STRATIGRAPHY OF MESOZOIC ROCKS EAST OF PEMBERTON, BRITISH COLUMBIA, AND THE SETTING OF MINERAL SHOWINGS (92J/2, 7, 10)

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INTRODUCTION

East of Pemberton, British Columbia (Figure 1-6-1), Mesozoic volcanic and sedimentary rocks form a northwest-striking pendant about 70 kilometres long and 10 to 30 kilometres wide that is almost entirely surrounded by rocks of the Coast plutonic complex (Woodsworth, 1977). During the 1989 field season, mapping in the southernmost part of this Mesozoic band, adjacent to Lillooet Lake, confirmed that a major north-northwest-striking fault cuts the pendant. Triassic rocks, probably of the Cadwallader Group, lie to the east, Cretaceous Fire Lake Group rocks to the west (Riddell, 1990). The goals of this project for the 1990 field season were to trace the fault to the north through the pendant, to improve the map coverage east of the fault and to expand the map area to the north to compare the stratigraphy in the Lillooet Lake area to that near Tenquille Lake.

The major thrust fault can be traced through the Owl Creek valley, and probably extends through the topographic notch east of Mount Pauline (Figures 1-6-2 and 3).

The Triassic rocks throughout the expanded map area generally comprise a lower unit of massive basaltic and andesitic flows (Tr1) and unsorted lithic tuffs (Tr2), overlain

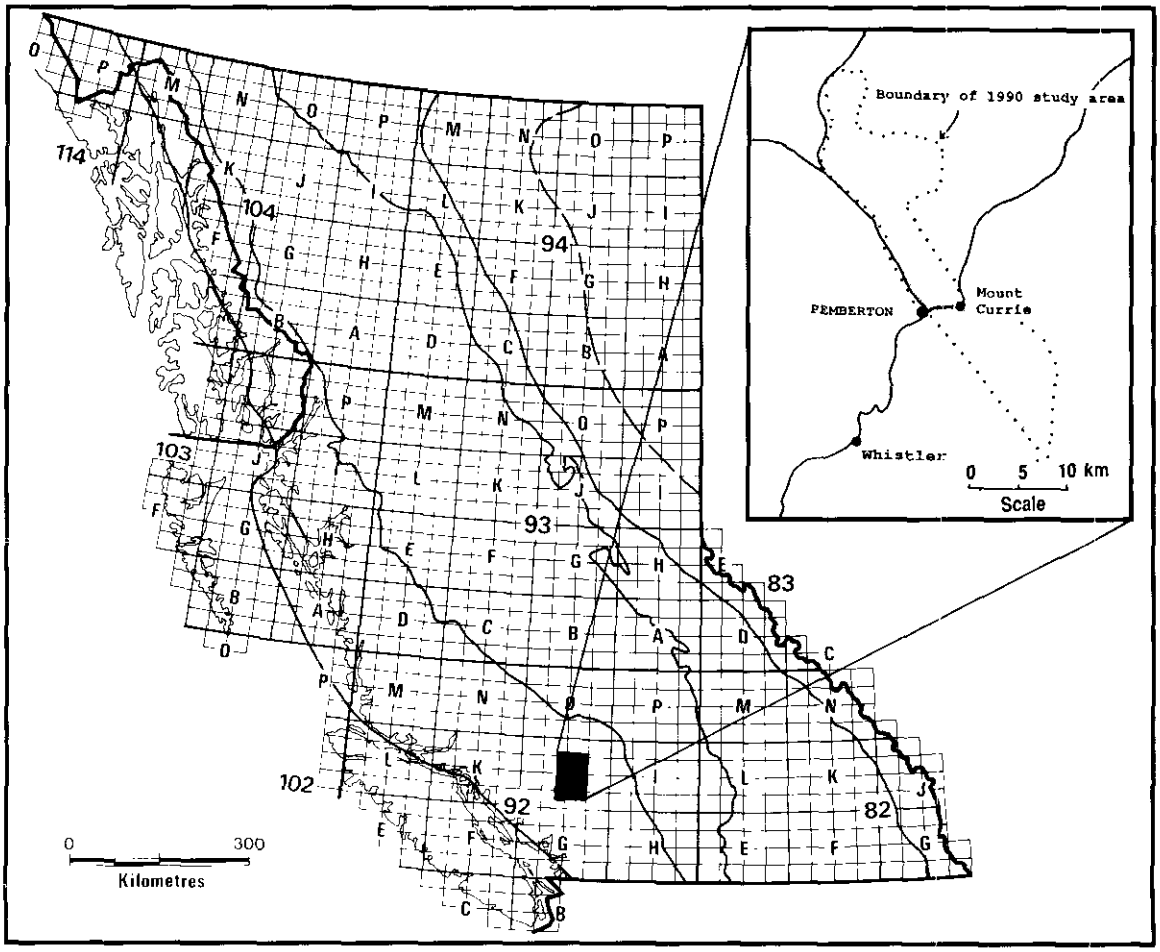

Figure 1-6-1. Location map.

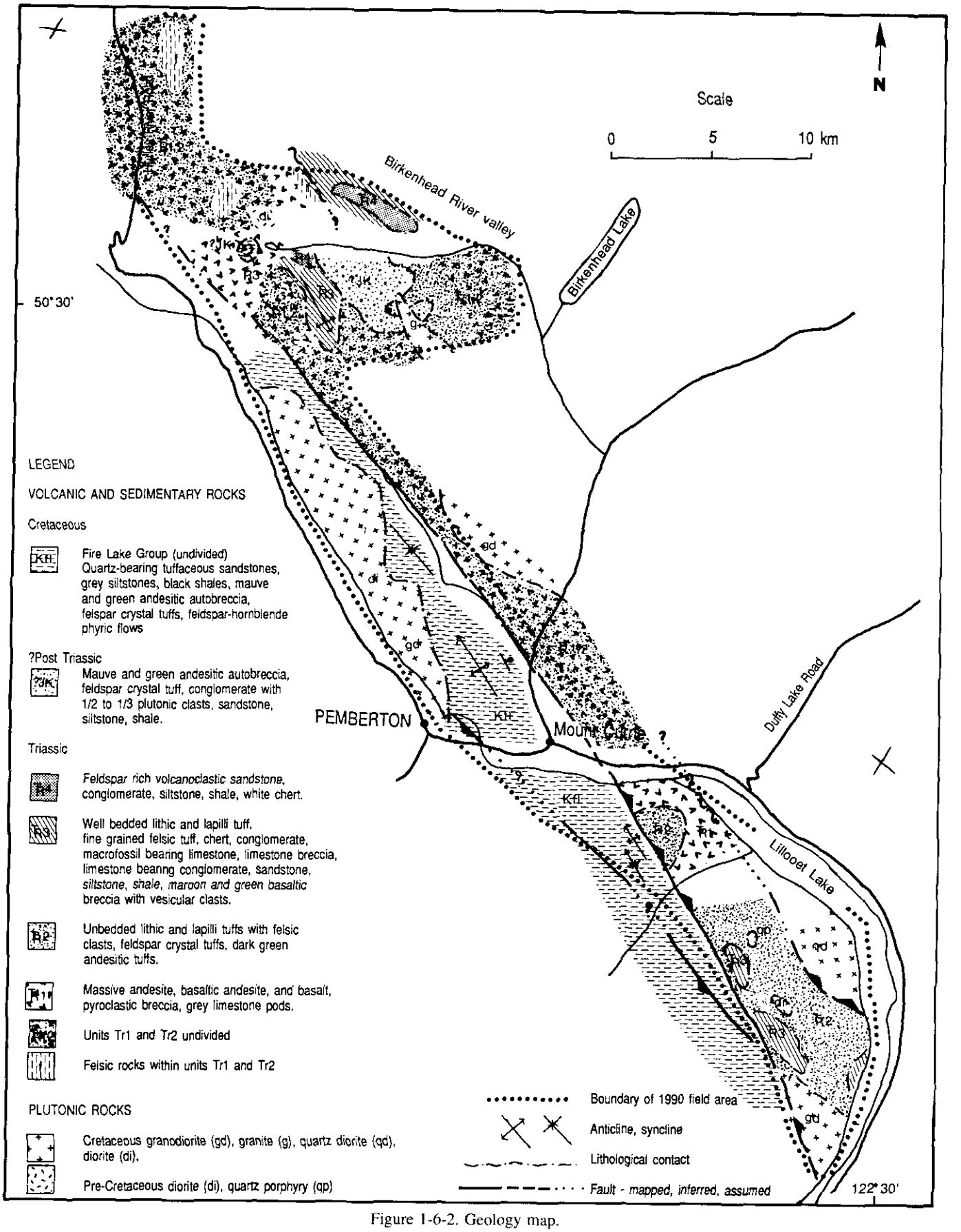

Figure 1-6-2. Geology map.

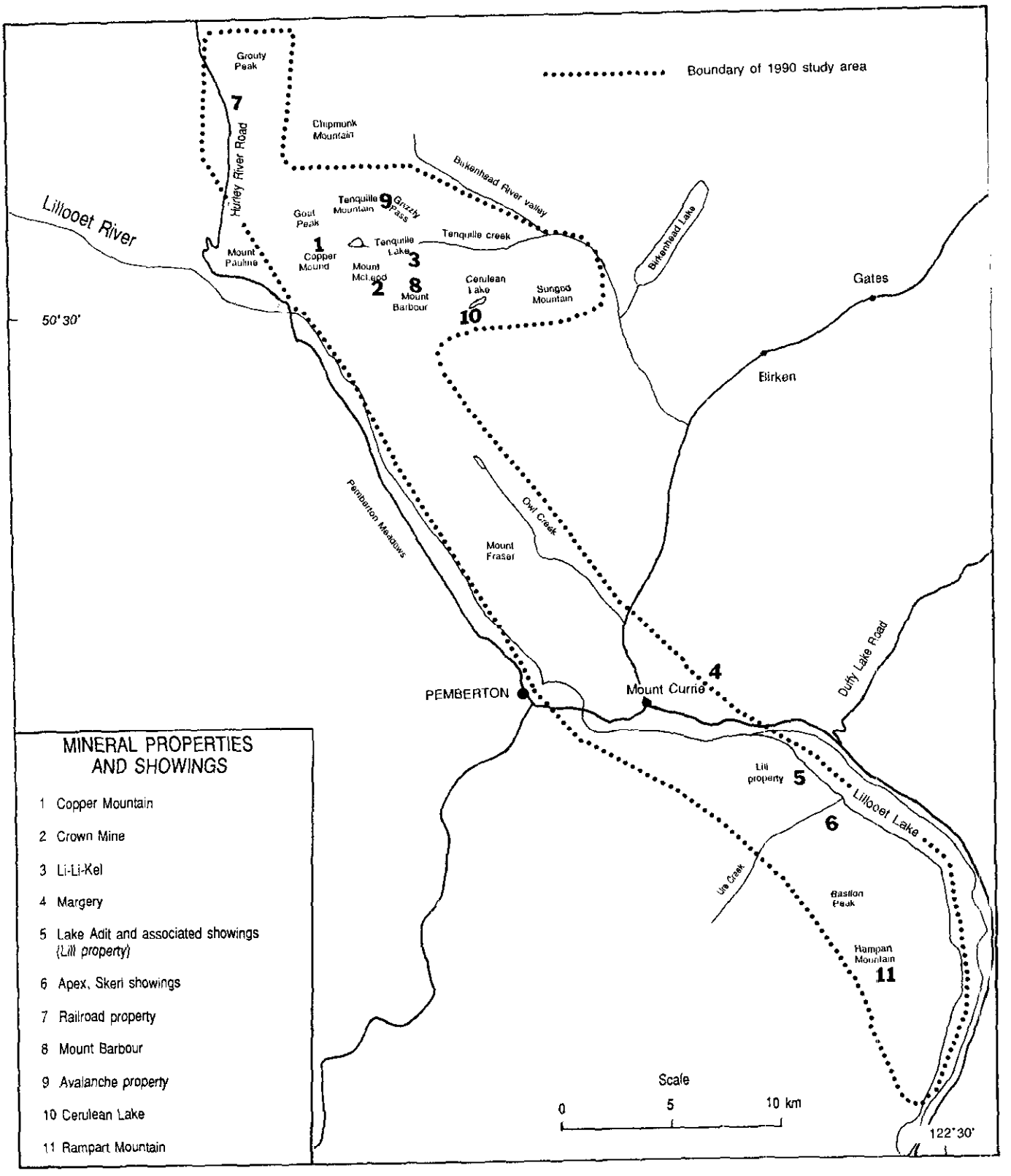

Figure 1-6-3. Place names and mineral showings in the Pemberton belt.

by a section of well-bedded tuffaceous and sedimentary rocks (Tr3). In some localities, a thin section of predominantly sedimentary rocks (Tr4) overlies Unit Tr3.

In the Tenquille Lake area, a relatively thin section of volcanic and sedimentary rocks sits unconformably on top of the rocks of the Triassic sequence. This section does not resemble rocks of the Cadwallader Group, and probably represents a younger overlap assemblage. If the age of this section can be determined, it will provide an upper constraint on the timing of accretion of the Triassic section.

TRIASSIC STRATIGRAPHY

Correlation With The Cadwallader Group

Triassic rocks in the Pemberton belt have been mapped as Cadwallader Group (Cairnes, 1925; Roddick and Hutchison, 1973; Woodsworth, 1977). The validity of this correlation is still a matter of discussion. My observations in the Pemberton belt, especially in the Mount Barbour area south of Tenquille Creek, support the correlation of these rocks with the Cadwallader section described by Rusmore (1985) in the Eldorado Creek area near Gold Bridge. There are, however, some significant differences between the two sections. Figure 1-6-4 compares the major stratigraphic components of the two sections. The important similarities between the sections are:

- A basal, massive, submarine mafic volcanic unit (the Pioneer Formation of the Cadwallader Group). Comparison of major and trace element analyses of mafic rocks from the Pemberton belt with those from Rusmore's study area shows that their chemical signatures are similar, and they could have formed within the same island arc (Schick, 1990).
- A transitional unit of mixed volcanic, volcaniclastic, and sedimentary rocks. Distinctive features common to the two sections include limestone beds containing Late Triassic microfossils and bivalve macrofossils (Woodsworth, 1977), felsic tuffs, a distinctive conglomerate with limestone clasts, and limestone breccias.

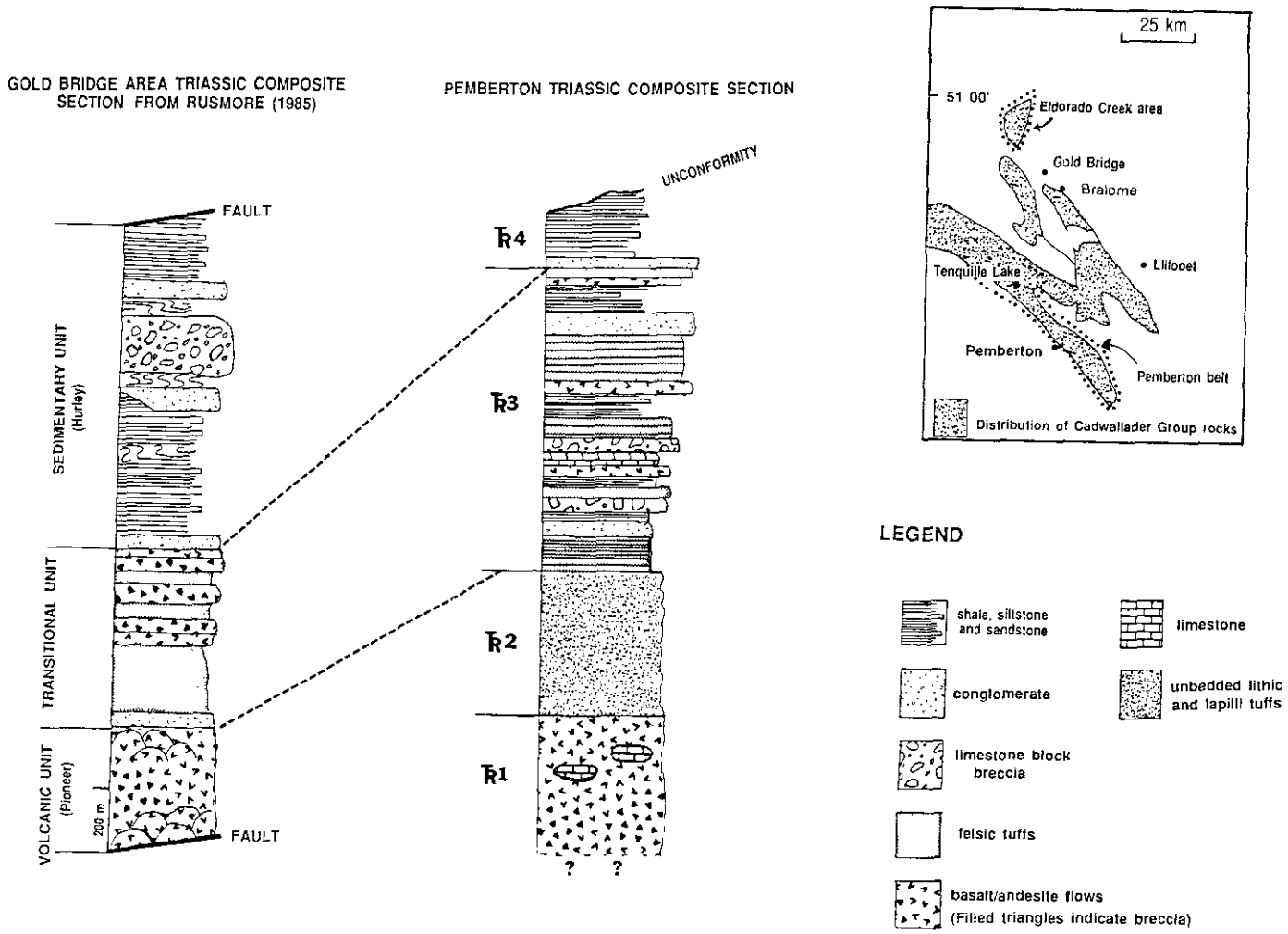

Figure 1-6-4. Composite Triassic sections from the Gold Bridge and Pemberton areas; Gold Bridge section from Rusmore (1985).

- A predominantly sedimentary unit at the top of the section (the Hurley Formation of the Cadwallader Group).

The most convincing evidence that the two sections are correlative lies in the striking similarities between Rusmore's "transitional unit" and the mixed bedded sequence (Tr3) of the Pemberton belt Triassic section. Most of Cairnes' (1937) observations of the Pioneer Formation in the Cadwallader valley near Bralorne accurately describe Units Tr1 and Tr2 of the Pemberton belt Triassic section. The two sections differ most significantly in that the Pemberton section contains a much greater volume of volcaniclastic rock, and a much smaller volume of purely sedimentary material than the Gold Bridge section. Also, the basal volcanic unit near Gold Bridge is dominantly basaltic and amygdaloidal, and often pillowed, whereas in the basal unit of the Pemberton Triassic section, andesite is dominant over basalt by volume, it is rarely amygdaloidal, and pillowed flows are absent. In the Pemberton section, isolated car-sized limestone pods are commonly found "floating" in the basal volcanic pile. Such pods are absent in the type Cadwallader section, and are more suggestive of stratigraphy in the Bridge River complex than of the Cadwallader Group.

The Pemberton Triassic Composite Section

The Pemberton Triassic section comprises four distinct mappable units (*see* Figure 1-6-4) but the idealized composite section is not preserved intact anywhere in the map area. There is wide variation with respect to both the internal stratigraphy of the units, and spatial relationships between them. For further discussion of this variation, the reader is referred to Riddell (1991).

Massive Basalt and Andesite (Tr1)

The lowermost, mafic volcanic unit is well exposed on the Lill property at the north end of Lillooet Lake, on the east side of the Owl Creek valley, below the 2000-metre elevation on Mount McLeod and Copper Mound, and in the bluffs of Finch Ridge west of the Grizzly Pass fault zone. This unit is characterized by massive, dark green basaltic andesite and lesser basalt flows, with common feldspar-porphyritic phases and abundant epidote clots and veinlets. Pyroclastic breccias with clasts 3 centimetres and smaller are common. Limestone pods 2 to 30 metres across are also present, and they are especially abundant in the Mount McLeod area. The massive nature of this unit makes it difficult to estimate its thickness. At Copper Mound, where the section is flat lying, it appears to be about 1000 metres thick. A belt of felsic rocks sits within this massive unit in the Goat Peak and Grouty Peak areas.

Unbedded Tuffaceous Rocks (Tr2)

A thick sequence of unbedded lithic, lapilli and feldspar-crystal tuffs and fine andesitic tuffs lies above Unit Tr1. It is well exposed on 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. Rocks in this unit are all rich in feldspar crystal fragments in the matrix. The fine andesitic tuffs are dark green on the fresh surface; the crystal, lapilli and lithic tuffs are pale green, and weather pale green or white. Clasts are subangular and are normally 3 to 4 centimetres across or smaller, but locally clasts twice this size are present. Andesitic and felsic volcanic fragments are the most common clast types in the lithic tuffs. Pale green chert, diorite and basalt clasts were found locally. Textures are best 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.

Well-bedded Mixed Volcanic and Sedimentary Rocks (Tr3)

The transition from massive lithic tuffs to well-bedded tuffs (without compositional change) marks the base of Unit Tr3. It is best exposed on the Mount Barbour ridge, on Bastion Peak and on Rampart Mountain. It comprises white and rusty weathering lithic and lapilli tuffs, macrofossil-bearing grey limestone beds, conglomerate, calcareous wackes rich in feldspar, grey siltstone and black shale, fine-grained felsic tuffs with cherty tops, limestone breccias, and mafic to intermediate flows. An outcrop of the distinctive limestone-clast 'Cadwallader' conglomerate described by Cairnes (1937) and Rusmore (1985) has been mapped northeast of Mount McLeod by M. Journeay (oral communication, 1990). A deep maroon and green basaltic breccia with vesicular clasts is associated with this section at Mount Barbour and Rampart Mountain.

Sedimentary Rocks (Tr4)

Predominantly sedimentary sequences are quite rare in the Pemberton Triassic section. Shales, siltstones, sandstones and conglomerates are present, but in almost all localities they are intermixed with tuffaceous sediments, tuffs, and flows, and are included in Unit Tr3. Exceptions are at the top of the Mount Barbour Triassic section, and on the eastern end of the ridge east of Grizzly Pass. These rocks are dominantly feldspar-rich, volcaniclastic sediments. Clasts of the underlying rock types are easily recognized. The sequence contains multiple, rapid fining-upward sequences from cobble conglomerate to black shale. White cherty beds are common.

POST-TRIASSIC(?) VOLCANIC AND SEDIMENTARY SECTION (?JK)

Southeast of Tenquille Lake, a relatively thin section of volcanic and sedimentary rocks sits unconformably on the Triassic sequence (Figure 1-6-2). This section does not resemble any known Cadwallader stratigraphy. It is well exposed in the area surrounding Cerulean Lake, and small outliers are preserved at the very top of Copper Mound and on the northern flank of Goat Peak. The lowest exposed rocks in this section are mauve and green andesitic autobreccia, with beige feldspar and hornblende-phyric flows, and mauve and green lapilli and feldspar-crystal tuffs. These rocks are remarkably similar in appearance to the auto-

breccia unit of the Cretaceous Brokenback Hill Formation mapped in the Lillooet Lake pendant (Riddell, 1990), but the bounding stratigraphy is different. About 100 metres of sedimentary rock overlies the volcanic pile. Its base is a boulder conglomerate and it grades smoothly, apparently through only one major cycle, through cobble, pebble and granule conglomerate, into quartz and feldspar-rich calcareous sandstone, grey siltstone and black shale. One third to one half of the clasts in the conglomerate are fresh hornblende granodiorite, quartz diorite and granite. Their source is unknown. Remaining clasts tend to be representative of the local underlying rocks. Clasts of feldspar-phyric andesitic volcanics, argillite, green aphanitic volcanics and mafic volcanics are common, chert pebbles, gneissic granitoids and pyroxene granitoid clasts appear locally. Thin crossbedded magnetite-rich sandstone beds are present within the conglomerate in a few places. North of Cerulean Lake these beds are several centimetres thick (P. Newman, oral communication, 1990). A granodiorite boulder from the conglomerate has been sampled for radiometric dating.

CRETACEOUS STRATIGRAPHY (K)

Cretaceous stratigraphy west of the Owl Creek fault is not well exposed within the map area north of Pemberton; much of the area is underlain by quartz diorites and granodiorites of the Coast plutonic complex. The mauve and green volcanic breccia of the Brokenback Hill Formation can be traced northwest to the Mount Fraser ridge system. Volcanic wackes, siltstones and shale, probably of the Peninsula Formation, underlie the breccia.

TERTIARY VOLCANICS (T)

Chipmunk Mountain, just north of Tenquille Mountain, is a Tertiary volcanic centre. Dikes and small isolated outcrops of related basalt flows, volcanic breccias and rhyolite are found throughout the map area. These rocks have distinctive, drab brown and beige colours, and outcrops are often crumbly or flaggy. The basaltic rocks commonly contain euhedral biotite crystals up to 5 millimetres across. Basalt is the most dominant clast type in the breccias, and they also contain biotite crystals and clear, anhedral quartz eyes.

INTRUSIVE ROCKS

Diorites are associated with volcanic rocks of Units Tr1 and Tr2 on Tenquille Mountain and southeast of Bastion Peak. These rocks show mutually crosscutting relationships with the volcanic rocks and so appear to be coeval. The diorites are characteristically altered or contaminated near the contacts with the Triassic rocks. Some appear to grade into tuffaceous rocks of Unit Tr2, and in some places it is difficult to distinguish contaminated diorites from feldspar-crystal tuffs.Large bodies of granodiorite and quartz diorite of the Cretaceous Coast plutonic complex are exposed within the map area.

STRUCTURE

The major fault that cuts the Lillooet Lake pendant continues to the northwest through the Owl Creek valley (Figure 1-6-3). Near Lillooet Lake, Cretaceous rocks of the Fire Lake Group (equivalent to the Gambier Group), are gently deformed, probably by the east-side-up movement on the fault (Riddell, 1990), into broad, open folds with gently plunging, north-northwest-trending fold axes that parallel the fault trace. East of the fault, the Triassic outcrops show a moderate to intense north-northwest-trending penetrative shear foliation, parallel or subparallel to bedding, indicating that the rocks have suffered high shear stress. This deformation is not apparent in the rocks east of the fault in the Tenquille Lake area. There, the Triassic rocks and the overlying post-Triassic(?) rocks are gently folded into a broad anticline with a gentle southeast-plunging axis that lies just east of Mount McLeod (Figure 1-6-3). Only one axial planar cleavage is present, so it appears that the Triassic rocks and the post-Triassic(?) section were deformed together by one event some time during or after deposition of Unit ?JK.

Part of a large shear zone is exposed in a new road on the Lill property, along the shoreline at the mouth of the Lillooet River. The andesites and andesite breccias are intensely silicified and bleached to a pale silver-grey colour, and massive and disseminated pyrite is abundant. This is probably a continuation of an east-side-up thrust fault that lies along strike to the south, on the western shore at the bend in Lillooet Lake. This structure continues across the lake farther to the south (Journeay, 1990) and appears to be an important regional feature. It may be related to the Grizzly Pass shear zone. Alternatively, it may continue north through the valley of the Birkenhead River (Figure 1-6-3).

STRATIGRAPHIC SETTING OF MINERAL SHOWINGS

Most of the mineral exploration that was done in the Pemberton area in the late 1890s and the 1930s was focused on the magnetite-garnet-epidote skarns that are commonly

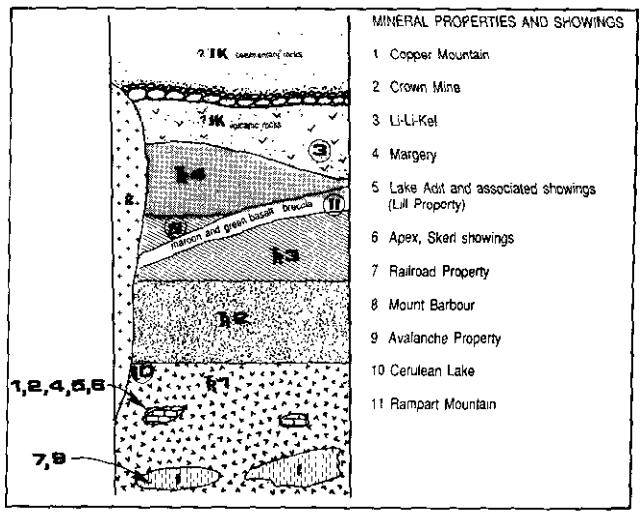

Figure 1-6-5. Locations of mineral showings within the Pemberton Triassic section. See text for details. Symbols as per Figure 1-6-2.

associated with limestone pods in Unit Tr1. A summary of the early exploration history of the area is provided by Cairnes (1925). In recent years attention has turned to volcanogenic massive sulphide deposit models. Favourable features such as a thick submarine volcanic pile with a history of explosive activity and the presence of felsic volcanic and exhalitive rock types are found within the stratigraphy of both the Fire Lake Group (Lynch, 1990), and the Cadwallader Group. Historically, the Tenquille Lake area has received most of the attention from prospectors, while the southern part of the Lillooet Lake pendant has been ignored. This may be due to the more difficult terrain in the Lillooet Lake area; below tree-line outcrop is scarce, and much of the alpine outcrop is too precipitous to walk on. Another factor is that Unit Tr1 does not outcrop south of Ure Creek, and the area is therefore not prospective for skarns. The remainder of the Triassic section is present, however, so there is potential for a volcanogenic massive sulphide occurrence in the Lillooet Lake pendant.

During the 1990 field season, I visited the mineral showings and properties shown on Figure 1-6-3. Figure 1-6-5 illustrates how they fit into the Pemberton belt stratigraphy. The following comments pertain to the general geology and stratigraphic setting of the showings. Cairnes (1925) visited localities 1 to 6 and other Pemberton area showings during September of 1924. His reports are detailed and complete, and I will not add to them here.

Railroad Property

The Railroad property covers a large rusty zone that extends over most of the southwest flank of Grouty Peak, at the north end of a zone of felsic volcanic rocks that sits within andesites and tuffs of Units Tr1 and Tr2. This zone stretches from Grouty Peak through Goat Peak and Tenquille Mountain to Grizzly Pass. The property is underlain by massive andesite flows and tuffs with abundant coeval quartz feldspar porphyry dikes and rhyolite flows. Mutually crosscutting relationships between quartz feldspar porphyries, and dacitic and andesitic feldspar porphyry dikes are abundant, as are breccias with mixed felsic and intermediate volcanic clasts. The rocks on this property are intensely to moderately silicified, and disseminated pyrite is ubiquitous. Quartz-sericite schists are common; most shear foliations strike north-northwest and dip gently to very steeply to the northeast.

Mount Barbour

A new showing, mapped by McLaren (1989), is hosted by Unit Tr3, adjacent to an icefield in the cirque on the north side of the peak of Mount Barbour. The showing is a pod of massive, banded pyrrhotite within a conspicuous northwest-striking rusty scar that cuts through the ridges east and west of the snowfield. The hostrocks are well-bedded felsic tuffs with cherty tops. The stratigraphy dips moderately to the northeast, and the associated rocks are well-bedded lithic tuffs and feldspar-rich wackes with pyritic quartz-sericite schists. Just south of the showing, a deep maroon and green basalt breccia outcrops on the peak of Mount Barbour. It is unclear how this breccia fits in with the Unit Tr3 stratigraphy, or if it is related to the showing.

Avalanche Property

The Avalanche property covers a wide, rusty alteration zone east of Tenquille Mountain. The rocks on the property are deformed by a complex set of anastamosing north-northwest-striking shears associated with a fault that passes through Grizzly Pass. The shear zone is bounded to the southwest by competent, unsheared massive basaltic andesite of Unit Tr1, and to the north by overlapping Tertiary basalt breccias. Rocks within the shear zone are banded parallel to the strike of the fault, and individual bands can be traced along strike for hundreds of metres. The sequence includes rhyolite flows, lithic and lapilli tuffs, rusty quartz-muscovite schists, bluish green chloritic tuffs and aplite with rhodonite specks. Large quartz grains or quartz grain clusters are present in all outcrops. Dark green chloritic flows with blue quartz eyes outcrop along the northeast edge of the shear zone. A thick ferrocrete deposit about 150 metres wide has formed around a rusty seep that is fed by a creek that drains the saddle at the top of the pass.

Cerulean Lake

A pod of massive pyrrhotite about 3 metres thick and 30 metres long lies along the contact zone between massive andesite flows (Tr1) and the Late Cretaceous Spetch Creek pluton, on the creek that flows into the southwest end of Cerulean Lake. It is surrounded by a large rusty zone on the west bank above the creek. Mineralized boulders have conspicuous black and iridescent manganese oxide coatings

Texas Showing

The Texas showing on the Birkenhead Lake road is an iron-copper-gold skarn within quartz-bearing calcareous andesitic lapilli tuff of the Unit Tr2. Banded and disseminated pyrite, chalcopyrite and malachite are associated with garnet-diopside calcsilicate rocks. No limestones were seen. The skarn mineralization may have formed by a reaction between the limy tuffs and a quartz feldspar porphyry dike that is exposed on the south end of the property.

Rampart Mountain

A large, intensely rusty zone is associated with a deep maroon and green basalt breccia on Rampart Mountain, near where the breccia lies unconformably on top of mixed tuffs and sediments of Unit Tr3. Quartz-bearing breccias and felsic porphyries within the maroon and green rocks are strongly pyritized. The rocks all show strong to intense north-northwest shear foliation. Pyritic quartz-sericite schists are abundant.

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