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Structure stratigraphy and contact relationships in Mesozoic volcanic and sedimentary rocks east of Pemberton southwestern British Columbia

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STRUCTURE, STRATIGRAPHY AND CONTACT RELATIONSHIPS IN MESOZOIC VOLCANIC AND SEDIMENTARY ROCKS, EAST OF PEMBERTON, SOUTHWESTERN BRITISH COLUMBIA

by

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Structure, stratigraphy, and contact relationships in Mesozoic volcanic and sedimentary rocks, east of Pemberton, southwestern British Columbia (162 pages)

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East of Pemberton, British Columbia, Mesozoic volcanic and sedimentary rocks crop out in a northwesterly striking body that is almost entirely surrounded by voluminous late Cretaceous to late Tertiary plutons of the Coast Plutonic Complex. On previous maps, the rocks in this body are correlated with the Upper Triassic Cadwallader Group. This paper describes the results of a mapping study of the part of this body that is exposed in the Tenquille Lake, Owl Creek, and Lillooet Lake pendant areas. I spent six months mapping these rocks at 1:25000 scale in order to produce more detailed geological maps, to confirm and/or establish valid regional correlations, and to identify important structural features.

The north-northwest striking Owl Creek fault bisects the study area. Rocks that correlate with the Cretaceous Gambier Group lie in the footwall; in the hanging wall, rocks that are correctly correlated with the Cadwallader Group are overlain unconformably by a late Mesozoic volcanic and sedimentary sequence, herein called the Cerulean Lake unit.

Movement sense on the Owl Creek fault is northeast-side-up with a component of right lateral oblique slip. There are no oceanic rocks or tectonic melange in the exposures of the fault zone, so it appears to be an ordinary fault rather than a tectonic suture. Rocks in the hanging wall have suffered a long complex structural history, and consequently exhibit strong to intense brittle and ductile structural features, both in Cadwallader Group and in Cerulean Lake unit rocks. Gambier Group rocks in the footwall of the fault are far less complex structurally.

The Cerulean Lake unit consists of a lower volcanic member and an upper sedimentary member. This unit overlies the Cadwallader Group on an angular unconformity that represents a depositional hiatus of at least 50 million years. Cerulean Lake unit conglomerates and sandstones contain material derived from the Cadwallader Group, from 158 to 160 Ma granitoids, and from the Cerulean Lake unit volcanic member. The Cerulean Lake unit shares some characteristics with the upper parts of the Gambier Group, but as its age is unknown, a positive regional correlation has not yet been established.

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CHAPTER 1 INTRODUCTION

1.1 General statement

The idea that much of the North American Cordillera is a mosaic of allochthonous crustal fragments emerged along with the acceptance of mobilist plate tectonic theory in the early 1970's and became mainstream thinking in the late 1970's and early 1980's (Monger and Price, 1979; Davis et al, 1978; Coney et al, 1980).

Five distinct belts are recognized in the Canadian Cordillera (Figure 1A). The Rocky Mountain belt is unmetamorphosed and low-grade metamorphic rock of North American origin, the Omineca Belt and the Coast Plutonic Belt consist mainly of intensely deformed high-grade metamorphic rocks and Mesozoic plutons, and the Intermontane and Insular belts are mainly volcanic and sedimentary rocks of oceanic affinity that show low-grade or no metamorphism. In 1982, Monger, Price, and Tempelman-Kluit outlined a unifying theory to explain the different geological characteristics of the Canadian part of the Cordillera; this paper became a working model for much of the work that has been done in British Columbia since then. In their model, the Omineca Belt and the Coast Plutonic Belt are 'welts' that formed as a result of compression and thickening due to collision of two composite terranes, Superterrane I and Superterrane II, respectively, with the North American plate. Timing of the accretion of Superterrane I (which includes Quesnellia, Cache Creek, and Stikinia terranes) is well constrained to the Early Jurassic. The accretion history of Superterrane II, which includes Wrangellia and Alexander terranes, is not as well understood. Debate on this subject falls into two main camps.The first, outlined by Monger et al (1982), and supported by, among others, Crawford et al (1987), Garver (1989) , argues that Superterranes I and II amalgamated during the Mid-Cretaceous, before which they were separated by ocean. Others favour a model in which the Superterrane I and Stikinia were together by Jurassic time; either they had collided by that time (Rusmore et al, 1988), or they are both formed within the same Jurassic arc system (van der Heyden,

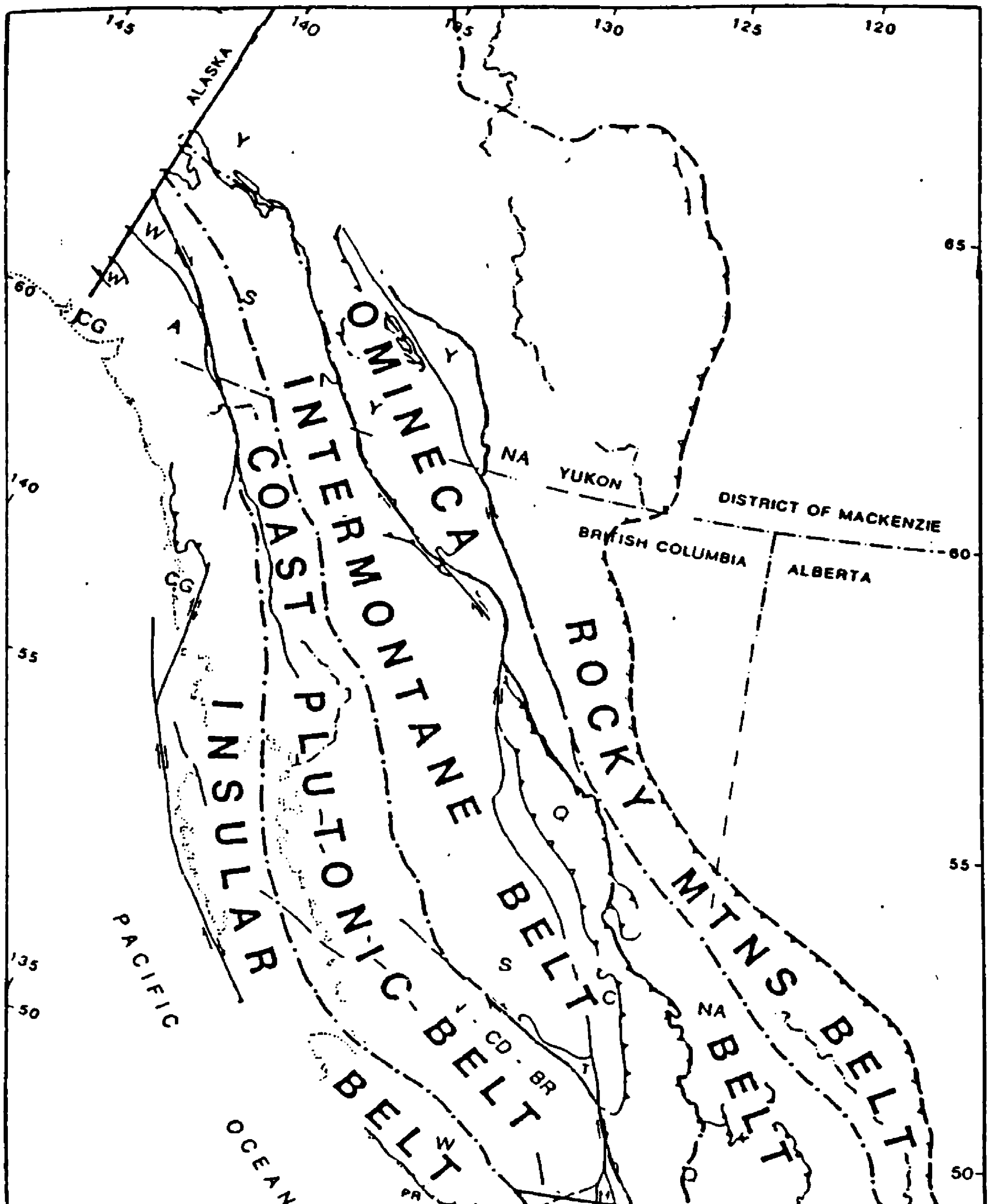


FIGURE 1A Tectonic belts of the Canadian Cordillera

1992). In van der Heyden's model, the Mid-Cretaceous and later compressional structures and voluminous plutonism could have formed by intra-arc compression and uplift.

Understanding the nature of the relationships between Mesozoic units in the boundary areas between the two Superterranes is key to resolving this debate. The boundary zone consists of a belt of smaller terranes and the Coast Plutonic Complex. To approach this kind of problem it is most useful to study the timing of faulting and deformation, plutonism, and the formation of sedimentary rock that overlaps two or more terranes.

This study examines the relationship between two terranes that lie in this border zone in southwestern British Columbia, the Cadwallader terrane and the Gambier Group. The Cadwallader terrane, which consists of Cadwallader Group and Tyaughton Group rocks (Rusmore, 1987) is one of these smaller, boundary zone terranes. The Gambier Group, which includes rocks of the Fire Lake Group (Roddick, 1965), is an autochthonous assemblage of Jura-Cretaceous rocks that overlaps Wrangellia and perhaps Stikinia (Wheeler and McFeely, 1987), and provides a tentative link between those terranes by Albian time.

1.2 Previous work

1.2.1. History of the study and nomenclature of the Cadwallader Group:

Cadwallader rocks were first defined and named by Drysdale (1915) in Cadwallader Creek at Bralorne, B.C., in the Bridge River area (See Figure 1B). The Bridge River Camp is historically the largest producer of gold in British Columbia, with a total production of 40 tons of gold, along with 130 tons of silver by 1980 (Leitch, 1991), so the geology of the area has been studied by a large number of workers. It seems that every worker that has discussed the stratigraphy in the area has defined the "Cadwallader" slightly differently.

Drysdale (1915) included within the Cadwallader Series sedimentary rocks with andesitic greenstone interflows, as well as the peridotites and serpentinites that were later

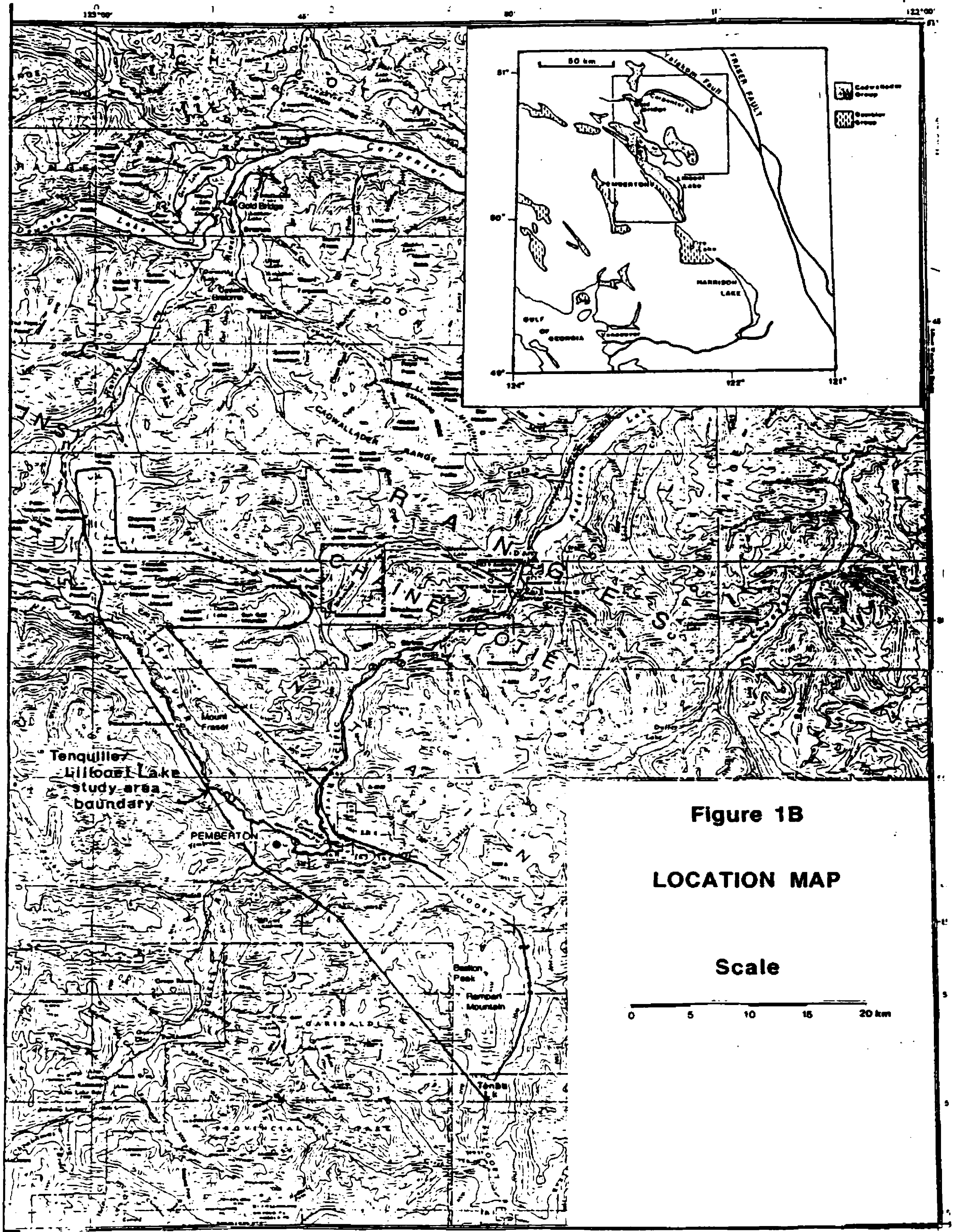


Figure 1B

LOCATION MAP

Scale

assigned to the Shulaps ultramafic body (Potter, 1985) . He had no fossil dates, but
he tentatively assigned these rocks to the Jura-Triassic based on their stratigraphic position. He felt that these rocks lay unconformably on the Paleozoic Bridge River Series.

During his work in the Bridge River Camp, McCann (1922) collected some fossils from the limestones within the Cadwallader Series. They were identified as Late Triassic faunas.

Cairnes spent his field seasons in the Bridge River area from 1934 to 1939. His reports on the Bridge River mining camp (1937) and the Tyaughton Lake area (1943) contain detailed descriptions of the rock units he encountered. He abandoned the use of the term "Cadwallader Series" and divided the Upper Triassic rocks into 3 formations:

1) Noel Formation: argillaceous and cherty sedimentary rocks that lie unconformably upon Paleozoic rocks now assigned to the Bridge River Group

2) Pioneer Formation: massive, amygdaloidal andesitic greenstones and associated diorites.

3) Hurley Formation: argillaceous sedimentary rocks, often calcareous, with interbedded tuffs, conglomerate, cherty beds, fossiliferous limestone and limestone breccias, and interbedded andesitic greenstone flows.

These divisions proved useful and are still commonly used by area prospectors and geologists. Cairnes 1937 paper includes an annotated bibliography of the work done in the Bridge River area up until that time.

Roddick and Hutchison (1973) grouped the Noel, Pioneer and Hurley formations together in the Cadwallader Group.

Rusmore (1985) studied the depositional environment and provenance of a section of correlative Upper Triassic rocks in the Eldorado Basin north of Gold Bridge in order to understand the tectonic setting of the Cadwallader Group. She avoided the rocks in Cadwallader Creek area because they lie in the structurally complex Bralorne Fault Zone where coherent thicknesses of stratigraphy are rare and isolated.

Rusmore redefined the Cadwallader Group. She noted that all of the rocks mapped as the

Noel Formation could belong to various other formations, including the Hurley, the Jura-Cretaceous Relay Mountain, and the Bridge River. She recommended that the term Noel Formation be abandoned. Her new stratigraphy comprises three parts:

1) a lower basaltic unit, with pillowed basalt, basalt breccia, and massive flows, equivalent to Cairnes' Pioneer Formation,
2) a transitional unit of mixed sedimentary rocks, tuffs, and flows and breccias,
3) a sedimentary unit distinguished from the transitional unit by its lack of volcanic rocks and tuff, with a thick section of turbidites.

Both the transitional and sedimentary units are included within the Hurley Formation..

On the basis of geochemistry of the basalts, and on the composition of the clastic rocks, Rusmore inferred that the Cadwallader Group accumulated near an active Late Triassic arc fringed by carbonate reefs.

Regional mapping and mineral deposits study programs by the British Columbia Geological Survey have been ongoing in the Bralorne and Gold Bridge areas for the past five or six years (Schiarizza et al, 1990; Church and Pettipas, 1989; Archibald et al, 1990; and references therein) . This work covers areas where Cadwallader Group rocks are spatially associated with the Bridge River Formation, the Tyaughton Group and the Shulaps Ultramafite.The tectonic relationships between these units are complex, but considerable progress is being made as a result of the cooperative efforts of government geologists, graduate students, and others.(Coleman, 1989; Calon et al, 1990; Umhoefer, 1990; and references therein).

The Triassic rocks in the Lillooet Lake pendant are the southernmost exposure of what is generally recognized as the Cadwallader Group. Correlation of the Cadwallader Group with the "Slollicum package" has been suggested by Monger (1986). Slollicum rocks include mafic, intermediate, and felsic flows, associated volcaniclastic rocks and breccias, and conglomerates with cobbles of carbonate and quartz-eye porphyry. Alternatively, the Cadwallader Group may correlate with northwest-trending bands of pre-Jurassic metavolcanic rock known as the Twin Island Group, which form isolated pendants within the Coast Plutonic Complex to the south and southeast of Lillooet Lake along the Lillooet River and in the Harrison Lake, Indian Arm, and Burrard Inlet areas. Rock types include amphibolite, quartzite, phyllite, schist, and minor conglomerate, meta-andesite, rhyodacite, and hornfels (Roddick, 1965). The Twin Islands Group may be the higher-grade equivalent of the Cadwallader Group that was brought up to the same level on a system of high-angle west-vergent faults. Absolute age of the Twin Islands Group is unknown.

1.2.2 Previous work on the Gambier Group and the Fire Lake Group

The name Fire Lake Group was proposed by Roddick (1965) for a very thick (5000 m) assemblage of sedimentary and volcanic sedimentary rocks of Upper Jurassic and Lower Cretaceous age that form a pendant in the Fire Lake area north of Harrison Lake. It includes the Peninsula and Brokenback Hill units of Crickmay (1930). Arthur (1986) measured sections and described the lithology, stratigraphy and environmental setting of the Brokenback Hill and Peninsula formations, and underlying Triassic and Jurassic strata on the west shore of Harrison Lake. Lynch (1990) studied the structure and stratigraphy of the Fire Lake Group in the Fire Lake pendant. The Fire Lake Group was recognized as equivalent to parts of the Gambier Group by Roddick (1965).

1.2.3 Previous work in the Tenquille/Lillooet Lake area

Regional access to the study area (Figure 1B) was first opened in the late 1850's when a trail was built from Port Douglas, at the north end of Harrison Lake, to Lillooet via Lillooet Lake to provide a route to the goldfields of the Cariboo during the gold rush there. In the 1890's, prospectors located and staked a number of copper skarn showings in the Tenquille Lake area, at the head of Lillooet Lake, and in the Owl Creek drainage.

Construction of the Pacific Great Eastern Railway (now British Columbia Rail) from

Vancouver to Prince George began in 1915. In 1918 Charles Camsell of the
Geological Survey of Canada (GSC) was sent to do reconnaissance mapping and natural resource evaluation along the new right-of-way between Squamish and Lillooet.

Cairnes (1925) spent a month mapping the area between the Birkenhead and Lillooet rivers northeast of Pemberton, and the north part of the Lillooet Lake pendant. He described highly deformed volcanic and sedimentary rocks that contained Upper Triassic fossils, and noted that could correlate with the Karmutsen Group on Vancouver Island, the Cadwallader Series as defined by McCann (1922) in the Bridge River area, or the Upper Triassic rocks in the Chilko Lake area as defined by Dolmage (1924). Cairnes also noted that a series of sediments overlie the Triassic rocks, apparently unconformably, on the ridge south of Tenquille Creek. He reasoned that these rocks are probably Cretaceous in age. (I suggest the name "Cerulean Lake unit" for these rocks. See section 2.3)

Roddick and Hutchison (1973) of the GSC mapped the east half of the Pemberton sheet (92J) at 1:250,000 scale. They correlated the Triassic rocks of the Tenquille Lake area and the Lillooet Lake pendant with the Cadwallader Group.

A compilation of the geology of the Pemberton sheet (92J) at 1:250,000 scale was released by Woodsworth in 1977. McLaren (1989) mapped felsic volcanic rocks in the Tenquille and Owl Creek areas to evaluate their potential for volcanogenic massive sulphide mineral deposits.

A geochemical study by Schick (1990) showed that the greenstones from the Lillooet Lake area have the same kinds of major and trace element signatures as Rusmore's Pioneer greenstones near Gold Bridge. The Lillooet Lake area data plot in the IAT (island arc) fields on most chemical discrimination diagrams.

A regional structural study led by Murray Journeay of the GSC was initiated in 1988 and is ongoing at present (Journeay and Csontos, 1989; Journeay, 1990; Journeay et al , 1992; Journeay and Friedman, in press).

The progress of my work in this area has been made public in fieldwork reports (Riddell

1990a, b, and 1991 a, b) and a set of preliminary field maps (Riddell et al, 1991).

1.3 Purpose of this study

Reconnaissance mapping by Journeay and Csontos (1989) led them to hypothesize that the Lillooet Lake pendant is transected by a north-northwesterly striking structure, probably a thrust fault, with rocks of the Cretaceous Fire Lake Group lying to the west, and Triassic rocks, probably of the Cadwallader Group, lying to the east. The "Lillooet Lake pendant" refers to the volcanic and volcaniclastic sedimentary rocks in the area bounded by Lillooet Lake on the east, by rocks of the Pemberton diorite complex on the west and southeast, and by the Green and Lillooet Rivers on the north.

My project was originally designed to test Journeay's hypothesis, and to determine the nature of the relationship between the rocks on either side of the structure. I spent the 1989 field season mapping the Lillooet Lake pendant to determine:

1) the location and nature of the hypothesized structure,

2) whether rocks to the west of the structure should be correlated with the Gambier Group,

3) whether the correlation of rocks east of the structure with the Cadwallader Group is valid.

These points are important because the relationship between the Gambier Group and the Cadwallader Group is unknown.

The project expanded to the north to the Tenquille Lake area in 1990 when Teck Exploration offered me the opportunity to map that area. This benefitted the project because the rocks are far less structurally disturbed in the Tenquille Lake area than they are in the Lillooet Lake pendant, consequently it is much easier to study the stratigraphy around Tenquille Lake.

1.4 Method

I spent 6 months in the field area over the summers of 1989 and 1990, mapping exposures

on the ridge south of the Tenquille Lake creek and in the Lillooet Lake pendant
at 1:25000 scale, noting lithology, stratigraphic relationships, and structural features. North of Tenquille Creek to Grouty Peak, in the Owl Creek area, and on the western edge of the Lillooet Lake pendant, I mapped at reconnaissance scale (1:50000), and interpreted and compiled the work of the others (see map in pocket for references). Lower, road-accessible areas were reached by 4-wheel drive truck; alpine camps were helicopter supported. I collected samples for lithology and fossils. 117 thin sections were studied to evaluate the correlation of units throughout the length of the study area. I analyzed 7 oriented samples from shear zones to determine movement sense. Fossils were turned over the Geological Survey of Canada for identification.

1.5 Location and physiography

The study area forms an elongate belt about 60 kilometres long and 10-15 kilometres wide in the ranges east of the town of Pemberton, British Columbia, which is 160 kilometres north of Vancouver on Highway 99. The elevation ranges from about 230 metres (700') in the Lillooet River valley and on Lillooet Lake, to 2500 metres (7500') at the highest peaks. Topography is characterized by high ridges cut by abundant steep-sided stream gullies. Thick coniferous forest on lower slopes thins out at about 1800 metres (5500'), giving way to alpine grasses and flowers and stunted conifers. Pleistocene glaciation left ice striations on some outcrops and thick coverings of till over much of the area.

CHAPTER 2 DESCRIPTIONS OF ROCK UNITS

2.1 The Cadwallader Group

2.1.1 Introduction

Triassic rocks east of Pemberton have been mapped as Cadwallader Group (Cairnes, 1925; Roddick and Hutchison, 1973; Woodsworth, 1977). Prior to this study, no attempt had been made to subdivide the Triassic stratigraphy in the Pemberton area, and the validity of the correlation with the Cadwallader Group was uncertain. My observations in the Tenquille/Lillooet Lake area support correlation of Triassic rocks east of the Owl Creek Fault with the Cadwallader Group.

Four distinctive mappable assemblages crop out in the study area. In previous reports I gave these assemblages the status of stratigraphic units and constructed an ideal composite section (Riddell, 1991a,b; Riddell et al, 1991). Subsequent study indicates that this stratigraphic scheme is oversimplified; it causes geometric problems and leaves some stratigraphic field relationships unexplained. In this paper, I treat these assemblages as lithofacies rather than discrete stratigraphic units, in order to avoid implying any stratigraphic order or direct time or stratigraphic correlation between similar rocks.
The four Triassic lithofacies are:

- **Mafic volcanic rocks** (previously referred to as Tr1)
- **Unbedded tuffs** (previously Tr2)
- **Bedded tuffs and sedimentary rocks** (previously Tr3 and Tr4)
- **Rhyolitic flows and tuffs** (previously Trf)

An undated body of **quartz diorite** that outcrops at the south end of Lillooet Lake is probably Triassic.

These lithofacies' names are printed in bold type in the following text.

Rocks of the **mafic volcanic lithofacies** are well exposed on top of Bastion peak.and at the Lill property at the north end of Lillooet Lake, on the east side of the Owl Creek valley, below 2000 metres elevation on Mount McLeod and Copper Mound, and in the bluffs of Finch Ridge west of the Grizzly Pass fault zone. Mafic dikes in quartz diorites at the south end of Lillooet Lake also belong to the **mafic volcanic lithofacies.**

This lithofacies is characterized by massive, dark green basaltic andesite and lesser basalt flows, with common feldspar porphyry phases and abundant epidote clots and veinlets. Pyroclastic breccias with clasts 3 cm and smaller are common. Limestone pods 2 to 30 m across are present in this unit, and they are especially abundant in the Mount McLeod area. There are no age data for this lithofacies.

Rock types within the **mafic volcanic lithofacies**

- Flows

Basaltic andesite dominate over basalt by volume throughout the study area. The proportion of basalt increases from less than 5% in the Lillooet Lake pendant to 15 to 20% in the Tenquille Mountain area. No pillowed flows were observed.

Greenschist metamorphism and alteration have affected the flows so that original compositions and textures are often difficult to discern in thin section (See Appendix A). Equant, stubby plagioclase crystals are the most abundant phenocrysts. Carlsbad twins are common, albite twins are slightly less abundant. Only 1 sample out of 7 contains hornblende phenocrysts large enough to be seen in hand sample. The more basaltic samples are bimodal in texture, with a few large phenocrysts in a very-fine-grained groundmass dominated by plagioclase microlites. The andesitic samples are coarser and more equigranular. The most abundant mineral in all samples is plagioclase. Lath-shaped crystals with albite twins are just as abundant as equant crystals in the matrix. In all samples, most of the original mafic material has been replaced by chlorite and/or epidote. In 2 samples, remnants of hornblende are distinguishable.

Fine-grained magnetite of primary origin is present in 6 of 7 samples; it is distributed evenly like dust throughout the matrix. Tiny actinolite needles are present in all samples. Microscopic quartz is present in 5 of the 7 samples. The amount of quartz ranges from 5 to 20%, and is interstitial to other grains. Two of the samples came from silicified zones, but in the 3 others quartz appears to be primary.

- Breccias

Pyroclastic breccias are associated with the flows. Six breccia samples from this unit were studied in the thin section (See Appendix A). Clast/matrix ratios range from 50/50 to 70/30. The matrix in all samples consists of mafic flow material with plagioclase microlites. The most abundant clast types are plagioclase-phyric andesite and basalt fragments, plagioclase crystals and crystal fragments, and non-porphyritic andesite and basalt. Amygdaloidal basalt fragments are present in all samples. Euhedral mafic crystals have been replaced by chlorite and/or epidote. Two samples contain rare felsic volcanic lithic fragments. One sample contains chert clasts. Chlorite, fine-grained magnetite, and actinolite needles are present in the groundmass of all samples.

- Limestones

Isolated limestone pods are found within the flows. In the Lillooet Lake pendant the pods are small (2 to 4 m across), dark grey, and recrystallized. In the Tenquille Lake area, the limestone pods are larger and more abundant, especially around Mount McLeod. A band of limestone on the south flank of Mount McLeod is about 5 metres thick, 30 metres wide, and bedded. None of the samples taken from these limestones yielded conodonts.

Thicknesses

It is difficult to determine thicknesses of the **mafic volcanic** rocks because they are massive and I have not observed both the top and bottom in any location. At Copper Mound, where the overlying rocks are flat-lying, the mafic rocks appear to be at least 1000 metres thick.

2.1.3 **Unbedded tuffs**

Distribution

Thick deposits of unbedded felsic lithic, lapilli, and feldspar-crystal tuffs and ash tuffs are well exposed in the mountain above the Lill property, on the flank of the ridge west of Lillooet Lake, in the eastern Owl Creek valley, and on the eastern flank of Sungod Mountain. In preliminary papers (Riddell, 1991a, b; 1990a, b) I reported that these tuffs were primarily andesitic because they have a medium green colour in the field. However, thin section study has shown that almost all of the unbedded tuffs in the field area are felsic; medium to dark green colours on fresh surfaces in the field are caused by fine-grained chlorite that makes up 5 to 10 percent of most samples and is disseminated throughout the tuff matrix.

Description of the tuffs

The tuffs weather pale green to white and are poorly sorted. Clasts are subangular and are normally 3 to 4 cm or smaller, but locally clasts as large as 6 to 7 cm are present. The most abundant clast types are feldspar crystals and crystal fragments, dacitic and andesitic volcanic lithic fragments. Quartz grains large enough to be visible in hand sample are absent. Basalt fragments were noted at some locations. The tuffs contain diorite clasts in the Bastion Peak area. Textures are well displayed on weathered surfaces. The lithic and lapilli tuffs tend to support a rusty coloured lichen that gives the rock a distinctive appearance in outcrop.

Fourteen samples of these tuffs were studied in thin section (See Appendix A). Clast/matrix ratios range from 15/85 to 90/10 but in most samples clasts make up about half of the volume. The matrix in 9 of the fourteen samples is felsic material; very fine-grained feldspar and microcrystalline quartz. The 5 others contain over 40% chlorite in the matrix which obscures the composition, but they are probably andesitic. A sample from the south end of Lillooet Lake has a felsic glassy matrix.

As noted in the field, feldspar crystals and crystal fragments are the most abundant clast types in all samples. Equant plagioclase, often with Carlsbad twins, are most common. Lath-like crystals with albite twins are rare; some samples have none. All of the samples studied show a mix of clast types. Fine-grained dacitic volcanic clasts are present in all 14 slides. 9 contain intermediate volcanic fragments. Mafic lithic fragments appear in 9 samples; amygdaloidal basalt clasts are present in samples from Mount McLeod and Bastion Peak. Chert is not abundant, but 7 slides contain at least one fragment of chert or cherty tuff. Quartz crystal fragments, mafic crystal fragments replaced by chlorite and/or epidote, and tuff fragments are less common.

Epidote veinlets and clots, chlorite, and fine-grained actinolite are common in all samples.

Thicknesses

Thicknesses of the **unbedded tuffs** are difficult to estimate, but they are the most abundant of the rock types in the Tenquille/Lillooet Lake area (aside from the large Cretaceous plutons). They make up most of the volume of Sungod Mountain, Bastion Peak, Rampart Mountain, and the mountain above the Lill property. Assuming a conformable contact with the overlying **bedded tuffs and sedimentary rocks** at Rampart Mountain, I estimate a minimum thickness of 1650 m for the **unbedded tuffs** there. There are no age data for this lithofacies.

2.1.4 Bedded tuffs and sedimentary rocks

Distribution

Bedded tuffs and sedimentary rocks are exposed on the Mount Barbour ridge, on Copper Mound, on Bastion Peak, and on Rampart Mountain.

Description of the **bedded tuffs and sedimentary rocks**

This lithofacies comprises white and rusty weathering lithic and lapilli tuffs similar in composition to the unbedded tuffs, macrofossil-bearing grey limestone beds, conglomerate, volcanic wacke, calcareous feldspar-rich wackes, grey siltstone and black shale, fine-grained felsic ash tuffs with cherty tops, limestone breccia and conglomerate, and some mafic to intermediate flows. Beds are 50 cm to 3 or 4 metres thick. Some tuffs and sedimentary beds are calcareous.

I studied 17 samples of these rocks in thin section (Appendix A). Ten of these samples are crystal and lithic tuffs similar to those found within the **unbedded tuff lithofacies** in that they contain feldspar crystals and fragments and a mixture of felsic, intermediate and mafic volcanic lithic clasts within fine-grained felsic matrix. The other 7 samples are sedimentary rock; volcanic wacke, siltstone, shale, and limestone. The volcanic wackes contain the same types of clasts as the tuffs; feldspar crystals, mixed volcanic lithic clasts, and chert. They differ from the tuffs in that they are completely clast supported, and clasts are rounded and well sorted. The one limestone studied is a fine-grained sample from near Mount Barbour. It is composed of discrete, rounded carbonate grains and other silty material.

Age of the **bedded tuffs and sedimentary rocks**

Upper Triassic macrofossils and conodonts have been found in limestones from this lithofacies at Mount Barbour and Copper Mound (Upper Triassic macrofossils, Cairnes, 1925; Norian conodonts, M. Orchard, 1991, written communication). I observed one bivalve fossil in a limestone at Rampart Mountain but was unable to collect a sample. There are no age data for this lithofacies in the Lillooet Lake pendant.

Thicknesses

The thickest section of **bedded tuffs and sedimentary rocks** is exposed on the

Mount Barbour ridge where it is over 1900 metres thick. The stratigraphy near
the bottom contact in this section is dominated by banded white and rusty weathering tuffs that are indistinguishable from the unbedded tuff in thin section (Appendix A). About one third of the way up the section the relative volume of volcaniclastic wackes, siltstones, and shales increases, and limestones and limestone breccias become abundant. In the top third of the section bluish-white weathering cherty ash tuff is the dominant lithology.

The sections of bedded tuffs and sedimentary rocks in the Lillooet Lake pendant are about 530 metres and 700 metres thick at Bastion Peak and Rampart Mountain, respectively. These sections are both dominated by cherty tuffs, but lithic tuffs, limestone breccias and limey volcaniclastic sedimentary rocks are present. Andesitic interflows are found in all of the bedded sections. Some of these may be feeders to the later Cerulean Lake unit volcanic sequence.

2.1.5 **Rhyolite flows and tuffs**

Significant volumes of **rhyolitic flows and tuffs** are restricted to the north end of the study area, from Grizzly Pass northwest to Grouty Peak. These rocks form a sub-facies within coeval **unbedded tuffs.** In much of this area the rhyolitic rocks are the dominant lithology. Rocks of this lithofacies are identified by the presence of conspicuous quartz-eyes that average 4 to 5 mm in diameter. Clusters of quartz crystals up to a centimetre across are locally abundant. Mutually cross-cutting relationships between quartz-feldspar porphyries, and dacitic and andesitic feldspar-porphyry dikes are abundant, as are volcanic breccias with clasts of intermediate and felsic flows and tuffs. Quartz and feldspar-rich epiclastic sandstone and grey siltstone directly overlie the rhyolite flows at Grouty Peak.

All of the 10 thin sections of **rhyolite flows and tuffs** contain large conspicuous quartz crystals and crystal fragments. Most sections have less than 5% mafic material. Feldspar spherulites are common in the flows. Feldspar crystals and fragments and rhyolite lithic fragments are abundant in the tuffs. Two of the tuff samples contain cherty tuff fragments.

2.1.6 Plutonic rocks at the south end of Lillooet Lake

A quartz diorite body intrudes **unbedded tuffs** at the south end of Lillooet Lake. Field relationships on the boundaries of the quartz diorite body indicate that it is coeval, and possibly comagmatic with the other Triassic lithofacies, and should be considered part of the Cadwallader Group. The following relationships can be observed on the lakeshore and along the skidder roads that climb the mountain flanks above the south end of the lake:

1) There is a textural continuum across the well exposed contact between the quartz diorite and feldspar crystal tuffs at about 900 m elevation; the quartz diorite probably intruded its own ejecta before the ejecta lithified.

2) A set of dark green mafic dikes intrude the quartz diorite, the dikes are in turn cut in places by quartz diorite. Agmatites with large quartz diorite fragments in aphanitic mafic matrix are exposed on the lakeshore adjacent to the narrows at the south end of the lake. These crosscutting relationships clearly demonstrate that these rock types belong to one magmatic system or coeval systems.

2.1.7 Lithofacies relationships in the Triassic section

Figure 2A illustrates the observed lithological sequences in six areas where reasonable amounts of section are exposed, to show local variation in stratigraphy.

Rampart Mountain

Crystal, lithic, and lapilli tuffs of the **unbedded tuff lithofacies** are the most abundant rocks in the Rampart Mountain area. They crop out on the east and west flanks of the mountain. As explained in section 2.1.6, the quartz diorites that intrude these tuffs at the south end of Lillooet Lake are probably coeval. The **unbedded tuffs** are overlain by **bedded tuffs and sedimentary rocks** that are exposed on the small plateau on the top of Rampart Mountain. The bedding strikes north-northwest with a near vertical western

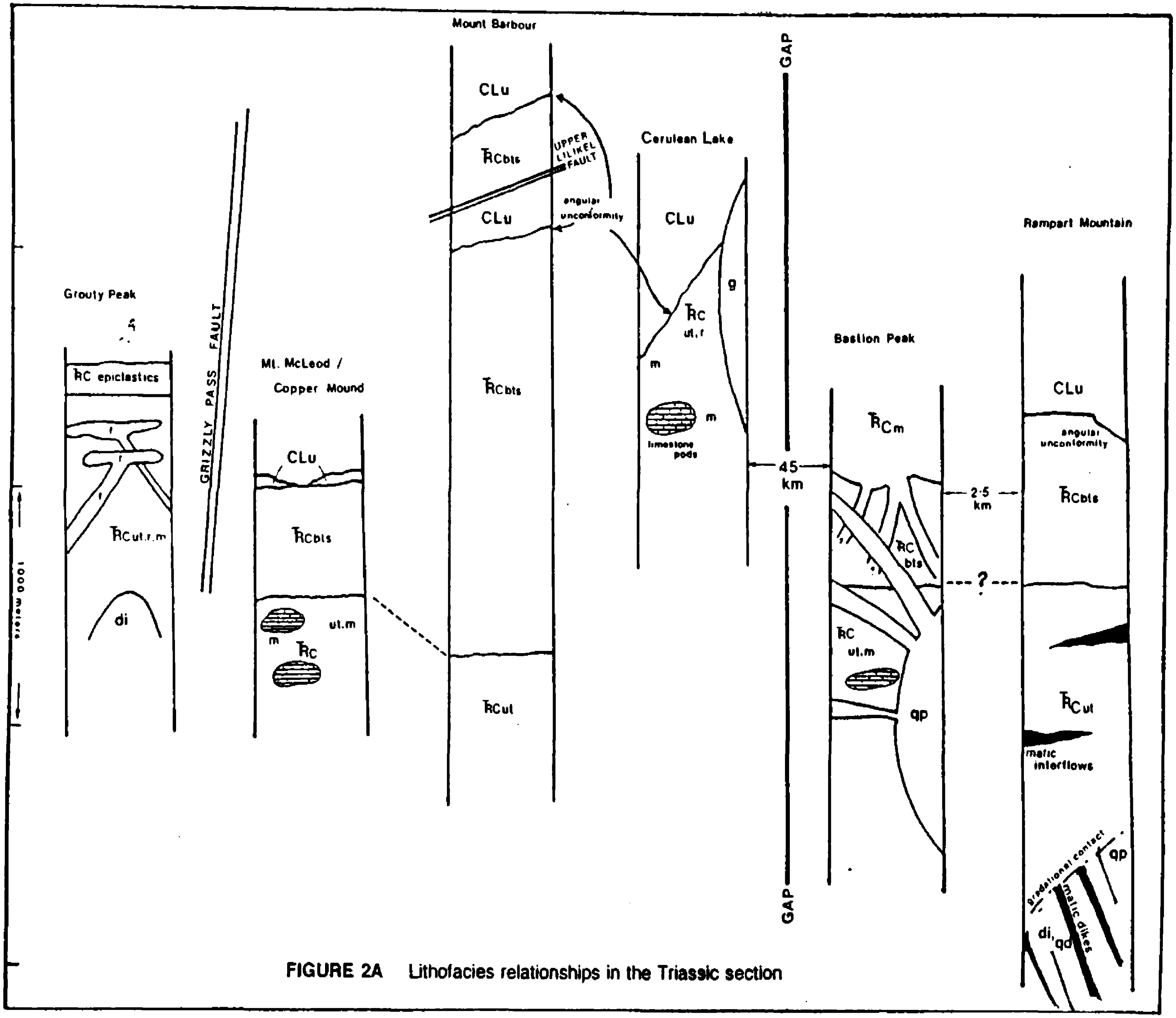


FIGURE 2A Lithofacies relationships in the Triassic section dip, younging to the west. The contact between the **unbedded tuffs** and

the **bedded tuffs and sedimentary rocks** was not observed at this location. Post-Triassic volcanic rocks of the Cerulean Lake unit (informal) overlie the **bedded tuffs and sedimentary rocks** along an angular unconformity that is easily traced across the top of the Rampart Mountain plateau.

Bastion Peak

Unbedded tuffs with **mafic volcanic** interflows make up most of the volume of Bastion Peak. These rocks are intruded by abundant quartz porphyritic and aplitic dikes that emanate from a large body of pale grey quartz porphyry of unknown age that forms a high knob just east of Bastion Peak. All of these rocks are overlain, apparently conformably, by **bedded tuffs and sedimentary rocks**. They dip about 45 degrees west and young to the west. The bedded rocks are dominated by cherty tuffs, but bedded lithic and feldspar crystal tuffs, and limestone breccia are common near the lower contact. Toward the top of the bedded section, the cherty tuffs are crosscut by **mafic volcanic** dikes. The volume of the basaltic andesite dike material increases upward (and upsection) until it overwhelms the bedded rocks. The needly peaks at the top of Bastion Peak ridge, and the northwest continuation of that ridge are composed of basaltic andesite flows and pyroclastic breccias of the **mafic volcanic lithofacies**. Small remnants of an old diorite body crop out at the south end of Halberd's Edge ridge just south of Bastion Peak. The **unbedded tuffs** there contain clasts of the diorite. These **unbedded tuffs** are cut by a well-exposed swarm of pale green andesitic to dacitic dikes. Most of these dikes strike east-west and dip steeply to the north (Stereonet projection, Appendix B, page 134). It is not clear where they belong. They may be Cadwallader arc magmas that made their way through the pre-existing tuffs by way of tension fractures produced by a previous subsidence event. Alternatively, they may be feeders to the breccias and flows of the Cerulean Lake unit that is exposed on Rampart Mountain.

Cerulean Lake/Sungod Mountain

Unbedded lithic tuffs with some **mafic volcanic** interflows make up Sungod Mountain. Some **rhyolite flows** occur on the top of Sungod Mountain, but they are volumetrically minor.

Volcanic and sedimentary rocks of the Cerulean Lake unit overlie the Triassic section on an angular unconformity.

Mount Barbour

The Mount Barbour ridge is almost entirely made up of **bedded tuffs and sedimentary rocks** as described in section 2.4.3. The lower contact is poorly exposed below treeline about 3 kilometres south of Mount Barbour. There, **unbedded tuffs** occur, and are intruded by altered diorite. Volcanic rocks of the Cerulean Lake formation overlie the **bedded tuffs and sedimentary rocks** along angular unconformities on the Mount Barbour peak and on the ridge north of the peak.

Mount McLeod and Copper Mound

Basaltic andesite with abundant limestone pods of the **mafic volcanic lithofacies** crop out below 2150 metres elevation at Mount McLeod and Copper Mound. Near Mount McLeod they are overlain by thin deposits of **unbedded tuff**, but these thin out to the west and are absent at Copper Mound. About 165 metres of **bedded tuffs and sedimentary rocks** form the tops of both peaks. The beds dip shallowly to the southeast at Mount McLeod and are flat-lying at Copper Mound. Sedimentary rocks are more abundant than tuffs in this section; it is dominated by coarse-grained volcanic wackes, grey fossiliferous limestone, limestone-bearing breccia and cobble conglomerate, with volumetrically minor siltstone and shale interbeds. It resembles the middle third of the Mount Barbour section.

A thin skiff of autobreccia of the Cerulean Lake unit overlies the Triassic section at

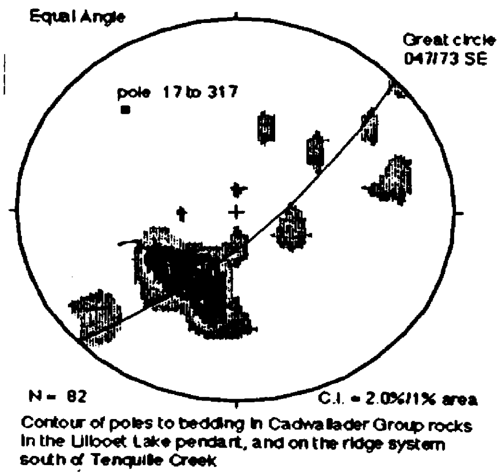
Grizzly Pass to Grouty Peak

Rhyolitic flows and tuffs occur as interflows, dikes and interbeds within coeval **unbedded tuffs** in the northernmost part of the map. Breccias containing clasts of both lithofacies can be observed on the ridge south of Grouty Peak. Quartz crystal tuffs and minor rhyolite flows are intensely sheared by a north-northwest striking 750 metre wide shear zone in Grizzly Pass.

I have not mapped Tenquille Mountain or Goat Peak. During reconnaissance mapping of the slopes north of Goat Peak I encountered a section of bedded volcaniclastic rocks and several different intrusions and dikes. I was not able to determine whether the volcaniclastic rocks belong to the Triassic section or the Cerulean Lake unit.

Owl Creek area - a gap in the data

There is a distance of more than 35 kilometres between the Lillooet Lake pendant and the ridge south of Tenquille Creek. Between these areas I have minimal information about the Triassic stratigraphy and it is difficult to tell whether rocks of a given lithofacies correlate across that distance. To approach this problem I attempted to draw a down-plunge projection using the base of the **bedded tuffs and sedimentary rocks** as a datum. The poles to bedding from this lithofacies define a great circle with a pole that has a 17 degree plunge toward 317 degrees, which represents the plunge of the fold system. The fit onto the great circle suggests that the Triassic rocks south of Tenquille Lake and those in the Lillooet Lake pendant are all folded around the same axial plane, so it is reasonable to assume that they lie within the same thrust plate. Figure 2B shows the relative locations of the bases of the **bedded tuffs and sedimentary rock** sections on a down-plunge projection. Note that the northwest plunge of 17 degrees is steep enough that if a bed is exposed at surface at Rampart Mountain (1980 metres elevation), then its correlative bed



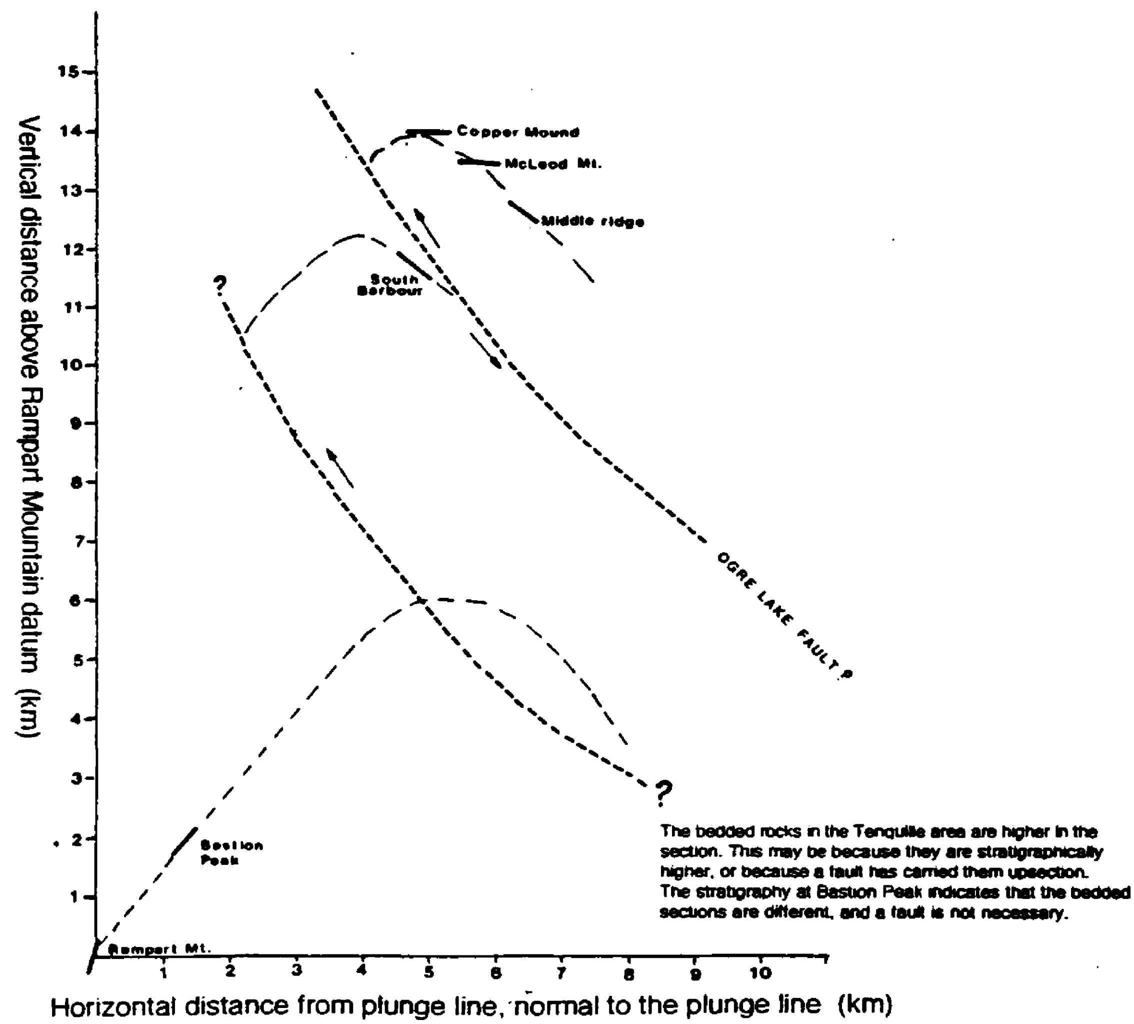
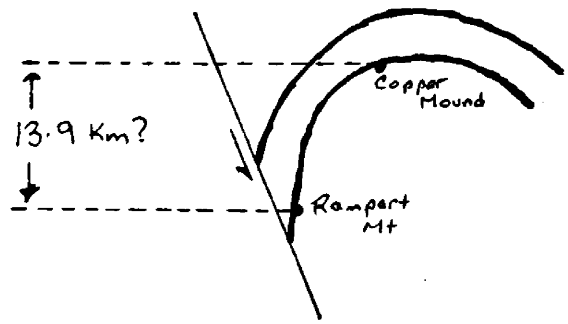


FIGURE 2B Down-plunge projection of the base of the bedded tuffs and sedimentary rocks lithofacies, from Rampart Mountain to Copper Mound

should be about 13.9 kilometres deeper 47.3 kilometres to the northwest at Copper Mound. Yet, at Copper Mound, the base of the bedded tuffs and sedimentary rocks is exposed at 2145 metres elevation. Can this discrepancy be explained by the curvature of a drag fold adjacent to the east-side-up Owl Creek fault, like this?



The geometry of the down-plunge projection shows that it cannot. Taking the curvature of the fold into consideration, the section in the Tenquille area is still at least 6 kilometres higher in the section than it should be. Therefore, the **bedded tuffs and sedimentary rocks** in the Tenquille area are higher in the section than those in the Lillooet Lake pendant. Rocks of the same lithofacies resemble each other because they were deposited in a similar environment and had a similar source, not because they are laterally equivalent.

This interpretation raises a new problem. If the rocks at Tenquille were originally about 6 kilometres higher in the section than those in the Lillooet Lake pendant, we should expect to see a decrease in the metamorphic grade as we move northwest (i.e. upsection). All of the Triassic rocks in the Tenquille/ Lillooet Lake area show effects of greenschist metamorphism. In this study, I have not made a detailed study of the metamorphic mineralogy of these rocks, however I have noted the presence of the metamorphic actinolite in the matrix in thin sections of samples from the entire length of the study area. Epidote and chlorite are universally abundant. If we assume that the geothermal gradient of 40 degrees per kilometre below northeastern Japan (Reference in Hyndman, 1985) is a reasonable one for an island arc setting, we can constrain the difference in temperature due to the 6 kilometres of depth between Rampart Mountain and Copper Mound to as high as

240 degrees. The stability field of actinolite has a temperature range of
about 180 degrees C. for any given pressure (See Figure 2C); 6 kilometres of burial would be accompanied by a difference of about 1.7 kilobars of pressure, which would widen temperature range to about 200 degrees C. So it seems unlikely that we would fail to see a decrease in grade between Rampart Mountain and Copper Mound. On the map the strip of Triassic rocks between Bastion Peak and Mount Barbour looks like a very thick section representing a long uninterrupted period of active volcanism. It is more likely, however that the section is somewhat thinner than it appears. **Bedded tuffs and sedimentary rocks** at Bastion Peak are younger than at least one episode of mafic volcanism, because mafic dikes cut them and mafic flows overlie them. I have not mapped nor seen described any bedded rocks in the area north of Bastion Peak, across the Lillooet River through the Owl Creek valley and up to the west side of Mount Ronayne. My work and mapping from mineral assessment reports indicate that all of this area is underlain by **mafic volcanic rock** and **unbedded tuff**. The plunge of the system may not be consistent along the whole length of the Owl Creek Valley. Also, extension may have occurred during subsidence and breaking apart of the arc. My assumption that the rocks south of the Tenquille Creek and those in the Lillooet Lake pendant lie in the same thrust plate may be incorrect, and there may be repetition of the section on faults that have not yet been mapped. There are good exposures on the west flank of Mount Ronayne, so there is good potential for resolving some of these uncertainties and getting a better picture of how this arc system looked in this area.

Bedded rocks occur on the east ridge of Mount Ronayne on the other side of the Spetch Creek pluton (G. McLaren, pers. comm. 1990). A thick section of white-weathering bedded rocks in the cliffs directly northeast of the new town of X'itolacw is visible from Pemberton. They have never been mapped, but I suspect that they are cherty tuffs because they are so resistant. Although there is structural complexity between these sections of bedded rocks and the sections I have described, study of them would provide

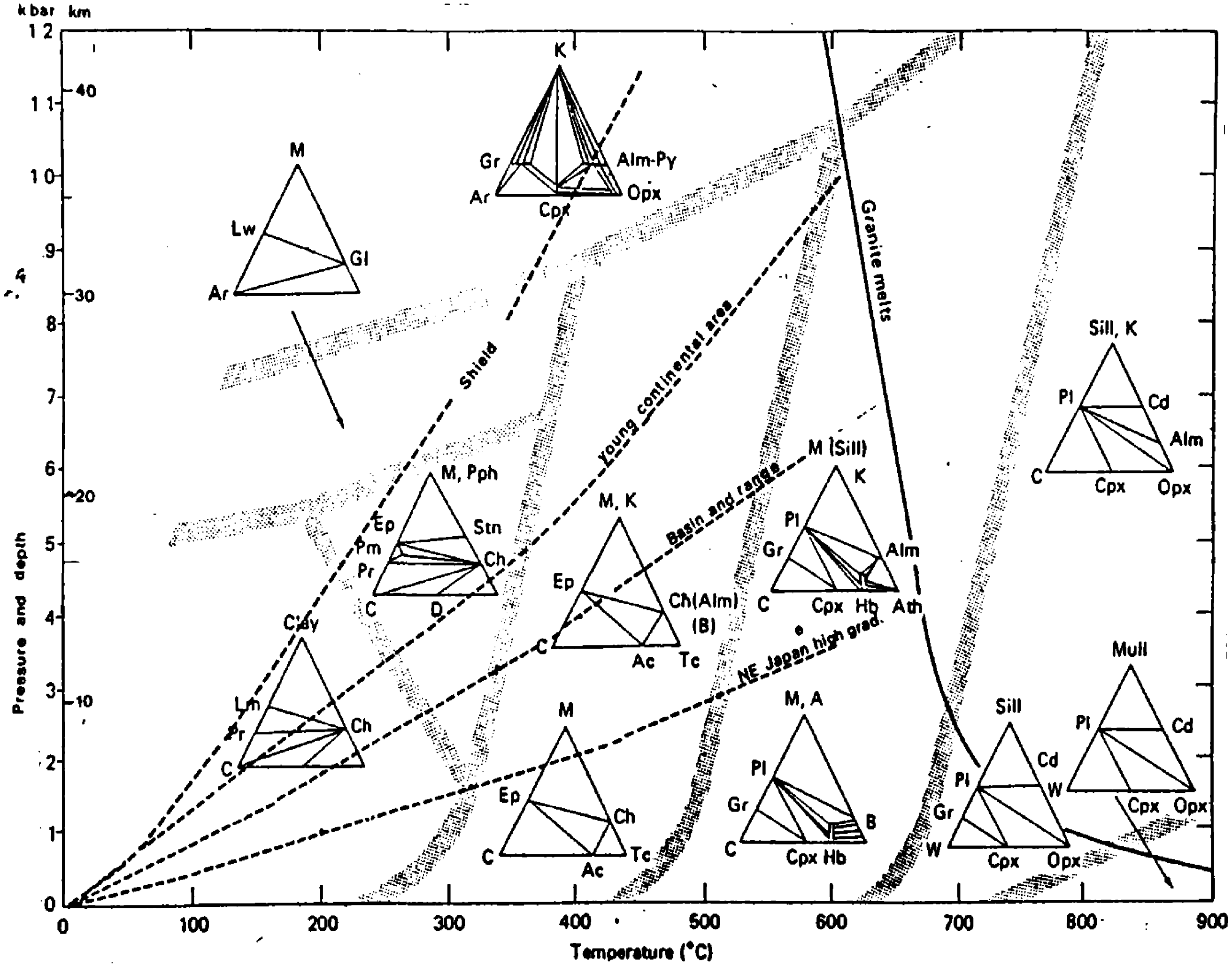


FIGURE 2C Petrogenetic grid, from Philipots (1990) Superimposed representative geothermal gradients from Hyndman (1985)

valuable insight about the spatial arrangement and subsequent deformation of this part of the arc system.

2.1.8 Correlation with the Cadwallader Group

Correlation of the Triassic rocks in the Tenquille/Lillooet Lake area with the Cadwallader Group is based on similarities with Cairnes' (1937) descriptions of rock types and stratigraphic sequences in Cadwallader Creek near Bralorne. The **mafic volcanic** and **unbedded tuff lithofacies** have important features in common with the Pioneer Formation; the **bedded tuffs and sedimentary rocks** resemble the Hurley Formation.

In describing the Pioneer Formation, Cairnes described light to dark green fine-grained andesitic greenstones with abundant associated pyroclastic deposits. He claimed that the formation is essentially volcanic, but he noted intrusive textures locally. He saw textural gradations between rock types which caused difficulty in distinguishing flows, dioritic intrusions, and tuffaceous rocks from one another. He found that thicknesses and compositions of particular rock types show considerable lateral variation. The rock types and their interrelationships that Cairnes observed are the same as those that I saw in the Tenquille/Lillooet Lake area.

A notable difference between the two areas is the occurrence of abundant amygdaloidal phases in the flows in Bralorne and Cadwallader Creek. Cairnes observed that the rocks in the "northern area" (presumably north of Bralorne to Gun Lake) are more amygdaloidal than those farther south up the Cadwallader valley. I observed no amygdaloidal rocks in the Tenquille/Lillooet Lake area, although in the samples I studied in thin section, amygdaloidal basalt clasts are present in all of the **mafic volcanic** pyroclastic breccias, and in some of the **unbedded tuffs** and volcanic wackes of the **bedded lithofacies.**

Pillow basalts and pillow breccias that Rusmore described at the base of the Pioneer formation are intruded by the Permian Bralorne Igneous Complex and may have been basement to the Cadwallader Group (Schiarizza, pers. comm, 1991). Pillow basalts were not observed in the Tenquille/Lillooet Lake area.

The Hurley formation overlies the Pioneer formation conformably in the Bralorne area. Like the **bedded tuff and sedimentary rock lithofacies** in the Tenquille/Lillooet Lake area, the Hurley Formation is mainly sedimentary but contains intercalated tuffs, tuffaceous sediments and andesitic flows. Cairnes described limestones, argillites, conglomerates and agglomerates, along with bodies of chert and "banded cherty halleflinta." Clasts in the sedimentary rocks are green and whitish volcanic rocks, and argillaceous and cherty sediments. He also noted some granitic and dioritic clasts. Laterally discontinuous limestone-bearing breccias and conglomerates are not volumetrically abundant, but they are so distinctive that they have become the hallmark of the Hurley Formation to mappers and prospectors in the region. Cairnes' "cherty halleflinta" outcrops are not described in detail; he wrote only that they are light grey in colour, fine-grained and dense. They may be equivalent to the rocks I have called "cherty tuffs" that occur in the higher parts of the **bedded lithofacies** in the Tenquille/Lillooet Lake area.

The **bedded tuffs and sedimentary rocks** resemble Rusmore's transitional subdivision of the Hurley formation.The overlying section of purely sedimentary rocks that she described near Eldorado Mountain does not have an equivalent in the Tenquille/Lillooet Lake area. Distinctive clasts of fine-grained tuff with a striking robin's-egg blue colour are present in the conglomerates that Rusmore described. I did not observe those clasts in Triassic conglomerates in the Tenquille/ Lillooet Lake area.

Fossils from limestones from the Tenquille area, Cairnes' Hurley Formation, and Rusmore's transitional division have been identified as Upper Triassic in age. I collected one conodont-bearing sample from the middle third of the Mount Barbour section which has been assigned an early Norian age (Orchard, written comm., 1991). Nine conodont-bearing samples from the Eldorado Mountain area gave Early to Middle Norian ages (Orchard *in* Rusmore, 1985). It is important to note that in both areas Norian fossils occur in rocks that formed after volcanic activity began to abate.

2.2 The Gambier Group

2.2.1 Introduction

Rocks belonging to the Gambier assemblage were first recognized in the Lillooet Lake pendant by Journeay in 1988 (Journeay and Csontos, 1989). They crop out west of the Owl Creek fault and can be observed in the pendant, and north of Pemberton in the hills northwest of Ivy Lake and on the Mount Fraser ridge. Their distribution is shown by Riddell et al (1991), where the rocks are referred to by their local name, the Fire Lake Group.

The rocks form three mappable units. The lowest unit is correlative with the Peninsula Formation, and is overlain conformably by an andesitic fragmental unit, the Brokenback Hill Formation. A northwest-striking, east-dipping fault (informally called the Warm Lake fault) cuts out an unknown amount of section and separates the folded Peninsula and Brokenback Hill rocks from the structurally higher unnamed unit to the west. I was able to give the unnamed unit and its relationship with the Pemberton diorite complex only a cursory examination. It may belong to the Gambier Group.

2.2.2 Peninsula Formation

The top 100 metres of the Peninsula Formation is the lowermost part of the Gambier Group that is exposed in the Lillooet Lake area. The well-bedded and graded section is exposed directly west of the Owl Creek Fault, and comprises interbedded volcanic wacke, siltstone, black shale, and white weathering feldspar-rich tuffaceous sandstone. Some of the tuffaceous sandstones and wackes are quartz-bearing and most have a slightly calcareous matrix. Shaly beds are millimetres to centimetres thick south of Ure Creek. North of Ure Creek the shaly beds are tens of metres thick and make up a major percentage of the section. Some of the shales and siltstones contain up to 5% pyrite along laminae. Plant

fossils can be found locally in thin shaly beds in the tuffaceous sandstones.
Shaly rip-up clasts are common. Coaly fragments and rounded pebbles of feldspar-phyric volcanic rocks occur in pebble bands in the wackes. Brown weathering dark grey massive limestone concretions 10-30 centimetres across are also found in the wacke. These concretions contain belemnites north of Ure Creek.

Pumice fragments are present within volcaniclastic sedimentary rocks in the westernmost exposures on the Lillooet River road (across the river from the Pemberton airstrip). This outcrop is isolated so I am not certain where it belongs. It could be part of the Peninsula Formation, or it may be part of the unnamed unit that structurally overlies the breccias and flows of the Brokenback Hill Formation.

I studied 5 thin sections of volcaniclastic sedimentary rocks from the Peninsula Formation (see Appendix A). There is great variety in the formation so this should by no means be considered representative suite. The two fine-grained rocks studied are composed mainly of quartz and plagioclase feldspar, with abundant dark unidentified opaque clay minerals. Both contain 5 to 10 % carbonate material. In one sample the carbonate grains are much larger than the average grain size, and probably formed during diagenesis. In the other sample, the carbonate grains are rounded and similar in size to the quartz and feldspar grains, so they may be clastic. Fine-grained chlorite is evenly distributed throughout the two fine-grained samples. In the two volcanic wackes studied, equant, zoned plagioclase crystals are the largest and most abundant clast types. They contain lesser amounts of hornblende crystals replaced with greenish-yellow chlorite. Chlorite blobs with deep blue interference colours are probably altered mafic lithic fragments. A few tiny interstitial quartz grains are present in each of these samples. This does not accurately represent what is seen in outcrop; abundant quartz grains that are big enough to see in hand sample were present in about a third of the sandstone and wacke outcrops that I mapped. In both of the samples the groundmass is very fine grained and contains tiny plagioclase laths and fine-grained chlorite within isotropic material. The fifth sample contains abundant carbonate crystal

fragments in dusty, isotropic matrix. Quartz, fine-grained felsic volcanic clasts,
and pyrite crystals are also present. These rocks differ from the bedded facies in the Cadwallader Group in that they contain a much lower proportion of volcanic lithic clasts relative to crystal fragments.

2.2.3 Brokenback Hill Formation

An andesitic unit dominated by coarse autobreccia overlies the Peninsula Formation. The conformable contact and the bottom of this formation are beautifully exposed west of the fault saddle west of Bastion Peak. This unit also contains pale green feldspar crystal tuffs and beige weathering feldspar and hornblende phyric andesitic flows.

Pale green weathering sandy tuff at the base of the Brokenback Hill Formation displays 30 centimetres thick trough cross-beds at its base. Isolated mauve and green andesitic breccia blocks appear within the sandy tuff, and then increase in volume upsection so that within a few tens of meters the rock is entirely composed of breccia. Breccia clasts are commonly 3-6 centimetres across, but are locally much larger. Clasts over a metre across occur in this unit south of Ure Creek. Some clasts are rounded with reaction rims; others are angular with distinct edges. Angular and rounded clasts are seen together in some outcrops.Clasts are feldspar-phyric and contain hornblende phenocrysts. Jasper clasts are present locally. Jasper is also seen in the interstices between closely packed blocks. Clast to matrix ratios range from 80/20 to 30/70. The matrix is compositionally equivalent to the clasts, although hornblende phenocrysts are not as abundant in the matrix. This unit is very resistant and forms ridges and benches.

I studied eight samples of Brokenback Hill breccias, flows, and tuffs in thin section. They all contain equant zoned plagioclase crystals, and hornblende crystals and crystal fragments. In the breccias most of the clasts are feldspar and hornblende andesite fragments of the same composition as the matrix. Fine-grained dacitic clasts are present in all of the samples, but they are not abundant. Hematite is abundant in the breccias as clots,

and outlining or completely replacing clasts, and finely disseminated
throughout the matrix. The hematite is responsible for the distinctive mauve colours of the breccias. Hematite is not present in the flows; consequently they have relatively bland beige and pale green colours even though their composition is nearly identical to the breccias. The flows do contain some accessory magnetite.

2.2.4 "Upper" unnamed unit

I have included the rocks that lie west of the informally named "Warm Lake fault" into this catch-all unit, even though there several distinctive rock types within it, because I have not covered this area well enough to provide an accurate map of their distribution. Greenstones with diorite intrusions are exposed adjacent to the fault; the other parts of the section lie to their southwest. Lithic and lapilli tuffs interbedded with volcaniclastic black shale, siltstone, pale green siliceous mudstone and minor conglomerate overlie the greenstones. These rocks are well exposed in large cliffy outcrops along the road on the west shore of Tenas Lake. (The rocks in these outcrops have been overturned by creep that probably occurred since Pleistocene time. They can be observed in place in the hills above the cliffs.) Farther west, pyroxene crystal tuffs or flows and minor thin beds of chert are interbedded with the tuffs and sedimentary rocks. Some of the chert beds weather a distinctive yellow colour. These rocks are bordered to the southwest along their entire length of the Lillooet Lake pendant by granodiorites, quartz diorites, and diorites of the Pemberton Diorite Complex. The contact zone is more than a kilometer wide in places. South of Ure Creek the granitoid rocks intrude the volcaniclastic rocks along hundreds of near-vertical, bedding-parallel sheets (Plate 2.2.4a). Foliations in these intrusive rocks are parallel to the sheet boundaries. North of Ure Creek, the east edge of the contact zone is marked by increasing recrystallization and foliation in the volcaniclastic rocks, and isolated small bodies and apophyses of granodiorite and quartz diorite. The relative abundance increases westward; at the west end of the contact zone coarse clean granitoids contain rounded and

PLATE 2.2.4a Quartz diorite sheets are injected parallel to bedding in volcaniclastic beds in the unnamed unit west of the "Warm Lake" fault.

angular dark grey, recrystallized inclusions of metasedimentary rocks (Plate 2.2.4b).

2.2.5 Correlation with the Gambier Group

Correlation of these rocks with the Gambier Group is based on lithological and fossil similarities with the Peninsula and Brokenback Hill formations on the west side of Harrison Lake as described by Arthur (1986), and in the Fire Lake pendant as described by Lynch (1990).

The top 100 metres of the Peninsula Formation are exposed in the Tenquille/Lillooet Lake area. Arthur and Lynch describe some features in the Peninsula Formation that I observed in the Lillooet Lake pendant; namely an up-section increase in tuffaceous material, coaly wood fragments in sandstones, plant fossils, and belemnites. Buchias are very abundant in the sections described by Arthur and Lynch but I did not find any in the Lillooet Lake pendant. Fossils collected by Arthur from the Peninsula Formation in the Harrison Lake area have been assigned Lower Berriasian to Lower Valanginian ages (Early Cretaceous). The fossils that I collected in the Lillooet Lake pendant were submitted to the Geological Survey of Canada. They have not yet been identified.

The nature of the Peninsula/Brokenback Hill contact in the Lillooet Lake pendant matches Arthur's (1986) description of that contact exposed above the shoreline of Harrison Lake west of Long Island. Lynch subdivided the Brokenback Hill Formation into four members. The rocks I have mapped as Brokenback Hill match his descriptions of the lower two members; a well-bedded unit dominated by feldspar crystal tuff, overlain by an andesitic fragmental member with feldspar and amphibole-phyric flows and breccias.

As mentioned above, I can only tentatively correlate rocks west of the Warm Lake Fault with the Gambier Group. They may correlate with upper parts of the Brokenback Hill Formation; alternatively they may be Peninsula Formation rocks that were shoved over the Brokenback Hill Formation on a thrust that was later rotated to its present position. (See discussion of this fault in Section 3.3.2)

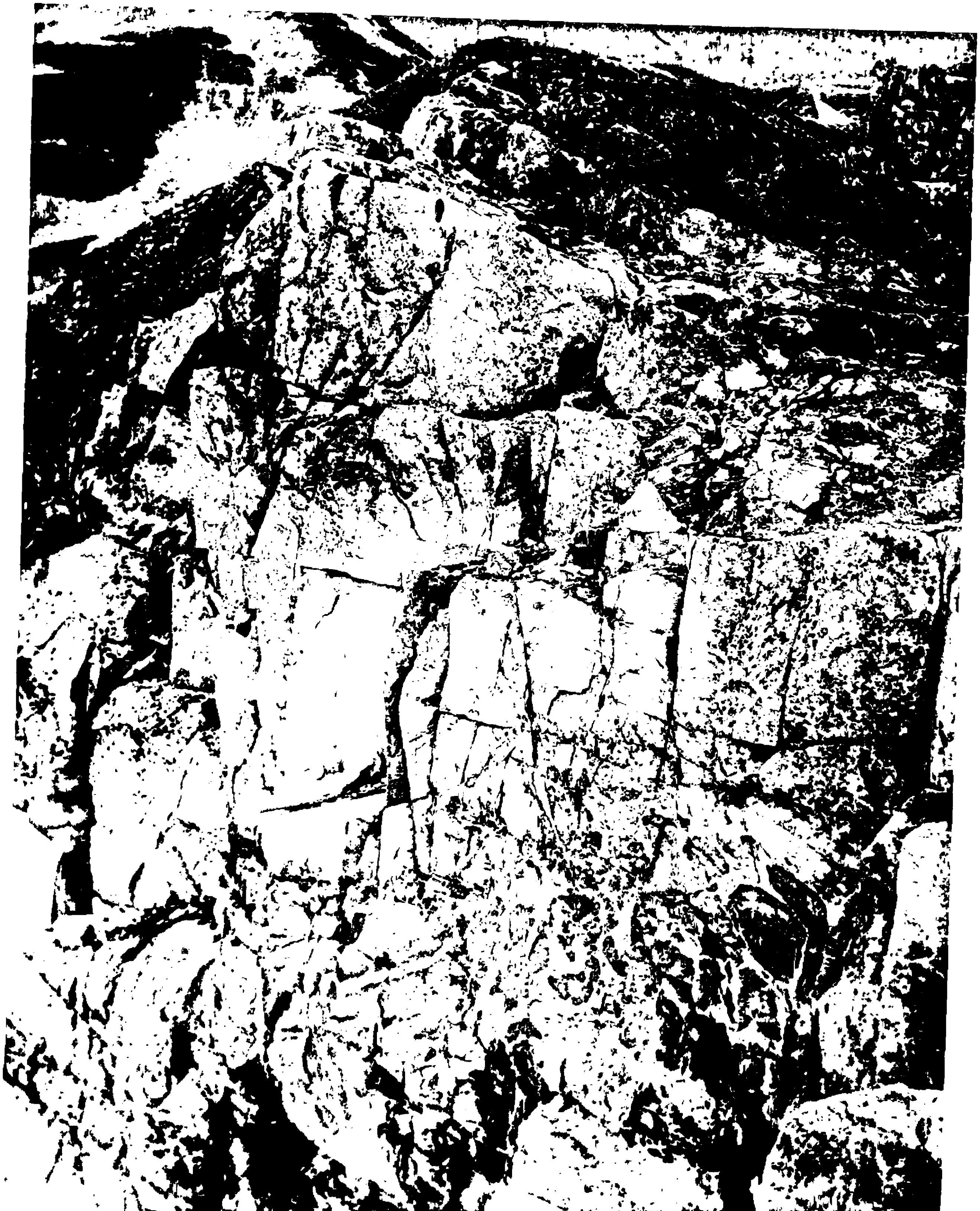


PLATE 2.2.4b Dark grey recrystallized inclusions of metasedimentary rocks of the unnamed unit in clean granitoids of the Pemberton Diorite Complex, on the ridge north of Ure Creek

2.3 Cerulean Lake unit

2.3.1 Introduction

On the ridge system south of Tenquille Creek, a relatively thin section of volcanic and sedimentary rocks sits unconformably on the Cadwallader Group (See Figure 2D). A lower volcanic member consists of dacitic to intermediate volcanic breccias and flows, and is overlain by a sedimentary member. This section does not resemble any known Cadwallader or Tyaughton Group stratigraphy. It is well exposed in the area surrounding Cerulean Lake. A thin skiff (about 30 metres) of the volcanic breccia overlies the Triassic section on Copper Mound. On Rampart Mountain in the Lillooet Lake pendant, breccias of the volcanic member overlie Cadwallader Group bedded tuffs and sedimentary rocks along an angular unconformity.

These rocks are clearly younger than the Cadwallader, but they have suffered more metamorphism and deformation than the Tertiary rocks in the area, so they are probably Jurassic or Cretaceous. Two granitoid clasts from Cerulean Lake conglomerate have yielded Late Jurassic ages (157.6 +/- 20 Ma and 158 Ma, R. Friedman, written communication, 1991). Cadwallader Group limestones beneath the unconformity contain lower Norian conodonts (see Appendix C), so the unconformity represents a time gap of at least 50 million years.

I have not found fossils in the Cerulean Lake unit rocks; my attempts to date siltstones using pollen have failed. I suggest that these rocks be referred to as the Cerulean Lake unit until a regional correlation can be established.

2.3.2 Volcanic member

The volcanic member consists of maroon to mauve and green breccia, with associated beige or pale green feldspar and hornblende-phyric flows, mauve and green lapilli tuffs, pale green feldspar crystal tuffs, and minor mauve and green epiclastic conglomerate and coarse sandstone.

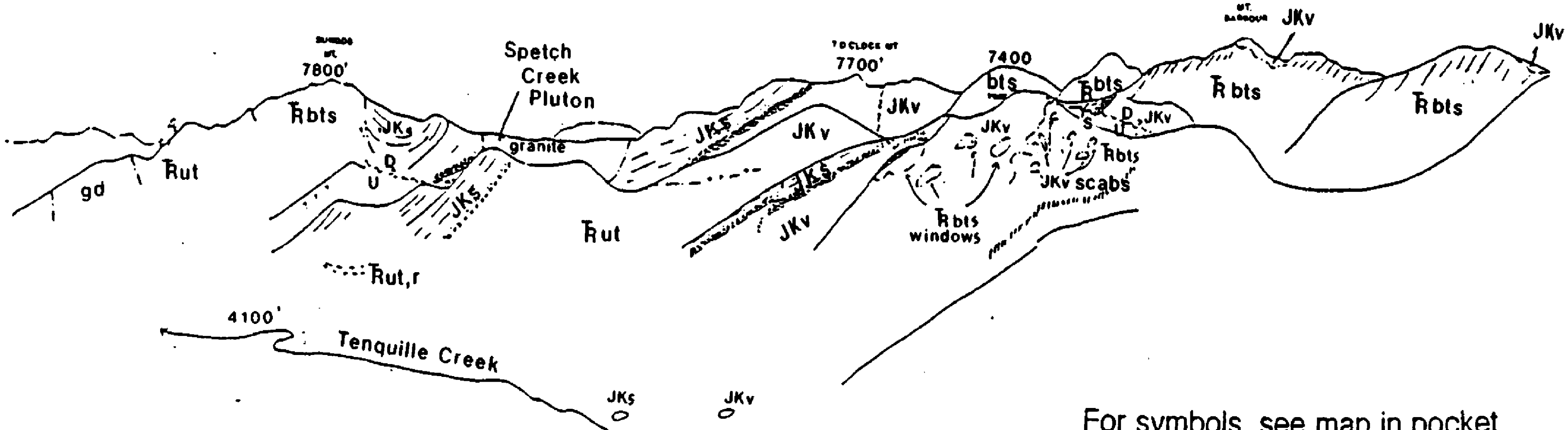


FIGURE 2D View south across Tenquille Creek from Grizzly Pass

Breccia clasts include fine-grained dacitic rock fragments, coarse feldspar-phyric and aphanitic andesite fragments, large plagioclase crystal fragments, cherty tuff and chert, and hornblende crystals that have been almost entirely replaced by epidote or chlorite. I saw rare vesicular maroon basalt clasts in outcrop at Mount Barbour, and one of the thin section samples from that location contains basalt clasts. The composition of the matrix varies from intermediate andesite to dacite. Interstitial fine-grained quartz is present in the matrix of all of the breccia samples in amounts ranging from less than 5% to 35 - 40%. Hematite is abundant in all of the breccias, and it is responsible for strong to intense colours of mauve, blood-red, and maroon.

The pale green flows at Mount Barbour contain equant and lath-shaped plagioclase crystals and hornblende laths that have been replaced by epidote or chlorite. These are in fine-grained dacitic matrix of feldspar and quartz, with chlorite, epidote, and actinolite. Dikes of the same material cut the cherty tuffs at the top of the Mount Barbour Triassic section. A strongly altered sample from north of Seven O'Clock Mountain contains large clinopyroxene phenocrysts in a similar matrix.

Epiclastic rocks occur in a small pocket just north of the north-side-up upper Lilikel fault. They are weakly sorted coarse sandstones and pebble and granule conglomerates that consist almost entirely of mauve/maroon and green volcanic clasts. About 10% of the clasts are diorite. They are redeposited equivalents of the breccias, which they grade into laterally.

The thickness of the volcanic member varies laterally. Above the west end of the Lilikel property and just west of Cerulean Lake the volcanic member is missing altogether and the sedimentary member sits directly on Cadwallader Group rocks. This indicates that the volcanic member was deposited on ground with variable topographic relief, or that there is an unconformity between it and the sedimentary member, or both. The maximum thickness of the volcanic member is about 300 metres.

These rocks are strikingly similar in appearance to the andesitic breccia and flow section of the Brokenback Hill Formation in the Lillooet Lake pendant and on Mount

Fraser. Comparison of the thin sections shows that the Cerulean Lake rocks are dacitic whereas the Brokenback Hill samples are generally andesitic.

2.3.3 Sedimentary member

The sedimentary member contains boulder, cobble, pebble, and granule conglomerates, (see Plate 2.3.3) sandstones, grey sandstones, and dark grey shales. All of the Cerulean Lake unit conglomerates contain 10 to 50% granitoid clasts. Beyond that the clast composition and the internal stratigraphy of this member varies from location to location.

In the area around the Lilikel property, the dominant clast type in the conglomerates is white-weathering, pale green hard siliceous rock. In thin section this rock is a fine felsic feldspar crystal tuff. Another common clast is a medium-grained sandstone consisting of 60% monocrystalline quartz and 40% rounded plagioclase grains. Near the Lilikel there are at least two separate conglomerates; above the property I mapped a conglomerate that overlies shales and siltstones. This conglomerate contains about 5% shale clasts, and that suggests that cannibalization of the lower beds provided some of the clast supply for this higher conglomerate.

On the north ridge of Mount Barbour, interbedded feldspar-rich siltstones and pebble conglomerates with felsic, intermediate, and mafic volcanic rock and cherty sedimentary clasts, directly overlie pale green flows of the volcanic member. This lower part of the section contains no boulder conglomerate and no granitoid clasts. About a third of the way up the section there are a few tens of meters of purple sandstones, siltstones, and conglomerates with purple clasts. The source of this material was clearly the breccia of the volcanic member. Rare diorite boulders appear in the pebble conglomerates about halfway up the section, and they become more abundant toward the top. The conglomerates are interbedded with feldspar-rich sandstones, quartz and feldspar wackes, and some coarse beds full of angular white-weathering clasts. A few granodiorite boulders can be found near the top of the section. Thin-section study of two Mount Barbour sandstones

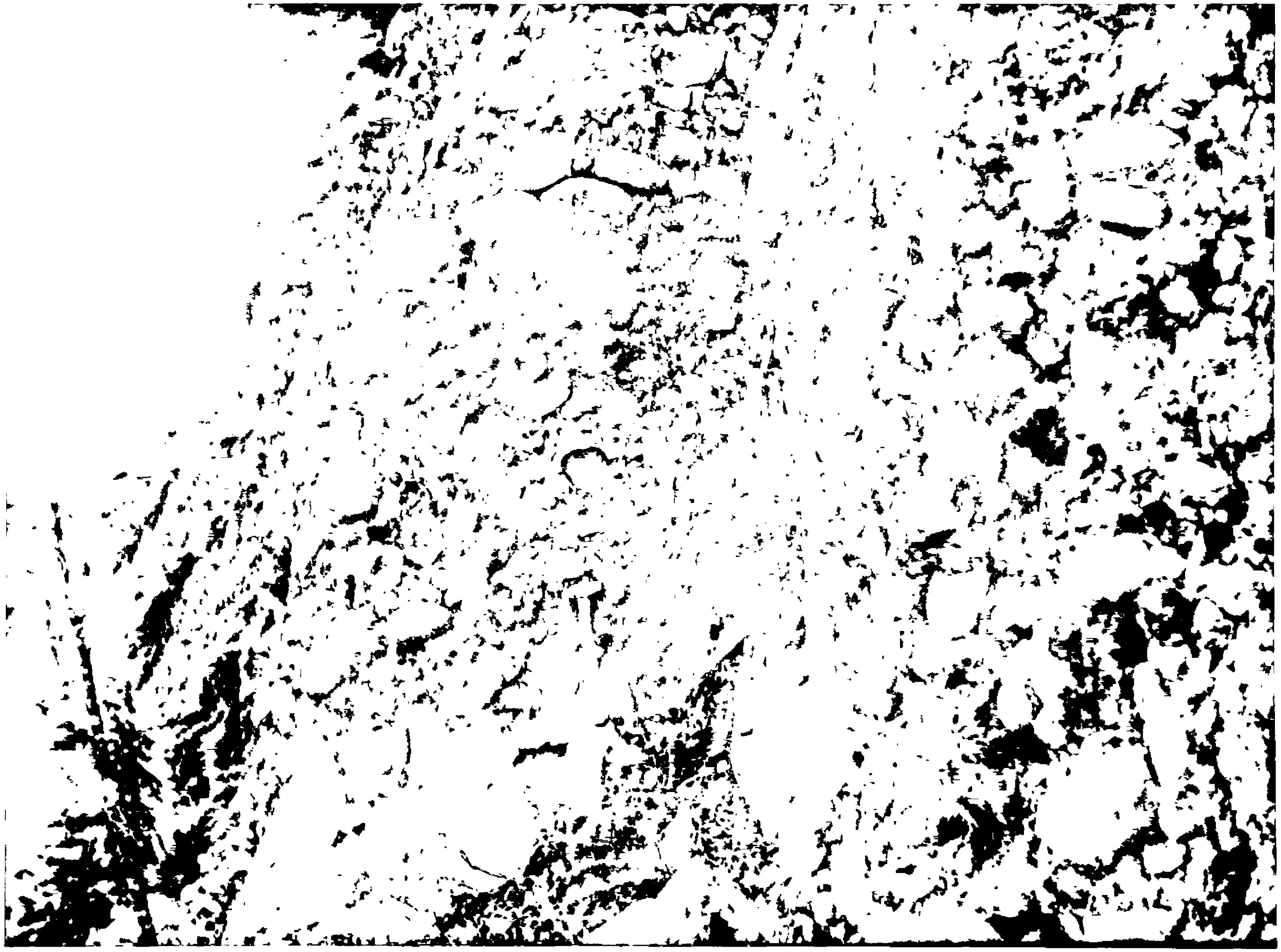


PLATE 2.3.3 Boulder conglomerate of the Cerulean Lake unit sedimentary member

shows that they contain a mixture of well-worn clasts (fragmented, ragged and
altered plagioclase grains, strained quartz, altered volcanic rock fragments), cherty tuff, and very fresh plagioclase crystal fragments. The bedding in many of the sandstone layers was swirled into large whorls while soft.

The sequence of sedimentary rocks exposed in the high meadow west of Cerulean Lake overlies basalt of the **mafic volcanic lithofacies** of the Cadwallader Group. Some sandstones from this section contain abundant basalt clasts. Most of the sandstones are rich in feldspar crystals and volcanic lithic fragments and no quartz; they have salt-and-pepper colouring. Very fine-grained hard white beds are common. About one half of the clasts in the conglomerate in that area are fresh coarse granodiorite. Other clast types are aphanitic white-weathering rocks (probably felsic volcanic rocks), argillite, gneissic and mylonitic rocks, banded sedimentary and metasedimentary rocks, and rare black chert. Relatively few volcanic rock clasts are present in the conglomerate there.

Above the southwest shore of Cerulean Lake, on the west flank of Sungod Mountain, boulder conglomerate overlies a thin section of mauve and green breccia of the volcanic member. About half of the clasts are coarse granodiorite; there are also feldspar-phyric volcanic rock clasts and some black shale and aphanitic green volcanic rocks. I saw no chert clasts. The boulder conglomerate grades up into granule conglomerate, volcanic wacke, brown and white weathering, cross-bedded sandstone, and some fine grey quartz and feldspar sandstone and black siltstone. A few of the sandstone beds are very rich in quartz. The entire section is rich in feldspar. Preserved thicknesses of the sedimentary member vary, and I never saw the top of it. The thickest unfaulted section that I have walked through is the one at the Lilikel property; it is just over 300 metres thick.

2.4 Tertiary volcanic rocks

Chipmunk Mountain, just north of Tenquille Mountain, is a Tertiary volcanic center. Dikes and small isolated outcrops of related basalt flows, volcanic breccias and rhyolite are found throughout the map area. These rocks are especially abundant in areas within 10 kilometres of Chipmunk Mountain, but I occasionally stumbled across small patches of them in the Lillooet Lake pendant. Flows occur at elevations above about 1830 metres (5500 feet); they are preserved in little hollows and valleys. Below that elevation these rocks

form dikes. It appears that the topography of this area was similar to the present day topography, but not so deeply incised.

The orientation of the Tertiary dikes are plotted on a stereonet (Appendix B, page 103); they show no preferred orientation direction.

The Tertiary rocks are unmetamorphosed and have distinctive drab brown and beige colours; the mafic rocks are often punky, and outcrops are always crumbly or flaggy.

The basaltic rocks commonly contain euhedral biotite crystals up to 5 millimetres across. In the breccias near Grizzly Pass, basalt is the dominant clast type, and they also contain biotite flakes and large clear anhedral quartz eyes. Rhyolites are bubbly and contain 2-3 millimetre quartz eyes. Thin section study of a mafic flow shows that equant pyroxene crystals are almost as abundant as the biotite. Apatite laths are common. Equant, zoned plagioclase crystals are present in all three of the rocks studied in thin section. Staining shows that all three samples have abundant fine-grained potassic feldspar in the matrix.

A regolith is preserved beneath the flows on the north side of the Grizzly Pass shear zone (J.M. Pautler, pers. comm. 1991). I found several pieces of silicified logs in a stream gully below the regolith.

Thin, flat-lying basalt flows of Mio-Pliocene age form plateaus at high elevations in many parts of south-central and south-west British Columbia. Chipmunk Mountain is a member of a chain of centres referred to as the "Pemberton belt" by Bevier (1983), which is an arc that formed above the subducting Juan de Fuca plate. Most of the Miocene rocks are classified as olivine basalts (Bevier et at 1979); however, I saw no olivine in the samples I collected in the Tenquille/Lillooet Lake area.

CHAPTER 3 STRUCTURE

3.1 Introduction to Chapter 3

The structural grain throughout the Coast Belt is marked by north-northwest striking fault systems, northwest-striking plutonic belts and pendant elongations. The generally accepted interpretation is that of Monger et al (1982); which is that this structural fabric formed as a response to the collision of the Insular Superterrane with the already-accreted Intermontane Superterrane. This interpretation is challenged by van der Heyden (1992), who believes that these features can be understood as the result of intra-arc compression. The Mid-Cretaceous to early Tertiary age of formation of the structural grain is not disputed.

The structural history of the southern Coast Belt is the focus of an ongoing study by Murray Journeay of the Geological Survey of Canada. Journeay has sub-divided the southeast flank of the Coast Belt into three tectonic domains; the Western Coast Belt, which is structurally overlain by the Central Coast Belt, which is itself structurally overlain by the Eastern Coast Belt. The boundary between the Western and Central Coast Belts coincides with steeply-dipping reverse faults of the Coast Belt Thrust System (Journeay and Friedman, in press; Journeay, 1990). These faults are part of a crustal ramp structure developed along the east flank of the Insular Superterrane in late Cretaceous time (97 to 91 Ma) (Journeay, pers. comm., 1992). The Coast Belt Thrust System consists of two distinct structural domains; a lower and upper plate, which are separated by an imbricate zone. Rocks in the Tenquille/Lillooet Lake study area lie in the lower plate of the Coast Belt Thrust System.

Rocks in the Tenquille/Lillooet Lake area display greenschist metamorphic fabrics such as penetrative shear foliations and mineral lineations, overprinted by discrete, through-going brittle shear zones and gouges.

The most important structure in the Tenquille/Lillooet Lake is the Owl Creek fault. It juxtaposes rocks with very different formational and structural histories; the Triassic Cadwallader Group on the east and the Cretaceous Gambier Group on the west (See Figure 3A).

3.2 Structural zones in the Tenquille/Lillooet Lake area

The structural style varies across the Owl Creek fault, and it also varies along the length of the Owl Creek fault within the hanging wall. In order to simplify the description of the structural features I have divided the study area into four structural "zones" (Figure 3A).

I treat the Owl Creek fault as a zone within itself. Zone 1 includes rocks found west of the Owl Creek Fault that lie within the Lillooet Lake pendant and as far north as the Mount Fraser ridge. The rocks in Zone 1 belong to the Peninsula Formation, the Brokenback Hill Formation, and the unnamed unit of the Gambier Group. Zone 2 includes the area within the Lillooet Lake pendant that lies east of the Owl Creek Fault, and includes Cadwallader Group rocks, plus breccias of the Cerulean Lake unit volcanic member that overlie the Cadwallader Group along an angular unconformity on Rampart Mountain. Zone 3 encompasses the Tenquille Creek area, where Cadwallader Group rocks and the overlying Cerulean Lake unit are exposed. All of the rocks in Zone 3 lie east of the Owl Creek fault, in the hanging wall.

3.3 The Owl Creek fault zone

The Owl Creek fault strikes north-northwest and dips very steeply to the northeast.I have observed the Owl Creek fault in two locations; on the logging road that runs along the south side of the Lillooet River just east of Pemberton, and in the saddle west of Bastion Peak.

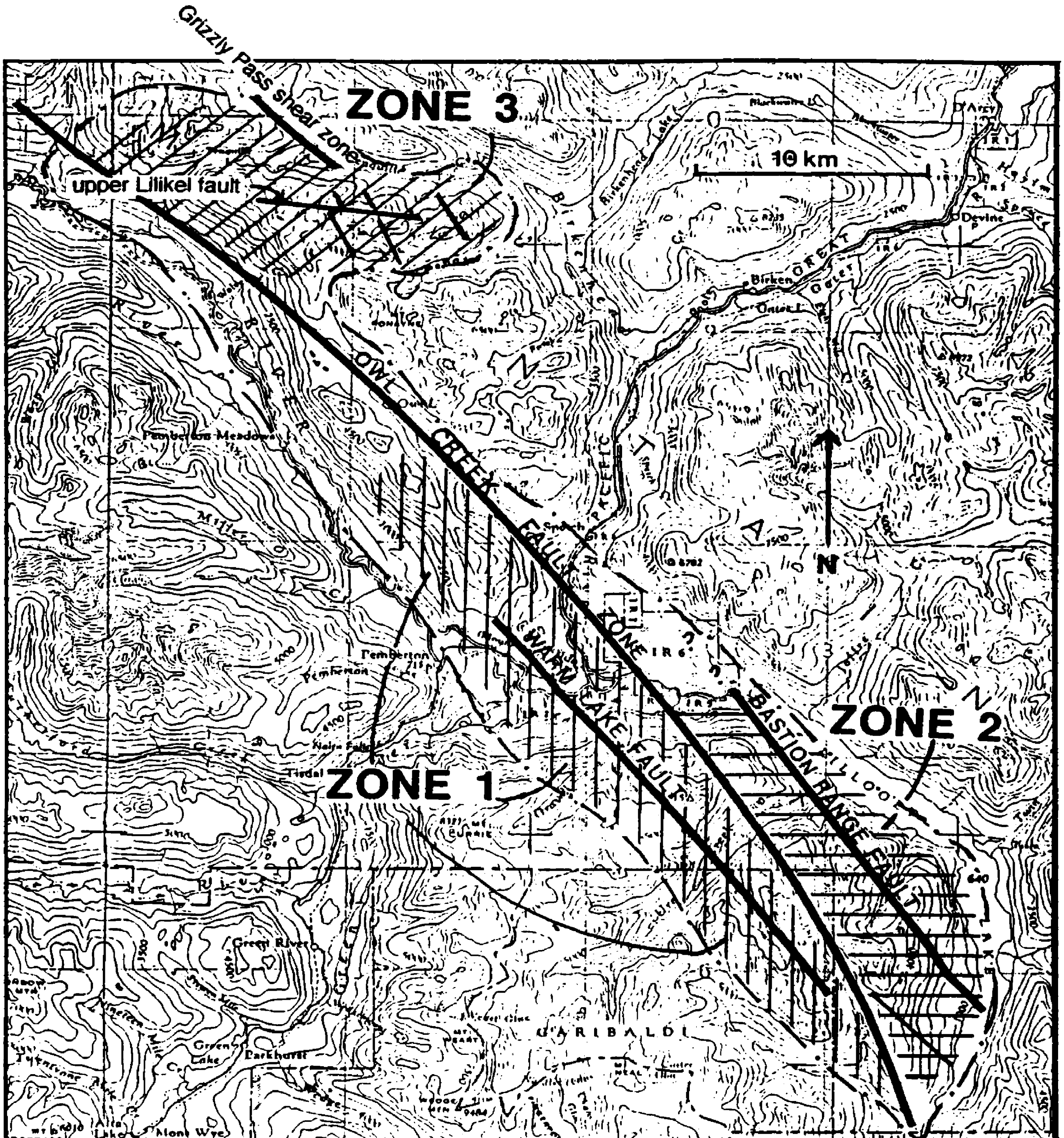


FIGURE 3A Structural zones in the Tenquille/Lillooet Lake area

- Lillooet River road - The Lillooet River road exposure of the Owl Creek
fault can be reached easily without a four-wheel-drive vehicle. There, the zone of intense shearing is nearly a kilometre wide, and affects the volcanic rocks and the quartz diorites that intrude them (see map in pocket). Where they are competent enough to be recognized, the volcanic rocks affected by the shear zone are mostly fine-grained pale greenstone with epidote clots. They resemble the basaltic andesite flows of the mafic volcanic lithofacies of the Cadwallader Group that are exposed on the Lill property. Competent zones of hard fractured rock with rusty weathering on all surfaces alternate with incompetent zones where the rock is literally powdered. The resulting quartz-sericite schists are talcose in some places; they are intensely foliated and in many places the foliations are folded and convoluted (Plate 3.3.1a). The plutonic rocks affected show no incompetent zones, but the intensity of the fracturing varies across the shear zone. Gouge zones, tension gashes, and quartz veins are ubiquitous (See Appendix B, pages 97 to 101).

- The saddle west of Bastion Peak

The "saddle" exposure of the fault can be reached by backpacking or helicopter. All exposures in the saddle are intensely deformed, in two directions by penetrative ductile shear foliations, and in one direction by a non-penetrative brittle fracture system (See Plate 3.3.1b). All of these planar features strike north-northwest, but there is no consistent pattern to their dip amounts or directions. The zone of intense deformation is about 250 metres wide.The rock types in the shear zone slivers include black shale, brown sandstone, rusty fractured greenstone, pale green volcanic breccia, and some amygdaloidal basalt with epidote and chlorite infillings. The sedimentary rocks resemble some of the outcrops of Peninsula Formation that are found west of the shear zone.The volcanic rocks and breccias match the Cadwallader Group unbedded lithic tuffs that forms cliffs on the east side of the saddle.

PLATE 3.3.1a Folded and convoluted shear foliations in talcose shear zone - Lillooet River road

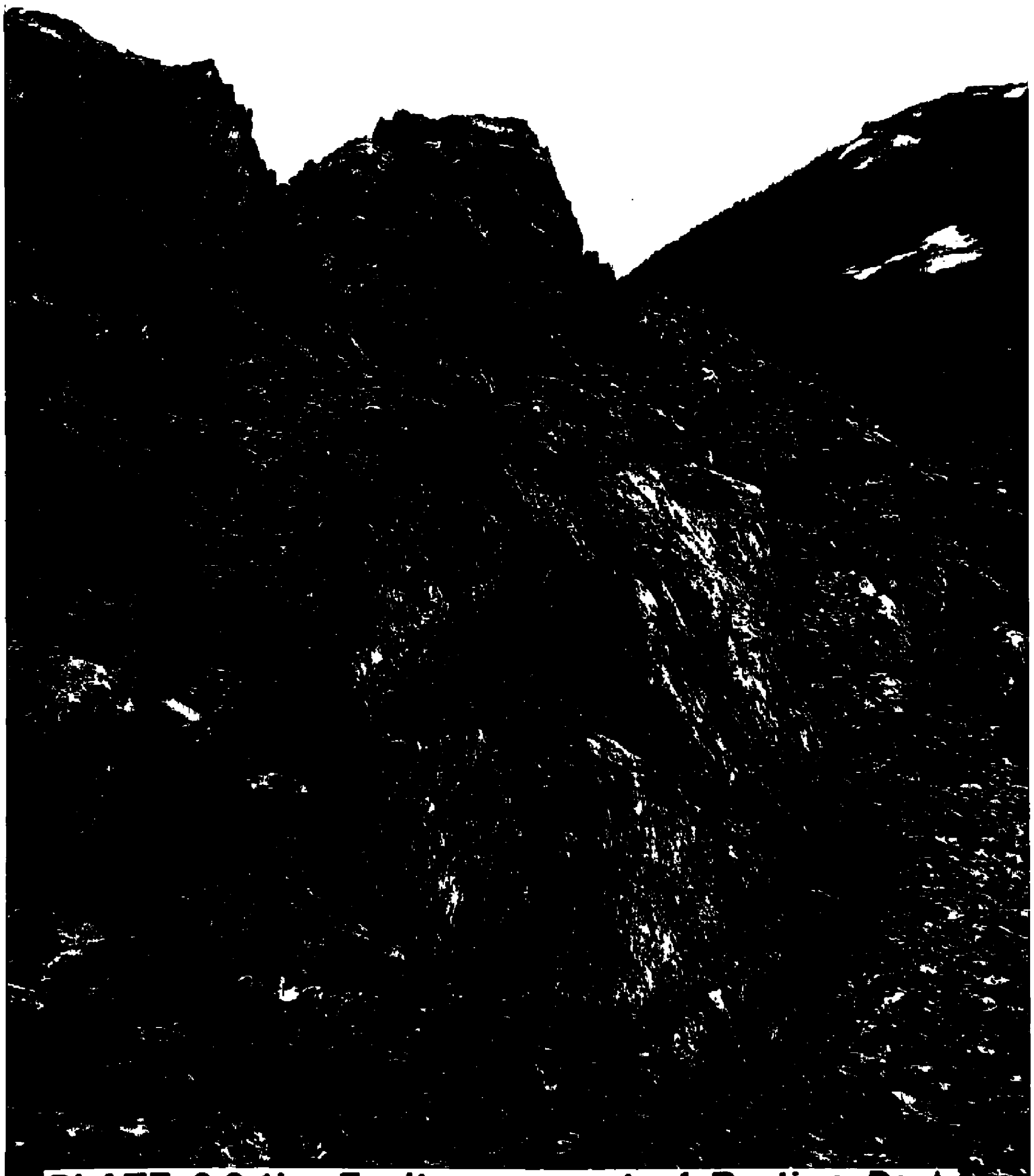


PLATE 3.3.1b Fault zone west of Bastion Peak

Where the fault cannot be directly observed, its location is inferred from
observations of shearing in adjacent outcrops, changes of rock type across gaps, and topographic and photo- linears. The diorite/quartz diorite body at the south end of Lillooet Lake is intensely sheared adjacent to the trace of the fault. On the ridge north of Ure Creek, the fault is not exposed; there, a flat grassy meadow separates well-exposed cliffs of grey siltstones and wackes of the Peninsula Formation on the west, from sparse, hummocky outcrops of unbedded crystal and lithic tuffs of the Cadwallader Group on the east. The fault is mapped in the Owl Creek area by Woodsworth (1977), and intense north-northwest striking shearing is described along the creek up to Owl Lake in many mineral assessment reports (Manyoso and Arscott, 1970; Anderson and Witherly, 1973; Naylor and Scott, 1973; Gatchalian and Witherly, 1974, Condon and Scott, 1964; Weick and Allan, 1986). North of Owl Lake I have extrapolated the trace of the fault based on its strike direction where its location is known, topography, and limited geological information.

Northeast -side-up movement on the Owl Creek fault is indicated by the style of deformation of Gambier Group rocks in the footwall (See section 3.4.1 below) and by the orientation of gouge fabrics within the fault zone (see Figure 3B and stereonets in Appendix B, page 98). The orientation of tension gashes and extension fractures in the fault zone indicates east-side-up movement with a component of dextral oblique slip (Figure 3C).

3. 4 Zone 1

Three factors are responsible for the structural fabrics in Zone 1; movement on the Owl Creek fault on the east, movement on the Warm Lake fault within the zone, and intrusion of rocks of the Pemberton Diorite Complex on the west and southwest.

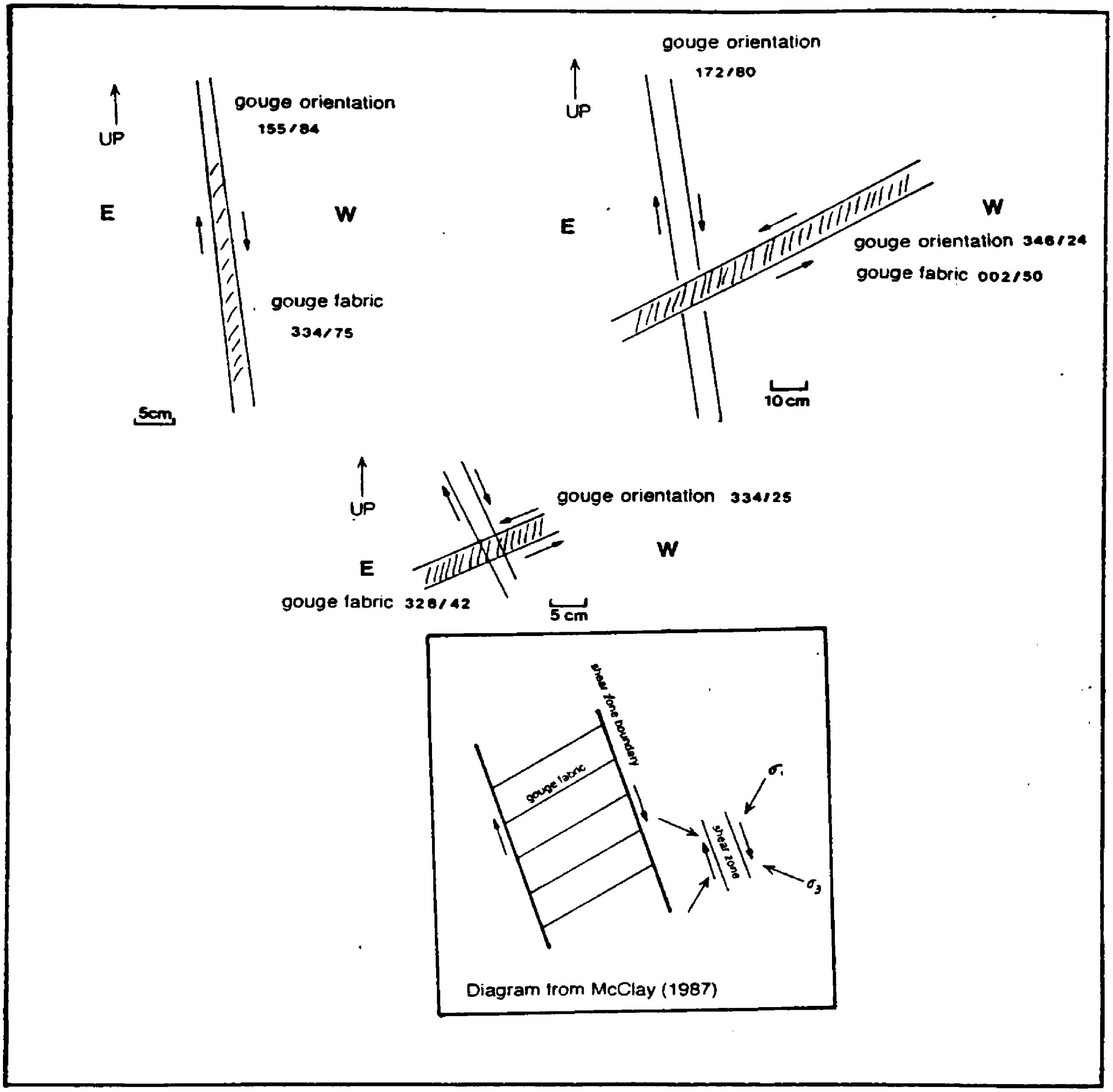
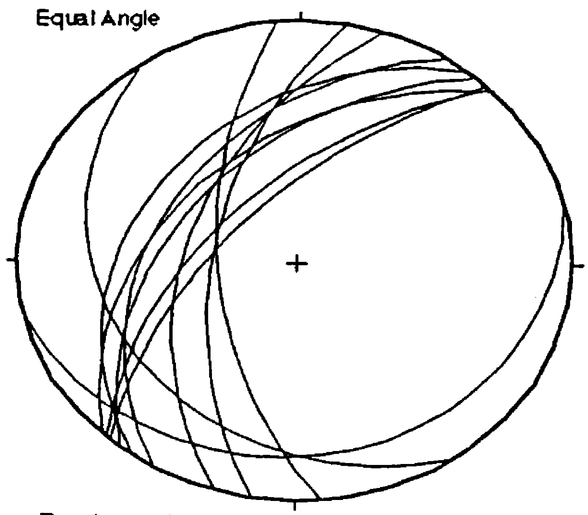
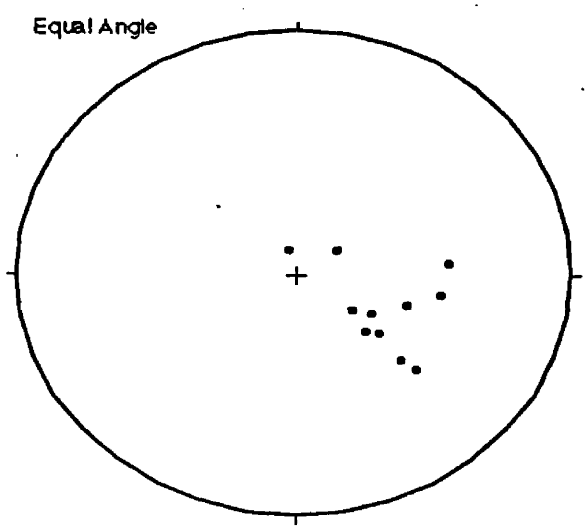


FIGURE 3B Representative field sketches of gouge zones in the Owl Creek fault zone - Lillooet River road.
The orientation of gouge fabrics within the gouge zones indicates east-side-up movement.



Tension gashes and quartz-filled veins in the Owl Creek Fault Zone



Poles to tension gashes and quartz-filled veins, in the Owl Creek fault zone

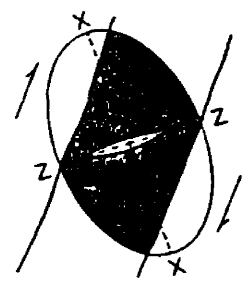


Diagram from Davis (1984), p. 272

FIGURE 3C The orientations of extension fractures in the Owl Creek fault zone indicate east-side-up movement with a component of dextral oblique slip.

3.4.1 Folding of Gambier Group rocks adjacent to the Owl Creek fault

Rocks that lie directly adjacent to the Owl Creek fault are well exposed on the ridge north of Ure Creek, and on the west side of the Owl Creek fault saddle west of Bastion Peak. These rocks are folded into parabolic folds with near-vertical axial planes and horizontal to shallowly plunging fold axes which parallel the strike of the Owl Creek fault. (Stereonet projections are in Appendix B, pages 104 - 113). At both of these locations west-dipping Peninsula Formation beds form the east limb of a syncline adjacent to the fault. (Figure 3D and 3E) There are no indications of pre-existing tectonic structures in these rocks so I infer that the folding occurred as a direct result of movement on the Owl Creek fault. The style of deformation is consistent with the interpretation of east-side-up movement on the fault.

3.4.2 The "Warm Lake" fault

The Warm Lake fault can be directly observed in the ridge west of the Bastion/Rampart Mountain ridge; it passes to the northwest through a topographic notch in the ridge north of Ure Creek, and is exposed in an intense shear zone in Peninsula Formation siltstones on the B.C. Rail track on the north side of Pemberton. This fault dips 45 to 50 degrees to the northeast at its southern end and steepens to the north. I did not observe any axial planar cleavage associated with folding adjacent to the fault. I noted only a few outcrop-scale movement indicators and they gave conflicting solutions. Quartz-filled tension gashes are well developed in Brokenback Hill Formation crystal tuffs that outcrop on the east shore of the small lake for which the fault is named (see Figure 3F). The gashes indicate oblique slip; the footwall (west side) moved up and to the northwest relative to the hanging wall.

Rocks in the footwall of this fault have not been studied in detail (see Section 2.2.4). They may correlate with upper parts of the Brokenback Hill

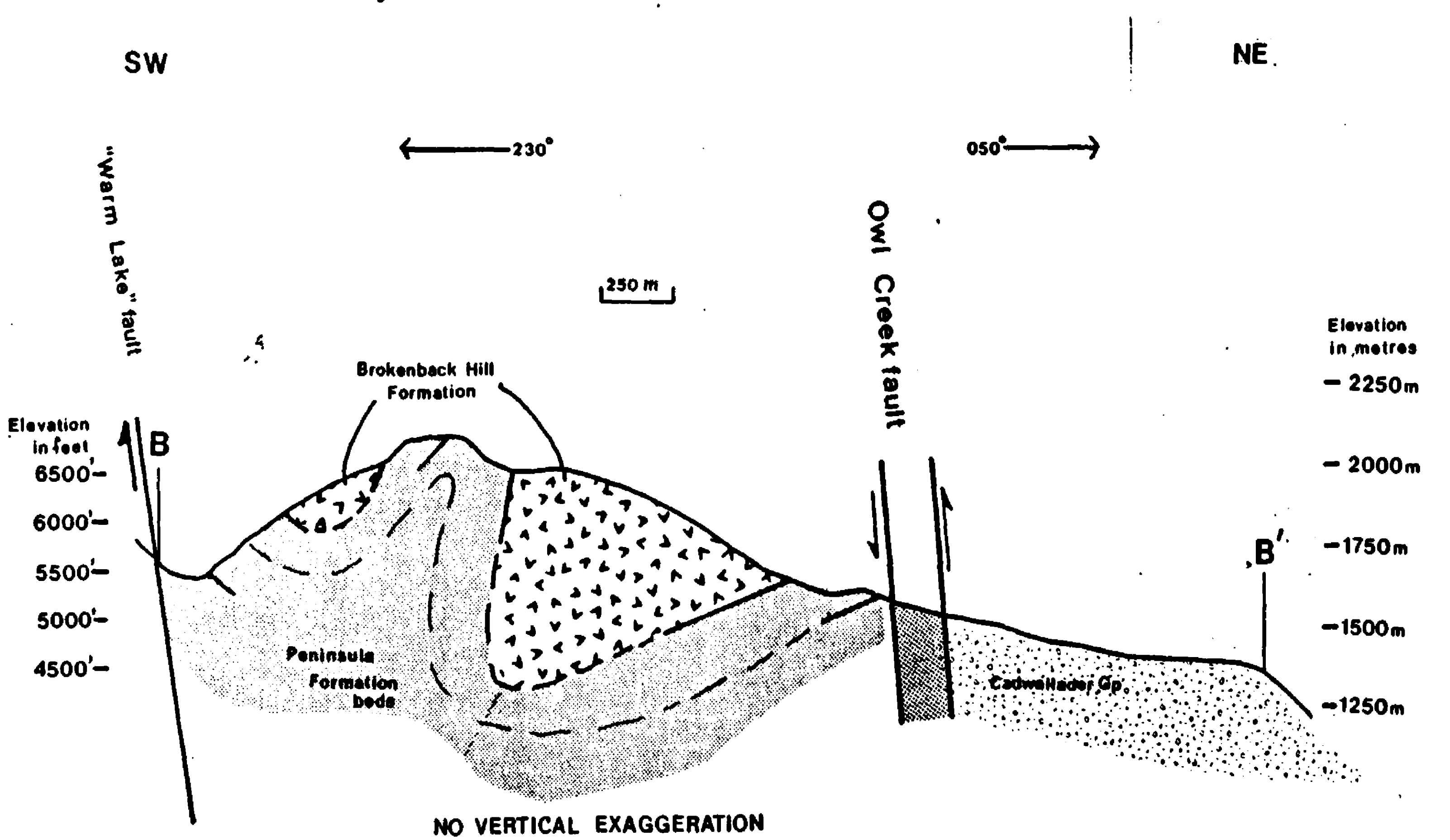


FIGURE 3D Cross-section B-B' (see map in pocket for location) Folding in Peninsula and Brokenback Hill Formation rocks adjacent to the Owl Creek fault north of Ure Creek

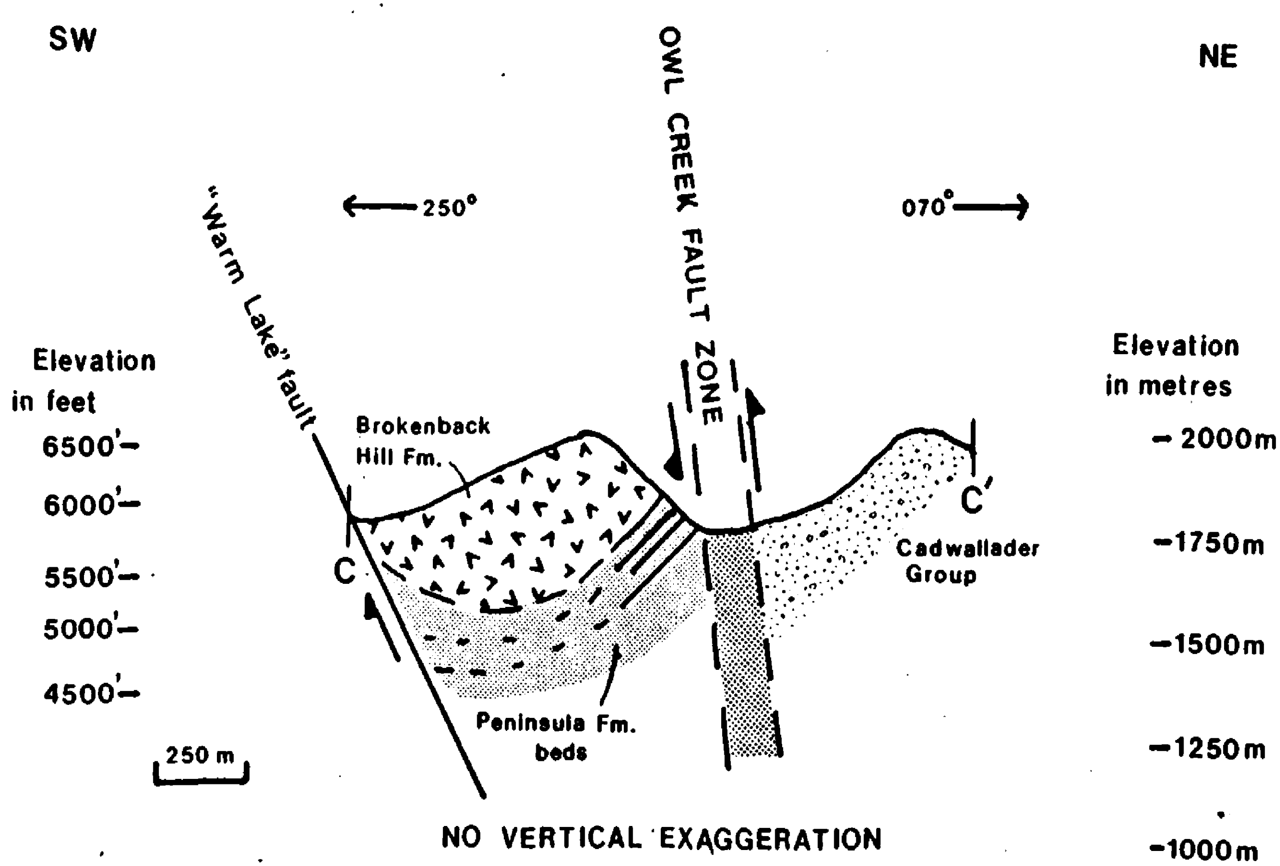
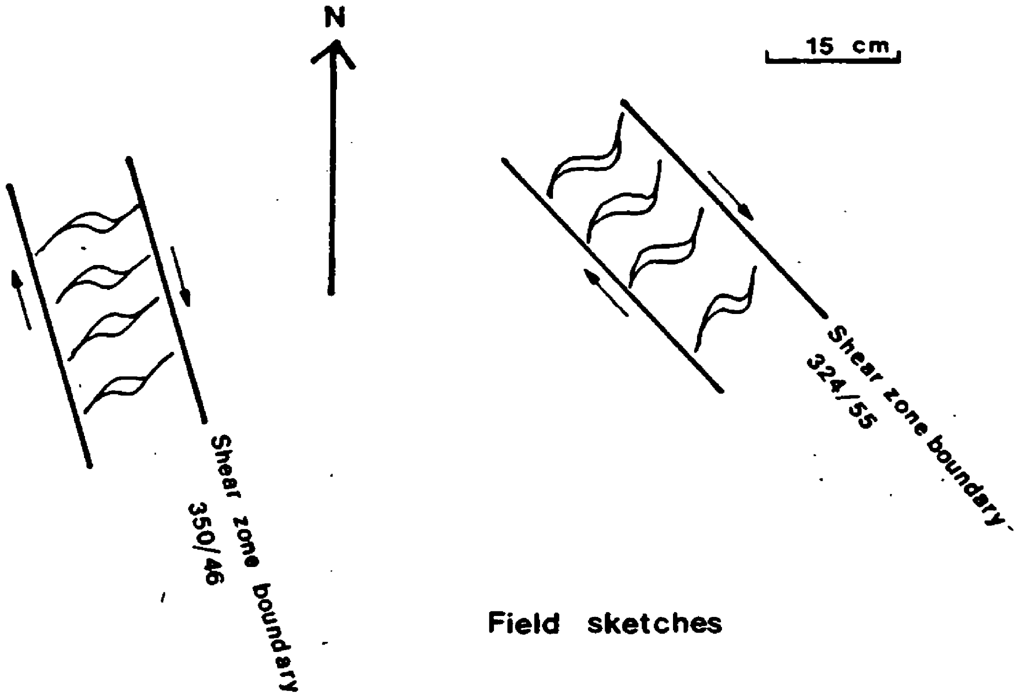


FIGURE 3E Cross-section C-C' (see map in pocket for location) Folding in Peninsula and Brokenback Hill Formation rocks adjacent to the Owl Creek fault west of Bastion Peak



Field sketches

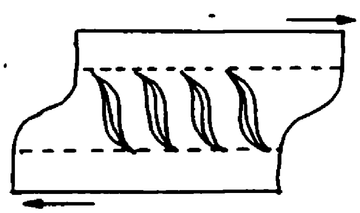


Diagram from McClay (1987)

FIGURE 3F Quartz-filled tension gashes in Brokenback Hill Formation crystal tuffs on the "Warm Lake" fault indicate west-side-up and dextral oblique slip.

Formation; alternatively they may belong to the Peninsula Formation. In the Fire Lake pendant to the south, Lynch (1990) has mapped thrust faults that put Peninsula Formation rocks over younger Brokenback Hill Formation strata. The Warm Lake fault may be a similar structure that has been subsequently rotated, so now it has an east-dipping orientation, and looks like a normal fault.

3.4.3 The Gambier Group/Pemberton Diorite Complex intrusive contact

The appearance of the intrusive contact between the Pemberton Diorite Complex and the Gambier Group rocks in the Lillooet Lake pendant is described in Section 2.2.4. Stress resulting from the intrusion of the Pemberton Diorite Complex pushed Gambier Groups rocks out of their way and overprinted them with shear foliations parallel to the intrusive/Gambier contact. An oriented sample from north of Ure Creek showed clockwise rotation of competent crystals in the Gambier Group volcaniclastic rock, indicating that the intrusive rocks moved upward relative to the country rock to the northeast. South of Ure Creek deformation of quartz veins indicate the same movement sense (see Plate 3.4.3).

3.5 Zone 2

3.5.1 The contrast in structural style across the Owl Creek fault

One notices a pronounced change in structural style on crossing the Owl Creek fault to the eastern part of the Lillooet Lake pendant (Zone 2). In contrast to the relatively simple, orderly folding one sees in the Gambier Group rocks in Zone 1, Zone 2 Cadwallader Group rocks seem structurally chaotic. Evidence of long-lived intense deformation is found in most outcrops. (The area around Bastion Peak is not as badly scarred, but even there the rocks are moderately to strongly foliated.) Most outcrops of Cadwallader Group rocks show evidence of both ductile and brittle deformation, with at least two directions of penetrative shear foliations, and

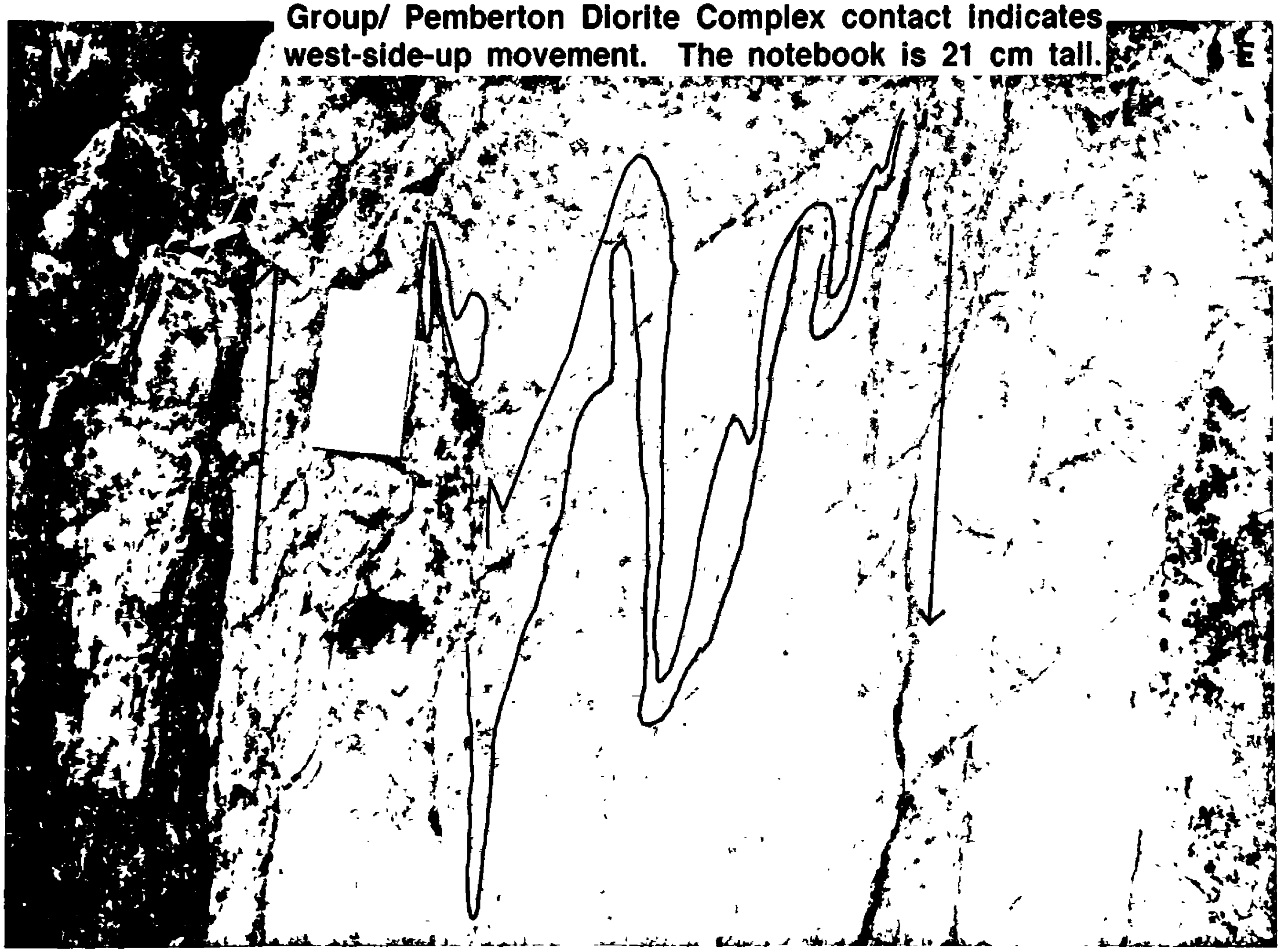


PLATE 3.4.3 Deformation of quartz-filled veins on the ?Gambier Group/ Pemberton Diorite Complex contact indicates west-side-up movement. The notebook is 21 cm tall.

abundant fractures and joints (see stereonets, Appendix B, pages 129 - 133).
Throughout the zone the density of small shear zones is high; most strike north-northwest. The Cerulean Lake unit breccias on Rampart Mountain show one direction of intense penetrative shear foliation and many brittle shear zones. The purple and green colours of the breccias accentuate the shear foliations with alternatively coloured stripes and smears.

3.5.2 The Bastion Range fault

A major fault that parallels the Owl Creek fault is exposed on a shoreline logging road at the Lill property at the north end of Lillooet Lake, and on the western shore at the bend in Lillooet Lake. I here refer to this fault as the Bastion Range fault. This structure continues across the lake farther south (Journeay, 1990) and appears to be a important regional feature. It likely continues to the north along the abrupt break in slope northeast of X'itolacw, and beyond (See map in pocket.). The outcrops at the bend in the lake display mylonitized quartz diorite with amphibolite-grade metamorphosed volcanic rocks. South of the shear zone at this location the rocks are metamorphosed only to greenschist grade and are brittly deformed. An east-side up movement sense is inferred.

3.5.3 Folding in Zone 2

Bedding in Cadwallader Group bedded tuffs and sedimentary rocks at Rampart Mountain dips steeply to the west (60 to 85 degrees). The corresponding beds at Bastion Peak also dip west, at moderate angles (37 to 48 degrees). The plot of poles to bedding at these two locations fit a great circle with a pole parallel to the trace of the Owl Creek fault. This suggests that these beds may form the west limb of an hanging wall anticline, as discussed in Section 2.7.7. It is not possible to be certain that movement on Owl Creek fault was responsible for this structure, as

these rocks clearly had a long history of deformation prior to formation of that
fault.

3.6 Zone 3

All of Zone 3 lies in the hanging wall of the Owl Creek fault. Deformation of Cadwallader Group and Cerulean Lake unit rocks in Zone 3 is noticeably less intense than it is in their Zone 2 counterparts. In Cadwallader Group rocks, most outcrops show only one shear foliation direction; fracture patterns and small shear zones are abundant, but they are not nearly so closely spaced as they are in Zone 2. As in Zone 2, Cerulean Lake unit rocks have clearly suffered less intense deformation than the Cadwallader Group rocks that underlie them.

3.6.1 Faults in Zone 3

Several north-northwest-striking steeply-dipping shear zones cut through the ridge south of Tenquille creek (see Figure 3A and map in pocket). One strikes across the eastern flank of Sungod Mountain, another just west of Cerulean Lake, and a third cuts across the top of 7 o'clock Mountain and continues northwest through the Lilikel property. I would need a better understanding than I now have of the internal stratigraphy of the Cadwallader Group rocks in the area around Sungod Mountain before I could speculate about the direction and amount of movement these shear zones have seen. Movement on the 7 O'clock Mountain shear zone has clearly been minor since deposition of the Cerulean Lake unit; south of 7 O'clock Mountain, identical rocks of the Cerulean Lake volcanic member lie on either side. At the Lilikel property the sedimentary member conglomerate is offset in an east-side-up sense by a few tens of metres.

The upper Lilikel fault

A west-by-northwest striking fault is exposed on the ridge north of the peak of Mount Barbour. The north side moved upwards relative to the south, displacing Cadwallader Group and Cerulean Lake unit rocks. Displacement on this fault is about 250 metres. (See Figures 3G and 2D). I have drawn an eastward continuation of this fault on strike as far as the northern flank of Sungod Mountain to account for the offset of the Cerulean Lake sedimentary member conglomerate that I observed across Cerulean Lake (see Figure 3A and map in pocket). (I have not mapped the eastern extension of this fault on the ground).The west-north-west strike direction is unusual for the Tenquille/Lillooet Lake area. The 7 O'clock Mountain shear zone is offset by the upper Lilikel fault, showing that movement occurred later on the upper Lilikel fault.

The Grizzly Pass shear zone

I mapped the areas north of Tenquille Creek only at reconnaissance scale and there are many problems in that area that should be addressed through more thorough mapping. The most important structural questions there, are :

1) What is the history of movement on the Grizzly Pass shear zone? and,
2) Where does the shear zone go?

The shear zone is 500 to 700 metres wide, and is bounded to the southwest by competent, relatively unsheared massive basaltic andesite of the Cadwallader Group **mafic volcanic lithofacies**, and associated diorites. The zone is not a single fault, but a complex set of anastomosing north-northwest-striking shears. Rocks within the shear zone are part of the rhyolitic flows and tuff lithofacies. They are a sequence of banded rhyolite flows, quartz-rich lithic and lapilli tuffs, rusty quartz sericite schist, aplite, bluish-green chloritic tuffs, and minor phyllite.

A conglomerate is exposed along the creek that drains south out of Grizzly

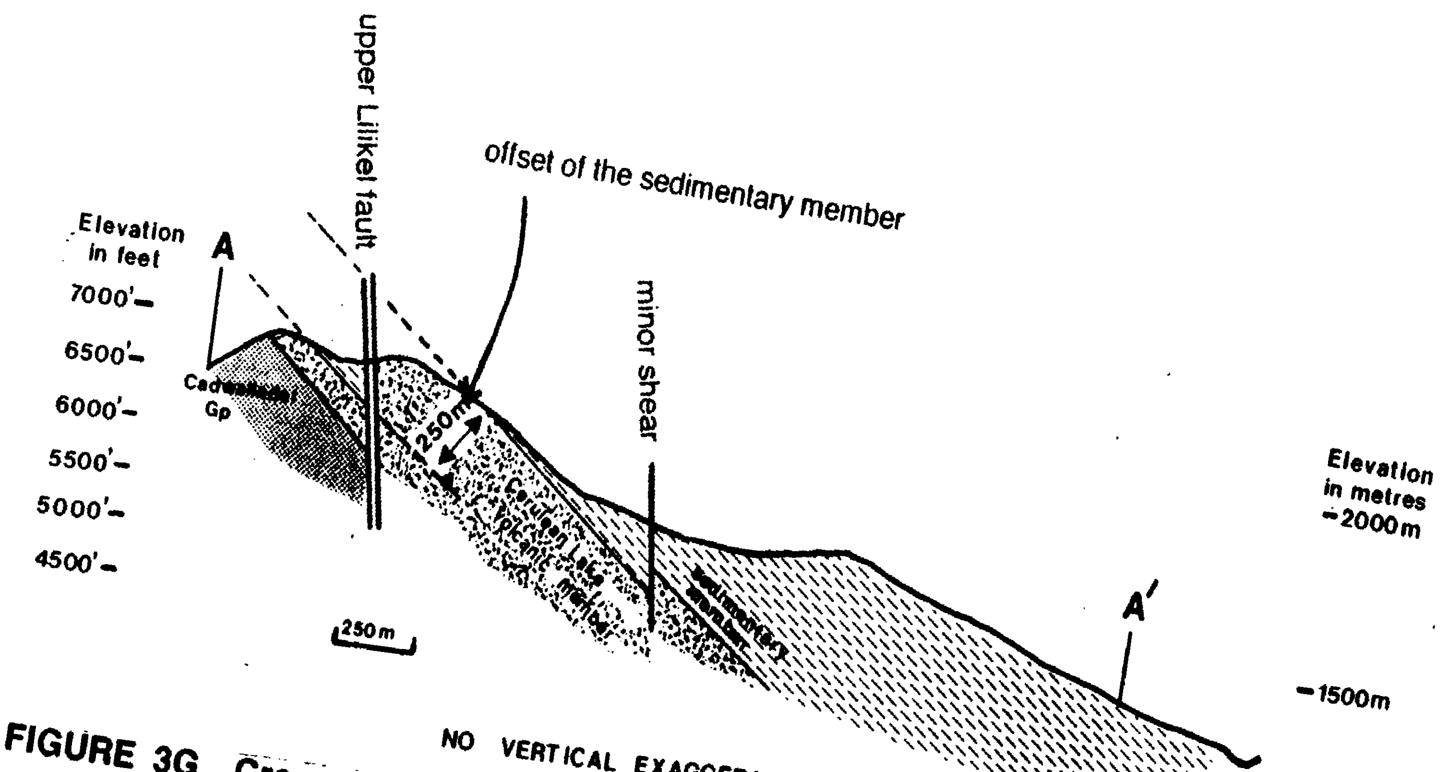


FIGURE 3G Cross-section A-A'
The offset of the sedimentary member of the Cerulean Lake unit across the upper Lilikel fault is about 250 metres

Pass into the Tenquille Creek valley. Clasts range from granule to boulder
size, and almost all are composed of rhyolitic rocks. Quartz crystal fragments are very abundant in the matrix; they resist weathering and give the outcrops a pimply appearance. Some, but not all the clasts show intense shear foliations that predate deposition. The conglomerate itself is cut by quartz-eye porphyry dikes. This conglomerate must have been deposited in the Triassic contemporaneously with fault movement. It may have formed adjacent to a Triassic fault scarp. The Grizzly Pass shear zone now parallels the north-northwest strike of the late Cretaceous - early Tertiary structural fabric; it was likely re-activated and rotated.

Rhyolitic rocks occur on both sides of the fault trace to the northwest, so the lithological map pattern does not give any indication of the movement direction. Horizontal slickensides are exposed on vertical surfaces in the shear zone indicating strike-slip movement; however these may represent only the most recent movement.

The shear zone disappears to the northwest beneath Tertiary (Miocene?) breccias of Chipmunk Mountain. To the southeast, it likely connects with one of the three north-northwest- striking shear zones described above. Mapping of the extensions of these structures on Mount Ronayne would show whether they pre- or post-date the 110-102 Ma (Journeay and Friedman, in press) Spetch Creek Pluton.

3.6.2 Folding in Zone 3 Cadwallader Group rocks

Cadwallader Group **bedded tuffs and sedimentary rocks** in the Tenquille Lake area are found on Copper Mound, Mount McLeod, Mount Barbour, and on the unnamed ridges between these peaks. At Copper Mound beds are close to horizontal, at Mount McLeod they dip shallowly to the east and northeast, and at Mount Barbour they dip moderately (45 to 65 degrees) to the northeast. Well preserved axial planar cleavages are rare in these rocks; those that I was able to measure are plotted on a stereonet on page148 (Appendix B). Axial planar

cleavages strike north-northwest and dip steeply to the east. The orientations
of the bedded rocks may represent the hinge and eastern limb of a broad anticline that folds over a north-northwest-striking hinge plane that intersects the surface somewhere near Mount McLeod (Riddell et al, 1991). In section 2.1.7 I discussed the configuration of a down-plunge projection that I drew using as a datum the base of Cadwallader Group bedded section at various locations in the Lillooet Lake pendant and in the Tenquille area (see Figure 2B). The projection clearly shows that the base of the Cadwallader bedded section on the ridge south of Mount Barbour does not match up with the one on the "middle ridge." (The middle ridge is the second unnamed ridge to the east of Mount McLeod.) Either there is an abrupt facies change between the middle ridge and Mount Barbour, or there is a fault there. The location of such a fault is not obvious on the ground. However, when I studied the map and field data, two candidates presented themselves.The first possibility is that the upper Lilikel fault clips the middle ridge and raises the rocks on the northeast side. The other, more likely possibility, is that a significant fault cuts the middle ridge along a relatively minor shear zone at the base of the bedded section there. It would strike to the south-southeast on-line with minor shear zones mapped just south of the Mount Barbour peak and in the intervening ridge. Such a fault would be on-line to track into the Ogre Lake valley. I have drawn the trace of this hypothetical fault as a dotted line on the map (in pocket).

3.6.3 Folding in the Cerulean Lake unit

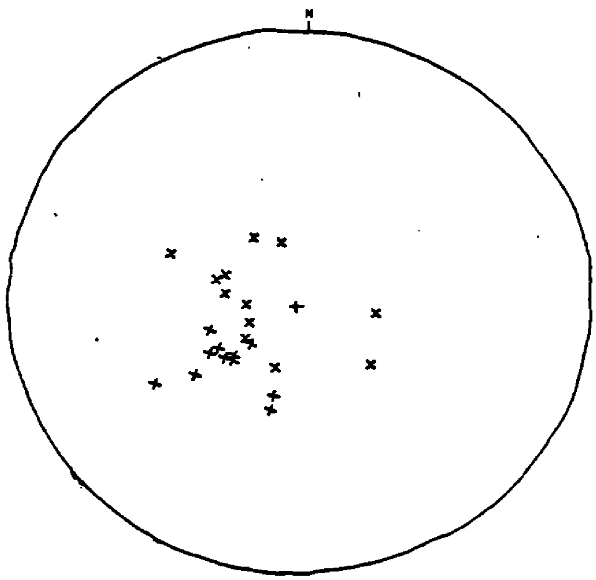
Bedded rocks in the Cerulean Lake unit are gently folded into a northeast-dipping monocline. Axial planar cleavage strikes north-northwest and dip steeply to the east, and fold axes plunge shallowly to the southeast. (See stereonets, Appendix B, pages 142 - 144).

Cerulean Lake unit rocks overlie Cadwallader Group cherty tuffs and limestones near Mount Barbour. Both bedded sections dip to the northeast; the Cerulean Lake sequence dips less steeply. Poles to bedding in Cadwallader and Cerulean Lake rocks are plotted on Figure 3H. When the cluster of Cerulean Lake poles are rotated to vertical (representing horizontal beds), the corresponding rotation of the Cadwallader poles results in those poles clustering around a pole that plunges 69 degrees to 227 degrees, which is the pole to the bedding plane with the orientation 316/21. The wide cluster shows that some of the folding, and about 20 degrees of the tilting of the Cadwallader Group rocks predates the deposition of the Cerulean Lake unit. The unconformity can be observed on the slopes north of the upper Lilikel fault. There the unconformity is close to the ground surface. Just northwest of the fault, adjacent to a small lake, "scabs" of the purple and green breccias and flows of the Cerulean Lake volcanic member are preserved on top of Cadwallader Group cherty tuffs, limestones, and limestone breccias (see Figure 2D). A caved adit by the lake marks the exposure of a copper skarn. East of the lake and adit, the Cerulean Lake purple and green breccias are more abundant, and windows of strongly deformed Cadwallader whitish-blue cherty tuffs peek through wherever the breccias thin out (See Figure 3I).

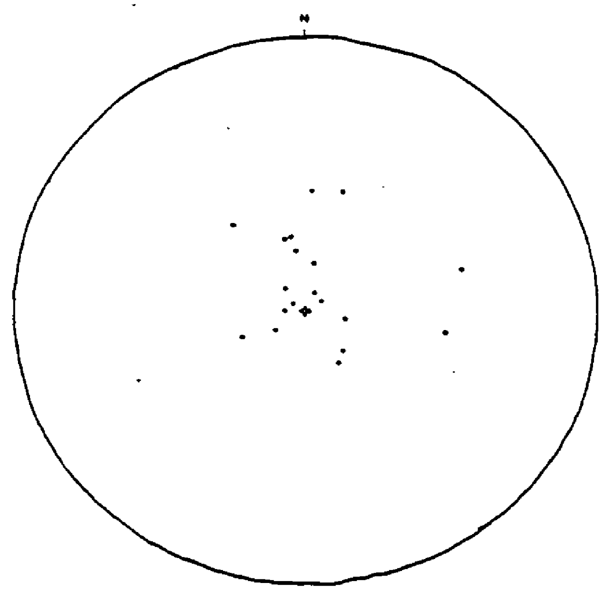
Overlying Cerulean Lake unit rocks cover up the transition in Cadwallader Group rock from the **bedded tuffs and sedimentary rocks lithofacies** at Mount Barbour to the **mafic volcanic lithofacies** near Cerulean Lake and Sungod Mountain. It is unknown if this is a lateral lithofacies change or a structural break.

3.7 Neogene tension cracks

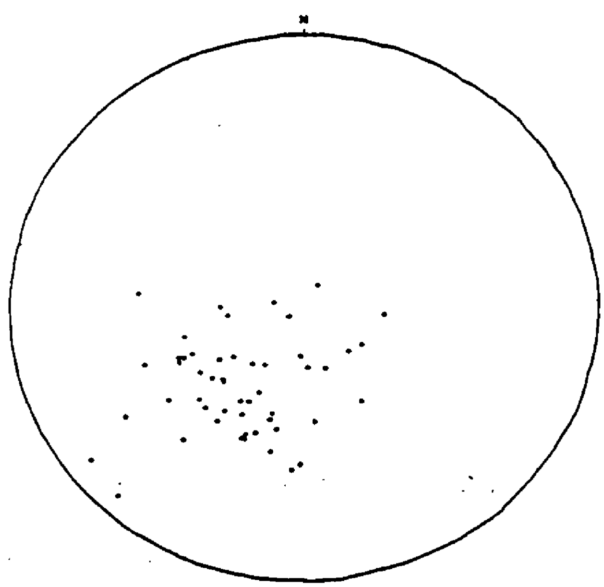
Large chasms, open cracks, and rubble pits are found in all parts of the Tenquille/



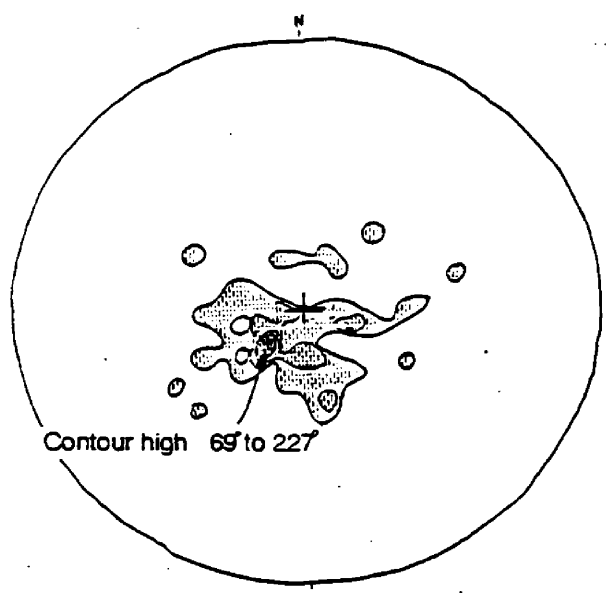
Present day orientation of poles to bedding in the Cerulean Lake unit on the ridge south of Tenquille Creek



Poles to bedding rotated to vertical, representing horizontal orientation of Cerulean Lake beds during deposition



Present day orientation of poles to bedding in Cadwallader Group rocks, on the ridge south of Tenquille Creek



Contoured poles to bedding in Cadwallader Group rocks, after rotation of Cerulean Lake unit beds to horizontal.

FIGURE 3H When poles to bedding in Cadwallader Group rocks are rotated so that Cerulean Lake beds are horizontal , Cadwallader Group poles to bedding cluster around a contour high at about 69 to 227, the pole to the 316/21 bedding plane.

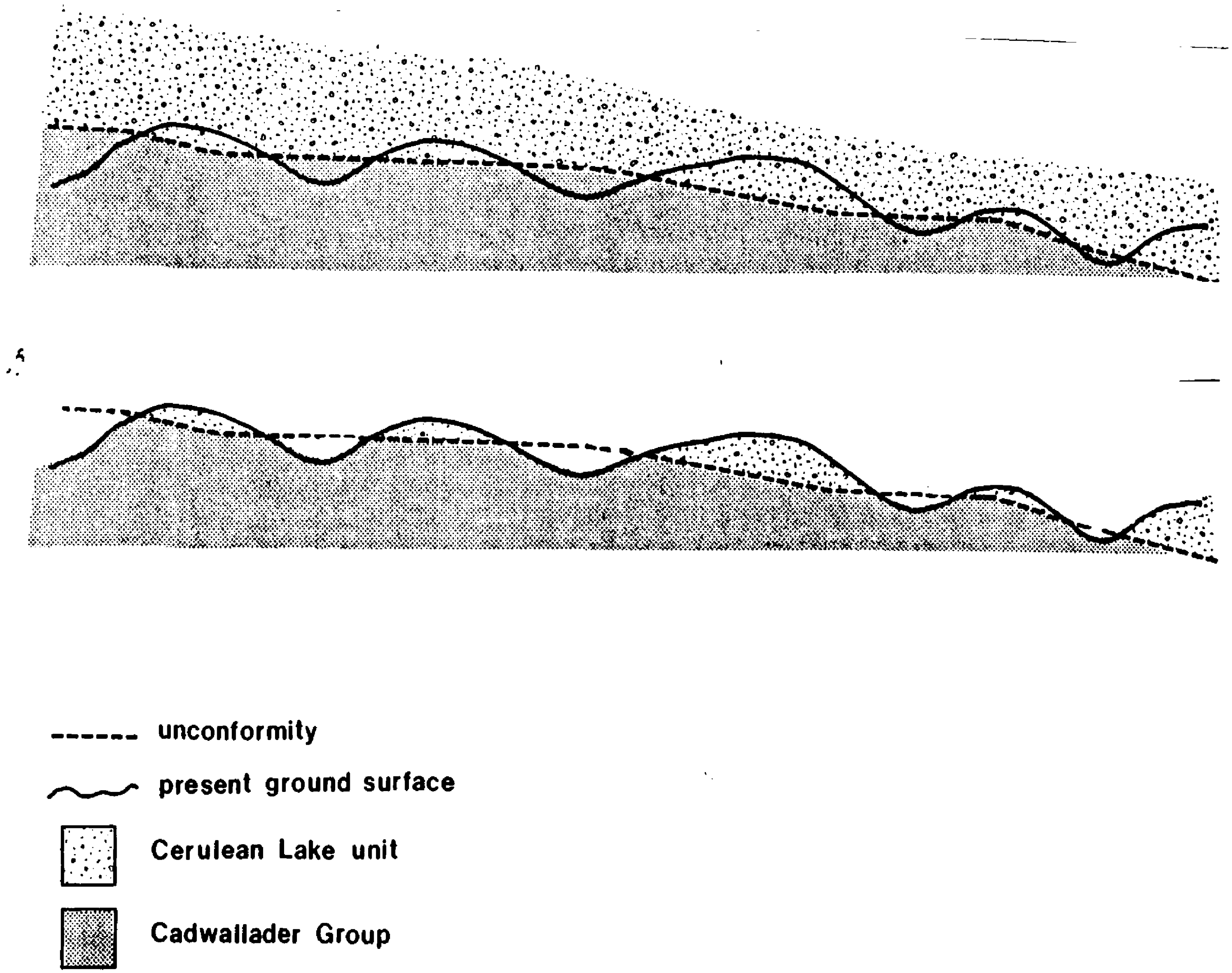


FIGURE 3 I Cartoon showing the outcrop pattern produced where an unconformity is very close to the present ground surface

Lillooet Lake study area. They are several metres to tens of metres wide,
and can in some places be traced across adjacent ridge systems. There is open space between the big blocks that have fallen into these chasms; clearly they are currently active. I plotted the strike directions of the cracks on a stereonet (Appendix B, page 102). (I assigned them vertical dips; their dips cannot be measured). They show that the Tenquille/Lillooet Lake area is suffering tension in an east-west direction at the present time.

3.8 Discussion of structural features

The Owl Creek fault is an important boundary in the Coast Belt. It thrusts rocks of the allochthonous Cadwallader island arc terrane over rocks of the Gambier Group; an intra-continental autochthonous sequence of near-shore and possibly sub-aerial deposits. Movement on the fault is east-side up. The Owl Creek fault is either a tectonic suture, or it is an ordinary reverse fault. The appearance of the rocks in the exposed parts of the Owl Creek shear zone shows clearly that it is not a tectonic suture. The rocks involved in the fault belong to the Cadwallader and Gambier Groups. None are rock types one would expect to find in a suture zone; there is no tectonic melange, no dismembered oceanic crust or ultramafic rocks. Clearly the Owl Creek fault is an ordinary reverse fault, probably a steepened thrust. Therefore Gambier Group rocks must have overlain Cadwallader Group rocks in the hanging wall. The nature of that contact cannot be determined here.

No significant change in metamorphic grade occurs across the Owl Creek fault; rocks on both sides of the fault are metamorphosed to greenschist facies. I attempted to use the accepted pressure/depth range of stability of the chlorite/actinolite/epidote assemblage (see Figure 2C) to constrain the amount of the displacement on the fault. This approach was not very helpful, as it is difficult to estimate what the geothermal gradient would have been in these rocks during late

Mesozoic to early Tertiary time. Blackwell (1970) has shown that a plot
of heat flow across the present day North American western margin show that thermal patterns have wide lateral variations with abrupt boundaries across breaks between crustal blocks. The geothermal gradient in the upper 25 kilometres of crust ranges from about 10 to 26 degrees per kilometre. At a gradient of 26 degrees C per kilometre, the maximum throw on the fault can be constrained only to about 12 kilometres. It is probably far less than that.

Rocks in Zone 1 (Gambier Group) were folded and intruded adjacent to the Pemberton Diorite Complex, faulted along the Warm Lake fault, and overridden on the east by Cadwallader Group rocks on the Owl Creek fault. These three events appear to be responsible for all fabrics in Zone 1.

In Zone 2, both Cadwallader Group rocks and Cerulean Lake unit volcanic rocks suffered compression. Cadwallader Group rocks show more abundant and closely spaced penetrative foliations. The contrast indicates that deformation in the Cadwallader Group began before deposition of the Cerulean Lake unit breccias, and continued after that.

Zone 3 rocks have suffered less deformation than their Zone 2 counterparts, and show a similar contrast in deformation intensity between Cadwallader and Cerulean Lake unit rocks.

4.1 Discussion of the stratigraphy and tectonic setting of sequences in the Tenquille/Lillooet Lake area

4.1.1 Cadwallader Group stratigraphy and island arcs

Rusmore (1985) inferred that the Cadwallader Group represents an exhumed island arc and the debris shed from the arc. My observations of the lithologies and stratigraphy in the Tenquille/Lillooet Lake area support that interpretation.

Modern island arc assemblages include the following rock types: tholeiitic basalts, mafic andesite, and their volcaniclastic and intrusive equivalents, and fringing carbonates (Hamilton, 1979; Karig, 1971). Clastic rocks do not contain continental debris. Tectonic activity in island arc systems is episodic; pulses of volcanism are followed by periods of quiescence, subsidence, and erosion of any sub-aerial parts of the arc. In modern arc sequences, pyroclastic volcanic rocks are generated in far greater abundances than flows, because arc-generated magmas generally produce explosive eruptions (Garcia, 1976). In contrast, eruptions in oceanic basins and oceanic islands are less violent and they produce abundant flows with only minor fragmental deposits. This is a preservable feature that can be used to distinguish ancient island arcs from other preserved oceanic volcanic terrains.

The lithofacies described in section 2.1 may fit together in the following way. Basaltic andesite, basalt interflows, and sills and mafic dikes of the **mafic volcanic lithofacies** represent the mafic component. Isolated limestone pods in mafic flows are probably fragments of reefs that formed on the shallow-water shoulders of arc volcanoes. Their occurrence indicates that volcanic activity waned periodically, and clastic supply was reduced enough so that reefs could form. The quartz porphyries and quartz diorites in the Lillooet Lake pendant are the subsurface roots of felsic volcanic centres. The rhyolitic flows, tuffs and mixed breccias at Grouty Peak were produced by another such centre where rocks that reached surface are preserved.

The mode of deposition of the unbedded tuffs is uncertain. They are notable for their lack of structures; I saw no bedding, outcrop-scale grading or bedforms

that would indicate reworking by currents. However these tuffs lack the chaotic mixture of large blocks, mud and intermediate-sized clasts that characterize debris flows. A weak sorting mechanism controls the maximum clast size, which ranges from 1-2 millimetres to 6-7 centimetres. Most clasts are subangular, so some reworking may have occurred. The tuffs were probably deposited quickly by direct suspension sedimentation during fallout of volcanic ejecta.

A major change in deposition style is marked by the transition upsection to bedded tuffs and sedimentary rocks. As described in section 2.4.4, the thickest exposure of these rocks at Mount Barbour shows a progression upsection, from bedded tuffs similar in composition to the unbedded tuffs, through volcaniclastic sedimentary rocks and limestones, and up into cherty ash tuffs. The sequences at Rampart Mountain and Bastion Peak are similar, but thinner. The transition from tuffs to epiclastic sedimentary rocks indicates a waning of explosive volcanism and the supply of primary ejecta. Subsequent erosion of the subaerial part of the arc provided the clastic material for the volcaniclastic conglomerates, wackes, siltstones, shales, and clastic limestones. The cherty tuffs at the top of the section represent a deep-water depositional environment with only very-fine-grained volcaniclastic input. They were probably deposited after the subaerial rocks had eroded and/or subsided. Ashy material may have been transported by wind from a more distant active centre in the arc system.

The types and relative amounts of clastic material observed in the entire bedded section can be summarized this way:

- plagioclase crystals > mixed volcanic rock fragments (felsic > mafic and intermediate) >> chert and cherty tuff > limestone > quartz

These are all arc-type clasts (Dickinson and Suczek, 1979), which indicates that this part of the arc and its basin were very distant from a continent, or were cut off from the supply of continental clastic material by some barrier.

Strikingly similar lithofacies assemblages in accreted ancient island arcs are
described in other parts of the world by many workers (Miller, 1989, and Watkins, 1990; Vallier, 1977; Aitchison and Landis, 1990; and many others), and modern island arc systems (Hawkins et al, 1984; Hamilton, 1988).

It should be noted that modern arc systems are hundreds to thousands of kilometers long and comprise scores of volcanic centers, and may be active for tens of millions of years (for example, Hamilton, 1979), or more (Rocks in the East Klamath terrane record more than 220 million years of volcanism (Miller, 1989).) The Tenquille/Lillooet Lake area is about 50 kilometres long, and two volcanic centers are exposed along its length. It probably represents only a tiny fragment of an arc system.

4.1.2 Tectonic history of the Cadwallader Group

4.1.2.1. The Cadwallader Group and the Cadwallader Terrane

The Cadwallader Group is the lowermost part of a tectonostratigraphic assemblage known as the Cadwallader terrane (see Figure 4A) which also includes the upper Triassic Tyaughton Group, and Lower to Middle Jurassic Last Creek Formation (Umhoefer, 1990). Although contacts between the Cadwallader and Tyaughton Groups are faulted, it is thought that the Tyaughton Group was deposited conformably on the Cadwallader Group (Rusmore, 1985, 1987). Both the top of the Hurley Formation and the lower red beds of the Tyaughton Group are Norian in age, and there are similarities in provenance of clastic material and in conodont types (Umhoefer, 1990), The Tyaughton Group is a distinctive fossil-rich sequence of non-marine to shallow marine clastic rocks and limestones. It is exposed in the mountains near Tyaughton Creek about 25 kilometres north of Gold Bridge.

No exposures of the Tyaughton Group are known in the Tenquille/Lillooet Lake study area. However, Woodsworth (1977) mapped rock around Place Glacier, directly south of Birken, as Tyaughton Group (See Figure 1B).

The Last Creek Formation is a transgressive sequence of clastic rocks that is

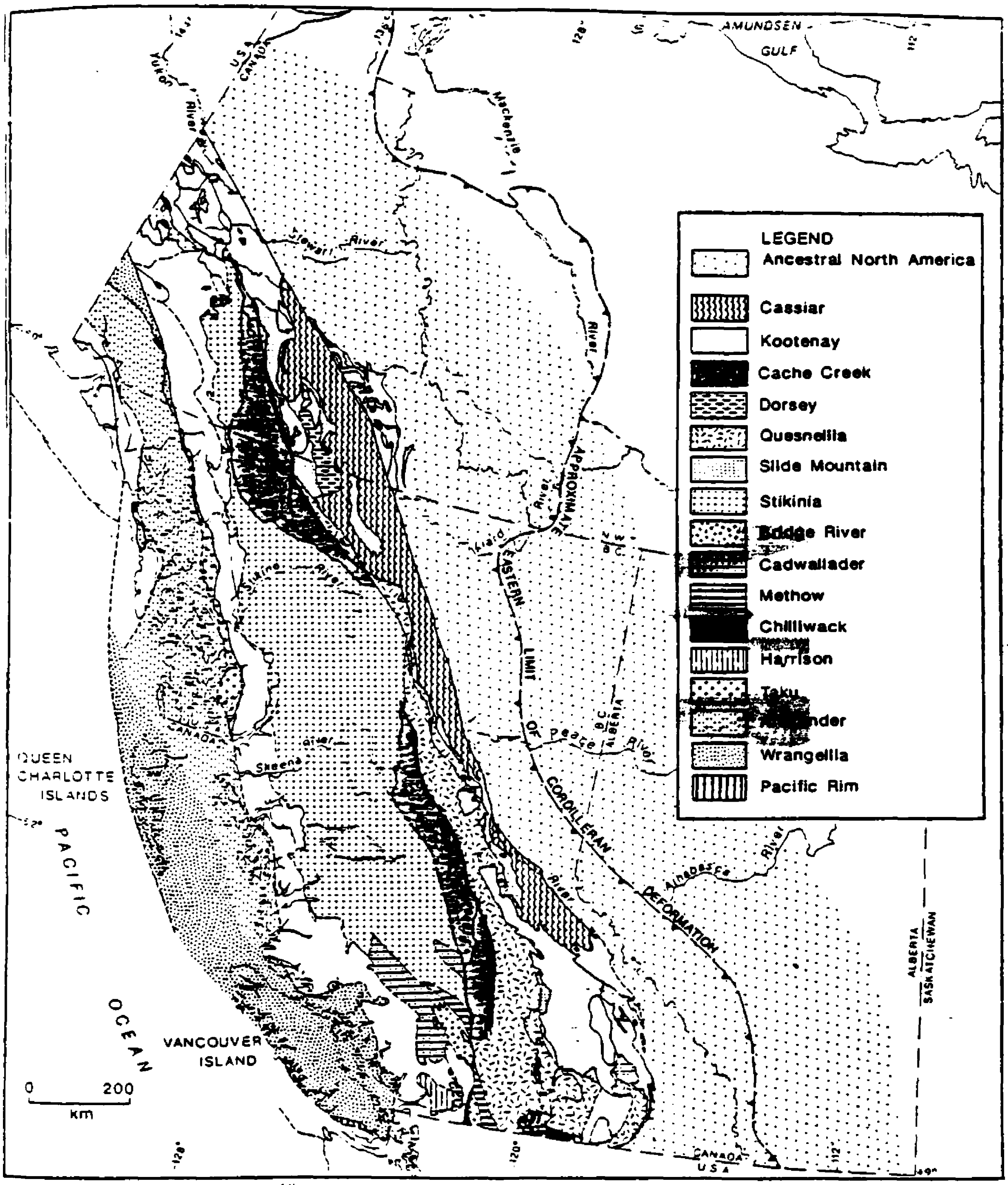


FIGURE 4A Terrane map of the British Columbia and Yukon Cordillera

distinguished from the Tyaughton Group across an erosional disconformity
(Umhoefer, 1990). Provenance of clasts in both the Tyaughton Group and the Last Creek Formation show that they had a mixed volcanic source. The Tyaughton Group contains no flows or tuffs; the Last Creek Formation contains minor ash beds. Umhoefer has interpreted the Tyaughton Group and the Last Creek Formation to be the sedimentary sequence deposited on the edge of the Cadwallader arc after volcanic activity ceased.

There are similarities between the Cadwallader terrane and other allochthonous oceanic volcanic terranes in the North American Cordillera. The Wrangell, Stikine, and Wallowa terranes all have thick marine Triassic volcanic sequences. In both the Wallowa and Cadwallader terranes, feldspar porphyries are abundant in the mafic volcanic sequences. Rusmore (1985) argued that important differences in basalt geochemistry and sedimentary sequences between Wrangell and Cadwallader terranes show that they are separate terranes that were not related in Upper Triassic time. Correlation of the Cadwallader terrane with Stikinia and/or Wallowa terrane are still theoretical possibilities worth further investigation.

4.1.2.2 Relationships between the Cadwallader terrane and the Bridge River terrane

In the Bralorne area Cadwallader terrane rocks are structurally juxtaposed against rocks of the Shulaps ultramafic body and the Bridge River complex. The Shulaps Ultramafic complex is a Pre-Mid Cretaceous harzburgite and dunite body surrounded by serpentinite melange that crops out over about 180 km^2 north of Carpenter Lake (Calon et al, 1990). It is bounded on the northeast by the Yalakom fault. The Shulaps has been interpreted as an ophiolite sequence (Wright et al, 1982; Potter, 1986; Calon et al, 1990).

Together, the Bridge River complex and the Shulaps Ultramafic complex are known as the Bridge River terrane. Throughout the Bridge River area rocks of the Cadwallader terrane are structurally interleaved with Shulaps and Bridge River rocks along late Mesozoic southwest-verging faults. The idea that the history of the Cadwallader terrane

is intimately tied to that of the Bridge River terrane suggests itself, but the
complexity of subsequently formed structures has made interpretation difficult.

4.1.2.3 The Cadwallader and Bridge River terranes and their relationship with the Stikine terrane

The nature of the relationship between the Cadwallader and Bridge River terranes with the Stikine terrane has been the subject of much discussion in the past few years (Cordey et al., 1987; Rusmore et al., 1988; Umhoefer, 1990, Rusmore and Woodsworth, 1991). In accretion models, a fault-bounded tectonostratigraphic assemblage is treated as a discrete terrane until a firm connection with other assemblages can be demonstrated.There is a growing feeling that the Cadwallader and Bridge River terranes could be the southern extensions of Stikinia and Cache Creek terranes, respectively. In both the Cadwallader and Stikine terranes, rock sequences show that Upper Triassic volcanic activity abated in Norian time. Rusmore et al (1988) and Umhoefer (1990) note that this suggests a related tectonic cut-off mechanism.

4.1.3 Tectonic setting of the Gambier Group, and stratigraphy in the Tenquille/Lillooet Lake area

Gambier Group rocks are part of a belt of early Cretaceous volcanic arc deposits that lies on and inboard of the Insular Superterrane along the entire length of the Canadian Cordillera and into Washington State (Wheeler and McFeely, 1987). It has been interpreted as a single arc that formed above an east-dipping plate that was being subducted below the Insular Superterrane in early Cretaceous time (Berg, 1972). Gambier Group rocks are included in the Nooksack terrane of Washington State (Monger and Berg, 1987).

Rock types observed in the Peninsula and Brokenback Hill formations in the Tenquille/Lillooet Lake area reflect the supracrustal nature of the Gambier arc. Monocrystalline quartz is abundant in the clastic deposits which demonstrate the proximity of the arc to a continental source of voluminous unroofed granitoid bodies. Coal fragments, plant fossils and rare pumice fragments attest to a shallow marine and partly sub-aerial depositional setting for the Peninsula Formation. The andesitic to dacitic lavas of the Brokenback Hill Formation are notably less mafic than those of the Cadwallader Group **mafic volcanic lithofacies.** This indicates that the melts from which they formed incorporated more continental crustal material.

4.1.4 Discussion of the Cerulean Lake unit stratigraphy

The Cerulean Lake unit represents a pulse of volcanic activity accompanied and followed by exposure and erosion of its volcanic pile and underlying rocks. The sandstones and conglomerates in the sedimentary member show a variety of clast types that reflect a mixed source. The Cadwallader Group is represented by cherty tuffaceous fragments and mafic and intermediate volcanic lithic clasts. The 160 to 158 million-year-old granitoid boulders, along with mylonitic pebbles and abundant monocrystalline quartz grains indicate proximity to an unroofed Late Jurassic pluton. Reworked fresh plagioclase crystals and purple-coloured dacitic clasts are clearly from the volcanic member of the Cerulean Lake unit. Cross-beds in sandstones on the west flank of Sungod Mountain indicate shallow-water deposition in that part of the basin. Soft-sediment slumping of sandstone beds north of Mount Barbour, and cannibalization of lower shaly beds into a stratigraphically higher conglomerate on the Lilikel property, are indications that the basin was tectonically active during deposition of the sedimentary member.

The age of the Cerulean Lake unit is important because its deposition recorded a tectonic event that affected rocks of the Cadwallader arc. The contrast between the Cadwallader Group and the Cerulean Lake unit in the intensity of north-northwest striking structures clearly show that compression in the Cadwallader Group began before deposition of the Cerulean Lake unit, and continued after that. Regional correlation of the Cerulean Lake unit is also important, because it overlies the Cadwallader Group on an

unconformity, so it can be used to demonstrate a link between the Cadwallader
Group and any other assemblage that it may have been deposited on.

The Cerulean Lake unit may or may not be part of the Gambier Group. The stratigraphic successions in the Cerulean Lake unit and the Gambier Group are different. Conglomerates with granitoid boulder clasts occur in lower parts of the Gambier assemblage, far below the breccias of the Brokenback Hill Formation. In the Cerulean Lake unit, the boulder conglomerates overlie the breccia unit. However, two features of the Cerulean Lake unit suggest a correlation with the Gambier Group. Firstly, the appearance in the field of the Cerulean Lake unit volcanic member is strikingly similar to that of the lowest part of the Brokenback Hill Formation in the Lillooet Lake pendant. The association of purple and green autoclastic and mixed breccias, beige and pale-green feldspar- and hornblende-phyric intermediate flows, and pale green feldspar crystal tuffs, is identical. Thin-section study shows that the Brokenback Hill Formation flows have a slightly higher proportion of mafic material, but this may not be significant. Secondly, the two dated diorite boulders from the sedimentary member conglomerate are very close in age to a granodiorite boulder from a similar conglomerate in the Empetrum Formation of Mathews (1958) near Black Tusk Mountain in Garibaldi Park (The Empetrum boulder gives a U-Pb date of 160 Ma, the Cerulean Lake boulders are 158 Ma and 157 Ma; R. Friedman, written communication, 1991.) Some workers correlate the Empetrum and Helm Formations with the Gambier Group (J.W.H. Monger, pers. comm, 1992). The source of the boulders could be one of any number of late-Jurassic plutonic bodies in the southern Coast Belt. Plutons in this suite all lie west of the West Coast Belt/Central Coast Belt boundary of Journeay and Friedman (1992), (R. Friedman, pers.comm., 1992).

4.2 Conclusions from this study

The rock sequences in the Tenquille/Lillooet Lake area (See Figures 4B and 4C), the Gambier Group, the Cadwallader Group and the Cerulean Lake unit are important elements

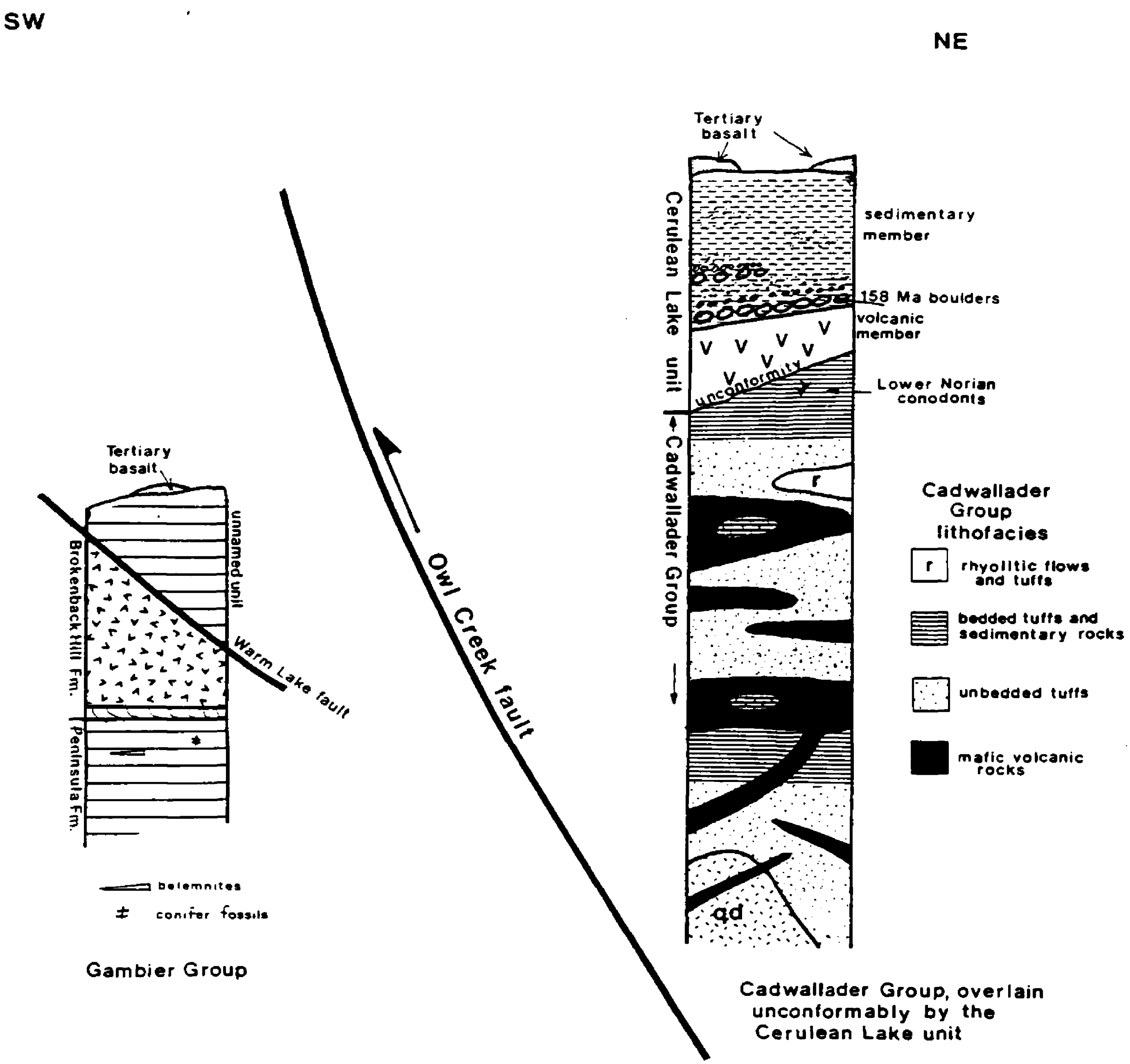


FIGURE 4B Cartoon of the stratigraphic scheme in the Tenquille/Lillooet Lake area

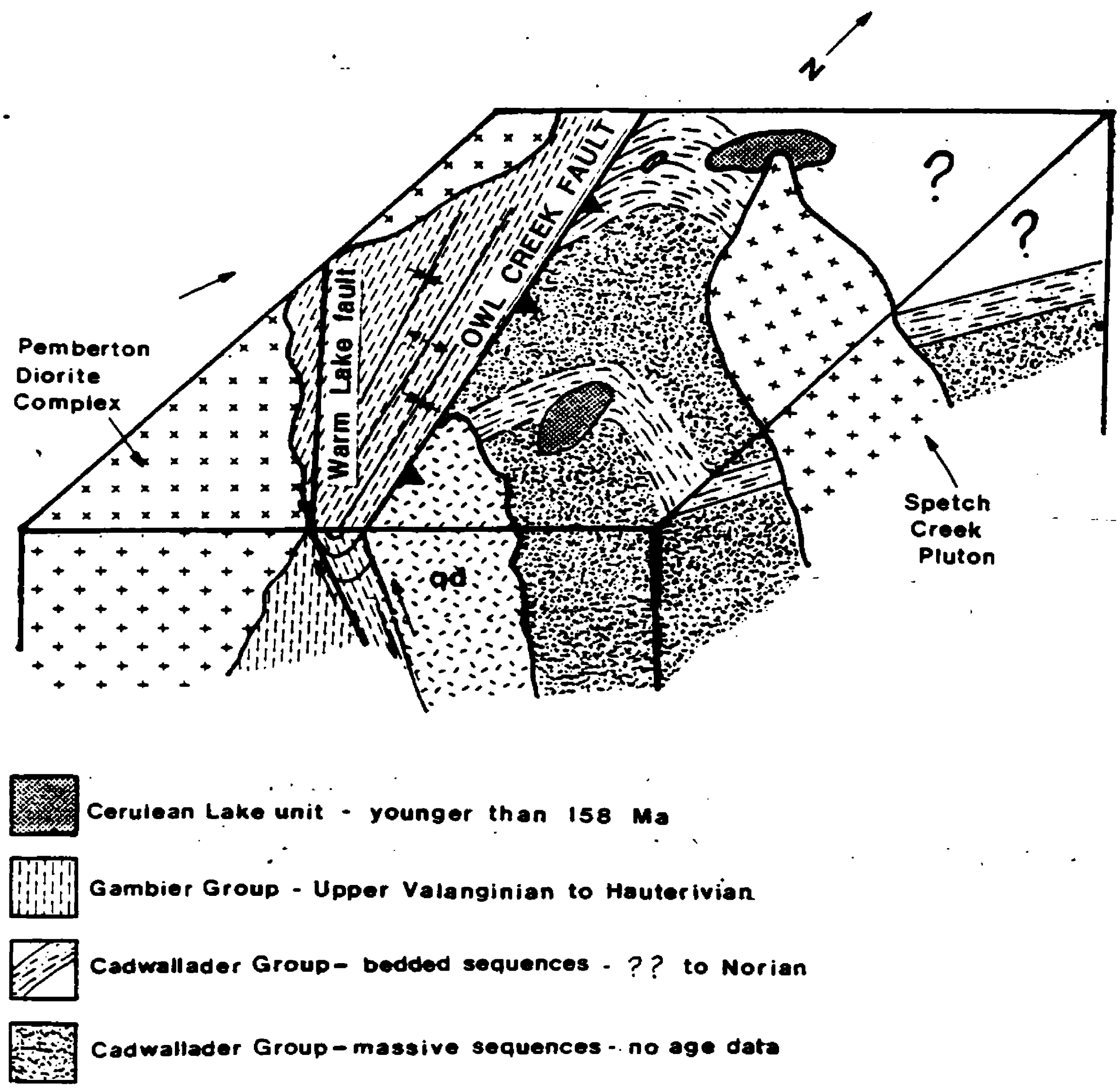


FIGURE 4C Cartoon block diagram of the Tenquille/Lillooet Lake map area

in the mid- to late- Mesozoic accretion history of the southern Cordillera. As a result of this study, the following statements can be made about these three sequences and their inter-relationships.

1. Correlation of Triassic rocks east of the Owl Creek fault with the Cadwallader Group in the Bralorne/Gold Bridge/Bridge River area is valid.
2. Volcanic and sedimentary rocks in the footwall of the Owl Creek fault are correlative with the Gambier Group.
3. Movement sense on the Owl Creek fault is northeast-side-up with a component of dextral oblique slip.
4. Cadwallader Group rocks in the hanging wall of the Owl Creek fault show strong to intense structural features that indicate a long-lived, complex history of deformation. Structures in Gambier Group rocks in the footwall are much less complex, and record a simpler history, dominated by deformation related to movement on the Owl Creek fault and intrusion of the Pemberton Diorite Complex.
5. The Owl Creek fault is an ordinary reverse fault (probably a steepened thrust); it is not a tectonic suture. The Gambier Group did overlie the Cadwallader Group in the hanging wall, but the nature of that contact cannot be determined here.
6. The Cadwallader Group section plunges to the northwest. Cadwallader Group rocks in the Lillooet Lake pendant are older than those in the Tenquille Creek area. How much older is unknown.
7. The Cerulean Lake unit was deposited on the Cadwallader Group rocks on an angular unconformity that represents a hiatus of at least 50 million years. This unconformity is exposed in several locations in the Tenquille Creek area, and on Rampart Mountain in the Lillooet Lake pendant.
8. Compression of rocks of the Cadwallader Group began before, and continued during and after deposition of the Cerulean Lake unit.
9. The age and the regional correlation of the Cerulean Lake unit are unknown at present.

Its age is very important, because it formed during a tectonic event that affected the Cadwallader Group, and so can provide an accurate date for that event and give us a clearer picture of the accretion history of the Cadwallader terrane. Assemblages that correlate with the Cerulean Lake unit can be used to demonstrate a link of Cerulean Lake age with any rock sequences that they overlie.

10. The Cerulean Lake unit shares some characteristics with the Gambier Group. The Cerulean Lake unit volcanic member resembles the Brokenback Hill Formation of the Gambier Group. Granitoid clasts in the Cerulean Lake sedimentary member are the same age as granitoid clasts in the Empetrum Formation, which has been correlated with the Gambier Group. The Gambier Group directly overlies rocks of the Wrangellia terrane. If the Cerulean Lake unit can be positively correlated with the Gambier Group, then a tie of Brokenback Hill Formation age will be established between Wrangellia and Cadwallader terrane.

4.3 Geological research priorities in the Tenquille Creek/Lillooet Lake area

Many unanswered geological questions remain in the Tenquille/Lillooet Lake area, and most will not be solved until many more field seasons have been spent there. However, answers to two of the most important questions are within our grasp.

1. There are Norian fossil ages for the bedded sections in the Cadwallader Group in the Bridge River and Tenquille Creek areas, but there is no lower age limit for the Cadwallader Group. It would be useful to know how old the arc is.

The quartz-diorite body at the south end of Lillooet Lake records at least two intrusive events in the stratigraphically-lowest part of what is generally recognized as the Cadwallader Group. Quartz-diorites, and granites formed by partial melting adjacent to mafic dikes, should be dated.

Carbonate and chert samples from the Lillooet Lake area did not bear microfossils. However, I found one brachiopod in a limestone bed on Rampart Mountain. I was unable to take the fossil, but its existence proves that conditions for preservation of fossils existed in that section. Rampart Mountain should be scoured for fossils.

If the lower age limit of the Cadwallader arc could be pushed back in time, it would be easier to evaluate the validity of the correlation of the Cadwallader terrane with other arc terranes.

2. The age of the Cerulean Lake unit is critical. The outcrops of the sedimentary member should be searched for fossils.

The nature of the relationship between the Cerulean Lake unit and the 110 to 102 million-year-old (Journeay and Friedman, in press) Spetch Creek pluton is unknown. The outcrop pattern on the map (in pocket) seems to indicate that the pluton intrudes the Cerulean Lake unit, but this should not be taken for granted. J. Pautler (pers. comm. 1990) reports hornfels on the west edge of the pluton, but it is unclear whether the protolith was part of the Cadwallader Group or the Cerulean Lake unit. Adjacent to Cerulean Lake, the contact is sheared. I saw no sign of contact metamorphism in Cerulean Lake unit sandstones and conglomerate on the eastern contact on the west flank of Sungod Mountain. The southern flank of 7 O'clock Mountain above Ogre Lake should be mapped in order to determine the nature of the contact. If the Cerulean Lake unit post-dates the Spetch Creek pluton, it is too young to be correlative with the Upper Valangian to Lower Hauterivian (Arthur, 1986) Brokenback Hill Formation.

APPENDIX A

Thin section notes

Sample # 123A Unit Trm UTM Loc 5571650 N 526900 E Loc name Lill property
Rock type basaltic andesite Texture porphyritic Phenocrysts plagioclase - no twins
Groundmass composition Plag microlites, actinolite needles and magnetite
Comments Plagioclase phenocrysts within finer grained lath-shaped plagioclase crystals, some equant, hornblende, and chlorite Mafic material makes up about 40% of the rock. Some interstitial quartz due to silicification in the shear zone

Sample # 668B Unit Trm UTM Loc 55945500 N 510350 E Loc name Cerulean Lake
Rock type basaltic andesite Texture fine, with small phenocrysts Phenocrysts plag with C/B twins
Groundmass composition finer crystal types are lath-shaped plagioclase, epidote, chlorite, magnetite
Comments 5% interstitial quartz, actinolite needles, epidote in stringers

Sample # 679 Unit Trm UTM Loc 5594050 N 511450 E Loc name Cerulean Lake
Rock type black basalt Texture massive Phenocrysts none
Groundmass composition plagioclase laths, chlorite, magnetite, actinolite needles
Comments 40% mafic material - all of it gone to chlorite. Finer crystals are stubby and lath-shaped plagioclase with albite and C/B twins less than 5% quartz Chlorite has bright yellow pleochroism

Sample # 861A Unit Trm UTM Loc 5596250 N 505300 E Loc name Mount McLeod
Rock type fsp-phyric basaltic andesite Texture med-coarse porphyritic Phenocrysts stubby plag
Groundmass composition plagioclase, chlorite, magnetitie, rare actinolite needles and quartz
Comments 35% mafic material totally replaced by chlorite finer crystals are stubby plagioclase and chlorite with pale to medium green pleochroism and high birefringent colours

Sample # 864 Unit Trm UTM Loc 5596400 N 503300 E Loc name Bastion Peak
Rock type fsp-phyric andesite Texture porphyritic - 30% phenocrysts Phenocrysts stubby plag
Groundmass composition chlorite, plag microlites, magnetite, actinolite needles
Comments almost 50% mafic material - all gone to chlorite and epidote, chlorite shows emerald-green pleochroism sample is altered - textures are felted, intense saussuritization

Sample # 881 Unit Trm UTM Loc 5563400 N 530000 E Loc name Bastion Peak
Rock type andesite Texture porphyritic Phenocrysts plagioclase
Groundmass composition plagioclase, quartz, hornblende, magnetite,
Comments 50% mafic material. - hornblende, most has gone to chlorite, finer crystal are plagioclase laths, hornblende blades, 20% interstitial quartz

Sample # 912B Unit Trm UTM Loc 5565350 N 530000 E Loc name Bastion Peak
Rock type altered andesite Texture glomeroporphyritic Phenocrysts clusters of stubby plag
Groundmass composition flooded with cryptocrystalline quartz, abundant stubby plagioclase
Comments 20% mafic material - gone to chlorite, Finer crystals are plagioclase, epidote and chlorite This rock is felsic - probably altered by silicic flooding related to quartz porphyry body

Sample # 697 Unit Trm UTM Loc 5594450 N 512650 E Loc name Sungod Mountain
Rock type dacite Texture porphyritic Phenocrysts plagioclase
Comments 10-15% mafic material is v.f.g. Finer crystals are plagioclase some actinolite needles Station 697 Trm pokes through the Cerulean Lake unit

Sample # 132A Unit Trm UTM Loc 5571200 N 526500 E Loc name Lill property
Rock type andesitic pyroclastic bx Clast/matrix ratio 50/50 Matrix composition basaltic
Clast types in order of abundance fsp-phyric andesite, feldspar basalt, feldspar crystal clots, amygdaloidal basalt, felsic volcanic rock fragments, abundant actinolite in matrix

Sample #391 Unit Trm UTM Loc 5579550 N 519450 E Loc name Spetch
Rock type basaltic and. bx Clast/Matrix ratio 60/40 Matrix composition basaltic andesite
Clast types in order of abundance euhedral plagioclase crystals with C/B and albite twins, massive andesite, euhedral mafic crystals (prob.hornblende, replaced by chlorite), fsp basalt, fsp basaltic andesite, amygdaloidal basalt,
Comments magnetite dust in clasts and matrix

Sample # 865 Unit Trm UTM Loc 5596150 N 503550 E Loc name Wolverine Ck
Rock type breccia Clast/Matrix ratio 70/30 Matrix composition cherty
Clast types in order of abundance feldspar andesite, feldspar basalt - some with mafic minerals replaced by magnetite or pyrite, amygdaloidal basalt, felsic volcanic fragments, feldspar crystals, cherty cherty fragments

Sample # 911 Unit Trm UTM Loc 5565300 N 528800 E Loc name Bastion Peak
Rock type basalt bx Clast/Matrix ratio 60/40 Matrix composition basalt
Clast types in order of abundance amygdaloidal basalt fragments, massive basalt fragments, dark isotropic material, chlorite clots, plagioclase laths, chlorite and quartz fill the amygdules
Comments

Sample # 670(2) Unit Trm UTM Loc 5594500 N 510650 E Loc name Cerulean Lake
Rock type basalt bx Clast/Matrix ratio 60/40 Matrix composition basalt
Clast types in order of abundance basalt, andesite, feldspar crystal fragments, amygdaloidal basalt
Comments Fine-grained actinolite needles in matrix

Sample # 708 Unit Trm,ut UTM Loc 5591500 N 508500 E Loc name south Barbour
Rock type basalt bx Clast/Matrix ? Matrix composition basalt
Clast types in order of abundance Large plagioclase crystals, basalt
Comments epidote in matrix Mapped as Trut - looks like Trm in T.S.

Sample # 28 Unit Trut UTM Loc 5556250 N 535500 E Loc name south Lillooet Lake
Rock type felsic lithic tuff Clast/Matrix ratio 40/60 Matrix composition rhyodacite
Clast types in order of abundance plagioclase crystal fragments, quartz fragments, felsic volcanic lithic fragments, chert, mafic lithic fragments with chlorite replacements, andesite fragments, mafic crystal fragments replaced with chlorite,
Comments Matrix is dominated by microcrystalline feldspar and quartz, plus chlorite, actinolite needles, muscovite some euhedral magnetite no magnetite dust

Sample # 48 Unit Trut UTM Loc 5557900 N 532750 E Loc name south Lillooet Lake
Rock type crystal lithic tuff Clast/Matrix ratio 40/60 Matrix composition isotropic material
Clast types in order of abundance plagioclase crystal fragments, felsic volcanic clasts, isotropic fragments, equant mafic replaced by chlorite
Comments

Sample # 80 Unit Trut UTM Loc 5559350 N 5314000 E Loc name Strawberry Ck
Rock type felsic lithic tuff Clast/Matrix ratio 65/35 Matrix composition Unknown -clouded by ep
Clast types in order of abundance plagioclase crystals (euhedral), chert, dacitic and rhyolitic clasts, intermediate volc. clasts, tuff clasts
Comments Fine-grained actinolite in matrix

Sample # 211 Unit Trut UTM Loc 5562000 N 530220 E Loc name Bastion Peak
Rock type andesitic lithic tuff Clast/Matrix 40/60 Matrix composition andesitic
Clast types in order of abundance basaltic andesite, amygdaloidal basalt, small plagioclase crystal fragments, felsic volcanic clasts, intermediate volc. clasts
Comments noticeably more mafic rock than 28, 48, 80 Abundant actinolite in matrix

Sample # 238 Unit Trut UTM Loc 5562600 N 529900 E Loc name Bastion Peak
Rock type andesitic lithic tuff Clast/Matrix ratio 80/20 Matrix composition andesitic
Clast types in order of abundance andesitic with equant plagioclase phenocrysts, basalt with plagioclase microlites, felsic volcanic fragments, some chert, large equant plagioclase crystal and crystal fragments
Comments abundant actinolite needles

Sample # 352 Unit Trut UTM Loc 5568700 N 525700 E Loc name above Lill property
Rock type unsorted felsic tuff Clast/Matrix ratio 80/20 Matrix composition unknown
Clast types in order of abundance Euhedral plagioclase crystals, fsp porphyritic andesitic lithic fragments, one ultramafic lithic clasts (pyroxenite?), basalt with plagioclase microlites, mafic crystals replaced by epidote
Comments abundant actinolite needles

Sample # 519A Unit Trut UTM Loc 5591150 N 525600 E Loc name Gates Lake
Rock type feldspar crystal tuff Clast/Matrix ratio 90/10 Matrix composition felsic
Clast types in order of abundance euhedral feldspar crystals and fragments, felsic volcanic frags. chert, quartz crystal fragments, feldspar phyric andesitic clasts, mafic lithic clasts replaced by chlorite,
Comments Epidote stringers, actinolite needles in matrix.

Sample # 546 Unit Trut UTM Loc 5590650 N 520950 E Loc name Birkenhead Road
Rock type andesitic crystal tuff Clast/Matrix ratio 90/10 Matrix composition ?? Qz rich
Clast types in order of abundance feldspar and hornblende crystal fragments make up most of the coarse material, groundmass contains quartz - overprinted by a lot of dark green chlorite
Comments Abundant actinolite in matrix

Sample # 550 Unit Trut UTM Loc 5594850 N 519150 E Loc name Tailefer Creek
Rock type felsic lithic tuff Clast/Matrix ratio 85/15 Matrix composition cherty tuff
Clast types in order of abundance plagioclase crystals, quartz crystals, rhyolitic clasts, coarser-grained andesite fragments, cherty tuff clasts, mafic lithic clasts replaced by chlorite and epidote
Comments actinolite in matrix

Sample # 565 Unit Trut UTM Loc 5608950 N 498010 E Loc name Railroad
Rock type felsic lithic tuff Clast/Matrix ratio 60/40 Matrix composition microcrystalline qz
Clast types in order of abundance feldspar crystals, felsic volcanic clasts, cherty tuff clasts, coarse andesite, hornblende crystal fragments, mafic lithic clasts replaced by chlorite
Comments actinolite in matrix

Sample # 552 Unit Trut UTM Loc 5596450 N 514750 E Loc name Sungod Mountain
Rock type mixed lithic tuff Clast/Matrix ratio 60/40 Matrix composition intermed. to dacitic
Clast types in order of abundance felsic volcanic fragments, some mafic lithic clasts gone to chlorite, some small quartz crystal fragments, mafic minerals replaced with epidote
Comments

Sample # 670(1) Unit Trut? UTM Loc 5594500 N 510650 E Loc name Cerulean Lake
Rock type felsic tuff Clast/Matrix ratio 15/85 Matrix composition cherty tuff
Clast types in order of abundance plagioclase crystals, felsic volcanics
Comments could be Cerulean Lake unit

Sample # 804 Unit Trut UTM Loc 5596150 N 506650 E Loc name Middle ridge
Rock type mixed tuff Clast/Matrix ratio 30/70 Matrix composition mafic tuffaceous material
Clast types in order of abundance felsic volcanic rocks, amygdaloidal basalt, plagioclase and quartz fragments, andesite fragments, actinolite
Comments matrix is felted, a lot of the chlorite is isotropic

Sample # SH-1 Unit Trut UTM Loc 5596200 N 505990 E Loc name Mount McLeod
Rock type felsic tuff Clast/Matrix ratio 60/40 Matrix composition f.g.qz & fsp & chert
Clast types in order of abundance sub-rounded quartz crystal fragments, chert, mafic crystal material replaced by chlorite, some feldspar crystal fragments
Comments actinolite in matrix

Sample # 749 Unit Trr UTM Loc 5599900 N 50700 E Loc name Grizzly Pass
Rock type qz crystal tuff Clast/Matrix ratio 40/60 Matrix composition rhyolite
Clast types in order of abundance large quartz grains, some show resorption, rhyolite fragments, NO mafic material
Comments Sheared- from Grizzly Pass shear zone, explosive volcanism preceded the shearing

Sample # 613 Unit Trr UTM Loc 5606300 N 500570 E Loc name Railroad
Rock type felsic tuff Clast/Matrix ratio 90/10 Matrix composition felsic
Clast types in order of abundance stubby fsp crystal fragments, strained quartz, rhyolite fragments cherty fragments, mafic crystals replaced with epidote
Comments welded

Sample # 631 Unit Trr UTM Loc 5608100 N 499750 E Loc name Grouty Peak
Rock type qz crystal tuff Clast/Matrix ratio 70/30 Matrix composition rhyolite
Clast types in order of abundance quartz crystal fragments, dacite, rhyolite, cherty tuff, plagioclase crystal fragments
Comments NO mafic material

Sample # 640 Unit Trr UTM Loc 5608000 N 499100 E Loc name Grouty Peak
Rock type Trr epiclastic Clast/Matrix ratio Matrix composition
Clast types in order of abundance
Comments NOT A USEFUL SLIDE

Sample # 561B Unit Trr UTM Loc 5609250 N 497700 E Loc name Railroad Pass
Rock type quartz crystal tuff Clast/Matrix ratio 50/50 Matrix composition rhyolite
Clast types in order of abundance quartz crystal fragments, sericitized feldspar crystals and crystal fragments, about 2% mafic material - replaced by epidote, epidote stringers
Comments Most of the slide shows spherulitic textures

Sample # 219 Unit Tr bts UTM Loc 5560900 N 531450 E Loc name Rampart Mountain
Rock type cherty tuff Clast/Matrix ratio 10/90 Matrix composition cherty
Clast types in order of abundance small quartz grains, rare small plagioclase crystals, epidote, very-fine-grained chlorite, actinolite
Comments

Sample # 257 Unit Tr bts UTM Loc 5563200 N 530500 E Loc name Bastion Peak
Rock type cherty tuff Clast/Matrix ratio 5/95 Matrix composition chert and clay or ash
Clast types in order of abundance NO quartz grains, some rare plagioclase fragments, abundant green opaque material (about 15%), epidote veins
Comments chlorite > epidote actinolite in matrix

Sample # 216 Unit Tr bts UTM Loc 5561100 N 531150 E Loc name Rampart Mountain
Rock type ???? Clast/Matrix ratio ?????? Matrix composition ??
Clast types in order of abundance plagioclase crystals, mafic crystals replaced by v.f.g. epidote
Comments altered mixed crystal tuff

Sample # SH-20B Unit Tr bts UTM Loc 5596000 N 507900 E Loc name Mt. McLeod
Rock type mixed lithic tuff Clast/Matrix ratio 70/30 Matrix composition intermediate
Clast types in order of abundance rhyolite, cherty tuff, bent and broken plagioclase crystals, fine-grained intermediate volcanic lithic fragments, mafic volcanic clasts replaced by epidote. 1 amygdaloidal basalt clast
Comments fine-grained actinolite in matrix

Sample # SH-12A Unit Tr bts UTM Loc 5595450 N 507900 E Loc name Mt McLeod
Rock type silty limestone Clast/Matrix ratio Matrix composition
Clast types in order of abundance limestone grains
Comments bedded silty clastic limestone

Sample # 812B Unit Tr bts UTM Loc 5594450 N 507850 E Loc name Mount Barbour
Rock type volcanic wacke Clast/Matrix ratio 90/10 Matrix composition ?? looks felsic
Clast types in order of abundance microlite basalt, amygdaloidal basalt, dacite, mafic crystal fragments replaced by epidote, andesite, plagioclase crystal fragments
Comments abundant actinolite needles in matrix

Sample # 816A Unit Tr bts UTM Loc 5595500 N 508150 E Loc name Mount Barbour
Rock type qz siltstone Clast/Matrix ratio Matrix composition
Clast types in order of abundance most clasts are monocrystalline quartz, lesser quartz
Comments shows a set of soft-sediment normal microfaults

Sample # 256A Unit Tr bts UTM Loc 55632000 N 530500 E Loc name Bastion Peak
Rock type fsp crystal/ lithic tuff Clast/Matrix ratio ?? Matrix composition andesitic
Clast types in order of abundance plagioclase crystals, basalt lithic fragments, andesite fragments, felsic volcanic fragments
Comments abundant actinolite needles in matrix

Sample # 735 Unit Tr bts/ ?JKs UTM Loc 5596250 N 508600 E Loc name Lilikel
Rock type cherty tuff Clast/Matrix ratio 30/70 Matrix composition cherty
Clast types in order of abundance severely altered plagioclase, mostly equant, some laths, Carlsbad twins, replaced by carbonate, small rounded quartz grains, abundant actinolite needles in matrix
Comments Clast of Tr bts in Cerulean Lake unit conglomerate

Sample # 752B Unit Trbts UTM Loc 5598750 N 511600 E Loc name East of Grizzly Pass
Rock type volcanic wacke Clast/Matrix ratio 100/0 Matrix composition
Clast types in order of abundance plagioclase crystals (fractured), felsic volcanic and cherty tuff clasts, mafic lithic fragments abundant actinolite needles in matrix
Comments Stained for kspar - negative abundant carbonate replacement and veinlets

Sample # 792B Unit Tr bts UTM Loc 5595400 N 505600 E Loc name Mt. McLeod
Rock type mafic tuff Clast/Matrix ratio Matrix composition andesite
Clast types in order of abundance basalt clasts dominate, also andesite, plagioclase crystals, one felsic volcanic clast, mafic crystal fragments, replaced by chlorite and epidote, abundant actinolite
Comments abundant epidote veinlets

Sample # 805A Unit Tr bts UTM Loc 5595400 N 506850 E Loc name Middle ridge
Rock type volcanic wacke Clast/Matrix ratio 100/0 Matrix composition
Clast types in order of abundance amygdaloidal basalt, (amygs filled with chlorite and carbonate), plagioclase crystals and fragments, chert, fine-grained mafic volcanics, intermediate and and felsic volcanic clasts in lesser amounts, quartz
Comments volcanic lithic fragments>>quartz> chert Well sorted Abundant carbonate

Sample # 805C Unit Tr bts UTM Loc 5596400 N 506850 E Loc name Middle ridge
Rock type sheared tuff Clast/Matrix ratio 60/40 Matrix composition felsic
Clast types in order of abundance plagioclase crystals, aphanitic felsic volcanics, small mono-crystalline quartz grains with resorbed edges, some mafic and intermediate volcanic clasts chlorite
Comments no epidote abundant fine-grained actinolite

Sample # 828 Unit Tr bts UTM Loc 5593700 N 507810 E Loc name Mount Barbour
Rock type volcanic wacke Clast/Matrix ratio Matrix composition
Clast types in order of abundance plagioclase crystals, microlite AND massive basalt, aphanitic felsic volcanics Blue birefringent chlorite, abundant actinolite needles
Comments Most of the matrix is replaced by chlorite

Sample # 916A Unit Tr bts UTM Loc 5561000 N 531500 E Loc name Rampart Mountain
Rock type steel-grey siltstone Clast/Matrix ratio Matrix composition
Clast types in order of abudance very-fine-grained quartz and plagioclase and epidote, about 5% mafic ashy material replaced by epidote, some chlorite, 1 to 2% carbonate abundant actinolite needles
Comments

Sample # 916B Unit Tr bts UTM Loc 5561000 N 531500 E Loc name Rampart Mountain
Rock type fine-grained felsic tuff Clast/Matrix ratio Matrix composition f.g. monocr. qz
Clast types in order of abundance felsic tuff even-grained MATRIX NOT CHERTY
some actinolite
Comments

Sample # 916C Unit Tr bts UTM Loc 5561000 N 531500 E Loc name Rampart Mountain

Rock type mafic lapilli tuff Clast/Matrix 50/50 Matrix composition clay and chlorite

Clast types in order of abundance plagioclase-phyric andesite, microlite basalt, amygdaloidal basalt, plagioclase crystals, felsic volcanic clasts are rare, abundant actinolite needles

Comments

Sample # 816B Unit CLsm UTM Loc 5595550 N 508150 E Loc name Mount Barbour
Rock type medium grained sst Clast/Matrix ratio 100/0 Matrix composition
Clast types in order of abundance chert, plagioclase crystal fragments, monocrystalline quartz, minor rock fragments (v.f.g. and clouded with chlorite, some fine grained epidote replacing mafic lithic fragments, some carbonate clots, disseminated actinolite
Comments Reworked Triassic Cadwallader sedimentary rock

Sample # 818 Unit CLsm UTM Loc 5595850 N 508300 E Loc name Mount Barbour
Rock type med. gr. sst Clast/Matrix ratio 100/0 Matrix composition
Clast types in order of abundance fresh to strongly strained monocrystalline quartz crystal fragments, fresh plagioclase crystal fragments, some cherty tuff, some biotite, cherty tuff grains in v.f.g. chlorite and quartz and epidote and plagioclase and actinolite matrix
Comments Clast sources are clearly a combination of CL volcanic member and Cadwallader sediments

Sample # 671 Unit CLsm UTM Loc 5594350 N 510750 E Loc name West of Cerulean Lake
Rock type coarse sst Clast/Matrix ratio 60/40 Matrix composition mafic
Clast types in order of abundance most clasts are basalt (some amygdaloidal) in felted mafic groundmass of chlorite, epidote, feldspar and actinolite
Comments rock sits on Cadwallader mafic volcanic rocks, which looks like the source of the clasts

Sample # 735 Unit CLsm UTM Loc 5596250 N 508600 E Loc name Lilikel property
Rock type fsp crystal tuff Clast/Matrix ratio 65/35 Matrix composition felsic
Clast types in order of abundance coarse plagioclase crystal fragments, in groundmass that is almost entirely quartz and feldspar, some late carbonate, a little f.g. actinolite and chlorite
Comments conglomerate clast

Sample # 573 Unit CLsm UTM Loc 5596500 N 509400 E Loc name Lilikel property
Rock type quartzite clast Clast/Matrix ratio 100/0 Matrix composition
Clast types in order of abundance coarse monocrystalline quartz (about 60%) and plagioclase grains, rounded (40%), plagioclase is sericitized
Comments conglomerate clast medium-coarse quartz and fsp sandstone qz not cherty

Sample # 39 Unit CLvm UTM Loc 5557600 N 534250 E Loc name Rampart Mountain
Rock type maroon lap. tuff/bx Clast/Matrix ratio 90/10 Matrix composition f.g. qz, cp, hem,plag,
Clast types in order of abundance plagioclase-phyric andesite, large plagioclase crystals, cherty tuff aphanitic dacite, aphanitic andesite
Comments all clasts edged with hematite, hematite is thick in the matrix

Sample # 666 Unit CLvm UTM Loc 5593800 N 509800 E Loc name 7 o'clock Mountain
Rock type maroon bx Clast/Matrix ratio 90/10 Matrix composition dacitic
Clast types in order of abundance very large, fresh plagioclase crystals, chert, battered dacite, coarse andesite (plag-phyric), partly or completely replaced by hematite, some quartzite clasts
Comments Stained for kspar - negative felsic types>>andesitic dacites are felted and damaged

Sample # 735 Unit CLvm UTM Loc 5596250 N 508600 E Loc name Lilikel property
Rock type maroon bx Clast/Matrix ratio 60/40 Matrix composition andesitic
Clast types in order of abundance f.g. andesite, medium-sized battered plagioclase crystals, horn-blende crystals replaced by epidote, coarse andesite, minor interstitial quartz
Comments abundant hematite is responsible for the maroon colour

Sample # 717 Unit CLvm UTM Loc 5594000 N 508300 E Loc name Mount Barbour
Rock type maroon bx Clast/Matrix ratio 100/0 Matrix composition ???
Clast types in order of abundance all fine-grained ??dacitic material - felted, rounded plagioclase crystals, abundant disseminated hematite
Comments NOT A USEFUL SLIDE

Sample # 809C Unit CLvm UTM Loc 5595850 N 507600 E Loc name Mount Barbour
Rock type maroon bx Clast/Matrix ratio 50/50 Matrix composition obscured by hematite
Clast types in order of abundance plagioclase crystal fragments, hematite clots, cherty tuff, dacite, chert, andesite, a couple of basalt fragments, epidote blots, coarse feldspar-phyric andesite
Comments Intense hematite colouring Stained for kspar - negative

Sample # 815B Unit CLvm UTM Loc 5595350 N 508100 E Loc name Mount Barbour
Rock type green dike Composition felted mass of plagioclase laths and hornblende laths - replaced by epidote and chlorite, a little bit of interstitial quartz actinolite needles
Comments

Sample # 817B Unit CLvm UTM Loc 5595750 N 508150 E Loc name Mount Barbour
Rock type dacite flow Composition dominated by ragged old plagioclase. v.f.g. quartz and plagioclase and chlorite groundmass some epidote clots
Comments

Sample # 668A Unit CLvm UTM Loc 5594500 N 510350 E Loc name 7 o'clock Mountain
Rock type flow Composition strongly altered flow, plagioclase phenocrysts' centres are replaced with carbonate, clinopx phenocrysts, in messy felted groundmass of plagioclase laths and epidote
Comments abundant actinolite in matrix

Sample # 202C Unit Peninsula UTM Loc 5561700 N 529150 E Loc name W of Bastion Peak
Rock type fine grey siltstone Clast/Matrix ratio all clasts Matrix composition ____________
Clast types in order of abundance monocrystalline quartz, plagioclase, chlorite, epidote, clay clots carbonate (rare and larger than other grains - probably diagenetic), isotropic dust
Comments ____________

Sample # 202 Unit Peninsula UTM Loc 5561700 N 529150 E Loc name west of Bastion Peak
Rock type shale Clast/Matrix ratio all clasts Matrix composition ____________
Comments Like 202C but finer, and more carbonate

Sample # 207A Unit Peninsula UTM Loc 5562300 N 529300 E Loc name west of Bastion Peak
Rock type volcanic wacke Clast/Matrix ratio 65/35 Matrix composition v.f.g plag, qz and chlor.
Clast types in order of abundance large equant plagioclase crystals, intensely sericitized, some saussuritized, carbonate, hornblende crystals replaced by chlorite, strongly strained quartz, traces of epidote, actinolite needles
Comments NO lithic fragments - some chlorite blots may have been mafic lithic clasts

Sample # 947B Unit Peninsula UTM Loc 5582700 N 512550 E Loc name Mount Fraser
Rock type volcanic wacke/tuff Clast/Matrix ratio 90/10 Matrix composition qz, fsp and dark dust
Clast types in order of abundance frayed plagioclase crystals, chloritic blots with blue birefringent colours - probably mafic lithic clasts or mafic crystals, some small quartz grains
Comments strongly strained rock not a very useful slide

Sample # 157 Unit Peninsula UTM Loc 5571600 N 519650 E Loc name Lillooet River road
Rock type grey calcareous sst Clast/Matrix ratio 70/30 Matrix composition fibrous chlorite
Clast types in order of abundance Carbonate clasts>>pyrite, rare aphanitic felsic volcanic clasts
Comments strongly strained actinolite needles in matrix

Sample #359B Unit Brokenback Hill UTM Loc 5564200 N 524850 E Loc name N of Ure Creek
Rock type fsp-hb bx Clast/Matrix ratio 50/50 Matrix composition f.g. chlorite & microlite plag
Clast types in order of abundance Large, equant, zoned plagioclase crystals, hornblende crystals replaced by yellowish green chlorite, small plagioclase laths abundant actinolite needles
Comments andesitic

Sample # 203B Unit Brokenback Hill UTM Loc 5561900 N 529100 E Loc name W. of Bastion
Rock type mauve andesitic bx Clast/Matrix 65/35 Matrix composition andesitic
Clast types in order of abundance broken, ragged, rounded plagioclase crystals, some zoned and twinned, hornblende crystals and fragments, some replaced with epidote, some etched with hematite, felsic lithic clasts with hematite rods intergrown, mafic lithic clasts actinolite needles
Comments Stained for kspar - negative some clasts completely replaced by hematite

Sample # 153 Unit Brokenback Hill UTM Loc 5571700 N 520700 E Loc name Lill. River road
Rock type mauve andesitic bx Clast/Matrix ratio 80/20 Matrix composition andesitic to dacitic
Clast types in order of abundance bent equant plagioclase with albite twins, mafic feldspar-phyric lithic clasts replaced with hematite, epidote, hornblende crystals replaced by chlorite, f.g. felsic clasts
Comments much fresher than same unit west of Bastion Peak

Sample # 288 Unit Brokenback Hill UTM Loc 5562300 N 528600 E Loc name w. of Bastion Peak
Rock type hb-fsp andesite Composition interlocking plagioclase laths and hornblende crystals, some hornblende gone to epidote, a few larger phenocrysts of equant zoned plagioclase, lots of bue-birefringent chlorite
Comments flow - mostly equigranular minor magnetite

Sample # 934 Unit Brokenback Hill UTM Loc 5580600 N 511500 E Loc name Mount Fraser
Rock type andesite-dacite flow Composition Bimodal - coarser equant to slightly lengthy plagioclase smaller hornblende and lath-shaped plagioclase, Hb shapes mostly replaced by chlorite and epidote. NO QUARTZ
Comments Flow - looks more like diorite in thin section, but hand sample looks volcanic

Sample # 393 Unit Brokenback Hill UTM Loc 5575900 N 519400 E Loc name Owl Creek
Rock type crystal tuff Clast/Matrix ratio 50/50 Matrix composition v.f.g. fsp and chlorite
Clast types in order of abundance ragged plagioclase crystals, ragged epidotized hornblende crystals dacitic lithic fragments, hematite-rimmed black opaques, late carbonate
Comments abundant hematite

Sample # 360 Unit Brokenback Hill UTM Loc 5568000 N 524800 E Loc name N. of Ure Creek
Rock type crystal/lithic tuff Clast/Matrix ratio 70/30 Matrix composition dacitic
Clast types in order of abundance ragged sericitized equant plagioclase crystals, epidotized horn-blende, epidotized plagioclase-phyric mafic volcanic clasts, aphanitic felsic clasts
Comments

Sample # 309 Unit unnamed unit UTM Loc 5559900 N 527500 E Loc name S. of Ure Creek
Rock type meta-tuff or flow Composition equant plagioclase crystals, some hornblende crystals, groundmass dominated by plagioclase and chlorite and minor quartz No opaques
Comments Not very useful - meta'd adjacent to Pemberton Diorite Complex

Sample # 314 Unit unnamed unit UTM Loc 5559700 N 527000 E Loc name westernmost ridge
Rock type px porph. or tuff Clast/Matrix ratio 90/10 Matrix composition
Clast types in order of abundance large euhedral pyroxenes, smaller elongate plagioclase, smaller still plagioclase laths, minor magnetite
Comments Pyroxenes make up about 5-10% of the volume, they are about 5mm across. Rock is strongly strained adjacent to the Pemberton Diorite Complex

Sample # 384 Unit unnamed unit UTM Loc 5567300 N 570200 E Loc name N. of Ure Creek
Rock type metased Composition quartz-rich metasedimentary rock, quartz is monocrystalline, biotite of same size lines up to foliation, between grains
Comments at the contact with the Pemberton Diorite Complex

Sample # 178 Unit unnamed unit UTM Loc 5553150 N 532450 E Loc name Tenas Lake
Rock type mixed lithic tuff Clast/Matrix ratio 80/20 Matrix composition isotropic dust
Clast types in order of abundance large plagioclase fragments, basalt, dacite, plagioclase-phyric andesite, vesicular basalt, hornblende crystal, a little quartz
Comments angular clasts, not much sorting

Sample # 300 Unit unnamed unit UTM Loc 5560600 N 526150 E Loc name westernmost ridge
Rock type px porphyry Composition Flow with equant pyroxene crystals and fresh plagioclase laths interlocking. magnetite, lesser hematite, abundant fine actinlite in matrix
Comments

Sample # 363 Unit unnamed unit UTM Loc 5566900 N 522900 E Loc name N. of Ure Creek
Rock type metased Composition
Comments recrystallized - all small recrystallized quartz with interstitial small aligned hornblende

Sample # SH-28 Unit Tertiary UTM Loc 5561650 N 530650 E Loc name Rampart Mountain
Rock type andesite flow Texture fine, even-grained Phenocrysts biotite laths and flakes
Groundmass composition fine Kspar (stained)
Comments Pyroxene and biotite crystals in groundmass of K-feldspar AND abundant quartz

Sample # 264B Unit Tertiary UTM Loc 5558350 N 528500 E Loc name westernmost ridge
Rock type bubbly rhyolite Texture bimodal Phenocrysts equant zoned plag
Groundmass composition fine plagioclase microlites and dark dust, and fine kspar
Comments Stained for kspar - positive

Sample # 315 Unit Tertiary UTM Loc 5560350 N 526900 E Loc name westernmost ridge
Rock type rhyolite ? Texture
Phenocrysts plagioclase, some hornblende
Groundmass composition v.f.g. kspar and isotropic material
Comments about 60% plagioclase lath phenocrysts (a few laths)

Sample # 894 Unit Tr pluton UTM Loc 5565100 N 531000 E Loc name Bastion Peak
Rock type aplite Texture fine, equigranular
Comments equigranular, fine-grained quartz and feldspar, graphic texture, plagioclase and K-feldspar

Sample # 903 Unit Tr pluton UTM Loc 5563900 N 531650 E Loc name Bastion Peak
Rock type aplite Texture equigranular Phenocrysts quartz and feldspar
Comments spherulitic - about 5% mafics - gone to epidote 95% quartz and feldspar

Sample # 36B Unit Tr pluton UTM Loc 5557100 N 533500 E Loc name south Lillooet Lake
Rock type qtz diorite or crystal tuff?? Texture ______ Phenocrysts feldspar
Comments large plagioclase crystals, qz is interstitial, so is chlorite, actinolite needles in matrix, stained for kspar - negative in contiuum zone between crystal tuff and quartz diorite

Sample # 91 Unit Tr pluton UTM Loc 5555600 N 533800 E Loc name south Lillooet Lake
Rock type quartz diorite Texture porphyritic, interstitial fine quartz Phenocrysts plag, hornblende
Comments at plutonic end of quartz-diorite--crystal tuff continuum fine crystals are quartz>>chlorite, actinolite Stained for kspar - negative

Sample # 104B Unit Tr pluton UTM Loc 5554900 N 534900 E Loc name south Lillooet Lake
Rock type granite Texture coarse - almost pegmatitic Phenocrysts plag, ksp, quartz
Comments very coarse plagioclase, Kfeldspar, quartz, minor hornblende Ksp is perthitic Minor amounts of actinolite needles

Sample # 41B Unit Tr pluton UTM Loc 5556900 N 533000 E Loc name south Lillooet Lake
Rock type quartz diorite Texture intensely sheared Phenocrysts quartz
Comments Coarse quartz eyes, broken feldspar crystals, bits of small grained quartz in groundmass, all highly strained some chlorite Stained for kspar - negative

Sample # 90 Unit Tr pluton UTM Loc 5555800 N 532550 E Loc name south Lillooet Lake
Rock type quartz porphyry Texture Porphyritic-med grained g/mass Phenocrysts quartz
Comments Groundmass composed of qz, microcline, plagioclase, some chlorite, actinolite needles, epidote veinlets

APPENDIX B
Structure data and stereonets

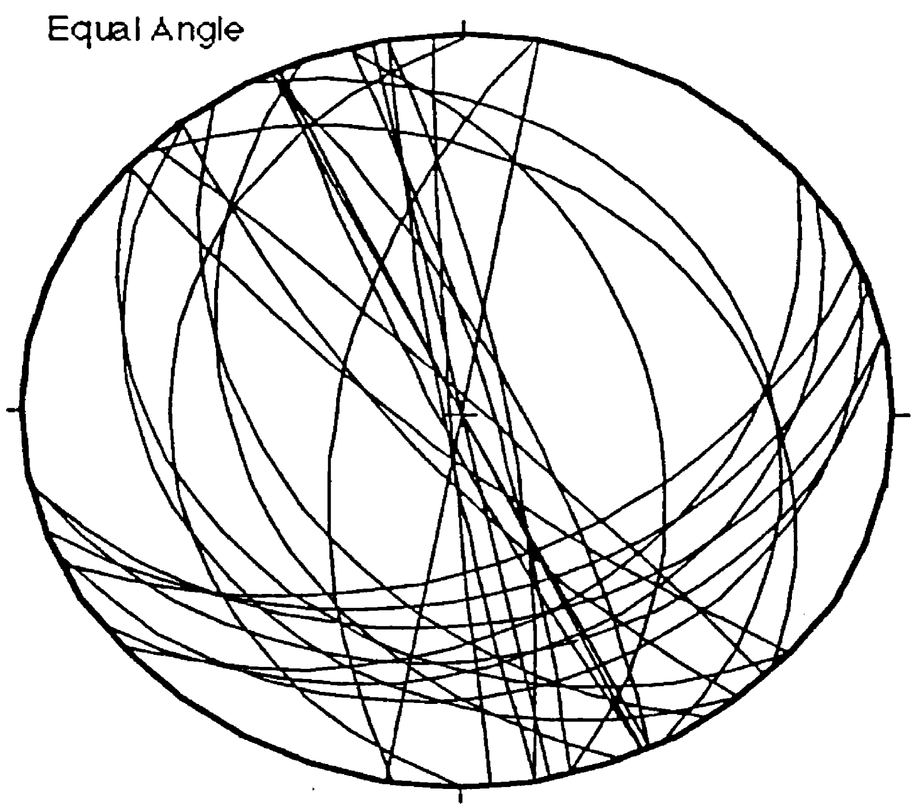
OWL CREEK FAULT ZONE STRUCTURES

GOUGES

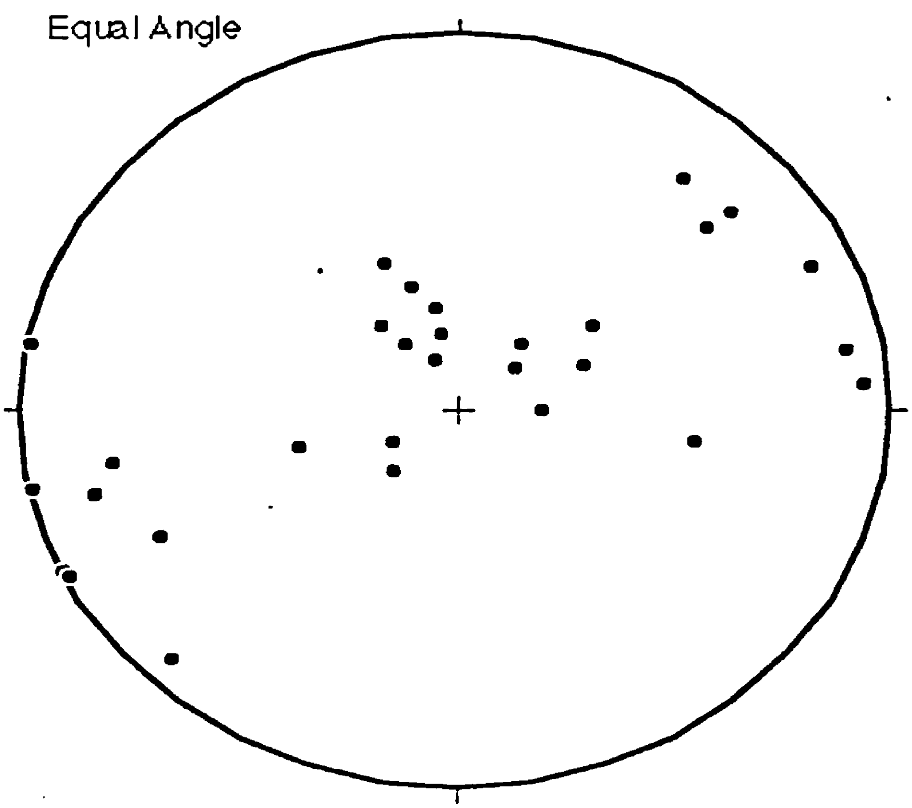
Data point	Station	Orientation	Location	
1	113	140/74	Lill River road	
2	113	140/79	"	
3	113	343/42	"	
4	113	348/90	"	
5	113	010/90	"	
6	113	155/84	"	
7	113	334/75	"	
8	114	[illegible]	"	
9	114	130/25	"	
10	114	130/78	"	
11	114	335/90	"	
12	114	334/90	"	
13	114	345/82	"	
14	114	315/86	"	
15	114	314/25	"	
16	114	066/46	"	slicks 16/256
18	114	332/20	"	
19	114	055/24	"	
20	114	170/85	"	
21	114	176/87	"	
22	114	145/42	"	
23	114	180/22	"	
24	114	350/78	"	
25	115	078/31	"	
26	170	071/38	"	
27	170	189/58	"	
28	170	140/20	"	
29	170	078/23	"	
30	170	067/16	"	

SHEAR FOLIATIONS

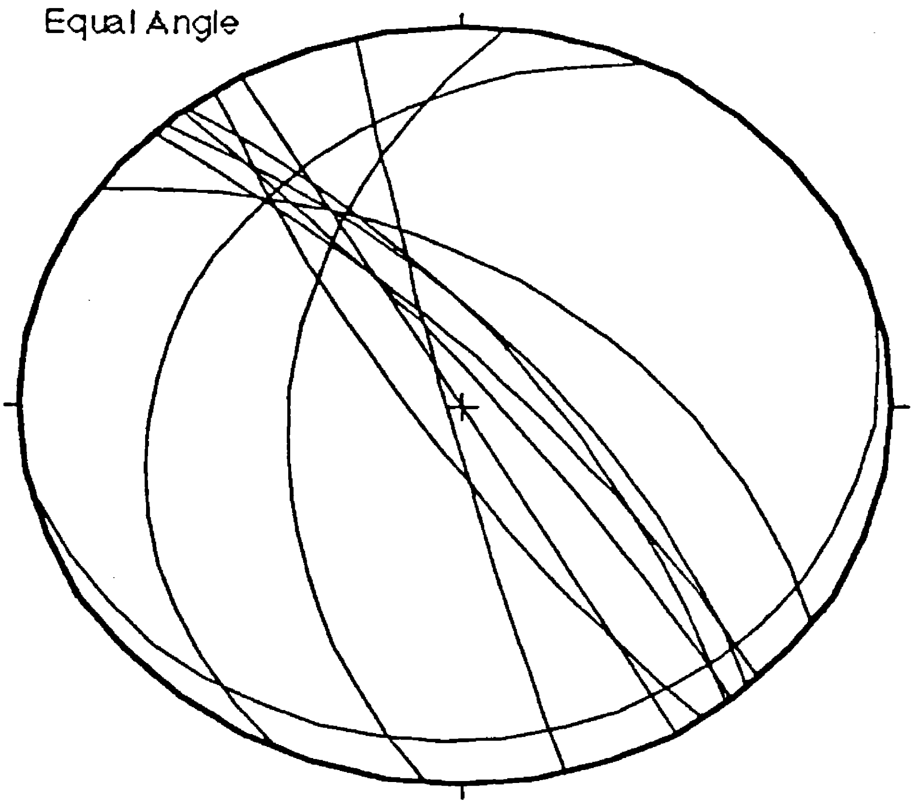
Data point	Station	Orientation	Location	
1	114	185/47	Lill River road	sericite sch
2	114	166/86	"	"
3	115	305/51	"	
4	115	318/68	"	
5	115	316/77	"	
6	170	075/07	"	sericite sch
7	170	205/21	"	sericite sch
8	234	146/78	saddle nr Bastion	
9	234	330/90	"	
10	234	321/82	"	
11	234	322/70	"	



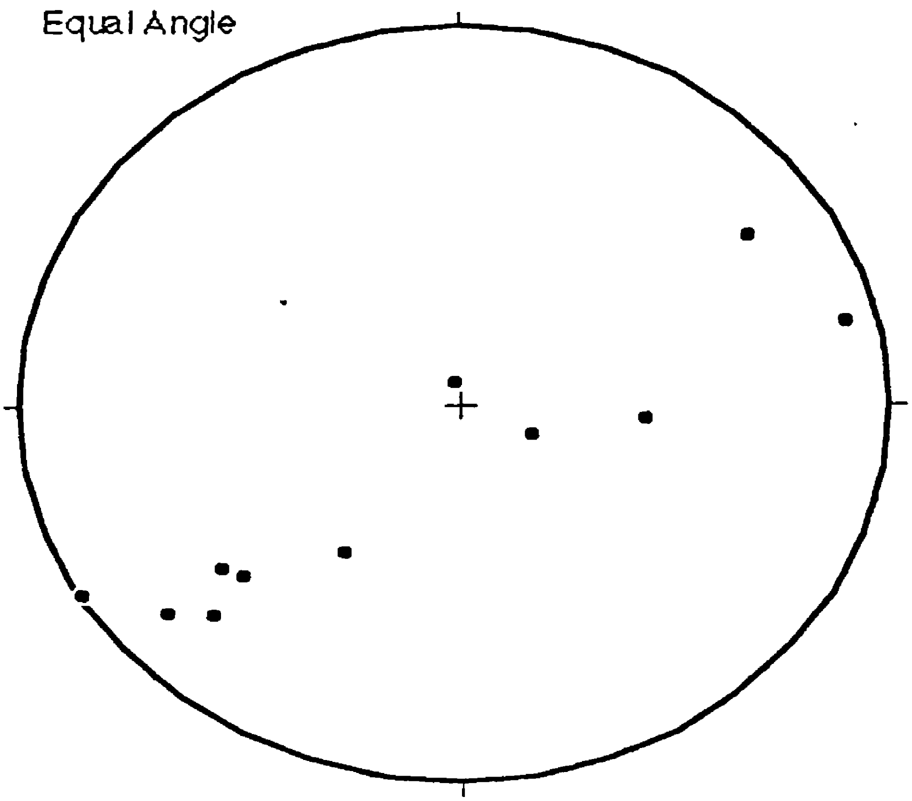
Owl Creek Fault - Gouges - Lillooet River road



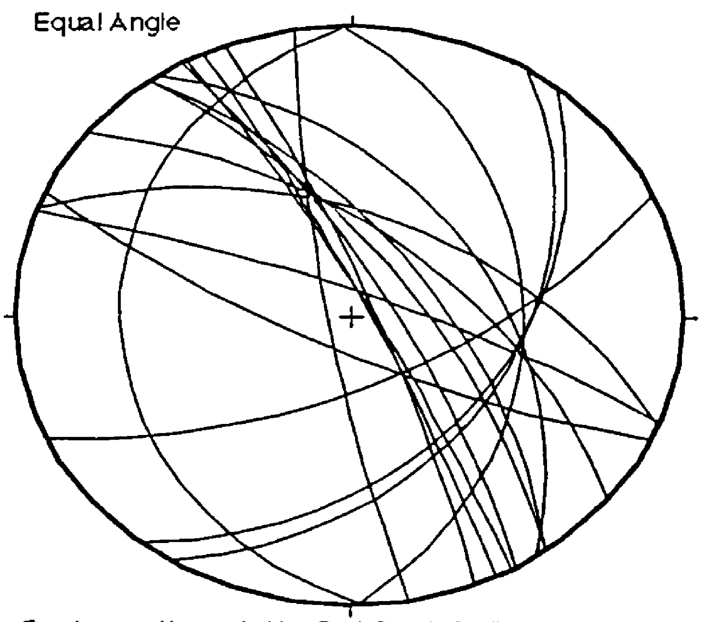
Poles to gouge planes in the Owl Creek Faut, Lilboet River road



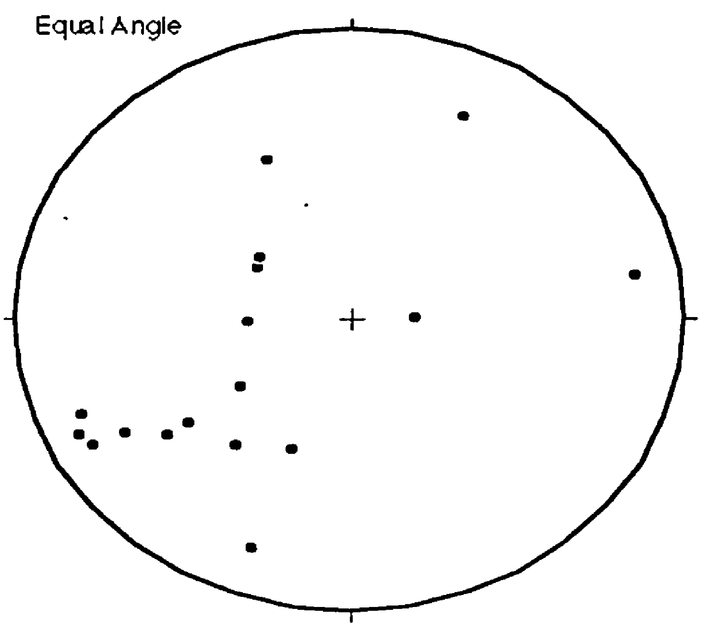
Shear foliations in the Owl Creek Fault



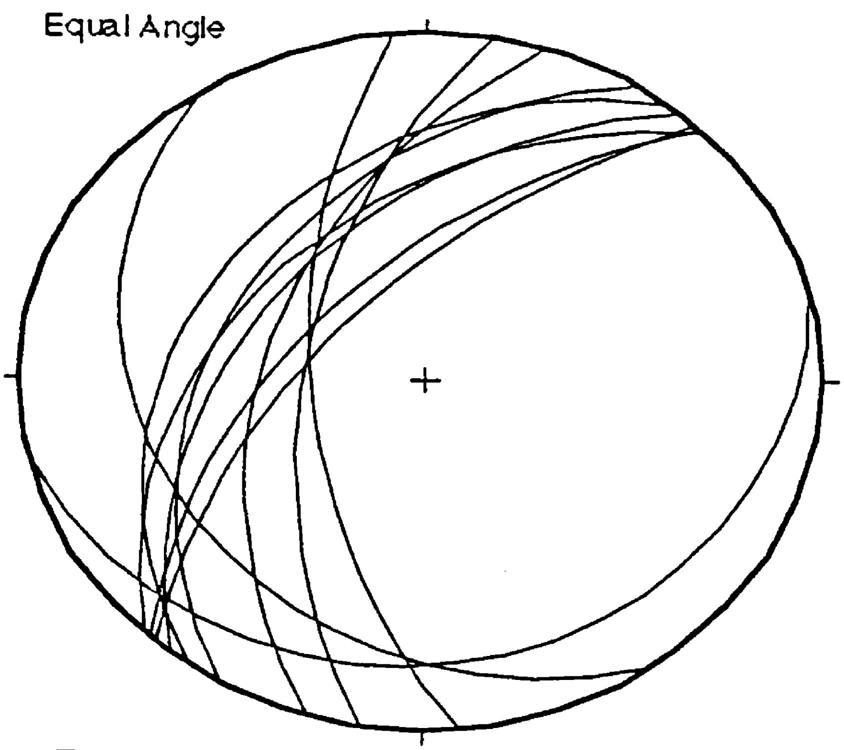
Poles to shear zone foliations in the Owl Creek fault zone



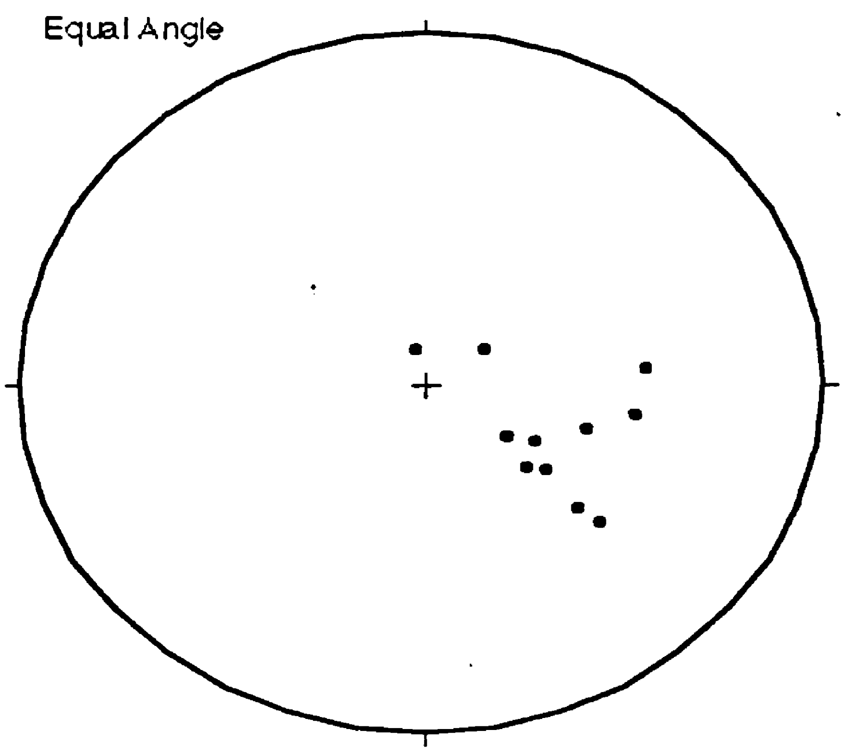
Fracture patterns in the Owl Creek fault zone



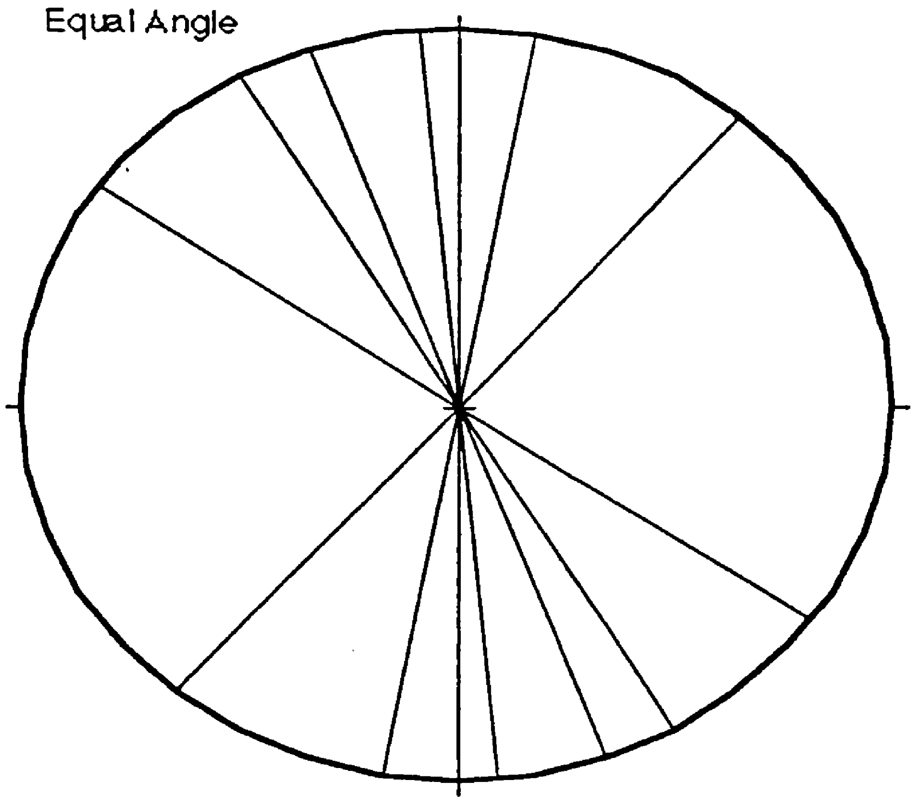
Poles to fracture patterns in the Owl Creek fault zone



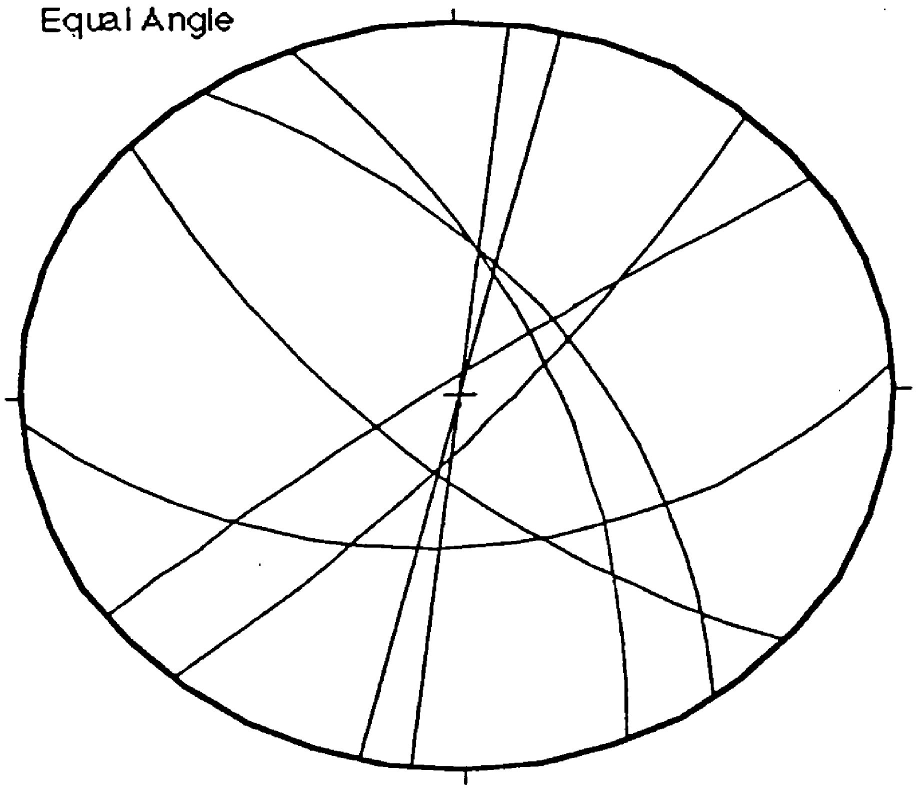
Tension gashes and quartz-filled veins in the Owl Creek Fault Zone



Poles to tension gashes and quartz-filled veins, in the Owl Creek fault zone



Late-stage tension cracks and rubble pits



Tertiary dikes in the Tenquille/Lilloet Lake area

GAMBIER GROUP ROCKS - BEDDING AND FOLDING DATA

BEDDING IN GAMBIER GROUP ROCKS ADJACENT TO THE OWL CREEK FAULT

Mount Fraser/Owl/ Wolverine Creek

1	397	115/68	Owl Creek	Gp
2	402	312/64	Owl Creek	Gp
3	510	102/60	Owl Creek	Gp
4	510	310/44	Owl Creek	Gp
5	948	258/56	" "	

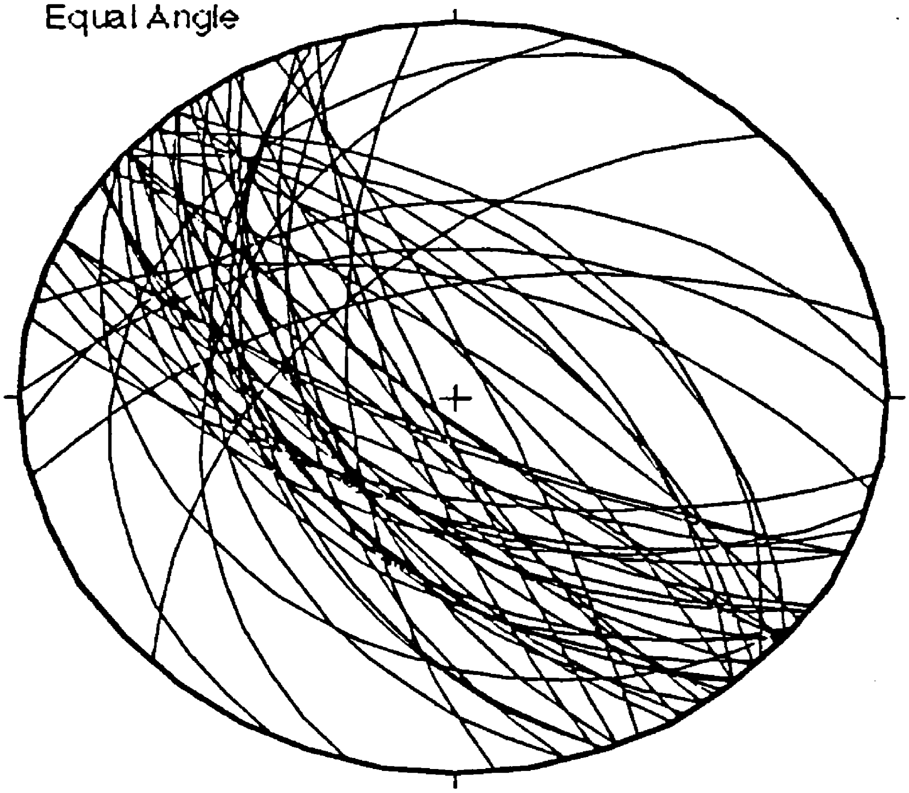
North of Ure Creek

1	157	115/76 RSU	Lill R North	Gp
2	157	149/81 RSU	" "	
3	157	335/81 "	"	
4	338	125/56	Glacier camp	Gu
5	344	271/46	Ridgetop	Gp
6	344	266/34	" "	
7	349	316/62	" "	
8				
9	349	225/50	" "	
10	349	320/80	" "	
11	350	128/22	" "	
12	356	315/40	" "	
13	363	320/57	" "	
14	365	108/50	" "	
15	365	130/42	" "	
16	365	285/55	" "	
17	365	131/56	" "	
18	365	140/46	" "	
19	365	145/46	" "	
20	365	128/38	" "	
21	365	130/74	" "	
22	365	161/75	" "	
23	365	145/76	" "	
24	365	158/84	" "	
25	365	130/84	" "	
26	366	115/78	" "	
27	367	125/52	" "	
28	367	135/42	" "	
29	367	136/59	" "	
30	367	124/61	" "	
31	367	143/68	" "	
32	369	195/30	" "	
33	374	115/55	" "	
34	375	111/55	" "	

West of the saddle west of Bastion Peak

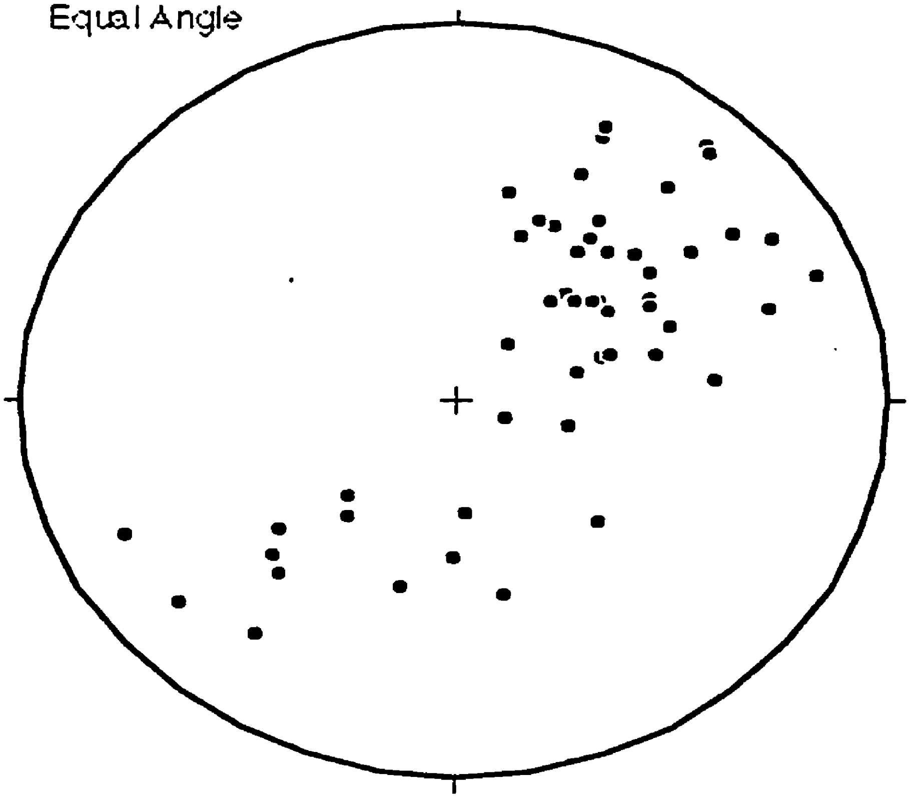
1	201	131/83
2	201	307/76
3	206	160/39
4	206	148/55
5	206	160/41

Equal Angle



Bedding in folded Gambier Group rocks adjacent to the Owl Creek fault

Equal Angle



Poles to bedding in folded Gambier Group rocks adjacent to the Owl Creek fault

BEDDING IN GAMBIER GROUP ROCKS ADJACENT TO THE OWL CREEK FAULT (CONT'D)

West of the saddle west of Bastion Peak (cont'd)

6	206	165/51
7	206	165/32
8	206	150/54
9	207	158/56
10	233	142/59
11	233	175/62
12	282	205/14

BEDDING IN GAMBIER GROUP ROCKS - West part of Zone 1

Saddle west of Warm Lake

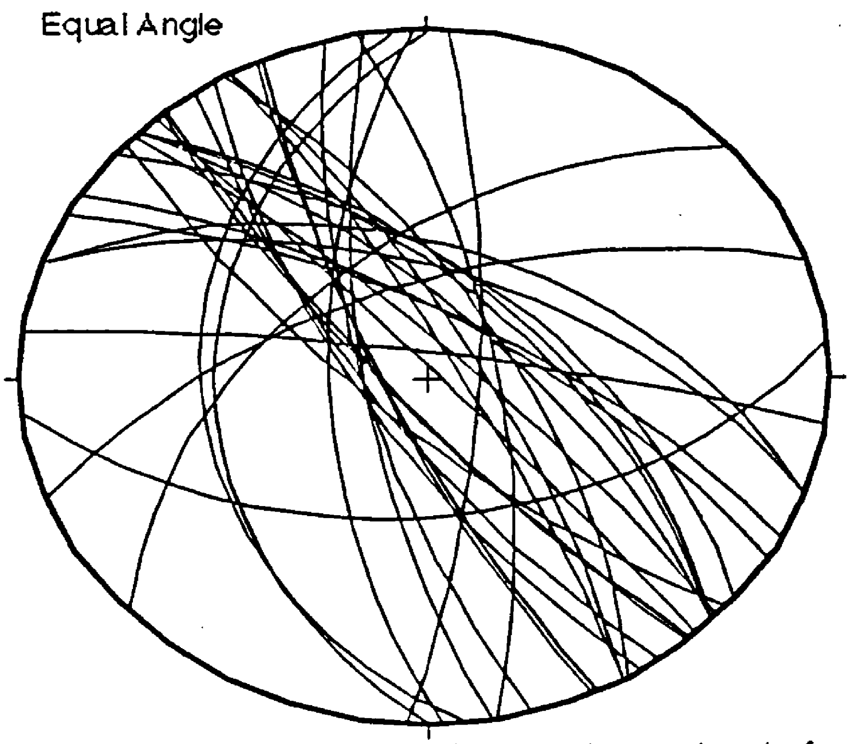
1	324	318/87
2	324	145/74
3	324	148/71
4	327	314/79
5	327	278/81
6	328	315/58
7	328	330/66
8	328	315/61
9	328	302/69
10	328	315/68
11	328	298/68

3 Lakes ridge

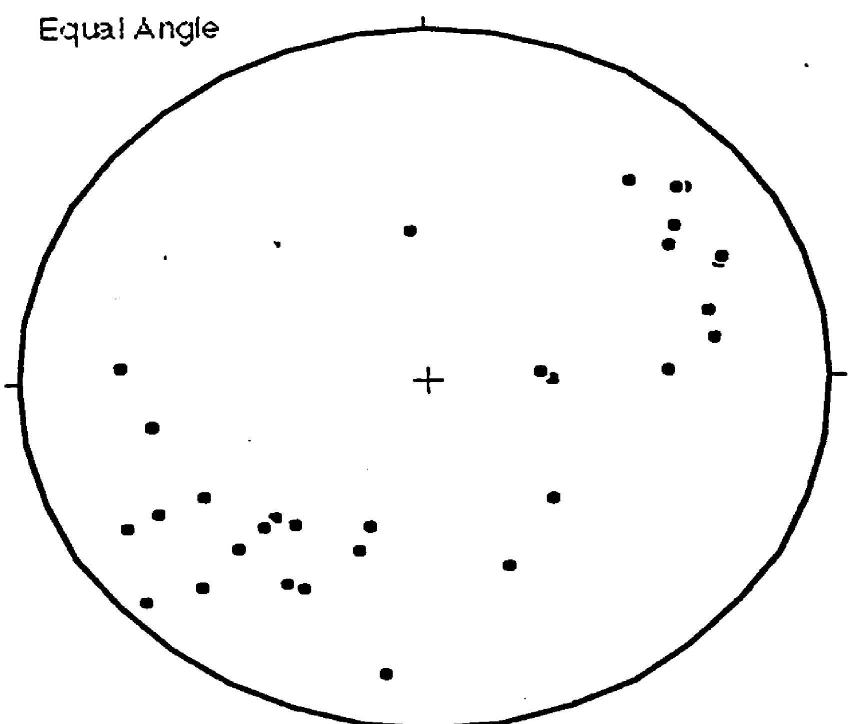
Data point	Station	Orientation
1	261	290/55
2	261	290/48
3	264	331/81
4	264	355/45
5	268	180/34
6	268	350/70
7	270	310/56
8	275	250/59
9	282	228/49
10	295	084/46
11	309	175/31

West shore of Tenas Lake

1	177	003/75	Tenas Lake
2	177	178/62	"
3	178	331/75	"
4	184	165/72	"
5	186	140/80	"
6	187	171/72	"
7	188	132/74	"
8	188	156/77	"
9	229	155/78	"
10	001	139/79	Kakila Ck



Bedding planes in Gambier Group rocks, west part of Zone 1



Poles to bedding in Gambier Group rocks, west part of Zone 1

AXIAL PLANAR CLEAVAGES

AXIAL PLANAR CLEAVAGES IN GAMBIER GROUP ROCKS - ADJACENT TO THE OWL CREEK FAULT

- Mt Fraser/Owl Creek

1	397	130/78	Ivy Lake
2	402	312/64	"
3	947	316/75	Mt. Fraser
4	951	258/56	N. of town, on tracks

- Ridge north ofUre Creek

1	157	323/77
2	344	249/29
3	345	235/29
4	349	318/84
5	349	316/62
6	349	290/75
7	349	320/80
8	350	120/76
9	350	118/70
10	365	319/61
11	365	310/54
12	365	142/63
13	365	295/80
14	365	295/86
15	365	308/84
16	365	315/50
17	365	302/84
18	365	305/53
19	365	300/55
20	365	305/60
21	365	300/72
22	365	305/61
23	367	315/84
24	367	130/74
25	367	140/75
26	367	300/81
27	367	126/84
28	369	315/80
29	374	288/71
30	375	110/86

- Saddle west of Bastion Peak

1	206	124/65
2	206	140/69
3	206	148/66
4	207	118/63
5	233	145/76
6	283	308/65

AXIAL PLANAR CLEAVAGES IN GAMBIER GROUP ROCKS - WEST PART OF ZONE 1

- Westernmost ridge in Lillooet Lake pendant

1	264	328/74
2	268	338/78
3	282	335/81
4	295	170/66
5	324	151/79
6	324	153/79
7	327	315/63
8	327	295/71
9	328	321/59
10	328	345/59
11	328	298/65
12	328	305/53
13	328	338/54
14	328	288/55

- Tenas Lake

1	061	325/78
2	061	343/76
3	177	002/72
4	179	334/63
5	184	334/68
6	187	354/79
7	188	326/87
8	188	348/88
9	229	155/75

FOLD AXES

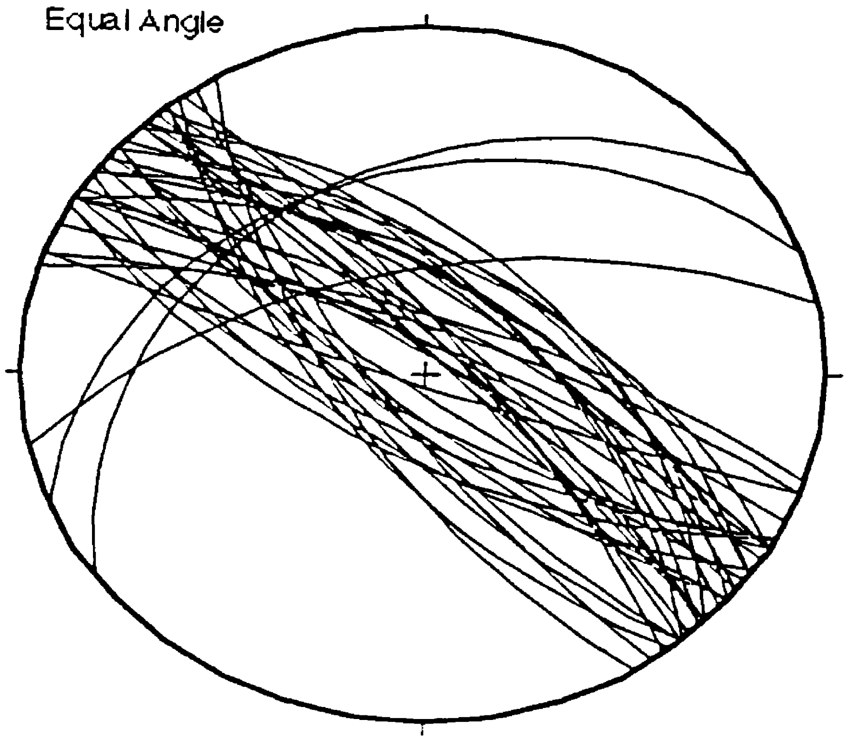
FOLD AXES IN GAMBIER GROUP ROCKS ADJACENT TO THE OWL CREEK FAULT

- Mt. Fraser/Owl creek

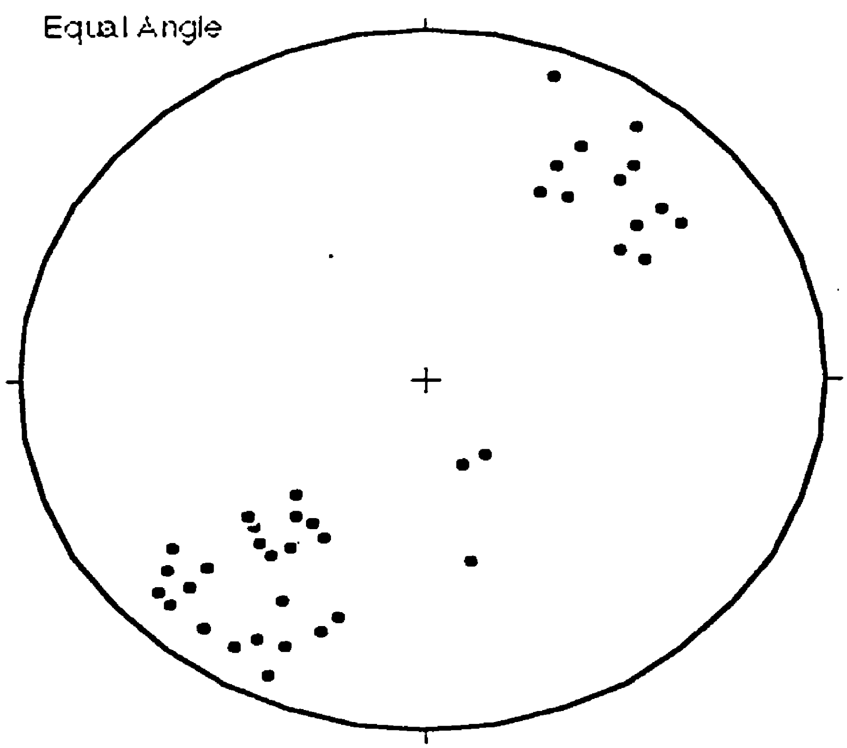
1	402	32/330
2	402	32/331
3	951	20/015
4	951	32/032

- Ridge north of Ure Creek

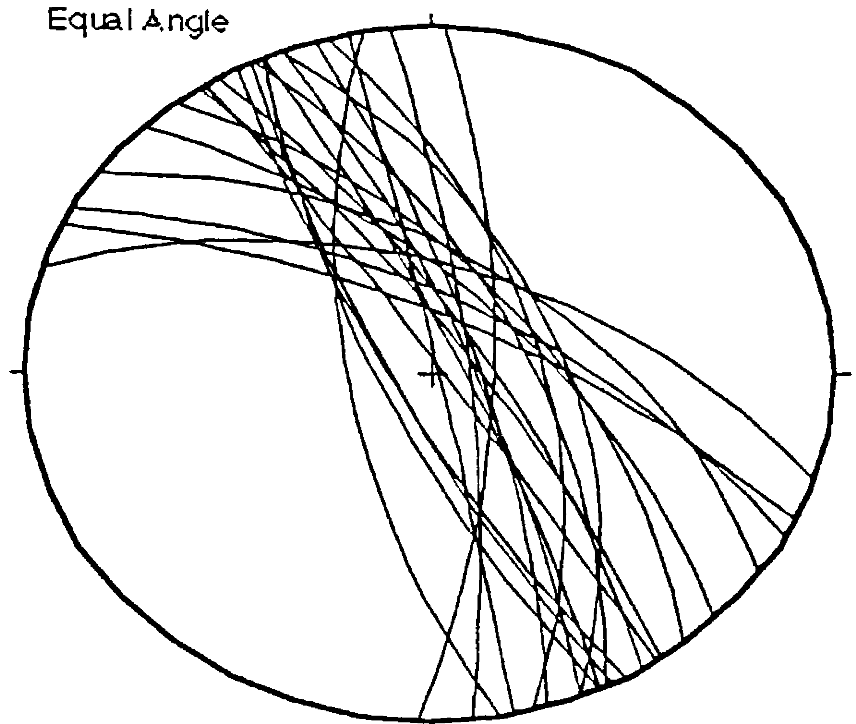
1	344	28/307
2	346	00/316
3	346	50/314
4	349	00/320
5	349	00/316
6	350	04/299
7	365	20/126
8	365	00/132
9	365	25/308
10	365	18/300
11	365	20/295
12	365	34/299
13	365	30/305



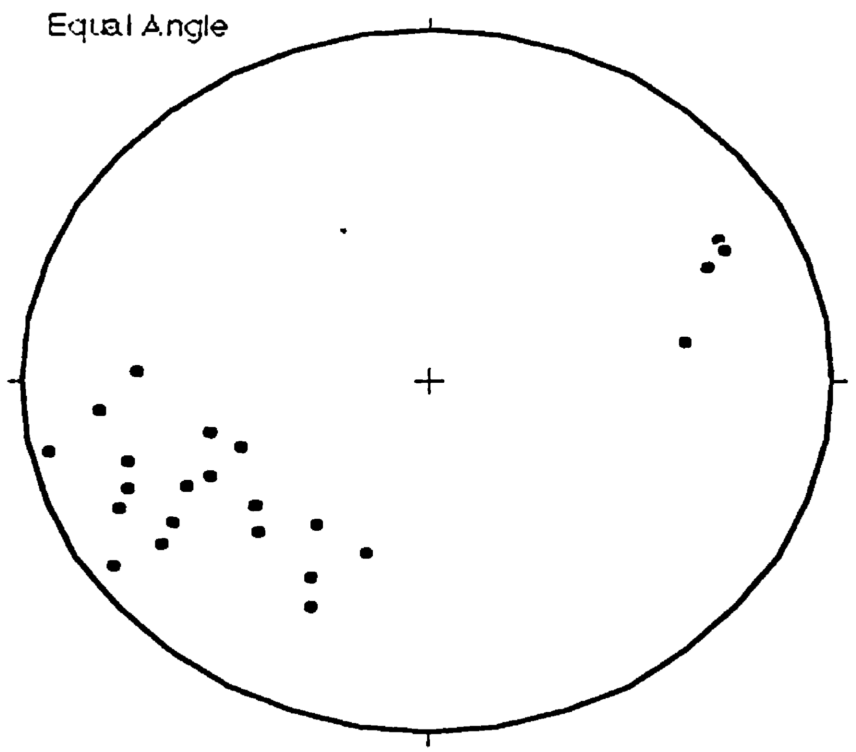
Axial planar cleavages in folds in Gambier Group rocks adjacent the Owl Creek fault



Poles to axial planar cleavages in Gambier Group rocks adjacent to the Owl Creek fault



Axial planar cleavages in Gambier Group rocks, West part of Zone 1



Poles to axial planar cleavages in Gambier Group rocks, west part of Zone 1

FOLD AXES IN GAMBIER GROUP ROCKS ADJACENT TO THE OWL CREEK FAULT (CONT'D)

14	365	05/135
15	365	20/304
16	365	34/332
17	365	22/318
18	365	56/330
19	365	08/310
20	367	12/135
21	367	08/307
22	367	13/145
23	367	06/302
24	367	48/300
25	369	20/322
26	374	14/292
27	375	04/292
28	157	65/356

- Saddle west of Bastion Peak

1	206	34/272
2	206	14/314
3	206	14/320
4	207	55/247
5	207	60/246
6	233	03/146
7	288	14/315

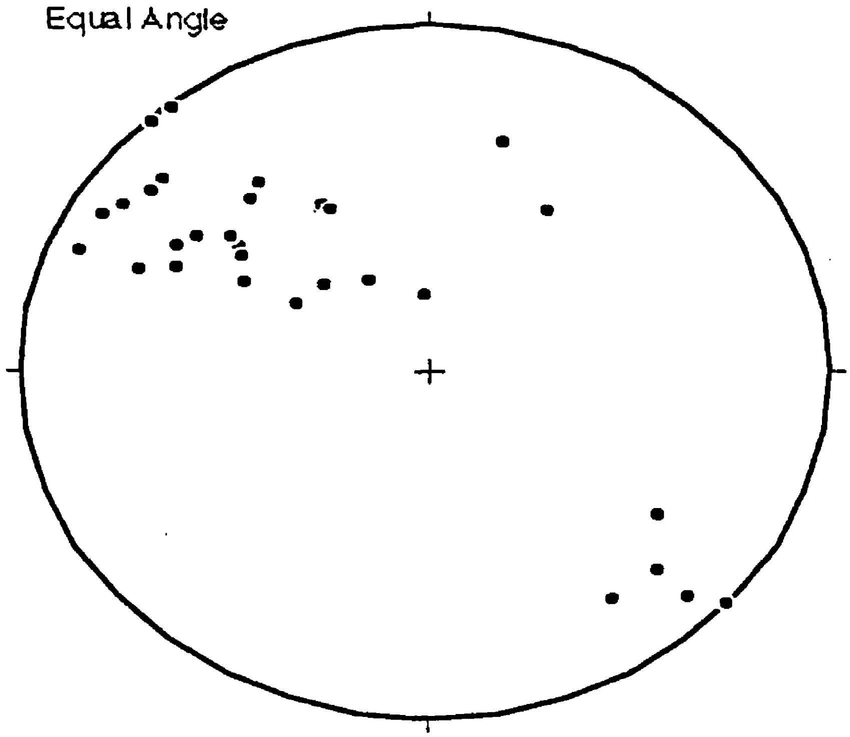
FOLD AXES IN GAMBIER GROUP ROCKS - WEST PART OF ZONE 1

- Westernmost ridge in Lillooet Lake pendant

1	261	22/334
2	268	49/143
3	282	44/346
4	295	42/196
5	324	48/162
6	324	28/157
7	327	06/132
8	327	05/086
9	328	58/044
10	328	50/119
11	328	48/088
12	328	10/119
13	328	50/102
14	328	27/310

- Tenas Lake

1	061	28/350
2	061	76/089
3	177	25/355
4	177	16/146
5	187	04/172
6	188	30/142

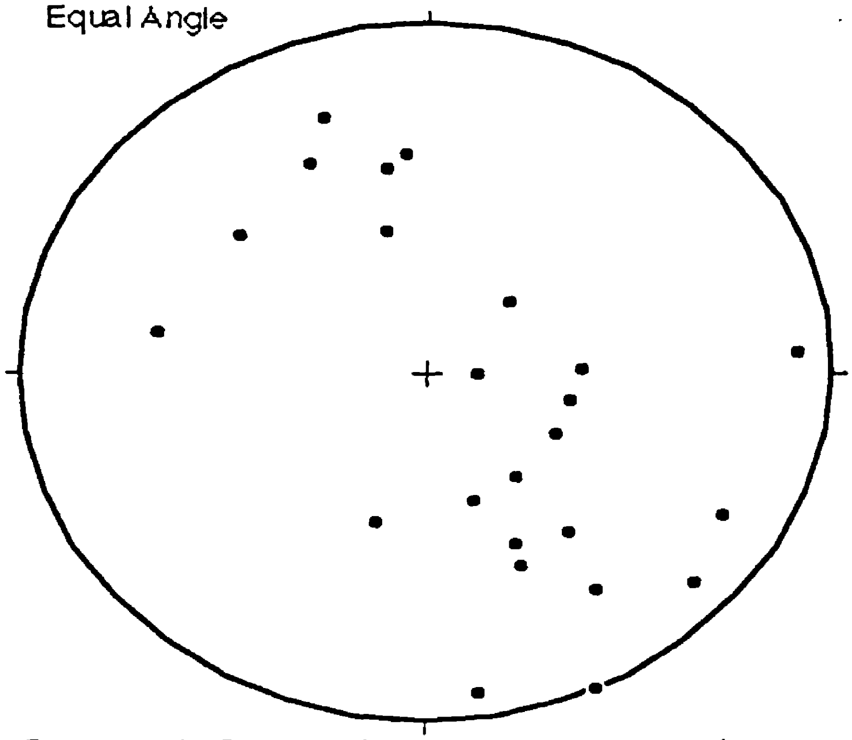


Zone 1
Fold axes of folds in Gambier Group rocks adjacent to the Owl Creek

FOLD AXES IN GAMBIER GROUP ROCKS IN THE WESTERN PART OF ZONE 1

- Tenas Lake faxes (cont'd)

7	188	33/156
8	184	14/340
9	229	00/155
10	230	21/280



Fold axes in Gambier Group rocks, west part of Zone 1

GAMBIER GROUP SHEAR FOLIATIONS AND SCHISTS

Data point	Station	Orientation	Bordering Pemberton Diorite Complex (Y/N)
1	055	308/24	N
2	056	340/35	N
3	059	348/73	N
4	059	032/50	N
5	059	358/70	N
6	059	020/36	N
7	059	076/31	N
8	059	080/28	N
9	059	345/76	N
10	059	010/42	N
11	059	010/64	N
12	059	011/65	N
13	059	351/75	N
14	059	030/40	N
15	059	356/76	N
16	067	345/75	N
17	069	319/75	N
18	070	300/53	N
19	071	316/49	N
20	075	125/84	N
21	076	310/84	N
22	078	010/79	N
23	078	343/64	Y
24	079	301/71	Y
25	147	302/79	N
26	147	142/59	N
27	147	120/76	N
28	147	301/79	N
29	151	065/35	N
30	152	120/63	N
31	154	145/57	N
32	154		
33		148/54	N
34	157	134/86	N
35	157	340/90	N
36	160	110/75	N
37	160	146/29	N
38	162	166/80	N
39	162	140/79	N
40	167	151/82	N
41	167	158/86	N
42	167	162/78	N
43	167	146/86	N
44	167	132/70	N
45	167	142/46	N
46	167	153/83	N
47	167	152/75	N
48	176	318/90	N
49	177	002/63	N

SHEAR FOLIATIONS AND SCHISTS IN GAMBIER GROUP ROCKS (CONT'D)

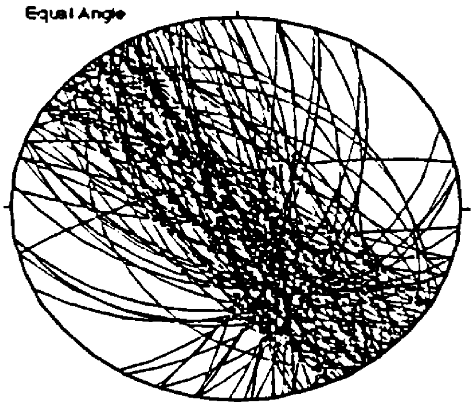
50	177	350/83	N
51	178	358/66	N
52	179	320/46	N
53	183	325/81	N
54	191	308/56	N
55	199	324/55	N
56	207	339/66	N
57	229	152/82	N
58	229	345/65	N
59	229	142/84	N
60	229	321/78	N
61	230	142/69	N
62	231	156/73	N
63	231	154/60	N
64	261	336/71	Y
65	264	320/60	Y
66	266	034/57	Y
67	267	002/56	Y
68	268	351/90	Y
69	294	340/50	N
70	296	195/75	Y
71	297	160/85	Y
72	298	150/75	Y
73	299	168/71	Y
74	300	141/84	Y
75	301	210/40	Y
76	303	161/80	Y
77	305	178/68	Y
78	309	004/31	Y
79	311	190/81	Y
80	315	187/63	Y
81	316	164/65	Y
82	317	168/79	Y
83	319	356/79	Y
84	322	341/84	N
85	323	325/85	N
86	324	330/90	N
87	325	328/56	N
88	325	314/56	N
89	329	095/78	N
90	330	135/73	
92	332	125/65	Y
93	334	155/53	Y
94	336	142/80	Y
95	337	150/78	Y
96	338	142/82	Y
97	340	128/56	Y
98	343	118/78	Y
99	346	301/55	Y
100	346	304/54	Y
101	346	280/81	Y
102	346	144/82	Y
103	349	300/80	N

SHEAR FOLIATIONS AND SCHISTS IN GAMBIER GROUP ROCKS (CONT'D)

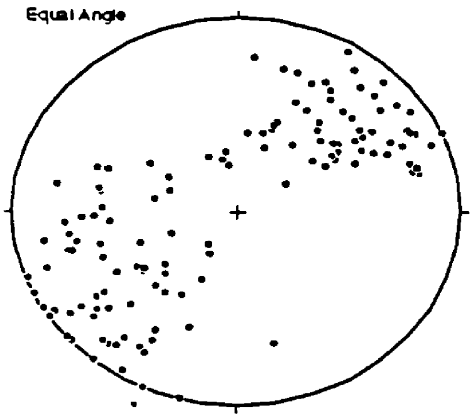
158	148	114/64	N
159	148	110/51	N
160	148	080/35	N
161	148	109/39	N
162	148	105/46	N
163	148	128/61	N
164	148	125/46	N

GOUGE ZONES IN GAMBIER GROUP ROCKS

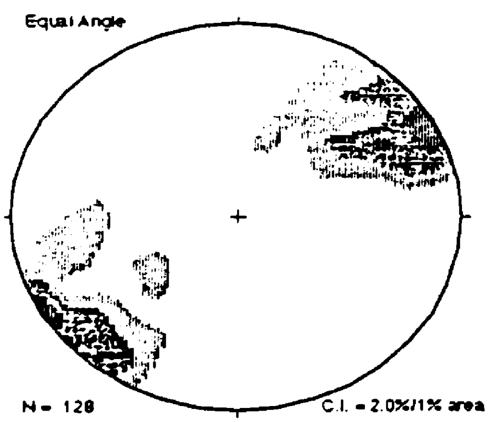
1	152	215/38	Gravell Ck
2	152	153/19	"
3	397	338/66	Ivy Lake



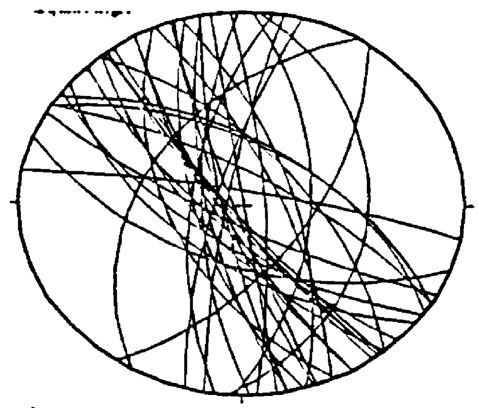
Shear foliations in Gambier Group rocks that are NOT adjacent to the Pemberton Diorite Complex



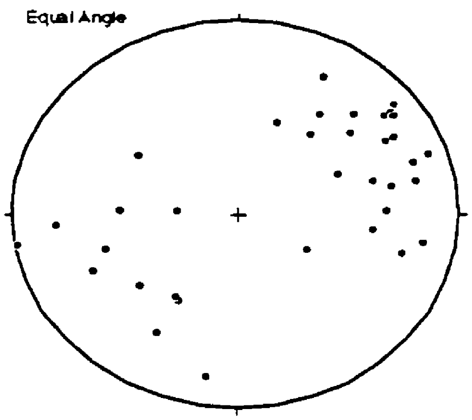
Poles to shear foliations in Gambier Group rocks that are NOT adjacent to the Pemberton Diorite Complex



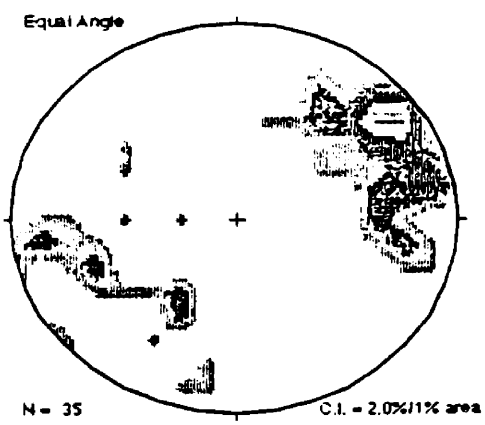
Contour of poles to shear foliations in Gambier Group rocks that are NOT adjacent to the Pemberton Diorite Complex



Shear foliations in Gambier Group rocks that are adjacent to the Pemberton Diorite Comlex

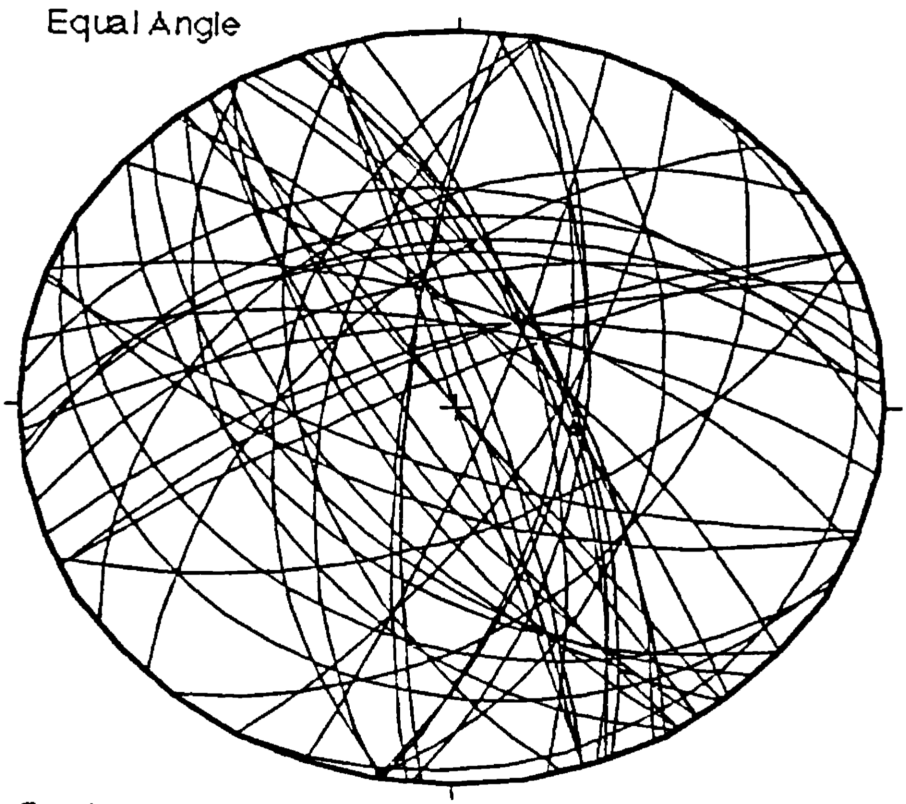


Poles to shear foliations in Gambier Group rocks that are adjacent to the Pemberton Diorite Complex

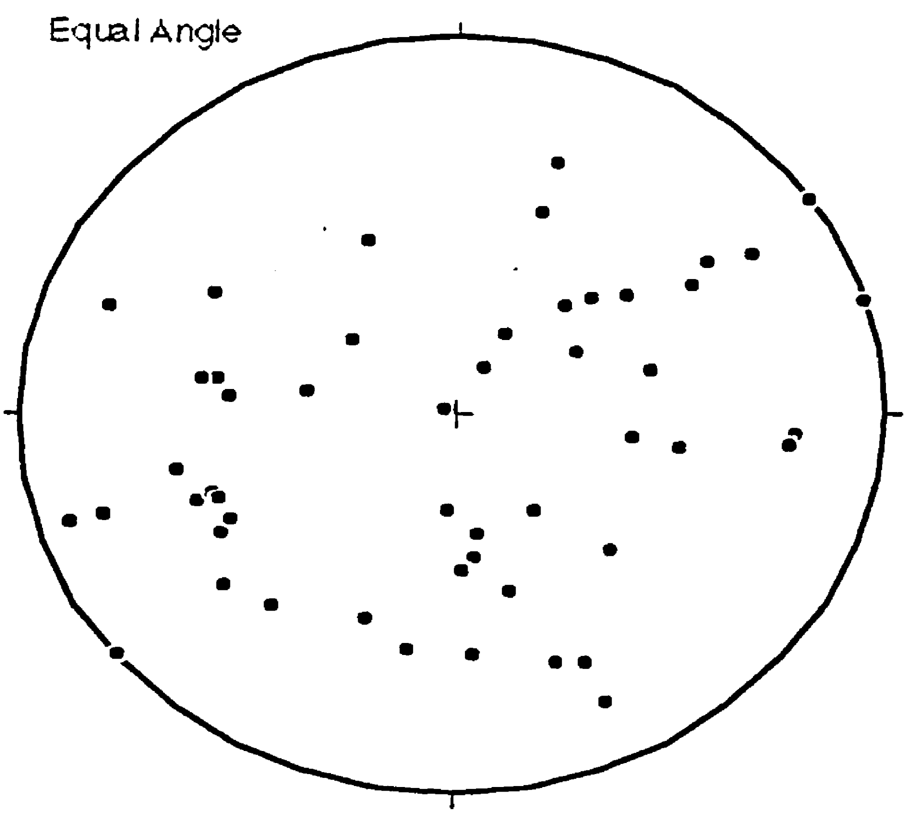


Contour of poles to shear foliations in Gambier Group rocks that are adjacent to the Pemberton Diorite Complex

1	001	148/78	Kakila Ck
2	059	245/72	Strawb Ck
3	059	250/70	"
4	071	115/16	"
5	072	130/42	"
6	079	339/65	"
7	079	275/29	"
8	149	165/50	Lill R. High road
9	149	266/65	"
10	149	347/67	"
11	149	135/48	"
12	149	149/36	"
13	160	264/42	Lill river west
14	189	342/81	Warm Lake
15	189	340/62	"
16	190	189/45	"
17	190	190/56	"
18	191	262/36	"
19	191	280/65	"
20	193	321/90	"
21	193	040/35	"
22	194	010/39	"
23	194	245/80	"
24	197	118/27	"
25	199	330/64	"
26	199	332/61	"
27	199	109/71	"
28	201	268/45	West of Bastion
29	203	225/54	"
30	203	030/66	"
31	204	066/54	"
32	205	110/60	"
33	207	255/52	"
34	207	148/66	"
35	207	145/90	"
36	232	141/54	"
37	233	010/59	"
38	234	005/56	"
39	261	020/81	3 Lakes
40	261	320/70	"
41	279	338/61	"
42	279	342/86	"
43	293	310/67	"
44	296	275/29	"
45	300	235/35	"
46	316	009/62	"
47	324	184/77	"
48	336	029/04	Glacier camp
49	519	186/76	Owl Creek
50	961	145/71	N of town on tracks
51	961	162/90	"
52	179	291/60	Tenas



Fracture patterns in Gambier Group rocks - Zone 1



Poles to fracture patterns in Gambier Group rocks - Zone 1

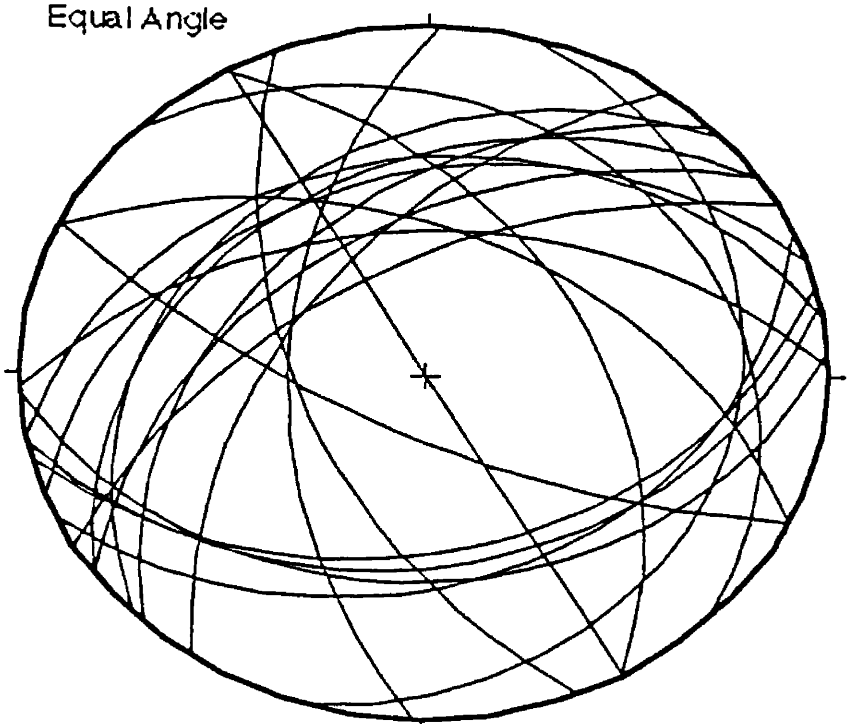
TENSION GASHES IN GAMBIER GROUP ROCKS

1	059	260/26	Tenas
2	149	157/55	High road
3	152	115/70	Gravel Ck
4	162	016/14	"
5	162	315/16	"
6	167	224/38	"
7	167	226/25	"
8	167	330/45	"
9	189	240/55	Warm Lake
10	189	235/44	"
11	189	215/51	"
12	189	295/45	"
13	189	075/36	"
14	189	078/32	"
15	189	065/28	"
16	189	086/28	"
17	201	268/45	Warm Lake
18	324	330/90	3 Lakes
19	345	235/29	N of Ure Ck
20	358	181/52	"
21	395	250/30	Owl

LINEATIONS IN GAMBIER GROUP ROCKS

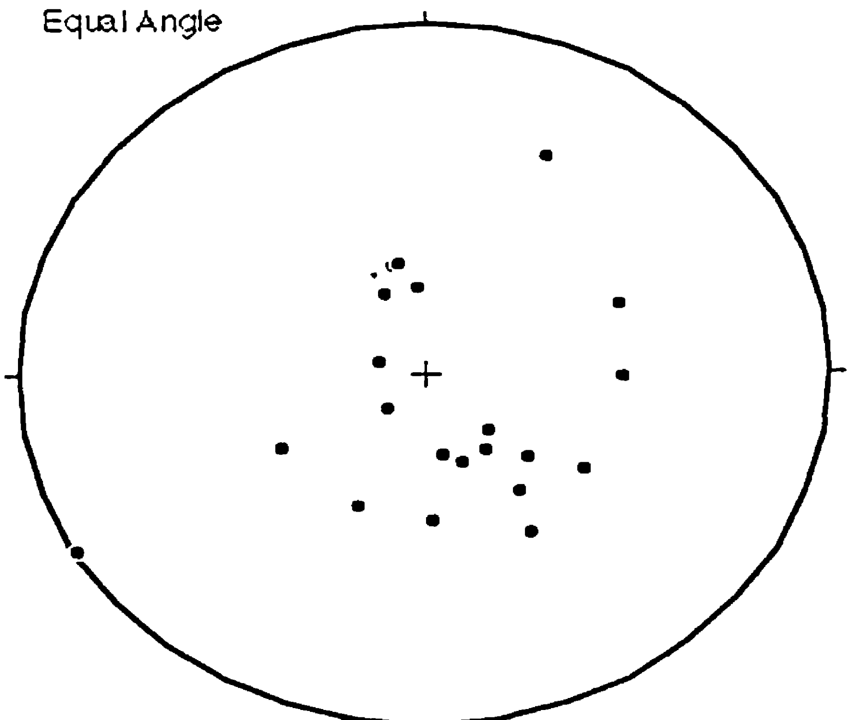
1	059	38/158	Tenas	shear lin
2	059	36/160	"	"
3	059	34/155	"	"
4	059	35/155	"	"
5	059	40/152	"	"
6	156	63/232	N. Lill R.	min elong
7	167	80/235	"	in schist
8	167	07/158	"	slicks
9	183	45/142	Tenas	slicks
10	184	57/138	"	clast elong.
11	207	16/265	W of Bas	slicks-dext
12	309	31/080	3 Lakes	shear lin
13	324	85/250	"	"
14	395	65/210	Owl Ck	stretch pebl
15	147	76/211	N. Lill R	shear lin
16	006		NE side-up movement on NNW fault	slicks

Equal Angle



Tension gashes in Gambier Group rocks - Zone 1

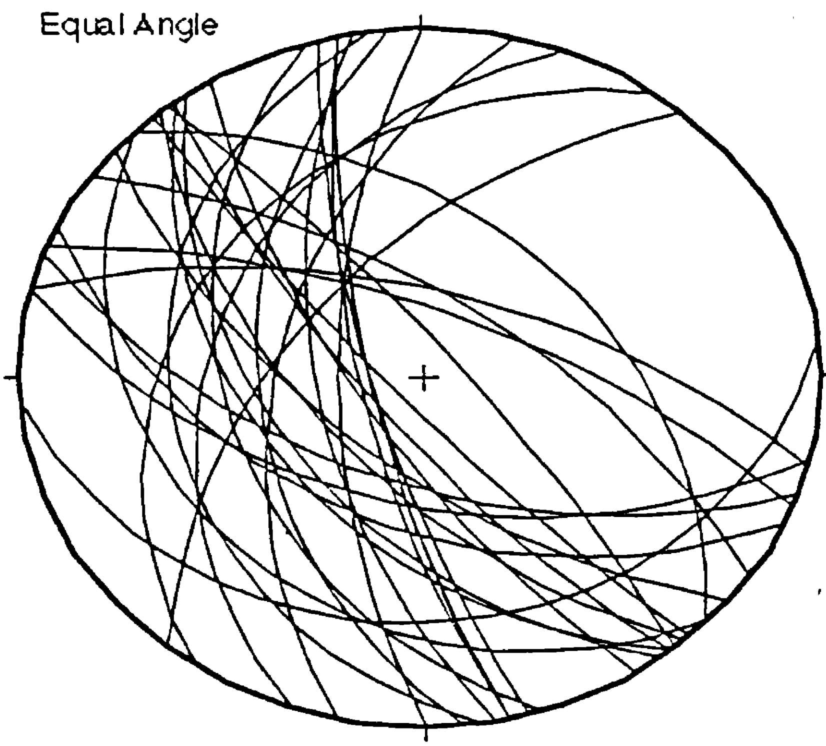
Equal Angle



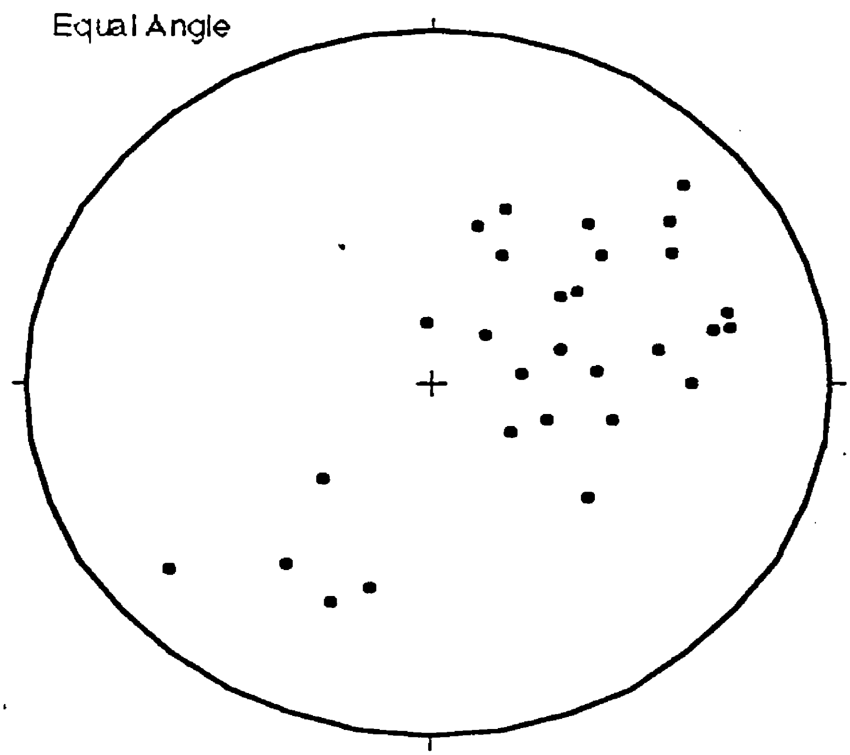
Poles to tension gashes in Gambier Group rocks
Zone 1

BEDDING IN CADWALLADER GROUP ROCKS - LILLOOET LAKE PENDANT

	Station	Orientation	Area	Unit
1	006	220/54	Lill Lk S.	TrCbts
2	006	285/62	"	"
3	006	315/42	"	"
4	018	305/64	"	"
5	026	292/68	"	"
6	040	115/44	"	"
7	171	085/20	Lill prop	TrCm
8	216	321/80	Rampart	TrCbts
9	217	168/75	"	"
10	218	148/71	"	"
11	219	165/75	"	"
12	220	138/81	"	"
13	256	168/72	"	"
14	256	180/66	"	"
15	256	170/60	"	"
16	141	104/50	"	"
17	141	144/48	"	"
18	874	172/25	Bastion	"
19	874	142/44	"	"
20	875	200/34	"	"
21	878	175/45	"	"
22	879	163/37	"	"
23	880	193/50	"	"
24	884	215/27	"	TrCm
25	887	134/22	"	TrCbts
26	898	110/56	"	"
27	915	130/62	Rampart	"
28	916	142/74	"	"
29	916	139/59	"	"



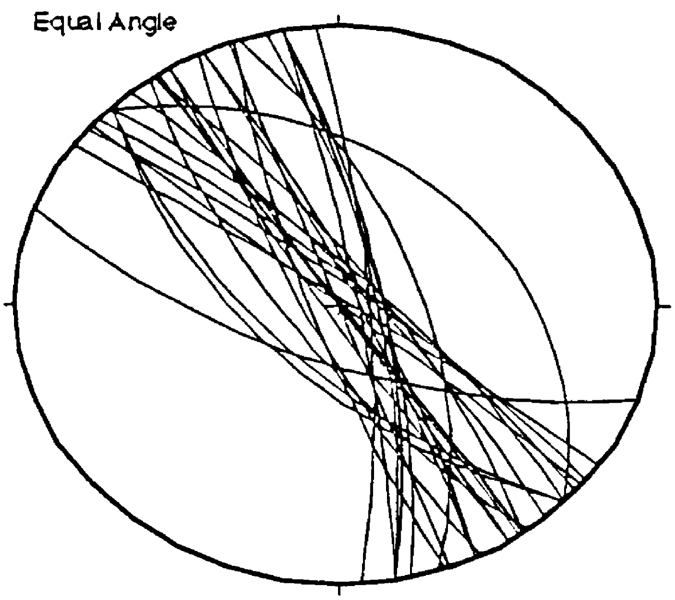
Bedding in Cadwallader Group rocks - Zone 2
Lillooet Lake pendant



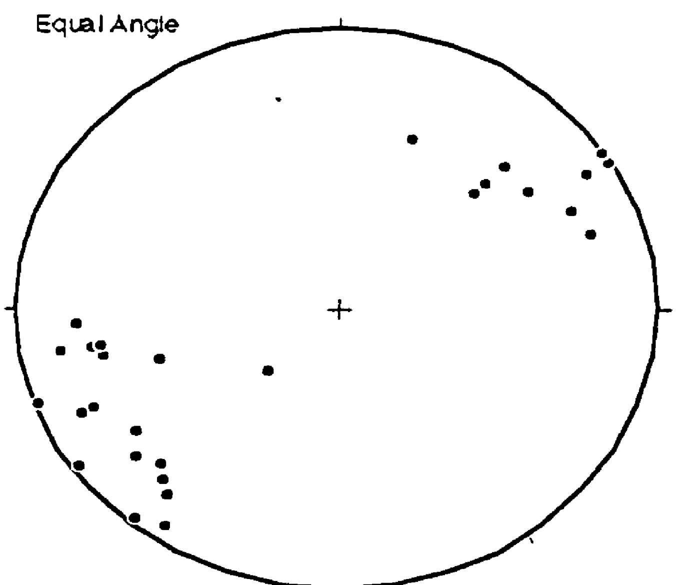
Poles to bedding in Cadwallader Group rocks -
Zone 2 - Lillooet Lake pendant

SHEAR FOLIATIONS IN THE TRIASSIC QUARTZ DIORITIC BODY AT THE SOUTH END OF LILLOOET LAKE

1	013	335/80	Lill Lk S
2	014	148/90	"
3	014	342/61	"
4	014	347/74	"
5	015	146/90	"
6	016	315/35	"
7	087	315/76	"
8	087	309/81	"
9	087	312/79	"
10	087	320/79	"
11	087	305/87	"
12	087	325/75	"
13	091	350/83	"
14	091	135/65	"
15	092	350/76	"
16	094	356/79	"
17	094	350/74	"
18	094	335/83	"
19	096	340/90	"
20	096	161/80	"
21	099	154/78	"
22	103	144/72	"
23	103	148/85	"
24	103	135/61	"
25	103	135/72	"
26	103	310/89	"
27	106	110/66	"
28	106	325/89	"



Shear foliations in the Triassic quartz diorite body at the south end of Lillooet Lake - Zone 2



Poles to shear foliations in the Triassic quartz diorite body at the south end of Lillooet Lake - Zone 2

SHEAR FOLIATIONS IN CADWALLADER GROUP ROCKS - LILLOOET LAKE PENDANT

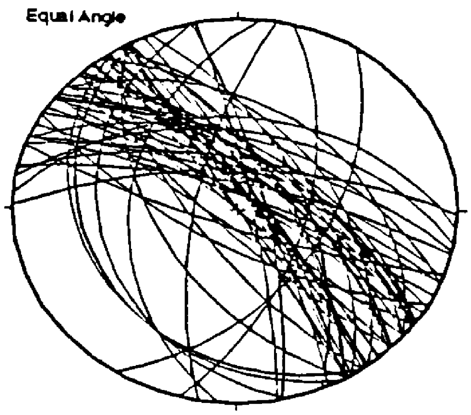
Data	Station	Orientation	Location	Unit
1	003	315/59	Lill Lk S	TrCm
2	003	325/81	"	"
3	003	282/60	"	"
4	003	310/69	"	"
5	004	271/66	"	"
6	005	305/58	"	TrCbts
7	005	290/66	"	
8	005	150/90	"	
9	007	292/81	"	
10	008	324/77	"	
11	009	319/82	"	
12	018	323/44	"	
13	019	323/90	"	
14	021	135/90	"	
15	022	135/75	"	
16	024	310/90	"	
17	025	330/81	"	
18	026	283/74	"	
19	026	302/81	"	
20	027	296/82	"	
21	028	348/75	"	
22	029	145/68	"	
23	031	320/81	"	
24	033	150/50	"	
25	033	152/21	"	
26	034	185/38	"	
27	035	145/20	"	
28	036	126/80	"	
29	037	167/26	"	
30	040	190/68	"	
31	042	306/62	"	
32	043	292/49	"	
33	043	310/34	"	
34	046	149/90	"	
35	048	119/68	"	
36	077	306/66	E.Strawb Ck	TrCut
37	080	328/51	"	"
38	080	337/56	"	"
39	080	316/64	"	"
40	080	335/78		"
41	081	330/64	"	"
42	082	275/38	"	"
43	084	109/79	"	
44	085	280/45	"	"
45	086	310/55	"	"
46	086	333/46	"	"
47	107	328/83		
48	107	325/78		
49	108	328/83		
50	110	323/83		
51	212	292/71	Bastion	TrCut

SHEAR FOLIATIONS IN CADWALLADER GROUP ROCKS - LILLOOET LAKE PENDANT (CONT'D)

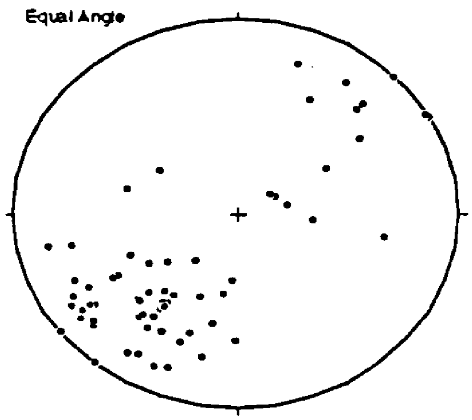
52	500	305/82	Lill prop	TrCm
53	500	315/64	"	"
54	500	307/59	"	"
55	500	305/60	"	"
56	500	330/66	"	"
57	524	015/55	BirkenheadRd	TrCut
58	524	305/71	"	"
59	529	331/75	" "	
60	530	349/82	" "	
61	531	300/70	" "	
62	532	305/54	" "	
63	535	135/78	Lill prop	TrCm
64	748	310/68	Lill Prop	TrCm

GOUGE ZONES IN CADWALLADER GROUP ROCKS - LILLOOET LAKE PENDANT

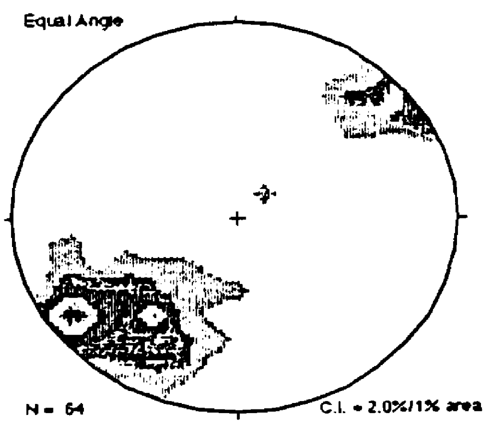
1	117	305/74	Lill property
2	128	005/35	"
3	129	181/85	"
4	129	345/82	"
5	129	192/82	"
6	129	165/81	"
7	132	040/36	"
8	141	354/74	"
9	142	025/74	"
10	144	354/76	"
11	220	000/65	Rampart SE side up



Shear foliations in Cadwallader Group rocks in the Lillooet Lake pendant



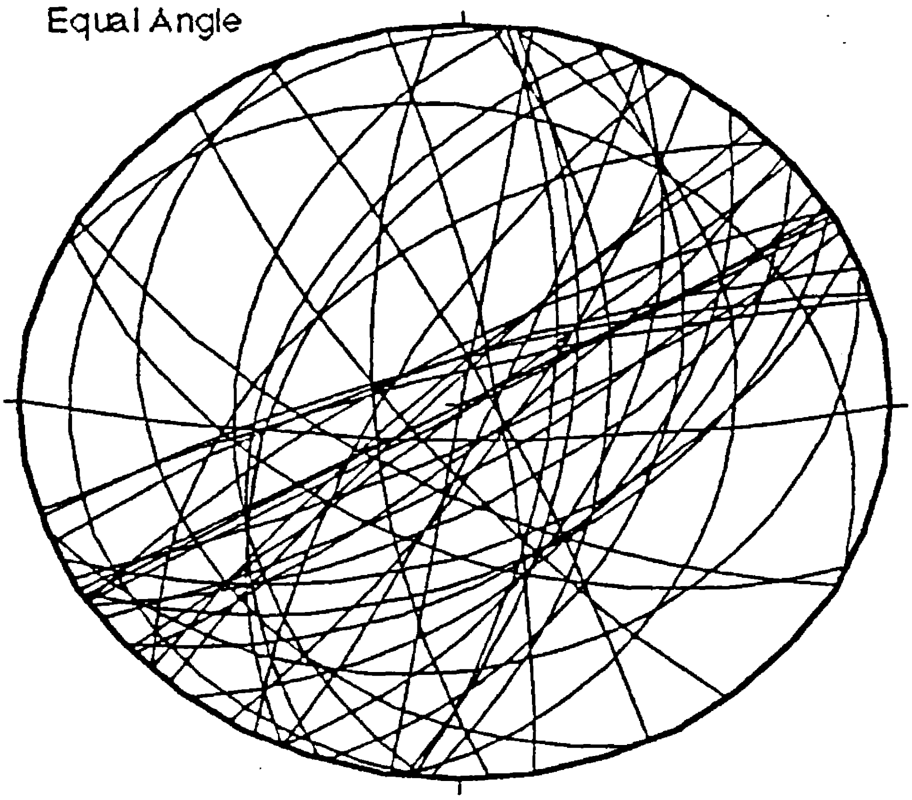
Poles to shear foliations in Cadwallader Group rocks in the Lillooet Lake pendant



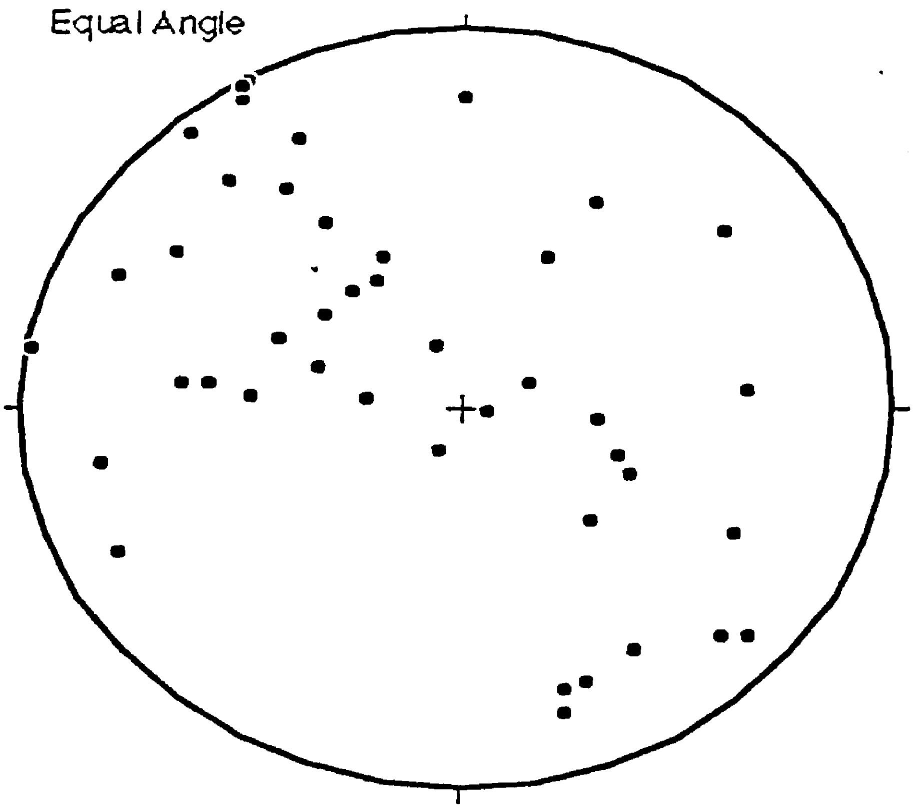
Contoured poles to shear foliations in Cadwallader Group rocks in the Lillooet Lake pendant

FRACTURE PATTERNS IN CADWALLADER GROUP ROCKS - LILLOOET LAKE PENDANT

Data point	Station	Orientation	Location
1	002	208/71	Lill Lk S.
2	005	185/35	"
3	009	018/39	"
4	009	024/50	"
6	036	225/46	"
7	077	204/46	Strawberry Ck
8	082	090/79	Lill Lk S., Cad pluton
9	094	252/76	"
10	094	199/42	"
11	096	024/82	"
12	102	116/48	"
13	102	176/67	"
14	105	059/43	"
15	105	156/19	"
16	105	184/06	"
17	120	119/64	Lill R. north
18	120	004/52	"
19	120	057/61	"
20	122	222/84	"
21	129	009/90	"
22	129	007/61	"
23	132	069/20	"
24	134	006/66	"
25	134	334/82	"
26	134	038/44	"
27	134	050/44	"
28	134	065/48	"
29	134	007/25	"
30	134	038/44	"
31	134	055/71	"
32	135	058/88	"
33	135	253/80	"
34	135	062/78	"
35	173	238/74	Lill property
36	173	296/14	"
37	209	142/75	Bastion
38	209	350/80	"
39	500	225/81	Lill prop
40	500	060/90	"
41	500	059/90	"
42	500	248/76	"
43	500	049/88	"
44	500	048/78	"
45	500	032/76	"



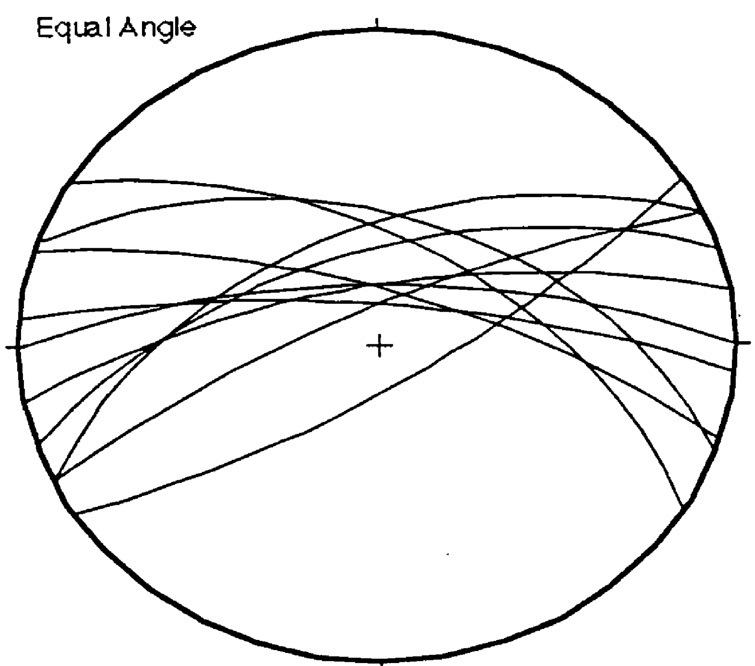
Fracture patterns in Cadwallader Group rocks - Lillooet Lake pendant - Zone 2



Poles to fracture patterns in Cadwallader Group rocks - Lillooet Lake pendant - Zone 2

ANDESITE DIKES IN CADWALLADER GROUP ROCKS
- at Bastion Peak and Rampart Mountain

1	209	058/75
2	209	290/45
3	242	302/53
4	242	275/75
5	242	245/76
6	244	260/68
7	244	288/70
8	244	270/68
9	252	252/56
10	253	245/49



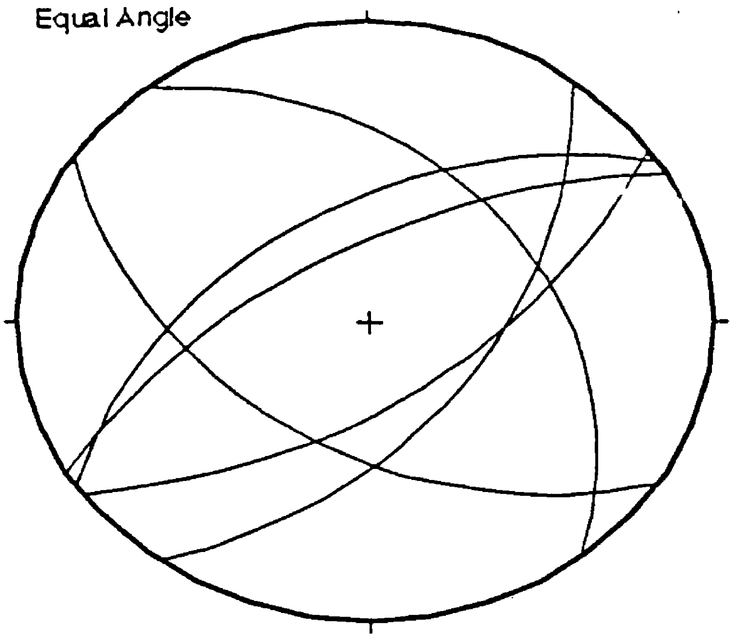
Pale green andesite dikes in Cadwallader Group rocks south of Bastion Peak

TENSION GASHES AND QUARTZ-FILLED FRACTURES IN CADWALLADER GROUP ROCKS - LILLOOET LAKE PENDANT

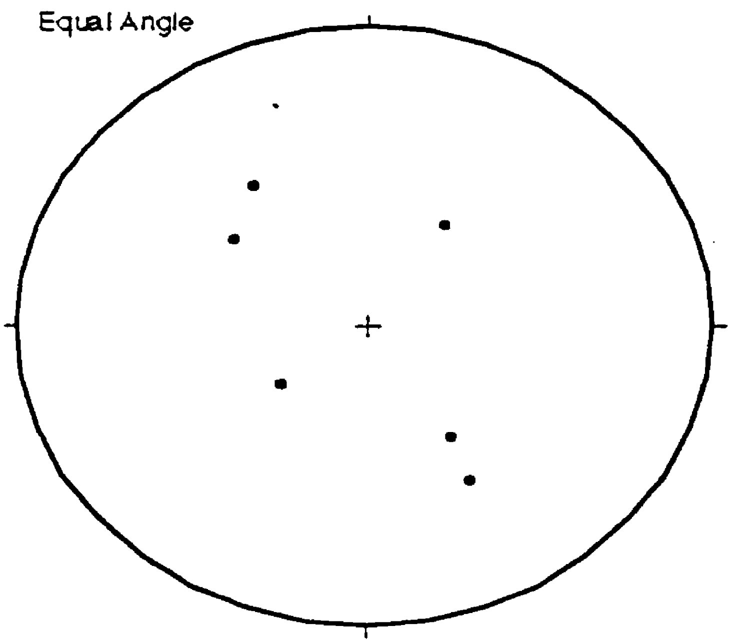
1	016	055/60	Lillooet Lk S
2	021	240/62	"
3	046	322/35	"
4	103	237/48	" in pluton
5	103	123/44	" "
6	103	037/52	" "

LINEATIONS IN CADWALLADER GROUP ROCKS - ZONE 2

1 Cad	005	12/316	Lill Lk S	shear lin
2 Cad	009	43/135	"	shear lin
3 Cad	014	09/135	"	slicks
4 Cad	077	13/310	Strawb Ck	"
5 Cad	107	20/33	Lill lk S	"
6 Cad	500	30/135	Lill	shear lin
7 Cad	500	25/117	"	"
8 Cad	500	20/120	"	"



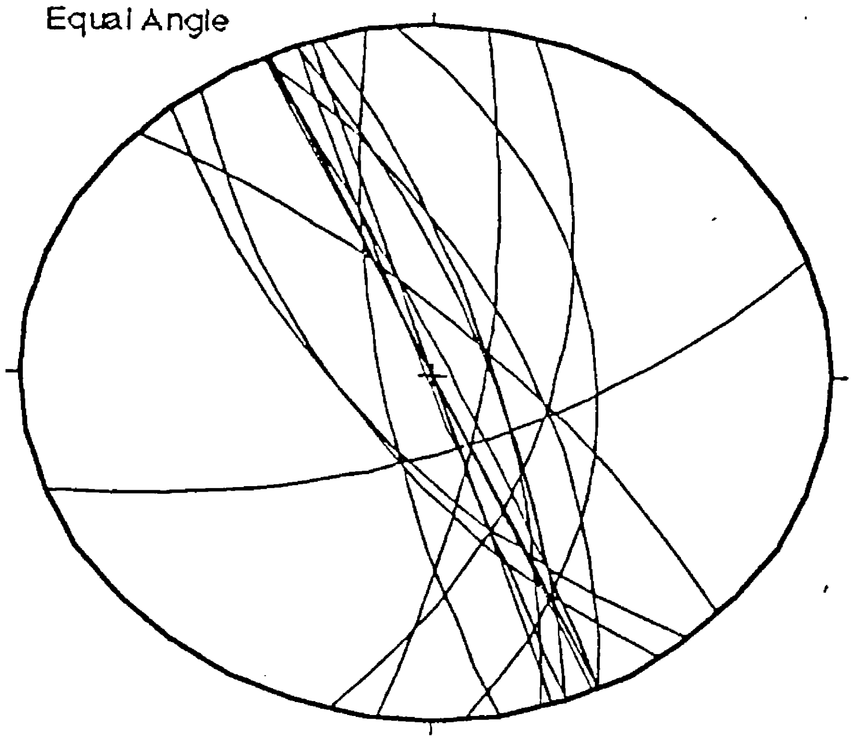
Tension gashes and quartz-filled fractures in Cadwallader Group rocks - Lillooet Lake pendant Zone 2



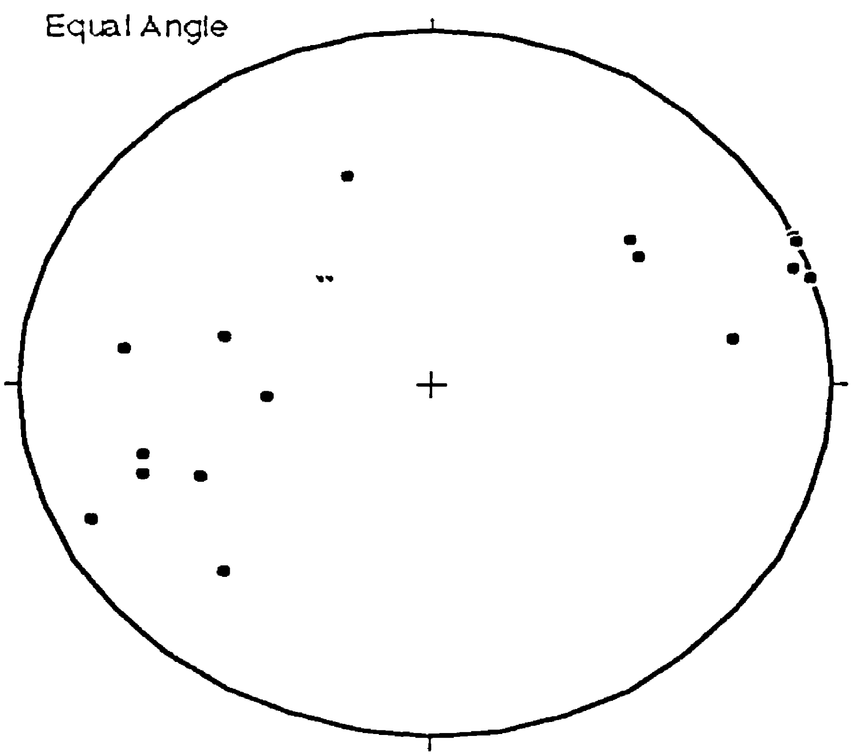
Poles to tension gashes and quartz-filled fractures in Cadwallader Group rocks - Lillooet Lake pendant - Zone 2

SHEAR FOLIATIONS IN CERULEAN LAKE UNIT ROCKS - LILLOOET LAKE PENDANT - ZONE 2

1	913	008/75	Rampart
2	913	140/66	"
3	918	015/56	"
4	918	314/73	"
5	919	145/65	"
6	919	155/90	"
7	922	162/90	"
8	923	156/90	"
9	924	160/88	"
10	925	335/85	"
11	925	355/45	"
12	927	070/65	"
13	221	340/74	"
14	222	170/75	"
15	226	335/64	"
16	226	344/73	"



Shear foliations in Cerulean Lake unit rocks in the Lillooet Lake pendant



Poles to shear foliations in Cerulean Lake unit rocks in the Lillooet Lake pendant

CERULEAN LAKE STRUCTURAL FEATURES

SHEAR FOLIATIONS IN CERULEAN LAKE UNIT

Data point	Station	Orientation	Location
1	571	290/74	Lilikel
2	573	315/68	"
3	666	325/80	7 oclock Mt
4	666	322/65	"
5	666	318/75	"
6	667	340/90	"
7	671	208/45	Cerulean
8	682	042/56	"
9	692	015/90	"
10	731	298/83	Lilikel
11	732	333/58	"
12	732	318/68	"
13	736	300/62	"

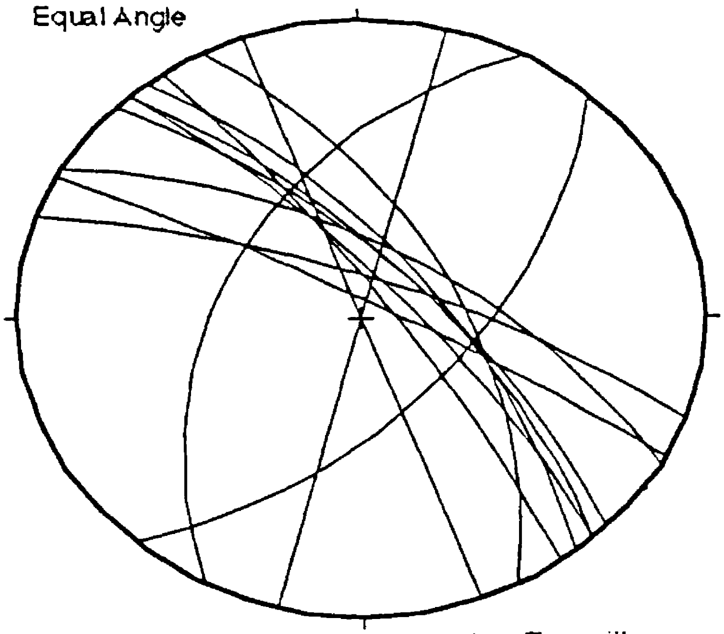
FRACTURE PATTERNS AND JOINT SETS IN CERULEAN LAKE UNIT ROCKS

1	666	280/76	7 oclock Mt.
2	669	003/62	"
3	669	008/84	"
4	817	315/37	Mt Barbour

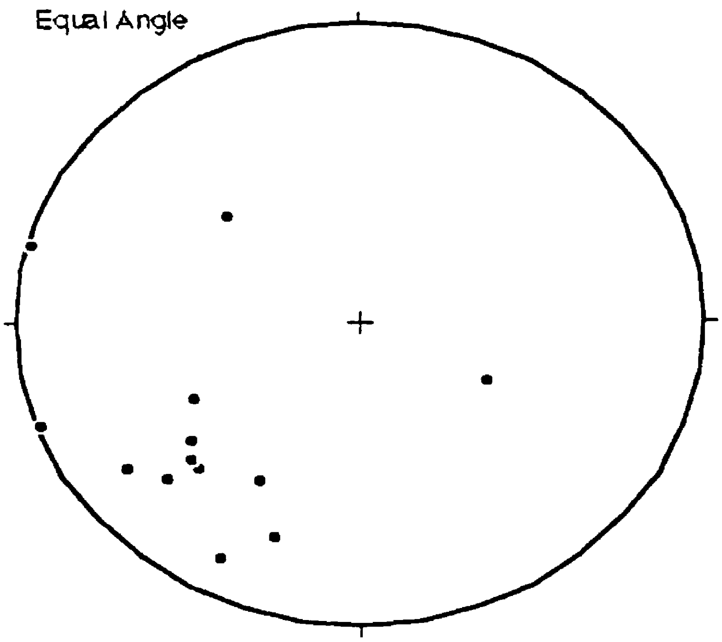
TENSION FRACTURES AND QUARTZ VEINS IN THE CERULEAN LAKE FORMATION

1	669	180/24	7 O'Clock Mt

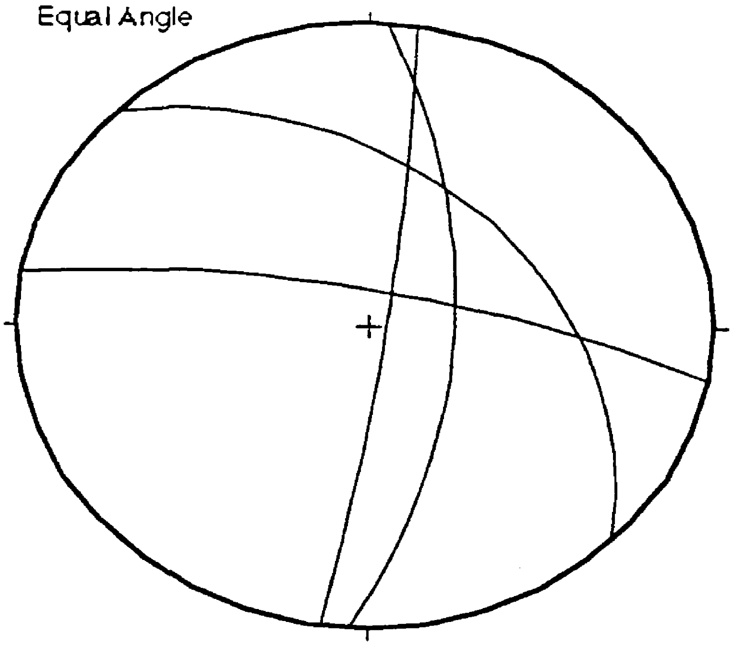
Fractures of this orientation are very abundant in this area



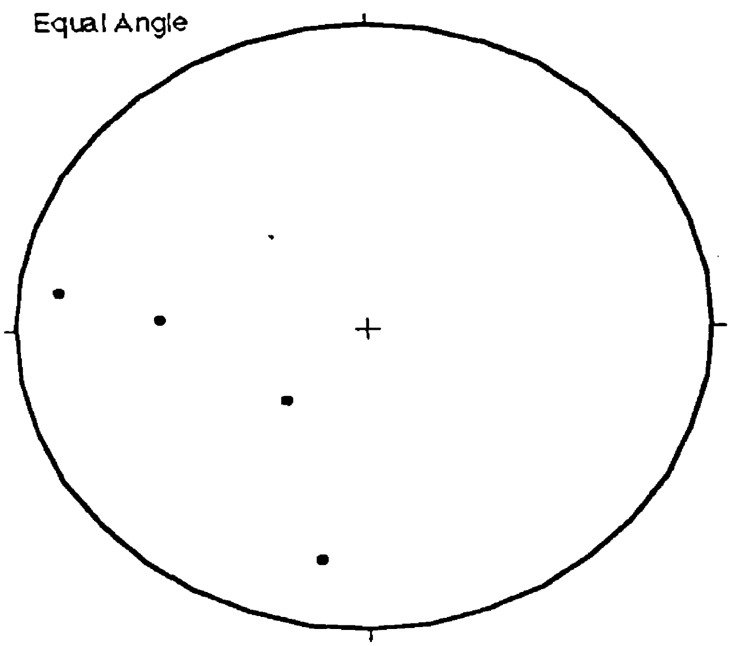
Shear foliation in Cerulean Lake rocks - Tenquille area - Zone 3



Poles to shear foliations in Cerulean Lake area rocks - Zone 3



Fracture patterns and joint sets in Cerulean Lake unit rocks - Tenquille Creek area - Zone 3



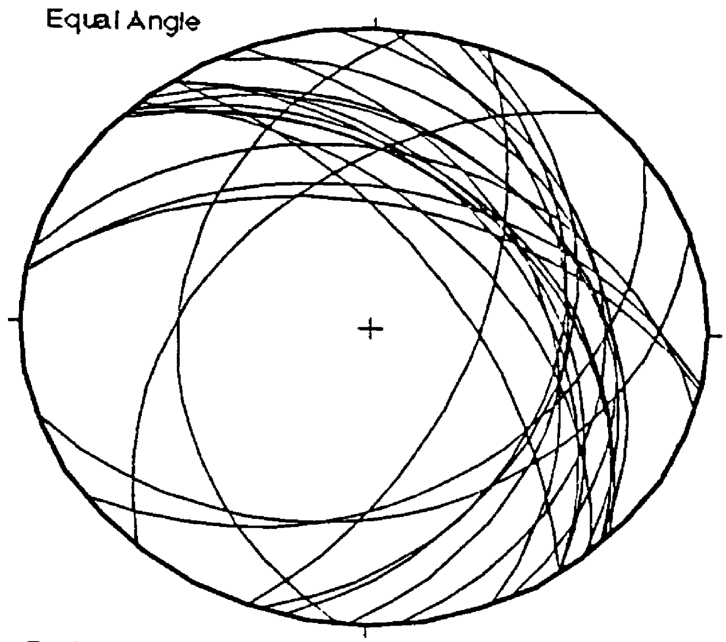
Poles to fracture patterns and joint set in Cerulean Lake unit rocks - Tenquille Creek area - Zone 3

BEDDING IN THE CERULEAN LAKE UNIT - TENQUILLE AREA

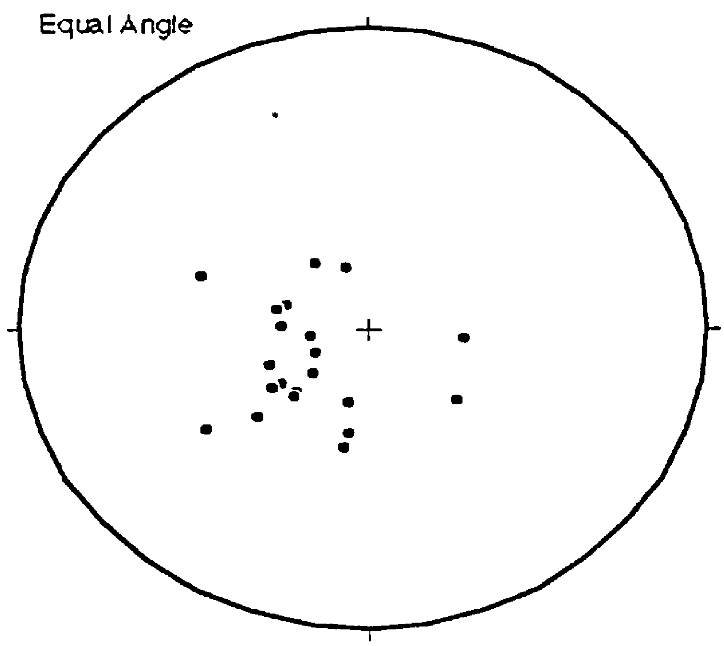
1	554	325/60
2	671	071/25
3	682	285/28
4	682	185/32
5	695	354/20
6	695	020/57
7	695	222/39
8	727	003/29
9	727	325/35
10	729	316/25
11	730	334/20
12	733	018/29
13	733	325/38
14	733	338/35
15	733	280/39
16	738	054/31
17	817	318/47
18	817	314/35
19	817	281/44
20	817	320/25
21	818	316/33
22	821	315/35
23	964	014/31

FOLD AXES IN THE CERULEAN LAKE FORMATION - TENQUILLE AREA

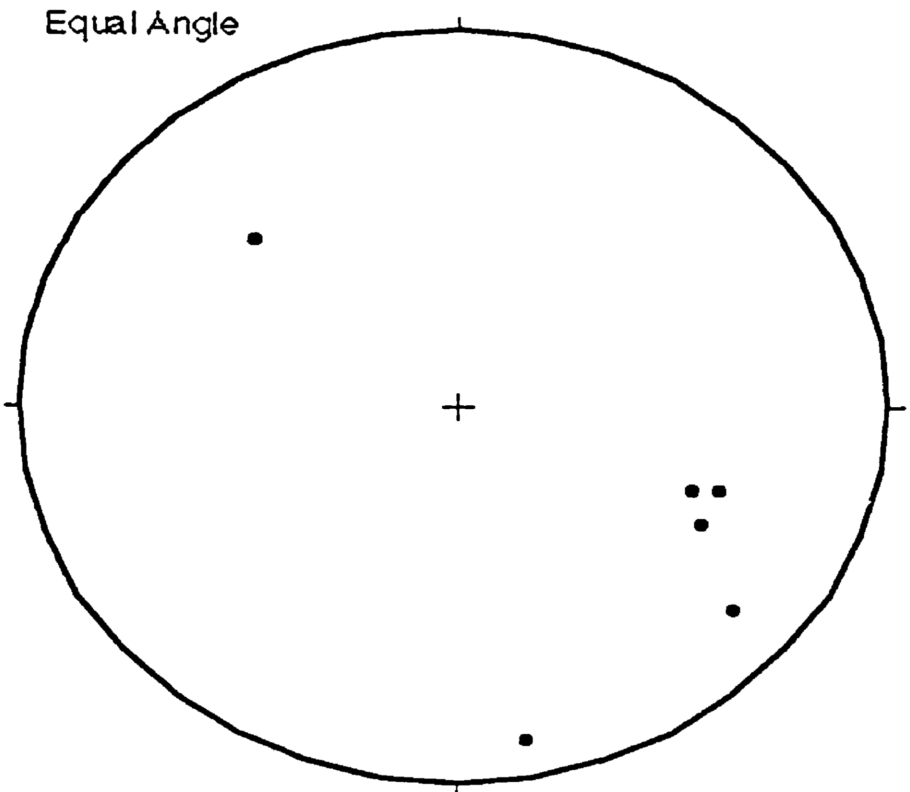
1	727	06/170	Lilikel
2	727	10/130	"
3	733	29/112	
4	733	24/110	"
5	733	24/119	"
6	733	24/313	"



Bedding in Cerulean Lake unit rocks



Poles to bedding in Cerulean Lake unit rocks



Fold axes in the Cerulean Lake unit - Tenquille area
Zone 3

BEDDING IN CADWALLADER GROUP ROCKS, TENQUILLE CREEK AREA - ZONE 3

1	530	192/21	Birkenhead Rd	TrCut
2	546	025/32	"	"
3	629	104/43	Grouty	TrCr
4	631	108/54	"	"
5	632	125/36	"	"
6	682	185/32	Cerulean Lk	TrCm
7	700	305/54	"	TrCr
8	700	325/38	"	"
9	712	355/29	Barbour	TrCbts
10	712	335/48	"	"
11	712	345/46	"	
12	714	304/50	"	TrCbts
13	714	316/52	"	"
14	715	321/85	"	"
15	724	285/46	"	"
16	519	269/59	near Gates	TrCbts
17	743	145/54	Grouty	TrCr
18	744	303/82	Barbour	TrCbts
19	750	036/35	Grizzly	"
20	750	235/90	Grizzly	"
21	751	036/35	Grizzly	"
22	752	006/42	"	"
23	755	310/09	"	"
24	756	340/32	"	"
25	756	345/17	"	"
26	760	095/50	"	"
27	762	300/32	"	"
28	775	132/74	Avalanche	TrCut,m,r
29	788	253/70	Mt. Mcleod	TrCm
30	790	247/27	"	"
31	792	325/07	"	"
32	792	273/62	"	"
33	792	264/45	"	"
34	794	240/54	"	"
35	802	000/32	"	"
36	805	312/86	"	"
37	805	320/44	"	"
38	806	295/38	Barbour	"
39	809	310/65	"	"
40	812	289/52	"	"
41	812	286/44	"	"
42	812	302/44	"	"
43	812	297/48	"	"
44	815	270/60	"	"
45	822	281/49	"	"
46	824	281/57	"	"
47	824	298/43	"	"
48	824	315/42	"	"
49	826	271/59	"	"
50	827	295/34	"	"
51	828	325/46	"	"
52	830	335/45	"	"

BEDDING IN CADWALLADER GROUP ROCKS, TENQUILLE CREEK AREA - ZONE 3

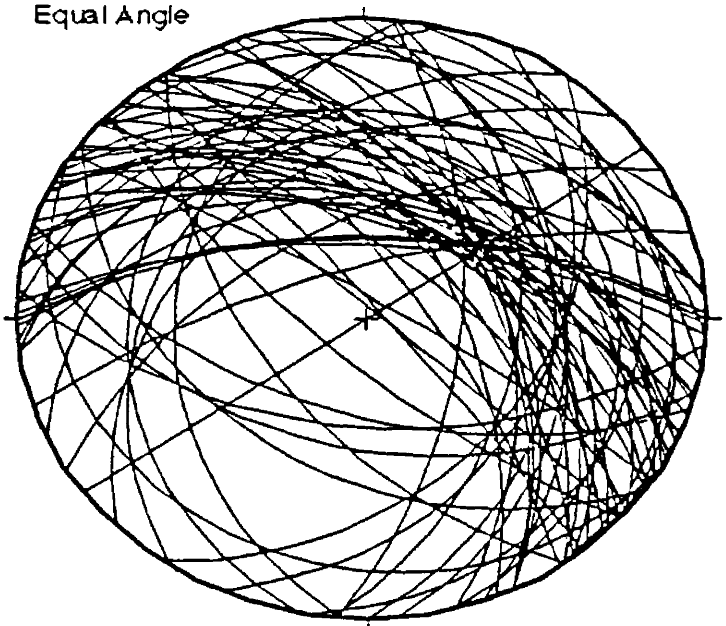
53	830	310/30	"	"
54	830	005/59	"	
55	837	227/36	McLeod	TrCbts
56	837	265/26	"	"
57	841	335/50	"	"
58	842	266/26	"	"
59	842	215/28	"	"
60	847	273/20	Copper M.	"
61	847	280/20	"	"
62	849	120/11	"	"
63	849	010/12	"	"
64	SH-10	338/60	McLeod	"
65	SH-12	323/59	Barbour	TrCbts
66	SH-13	323/33	"	"
67	SH-14	293/53	"	"
68	SH-15	326/72	"	"
69	SH-17	312/53	"	"
70	SH-19	293/55	"	"
71	SH-20	302/28	"	"

AXIAL PLANAR CLEAVAGES IN CADWALLADER GROUP ROCKS - TENQUILLE AREA

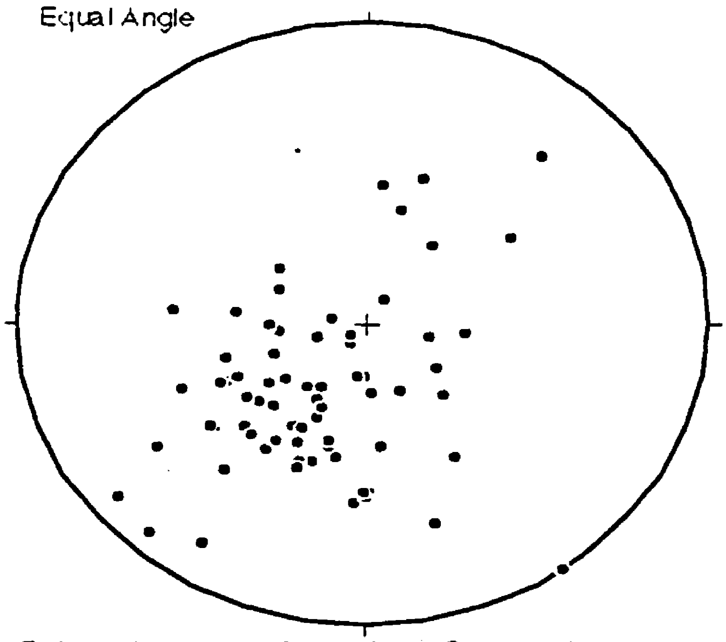
1	756	338/39	Grizzly
2	760	290/42	"
3	805	324/42	Mcleod
4	805	152/80	"
5	830	005/90	Barbour

FOLD AXES (Calculated and measured) IN CADWALLADER GROUP ROCKS - TENQUILLE AREA

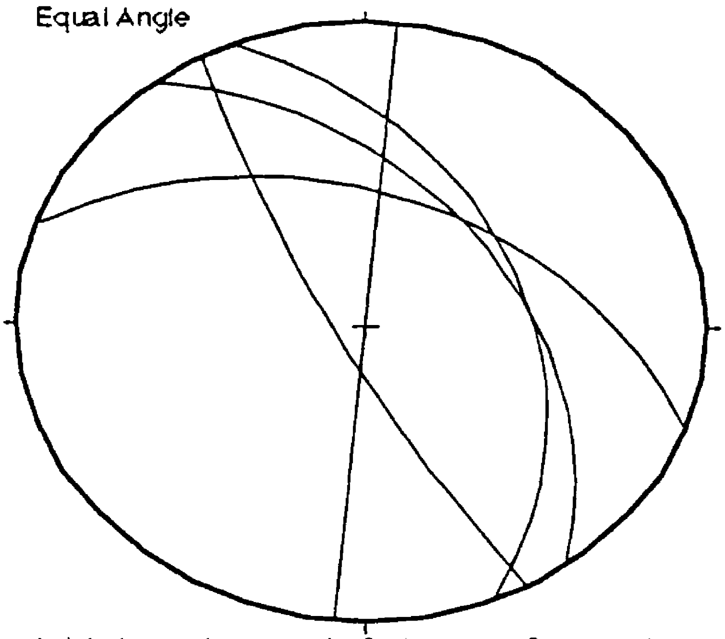
1	756	03/153	Grizzly
2	760	08/111	"
3	805	11/132	Mcleod
4	805	09/330	"
5	830	00/005	Barbour



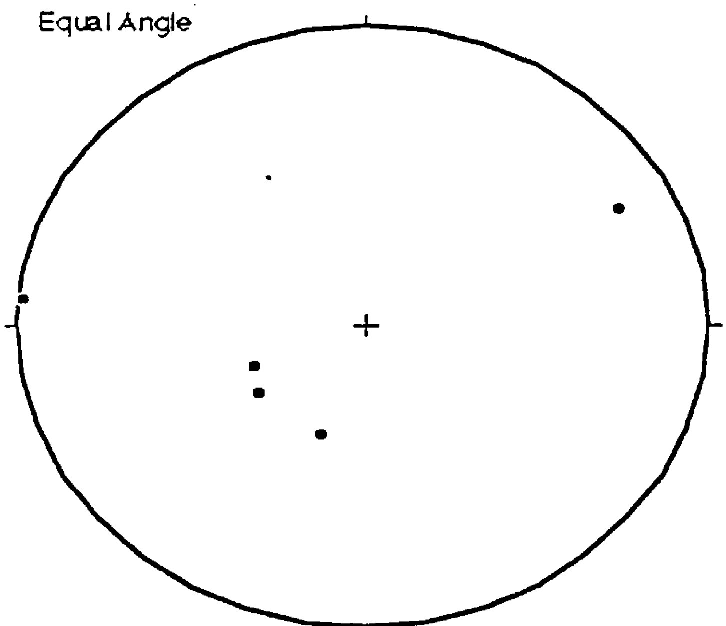
Bedding in Cadwallader Group rocks - Zone 3
Tenquille area



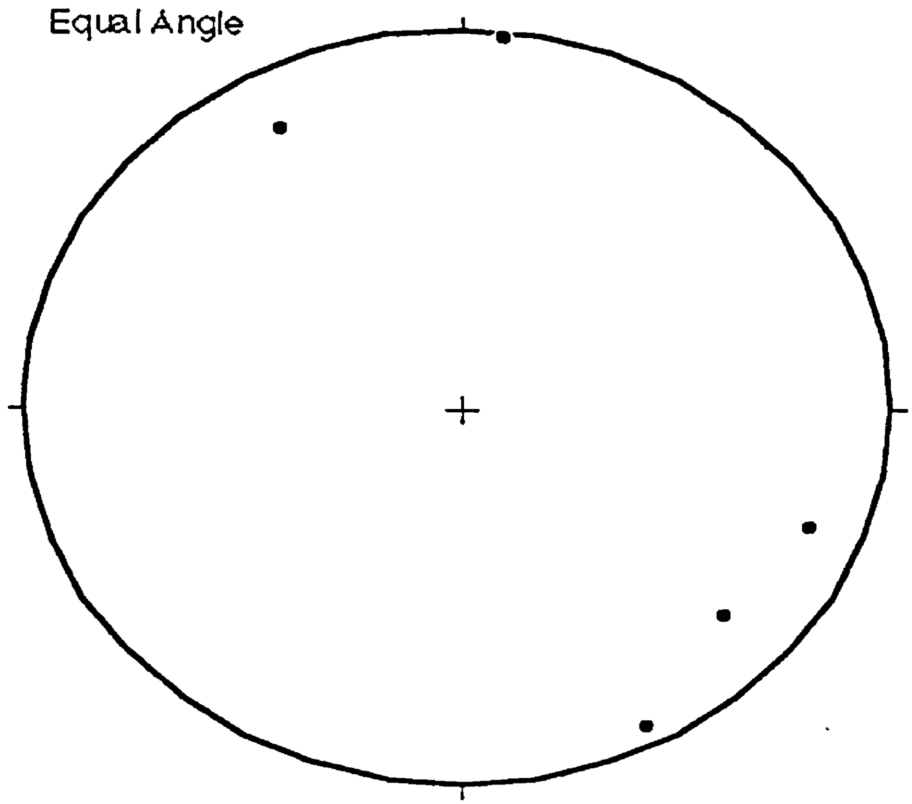
Poles to bedding in Cadwallader Group rocks
Zone 3 - Tenquille Creek area



Axial planar cleavages in Cadwallader Group rocks
- Tenquille Area - Zone 3



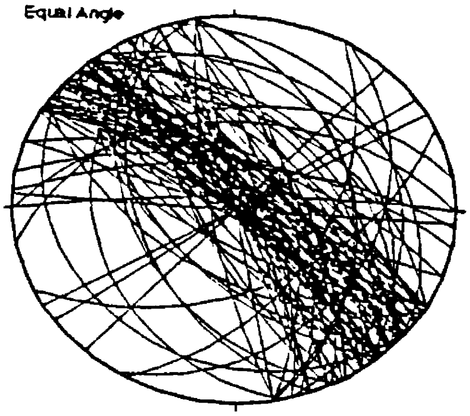
Poles to axial planar cleavages in Cadwallader Group rocks - Tenquille area - Zone 3



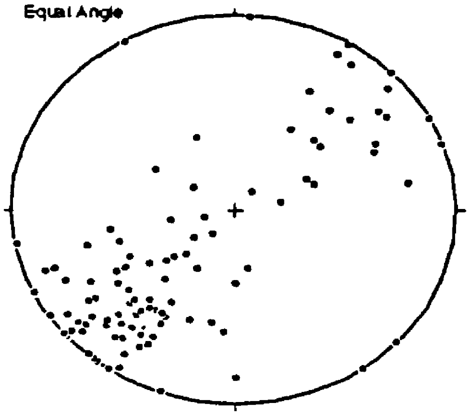
Fold axes in Cadwallader Group rocks - Tenquille area - Zone 3

SHEAR FOLIATIONS AND SCHISTS IN CADWALLADER GROUP ROCKS - TENQUILLE CREEK AREA - ZONE 3

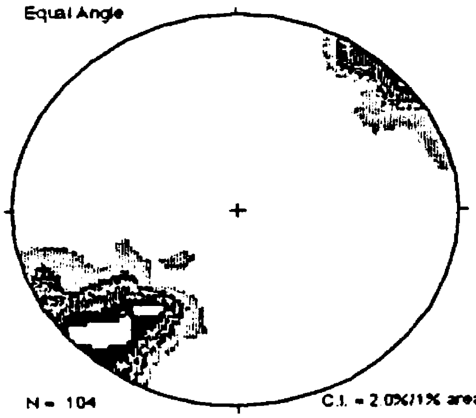
1	551	319/84	Tenquille Road	TrCut
2	551	320/81	"	"
3	553	135/54	"	"
4	556	281/61	Grouty	"
5	556	275/64	"	"
6	557	290/62	"	"
7	563	300/65	"	"
8	567	312/51	"	"
9	574	308/75	Sungod	TrCut,r
10	574	302/79	"	"
11	575	304/84	"	"
12	579	315/68	"	"
13	583	160/90	Grouty	TrCr
14	584	135/90	"	"
15	587	300/74	"	"
16	597	152/72	"	"
17	604	310/70	"	"
18	604	345/70	"	"
19	604	320/90	"	"
20	607	270/82	"	"
21	610	125/85	"	"
22	611	315/80	"	"
23	612	155/70	"	"
24	613	335/90	"	"
25	613	122/52	"	"
26	613	330/60	"	"
27	617	340/82	"	"
28	623	309/90	"	"
29	623	340/85	"	"
30	628	145/80	"	"
31	628	300/68	"	"
32	632	331/74	"	"
33	633	335/81	"	"
34	636	350/60	"	"
35	636	325/86	"	"
36	655	302/64	Goat Peak	TrCr
37	700	300/38	Cerulean	TrCm
38	712	308/80	Barbour	TrCbts
39	715	321/85	"	"
40	717	310/81	"	"
41	718	312/76	"	"
42	722	270/41	"	"
43	723	140/54	"	"
44	741	315/74	Grouty	TrCr
45	743	318/86	Grouty	TrCr
46	744	065/45	Barbour	TrCbts
47	745	345/16	Grouty	TrCr
48	745	303/88	Grouty	TrCr
49	745	310/68	Grouty	TrCr
50	749	315/68	Grizzly	TrCbts
51	750	320/40	Grizzly	TrCbts



Shear foliations and schists in Tenquille area
Cadwallader Group rocks



Poles to shear foliations in Cadwallader Group rocks
in the Tenquille area



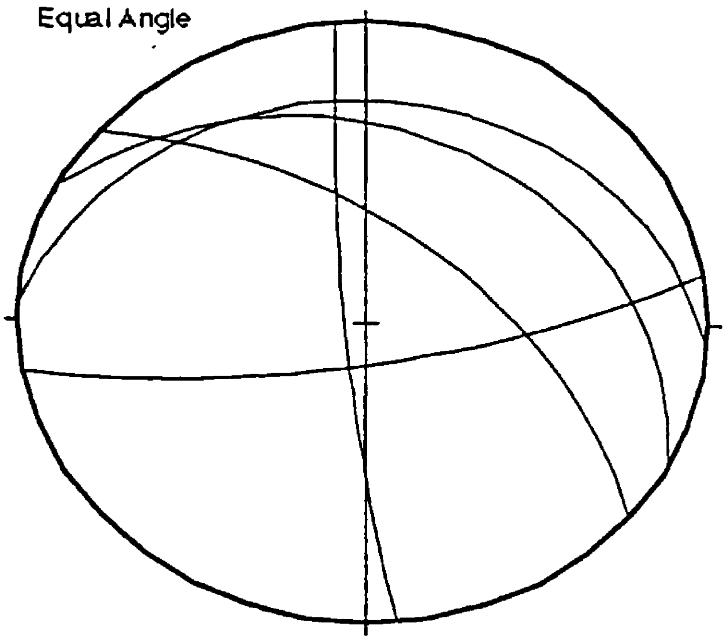
Contour of poles to shear foliations and schists in Tenquille area
Cadwallader Group rocks

FRACTURE PATTERNS AND JOINT SETS IN CADWALLADER GROUP ROCKS - TENQUILLE CREEK AREA - ZONE 3

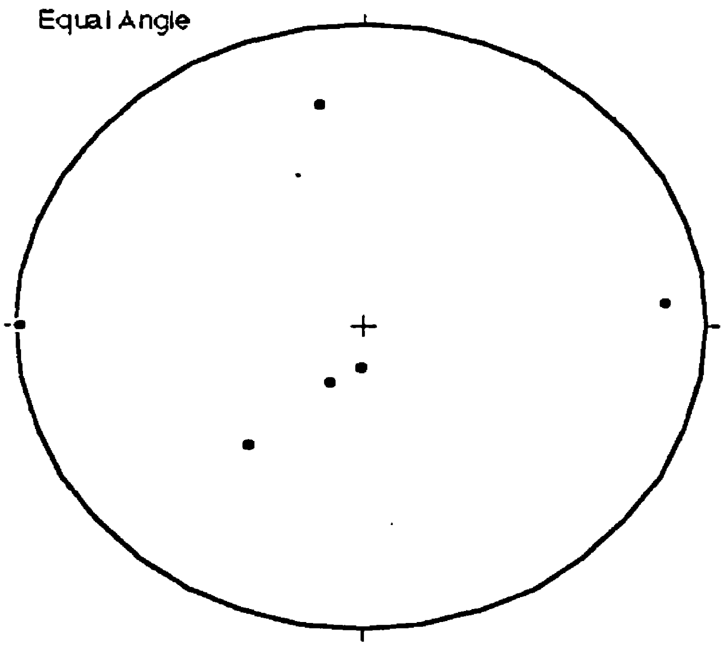
1	547	298/24	Birkenhead road
2	547	080/74	"
3	551	274/16	Tenquille Road
4	643	310/55	Grouty
5	674	000/90	Cerulean
6	804	175/83	McLeod

TENSION GASHES AND QUARTZ-FILLED FRACTURES IN CADWALLADER GROUP ROCKS - TENQUILLE AREA - ZONE 3

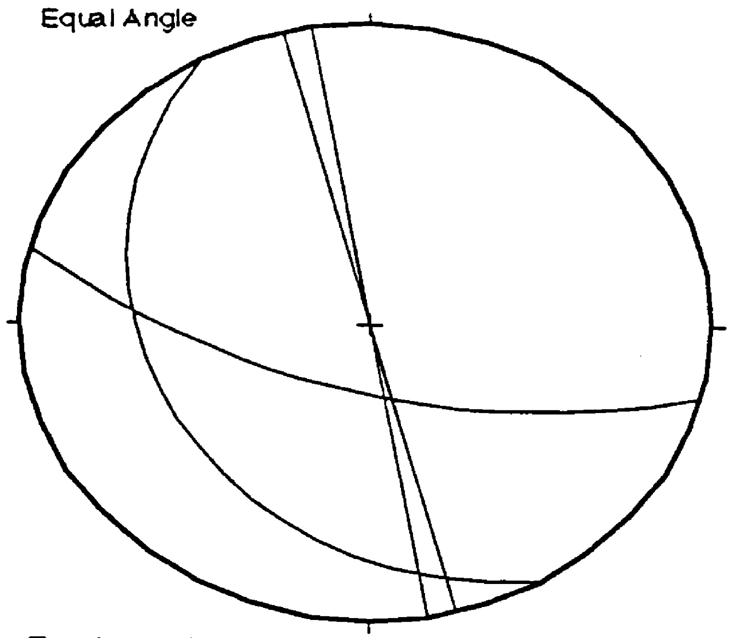
1	584	345/90	Grouty
2	593	170/90	"
3	633	150/24	"
4	814	104/64	Barbour



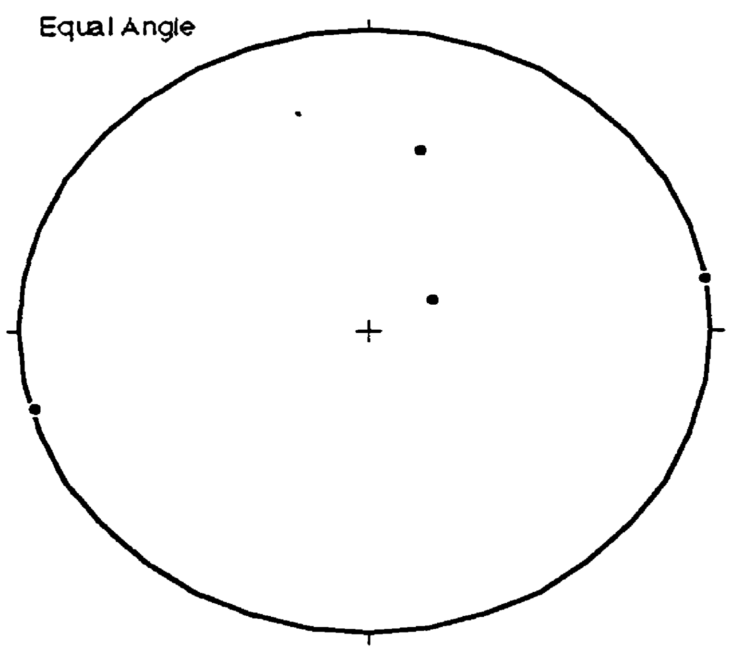
Fracture patterns and joint sets in Cadwallader Group rocks - Tenquille Creek area - Zone 3



Poles to fracture patterns and joint sets in Cadwallader Group rocks - Tenquille area Zone 3



Tension gashes and quartz-filled fractures in
Cadwallader Group rocks - Tenquille area - Zone 3



Poles to tension gashes and quartz-filled fractures in
Cadwallader Group rocks - Tenquille area - Zone 3

APPENDIX C

Conodont report

GSC Loc. No: **C-177511** **NTS**: Pemberton, 92J
Collector: M. Journeay/J. Riddell **Fld. No**: 90-JR-JMR-824
GEOGR - **Lat./Long.:**
UTM: Zone 10; 507000E, 5594500N.
Description: Pemberton, Mt. Barbour
STRAT - **Rock Unit:** Cadwallader Group, Hurley Formation, Tr3 - Tr4 Boundary Member
Description:
PALEO - **Fossils:** conodonts, ichthyoliths
Conodont taxa: **CAI:** 5 - 5.5
Epigondolella triangularis (Budurov, 1972) (6)
ramiform elements (5)
AGE - Late Triassic, Early Norian

GSC Loc. No: **C-142705** **NTS**: Pemberton, 92J
Collector: M. Journeay **Fld. No**: 89-JR-561
GEOGR - **Lat./Long.:** 50.5353°, 122.1361°
UTM: Zone 10;
Description: Confluence of Gott and Cottonwood Creeks.
STRAT - **Rock Unit:** Bridge River Group?.
Description: carbonate, Isolated outcrop.
PALEO - **Fossils:** ichthyoliths
AGE - Phanerozoic
Remarks: Probable age specified by collector as Triassic.

GSC Loc. No: **C-177514** **NTS**: Pemberton, 92J
Collector: M. Journeay/J. Riddell **Fld. No**: 90-JR-915C
GEOGR - **Lat./Long.:**
UTM: Zone 10; 531500E, 5561000N.
Description: Rampart Mountain, Lillooet Lake
STRAT - **Rock Unit:** Cadwallader Group, Hurley? (equivalent) Formation, TR3, equiv. to Rushmore's trans. unit?
Description: carbonate
PALEO - **Fossils:** ichthyoliths
AGE - Phanerozoic
Remarks: Original slide held by J. Riddell?

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