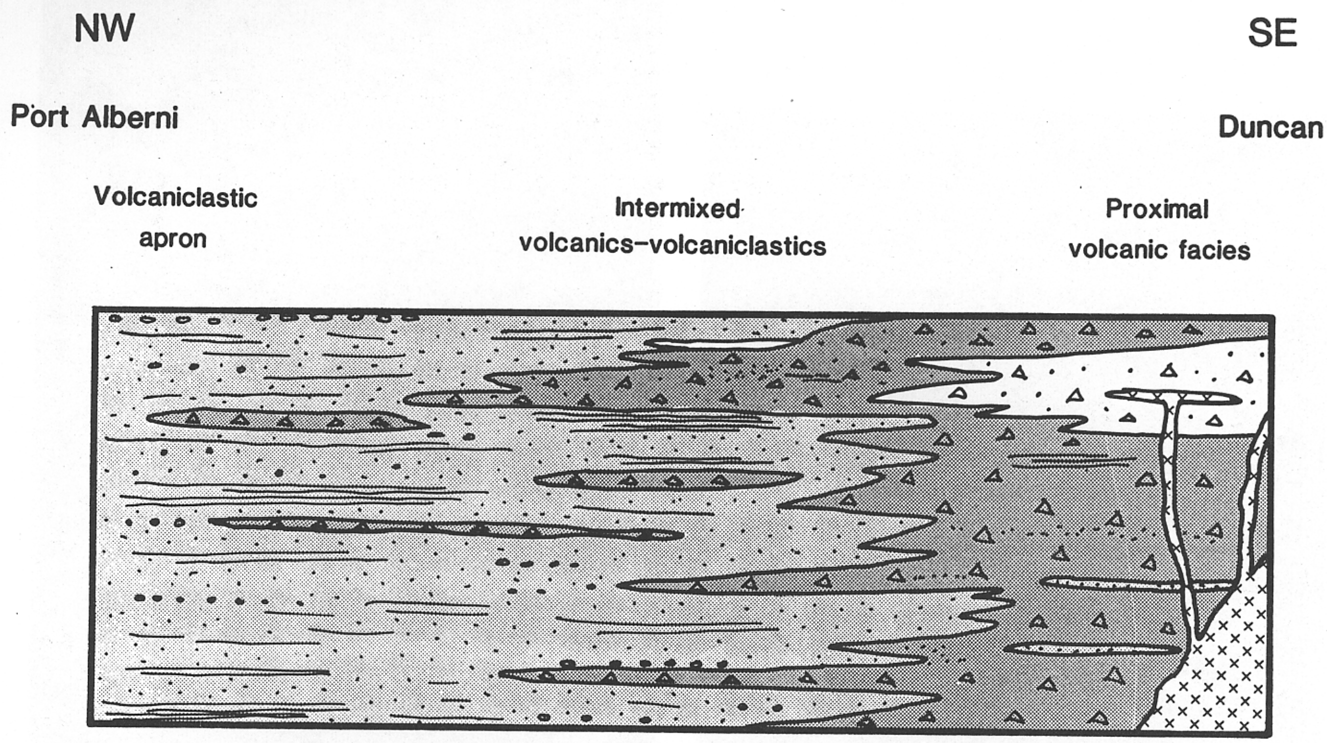


**Figure 4. Lithofacies variations in the McLaughlin Ridge Formation along the length of the Cowichan uplift. Section is diagrammatic and not to scale. Volcaniclastic rocks are shown in the light shading, intermediate to mafic volcanics in the darker shading, felsic volcanics unshaded and felsic intrusions with the cross pattern.**

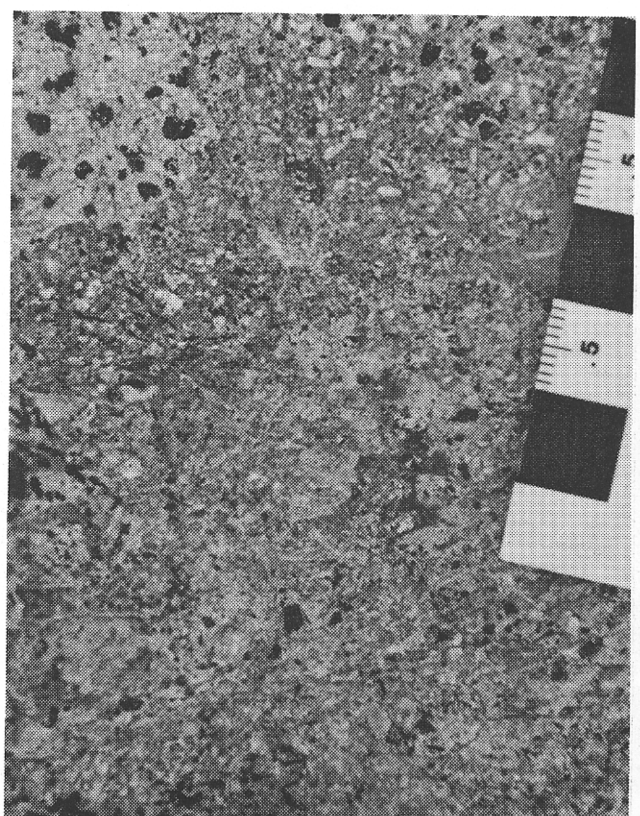

**Plate 8. Heteolithic andesite lapilli tuff, McLaughlin Ridge Formation (north slope of Meade Creek valley; NMA86-52-07: 5415508N; 418337E).**

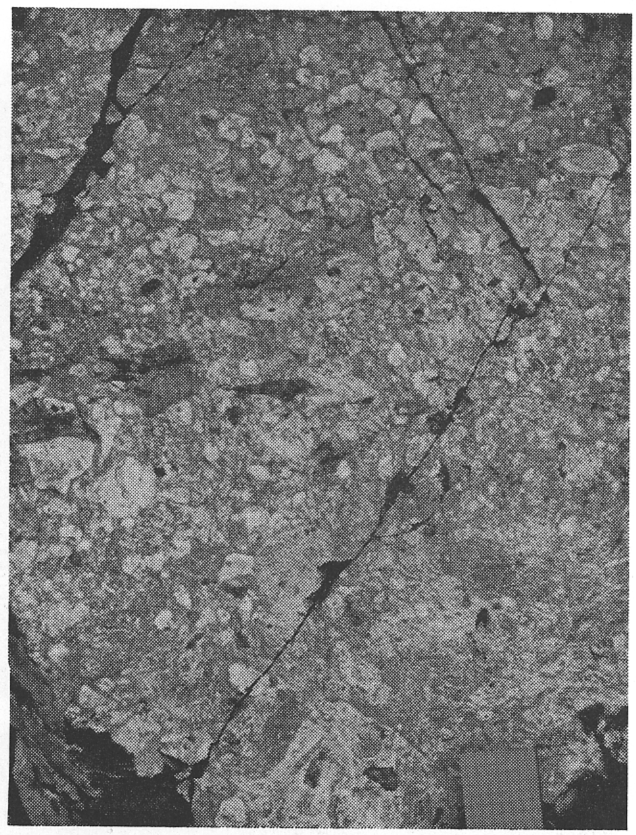

**Plate 9. Polymictic volcanic conglomerate, McLaughlin Ridge Formation. Dark diorite cobble in left centre of photograph; breccia boulder next to notebook (north Shaw Creek; NMA86-08-19: 5427689N; 397552E).**

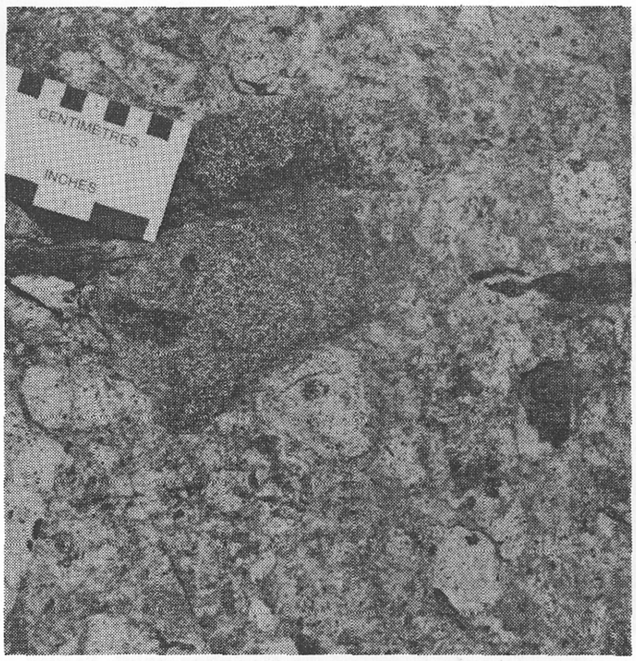

Plate 10. Close-up of diorite cobble in volcanic conglomerate of Plate 9. Note also angular basalt clast on left (north Shaw Creek; NMA86-08-19: 5427689N; 397552E).

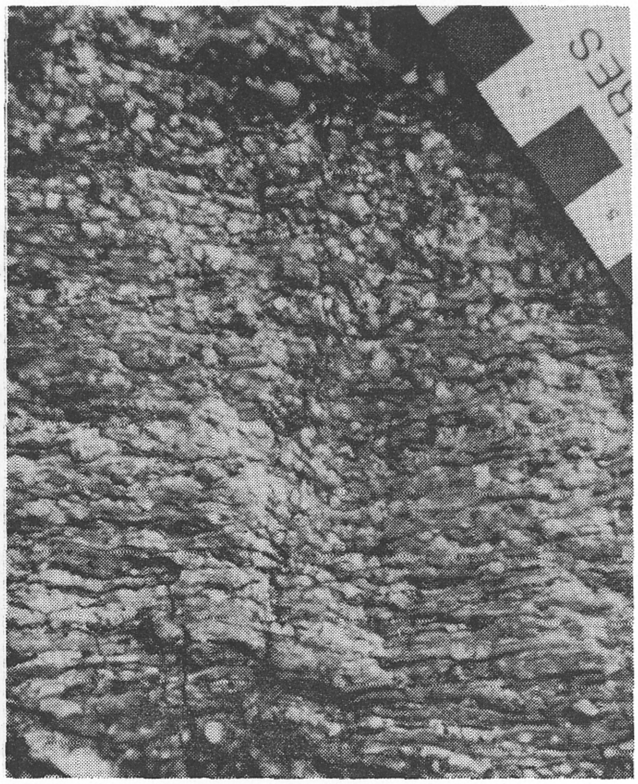

Plate 11. Schistose sericitic quartz-feldspar crystal tuff, McLaughlin Ridge Formation (B road, upper Boulder Creek; NMA87-06-07-1: 5419847N; 424117E).

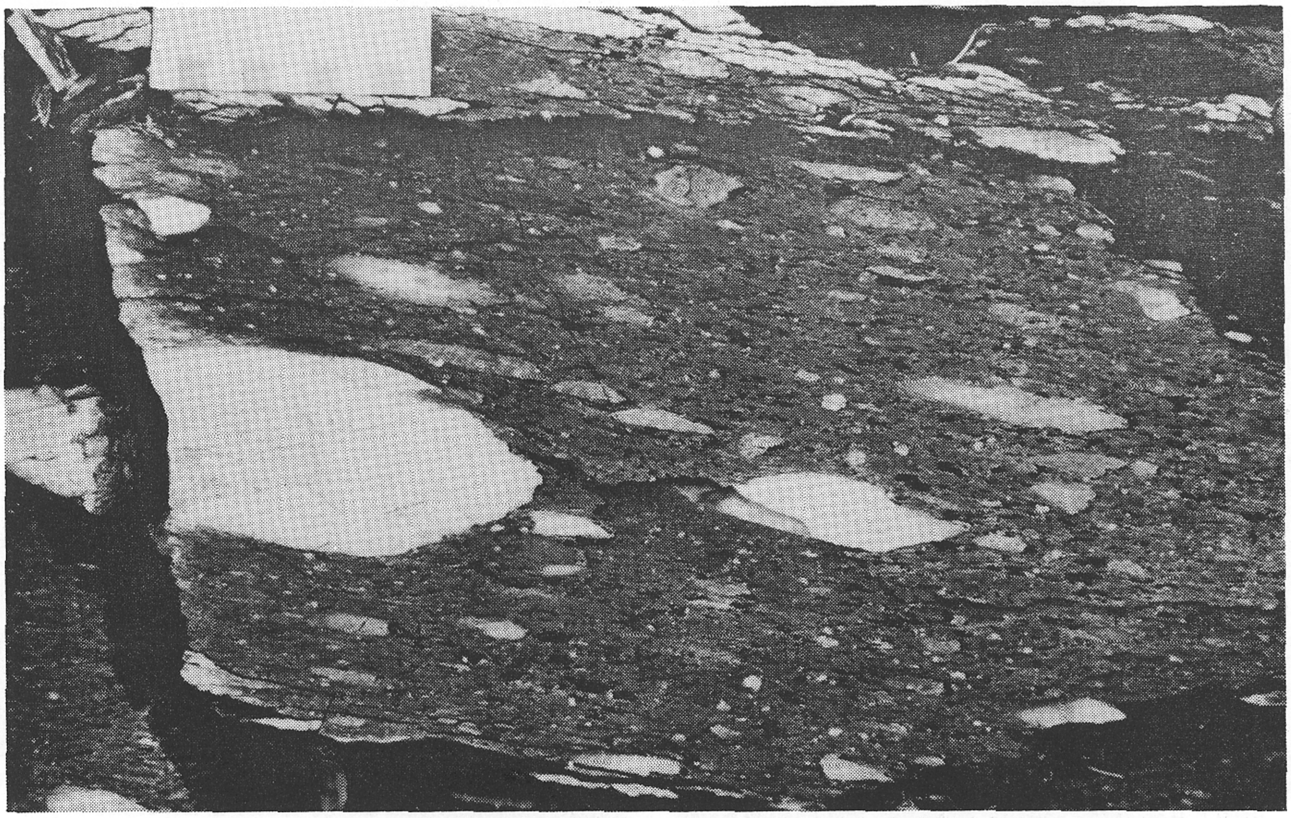

Plate 12. Maroon schistose, chloritic, heterolithic lapilli tuff, uppermost McLaughlin Ridge Formation. Note flattening of clasts within the foliation plane (logging road C19F, west side of Rheinhart Creek; NMA87-09-14: 5421570N; 419405E).

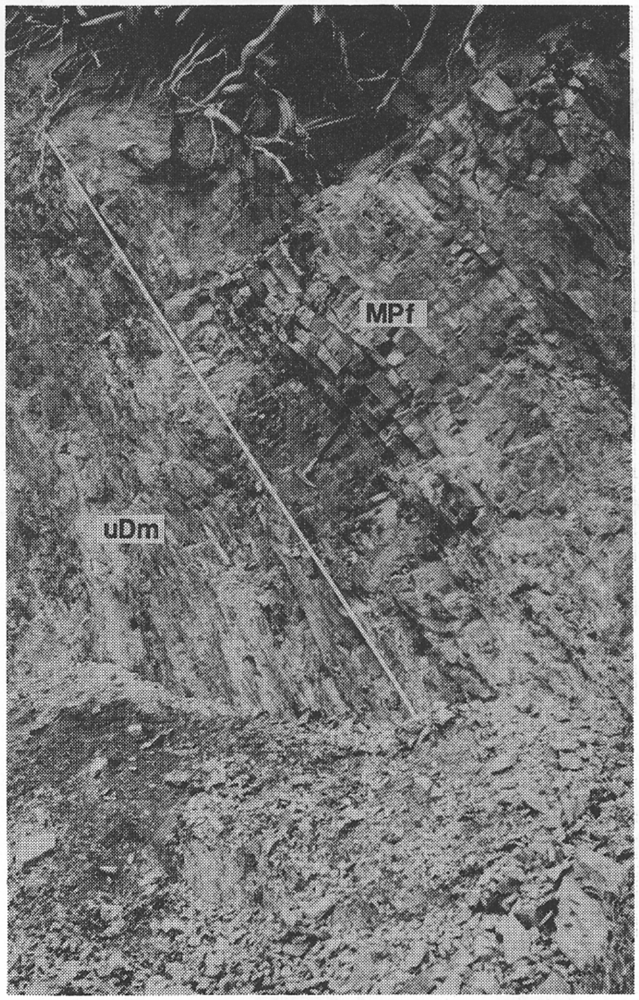


Plate 13. Maroon schistose lapilli tuffs of the McLaughlin Ridge Formation (uDm) passing conformably up into green cherts and cherty tuffaceous sediments of the Fourth Lake Formation (MPf) (logging road C17B, west side of Rheinhart Creek; NMA87-09-21: 5421811N; 419799E).

canic country rocks. The age of these dikes is unknown. They have not been observed to intrude Buttle Lake Group or younger rocks in outcrop, though basaltic lapilli and breccia of similar chemistry to the "older dikes", interbedded with cherty sediments of the Fourth Lake Formation, was intersected in drill cores south of Mount Brenton in the adjacent Duncan map area (D.R. Stewart, personal communication).

## Geochemistry of the Sicker Group

All samples of Sicker Group rocks analyzed show the effects of variable low-grade alteration. This is reflected in high values for $CO_2$ (± CaO), loss-on-ignition, ferric/ferrous ratios and variable mobility of alkalis and possibly silica. However, many elements traditionally regarded as immobile during low-grade metamorphism seem to be also unaffected in these rocks and yield smooth patterns on extended trace-element plots, for example Figures 5 to 7, and give consistent results on petrotectonic discrimination diagrams (Figures 10 to 15).

Basalts of the Duck Lake Formation in the Alberni - Nanaimo Lakes area can be subdivided into two geochemical suites which apparently have a stratigraphic basis, though no distinction was recognized in the field (Massey, 1993b). The lower Suite I is tholeiitic in character while the upper Suite II is high-potassium calcalkaline. No geochemical data are available from suspected Duck Lake basalts in the Cowichan Lake map area.

Volcanic rocks of the Nitinat and McLaughlin Ridge Formations form a coherent suite of medium-potassium calcalkaline chemistry (Figures 8 and 9) and fall within the appropriate calcalkaline or arc fields in petrotectonic discrimination diagrams (Figures 10 to 15). The Nitinat Formation is dominated by basalts and basaltic andesites with few intermediate or felsic rocks. Those dacites and rhyolites that do occur form dikes or sills and are indistinguishable from similar rocks within the McLaughlin Ridge Formation. Geochemically, the volcanics of the Nitinat Formation can be divided into two subgroups which are differentiated by incompatible element ratios (Figures 5 and 10). The $TiO_2/P_2O_5$ ratio for most samples is in the range 2 to 5. However, a subgroup has $TiO_2/P_2O_5$ ratios less than 2. This group also has lower niobium, higher zirconium, and higher La/Nb, Ce/Sr and Ce/Y ratios. Both subgroups are otherwise typically calcalkaline and show considerable overlap in chemical characteristics (Figures 5 and 8 to 15). There is an apparent spatial control on the distribution of the two subgroups, with the low $TiO_2/P_2O_5$ samples being located north of Cowichan Lake in the Meade Creek - Cottonwood - east Shaw Creek area. The main Suite I rocks are found to the north and east of this area.

The McLaughlin Ridge Formation shows a complete range of compositions from mafic to felsic. Volumetrically, it is dominated by intermediate volcaniclastics, though these are under represented in the accompanying geochemical data which emphasize liquid compositions, that is flows and minor intrusions. The McLaughlin Ridge volcanics demonstrate the same typical calcalkaline geochemistry as the main Nitinat Formation Suite I (with $TiO_2/P2O_5$ ratios between 2 and 5) with which they are probably consanguineous (Figures 6 and 9 - 15). However, no samples were collected from McLaughlin Ridge volcanics in the Meade Creek - east Shaw Creek area.

The "older dikes" which intrude the upper McLaughlin Ridge volcanics, differ noticeably from their hosts in being high iron-titanium tholeiites (Figure 8). Extended trace-element patterns are flat, MORB-like from cerium to yttrium but have elevated niobium and lanthanum contents (Figure 7). This is similar to some Karmutsen flows and intrusions (*see* below). Petrotectonic discrimi-

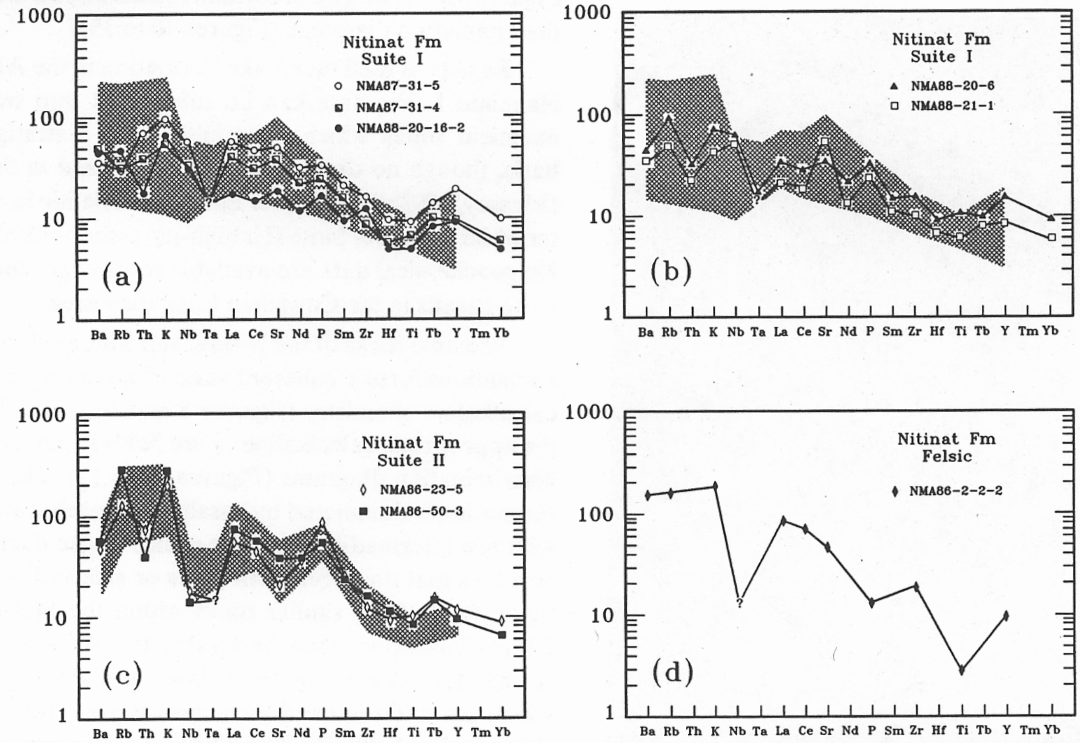


**Figure 5. Normalized trace-element plots for volcanic rocks of the Nitinat Formation. Normalizing values after Thompson *et al.* (1983). Shaded area represents the range of values for all samples of a particular suite in the Sicker Project area. It is based on XRF data only. Samples for which INAA data are available are plotted individually: (a) and (b) Suite I: calcalkaline basalts and basaltic andesites; (c) Suite II: low Ti/ P calcalkaline basalts and basltic andesites; (d) dacite, affinity unknown; compare with felsic rocks from the McLaughlin Ridge Formation, Figure 7.**

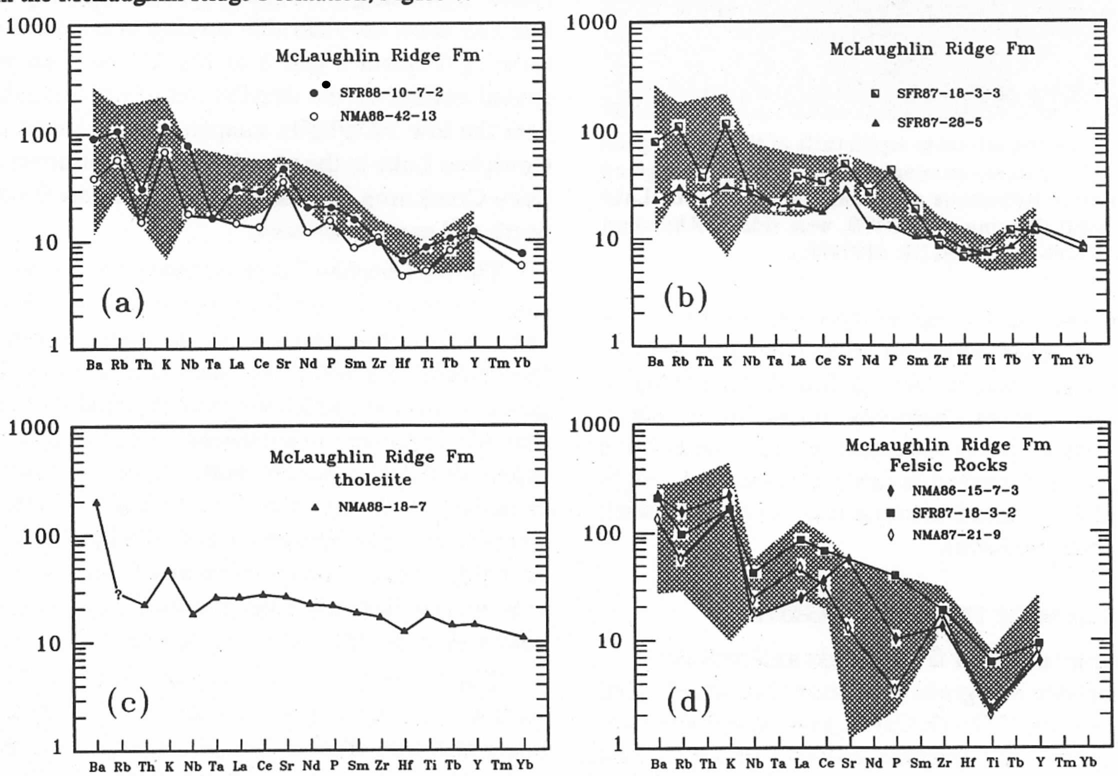


**Figure 6. Normalized trace-element plots for volcanic rocks of the McLaughlin Ridge Formation. Normalizing values after Thompson *et al.* (1983). Shaded area represents the range of values for all samples of a particular suite in the Sicker Project area. It is based on XRF data only. Samples for which INAA data are available are plotted individually: (a) and (b) calcalkaline basalts and basaltic andesites; (c) tholeiite from the Nitinat River area (Massey 1992b); (d) felsic rocks.**

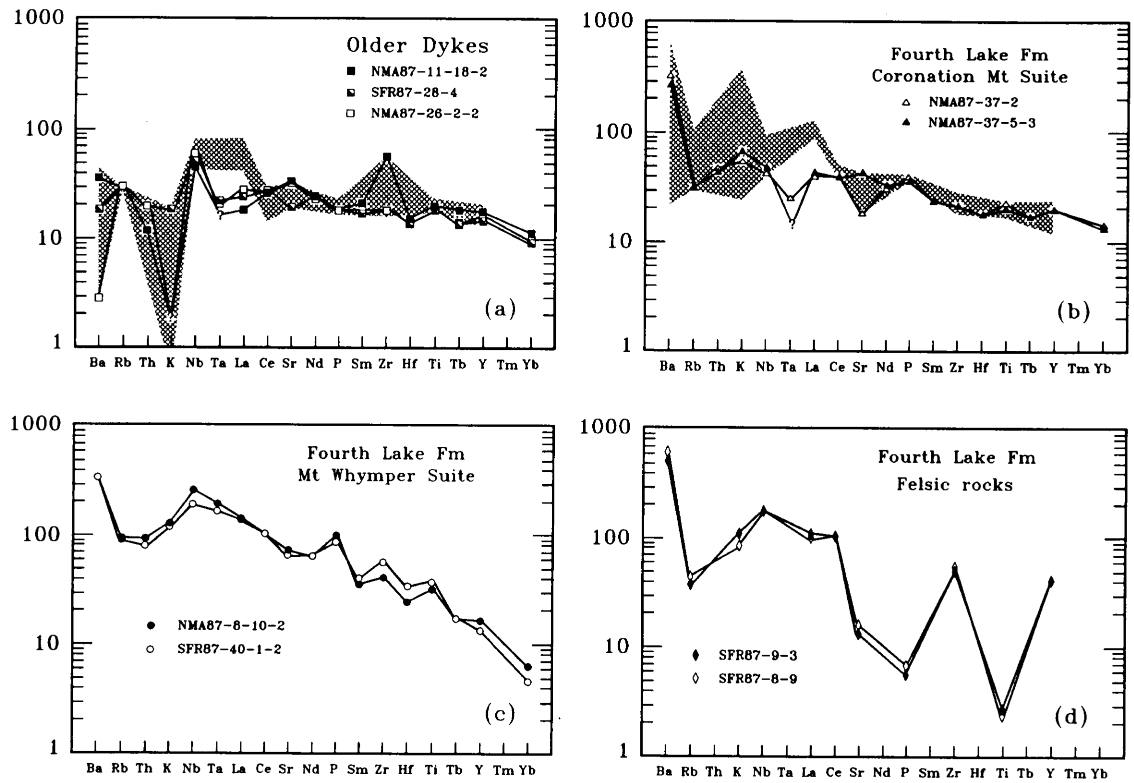


**Figure 7. Normalized trace-element plots for the older dikes and volcanic rocks of the Fourth Lake Formation. Normalizing values after Thompson *et al.* (1983). Shaded area represents the range of values for all samples of a particular suite in the Sicker Project area. It is based on XRF data only. Samples for which INAA data are available are plotted individually: (a) older dikes: high Fe-Ti tholeiites; (b) Coronation Mt. suite: transitional basalts; (c) Mt. Whymper suite: alkalic basalts; (d) dacites spatially and chemically related to the Mt. Whymper suite.**

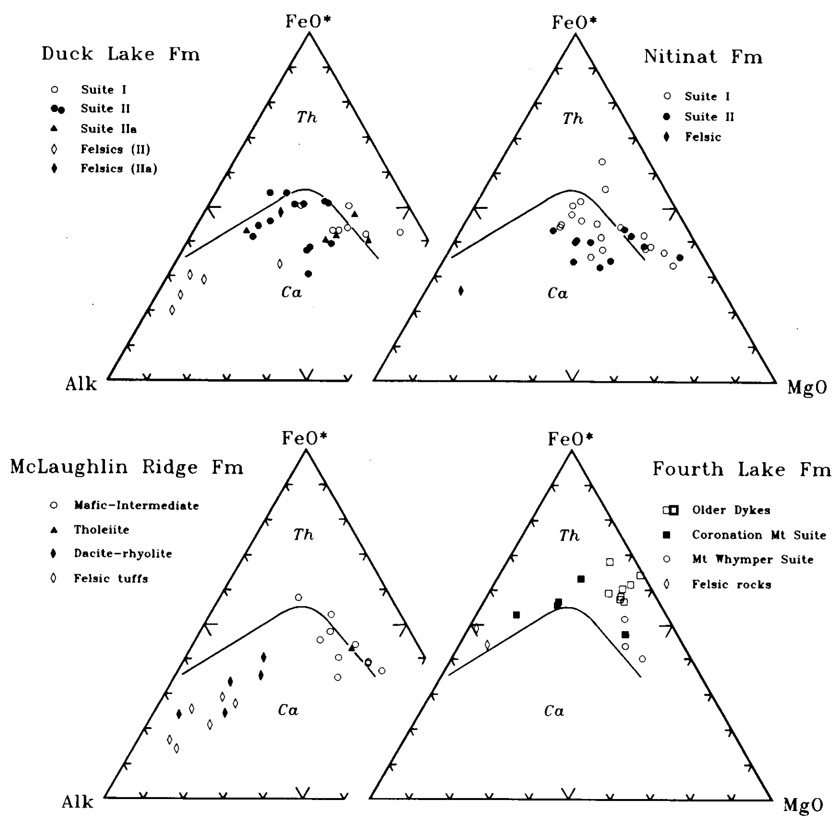


**Figure 8. AFM triangle diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Tholeiite (Th) - calcalkaline (Ca) dividing line after Irvine and Baragar (1971). Alk = Na2O + K2O; FeO* = total iron as FeO.**

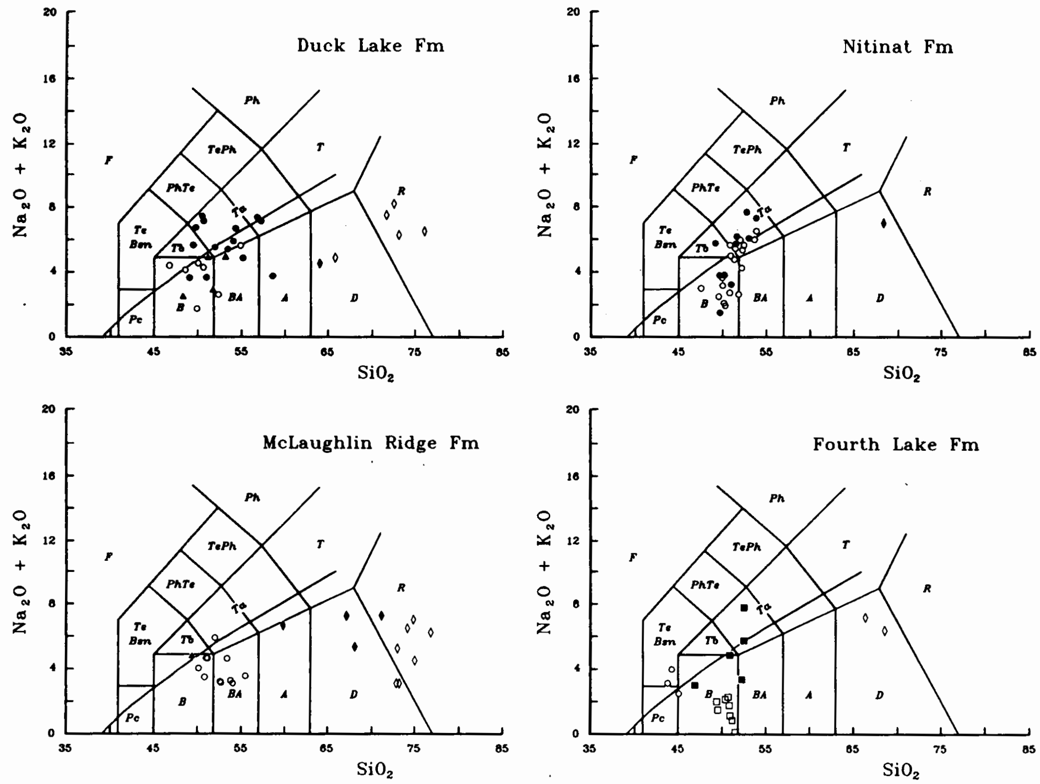


Figure 9. Alkali-silica diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Fields after Le Maitre (1984); F: foidites; Pc: picrobasalt; Bsn: basanite; Te: tephrite; PhTe: phonotephrite; TePh: tephriphonolite; Ph: phonolite; Tb: trachybasalt; Ta: trachyandesite; T: trachyte and alkali trachyte; B: basalt; BA: basaltic andesite; A: andesite; D: dacite; R: rhyolite and alkali rhyolite. Sloping solid line divides alkaline rocks (above line) from subalkaline rocks (below line), after Irvine and Baragar (1971). Symbols as in Figure 8.

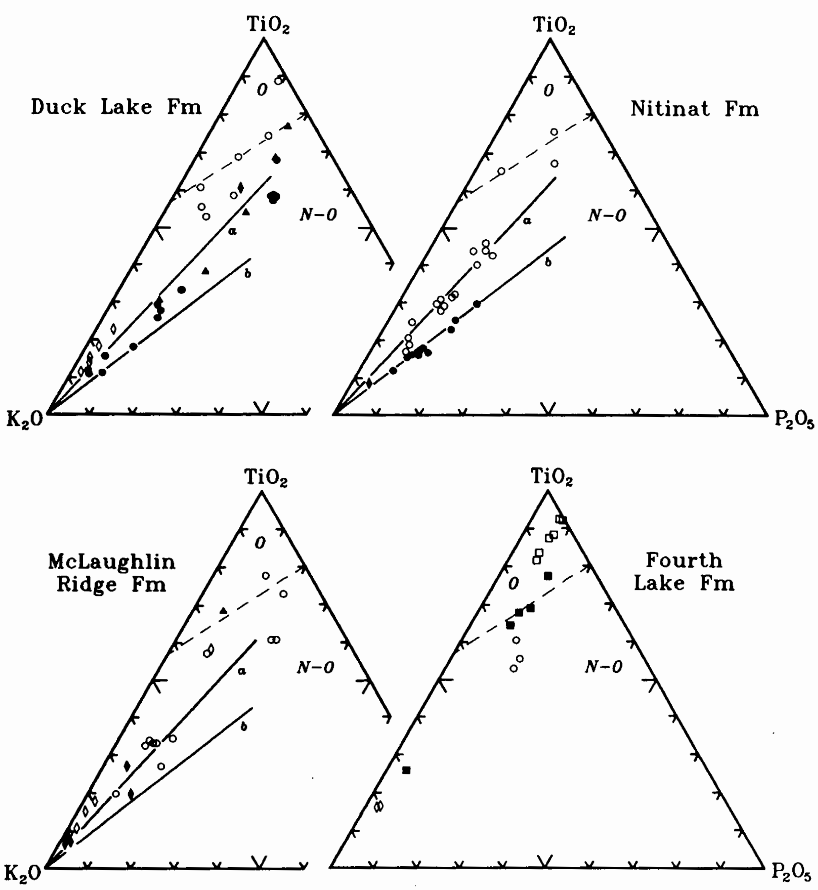


Figure 10. $TiO_2$-$K_2O$-$P_2O_5$ diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Fields after Pearce *et al.* (1975) are shown for reference; O: oceanic basalts; N-O: continental basalts. Lines *a* and *b* are of differing $TiO_2/P_2O_5$ ratio and distinguish Suites I and II of the Nitinat Formation. They are included for reference in the plots of the Duck Lake and McLaughlin Ridge formations. Symbols as in Figure 8.

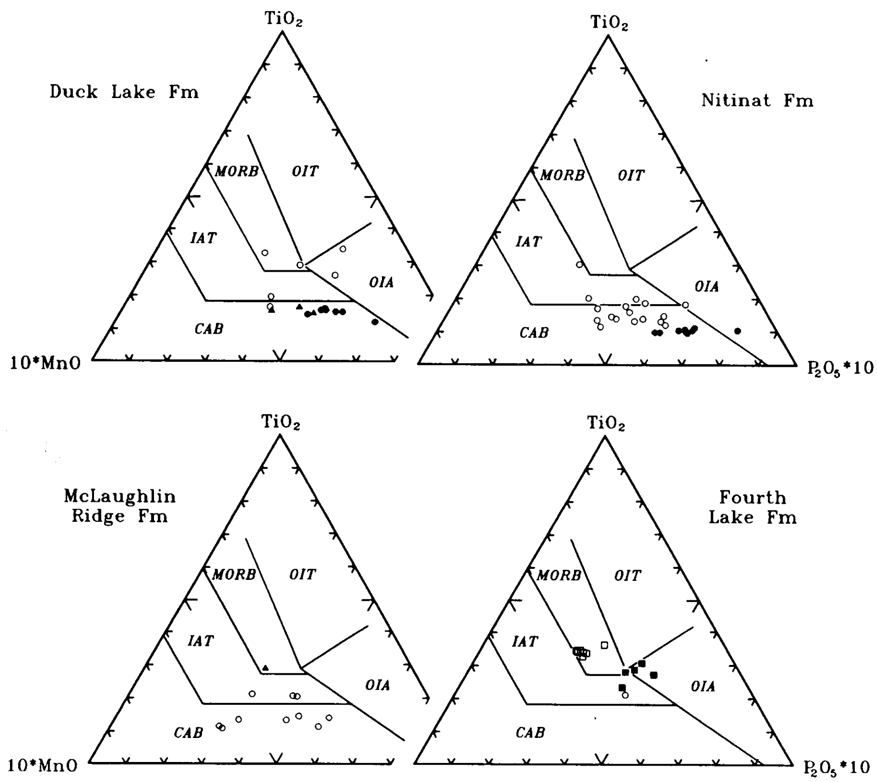


Figure 11. $TiO_2$-$MnO$-$P_2O_5$ diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Fields after Mullen (1983); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; OIT: ocean-island tholeiites; OIA: ocean-island alkalic basalts. Symbols as in Figure 8.

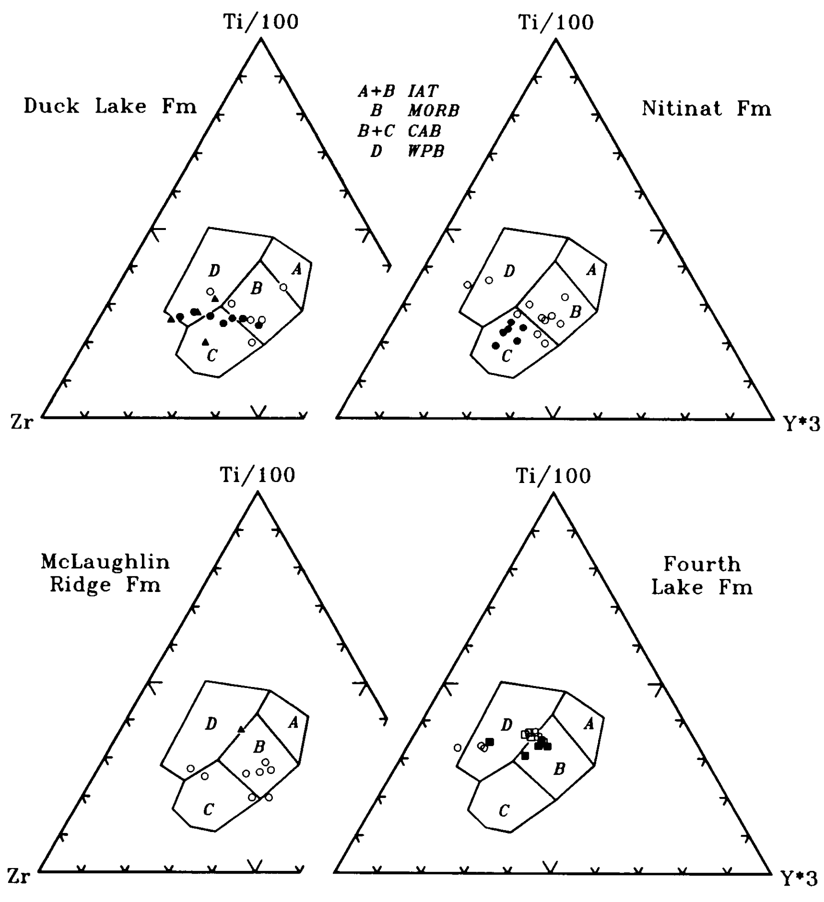


Figure 12. Ti-Zr-Y diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; WPB: within-plate basalts. Symbols as in Figure 8.

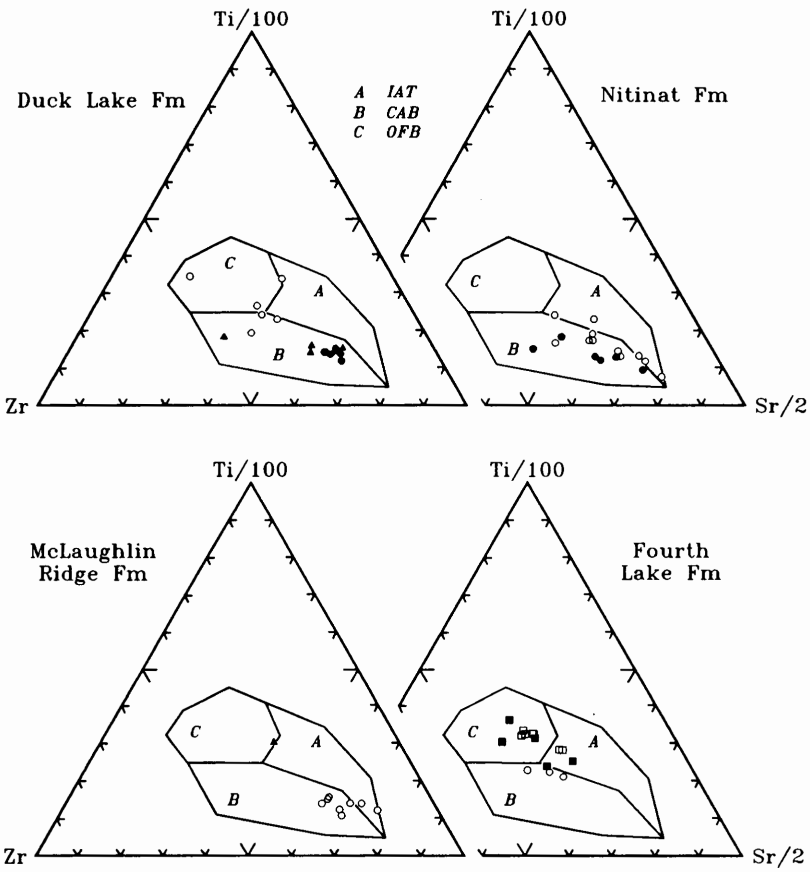


**Figure 13. Ti-Zr-Sr diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 8.**

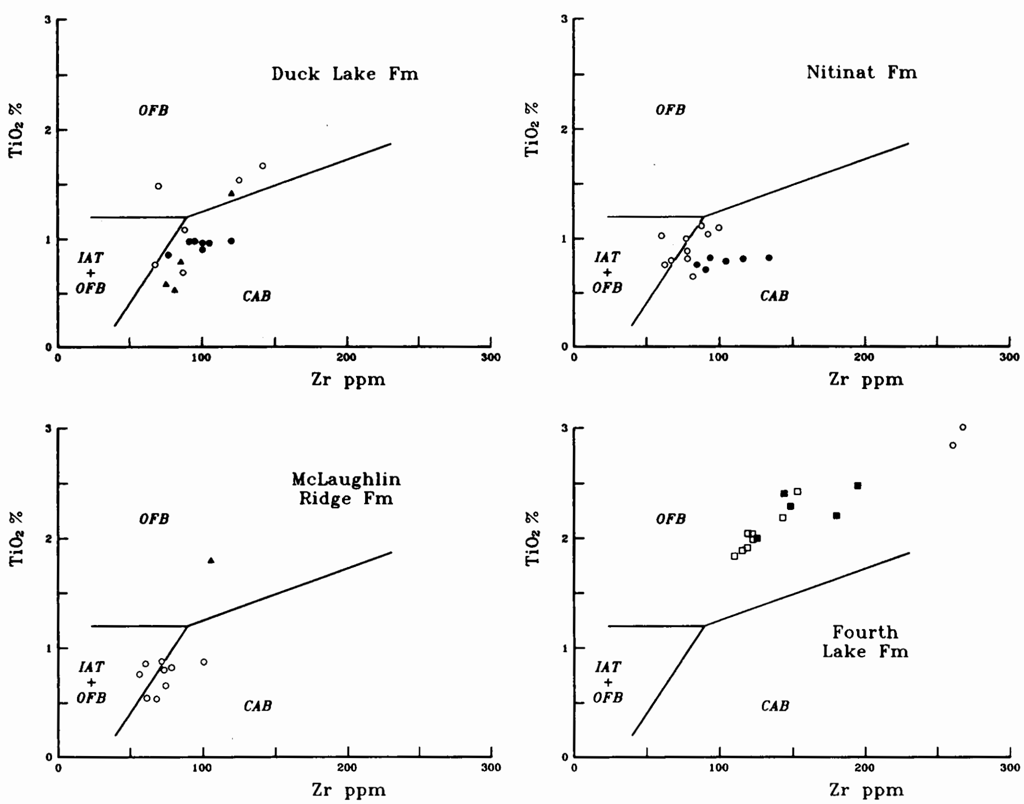


**Figure 14. $TiO_2$-Zr diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Fields after Garcia (1978); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 8.**

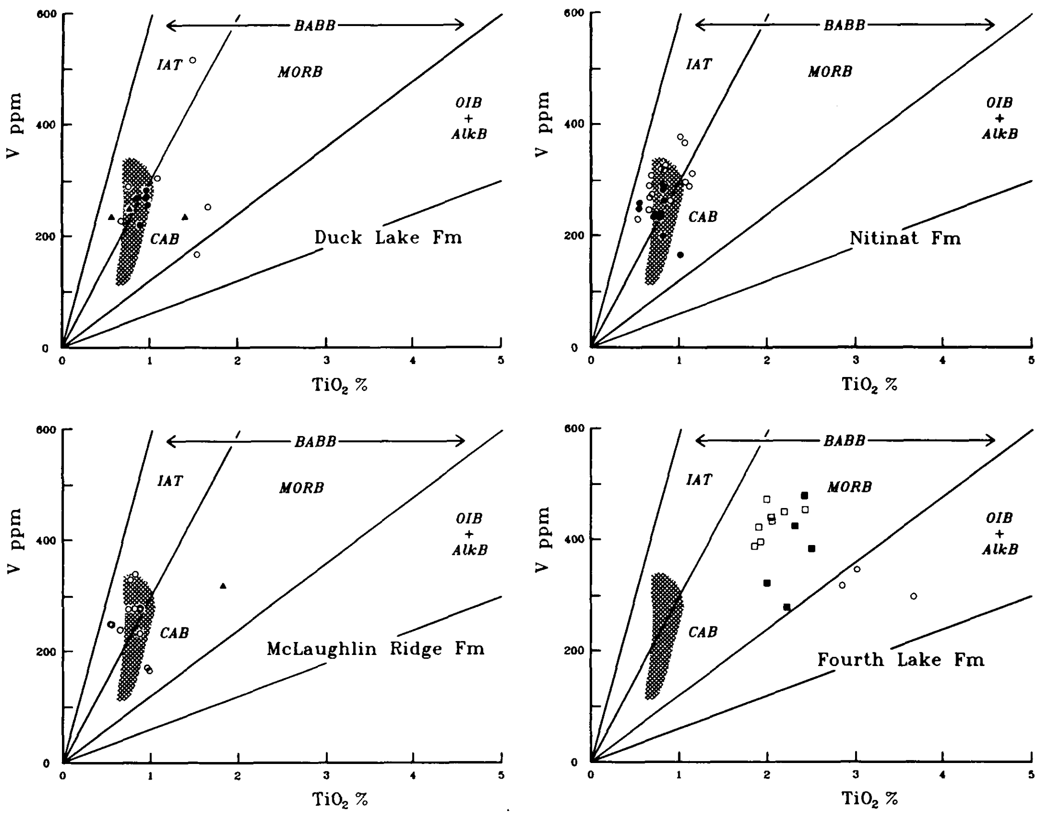


**Figure 15. $TiO_2$-V diagrams for volcanic rocks of the Sicker Group and Fourth Lake Formation. Fields after Shervais (1982); IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; BABB: back-arc basin basalts; OIB: ocean-island basalt; AlkB: alkalic basalt. Shaded area labelled CAB is that occupied by typical calcalkaline basalts. Symbols as in Figure 8.**

nants suggest an affinity to transitional or enriched ocean-floor basalts (Figures 10 to 15).

## The Sicker Arc

The Sicker Group records the complete evolution of an oceanic island arc. The lower tholeiitic basalts of the Duck Lake Formation represent the oceanic substrate upon which the arc developed. The age of the substrate relative to the overlying arc is unknown but there is no evidence to suggest that it is significantly older. The initiation of the arc produced the bimodal high-potassium calcalkaline suite of the Duck Lake Formation. Enriched lavas such as this are believed to characterize the renewal stage of arc construction after an episode of back-arc rifting, such as observed in the Marianas (Stern *et al.*, 1988). However, evidence for the earlier back-arc basin is lacking on southern Vancouver Island. The initiation of a new subduction zone, though normally marked by boninitic or low-potassium tholeiitic melts (Hawkins *et al.*, 1984, Stern *et al.*, 1988), may produce enriched calcalkaline magmas where an enriched mantle wedge is involved in magma generation. The prior generation of the lower Duck Lake Formation E-MORB lavas suggests that this may be the case for the Sicker arc.

As the arc developed, magmatism became typically medium-potassium calcalkaline in composition. In the Nitinat Formation, volcanism was fairly mafic and magma probably erupted from several volcanic centres. The differing chemistry of the Suite II rocks of the Meade Creek - east Shaw Creek area probably erupted from one such centre while others are marked by the abundant massive flows in the Banon Creek area (Massey, 1993a) and the thick sequence of flows and coarse pyroclastics in the Nitinat River area (Massey, 1993b). Lithologies and sedimentary facies in the Nitinat Formation are very similar to those observed in young submarine arcs, both modern and in the geological record (Jones, 1967; Mitchell, 1970; Bogen, 1985).

Eruptive style changed during deposition of the McLaughlin Ridge Formation, with the development of a single large central volcano in the Duncan - Saltspring Island area, surrounded by a volcaniclastic apron extending to the Alberni area (Massey, 1993a, b). Magma chemistry evolved to andesitic and dacitic compositions. Rare plant material and trace fossils show that the volcano became subaerial for at least part of its history. This central volcano was contemporaneous with that developed in the Myra Falls area of the Buttle Lake uplift (Juras, 1987), though the spatial relationship between these two centres during the Late Devonian is uncertain due to later tectonic disruption and differential rotation of structural blocks within Vancouver Island (Irving and Yole, 1987; Irving and Wynne, 1990).

Volcanism waned at the end of McLaughlin Ridge time, with only comparitively minor eruptions occurring within the Fourth Lake Formation (*see* below). Magmatic compositions changed to enriched tholeiitic (older dikes) to transitional basalts and alkalic basalts and dacites (Fourth Lake Formation). This volcanism, and its associated sediments, was contemporaneous with the Thelwood and Flower Ridge formations of the Buttle Lake uplift, interpreted as forming in an extensional back-arc basin environment (Juras, 1987), and may have formed at the propagating tip of that developing rift. Extension, however, was very limited in the Cowichan uplift, the basin being dominated by sedimentary infill.

Throughout the Sicker Group, and succeeding Fourth Lake Formation, there is no evidence for continental influence on the developing arc. The oceanic substrate of the lower Duck Lake Formation, lithofacies of volcanics in the Nitinat and McLaughlin Ridge formation, the arc-derived debris of the Fourth Lake sediments, the lack of U-Pb inheritence in zircons, and the juvenile nature of neodymium and strontium isotopic data (Samson *et al.*, 1990) all support an intra-oceanic arc environment. However, two pieces of geochemical data seemingly point to continental influence. Lead isotope data from galenas and whole-rocks from the Sicker Group of the Buttle Lake uplift resemble those from other island-arc environments, but are more radiogenic than mid-ocean ridge basalts or the proposed Devonian mantle (Andrew and Godwin, 1989). The radiogenic lead is interpreted to be derived from sedimentary rocks, implying that the subduction zone producing the Sicker arc was sediment rich and near a supply of continental detritus.

The ratio Zr/Y has been suggested (Pearce, 1983) as an effective discriminant between arcs formed on oceanic crust (Zr/Y< 3) and arcs formed on transitional or continental crust (Zr/Y> 3). The majority of Zr/Y ratios for Sicker arc rocks are higher than 3, suggesting a continental-arc environment (Figure 16). There is a tendency for the average Zr/Y ratio to decrease with time from upper Duck Lake to McLaughlin Ridge formations, but this is complicated by possible spatial variations, for example the differences between Suites I and II in the Nitinat Formation. However, Zr/Y is a measure of the enrichment of the mantle source of the magmas and is also a characteristic of within-plate volcanics. If subduction took place beneath the source of trace-element enriched basalts, such as the lower Duck Lake Formation, it would be possible for magmas in an oceanic arc to possess high Zr/Y ratios and hence plot in the continental-arc field (Pearce, 1983). No modern example of this has been documented. Such a mantle source could also produce

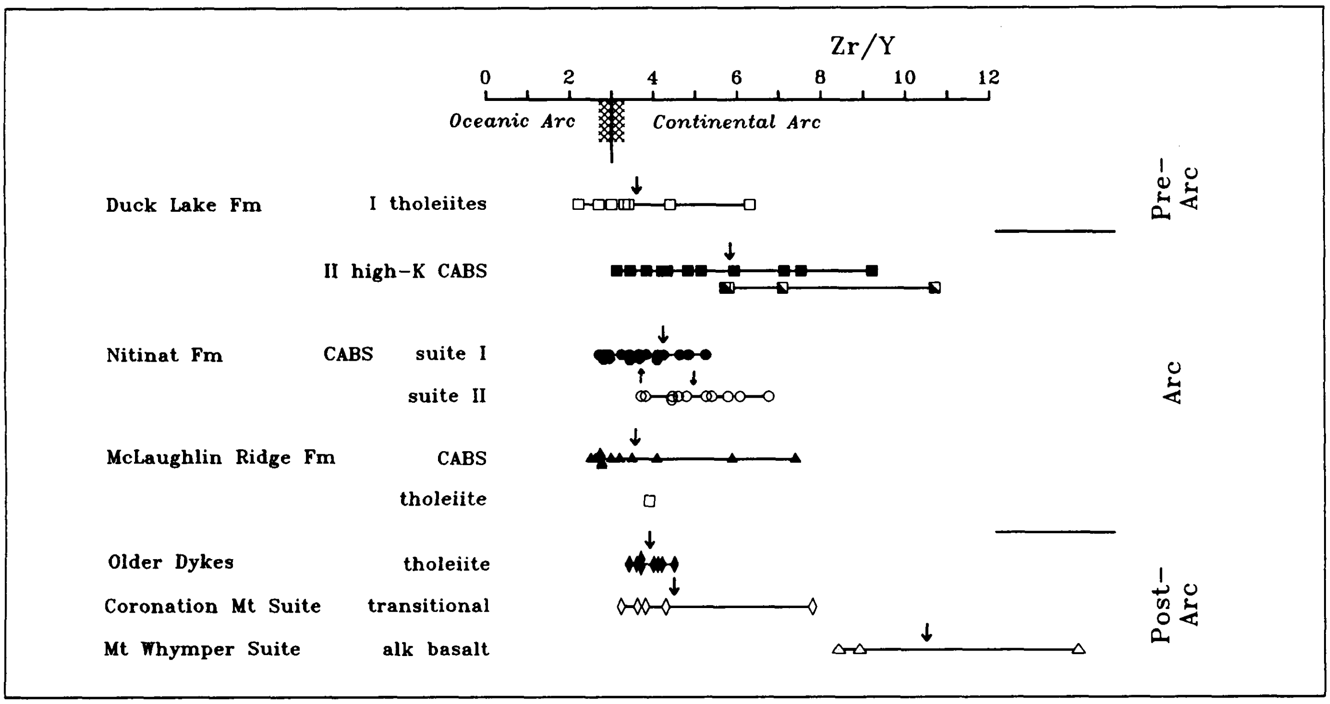


Figure 16. Zr/Y ratios in magmas of the Sicker arc. Oceanic-continental arc division from Pearce (1983). Range of data is plotted for each magma suite and formation; samples with yttrium below detection limit are omitted. The large arrow above the range designates the average ratio for the formation (or suite for the Duck Lake Formation); smaller arrows for the Nitinat Formation designate the average ratios for the separate suites. Duck Lake tholeiites are considered to represent the pre-arc oceanic substrate; the upper Duck Lake, Nitinat and McLaughlin Ridge formations to constitute the Sicker arc; and the older dikes and Fourth Lake volcanics to represent late or post-main-arc activity.

radiogenic lead enriched isotope charateristics similar to those observed in Sicker Group rocks, without the need for involvement of continental sediment.

## BUTTLE LAKE GROUP

The Buttle Lake Group comprises a dominantly epiclastic and limestone sedimentary package ranging from Mississippian to Early Permian in age. Within the Cowichan Lake area, as elsewhere along the southwest limb of the Cowichan uplift, the Buttle Lake Group is either in fault contact with, or rests unconformably on the Sicker Group. The Fourth Lake Formation cherts lie unconformably on the Nitinat Formation in the Dixie Lake, Widow Creek - Sherk Lake and Hill 60 Ridge areas. Mount Mark Formation limestone directly overlies the volcanics of the Sicker Group at Marble Bay and on Fairservice Ridge. In contrast, in the Rheinhart Creek - Chipman Creek area, on the northeast limb of the Cowichan uplift, McLaughlin Ridge Formation volcanics pass conformably upward into cherty sediments of the Fourth Lake Formation (Plate 13).

### FOURTH LAKE FORMATION

Referred to as the "Cameron River Formation" during earlier stages of the mapping.

South of the Chemainus River, the base of the sedimentary unit is marked by a sequence of radiolarian ribbon cherts, laminated cherts and cherty siltstones with thin argillite interbeds, 100 to 200 metres thick, informally called the Shaw Creek member (Plate 14). This is the only marker unit in the Paleozoic rocks of the area. The lower part of the sequence consists of grey, red and green ribbon cherts that contain visible conodonts and abundant radiolarians in the Shaw Creek and Sherk Lake areas. The conodonts indicate an early Mississippian age. Up-section, the clastic component in the cherts increases, although radiolarians are still found.

In the Sherk Lake and Mount Franklin areas, the Shaw Creek member passes upwards into monotonous thinly bedded, sometimes cherty, turbiditic sandstone-siltstone-argillite intercalations that exhibit graded bedding, flame structures, argillite rip-ups, small-scale sandstone dikes and slump folds (Plates 15 and 16). Thicker beds of sandstone, granule sandstone, breccia and conglomerate, containing clasts of cherty material, volcanic-derived lithic clasts and feldspar and pyroxene crystals, are found to the south of the Chemainus River.

A fault-bound block near Mount Franklin comprises well-bedded crinoidal calcarenites and calcirudite with volcanic and chert clasts (Plates 17 and 18). Chert and cherty sediments occur as interbeds and also overlie the limestone. These outcrops may represent the uppermost part of the Fourth Lake Formation, correlative with interbedded limestone and argillite in the Cameron River

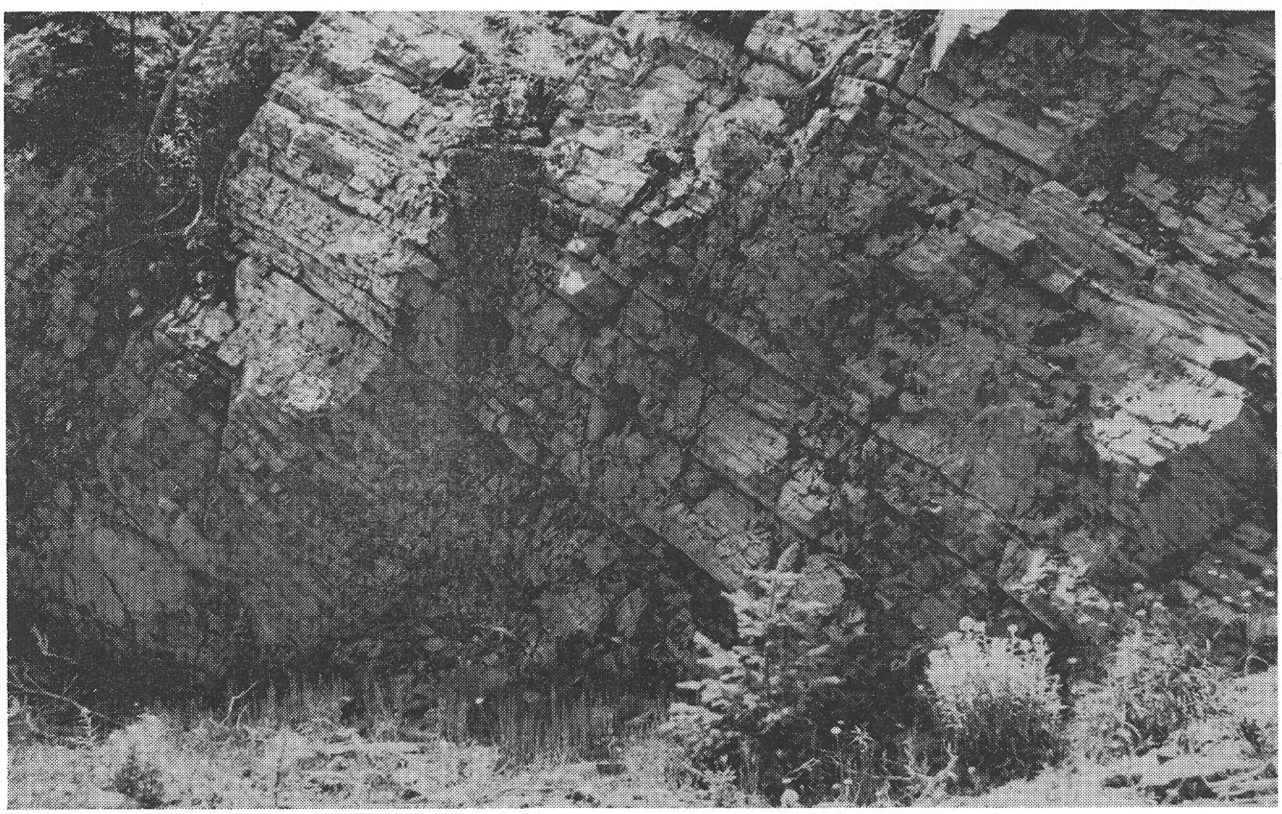

Plate 14. Radiolarian ribbon cherts of the Shaw Creek chert member, Fourth Lake Formation. This outcrop yielded visible conodonts (logging road S10, ridge between west and north Shaw Creeks; NMA86-19-08: 5426842N; 395633E).

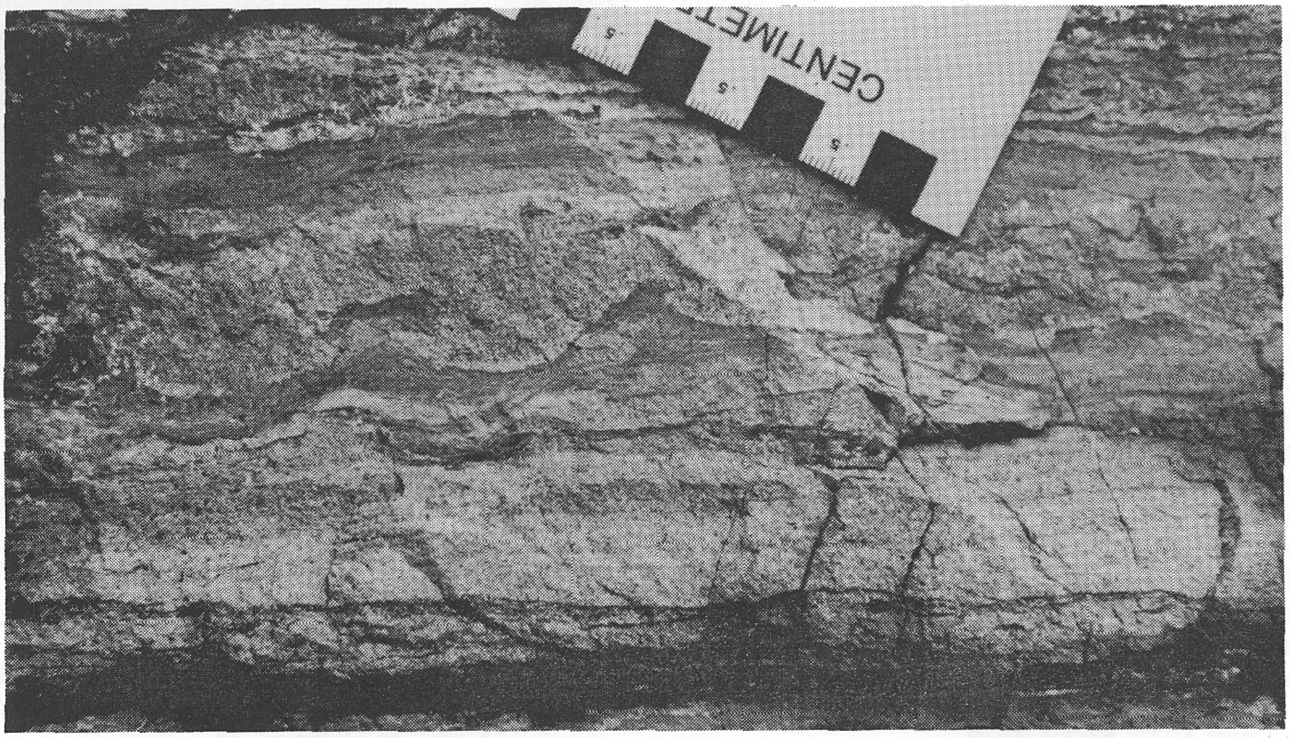

Plate 15. Flame structures in graded and laminated turbiditic sandstone-siltstone, Fourth Lake Formation (north Shaw Creek; NMA86-08-02: 5429325N; 396856E).

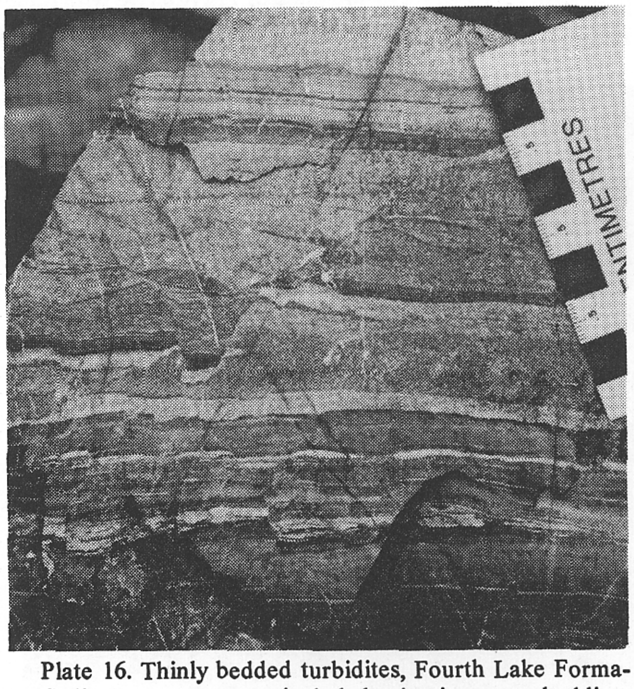

Plate 16. Thinly bedded turbidites, Fourth Lake Formation. Sedimentary structures include laminations, crossbedding, grading and load structures (Widow Creek - Meade Creek area, NMA86-37-08: 5417677N; 413303E).

(92F/2, Massey 1995b) and Separation Point areas (92B/13, Massey 1995a).

The ribbon cherts are absent north of the Chemainus River, where thinly bedded turbiditic clastic sediments conformably overlie the McLaughlin Ridge volcanics and dominate the sequence. The thinly bedded sediments are intruded by numerous thick gabbroic dikes and sills of late Triassic age and were informally termed the "sediment-sill unit" by Muller (1980).

The polarity of the Sicker arc is not suggested in the geochemical data from Sicker Group volcanics. However, the sedimentary facies of the lower Fourth Lake Formation may resolve this problem. The radiolarian cherts of the Shaw Creek member, sitting unconformably on the Sicker Group volcanics, probably developed on the open-ocean side of the arc. In contrast, the conformable, clastic-dominated sediments found on the northeast limb of the Cowichan uplift appear to have accumulated in the marginal basin adjacent to and behind the arc. As erosion proceeded, clastic sediment was shed to both sides of the extinct arc and buried it.

Minor volcanism was synchronous with early Fourth Lake Formation sedimentation in the Mount Whymper - Rheinhart Creek area. Aphyric basalt forms amygdaloidal flows, up to 3 metres thick, interbedded with cherts and cherty sediments (Plate 19). The basalts are lithologically distinct from the thicker, more massive, coarser grained, Late Triassic gabbros and diabase dikes of the area. A similar dark green, vesicular pillowed basalt flow occurs within hornfelsed, thinly bedded sandstone-siltstone in a roadcut on the north slope of Chipman Creek, about 3 kilometres west of Coronation Lake in the adjacent Duncan map area (Massey 1995a, Massey *et al.*


Plate 17. Well bedded crinoidal calcirudite, upper Fourth Lake Formation. Silicified crinoidal clasts together with chert and cherty sediment in calcareous matrix (south slope of Mount Franklin; NMA86-48-12: 5417375N; 414946E).


Plate 18. Laminated and graded crinoidal calcarenite, upper Fourth Lake Formation (southwest slope of Mount Franklin; NMA86-38-06: 5417364N; 414664E).

1988). Olive-green, amygdaloidal, aphyric dacitic flows are interbedded with maroon and green chert, jasper, magnetite-jasper and cherty sediments near Pat Lake, about 2 kilometres east-northeast of Mount Whymper.

This "Mount Whymper suite" of volcanics differs markedly in chemistry from any of the Sicker Group volcanics or the possibly contemporaneous suites such as the older dikes or Coronation Mountain suite. The basalts are undersaturated, with normative mineralogy suggesting olivine tholeiite, whereas immobile trace elements point to a more alkalic chemistry. The flows are enriched in both compatible and incompatible trace elements (Figure 7) and have a within-plate affinity on petrotectonic discriminant plots (Figures 10 - 15). The dacites from Pat Lake are similarly enriched in incompatible trace elements with relative depletions of strontium, phosphorus and titanium probably due to fractionation of plagioclase, apatite and magnetite. The Mount Whymper suite is believed to have formed at the propagating tip of a back-arc basin rift, with its more mature products including the volcanics of the Thelwood and Flower Ridge formations of the Buttle Lake uplift (*see* above).

## Mount Mark Formation

Outcrops of the Mount Mark Formation limestones are not common in the Cowichan Lake area. Bioclastic

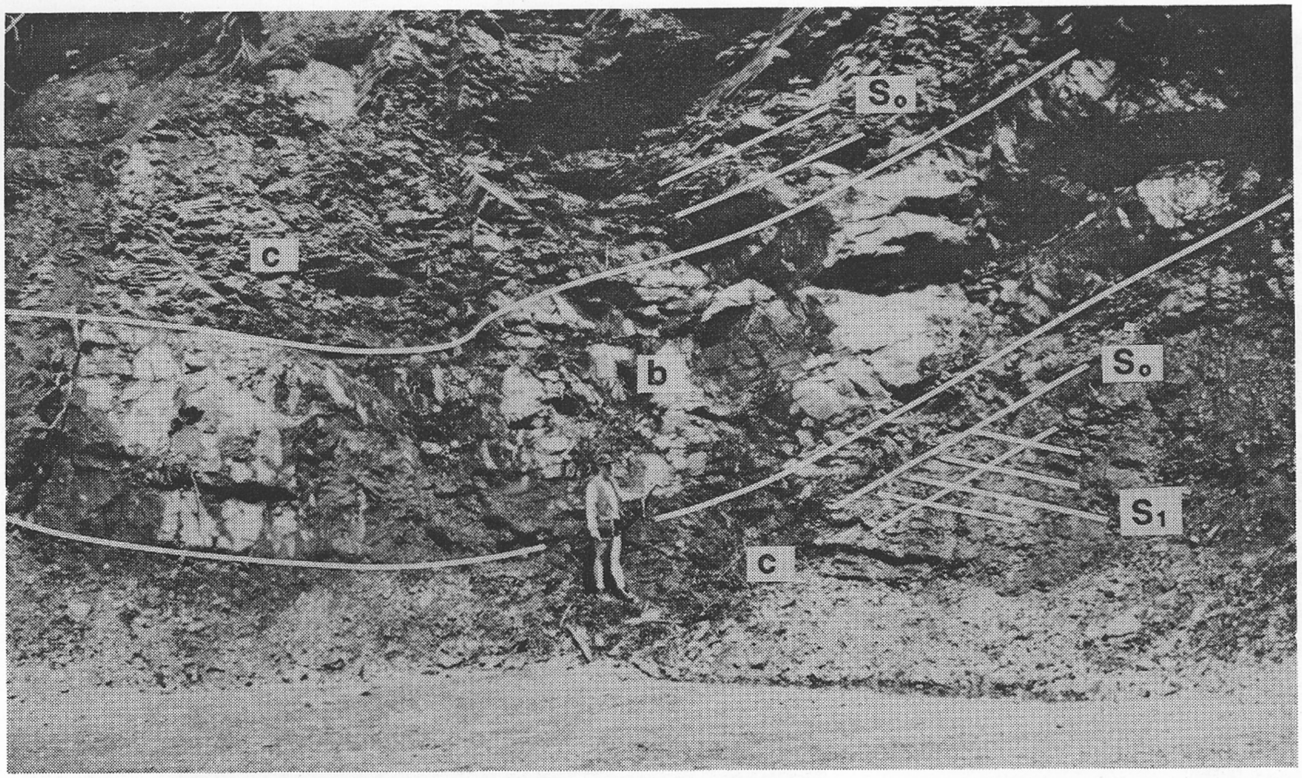


Plate 19. Vesicular massive basalt flow (b) of the alkalic Mount Whymper volcanic suite interbedded with cherts and cherty sediments (c) of the Fourth Lake Formation. S0: bedding in cherts; S1: cleavage (logging road C19G, Chemainus River, east of Mount Whymper; NMA87-08-10: 5421690N; 417524E).

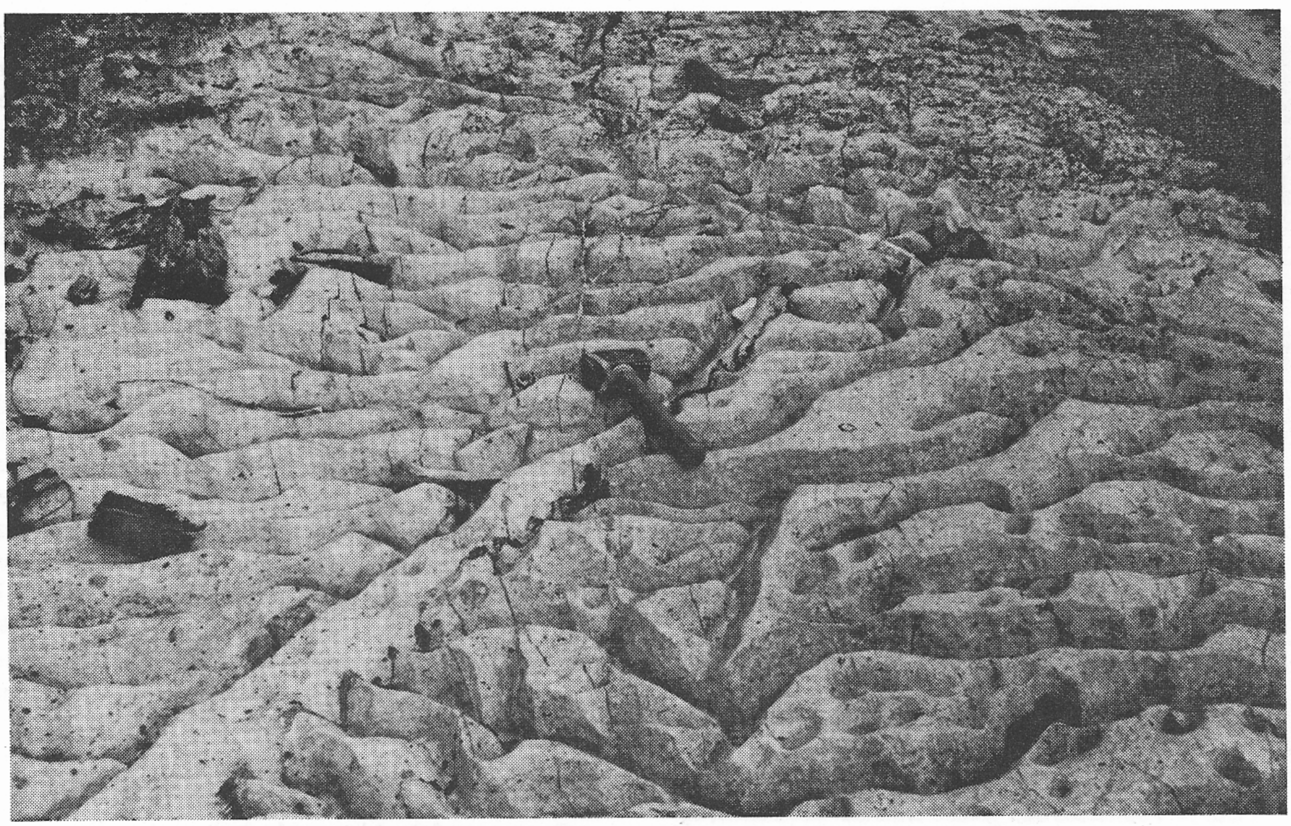

Plate 20. Rillen developed on massive crinoidal limestone of the Mount Mark Formation (south shore, North Arm, Cowichan Lake; NMA86-63-09: 5411976N; 413962E).

calcarenites, with porcellaneous micrite and tuffaceous limestone interbeds, occur on the north side of Bald Mountain (Plate 20) and in Marble Bay, where they are directly overlain by Karmutsen Formation basalts. Massive to well-bedded crinoidal limestones and thinly bedded black cherts occur on Fairservice Mountain and have been described in some detail by Yole (1964).

Flat-lying beds of grey limestone, grading into green calcareous sediments, were reported by Fyles (1955) beneath Triassic basalts in the Mount Landale and Mount Service area. The stratigraphic position of these limestone units is uncertain. They are tentatively assigned to the Mount Mark Formation, but their association with cherty sediments suggests they may be limestone interbeds in the upper part of the Fourth Lake Formation, as seen on Mount Franklin.

### Biostratigraphy of the Buttle Lake Group

Detailed study of the biostratigraphy of the Buttle Lake Group has not yet been undertaken. However, enough regional data have accumulated from various investigators to indicate the broad age relationships (Appendix 5). The bulk of the Fourth Lake Formation is clastic in nature and unfossiliferous. However, its age can be bracketed by fossiliferous units at the top and bottom of the formation. The ribbon cherts of the Shaw Creek member have yielded a rich conodont fauna which indicates an early Mississippian age. Radiolaria, though often poorly preserved in the cherts, support a Mississippian age. This is only slightly younger than the upper parts of the Late Devonian McLaughlin Ridge Formation, despite the unconformable contact with the Sicker Group along the southwestern limb of the uplift. No fossils have been found in the basal cherty sediments on the northeastern limb, which are in conformable contact with the volcanic rocks, and it is not known whether or not they are older than the Shaw Creek cherts. Limestone-argillite interbeds in the upper parts of the Fourth Lake Formation contain a middle to late Pennsylvanian conodont fauna. The lack of both fossil data and distinctive lithological marker horizons makes it impossible to determine if sedimentation in the Fourth Lake Formation was continuous during the Carboniferous or possibly punctuated by one or more nondepositional interludes.

The base of the Mount Mark Formation is time transgressive. In the Alberni area, the limestones yield conodont and macrofossil faunas that range from Middle to Late Pennsylvanian at the base, up to Early Permian in higher beds. The basal layers are thus time equivalent to the upper Fourth Lake limestone-argillite interbeds of the Cowichan and Duncan areas. The contact between the two formations is interpreted as being a major facies boundary which migrated eastwards through time. Massive limestones of the Mount Mark Formation in the eastern part of the uplift contain Early Permian macrofaunas but supporting conodont data are lacking.

## VANCOUVER GROUP

Rocks of the Upper Triassic Vancouver Group outcrop both north and south of Cowichan Lake. They form the core of the Seymour Range anticline in the south and Karmutsen Formation basalts unconformably overlie the Paleozoic sequences north of Cowichan Lake, in the Mount Franklin, Mount Whymper and Mount Landale - El Capitan areas. The group is subdivided into a thick, lower volcanic package (Karmutsen Formation) and a thin, upper sedimentary package (Quatsino and Parson Bay formations). The sediments are equivalent to the lower Kunga Group of the Queen Charlotte Islands. Biostratigraphic data indicate that the Vancouver Group in the map area is predominantly Carnian in age, though the Parson Bay Formation may extend into the early Norian (Appendix 5). However, the Sutton limestone member of the Parson Bay Formation contains late Norian macrofossils and conodonts, suggesting a hiatus in deposition in the early to middle Norian, perhaps due to emergence.

### Karmutsen Formation

The Karmutsen Formation consists essentially of basaltic flows (Plate 21) that typically weather orange-brown. They generally form rounded bluffs and hills. Pillowed and massive flows occur interbedded, though there is a tendency for massive flows to be dominant toward the top of the formation and pillowed flows in lower parts. Hyaloclastite, hyaloclastite breccia and pillowed breccia occur within pillowed sections, often forming the tops of flow units (Plate 22). Hyaloclastite breccia may also be interbedded with massive flows. Lithologically the flows are dark grey, variably feldspar-phyric basalts. Feldspars are typically clumped and rarely single crystals. Coarser glomeroporphyritic "daisy-stone" flows and hyaloclastite breccia are commonly seen at the top of the pile (Plate 23). Nearly all flows are amygdaloidal and are infilled with chlorite, calcite, epidote or rare pumpellyite or prehnite. Drain-away ledges are occasionally preserved within pillows (Plate 24). The total thickness of the Karmutsen Formation in the area is difficult to estimate but is believed to be at least 2500 metres.

The geochemistry of the Karmutsen Formation lavas of the Cowichan uplift, and associated gabbros and diabases of the Mount Hall gabbro, shows that they formed from a iron-titanium-enriched tholeiitic magma. They are similar in composition to other Karmutsen lavas and Late Triassic intrusions on Vancouver Island (Barker *et al.*, 1989; Kuniyoshi, 1972). Extended trace-element diagrams of this "standard suite" show moderate enrichments in niobium and the light rare-earth elements (Figure 17). Lanthanum may be even more enhanced in more altered

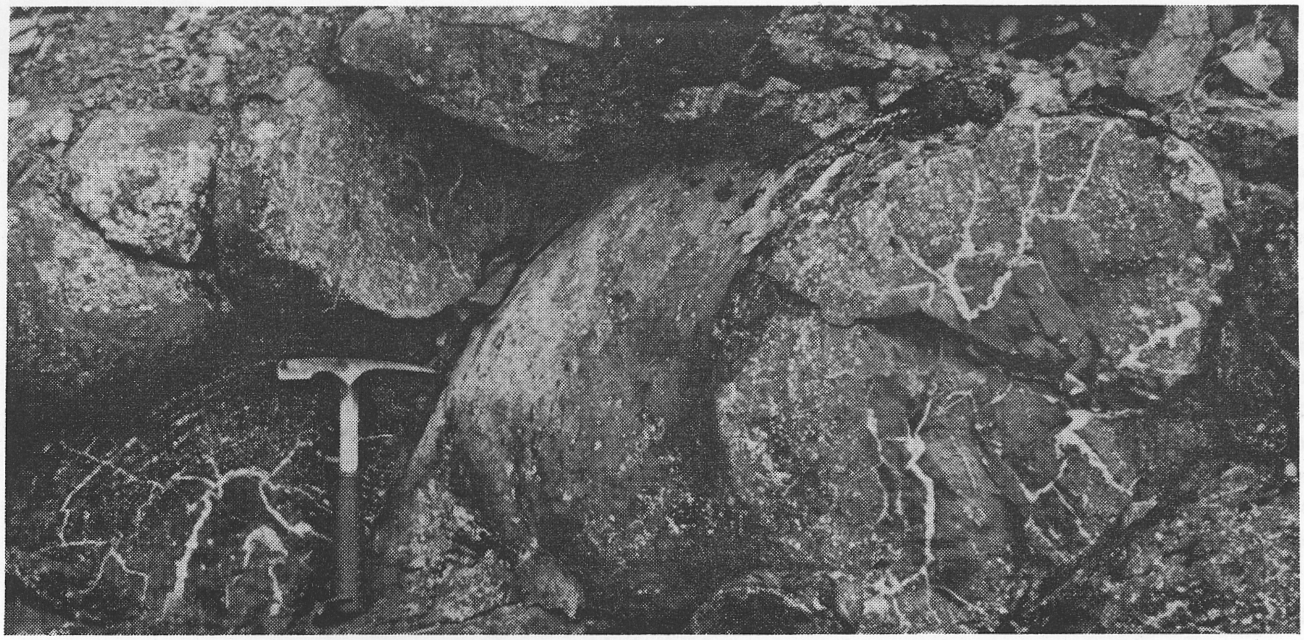

Plate 21. Lava tubes and pillows with concentric zones of amygdules and radial cooling cracks, Karmutsen Formation (logging road C11, about 4 km west of Towincut Mountain; PTE86-33-04: 5408280N; 394398E).

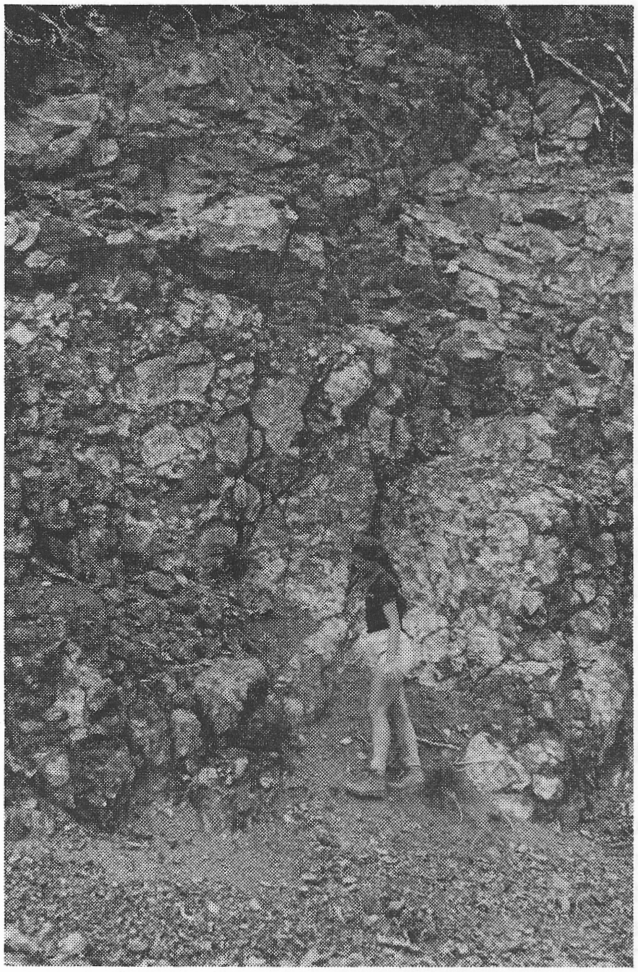

Plate 22. Pillowed basalt, at base of rock-cut, passes upwards into isolated pillow breccia with hyaloclastite matrix (centre-left of photo), Karmutsen Formation (logging road M4, about 3 km southwest of Towincut Mountain; SFR86-42-06-1: 5406928N; 395308E).

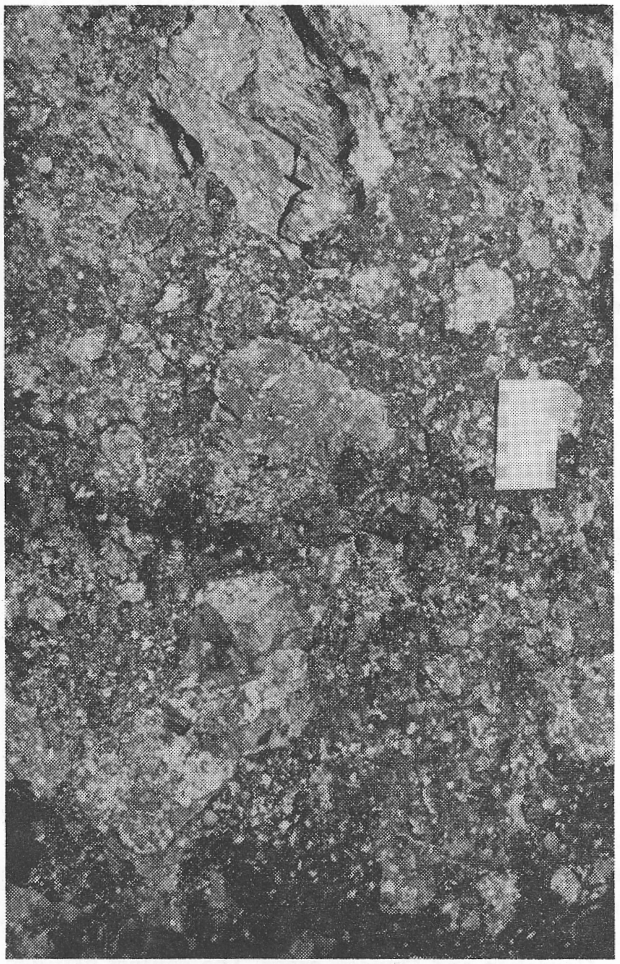

Plate 23. Glomeroporhyritic hyalocastite breccia, Karmutsen Formation. Daisy-like feldspar clusters are developed both in clasts and within the glassy matrix material (truck road 7, Seymour Range, NMA86-31-07. 5401726N; 409471E).

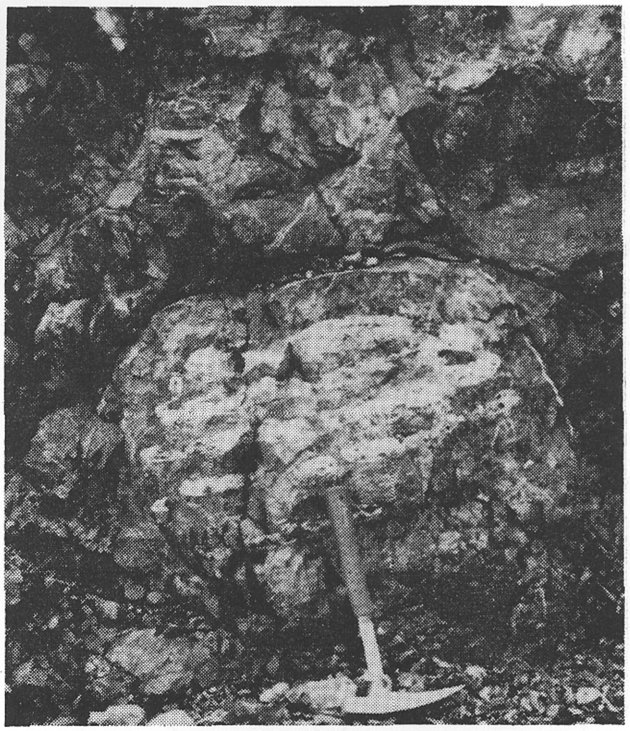

Plate 24. Carbonate filled horizontal cavities produced by lava drain-away in lava tube in pillowed basalt, Karmutsen Formation (R branch, Heather Mountain; JRU86-02-16: 5421824N; 392707E).

samples, along with relative depletions and enrichments of potassium, rubidium and barium. The major elements illustrate the tholeiitic character of the magma (Figures 18 and 19) while trace-element patterns and discriminant diagrams (Figures 20 - 26) suggest an affinity to an enriched mid-ocean ridge basalt or continental tholeiite. These geochemical characteristics, coupled with the large areal extent and thickness of the Karmutsen Formation, its essentially basaltic character, the pillow and massive flow dominated lithofacies, short duration of formation (entirely within the Carnian, about 6 Ma), suggest that the Karmutsen Formation formed in an oceanic flood-basalt province.

A subset of samples is marked by much lower niobium contents (Figures 17 and 24). Extended trace-element patterns are either flat or depleted to the left of niobium (Figure 17) or may even show a marked negative niobium anomaly where potassium and rubidium are high. This suite also tends to have lower titanium, zirconium and yttrium and higher strontium, although there is much overlap and the two suites cannot be distinguished on most geochemical diagrams (Figures 18 - 23, 25 and 26). The low-niobium suite is found in massive and pillowed flows south of Caycuse and in intrusions between Meade Creek and the Chemainus River, from about

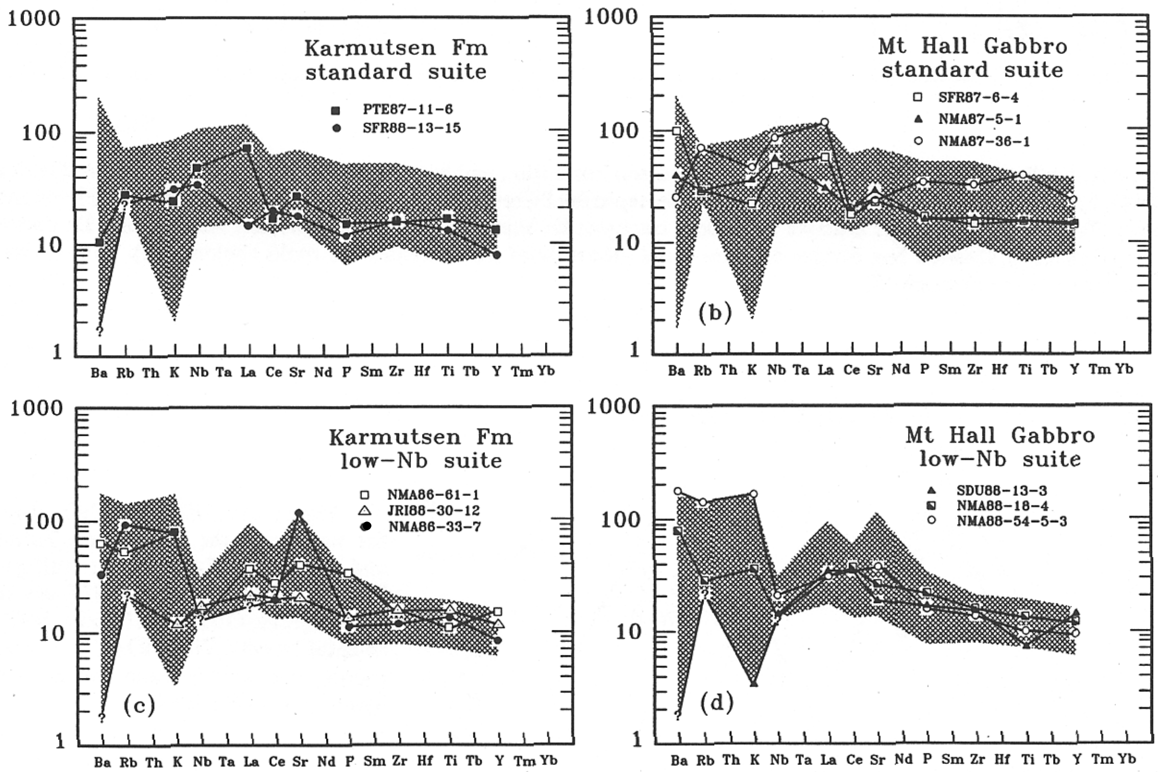


Figure 17. Normalized trace-element plots for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Normalizing values after Thompson *et al.*, 1983. Shaded area represents the range of values for all samples of a particular suite in the Sicker Project area. Selected representative samples are shown individually: (a) Karmutsen Formation, standard suite; (b) Mount Hall gabbro, standard suite; (c) Karmutsen Formation, low-niobium suite; (d) Mount Hall gabbro, low-niobium suite.

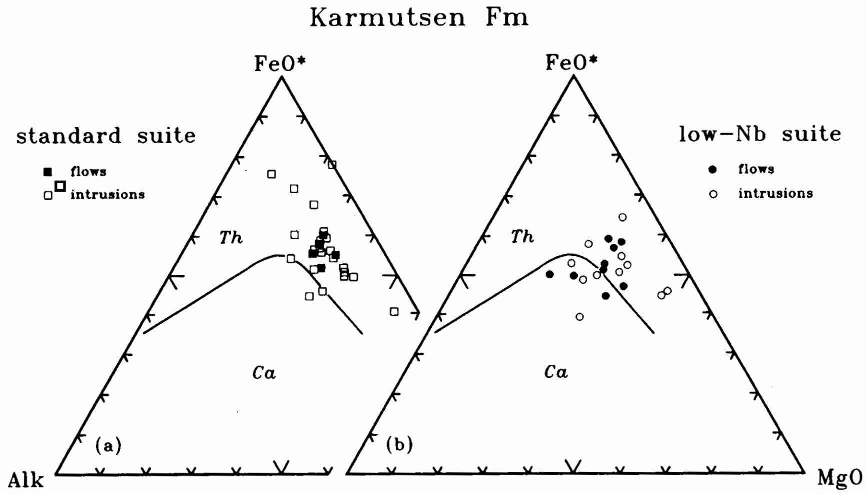


**Figure 18. AFM triangle diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Tholeiite (Th) - calcalkaline (Ca) dividing line after Irvine and Baragar (1971). Alk = $Na_2O + K_2O$; $FeO^*$ = total iron as FeO.**

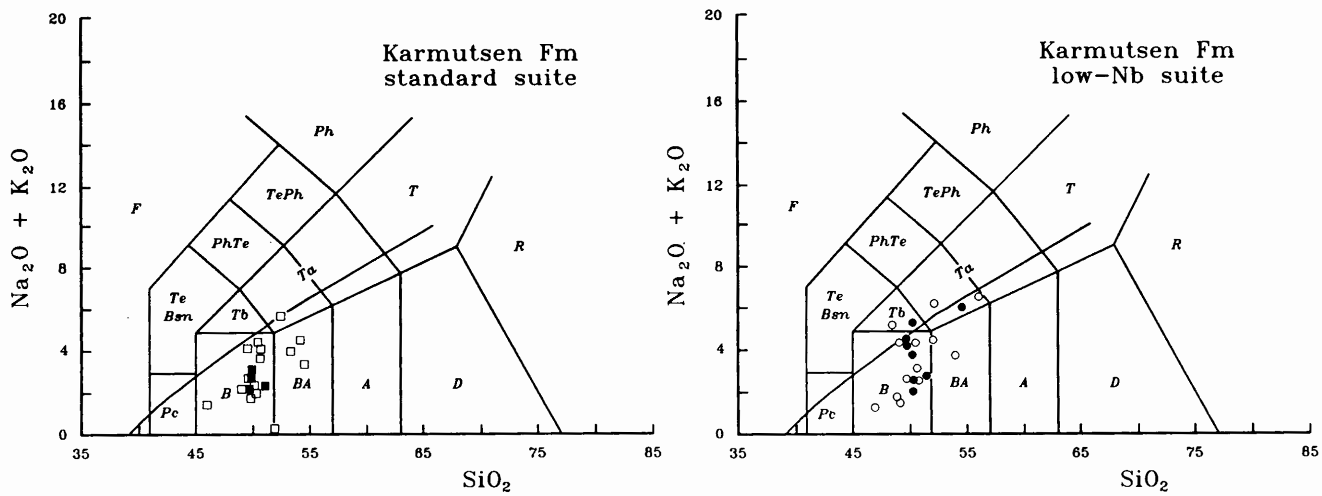


Figure 19. Alkali-silica diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Le Maitre (1984); F: foidites; Pc: picrobasalt; Bsn: basanite; Te: tephrite; PhTe: phonotephrite; TePh: tephriphonolite; Ph: phonolite; Tb: trachybasalt; Ta: trachyandesite; T: trachyte and alkali trachyte; B: basalt; BA: basaltic andesite; A: andesite; D: dacite; R: rhyolite and alkali rhyolite. Dashed line divides alkaline rocks (above line) from subalkaline rocks (below line), after Irvine and Baragar (1971). Symbols as in Figure 18.

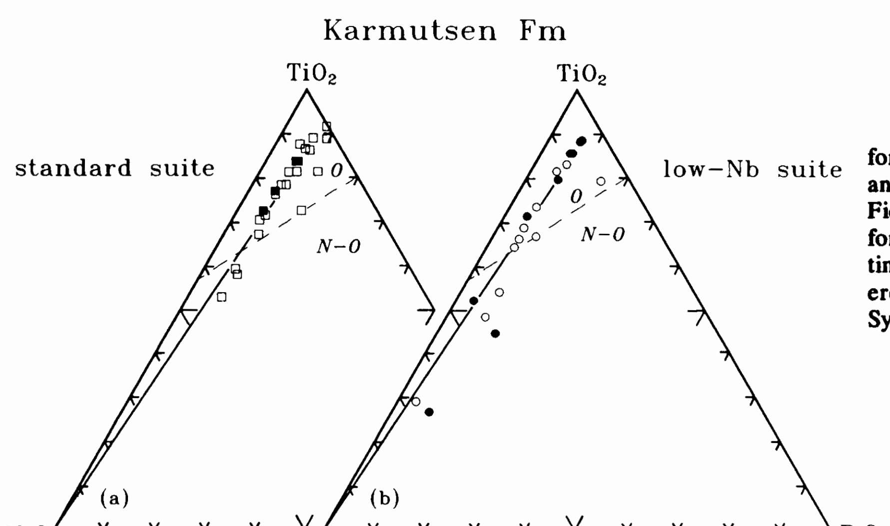


Figure 20. $TiO_2$-$K_2O$-$P_2O_5$ diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Pearce *et al.* (1975) are shown for reference; O: oceanic basalts; N-O: continental basalts. The $TiO_2/P_2O_5$ ratio reference line is the same for both plots. Symbols as in Figure 18.

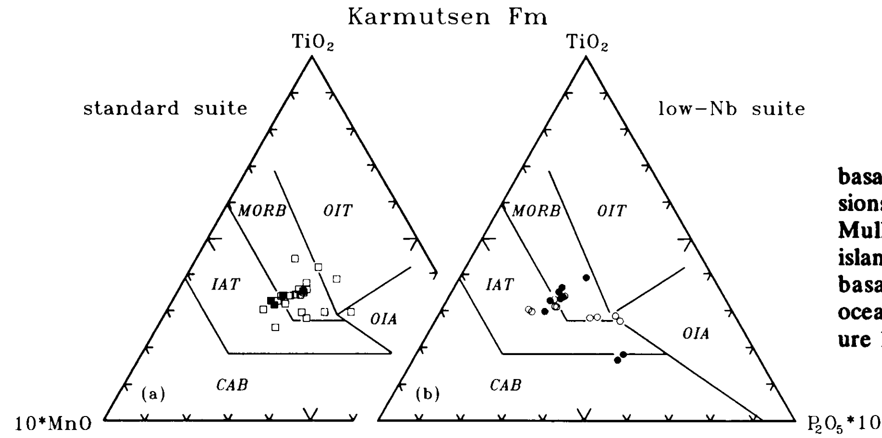


**Figure 21.** $TiO_2$-MnO-$P_2O_5$ **diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Mullen (1983); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; OIT: ocean-island tholeiites; OIA: ocean-island alkalic basalts. Symbols as in Figure 18.**

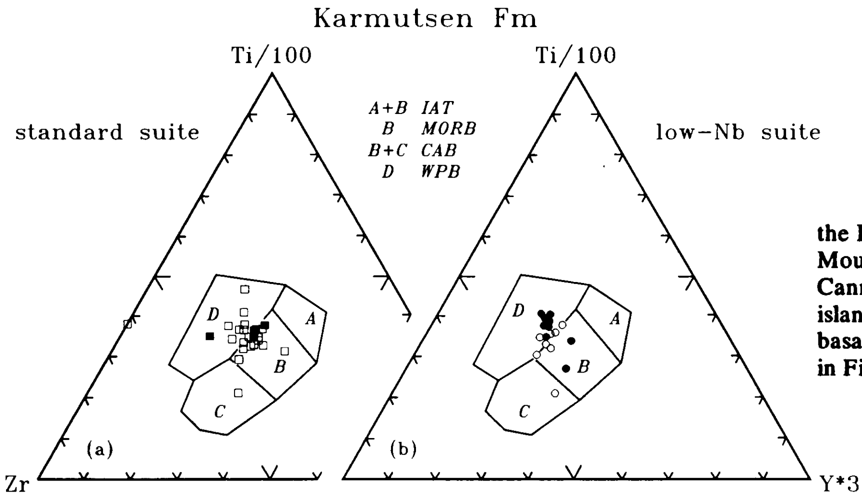


**Figure 22. Ti-Zr-Y diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; WPB: within-plate basalts. Symbols as in Figure 18.**

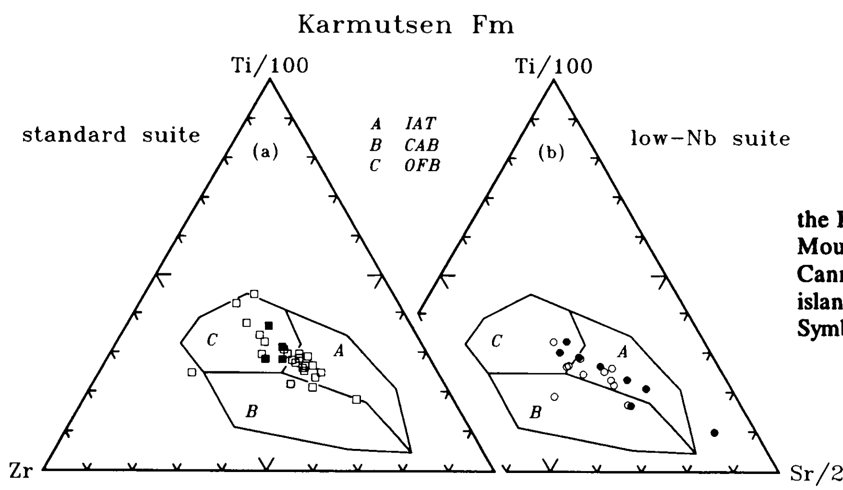


**Figure 23. Ti-Zr-Sr diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 18.**

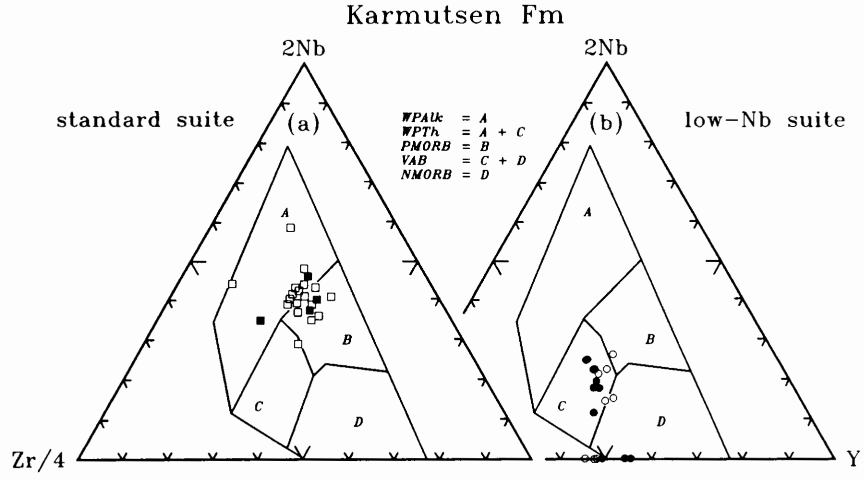


**Figure 24. Nb-Zr-Y diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Menschede (1986); WPAlk: within-plate alkalic basalt; WPTh: within-plate tholeiite; PMORB: plume-type or enriched mid-ocean ridge basalts; NMORB: normal mid-ocean ridge basalts; VAB: volcanic arc basalts (tholeiites). Symbols as in Figure 18. Data points on the Zr-Y margin of the triangle have Nb values below detection limit.**

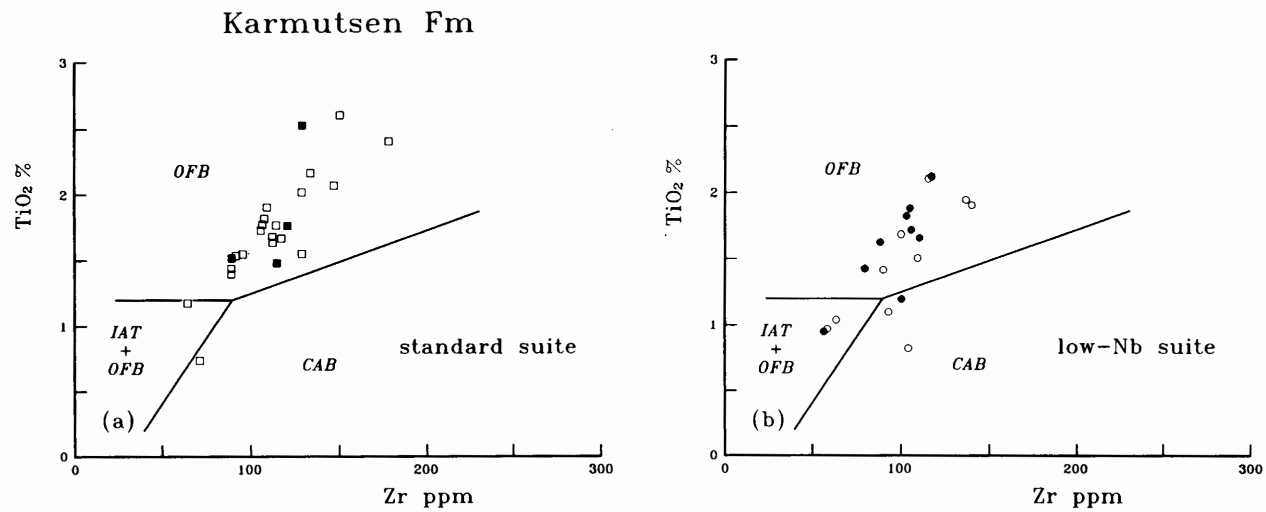


**Figure 25. $TiO_2$-Zr diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Garcia (1978); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 18.**

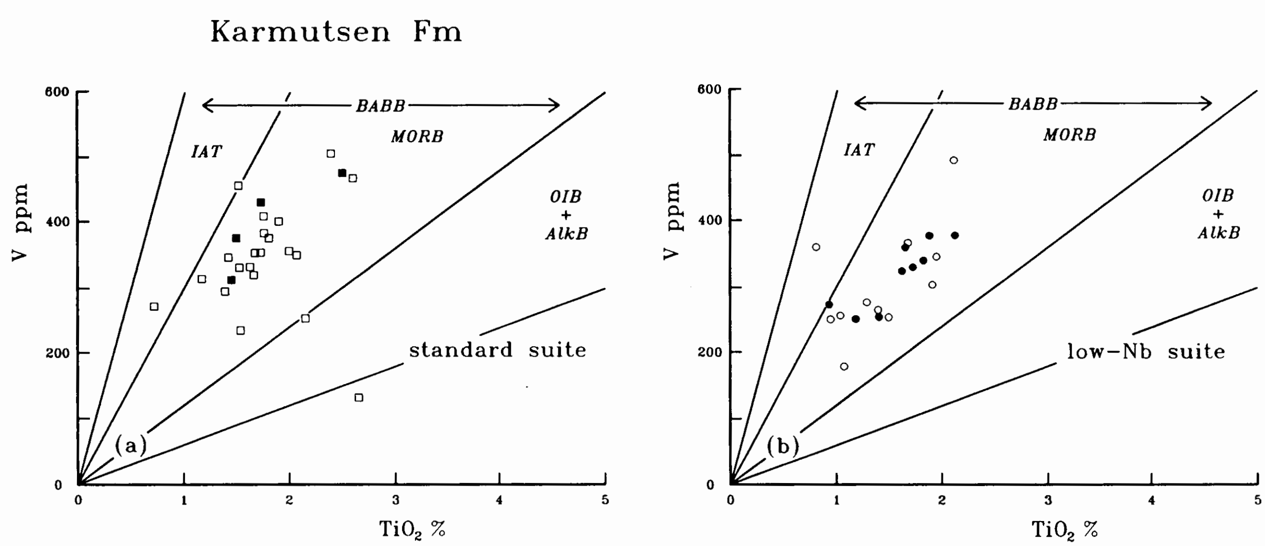


**Figure 26. $TiO_2$-V diagrams for basalts of the Karmutsen Formation and intrusions of the Mount Hall gabbro. Fields after Shervais (1982); IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; BABB: back-arc basin basalts; OIB: ocean-island basalt; AlkB: alkalic basalt. Symbols as in Figure 18.**

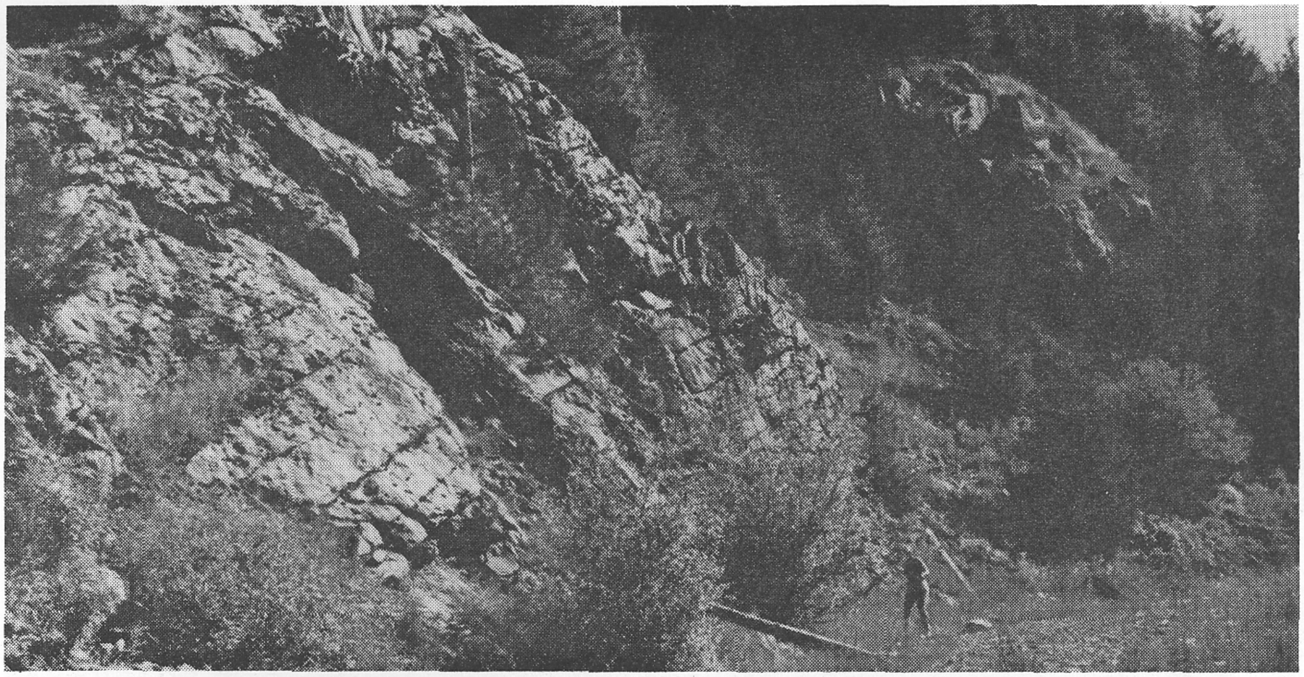

Plate 25. Thickly bedded micrite, Quatsino Formation (logging road M13, 3 km east of McClure Lake; PTE86-30-03: 5402876N; 395235E).

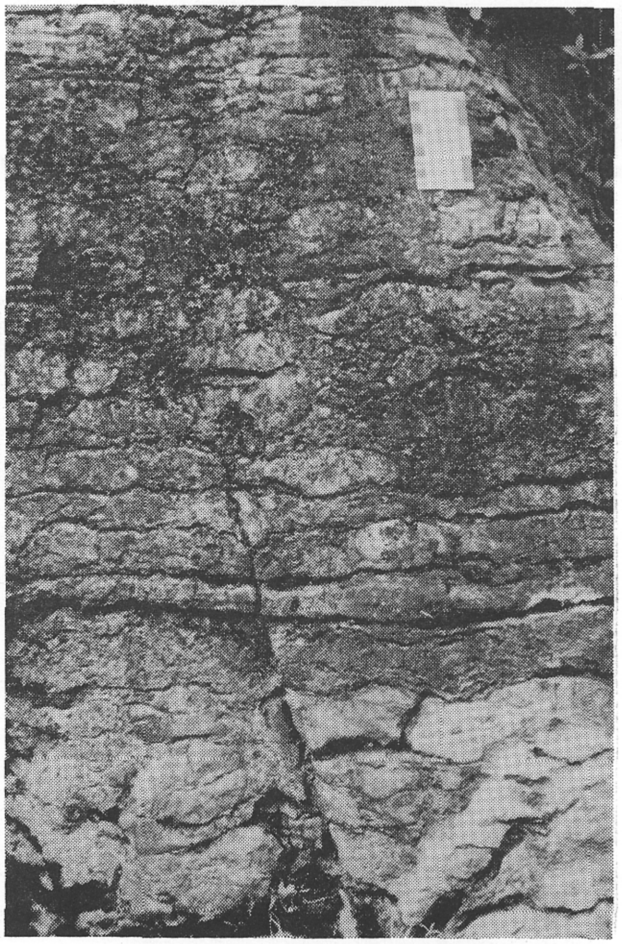

Plate 26. Thin-bedded micrite, Quatsino Formation (west end of Ashburnham Main; NMA86-33-14; 5405859N; 406272E).

Sherk Lake to Hill 60. In contrast, flows and intrusions of the standard suite appear to occur only to the north of the Chemainus fault. More rigorous sampling is needed, however, to sufficiently determine the full areal extent of the two suites both within the map area and to the west.

## Quatsino Formation

The Quatsino Formation is characterized by massive, thickly bedded, micritic limestone (Plate 25). It is fine grained, black in colour and often cut by a dense network of white, sparry calcite veins. Weathered surfaces are grey and rough in texture due to secondary silica veinlets. Karst landforms are well developed. Except for microfossils, the micritic limestone is essentially unfossiliferous, but bioclastic micrite, oolitic limestone, calcirudite and calcarenite may occur locally (Plates 26 and 27).

The contact between the Karmutsen and the Quatsino Formations is often transitional with micritic limestones interbedded with massive flows and hyaloclastite breccias containing limestone clasts (Plate 28). A distinctive brick-red tuffaceous breccia or tuffaceous sandstone underlies the lowermost limestone in the Caycuse area. About 7 kilometres east of Gordon River, Quatsino limestone rests unconformably on the side of a hillslope of Karmutsen basalt, perhaps having formed around an originally emergent basaltic island. Apparently conformable limestone occurs towards the top of the hill. The Quatsino Formation is estimated to be no more than 75 metres thick, averaging 25 to 40 metres (Figure B - in pocket). It may be absent in some areas.

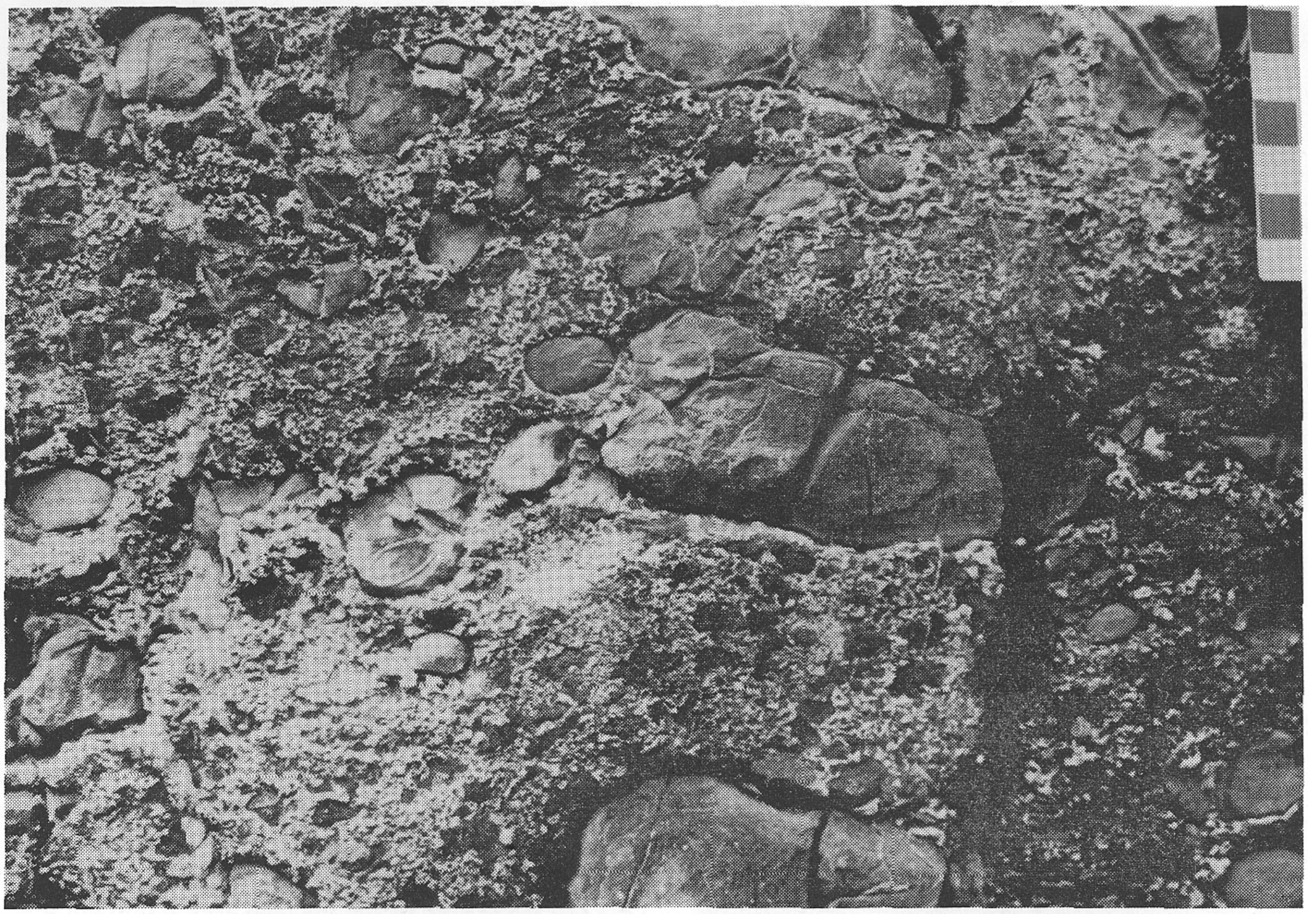

Plate 27. Bedded calcirudite, Quatsino Formation. Note bivalve in clast just left of centre (west end of Ashburnham Main; NMA86-34-04-2; 5405266N; 406542E).

Plate 28. Hyaloclastite lapilli tuff with accidental clasts of micritic limestone, Quatsino Formation (logging road C5, about 8 km southwest of Caycuse; JRU86-17-04: 5411509N; 392768E).

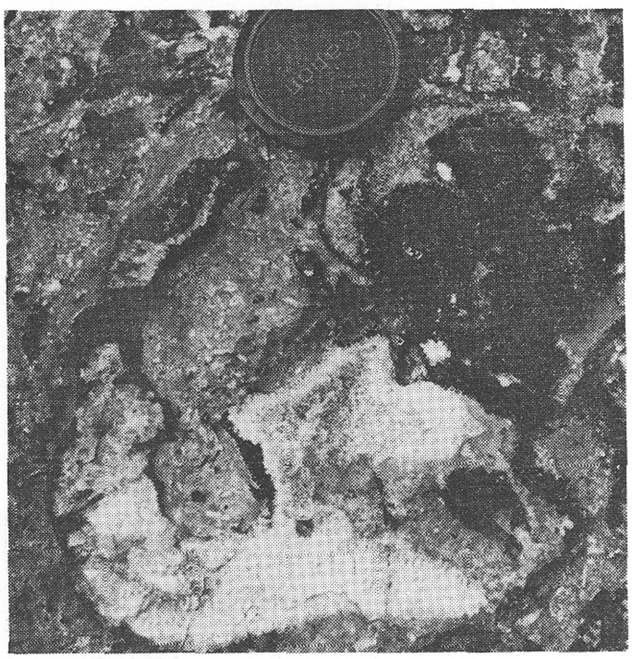

Plate 29. Flat, encrusting colonial coral, Sutton limestone member, Parson Bay Formation (south shore, Cowichan Lake; NMA86-62-05-03: 5412025N; 409615E).

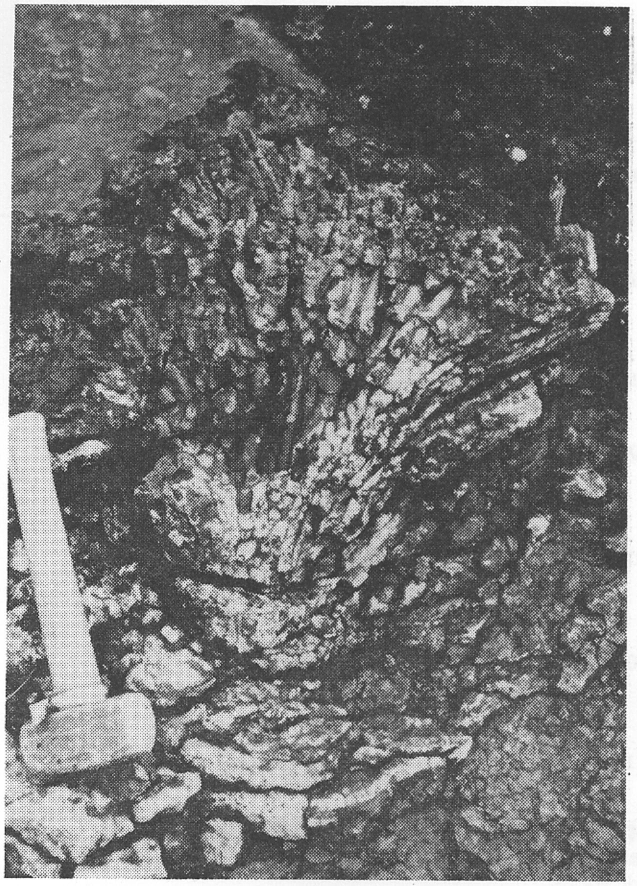

Plate 30. Branching coral (?*Retiophyllia sp.*), Sutton limestone member, Parson Bay Formation (south shore, Cowichan Lake; NMA86-62-05-03: 5412025N; 409615E).

### Parson Bay Formation

In the Caycuse area, the Quatsino Formation is immediately overlain, apparently conformably, by a sequence of thinly bedded sediments and tuffs 35 metres thick, provisionally correlated with the Parson Bay Formation (Figure B - in pocket). The lowermost unit is a pale grey to maroon tuff and tuffaceous sandstone. It is overlain by flaggy limestones and black limy argillites, with abundant ammonite, gastropod and pelecypod remains. This unit grades vertically into thinly bedded argillites with minor fossiliferous limestone interbeds.

Maroon tuffs with flaggy, sandy limestone and biohermal limestone ascribed to the Parson Bay Formation (Sutton limestone member) outcrop on the south shore of Cowichan Lake, northwest of Blue Grouse Mountain (Plates 29 and 30), where they appear to rest directly on Karmutsen Formation flows. The Sutton limestone is also exposed in Redbed Creek just west of the map area, but is otherwise absent from the area.

## BONANZA GROUP

Within the map area, the Bonanza Group overlies the Vancouver Group sediments with a slight angular unconformity, only readily detectable from the regional distribution of rock units. The unconformity cuts down section and may result in the thinning or elimination of the Parson Bay Formation.

Unlike northern Vancouver Island, where the Bonanza Group can be subdivided into a lower sedimentary Harbledown Formation and the upper "Bonanza volcanics" (Muller *et al.*, 1974; 1981), no formal subdivision is yet possible in the Cowichan Lake area. However, sedimentary beds are found interbedded with lapilli and crystal tuffs, within the basal part of the sequence. They include maroon tuffaceous sandstone (Plate 31), orange-grey sandstone, granule sandstone and conglomerate, laminated sandy tuffs and argillites, and minor limestone and chert. Several beds have yielded macrofossil remains (gastropods, pelecypods and ammonites) that are suggestive of Sinemurian to Pliensbachian ages (Appendix 5), in agreement with biostratigraphic and geochronometric

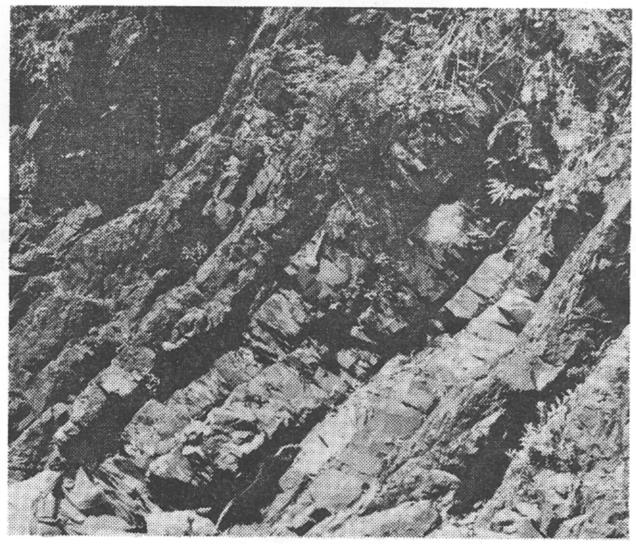

Plate 31. Bedded maroon tuffs of basal marine facies, Bonanza Group (Red Bed Creek; NMA86-12-06-5: 5422988N; 389006E).

Plate 32. Heterolithic lapilli tuff, Bonanza Group (B road, southeast of Caycuse; SFR86-50-02: 5411377N; 403602E).

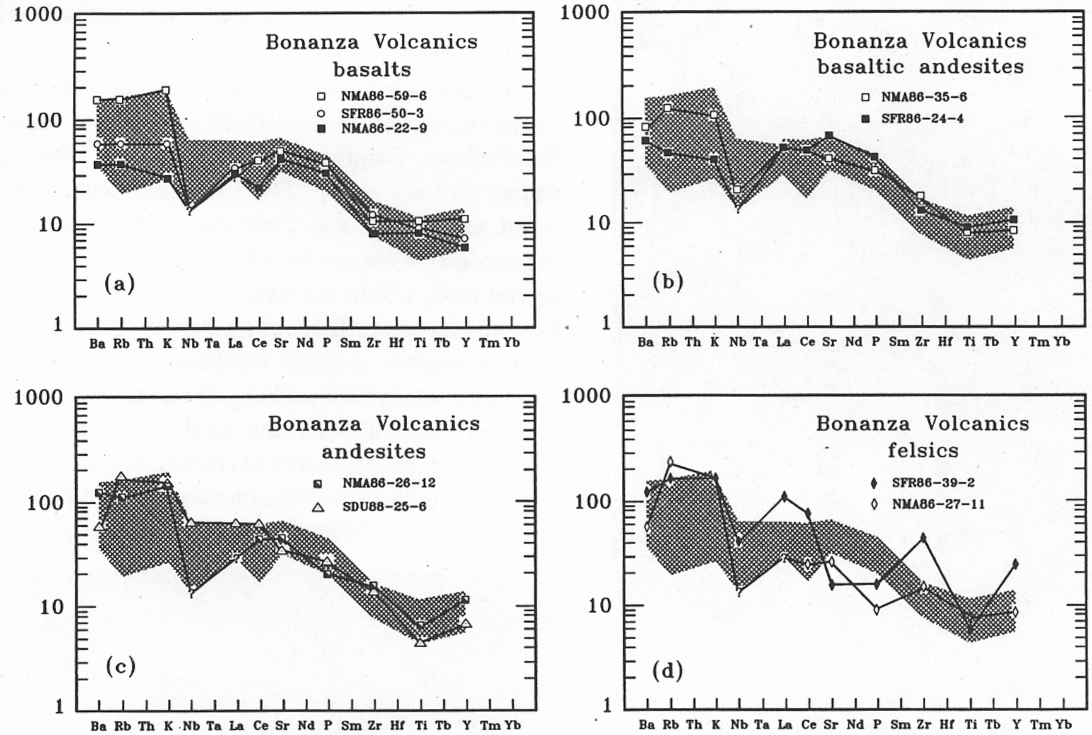


**Figure 27. Normalized trace-element plots for Bonanza Group volcanics. Normalizing values after Thompson *et al.*, 1983. Shaded area represents the range of values for all mafic to intermediate samples. Selected representative samples are shown individually: (a) basalts; (b) basaltic andesites; (c) andesites; (d) felsic rocks.**

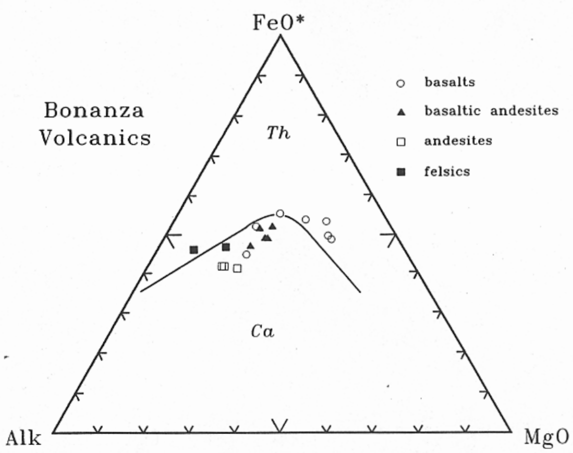


**Figure 28. AFM triangle diagram for Bonanza Group volcanics. Tholeiite (Th) - calcalkaline (Ca) dividing line after Irvine and Baragar (1971): Alk = $Na_2O$ + $K_2O$; FeO* = total iron as FeO.**

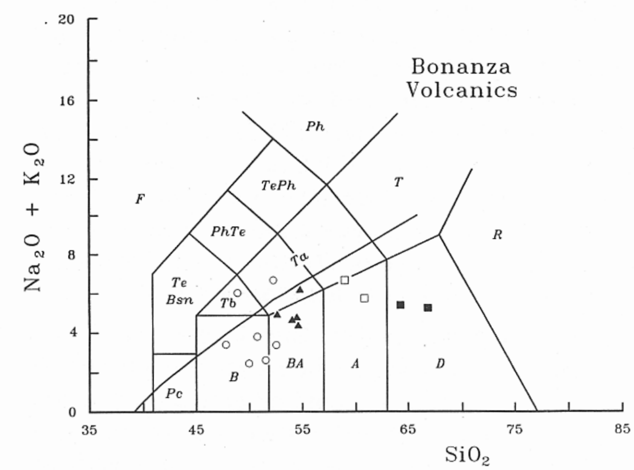


**Figure 29. Alkali-silica diagram for Bonanza Group volcanics. Fields after Le Maitre (1984); F: foidites; Pc: picrobasalt; Bsn: basanite; Te: tephrite; PhTe: phonotephrite; TePh: tephriphonolite; Ph: phonolite; Tb: trachybasalt; Ta: trachyandesite; T: trachyte and alkali trachyte; B: basalt; BA: basaltic andesite; A: andesite; D: dacite; R: rhyolite and alkali rhyolite. Sloping solid line divides alkaline rocks (above line) from subalkaline rocks (below line), after Irvine and Baragar (1971). Symbols as in Figure 28.**

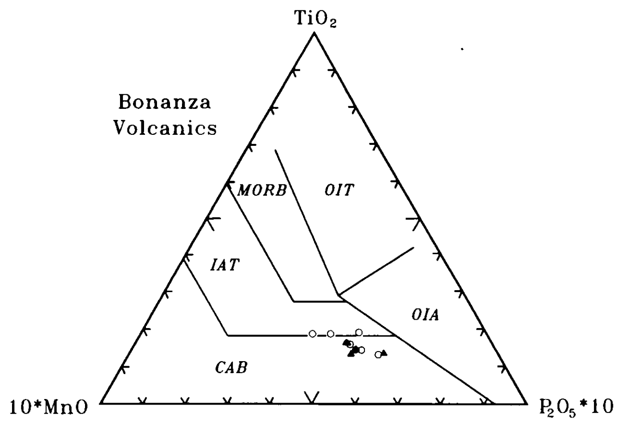


**Figure 30. $TiO_2$-MnO-$P_2O_5$ diagram for Bonanza Group volcanics. Fields after Mullen (1983); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; OIT: ocean-island tholeiites; OIA: ocean-island alkalic basalts. Symbols as in Figure 28.**

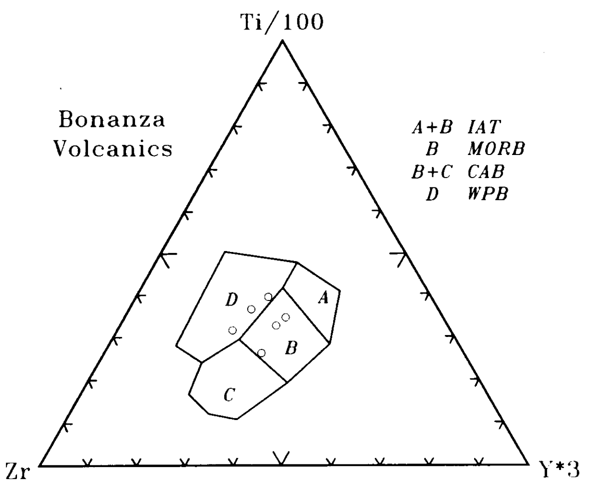


**Figure 31. Ti-Zr-Y diagram for Bonanza Group volcanics. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; WPB: within-plate basalts. Symbols as in Figure 28.**

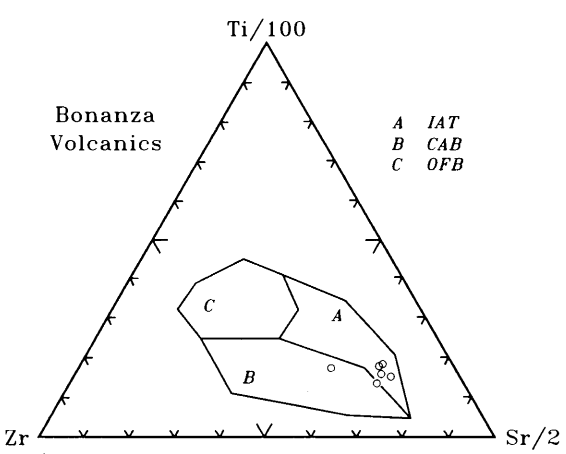


**Figure 32. Ti-Zr-Sr diagram for Bonanza Group volcanics. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 28.**

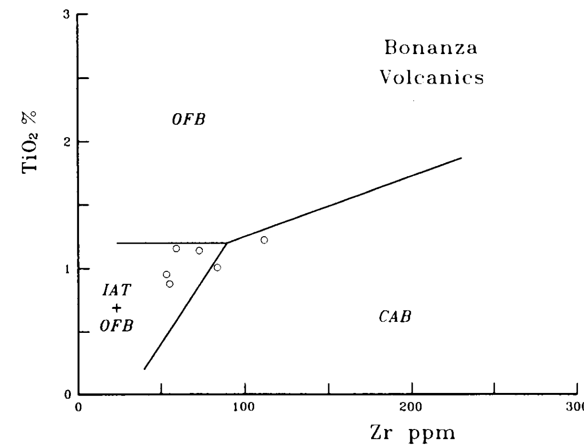


**Figure 33. $TiO_2$-Zr diagram for Bonanza Group volcanics. Fields after Garcia (1978); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 28.**

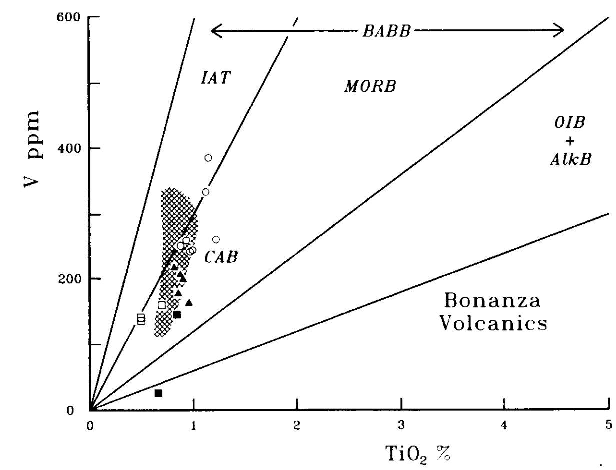


**Figure 34. $TiO_2$-V diagram for Bonanza Group volcanics. Fields after Shervais (1982); IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; BABB: back-arc basin basalts; OIB: ocean-island basalt; AlkB: alkalic basalt. Shaded area labelled CAB is that occupied by typical calcalkaline basalts. Symbols as in Figure 28.**

findings from the Bonanza Group of northern Vancouver Island (Muller *et al.*, 1974; Armstrong *et al.*, 1986). Although none of the sediments appear to have any great lateral extent in the Cowichan Lake area, they are more extensive and continuous in the adjacent Little Nitinat River area where Sutherland Brown informally called them the Redbed Creek facies (*in* Yorath, in preparation).

The bulk of the Bonanza Group within the Cowichan Lake area consists of a variety of maroon to green-grey, feldspar-phyric basalt and andesite flows, lapilli and crystal tuffs (Plate 31 and 32), feldspar-hornblende andesite flows, dacite and felsic lapilli tuff, and various minor basalt, andesite and dacite dikes. There is a lack of lithologic continuity between outcrops and distinctive marker beds are lacking. Rapid facies changes and poor stuctural control make estimates of thickness very uncertain, however, the Bonanza Group is estimated to be at least 1000 metres thick within the map area. The volcanic pile evolved in a convergent-margin setting as an arc on the Paleozoic and Triassic transitional crust.

Geochemically, the Bonanza volcanics form a coherent, medium-potassium calcalkaline suite varying from basalt to rhyolite in composition (Figures 27 - 29). Major and trace-element characteristics are typical of calcalkaline arc rocks (Figures 30 - 34) and there is overlap with the consanguineous Island Plutonic Suite and related minor intrusions (*see* below). Isotopic data from both volcanic and intrusive rocks are similar to other arc suites and also suggest some incorporation of older crustal material (Andrew and Godwin, 1989; Samson *et al.*, 1990).

## NANAIMO GROUP

Clastic sediments of the Nanaimo Group unconformably overlie older volcanic units and intrusive rocks of the Island Plutonic Suite. They outcrop mainly around the shores of Cowichan Lake, but are also preserved in fault-controlled valleys to the north of the lake, for example Meade Creek. The sediments constitute a major fining-upward cycle, with conglomerates and sandstones of the Benson Formation (England, 1989) succeeded by argillites of the Haslam Formation.

### BENSON FORMATION

Basal sediments of the Benson Formation are usually coarse, poorly bedded cobble and boulder conglomerates (Tzuhalem Member of England, 1989) which pass upwards into moderately to well-bedded sandstones, with interbedded pebble and granule conglomerates (Saanich Member of England, 1989). Conglomerates have rounded clasts, although larger boulders are often angular. They are polymictic, including a variety of volcanic and intrusive lithologies generally of local origin (Plate 33). Sandstones are medium to coarse grained, grey with rusty weathered surfaces. They contain feldspar crystals and abundant lithic fragments, mostly volcanic of local provenance. Black plant fragments are characteristic of many beds. Occasionally calcareous concretions are developed with internal structure matching the enclosing sandstone and differing only in the calcareous cement (Plate 34). Many sandstones, and a few granule and pebble conglomerate beds, yield abundant fossil faunas, including gastropods, pelecypods (Plate 35), echinoderms, and nautiloids. The thickness of the Benson Formation is estimated to vary from 0 to 200 metres within the map area.

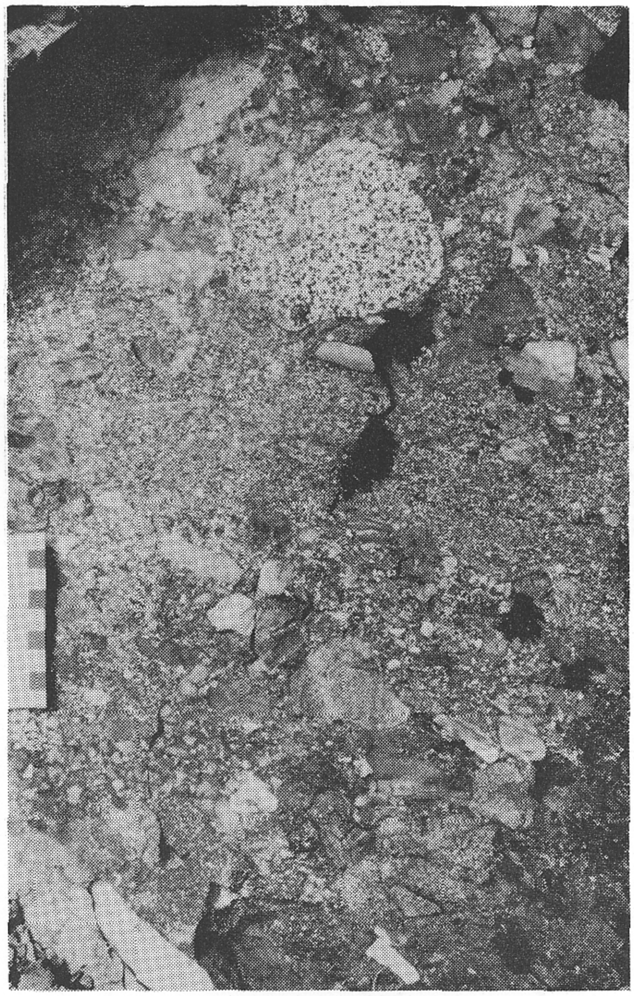

Plate 33. Basal conglomerate, Benson Formation (west side of Rheinhart Creek; NMA87-05-11-1: 5420084N; 420275E).

Plate 34. Large calcareous nodules in sandstone, Benson Formation (Island I8 in Cowichan Lake, east of Caycuse; NMA86-86-62-01: 5415364N; 402137E).

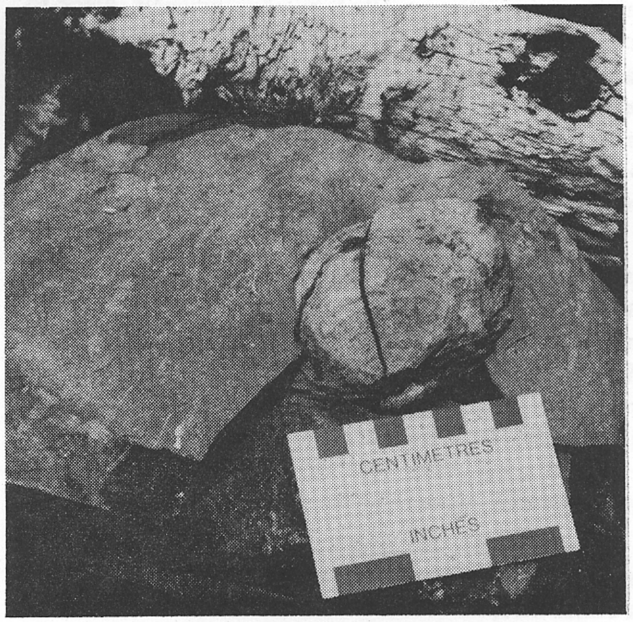


Plate 35. Pelycypod clast in sandstone, Benson Formation (Nitinat Camp; NMA86-33-03; 5405935N; 407675E).

### HASLAM FORMATION

The Haslam Formation consists of a characteristic rusty weathering, black argillite. It is fine to silty, poorly bedded and friable, fracturing to pencil-shaped pieces. Calcareous nodules are common, averaging 10 to 15 centimetres in diameter, but ranging up to 1 metre. Fossils are present but usually poorly preserved due to fracturing. Occasional interbeds of fine to medium-grained, grey silty sandstone are found within the argillites. They vary up to 1 metre thick and are massive to flaggy. The thickness of the Haslam Formation is estimated to vary from about 50 to 400 metres within the map area.

## INTRUSIONS

### LATE TRIASSIC MOUNT HALL GABBRO

In the northeast corner of the map area, a number of thick, massive, medium to coarse-grained diabase and gabbro sills and dikes intrude the Paleozoic sequences. These mafic intrusions have been recently defined as components of the Mount Hall gabbro (Massey, 1992a) and are believed to be coeval and comagmatic with the Karmutsen basalts. In the Mount Whymper and Mount Landale - El Capitan areas, the Karmutsen Formation shows an increasing proportion of massive sills towards the base of the volcanic sequence, which passes downward into diabase and gabbro bodies with intervening screens of Fourth Lake Formation sediments (Figure 35). These mafic sills and dikes are widespread in the area, occurring also at deeper structural levels, although they are most commonly found intruding the Fourth Lake Formation (in the informal "sediment-sill unit" of Muller, 1980). The intrusions are medium to coarse-grained diabase, gabbro and leucogabbro with minor diorite. They are commonly porphyritic with feldspar phenocrysts often being glomeroporphyritic clusters up to 3 centimetres in diameter. Mafic phenocrysts are generally absent. Equigranular gabbros are also common and coarse varieties contain frequent pegmatitic veins and pods.

The intrusions vary in size and form. Sill-like bodies are subconcordant with bedding in the sediments, although they usually follow the foliation where this is strongly developed. They thus show a variety of attitudes from shallow dipping to vertical. They vary from a few metres up to 200 metres thick. Discordant dikes are also common, varying from 10 centimetres to about 50 metres wide. The numerous intrusions are believed to have occurred during dilation of the Paleozoic basement in the Late Triassic, and acted in part as feeders to the overlying volcanics (Figure 35). Elsewhere, the Karmutsen volcanics overlap onto the Paleozoic basement and evidence of the rifting is covered.

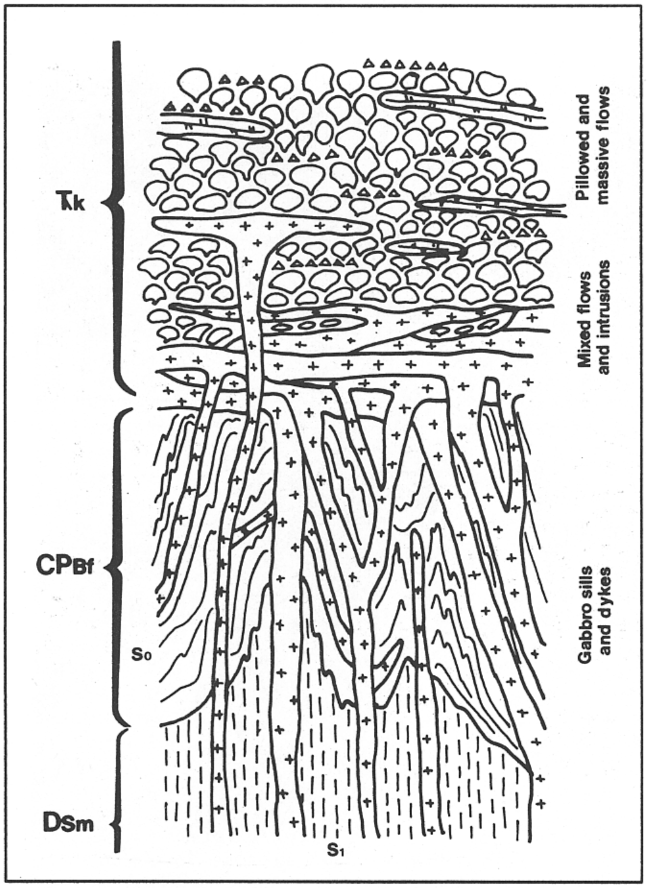


Figure 35. Diagrammatic cross-section, not to scale, showing the relationship of Karmutsen Formation volcanic and intrusive rocks to the rifted Paleozoic basement in the Mount Whymper - Rheinhart Creek area. DSm: McLaughlin Ridge Formation; CPBf: Fourth Lake Formation; Trk: KarmutsenFormation; $S_0$: bedding within Fourth Lake Formation; $S_1$: schistosity in McLaughlin Ridge Formation.

Abundant smaller diabase and feldspar diabase dikes of Late Triassic age intrude Paleozoic rocks in the northwest of the area and also crosscut Karmutsen volcanics in the Seymour Ranges. They vary in width from centimetres to 50 metres.

The geochemistry of the intrusions of the Mount Hall gabbro is similar to that of the Karmutsen basalts, with representatives of both the standard and low-niobium suites occurring in the Cowichan Lake area.

## Jurassic Island Plutonic Suite

Several granodioritic stocks of Early to Middle Jurassic age occur in the area. They are coeval with the Bonanza Group volcanics, although they intrude all Paleozoic and Mesozoic formations. Samples from plutons throughout Vancouver Island have yielded a composite Rb-Sr isochron date of 183± 7 Ma (Armstrong *et al.*, 1986). The major lithology is a medium to coarse-grained, equigranular granodiorite to quartz diorite with a characteristic "salt-and-pepper" texture (Plate 36). Quartz is usually irregular in shape, often interstitial to the feldspars. Feldspars are white, though some pink staining is seen on weathered surfaces. Hornblende is the principal mafic mineral. It is usually tabular to acicular, black to green-black in colour and may be slightly larger in size than the feldspars. Biotite is only rarely observed. Chlorite replaces hornblende in altered rocks. Colour index varies from 10 to 20 in the granodiorites, but may range up to 40 in diorites. White, fine-grained aplite dikelets and veins crosscut the granodiorites.

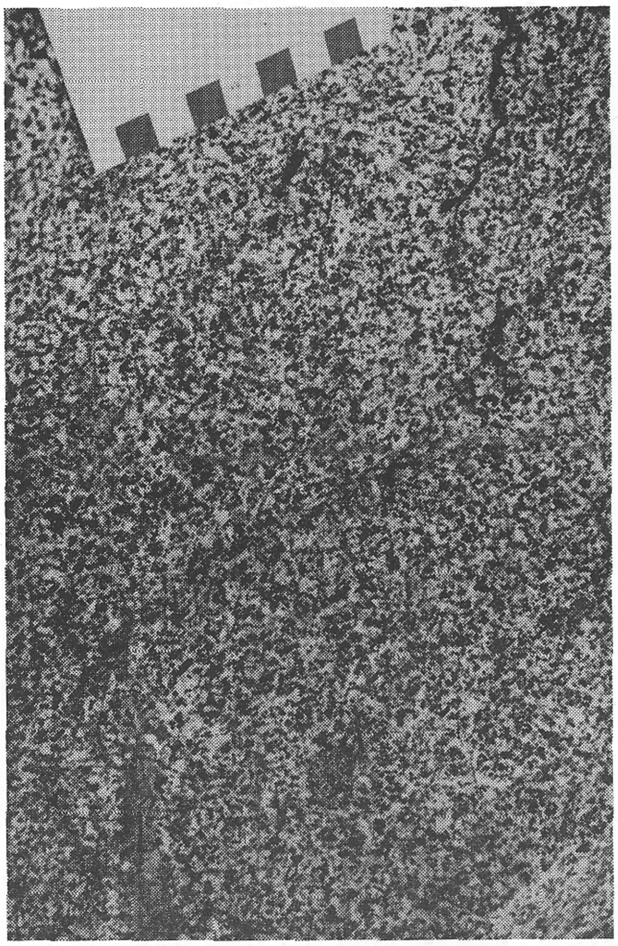

Plate 36. Hornblende biotite granodiorite, Island Plutonic Suite (logging road C24, north side of Chemainus River, west of Rheinhart Creek; NMA87-05-08: 5420783N; 417594E).

Most of the stocks are rich in mafic inclusions, particularly in marginal zones were agmatitic intrusive breccias are developed (Plate 37). The angular to subrounded xenoliths are mostly accidental and of local country rock lithologies, but rare cognate gabbro-diorite xenoliths do occur (Plate 38). They show a range of amphibolitization and assimilation features. Complete assimilation results in ragged mafic clots that may also contain inherited pyroxenes with white reaction rims.

Stocks north of Cowichan Lake have an elongate outcrop pattern, often with different stratigraphic units on either side, as with the Mount Buttle - Meade Creek stock. This suggests that the emplacement of granodiorite was controlled by pre-existing structures such as faults and possibly the axial regions of anticlinal folds. Stocks intruded into the Mesozoic sequences to the south of Cowichan Lake are more rounded in outcrop shape.

Intrusions of the Island Plutonic Suite of the Cowichan uplift span the compositional range from gabbro to granite, with the mean being granodiorite to quartz monzodiorite (Figures 36, 37, 40). They are a typical metaluminous, medium to high-potassium calcalkaline suite (Figures 36 - 43). Normative mineralogy suugests that the suite evolved from mafic compositions along a typical calcalkaline trend to the 5 kilobar eutectic (Figure 42). At lower pressures the melts cluster close to the locus of the isobaric minima. Major and trace-element discriminants show characteristics of a convergent-margin environment for both the felsic and more mafic lithologies (Figures 44 - 55). Bonanza Group volcanics have very similar geochemical signatures and are consanguineous with the plutonic rocks.

## Minor Intrusions

Several lithologies are found as dikes and small, irregular intrusions. These include intermediate feldspar porphyry, feldspar pyroxene porphyry, hornblende-feldspar andesite and minor diabase. Four hornblende porphyries in the area yielded hornblende K-Ar ages ranging from 148 to 181 Ma (Table C2, Figure C, in pocket), similar to the range found in the Island Plutonic Suite (Armstrong *et al.*, 1986). Many of the other minor intrusions are probably also of Early to Middle Jurassic age and comagmatic with the Bonanza volcanics and the Island Plutonic Suite, to which they are spatially and geochemically related (Figures 36 - 55). A hornblende

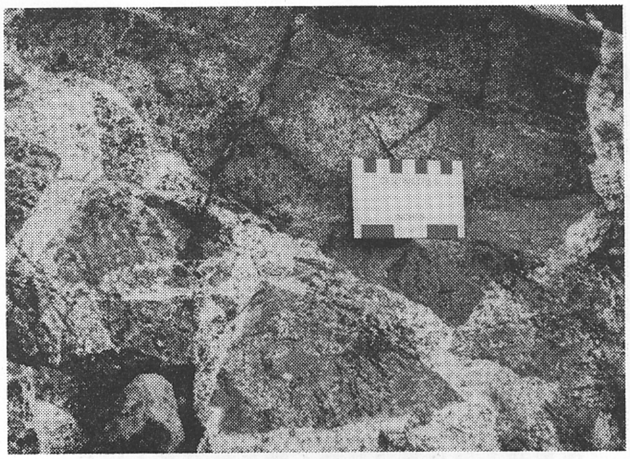

Plate 37. Agmatitic contact breccia with xenoliths of pyroxene-phyric Nitinat Formation enclosed in diorite leucosome, Island Plutonic Suite (Heather Lake area; NMA86-07-07: 5424044N; 390839E).

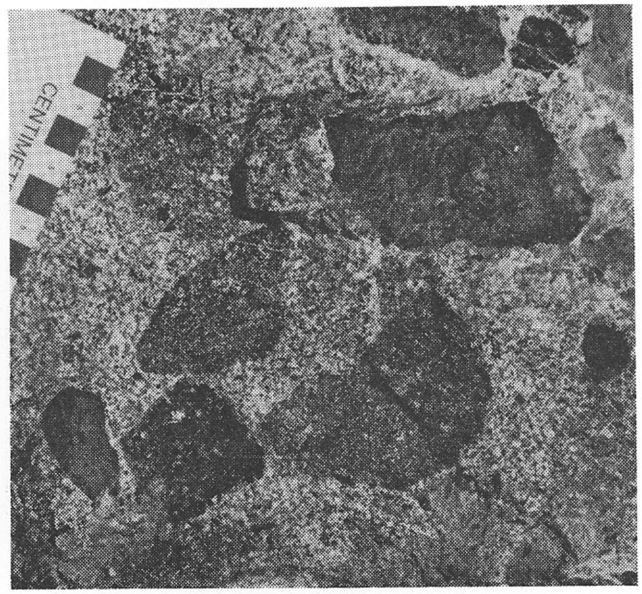


Plate 38. Diorite with angular amphibolitized basalt xenoliths and rounded cognate diorite-gabbro xenoliths, Mount Buttle pluton, Island Plutonic Suite (west of Mount Holmes; NMA86-44-09: 5416168N; 410765E).

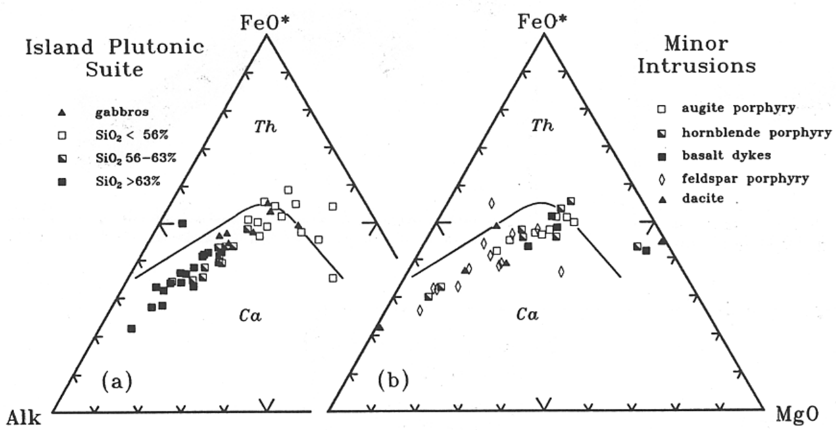


Figure 36. AFM triangle diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions. Tholeiite-calcalkaline dividing line after Irvine and Baragar (1971). Alk = $Na_2O + K_2O$; FeO* = total iron as FeO.

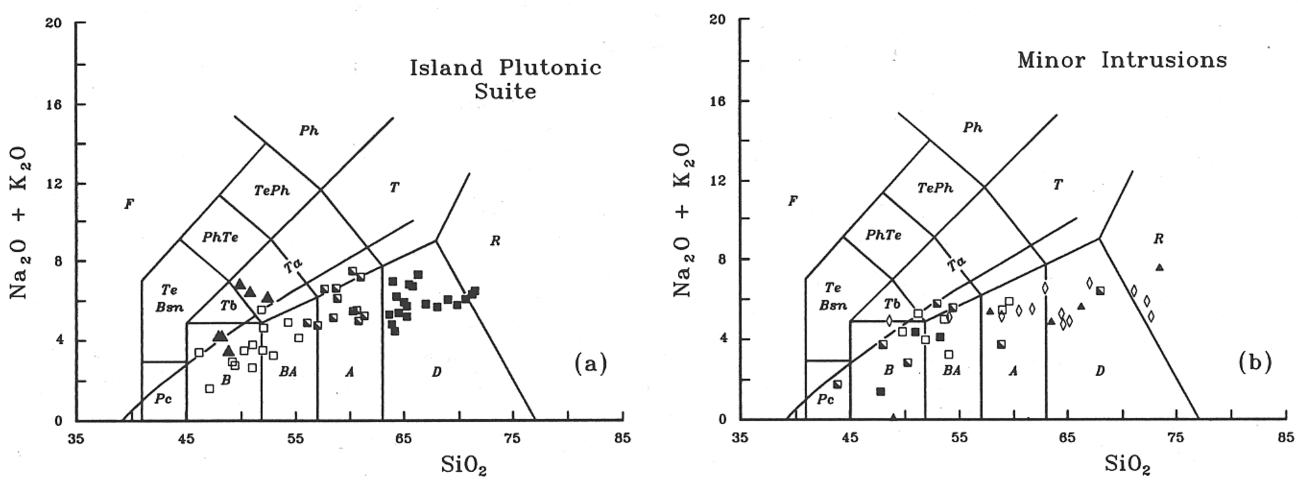


Figure 37. Alkali-silica diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions. Fields after Le Maitre (1984); dashed line divides alkaline rocks (above line) from subalkaline rocks (below line), after Irvine and Baragar (1971). Symbols as in Figure 36.

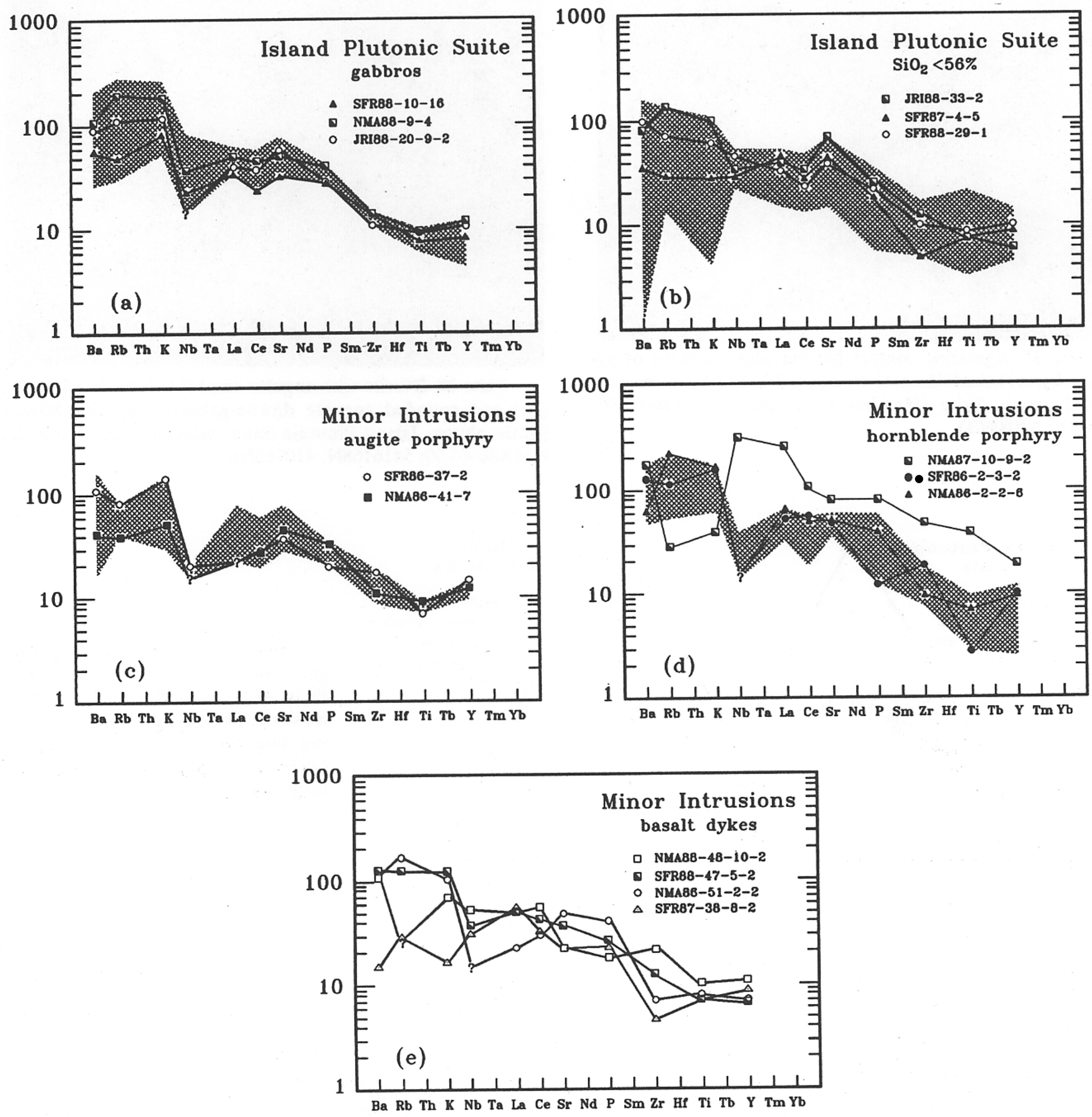


Figure 38. Normalized trace-element plots for mafic lithologies of the Island Plutonic Suite and probably coeval minor intrusions. Normalizing values after Thompson *et al.*, 1983. Shaded area represents the range of values for all samples of a particular suite in the Sicker Project area. Selected representative samples are shown individually: (a) gabbros of unknown age from the Alberni area, possibly part of the Island Plutonic Suite; (b) Island Plutonic Suite, $SiO_2$ < 56%; (c) minor intrusions, augite porphyries; (d) minor intrusions, hornblende porphyries; (e) minor intrusions, basalt dikes.

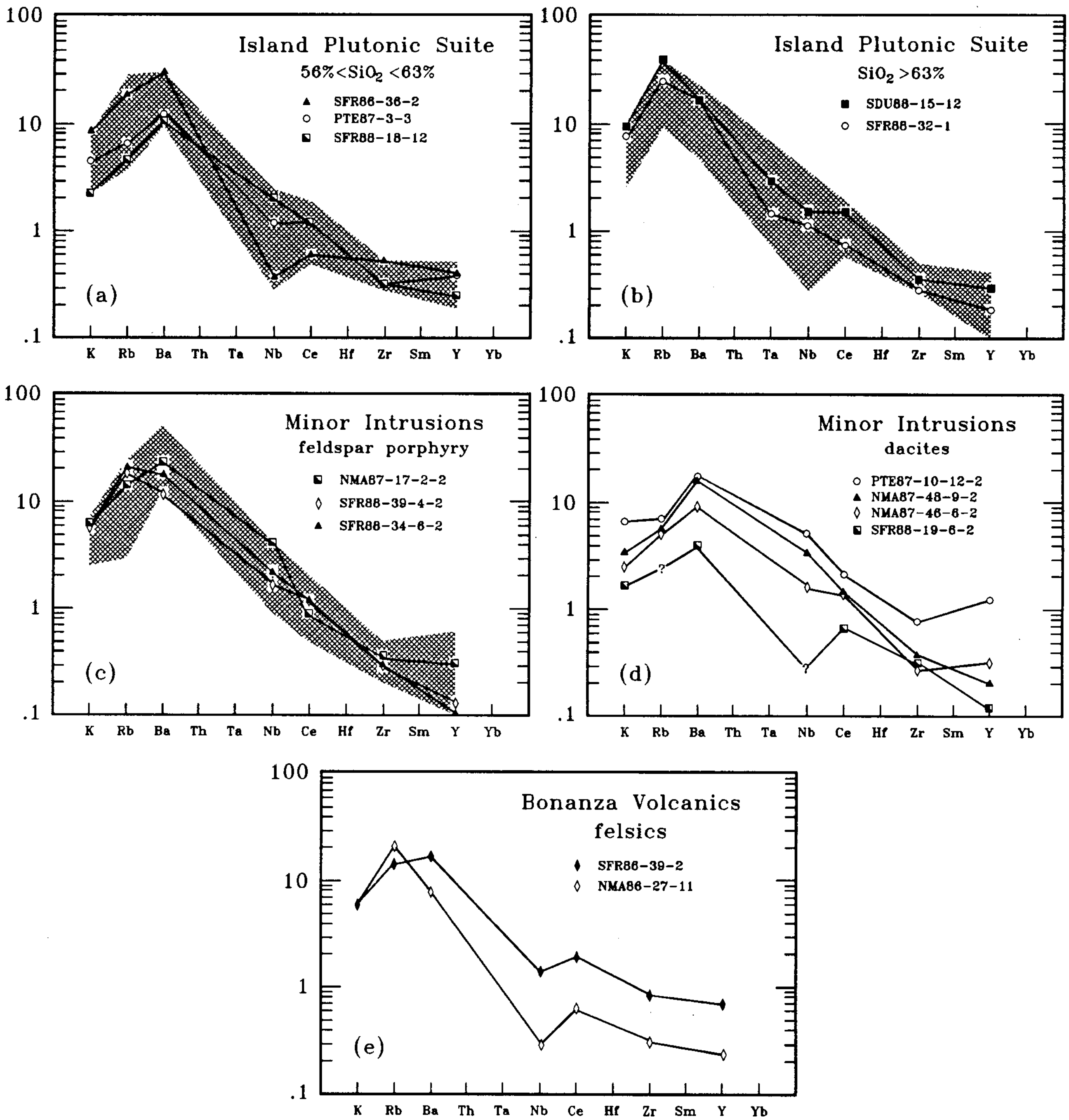


Figure 39. Normalized trace-element diagrams for intermediate to felsic lithologies of the Island Plutonic Suite and probably coeval minor intrusions. Normalizing values after Pearce *et al.* (1984). Shaded area represents the range of values for all samples of a particular suite in the Sicker Project area. Selected representative samples are shown individually: (a) Island Plutonic Suite, $SiO_2$ 56 - 63%; (b) Island Plutonic Suite, $SiO_2$ 63%; (c) minor intrusions, feldspar porphyries; (d) minor intrusions, dacites; (e) Bonanza Group, felsic volcanics.

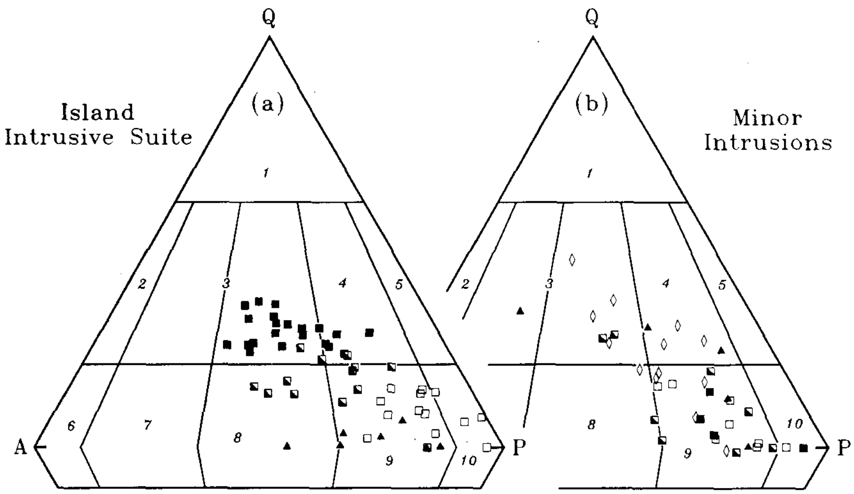


Figure 40. Normative Q-A-P-F diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions. Fields after Streckeisen (1967); 1: quartz-rich granitoids; 2: alkali feldspar granite; 3: granite; 4: granodiorite; 5: tonalite-trondhjemite; 6: alkali feldspar syenite; 7: syenite; 8: monzonite; 9: monzodiorite, monzogabbro; 10: diorite, gabbro. Normative Ab is partitioned between alkali feldspar (A) and plagioclase feldspar (P) by the method of Le Maitre (1976); A = Or x T, P = An x T, where T = (Or + Ab + An)/ (Or + An). Symbols as in Figure 36.

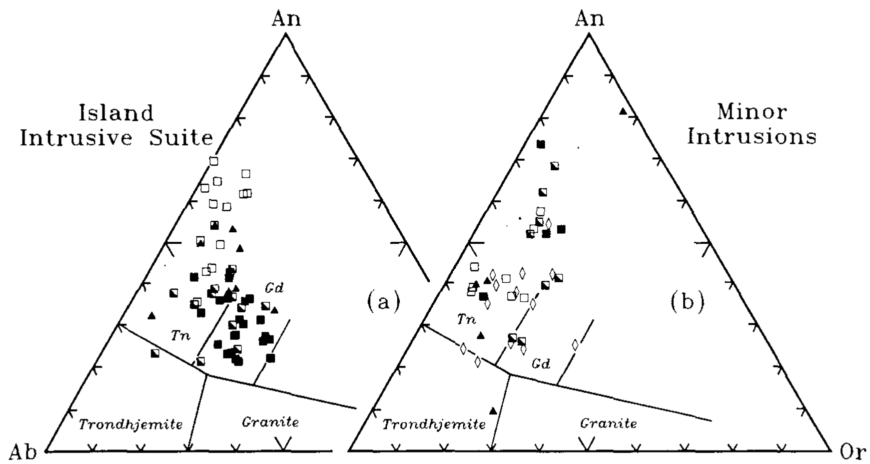


Figure 41. Normative An-Ab-Or diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions. Fields are after Barker (1979) and O'Connor (1965); Tn: tonalite; Gd: granodiorite. Symbols as in Figure 36.

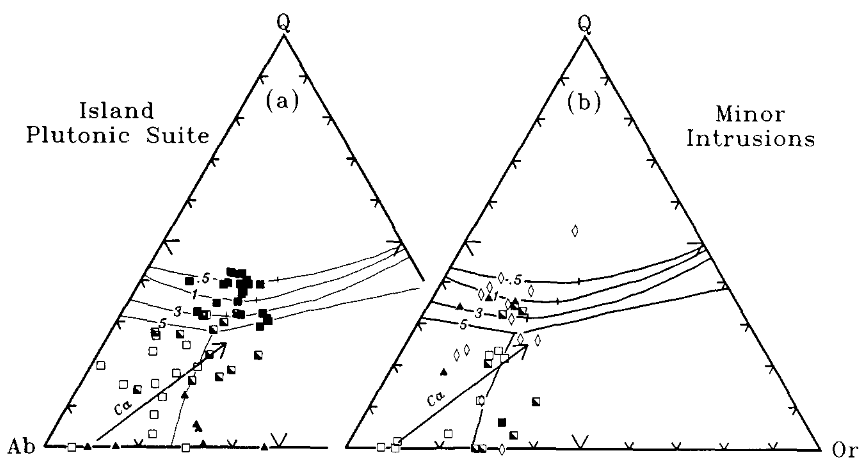


Figure 42. Normative Q-Ab-Or diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions. Curves are for water-saturated liquids in equilibrium with quartz and alkali feldspar at indicated confining pressures in kilobars (Carmichael *et al.*, 1974, after data of Tuttle and Bowen, 1958). Isobaric minima are indicated on the curves except at 5 kilobars where a ternary eutectic is generated by intersection of the alkali feldspar solvus with the liquidus surface. Ca: trend for typical calkalkine suite (Abdel-Rahman, 1990, after Arth *et al.*, 1978). Symbols as in Figure 36.

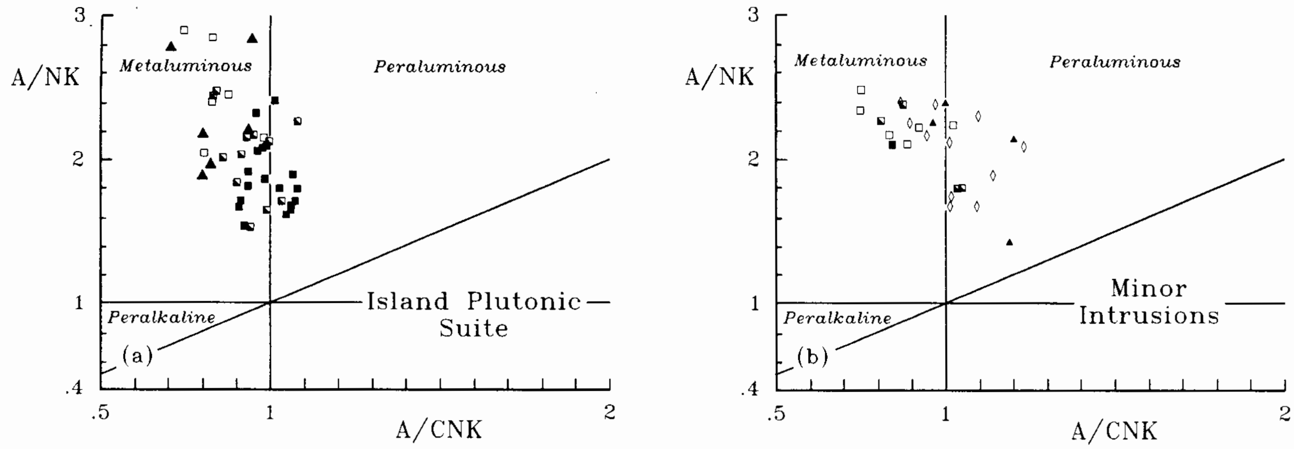


**Figure 43. Shand's Index for rocks of the Island Plutonic Suite and probably coeval minor intrusions (Shand, 1927). A, C, N and K are the molar values of $Al_2O_3$, CaO, $Na_2O$ and $K_2O$ respectively. Symbols as in Figure 36.**

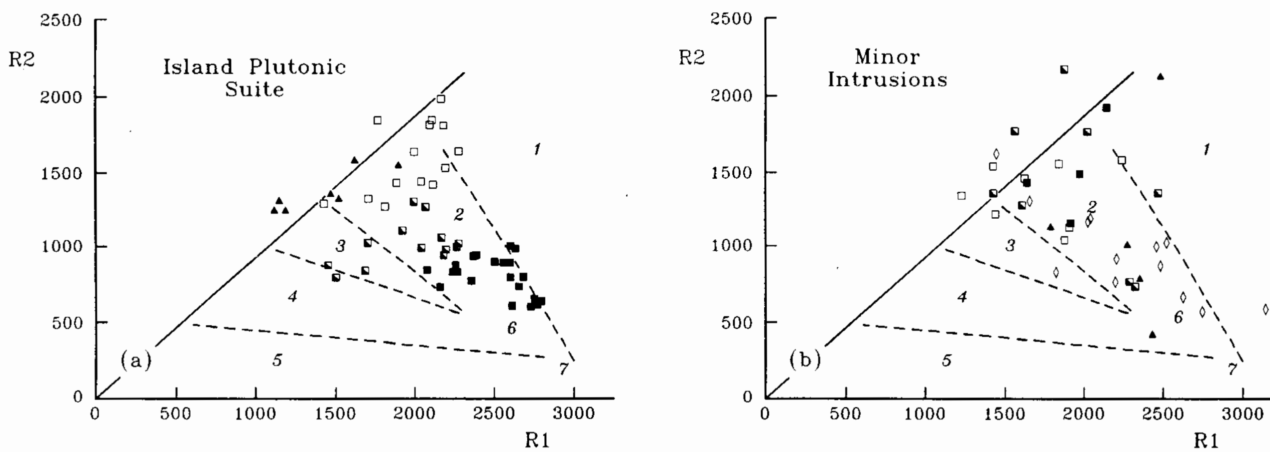


**Figure 44. de la Roche R1 - R2 multicationic diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions (after de la Roche *et al.*, 1980); R1 = 4Si - 11(Na + K) - 2(Fe + Ti); R2 = 6Ca + 2Mg + Al. Fields after Batchelor and Bowden (1985): 1, mantle fractionates; 2, destructive plate margin (pre-plate collision); 3, post-plate collision ("permitted" plutons); 4, late orogenic (subalkaline); 5, anorogenic (alkaline-peralkaline); 6, synorogenic (anatectic); 7, postorogenic. Symbols as in Figure 36.**

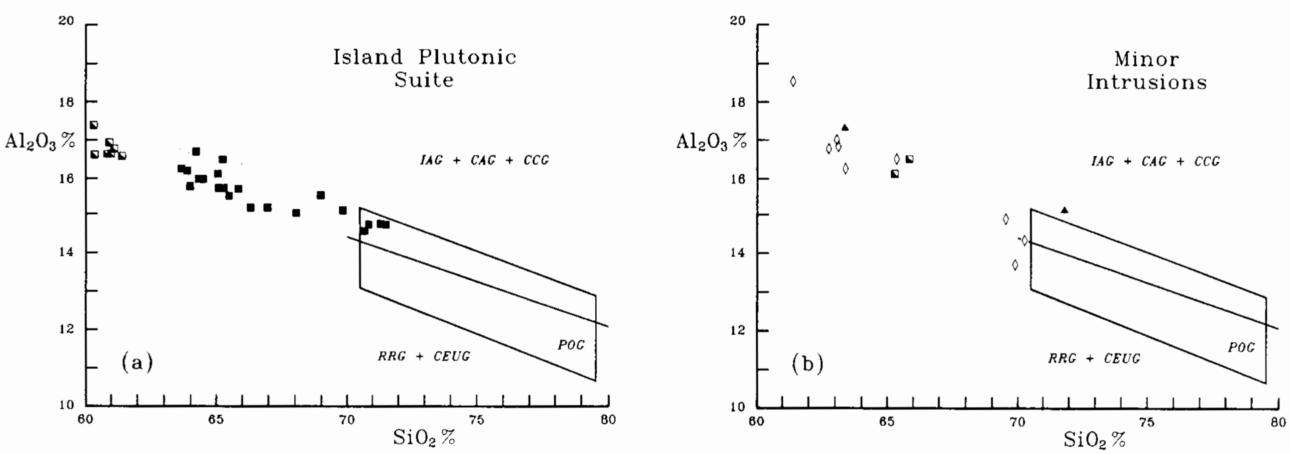


**Figure 45. $Al_2O_3$-$SiO_2$ diagram for felsic lithologies of the Island Plutonic Suite and probably coeval minor intrusions; fields after Maniar and Piccoli (1989). IAG: island-arc granitoids; CAG: continental-arc granitoids; CCG: continental-collision granitoids; POG: postorogenic granitoids; RRG: rift-related granitoids; CEUG: continental epeirogenic uplift granitoids. Symbols as in Figure 36.**

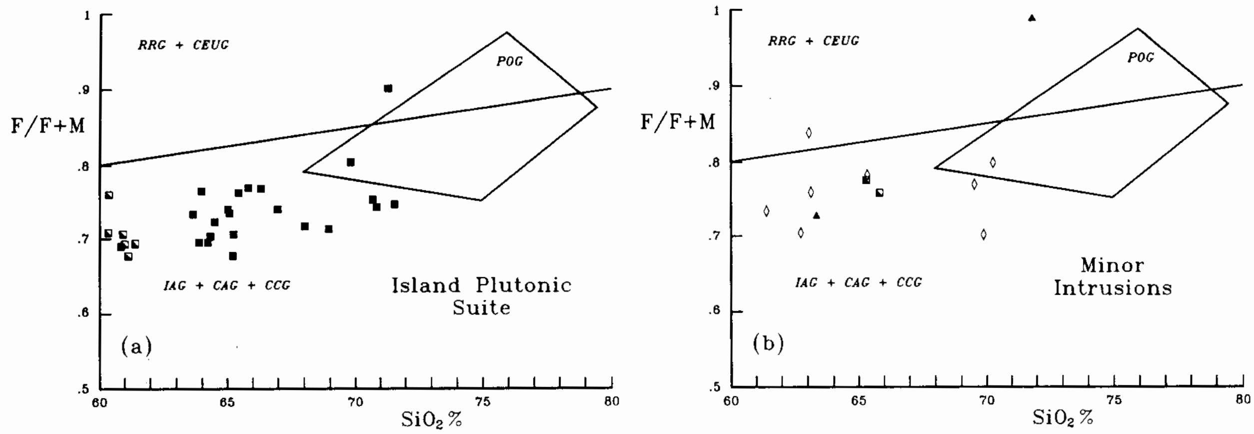


**Figure 46. F/ (F + M) versus $SiO_2$ diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions; fields after Maniar and Piccoli (1989). F = total iron as FeO; M = MgO. Field labels as in Figure 51. Symbols as in Figure 36.**

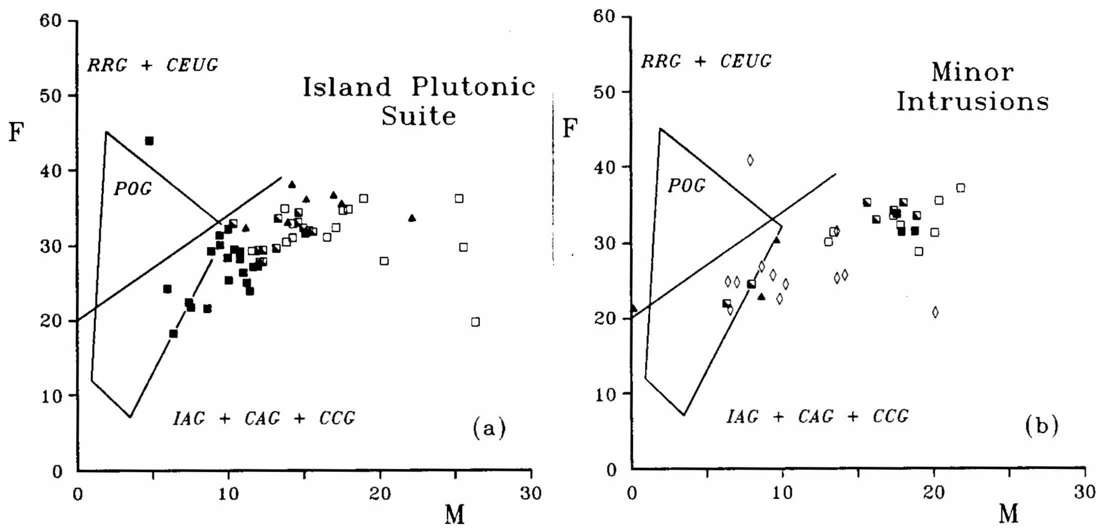


**Figure 47. F-M diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions; fields after Maniar and Piccoli (1989). F = total iron as FeO; M = MgO. Note that F and M, in this diagram, are the normalized values from plotting samples in the ternary ($Al_2O_3$ - $Na_2O$ - $K_2O$)-($FeO^*$)-(MgO) diagram. Field labels as in Figure 51. Symbols as in Figure 36.**

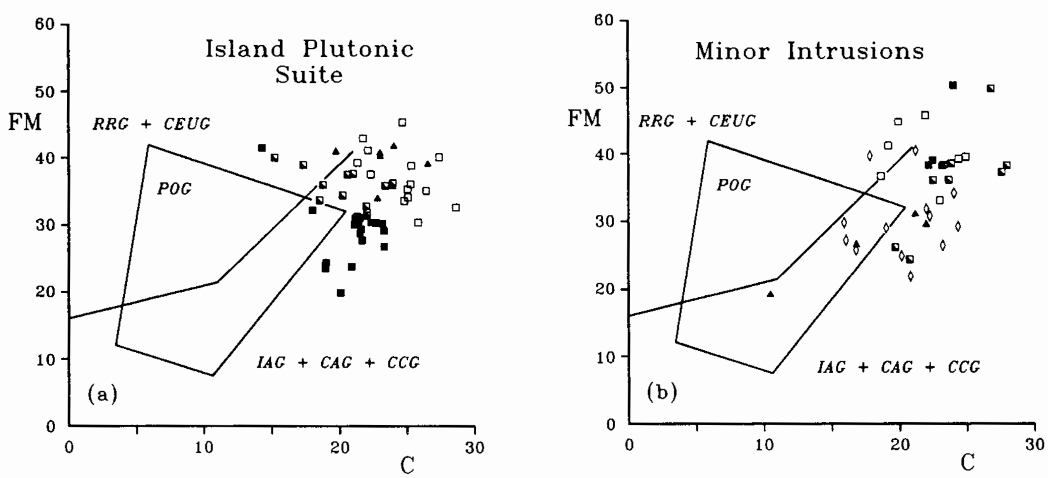


Figure 48. FM-C diagram for rocks of the Island Plutonic Suite and probably coeval minor intrusions; fields after Maniar and Piccoli (1989). F = total iron as FeO; M = MgO; C = CaO. Note that FM and C, in this diagram, are the normalized values from plotting samples in the ternary ($Al_2O_3$ - $Na_2O$ - $K_2O$)-($FeO^*$ + MgO)-(CaO) diagram. Field labels as in Figure 47. Symbols as in Figure 20.

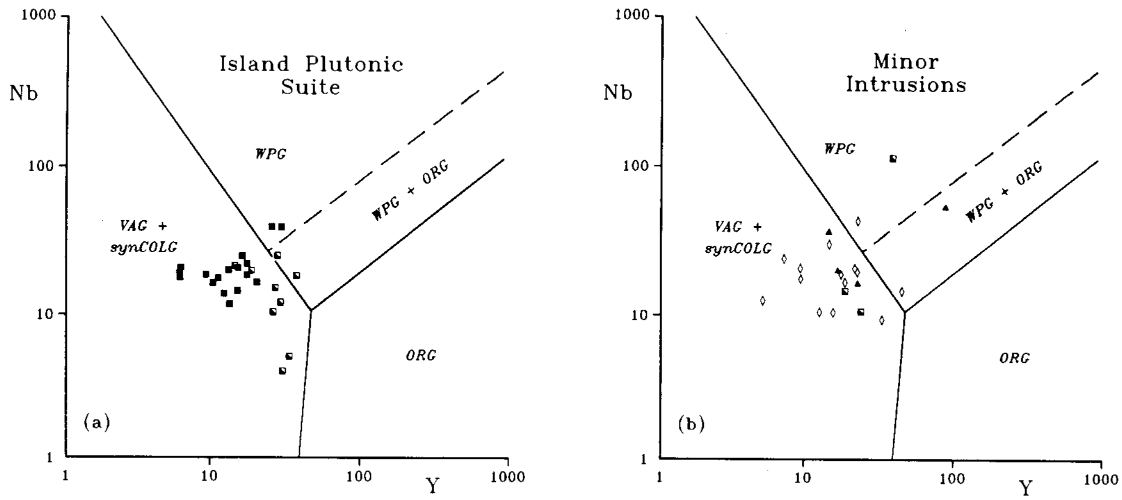


**Figure 49.** Nb-Y diagram for intermediate to felsic lithologies of the Island Plutonic Suite and probably coeval minor intrusions; fields after Pearce *et al.* (1984). VAG: volcanic-arc granites; synCOLG: syncollision granites; WPG: within-plate granites; ORG: ocean-ridge granites. Symbols as in Figure 36.

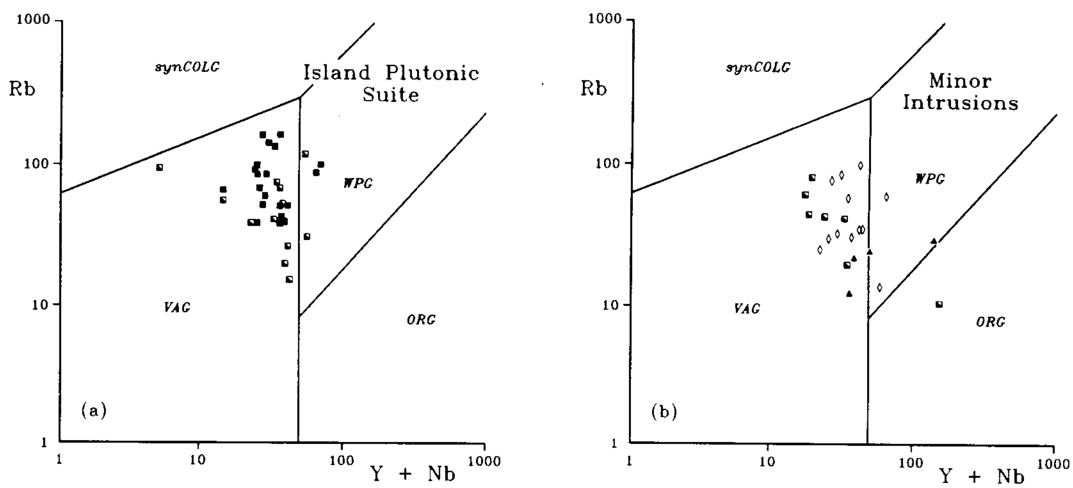


**Figure 50.** Rb-(Nb+ Y) diagram for intermediate to felsic lithologies of the Island Plutonic Suite and probably coeval minor intrusions; fields after Pearce *et al.* (1984), labelled as in Figure 49. Symbols as in Figure 36.

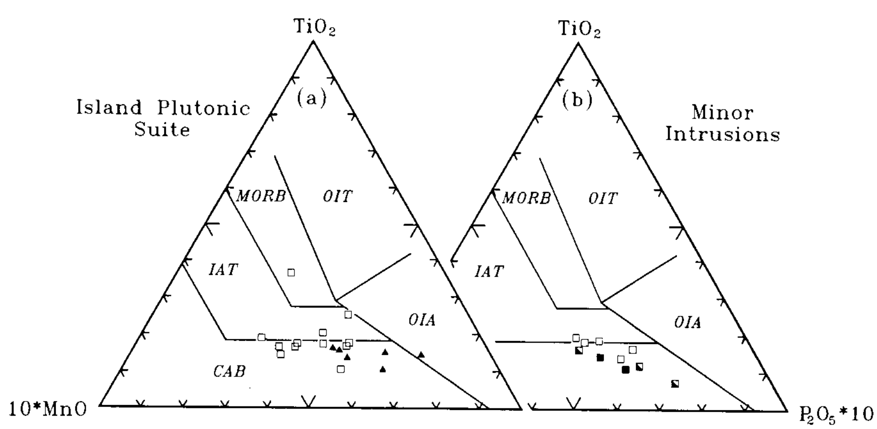


**Figure 51.** $TiO_2$-MnO-$P_2O_5$ diagrams for mafic lithologies of the Island Plutonic Suite and probably coeval minor intrusions. Fields after Mullen (1983); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; OIT: ocean-island tholeiites; OIA: ocean-island alkalic basalts. Symbols as in Figure 36.

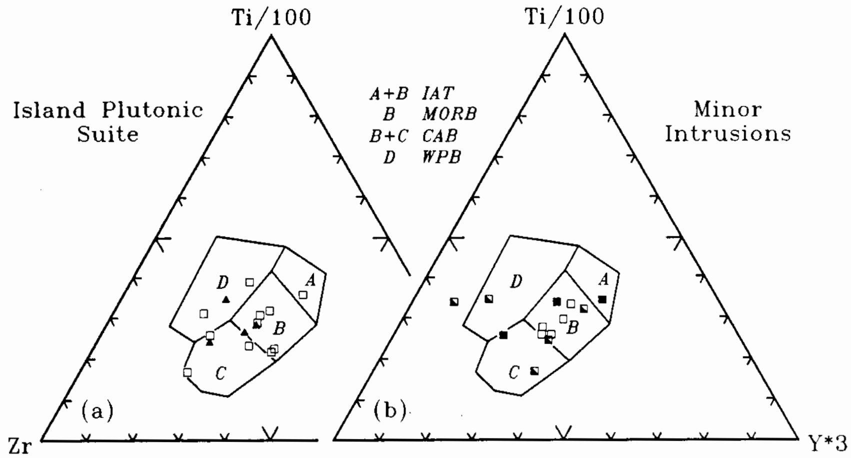


**Figure 52.** Ti-Zr-Y diagrams for mafic lithologies of the Island Plutonic Suite and probably coeval minor intrusions. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; WPB: within-plate basalts. Symbols as in Figure 36.

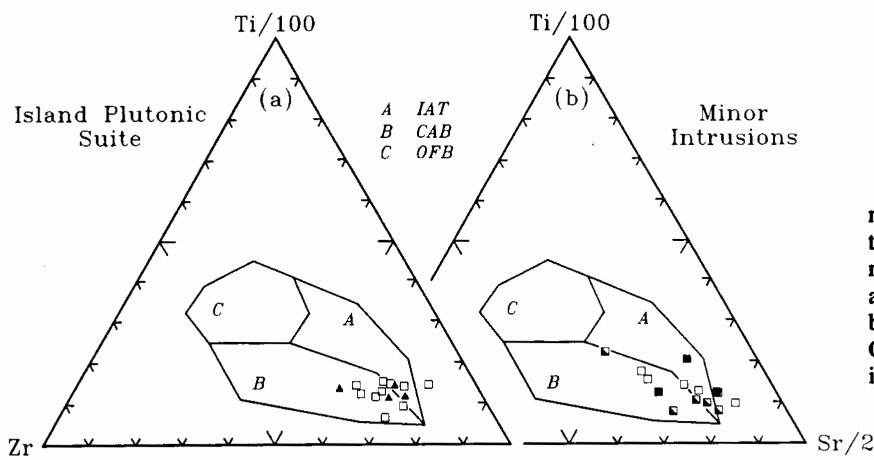


**Figure 53.** Ti-Zr-Sr diagrams for mafic lithologies of the Island Plutonic Suite and probably coeval minor intrusions. Fields after Pearce and Cann (1973); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 36.

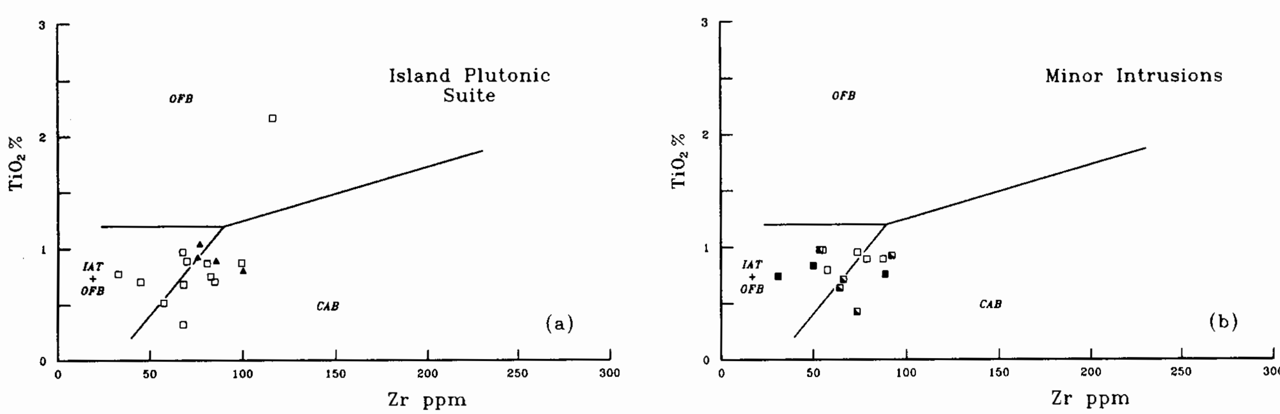


**Figure 54.** $TiO_2$-Zr diagrams for mafic lithologies of the Island Plutonic Suite and probably coeval minor intrusions. Fields after Garcia (1978); CAB: calcalkaline basalts; IAT: island-arc tholeiites; OFB: ocean-floor basalts. Symbols as in Figure 36.

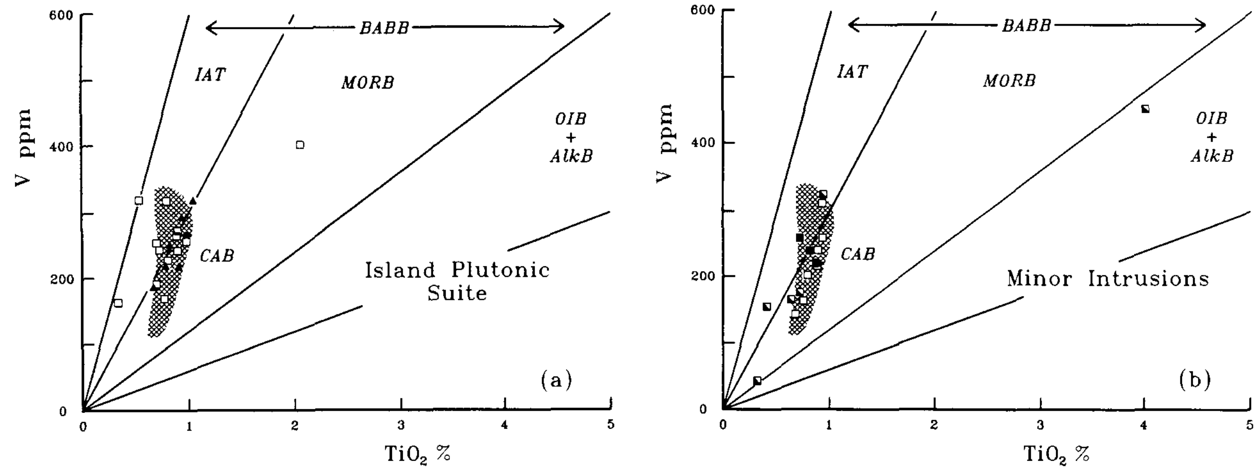


**Figure 55.** $TiO_2$-V diagrams for mafic lithologies of the Island Plutonic Suite and probably coeval minor intrusions. Fields after Shervais (1982); IAT: island-arc tholeiites; MORB: mid-ocean ridge basalts; BABB: back-arc basin basalts; OIB: ocean-island basalt; AlkB: alkalic basalt. Shaded area labelled CAB is that occupied by typical calcalkaline basalts. Symbols as in Figure 36.

andesite sill (NMA87-10-9-2) in the Rheinhart Creek area has yielded an Early Jurassic hornblende K-Ar age of 181± 6 Ma, but is geochemically distinct from other Jurassic rocks. It is alkalic in character with a within-plate affinity (Figures 38, 52 and 55). The significance of this magma type in the development of the Bonanza arc remains to be investigated.

Some minor feldspar quartz porphyry bodies intrude Sicker Group rocks and may be contemporaneous with them. The porphyry contains abundant white subhedral feldspars and sparse quartz in a dark green-grey to black aphanitic matrix. Coarse pyroxene feldspar dikes, similar to Sicker Group porphyritic flows and agglomerates, intrude the area north of Cowichan Lake. Though many are undoubtedly of Sicker Group age, they are difficult to separate lithologically from the Jurassic pyroxene feldspar porphyries that intrude Mesozoic rocks south of Cowichan Lake.

Rhyolite forms a thick sill within the cherty sediments exposed on the hill between the two forks of Rheinhart Creek. The rhyolite is white to maroon, fine grained with minor quartz phenocrysts. It is mostly massive but shows flow banding near margins and contains xenolithic blocks of cherty sediment in places. The age of the intrusion is unknown, but it cuts the alkalic hornblende andesite sill that yielded an Early Jurassic K-Ar date.

# STRUCTURE AND TECTONICS

Southern Vancouver Island has undergone a complex tectonic history with an alternation of major tectonic settings (Figure 2) and involving at least five major deformational events. These events have often rejuvenated previous structures, rendering specific analysis of their effects difficult. The area is divided into two regions of differing structural style by a major thrust fault running along the north side of Cowichan Lake. The northern region is underlain by Paleozoic rocks forming the southwest limb of the Cowichan uplift. It is cut into several slices by a set of west-northwesterly trending faults paralleling the Cowichan Lake thrust. South of Cowichan Lake, Mesozoic sequences form a syncline-anticline pair that parallels the Cowichan uplift and plunges to the northwest. Small crossfolds are also developed but are only defined where suitable bedded strata are seen. Northwest-trending vertical faults parallel the major folds and may be related to the same deformational event.

## PHASE 1 - LATE DEVONIAN

A major deformational event in late Devonian to earliest Mississippian times produced large-scale open folds in the Sicker Group volcanic rocks of the Cowichan Lake area. Subsequent uplift and erosion are reflected in the unconformity below the basal Shaw Creek cherts of the Fourth Lake Formation along the southwestern limb of the Cowichan uplift.

## PHASE 2 - MIDDLE PERMIAN - PRE-MIDDLE TRIASSIC

All Paleozoic rocks have been affected by a series of southeast-trending, southwest-verging asymmetric folds with abundant parasitic minor folds. Major fold axes are often difficult to map in the field but can be interpreted from regional map patterns. The folds are truncated by the overlying Karmutsen Formation. Overturning of beds is seen occasionally in minor folds. On the west slope of Rheinhart Creek, a sliver of McLaughlin Ridge breccia occurs between Fourth Lake Formation sediments in an apparently overturned anticline. However, the structurally lower sediments are right-way-up, suggesting a thrust and nappe structure is more likely (Plate 39).

Penetrative axial-planar foliation is generally absent throughout most of the area. However, to the west of Mount Whymper and north of the Chemainus River fault, foliation (schistosity in volcanics and cleavage in sediments) is well developed, trending north-northwest with generally steep northeasterly dips. Intense flattening normal to the foliation is observed in volcanic rocks, whereas cherty sediments of the Fourth Lake Formation behaved more competently and lack flattening fabrics. Lineations due to bedding-foliation intersections and elongation of crystals and clasts are common. Plunges of lineations are usually shallow, up to 15, and may be to the west-northwest or east-southeast.

Faulting may have accompanied or postdated the folding. Structures attributed to this deformational event include a north-trending vertical fault south of Mount Buttle and a peculiar triangle-shaped down-dropped block, cored by a southerly plunging anticline, at Mount Franklin.

## PHASE 3 - LATE TRIASSIC

Crustal dilation accompanied the evolution of Karmutsen Formation lavas and intrusions, but specific structures associated with the dilation have not yet been documented. Shear zones within gabbros, and especially along their margins, may be contemporaneous or later.

## PHASE 4 - EARLY TO MIDDLE JURASSIC

Regional-scale warping of Vancouver Island produced the three major geanticlinal uplifts cored by Paleozoic rocks (Figure 1), including the Cowichan uplift. Within the map area, the effects of this deformation are best seen south of Cowichan Lake where the Mesozoic sequences form broad northwest-plunging folds. Northwest-trending vertical faults are apparently axial to these folds. Regionally, the plutons and stocks of the Middle Jurassic Island Plutonic Suite are often elongate parallel to the uplifts. However, they show little or no affects of the deformation themselves, suggesting the intrusions were syntectonic to postdeformation. Uplift and erosion followed sometime in the Late Jurassic to Middle Cretaceous, establishing the pre-Nanaimo Group topography.

## PHASE 5 - EOCENE

Large-scale west-northwesterly trending contractional faults of the Cowichan fold and thrust system (England and Calon, 1991) cut the map area into several slices (Figure 56). The Cowichan fault runs along the northern side of Lake Cowichan before dividing into several splays that trend more northwesterly into the Alberni area. The Chemainus and Fulford faults cut across the northeast corner of the map area. The Robertson River fault may

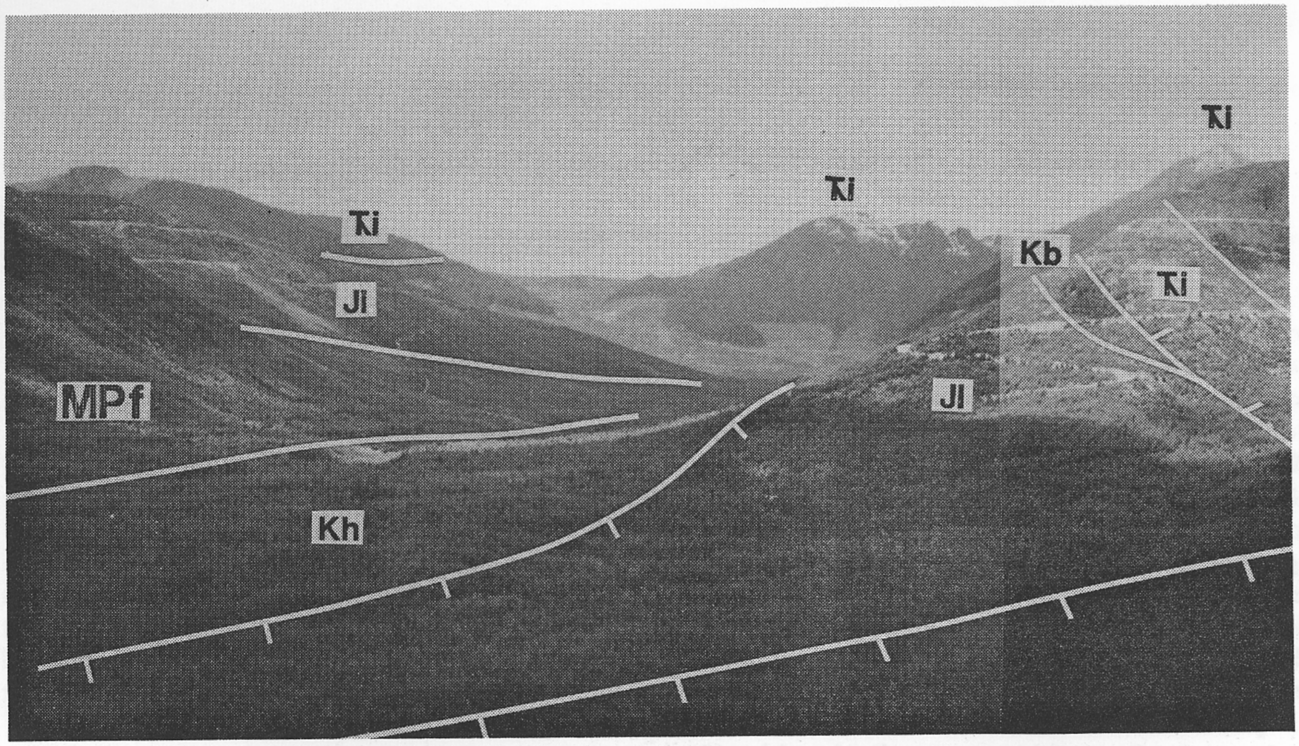


Plate 39. Composite view of the Chemainus - Rheinhart confluence area, looking westwards: uDm= McLaughlin Ridge Formation; MPf= Fourth Lake Formation; Tri= Triassic gabbro; JI= Island Plutonic Suite; Kb= Benson Formation; Kh= Haslam Formation.

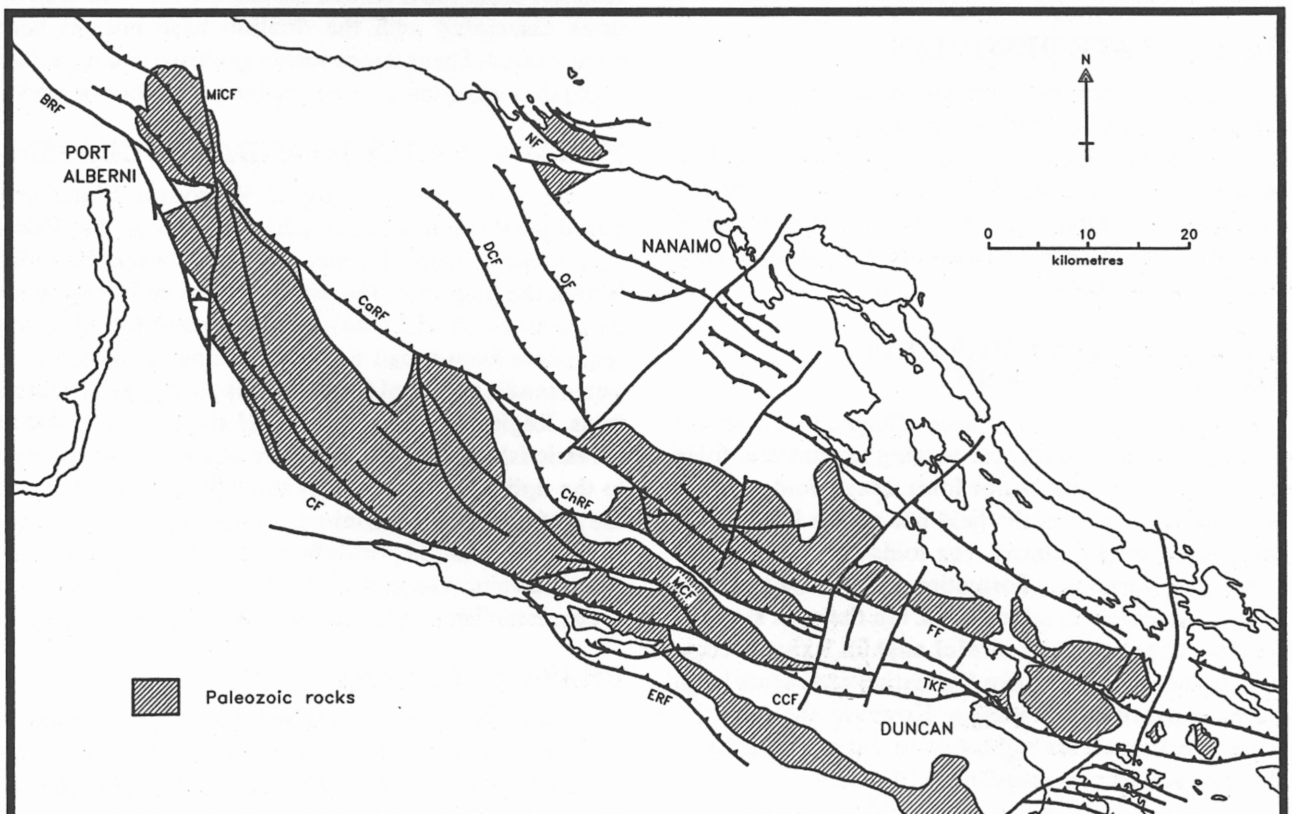


Figure 56. Major faults of the Cowichan fold and thrust system (after Massey and Friday, 1988; England & Calon, 1991): BRF: Beaufort Range fault; CF: Cowichan fault; CaRF: Cameron River fault; ChRF: Chemainus River fault; CCF: Copper Canyon fault; DCF: Dash Creek fault; ERF: East Robertson fault; FF: Fulford fault; MCF: Meade Creek fault; MiCF: Mineral Creek fault; NF: Nanoose fault; OF: Okay fault; TKF: Tzuhalem-Keppel fault.

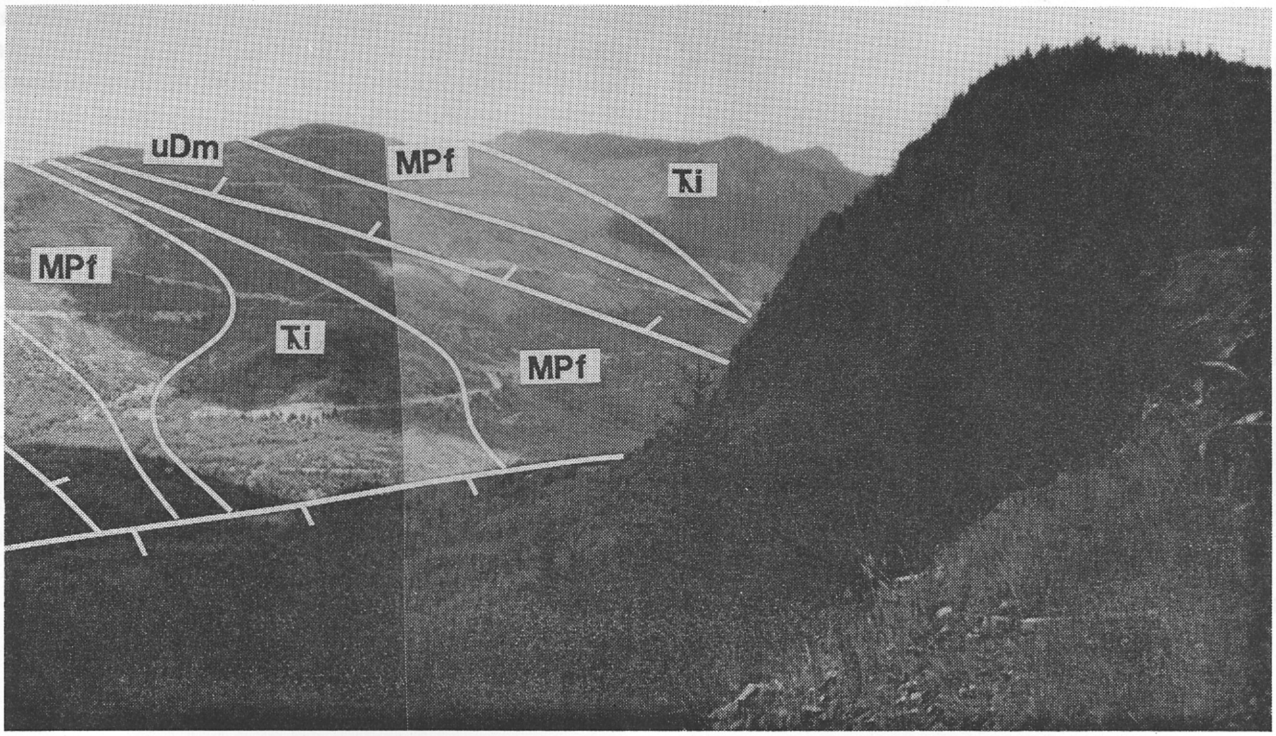


Plate 39. (Continued)

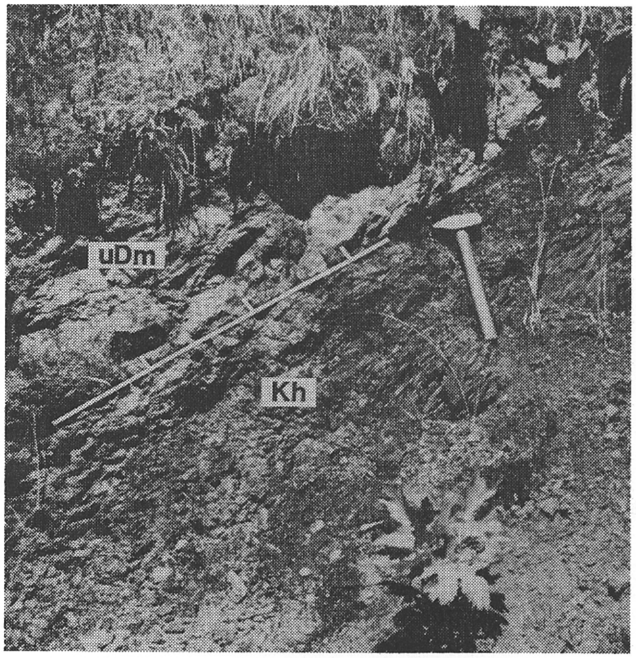


Plate 40. Meade Creek fault; massive tuffite of McLaughlin Ridge Formation (uDm) is superposed on strongly foliated argillites of the Haslam Formation (Kh) (logging road 15F, southwest of Mount Holmes; JRU86-27-09: 5415674N; 411692E).

be the sole thrust for the whole system, but its geometry has not yet been adequately documented.

Where exposed, these thrusts are high-angle reverse faults which dip between 45° and 90° to the east or north-northeast. The thrusts generally place older rocks over younger (Plate 40) and become listric at midcrustal depths (Sutherland Brown and Yorath, 1985; England and Calon, 1991). Slip planes may be relatively sharp and narrow, but wide schistose zones have formed in some hangingwall lithologies (Plate 41) and splays and imbricate zones are well developed. Deformation in the footwalls is limited. Where present, Nanaimo Group sediments dip northeastwards into the faults. A footwall syncline is developed in the thicker Nanaimo Group section beneath the Cowichan fault at the east end of Lake Cowichan. Displacements along fault planes are undetermined. Lithological and stratigraphical comparison along the Cameron River fault in the Alberni area suggests that offsets are probably in the order of 5 to 10 kilometres horizontally and 1 to 2 kilometres vertically. Other faults are not expected to differ markedly from this. Direction of motion is suspected to be westwards; slickensides on fault planes indicate latest movement was horizontal and northwesterly directed.

The maximum age of faulting is bracketed by the involvement of Maastrichtian sediments of the Nanaimo Group in the Cowichan fold and thrust system and sand-

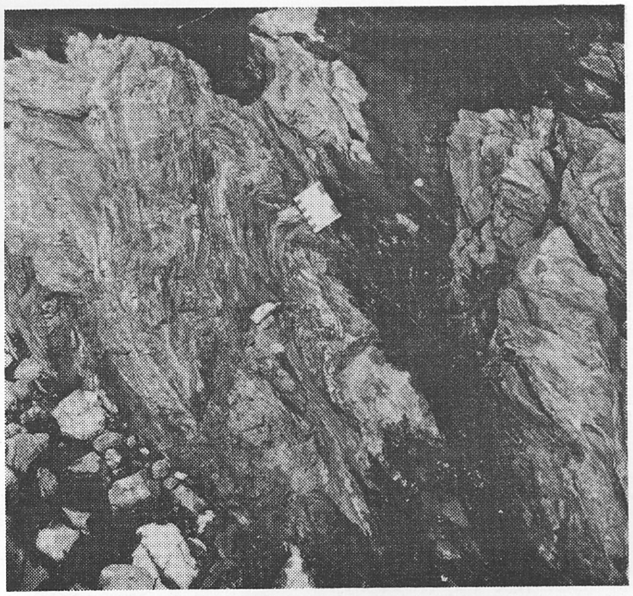

Plate 41. Folding of schistosity within the north strand of the Cowichan fault (R Main, head of Little Shaw Creek; NMA86-05-10: 5421368N; 393226E).

stones of the Eocene Chuckanut Formation (England *et al.*, 1991). This is further constrained by the results of burial history modelling for the Nanaimo Group based on vitrinite reflectance data (England, 1990) which indicate that the Nanaimo Group had to have been buried about 20 million years past the end of the Cretaceous, that is to 46 to 48 Ma before uplift by the thrust system. In the Alberni area, the faults are intruded by Late Eocene porphyry dikes, with an average age of 41 Ma (Massey 1992b), which show only minor late-stage brittle fracturing. Apatites in footwall granodiorites and sediments in the Chemainus and Duncan area yield apparent fission-track ages ranging from 31± 3 Ma to 55± 7 Ma, averaging 42 Ma. Model ages for the apatite fission-tracks average 45± 5 Ma (England *et al.*, 1992). It is thus suspected that faulting took place between about 48 and 45 Ma in the Middle Eocene, possibly during crustal shortening accompanying the formation and accretion of the Pacific Rim and Crescent terranes to the south and west of the project area.

# METAMORPHISM AND ALTERATION

The metamorphic grade in the area is generally low, but increases with the age and structural position of the rocks. Nanaimo sediments are essentially unmetamorphosed, showing only diagenetic alteration of detrital iron oxides and calcareous cements. Bonanza Group volcanics are veined and show minor replacement by laumontite, stilbite, calcite and minor quartz, assemblages typical of the zeolite facies. Karmutsen Formation basalts show amygdule infillings and veins of chlorite, calcite, epidote and quartz, and alteration assemblages typical of the prehnite-pumpellyite facies. Triassic gabbros and diabases, however, show only minor alteration of feldspar and pyroxene, except in chloritic shear zones.

Paleozoic rocks generally show greenschist facies assemblages, although the extent of alteration varies with structural position and lithology. The highest grade rocks are found in the northeast corner of the map area, in the thrust slices overlying the Chemainus River and Fulford faults. Felsic volcanics develop sericite, talc and chlorite along foliation planes and are interbedded with chlorite schists. Intermediate to mafic rocks have chloritic schistose matrixes with epidote and calcite alteration of feldspars. Pyroxene phenocrysts are often replaced by chlorite and may be difficult to discriminate from chlorite amygdules in deformed clasts. Sicker Group volcanic rocks in the rest of the map area generally lack schistosity, though they still show variable saussuritization of feldspars, uralitization of pyroxene and hydration of the matrix. Chlorite schists develop in minor shear zones. The typical thinly bedded sediments of the Fourth Lake Formation show very little affect of alteration except for diagenetic development of siliceous cement. Coarser tuffites and lithic tuffites, however, have matrix chlorite and variably altered clasts. Where involved in intense shearing, however, chlorite and sericite develop along foliation planes.

Stocks and plutons of the Island Plutonic Suite often have contact metamorphic aureoles developed around their perimeters. Porphyroblasts of chiastolite or biotite form in hornfelsed Fourth Lake sediments around the Mount Buttle stock. Rhodonite development in the Shaw Creek chert seems to be restricted to contact aureoles. Hornblende and pyroxene porphyroblasts are present in some volcanic rocks adjacent to intrusions and especially in xenoliths enclosed within the granodiorite. A few garnet-diopside skarns are developed in suitable lithologies of both Paleozoic (Sherk Lake area) and Triassic (Blue Grouse) age.

# ECONOMIC GEOLOGY

## HISTORY OF EXPLORATION

No mines are presently active in the Cowichan Lake area, although the area has been prospected intermittently since about 1900. Small quantities of copper, from the Blue Grouse mine (Plate 42), and manganese, from Hill 60, were shipped during and immediately after World War I. Sporadic prospecting activity, mostly concentrated on gold and copper, resulted in several shafts and adits being sunk on various properties between the wars, but no production ensued. The Blue Grouse mine underwent further development in the early 1950s but production ceased in 1960. The 1960s witnessed a major round of exploration on Vancouver Island, focused on the search for porphyry copper and iron-copper skarn deposits, and the regional evaluation of the Esquimalt and Nanaimo Railway Land Grant. However, no production resulted in the Cowichan Lake area. The present cycle of exploration followed the discovery of the H-W polymetallic massive sulphide orebody at Buttle Lake in 1979. All areas of Sicker Group outcrop north of Cowichan Lake have since been staked and numerous exploration targets defined by mining companies and local prospectors. Some prospecting activity has also taken place in the Mesozoic rocks south of the lake. Sporadic small-scale production of rhodonite has taken place from the Hill 60 deposit.

## CLASSIFICATION OF DEPOSITS

Details of the individual mineral occurrences in the Cowichan Lake area have been compiled in Appendix 1. There are several types of mineral deposits present in the area:

### VOLCANOGENIC, POLYMETALLIC MASSIVE SULPHIDES AND EXHALATIVE OXIDES

Polymetallic massive sulphide deposits are the principal exploration target in the Sicker Group rocks following the success of exploration at the Buttle Lake mine. However, the relatively poor development of felsic volcanics in the Sicker Group of the Cowichan Lake area may mitigate against repeating such finds here. Exhalative oxide deposits occur in the Alberni area at the top of the Duck Lake Formation, which has not been positively indentified in the Cowichan Lake area, but may hold

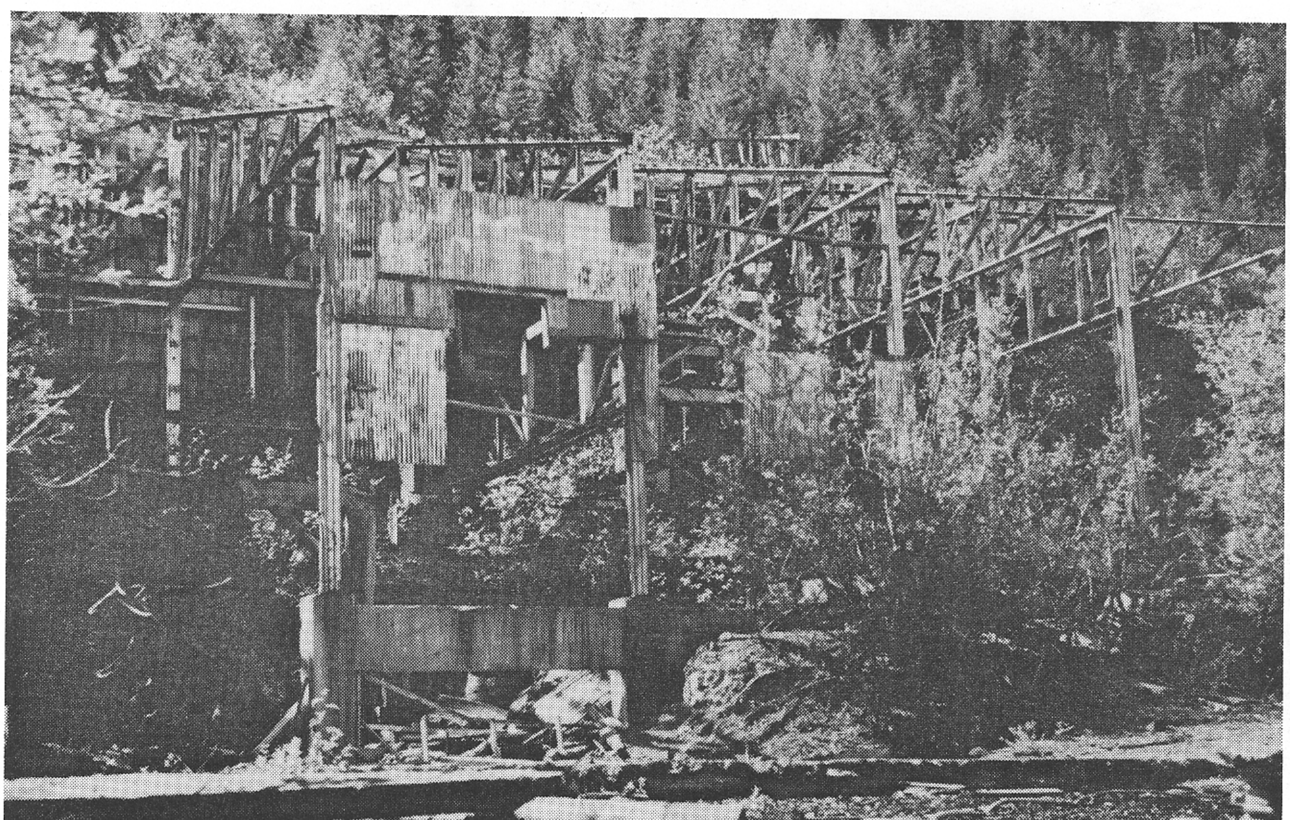

Plate 42. Blue Grouse mine: remains of mill, 1986.

some potential for future investigation. Potential for auriferous massive sulphides may exist within the Bonanza Group volcanics; sulphidic argillites are found interbedded with tuffs and argillite in the basal part of the sequence in the Nixon Creek area.

## Manganese Deposits

Manganese minerals are found in lenticular masses in several places in the cherts of the Shaw Creek Member of the Fourth Lake Formation. Rhodonite is the primary manganese mineral; manganese garnets, rhodochrosite and manganite have also been reported. All occurrences are in the aureoles of Jurassic granodiorite intrusions and owe their origin to the contact metamorphism of manganiferous sediments and associated ribbon chert. The protolith manganiferous sediment may have been of an exhalative origin (Cowley, 1979; Danner and Cowley, 1980). However, contemporaneous volcanic rocks are restricted in volume occurring only on the northeast side of the Cowichan uplift and being absent in the immediate area of the manganese deposits. A low-temperature hydrogenous origin may be more likely. Oxidized deposits near Hill 60 were worked for manganese ore in 1919-20, producing 1013.1 tonnes (1117 tons) of ore, yielding 1 058 679 kilograms of manganese (MINFILE, 1990). This, and several other deposits in the Cowichan valley, were further investigated during the Second World War as a source of manganese for the munitions industry, but proved too small and lean (Fyles, 1955). The main potential for these deposits lies in the production of rhodonite for lapidary uses. Reported localities (with MINFILE numbers: all numbers prefixed by 92C) are Rocky - Widow Creek (113), Wardroper (114), Meade (115) and Stanley Creek - Lookout locality (116).

## Skarns

Zones of chalcopyrite-bearing skarn have been worked at two localities. The Blue Grouse (17) and neighbouring Sunnyside (108) properties are underlain by Karmutsen basalts, Quatsino limestone and Parson Bay limy sediments and limestone, cut by numerous Jurassic feldspar and feldspar pyroxene porphyry dikes. Skarns are developed in limy sediments apparently interbedded with the basalts (Plate 43). Garnet, epidote and actinolite occur as gangue in the skarn. The two mines operated over two time periods, 1917-19 and 1954-60. They produced a combined total of 249 402 tonnes of ore, yielding 218 grams of gold, 2 508 884 grams of silver and 6 818 750 kilograms of copper (MINFILE, 1990).

Other skarn occurrences in Upper Triassic limestones are known in the area south of Cowichan Lake but, in general, these deposits appear to have little economic potential for base metals. The precious metal potential of these skarns has not yet been evaluated, although similar

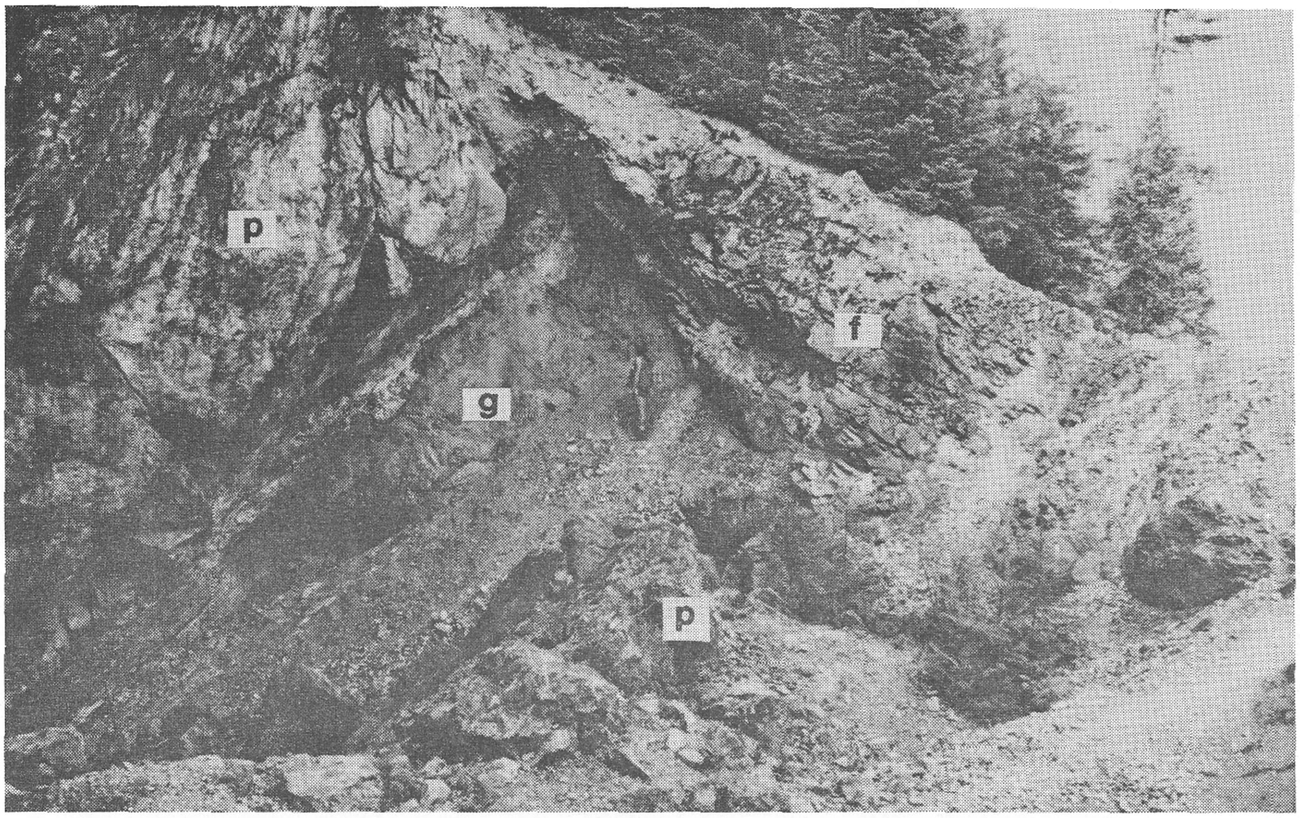


Plate 43. Garnetite skarn zone (g) developed in limy tuff between pillowed flows (p) and adjacent to feldspar basalt dike (f), Blue Grouse mine. (NMA86-58-09: 5410508N; 410530E).

deposits on Texada Island carry gold and silver values (Ettlinger and Ray, 1989).

### Copper-Molybdenum Quartz Veins, Stockworks and Skarns

Sulphide-bearing quartz veins and stockworks occur in Jurassic granodiorite and adjacent country rock on several properties. Chalcopyrite and pyrite, with or without molybdenite, are the principal sulphides; minor sphalerite, galena and arsenopyrite are also reported. Veins are usually less than 1 metre wide. Reported prospects are Delphi (13), Mount Buttle - Allies (14), Lorry (35), Viking (42), Paget (46), AB (75) and Close (112).

On the Comego property (18) copper-molybdenum garnetite skarns are hosted by Fourth Lake Formation sediments intruded by Triassic diabase sills and dikes. However, mineralization is probably related to the nearby Jurassic Reynard Creek stock. Chalcopyrite is accompanied by pyrite, pyrrhotite, magnetite and minor molybdenite. Quartz, calcite and garnet are the principal gangue minerals.

### Gold-Bearing Pyrite-Chalcopyrite-Quartz-Carbonate Veins Along Shears

Many of the faults and shears cutting the Sicker Group volcanics and Triassic gabbro intrusions north of Cowichan Lake are veined by rusty weathering quartz-carbonate. The age of the veining is uncertain, several events being suspected. Some veins are localized along the Tertiary thrusts and crossfaults, but others may represent older structures and mineralizing events. The veins and alteration zones vary in thickness up to 10 metres, but often are about 1 metre wide. They are very variable in lateral extent. The carbonate is principally ankerite and calcite. Sulphides are common with pyrite, pyrrhotite, chalcopyrite and arsenopyrite reported. Gold probably occurs as fine particles. Occurrences investigated in the past include El Capitan (19), Cottonwood (20), Silver Leaf (21), Paint Pot (43) and Candy (76).

### Other Deposits

Two placer leases stretching about 1.5 kilometres along the lower reaches of Meade Creek were issued in 1950. Some testing by panning and sluicing was reported but no production is recorded.

Limestones of the Buttle Lake Group (Mount Mark Formation) and the Quatsino Formation have been exploited for cement manufacture elsewhere on Vancouver Island. Although both limestones have been prospected within the map area (Mount Mark limestone on Fairservice Creek (15) and Marble Bay (16) properties; Quatsino Formation in Gordon River (86) and Nixon Creek (87) areas) none have been worked.

## REGIONAL METALLOGENY

Mineralization in southern Vancouver Island has resulted from three major metallogenic episodes, one of syngenetic character, the other two epigenetic (Figure 57). The localization of metal deposits is controlled by the interplay of stratigraphy and spatial association with later intrusions and structures.

The first major metallogenic episode took place in the Paleozoic during the development of the Sicker island arc. Significant syngenetic metal deposits are associated with these volcanic rocks. Polymetallic, volcanogenic massive sulphides are restricted to two major stratigraphic units. The most important, both for past production and present exploration, is the McLaughlin Ridge Formation in which massive sulphides are associated with felsic volcanics in the upper part of the sequence. They occur in a belt extending from Saltspring Island to Rheinhart Creek, bounded on the south by the Fulford fault, and appear to have formed close to the volcanic centre located in the Duncan-Saltspring area. Exhalites are also found in the uppermost Duck Lake Formation. These are dominantly oxide facies although sulphides are present in some areas, for example, the Regina property in the China Creek area south of Port Alberni. The oxide facies deposits themselves may be of some importance for their gold content, particularly where cut by later structures that have enhanced the grade, as in the 900 zone of the Debbie property, Port Alberni area. This is somewhat analogous to the gold iron formation association common in many Archean greenstone belts. However, the Duck Lake Formation is unknown within the Cowichan Lake area. Other jasper and oxide-rich cherts occur within the Nitinat and McLaughlin Ridge formations but appear to have negligible gold values. The final phase of mineralization during this episode was the development of thin manganese beds and sulphidic argillites within the ribbon cherts of the Shaw Creek member.

The second major metallogenic episode took place during the Early Jurassic, again within an island-arc setting. Unlike the Paleozoic, however, this episode was characterised by epigenetic mineralization of various types and styles, spatially related to intrusions of the Island Plutonic Suite. Copper-molybdenum veins and stockworks occur both within intrusions and in surrounding volcanic country rocks of either Paleozoic or Mesozoic age (Figure 57). Other deposits show stronger stratigraphic control. Iron-copper-gold skarns are developed in calcareous tuffs and limestones of the Karmutsen and Quatsino formations intruded by feldspar porphyry dikes or granodiorite bodies. Limestones of the Buttle Lake Group are rarely skarned, with the exception of small showings north of Fourth Lake (Massey, 1993b) and the copper-molybdenum skarns of the Comego property. Rhodonite development is restricted to areas where man-

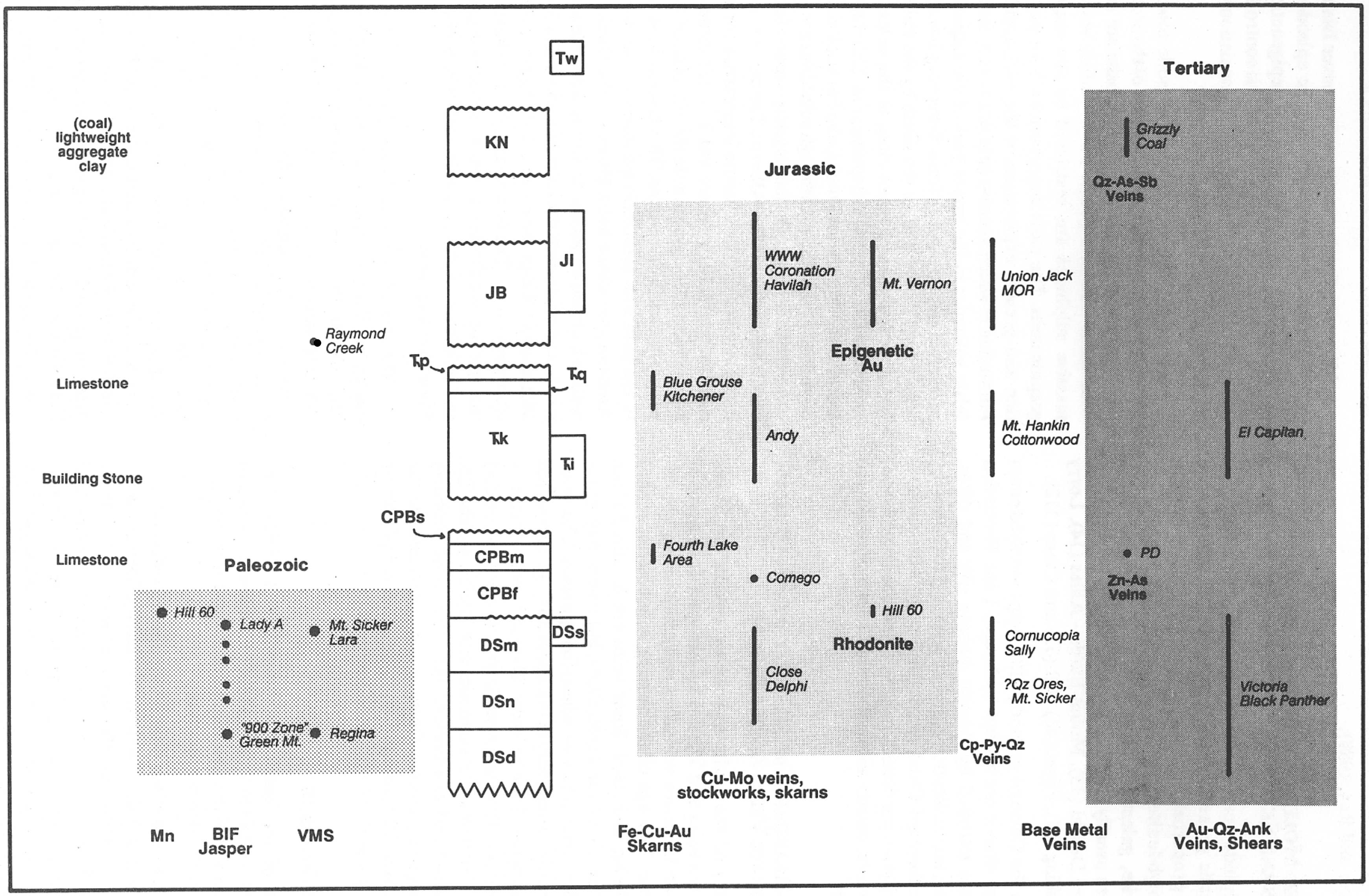


Figure 57. Stratigraphic distribution of mineral deposits in the Cowichan uplift. Stratigraphic column is diagrammatic and not to scale. Syngenetic deposits are illustrated to the left of the stratigraphic column and epigenetic deposits to the right. Shaded blocks indicate the three major metallogenic episodes.

ganiferous cherts of the Shaw Creek member are metamorphosed in the aureoles of granodiorite intrusions.

Metallogeny in the Tertiary differs significantly from the other two episodes. It took place in a contractional fore-arc setting with only limited associated magmatism. Mesothermal gold-bearing quartz-carbonate veins and alteration are common along the major west-northwest-trending contractional faults and crosscutting north-south faults. They are also hosted in older structures. Carbonate alteration varies along the Cowichan uplift, being common in the Alberni and Cowichan Lake areas but essentially absent in much of the Duncan area. The controls on the extent of alteration along faults and the deposition of gold within the zones is still poorly understood.

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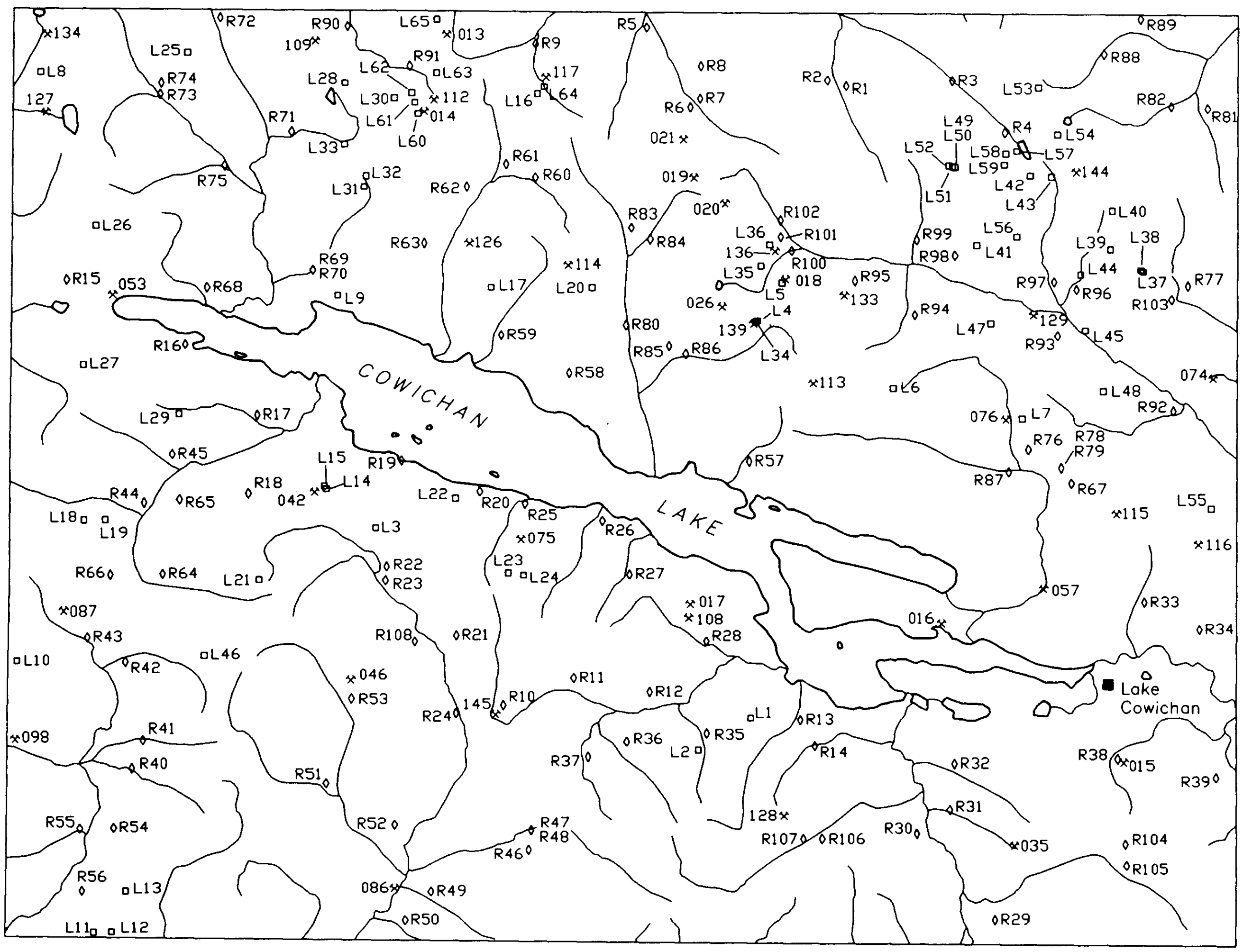
# APPENDICES

# APPENDIX 1

## TABULATED MINFILE, LITHOGEOCHEMICAL ASSAY, MOSS MAT SAMPLE AND R.G.S. SAMPLE DATA




MINFILE (A1-1; Appendix 2)........................ ×

Moss-mat samples (A1-3)............................................................ ▵

RGS samples (A1-4)............................................ ◊

Lithogeochemical assay samples (A1-2)....................... ▫

## APPENDIX 1 - TABLE 1
## MAPPED OCCURRENCES IN THE COWICHAN LAKE MAP AREA

| | PROPERTY NAME | MINFILE NUMBER | STATUS | COMMODITIES |
|---|---|---|---|---|
| **I Vocanogenic massive sulphides and exhalative oxides:** | | | | |
| | SOGNIDORO | 144 | SHOWING | Jasper, Au, Ag, Cu, Mn, Gs |
| **II Copper- and gold-bearing veins along shears:** | | | | |
| (a) El Capitan area | | | | |
| | EL CAPITAN | 019 | PROSPECT | Au, Ag, Cu |
| | COTTONWOOD | 020 | SHOWING | Au, Cu |
| | SILVER LEAF (L.29G) | 021 | SHOWING | Au, Ag, Cu |
| | CHERYL | 136 | SHOWING | Cu |
| (b) Chemainus River - Rheinhart Creek | | | | |
| | COW | 074 | SHOWING | Cu, Pb, Zn, Au, Ag |
| | MIKE | 129 | SHOWING | Au, Ag, Cu |
| | HARBEY | 133 | SHOWING | Au, Ag |
| (c) Heather Mt area | | | | |
| | HEATHER | 127 | SHOWING | Cu, Au |
| | MCDOUGALL | 134 | SHOWING | Au, Cu |
| (d) | PAULA | 126 | SHOWING | Au, Ag, Cu |
| (e) Gordon River | | | | |
| | GOLD DYKE | 042 | SHOWING | Au, Ag, Pb, Zn, Cu |
| | EAGLE | 145 | SHOWING | Cu, Ag, Zn |
| (f) | VIKING | 035 | SHOWING | Cu, Ag |
| (g) | ECHO 1 | 128 | SHOWING | Au, Cu, Ag |
| **III Copper-molybdenite veins and skarns:** | | | | |
| (a) Mount Buttle | | | | |
| | DELPHI | 013 | SHOWING | Cu |
| | ALLIES | 014 | SHOWING | Cu, Mo |
| | RITE 2 | 109 | SHOWING | Au, Ag, Mo, Cu |
| | CLOSE | 112 | SHOWING | Mo, Cu |
| | AMORE | 117 | SHOWING | Au, Ag, Pb, Zn, Mo |
| (b) | AB | 075 | SHOWING | Cu |
| **IV Other base-metal veins, etc.:** | | | | |
| (a) | PAGET | 046 | SHOWING | Au, Zn, Pb |
| (b) | PETERSON | 053 | SHOWING | Cu |
| **V Manganese-rhodonite deposits:** | | | | |
| (a) Widow Creek area | | | | |
| | SHERK LAKE | 026 | SHOWING | Ro, Gs, Mn |
| | ROCKY | 113 | PAST PRODUCER | Ro, Gs, Mn, Cu |
| | WIDOW CREEK | 139 | SHOWING | Ro, Mn, Gs |
| (b) Hill 60 Ridge | | | | |
| | MEADE | 115 | SHOWING | Ro, Mn, Gs, Cu |
| | STANLEY CREEK | 116 | SHOWING | Au, Ag, Cu, Mn, Ro |
| (c) | CANDY | 076 | SHOWING | Cu, Au, Ag, Ro, Gs |
| (d) | WARDROPER | 114 | SHOWING | Ro, Mn, Gs |
| **VI Iron-copper skarns:** | | | | |
| (a) Blue Grouse | | | | |
| | BLUE GROUSE (L.32 & 33) | 017 | PAST PRODUCER | Cu, Ag, Au |
| | SUNNYSIDE (L.34 & 39) | 108 | PAST PRODUCER | Cu, Ag |
| (b) | COMEGO | 018 | SHOWING | Cu, Au, Ag, Mo, Wo |
| (c) | CR | 098 | SHOWING | Cu, Ag, Zn, Au |
| **VII Others:** | | | | |
| (a) | FAIRSERVICE CREEK | 015 | SHOWING | Limestone |
| (b) | MARBLE BAY | 016 | SHOWING | Limestone |
| (c) | GORDON RIVER | 086 | SHOWING | Limestone |
| (d) | NIXON CREEK | 087 | SHOWING | Limestone |
| (e) | MEADE CREEK | 057 | SHOWING | Placer gold |

**Commodities:**

Ag: Silver
Au: Gold
Cu: Copper
Gs: Gemstone
Mn: Magnetite
Mn: Manganese
Mo: Molybdenum
Pb: Lead
Ro: Rhodonite
Wo: Tungsten
Zn: Zinc

## APPENDIX 1 - TABLE 2
## LITHOGEOCHEMICAL ASSAY SAMPLES FROM THE COWICHAN LAKE MAP AREA

| MAP NUMBER | SAMPLE NUMBER | EASTING | NORTHING | MINZ/ALT* | Au ppb | Ag ppm | Cu ppm | Pb ppm | Zn ppm | Co ppm | Ni ppm | Mo ppm | Cr ppm | Hg ppb | As ppm | Sb ppm | Ba ppm | Sr ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L1 | NMA86-26-11-1 | 412093 | 5406882 | SU/SZ | <15 | <10 | 1.21% | 12 | 130 | 24 | 15 | <5 | 18 | nd | <25 | <10 | nd | nd |
| L2 | NMA86-27-06-1 | 410515 | 5405946 | SU/GO | 22 | <10 | 47 | 16 | 48 | 50 | 8 | <5 | 28 | nd | <25 | <10 | nd | nd |
| L3 | NMA86-36-06-1 | 400936 | 5412679 | SU/SZ | 47 | <10 | 28 | 310 | 550 | 28 | 13 | <5 | 18 | nd | 137 | <10 | nd | nd |
| L4 | NMA86-45-01-1 | 412408 | 5418776 | GA | 145 | <10 | 18 | 27 | 15 | 70 | 23 | 33 | 16 | nd | 35 | <10 | nd | nd |
| L5 | NMA86-46-03-1 | 413163 | 5419909 | SU | 16 | <10 | 51 | 10 | 117 | 31 | 14 | 6 | 16 | nd | <25 | <10 | nd | nd |
| L6 | NMA86-48-11-1 | 416452 | 5416684 | SU/GO | <15 | <10 | 35 | 15 | 159 | 39 | 24 | 6 | 46 | nd | <25 | <10 | nd | nd |
| L7 | NMA86-54-04-1 | 420281 | 5415733 | SU/GO/GA | 31 | <10 | 29 | 24 | 38 | 15 | 57 | 110 | 95 | nd | <25 | <10 | nd | nd |
| L8 | SFR86-09-18-3 | 391090 | 5426417 | SU/QC/SZ | 537 | <10 | 1.10% | 9 | 43 | 210 | 295 | 20 | 201 | nd | <25 | <10 | nd | nd |
| L9 | SFR86-18-11-1 | 399880 | 5419671 | SU/GA/SZ | 27 | <10 | 53 | 16 | 287 | 32 | 31 | <5 | 62 | nd | <25 | <10 | nd | nd |
| L10 | SFR86-29-01-1 | 390187 | 5408808 | SU/GA/GO | <15 | <10 | 34 | 12 | 67 | 21 | 16 | 7 | 19 | nd | <25 | <10 | nd | nd |
| L11 | SFR86-36-03-2 | 392435 | 5400358 | SU/GO | 111 | <10 | 59 | 11 | 18 | 29 | 20 | <5 | 40 | nd | <25 | <10 | nd | nd |
| L12 | SFR86-36-04-1 | 392891 | 5400426 | SU/GO | <15 | 16 | 30 | 8 | 101 | 23 | 16 | <5 | 40 | nd | 35 | <10 | nd | nd |
| L13 | SFR86-39-07-1 | 393393 | 5401894 | SU/SI | 16 | <10 | 35 | 8 | 75 | 32 | 20 | <5 | 33 | nd | <25 | 48 | nd | nd |
| L14 | SFR86-46-02-1 | 399477 | 5413852 | GO | <15 | 139 | 46 | 20 | 65 | 30 | 14 | <5 | 28 | nd | <25 | 22 | nd | nd |
| L15 | SFR86-46-03-1 | 399425 | 5413937 | SU | 74 | <10 | 430 | 7 | 27 | 46 | 10 | 22 | 25 | nd | <25 | <10 | nd | nd |
| L16 | PTE86-04-12-1 | 388474 | 5425285 | SU/QV/GO | <15 | <10 | 43 | 30 | 17 | 75 | 37 | 10 | 88 | nd | 0.11% | 22 | nd | nd |
| L17 | PTE86-17-04-1 | 404457 | 5419867 | SU/QV/GA | 35 | <10 | 126 | 40 | 270 | 38 | 113 | 290 | 62 | nd | 56 | 40 | nd | nd |
| L18 | PTE86-22-01-3 | 392254 | 5413002 | SU/GA | <15 | <10 | 80 | 19 | 129 | 31 | 36 | 10 | 27 | nd | <25 | <10 | nd | nd |
| L19 | PTE86-22-05-1 | 392891 | 5412998 | SU/GA | <15 | <10 | 133 | 12 | 60 | 35 | 20 | <5 | 25 | nd | <25 | <10 | nd | nd |
| L20 | PTE86-29-02-1 | 407475 | 5419824 | SU/GA | 16 | <10 | 32 | 20 | 38 | 46 | 22 | 10 | 64 | nd | <25 | <10 | nd | nd |
| L21 | PTE86-36-01-1 | 397451 | 5411172 | SU | <15 | <10 | 89 | 8 | 87 | 35 | 15 | <5 | 29 | nd | <25 | <10 | nd | nd |
| L22 | PTE86-37-04-2 | 403327 | 5413535 | SU/SI | 31 | <10 | 32 | 11 | 72 | 38 | 15 | <5 | 27 | nd | <25 | <10 | nd | nd |
| L23 | PTE86-39-04-1 | 404882 | 5411303 | SU | <15 | <10 | 124 | 10 | 23 | 46 | 10 | <5 | 22 | nd | <25 | <10 | nd | nd |
| L24 | PTE86-39-05-1 | 405331 | 5411236 | SU/QC/SI/GO | 20 | <10 | 15 | 11 | 35 | 34 | 23 | 6 | 26 | nd | <25 | <10 | nd | nd |
| L25 | JRU86-01-08-1 | 395506 | 5426956 | SU/GA | 69 | <10 | 38 | 27 | 94 | 77 | 42 | 17 | 58 | nd | 72 | <10 | nd | nd |
| L26 | JRU86-02-16-1 | 392707 | 5421824 | QA | <15 | <10 | 25 | 8 | 78 | 35 | 134 | <5 | 492 | nd | <25 | <10 | nd | nd |
| L27 | JRU86-04-01-1 | 392289 | 5417643 | IF | 27 | <10 | 0.16% | 21 | 52 | 160 | 43 | <5 | 45 | nd | 150 | <10 | nd | nd |
| L28 | JRU86-06-03-1 | 400175 | 5425990 | GA | <15 | <10 | 73 | 9 | 167 | 38 | 41 | 5 | 38 | nd | <25 | <10 | nd | nd |
| L29 | JRU86-10-02-2 | 395138 | 5416126 | IF | 24 | <10 | 132 | 14 | 136 | 35 | 44 | <5 | 90 | nd | <25 | <10 | nd | nd |
| L30 | JRU86-11-06-1 | 401627 | 5425525 | SU/SI | 214 | <10 | 560 | 67 | 156 | 41 | 58 | 15 | 89 | nd | <25 | <10 | nd | nd |
| L31 | JRU86-13-05-2 | 400691 | 5422895 | SU/QC | 62 | <10 | 157 | 12 | 134 | 40 | 35 | <5 | 89 | nd | 25 | <10 | nd | nd |
| L32 | JRU86-13-07-1 | 400757 | 5423210 | SU | 107 | <10 | 0.22% | 17 | 147 | 130 | 159 | 15 | 194 | nd | 30 | <10 | nd | nd |
| L33 | JRU86-15-05-1 | 400128 | 5424166 | SU | 20 | <10 | 155 | 9 | 50 | 50 | 20 | <5 | 16 | nd | 9 | <10 | nd | nd |
| L34 | JRU86-30-05-2 | 412365 | 5418734 | SU/GA/GO | 16 | <10 | 74 | 43 | 47 | 52 | 31 | 10 | 17 | nd | <25 | <10 | nd | nd |
| L35 | JRU86-30-06-2 | 412530 | 5420429 | SU/QC | <15 | <10 | 83 | 11 | 46 | 38 | 96 | <5 | 127 | nd | 107 | <10 | nd | nd |
| L36 | NMA87-02-04-1 | 412799 | 5420923 | SU/GA | <20 | <0.5 | 110 | 11 | 194 | 73 | 320 | nd | nd | 90 | 256 | <10 | nd | nd |
| L37 | NMA87-06-09-2 | 423926 | 5420144 | QC | <20 | <0.5 | 173 | 11 | 50 | 18 | 84 | nd | nd | 105 | <40 | <10 | nd | nd |
| L38 | NMA87-06-09-3 | 423864 | 5420192 | QC | 68 | <0.5 | 58 | 7 | 48 | 19 | 108 | nd | nd | 110 | <40 | <10 | nd | nd |
| L39 | NMA87-07-01-2 | 422960 | 5420820 | IF | <20 | <0.5 | 41 | 3 | 46 | 67 | 54 | nd | nd | 90 | <40 | <10 | nd | nd |
| L40 | NMA87-07-07-1 | 423020 | 5421961 | IF | 161 | <0.5 | 174 | 7 | 69 | 73 | 58 | nd | nd | 80 | <40 | <10 | nd | nd |
| L41 | NMA87-08-15-1 | 418974 | 5420981 | QC | 25 | <0.5 | 111 | 7 | 61 | 21 | 32 | nd | nd | 96 | <40 | <10 | nd | nd |
| L42 | NMA87-10-03-1 | 420583 | 5423025 | QC | <20 | <0.5 | 500 | 4 | 177 | 38 | 4 | nd | nd | 490 | 133 | 52 | nd | nd |
| L43 | NMA87-10-07-1 | 421226 | 5422981 | QC | 754 | <0.5 | 90 | 6 | 77 | 26 | 40 | nd | nd | 24 | <40 | <10 | nd | nd |
| L44 | NMA87-12-08-2 | 422064 | 5420068 | QV | 197 | <0.5 | 11 | 3 | 23 | 19 | 2 | nd | nd | 40 | <40 | <10 | nd | nd |
| L45 | NMA87-12-10-1 | 422187 | 5418382 | SU | <20 | <0.5 | 42 | 6 | 95 | 3 | 14 | nd | nd | 25 | <40 | <10 | nd | nd |
| L46 | NMA87-60-01-1 | 395814 | 5408914 | SI | 30 | 0.7 | 115 | 5 | 48 | 13 | 18 | <10 | nd | 19 | 27 | 0.6 | nd | nd |
| L47 | SFR87-01-05-2 | 419369 | 5418622 | SU/SI | 41 | 0.6 | 113 | 15 | 74 | 27 | 13 | nd | nd | 45 | <40 | <10 | nd | nd |
| L48 | SFR87-03-05-2 | 422707 | 5416536 | SU/GO | <20 | <0.5 | 96 | 8 | 91 | 18 | 16 | nd | nd | 63 | <40 | <10 | nd | nd |
| L49 | SFR87-09-05-1A | 418354 | 5423291 | IF | 269 | <0.5 | 58 | 15 | 75 | 53 | 33 | nd | nd | 48 | <40 | <10 | nd | nd |
| L50 | SFR87-09-05-1B | 418354 | 5423291 | IF | <20 | <0.5 | 156 | 15 | 58 | 30 | 31 | nd | nd | 56 | <40 | <10 | nd | nd |
| L51 | SFR87-09-06-1 | 418280 | 5423306 | IF | <20 | <0.5 | 56 | 6 | 44 | 41 | 18 | nd | nd | 30 | <40 | <10 | nd | nd |
| L52 | SFR87-09-07-1 | 418166 | 5423339 | SU | 511 | <0.5 | 30 | 12 | 109 | 16 | 4 | nd | nd | 66 | <40 | <10 | nd | nd |
| L53 | SFR87-11-03-1 | 420866 | 5425642 | SU | <20 | <0.5 | 7 | 7 | 30 | 37 | 28 | nd | nd | 45 | <40 | <10 | nd | nd |
| L54 | SFR87-11-22-1 | 421420 | 5424236 | SU | <20 | 0.5 | 810 | <3 | 14 | 70 | 8 | nd | nd | 31 | <40 | <10 | nd | nd |
| L55 | SFR87-13-17-1 | 425916 | 5413012 | SU/QV | 950 | 3 | 0.18% | <5 | 41 | 26 | 28 | <10 | nd | 51 | 40 | 1.0 | nd | nd |
| L56 | SFR87-14-06-1 | 420161 | 5421215 | QC | 90 | <0.5 | 44 | 17 | 16 | 60 | 10 | <10 | nd | 61 | 40 | 12 | nd | nd |
| L57 | PTE87-08-02-1 | 420193 | 5423757 | IF | 217 | <0.5 | 86 | 6 | 95 | 15 | 32 | nd | nd | 61 | <40 | <10 | nd | nd |
| L58 | PTE87-10-02-1 | 419872 | 5423682 | SU/GO | <20 | <0.5 | 51 | 15 | 68 | 60 | 305 | <10 | nd | 19 | 150 | 2 | nd | nd |
| L59 | PTE87-10-04-1 | 419822 | 5423348 | SU | <20 | <0.5 | 45 | 13 | 120 | 28 | 59 | <10 | nd | 10 | 51 | 1 | nd | nd |
| L60 | SFR88-32-02-1 | 402327 | 5425046 | QV | 29 | 2 | 108 | 6 | 20 | nd | 3 | 320 | <50 | 90 | 170 | 0.7 | <100 | 26 |
| L61 | SFR88-32-03-1 | 402240 | 5425390 | QV/SU | 55 | 1 | 440 | 5 | 14 | nd | 3 | 28 | <50 | 71 | 12 | <0.5 | <100 | 17 |
| L62 | SFR88-32-04-1 | 402152 | 5425671 | QV/SU | 61 | 0.8 | 550 | 33 | 17 | nd | 3 | 452 | <50 | 117 | 50 | 0.7 | <100 | 38 |
| L63 | SFR88-36-14-1 | 402889 | 5426255 | QV/SU | 530 | 9 | 0.41% | 14 | 25 | nd | 9 | 45 | 25 | 135 | 120 | <0.5 | nd | nd |
| L64 | SFR88-37-16-1 | 406110 | 5425809 | QC | 1 | <0.5 | 2 | 7 | 25 | nd | 3 | <8 | <50 | 41 | 8 | 0.5 | 510 | 115 |
| L65 | JRI88-33-12-2 | 402925 | 5427867 | SU/GO | 7 | 2 | 0.18% | 9 | 78 | nd | 46 | <8 | 274 | 61 | 5 | <0.5 | nd | nd |
| L66 | JRI88-34-08-1 | 405908 | 5425608 | SZ | 31 | <0.5 | 300 | 4 | 43 | nd | 11 | <8 | 42 | 32 | 22 | <0.5 | nd | nd |

* **Mineralization/ alteration codes:**

GO Gossan or rusty weathering
IF Iron formation
SI Silicification
SU Sulphide mineralization
SZ Shear or fault zone
QC Quartz ankerite alteration
QV Quartz vein

nd: not determined
<20: below indicated detection limit

*(APPENDIX 1 - TABLE 2 Continued)*

## ANALYTICAL PROCEDURES FOR LITHOGEOCHEMISTRY

Analysis performed by B.C. Geological Survey - Analytical Sciences Laboratory

*1. GOLD (Au)*
**Fire Assay/Atomic Absorption** A 0.5 Assay Ton (approx. 15 gram) sample weight is subjected to a standard fire assay technique to generate a Au/Ag bead. The bead is dissolved in acid and Au is measured to a detection limit of <20 ppb by atomic absorption analysis.

*2. SILVER AND BASE METALS (Ag, Cu, Pb, Zn, Co*, Mo, Ni)*
**Atomic Absorption** Samples are digested using a mixed acid attack which includes HF. The dilute acid solution is further diluted to a specific volume and the elements are measured using AAS.

*3. MERCURY (Hg)*
**Cold Vapour/Atomic Absorption** A 0.1 g to 1 g sample is subjected to a HCl and $HNO_3$ digestion followed by the generation of Hg vapour using $SnCl_2$ as a reducing agent. The vapour is swept through a cell in the AAS light path and measured.

*4. ELEMENTS As AND Sb*
**Hydride Generation** A 1 g sample is digested using a mixture of HCl and $HNO_3$; a portion of the diluted sample solution is treated with $NaBH_4$ and the liberated hydride compound is swept into a hot cell in the light path of the AAS unit. The hydride decomposes to give a vapour of the element which is measured.

*5. OTHER ELEMENTS (Sr, Ba, Cr)*
**X-Ray Fluorescence** An approximately 4 gram pulverized sample is mixed with boric oxide and a fusion-flux (lithium tetraborate and lithium metaborate) and fused at 1150°C until completely dissolved in a platinum crucible. The resulting fused disk is then subjected to the x-ray fluorescence spectrometer.

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* - As samples are crushed using tungsten carbide equipment inevitable contamination of Co may occur.

## APPENDIX 1 - TABLE 3
## REGIONAL GEOCHEMICAL SURVEY MOSS-MAT STREAM SEDIMENT SAMPLES FROM THE COWICHAN LAKE MAP AREA

| MAP NUMBER | RGS ID | EASTING | NORTHING | FORM** | Au1 ppb | Au2 ppb | Sb ppm | As ppm | Bi ppm | Cd ppm | Cr ppm | Co ppm | Cu ppm | F ppm | Fe % | Pb ppm | Mn ppm | Hg ppm | Mo ppm | Ni ppm | Ag ppm | Sn ppm | W ppm | U ppm | V ppm | Zn ppm | LOI % | F# ppb | U# ppb | pH# |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R1 | 891005 | 415040 | 5425602 | MJgd | 7 | 0 | 0.5 | 7 | 0.3 | 0.5 | 178 | 14 | 107 | 130 | 2.42 | 3 | 218 | 38 | 5 | 30 | 0.1 | 1 | 1 | 0.8 | 92 | 64 | 6.6 | 10 | 0.02 | 6.0 |
| R2 | 891006 | 414480 | 5425768 | MJgd | 8 | 0 | 0.1 | 1 | 0.1 | 0.1 | 254 | 14 | 110 | 90 | 1.95 | 1 | 243 | 30 | 3 | 23 | 0.1 | 1 | 1 | 0.3 | 60 | 36 | 10.2 | 10 | 0.02 | 6.2 |
| R3 | 891007 | 418203 | 5425717 | Cs | 3 | 0 | 0.2 | 1 | 0.2 | 0.1 | 48 | 12 | 48 | 150 | 2.94 | 1 | 296 | 50 | 4 | 9 | 0.1 | 1 | 1 | 1.2 | 115 | 45 | 7.9 | 10 | 0.02 | 6.2 |
| R4 | 891008 | 419752 | 5424158 | Cs | 34 | 0 | 0.5 | 5 | 0.3 | 0.6 | 92 | 13 | 71 | 190 | 2.06 | 2 | 440 | 37 | 4 | 20 | 0.2 | 1 | 1 | 1.2 | 83 | 76 | 7.5 | 24 | 0.02 | 6.5 |
| R5 | 891032 | 409101 | 5427413 | uTK | 24 | 0 | 0.3 | 8 | 0.2 | 0.2 | 124 | 16 | 71 | 130 | 2.69 | 2 | 300 | 38 | 2 | 22 | 0.2 | 1 | 1 | 1.9 | 82 | 45 | 9.1 | 20 | 0.02 | 6.9 |
| R6 | 891033 | 410382 | 5425009 | uTK | 61 | 0 | 0.6 | 24 | 0.4 | 0.3 | 157 | 27 | 153 | 90 | 3.42 | 2 | 372 | 43 | 2 | 36 | 0.1 | 1 | 1 | 0.4 | 105 | 50 | 9.0 | 10 | 0.05 | 5.3 |
| R7 | 891034 | 410674 | 5425262 | Cs | 77 | 0 | 0.3 | 14 | 0.2 | 0.2 | 268 | 21 | 122 | 90 | 2.98 | 1 | 338 | 30 | 3 | 40 | 0.1 | 1 | 1 | 0.2 | 81 | 46 | 5.4 | 10 | 0.02 | 5.7 |
| R8 | 891035 | 410703 | 5426232 | Cs | 152 | 40 | 0.1 | 2 | 0.1 | 0.1 | 320 | 16 | 139 | 80 | 2.27 | 1 | 220 | 45 | 2 | 28 | 0.1 | 1 | 2 | 0.3 | 63 | 39 | 6.3 | 10 | 0.07 | 5.7 |
| R9 | 891036 | 405766 | 5426953 | uTK | 1 | 0 | 0.1 | 2 | 0.2 | 0.1 | 120 | 15 | 83 | 120 | 2.39 | 1 | 541 | 29 | 2 | 18 | 0.1 | 1 | 1 | 21.8 | 60 | 46 | 4.8 | 20 | 0.11 | 6.0 |
| R10 | 891116 | 404596 | 5407187 | uTQ | 44 | 0 | 0.4 | 6 | 0.2 | 0.3 | 138 | 35 | 139 | 170 | 7.25 | 11 | 1160 | 155 | 7 | 68 | 0.1 | 1 | 1 | 0.8 | 170 | 146 | 6.1 | 44 | 0.02 | 7.0 |
| R11 | 891117 | 406709 | 5407980 | lJB | 5 | 0 | 0.5 | 6 | 0.3 | 0.7 | 67 | 23 | 57 | 160 | 5.47 | 5 | 692 | 10050 | 4 | 18 | 0.1 | 1 | 2 | 1.3 | 127 | 85 | 6.0 | 42 | 0.12 | 7.1 |
| R12 | 891118 | 408983 | 5407545 | lJB | 1 | 0 | 0.4 | 4 | 0.2 | 0.2 | 43 | 20 | 55 | 160 | 5.43 | 3 | 693 | 890 | 3 | 12 | 0.1 | 1 | 2 | 1.2 | 131 | 81 | 5.5 | 38 | 0.12 | 6.9 |
| R13 | 891119 | 413479 | 5406664 | lJB | 19 | 0 | 0.4 | 4 | 0.1 | 0.2 | 45 | 23 | 57 | 140 | 6.65 | 4 | 777 | 64 | 2 | 11 | 0.1 | 2 | 1 | 1.2 | 134 | 85 | 4.6 | 38 | 0.11 | 7.0 |
| R14 | 891120 | 413898 | 5405886 | lJB | 53 | 0 | 0.5 | 2 | 0.2 | 0.2 | 61 | 21 | 41 | 160 | 5.00 | 3 | 728 | 145 | 2 | 16 | 0.1 | 2 | 1 | 1.1 | 113 | 83 | 6.9 | 56 | 0.07 | 7.3 |
| R15 | 891131 | 391706 | 5420077 | lJB | 33 | 0 | 0.3 | 2 | 0.1 | 0.2 | 223 | 26 | 74 | 150 | 4.46 | 2 | 613 | 52 | 1 | 36 | 0.1 | 2 | 1 | 0.6 | 112 | 57 | 3.2 | 40 | 0.02 | 7.1 |
| R16 | 891132 | 395236 | 5418077 | lJB | 1 | 0 | 0.5 | 1 | 0.2 | 0.1 | 35 | 17 | 28 | 160 | 6.59 | 5 | 1048 | 165 | 2 | 6 | 0.1 | 3 | 2 | 1.1 | 173 | 86 | 5.6 | nd | nd | nd |
| R17 | 891133 | 397368 | 5415920 | lJB | 2 | 0 | 0.5 | 1 | 0.1 | 0.1 | 62 | 20 | 33 | 140 | 5.60 | 3 | 754 | 80 | 3 | 10 | 0.1 | 1 | 1 | 1.2 | 156 | 79 | 5.5 | nd | nd | nd |
| R18 | 891134 | 397065 | 5413587 | uTK | 1080 | 205 | 0.9 | 15 | 0.5 | 0.5 | 20 | 25 | 56 | 200 | 7.05 | 25 | 1115 | 215 | 3 | 8 | 0.6 | 1 | 1 | 1.0 | 147 | 134 | 7.7 | 50 | 0.02 | 7.6 |
| R19 | 891135 | 401629 | 5414512 | lJB | 18 | 0 | 0.7 | 9 | 0.2 | 0.3 | 36 | 20 | 41 | 160 | 5.08 | 7 | 846 | 92 | 3 | 8 | 0.1 | 1 | 1 | 1.2 | 110 | 84 | 7.6 | 54 | 0.02 | 7.5 |
| R20 | 891136 | 403955 | 5413581 | lJB | 13 | 0 | 0.4 | 2 | 0.2 | 0.2 | 12 | 26 | 51 | 130 | 5.91 | 2 | 784 | 84 | 3 | 7 | 0.1 | 1 | 1 | 1.0 | 109 | 82 | 10.9 | nd | nd | nd |
| R21 | 891137 | 403212 | 5409291 | uTQ | 4 | 0 | 0.5 | 5 | 0.2 | 0.4 | 25 | 25 | 46 | 140 | 6.04 | 4 | 801 | 96 | 2 | 8 | 0.1 | 2 | 3 | 1.1 | 140 | 108 | 10.5 | 38 | 0.02 | 7.3 |
| R22 | 891138 | 401143 | 5411383 | uTQ | 12 | 0 | 0.5 | 5 | 0.1 | 0.1 | 19 | 22 | 34 | 160 | 5.00 | 5 | 926 | 55 | 1 | 6 | 0.1 | 1 | 2 | 1.3 | 107 | 80 | 13.8 | 38 | 0.02 | 7.3 |
| R23 | 891139 | 401108 | 5410972 | uTQ | 14 | 0 | 0.7 | 14 | 0.6 | 0.6 | 47 | 23 | 51 | 130 | 5.67 | 19 | 760 | 89 | 2 | 15 | 0.1 | 2 | 2 | 1.8 | 130 | 103 | 6.8 | 40 | 0.02 | 7.2 |
| R24 | 891140 | 403182 | 5406964 | uTK | 5 | 0 | 0.3 | 3 | 0.3 | 0.2 | 116 | 27 | 150 | 110 | 4.86 | 4 | 731 | 76 | 2 | 35 | 0.1 | 1 | 1 | 2.0 | 143 | 80 | 13.8 | 36 | 0.02 | 7.1 |
| R25 | 891142 | 405305 | 5413210 | lJB | 128 | 29 | 0.5 | 4 | 0.8 | 0.1 | 20 | 20 | 121 | 130 | 7.00 | 3 | 404 | 165 | 23 | 8 | 0.1 | 1 | 2 | 1.3 | 112 | 59 | 5.8 | 44 | 0.02 | 6.8 |
| R26 | 891143 | 407620 | 5412672 | lJB | 7 | 0 | 0.5 | 2 | 0.3 | 0.1 | 24 | 26 | 90 | 140 | 6.05 | 2 | 651 | 190 | 2 | 9 | 0.1 | 1 | 2 | 0.9 | 145 | 73 | 4.7 | 40 | 0.02 | 7.0 |
| R27 | 891144 | 408413 | 5411074 | uTQ | 48 | 0 | 0.4 | 2 | 0.1 | 0.1 | 35 | 26 | 87 | 130 | 5.48 | 3 | 675 | 8520 | 1 | 11 | 0.1 | 1 | 2 | 1.0 | 151 | 6 | 4.5 | 38 | 0.02 | 6.8 |
| R28 | 891145 | 410693 | 5409040 | lJB | 1 | 0 | 0.6 | 4 | 0.2 | 0.1 | 102 | 21 | 68 | 140 | 5.75 | 4 | 617 | 10070 | 2 | 21 | 0.1 | 1 | 4 | 1.1 | 129 | 68 | 4.7 | 42 | 0.02 | 7.0 |
| R29 | 891147 | 419209 | 5400627 | lJB | 4 | 0 | 0.4 | 5 | 0.1 | 0.8 | 145 | 19 | 77 | 140 | 4.56 | 2 | 550 | 155 | 2 | 42 | 0.1 | 1 | 1 | 1.5 | 119 | 96 | 10.1 | nd | nd | nd |
| R30 | 891148 | 416912 | 5403245 | lJB | 104 | 36 | 0.4 | 2 | 0.1 | 0.7 | 62 | 19 | 54 | 130 | 4.58 | 3 | 652 | 99 | 4 | 16 | 0.1 | 1 | 2 | 1.1 | 101 | 92 | 6.3 | 40 | 0.02 | 6.9 |
| R31 | 891149 | 417899 | 5403957 | lJB | 7 | 0 | 0.1 | 1 | 0.1 | 0.1 | 391 | 32 | 111 | 110 | 6.80 | 1 | 654 | 245 | 3 | 114 | 0.1 | 1 | 1 | 0.4 | 160 | 72 | 4.6 | 38 | 0.02 | 7.3 |
| R32 | 891150 | 418052 | 5405318 | uTK | 1240 | 105 | 0.1 | 1 | 0.1 | 0.2 | 230 | 24 | 92 | 120 | 5.84 | 1 | 538 | 1440 | 2 | 43 | 0.2 | 1 | 2 | 0.6 | 158 | 63 | 3.0 | 38 | 0.02 | 7.5 |
| R33 | 891151 | 423768 | 5410085 | Cs | 8 | 0 | 1.7 | 19 | 0.2 | 0.3 | 59 | 18 | 49 | 160 | 3.55 | 7 | 769 | 135 | 4 | 19 | 0.1 | 1 | 2 | 2.0 | 69 | 74 | 11.0 | 48 | 0.02 | 7.6 |
| R34 | 891152 | 425417 | 5409253 | MJgd | 16 | 0 | 0.1 | 1 | 0.1 | 0.2 | 32 | 7 | 13 | 150 | 1.86 | 7 | 923 | 81 | 2 | 7 | 0.1 | 1 | 1 | 6.7 | 36 | 37 | 14.7 | 88 | 0.12 | 7.3 |
| R35 | 891162 | 410678 | 5406293 | lJB | 27 | 0 | 0.3 | 2 | 0.2 | 0.1 | 37 | 17 | 35 | 150 | 5.40 | 2 | 804 | 79 | 1 | 10 | 0.1 | 1 | 1 | 1.2 | 104 | 71 | 8.4 | 54 | 0.02 | 7.1 |
| R36 | 891163 | 408275 | 5406071 | lJB | 35 | 0 | 0.4 | 6 | 0.2 | 0.1 | 39 | 18 | 50 | 240 | 5.64 | 7 | 786 | 81 | 3 | 10 | 0.1 | 1 | 2 | 1.4 | 116 | 91 | 9.0 | 56 | 0.02 | 7.2 |
| R37 | 891164 | 407110 | 5405630 | uTQ | 3 | 0 | 0.5 | 4 | 0.1 | 0.3 | 51 | 12 | 42 | 220 | 3.44 | 6 | 868 | 320 | 3 | 22 | 0.1 | 1 | 1 | 1.7 | 80 | 67 | 14.4 | 50 | 0.02 | 7.2 |
| R38 | 891165 | 422914 | 5405411 | PBL | 47 | 0 | 0.3 | 2 | 0.1 | 0.1 | 175 | 22 | 112 | 150 | 5.81 | 1 | 627 | 120 | 3 | 42 | 0.1 | 1 | 1 | 0.8 | 159 | 78 | 6.7 | 42 | 0.02 | 7.0 |
| R39 | 891166 | 425863 | 5404833 | uKN | 4 | 0 | 0.6 | 4 | 0.1 | 0.5 | 74 | 12 | 47 | 190 | 2.75 | 6 | 716 | 165 | 3 | 24 | 0.1 | 1 | 2 | 1.0 | 74 | 64 | 11.1 | 38 | 0.02 | 7.4 |
| R40 | 891174 | 393527 | 5405417 | uTK | 3 | 0 | 0.8 | 6 | 0.2 | 0.3 | 109 | 21 | 88 | 140 | 5.83 | 4 | 764 | 76 | 3 | 34 | 0.1 | 1 | 2 | 1.1 | 133 | 92 | 6.2 | 42 | 0.02 | 7.4 |
| R41 | 891175 | 393864 | 5406252 | uTK | 4 | 0 | 0.2 | 2 | 0.1 | 0.1 | 146 | 25 | 120 | 140 | 6.86 | 1 | 808 | 51 | 4 | 58 | 0.1 | 1 | 1 | 0.6 | 207 | 83 | 5.9 | 36 | 0.02 | 7.3 |
| R42 | 891176 | 393355 | 5408593 | uTK | 5 | 0 | 0.7 | 4 | 0.1 | 1.2 | 134 | 20 | 84 | 160 | 6.44 | 3 | 793 | 66 | 4 | 42 | 0.1 | 1 | 1 | 1.4 | 189 | 122 | 6.7 | 36 | 0.02 | 7.3 |
| R43 | 891177 | 392225 | 5409343 | uTQ | 11 | 0 | 1.7 | 14 | 0.1 | 2.1 | 332 | 21 | 78 | 210 | 5.68 | 16 | 817 | 190 | 6 | 59 | 0.3 | 1 | 4 | 2.3 | 138 | 171 | 7.4 | 40 | 0.02 | 7.6 |
| R44 | 891178 | 393963 | 5413349 | uTQ | 98 | 0 | 0.7 | 15 | 0.3 | 0.2 | 23 | 18 | 68 | 200 | 6.88 | 3 | 646 | 115 | 6 | 10 | 0.1 | 1 | 2 | 1.0 | 123 | 81 | 6.5 | 42 | 0.02 | 7.0 |
| R45 | 891180 | 394822 | 5414769 | uTQ | 3 | 0 | 0.5 | 4 | 0.1 | 0.2 | 36 | 18 | 36 | 180 | 5.70 | 4 | 783 | 88 | 2 | 9 | 0.1 | 1 | 1 | 0.7 | 167 | 91 | 7.0 | 64 | 0.02 | 7.1 |
| R46 | 891182 | 405299 | 5402878 | uTK | 225 | 13 | 0.6 | 9 | 0.1 | 0.6 | 190 | 25 | 69 | 190 | 5.41 | 9 | 771 | 66 | 2 | 37 | 0.1 | 1 | 2 | 1.4 | 117 | 120 | 4.8 | 38 | 0.02 | 7.0 |
| R47 | 891183 | 405383 | 5403460 | uTK | 8 | 0 | 0.7 | 8 | 0.1 | 0.7 | 167 | 25 | 87 | 210 | 4.76 | 3 | 716 | 92 | 2 | 49 | 0.1 | 1 | 2 | 3.0 | 122 | 92 | 6.7 | 40 | 0.02 | 7.1 |
| R48 | 891184 | 405383 | 5403454 | uTK | 12 | 0 | 0.7 | 8 | 0.1 | 0.8 | 162 | 25 | 89 | 220 | 5.64 | 4 | 753 | 72 | 3 | 51 | 0.1 | 1 | 1 | 2.8 | 135 | 92 | 6.8 | 42 | 0.02 | 7.4 |
| R49 | 891185 | 402377 | 5401641 | uTK | 300 | 6 | 0.7 | 6 | 0.1 | 0.2 | 134 | 20 | 45 | 180 | 3.81 | 3 | 693 | 75 | 3 | 23 | 0.1 | 1 | 3 | 1.6 | 84 | 80 | 3.7 | 44 | 0.10 | 7.3 |

*(APPENDIX 1 - TABLE 3 Continued)*

| MAP NUMBER | RGS ID | EASTING | NORTHING | FORM** | Au1 ppb | Au2 ppb | Sb ppm | As ppm | Bi ppm | Cd ppm | Cr ppm | Co ppm | Cu ppm | F ppm | Fe % | Pb ppm | Mn ppm | Hg ppm | Mo ppm | Ni ppm | Ag ppm | Sn ppm | W ppm | U ppm | V ppm | Zn ppm | LOI % | F# ppb | U# ppb | pH# |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R50 | 891186 | 401608 | 5400783 | uTQ | 74 | 89 | 3.4 | 31 | 0.1 | 0.4 | 136 | 23 | 68 | 230 | 3.97 | 5 | 792 | 62 | 2 | 37 | 0.1 | 1 | 140 | 1.7 | 92 | 91 | 7.1 | 38 | 0.02 | 6.7 |
| R51 | 891187 | 399283 | 5404918 | uTK | 5 | 0 | 1.1 | 12 | 0.1 | 1.0 | 104 | 21 | 57 | 220 | 3.71 | 4 | 695 | 110 | 2 | 29 | 0.1 | 1 | 2 | 2.4 | 100 | 108 | 7.2 | 40 | 0.02 | 7.4 |
| R52 | 891189 | 401315 | 5403664 | uTK | 57 | 0 | 0.3 | 2 | 0.1 | 0.1 | 131 | 30 | 137 | 140 | 6.00 | 1 | 760 | 71 | 2 | 41 | 0.1 | 1 | 2 | 0.4 | 165 | 75 | 7.1 | 34 | 0.02 | 7.3 |
| R53 | 891190 | 400078 | 5407431 | uTK | 9 | 0 | 0.6 | 7 | 0.3 | 0.4 | 65 | 23 | 62 | 190 | 5.58 | 6 | 705 | 77 | 1 | 21 | 0.1 | 1 | 1 | 1.1 | 130 | 91 | 6.1 | 28 | 0.02 | 7.0 |
| R54 | 891191 | 392959 | 5403647 | lJB | 10 | 0 | 0.3 | 2 | 0.1 | 0.2 | 60 | 20 | 45 | 190 | 3.85 | 3 | 700 | 73 | 1 | 18 | 0.1 | 1 | 1 | 1.5 | 93 | 71 | 6.2 | 32 | 0.02 | 7.0 |
| R55 | 891192 | 391950 | 5403633 | lJB | 3 | 0 | 0.3 | 2 | 0.1 | 0.1 | 43 | 18 | 51 | 180 | 4.05 | 3 | 564 | 70 | 2 | 12 | 0.1 | 1 | 2 | 1.5 | 95 | 69 | 6.2 | 38 | 0.02 | 6.8 |
| R56 | 891193 | 391994 | 5401760 | lJB | 25 | 0 | 0.2 | 1 | 0.1 | 0.1 | 57 | 17 | 37 | 160 | 3.84 | 2 | 545 | 48 | 1 | 14 | 0.1 | 1 | 2 | 1.8 | 97 | 67 | 6.7 | 38 | 0.02 | 6.6 |
| R57 | 891206 | 412025 | 5414392 | uKN | 10 | 0 | 0.3 | 2 | 0.1 | 0.1 | 293 | 19 | 64 | 260 | 2.23 | 2 | 444 | 68 | 2 | 23 | 0.1 | 1 | 2 | 2.0 | 62 | 62 | 6.2 | 54 | 0.02 | 7.4 |
| R58 | 891207 | 406665 | 5417089 | MJgd | 2 | 0 | 0.3 | 2 | 0.1 | 0.2 | 159 | 18 | 80 | 260 | 2.75 | 2 | 730 | 71 | 1 | 20 | 0.1 | 1 | 2 | 1.7 | 76 | 51 | 16.2 | 46 | 0.02 | 7.6 |
| R59 | 891208 | 404650 | 5418260 | MJgd | 175 | 300 | 0.3 | 3 | 0.1 | 0.3 | 123 | 16 | 42 | 160 | 2.48 | 3 | 439 | 49 | 3 | 13 | 0.2 | 1 | 2 | 2.3 | 67 | 52 | 7.6 | 40 | 0.02 | 6.7 |
| R60 | 891209 | 405713 | 5422967 | Cs | 3 | 2 | 0.2 | 1 | 0.1 | 0.1 | 102 | 12 | 36 | 190 | 2.20 | 1 | 394 | 31 | 2 | 11 | 0.1 | 1 | 8 | 1.9 | 50 | 38 | 3.8 | 36 | 0.02 | 6.6 |
| R61 | 891210 | 404847 | 5423362 | Cs | 7 | 0 | 0.3 | 5 | 0.1 | 0.2 | 51 | 15 | 37 | 150 | 2.56 | 3 | 512 | 89 | 2 | 11 | 0.1 | 1 | 3 | 3.5 | 62 | 49 | 10.0 | 34 | 0.02 | 6.9 |
| R62 | 891211 | 403658 | 5422712 | MJgd | 16 | 0 | 0.1 | 3 | 0.1 | 0.2 | 69 | 12 | 48 | 120 | 2.23 | 2 | 316 | 38 | 3 | 8 | 0.1 | 1 | 2 | 3.0 | 59 | 39 | 4.5 | 32 | 0.02 | 6.7 |
| R63 | 891212 | 402368 | 5421048 | Cs | 41 | 0 | 0.2 | 8 | 0.1 | 0.1 | 120 | 18 | 70 | 190 | 2.71 | 3 | 584 | 64 | 2 | 18 | 0.1 | 1 | 1 | 1.2 | 65 | 47 | 14.5 | 48 | 0.10 | 7.4 |
| R64 | 891217 | 394484 | 5411224 | uTK | 7 | 0 | 0.4 | 5 | 0.1 | 0.6 | 47 | 20 | 55 | 160 | 4.00 | 5 | 627 | 98 | 2 | 13 | 0.1 | 1 | 3 | 1.3 | 118 | 82 | 8.1 | 30 | 0.02 | 7.1 |
| R65 | 891222 | 395018 | 5413426 | uTK | 9 | 0 | 0.5 | 8 | 0.2 | 0.4 | 37 | 22 | 50 | 130 | 5.20 | 4 | 711 | 84 | 3 | 15 | 0.1 | 1 | 2 | 1.1 | 124 | 89 | 8.3 | 220 | 0.02 | 7.0 |
| R66 | 891223 | 392923 | 5411217 | uTK | 6 | 0 | 1.1 | 9 | 0.1 | 2.4 | 162 | 23 | 76 | 170 | 4.65 | 5 | 1120 | 130 | 4 | 47 | 0.1 | 1 | 2 | 2.1 | 141 | 151 | 13.6 | 36 | 0.02 | 7.3 |
| R67 | 891252 | 421626 | 5413650 | uKN | 3 | 0 | 1.1 | 8 | 0.1 | 0.4 | 66 | 15 | 46 | 180 | 3.42 | 4 | 663 | 93 | 2 | 20 | 0.1 | 1 | 2 | 1.4 | 68 | 75 | 13.6 | 54 | 0.02 | 6.8 |
| R68 | 891253 | 395893 | 5419794 | Cs | 40 | 0 | 0.8 | 25 | 0.1 | 0.2 | 321 | 29 | 92 | 170 | 3.98 | 2 | 600 | 46 | 1 | 43 | 0.1 | 1 | 2 | 0.6 | 105 | 55 | 4.2 | 28 | 0.02 | 7.2 |
| R69 | 891254 | 399038 | 5420277 | Cs | 6 | 0 | 0.1 | 2 | 0.1 | 0.1 | 160 | 20 | 79 | 210 | 2.42 | 2 | 481 | 56 | 2 | 17 | 0.1 | 1 | 2 | 2.7 | 67 | 47 | 16.0 | 34 | 0.02 | 7.1 |
| R70 | 891255 | 399038 | 5420284 | Cs | 122 | 0 | 0.2 | 3 | 0.1 | 0.1 | 168 | 20 | 71 | 200 | 2.38 | 1 | 414 | 39 | 2 | 15 | 0.1 | 1 | 1 | 1.7 | 63 | 46 | 4.2 | 36 | 0.02 | 7.0 |
| R71 | 891256 | 398470 | 5424402 | Cs | 174 | 9 | 0.1 | 1 | 0.1 | 0.2 | 175 | 16 | 68 | 210 | 2.62 | 1 | 426 | 37 | 2 | 18 | 0.1 | 1 | 1 | 1.6 | 65 | 47 | 3.5 | 34 | 0.02 | 6.8 |
| R72 | 891257 | 396393 | 5428055 | Cs | 8 | 0 | 0.2 | 2 | 0.1 | 0.2 | 524 | 19 | 71 | 230 | 2.24 | 2 | 558 | 35 | 1 | 53 | 0.1 | 1 | 2 | 1.2 | 61 | 45 | 4.9 | 28 | 0.02 | 7.5 |
| R73 | 891258 | 394583 | 5425560 | Cs | 45 | 0 | 0.2 | 2 | 0.1 | 0.2 | 276 | 24 | 92 | 190 | 2.87 | 2 | 628 | 45 | 2 | 27 | 0.1 | 1 | 1 | 1.0 | 73 | 48 | 7.5 | 30 | 0.02 | 7.2 |
| R74 | 891259 | 394617 | 5425908 | Cs | 11 | 0 | 0.4 | 4 | 0.1 | 0.2 | 271 | 20 | 61 | 170 | 2.71 | 4 | 626 | 34 | 1 | 23 | 0.1 | 1 | 1 | 1.1 | 64 | 50 | 6.2 | 28 | 0.02 | 7.5 |
| R75 | 891260 | 396467 | 5423409 | Cs | 18 | 0 | 0.1 | 2 | 0.1 | 0.1 | 538 | 18 | 55 | 160 | 2.29 | 1 | 417 | 22 | 3 | 31 | 0.1 | 1 | 2 | 0.7 | 59 | 36 | 3.7 | 28 | 0.02 | 7.3 |
| R76 | 891360 | 420356 | 5414665 | uKN | 8 | 0 | 0.5 | 10 | 0.1 | 0.1 | 68 | 14 | 58 | 160 | 2.77 | 3 | 450 | 39 | 1 | 15 | 0.1 | 1 | 1 | 1.4 | 70 | 54 | 4.1 | 22 | 0.02 | 6.7 |
| R77 | 891402 | 425168 | 5419556 | Cs | 13 | 0 | 0.2 | 2 | 0.1 | 0.1 | 116 | 17 | 74 | 210 | 3.25 | 2 | 587 | 32 | 2 | 24 | 0.1 | 1 | 2 | 1.1 | 58 | 57 | 5.3 | nd | nd | nd |
| R78 | 891403 | 421327 | 5414115 | uKN | 41 | 0 | 0.3 | 5 | 0.1 | 0.1 | 105 | 14 | 56 | 160 | 2.84 | 2 | 431 | 50 | 1 | 17 | 0.1 | 1 | 3 | 1.3 | 67 | 49 | 5.0 | 22 | 0.02 | 6.7 |
| R79 | 891404 | 421327 | 5414115 | uKN | 2 | 0 | 0.5 | 6 | 0.1 | 0.2 | 103 | 14 | 61 | 160 | 2.86 | 3 | 447 | 53 | 2 | 19 | 0.1 | 1 | 3 | 1.4 | 69 | 53 | 5.1 | 22 | 0.02 | 6.7 |
| R80 | 891406 | 408382 | 5418529 | Cs | 16 | 0 | 0.3 | 3 | 0.1 | 0.2 | 55 | 12 | 27 | 210 | 2.74 | 2 | 437 | 64 | 1 | 9 | 0.1 | 1 | 1 | 2.6 | 51 | 46 | 4.7 | 34 | 0.02 | 7.0 |
| R81 | 891407 | 425826 | 5424818 | Cs | 3 | 0 | 0.3 | 2 | 0.1 | 0.1 | 63 | 14 | 56 | 130 | 3.03 | 3 | 538 | 37 | 2 | 23 | 0.1 | 1 | 2 | 0.9 | 70 | 62 | 6.7 | 26 | 0.02 | 6.6 |
| R82 | 891408 | 424730 | 5424889 | Cs | 13 | 0 | 0.4 | 4 | 0.1 | 0.2 | 262 | 17 | 91 | 160 | 3.19 | 3 | 422 | 36 | 1 | 44 | 0.1 | 1 | 2 | 1.2 | 84 | 72 | 5.6 | 24 | 0.02 | 6.3 |
| R83 | 891409 | 408572 | 5421449 | Cs | 3 | 0 | 0.3 | 4 | 0.1 | 0.2 | 141 | 16 | 73 | 210 | 3.27 | 2 | 386 | 23 | 1 | 26 | 0.1 | 1 | 2 | 1.2 | 69 | 50 | 4.0 | 24 | 0.02 | 6.7 |
| R84 | 891410 | 409134 | 5421099 | Cs | 1320 | 13 | 0.5 | 6 | 0.1 | 0.1 | 205 | 21 | 101 | 200 | 3.35 | 5 | 432 | 34 | 2 | 35 | 0.4 | 1 | 2 | 0.8 | 71 | 54 | 4.9 | 22 | 0.02 | 6.5 |
| R85 | 891411 | 409667 | 5417876 | Cs | 16 | 0 | 0.4 | 10 | 0.3 | 0.4 | 112 | 17 | 88 | 220 | 2.84 | 3 | 501 | 56 | 1 | 22 | 0.1 | 1 | 4 | 1.6 | 82 | 73 | 10.9 | 24 | 0.12 | 6.6 |
| R86 | 891412 | 410162 | 5417630 | Cs | 51 | 0 | 0.5 | 5 | 0.2 | 0.1 | 153 | 14 | 92 | 230 | 2.59 | 2 | 369 | 40 | 2 | 25 | 0.1 | 1 | 3 | 1.5 | 63 | 48 | 5.1 | 26 | 0.10 | 6.8 |
| R87 | 891413 | 419763 | 5414006 | uKN | 122 | 71 | 0.4 | 5 | 0.1 | 0.2 | 116 | 14 | 50 | 180 | 2.91 | 3 | 413 | 145 | 1 | 21 | 0.1 | 1 | 3 | 1.3 | 57 | 52 | 4.1 | 32 | 0.02 | 6.7 |
| R88 | 891414 | 422732 | 5426478 | Cs | 18 | 0 | 0.7 | 6 | 0.1 | 1.1 | 438 | 16 | 92 | 130 | 3.43 | 2 | 364 | 44 | 2 | 43 | 0.2 | 1 | 2 | 1.0 | 89 | 94 | 7.4 | 24 | 0.02 | 6.8 |
| R89 | 891415 | 423865 | 5427695 | Cs | 8 | 10 | 3.1 | 25 | 0.2 | 1.2 | 204 | 20 | 120 | 130 | 3.46 | 5 | 1280 | 120 | 7 | 45 | 0.3 | 1 | 1 | 1.9 | 81 | 105 | 11.6 | 24 | 0.02 | 6.7 |
| R90 | 891416 | 400171 | 5427543 | Cs | 93 | 0 | 0.3 | 3 | 0.1 | 0.1 | 113 | 14 | 61 | 180 | 2.46 | 4 | 439 | 43 | 2 | 18 | 0.1 | 1 | 1 | 1.3 | 55 | 45 | 3.9 | 20 | 0.02 | 6.5 |
| R91 | 891417 | 402001 | 5426332 | Cs | 1 | 0 | 0.1 | 2 | 0.2 | 0.1 | 101 | 11 | 44 | 190 | 1.79 | 2 | 475 | 46 | 7 | 12 | 0.1 | 1 | 2 | 2.5 | 45 | 36 | 5.8 | 20 | 0.02 | 6.6 |
| R92 | 891428 | 424697 | 5415779 | Cs | 43 | 0 | 0.6 | 9 | 0.1 | 0.2 | 67 | 13 | 56 | 140 | 2.80 | 3 | 630 | 62 | 2 | 15 | 0.1 | 1 | 1 | 1.4 | 67 | 51 | 6.9 | 10 | 0.02 | 6.7 |
| R93 | 891429 | 421256 | 5418076 | Cs | 10 | 0 | 0.3 | 3 | 0.1 | 0.2 | 114 | 10 | 63 | 150 | 2.41 | 2 | 406 | 41 | 2 | 15 | 0.1 | 1 | 1 | 1.3 | 60 | 44 | 4.4 | 10 | 0.02 | 6.9 |
| R94 | 891430 | 417009 | 5418748 | Cs | 172 | 4 | 0.1 | 2 | 0.1 | 0.1 | 70 | 14 | 52 | 170 | 2.84 | 6 | 780 | 66 | 1 | 15 | 0.1 | 1 | 2 | 2.7 | 62 | 45 | 14.9 | 10 | 0.02 | 6.8 |
| R95 | 891431 | 415238 | 5419793 | MJgd | 8 | 0 | 0.2 | 2 | 0.3 | 0.1 | 71 | 9 | 51 | 140 | 2.17 | 3 | 501 | 88 | 3 | 11 | 0.1 | 1 | 3 | 1.8 | 51 | 30 | 8.8 | 10 | 0.02 | 6.4 |
| R96 | 891432 | 421829 | 5419477 | Cs | 94 | 0 | 0.4 | 5 | 0.1 | 0.2 | 74 | 17 | 79 | 160 | 2.73 | 6 | 1060 | 47 | 1 | 26 | 0.1 | 1 | 1 | 1.0 | 69 | 66 | 6.7 | nd | nd | nd |
| R97 | 891433 | 421162 | 5419708 | Cs | 8 | 0 | 0.7 | 8 | 0.2 | 0.3 | 107 | 17 | 71 | 180 | 2.86 | 3 | 980 | 54 | 1 | 29 | 0.1 | 1 | 2 | 1.2 | 60 | 73 | 5.0 | 22 | 0.02 | 6.8 |
| R98 | 891434 | 418219 | 5420534 | Cs | 12 | 0 | 0.5 | 6 | 0.2 | 0.2 | 104 | 18 | 93 | 140 | 3.34 | 4 | 1120 | 57 | 2 | 35 | 0.1 | 1 | 2 | 1.1 | 77 | 78 | 6.9 | 10 | 0.02 | 6.5 |
| R99 | 891435 | 417094 | 5421004 | Cs | 6 | 0 | 0.8 | 13 | 0.3 | 0.5 | 143 | 21 | 104 | 210 | 3.97 | 7 | 1340 | 63 | 5 | 39 | 0.1 | 1 | 1 | 2.0 | 95 | 111 | 7.0 | nd | nd | nd |
| R100 | 891437 | 413357 | 5420713 | Cs | 41 | 0 | 1.6 | 22 | 0.3 | 0.2 | 153 | 24 | 182 | 160 | 3.86 | 3 | 727 | 80 | 5 | 33 | 0.2 | 1 | 27 | 0.9 | 80 | 56 | 6.5 | 20 | 0.02 | 7.0 |
| R101 | 891438 | 413037 | 5421127 | Cs | 265 | 36 | 2.1 | 33 | 0.8 | 0.3 | 174 | 26 | 173 | 130 | 3.43 | 3 | 593 | 71 | 4 | 42 | 0.1 | 1 | 2 | 0.5 | 92 | 57 | 9.7 | 10 | 0.02 | 6.7 |
| R102 | 891439 | 413036 | 5421622 | uTK | 1120 | 6 | 0.3 | 12 | 0.1 | 0.2 | 229 | 22 | 139 | 130 | 3.00 | 3 | 542 | 36 | 1 | 38 | 0.2 | 1 | 3 | 0.7 | 70 | 48 | 7.0 | 10 | 0.02 | 6.7 |

*(APPENDIX 1 - TABLE 3 Continued)*

| MAP NUMBER | RGS ID | EASTING | NORTHING | FORM** | Au1 ppb | Au2 ppb | Sb ppm | As ppm | Bi ppm | Cd ppm | Cr ppm | Co ppm | Cu ppm | F ppm | Fe % | Pb ppm | Mn ppm | Hg ppm | Mo ppm | Ni ppm | Ag ppm | Sn ppm | W ppm | U ppm | V ppm | Zn ppm | LOI % | F# ppb | U# ppb | pH# |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R103 | 891440 | 424676 | 5419149 | Cs | 8 | 0 | 0.2 | 4 | 0.1 | 0.2 | 106 | 18 | 80 | 140 | 3.41 | 2 | 1160 | 47 | 2 | 25 | 0.1 | 1 | 2 | 1.4 | 54 | 56 | 3.7 | nd | nd | nd |
| R104 | 893045 | 423114 | 5402868 | uTK | 7 | 0 | 0.2 | 1 | 0.1 | 0.1 | 267 | 33 | 155 | 100 | 6.35 | 1 | 1125 | 71 | 1 | 88 | 0.1 | 1 | 2 | 0.3 | 185 | 105 | 9.2 | 26 | 0.02 | 7.1 |
| R105 | 893046 | 423143 | 5402227 | uTK | 1 | 0 | 0.2 | 1 | 0.1 | 0.1 | 251 | 31 | 151 | 110 | 6.22 | 1 | 730 | 190 | 1 | 73 | 0.1 | 1 | 1 | 0.5 | 178 | 138 | 6.9 | 22 | 0.02 | 7.0 |
| R106 | 893050 | 414086 | 5403122 | lJB | 2 | 0 | 0.2 | 2 | 0.1 | 0.1 | 37 | 11 | 26 | 140 | 2.98 | 2 | 483 | 55 | 3 | 11 | 0.1 | 1 | 2 | 2.1 | 84 | 34 | 12.7 | 24 | 0.02 | 6.7 |
| R107 | 893051 | 413521 | 5403123 | lJB | 10 | 0 | 0.4 | 3 | 0.1 | 0.2 | 104 | 19 | 40 | 160 | 5.20 | 3 | 560 | 64 | 2 | 17 | 0.1 | 1 | 2 | 1.2 | 127 | 75 | 7.2 | 26 | 0.02 | 6.8 |
| R108 | 893052 | 401978 | 5409121 | uTK | 9 | 0 | 0.6 | 12 | 0.3 | 0.3 | 142 | 20 | 64 | 180 | 4.35 | 4 | 538 | 66 | 2 | 38 | 0.1 | 1 | 2 | 2.4 | 120 | 95 | 9.3 | 22 | 0.02 | 6.8 |

* *Complete data and methods of sample analysis are contained within Matysek et al., 1990*

** *Dominant geological formation in watershed (determined from Roddick et al., 1979)*

- *Cs :* *Sicker Group & lower Buttle Lake Group*
- *PBL :* *upper Buttle Lake Group*
- *uTK :* *Karmutsen Formation*
- *uTQ :* *Quatsino and Parson Bay Formations*
- *lJB :* *Bonanza Group*
- *MJgd :* *Island Plutonic Suite*
- *uKN :* *Nanaimo Group*

*Au1:* *Initial gold determination*

*Au2:* *Repeat determination if sample was anomalous for Au1 (100ppb) or a pathfinder element (As,Cu,Pb,Zn,Sb,Hg)*

\# *in waters*

# APPENDIX 2

## MINERAL OCCURRENCES IN THE COWICHAN LAKE MAP AREA

The data in this appendix has been extracted from the British Columbia Ministry of Energy, Mines and Petroleum Resources mineral inventory database MINFILE. Only the geological descriptions of the occurrences are included here; the complete data set is included in the MINFILE release for 92C Cape Flattery (1991).

NOTE: This material is reproduced directly from the MINFILE database (June 1991) for the convenience of the reader.

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**MINFILE NUMBER: 092C 013** **NAME: DELPHI**
NORTHING: 5427400 EASTING: 403200 STATUS: Showing

CAPSULE GEOLOGY:

The Delphi showings are located just south of the 49th parallel on Vaughn Creek approximately 8.5 kilometres north of Cowichan Lake.The claims were first staked in 1900.

A series of subparallel, steeply dipping quartz-calcite veins crosscut pyroxene phyric tuffs and breccias of the Middle Devonian Nitinat Formation (Sicker Group). The veins are probably genetically related to the Delphi Lake stock, 300 metres to the south, which is probably related to the Early to Middle Jurassic Island Plutonic Suite. The area has undergone regional greenschist metamorphism.

Mineralization consists of disseminated pyrite, chalcopyrite and pyrrhotite in veins and pods of magnetite in epidote-rich, skarn-likerocks. A sample of pyritized quartz from the dump on the Iron Crown claim assayed trace gold and 1% copper (Minister of Mines Annual Report 1930, page 303). The veins are up to 15.2 metres long and are generally less than 23 centimetres wide. A vein on the Brass claim strikes 005 degrees and dips 80 degrees east.

The workings consist of a 2.5 metre shaft on the Brass claim (Lot 78), a 10 metre shaft on the Iron Crown claim (Lot 79) and a short adit on the Tyro claim (Lot 77), collectively known as the Delphi or Jubilee property.

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**MINFILE NUMBER: 092C 014** **NAME: ALLIES**
NORTHING: 5425100 EASTING: 402500 STATUS: Showing

CAPSULE GEOLOGY:

The Allies showings occur at the headwaters of Green River just north of Mount Buttle over an area 2 by 0.6 kilometres. There is some overlap with the Close showings (092C 112) located about 1 kilometre to the north.

The area is underlain by volcanic rocks (greeenstone) of the Middle Devonian Nitinat Formation, Sicker Group. These volcanic rocks have been intruded by the Saanich granodiorite which is probably related to the Early to Middle Jurassic Island Plutonic Suite.

A series of subparallel quartz veins carry erratically distributed accessory amounts of pyrite, molybdenite and chalcopyrite. The veins crosscut a monzonitic (aplogranitic) marginal phase of the Delphi Lake/Saanich granodiorite stock. Theveins, generally 10 to 30 centimetres wide but up to 1.5 metres, generally strike slightly west of north and dip steeply east. The sulphides occur as disseminations, and as coarse crystals or aggregates up to 10 centimetres across. Molybdenite occurs in flakes, clumps and rosettes from grain size to several centimetres across, most commonly as rosettes.

A grab sample (#14) taken from the higher grade pieces in a shear zone with fine molybdenite in the walls assayed 0.4% molybdenum (Property File - Laanela, 1965).

Workings consist of 2 adits, a shaft and several trenches. The mineralization appears to be related to the emplacement of a late, high level monzonitic phase of intrusion into Nitinat Formation volcanics. The volcanics are preserved in a pendant on the ridgecrest of Mount Buttle.

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**MINFILE NUMBER: 092C 015** **NAME: FAIRSERVICE CREEK**
NORTHING: 5405450 EASTING: 423180 STATUS: Showing

CAPSULE GEOLOGY:

The Fairservice Creek showing is located 2.5 kilometres south of the community of Lake Cowichan, 25 kilometres west of Duncan.

A band of limestone outcrops just east of Fairservice Creek and continues east-southeast for at least 2.4 kilometres. The limestone has been correlated to the Upper Pennsylvannian to Lower Permian Mount Mark Formation, Buttle Lake Group (previously Buttle Lake Formation, Sicker Group). In this vicinity, bedding strikes 132 to145 degrees and dips 55 to 56 degrees southwest. The limestone is overlain to the southwest by pillowed basalts of the Upper Triassic Karmutsen Formation, Vancouver Group and underlain to the northeast by bedded chert, tuff and breccia of the Upper Devonian McLaughlin Ridge Formation, Sicker Group.

The deposit is comprised of light grey to white, fine to medium grained, crinoidal limestone with a few intercalations of thinly bedded sandstone, siltstone and argillite.

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**MINFILE NUMBER: 092C 016** **NAME: MARBLE BAY**

NORTHING: 5409650 EASTING: 417800 STATUS: Showing

CAPSULE GEOLOGY:

The Marble Bay showing is located at the east end of Cowichan Lake, 30 kilometres west-northwest of Duncan.

A 150 to 300 metre thick limestone bed strikes northwest for 4.75 kilometres across the peninsula at the east end of Cowichan Lake. The limestone has been correlated to the Upper Pennsylvannian to Lower Permian Mount Mark Formation, Buttle Lake Group (previously Buttle Lake Formation, Sicker Group). The bed dips between 30 and 72 degrees southwest. The limestone is overlain by Upper Triassic Karmutsen Formation, Vancouver Group basalt and underlain by bedded chert, tuff and breccia of the Upper Devonian McLaughlin Ridge Formation, Sicker Group. A few dikes intrude the limestone.

The formation consists of chert and well-bedded siliceous limestone interbedded with relatively pure, light grey to white,massive, fine to medium grained limestone containing abundant crinoid fragments. Thin sections reveal numerous crinoid stems and sponge spicules. A chip sample taken at 3.0 metre intervals across 61metres of limestone just north of Marble Bay on the south side of the peninsula contained 51.5% CaO, 0.84% MgO, 5.70% insolubles, 0.28% $R_2O_3$, 0.10% $Fe_2O_3$, 0.02% MnO, 0.04% $P_2O_5$, 0.011% sulphur, 41.4% ignition loss and 0.13% water (Bulletin 40, page 47, Sample 2).

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**MINFILE NUMBER: 092C 017** **NAME: BLUE GROUSE (L.32, 33)**

NORTHING: 5410300 EASTING: 410300 STATUS: Past Producer

CAPSULE GEOLOGY:

The Blue Grouse mine is located on the south side of Cowichan Lake, 4.8 kilometres northeast of Honeymoon Bay. Mineralized outcrops on the property were first located between 1900 and 1910.The mine was abandoned in 1960, reportedly leaving some reserves.The workings were rehabilitated in 1979 by Corrie Copper Ltd. Copper mineralization of mineable grade was reported to be present at the 1100 level. The workings were backfilled sometime between 1987 and 1989.

The Cowichan Lake area is at the eastern end of the Cowichan uplift, one of a series of major geanticlines on Vancouver Island.The area is underlain by pyroclastic, sedimentary and volcanic rocksof the Paleozoic Sicker Group, the Mississippian to Permian Buttle Lake Group, the Upper Triassic Vancouver Group and the Lower Jurassic Bonanza Group which have been intruded by Triassic gabbros (informally named Mount Hall) and Early to Middle Jurassic Island Plutonic Suite rocks, and overlapped by Upper Cretaceous sediments of the Nanaimo Group.

The Vancouver Group comprises pillow and massive basalt, volcaniclastics, tuffs and breccias of the Karmutsen Formation; siltstone, argillite and micrite of the Quatsino Formation and limestone, tuff and argillite of the Parson Bay Formation.

The property is underlain by Karmutsen Formation volcanics and Parson Bay Formation sediments. Sediments of the Nanaimo Group and volcanics of the Bonanza Group occur near the property. These arecut by numerous Jurassic feldspar and feldspar-pyroxene porphyry dikes related to the Bonanza Group.

The orebodies occur in limestone and tuffaceous members which are folded in a series of overturned folds. The beds are displaced by a series of thrust faults which have a general east strike and dips of 10 to 20 degrees south. Garnet-epidote-actinolite skarns are developed in limy tuff, limy sediments and limestone, apparently interbedded with the upper portions of Karmutsen Formation basalts.

Mineralization was present in ten small tabular sulphide zonesand consisted of chalcopyrite, pyrrhotite, pyrite and lesser magnetite and sphalerite.

The main orebody, hosted in volcanic rocks, was the G-H. The ore consisted of a skarn zone which formed a southwest plunging pipe-like body extending from the surface to the 335 metre level.The mineralization comprised chalcopyrite, pyrite and pyrrhotite irregularly occurring as stringers and small masses. The orebody was displaced to the northeast, the top block moved 305 metres to the north and 46 to 61 metres to the east in relation to the lower block.

The E ore body, 300 metres due south of the G-H, was a 3 to 4metre wide tuffaceous horizon mineralized with pyrrhotite. The pyrrhotite almost completely replaced the bedded rock and was veined with small stringers and irregular masses of chalcopyrite and pyrite. Small grains of hematite were noted locally.

The mine was in production from 1917 to 1919 and from 1956 to1960. From 249 298 tonnes of rock, 6 814 623 kilograms of copper, 2 508 644 grams of silver and 218 grams of gold were produced. Exploration in 1989 located several gossanous zones in the southwest portion of the property. A 1-metre chip sample (109075) of intermediate tuff with copper staining from the BGN-4 site assayed 0.7% copper and 0.043 grams per tonne gold (Assessment Report19387). Sampling results ranged from 0.0007 to 1.1824% copper and 0.001 to 0.043 grams per tonne gold (Assessment Report19387).

**MINFILE NUMBER: 092C 018** **NAME: COMEGO**
NORTHING: 5420000 EASTING: 413250 STATUS: Showing

CAPSULE GEOLOGY:

The Comego showing is located on the Widow claims about 6.5 kilometres north of Youbou at the headwaters of Chemainus River. The claims were originally staked in 1902 as the Cascade claim.Considerable exploration has been done on the property.

Skarns are developed in the Mississippian to Pennslvanian Fourth Lake Formation (Buttle Lake Group) sediments which have been intruded by Triassic diabase and gabbro sills informally called the Mount Hall gabbro. Mineralization may, however, be related to the nearby Jurassic Reynard Creek diorite stock. The rock types in the area comprise chert, cherty tuffs and sediments, agglomerates and argillites.

Mineralization consists of chalcopyrite, pyrite, pyrrhotite, magnetite, minor molybdenite, sphalerite, tetrahedrite, rare borniteand arsenopyrite. Pyritiferous quartz- carbonate altered shear zones outcrop in the Chemainus River south of the areas of skarn mineralization. Assays from the quartz-carbonate zones are very low.

Mineralization occurs as three types: 1) Quartz-calcite-garnet-actinolite skarn with magnetite, chalcopyrite, pyrrhotite, pyrite and locally tetrahedrite replacing sediments 2) Quartz veins hosting molybdenite, pyrite and chalcopyrite; and 3) quartz-carbonate veins in shear zones.

**MINFILE NUMBER: 092C 019** **NAME: EL CAPITAN**
NORTHING: 5423050 EASTING: 410550 STATUS: Prospect

CAPSULE GEOLOGY:

The El Capitan prospect is located 8 kilometres north of Youbou on the flanks of El Capitan Mountain. The prospect encompasses old underground workings and a quartz vein located approximately 120 metres to the southeast of the workings (Paint Pot). The claim was staked in 1925, adits #1 and #2 and a tunnel were developed in 1927-30 and adit #3 was completed in 1932-35.

The area is underlain by volcanic rocks of the Upper TriassicKarmutsen Formation, Vancouver Group.

Mineralization occurs in shear zones and quartz veins in massive porphyritic basalt. In the workings, a shear zone, 1 metre wide, occurs along the south wall of a hornblende porphyry dike. The dike is 3 metres wide, strikes 080 degrees and is nearly vertical. The shear zone exhibits copper and iron oxidation and hosts pyrite, pyrrhotite, chalcopyrite, arsenopyrite and minor amounts of quartz and calcite. Sampling across 3 metres of the shear zone assayed up to 68.56 grams per tonne gold and 8% copper (Property File -Dayton Developments, 1989). The workings are in bad condition and therefore exploration in 1986 was unable to confirm previous (1979) assays of up to 141.27 grams per tonne gold, 44.35 grams per tonne silver and 2.16% copper (Assessment Report 7832).

To the south of the workings, about 120 metres, a quartz vein in a shear zone hosts chalcopyrite mineralization (Paint Pot). The vein strikes 155 degrees, dips 45 degrees east, is exposed for 4 metres and is 0.15 to 0.40 metres wide. Chip samples from quartz veins assayed up to 26.05 grams per tonne gold (Property File - Dayton Developments, 1989).

**MINFILE NUMBER: 092C 020** **NAME: COTTONWOOD**
NORTHING: 5422275 EASTING: 411470 STATUS: Showing

CAPSULE GEOLOGY:

The Cottonwood showing is located near the El Capitan prospect (092C 019), on the flanks of El Capitan Mountain. In 1927 to 1929 three short adits and two opencuts were developed on the property.

The area is underlain by porphyritic basalt of the Upper Triassic Karmutsen Formation, Vancouver Group.

The showing consists of a continuous shear zone which contains lenses of quartz and iron oxides. Pyrite and pyrrhotite occur locally with the iron oxides. The shear zone has been traced for 150metres and is up to 9 metres wide, with up to 1.8 metres mineralized. Material from an old dump is reported to have contained massive pyrite, pyrrhotite, arsenopyrite, chalcopyrite and erythrite coatings.

Grab samples from shears and quartz veins assayed up to 24.0 grams per tonne gold (Property File - Dayton Developments, 1989).

**MINFILE NUMBER: 092C 021** **NAME: SILVER LEAF (L.29G)**
NORTHING: 5424200 EASTING: 410250 STATUS: Showing

CAPSULE GEOLOGY:

The Silver Leaf showings are located just to the north of the El Capitan prospect (092C 019). The claims were staked in about 1911.Previous work consists of 3 adits, the first and main adit was driven in 1922-23 and the other two were driven in 1945.

The area is underlain by massive basalt of the Upper Triassic Karmutsen Formation, Vancouver Group. The area is cut by east striking, steeply dipping shear zones which contain sulphide mineralization with gold values. Some zones are up to 610 metres in vertical distance, and 1.6 kilometres in length but these are not known to contain mineralization. The shorter, rusty zones are the best mineralized.

The showings consist of 3 shear zones which strike 270 degrees and dip 65 degrees south. The shear zones contain massive sulphide pods in a quartz-calcite sheared basalt gangue. The sulphide-rich zone is up to 1.2 metres wide. Mineralization consists of pyrite, chalcopyrite, pyrrhotite and minor arsenopyrite.

A sample, taken over 1.3 metres, assayed 17.14 grams per tonne gold, 150.83 grams per tonne silver, and 4.5% copper (Bulletin 37 page 65).

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**MINFILE NUMBER: 092C 026** **NAME: SHERK LAKE**
NORTHING: 5419200 EASTING: 411350 STATUS: Showing

CAPSULE GEOLOGY:

The Sherk Lake showing is located about 805 metres south of Sherk Lake, which is 5.5 kilometres north of Cowichan Lake.

The area is underlain by Upper Devonian McLaughlin Ridge Formation (Sicker Group) mafic volcanics and Mississippian to Pennsylvannian Fourth Lake Formation (Buttle Lake Group) ribbon cherts and crinoidal limestone. A major anticline occurs to the east and the area is highly faulted.

Rhodonite, rhodochrosite and jasper occur in cherts and cherty tuffs of the Fourth Lake Formation in the Lower Mississippian Shaw Creek Member (dated by conodonts, Personal Communication - Nick Massey, 1991). Rhodonite development is restricted to dark ribbon chert and it may be cut by major faults. Pyrite and pyrrhotite also occur in the area hosted by felsic tuffs.

A cherty tuff bed contains a jasper horizon which hosts irregular, lenticular masses of rhodonite and rhodochrosite. The jasper horizon has been traced along strike for more than 305 metresand is up to 1 metre wide. The largest lens is several centimetres wide and 30 to 61 centimetres long.

The rhodonite and jasper have been analyzed for sulphide content and the assays were low in gold, silver, copper, and molybdenum (Assessment Report 16210).

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**MINFILE NUMBER: 092C 035** **NAME: VIKING**
NORTHING: 5403000 EASTING: 419900 STATUS: Prospect

CAPSULE GEOLOGY:

The Viking showings are located east of the Robertson River, approximately 5 kilometres south of Mesachie Lake. There are remains of an old cabin at the 610 metre level and an opencut was developed on a quartz vein in the early 1900s.

The area is underlain by volcanic rocks of the Upper Triassic Karmutsen Formation (Vancouver Group) and diorite, granodiorite and quartz diorite of the Early to Middle Jurassic Island Plutonic Suite.The showing is underlain by basalt which is cut by an irregular body of feldspar porphyry (probably Jurassic in age). Both have been cut by several tight shear zones which have been locally silicified and weakly mineralized with quartz and disseminated chalcopyrite.

The main showing consists of a high grade chalcopyrite shoot in a quartz vein structure about 1.8 metres in width. An adit was driven, on Viking 2 claim, on the shoot at the 762 metre level for 82.3 metres. The adit was cleared and examined in 1967 (Property File - Elwell, J.P.). A mineralized fault/shear hosts a sinuous quartz vein, averaging 10 centimetres in width, which is heavilymineralized at intervals with chalcopyrite. It was reported that the vein was widening and mineralization improving below the level, but this could not be checked as the cut was filled with water.

Five zones of mineralization have been outlined on the Viking property. These consist of two types of mineralization: 1) vein in shear zones hosted in volcanics and 2) disseminated mineralization in basalts and related rocks.

A mineralized fault zone, striking northwest and dipping at about 60 degrees east, comprises Zone 1. The hanging wall of the fault can be traced by a steep rocky bluff with malachite-stained and copper mineralized float found downslope. Above the adit, near the post of Viking 1 and 2 claims, trenching revealed fractured volcanics with veins and masses of quartz and chalcopyrite. This zone may be part of a shear zone parallel to that found in the adit. A grab sample assayed 7.65% copper with 30.852 grams per tonne silver (Property File - Elwell, 1967).

Zone 2 is located 106 metres northeast of the adit, at 542metres elevation. The zone consists of a shear in basaltic rocks which outcrop on a steep bluff. Blasting of the bluff has exposed a well-fractured shear zone containing quartz stringers with pyrite,chalcopyrite and bornite as disseminations, small blebs and fracture-fillings. Malachite is present as surface alteration. Two samples, taken across 1.83 metres, assayed 4.6 and 1.05% copper respectively, with 33.78 grams per tonne silver (Property File -Elwell, 1967).

Zone 3 occurs on the Viking 3 claim, 366 metres to the northwest of Zone 1. Stripping has revealed a pod of magnetic basalt, mineralized with chalcopyrite. Copper-stained and mineralizedvolcanics have also been noted.

Zones 4 and 5 comprise pyrite, chalcopyrite and bornite as fracture-fillings and disseminations in basaltic rocks. These have not been located, but occur in this area.

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**MINFILE NUMBER: 092C 036** **NAME: HILLCREST**

NORTHING: 5399800 EASTING: 420800 STATUS: Showing

CAPSULE GEOLOGY:

The Hillcrest occurrence is underlain by Lower Jurassic Bonanza Group volcanics consisting of lava, tuff and breccia of mainly basaltic to rhyolitic composition. It contains occasional interbeds and sequences of marine argillite and greywacke. A stock of the Early to Middle Jurassic Island Plutonic Suite (formerly called the Island Intrusions) lies to the southwest of the showings. The volcanics have been intruded by dikes and irregularly shaped bodies of granodiorite, granite porphyry and diorite porphyry. Limestone, reported to occur as lenses and roof pendants in both the volcanicsand the intrusive, is probably related to the Quatsino Formation, Vancouver Group.

Mineralization consists of magnetite, pyrrhotite and chalcopyrite occurring irregularly along the contact of a basalt (andesite?) flow and a fine-grained granodiorite intrusive. The area has been extensively trenched and skarn outcrops at a number of locations over an area 150 metre long and 30 metres wide. The zone appears to trend in a northeast direction and granite dikes appear to cut the mineralization at several locations. Assays range up to 2.18% copper with 5.49 grams per tonne silver over 1 metre (Assessment Report 8209, page 8). Several X-ray holes were reported to have been completed with one grading 2.60% over 7 metres (White, 1966).

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**MINFILE NUMBER: 092C 042** **NAME: GOLD DIKE**

NORTHING: 5413750 EASTING: 399120 STATUS: Showing

CAPSULE GEOLOGY:

The Gold dike showing is located 2.5 kilometres south of Caycuse on the southern shore of Cowichan Lake. The Eagle showing (092C 145) is just to the south.

The area is underlain by southeasterly dipping Lower Jurassic Bonanza Group intermediate to felsic volcanic rocks. These are cut by numerous faults infilled with quartz-carbonate material.

Drilling in 1986 revealed pyrite, galena, sphalerite and trace chalcopyrite and arsenopyrite in drill core. Pyrite, 1 to 20%, and trace chalcopyrite is disseminated throughout the rock units. Generally associated with more siliceous zones, coarse sphalerite and galena (up to 4%) occur disseminated in quartz-carbonate and siliceous veins. The siliceous veins are up to 0.10 metre wide. Associated with vuggy portions of quartz-carbonate veins, arsenopyrite occurs in irregular masses.

A sample from DDH 213-4, from the 78 to 80.47 metre interval, of quartz-carbonate veining in porphyritic andesite, assayed 1.389 grams per tonne gold, 2 grams per tonne silver, 1.5% lead and 1.04 % zinc (Assessment Report 15821). This was the highest assay result.

Geochemistry suggests that mineralization may extend another 100metres to the east and is open to the west.

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**MINFILE NUMBER: 092C 046** **NAME: PAGET**

NORTHING: 5408125 EASTING: 400150 STATUS: Showing

CAPSULE GEOLOGY:

The Paget showing is located about 8 kilometres south of Cowichan Lake on a slope drained by the Gordon River.

The area is underlain by granite, diorite and granodiorite of the Early to Middle Jurassic Island Plutonic Suite.

The workings are located at 808 and 758 metres elevation and consist of an upper and lower tunnel.

The upper tunnel was driven at 070 degrees for 18.3 metres on a well-defined quartz vein. The vein is about 1.8 metres wide and is mineralized with arsenopyrite, pyrite, sphalerite and minor galena.High gold values have been reported, but the values must be sporadic because a sample from the dump containing arsenopyrite assayed negative results.

The lower tunnel, almost parallel with the upper tunnel, was also reported to be 18.3 metres long. The tunnel is flooded, however, and therefore cannot be explored. This tunnel was apparently in gravel and no ore was encountered.

**MINFILE NUMBER: 092C 053** **NAME: PETERSON**
NORTHING: 5419750 EASTING: 393170 STATUS: Showing

CAPSULE GEOLOGY:

The Peterson occurrence is located near the northwest end of Cowichan Lake, 91.44 metres above the lake.

The area is underlain by volcanic rocks of the Upper Triassic Karmutsen Formation, Vancouver Group and of the Lower Jurassic Bonanza Group and sediments of the Upper Cretaceous Comox Formation, Nanaimo Group.

A narrow seam in the face of a cliff contains a small amount of chalcopyrite. The seam is hosted in highly altered and shattered shale of the Comox Formation which is cut by fine-grained igneous dikes.

A 4.6 metre tunnel has been driven northeast from the seam along a fissure in the rock. The shattered rock in the roof of the tunnel and the over hanging cliff makes the workings dangerous. No mineralization was observed in the workings.

A sample from a small pile at the tunnel mouth assayed 1% copper with traces of gold and silver (Minister of Mines Annual Report 1906 p. 213).

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**MINFILE NUMBER: 092C 057** **NAME: MEADE CREEK**
NORTHING: 5410650 EASTING: 420850 STATUS: Past Producer

CAPSULE GEOLOGY:

The Meade Creek placer comprises two leases located on Meade Creek, 2.5 miles west of Lake Cowichan village. The leases extend upstream from about 152 metres above the CNR railway bridge, covering more than 1.6 kilometres of the creek bed.

The area is underlain by volcanic and sedimentary rocks of the Devonian Nitinat Formation (Sicker Group) which have been intruded by granitic rocks of the Early to Middle Jurassic Island Plutonic Suite.

The panning and sluicing was done along a stretch 671 metres long between 800 metres and 1600 metres above the bridge. The creek flows through a canyon along this stretch which contains stream debris that ranges in size from fine sand to boulders 1.2 metres in diameter. In the canyon, fine colors are seen in most pans containing bedrock material and in sand among the roots of the trees near the high water mark, 0.5 metre or so above bedrock.

Gold is also reported to have been panned from overburden near the creek as much as 6.1 metres above high water level outside thecanyon.

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**MINFILE NUMBER: 092C 064** **NAME: ARCHER**
NORTHING: 5414755 EASTING: 390000 STATUS: Showing

CAPSULE GEOLOGY:

The area is underlain by extensively faulted rocks of the Upper Triassic Vancouver Group and the Lower Jurassic Bonanza Group. The basal Vancouver Group sequence is comprised of basalt flows, breccias and tuffs of the Karmutsen Formation overlain by Quatsino Formation limestone, which in turn is overlain by black argillites of the Parsons Bay Formation. The overlying Bonanza Group consists of a sequence of argillites, cherts, cherty tuffs, volcanic and/or sedimentary breccias, sandstones and basaltic to rhyolitic flows.

The overall package of rocks have been broadly to tightly folded with fold axes generally trending northwest, and have been intruded by granodioritic and feldspar porphyritic dikes.

At the Archer showing, a pyritic fracture/shear zone occurs in dacite (possibly siliceous andesite) and chert of the Bonanza Group.Pyrite occurs as stringers and fine to coarse disseminations. Some calcite and epidote veinlets are also evident in this zone. Several massive pods of pyrite up to 1 metre thick occur locally in bedded chert; minor magnetite was also observed. Drill core from holes intersecting this zone assayed up to 2.8 grams per tonne gold and 11.5 grams per tonne silver (Assessment Report 17164).

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**MINFILE NUMBER: 092C 074** **NAME: COW**
NORTHING: 5416875 EASTING: 425990 STATUS: Prospect

CAPSULE GEOLOGY:

The Cow showing is located 27 kilometres northwest of Duncan. Several showings occur in the area; the Pogo showing was the initial discovery.

The property is underlain by Mississippian to Pennsylvanian Fourth Lake Formation (Buttle Lake Group) cherty argillite and by Upper Devonian McLaughlin Ridge Formation (Sicker Group) volcaniclastics. These rocks are intruded by granodiorite and quartz diorite of the Early to Middle Jurassic Island Plutonic Suite and Triassic gabbro (informally called the Mount Hall gabbro). Sulphide mineralization occurs in rusty shear zones as disseminations, and/or stringers along bedding, cleavage or crosscutting fractures. Mineralization is hosted in laminated sediments and volcaniclastics spatially associated with the gabbroic dikes. Pyrite and minor chalcopyrite are finely disseminated throughout the rocks.

The Pogo showing, near the centre of the Cow property on the Cow 15 claim, consists of pyrrhotite, pyrite (up to 5%), chalcopyrite (less than 1%), sphalerite and galena. Spahlerite and galena have not been confirmed for the Pogo showing and if present would be rare. Mineralization occurs disseminated, along fracture planes and in quartz-carbonate stringers (up to 2 centimetres wide) in a fractured-medium grained gabbroic dike which intrudes black cherty argillites of the Fourth Lake Formation (previously known as the "Sediment-Sill Unit" of the Paleozoic Sicker Group). Mineralization occurs at a synclinal fold axis where the sill is "pinched" as it crosses from the west limb to the east limb. The best assays are 0.42% zinc over 3 metres, 0.48% lead, 0.09% copper and trace silver from different 1.5 metre samples (Assessment Report 14462).

The area of the main quartz carbonate vein, on the Cow 14 claim,is underlain by pyroclastic and sedimentary rocks of the McLaughlin Ridge Formation adjacent to a gabbro dike (130 metres to the east).The rocks trend west-northwest, are tightly folded and contain 3 to 5% pyrrhotite. The vein occurs in a east trending shear zone, several metres wide, in silty, sandy and lapilli tuffs. The vein, exposed along strike for 20 metres, strikes 94 to 100 degrees and dips 85 degrees south. The vein, 5 to 20 centimetres wide, is well mineralized with pyrite (2 to 10%) and lesser amounts of pyrrhotite, galena and sphalerite (up to 3%) and chalcopyrite. The highest assay from a sample (#14024) of vein material was 13.03 grams per tonne gold over 5 centimetres (Assessment Report 16097).

On the Cow 12 claim, several mineralized shears hosted in northwest trending fine-grained sediments of the Fourth Lake Formation are exposed along a road. These define a 100 metre widezone of sporadic mineralization. The shears are up to 0.20 metres wide, gougy, limonitic and contain up to 5% each of pyriteand chalcopyrite. A few pyrite and chalcopyrite bearing shear zones adjacent to gabbroic rocks carry weakly elevated gold values and up to 28 grams per tonne silver (Assessment Report 16097).

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**MINFILE NUMBER: 092C 075** **NAME: AB**

NORTHING: 5412293 EASTING: 405255 STATUS: Showing

CAPSULE GEOLOGY:

The AB showing is located on the south side of Cowichan Lake, 1mile south-southeast of the Island No.6 Highway.

The area is underlain by volcanic rocks of the Lower Jurassic Bonanaza Group which have been intruded by Early to Middle Jurassic Island Plutonic Suite granitic rocks.

Chalcopyrite, pyrite and chalcocite are associated with the volcanic rocks. No other information is available.

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**MINFILE NUMBER: 092C 076** **NAME: CANDY**

NORTHING: 5415700 EASTING: 419775 STATUS: Showing

CAPSULE GEOLOGY:

The Candy showings are located about 8 kilometres northeast of the community of Lake Cowichan.

The area is underlain by Devonian Nitinat Formation Formation (Sicker Group) volcanics and Mississippian to Pennsylvannian Fourth Lake Formation (Buttle Lake Group) sediments intruded by sills, dikes and granitic rocks probably of the Jurassic Island Plutonic Suite.The area is highly faulted and major folds are present. The Paleozoic Sicker Group rocks have undergone greenschist metamorphism.

The showings are underlain by massive basaltic flows, vesicular flows, tuffs, andesitic tuffs, cherty tuffs and argillite. Granodiorite and diorite plugs are exposed on the property.

Mineralization occurs in intrusion-related veins and shear zones, replacement pods of rhodonite, rhodochrosite and jasper, and syndepositional pyrite in argillites.

The original Candy showing consisted of chalcopyrite and pyrrhotite in quartz veins in fractured and sheared andesites and basalts. The location of this showing is uncertain.

Samples of a diorite body containing fracture pyrite and quartz veins with disseminated pyrite assayed 0.32 to 0.912 grams per tonne gold, 3.8 grams per tonne silver and 0.0319 to 0.0604% copper (Assessment Report 15117). A sample from a shear zone (85SNT-107) assayed 0.510 gram per tonne gold (Assessment Report 15117).

Sample #85SBT-23 from a south flowing creek contains a 3 millimetre band of rhodonite which assayed 0.5% copper, 5.5 grams per tonne silver and 0.55 gram per tonne gold (Assessment Report 15117). A second rhodonite occurrence was noted along the eastern road and was banded with spessartine and jasper (Assessment Report 15117). The manganese minerals are hosted in the Lower Mississippian Shaw Creek Member (dated by conodonts, Personal Communication - Nick Massey, 1991).

**MINFILE NUMBER: 092C 086** **NAME: GORDON RIVER**
NORTHING: 5401889 EASTING: 401382 STATUS: Showing

CAPSULE GEOLOGY:

The Gordon River showing is located south of the Gordon River logging camp, 25 kilometres southwest of Cowichan Lake.

A limestone mass, of the Upper Triassic Quatsino Formation (Vancouver Group) extends west-northwest from Gordon River for 2 kilometres and is 1 to 1.5 kilometres in width. The limestone is underlain by basaltic volcanics of the Upper Triassic Karmutsen Formation, Vancouver Group which outcrop along the southern margin of the deposit. The limestone is in fault contact with Karmutsen and Lower Jurassic Bonanza Group volcanics to the north. Bedding within the limestone mass dips 25 to 45 degrees north.

The limestone is fine grained, dark grey to black on fresh surfaces, weathering to medium to light grey. It is generally high calcium in composition, but does contain a few magnesian beds. Asample of randomly collected chips taken along a 60 metre long road-cut next to the Gordon River contained 54.72% CaO, 0.21% MgO, 1.30% insolubles, 0.24% $R_2O_3$, 0.17% $Fe_2O_3$, 0.02% MnO, 0.02% $P_2O_5$, 0.068% sulphur and 43.22% ignition loss (Minister of Mines Annual Report 1966, page 270, Sample 6).

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**MINFILE NUMBER: 092C 087** **NAME: NIXON CREEK**
NORTHING: 5410287 EASTING: 391601 STATUS: Showing

CAPSULE GEOLOGY:

The Nixon Creek showing is located along the west side of the creek, 30 kilometres west of the community of Lake Cowichan

The showing is comprised of two limestone horizons of the Upper Triassic Quatsino Formation, Vancouver Group. These strike northeast for 2.5 kilometres and dip 05 to 40 degrees northwest. The two horizons are separated by a mafic flow or sill. The upper horizon is overlain by argillite of the Upper Triassic Parson Bay Formation,Vancouver Group and volcanics of the Lower Jurassic Bonanza Group.The lower horizon is underlain by mafic volcanics of the Upper Triassic Karmutsen Formation, Vancouver Group. This sequence is segmented by several faults trending west-northwest.

The horizons consist of fine grained, dark grey to black, high calcium limestone. A chip sample taken at 3.0 metre intervals along a 60 metre long road-cut from the upper horizon, contained 54.52% CaO, 0.23% MgO, 1.65% insolubles 0.34% $R_2O_3$, 0.21% $Fe_2O_3$, 0.03% MnO, 0.04% $P_2O_5$, 0.024% sulphur and 43.37% ignition loss (Minister ofMines Annual Report 1966, page 270, Sample 5).

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**MINFILE NUMBER: 092C 098** **NAME: CR**
NORTHING: 5406455 EASTING: 390098 STATUS: Prospect

CAPSULE GEOLOGY:

The CR showing is located on the bank of the Caycuse River (on the Hank claim) 23 kilometres southwest of the village of Caycuse. On the Caycuse River, copper mineralization was first observed in 1920.

The area is underlain by intermediate volcanic and minor intercalated impure carbonate rocks of the Upper Triassic Karmutsen Formation, Vancouver Group. These have been intruded by diorite of the Early to Middle Jurassic Island Plutonic Suite. The Caycuse River is believed to be a major fault. The rocks, comprising basalt, limestone, marble, and diorite, are altered and sheared.

The skarns are primarily exposed on the north side of the Caycuse River and form an en echelon arrangement. Skarn occurs as pods and tabular vertical bodies, replacing impure limestone or volcanic rocks. The mineral assemblage comprises quartz and tremolite with lesser amounts of garnet, epidote, actinolite and ilvaite. Mineralization consisting of pyrite, chalcopyrite, magnetite and minor sphalerite occurs within massive irregular sulphide pods. Magnetite occurs ubiquitously in small amounts and iron oxides, malachite and azurite are common. Volcanic rocks are locally altered to a dark green massive and dense hornfels containing massive and disseminated pyrite and minor chalcopyrite in small lenses.

The CR zone strikes 75 degrees and the bedding dips 60 to 80 degrees north. The 12 metre thick zone occurs within the alteration halo of diorite. Rock chip samples, taken from the exposed sections of the CR zone, assayed a weighted average over 1.55 metres of 2.02% copper, 0.045% zinc, and 7.3 grams per tonne silver (Assessment Report 12618). Diorite, in the footwall limestone bed, contained an estimated 0.5 to 1% disseminated copper in chalcopyrite over 1 metre (Assessment Report 11232).

A brecciated zone in a north trending fault, exposed in the north bank of the Caycuse River, was sampled and the highest assay was 0.17 gram per tonne gold and 62.32 grams per tonne silver (Assessment Report 12618).

The Cougar Creek or CC showing has been described as follows: "good grade chalcopyrite occurs in the limestone skarns over an area 120 metres long and 30 metres wide in narrow folded bands of limestone and tuff".

**MINFILE NUMBER: 092C 108** **NAME: SUNNYSIDE (L.34, 39)**
NORTHING: 5409900 EASTING: 410250 STATUS: Past Producer

CAPSULE GEOLOGY:

The Sunnyside deposit was part of the Blue Grouse mine (092C017) which is located on the south side of Cowichan Lake, 4.8 kilometres northeast of Honeymoon Bay. The Sunnyside workings are about 800 metres south of the main Blue Grouse workings. Developmental work on the Sunnyside deposit was first reported in 1906. The mine was abandoned in 1960 with some reserves left at the Blue Grouse main workings.

The Cowichan Lake area is at the eastern end of the Cowichan uplift, one of a series of major geanticlines on Vancouver Island. The area is underlain by pyroclastic, sedimentary and volcanic rocks of the Paleozoic Sicker Group, the Mississippian to Permian ButtleLake Group, the Upper Triassic Vancouver Group and the Lower Jurassic Bonanza Group which have been intruded by Triassic gabbros (informally named Mount Hall) and Early to Middle Jurassic Island Plutonic Suite rocks and overlapped by Upper Cretaceous sediments of the Nanaimo Group.

The Vancouver Group comprises pillow and massive basalt,volcaniclastics, tuffs and breccias of the Karmutsen Formation, siltstone, argillite and micrite of the Quatsino Formation and limestone, tuff and argillite of the Parson Bay Formation.

The area is underlain by Karmutsen Formation volcanics and Parson Bay Formation sediments. These are cut by numerous Jurassic feldspar and feldspar-pyroxene porphyry dikes.

The orebodies occur in limestone and tuffaceous members which are folded in a series of overturned folds. The beds are displaced by a series of thrust faults which have a general east strike and dips of 10 to 20 degrees south.

Chalcopyrite-bearing skarn is developed at the contact between Parson Bay Formation limestone (Sutton member) and Karmutsen Formation basalts. Lenses of chalcopyrite occur in a quartz gangue along the contact zone which is up to 100 metres wide. Garnet-epidote-actinolite skarns are also developed in limy tuff, limy sediments and limestone, apparently interbedded with the upper portions of Karmutsen Formation basalts.

A few open pits and short adits comprise the workings. From this property 103.4 tonnes of ore were mined in 1917, yielding 4127 kilograms of copper and 240 grams of silver. A 1-metre chip sampleacross weakly argillically altered volcanic rock containing five white zeolite veinlets assayed 1.2% copper (Assessment Report 19387).

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**MINFILE NUMBER: 092C 109** **NAME: RITE 2**
NORTHING: 5427254 EASTING: 399289 STATUS: Showing

CAPSULE GEOLOGY:

The Rite 2 showing is located 40 kilometres southwest of Nanaimo, 2 kilometres south of the Rite 1 showing (092F 562).

The area is underlain by tuff, chert and argillite of the Mississippian to Pennsylvanian Fourth Lake Formation (Buttle LakeGroup) which have been intruded by diorite and granodiorite of the Early to Middle Jurassic Island Plutonic Suite. A broad zone of imbricate faulting and shearing is present and exposures of fault breccia, intense shearing and alteration occur.

Exploration in 1988 identified four target areas characterized by gold, silver, arsenic, copper and molybdenite mineralization hosted in quartz-sulphide veins within quartz-ankerite, sericite, fuchsite and hematite bearing shear zones. The main target has a strike length of 3.2 kilometres over widths up to 1 kilometre, within which a series of 10 to 100 metre wide alteration packages occur.These comprise the Rite and Rain property which includes the Rite 1showing (092F 562).

On the Rite 2 claim, target D was anomalous in copper and molybdenum plus or minus gold and silver. The anomalies occur associated with quartz veins crosscutting volcaniclastic and intrusive rocks. The veins are up to 0.10 metres wide and contain upto 15% pyrite, 4% molybdenite and trace chalcopyrite.The volcaniclastic rocks adjacent to intrusives are locally intensely epidote altered. The area of interest is approximately 600 by 1200 metres.

A grab sample was taken from an outcrop containing a quartz vein which crosscuts a granodioritic dike along a shear plane. This sample (#25063) assayed 0.4 gram per tonne gold , 3.9 grams per tonne silver, and 0.0427% copper (Assessment Report 18635). Molybdenum has been documented on the nearby Close occurrence (092C112) to the south.

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**MINFILE NUMBER: 092C 112** **NAME: CLOSE**
NORTHING: 5425450 EASTING: 402800 STATUS: Showing

CAPSULE GEOLOGY:

The Close showing is located just west of Delphi Lake, 32 kilometres southwest of Nanaimo. The Close claim covers the northern Allies showings (092C 014). One crosscut and several trenches were opened in the early 1900s (probably part of the Allies workings).

The area is underlain by volcanic rocks of the Devonian Nitinat Formation, Sicker Group intruded by Early to Middle Jurassic Island Plutonic Suite rocks. Major northeast and northwest striking faults have resulted in fracturing of the intrusive rocks. These fractures are generally quartz-filled and some host mineralization.

Mineralization consisting of molybdenite, chalcopyrite and pyrite occurs in siliceous veins and shears in intrusive rocks and disseminated in adjacent volcanics. Molybdenite occurs sparsely disseminated in fissures, veinlets and veins up to 1.5 metres wide over an area 2 by 2.5 kilometres. The veins strike between 320 and 360 degrees with dips between 65 and 85 degrees east.

A sample from a 41 centimetre quartz vein assayed 0.625% molybdenite and 0.556% copper (Assessment Report 8782).

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**MINFILE NUMBER: 092C 113** **NAME: ROCKY**

NORTHING: 5416850 EASTING: 414050 STATUS: Past Producer

CAPSULE GEOLOGY:

The Rocky deposit is located on the south slopes of Mount Franklin, about 3.5 kilometres north of Youbou. The Rocky workings have not been located, but are believed to be in the vicinity of the Osirus A claim.

The area is underlain by rocks of the Early to Middle Jurassic Island Plutonic Suite which intrude Upper Devonian McLaughlin Ridge Formation (Sicker Group) mafic volcanics and Mississippian to Pennsylvanian Fourth Lake Formation (Buttle Lake Group) ribbon cherts and crinoidal limestone. A major anticline occurs to the east of the property and the area is highly faulted.

Rhodonite and jasper occur in lenticular masses in cherts andcherty tuffs of the Lower Mississippian Shaw Creek Member (dated by conodonts, Personal Communication - Nick Massey, 1991) with associated rhodocrosite and spessartine. Disseminated pyrite and chalcopyrite occur in quartz veins associated with diorite.Rhodonite development is restricted to areas of very dark ribbon chert which may be cut by major faults. Chert occurs in the general vicinity of Island Plutonic Suite intrusives and major faults. The main rhodonite pod is adjacent to a fault.

The main showing on the Osirus A claim is good quality, deep pink rhodonite which compares favourably with Hill 60 (092B 027) rhodonite. Lower quality rhodonite also occurs in the area. Rhodonite locally occurs in bands 2 to 5 millimetres wide and in crackle breccia veinlets and lenses. A faint pink colouration was noted in wider alteration zones. The main zone strikes 149 degrees and dips 30 degrees east over a 1 metre square area. The zone is capped by intense maganese oxide staining.

Surface stripping was done on the Rocky claim in 1977 and 1978; 555 kilograms of rhodonite were produced (Exploration in British Columbia 1977, 1978). The quantity of gem quality rhodonite on the Osirus A claim is low.

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**MINFILE NUMBER: 092C 114** **NAME: WARDROPER**

NORTHING: 5420500 EASTING: 406750 STATUS: Showing

CAPSULE GEOLOGY:

The Wardroper showings are located 4 kilometres north of Cowichan Lake and 88 kilometres northwest of Victoria. The showing was first reported in 1939.

The occurrence comprises several lenses of rhodonite and yellow manganiferous chert in cherty tuff of the Lower Mississippian Shaw Creek Member (dated by conodonts, Personal Communication - Nick Massey, 1991) of the Mississippian to Pennsylvanian Fourth Lake Formation, Buttle Lake Group.

Individual lenses are less than 30 centimetres wide but together they total about 3 metres and are exposed for about 6 metres along strike. The lenses are parallel to bedding which strikes 165 degrees and dips 55 degrees northeast.

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**MINFILE NUMBER: 092C 115** **NAME: MEADE**

NORTHING: 5412875 EASTING: 423050 STATUS: Showing

CAPSULE GEOLOGY:

The Meade Creek showing is located 1.5 kilometres east of Meade Creek, 5 kilometres north of the community of Lake Cowichan and 65 kilometres northwest of Victoria. This showing has been known since 1939 and is located on the northeast corner of the Cow property (092C074).

The area is underlain by Upper Devonian McLaughlin Ridge Formation (Sicker Group) volcanics and Mississippian to Pennsylvanian Fourth Lake Formation (Buttle Lake Group) sediments intruded by sills, dikes and granitic rocks of the Early to Middle Jurassic Plutonic Suite. The area is highly faulted and major folds are present. The rocks have undergone greenschist facies metamorphism.

The showings are underlain by a basalt, andesite, cherty tuffs,cherty argillites and andesite tuffs. Diorite dikes and plugs are exposed on the property.

The Meade Creek occurrence consists of lenses containing rhodonite and manganiferous garnet in red and white cherty tuffs of the Lower Mississippian Shaw Creek Member (dated by conodonts, Personal Communication - Nick Massey, 1991). Lenses are up to 1metre wide and appear to be more or less continuous along strike between 2 opencuts about 61 metres apart. The lenses are thinly coated with oxides.

A fault structure on the lower north slopes of Hill 60 contains 0.22% copper, 3.8 grams per tonne silver and 0.024 gram per tonne gold (rock chip sample # 86STRAT-70). The rock has been silicified, clay and limonite altered and contains malachite. Other samples from this structure assayed much lower. Trace amounts of chalcopyrite, sphalerite and galena were noted in the area. Argillites and cherty argillites in the Hill 60 area contain 15 to 20% pyrite and pyrrhotite. Samples from a shear assayed low values in molybdenum, lead, zinc, arsenic and gold.

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**MINFILE NUMBER: 092C 116** **NAME: STANLEY CREEK**
NORTHING: 5411950 EASTING: 425500 STATUS: Showing

CAPSULE GEOLOGY:

The Stanley Creek showing is located 4 kilometres northeast of Lake Cowichan on the Cow 7 claim (Chem property), east of the head of Stanley creek. The rhodonite has been known of since about 1939 and exploration in 1986 discovered sulphide mineralization in the area.

The property is underlain by pyroclastic and sedimentary rocksof the Upper Devonian McLaughlin Ridge Formation (Sicker Group) and the Mississippian to Pennsylvanian Fourth Lake Formation (Buttle LakeGroup). Lithologies comprise cherty tuff, chert, argillite, iron formation, volcanic and volcaniclastic rocks.

Sulphide mineralization consists of widely disseminated pyriteand chalcopyrite associated with shear zones and stratiform iron-richdeposits consisting of layered pyrite and magnetite.

Rhodonite occurs in thinly laminated chert and cherty tuff ofthe Fourth Lake Formation in the Lower Mississippian Shaw Creek Member (dated by conodonts, Personal Communication - Nick Massey,1991) adjacent to a Jurassic granodiorite stock. The showing consists of two irregular lenses of rhodonite, parallel to the bedding, about 5 to 30 centimetres wide and 6 metres long. Microprobe analyses assayed 42.25% MnO (Cowley, 1979).

Three hundred metres to the northeast, limonitic shears, trending east and up to 20 centimetres wide, are mineralized with 5% pyrite and 2 to 3% chalcopyrite. A sample assayed 1.4 grams per tonne gold, 17.6 grams per tonne silver, and 1.58% copper (Assessment Report 16053).

A hematitic chert (iron formation) horizon has been traced for 700 metres, possibly extending along strike for several kilometres. The horizon is up to 10 metres wide and hosts pyrite, magnetite and up to 0.3 gram per tonne gold (Assessment Report 16053). Several fault zones cut this unit and, where exposed, are enriched in manganese, barium, zinc and anomalous gold values. These may be the source of the well mineralized float found on the property. The bed, composed of blue-grey cryptocrystalline quartz (sporadically jasperoidal), contains up to 5% pyrite and specular hematiteand several percent magnetite.

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**MINFILE NUMBER: 092C 117** **NAME: AMORE**
NORTHING: 5426000 EASTING: 406150 STATUS: Showing

CAPSULE GEOLOGY:

The Amore showing is located on the Amore 2 claim 11 kilometres northwest of Youbou on Cowichan Lake. The area was originally prospected in the 1910s and 1920s.

The area is underlain by sedimentary and volcaniclastic rocks of the Mississippian to Pennsylvanian Fourth Lake Formation, ButtleLake Group and basaltic rocks of the Upper Triassic Karmutsen Formation, Vancouver Group. These have been intruded by rocks of the Early to Middle Jurassic Island Plutonic Suite.

The claim is underlain by chert, cherty argillite, cherty tuff,tuff and argillite of the Fourth Lake Formation in the northern portion and in the south by Karmutsen Formation volcanics intruded by diorite to quartz diorite. To the northeast of the claim, lenses of jasper a few metres thick dip steeply and strike north.

Mineralization occurs mainly in shears and quartz veins within cherty sediments in the northern portion of the claim. One sulphide-rich vein, 3 to 30 centimetres wide, lies in a shear zone in silicified and carbonatized rocks. Gold mineralization occurs with galena, sphalerite and arsenopyrite in quartz veins, stringers and lenses. Mineralization comprising pyrite, arsenopyrite, galena,molybdenite and chalcopyrite occurs as massive sulphide lenses and stringers in siliceous zones, quartz veins and altered tuffs.Mineralization appears to be structurally controlled.

Drilling and trenching in 1979 traced the sulphide-rich vein for 300 metres, and the highest assay, across 9 centimetres, was 19.2 grams per tonne gold and 51.429 grams per tonne silver (Assessment Report 7187). A 1.8-tonne shipment of ore in 1979 produced approximately 685.6 grams per tonne gold (Assessment Report 7187).

A sampling program on the northern portion of the claim resulted in a highest assay of 19.2 grams per tonne gold and 4.4 grams per tonne silver from a 2 metre chip sample of cherty argillite (Assessment Report 16227, Sample 18205).

**MINFILE NUMBER: 092C 126** **NAME: PAULA**
NORTHING: 5421175 EASTING: 403800 STATUS: Showing

CAPSULE GEOLOGY:

The Paula vein is located on the Marathon claim which straddles McKay Creek, north of Cowichan Lake. The Amore 2 (092C 117) showing, which produced a small amount of ore in 1979, adjoins theTaurus claim which to date has no known mineralization.

The area is underlain by granodiorite of the Early to Middle Jurassic Island Plutonic Suite and hornfelsed basalt, andesite andrhyolite tuff of the Upper Devonian McLaughlin Ridge Formation, Sicker Group. The granodiorite is cut by narrow aplite and basalt dikes.

Mineralization occurs in a narrow discontinuous quartz veinwhich appears to lie at the contact between the volcanic and intrusive rocks hosted in a shear zone in the volcanics. The vein contains up to 30% sulphides comprising pyrite, pyrrhotite and minor chalcopyrite. The vein, 1 to 15 centimetres wide, pinches out 5 metres to the south, strikes 35 to 60 degrees and dips 76 to 85degrees east.

The average weighted assay of grab samples of "better material" taken over a 42 centimetre width of the vein and shear (M1-R to M3-R) was 152.20 grams per tonne gold (Assessment Report 18093). One sample contained 1.97% copper and 50 grams per tonne silver (M1-R) (Assessment Report 18093).

About 300 metres to the south, a shear zone approximately 15 metres wide, assayed low in gold from sub-shears and 0.93% copper from an altered dike (Assessment Report 18093). Mineralization is related to the intrusive event and appears to favour structural zones developed along contact zones.

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**MINFILE NUMBER: 092C 127** **NAME: HEATHER**
NORTHING: 5425200 EASTING: 391225 STATUS: Showing

CAPSULE GEOLOGY:

The Heather showing is located 40 kilometres southwest of Nanaimo and 7 kilometres north of Cowichan Lake.

The area is within the Cowichan uplift and is underlain by Paleozoic Sicker Group rocks. These, in the area of the showing,conmprise northwest trending volcanic and volcaniclastic rocks of the Upper Devonian McLaughlin Ridge and Devonian Nitinat formations. Intrusions of the Early to Middle Jurassic Island Plutonic Suite also occur in the area.

The main showing, on the Carol S claim, was discovered by trenching in 1982 and comprises quartz-carbonate veining containing disseminated pyrite and minor chalcopyrite. The mineralization occurs in a northwest striking, 50 to 60 degree south dipping, shear zone (bounded by faults) hosted in andesitic tuffs in the central part of a large antiform. Alteration consists of ankerite, clay, chlorite and sericite in the immediate vicinity of the mineralization. The shear zone extends for 3 kilometres onto the Tania S and Tania S3 claims. Surface grab samples of the shear zone assayed 8.57 grams per tonne gold and 0.18% copper (Assessment Report 13516). Drilling in 1984 encountered intensely sheared green tuff and minor cherty sections. The best intersection was 3 gram per tonne gold over 1.5 metres and occurred in the upper contact area of a cherty and hematized section (Assessment Report 13516). Mineralization appears to decrease with depth. Drilling in 1987 confirmed the orientation of the shear zone but the results were poor. Wide zonesof altered andesitic tuff with low gold values are present at shallow levels, less than 50 metres, but at greater depths these zones thin.

The McDougall (092C 134) vein occurs on the Heather property approximately 1.7 kilometres to the north of the main showing.

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**MINFILE NUMBER: 092C 128** **NAME: ECHO 1**
NORTHING: 5403970 EASTING: 413040 STATUS: Showing

CAPSULE GEOLOGY:

The Echo showing, on the Echo 1 and 2 claims, is located 4 kilometres south of Honeymoon Bay on Cowichan Lake, just north of Nineteen Creek. The area was prospected in 1985.

The area is underlain by a succession of basaltic tuffs, feldspar porphyry basalt, crystal tuffs and basalt of the Lower Jurassic Bonanza Group intruded by diorite of the Early to Middle Jurassic Island Plutonic Suite.

Mineralization, consisting of malachite and chalcopyrite, occurs in a 6.5 metre zone within a main shear zone in basaltic tuffs. The zone comprises a network of irregularly branching shears, 5 to 12 centimetres in thickness. The shears are irregularly spaced and, on average, strike 066 degrees and dip 63 degrees east. Abundant small fractures and secondary shears, striking between 245 and 272 degrees and dipping 65 to 80 degrees north, are coated with malachite and iron oxides. Locally, up to 25% of the sheared rock material is malachite.

To the northwest and west, the shear zone and host tuffs are cut by a complex network of 1 to 5 millimetre thick, calcite-filled fractures and shears.

A total of fourteen 0.5 kilogram samples were taken from random rock chip sampling conducted over an area 2 metres wide and 2 metres high of the mineralized shear zone. The samples assayed between 0.35 to 218.6 grams per tonne gold, 0.52 to 3.15% copper and 5.0 to 42.5 grams per tonne silver (Assessment Report 14996).

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**MINFILE NUMBER: 092C 129** **NAME: MIKE**

NORTHING: 5418847 EASTING: 420632 STATUS: Prospect

CAPSULE GEOLOGY:

The Mike showing is located in the Chemainus River valley, between Meade Creek and Chemainus River, near the Rheinhart Creek junction, approximately 28 kilometres northwest of Duncan.

The area is underlain by pyroclastics and sediments of the Paleozoic Sicker Group and the Mississippian to Permian Buttle LakeGroup. These have been intruded by Triassic gabbros and Early to Middle Jurassic Island Plutonic Suite granodiorites to quartz diorites. The gabbroic sills and dikes are thought to be coeval with Upper Triassic Karmutsen Formation basalts and are informally referred to as the Mount Hall gabbro. The sediments and pyroclastics are silicified and hornfelsed near the intrusive contact.

The Sicker Group on the Mike property is comprised of cherty tuffs to agglomerates of the Upper Devonian McLaughlin Ridge Formation. The Buttle Lake Group comprises chert, argillite, siltstone, sandstone, conglomerate and minor limestone with pyroclastic flows of the Mississippian to Pennsylvanian Fourth LakeFormation, and limestone, marble with minor chert, argillite and sandstone of the Upper Pennsylvanian to Lower Permian Mount Mark Formation. The contacts between these formations appear to be fault related. The rocks are weakly regionally metamorphosed, probably tolower greenschist facies, and are folded along a northwest trending fold axis.

Mineralization occurs in east trending shears and quartz veins hosted in the Mississippian to Pennsylvanian Fourth Lake Formation fine-grained sediments and the Triassic gabbro dikes. Quartz veins, up to 1.0 metre in width, contain pyrite, pyrrhotite, chalcopyrite, minor arsenopyrite and anomalous gold values (up to 60.0 grams per tonne gold).

The main showing consists of five east trending quartz veins. The uppermost vein is comprised of vuggy, bluish-grey quartz within a shear zone up to 2.0 metres in width striking 098 degrees and dipping 83 degrees southwest.

In 1986, sampling across 1.0 metre, along a strike length of 14 metres, averaged 18.617 grams per tonne gold (Assessment Report 15578). Sampling of the four other quartz veins ranged from 1.1 to27.09 grams per tonne gold (Assessment Report 15578).

A 10 centimetre wide shear zone, striking 133 degrees and dipping 65 degrees northwest cuts silicious siltstone and is mineralized with pyrrhotite and pyrite. Up to 0.5% copper with low gold, silver, cobalt and tungsten values were obtained.

An area containing quartz veins, well-mineralized with pyriteand chalcopyrite, is located near the gabbro dike associated with the gold-bearing veins. A sample of this vein material in 1986 assayed 0.2 gram per tonne gold, 3.2 grams per tonne silver, 0.9%copper and 0.17% arsenic (Assessment Report 15578).

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**MINFILE NUMBER: 092C 133** **NAME: HARBEY**

NORTHING: 5419500 EASTING: 415000 STATUS: Showing

CAPSULE GEOLOGY:

The Harbey showing occurs on the Harbey claim located at the headwaters of Reynard Creek, 6 kilometres northeast of Youbou. The Comego (092C 018) showing is 1.6 kilometres to west.

The area is within the Cowichan uplift comprising PaleozoicSicker Group sedimentary and volcanic rocks. Triassic diabase and gabbro sills and dikes (informally Mount Hall gabbro), coeval with Karmutsen Formation (Vancouver Group) volcanics, occur in the area.Granodiorite and quartz diorite of the Early to Middle Jurassic Island Plutonic Suite intrude the rocks in the area.

Mineralization occurs in shear zones in pyritized, and/or hematitic chert, and in pyritized and silicified sheared diorite.The chert outcrops on the southern portion of the claim and is part of the Mississippian to Pennsylvanian Fourth Lake Formation (Buttle Lake Group). The intrusives have locally been kaolinitized, the chert has been silicified, and limonite staining was noted.

A sample across 1.2 metres of chert from a shear zone assayed 1.2 grams per tonne gold and 0.69 gram per tonne silver (Assessment Report 17125). A 0.61 metre sample of rusty, sheared diorite assayed 12.07 grams per tonne gold and 3.77 grams per tonne silver (Assessment Report 17125).

**MINFILE NUMBER: 092C 134** **NAME: MCDOUGALL**
NORTHING: 5427550 EASTING: 391300 STATUS: Showing

CAPSULE GEOLOGY:

The McDougall showing is located 40 kilometres southwest of Nanaimo and 7 kilometres north of Cowichan Lake. This showing occurs on the Heather property (092C 127), 1.7 kilometres north of the main showing.

The area is within the Cowichan uplift and is underlain by Paleozoic Sicker Group rocks. The showing is underlain by northwest trending Devonian Nitinat and Upper Devonian McLauglin Ridge formations comprising volcanic and volcaniclastic rocks. Early to Middle Jurassic Island Plutonic Suite intrusives also occur in thearea.

The McDougall showing consists of three en echelon quartz veins which strike northeast and dip near vertically. The veins locally contain trace pyrite and chalcopyrite-rich (2-3%) malachite-stained pods. The veins occur in relatively unaltered Nitinat flow breccias. The veins are 12.0 by 0.3 metres, 4.5 by 0.3 metres and 2.0 by 0.2 metres in size, respectively.

The highest gold value was obtained from a panel sample, 6.5 by 0.25 metres in size, of the largest vein. This sample assayed 9.15grams per tonne gold (Assessment Report 17833).

Diamond drilling results in 1988 were disappointing.

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**MINFILE NUMBER: 092C 136** **NAME: CHERYL**
NORTHING: 5420850 EASTING: 412950 STATUS: Showing

CAPSULE GEOLOGY:

The Cheryl occurrence is located 30 kilometres southwest of Nanaimo at the headwaters of Chemainus River on Mount Whymper.

The area, within the Cowichan uplift, is underlain by Mississippian to Pennsylvannian Fourth Lake Formation (Buttle Lake Group) sediments and Upper Triassic Karmutsen Formation (VancouverGroup) volcanic rocks which have been intruded by dioritic to granodioritic rocks of the Early to Middle Jurassic Island Plutonic Suite.

Outcrops on the claim host pyrite and chalcopyrite mineralization. Magnetite was observed in silt samples. A silicified chert and turbidite outcrop (OC4), hosts a quartz vein 1.5 metres long and up to 0.3 metre wide. Mineralization increases close to the vein but it appears that the wallrock contains more mineralization than the vein. Small shear zones with limonitic staining were also noted. A sample from this outcrop contained 5 to 10% pyrite and 3 to 5% chalcopyrite (Assessment Report 18598).

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**MINFILE NUMBER: 092C 139** **NAME: WIDOW CREEK**
NORTHING: 5418664 EASTING: 412284 STATUS: Showing

CAPSULE GEOLOGY:

The Widow Creek showings are located near the head of Widow Creek. This occurrence comprises 2 showings, the Widow Creek and the Cottonwood, now located on the Striker property.

The area is underlain by sedimentary rocks of the Mississippian to Pennsylvanian Fourth Lake Formation, Buttle Lake Group. The manganese minerals are hosted in the Lower Mississippian Shaw Creek Member (dated by conodonts, Personal Communication - Nick Massey, 1991).

The Widow Creek showing is located on the east side of the creek at an elevation of 640 metres. The showing consists of rhodonite in a 46 to 61 centimetre wide band exposed at two places about 30 metres apart in cherty tuff.

The Cottonwood showing, discovered in 1919 and staked as the Sentinel, Wonderland and Wonderland No. 2 claims, is 800 metres west of Widow Creek at an elevation of 792 metres. Rhodonite and rhodochrosite lenses occur parallel to bedding in cherty tuffs. They occur over an area about 30 metres north-south by 15 metres east-west. The lenses are coated with oxides. Rhodochrosite in small amounts occurs in irregular masses that grade into rhodonite.

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**MINFILE NUMBER: 092C 144** **NAME: SOGNIDORO**
NORTHING: 5423100 EASTING: 421950 STATUS: Prospect

CAPSULE GEOLOGY:

The Sognidoro showing is located approximately 27 kilometres northwest of Chemainus, south of Rheinhart Lake. A 100 metre adit occurs on the nearby Trek claims possibly from as early as 1918.

The area is underlain by metasedimentary rocks of the Mississippian to Pennsylvannian Fourth Lake Formation (Buttle Group) and volcanic rocks of the Upper Devonian McLaughlin Ridge Formation (Sicker Group). These two formations were historically referred to as the Myra Formation and contained the "Sediment-Sill Unit" of the Sicker Group. The Sediment-Sill unit has been tentatively correlated with the Fourth Lake Formation and the "sills" have been mapped separately. The sills are believed to be coeval with the Karmutsen Formation basalts and are informally named Mount Hall gabbro. These rocks have been intruded by granitic rocks of the Early to Middle Jurassic Island Plutonic Suite.

Mineralization comprises pyrite, chalcopyrite, galena, bornite, molybdenite, azurite, malachite and chalcanthite hosted within quartz veins. Pyrite, chalcopyrite, hematite and magnetite also occur within jasper horizons. Galena was observed in a quartz vein cutting a diabasic outcrop within the southerly flowing creek on the western side of the claim. Base and precious metal values are locally associated with this mineralization.

The main vein is the McDougall vein, striking 320 degrees and dipping 70 degrees east, which has been traced for 265 metres. Mineralization apparently increases in quantity toward the northern end of the vein. The vein is hosted in, and conformable with, chloritic schists. The McDougall vein may be truncated by faults at both ends with a suggested right-lateral displacement of 200 metres at the northern extent. A sample, from a pit on the vein, containing iron oxides, malachite, chalcanthite and up to 2% chalcopyrite, assayed 0.58 gram per tonne gold, 3.7 grams per tonne silver,and 0.28% copper (Assessment Report 16802).

Two jasper showings are located in the central claim area. These are also hosted in and conformable with the chloritic schists. The horizons are exposed over 30 and 25 metre widths and along strikefor 200 metres and 50 metres respectively. The jasper appears to occur in lenses but it could be part of a continuous horizon displaced by right-lateral faulting. The jasper, brick to scarlet red with metallic grey patches, is cut by numerous quartz veinlets (up to 0.5 centimetres). Iron oxides and malachite staining occurs locally. Pyrite and chalcopyrite occur primarily in the veinlets. Finely disseminated and massive magnetite occurs within the jasper "lenses". A sample of jasper cut by quartz veinlets containing pyrite and magnetite assayed 0.72 gram per tonne gold, 0.5 grams per tonne silver, 0.0418% copper and 41.69% magnetite (Assessment Report 16802).

Geochemical and geophysical surveys have been done on the nearby Imp and Imperial claims. The results of these programs were discouraging and no mineralization was found.

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**MINFILE NUMBER: 092C 145** **NAME: EAGLE**

NORTHING: 5407050 EASTING: 404450 STATUS: Showing

CAPSULE GEOLOGY:

The Eagle showings are located in the Sutton Creek/Gordon River area, 14 kilometres south of Caycuse. The main showing is on Sutton Creek near the Gordon River-Honeymoon Bay road. The Eagle showings occur in the southern portion of a 3 by 1 kilometre alteration zone (Malcolm, 1971).

The area is underlain by basaltic rocks of the Karmutsen Formation, sedimentary rocks of the Quatsino and Parson Bay formations,all of the Upper Triassic Vancouver Group and by volcanic rocks of the Lower Jurassic Bonanaza Group. These are intruded by Early to Middle Jurassic Island Plutonic Suite rocks. A major fault trends parallel to Gordon River striking 110 to 150 degrees. Shearing is prevalent with shears striking 060 to 120 degrees. Faults in the area contain sulphides, quartz and calcite.

The claims are underlain by feldspar porphyry, basalt, volcanic flows, pillow and amygdaloidal basalts, breccias, tuffs, limestoneand intrusive rocks.

The occurrence comprises several showings in a northwest trending linear area originating at the main showing. The main showing consists of chalcopyrite, bornite and pyrite hosted in altered and brecciated feldspar porphyry in a shear zone closely associated with the main fault. Sphalerite and pyrite occur about 250 metres to the south in a similar setting. Silver was observed in fractures in volcanic rocks on the banks of Sutton Creek.

About 2 kilometres to the northwest, chalcopyrite, pyrite and sphalerite occur in a gossanous zone in tuffs ("Hematite" tuff), intrusive breccias, and feldspar porphyry associated with faulting and brecciation.

Copper anomalies outlined by geochemical and geophysical surveys in 1985 coincide with surface gossans. Assays from these showingswere low in precious and base metals.

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**MINFILE NUMBER: 092F 563** **NAME: FLIGHT 5**

NORTHING: 5430650 EASTING: 396775 STATUS: Showing

CAPSULE GEOLOGY:

The Flight 5 showing is located 9 kilometres northeast of the west tip of Cowichan Lake.

The area is underlain by volcanic and volcaniclastic rocks of the Paleozoic Sicker Group. These rocks comprise jasper, tuff, basaltic to andesitic agglomerates, volcanic breccia and minor flows of the Upper Devonian McLaughlin Ridge Formation and the Devonian Nitinat Formation. Minor shearing and faulting have been identified in the area.

An extensive jasper body containing minor magnetite occurs at the McLaughlin Ridge Formation\Nitinat Formation contact. A 10 centimetre band of conformable massive pyrrhotite is reported to occur near this contact, however, it does not appear to have been mapped or documented.

The jasper body is 10 to 15 metres thick, traceable for 250 metres, dips vertically and is hosted in basaltic rocks overlain by epiclastic sandstones and siltstones. The jasper is locally broken with minor infillings of magnetite and is laterally succeeded bylenses, blocks or wedges of jasper with minor pyrite. These areoverlain by fine-grained chloritic tuff, laminated cherty tuff andfinally by hemaititc altered lapilli tuff. The tuff containsgraphitic partings and quartz veining carrying pyrite and trace chalcopyrite. A 30 centimetres wide associated shear zone contains chlorite, kaolinite, sericite, pyrite, trace chalcopyrite and malachite. Rock samples of the jasper body assayed only low values for gold, silver, copper, lead and zinc (Assessment Report 15887).

# APPENDIX 3

## SUMMARY OF ASSESSMENT REPORT WORK RECORDED WITHIN THE COWICHAN LAKE MAP AREA

Data is abstracted from the Ministry's ARIS database which should be consulted for more complete information and for assessment reports filed after December 1989.

| ASSESSMENT REPORT NO. | EASTING | NORTHING | MINING DIVISION | CLAIM(S) WORKED ON | OPERATOR(S)/ AUTHOR(S) | REPORT YEAR | WORK TYPE** |
|---|---|---|---|---|---|---|---|
| 97 | 410147 | 5412397 | VICT | Lake<br>Osslyn<br>TT | Cowichan Copper<br>Skerl A. | 1953 | GEOL<br>GEOP |
| 169 | 419496 | 5399283 | VICT | Stella | Rosea Copper Mines<br>Hemsworth F. | 1957 | GEOP |
| 566 | 425859 | 5416984 | VICT | Pogo | Wilson E.M.<br>Wilson E.M. | 1964 | GEOL |
| 616 | 410147 | 5412397 | VICT | Blue Grouse<br>CC<br>Jud<br>Lake | Cowichan Copper<br>Malcolm D. | 1964 | GEOL |
| 641 | 414429 | 5420483 | VICT | Comego<br>MacD<br>New Comego | MacDonald O.<br>Malcolm D. | 1964 | GEOL |
| 935 | 425049 | 5420330 | VICT | Ohm<br>Yam | Cominco<br>Tikkanen G. | 1966 | GEOP |
| 1949 | 413196 | 5419761 | VICT | Anne | Hibernia Min.<br>Montgomery J.H. | 1969 | GEOC |
| 2163 | 389958 | 5411832 | VICT | AV<br>Gate<br>Tan<br>Tana | Quintana Min.<br>Malcolm D. | 1969 | GEOL<br>GEOP<br>GEOC |
| 2167 | 413196 | 5419761 | VICT | Anne | Hibernia Min.<br>Montgomery J.H. | 1969 | GEOC |
| 2849 | 413196 | 5419761 | VICT | Anne | Hibernia Min.<br>Montgomery J.H.<br>Cochrane D. | 1970 | GEOL<br>GEOP |
| 6063 | 402904 | 5424749 | NIMO | Skyline | Echo Min.<br>Ostensoe L.O. | 1976 | GEOC |
| 6297 | 410147 | 5412397 | VICT | Blue Grouse<br>Cindy | Placer Dev.<br>Rivera R. | 1976 | GEOP |
| 6963 | 405061 | 5422488 | NIMO | Amore<br>Close<br>Dibenedetto | Specogna E.<br>Specogna E. | 1978 | PROS |
| 7187 | 405061 | 5422488 | VICT | Amore | Aquarius Res.<br>Specogna E. | 1978 | PROS |
| 7832 | 410683 | 5422951 | VICT | Cap | Pacer Ex.<br>McIntyre R. | 1979 | GEOP<br>GEOC |
| 7880 | 405061 | 5422488 | VICT<br>NIMO | Amore<br>Close<br>Dibenedetto | Aquarius Res.<br>Ashton A. | 1979 | DRIL |
| 7908 | 405061 | 5422488 | VICT | Amore | Aquarius Res.<br>Ashton A. | 1979 | DRIL<br>PHYS |
| 8283 | 412822 | 5419211 | VICT | Sherk<br>Widow | DRC Res.<br>Crooker G.F. | 1980 | GEOL<br>PHYS<br>GEOC |
| 8782 | 405061 | 5422488 | VICT<br>NIMO | Amore<br>Close | Aquarius Res.<br>Ashton A. | 1980 | GEOC |
| 8805 | 391897 | 5410867 | VICT | Lui<br>Non<br>Oui | Union Miniere Ex.<br>Pauwels A.M. | 1980 | GEOC |

| ASSESSMENT REPORT NO. | EASTING | NORTHING | MINING DIVISION | CLAIM(S) WORKED ON | OPERATOR(S)/ AUTHOR(S) | REPORT YEAR | WORK TYPE** |
|---|---|---|---|---|---|---|---|
| 8895 | 410147 | 5412397 | VICT | Cindy | Corrie Copper | 1980 | GEOP |
| | | | | Joy | White G.E. | | PHYS |
| | | | | Mac | | | |
| 8896 | 483496 | 5411698 | VICT | SS | Corrie Copper | 1980 | DRIL |
| | | | | | Phendler R. | | |
| 9856 | 421558 | 5397771 | VICT | Maxi | Strata Energy | 1981 | GEOL |
| | | | | | Crooker G.F. | | GEOC |
| 9861 | 405061 | 5422488 | VICT | Amore | Aquarius Res. | 1981 | GEOC |
| | | | NIMO | | Chase W.F. | | |
| | | | | | Ashton A. | | |
| 10102 | 412822 | 5419211 | VICT | Sherk | DRC Res. | 1981 | GEOL |
| | | | | Widow | Crooker G.F. | | |
| 10324 | 405061 | 5422488 | VICT | Amore | Aquarius Res. | 1981 | GEOC |
| | | | | | Chase W.F. | | |
| | | | | | Ashton Q. | | |
| 10331 | 412826 | 5403830 | VICT | Ash | Pace Ind. | 1981 | PROS |
| | | | | | Ashton A. | | |
| 10970 | 405061 | 5422488 | NIMO | Amore | Aquarius Res. | 1982 | GEOL |
| | | | | | Chase W.F. | | GEOC |
| 11097 | 424616 | 5424412 | NIMO | Imperial H | Imperial Metals | 1982 | GEOP |
| | | | | | Quin S. | | |
| | | | | | De Carle R.J. | | |
| 11098 | 424616 | 5424412 | NIMO | Imp J-M | Imperial Metals | 1982 | GEOL |
| | | | | Imp S | Quin S. | | GEOC |
| 11232 | 389630 | 5407576 | VICT | Hank | Strato Geological Eng. | 1982 | PROS |
| | | | | | Armstrong C. | | |
| 11302 | 405061 | 5422488 | VICT | Amore | Aquarius Res. | 1983 | GEOP |
| | | | NIMO | | Chase W.F. | | |
| 11303 | 390244 | 5426282 | VICT | Carol S | Chevron Can. Res. | 1983 | GEOL |
| | | | | Efrem S | Dyson C. | | GEOC |
| | | | | Marino S | | | |
| | | | | Tania S | | | |
| 11311 | 404169 | 5420280 | VICT | Paula | Noranda Ex. | 1983 | PROS |
| | | | | | Baldry K. | | GEOP |
| | | | | | | | GEOC |
| 11347 | 419149 | 5417633 | VICT | NTI | Noranda Ex. | 1983 | GEOC |
| | | | | | Stewart C. | | |
| 11401 | 421293 | 5422420 | VICT | Sognidoro | Canamin Res. | 1983 | GEOC |
| | | | | | Zastavnikovich S. | | |
| 11564 | 420675 | 5421873 | VICT | Hart 1-2 | Cominco | 1983 | GEOL |
| | | | | | Freeze A. | | GEOC |
| 12002 | 404817 | 5422492 | VICT | Amore II | Specogna E. | 1983 | PROS |
| | | | | | Specogna E. | | GEOC |
| 12132 | 400036 | 5428136 | NIMO | Dixie 1 | Noranda Ex. | 1983 | GEOL |
| | | | | Snooky | Stewart C. | | GEOP |
| | | | | Snuffy | Bradish L. | | GEOC |
| 12173 | 421875 | 5420374 | VICT | Erd | Stevens E. | 1983 | PROS |
| | | | | | Stevens E. | | GEOC |
| 12378 | 425002 | 5425890 | NIMO | Imp T | Imperial Metals | 1983 | GEOP |
| | | | | Imp U | Quin S. | | |
| | | | | Imp V | Decarle R. | | |
| | | | | Imp W | | | |
| 12445 | 390211 | 5424615 | VICT | Carol S | Chevron Can. Res. | 1983 | GEOP |
| | | | | Tania S4 | Dyson C. | | PHYS |
| | | | | | LeBel J.L. | | |
| 12606 | 420615 | 5417612 | VICT | NTI | Noranda Ex. | 1984 | GEOL |
| | | | | NTI 2-4 | Dance D. | | GEOC |
| | | | | | Stewart C. | | |
| 12618 | 389630 | 5407576 | VICT | Hank | Ajax Res. | 1984 | GEOL |
| | | | | | Harris M.W. | | GEOP |
| | | | | | | | GEOC |
| 12678 | 424367 | 5424045 | NIMO | Imp J | Imperial Metals | 1983 | GEOP |
| | | | | Imp K | Quin S. | | |
| | | | | ImpL | De Carle R.J. | | |
| | | | | Imp M | | | |
| 12909 | 423070 | 5418504 | VICT | Bedrock 2 | Francis A. | 1984 | PROS |

| ASSESSMENT REPORT NO. | EASTING | NORTHING | MINING DIVISION | CLAIM(S) WORKED ON | OPERATOR(S)/ AUTHOR(S) | REPORT YEAR | WORK TYPE** |
|---|---|---|---|---|---|---|---|
| | | | | | Francis A. | | |
| 13291 | 400036 | 5428136 | NIMO | Snooky | Noranda Ex. | 1984 | GEOL |
| | | | | Snuffy | Stewart C. | | GEOC |
| 13333 | 413359 | 5422353 | VICT | Whymp 1-2 | Imperial Metals | 1984 | GEOC |
| | | | | | Clark A.M. | | |
| 13359 | 425599 | 5424955 | NIMO | Imp H | Imperial Metals | 1985 | GEOP |
| | | | | Imp J | Clark A. | | GEOC |
| | | | | ImpL | | | |
| 13468 | 425611 | 5425882 | NIMO | Imp J | Imperial Metals | 1984 | GEOP |
| | | | | ImpL | Clark A.M. | | |
| | | | | Imp H | Walcott P.E. | | |
| 13516 | 390247 | 5426468 | VICT | Carol S | Chevron Can. Res. | 1985 | DRIL |
| | | | | Tania S | Dyson C. | | PHYS |
| | | | | | | | GEOC |
| 13568 | 421901 | 5422226 | VICT | Sognidoro | Canamin Res. | 1985 | PROS |
| | | | | | McDougall J.J. | | GEOC |
| | | | | | Specogna E. | | |
| 13962 | 412051 | 5416814 | VICT | Cot 3-5 | BHP-Utah Mines | 1985 | GEOL |
| | | | | Cott 1-2 | Cowley P. | | GEOP |
| | | | | Footloose 1-5 | Ord R.S. | GEOC | |
| | | | | Ridge 1-3 | | | |
| | | | | Striker 1 | | | |
| | | | | Striker 3-6 | | | |
| | | | | Thriller 1-6 | | | |
| | | | | Zip 1-3 | | | |
| 14116 | 406069 | 5424324 | VICT | Amore B | Canamin Res. | 1985 | PROS |
| | | | | | Specogna E. | | |
| 14153 | 403946 | 5407311 | VICT | Eagle 4 | Western Forest Ind. | 1985 | PROS |
| | | | | | Allan V. | | PHYS |
| | | | | | | | GEOP |
| | | | | | | | GEOC |
| 14302 | 408997 | 5416863 | VICT | Cott 1-5 | BHP-Utah Mines | 1985 | GEOP |
| | | | | Footloose 1-5 | Cowley P. | GEOC | |
| | | | | Striker 1-6 | | | |
| | | | | Thriller 1-6 | | | |
| | | | | Zip 1-3 | | | |
| 14316 | 406766 | 5535515 | VICT | Amore 2 | Canamin Res. | 1985 | PROS |
| | | | NIMO | | Specogna M. | GEOP | |
| | | | | | | | GEOC |
| 14462 | 426345 | 5416792 | VICT | Cow 12-16 | J.B.L. Res. | 1986 | GEOL |
| | | | | | Neale T. | | GEOC |
| | | | | | Hawkins T. | | |
| 14712 | 430373 | 5416555 | VICT | Chip 1-5 | Kidd Creek Mines | 1986 | GEOP |
| | | | | Chip 8 | Hendrickson G.A. | | PHYS |
| 14792 | 412734 | 5421436 | VICT | Whymp 1-2 | Imperial Metals | 1986 | GEOP |
| | | | | | Clark A. | | PHYS |
| | | | | | | | GEOC |
| 14793 | 425574 | 5423102 | NIMO | Imp J | Imperial Metals | 1986 | GEOL |
| | | | | Imp K | Clark A. | | GEOP |
| | | | | Imp L | | | GEOC |
| | | | | Imp W | | | PHYS |
| 14821 | 397730 | 5428734 | VICT | Flight 1 | BHP-Utah Mines | 1986 | GEOL |
| | | | NIMO | Flight 3 | Cowley P. | | GEOC |
| 14828 | 394682 | 5422304 | VICT | Joss 1-5 | BHP-Utah Mines | 1986 | GEOL |
| | | | | | Cowley P. | | GEOC |
| 14891 | 420527 | 5411498 | VICT | Cow | Int. Cherokee Dev. | 1986 | GEOL |
| | | | | Cow 2-4 | Neale T. | | GEOC |
| | | | | | Hawkins T. | | |
| 14925 | 403836 | 5408054 | VICT | Eagle 4 | Western Forest Ind. | 1986 | GEOL |
| | | | | | Allan V. | | |
| 14996 | 412832 | 5404201 | VICT | Echo 1-4 | Orbex Ind. | 1986 | PROS |
| | | | | | Fox P.E. | | GEOC |
| 15013 | 426152 | 5411421 | VICT | Cow 7 | Int. Cherokee Dev. | 1986 | GEOL |
| | | | | Cow 9-11 | Neale T. | | GEOC |
| | | | | | Hawkins T. | | |
| 15065 | 410680 | 5422766 | VICT | Capitan | Dayton Dev. | 1986 | GEOL |
| | | | | Spaniard | Christopher P.A. | | GEOC |

| ASSESSMENT REPORT NO. | EASTING | NORTHING | MINING DIVISION | CLAIM(S) WORKED ON | OPERATOR(S)/ AUTHOR(S) | REPORT YEAR | WORK TYPE** |
|---|---|---|---|---|---|---|---|
| | | | | | | | PHYS |
| 15082 | 423108 | 5421283 | VICT | Trek | Trek Res. | 1986 | DRIL |
| | | | NIMO | | Poloni J.R. | | GEOC |
| 15117 | 412051 | 5416814 | VICT | Cott | BHP-Utah Mines | 1986 | GEOL |
| | | | | Footloose | Cowley P. | | GEOP |
| | | | | Ridge | Ord R.S. | | PHYS |
| | | | | Striker 2-4 | | | GEOC |
| | | | | Striker 6 | | | |
| | | | | Thriller | | | |
| | | | | Zip | | | |
| 15206 | 390491 | 5426463 | VICT | Carol S | Int. Cherokee Dev. | 1986 | GEOP |
| | | | | Tania S3 | Gibson H.L. | | PHYS |
| | | | | Tania S | | | |
| 15258 | 405568 | 5423592 | VICT | Amore | Canamin Res. | 1986 | PROS |
| | | | | Amore 2 | Specogna M. | | GEOC |
| 15504 | 429770 | 5417118 | VICT | Chip 1-5 | Kidd Creek Mines | 1987 | GEOP |
| | | | | Chip 7-8 | Hendrickson G.A. | | |
| | | | | Chip 11 Fr. | | | |
| | | | | Chip 13 Fr. | | | |
| 15578 | 418677 | 5418752 | VICT | Mike 1-4 | Int. Cherokee Dev. | 1987 | DRIL |
| | | | | | Allen G.J. | | GEOC |
| | | | | | | | GEOP |
| | | | | | | | GEOL |
| | | | | | | | PHYS |
| 15821 | 399403 | 5413321 | VICT | Gold Dyke 1 | Orbex Ind. | 1987 | DRIL |
| | | | | | Payne C. | | GEOC |
| | | | | | | | PHYS |
| 15883 | 421540 | 5422602 | VICT | Sognidoro | Canamin Res. | 1987 | PROS |
| | | | | | Specogna M. | | GEOP |
| 15887 | 396379 | 5428203 | VICT | Flight 1 | BHP-Utah Mines | 1987 | GEOC |
| | | | | Flight 4-5 | Cowley P. | | GEOL |
| | | | | | Ord R.S. | | GEOP |
| 15890 | 394631 | 5421749 | VICT | Joss 1-5 | BHP-Utah Mines | 1987 | GEOC |
| | | | | | Cowley P. | | GEOL |
| | | | | | Robinson C. | | |
| 16053 | 429121 | 5414162 | VICT | Cow 7 | Int. Cherokee Dev. | 1987 | DRIL |
| | | | | Cow 9-11 | Allen G.J. | | GEOC |
| | | | | | | | GEOP |
| | | | | | | | GEOL |
| | | | | | | | PHYS |
| 16097 | 425971 | 5416241 | VICT | Cow 12-16 | Int. Cherokee Dev. | 1987 | DRIL |
| | | | | | Allen G.J. | | GEOC |
| | | | | | | | GEOP |
| | | | | | | | GEOL |
| | | | | | | | PHYS |
| 16122 | 419549 | 5411512 | VICT | Cow 1-4 | Int. Cherokee Dev. | 1987 | GEOC |
| | | | | | Allen G.J. | | GEOL |
| | | | | | Thomae B. | | |
| 16162 | 390097 | 5406454 | VICT | Hank | Ajax Res. | 1987 | GEOC |
| | | | | | Bartier P. | | GEOP |
| | | | | | | | GEOL |
| 16210 | 409891 | 5419258 | VICT | Cott 1-2 | BHP-Utah Mines | 1987 | GEOC |
| | | | | Cott 4-5 | Cowley P. | | GEOP |
| | | | | Footloose 1 | Ord R.S. | | GEOL |
| | | | | Footloose 4-5 | Robinson C. | | PHYS |
| | | | | Ridge 1-3 | | | |
| | | | | Striker 1-6 | | | |
| | | | | Thriller 1-6 | | | |
| | | | | Zip 1-3 | | | |
| 16227 | 406303 | 5423764 | VICT | Amore | Canamin Res. | 1987 | GEOC |
| | | | NIMO | Amore 2 | Hawkins T. | | GEOL |
| | | | | Amore B | Thomae B. | | |
| | | | | Natalie-L | | | |
| 16237 | 428832 | 5410645 | VICT | Cow 5-6 | Int. Cherokee Dev. | 1987 | GEOC |
| | | | | Cow 8 | Allen G.J. | | GEOL |
| | | | | Namiko | | | PHYS |
| | | | | Namiko 1 Fr. | | | |

| ASSESSMENT REPORT NO. | EASTING | NORTHING | MINING DIVISION | CLAIM(S) WORKED ON | OPERATOR(S)/ AUTHOR(S) | REPORT YEAR | WORK TYPE** |
|---|---|---|---|---|---|---|---|
| | | | | Namiko 2 Fr. | | | |
| 16357 | 390473 | 5425536 | VICT | Carol S | Minnova | 1987 | DRIL |
| | | | | Tanya S | Wells G.S. | | GEOC |
| 16478 | 426411 | 5421794 | VICT | Imp K | Imperial Metals | 1987 | GEOC |
| | | | NIMO | | Baknes M. | | GEOL |
| | | | | | Gorc D.M. | | |
| 16541 | 416842 | 5418593 | VICT | JR | Vancouver Venture | 1987 | GEOC |
| | | | | | Wahl H.J. | | GEOL |
| | | | | | | | PHYS |
| 16802 | 421214 | 5422576 | VICT | Sognidoro | Canamin Res. | 1987 | GEOL |
| | | | | | Hawkins T.G. | | GEOC |
| | | | | | Thomae B. | | |
| 17039 | 409615 | 5410985 | VICT | Blue Grouse | Nic Nik Res. | 1987 | GEOL |
| | | | | Blue Grouse 1-2 | Hulme N.J. | | GEOP |
| | | | | SS 1-6 | DiSpirito F. | | GEOC |
| | | | | SS 8 | | | PHYS |
| | | | | Dads Birthday | | | |
| | | | | Le Hurel | | | |
| | | | | Skye | | | |
| | | | | Split | | | |
| 17125 | 415147 | 5419546 | VICT | Harbey | Sierra Madre | 1987 | GEOC |
| | | | | | Cukor V. | | GEOP |
| 17164 | 388761 | 5414141 | VICT | Archer I-II | Nuspar Res. | 1988 | GEOL |
| | | | | Tatters II | Fischl P. | | DRIL |
| | | | | | | | PHYS |
| 17422 | 396822 | 5425786 | VICT | Taurus | Int. Black Gold Res. | 1988 | GEOC |
| | | | | | Verzosa R.S. | GEOP | |
| 17447 | 424209 | 5419909 | VICT | Schist | Francis A. | 1988 | PROS |
| | | | | | Francis A. | | |
| 17702 | 414238 | 5400102 | VICT | Eagle 4 | Western Forest Products | 1987 | GEOP |
| | | | | | Harrington J.R. | | GEOC |
| | | | | | | | PHYS |
| 17736 | 405435 | 5416922 | VICT | Cott 6 | Nootka Min. | 1988 | PROS |
| | | | | | Freeze J.C. | | |
| 17833 | 390266 | 5427394 | VICT | Lucia S | Minnova | 1988 | DRIL |
| | | | | | Int. Cherokee Dev. | | |
| | | | | | Wells G.S. | | |
| 17835 | 390857 | 5426456 | VICT | Carol S | Minnova | 1988 | DRIL |
| | | | | | Int. Cherokee Dev. | | |
| | | | | | Wells G.S. | | |
| 17932 | 402409 | 5424387 | VICT | Taurus II | Int. Black Gold Res. | 1988 | GEOP |
| | | | | | Hermary R.G. | | |
| | | | | | Woods D.V. | | |
| 18010 | 425537 | 5420323 | NIMO | Imperial H | Imperial Metals | 1988 | GEOL |
| | | | | Imp K | DeLancey P.R. | | GEOC |
| 18093 | 404175 | 5420650 | VICT | Marathon | Ruza Res. | 1988 | PROS |
| | | | | Taurus III | Wahl H.J. | | |
| 18097 | 414494 | 5416776 | VICT | Osirus A | Osirus Ent. | 1988 | PROS |
| | | | | | Shearer J.T. | | |
| 18394 | 410918 | 5422391 | VICT | Capitan | Omega Gold | 1989 | GEOL |
| | | | | Spaniard | Lorenzetti G.M. | | GEOC |
| | | | | | | | GEOP |
| 18598 | 412139 | 5422372 | VICT | Cheryl | Perrett D.G. | 1989 | PROS |
| | | | | Ria | Perrett D.G. | | GEOC |
| 18635 | 400036 | 5428136 | NIMO | Rite 1-2 | Galico Res. | 1989 | GEOC |
| | | | | Rain 1-2 | Hawkins T.G. | | |
| | | | | | Laura 1-2 | | |
| 18640 | 420522 | 5411128 | VICT | Cow 1-4 | Int. Cherokee Dev. | 1989 | GEOC |
| | | | | | Yip G. | | GEOL |
| 18731 | 423843 | 5421458 | VICT | Trek 1-8 | Trek Res. | 1989 | DRIL |
| | | | NIMO | Kristal 6 | Body T.W. | | |
| | | | | Kristal 6 Fr. | | | |
| 18797 | 420522 | 5411128 | VICT | Cow 1-4 | Int. Cherokee Dev. | 1989 | GEOL |
| | | | | | Yip G. | | GEOC |
| 18871 | 425413 | 5411060 | VICT | Cow 1-6 | Int. Cherokee Dev. | 1989 | GEOL |
| | | | | Cow 8 | Lorenzetti G.M. | | GEOC |
| | | | | Namiko | | | GEOP |

| ASSESSMENT REPORT NO. | EASTING | NORTHING | MINING DIVISION | CLAIM(S) WORKED ON | OPERATOR(S)/ AUTHOR(S) | REPORT YEAR | WORK TYPE** |
|---|---|---|---|---|---|---|---|
| 19028 | 412051 | 5416814 | VICT | Namiko 1<br>Namiko 2 Fr.<br>Joss 6<br>Footloose 6<br>Cott 6 | Stetson Res. Management<br>Wetherill J.W. | 1989 | GEOP |

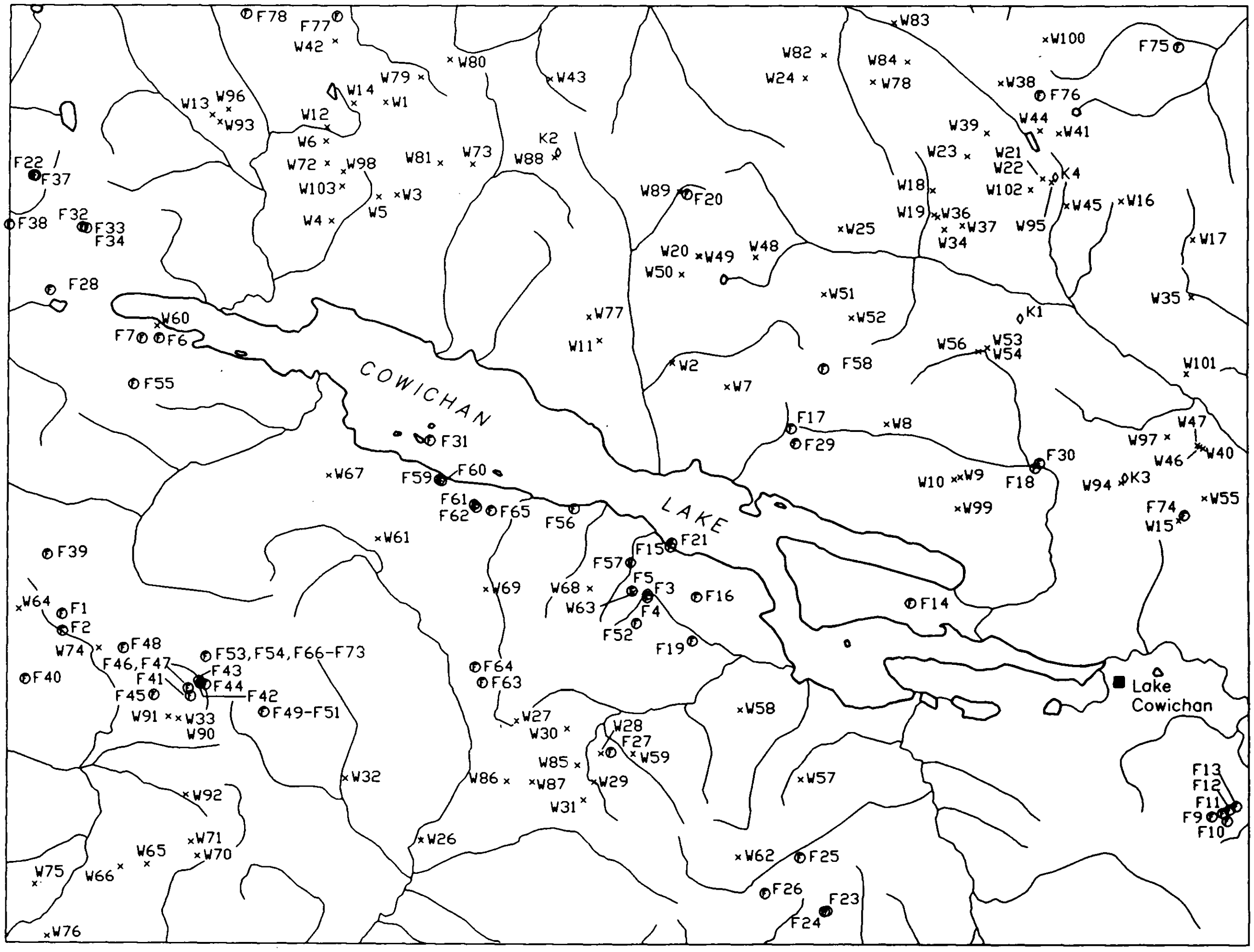
* *Mining Division*

| | |
|---|---|
| *NIMO:* | *Nanaimo* |
| *VICT:* | *Victoria* |

| | |
|---|---|
| ** *DRIL* | *Drilling* |
| *GEOC* | *Geochemistry* |
| *GEOL* | *Geological mapping* |
| *GEOP* | *Geophysics* |
| *PHYS* | *Physical work (trenching, line cutting,etc.)* |
| *PROS* | *Prospecting* |

# APPENDIX 4

## TABULATED K-Ar ISOTOPIC AGE SAMPLE DATA, WHOLE-ROCK GEOCHEMICAL ANALYSIS AND FOSSIL SAMPLE LOCATIONS




Whole rock geochemical samples (A4-2; A4-3) .................. ×

K-Ar isotopic age samples (A4-1) .................. ◊

Fossil locations (A5) .................. ⊕

## APPENDIX 4 - TABLE 1
## POTASSIUM-ARGON ISOTOPIC AGE DETERMINATIONS IN THE COWICHAN LAKE MAP AREA

| MAP NO. | SAMPLE NO. | UTM (ZONE 10) EASTING | NORTHING | ROCK TYPE | MINERAL | K (%) | $^{40*}Ar$ ($x10^{-6}$ cc/gm) | $^{40}Ar$ (%) | Age ± δ (Ma) |
|---|---|---|---|---|---|---|---|---|---|
| K1 | SFR87-1-3-3 | 419899 | 5418418 | Feldspar-hornblende porphyry | Hornblende | 0.550±0.010 | 3.822 | 91.6 | 171±6 |
| K2 | SFR86-17-2-2 | 406306 | 5423534 | Hornblende porphyry | Hornblende | 0.332±0.008 | 1.987 | 88.8 | 148±6 |
| K3 | NMA86-56-11- | 422924 | 5413661 | Hornblende porphyry | Hornblende | 0.440±0.017 | 2.97 | 93.1 | 166±8 |
| K4 | NMA87-10-9-2 | 420980 | 5422595 | Hornblende andesite sill | Hornblende | 0.161±0.002 | 1.188 | 81.2 | 181±6 |

* = Radiogenic argon.

Decay constants: $^{40}K_e = 0.581 \times 10^{-10}$ year$^{-1}$; $^{40}K_b = 4.96 \times 10^{-10}$ year$^{-1}$; $^{40}K/K = 1.167 \times 10^{-4}$.

Potassium determined at The University of British Columbia, Geochronology Laboratory.

Argon determination and age calculation by J.E. Harakal, The University of British Columbia.

## APPENDIX 4 - TABLE 2
## WHOLE ROCK GEOCHEMICAL DATA FOR ROCKS FROM THE COWICHAN LAKE MAP AREA

| MAP NUMBER | SAMPLE NUMBER | FORMATION | LITHO-LOGIC CODE | EASTING | NORTHING | $SiO_2$ % | $TiO_2$ % | $Al_2O_3$ % | $Fe_2O_3$ % | FeO % | MnO % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sicker Group: | | | | | | | | | | | |
| W1 | NMA86-17-2 | Nitinat Fm: suite 1 | PXPP | 401334 | 5425254 | 47.89 | 0.61 | 13.34 | 1.95 | 6.21 | 0.25 |
| W2 | NMA86-37-17 | Nitinat Fm: suite 1 | BSLT | 409737 | 5417395 | 49.97 | 0.77 | 14.05 | 1.31 | 7.04 | 0.17 |
| W3 | NMA86-18-1 | Nitinat Fm: suite 2 | PXPP | 401641 | 5422510 | 48.77 | 0.76 | 14.89 | 3.59 | 3.24 | 0.18 |
| W4 | NMA86-20-6 | Nitinat Fm: suite 2 | PLLV | 399702 | 5421784 | 48.87 | 0.52 | 12.40 | 3.41 | 5.62 | 0.18 |
| W5 | NMA86-21-9 | Nitinat Fm: suite 2 | BSLT | 401096 | 5422466 | 45.84 | 0.65 | 11.98 | 4.39 | 3.74 | 0.15 |
| W6 | NMA86-23-5 | Nitinat Fm: suite 2 | PLLV | 399561 | 5424130 | 48.95 | 0.75 | 13.94 | 3.07 | 4.94 | 0.15 |
| W7 | NMA86-44-7 | Nitinat Fm: suite 2 | PXPP | 411351 | 5416670 | 50.56 | 0.69 | 13.27 | 1.91 | 5.92 | 0.17 |
| W8 | NMA86-49-3 | Nitinat Fm: suite 2 | PXBAS | 416039 | 5415493 | 46.72 | 0.76 | 12.30 | 2.42 | 7.26 | 0.19 |
| W9 | NMA86-50-2 | Nitinat Fm: suite 2 | PXBAS | 418193 | 5413895 | 48.38 | 0.78 | 12.80 | 3.18 | 6.87 | 0.20 |
| W10 | NMA86-50-3 | Nitinat Fm: suite 2 | BSLT | 418006 | 5413838 | 51.97 | 0.99 | 17.74 | 7.25 | 3.03 | 0.10 |
| W11 | SFR86-38-12 | Nitinat Fm: suite 2 | PLLV | 407587 | 5418095 | 52.64 | 0.81 | 15.78 | 3.11 | 4.56 | 0.14 |
| W12 | JRU86-15-6 | Nitinat Fm: suite 2 | ANDS | 399599 | 5424528 | 49.24 | 0.72 | 15.45 | 2.74 | 5.62 | 0.15 |
| W13 | NMA86-2-2-2 | Nitinat Fm: felsic | DCIT | 396248 | 5424962 | 65.38 | 0.26 | 16.01 | 1.36 | 1.50 | 0.17 |
| W14 | NMA86-15-7-3 | McLaughlin Ridge Fm: felsic | RYLT | 400396 | 5425234 | 68.97 | 0.23 | 14.86 | 1.06 | 1.43 | 0.10 |
| W15 | SFR87-17-5 | McLaughlin Ridge Fm: felsic | DCIT | 424612 | 5412535 | 64.45 | 0.47 | 16.18 | 1.22 | 2.96 | 0.08 |
| W16 | NMA87-7-7-2 | Older Dykes | BSLT | 423030 | 5422013 | 48.00 | 2.07 | 13.55 | 3.16 | 10.65 | 0.24 |
| W17 | NMA87-11-18-2 | Older Dykes | BSLT | 425134 | 5420842 | 49.71 | 1.97 | 13.38 | 6.41 | 6.85 | 0.22 |
| W18 | NMA87-8-6-2 | Fourth Lake Fm: Mt Whymper suite | BSLT | 417481 | 5422399 | 39.83 | 2.59 | 12.56 | 1.31 | 8.23 | 0.32 |
| W19 | NMA87-8-10-2 | Fourth Lake Fm: Mt Whymper suite | BSLT | 417524 | 5421690 | 40.39 | 2.74 | 13.14 | 2.17 | 8.99 | 0.29 |
| W20 | NMA86-29-5 | Fourth Lake Fm: Mt Whymper felsic | DCIT | 410541 | 5420571 | 63.52 | 0.46 | 16.65 | 1.08 | 2.82 | 0.07 |
| W21 | SFR87-8-9 | Fourth Lake Fm: Mt Whymper felsic | DCIT | 420721 | 5422701 | 64.56 | 0.25 | 16.39 | 2.65 | 4.43 | 0.23 |
| W22 | SFR87-8-9 | duplicate analysis | DCIT | 420721 | 5422701 | 64.57 | 0.26 | 16.30 | 2.61 | 4.43 | 0.24 |
| W23 | SFR87-9-3 | Fourth Lake Fm: Mt Whymper felsic | DCIT | 418517 | 5423386 | 67.38 | 0.30 | 15.69 | 1.58 | 4.31 | 0.15 |
| Late Triassic: | | | | | | | | | | | |
| W24 | PTE87-3-1 | Karmutsen Fm: standard suite | PLLV | 413764 | 5425767 | 49.57 | 1.51 | 14.48 | 0.00 | 11.82 | 0.20 |
| W25 | NMA87-4-9 | Karmutsen Fm: standard suite | PLLV | 414759 | 5421307 | 48.49 | 1.70 | 14.77 | 2.63 | 9.05 | 0.20 |
| W26 | NMA86-32-2 | Karmutsen Fm: low-Nb suite | BSLT | 402071 | 5403395 | 47.21 | 1.72 | 13.74 | 4.16 | 8.12 | 0.20 |
| W27 | NMA86-32-5 | Karmutsen Fm: low-Nb suite | BSLT | 404967 | 5406892 | 47.77 | 1.79 | 13.70 | 2.45 | 9.61 | 0.20 |
| W28 | NMA86-33-4 | Karmutsen Fm: low-Nb suite | AMBAS | 407456 | 5405910 | 45.94 | 1.95 | 13.27 | 6.08 | 6.21 | 0.15 |
| W29 | NMA86-33-7 | Karmutsen Fm: low-Nb suite | BSLT | 407233 | 5405073 | 47.11 | 1.34 | 16.99 | 3.35 | 6.33 | 0.15 |
| W30 | NMA86-33-12 | Karmutsen Fm: low-Nb suite | BSLT | 406459 | 5406656 | 48.11 | 1.56 | 13.52 | 3.67 | 7.83 | 0.16 |
| W31 | NMA86-34-5 | Karmutsen Fm: low-Nb suite | BSLT | 406916 | 5404541 | 47.26 | 0.90 | 16.81 | 3.07 | 6.93 | 0.18 |
| W32 | NMA86-61-1 | Karmutsen Fm: low-Nb suite | BSLT | 399870 | 5405302 | 52.22 | 1.14 | 16.37 | 3.24 | 6.56 | 0.20 |
| W33 | SFR86-42-2 | Karmutsen Fm: low-Nb suite | BSLT | 395004 | 5407119 | 50.41 | 1.68 | 13.55 | 2.93 | 8.41 | 0.25 |
| W34 | NMA87-5-1 | Mt Hall Gabbro: standard suite | DIAB | 417809 | 5421238 | 48.85 | 1.63 | 17.57 | 1.90 | 8.13 | 0.16 |
| W35 | NMA87-6-5-2 | Mt Hall Gabbro: standard suite | GBBR | 425081 | 5419121 | 48.37 | 2.33 | 14.18 | 2.08 | 10.85 | 0.22 |
| W36 | NMA87-8-11 | Mt Hall Gabbro: standard suite | DIAB | 417618 | 5421623 | 48.07 | 1.58 | 15.67 | 1.67 | 8.23 | 0.18 |
| W37 | NMA87-8-14-2 | Mt Hall Gabbro: standard suite | GBBR | 418342 | 5421362 | 49.07 | 1.61 | 18.43 | 1.76 | 7.49 | 0.16 |
| W38 | SFR87-6-4 | Mt Hall Gabbro: standard suite | GBBR | 419525 | 5425526 | 48.84 | 1.76 | 16.48 | 1.55 | 9.00 | 0.18 |
| W39 | SFR87-9-11 | Mt Hall Gabbro: standard suite | DIAB | 419097 | 5424064 | 49.78 | 1.75 | 15.22 | 2.25 | 9.71 | 0.21 |
| W40 | PTE87-11-6 | Mt Hall Gabbro: standard suite | DIAB | 425374 | 5414651 | 49.02 | 1.86 | 13.05 | 1.57 | 10.85 | 0.22 |
| W41 | SFR87-11-23 | Mt Hall Gabbro: standard suite | GBBR | 421223 | 5424019 | 48.96 | 1.69 | 14.56 | 2.14 | 8.14 | 0.18 |
| W42 | SFR88-33-2-2 | Mt Hall Gabbro: standard suite | DIAB | 399870 | 5427099 | 49.06 | 1.92 | 14.53 | 11.29 | 2.12 | 0.26 |
| W43 | SFR88-37-17 | Mt Hall Gabbro: standard suite | DIAB | 406212 | 5425862 | 48.19 | 1.71 | 13.95 | 10.68 | 2.62 | 0.22 |
| W44 | PTE87-5-12 | Mt Hall Gabbro: standard suite | GBBR | 420669 | 5424107 | 48.79 | 1.36 | 15.43 | 1.61 | 7.64 | 0.15 |
| W45 | PTE87-8-16 | Mt Hall Gabbro: standard suite | GBBR | 421419 | 5421898 | 47.29 | 3.76 | 11.17 | 4.70 | 12.00 | 0.27 |
| W46 | PTE87-11-7 | Mt Hall Gabbro: standard suite | GBBR | 425278 | 5414705 | 53.37 | 2.60 | 10.90 | 2.93 | 14.57 | 0.31 |
| W47 | PTE87-11-8 | Mt Hall Gabbro: standard suite | DORT | 425206 | 5414745 | 49.02 | 1.40 | 15.44 | 1.81 | 8.57 | 0.18 |
| W48 | NMA86-29-8 | Mt Hall Gabbro: low-Nb suite | DIAB | 412247 | 5420512 | 49.16 | 1.62 | 13.85 | 0.98 | 10.46 | 0.20 |
| W49 | PTE86-19-6 | Mt Hall Gabbro: low-Nb suite | DIAB | 410585 | 5420550 | 51.82 | 1.93 | 15.36 | 1.65 | 8.31 | 0.19 |
| W50 | NMA86-29-3-2 | Mt Hall Gabbro: low-Nb suite | BSLT | 410044 | 5420020 | 49.52 | 1.81 | 14.96 | 3.81 | 8.54 | 0.19 |
| W51 | NMA86-46-7 | Mt Hall Gabbro: low-Nb suite | GBBR | 414241 | 5419366 | 47.70 | 0.93 | 14.48 | 0.00 | 9.65 | 0.15 |
| W52 | NMA86-48-1 | Mt Hall Gabbro: low-Nb suite | DIAB | 415042 | 5418649 | 46.73 | 0.99 | 15.00 | 1.06 | 7.90 | 0.16 |
| W53 | NMA86-53-11 | Mt Hall Gabbro: low-Nb suite | GBBR | 419039 | 5417708 | 48.22 | 1.33 | 15.62 | 1.04 | 9.08 | 0.18 |
| W54 | NMA86-53-11 | duplicate analysis | GBBR | 419039 | 5417708 | 48.15 | 1.25 | 15.49 | 1.43 | 9.41 | 0.17 |
| W55 | SFR87-13-19 | Mt Hall Gabbro: low-Nb suite | DIAB | 425387 | 5413176 | 48.00 | 2.05 | 14.46 | 3.47 | 10.64 | 0.23 |
| W56 | NMA86-53-6 | Mt Hall Gabbro: affinity uncertain | GBBR | 418770 | 5417605 | 51.01 | 2.51 | 11.45 | 2.15 | 13.68 | 0.29 |

*(APPENDIX 4 - TABLE 2 Continued)*

| MAP NUMBER | MgO % | CaO % | $Na_2O$ % | $K_2O$ % | $P_2O_5$ % | LOI % | $CO_2$ % | S % | Ba ppm | Sr ppm | Rb ppm | La ppm | Ce ppm | Ni ppm | Cr ppm | V ppm | Cu ppm | Zn ppm | Sc ppm | Y ppm | Zr ppm | Nb ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sicker Group:** | | | | | | | | | | | | | | | | | | | | | | |
| W1 | 10.05 | 13.38 | 1.07 | 1.33 | 0.23 | 2.52 | 0.27 | 0.01 | 126 | 316 | 60 | -15 | -15 | 138 | 475 | 268 | 44 | 100 | 43.0 | 13 | 47 | -5 |
| W2 | 8.30 | 7.52 | 2.42 | 2.98 | 0.33 | 2.08 | 0.24 | 0.02 | 845 | 463 | 45 | 15 | 41 | 52 | 218 | 271 | 130 | 77 | 33.0 | 16 | 79 | -5 |
| W3 | 7.86 | 9.04 | 2.39 | 3.10 | 0.48 | 4.52 | 1.78 | 0.01 | 460 | 282 | 59 | 42 | 68 | 56 | 221 | 199 | 96 | 64 | 31.0 | 22 | 134 | 17 |
| W4 | 10.68 | 10.36 | 1.87 | 1.21 | 0.32 | 3.00 | 0.10 | 0.01 | 345 | 342 | 17 | 17 | 35 | 116 | 499 | 260 | 114 | 77 | 39.0 | 13 | 49 | -5 |
| W5 | 9.14 | 10.98 | 1.06 | 4.28 | 0.41 | 5.76 | 3.34 | 0.01 | 638 | 223 | 74 | 16 | 34 | 71 | 311 | 234 | 124 | 70 | 37.0 | 17 | 76 | -5 |
| W6 | 6.39 | 11.15 | 2.18 | 2.85 | 0.47 | 3.30 | 1.28 | 0.06 | 320 | 432 | 43 | 38 | 77 | 63 | 226 | 242 | 166 | 79 | 31.0 | 18 | 104 | 6 |
| W7 | 5.67 | 10.77 | 2.36 | 3.35 | 0.42 | 3.29 | 2.15 | 0.01 | 544 | 683 | 58 | 44 | 48 | 56 | 323 | 242 | 76 | 92 | 33.0 | 17 | 91 | -5 |
| W8 | 9.69 | 10.27 | 0.21 | 3.31 | 0.53 | 3.72 | 1.43 | 0.02 | 262 | 330 | 108 | 24 | 42 | 116 | 413 | 280 | 126 | 90 | 38.0 | 19 | 91 | -5 |
| W9 | 8.99 | 10.47 | 1.56 | 2.11 | 0.54 | 2.43 | 0.10 | 0.02 | 324 | 511 | 35 | 19 | 57 | 67 | 441 | 289 | 157 | 113 | 41.0 | 25 | 116 | -5 |
| W10 | 5.10 | 3.68 | 3.56 | 3.99 | 0.76 | 1.58 | 0.10 | 0.01 | 373 | 243 | 102 | 15 | 47 | 67 | 197 | 167 | 146 | 155 | 29.0 | 23 | 86 | 5 |
| W11 | 6.85 | 6.08 | 3.47 | 3.60 | 0.48 | 1.76 | 0.10 | 0.01 | 510 | 269 | 62 | -15 | 49 | 54 | 218 | 262 | 149 | 73 | 28.0 | 21 | 94 | -5 |
| W12 | 6.07 | 8.66 | 2.83 | 3.07 | 0.46 | 4.08 | 1.70 | 0.01 | 590 | 457 | 50 | -15 | 51 | 52 | 174 | 233 | 129 | 80 | 27.0 | 16 | 84 | -5 |
| W13 | 0.89 | 3.10 | 4.23 | 2.55 | 0.11 | 3.34 | 1.98 | 0.16 | 992 | 530 | 53 | 27 | 57 | 6 | -10 | 39 | 18 | 78 | 3.3 | 18 | 123 | -5 |
| W14 | 0.69 | 2.49 | 3.93 | 3.20 | 0.09 | 1.52 | 0.68 | 0.01 | 1519 | 649 | 53 | -15 | 30 | -5 | -10 | 26 | 6 | 52 | 3.0 | 13 | 90 | -5 |
| W15 | 2.45 | 1.78 | 0.17 | 4.90 | 0.08 | 4.76 | 2.61 | 0.36 | 902 | 112 | 83 | 26 | 66 | 6 | -10 | 39 | 32 | 98 | 9.8 | 49 | 203 | 14 |
| W16 | 7.89 | 7.21 | 2.08 | 0.01 | 0.16 | 3.73 | 0.10 | 0.01 | 94 | 261 | 10 | -15 | -15 | 104 | 219 | 450 | 174 | 224 | 43.6 | 39 | 143 | 27 |
| W17 | 6.91 | 10.45 | 0.88 | 0.00 | 0.15 | 3.41 | 0.10 | 0.03 | 238 | 372 | 10 | 21 | 15 | 98 | 202 | 434 | 167 | 123 | 41.7 | 30 | 372 | 16 |
| W18 | 11.25 | 11.11 | 1.52 | 1.37 | 0.78 | 6.85 | 3.46 | 0.40 | 5074 | 662 | 21 | 71 | 71 | 160 | 377 | 317 | 60 | 109 | 30.8 | 31 | 260 | 88 |
| W19 | 10.40 | 8.59 | 1.97 | 1.66 | 0.83 | 7.03 | 3.05 | 0.10 | 2141 | 803 | 31 | 63 | 86 | 173 | 393 | 349 | 52 | 119 | 28.5 | 30 | 267 | 85 |
| W20 | 2.64 | 0.37 | 2.88 | 6.23 | 0.08 | 1.72 | 0.13 | 0.40 | 1687 | 163 | 107 | 21 | 65 | 7 | 11 | 38 | 21 | 91 | 7.0 | 50 | 208 | 6 |
| W21 | 0.35 | 1.52 | 5.78 | 1.21 | 0.05 | 1.92 | 0.70 | 0.22 | 4329 | 156 | 10 | 33 | 87 | -5 | -10 | 18 | 17 | 150 | 3.0 | 80 | 353 | 59 |
| W22 | 0.36 | 1.47 | 5.94 | 1.17 | 0.06 | 1.95 | 0.77 | 0.22 | 4136 | 155 | 22 | 37 | 83 | -5 | -10 | 30 | -10 | 143 | 3.0 | 76 | 355 | 60 |
| W23 | 0.93 | 1.63 | 4.80 | 1.54 | 0.05 | 1.08 | 0.10 | 0.01 | 3422 | 196 | 13 | 31 | 84 | 11 | -10 | 18 | 14 | 150 | 8.0 | 83 | 329 | 58 |
| **Late Triassic:** | | | | | | | | | | | | | | | | | | | | | | |
| W24 | 7.25 | 12.28 | 2.10 | 0.18 | 0.11 | 0.58 | 0.21 | 0.02 | 49 | 215 | 10 | 15 | 25 | 109 | 306 | 376 | 177 | 100 | 43.4 | 24 | 90 | 14 |
| W25 | 6.06 | 11.39 | 2.35 | 0.39 | 0.13 | 1.61 | 0.10 | 0.01 | 74 | 284 | 10 | 18 | 27 | 77 | 82 | 434 | 164 | 109 | 42.9 | 32 | 121 | 26 |
| W26 | 6.89 | 8.58 | 3.79 | 0.10 | 0.14 | 3.59 | 0.82 | 0.02 | 44 | 372 | 13 | 18 | 29 | 102 | 221 | 344 | 163 | 92 | 36.0 | 22 | 103 | 5 |
| W27 | 5.52 | 10.94 | 2.34 | 0.17 | 0.13 | 2.63 | 1.10 | 0.02 | 77 | 249 | 10 | -15 | 20 | 75 | 88 | 381 | 179 | 106 | 39.0 | 21 | 105 | 8 |
| W28 | 6.99 | 7.32 | 3.96 | 0.18 | 0.15 | 5.74 | 2.47 | 0.01 | 36 | 583 | 11 | -15 | 18 | 117 | 284 | 380 | 82 | 100 | 35.0 | 26 | 117 | 6 |
| W29 | 7.20 | 7.66 | 3.20 | 1.13 | 0.10 | 3.50 | 0.34 | 0.01 | 226 | 1399 | 31 | -15 | 17 | 147 | 323 | 255 | 132 | 79 | 27.0 | 17 | 80 | -5 |
| W30 | 8.75 | 8.35 | 3.11 | 0.53 | 0.11 | 3.11 | 0.24 | 0.01 | 103 | 560 | 19 | 21 | 25 | 173 | 410 | 325 | 175 | 90 | 35.0 | 20 | 88 | -5 |
| W31 | 4.91 | 8.72 | 2.75 | 2.20 | 0.26 | 3.95 | 0.82 | 0.02 | 955 | 996 | 51 | -15 | 26 | 26 | 59 | 273 | 51 | 93 | 28.0 | 18 | 57 | -5 |
| W32 | 3.69 | 6.11 | 4.61 | 1.12 | 0.31 | 2.77 | 0.24 | 0.02 | 428 | 490 | 19 | 12 | 24 | 10 | 17 | 252 | 72 | 113 | 25.0 | 30 | 101 | -5 |
| W33 | 5.97 | 11.70 | 2.37 | 0.28 | 0.14 | 0.90 | 0.27 | 0.01 | 71 | 303 | 13 | -15 | 22 | 96 | 190 | 335 | 189 | 99 | 36.0 | 22 | 105 | 7 |
| W34 | 5.03 | 11.31 | 2.12 | 0.51 | 0.14 | 1.88 | 0.14 | 0.02 | 274 | 342 | 10 | -15 | 18 | 87 | 78 | 356 | 161 | 99 | 32.4 | 30 | 113 | 20 |
| W35 | 6.24 | 9.94 | 2.48 | 0.31 | 0.20 | 1.32 | 0.10 | 0.02 | 145 | 328 | 10 | 25 | -15 | 89 | 154 | 508 | 187 | 149 | 42.9 | 41 | 179 | 28 |
| W36 | 7.26 | 11.23 | 1.83 | 0.26 | 0.13 | 1.61 | 0.28 | 0.01 | 1441 | 344 | 10 | 17 | 25 | 151 | 417 | 334 | 119 | 99 | 37.5 | 26 | 113 | 20 |
| W37 | 4.02 | 10.45 | 3.12 | 0.38 | 0.13 | 2.62 | 0.78 | 0.20 | 291 | 408 | 10 | -15 | 15 | 51 | 61 | 324 | 148 | 91 | 30.7 | 30 | 118 | 23 |
| W38 | 5.31 | 11.64 | 2.02 | 0.32 | 0.15 | 1.54 | 0.21 | 0.01 | 704 | 261 | -10 | 17 | 15 | 75 | 114 | 378 | 161 | 105 | 35.6 | 29 | 109 | 17 |
| W39 | 5.50 | 12.21 | 1.89 | 0.14 | 0.14 | 0.18 | 0.10 | 0.02 | 79 | 191 | 10 | 25 | 16 | 66 | 120 | 412 | 177 | 113 | 42.6 | 30 | 108 | 16 |
| W40 | 6.99 | 11.02 | 2.12 | 0.37 | 0.14 | 1.30 | 0.10 | 0.02 | 71 | 324 | 10 | 24 | 15 | 95 | 205 | 402 | 153 | 117 | 41.8 | 29 | 110 | 17 |
| W41 | 7.19 | 12.20 | 1.69 | 0.38 | 0.14 | 1.65 | 0.28 | 0.01 | 196 | 311 | 10 | 21 | 19 | 130 | 390 | 355 | 145 | 100 | 38.7 | 24 | 107 | 19 |
| W42 | 7.03 | 6.20 | 2.82 | 1.15 | 0.24 | 2.74 | -0.15 | 0.11 | 570 | 350 | 24 | -15 | 37 | -20 | -50 | 361 | nd | nd | 30.0 | 39 | 130 | 20 |
| W43 | 6.87 | 8.58 | 3.03 | 1.00 | 0.19 | 2.45 | -0.15 | 0.07 | 320 | 320 | 16 | -15 | 34 | 40 | 60 | 387 | nd | nd | 38.0 | 21 | 115 | 33 |
| W44 | 7.49 | 13.10 | 1.54 | 0.22 | 0.10 | 1.69 | 0.10 | 0.01 | 132 | 279 | 10 | 17 | 31 | 140 | 468 | 295 | 113 | 82 | 34.8 | 22 | 90 | 20 |
| W45 | 5.50 | 9.34 | 1.90 | 0.33 | 0.20 | 1.53 | 0.10 | 0.02 | 750 | 255 | 10 | 26 | 15 | 95 | 23 | 971 | 213 | 146 | 42.7 | 34 | 163 | 25 |
| W46 | 2.26 | 6.92 | 2.78 | 0.54 | 0.46 | 0.73 | 0.29 | 0.03 | 152 | 260 | 10 | 27 | 52 | 16 | -10 | 133 | 234 | 152 | 35.0 | 81 | 350 | 35 |
| W47 | 5.47 | 13.02 | 1.86 | 0.48 | 0.11 | 1.59 | 0.72 | 0.02 | 57 | 340 | 10 | 15 | 15 | 67 | 113 | 349 | 127 | 99 | 40.9 | 25 | 90 | 14 |
| W48 | 6.83 | 10.79 | 2.35 | 0.20 | 0.13 | 0.93 | 0.10 | 0.01 | 44 | 207 | 16 | 15 | 51 | 87 | 119 | 366 | 175 | 98 | 37.0 | 22 | 101 | 7 |
| W49 | 4.32 | 10.90 | 3.19 | 1.34 | 0.28 | 3.02 | 0.58 | 0.14 | 761 | 566 | 23 | 16 | 36 | 18 | 33 | 344 | nd | nd | 32.0 | 28 | 137 | -5 |
| W50 | 6.72 | 3.19 | 4.24 | 1.62 | 0.30 | 3.21 | 0.45 | 0.07 | 513 | 341 | 31 | 29 | 45 | 26 | 38 | 302 | 52 | 87 | 21.0 | 34 | 141 | 6 |
| W51 | 10.01 | 12.40 | 1.33 | 0.15 | 0.07 | 1.19 | 0.10 | 0.01 | 41 | 168 | -10 | -15 | -15 | 230 | 678 | 248 | 146 | 72 | 36.0 | 13 | 59 | -5 |
| W52 | 9.10 | 12.51 | 1.41 | 0.28 | 0.07 | 1.53 | 0.10 | 0.01 | 58 | 242 | 12 | -15 | -15 | 192 | 571 | 254 | 74 | 66 | 36.0 | 16 | 64 | 5 |
| W53 | 6.96 | 9.68 | 2.40 | 0.56 | 0.12 | 2.14 | 0.26 | 0.02 | 131 | 371 | 25 | -15 | 23 | 111 | 164 | 264 | 150 | 80 | 30.0 | 21 | 91 | 6 |
| W54 | 7.30 | 10.91 | 1.93 | 0.58 | 0.11 | 1.92 | 0.10 | 0.01 | 113 | nd | nd | -15 | -15 | nd | nd | 273 | nd | nd | 32.0 | nd | nd | nd |
| W55 | 5.82 | 8.28 | 3.49 | 0.77 | 0.17 | 1.40 | 0.10 | 0.16 | 584 | 488 | 10 | 25 | 25 | 33 | 31 | 491 | 75 | 161 | 37.4 | 32 | 116 | 11 |
| W56 | 2.22 | 7.24 | 2.55 | 1.05 | 0.38 | 2.17 | 0.81 | 0.15 | 309 | 140 | 32 | -15 | 55 | 9 | -10 | 95 | 373 | 180 | 30.0 | 63 | 277 | 24 |

*(APPENDIX 4 - TABLE 2 Continued)*

| MAP NUMBER | SAMPLE NUMBER | FORMATION | LITHO-LOGIC CODE | EASTING | NORTHING | $SiO_2$ % | $TiO_2$ % | $Al_2O_3$ % | $Fe_2O_3$ % | FeO % | MnO % |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Early to Middle Jurassic:** | | | | | | | | | | | |
| W57 | NMA86-22-9 | Bonanza Volcanics | BSLT | 413349 | 5405057 | 46.18 | 0.78 | 13.91 | 4.78 | 3.56 | 0.17 |
| W58 | NMA86-26-12 | Bonanza Volcanics | ANDS | 411583 | 5407127 | 56.48 | 0.66 | 17.12 | 2.91 | 4.18 | 0.14 |
| W59 | NMA86-27-11 | Bonanza Volcanics | BSLT | 408405 | 5405890 | 61.16 | 0.80 | 16.42 | 1.82 | 4.59 | 0.13 |
| W60 | NMA86-35-6 | Bonanza Volcanics | BSLT | 394536 | 5418754 | 49.58 | 0.78 | 17.33 | 2.92 | 5.38 | 0.17 |
| W61 | NMA86-36-5 | Bonanza Volcanics | ANDS | 400948 | 5412343 | 49.62 | 0.79 | 16.77 | 3.05 | 5.24 | 0.16 |
| W62 | NMA86-42-2 | Bonanza Volcanics | ANDS | 411470 | 5402766 | 49.61 | 0.93 | 17.66 | 3.26 | 5.37 | 0.19 |
| W63 | NMA86-59-6 | Bonanza Volcanics | BSLT | 408486 | 5410624 | 46.18 | 1.05 | 17.88 | 5.01 | 5.84 | 0.23 |
| W64 | SFR86-24-4 | Bonanza Volcanics | FANDS | 390314 | 5410448 | 50.67 | 0.92 | 19.92 | 5.33 | 3.63 | 0.24 |
| W65 | SFR86-39-2 | Bonanza Volcanics | FANDS | 394007 | 5402820 | 63.63 | 0.63 | 15.20 | 1.91 | 3.32 | 0.12 |
| W66 | SFR86-40-1 | Bonanza Volcanics | BSLT | 393230 | 5402760 | 52.92 | 0.79 | 17.94 | 3.86 | 4.59 | 0.15 |
| W67 | SFR86-46-5 | Bonanza Volcanics | FBSLT | 399531 | 5414234 | 50.29 | 0.84 | 18.51 | 3.20 | 4.56 | 0.17 |
| W68 | SFR86-49-4-2 | Bonanza Volcanics | PXBAS | 407213 | 5410768 | 46.01 | 1.10 | 15.54 | 5.07 | 6.04 | 0.21 |
| W69 | SFR86-50-3 | Bonanza Volcanics | PXBAS | 404119 | 5410796 | 48.77 | 0.95 | 18.11 | 4.48 | 4.85 | 0.20 |
| W70 | PTE86-30-2-2 | Bonanza Volcanics | PXFPP | 395494 | 5403054 | 50.41 | 1.16 | 16.64 | 2.52 | 7.91 | 0.17 |
| W71 | PTE86-32-7 | Bonanza Volcanics | ANDS | 395309 | 5403478 | 47.32 | 0.88 | 18.06 | 3.84 | 6.02 | 0.19 |
| W72 | NMA86-23-7 | Island Plutonic Suite | DORT | 399592 | 5423469 | 49.36 | 0.67 | 15.62 | 3.17 | 5.70 | 0.20 |
| W73 | SFR86-13-1 | Island Plutonic Suite | GRDR | 403883 | 5423378 | 60.80 | 0.49 | 16.63 | 2.50 | 3.63 | 0.15 |
| W74 | SFR86-34-1 | Island Plutonic Suite | GRDR | 392689 | 5409237 | 47.22 | 2.02 | 14.09 | 3.50 | 8.41 | 0.20 |
| W75 | SFR86-35-1 | Island Plutonic Suite | GRDR | 390665 | 5402285 | 58.76 | 0.84 | 17.02 | 2.58 | 4.05 | 0.09 |
| W76 | SFR86-36-2 | Island Plutonic Suite | GRDR | 391009 | 5400733 | 61.09 | 0.71 | 16.76 | 2.58 | 3.36 | 0.08 |
| W77 | SFR86-38-10 | Island Plutonic Suite | GRDR | 407280 | 5418798 | 65.04 | 0.41 | 16.13 | 2.45 | 2.67 | 0.13 |
| W78 | SFR87-4-5 | Island Plutonic Suite | DORT | 415763 | 5425630 | 49.69 | 0.77 | 18.88 | 4.12 | 5.82 | 0.20 |
| W79 | SFR88-32-1 | Island Plutonic Suite | QDORT | 402388 | 5425976 | 66.96 | 0.36 | 15.22 | 2.23 | 2.27 | 0.12 |
| W80 | SFR88-36-15 | Island Plutonic Suite | QDORT | 403243 | 5426491 | 65.10 | 0.42 | 15.75 | 2.91 | 2.41 | 0.13 |
| W81 | PTE86-15-2 | Island Plutonic Suite | DORT | 402924 | 5423428 | 64.52 | 0.41 | 16.00 | 2.23 | 2.85 | 0.13 |
| W82 | PTE87-3-3 | Island Plutonic Suite | GRDR | 414329 | 5426446 | 57.10 | 0.87 | 16.89 | 6.34 | 1.94 | 0.17 |
| W83 | PTE87-4-3 | Island Plutonic Suite | QDORT | 416407 | 5427378 | 55.35 | 0.70 | 17.67 | 3.48 | 4.56 | 0.17 |
| W84 | PTE87-7-2 | Island Plutonic Suite | GRDR | 416791 | 5426201 | 56.10 | 0.80 | 17.23 | 3.35 | 4.61 | 0.16 |
| W85 | NMA86-33-9 | Minor Intrusion: augite porphyry | BSLT | 406754 | 5405581 | 51.43 | 0.86 | 17.66 | 2.40 | 6.41 | 0.18 |
| W86 | NMA86-41-6-2 | Minor Intrusion: augite porphyry | PXDIB | 404649 | 5405139 | 47.88 | 0.92 | 16.40 | 3.53 | 7.81 | 0.21 |
| W87 | NMA86-41-7 | Minor Intrusion: augite porphyry | PXDIB | 405398 | 5405109 | 48.32 | 0.90 | 17.02 | 4.22 | 5.92 | 0.16 |
| W88 | SFR86-17-2-2 | Minor Intrusion: augite porphyry | BSLT | 406306 | 5423534 | 50.47 | 0.77 | 18.12 | 4.25 | 5.35 | 0.18 |
| W89 | SFR86-37-2 | Minor Intrusion: augite porphyry | BSLT | 410004 | 5422466 | 58.01 | 0.67 | 17.26 | 2.86 | 3.58 | 0.14 |
| W90 | SFR86-42-2-2 | Minor Intrusion: augite porphyry | BSLT | 395004 | 5407119 | 51.50 | 0.86 | 16.74 | 2.67 | 5.99 | 0.16 |
| W91 | SFR86-42-4 | Minor Intrusion: augite porphyry | BSLT | 394708 | 5407192 | 52.76 | 0.86 | 16.67 | 2.78 | 6.34 | 0.18 |
| W92 | PTE86-31-5 | Minor Intrusion: augite porphyry | PXFPP | 395184 | 5404884 | 57.00 | 0.75 | 17.57 | 2.59 | 4.70 | 0.13 |
| W93 | NMA86-2-2-6 | Minor Intrusion: hornblende porphyry | HBFPP | 396465 | 5424746 | 50.51 | 0.69 | 17.51 | 3.69 | 5.33 | 0.17 |
| W94 | NMA86-56-11-2 | Minor Intrusion: hornblende porphyry | ANDS | 422924 | 5413661 | 51.82 | 0.61 | 17.54 | 3.59 | 4.66 | 0.18 |
| W95 | NMA87-10-9-2 | Minor Intrusion: hornblende porphyry | HBAND | 420980 | 5422595 | 41.43 | 2.71 | 12.31 | 1.73 | 9.10 | 0.22 |
| W96 | SFR86-2-3-2 | Minor Intrusion: hornblende porphyry | HBPP | 396724 | 5425110 | 65.33 | 0.28 | 16.12 | 1.73 | 1.47 | 0.22 |
| W97 | PTE87-11-10 | Minor Intrusion: hornblende porphyry | HBFPP | 424311 | 5415009 | 57.57 | 0.44 | 16.40 | 1.40 | 5.71 | 0.16 |
| W98 | JRU86-12-11 | Minor Intrusion: hornblende porphyry | HBFPP | 400064 | 5423222 | 65.85 | 0.33 | 16.50 | 2.03 | 1.82 | 0.16 |
| W99 | NMA86-51-2-2 | Minor Intrusion: basalt dyke | BSLT | 418103 | 5412980 | 47.34 | 0.77 | 17.54 | 3.87 | 5.80 | 0.22 |
| W100 | SFR87-11-12-2 | Minor Intrusion: basalt dyke | DIAB | 420856 | 5426813 | 47.89 | 1.45 | 14.73 | 2.47 | 8.97 | 0.18 |
| W101 | SFR87-15-7-2 | Minor Intrusion: feldspar porphyry | QZPPP | 424905 | 5416857 | 62.73 | 0.41 | 16.74 | 1.74 | 2.97 | 0.12 |
| W102 | PTE87-10-12-2 | Minor Intrusion: dacite | DCIT | 420362 | 5422386 | 71.78 | 0.04 | 15.14 | 0.27 | 1.86 | 0.11 |
| **Age Uncertain:** | | | | | | | | | | | |
| W103 | NMA86-18-11 | augite porphyry: ?Jurassic/Devonian | PXPP | 400027 | 5422785 | 46.23 | 0.87 | 16.81 | 3.58 | 5.49 | 0.18 |

*(APPENDIX 4 - TABLE 2 Continued)*

| MAP NUMBER | MgO % | CaO % | $Na_2O$ % | $K_2O$ % | $P_2O_5$ % | LOI % | $CO_2$ % | S % | Ba ppm | Sr ppm | Rb ppm | La ppm | Ce ppm | Ni ppm | Cr ppm | V ppm | Cu ppm | Zn ppm | Sc ppm | Y ppm | Zr ppm | Nb ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Early to Middle Jurassic:** | | | | | | | | | | | | | | | | | | | | | | |
| W57 | 5.97 | 11.35 | 2.00 | 0.41 | 0.28 | 9.39 | 6.15 | 0.01 | 260 | 492 | 13 | -15 | 20 | 210 | 314 | 252 | 22 | 67 | 28.0 | 12 | 55 | -5 |
| W58 | 3.25 | 4.34 | 4.38 | 2.03 | 0.18 | 3.12 | 0.31 | 0.01 | 833 | 523 | 38 | -15 | 39 | 8 | 17 | 158 | 123 | 80 | 15.9 | 23 | 106 | -5 |
| W59 | 1.91 | 3.11 | 2.74 | 2.42 | 0.08 | 4.03 | 1.28 | 0.02 | 397 | 320 | 82 | -15 | 22 | 10 | 22 | 144 | 43 | 84 | 16.2 | 17 | 104 | -5 |
| W60 | 3.41 | 6.82 | 2.51 | 1.50 | 0.28 | 7.15 | 3.73 | 0.01 | 575 | 459 | 44 | 17 | 43 | 9 | 13 | 177 | 29 | 94 | 15.8 | 16 | 118 | 7 |
| W61 | 3.36 | 5.63 | 3.58 | 2.05 | 0.24 | 7.22 | 4.11 | 0.01 | 413 | 401 | 59 | -15 | 42 | 9 | 18 | 209 | 16 | 87 | 17.8 | 19 | 110 | 5 |
| W62 | 3.58 | 7.49 | 4.10 | 2.19 | 0.41 | 4.19 | 1.09 | 0.01 | 629 | 429 | 45 | 20 | 43 | 11 | 16 | 246 | 69 | 91 | 18.0 | 24 | 114 | 8 |
| W63 | 3.76 | 8.07 | 2.81 | 2.84 | 0.36 | 4.12 | 1.57 | 0.01 | 1072 | 577 | 55 | -15 | 34 | 14 | 36 | 333 | 107 | 114 | 26.0 | 22 | 73 | -5 |
| W64 | 3.27 | 7.07 | 4.13 | 0.59 | 0.37 | 3.44 | 1.22 | 0.01 | 421 | 801 | 16 | 17 | 43 | 10 | 13 | 162 | 57 | 113 | 14.0 | 21 | 90 | -5 |
| W65 | 0.88 | 4.35 | 2.66 | 2.36 | 0.14 | 4.79 | 2.72 | 0.01 | 847 | 185 | 58 | 37 | 67 | 5 | -10 | 25 | 42 | 66 | 12.6 | 49 | 296 | 14 |
| W66 | 3.78 | 8.03 | 2.40 | 2.27 | 0.34 | 3.01 | 1.28 | 0.01 | 650 | 612 | 57 | -15 | 39 | 27 | 24 | 217 | 58 | 83 | 20.0 | 14 | 84 | -5 |
| W67 | 3.37 | 7.37 | 3.63 | 0.75 | 0.26 | 6.83 | 3.33 | 0.01 | 313 | 480 | 14 | 17 | 32 | 13 | 21 | 200 | 42 | 99 | 23.0 | 18 | 123 | 5 |
| W68 | 7.54 | 10.98 | 2.10 | 1.10 | 0.26 | 2.63 | 0.24 | 0.01 | 636 | 498 | 24 | 20 | 24 | 31 | 58 | 385 | 30 | 97 | 41.0 | 16 | 59 | -5 |
| W69 | 3.55 | 10.97 | 2.74 | 0.87 | 0.35 | 2.63 | 0.24 | 0.01 | 419 | 597 | 21 | -15 | 35 | 20 | 30 | 246 | 87 | 93 | 22.0 | 15 | 84 | -5 |
| W70 | 5.32 | 8.15 | 2.66 | 0.61 | 0.30 | 2.88 | 0.21 | 0.03 | 535 | 456 | -10 | 15 | 32 | 30 | 73 | 263 | nd | nd | 31.0 | 29 | 112 | -5 |
| W71 | 5.91 | 9.59 | 1.80 | 0.59 | 0.19 | 4.43 | 1.54 | 0.01 | 398 | 423 | 16 | -15 | -15 | 27 | 27 | 260 | nd | nd | 29.0 | 18 | 53 | -5 |
| W72 | 7.39 | 10.84 | 2.08 | 0.79 | 0.14 | 3.27 | 1.38 | 0.04 | 372 | 413 | 17 | -15 | 21 | 66 | 272 | 251 | 185 | 76 | 35.0 | 15 | 45 | -5 |
| W73 | 2.61 | 5.00 | 3.25 | 2.23 | 0.16 | 1.71 | 0.10 | 0.01 | 753 | 427 | 56 | 17 | 18 | 8 | 23 | 119 | 22 | 64 | 11.5 | 14 | 98 | -5 |
| W74 | 8.15 | 10.50 | 1.61 | 0.06 | 0.15 | 2.86 | 0.10 | 0.01 | 40 | 182 | -10 | 18 | 43 | 150 | 352 | 401 | 188 | 111 | 40.0 | 29 | 117 | 10 |
| W75 | 3.00 | 5.24 | 3.79 | 2.82 | 0.24 | 1.62 | 0.10 | 0.01 | 1137 | 481 | 52 | 19 | 39 | 10 | 22 | 141 | 16 | 31 | 19.0 | 32 | 144 | 5 |
| W76 | 2.68 | 3.69 | 4.00 | 3.35 | 0.17 | 1.48 | 0.10 | 0.01 | 1556 | 441 | 74 | 20 | 21 | 19 | 26 | 124 | 31 | 20 | 15.0 | 29 | 187 | -5 |
| W77 | 1.72 | 3.63 | 3.38 | 2.70 | 0.16 | 1.85 | 0.10 | 0.01 | 877 | 419 | 64 | 24 | 21 | 7 | 10 | 87 | 18 | 48 | 8.1 | 14 | 101 | -5 |
| W78 | 5.09 | 11.01 | 2.34 | 0.40 | 0.17 | 0.89 | 0.14 | 0.02 | 254 | 493 | 10 | 15 | 24 | 18 | 17 | 317 | 277 | 103 | 33.3 | 17 | 33 | 10 |
| W79 | 1.50 | 4.03 | 2.87 | 3.06 | 0.11 | 1.05 | -0.15 | 0.01 | 850 | 290 | 98 | 15 | 26 | -20 | -50 | 67 | nd | nd | 7.4 | 13 | 93 | 11 |
| W80 | 1.80 | 4.67 | 2.88 | 2.58 | 0.14 | 1.00 | -0.15 | -0.01 | 850 | 325 | 90 | 18 | 26 | 24 | -50 | 85 | nd | nd | 10.0 | -10 | 110 | 17 |
| W81 | 1.85 | 4.67 | 2.98 | 2.52 | 0.15 | 1.29 | 0.10 | 0.02 | 740 | 320 | 62 | 24 | 37 | 14 | 17 | 87 | nd | nd | 8.6 | 14 | 94 | -5 |
| W82 | 3.35 | 7.30 | 3.01 | 1.83 | 0.18 | 0.63 | 0.21 | 0.01 | 623 | 374 | 26 | 15 | 44 | 10 | -10 | 220 | 41 | 88 | 23.1 | 28 | 113 | 12 |
| W83 | 3.57 | 8.26 | 2.93 | 1.28 | 0.14 | 1.16 | 0.10 | 0.01 | 83 | 417 | 15 | 15 | 22 | 14 | 14 | 243 | 66 | 93 | 24.5 | 22 | 85 | 10 |
| W84 | 3.45 | 7.39 | 3.01 | 1.87 | 0.17 | 1.36 | 0.10 | 0.02 | 754 | 425 | 30 | 15 | 37 | 8 | -10 | 215 | 58 | 84 | 25.4 | 36 | 120 | 18 |
| W85 | 4.45 | 6.07 | 4.38 | 0.73 | 0.20 | 2.83 | 0.10 | 0.02 | 282 | 478 | 14 | 25 | 32 | 10 | 24 | 245 | 49 | 82 | 24.0 | 22 | 82 | -5 |
| W86 | 6.49 | 8.31 | 3.74 | 0.43 | 0.23 | 3.43 | 0.10 | 0.03 | 118 | 923 | 22 | -15 | 18 | 28 | 60 | 316 | 65 | 95 | 35.0 | 20 | 56 | -5 |
| W87 | 5.58 | 6.85 | 4.30 | 0.73 | 0.31 | 3.86 | 0.68 | 0.02 | 289 | 539 | 14 | -15 | 24 | 25 | 36 | 264 | 66 | 105 | 25.0 | 24 | 74 | -5 |
| W88 | 5.08 | 8.71 | 2.64 | 1.32 | 0.30 | 2.30 | 0.61 | 0.04 | 306 | 508 | 29 | -15 | 32 | 43 | 28 | 208 | 58 | 98 | 23.0 | 19 | 58 | -5 |
| W89 | 2.65 | 6.09 | 3.62 | 2.11 | 0.18 | 2.64 | 0.68 | 0.02 | 765 | 455 | 28 | -15 | 23 | 11 | 17 | 148 | 47 | 62 | 18.0 | 29 | 119 | 7 |
| W90 | 4.73 | 8.29 | 3.51 | 1.32 | 0.21 | 3.38 | 0.37 | 0.01 | 450 | 405 | 30 | -15 | 31 | 36 | 68 | 217 | 56 | 81 | 26.0 | 22 | 88 | -5 |
| W91 | 5.66 | 9.08 | 2.12 | 1.11 | 0.18 | 1.74 | 0.10 | 0.02 | 419 | 346 | 27 | -15 | 17 | 42 | 120 | 233 | 86 | 88 | 29.0 | 20 | 79 | -5 |
| W92 | 3.01 | 5.09 | 3.66 | 1.72 | 0.19 | 3.12 | 0.21 | 0.03 | 1094 | 508 | 28 | 21 | 52 | 10 | 23 | 167 | nd | nd | 18.0 | 27 | 124 | -5 |
| W93 | 3.83 | 7.60 | 3.12 | 2.42 | 0.35 | 3.34 | 1.85 | 0.16 | 445 | 626 | 79 | 22 | 42 | 8 | 11 | 180 | 70 | 78 | 18.0 | 19 | 67 | -5 |
| W94 | 3.87 | 6.88 | 2.82 | 2.59 | 0.55 | 3.21 | 1.26 | 0.09 | 974 | 714 | 43 | -15 | 16 | 12 | 20 | 169 | 31 | 91 | 14.7 | 18 | 65 | -5 |
| W95 | 12.31 | 12.27 | 1.08 | 0.59 | 0.75 | 3.94 | 0.35 | 0.11 | 1228 | 985 | 10 | 86 | 96 | 310 | 590 | 466 | 86 | 138 | 42.0 | 38 | 337 | 111 |
| W96 | 0.87 | 3.61 | 3.97 | 2.24 | 0.11 | 3.52 | 1.97 | 0.01 | 897 | 562 | 41 | 18 | 49 | 7 | -10 | 41 | 26 | 90 | 3.0 | 20 | 124 | -5 |
| W97 | 4.62 | 7.49 | 2.49 | 1.19 | 0.13 | 1.81 | 0.10 | 0.01 | 490 | 419 | 40 | 15 | 40 | 23 | 99 | 160 | 14 | 76 | 23.7 | 18 | 74 | 14 |
| W98 | 1.17 | 3.60 | 3.91 | 2.53 | 0.15 | 1.76 | 0.61 | 0.01 | 1022 | 607 | 59 | 19 | 47 | 11 | -10 | 46 | 34 | 98 | 4.6 | 17 | 106 | -5 |
| W99 | 4.76 | 7.98 | 2.41 | 1.62 | 0.38 | 5.19 | 2.39 | 0.15 | 749 | 596 | 63 | -15 | 27 | 23 | 24 | 247 | 71 | 132 | 22.0 | 15 | 50 | -5 |
| W100 | 7.86 | 12.03 | 1.44 | 0.15 | 0.11 | 1.76 | 0.10 | 0.02 | 89 | 188 | 10 | 21 | 15 | 152 | 174 | 327 | 137 | 100 | 39.0 | 24 | 89 | 14 |
| W101 | 1.89 | 5.59 | 3.63 | 0.99 | 0.19 | 2.73 | 1.12 | 0.15 | 694 | 643 | 12 | 20 | 47 | 8 | -10 | 95 | 29 | 70 | 11.0 | 17 | 106 | 18 |
| W102 | 0.03 | 1.17 | 4.72 | 2.64 | 0.00 | 1.79 | 0.95 | 0.02 | 885 | 108 | 28 | 27 | 77 | -5 | -10 | 5 | 27 | 102 | 3.0 | 86 | 260 | 52 |
| **Age Uncertain:** | | | | | | | | | | | | | | | | | | | | | | |
| W103 | 5.98 | 9.57 | 2.28 | 0.90 | 0.18 | 4.52 | 1.78 | 0.01 | 297 | 565 | 31 | -15 | 25 | 32 | 49 | 294 | 84 | 164 | 31.0 | 15 | 42 | -5 |

**Analyses performed by B.C. Geological Survey - Analytical Sciences Laboratory.**
**Majors and traces by XRF; LOI by gravimetry; CO2 and S by LECO induction furnace; FeO by titration**
**Negative values indicate sample is below the stated dectection limit**
**Major element data has been rusumed to 100% following correction of XRF Fe3O2 (total iron) for FeO**

***Lithological codes:**

- AMBAS: amygdaloidal basalt
- ANDS: andesite
- BSLT: basalt
- DCIT: dacite
- DIAB: diabase
- DORT: diorite
- FANDS: feldspar andesite
- FBSLT: feldspar basalt
- GBBR: gabbro
- GRDR: granodiorite
- HBAND: hornblende andesite
- HBPP: hornblende porphyry
- HBFPP: hornblende-feldspar porphyry
- PLLV: pillow lava
- PXBAS: pyroxene basalt
- PXDIB: pyroxene diabase
- PXFPP: pyroxene-feldspar porphyry
- PXPP: pyroxene porphyry
- QDORT: quartz diorite
- QZPPP: quartz-plagioclase porphyry
- RYLT: rhyolite

## APPENDIX 4 - TABLE 3
## REE, Sc, Hf, Ta and Th DATA FOR ROCKS FROM THE COWICHAN LAKE MAP AREA

| MAP NUMBER | SAMPLE NUMBER | FORMATION | LITHOLOGIC CODE | EASTING | NORTHING | La ppm |
|---|---|---|---|---|---|---|
| W6 | NMA86-23-5 | Nitinat Fm: suite 2 | PLLV | 399561 | 5424130 | 22.6 |
| W10 | NMA86-50-3 | Nitinat Fm: suite 2 | BSLT | 418006 | 5413838 | 18.3 |
| W17 | NMA87-11-18-2 | Older Dykes | BSLT | 425134 | 5420842 | 5.9 |
| W19 | NMA87-8-10-2 | Fourth Lake Fm: Mt Whymper suite | BSLT | 417524 | 5421690 | 42.1 |

| MAP NUMBER | Ce ppm | Nd ppm | Sm ppm | Eu ppm | Tb ppm | Yb ppm | Lu ppm | Sc ppm | Hf ppm | Ta ppm | Th ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|
| W6 | 46 | 23 | 4.6 | 1.46 | 0.7 | 1.40 | 0.22 | 26 | 2.1 | -0.3 | 3.0 |
| W10 | 40 | 22 | 4.9 | 1.58 | 0.8 | 1.95 | 0.32 | 31 | 1.9 | -0.3 | 1.6 |
| W17 | 20 | 14 | 3.6 | 1.21 | 0.7 | 2.14 | 0.33 | 33 | 2.7 | -0.3 | 0.5 |
| W19 | 84 | 37 | 6.7 | 2.07 | 0.8 | 1.24 | 0.18 | 19 | 4.4 | 3.5 | 3.6 |

Analyses by Activation Laboratories Ltd., Ancaster, Ontario.
Negative Ta values are below the detection limit (0.3 ppm)
Lithological codes are the same as for Table D1

# APPENDIX 5

## FOSSIL SAMPLES FROM THE COWICHAN LAKE AREA

The following tabulation of fossil identifications combines data extracted from published literature as well as samples collected during the present mapping project. Locations of the samples are plotted on map included in Appendix 4, page 95.

References for already published data:


1: Sutherland Brown, A. (1964): Fossil List for Southern Vancouver Island; *B.C. Ministry of Energy, Mines and Petroleum Resources*, Property Files.

2: Brandon, M.T., Orchard, M.J., Parrish, R.R., Sutherland Brown, A. and Yorath, C.J. (1986): Fossil Ages and Isotopic Dates from the Paleozoic Sicker Group and Associated Intrusive Rocks, Vancouver Island, British Columbia, *in* Current Research, Part A, *Geological Survey of Canada*, Paper 86-1A, pages 683-696.

3: Yole, R.W. (1965): A Faunal and Stratigraphic Study of Upper Paleozoic Rocks of Vancouver Island, British Columbia; unpublished Ph.D. thesis, *The University of British Columbia*, 254 pages.

4: Fyles, J.T. (1955): Geology of the Cowichan Lake Area, Vancouver Island, British Columbia; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Bulletin 37.

5: Stanley, G.D. Jr., ((1988): A Late Triassic Reefal Limestone, Southern Vancouver Island, British Columbia; *in* Geldseteer, H.H.J., James, Noel P. and Tebbutt, G.E., Editors, Reefs; Canada and Adjacent Areas; Canadian Society of Petroleum Geologists, Memoir 13, pages 766-775.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## COWICHAN FOSSIL DATA

**MAP NUMBER: F1** **NTS MAP: 92C/16**
SAMPLE NUMBER: 64AB68
EASTING: 391584 NORTHING: 5410252
LOCATION: On side road at head of Cayuse Creek drainage on McClure Lake Road
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: ammonites
*juvavites* sp.
*Arcestes*" sp.
*Discotropites*? sp.
(GSC 66921)
AGE: Late Carnian
IDENTIFIED BY: ETT REFERENCE: 1

**MAP NUMBER: F2** **NTS MAP: 92C/16**
SAMPLE NUMBER: 64AB69
EASTING: 391587 NORTHING: 5409752
LOCATION: On side road at head of Caycuse Creek drainage on McClure Lake Road
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: ammonoids indeterminate
(GSC 66922)
AGE: Indeterminate
IDENTIFIED BY: ETT REFERENCE: 1

**MAP NUMBER: F3** **NTS MAP: 92C/16**
SAMPLE NUMBER: 64AB28
EASTING: 408889 NORTHING: 5410553
LOCATION: South Cowichan Lake Road near Blue Grouse
STRATIGRAPHIC UNIT: ?JB
FOSSIL TYPE: pelecypods
*Trigonia* sp. ?
AGE: Jurassic-Cretaceous
IDENTIFIED BY: REFERENCE: 1

**MAP NUMBER: F4** **NTS MAP: 92C/16**
SAMPLE NUMBER: 64AB29
EASTING: 408875 NORTHING: 5410452
LOCATION: South Cowichan Lake Road near Blue Grouse
STRATIGRAPHIC UNIT: ?JB
FOSSIL TYPE: pelecypods
*Trigonia* sp.
AGE: Jurassic-Cretaceous
IDENTIFIED BY: REFERENCE: 1

**MAP NUMBER: F5** **NTS MAP: 92C/16**
SAMPLE NUMBER: 64AB31
EASTING: 408430 NORTHING: 5410663
LOCATION: South Cowichan Lake, hill down to lake
STRATIGRAPHIC UNIT: ?
FOSSIL TYPE: plant
AGE: Jurassic-Cretaceous
IDENTIFIED BY: REFERENCE: 1

**MAP NUMBER: F6** **NTS MAP: 92C/16**
SAMPLE NUMBER: 64AB35
EASTING: 394561 NORTHING: 5418360
LOCATION: South Cowichan Lake Road
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: pelecypods (dwarfish)
AGE: Cretaceous
IDENTIFIED BY: REFERENCE: 1

**MAP NUMBER: F7** **NTS MAP: 92C/16**
SAMPLE NUMBER: 64AB36
EASTING: 394056 NORTHING: 5418370
LOCATION: South Cowichan Lake Road
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Amphinuera*
AGE: Cretaceous
IDENTIFIED BY: REFERENCE: 1

**MAP NUMBER: F9** **SAMPLE NUMBER: 62482F**
NTS MAP: 92C/16
EASTING: 425437 NORTHING: 5403741
LOCATION: Top of Fairservice Mountain section (Unit 32) (2.25 km southwest of Chanlog railpoint)
STRATIGRAPHIC UNIT: PPm
FOSSIL TYPE: *Tetrataxis* sp.
*Cladochonus* sp. (UBC20100)
*Rhabdomeson* sp.
*Strablascopora pulchra*?
AGE: Early Permian
IDENTIFIED BY: REFERENCE: 3

**MAP NUMBER: F10** **NTS MAP: 92C/16**
SAMPLE NUMBER: 6243A3
EASTING: 425894 NORTHING: 5403598
LOCATION: Fairservice Mountain section, limestone between 1773' and 1851' (540 - 564 m) from base of section (Unit 30)
STRATIGRAPHIC UNIT: PPm
FOSSIL TYPE: *Schwagerina*? sp.
*Goniocladia* sp.
*Streblascopora pulchra*?
AGE: Early Permian
IDENTIFIED BY: REFERENCE: 3

**MAP NUMBER: F11** **NTS MAP: 92C/16**
SAMPLE NUMBER: 624312
EASTING: 425760 NORTHING: 5403837
LOCATION: Fairservice Mountain section, limestone 1013' (309 m) from base of section (Unit 22)
STRATIGRAPHIC UNIT: PPm
FOSSIL TYPE: fistuliporid bryozoan
AGE: Indeterminate (?Early Permian)
IDENTIFIED BY: REFERENCE: 3

**MAP NUMBER: F12** **NTS MAP: 92C/16**
SAMPLE NUMBER: 624311
EASTING: 425965 NORTHING: 5403935
LOCATION: Fairservice Mountain section, limestone 957' (292 m) from base of section (Unit 20)
STRATIGRAPHIC UNIT: PPm
FOSSIL TYPE: fusulinid
AGE: Indeterminate (?Early Permian)
IDENTIFIED BY: REFERENCE: 3

**MAP NUMBER: F13** **NTS MAP: 92C/16**
SAMPLE NUMBER: 62453F
EASTING: 426170 NORTHING: 5404041
LOCATION: Fairservice Mountain section, limestone between 150' and 240' (46 - 73 m) from base of section (Unit 2)
STRATIGRAPHIC UNIT: PPm
FOSSIL TYPE: *Tetrataxis*
AGE: Indeterminate (?Early Permian)
IDENTIFIED BY: REFERENCE: 3

**MAP NUMBER: F14** **NTS MAP: 92C/16**
SAMPLE NUMBER: FYLES551
EASTING: 416646 NORTHING: 5410172
LOCATION: 2.4 km northwest of Marble Bay on the top of the ridge of the peninsula at the east end of Cowichan Lake, elev. 300 m, from beds between 60 and 120 m below the base of the Franklin Creek Basalt
STRATIGRAPHIC UNIT: PPm
FOSSIL TYPE: brachiopods
*Productus* cf. *P. uralicus*
*Productus cf. P. weypirchti*
*Spiriferella saranoe* var. *arctica*
fusulinids
*Schwagerina*
*Quasifusulina*
AGE: Early Permian
IDENTIFIED BY: REFERENCE: 4

**MAP NUMBER: F15** **NTS MAP: 92C/16**
SAMPLE NUMBER: FYLES552A,B
EASTING: 409589 NORTHING: 5411954
LOCATION: Same location as STANLEY881. South shore of Cowichan Lake (also at northwest end of lake) in Sutton limestone
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: colonial corals
bryozoa
pelecypods
gastropods
fossil tree trunks
AGE: Triassic
IDENTIFIED BY: REFERENCE: 4

**MAP NUMBER: F16** **NTS MAP: 92C/16**
SAMPLE NUMBER: FYLES552C
EASTING: 410338 NORTHING: 5410451
LOCATION: Near top of Blue Grouse Hill
STRATIGRAPHIC UNIT: ?uTrp
FOSSIL TYPE: colonial corals
bryozoa
pelecypods
gastropods
AGE: Triassic
IDENTIFIED BY: REFERENCE: 4

**MAP NUMBER: F17** **NTS MAP: 92C/16**
SAMPLE NUMBER: FYLES555
EASTING: 413194 NORTHING: 5415381
LOCATION: Black shale outcrops in the west fork of Meade Creek, Haslam Formation
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: *Tellina* sp.
*Nucula (acila) truncata*, Gabb.
*Nucula richardsoni*, Whiteaves
*Meretrix (Caryatis) plana*, Sowerby
*Dentalium* sp.
*Anomia vancouverensis*, Gabb.
*Clisocolus* sp.
*Inoceramus* cf. *undulatoplicatus*, Roemer
AGE: Late Cretaceous
IDENTIFIED BY: REFERENCE: 4

**MAP NUMBER: F18** **NTS MAP: 92C/16**
SAMPLE NUMBER: FYLES556
EASTING: 420371 NORTHING: 5414117
LOCATION: Black shales toward the head of Coonskin Creek, Haslam Formation
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: *Tellina* sp.
*Nucula (Acila) truncata*
*Nucula richardsoni*
*Meretrix (Caryatis) plana*
*Dentalium* sp.
*Anomia vancouverensis*
*Clisocolus* sp.
*Inoceramus* cf. undulatoplicatus
AGE: Late Cretaceous
IDENTIFIED BY: REFERENCE: 4

**MAP NUMBER: F19** **NTS MAP: 92C/16**
SAMPLE NUMBER: FYLES554
EASTING: 410181 NORTHING: 5409143
LOCATION: In the sandstone near the base of the Haslam Formation west of Honeymoon Bay
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: abundant fossils
AGE: Late Cretaceous
IDENTIFIED BY: REFERENCE: 4

**MAP NUMBER: F20** **NTS MAP: 92C/16**
SAMPLE NUMBER: FYLES553
EASTING: 410205 NORTHING: 5422376
LOCATION: Limestone on Mount Landalt.
STRATIGRAPHIC UNIT: PPm
FOSSIL TYPE: fossil type(s) unstated
AGE: Early Permian
IDENTIFIED BY: REFERENCE: 4

**MAP NUMBER: F21** **NTS MAP: 92C/16**
SAMPLE NUMBER: STANELY881
EASTING: 409632 NORTHING: 5412066
LOCATION: Same location as FYLES552A,B. South shore of Cowichan Lake, Sutton limestone
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: carbonized conifer logs
FORAMINIFERA
?*Spiroplectammina* sp.
?endothyrid types
biserial textularids
PORIFERA
?*Euepirrhysia* sp.
*Thaumastocoelia* sp.
indeterminate spicules
CNIDARIA
*Astraeomorpha crassisepta*
*A. confusa var. minor*
*Coccophylum acanthophorum*
*Cyathocoenia idahoensis*
*C. schafhaeutli*
*C. squiresi*
*Distichophyllia norica*
*Gablonzeria major*
*G. profunda*
*Guembelastraea vancouverensis*
*G. cowichanensis*
*G. whiteavesia*
*Parmiroseris smithi*
*Retiophyllia dawsoni*
*R. suttonensis*
BRACHIOPODA
*Terebratula suttonensis*

indeterminate rhynchonellid
MOLLUSCA
**Bivalvia**
*Cardinia* sp.
?*Costatoria* sp.
*Minetrigonia suttonensis*
?*Myophoria* sp.
*Ostrea* sp.
pectenids
*Septocardia* sp.
*Trigonia (Kumatrigonia)* sp.
indeterminate? cardiaceans
**Gastropoda**
indeterminate small trochoid form
indeterminate small turritellid form
**Cephalopoda**
aulacoceratids (gen. et species indeterminate)
*Choristoceras* sp.
ECHINODERMATA
**Echinoidea**
*Levicidaris* sp.
*Triadocidaris* sp.
INOCERTAE SEDIS
indeterminate small encrusting serpulid
"worm" tubes
small spicules
AGE: Late Norian, latest Triassic
IDENTIFIED BY: REFERENCE: 5

**MAP NUMBER: F22** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA860720
EASTING: 390900 NORTHING: 5423250
LOCATION: Heather Lake - Redbed Creek, west of Cowichan Lake
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: Inoceramus sp. cf. *I. orientalis* (Sokolow)
(GSC C143425)
AGE: Late Santonian to early Campanian
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F23** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8624101
EASTING: 414040 NORTHING: 5401100
LOCATION: Sixteen Creek
STRATIGRAPHIC UNIT: JB
FOSSIL TYPE: pelecypods
*Weyla*?
(GSC C143426)
AGE: Possibly Early Jurassic
IDENTIFIED BY: HWT REFERENCE:

**MAP NUMBER: F24** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8624111
EASTING: 413960 NORTHING: 5401090
LOCATION: Sixteen Creek
STRATIGRAPHIC UNIT: JB
FOSSIL TYPE: pelecypods
(GSC C143427)
AGE: Possibly Early Jurassic
IDENTIFIED BY: HWT REFERENCE:

**MAP NUMBER: F25** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8625021
EASTING: 413270 NORTHING: 5402700
LOCATION: Nineteen Creek
STRATIGRAPHIC UNIT: JB
FOSSIL TYPE: *Frenguelliella* sp.
gastropods
(GSC C143450)
AGE: Probably Sinemurian or Pliensbachian
IDENTIFIED BY: HWT REFERENCE:

**MAP NUMBER: F26** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8625111
EASTING: 412220 NORTHING: 5401650
LOCATION: Nineteen Creek
STRATIGRAPHIC UNIT: JB
FOSSIL TYPE: *Paltechioceras rothpletzi* (Bose)
bivalve fragments
(GSC C143428)
AGE: Late Sinemurian (upper half)
IDENTIFIED BY: HWT REFERENCE:

**MAP NUMBER: F27** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8633021
EASTING: 407720 NORTHING: 5405920
LOCATION: Ashburnham Main
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: ?echinoid plate
(GSC C143435)
AGE: Probably Late Triassic
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F28** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA863503
EASTING: 391360 NORTHING: 5419850
LOCATION: Old Nitnat Camp, Northwest Cowichan Lake
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Pterotrigonia* cf. *P. evansana* (Meek)
*Tellina* sp.
decapod crustaceans
indeterminate nuculoid bivalves
indeterminate gastropods
indeterminate plant remains
(GSC C143429)
AGE: Coniacian to Campanian
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F29** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8647031
EASTING: 413320 NORTHING: 5414940
LOCATION: Meade Creek (west of Cowichan Lake)
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: indeterminate bivalves
indeterminate gastropods
indeterminate plant fragments
(GSC C143430)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F30** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8649061
EASTING: 420500 NORTHING: 5414260
LOCATION: Meade Creek Main., west of Cowichan Lake
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: *Parallelodon (Nanonavis) vancouverensis* (Meek)
*Inoceramus* sp. cf. *I. orientalis* (Sokolow)?
*Acila* sp.
indeterminate nuculoid bivalve

indeterminate plant remains
(GSC C143431)
AGE: Late Santonian to early Campanian
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F31** **NTS MAP: 92C/16**
SAMPLE NUMBER: NMA8662021
EASTING: 402500 NORTHING: 5415200
LOCATION: Islands off Caycuse, Cowichan Lake. Calcareous nodules in sandstone
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Tellina* sp.
*Polyptychoceras*? sp.
indeterminate gastropods and bivalves
echinoderm fragment
(GSC C143433)
AGE: Coniacian to Campanian
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F32** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8604101
EASTING: 392339 NORTHING: 5421703
LOCATION: Ccawichan Lake - R Main; road R12A
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Inoceramus*? sp.
*Dentalium* sp. indeterminate
small indeterminate gastropod
indeterminate nuculoid bivalves
indeterminate plant remains
(GSC C143401)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F33** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8604111
EASTING: 392463 NORTHING: 5421670
LOCATION: Cowichan Lake - R Main; road R12A
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: *Inoceramus* sp.cf. *I. orientalis* (Sokolow)
*Baculites*? sp.
indeterminate plant remains
(GSC C143402)
AGE: Late Santonian to early Campanian
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F34** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8604112
EASTING: 392463 NORTHING: 5421670
LOCATION: Cowichan Lake - R Main: road R12A.
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: *Inoceramus* sp.cf. *I. orientalis* (Sokolow)
(GSC C143403)
AGE: Late Santonian to early Campanian
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F35** **NTS MAP: 92C/15**
SAMPLE NUMBER: SFR8606011
EASTING: 389865 NORTHING: 5424040
LOCATION: Redbed Creek area, near Nitinat, west of Cowichan Lake
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: oyster? fragments
indeterminate plant remains
(GSC C143404)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F36** **NTS MAP: 92C/15**
SAMPLE NUMBER: SFR8606022
EASTING: 389848 NORTHING: 5424126
LOCATION: Redbed Creek area, near Nitinat, west of Cowichan Lake
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Rhynchonella suciensis* (Whiteaves)
abundant oyster fragments
indeterminate plant remains
(GSC C143405)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F37** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8606171
EASTING: 390962 NORTHING: 5423242
LOCATION: Redbed Creek area, near Nitinat, west of Cowichan Lake
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Inoceramus* sp.cf. *I. orientalis* (Sokolow)
(GSC C143418)
AGE: Late Santonian to early Campanian
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F38** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8619021
EASTING: 390154 NORTHING: 5421814
LOCATION: Redbed Creek area
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: fragmentary molluscs
(GSC C143409)
AGE: Indeterminate (possibly Jurassic)
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F39** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8623031
EASTING: 391170 NORTHING: 5412025
LOCATION: Caycuse C5 Road
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: ichthyoliths
(GSC C143157)
AGE: Phanerozoic
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F40** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8629071
EASTING: 390447 NORTHING: 5408344
LOCATION: Caycuse W1B Road
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: ichthyoliths
(GSC C143161)
AGE: Phanerozoic
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F41** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8643032
EASTING: 395347 NORTHING: 5407763
LOCATION: Caycuse C11 Road
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: conodonts: *Metapolygnatus nodosus*
(Hayashi, 1968)
ramiform elements

CAI:- 67
(GSC C143166)
AGE: Late Triassic, late Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F42** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8643043
EASTING: 395642 NORTHING: 5408118
LOCATION: Caycuse C11 Road
STRATIGRAPHIC UNIT: uTr?p
FOSSIL TYPE: conodonts *Metapolygnathus nodosus* (Hayashi, 1968)
CAI: 6-7
(GSC C143169)
AGE: Late Triassic, late Carnian (possibly basal Norian)
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F43** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8643043
EASTING: 395599 NORTHING: 5408203
LOCATION: Caycuse C11 Road
STRATIGRAPHIC UNIT: uTr?p
FOSSIL TYPE: indeterminate solitary rugose coral
(GSC C143410)
AGE: Probably Late Triassic
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F44** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8643051
EASTING: 395790 NORTHING: 5408091
LOCATION: Caycuse Main C11 Road
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: *Halobia* sp.
(GSC C143411)
AGE: Late Triassic
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F45** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8644012
EASTING: 394266 NORTHING: 5407817
LOCATION: Caycuse C11 Road
STRATIGRAPHIC UNIT: uTrk
FOSSIL TYPE: ichthyoliths
conodonts*Metapolygnathus* ex gr. *polygnathiformis* (Budurov & Stefanov, 1965)
CAI: 34
(GSC C143170)
AGE: Late Triassic, Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F46** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8644041
EASTING: 395276 NORTHING: 5407992
LOCATION: Caycuse C11 Road
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: sponge spicules
conodonts *Metapolygnathus nodosus* (Hayashi, 1968)
CAI: 3
(GSC C143172)
AGE: Late Triassic, late Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F47** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8644042
EASTING: 395276 NORTHING: 5407992
LOCATION: Caycuse C11 road
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: *"Arcestes"* sp.
(GSC C143412)
AGE: Late Triassic
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F48** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8644061
EASTING: 393390 NORTHING: 5409212
LOCATION: Caycuse C11 Road
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: ichthyoliths
(GSC C143713)
AGE: Phanerozoic
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F49** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8648021
EASTING: 397486 NORTHING: 5407265
LOCATION: Gordon River TR2/SP3
STRATIGRAPHIC UNIT: uTr?p
FOSSIL TYPE: *Halobia* sp.
(GSC C143413)
AGE: Late Triassic
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F50** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8648022
EASTING: 397486 NORTHING: 5407265
LOCATION: Gordon River TR2/SP3
STRATIGRAPHIC UNIT: uTr?p
FOSSIL TYPE: foraminiferid steinkerns
sponge spicules
conodonts - *Metapolygnathus nodosus* (Hayashi, 1968)
*Metapolygnathus* sp.cf. *M. primitius* (Mosher, 1970)
CAI:- 34
(GSC C143175)
AGE: Late Triassic, late Carnian, possibly basal Norian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F51** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8648023
EASTING: 397486 NORTHING: 5407265
LOCATION: Gordon River TR2/SP3
STRATIGRAPHIC UNIT: uTr?p
FOSSIL TYPE: *"Arcestes"* sp.
(GSC C143414)
AGE: Late Triassic
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F52** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8652034
EASTING: 408535 NORTHING: 5409694
LOCATION: Cowichan Lake B Road
STRATIGRAPHIC UNIT: JB
FOSSIL TYPE: *Weyla acutiplicata*
*Weyla alata*
broken indeterminate bivalves
coral fragments

*harpoceratid* ammonite fragment cf.
*Paciferas? propinquum*
(GSC C143415)
AGE: Early Jurassic, latest Pliensbachian
IDENTIFIED BY: HWT REFERENCE:

**MAP NUMBER: F53** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8653028
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse Main C8 Branch
STRATIGRAPHIC UNIT: uTr?p
FOSSIL TYPE: *Tropites*" sp.
*Juvavitinae* indeterminate
(GSC C143416)
AGE: Late Carnian
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F54** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR86530210
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C11 Road
STRATIGRAPHIC UNIT: uTr?p
FOSSIL TYPE: radiolarians
conodonts *Metapolygnathus nodosus*
(Hayashi, 1968)
CAI: 3..5-4
(GSC C143180)
AGE: Late Triassic, late Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F55** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE861205
EASTING: 393800 NORTHING: 5417020
LOCATION: Cowichan Lake at Caycuse A branch
STRATIGRAPHIC UNIT: JB
FOSSIL TYPE: wood and other plant remains
(GSC C143602)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F56** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8623041
EASTING: 406740 NORTHING: 5413120
LOCATION: Cowichan Lake, South Shore Main
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: nuculoid bivalve
echinoderm fragment
indeterminate bivalves
indeterminate plant remains
(GSC C143424)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F57** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8623062
EASTING: 408400 NORTHING: 5411500
LOCATION: Cowichan Lake, South Shore Main
STRATIGRAPHIC UNIT: uKh
FOSSIL TYPE: wood and other plant remains
(GSC C143601)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F58** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE862405
EASTING: 414170 NORTHING: 5417144
LOCATION: Mount Franklin
STRATIGRAPHIC UNIT: MPf
FOSSIL TYPE: conodonts:
ramiform elements
AGE: Phanerozoic
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F59** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8637011
EASTING: 402760 NORTHING: 5414040
LOCATION: South shore of Cowichan Lake - B1 Branch
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: oyster fragments
indeterminate gastropods
indeterminate plant remains
(GSC C143418)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F60** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8637021
EASTING: 402820 NORTHING: 5414000
LOCATION: South shore of Lake Cowichan - B1 Branch
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Tellina occidentalis*? (Meek)
*Dentalium* sp. indeterminate
oyster fragments
indeterminate highspired gastropods
indeterminate nuculoid bivalves
(GSC C143419)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F61** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8637061
EASTING: 403780 NORTHING: 5413280
LOCATION: South shore of Cowichan Lake - B1 Branch
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Dentalium* sp. indeterminate
*Rhynchonella suciensis* (Whiteaves)
*Cerithium vancouverense* (Whiteaves)
*Tellina occidentalis* (Whiteaves)
indeterminate bivalves & gastropods
asteroid echinoderm
indeterminate plant remains
(GSC C143420)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F62** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8637062
EASTING: 403840 NORTHING: 5413200
LOCATION: South shore of Cowichan Lake - B1 Branch
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: indeterminate nucloid bivalves
indeterminate plant remains
(GSC C143421)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F63** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8638041
EASTING: 403947 NORTHING: 5408016
LOCATION: South shore of Cowichan Lake - B16 Road

STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: shelly material
"worm tubes"
(GSC C103981)
AGE: Indeterminate
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F64 SAMPLE NUMBER: PTE8638051**
NTS MAP: 92C/ 16
EASTING: 403740 NORTHING: 5408480
LOCATION: South shore of Cowichan Lake - B16 Branch
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: "*Arcestes*" sp. indeterminate
(GSC C143422)
AGE: Late Triassic
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F65 NTS MAP: 92C/ 16**
SAMPLE NUMBER: PTE8639021
EASTING: 404280 NORTHING: 5413100
LOCATION: South shore of Cowichan Lake - B13 Branch
STRATIGRAPHIC UNIT: uKb
FOSSIL TYPE: *Rhynchonella suciensis* (Whiteaves)
oyster fragments
indeterminate bivalves & gastropods
indeterminate plant remains
(GSC C143423)
AGE: Indeterminate
IDENTIFIED BY: JWH REFERENCE:

**MAP NUMBER: F66 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876005
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; "Gulley" section interval 29.0 to 29.3 m
STRATIGRAPHIC UNIT: uTrq
FOSSIL TYPE: ichthyoliths
conodonts ramiform elements
*Metapolygnathus* ex gr. *polygnathiformis*
(Burdurov & Stefanov, 1965)
*Cornudina*? n.sp. A Orchard, 1991
CAI: 3
(GSC C154183)
AGE: Late Triassic, Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F67 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876006
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; 'Gulley" section, interval 39.2 to 39.5 m, limestone
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: conodonts: *Metapolygnathus nodosus*
(Hayashi, 1968)
CAI: 3
(GSC C164184)
AGE: Late Triassic, late Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F68 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876007
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; 'Gulley" section, interval 41.2 to 41.4 m
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: *Paratropites* sp. indeterminate
*Arcestid* indeterminate
(GSC C154190)
AGE: Late Carnian, probably Welleri Zone
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F69 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876008
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; 'Gulley" section, interval 44.4 to 44.8 m, fossiliferous limestone
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: indeterminate ammonoids
(GSC C154191)
AGE: Probably Late Carnian
IDENTIFIED BY: ETT REFERENCE:

**MAP NUMBER: F70 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876009
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; 'Gulley" section, interval 46.0 to 46.2 m, limestone
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: conodonts: *Metapolygnathus nodosus*
(Hayashi, 1968)
ramiform elements
CAI: 3
radiolaria *Palaeosaturnalis* sp.
(GSC C154185)
AGE: Late Triassic, late Carnian
IDENTIFIED BY: MJO,FC REFERENCE:

**MAP NUMBER: F71 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876011
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; 'Gulley" section, interval 53.25 to 53.50 m, calcareous siltstone
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: ammonoid fragments
conodonts: *Metapolygnathus* sp.
CAI: 3
(GSC C154187)
AGE: Late Triassic, Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F72 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876012
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; 'Gulley" section, interval 60.2 to 60.5 m, sandy limestone
STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: conodonts: *Metapolygnathus nodosus*
(Hayashi, 1968)
*Metapolygnathus* cf. *primitius* (Mosher, 1970)
ramiform elements
CAI: 3
(GSC C154188)
AGE: Late Triassic, late Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F73 NTS MAP: 92C/ 16**
SAMPLE NUMBER: NMA876013
EASTING: 395814 NORTHING: 5408914
LOCATION: Caycuse C8 Road; 'Gulley" section, interval 61.0 to 61.3 m, calcareous silstone/ shale

STRATIGRAPHIC UNIT: uTrp
FOSSIL TYPE: conodonts: *Metapolygnathus nodosus* (Hayashi, 1968)
CAI: 3 -4
(GSC C154189)
AGE: Late Triassic, late Carnian
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F74** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8717061
EASTING: 424756 NORTHING: 5412658
LOCATION: Hill 60; Cherty argillite
STRATIGRAPHIC UNIT: MPf
FOSSIL TYPE: conodonts ramiform elements
*Polygnathus* sp.
*Pseudopolygnathus* sp.
*Bispathodus* ex gr. *stabilis* (Branson & Mehl, 1934)
CAI: 5
(GSC C158211)
AGE: Late Devonian early Carboniferous (Mississippian), (late Famennian - Tournaisian)
IDENTIFIED BY: MJO REFERENCE:

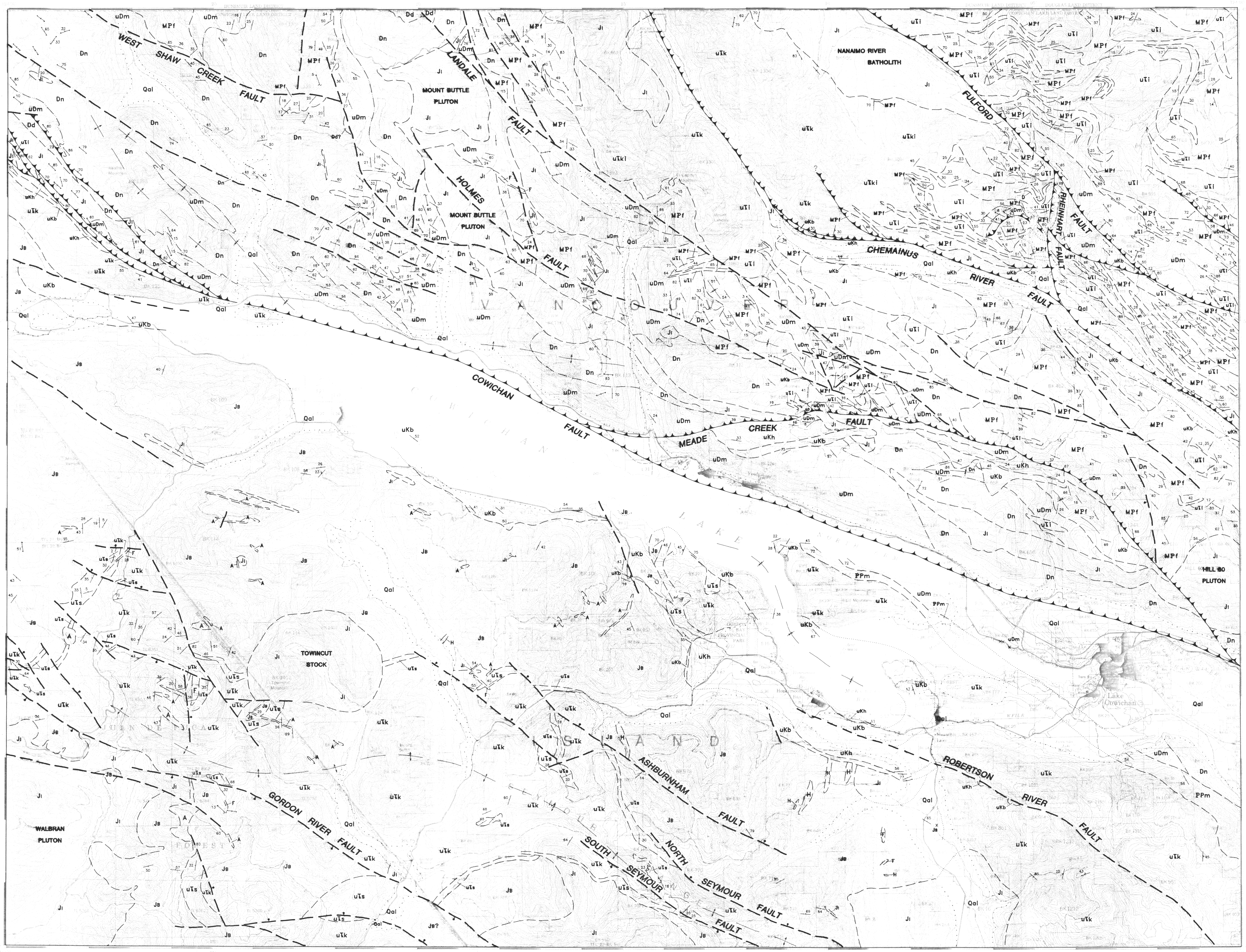
**MAP NUMBER: F75** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8731062
EASTING: 424760 NORTHING: 5426506
LOCATION: Haslam Creek area
STRATIGRAPHIC UNIT: MPf
FOSSIL TYPE: *Echinoderm ossicles* indeterminate fragments of ?brachiopods
(GSC C158230)
AGE: No age determination possible
IDENTIFIED BY: EWB REFERENCE:

**MAP NUMBER: F76** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8705083
EASTING: 420644 NORTHING: 5425131
LOCATION: Yip Yip Road, NE of Rheinhart Lake
STRATIGRAPHIC UNIT: MPf
FOSSIL TYPE: Indeterminate burrows
(GSC C168368)
AGE: No age determination possible
IDENTIFIED BY: EWB REFERENCE:

**MAP NUMBER: F77** **NTS MAP: 92C/16**
SAMPLE NUMBER: SFR8833071
EASTING: 399921 NORTHING: 5427815
LOCATION: Delphi Lake
STRATIGRAPHIC UNIT: MPf
FOSSIL TYPE: conodonts *Polygnathus*? sp
ramiform elements
CAI: 6 7
(GSC C168440)
AGE: Middle Devonian - Early Carboniferous
IDENTIFIED BY: MJO REFERENCE:

**MAP NUMBER: F78** **NTS MAP: 92C/16**
SAMPLE NUMBER: PTE8602061
EASTING: 397260 NORTHING: 5427940
LOCATION: North Shaw Creek area, logging road 150NS
STRATIGRAPHIC UNIT: uDm
FOSSIL TYPE: plant material, unidentified
AGE: unknown
IDENTIFIED BY: REFERENCE:

Energy, Mines and Resources Canada
BC Province of British Columbia
This project is a contribution to the Canada/British Columbia Mineral Development Agreement, 1985–1990.




BC
Ministry of Energy, Mines and Petroleum Resources

British Columbia Geological Survey

GEOSCIENCE MAP 1991-2

# GEOLOGY OF THE COWICHAN LAKE AREA

## NTS 92C/16

GEOLOGY BY N.W.D. MASSEY, S.J. FRIDAY,
P.E. TERCIER, V.J. RUBLEE AND T.E. POTTER (1986–87)

COMPILATION BY N.W.D. MASSEY

SCALE 1:50 000

KILOMETRES 0 1 2 3 KILOMETRES

## LEGEND

### INTRUSIVE ROCKS

**JURASSIC(?)**
MINOR INTRUSIONS

A F H D — Pyroxene–feldspar diabase (A); feldspar, quartz–feldspar porphyry (F); hornblende–feldspar porphyry (H); dacite, rhyolite (D)

**EARLY TO MIDDLE JURASSIC**
ISLAND PLUTONIC SUITE

Jı — Diorite, granodiorite, quartz diorite often with abundant xenoliths, aplite

**LATE TRIASSIC**
MOUNT HALL GABBRO

uTi — Sills and dikes coeval with Karmutsen Formation: diabase, gabbro and flower gabbro

### VOLCANIC AND SEDIMENTARY ROCKS

**QUATERNARY**

Qal — Unconsolidated glacial till and poorly sorted alluvium

**UPPER CRETACEOUS**
NANAIMO GROUP

uKh — HASLAM FORMATION: argillite, siltstone, shale and minor sandstone

uKb — BENSON FORMATION: boulder and pebble conglomerate, sandstone and minor siltstone

**LOWER JURASSIC**
BONANZA GROUP

JB — Feldspar basalt, andesite, dacite, tuff, sandy tuff, crystal tuff, lapilli tuff and breccia, with minor argillite and sandstone

**UPPER TRIASSIC**
VANCOUVER GROUP

uTs — QUATSINO AND PARSON BAY FORMATIONS (undifferentiated): massive and bedded micrite, hyaloclastite with limestone clasts, laminated siltstone, argillite, flaggy limestone, biohermal limestone, minor tuff

uTk — KARMUTSEN FORMATION: pillowed and massive basaltic flows, hyaloclastite and hyaloclastite breccia, glomeroporphyritic flows and breccia

**MISSISSIPPIAN TO LOWER PERMIAN**
BUTTLE LAKE GROUP
UPPER PENNSYLVANIAN TO LOWER PERMIAN

PPm — MOUNT MARK FORMATION: massive crinoidal limestone, bedded limestone, marble, chert, cherty argillite and siltstone

MISSISSIPPIAN TO PENNSYLVANIAN

MPf — FOURTH LAKE FORMATION: ribbon chert, cherty tuff, graphitic argillite, intercalated thinly bedded sandstone, siltstone and argillite, epiclastic sandstone, conglomerate, argillite and crinoidal limestone, minor hematite–magnetite chert

**MIDDLE(?) TO UPPER DEVONIAN**
SICKER GROUP

uDm — MCLAUGHLIN RIDGE FORMATION: thickly bedded tuffite and lithic tuffite, feldspar–crystal tuff, heterolithic lapilli tuff and breccia, rhyolite, dacite, laminated tuff, and chert

Dn — NITINAT FORMATION: pyroxene–feldspar phyric agglomerate, breccia and lapilli tuff, massive and pillowed flows, massive tuffite and lithic tuffite, laminated tuff, and chert

Dd — DUCK LAKE FORMATION: pillowed and massive basaltic flows, monolithic basalt breccias and pillow breccias, chert, jasper and cherty tuff, massive dacite and rhyolite

### SYMBOLS

Geological contact (defined, approximate, assumed, transitional)
Limit of drift covered area
Bedrock outcrops within drift covered area
Bedding (horizontal, inclined, overturned)
Bedding estimated from pillows (inclined)
Schistosity and cleavage (inclined, vertical)
Secondary schistosity (inclined, vertical)
Lineation (plunge indicated)
Axis of minor folds (plunge indicated)
Fault; downthrown side and dip indicated (defined, approximate, assumed) — 30
Reverse and thrust faults with dip indicated; teeth indicate upthrust side (defined, approximate, assumed) — 30
Anticline (with plunge indicated)
Syncline (with plunge indicated)

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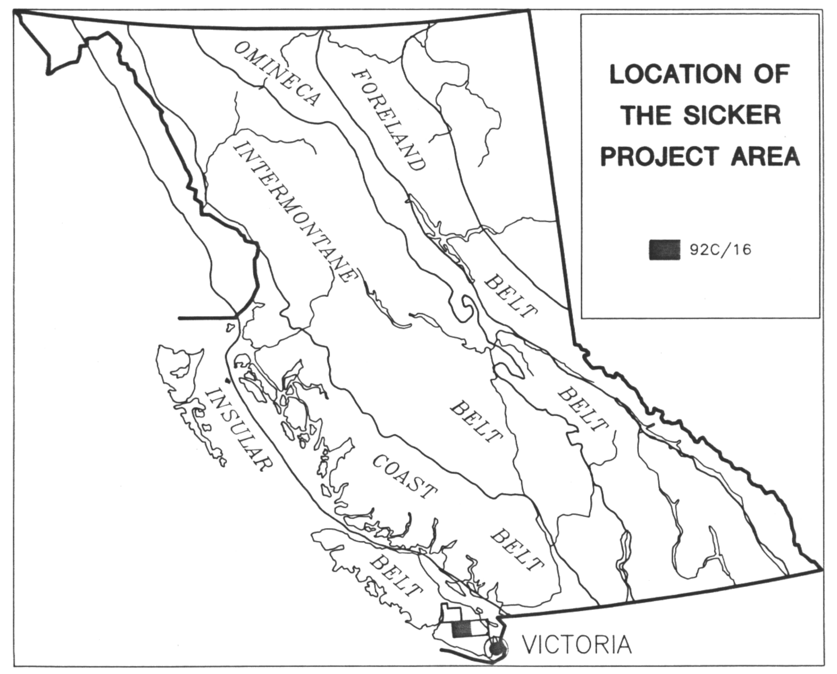

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