Bralorne
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FIELD TRIP ROAD LOG AND COMMENTS

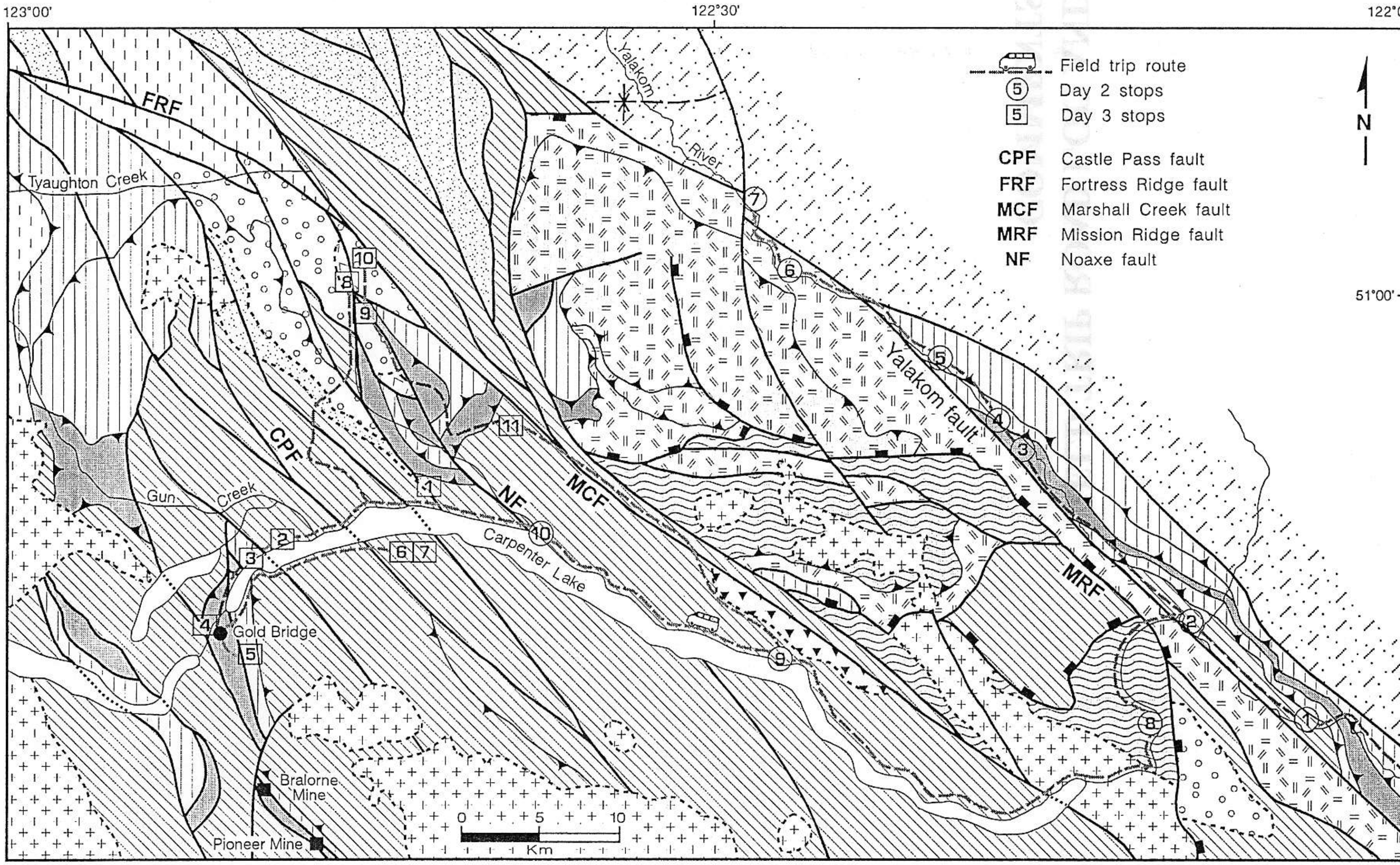

Figure 11. Simplified geolgy of the Bridge River area, showing stop locations for days 2 and 3 of the GAC/MAC Victoria '95 field trip. Geology from Schiarizza et al. (1993a,b,c), Cairnes (1937, 1943), Church et al. (1988b) and Journeay & Mahoney (1994).

EOCENE

Jones Creek volcanics:
dacite, volcanic breccia

LATE CRETACEOUS - EARLY TERTIARY

Intrusive rocks:
granodiorite, quartz diorite;
hornblende-feldspar porphyry, quartz-feldspar porphyry

UPPER CRETACEOUS

Powell Creek formation:
volcanic breccia, andesite

TYAUGHTON BASIN

MID-CRETACEOUS

Silverquick formation:
conglomerate, sandstone, shale

Taylor Creek Group:
shale, sandstone, conglomerate

UPPER JURASSIC - LOWER CRETACEOUS

Relay Mountain Group:
sandstone, shale

BRIDGE RIVER TERRANE

MISSISSIPPIAN - CRETACEOUS

Bridge River Complex:
chert, greenstone, argillite, limestone, sandstone, blueschist, gabbro serpentinite;
Cayoosh Assemblage: *sandstone, shale, conglomerate*

Bridge River schists: *biotite-quartz schist, biotite-chlorite-actinolite schist; includes bodies of variably deformed granodiorite and orthogneiss*

CADWALLADER TERRANE

TRIASSIC - MIDDLE JURASSIC

Tyaughton Group:
conglomerate, limestone, sandstone
Last Creek formation:
shale, sandstone

Cadwallader Group:
greenstone, volcanic breccia, sandstone, conglomerate;
Junction Creek unit:
shale, cherty argillite

OPHIOLITIC ASSEMBLAGES

EARLY PERMIAN

Bralorne-East Liza Complex:
greenstone, diabase diorite, tonalite, gabbro, serpentinite

Shulaps Ultramafic Complex:
serpentinite mélange containing knockers of ultramafic rock, gabbro, diabase amphibolite, roddingite, greenstone, limestone, chert and sandstone

Shulaps Ultramafic Complex:
harzburgite and dunite with a mantle tectonite fabric

METHOW TERRANE and METHOW BASIN

LOWER JURASSIC - LOWER CRETACEOUS

Dewdney Creek Formation:
shale, sandstone, granule conglomerate;
Jackass Mountain Group:
sandstone, conglomerate shale

Legend to accompany figure 11.

DAY 2: LILLOOET TO TYAUGHTON CREEK

START POINT

0.0 km Victoria Hotel in downtown Lillooet. Proceed northward. To the east, across the Fraser River, is Fountain Ridge, underlain largely by Lower Cretaceous, extensively zeolitized sandstones, shales and conglomerates of the Jackass Mountain Group. The main strand of the Fraser fault lies in Fountain Valley, east of the ridge.

0.9 km Small outcrops on the left are shales and sandstones assigned to Division A of the Lillooet Group (Trettin, 1961).

Comment

The Lillooet Group was defined by Duffell and McTaggart (1952) to include clastic sedimentary rocks exposed in a northwest-trending belt extending from the lower Bridge River southward along the Fraser River to the mouth of Laluwissin Creek. The group was assigned a Lower Cretaceous age based on an occurrence of *Aucella* (*Buchia*) near the south end of the belt. Trettin (1961) subdivided the group into a lower division (Division A) consisting of thin-bedded argillite, siltstone and fine-grained sandstone, and two higher divisions that include significant proportions of coarse-grained lithic sandstone and granule conglomerate. Monger and McMillan (1989) re-assigned most of the Lillooet Group to the Jura-Cretaceous Relay Mountain Group, but included a small area near the mouth of the Bridge River in the Jurassic Ladner Group. Mahoney (1992, 1993) correlated the entire Lillooet Group with the Lower to Middle Jurassic Dewdney Creek Formation of the Ladner Group (Methow Terrane). We concur with the Dewdney Creek correlation for the upper divisions of the Lillooet Group, but suggest, as will be discussed further on, that division A may be a separate fault-bounded domain that correlates with Jura-Cretaceous Tyaughton basin strata and underlying Triassic and Jurassic rocks of Cadwallader Terrane, which are exposed along strike to the northwest.

1.2 km Road junction: turn left to Gold Bridge, Seton Portage, Shalalth.

1.3 - 5.6 km Scattered outcrops of mainly thin-bedded siltstone and fine-grained sandstone, locally cut by feldspar porphyry dikes and deformed by tight northwest-trending folds. These rocks are within Division A of the Lillooet Group, as defined by Trettin (1961).

7.1 - 7.3 km Thin-bedded shale and siltstone intercalated with thin to medium beds of coarse-grained lithic sandstone. These rocks were assigned to Division B of the Lillooet Group by Trettin (1961). They contain the Middle Jurassic ammonite *Stephanoceras* in this vicinity, and correlate with the Lower to Middle Jurassic (upper Toarcian to Bajocian) Dewdney Creek Formation of the Ladner Group (Mahoney, 1992, 1993). These exposures comprise part of a continuous belt that has been traced for 50 kilometres to the northwest, where they will be examined at Stop 2-7.

7.3 km Road crosses the Bridge River

7.9 - 8.2 km Outcrops of Dewdney Creek Formation consisting of thin-bedded, laminated to cross-laminated siltstone and argillite, intercalated with thin to thick beds of coarse-grained sandstone and granule conglomerate.

10.3 - 10.5 km Small outcrops of Dewdney Creek Formation on the right consist of thin-bedded, laminated siltstone and shale, with some medium to thick sandstone beds and beds of granule conglomerate with mainly shale clasts. Quartz-feldspar porphyry cuts the sedimentary rocks at the west end.

14.0 km Somewhere near here we cross through the unexposed trace of the Camelsfoot fault, an important structure which has been traced northward about 30 kilometres, where it is apparently truncated by the Yalakom fault. Over this distance it separates a homoclinal, east-northeast facing belt of Methow Terrane rocks on the northeast from rocks of the Camelsfoot thrust belt to the southwest. The latter belt includes Upper Triassic to Middle Jurassic rocks of Cadwallader Terrane, Jura-Cretaceous siltstone and fine-grained sandstone of the Tyaughton basin, and Permian greenstone, gabbro and serpentinite of the Bralorne-East Liza Complex. These units are deformed by west to southwest-verging overturned folds, and are imbricated across northeast-dipping thrust faults. The Camelsfoot fault is not exposed, but it was apparently the locus of igneous intrusion as quartz feldspar porphyry, hornblende feldspar porphyry, granodiorite and diorite were noted at several localities along or near its inferred trace. As mapped, the apparent surface trace of the fault suggests a moderate to steep northeast dip, but the trace is not sufficiently well constrained to be certain.

Comment: Camelsfoot Fault

The Camelsfoot fault has not been mapped to the south, but may extend to the Fraser fault as shown in Figure 12, such that it separates Division A from Divisions B and C of the Lillooet Group, as subdivided by Trettin (1961). The northeastern part of the Lillooet Group (Divisions B and C) correlates with the Dewdney Creek Formation of Methow Terrane as it is characterized by thick beds of volcanic lithic sandstone and granule conglomerate, contains Middle Jurassic ammonites (Monger and McMillan, 1989; Mahoney, 1992) and rests stratigraphically beneath the Jackass Mountain Group. The southwestern part of the Lillooet Group (Division A) consists mainly of argillite, siltstone and fine-grained sandstone that, at the southern end of the belt, contains Early Cretaceous *Buchia* pelecypods (Dawson, 1896; Duffell and McTaggart, 1952). These rocks are lithologically similar to the Jurassic Junction Creek unit and overlying, *Buchia*-bearing, Jura-Cretaceous Grouse Creek unit, which occur along strike in the Camelsfoot thrust belt. Furthermore, cobble conglomerate containing clasts of limestone, granitic rock and chert was noted at two localities along the western limit of the Lillooet Group belt by Duffell and McTaggart (1952; localities shown in Figure 12); these conglomerates are lithologically similar to conglomerates within the Upper Triassic Hurley Formation, which underlies the Junction Creek unit in the Camelsfoot thrust belt. As thus defined the proposed southern extension of the Camelsfoot fault corresponds to a contrast in structural style noted by Trettin (1961), who mapped southwest-overturned folds in Division A, whereas Divisions B and C dip homoclinally to the northeast and locally underlie the Jackass Mountain Group in the hinge of a broad fold. As noted above, a similar change in structural style is apparent across the Camelsfoot fault to the northwest (compare cross-sections A and B of Figure 12). One additional criteria for defining the Camelsfoot fault south of Lillooet is a linear belt of six small granodiorite, quartz diorite and dacite intrusions mapped within the Lillooet Group (Duffell and McTaggart, 1952; Trettin, 1961; Monger and McMillan, 1989). Similar granodiorite to quartz porphyry intrusions were noted along or near the trace of the Camelsfoot fault to the northwest. The intrusive bodies within the Lillooet Group are described as being generally elongate parallel to the strike of the belt (Duffell and McTaggart, 1952; Trettin,

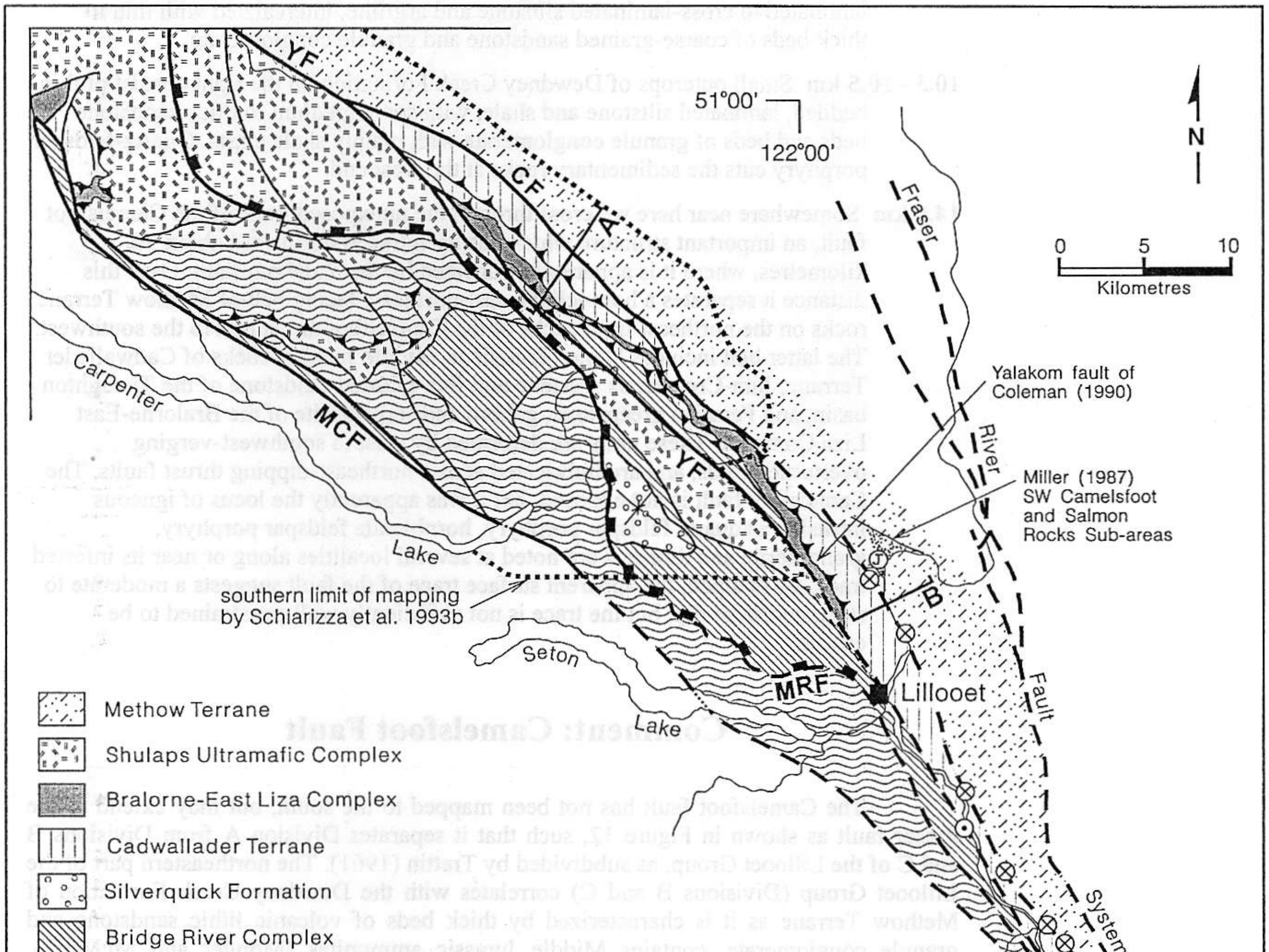

Figure 12. Postulated southeast continuation of the Camelsfoot fault.

1961), and the northern two lie along the contact between Divisions A and B of Trettin, which is inferred to mark the trace of the Camelsfoot fault, on both lithologic and structural grounds as outlined above. Because Trettin's mapping covered only the northern part of the Lillooet Group, and it is not subdivided by other workers, the proposed trace of the Camelsfoot fault is drawn to coincide with this belt of intrusions (Figure 12).

The proposed southward extension of the Camelsfoot fault puts the study of Miller (1988) into perspective. He examined the structures in a relatively small area north of the confluence of the Bridge and Fraser rivers (Southwest Camelsfoot and Salmon Rocks sub-areas, Figure 12), and concluded that they fit a strain ellipse for left-lateral slip along the Yalakom fault. As shown in Figure 12, his conclusions were derived from a study area immediately northeast of the Camelsfoot fault, and so presumably relate to that fault, rather than to the Yalakom which is about three kilometres across strike to the southwest. East-striking sinistral faults were also mapped at several localities within Methow Terrane rocks directly northeast of the Camelsfoot fault by Schiarizza *et al.* (1993b), and a sinistral component of movement was noted along some thrust faults within the Camelsfoot thrust belt (Schiarizza et al., 1990a) directly southwest of the Camelsfoot fault. The Camelsfoot thrust belt and Camelsfoot fault are thought to be components of a widespread middle to early Late Cretaceous contractional fault system which also displays a component of sinistral motion elsewhere (*e.g.* Eldorado fault zone).

16.5 km Small outcrop on the right consists of thin to medium-bedded argillite with rare thin beds of well indurated sandstone. These rocks probably belong to the Lower to Middle Jurassic Junction Creek unit of Cadwallader Terrane.

18.7 km Applespring Creek

20.2 - 20.4 km Small outcrops of Hurley Formation

20.5 km Begin outcrops of the Bridge River Complex, which is situated structurally beneath the Hurley Formation and comprises the lowest slice in the Camelsfoot thrust belt. This narrow slice of Bridge River Complex is bounded to the southwest by the Yalakom fault, and together with overlying Cadwallader Terrane rocks has been displaced more than 100 kilometres southeastward relative to the extensive exposures of Bridge River Complex across the fault to the west.

STOP 2-1

20.8 km ***TRIASSIC ROCKS OF THE BRIDGE RIVER COMPLEX***

This is a fairly typical exposure of the Bridge River Complex. It consists of contorted and faulted chert together with greenstone and argillite. The chert at this locality has yielded Middle Triassic radiolarians (Cordey, 1986), whereas the offset portion of this Bridge River slice, exposed south of the Nemaia valley 120 km to the west-northwest, contains radiolarians of Permian age (F. Cordey, personal communication 1993).

Comment: Camelsfoot Thrust Belt

The Camelsfoot thrust belt has been traced for 30 kilometres between the Yalakom and Camelsfoot faults (Figure 12). As suggested above, this narrow belt may extend an additional 45 kilometres southeastward before being truncated by the Fraser fault. The Bridge River Complex exposed here is part of the lowest exposed fault slice within the thrust belt. Higher structural levels are dominated by sedimentary rocks of the

Upper Triassic Hurley Formation and Lower to Middle Jurassic Junction Creek unit. The youngest rocks within the belt are locally exposed siltstones and fine-grained sandstones of the Grouse Creek unit, which contain *Buchia* pelecypods of Early Cretaceous and/or latest Jurassic age. These sedimentary rocks are deformed by southwesterly-overturned folds and associated thrust faults, and are imbricated with two separate northeast-dipping fault panels of greenstone, gabbro, diabase and serpentinite assigned to the Bralorne-East Liza Complex. Sparse but consistent kinematic evidence suggests that at least some of the faults record sinistral transpressional deformation. The kinematic indicators include: sinistral shear bands cutting foliated serpentinite of the Bralorne-East Liza Complex along a northeast-dipping fault contact with the Hurley Formation west of Applespring Creek; outcrop-scale fault systems with oblique east to east-northeast plunging striations preserved on northeast-dipping faults and top-to-the-west sense of movement indicated by offset marker beds; and west to southwest-verging folds with axes locally trending more northerly than the strike of adjacent northeast-dipping faults.

The age of thrusting within the Camelsfoot belt is constrained to be Early Cretaceous or younger, as the Jura-Cretaceous Grouse Creek unit is imbricated within the belt. The northeast-dipping faults were first recognized by Coleman (1989, 1990), who interpreted them to be part of the Yalakom system, and suggested that the faults and associated southwest-verging folds formed in response to Eocene dextral-oblique-slip motion. We interpret these southwest-vergent structures to be part of the earlier, mid-Cretaceous contractional fault system that is well-dated elsewhere in the region, in part because they display the same stacking order characteristic of the mid-Cretaceous thrust system elsewhere, that is imbricated Cadwallader Terrane and Bralorne-East Liza Complex thrust over Bridge River Complex. Furthermore, the component of sinistral slip locally evident along the Camelsfoot thrust faults is inconsistent with the Eocene dextral movement on the Yalakom fault system, but is consistent with the sinistral component of movement recognized on Cretaceous contractional faults elsewhere in the Bridge River area (Eldorado fault system). Thrust faults within the Camelsfoot thrust belt are truncated by the Yalakom fault, which we infer to follow the lower Yalakom and adjacent Bridge River valleys. This fault was not considered an important structure by Coleman (1990), in part because she included rocks we have mapped as Shulaps serpentinite mélange within the Bridge River Complex and therefore did not identify a major structural boundary along the Bridge River. Further corroboration for the pre-Yalakom age of the Camelsfoot thrust belt is provided by Riddell *et al.* (1993), who identified offset counterparts of the Camelsfoot thrust belt, Camelsfoot fault and adjacent Methow Terrane on the southwest side of the Yalakom fault near Konni Lake, indicating that the entire structural succession has been offset about 115 kilometres along the Yalakom fault.

20.8 - 28.7 km Discontinuous outcrops of Bridge River Complex at the base of the Camelsfoot thrust belt. The outcrops of grey rock on Mission Ridge, across the Bridge River valley (followed by the Yalakom fault) to the southwest, are chert-bearing conglomerates and sandstones of the mid-Cretaceous Silverquick conglomerate.

STOP 2-2

29.6 km ***VIEW OF YALAKOM FAULT, CAMELSFOOT THRUST BELT, SHULAPS RANGE AND MISSION RIDGE***

This stop is on or near the trace of the Yalakom fault, which is largely covered by thick Quaternary glaciofluvial deposits that are well exposed in the cliffs bounding the horseshoe bend of the Bridge River to the northwest. To the northeast is the Camelsfoot thrust belt, including a lower slice of Bridge River Complex which we have been driving through since km 20.5. The thrust contact between this slice and the overlying Hurley Formation of Cadwallader Terrane is exposed 1 km to the northeast. The Hurley Formation is in turn structurally overlain by an extensive thrust slice of Permian greenstone, diabase and gabbro of the Bralorne-East Liza Complex, and then by additional panels of Triassic-Jurassic sedimentary rocks of Cadwallader Terrane. These upper thrust slices are well exposed on Mount Bishop which can be seen to the north-northwest.

Outcrops of serpentinite, gabbro and greenstone along the banks of the Bridge River to the west and northwest belong to the serpentinite mélange unit of the Shulaps Ultramafic Complex, which here comprises a narrow belt directly southwest of the Yalakom fault. This belt is in part bounded to the southwest by the northeast-dipping Mission Ridge normal fault, which forms the northeast boundary of upper greenschist to lower amphibolite facies metamorphic rocks, the Bridge River schists, that are exposed in the Bridge River canyon to the west and southwest. Capping the southern part of the Shulaps Range farther to the west and northwest, however, are prehnite-pumpellyite-grade Bridge River rocks that are structurally and topographically above the schists. The contact was interpreted as an abrupt metamorphic transition by Potter (1983, 1986), and as a normal fault that predates the Mission Ridge fault by Schiarizza *et al.*, (1993b).

East of the Bridge River canyon the immediate hangingwall of the Mission Ridge fault comprises prehnite-pumpellyite grade Bridge River Complex and unconformably overlying mid-Cretaceous conglomerates and sandstones of the Silverquick conglomerate. These units outcrop on Mission Ridge, where they underlie the wooded slopes that extend to the skyline to the south.

31.6 km Road junction: Turn right onto the Yalakom road. For the next 24 kilometres we will be driving through the Camelsfoot thrust belt, and approximately parallel to the Yalakom fault, which will remain a short distance to the left of the road. The Camelsfoot thrust belt is gradually truncated along the Yalakom fault, such that our route will pass through progressively higher structural levels within the belt.

Comment: Yalakom Fault

Leech (1953) first used the name Yalakom fault for a system of steeply-dipping faults bounding the northeast margin of the Shulaps Ultramafic Complex along the Yalakom River. The fault was subsequently traced northwestward through the Taseko Lakes and Mount Waddington map areas (Tipper, 1969a, 1978), and southeastward to the Fraser River (Duffell and McTaggart, 1952; Roddick and Hutchison, 1973; Monger and McMillan, 1989), for a total strike length of almost 300 kilometres. Tipper (1969a) postulated that the Yalakom fault system was the locus of 80 to 190 kilometres of right-lateral displacement, based on the regional distribution of volcanic *versus* sedimentary facies in Middle Jurassic rocks. A similar estimate of 150±25 kilometres was made by Kleinspehn (1985), who matched the Lower Cretaceous Jackass Mountain Group exposed on the southwest side of the fault at Tsuniah Lake with exposures on the northeast side of the fault in the Camelsfoot Range along Nine Mile Ridge (Figure 13, Points B and B'). This estimate was revised by Riddell *et al.* (1993a), who postulated about 115 kilometres of dextral displacement based on the offset of a structural succession comprising Bridge River, Cadwallader and Methow terranes, including the Camelsfoot thrust belt and Camelsfoot fault (Figure 13, Points A and A'); the offset Methow Terrane successions include the same belts of Jackass Mountain Group on which Kleinspehn's calculation was based.

An independent estimate of displacement along the Yalakom - Hozameen fault system is provided by matching the Shulaps Ultramafic Complex with the Coquihalla serpentine belt that outcrops east of Hope (Figure 13, points C and C'). The two

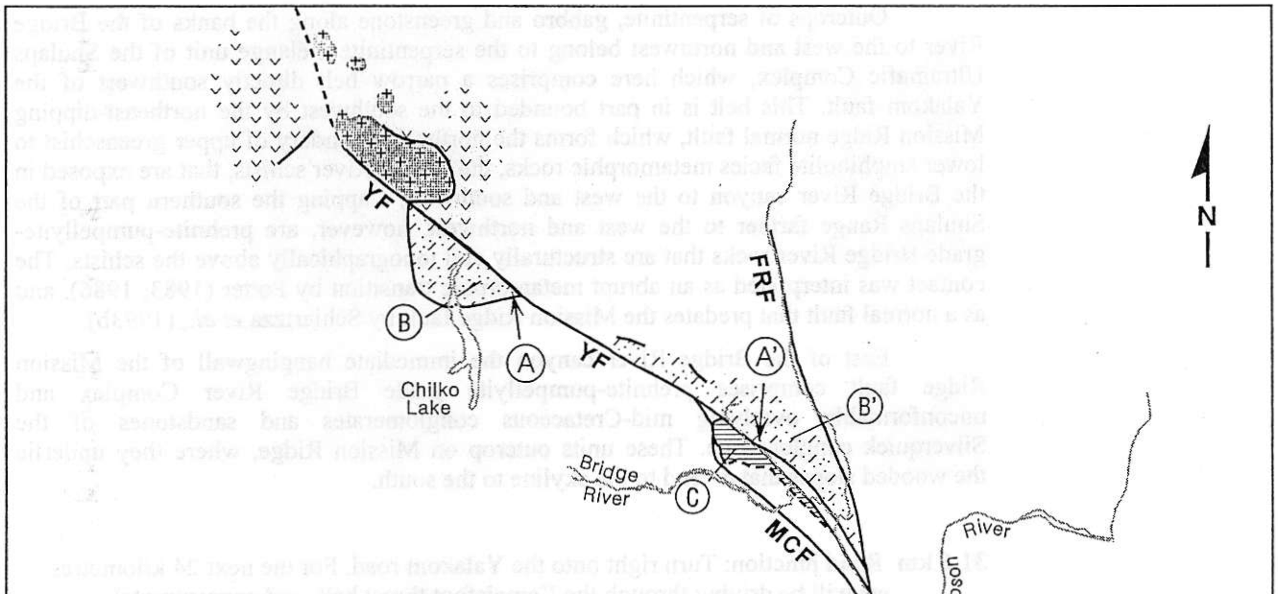

Figure 13. Map of the Yalakom, Fraser and Hozameen fault systems showing correlations used for estimating displacement on the Yalakom fault.

ultramafic complexes can be juxtaposed by restoring 90 to 125 kilometres of dextral displacement along the Yalakom-Hozameen fault, which must first be restored to a single fault strand by removing about 72 kilometres of dextral offset along the Fraser fault. Although the Shulaps-Coquihalla correlation is considered sound, the apparent dextral offset must be viewed with some reservation because thin lenses and slivers of serpentinized ultramafic rocks occur along much of the Yalakom - Hozameen fault system and unequivocal piercing points are not present (the 90 and 125 kilometre estimates are based on restoring the Coquihalla lens opposite the southern and northern portions of the 55-kilometre-long Shulaps Complex respectively). Furthermore, as relationships in the Shulaps Range suggest that the ophiolitic rocks were originally emplaced as thrust sheets on low-angle faults sub parallel to the strike-slip fault system, vertical movement along the fault system may contribute significantly to the apparent offsets. Nevertheless, the lower (90 kilometres) estimate matches closely with the expected displacement when it is noted that offset of the Shulaps Complex from the Coquihalla belt does not include the component of displacement that has been transferred to the northwestern segment of the Yalakom fault from the Marshall Creek fault system, and therefore should be somewhat less than that derived from the Camelsfoot - Konni Lake correlation.

The Yalakom fault displaces mid-Cretaceous and older rocks, and is overlapped by Neogene plateau lavas of the Chilcotin Group (Schiarizza *et al.*, 1993b,c,d; Riddell *et al.*, 1993). Coleman and Parrish (1991) relate dextral shear within Bridge River schists and associated 46.5-48.5 Ma intrusions in the southern Shulaps Range to movement on the adjacent Yalakom fault, suggesting that at least some of the displacement was Eocene in age. Eocene movement is also indicated by relationships 200 kilometres to the northwest, where the Yalakom fault defines the southwestern boundary of the Tatla Lake Metamorphic Complex (Figure 13). Friedman and Armstrong (1988) document 55 to 47.5 Ma extensional shear along subhorizontal west-northwest-trending mineral lineations within the mylonite zone comprising the upper part of the complex, followed by folding and brittle faulting during the final stages of uplift. Although they implicate the Yalakom fault only in the post-ductile deformation phase of folding and brittle faulting, the earlier ductile strain is also kinematically compatible with dextral slip along the Yalakom system. The Yalakom fault has not been mapped beyond the Tatla Lake Complex but Schiarizza *et al.* (1995) infer that it, or a kinematically linked extensional fault segment, extends north-northwestward from there, along the Dean River, to mark the western limit of a belt of metamorphic tectonites that are locally exposed beneath an extensive cover of Quaternary alluvium and Late Tertiary volcanics (Figure 13; Tipper, 1969b). The right-stepping, extensional geometry of the system is consistent with the regional pattern of Eocene dextral strike-slip and associated extension that has been documented by numerous workers in the province, including Price (1979), Ewing (1980), Price and Carmichael (1986), Coleman and Parrish (1991) and Struik (1993).

35.7 km Outcrops to the right are of Hurley Formation. The Bridge River slice that comprises the base of the Camelsfoot thrust belt to the south has been largely or entirely truncated along the Yalakom fault. Outcrops of fractured and faulted greenstone that occur along the banks of the Yalakom River a short distance to the left of the road may be the last remnants of this basal slice; alternatively, these rocks may represent the Bralorne-East Liza Complex in a higher fault slice, or be part of the Shulaps serpentinite mélange unit southwest of the Yalakom fault.

39.3 - 44.6 km Discontinuous outcrops of greenstone, diabase and local serpentinite that occur within a fault slice of Bralorne-East Liza Complex which has been traced for more than 30 km to the southeast. Here these rocks are in large part intensely fractured and veined, and are cut by a network of splay faults related to the adjacent Yalakom fault. This fault slice terminates against the Yalakom fault a short distance to the northwest.

39.4 km Ore Creek.

40.1 km Bridge over the Yalakom River.

that are cut by shear bands that also indicate dextral movement. These relationships suggest that dextral movement occurred both prior to and during listwanite alteration.

Listwanite alteration is a common feature of ultramafic rocks along early Tertiary dextral strike-slip faults of the Bridge River area, where it has been explored in several localities as a potential source of magnesite.

66.4 - 66.7 km Outcrops of Dewdney Creek Formation of Methow Terrane.

STOP 2-7

66.7 km ***DEWDNEY CREEK FORMATION***

Park at the bridge over the Yalakom River and look at the good exposures we have just passed along the road. The Dewdney Creek Formation here consists of well-bedded siltstone intercalated with medium to thick beds of well indurated lithic arkosic sandstone and gritty sandstone (Figure 16). Aalenian ammonites have been collected from here, and Aalenian to possibly late Toarcian fossils occur lower in the section to the southeast (Poulton and Tipper (1991). Additional exposures occur across the Yalakom River to the northwest, and a large ammonite (Bajocian *Stephanoceras*?) occurs within an outcrop along the road 200 metres beyond the bridge (Figure 17). These Jurassic rocks are disconformably overlain by the Lower Cretaceous Jackass Mountain Group a few hundred metres to the northeast.

From this point turn around and retrace the route along the Yalakom Road.

101.6 km Back at the junction with the Lillooet - Gold Bridge road. Turn right towards Gold Bridge.

102.0 km First switchback coincides roughly with the trace of the Yalakom fault.

102.9 km Last switchback affords view of serpentinite, diabase and greenstone on the south side of the Bridge River. These rocks are part of a thin belt of Shulaps serpentinite mélange along the southwest side of the Yalakom fault.

103.2 km Cross the Yalakom River and proceed southwestward into the Bridge River canyon.

104.1 km Cross the unexposed trace of the Mission Ridge Fault, which here separates the serpentinite mélange unit of the Shulaps Complex from Bridge River schists.

Comment: Mission Ridge Fault

The moderately northeast-dipping Mission Ridge fault was first recognized and named by Coleman (1989, 1990) who traced it from Lillooet northwestward almost 40 kilometres to Shulaps Creek. She estimates that the fault dips between 25° and 40° to the northeast on the basis of careful mapping of its surface trace southeast of the Bridge River canyon, where it juxtaposes Bridge River schists and the Mission Ridge pluton in its footwall beneath prehnite-pumpellyite grade Bridge River Complex and overlying Cretaceous sedimentary rocks of the Silverquick conglomerate. The Cretaceous sedimentary rocks are deformed into a northwest-plunging syncline which is also truncated by the fault. The Mission Ridge fault truncates an older structure in its hangingwall a short distance south of the Bridge River, and northward from there carries the Shulaps serpentinite mélange unit in its hangingwall, and juxtaposes it against Bridge River schists and associated rocks of the Shulaps - Mission Ridge metamorphic belt. For about 6 kilometres north of the Bridge River the fault trace follows the base of a distinctive planar slope which dips 30° to 35° northeastward and may be the exhumed fault surface (Coleman, 1990). Schiarizza *et al.* 1990b, 1993b,c) trace the Mission Ridge fault into the Shulaps Complex in the northern Shulaps Range, where it may connect with a northeast-striking fault that is truncated to the west by the Quartz Mountain fault system.

Coleman (1990) interpreted the Mission Ridge fault as an extensional structure because it typically juxtaposes relatively high-grade metamorphic rocks in its footwall against low-grade rocks in its hangingwall, and thus marks an omission of crust. This is confirmed by direct kinematic evidence for normal-sense displacement where the fault places Silverquick conglomerate against Bridge River schists on the southeast side of the Bridge River canyon. There, Coleman (1990) reports down-dip slickensides within a 5 to 10-metre-wide zone of closely spaced, fault-parallel fractures superimposed on foliation of the Bridge River schists, as well as outcrop-scale normal offsets of bedding over a zone 50 metres wide parallel to the fault in hangingwall conglomerate. Outcrop-scale normal faults were also documented along the northern part of the fault trace within the Shulaps Complex (Schiarizza *et al.*, 1990a).

Coleman (1990) calculated a pressure of 2.9-3.03 ±0.5 kilobars during the 47.5 Ma crystallization of the Mission Ridge pluton, using aluminum-in-hornblende geobarometry. She used this constraint to estimate a depth of about 15 kilometres for the Bridge River schists during synkinematic greenschist-facies metamorphism, as compared to an estimated depth of 6 to 10 kilometres for the prehnite-pumpellyite-grade Bridge River rocks in the hangingwall of the Mission Ridge fault. These depth calculations suggest a minimum of 5 to 9 kilometres of vertical omission south of the Bridge River canyon. Coleman assumed that all of this omission resulted from displacement on the Mission Ridge fault, which dips about 30° northeastward, and therefore translates into a minimum of 10 to 18 kilometres of down-dip displacement along the fault. Coleman, however, did not study the structural and metamorphic relationships <u>within</u> the Shulaps-Mission Ridge metamorphic belt, where slightly older Eocene extensional faulting may be inferred for the Brett Creek and South Shulaps fault systems, as described further on. The vertical displacement may therefore reflect the cumulative offset on several fault systems, and not just down-dip displacement on the Mission Ridge fault. New fission-track (FT) data (Garver, unpublished) combined with general stratigraphic observations suggest that the total vertical displacement may have been underestimated. Apatite FT ages from sandstones of the Bridge River Complex and stratigraphically overlying strata of the Taylor Creek Group and Silverquick conglomerate suggest regional cooling (below ~75 to 100° C) at about 60 Ma. These data suggest that the prehnite-pumpellyite grade metamorphism and subsequent denudation of the Bridge River Complex in the upper plate predated significant movement on these faults. Therefore the FT data suggest that the hanging wall rocks were not at 6 to 10 km but more likely at depths of less than 3 km at the onset of rapid denudation of this block. In this case the total vertical movement, assuming a constant geothermal gradient, was likely ~12 km.

The Mission Ridge fault truncates the 47 Ma Mission Ridge pluton as well as ductile fabrics within the Bridge River schists that formed, at least in part, during dextral shear that was operative before, during and after intrusion of the pluton. Development of the pre-Mission Ridge fault ductile fabrics is attributed to Eocene (and older?) dextral movement along the Yalakom fault system (Coleman, 1990). The northern part of the Mission Ridge fault is cut by a dextral strike-slip fault that is apparently a splay from the Marshall Creek fault; this fault continues northward to also cut the Yalakom fault near the mouth of Blue Creek. The Mission Ridge fault was therefore active both before and after dextral movement along different components of the Yalakom - Marshall Creek fault system, and is inferred to be an integral part of the overall dextral fault system. The Yalakom, Mission Ridge and Marshall Creek faults are all cut by (or in part merge with) the Fraser fault system, which in turn is cut by 35 Ma phases of the Chilliwack batholith (Coleman and Parrish, 1991; Monger and Journeay, 1994).

104.2 - 114.8 km Discontinuous outcrops of Bridge River schists, and good views of the schists laced with felsic dikes and sills on the opposite (east) side of the Bridge River (Figure 18).

STOP 2-8

111.7 km *BRIDGE RIVER SCHISTS*

Park on the left side of the road, at the south end of the outcrop. The exposure includes gently-dipping quartzose schist with biotite partings, as well as actinolitic schist and biotite-muscovite-quartz schist, locally with small garnets. These are part of the main belt of Bridge River schists (Potter, 1983, 1986; Coleman, 1990; Coleman and Parrish, 1991), which underlies the southernmost Shulaps Range and contiguous Mission Ridge, and extends southward almost 50 kilometres to the Fraser River fault system (Monger and McMillan, 1989). The schists are at upper greenschist to lower amphibolite facies metamorphic grade and are intruded by the Eocene Mission Ridge pluton and numerous associated syntectonic to post-tectonic granodiorite to felsic porphyry dikes and sills. In the Bridge River area, foliation has a rather persistent northwest to west strike, and moderate northeast to north dips, although local variations do occur, particularly adjacent to late faults. The foliation is locally axial planar to tight to isoclinal folds outlined by compositional layering, and it is commonly folded by later folds and crenulations. Stretching and intersection lineations plunge at shallow angles to the northwest, as do the fold hinges of most early and late folds. Detailed work by Coleman (1990) indicates that the foliation is predominantly a mylonitic shear foliation. Kinematic indicators are provided by S-surfaces defined by fish-shaped quartz aggregates at an oblique angle to

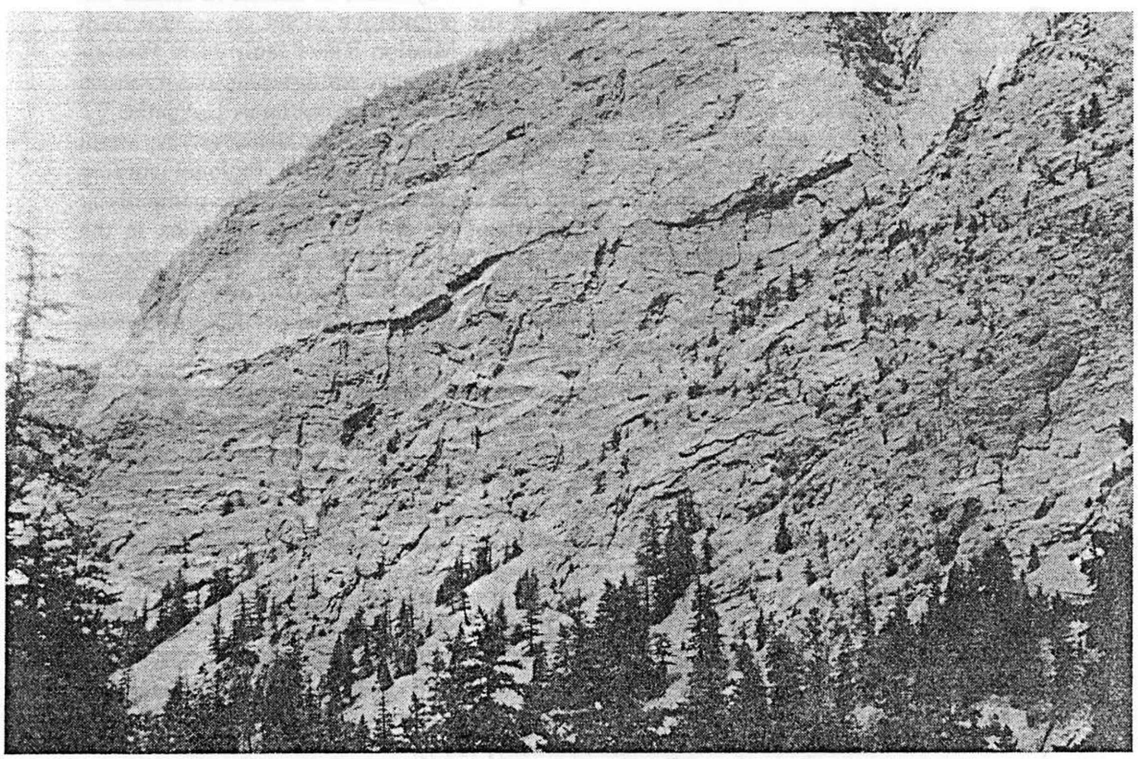

Figure 18. Bridge River schists intruded by synkinematic sills and dikes, Bridge River canyon.

the predominant C-foliation, rotated garnet porphyroblasts with asymmetric pressure shadows, and shear bands that typically intersect the dominant shear foliation at 20 to 40 degrees. All of these indicators show a consistent dextral sense of shear along the gently-northwest-plunging stretching direction (Coleman, 1990). The northwest-trending Mission Ridge pluton is broadly concordant to foliation in the surrounding schists. The interior of the pluton is generally undeformed, whereas the margins display a variably developed mylonitic foliation. Bridge River schists throughout the domain are intruded by abundant sills and dikes of similar granodioritic composition; some of the intrusions are strongly foliated and concordant with the foliation in surrounding Bridge River schists, while others cross cut it, but are folded or have weakly follated margins. The intrusions are therefore interpreted by Coleman (1990) to range from syntectonic to late syntectonic with respect to foliation development within the enclosing Bridge River schists. Kinematic indicators from foliated plutonic rocks are congruent with those from Bridge River schists, and indicate dextral shear along gently-northwest-plunging stretching lineations (Coleman, 1990). Constraints on the timing of magmatism and deformation are provided by 48.5 - 46.5 Ma U-Pb zircon ages from three deformed granodioritic bodies, including the Mission Ridge pluton

Comment: Shulaps - Mission Ridge Metamorphic Belt

The Bridge River schists outcrop in an area designated the Shulaps-Mission Ridge metamorphic belt on Figure 19. This belt also includes fault panels of lower grade, non-penetratively deformed rocks of the Bridge River Complex, Shulaps Serpentinite Mélange unit and Cadwallader Group. It is bounded by the Marshall Creek fault to the southwest, by the Mission Ridge fault to the east and northeast, and by the Brett Creek fault to the north (Figure 19). Potter (1983) attributed the metamorphism and related ductile deformation of the Bridge River schists to overthrusting by a hot Shulaps Ultramafic Complex in Early to Middle Jurassic time. Subsequent dating of penetratively deformed Eocene dikes within the Bridge River schists led him to revise this interpretation somewhat, and suggest a Mesozoic phase of amphibolite to greenschist-facies metamorphism associated with Shulaps thrusting, followed by a phase of Eocene deformation and greenschist-facies metamorphism (Potter, 1986). The work of Coleman (1990) suggests that most of the metamorphism and associated ductile deformation was synchronous with middle Eocene granodioritic intrusions, and that Potter's Shulaps thrust fault is, at least in part, an Eocene normal fault. Furthermore, more recent work has documented a well-exposed thrust contact at the base of the Shulaps Complex, but this fault juxtaposes the complex above the Bralorne-East Liza Complex and Cadwallader Group, rather than Bridge River Complex, and was synchronous with only sub-greenschist or lower-greenschist-grade metamorphism (Calon *et al.*, 1990). Relationships outside the Shulaps Range indicate that the Bridge River Complex typically occurs at a lower structural level, beneath the Cadwallader Group and Bralorne-East Liza Complex within the stack of thrust faults generated by mid-Cretaceous contractional deformation. This structurally low position is consistent with the fact that only the Bridge River Complex is heavily invaded by igneous intrusions and metamorphosed to upper greenschist or higher grade in the Shulaps Range. Accordingly, we interpret the faults bounding the metamorphic rocks of the southern Shulaps Range as a system of Eocene extensional to transtensional structures, which were responsible for the final unroofing of the metamorphic belt. Structural relationships within the belt indicate an earlier phase of transpressive deformation that was also Eocene in age. These relationships are summarized below.

The Bridge River schists and Mission Ridge pluton are truncated and structurally overlain to the north by prehnite-pumpellyite to lower greenschist grade rocks that includes a belt of Shulaps serpentinite mélange, structurally underlain by a large area of low-grade Bridge River Complex to the east of the Mission Ridge pluton and by a narrow belt of clastic metasedimentary rocks of the Hurley Formation to the

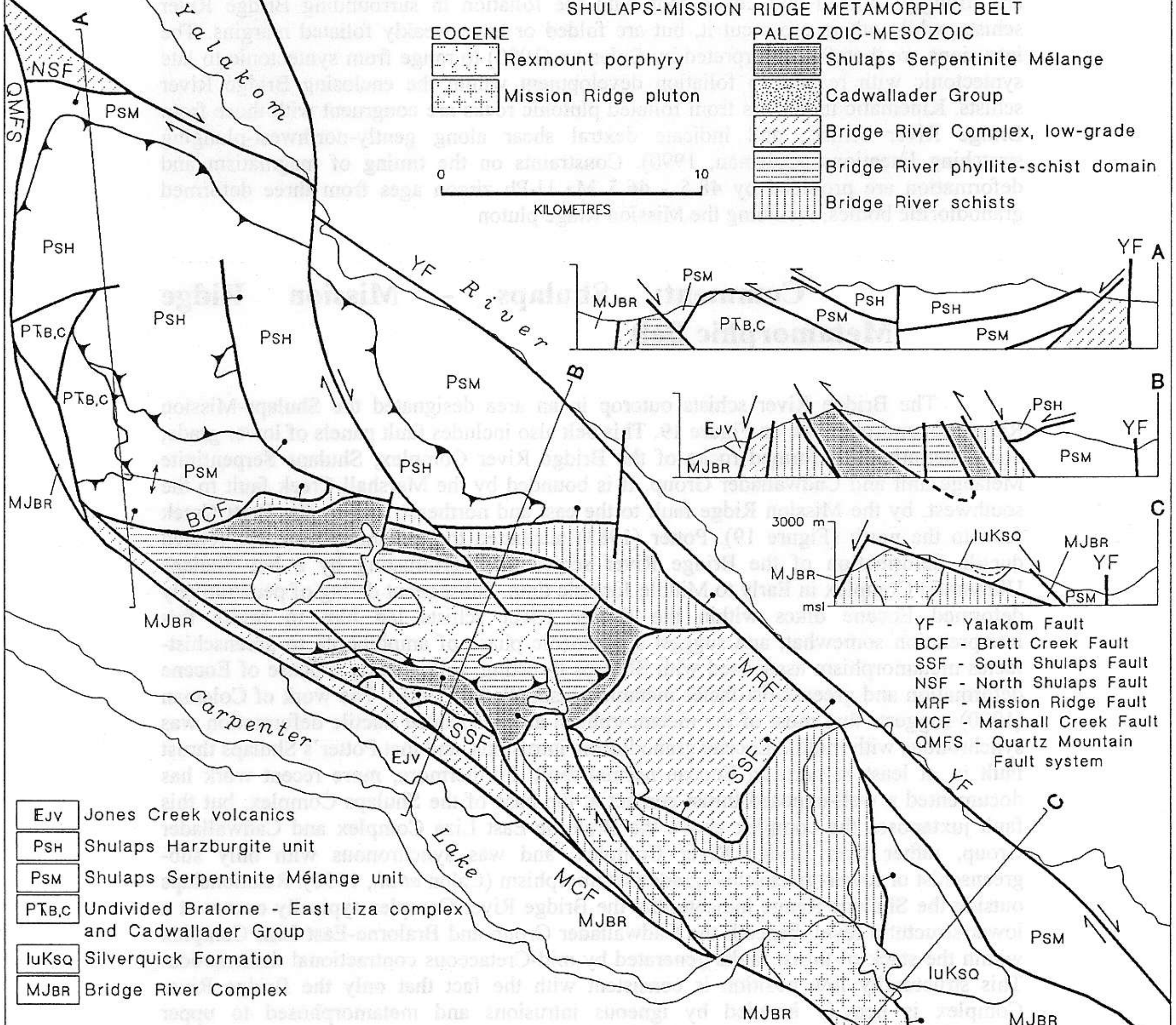

Figure 19. The Shulaps - Mission Ridge metamorphic belt.

northwest. The rocks within this low-grade belt are mainly phyllites with a moderately developed chlorite±sericite foliation that dips mainly to the northeast. The southern boundary of this belt of low-grade rocks, together with the contacts between the three major components of the belt, are interpreted as an imbricate fault system referred to as the South Shulaps fault system. The sense of movement on these faults is not well constrained, but they are suspected to be mainly extensional to dextral-transtensional because they thin and truncate units but leave them in the typical order of superposition established during Cretaceous thrusting. Furthermore, some of the faults mark an omission of section by juxtaposing upper greenschist to amphibolite-grade rocks directly beneath sub-biotite-grade rocks. This sense of movement is corroborated by observations at one place along the fault contact between serpentinite mélange and Hurley Formation, where foliation in the Hurley Formation is cut by shear bands that suggest components of dextral strike-slip and normal-sense dip-slip movement, when exposed on horizontal and vertical outcrop faces, respectively

The belt of low-grade rocks in the southern Shulaps Range is structurally overlain by sub-biotite to biotite-grade Bridge River phyllites and schists assigned to the phyllite-schist domain on Figure 19. Foliation in the phyllite-schist domain dips persistently at moderate to steep angles to the north, while stretching and crenulation lineations plunge gently to the west-northwest. Lower structural levels are at mainly sub-biotite-grade, but biotite-bearing rocks occur locally along the structural base of the domain, where they are spatially associated with substantial bodies of granodiorite similar to that of the Mission Ridge pluton. Higher structural levels comprise mainly biotite-bearing rocks which may be separated from underlying sub-biotite grade rocks by a thrust fault (Potter, 1983; Schiarizza et al., 1993a,b). The base of the phyllite-schist domain was observed southwest of Rex Peak, where it is separated from underlying serpentinite mélange by a narrow mylonitic zone that grades upward into the pervasive north-dipping foliation in overlying Bridge River phyllites. The contact is folded about later upright, gently-east plunging, south-verging asymmetric folds. It is inferred to be a transpressional fault as shear bands in the overlying Bridge River phyllites indicate dextral-thrust motion along the west-northwest plunging stretching lineation. This interpretation is consistent with the fact that it repeats the Bridge River Complex which, to the south, is structurally beneath the low-grade belt, and locally places higher-metamorphic-grade rocks above lower.

The Bridge River phyllite-schist domain is structurally overlain by a belt of Shulaps serpentinite mélange, which in turn is structurally overlain by a belt of upper greenschist facies Bridge River schists. The schists are juxtaposed against the main part of the Shulaps Complex across the Mission Ridge and Brett Creek faults. They strongly resemble those of the southernmost Shulaps Range in structural style, metamorphic grade and abundance of syntectonic granodioritic intrusions. It is suspected, therefore, that they may comprise a fault repetition of the same structural level. The underlying belt of serpentinite mélange may likewise be a structural repetition of the mélange belt directly beneath the Bridge River phyllite-schist domain (Figure 19, Section B). It seems most likely, therefore, that these northern elements of the Shulaps-Mission Ridge metamorphic belt were repeated across transpressional structures during the same structural regime that somewhat earlier had repeated the Bridge River phyllite-schist domain.

The north end of the Shulaps - Mission Ridge metamorphic belt is defined by the Brett Creek fault, which is truncated by the Mission Ridge fault to the east and is apparently truncated by the Marshall Creek fault to the west. The Brett Creek fault is nowhere exposed, but its trace from Brett Creek to the Mission Ridge fault suggests that it dips north to northeast. The Brett Creek fault, and part of the Mission Ridge fault to the east, was inferred by Potter (1983, 1986) to be a Mesozoic thrust across which the Shulaps Complex was emplaced above the Bridge River Complex. The Brett Creek fault, however, truncates ductile fabrics within the Bridge River schists that are now thought to be Eocene in age. Furthermore, it juxtaposes Bridge River schists beneath rocks of the Shulaps Ultramafic Complex that originated at a considerably higher structural level. It is therefore interpreted as a normal fault that developed somewhat earlier than the Mission Ridge fault during the extensional unroofing of the Shulaps - Mission Ridge metamorphic belt. The Brett Creek fault is, in fact, the main locus of normal displacement at the north end of the belt as the Mission Ridge fault extends northwestward into the Shulaps Complex with considerably less apparent offset north of the Brett Creek fault's truncation

The northern part of the Shulaps Range is underlain by the Shulaps Ultramafic Complex. Structures related to southwest-vergent thrust stacking are prominent within the serpentinized sole of the harzburgite unit and the underlying serpentinite mélange unit in the southwestern part of the complex (Calon *et al.*, 1990). The structural base of the Shulaps Complex is well exposed in a relatively small half window along East Liza Creek. There, serpentinite of the mélange unit lies directly above Bralorne-East Liza Complex and Hurley Formation across a gently dipping mylonite zone containing excellent S-C fabrics that indicate west-directed thrusting (Calon *et al.*, 1990). Because the Shulaps and Bralorne-East Liza complexes are thought to be related, it seems most likely that emplacement of the Shulaps Complex was coincident with the imbrication of the Bralorne-East Liza Complex (equivalent to crustal elements of the Shulaps ophiolite) with Cadwallader Terrane. This was a mid-Cretaceous event as faults related to this imbrication cut Lower Cretaceous (Valanginian or older) rocks in the Camelsfoot thrust belt, whereas 25 kilometres west of the Shulaps Range correlative structures predate the 92 Ma Mount Dickson pluton. This timing is corroborated by the presence of ophiolitic detritus and a distinct geochemical signature within the synorogenic clastic rocks of the upper Tyaughton basin (Garver, 1989, Garver and Scott, in press).

The northern boundary of the Shulaps Ultramafic Complex is the North Shulaps fault, a south-dipping fault that separates serpentinite mélange from underlying Bridge River Complex. It extends for about 4 kilometres between the Quartz Mountain fault system to the west and the Yalakom fault to the east. The fault was not observed, but southerly-dipping striated shear surfaces locally bounding a sigmoidal flattening(?) foliation within Bridge River rocks near the contact suggest southerly directed movement of the Shulaps Complex over the Bridge River Complex. Schiarizza *et al.* (1990a) speculated that this south-dipping fault might be a folded thrust, broadly correlative with the southwest-vergent thrusts that are well displayed beneath the Shulaps Complex in the East Liza Creek window. It is more likely, however, that it is a post-thrusting normal fault, as its present geometry indicates, that is antithetic to the north-dipping Brett Creek fault. This interpretation provides the simplest explanation for the omission of the Bralorne-East Liza Complex and Cadwallader Group that are directly beneath the Shulaps Complex where the basal Shulaps thrust is actually exposed near East Liza Creek.

Structural Evolution of the Shulaps-Mission Ridge Metamorphic Belt

The structures in the Shulaps Range are inferred to have been superimposed on a thrust stack established during Cretaceous thrusting, comprising the Shulaps Complex structurally above Bralorne-East Liza Complex and Cadwallader Group, which in turn are structurally above the Bridge River Complex. Eocene metamorphism was related to structural level within this thrust stack, and was directly related to intrusion of a suite of Eocene granodioritic plutons into the Bridge River Complex at the base of the succession.

Eocene magmatism and metamorphism were coincident with dextral shear and foliation development within the metamorphic belt, as well as with the formation of macroscopic structures that included the north-dipping faults that imbricate the phyllite-schist domain and separate it from underlying serpentinite mélange. These faults had a component of contraction because they place relatively high metamorphic grade rocks that originated at low structural levels of the mid-Cretaceous thrust stack above lower grade rocks higher in the stack. Continued deformation resulted in further duplication, with the emplacement of the northern belt of schist and mélange above the previously stacked sequence. These structures are not well documented, but are inferred to have been transpressional because they, at least in part, were responsible for elevation of biotite-bearing schists to the highest structural level of the metamorphic belt.

The deformation described above is inferred to be related to Early to Middle dextral slip along the Yalakom fault, following Coleman (1990) and Coleman and Parrish (1991). The transpressional nature of the deformation may reflect a restraining bend linking the Yalakom fault to the more northerly striking Hozameen and/or Straight Creek fault systems to the south (Potter, 1986). The final stages of deformation within the Shulaps-Mission Ridge metamorphic belt record a change from contractional to extensional deformation, presumably reflecting a change in organization of the bounding strike-slip faults. This change may specifically reflect the initiation of the Marshall Creek fault as an important component of the strike-slip system, with the consequent development of a right-stepping transfer zone between it and the northwestern part of the Yalakom fault. The earliest extensional structures to form were the South Shulaps fault system, which thins and truncates units that otherwise remain in their original pre-Eocene order of superposition in the lower part of the metamorphic belt, and the Brett Creek fault, which separates the upper part of the belt from the overlying Shulaps Complex. This faulting may have been ductile, in part, and may have been synchronous with extension at the north end of the Shulaps Complex, where the ophiolitic rocks are juxtaposed above low grade Bridge River Complex across the south-dipping North Shulaps fault. Continued extensional deformation gave rise to the brittle Mission Ridge normal fault. The final stage in the evolution of the system may have involved the development of the Quartz Mountain fault system linking the Marshall Creek fault with the northwestern part of the Yalakom fault. The southeastern segment of the Yalakom fault, the Mission Ridge fault and structures within the Shulaps-Mission Ridge metamorphic belt were all inactive at this time as they are cut by the dextral-slip Red Mountain fault, which also splays off the Marshall Creek fault and mimics the sigmoidal pattern of the Quartz Mountain system. Southwest-side-down displacement on the Marshall Creek system may have been synchronous with dextral strike-slip, or may reflect a later history of normal movement. In either case, zircon fission-track ages of 39.5 and 42.9 Ma (Garver *et al.,* 1994) and apatite fission-track ages of 37.5 ±4.5, 35.6 ±7.0 and 34.1 ±3.7 Ma (all ~1σ; Garver, unpublished) from rocks on the northeast side of the Marshall Creek fault indicate that extremely rapid denudation occurred during the Late Eocene to Early Oligocene. This denudation was almost certainly driven by movement on the Marshall Creek - Yalakom fault system (Coleman and Parrish, 1991; Garver *et al.*, 1994). An important point is that the nearby north-trending Fraser fault was also moving at this time and it is likely that some movement on the Fraser fault was transferred to this northwest-trending system of faults.

113.2 - 114.2 km To the left, on the east side of the Bridge River, are gently dipping Bridge River schists laced with concordant to cross-cutting felsic sills and dikes. Straight ahead, to the south, are massive cliffs made up of Eocene granodiorite of the Mission Ridge pluton.

114.8 km Cross the contact between Bridge River schists and the Mission Ridge pluton.

116.9 km To the north-northeast one can see the eastern contact of the Mission Ridge pluton (marked in part by white-weathering massive rock that probably correlates with the younger Rexmount quartz porphyry). Bridge River schists above the contact are laced with planar and deformed dikes and sills, as are the schists exposed to the east, in the cliffs on the south side of the river.

118.3 km Terzaghi dam, which impounds Carpenter Lake. Continue east towards Gold Bridge.

118.3 - 118.8 km Outcrops of granodiorite belonging to the Mission Ridge pluton.

119.6 - 120.5 km Outcrops of Bridge River schists intruded by granodiorite and quartz porphyry.

120.6 km Cross the trace (closely constrained but not exposed) of the Marshall Creek fault.

Comment

The Marshall Creek fault was defined by Potter (1983, 1986) as a northwest-striking structure that separates greenschist-facies Bridge River schists exposed in the Shulaps Range from lower grade Bridge River rocks to the southwest. It extends from Marshall Lake, 30 kilometres northwest of here, for about 90 kilometres to the southeast (Coleman, 1991, Monger and McMillan, 1989), where it apparently merges with the Fraser fault system. At Marshall Lake it apparently merges with the more northerly trending Quartz Mountain fault system; which in turn merges with the Yalakom fault farther to the north-northwest. Coleman (1990) estimates that south of Carpenter Lake the Marshall Creek fault dips 50° to 75° southwest. North of the lake it bifurcates into two parallel strands, each of which seems to dip steeply. The northeastern strand truncates map units and structures within the Shulaps - Mission Ridge metamorphic belt and separates them from prehnite-pumpellyite-grade Bridge River rocks to the southwest. The southwestern strand is marked by the truncation of the Eocene Jones Creek volcanics, which overlie low-grade Bridge River rocks to the southwest of the fault zone.

A component of dextral movement along the Marshall Creek fault is suggested by three faults that splay from the main structure northwest of Carpenter Lake and cause dextral offsets of older structures within the Shulaps - Mission Ridge metamorphic belt. The most prominent is the Red Mountain fault which cuts through the entire Shulaps Range and offsets both the Mission Ridge and Yalakom faults. It follows a markedly sigmoidal trace which matches the shape of the Quartz Mountain fault system to the west (*see* Figure 9), which is also a late, and presumably coeval component of the Yalakom - Marshall Creek fault system. The Marshall Creek fault was also the locus of significant southwest-side-down vertical offset, as indicated by the juxtaposition of different metamorphic facies across the fault zone, as well as the preservation of the Eocene Jones Creek volcanics on its southwest side. Coleman (1990) estimated that vertical displacement across the Marshall Creek fault amounts to about 3.5 kilometres, based on matching the Mission Ridge fault with an inferred counterpart on the southwest side of the Marshall Creek fault near Seton Lake. Zircon fission-track dates of 39.5 and 42.9 Ma reported by Garver *et al.* (1994) from the metamorphic belt northeast of the Marshall Creek fault suggest that major movement had ended by Late Eocene time

120.7 - 162.5 km For the next 42 kilometres our route follows the north shore of Carpenter Lake and passes through abundant exposures of Bridge River Complex. These rocks were referred to as the Carpenter Lake assemblage by Potter (1986). The exposures are dominated by ribbon chert and greenstone, but also includes limestone, clastic rocks, mafic intrusive rocks and serpentinite. The rocks are at prehnite-pumpellyite metamorphic grade, and are pervaded by a complex array of brittle faults. Some of these structures relate to the Cretaceous - Tertiary deformation that characterizes the southeastern Coast Belt, but much of the structural complexity was probably generated by earlier deformation within a subduction-related accretionary complex. This belt of Bridge River rocks, which extends for a considerable distance to the southeast (Monger and Journeay, 1994), is bounded on the northeast by the Marshall Creek fault and is structurally overlain to the northwest by thrust-imbricated Bralorne-East Liza Complex and Cadwallader Terrane.

128.2 km Exposed here are a set of east-striking, steeply dipping sheeted gabbroic dikes approximately 15 metres thick. Individual dikes are less than 2 metres thick and typically display only one chilled margin, commonly their southern contact. The dikes are apparently intrusive into pillowed greenstone of the Bridge River complex, although the southernmost dike appears to be chilled against a linear altered breccia zone. The sheeted dikes were presumed by Schiarizza *et al.* (1989) to be components of the Bridge River Complex, but amphibole from one of the dikes subsequently yielded an Ar-Ar step-heating date of 107 ±3 Ma; (Archibald *et al.*, 1991a). It is unlikely that this late Early Cretaceous age reflects the age of relict Bridge River oceanic crust, because cherts from the immediate area are Late Triassic and age and are only known to be as young as late Middle Jurassic for the complex as a whole (Cordey, 1986; Cordey and Schiarizza, 1993). The dikes are apparently the products of a younger magmatic event that was coincident with contractional deformation and the deposition of synorogenic clastic deposits of the Taylor Creek Group (*see* discussion in Garver, 1989).

131.4 km Cedar Creek. Exposures of Bridge River chert with minor greenstone, cut by diabasic to gabbroic dikes of unknown age.

133.1 km Falls Creek. The Bridge River Complex here is represented mainly by chert, which has yielded Late Triassic radiolarians (Cordey, 1986; Figure 20).

136.0 km Visible on the slopes directly ahead are light coloured dacitic volcanic rocks of the Jones Creek succession. They unconformably overlie the Bridge River Complex and outcrop in a northwest-trending belt bounded to the northeast by the Marshall Creek fault. The volcanics are probably Middle Eocene in age based on a 43.5 Ma zircon fission-track date reported by Garver *et al.* (1994).

136.7 km Bighorn Creek. Exposures of Bridge River chert.

137.7 km Unnamed intermittent creek. The Jones Creek volcanics are only about 100 metres above the road here.

139.0 km Jones Creek. The Bridge River Complex here consists of pillowed greenstone.

139.3 km Marshall Lake road branches off to the right. Exposures of Bridge River pillowed greenstone. Stay on the main Carpenter Lake road.

STOP 2-9

140.4 km ***BRIDGE RIVER CLASTIC ROCKS***

Stop at the Bridge over Marshall Creek. Exposed on the east side of the creek are sandstones and pebble conglomerates intercalated with lesser amounts of argillite and ribbon chert. Clastic intervals such as these are a widespread but volumetrically minor component of the Bridge River Complex. They typically comprise planar, thin to medium beds with total thicknesses of only a few metres, although thicker accumulations, up to several tens of metres, occur rarely. Most of the sandstones and pebble conglomerates are composed primarily of chert clasts, locally with minor proportions of volcanic rock fragments and quartz and feldspar crystals. None of these chert-rich clastic units are dated or are in depositional contact with dated chert, but they are scattered throughout much of the complex and occur in proximity to dated Permian, Triassic and Jurassic chert. Less common are sandstones and pebble conglomerates composed primarily of volcanic rock fragments and feldspar and quartz crystals. These rocks typically contain subordinate amounts of chert, and locally contain minor amounts of quartz tectonite, siltstone, clinopyroxene, epidote, hornblende and biotite. The volcanic-rich sandstones are also undated, but one three-metre-thick interval occurs in close proximity to Jurassic chert west of the mouth of Gun Creek.

Exposures on the west side of Marshall Creek consist of pillowed greenstones that pass westward into ribbon cherts.

141.1 km Limestone lenses within greenstone here have yielded Late Triassic (Norian) conodonts.

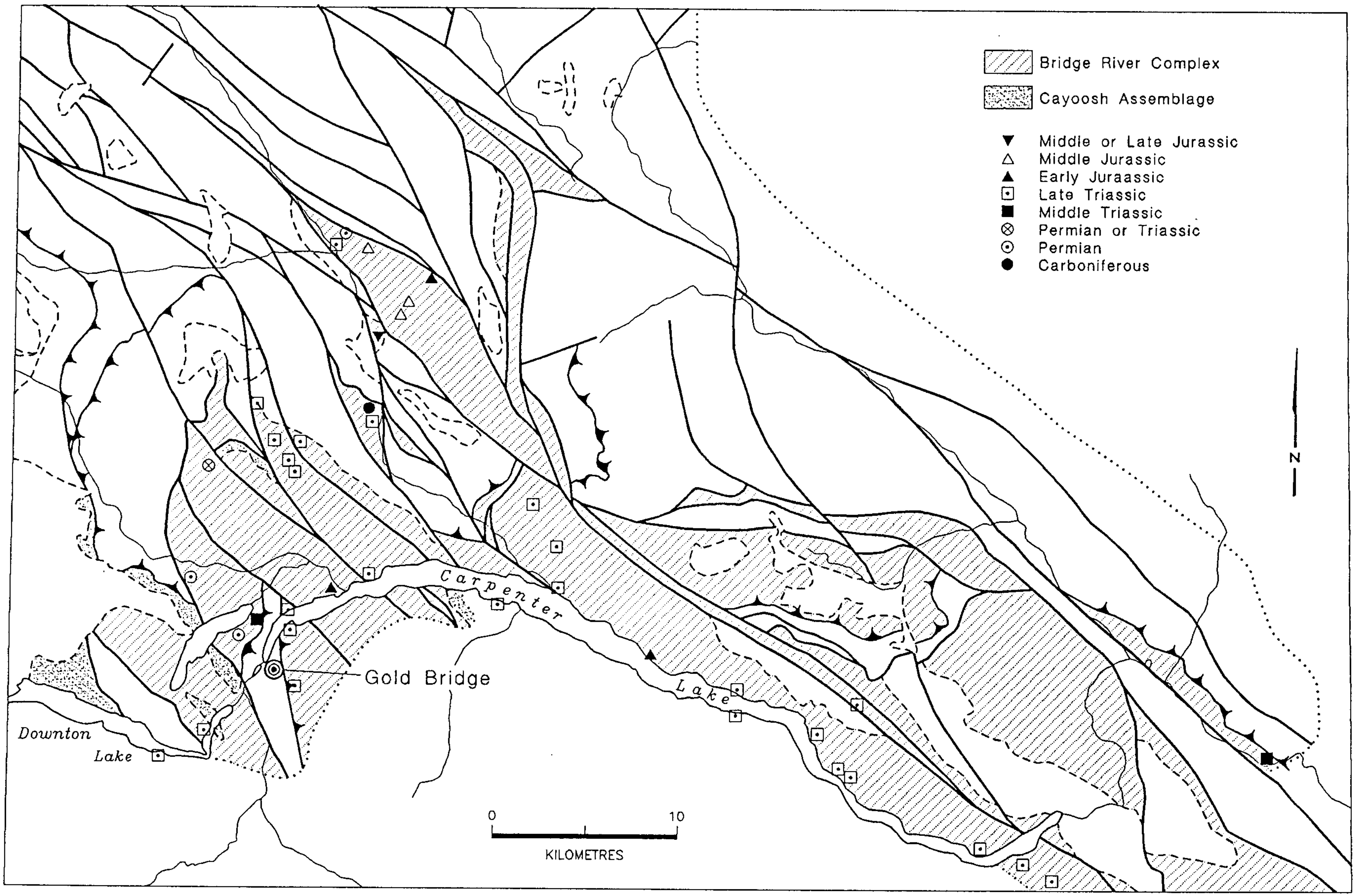

Figure 20. Distribution and age control of the Bridge River Complex in the Bridge River area.

STOP 2-10

153.6 km ***LIMESTONE, CHERT AND GREENSTONE STRUCTURALLY INTERLEAVED WITHIN THE BRIDGE RIVER COMPLEX***

Stop just before the Tyaughton Creek bridge. A large lens of limestone (Figure 21) occurs at the north end of an outcrop belt that is dominated by sheared and contorted ribbon chert and cherty argillite, structurally interleaved with lenses of greenstone and limestone. The large limestone block has yielded conodonts that were reported as Middle Triassic by Cameron and Monger (1971), but have subsequently been assigned a Late Triassic (Early Norian) age (Orchard, 1981). The structures across which the different Bridge River lithologies are interleaved here probably formed in a Triassic - Jurassic accretionary complex. The argillaceous component shows a rare-earth element geochemistry consistent with derivation from a continental source terrain (Garver and Scott, in press).

This is the last stop of day 2. Continue westward along the Carpenter Lake road to the Tyaughton Lake road (162.5 km). Proceed northward on the Tyaughton Lake road to Tyax Mountain Lake Resort (171.1 km).

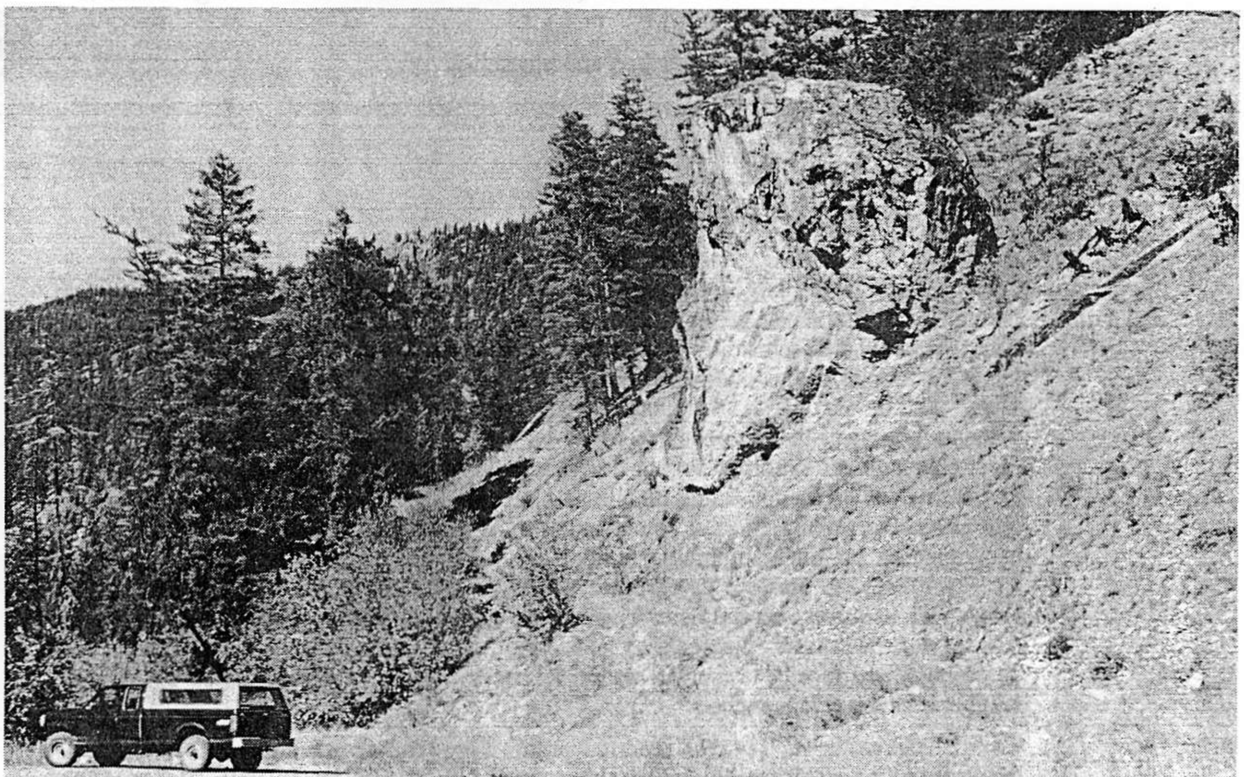

Figure 21. Large limestone lens within the Bridge River Complex at Stop 2-10.

DAY 3: GOLD BRIDGE AREA

START POINT

0.0 km Tyax Mountain Lake Resort. Turn left onto the Tyaughton Lake road and proceed southward towards Carpenter Lake.

8.6 km Junction with the Carpenter Lake road. Turn left towards Lillooet.

10.1 km Turn left onto side road.

11.4 km A road branches off to the right. Stay on the main road which bends sharply to the left.

11.7 km Junction of 4 roads. Stay on road that switches back to the right and heads up slope to the northeast.

12.3 km Cross small stream with outcrop of sheared quartz-carbonate-fuchsite-altered rock.

12.6 - 12.8 km Outcrops of sheared and fractured greenstone and chert, with local blueschist partings.

13.0 km Road switches back to the left (don't take road that branches straight ahead to the east).

13.3 - 13.5 km Outcrops of metachert and blueschist.

STOP 3-1

13.6 km ***BRIDGE RIVER BLUESCHIST***

Park in the large clearing. Low ridges to the north and south are underlain mainly by Bridge River greenstone containing common foliae and lenses of blueschist. Also present are schistose metadiorite, metachert and narrow carbonate lenses. Blueschist-facies metamorphic rocks were discovered in the Bridge River Complex in 1987 (Garver *et al.*, 1989a), and were subsequently mapped within a narrow, discontinuous belt that extends for about 14 kilometres (Schiarizza et al., 1993a). The most characteristic lithology within this belt is dark blue, fine grained, strongly foliated and crenulated schist consisting mainly of blue amphibole (glaucophane and/or crossite) and lawsonite. White mica is a conspicuous component of some blueschists and is accompanied by blue amphibole, epidote and garnet. More common, however, are weakly foliated to massive greenstones, pillowed greenstones and diabasic to gabbroic rocks such as those exposed here. These rocks generally display relict igneous minerals (clinopyroxene and/or plagioclase) and textures in thin section, but contain blue amphibole, and locally lawsonite, within alteration assemblages dominated by chlorite, stilpnomelane and leucoxene.

Garver *et al.* (1989c) reported preliminary whole-rock and white mica K-Ar dates from Bridge River blueschists that ranged from 195 ±6 to 250 ±9 Ma. More recently, two different samples of white mica from blueschist at the head of North Cinnabar Creek have yielded well-defined Ar-Ar plateau dates of 229.8 ±1.0 Ma and 230.1 ±1.0 Ma, respectively (Archibald *et al.*, 1991a,b). Three other samples of white mica from the same area gave slightly younger plateau dates of 221 ±1.2 Ma, 223.9 ±1.8 Ma and 224.9 ±1.0 Ma, as well as low-temperature steps indicating that the area was effected by a low-temperature thermal event in post-Late Triassic time (Archibald *et al.*, 1990, 1991a). The two older Ar-Ar dates, with age spectra that do not record any later thermal event, provide the most reliable estimate of the age of blueschist-facies metamorphism, and suggest that it was a Middle Triassic or older event that ended by 230 Ma.

Comment

The Bridge River blueschists exposed here and to the east are structurally overlain by imbricated Bralorne-East Liza Complex and Cadwallader Group of the mid-Cretaceous Liza Lake thrust belt (Figure 7). To the west, however, the blueschists are unconformably overlain by Albian rocks of the Taylor Creek Group, which in turn are unconformably overlain by the Albian - Cenomanian Silverquick conglomerate (Garver, 1989); this entire stratigraphic succession occupies the overturned limb of a northeast-vergent syncline. Assuming that the blueschists are a reliable local marker within the Bridge River Complex, this implies one of three possible relationships between the Cadwallader - Bralorne-East Liza thrust stack and the mid-Cretaceous clastic succession: (1) the thrust stack was removed by erosion prior to deposition of the Taylor Creek Group; (2) the thrust stack ramped to the west, over the top of the Taylor Creek Group, and was then removed by erosion prior to deposition of the Silverquick conglomerate; (3) the Cadwallader - Bralorne-East Liza thrust stack ramped to the west over both the Taylor Creek Group and Silverquick conglomerate. The second or third interpretation is preferred because the Taylor Creek Group is nowhere seen in depositional contact with the Cadwallader Group and does not contain detritus that can be linked to the Cadwallader Group, whereas Silverquick conglomerates commonly contain abundant sandstone clasts that resemble, and may have been derived from, the Hurley Formation. The evidence is not conclusive, however, and the alternative interpretation cannot be completely dismissed. In particular, it should be noted that there are folds and faults in the Bridge River Complex beneath the unconformity that may be older than the northeast-vergent structures related to the overturned syncline, and that these structures can generally be restored to a southwest-vergent orientation when the effects of northeast-vergent deformation are removed (Garver, 1991). Further, some of these early faults probably formed prior to deposition of the Albian Taylor Creek Group as it rests on different components of Bridge River basement from place to place within this area (Garver, 1989). However, these early faults are not necessarily related to the fault beneath the Cadwallader - Bralorne-East Liza thrust stack; they may have formed earlier within the demonstrably protracted Cretaceous contractional event, or be still older and related to Triassic-Jurassic subduction-accretion processes within the Bridge River Complex

Turn around and retrace route back to the Carpenter Lake road.

16.8 km Turn right onto the Carpenter Lake road.

18.3 km Tyaughton Lake road. Continue on the Carpenter Lake road towards Gold Bridge.

19.3 - 20.7 km Outcrops of Bridge River Complex dominated by chert and chert granule to pebble conglomerate, along with lesser amounts of greenstone and gabbro. These rocks are intruded by abundant dikes of biotite-hornblende-feldspar porphyry.

Comment: Minto Mine and Castle Pass fault

The Bridge River rocks here host the past producing Minto Mine, a polymetallic vein that produced 546 kilograms of gold, 1573 kilograms of silver, 9673 kilograms of copper and 56 435 kilograms of lead from 80 650 tonnes of ore, mined mainly during the period 1934 to 1940. The mine occurs within a belt of similar mineral occurrences that extends for 15 kilometres to the north-northwest and across the lake to the southeast. The mineralization is associated with a belt of intermediate dikes and small plugs that include the 67 Ma Eldorado pluton (Garver *et al.*, 1994) and the 69 Ma Minto dike (Pearson, 1977; Leitch *et al.*, 1991a). This belt of intrusions is spatially associated with, and may have been controlled by, the Castle Pass dextral strike-slip fault system, which exhibits a prominent extensional bend in this area.

21.3 - 21.7 km Small outcrops of Bridge River chert and greenstone.

22.0 km Bridge over Gun Creek.

22.1 - 24.3 km Fairly continuous outcrop of Bridge River greenstone, chert and argillite, with local thin sandstone intervals. The road locally provides good views eastward, down Carpenter Lake, into the northern Shulaps Range (Figure 22).

STOP 3-2

23.6 km ***PILLOWED GREENSTONE OF THE BRIDGE RIVER COMPLEX***

Park near the junction with the Slim Creek logging road to view exposures of pillowed greenstone within the Bridge River Complex (Figure 23). Greenstone such as this is a major constituent of the complex. Most commonly it is structurally imbricated with chert and other Bridge River lithologies on the scale of an individual outcrop, but locally it is the only lithology exposed for hundreds of square metres. Most greenstones consist of a meshwork of random or aligned saussuritized plagioclase laths interspersed with an alteration assemblage typically dominated by calcite, chlorite and pumpellyite; these same alteration minerals commonly occur as amygdules and veins. Clinopyroxene, generally titaniferous augite, is preserved locally within the groundmass, and clinopyroxene and plagioclase may occur as relict phenocrysts.

None of the greenstone bodies within the Bridge River Complex have been directly dated. Some of the greenstone is Late Triassic in age because it is in depositional contact with Upper Triassic limestone. The greenstone protolith for the blueschist facies rocks within the complex is older, since it was metamorphosed in late Middle Triassic time. It is suspected that the greenstone within the Bridge River complex may span a considerable time range, comparable to that of the Mississippian to Jurassic chert with which it is associated

Potter (1983) obtained chemical analyses on 10 greenstone samples from the Bridge River Complex and plotted them on a number of published trace element discriminant diagrams. The greenstones he analyzed have variable geochemical signatures that resemble those of ocean floor tholeiites and more alkalic ocean-island-type basalts. Macdonald (1990b) obtained similar results, and concluded that the volcanics of the Bridge River Complex form a chemically diverse volcanic suite that includes mid-ocean ridge, within plate, and alkalic basalts. Church (1990) and Dostal and Church (1992) also discuss the geochemistry of mafic volcanic rocks from the Bridge River area. They refer to the volcanic suite as the Pioneer Formation, but the samples they discuss are almost entirely from what is here considered to be the Bridge River Complex (sample locations provided by B.N. Church, 1992). Their results are consistent with those of Potter and Macdonald in that the geochemistry of their samples suggests an ocean island to mid-ocean ridge origin.

Comment: Howard Prospect and Congress Mine

The greenstone exposed here is cut by narrow brownish-weathered ankeritic alterations zones, locally containing pyrite and minor amounts of stibnite, that are controlled by steeply dipping, northerly striking faults and fractures. This mineralization is part of the Howard prospect, which includes underground workings, in part accessed by an adit below the road to the south, which extend for several hundred metres to the north-northwest. These workings follow quartz-ankerite veins that contain stibnite, pyrite, arsenopyrite and rare free gold. The veins follow northerly-striking faults and fractures and are commonly associated with feldspar porphyry dikes that are in part altered and mineralized. They cut greenstone and gabbro of the Bridge River Complex, and are typically enclosed in ankerite-quartz-sericite alteration envelopes up to several metres wide.

The Howard prospect is part of a cluster of auriferous stibnite vein systems that are concentrated a short distance west of the belt of polymetallic mineral occurrences that follows the Castle Pass fault. This cluster also includes the past-producing Congress Mine, about a kilometre east of the Howard showing, which yielded 2582 grams of gold and 1306 grams of silver from 943 tonnes of ore mined in 1937. Stibnite veins also occur on the eastern and northern flanks of the polymetallic veins, and it is suspected that they represent higher level expressions of the same mineralizing systems. This inferred relationship is supported by available dates, as a 67 Ma K-Ar date from a dike associated with mineralization at the Congress Mine (Pearson, 1977; Leitch *et al.* 1991a) is similar to dates from the Eldorado pluton (67 Ma) and Minto dike (69 Ma), which are associated with polymetallic vein systems.

24.9 km Cross the unexposed trace of the Steep Creek fault, a northeast-dipping oblique reverse-sinistral fault that is thought to be a component of the Late Cretaceous Eldorado fault system.

25.4 - 26.1 km Outcrops of Upper Triassic greenstone, limestone and chert of the Bridge River Complex, bounded to the west by an east-dipping fault zone that juxtaposes them above the Hurley Formation.

STOP 3-3

26.2 km ***HURLEY FORMATION AND BRIDGE RIVER COMPLEX, SEPARATED BY AN EAST-DIPPING THRUST FAULT***

Park on the left side of the road at the west end of the outcrop belt. The outcrop on the opposite side of the road consists of thin-bedded slate, siltstone and fine-grained sandstone of the Hurley Formation. A small gap in exposure separates this outcrop from the one to the northeast, which consists of sandstone and granule to small pebble conglomerate of the Hurley Formation, structurally overlain by the Bridge River Complex across an east-dipping fault zone marked by 2 metres of sheared and brecciated slaty rock. Individual fault surfaces and cleavage domains dip moderately to steeply eastward. These include moderately-east-dipping fault surfaces, with down-dip striations, that are spaced several centimetres apart and enclose domains of more steeply-dipping cleavage that deflects sigmoidally into bounding fault surfaces. The west-directed movement indicated by these fabrics is corroborated by folds in footwall Cadwallader Group overturned to the west, and asymmetric west-verging mesoscopic folds in hangingwall Bridge River Complex. The Bridge River Complex directly above the fault consists mainly of a strongly faulted succession of cherts, which have yielded a collection of Triassic conodonts. Three hundred metres farther to the northeast, however, is a distinctive assemblage of greenstones intercalated with beds of limestone and chert. This assemblage has been recognized in several different fault panels in the vicinity, and has yielded numerous collections of Early Norian conodonts.

The fault exposed here is truncated by the Steep Creek fault to the north. It has been traced for about 8 kilometres to the south, where it is apparently truncated by a younger north-northeast-striking dextral fauth. Its offset counterpart to the south is the Fergusson fault (Joubin, 1948), which places Bridge River Complex above the slices of Cadwallader Group and Bralorne-East Liza Complex that host the Bralorne and Pioneer mines (Figure 11).

26.3 - 26.6 km Outcrops of diorite and tonalite of the Bralorne-East Liza Complex. These rocks are separated from the Hurley Formation of the last stop by a steep northwest-striking fault of unknown sense of displacement.

Comment: Wayside Mine

These outcrops of Bralorne-East Liza Complex include the southernmost workings of the past-producing Wayside Mine, which between 1915 and 1937 produced 36 977 tonnes of ore that yielded 166 122 grams of gold and 26 064 grams of silver (Gaba and Church, 1988). The precious metals occur in a system of east-northeast-dipping mesothermal quartz veins hosted by the Bralorne-East Liza Complex. The host rock, structural setting and style of mineralization are the same as for the Bralorne - Pioneer vein system, 11 kilometres to the south, which produced 130 tonnes of gold and 40 tonnes of silver to rank as British Columbia's foremost historical gold producer (Leitch, 1990).

27.0 km Outcrops of contorted Bridge River chert on both sides of the road (Figure 24).

27.4 km Small outcrop of Bridge River greenstone.

28.1 km Small diorite outcrop belonging to the Bralorne-East Liza Complex.

29.0 - 29.7 km Outcrops of Bralorne-East Liza Complex.

STOP 3-4

29.8 km ***DIORITE, TONALITE AND SERPENTINITE OF THE BRALORNE-EAST LIZA COMPLEX CUT BY THE ELDORADO FAULT***

Stop at the large pullout on the left side of the road just before the bridge. The exposures on the northwest side of the road consist of medium to coarse-grained diorite, locally invaded by lenticular masses of light-grey tonalite (Figure 25), and cut by steeply-dipping diabase dikes. The diorite and tonalite represent the Bralorne diorite and soda granite of Cairnes (1937), which were assigned Early Permian (possibly Late Carboniferous) ages by Leitch *et al.* (1991a) on the basis of U-Pb dating of zircons extracted from samples collected at the Bralorne mine. Hornblende collected from diorite at the Gold Bridge quarry, directly above these road cuts, yielded a similar K-Ar date of 287 ±20 Ma.

At the west end of the outcrop, the diorite is structurally underlain by serpentinite containing boudinaged dike fragments across a well-exposed fault that dips 50° to 60° to the east-northeast. The serpentinite is cut by several discrete shear zones that are parallel to the overlying fault and are spaced several centimetres apart. These fault surfaces contain east-southeast-plunging stretching lineations and enclose domains of sigmoidally disposed foliation that indicate oblique reverse-sinistral movement. The serpentinite (assigned to the President intrusives by Cairnes, 1937) is included in the Bralorne-East Liza Complex, and the fault zone is inferred to be a subsidiary to the Eldorado fault which bounds the complex to the west. The main fault separates these exposures from outcrops of Bridge River chert and argillite 50 metres to the west, which are also cut by moderately northeast-dipping faults.

Proceed across the bridge to the town of Gold Bridge

30.5 km Gold Bridge Hotel. Continue south on the Bralorne road.

32.9 - 34.1 km Discontinuous outcrops of diorite, tonalite and greenstone of the Bralorne-East Liza Complex.

34.4 km Brexton townsite.

34.7 - 35.4 km Discontinuous outcrops of Bralorne-East Liza Complex.

36.0 km Turn left onto Kingdom Lake Forest Service Road.

STOP 3-5

36.8 km *CADWALLADER GROUP VOLCANICS*

Stop at the bend in the road where it switches back to the right. Mafic volcanic breccia and pillow breccia outcrop on the wooded ridges east of the road. These volcanic rocks are assigned to the Cadwallader Group because they are overlain, across a conformable stratigraphic contact, by Upper Triassic sedimentary rocks of the Hurley Formation a short distance to the east. The contact between this belt of Cadwallader Group rocks and the Bralorne-East Liza Complex to the west was not observed but is thought to be a fault. Correlative volcanic rocks were mapped in the Eldorado Creek area, 20 kilometres to the north-northwest, by Rusmore (1985, 1987) who documented abrupt to gradational stratigraphic contacts between the volcanics and the overlying Hurley Formation. Rusmore concluded that the Cadwallader basalts probably erupted in or near an island arc on the basis of trace-element compositions of 10 basalt samples from the Eldorado Creek area. This conclusion is supported by the trace element compositions of volcanic rocks of the Cadwallader Group from elsewhere in the Bridge River area, which also plot mainly in island-arc tholeiite compositional fields (Macdonald, 1990a,b).

Comment: Cadwallader Group nomenclature

Cairnes (1937, 1943) first used the designations Noel Formation, Pioneer Formation, and Hurley Group for rocks in the Bralorne and Eldorado Mountain areas which had previously been included in the Cadwallader Series of Drysdale (1916, 1917) and McCann (1922). The Noel, Pioneer and Hurley were all assigned formational status by Roddick and Hutchison (1973), and included within the Cadwallader Group. Rusmore (1985, 1987) was the first to study the Cadwallader Group in detail. She concluded that the Noel Formation was not a coherent unit and should be abandoned. Her revised stratigraphy, based on sections west of Eldorado Mountain, comprised mafic volcanic rocks of the Pioneer Formation, and conformably overlying siltstone, sandstone and conglomerate of the Hurley Formation; neither the stratigraphic base nor the stratigraphic top of the section was recognized. Rusmore assigned the Cadwallader Group a Late

Triassic age on the basis of latest Carnian or earliest Norian to Middle Norian conodonts collected from the Hurley Formation

Church (1987) and Church *et al.* (1988a, 1988b) retained Roddick and Hutchison's three-fold division of the Cadwallader Group. However, they assigned all mafic volcanic rocks within the Bralorne map area to the Pioneer Formation, including greenstone units that previous workers had assigned to the Bridge River Complex. They used the term Noel Formation for black argillite, siltstone and calcareous siltstone exposed in several areas in the Downton Lake - Bralorne - Gold Bridge area. This usage excluded some rocks originally assigned to the formation by Cairnes (included by Church *et al.* in the Bridge River complex), and locally included some rocks previously assigned to the Hurley Formation. Their assignment was apparently based on lithology, regardless of stratigraphic position, because they included some rocks that occur between their Pioneer and Hurley formations, whereas previous workers had assigned the Noel Formation a stratigraphic position beneath the Pioneer Formation

Further confusion as to the status of the Cadwallader Group arose when Leitch (1989) obtained Early Permian U-Pb crystallization ages from Bralorne diorite and soda granite. This conflicted with the Triassic age assigned to the Cadwallader Group by Rusmore (1985, 1987) because rocks traditionally included in the Pioneer Formation of Cadwallader Terrane commonly display complex interfingering to gradational contacts with the Bralorne diorite, suggesting an intrusive and possibly co-magmatic relationship (Cairnes, 1937, 1943; Leitch, 1989; Leitch *et al.*, 1991a).

Schiarizza *et al.* (1993a,b,c) follow Rusmore (1985, 1987) and subdivide the Cadwallader Group into a lower volcanic unit and an overlying sedimentary unit (Hurley Formation). Rocks assigned to the Noel Formation by Cairnes (1937, 1943) are included in the informal Gun Creek and Downton Lake units which are inferred to be of Jura-Cretaceous age and to have been deposited above the Bridge River Complex. The volcanic unit of the Cadwallader Group includes some rocks that have traditionally been assigned to the Pioneer Formation, but much of the Pioneer Formation as defined by Cairnes (1937, 1943) is included in the Lower Permian Bralorne-East Liza Complex. Because greenstones in the type area of the Pioneer Formation, at the Pioneer mine, apparently fall into the latter category, the name "Pioneer" is not used for the Cadwallader Group volcanic rocks. Preliminary geochemical data presented by Macdonald (1990a,b) confirms this two-fold division of rocks that had previously been included in the Pioneer Formation. Volcanic rocks assigned to the Cadwallader Group on the basis of observed stratigraphic contacts with the Hurley Formation display the chemistry of island arc tholeiites. Greenstones included within the Bralorne-East Liza Complex, which commonly interfinger with intrusive rocks of the complex, have the chemical characteristics of ocean floor basalts.

Much of the confusion over Cadwallader Group nomenclature, as well as continuing difficulties in distinguishing Cadwallader volcanics from Bralorne-East Liza volcanics, results from the close spatial relationship shown by the Cadwallader Group and Bralorne-East Liza Complex. This spatial relationship may reflect an original stratigraphic relationship, with the Cadwallader Group having been deposited above an oceanic basement represented by the Bralorne-East Liza Complex. This has not been proven in the Taseko - Bridge River map area, however, as all observed contacts between the two units are faults.

From here turn around and retrace the route back to Gold Bridge. The mountains to the west are underlain mainly by Late Cretaceous granodiorite and quartz diorite of the Coast Plutonic Complex. The twin peaks of Mount Sheba, a Paleogene volcanic-plutonic complex built across mid to Late Cretaceous rocks of the Taylor Creek Group and Powell Creek formation, are visible to the northwest.

42.9 km At the Gold Bridge Hotel turn right onto Fergusson Street. Proceed eastward and keep to the left (on Bralorne Avenue) past the cemetery.

44.3 km Bridge over Fergusson Creek.

GEOLOGIC SETTING OF THE BRIDGE RIVER AREA

General Geology of the Southern Coast Belt

The Coast Belt is one of the five morphogeological belts of the Canadian Cordillera. It extends for more than 1700 kilometres from northern Washington state to the southern Yukon, and is characterized by rugged mountains underlain in large part by Late Jurassic to early Tertiary granitic rocks of the Coast Plutonic Complex. The Intermontane Belt to the east is underlain by Quesnel, Cache Creek and Stikine terranes (Intermontane superterrane), which were amalgamated and accreted to the western margin of North America by Early to Middle Jurassic time. The Insular Belt to the west is underlain by the composite Insular superterrane, which consists mainly of Wrangellia and Alexander terranes. Mid-Cretaceous southwest-directed contractional faults are prominent structures in several areas within and along the western margin of the Coast Belt, and coeval to slightly younger east-directed thrusts are locally prominent in the eastern part of the belt (Rubin *et al.*, 1990; Rusmore and Woodsworth, 1991b). These structures and associated magmatism were interpreted by Monger *et al.* (1982) to reflect crustal thickening associated with the accretion of the Insular superterrane to the western margin of North America (Intermontane superterrane) in mid-Cretaceous time. Other workers, including van der Heyden (1992), suggest that the Insular superterrane was amalgamated with the Intermontane superterrane by Middle Jurassic time, and the Coast Belt is a long-lived (Middle Jurassic to Tertiary) Andean-style magmatic arc built across both superterranes. In this interpretation, the mid-Cretaceous contractional structures within the Coast Belt are intraplate structures that in part collapsed a series of intra-arc basins. Further debate about the relationships between Insular, Coast and Intermontane belts relates to their mid-Cretaceous paleolatitudes. Many geological models place them at approximately their present location along the North American margin, whereas several sets of tilt-corrected paleomagnetic data suggest that in mid-Cretaceous time parts of the Coast Belt lay about 1800 km south of presently adjacent rocks of the Intermontane Belt, which themselves were about 1200 km south of their current position with respect to the North American craton (Ague and Brandon, 1992; Irving *et al.*, 1993; Wynne *et al.*, 1993).

Recent geological studies indicate that the southern Coast Belt can be divided into western and eastern parts (Figure 3) based on differences in plutonic rocks, terranes and structural style (Monger *et al.*, 1990; Monger and Journeay, 1994). The southwestern Coast Belt consists of about 80 per cent Middle Jurassic to mid-Cretaceous plutonic rocks. Its western boundary is a Late Jurassic magmatic front along which granitic rocks of the Coast Belt intrude Triassic and Jurassic rocks of Wrangellia Terrane along a linear system of northeast-side-down Jurassic faults (Nelson, 1979; Monger, 1991a). The Late Jurassic plutonic rocks extend across the entire width of the southwestern Coast Belt, and enclose pendants and septa of Jurassic Wrangellian rocks in the western and central portions. At the southeast corner of the southwestern Coast Belt, this same suite of Jurassic plutonic rocks intrudes the lower part of Harrison Terrane, which includes Middle Triassic cherty argillites and mafic volcanics (Camp Cove Formation) overlain by Middle Jurassic andesitic to dacitic volcanics of the Harrison Lake Formation (Arthur *et al.*, 1993). Stratigraphically above the Harrison Lake Formation are upper Middle Jurassic to Upper Jurassic sedimentary and andesitic volcanic rocks that are coeval with some of the Jurassic plutons in the southwestern Coast Belt. These are unconformably overlain by Lower Cretaceous sedimentary and volcanic rocks of the Peninsula and

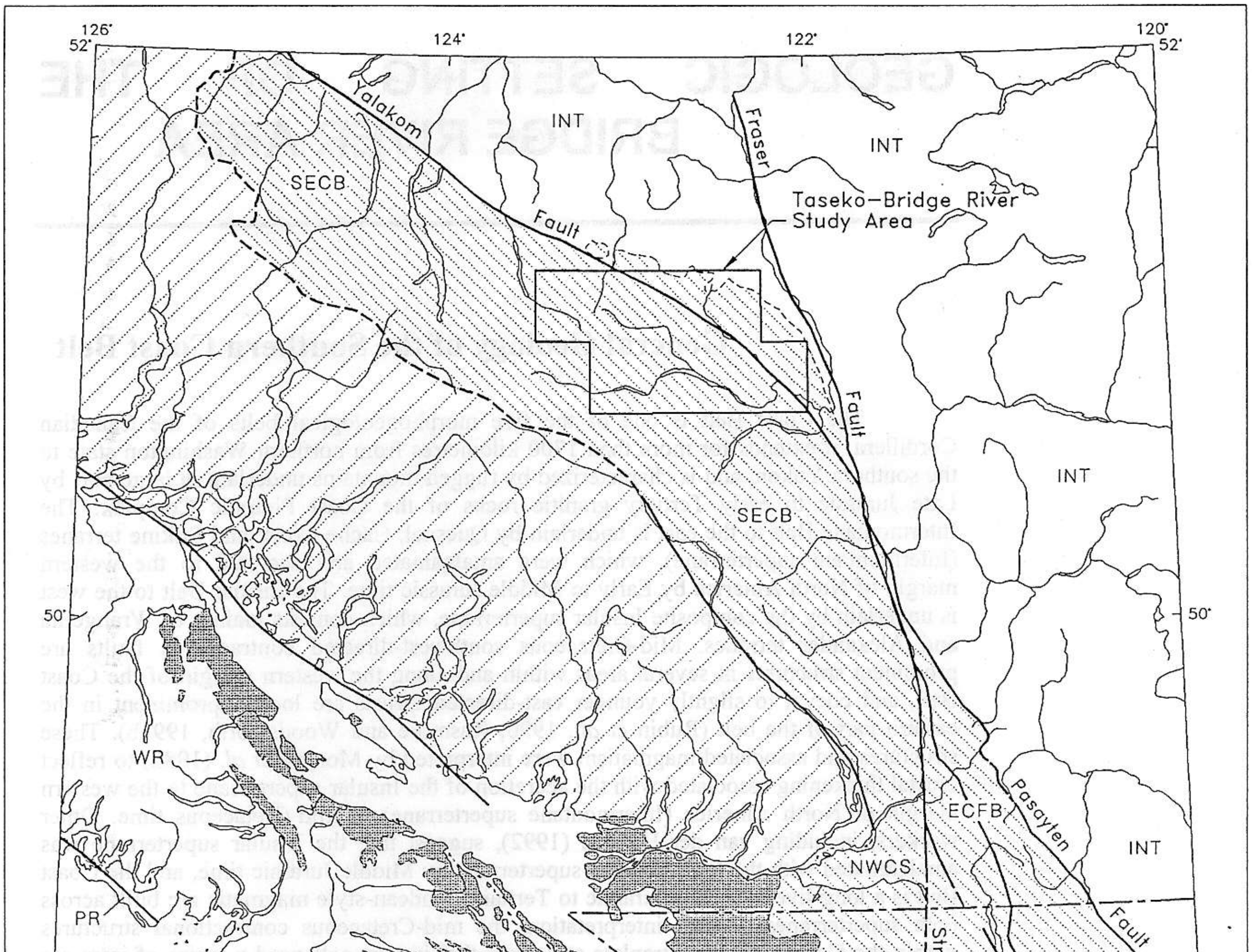

Figure 3. Main Tectonic elements of the southern Coast Belt and adjacent Cascade Orogen.

Brokenback Hill formations. A similar unconformity is present elsewhere in the southwestern Coast Belt, where it separates volcanic and sedimentary rocks of the Lower Cretaceous Gambier Group from older assemblages, including Late Jurassic plutonic rocks (Monger, 1993).

The southeastern Coast Belt, including the Bridge River area, contains a smaller percentage of granitic rocks than the southwestern belt, and these are mid-Cretaceous through Early Tertiary in age. Supracrustal rocks include a number of distinct, partially coeval lithotectonic assemblages, including Bridge River, Cadwallader and Methow terranes, that originated in ocean basin, volcanic arc and clastic basin environments. These lithotectonic units are Late Paleozoic to Cretaceous in age, and are juxtaposed across complex systems of contractional, strike-slip and extensional faults of mainly Cretaceous and Tertiary age. Upper greenschist to amphibolite facies metamorphic rocks are exposed in the south-central part of the belt, where they formed and were exhumed during two stages of early Late Cretaceous contractional deformation (Journeay, 1990; Journeay and Friedman, 1993). Kinematically-linked thrust faults to the west imbricate rock units of the eastern edge of the southwestern Coast Belt, and separate them from terranes of the overlying southeastern Coast Belt. The metamorphic grade decreases to prehnite-pumpellyite facies farther north, where terranes of the southeastern Coast Belt are imbricated across similar polyphase mid to early Late Cretaceous contractional faults in the Bridge River area (Schiarizza et al., 1990c). Still farther north, near 52° North latitude, rocks of the eastern Coast Belt are imbricated by slightly younger northeast-directed thrust faults of the Eastern Waddington thrust belt (Rusmore and Woodsworth, 1991b, 1994). The upper faults of this Late Cretaceous thrust system juxtapose these rocks beneath slices of Jurassic plutonic rocks characteristic of the southwestern Coast Belt (van der Heyden *et al.*, 1994).

Lithotectonic units and mid-Cretaceous contractional structures of the southeastern Coast Belt extend southward into the north Cascade mountains of Washington State (Misch, 1966; McGroder, 1991; Monger, 1991b; Monger and Journeay, 1994), which includes a central belt of greenschist to amphibolite facies metamorphic rocks (Cascade metamorphic core) flanked by lower grade rocks to the west and east (Figure 3). The western belt is an imbricate stack of west-vergent thrust sheets referred to as the northwest Cascades system, and the eastern part of the orogen, referred to as the eastern Cascades foldbelt, comprises low-grade rocks deformed by both northeast and southwest-directed folds and thrust faults. Methow and Bridge River terranes are the principal components of the eastern Cascade foldbelt, and they extend northwestward, after restoring about 100 kilometres of dextral offset along the Fraser fault, into easily identified correlatives within the southeastern Coast Belt exposed in the Bridge River area. Bridge River Terrane (including the Jura-Cretaceous Cayoosh assemblage in its upper part) also has probable correlatives within the Cascade metamorphic core, as well as in the upper thrust slices of the northwest Cascades system (Monger, 1991b; Monger and Journeay, 1994). The northwest Cascade system marks an abrupt southern limit to the extensive belt of Jura-Cretaceous plutonic rocks which characterize the southwestern Coast Belt, although lower thrust slices of the system locally include rocks correlative with Harrison Terrane. Furthermore, Monger (1991b) and Monger and Journeay (1994) point to the possible correlation of the Cretaceous-Tertiary Western Mélange Belt in the foothills of the northwest Cascade system with the Pacific Rim Complex and Leech River schist, which are thrust beneath Wrangellia along the western and southern coasts of Vancouver Island (*see* Figure 3). This correlation suggests that the southwestern Coast Belt and adjacent Wrangellia Terrane can be regarded as the southern end of a huge block that has been incorporated into a long-lived accretionary complex represented in part by the southeastern Coast - north Cascade orogen (Monger, 1986; Monger and Journeay, 1994).

East of the Fraser fault the eastern boundary of the southeastern Coast - north Cascade orogen is the Pasayten fault zone, which has been traced continuously for more than 200 kilometres and separates Methow Terrane from a belt of Mesozoic plutonic rocks along the western edge of the Intermontane Belt (Monger, 1989; Monger and McMillan, 1989). This belt includes Late Triassic granodiorite within the Mount Lytton

Complex, which has been correlated with similar plutons of Quesnel Terrane (Parrish and Monger, 1992), the Middle to Late Jurassic Eagle tonalite which intrudes the Nicola Group of Quesnel Terrane (Greig, 1992; Greig *et al.*, 1992), and a suite of Early Cretaceous plutonic rocks that include the Okanogan Range batholith (Hurlow and Nelson, 1993) and the Fallslake plutonic suite (Greig *et al.*, 1992). The Cretaceous plutons are probably related to continental arc volcanics of the late Early Cretaceous Spences Bridge Group, which overlaps Quesnel and Cache Creek terranes a short distance east of the bonndary (Thorkelson and Smith, 1989). Latest motion on the Pasayten fault zone was Eocene, and this was superimposed on a zone of mid-Cretaceous sinistral transpressional deformation documented within the plutonic rocks along the western edge of the Intermontane Belt (Greig, 1992; Hurlow, 1993).

West of the Fraser fault, the northeastern boundary of the southeastern Coast Belt is largely obscured by Eocene and younger deposits, but corresponds in part to the Slok Creek and Hungry Valley fault systems, which separate Methow Terrane from a succession of Cretaceous volcanic and sedimentary rocks to the northeast. (Tipper, 1978; Read, 1988; Monger and McMillan, 1989). These Cretaceous rocks of the Intermontane Belt include Lower Cretaceous volcanic and comagmatic intrusive rocks correlated with the Spences Bridge Group, as well as overlying mid to Upper Cretaceous sedimentary and volcanic rocks that have been correlated with the Silverquick - Powell Creek succession of the adjacent Coast Belt (Green, 1990; Hickson, 1992; Mahoney *et al.*, 1992). Farther to the northwest, the Eocene Yalakom fault marks the physiographic boundary between the Coast and Intermontane belts, as well as the northeastern limit of terranes and clastic basin deposits that are unequivocally part of the southeastern Coast Belt (Riddell *et al.*, 1993; Schiarizza *et al.*, 1995). In the vicinity of Chilko Lake these assemblages are juxtaposed against Jurassic volcanic rocks included within Stikine Terrane (Tipper, 1969a,b; Schiarizza *et al.*, 1995), demonstrating that the northeastern boundary of the southeastern Coast - north Cascade orogen cuts obliquely across the triad of terranes, Quesnel, Cache Creek and Stikine, that make up the Intermontane Belt. The lithotectonic assemblages and mid-Cretaceous contractional structures characteristic of the southeastern Coast Belt are not recognized beyond 52° North latitude, having apparently pinched out between Stikine Terrane to the northeast (across the Yalakom fault), and Jurassic-Cretaceous plutons characteristic of the southwestern Coast Belt to the west (in part across the Eastern Waddington thrust belt).

Tectonic Assemblages of the Bridge River Area

The Bridge River area lies along the northeast margin of the southeastern Coast Belt (Figure 3). It is underlain by strongly deformed Upper Paleozoic through Lower Cretaceous rocks of the Tyaughton - Methow basin and Bridge River, Cadwallader and Methow terranes, together with Late Paleozoic ophiolitic rocks of the Shulaps and Bralorne-East Liza complexes. These assemblages are overlain by Upper Cretaceous, Paleogene and Neogene non-marine volcanic and sedimentary rocks and are cut by mid-Cretaceous through mid-Tertiary intrusions.

Bridge River Terrane

The Bridge River Terrane is represented mainly by the Bridge River Complex, an assemblage of chert, argillite, greenstone, gabbro, blueschist, serpentinite, limestone and clastic rocks with no apparent coherent stratigraphy (Potter, 1983, 1986). Cherts range from at least Mississippian to late Middle Jurassic in age (Cordey and Schiarizza, 1993), limestones are mainly Late Triassic (M.J. Orchard, personal communication), and blueschist-facies metamorphism occurred in the Middle to Late Triassic (Archibald *et al.*, 1990, 1991a,b). Clastic rocks occur as relatively thin intervals that are not directly dated, but are known from sections containing Late Triassic and Jurassic radiolarite. They comprise sandstones, siltstones and pebble conglomerates that contain clasts of mainly chert and mafic volcanic rock, but locally include significant proportions of monocrystalline volcanic(?) quartz, suggesting a possible volcanic arc provenance (Potter, 1983). In the Bridge River area, the upper part of Bridge River Terrane is a poorly exposed and undated succession of clastic sedimentary rocks that were in part included in the Noel Formation of Cairnes (1937, 1943), and are informally assigned to the Gun Lake unit by Schiarizza *et al.* (1993a). The Gun Lake unit correlates with the basal part of the Cayoosh assemblage, a thick coherent succession of clastic metasedimentary rocks that is well exposed farther to the south, where it conformably overlies the Bridge River Complex (Journeay and Northcote, 1992; Mahoney and Journeay, 1993; Journeay and Mahoney, 1994). The Cayoosh assemblage may in part correlate with the Jura-Cretaceous Relay Mountain Group, which forms the basal part of the Tyaughton basin northwest of the Bridge River. The basal contact of the Relay Mountain Group is not exposed, but indirect evidence suggests that it may have been deposited on the Bridge River Complex.

The Bridge River Complex and overlying Cayoosh assemblage outcrop in a belt that extends for about 150 kilometres southeastward from the Bridge River area, where it is truncated by the Fraser fault. Rocks correlative with the Bridge River Complex on the east side of the fault comprise Permian to Jurassic chert, greenstone and pelite of the Hozameen Group, which outcrops within the eastern Cascade foldbelt of southern British Columbia and adjacent Washington state. The metachert and metabasite-bearing Napeequa unit and Twisp valley schists of the Cascade Metamorphic Core may also correlate with the Bridge River Complex (Miller *et al.*, 1993). Other potentially correlative assemblages include the Cogburn Group within the metamorphic culmination of the southeastern Coast Belt east if Harrison Lake, and the Elbow Lake Formation within the northwest Cascade system to the south (Monger and Journeay, 1994). Structurally higher levels within this part of the orogen include the Settler schist and the correlative(?) Darrington phyllite and Shuksan greenschist-blueschist (Monger, 1991b), which may correlate with the Cayoosh assemblage (Monger and Journeay, 1994).

The Bridge River complex is thought to have accumulated as an accretion-subduction complex on the basis of its wide age range, the apparent lack of an internal stratigraphy, commonly observed outcrop-scale tectonic disruption, and presence of Middle to Late Triassic blueschist. Accretionary tectonics, presumably related to subduction, apparently continued until at least latest Middle Jurassic time, as cherts of this age are known to be imbricated within the complex (Cordey and Schiarizza, 1993) whereas overlying clastic rocks (Cayoosh assemblage and? Relay Mountain Group) display a coherent stratigraphy. The continuous sedimentation recorded across the Bridge River/Cayoosh contact indicates that the early to mid Mesozoic phase of accretionary tectonics did not close the Bridge River ocean basin, but may have narrowed it to the extent that younger sedimentation was dominated by clastic deposits, perhaps derived from flanking arc terranes (Mahoney and Journeay, 1993; Journeay and Mahoney, 1994). A later pulse of subduction-related deformation within Bridge River Terrane may be recorded by Early Cretaceous blueschists of the Shuksan Terrane of the North Cascade Mountains, which have been correlated with the Settler schist and Cayoosh assemblage of the southeastern Coast Belt (Monger. 1991b; Monger and Journeay, 1994). This episode may have led to the final closure of the Bridge River basin, and culminated in the mid to early Late Cretaceous contractional deformation that characterizes the southeastern Coast - north Cascade orogen. Mid-Cretaceous clastic sedimentary rocks deposited in the Tyaughton - Methow basin during this contractional deformation contain detritus derived from the Bridge River Complex and provide the first record of uplift and erosion of Bridge River Terrane (Garver, 1989, 1992).

Some workers (*e.g.* Rusmore *et al.*, 1988) have correlated the Bridge River Complex with Cache Creek Terrane, which outcrops between Quesnel and Stikine terranes in the Intermontane Belt. This correlation is not supported by recent data, summarized above, which indicate that the Bridge River ocean basin remained open for a considerable time after the Cache Creek terrane had already been uplifted and eroded following its amalgamation with adjacent terranes in Early Jurassic time (Monger *et al.*, 1982). This does not preclude the possibility that Cache Creek and Bridge River terranes contain remnants of the same late Paleozoic - early Mesozoic ocean basin, or that the Triassic component of accretion within the Bridge River Complex may have been linked to that of Cache Creek Terrane.

Cadwallader Terrane

Cadwallader terrane includes the Upper Triassic Cadwallader and Tyaughton groups together with Lower to Middle Jurassic rocks of the Last Creek formation and Junction Creek unit (Rusmore, 1987, Umhoefer, 1990; Schiarizza *et al.*, 1993a,b,c,d). The most extensively exposed component is the Hurley Formation of the Cadwallader Group, which consists of lower to upper Norian sandstone, siltstone, conglomerate and minor micritic limestone that were deposited mainly as turbidites. The Hurley Formation is stratigraphically underlain by mafic volcanic rocks that are also part of the Cadwallader Group, and is locally overlain by a succession of Lower to Middle Jurassic shales, siliceous argillites and siltstones assigned to the Junction Creek unit. The Tyaughton Group and Last Creek formation are facies equivalents of the Hurley Formation and Junction Creek unit that are in fault contact with the Cadwallader Group northwest of Gold Bridge (*see* Figure 11). The Tyaughton Group comprises middle to upper Norian nonmarine and shallow-marine conglomerate, sandstone and minor limestone, while the overlying Last Creek formation is a transgressive sequence comprising upper Hettangian to Sinemurian conglomerate and sandstone grading upward into upper Sinemurian to middle Bajocian shale (Umhoefer, 1990).

The volcanic rocks of the Cadwallader Group have trace element compositions similar to island arc tholeiites, and the clastic rocks of the Hurley Formation, Tyaughton Group and Last Creek formation contain clasts of limestone, basalt, andesite, dacite, rhyolite and granitoids, suggesting that Cadwallader Terrane represents part of a Late Triassic volcanic arc (Rusmore, 1987; Umhoefer, 1990). Rusmore *et al.* (1988), Umhoefer (1990) and Rusmore and Woodsworth (1991a) point out general similarities between Cadwallader Terrane and the Triassic - Jurassic rocks of Stikine terrane, and suggest that they may be correlative or related portions of the same arc system.

Throughout the Bridge River area the Triassic and Jurassic rocks of Cadwallader terrane are structurally imbricated with slices of ophiolitic ultramafic to intermediate plutonic and volcanic rocks of the Early Permian Bralorne-East Liza Complex. These panels of thrust-imbricated Cadwallader Terrane and Bralorne-East Liza Complex are interleaved with the Bridge River Complex across a complex array of mid-Cretaceous contractional faults and Late Cretaceous through early Tertiary dextral strike-slip faults. The oldest of these structures comprise a system of southwesterly-directed thrust faults that typically place Cadwallader Terrane and associated ophiolitic rocks above the Bridge River Complex. This stacking order suggests that Cadwallader Terrane was situated east of the Bridge River Complex prior to mid-Cretaceous thrusting. This spatial relationship is generally confirmed by the overall distribution of units along the northeastern margin of the southeastern Coast Belt from the Bridge River area northward, where Cadwallader Terrane occurs between Methow Terrane to the northeast and Bridge River Terrane to the west (Figure 4; Schiarizza *et al.*, 1993b; Riddell *et al.*, 1993).

A separate belt containing Upper Triassic arc-related rocks that have been assigned to the Cadwallader Group outcrops in the Lillooet Lake area, to the southwest of Bridge River Terrane (Figure 4). The Triassic rocks of this belt contain a more varied assemblage of mafic to felsic volcanic rocks than are found in the type area of the Cadwallader Group (Riddell, 1992) and they are locally overlain by Lower to Middle Jurassic arc-like volcanic rocks correlated with Harrison Lake Formation (Journeay and Mahoney, 1994), which contrast markedly with the Lower to Middle Jurassic shales of Cadwallader Terrane in its type area to the northeast (Umhoefer, 1990; Riddell *et al.*, 1993). Along strike to the northwest of the Lillooet Lake belt is another sequence of Triassic arc volcanics (Niut belt of Figures 4 and 5), which has been correlated with Stikine Terrane (Mount Moore and Mosley formations, Rusmore and Woodsworth, 1991a). These rocks may correlate with those of the Lillooet Lake belt on the basis of general lithologic similarity, their along strike position, and the presence of Triassic quartz dioritic intrusive rocks within both belts (Riddell, 1992; Mustard and van der Heyden, 1994). Furthermore, the Triassic successions within both belts are associated with younger arc-like sequences of volcanic and sedimentary rocks that may correlate with the Lower Cretaceous Gambier Group (Cerulean Lake unit of the Lillooet Lake belt, Riddell, 1992; Ottarasko and Cloud Drifter formations of the Niut belt, Rusmore and Woodsworth, 1989). The northernmost exposures of Cadwallader Terrane in the southeastern Coast Belt comprise a westerly-striking belt that is juxtaposed against the Niut belt at Chilko Lake (Figure 4; Riddell *et al.*, 1993; Schiarizza *et al.*, 1995). Along the southern margin of this belt is a narrow fault-bounded sliver of Bridge River Complex (too small to be shown on Figure 4) which is the northernmost known exposure of Bridge River Terrane. This distribution suggests the possibility that the Lillooet, Niut and Cadwallader belts are components of a once-continuous arc system that bounded the Bridge River ocean basin to the west, north and northeast. Alternatively, the Lillooet Lake - Niut belt and the Cadwallader Terrane may represent completely different arc sequences that formed on opposite sides of the Bridge River ocean basin. Other interpretations are also possible, but must be consistent with the contrasting structural positions of the type Cadwallader Terrane and the Lillooet Lake belt, on opposite sides of Bridge River Terrane. One other way to achieve this distribution is by pre-Hauterivian sinistral displacement of the northern portion of the Cadwallader arc system to a more southerly and outboard position now represented by the Lillooet Lake belt (*e.g.* Monger *et al.*, 1994).

Methow Terrane

Lower to Middle Jurassic sedimentary and volcanic rocks of Methow Terrane, together with overlying Jura-Cretaceous clastic sedimentary rocks comprising the Methow portion of the Tyaughton - Methow basin, comprise the northeastern element of the southeastern Coast - north Cascade orogen from the vicinity of Chilko Lake southeastward to northern Washington state. In the west, this belt of Methow Terrane rocks is separated from other components of the southeastern Coast Belt in part by the Tertiary Yalakom fault and in part by an older structure that is offset by the Yalakom fault; this older structures is referred to as the Camelsfoot fault in the southeast (Schiarizza *et al.*, 1993b) and the Konni Lake fault in the northwest (Riddell *et al.*, 1993). East of the Fraser fault, the Methow belt is bounded to the southwest by the Hozameen fault (Monger, 1989; Monger and McMillan, 1989).

East of the Fraser fault, Lower to Middle Jurassic rocks of Methow Terrane consist of mainly fine-grained clastic sedimentary rocks of the Ladner Group, which in its upper part includes a distinctive assemblage of upper Toarcian to Bajocian volcanic and sedimentary rocks assigned to the Dewdney Creek Formation (O'Brien, 1986, 1987). The Dewdney Creek Formation includes a proximal eastern facies that includes arc-related pyroclastic rocks and lava flows together with clastic sedimentary rocks, and a more distal western facies that consists of volcanic-derived coarse-grained sandstones and conglomerates intercalated with thin-bedded sandstone, siltstone and argillite (Mahoney, 1993). Rocks correlative with the Dewdney Creek Formation were recognized in the Camelsfoot Range, west of the Fraser fault, by Monger and McMillan (1989) and Schiarizza *et al.* (1990a,b). These correlations were confirmed by Mahoney (1992), who specifically correlated the Lower to Middle Jurassic rocks of the Camelsfoot Range with the distal western facies of the Dewdney Creek Formation (Mahoney, 1993). Middle Jurassic rocks in the Chilko Lake area were subsequently assigned to Methow Terrane by Riddell *et al.* (1993) and Schiarizza *et al.* (1995). There they are characterized by thick beds of volcanic-derived sandstone and granule conglomerate, as well as local occurrences of andesitic breccias, tuffs and flows, within a succession of predominantly siltstones, shales and fine-grained sandstones. These Middle Jurassic rocks are markedly different from age-equivalent strata found within other major tectonostratigraphic assemblages of the southeastern Coast Belt: the Middle Jurassic portion of Cadwallader

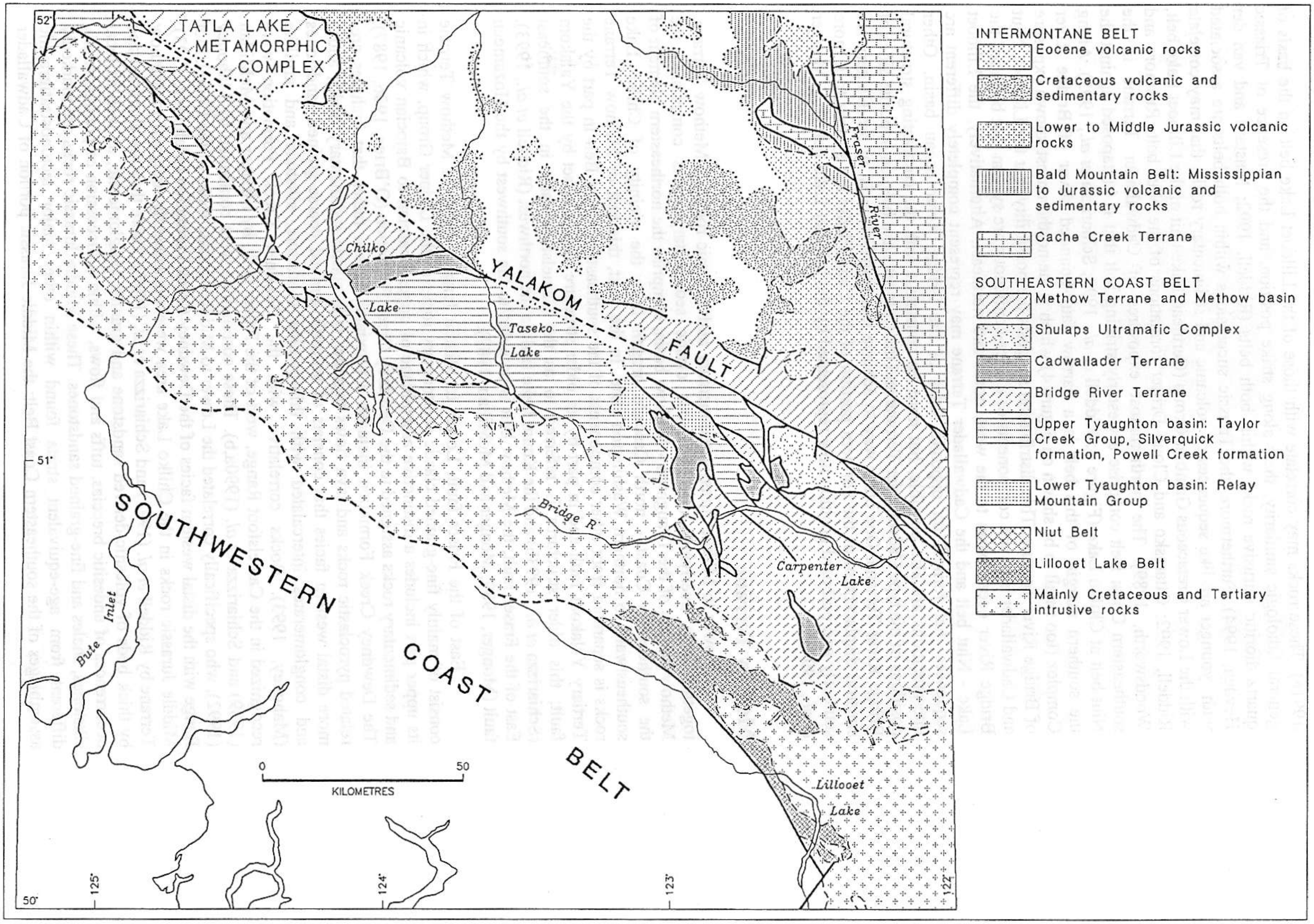

Figure 4. Distribution of major tectonstratigraphic assemblages in the northern and central part of the southeastern Coastal Belt.

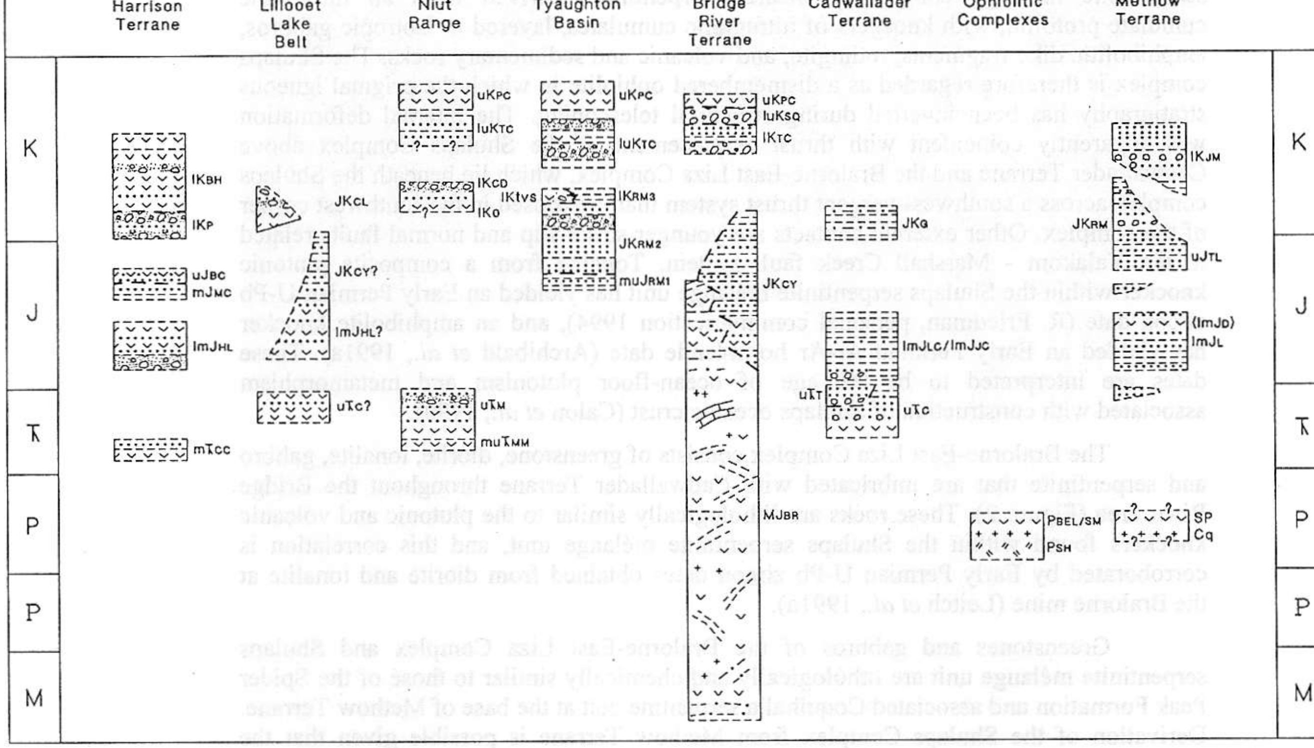

Figure 5. Correlation chart of tectonstratigraphic assemblages of the southeastern Coast Belt and ajacent HarrisonTerrane of the southwestern Coast Belt. Abbreviations: **BH,** *Brokenback Hill Fm;* **BC,** *Billhook Creek Fm;* **CC,** *Camp Cove Fm;* **BEL/SM,** *Bralorne-East Liza Complex/Shulaps serpentinite mélange;* **BR,** *Bridge River Complex;* **C,** *Cadwallader Group;* *CD, Cloud Drifter Fm;* *CL, Cerulean Lake unit;* *Cq, Coquihalla serpentine belt;* *CY, Cayoosh assemblage;* **D,** *Dewdney Creek Fm;* **G,** *Grouse Creek unit;* **HL,** *Harrison Lake Fm;***JC,** *Junction Creek unit;* **JM,** *Jackass Mountain Group;* **L,** *Ladner Group;* **LC,** *Last Creek Fm;* **M,** *Mosley Fm;* **MC,** *Mysterious Creek Fm;* **MM,** *Mount Moore Fm;* **O,** *Ottrasko Fm;* **P,** *Peninsula Fm;* **PC,** *Powell Creek Fm;* **RM,** *Relay Mountain Group;* **SH,** *Shulaps harzburgite unit;* **SP,** *Spider Peak;* **SQ,** *Silverquick Fm;* **T,** *Tyaughton Group;* **TC,** *Taylor Creek Group;* **TL,** *Thunder Lake Sequence;* **tvs,** *Tosh Creek unit*

Terrane is predominantly shale with no coarser clastics and no volcanic rocks (Umhoefer, 1990; Schiarizza *et al.*, 1993b), and the Middle Jurassic of the Bridge River Terrane is mainly chert (Cordey and Schiarizza, 1993).

East of the Fraser fault, the basement to Methow Terrane is a sequence of ocean floor basalts and associated gabbro and ultramafic rock assigned to the Spider Peak Formation and Coquihalla serpentine belt (Ray, 1986). These basement rocks are not directly dated, but may in part be Lower Triassic if interpillow chert breccias in the Spider Peak basalts were the source of an Early Triassic chert clast within the overlying Ladner Group (Ray, 1986). Pre-Jurassic rocks also occur within the Methow Terrane belt east of Chilko Lake, where they comprise Late Triassic clastic rocks, including granitoid-bearing conglomerates, that overlie quartz diorite plutons of early Late Triassic age (Schiarizza *et al.*, 1995).

Ophiolitic Complexes

Ophiolitic rocks in the Bridge River area are assigned to the Shulaps Ultramafic Complex and the Bralorne-East Liza Complex. The Shulaps Complex covers most of the northern Shulaps Range and is subdivided into two major components (Calon *et al.*, 1990; *see* Figure 11). The structurally highest part of the complex consists of harzburgite and dunite with a mantle tectonite fabric. The harzburgite unit is structurally underlain by serpentinite mélange comprising sheared serpentinite, derived from an ultramafic cumulate protolith, with knockers of ultramafic cumulates, layered to isotropic gabbros, amphibolitic dike fragments, rodingite, and volcanic and sedimentary rocks. The Shulaps complex is therefore regarded as a dismembered ophiolite in which the original igneous stratigraphy has been inverted during structural telescoping. The internal deformation was apparently coincident with thrust emplacement of the Shulaps Complex above Cadwallader Terrane and the Bralorne-East Liza Complex, which lie beneath the Shulaps complex across a southwest-vergent thrust system that is exposed in the southwest corner of the complex. Other external contacts are younger strike-slip and normal faults related to the Yalakom - Marshall Creek fault system. Tonalite from a composite plutonic knocker within the Shulaps serpentinite mélange unit has yielded an Early Permian U-Pb zircon date (R. Friedman, personal communication 1994), and an amphibolite knocker has yielded an Early Permian Ar-Ar hornblende date (Archibald *et al.*, 1991a). These dates are interpreted to be the age of ocean-floor plutonism and metamorphism associated with construction of Shulaps oceanic crust (Calon *et al.*, 1990).

The Bralorne-East Liza Complex consists of greenstone, diorite, tonalite, gabbro and serpentinite that are imbricated with Cadwallader Terrane throughout the Bridge River area (Figure 2). These rocks are lithologically similar to the plutonic and volcanic knockers found within the Shulaps serpentinite mélange unit, and this correlation is corroborated by Early Permian U-Pb zircon dates obtained from diorite and tonalite at the Bralorne mine (Leitch *et al.*, 1991a).

Greenstones and gabbros of the Bralorne-East Liza Complex and Shulaps serpentinite mélange unit are lithologically and chemically similar to those of the Spider Peak Formation and associated Coquihalla serpentine belt at the base of Methow Terrane. Derivation of the Shulaps Complex from Methow Terrane is possible given that the Shulaps Complex is the structurally highest and presumably most easterly-derived element of the mid-Cretaceous thrust stack exposed west of the Yalakom fault. Furthermore, when the 115 kilometres of dextral displacement known from other correlations is restored along the Yalakom - Hozameen fault system (restored to a single fault by removing 70 to 80 kilometres of dextral offset along the Fraser fault) the Shulaps Complex and Coquihalla serpentine belt are brought together (*see* Figure 13). Assuming that this correlation is correct, the intimate relationship between Cadwallader Terrane and the Bralorne-East Liza Complex may reflect their imbrication within a wide duplex zone generated during obduction of the Shulaps ophiolite above Cadwallader Terrane. Alternatively, or in addition, this intimate relationship may reflect a stratigraphic relationship between Cadwallader Terrane and the Bralorne-East Liza Complex, which would suggest that Cadwallader and Methow terranes were deposited above the same or similar oceanic basement.

Tyaughton - Methow basin

The Tyaughton - Methow basin is a belt of Jura-Cretaceous clastic sedimentary rocks that occurs along the northeast side of the southeastern Coast - north Cascade orogen. As originally used, the term Methow basin referred to Lower Jurassic to mid-Cretaceous rocks in the eastern Cascade foldbelt, while the Tyaughton basin corresponded to Jura-Cretaceous rocks that outcrop west of the Fraser fault in the southeastern Coast Belt (Jeletzky and Tipper, 1968; Kleinspehn, 1985). As used here, the Methow basin refers to latest Middle Jurassic (Callovian) to mid-Cretaceous rocks that were deposited above Methow Terrane on both sides of the Fraser fault, whereas the Tyaughton basin refers to coeval rocks that outcrop southwest of the Methow Terrane/basin belt in the southeastern Coast Belt, where they were deposited on older rocks of the Bridge River and Cadwallader terranes. The distinction between the Tyaughton and Methow basins are most apparent in the mid-Cretaceous, when the two parts of the basin were in part separated by an intervening landmass uplifted during Cretaceous contractional deformation (Garver, 1989, 1992). Older Jura-Cretaceous deposits in both parts of the basin are similar but are only locally exposed, in part because of erosion beneath a mid-Cretaceous disconformity (Schiarizza *et al.*, 1995). Although the Cayoosh assemblage was discussed as part of Bridge River Terrane, it is most likely a facies equivalent of the older part of the Tyaughton - Methow basin (Journeay and Mahoney, 1994).

The older part of the Tyaughton - Methow basin is represented mainly by latest Middle Jurassic to Lower Cretaceous rocks of the Relay Mountain Group. In its type locality in the Taseko - Bridge River area, the Relay Mountain Group is interpreted to overlie the Bridge River Complex, although unfaulted contacts are not exposed. This interpretation is based partly on contact relationships of the younger mid-Cretaceous portion of the Tyaughton basin, which is documented to stratigraphically overlie the Bridge River Complex near the southern end of the Tyaughton basin belt (Garver, 1989). The thin mid-Cretaceous section in this area passes northward into a thicker section that overlies the Relay Mountain Group, suggesting that the Relay Mountain Group was eroded along the mid-Cretaceous basin edge to the south and that the Bridge River Complex may extend northward to also underlie this thicker Jura-Cretaceous part of the basin. This interpretation is corroborated by a local zone of uplift within the Tyaughton basin belt, along the Relay Creek fault system, which exposes a lens of Bridge River Complex that is flanked by thin slivers of Relay Mountain Group and then extensive belts of mid-Cretaceous rocks to the northeast and southwest (Schiarizza *et al.*, 1993c). Furthermore, these exposures of Tyaughton basin strata (mainly mid-Cretaceous rocks, but with locally exposures of Relay Mountain Group) extend continuously along the southwest side of the Yalakom fault for 80 kilometres to Chilko Lake, where they are bounded to the north by a fault bounded panel of Bridge River Complex (Riddell *et al.*, 1993), suggesting that the Bridge River Complex underlies the full length of this Tyaughton basin belt.

Cadwallader Terrane has been traditionally thought of as the probable basement to the Tyaughton basin, in part because the Tyaughton Group and overlying Last Creek formation of Cadwallader Terrane are spatially associated with the Relay Mountain Group in the Tyaughton Creek area, near its type section. The Tyaughton Group and Last Creek formation, however, are part of a composite slice of thrust-imbricated Cadwallader Terrane and Bralorne-East Liza Complex that is in thrust contact with the underlying Relay Mountain Group along most of its western margin, but rests structurally above Bridge River Terrane to the south (Figure 2). The apparent continuity of Bridge River Terrane (including Bridge River Complex and overlying Cayoosh assemblage) and Relay Mountain Group, in the footwall of this mid-Cretaceous thrust fault (*see* Figure 8), provides further support for their inferred stratigraphic relationship and also suggests that the Cayoosh assemblage in this area (Gun Lake unit) may correlate with the basal shale - turbidite unit of the Relay Mountain Group (unit muJRM1 of Schiarizza *et al.*, (1993a,c,d).

Although we infer that the main belt of Tyaughton basin rocks was deposited above the Bridge River Complex, Jura-Cretaceous siltstones and fine-grained sandstones that are exposed very locally in the Camelsfoot thrust belt (Grouse Creek unit of Schiarizza *et al.*, 1993b), may correlate with the Relay Mountain Group and are in apparent stratigraphic contact with Cadwallader Terrane. Moreover, a separate belt of Relay Mountain Group rocks that is well exposed 100 kilometres northwest of the type area, between Chilko and Tatlayoko lakes (Tipper, 1969a), is in stratigraphic contact with Middle Jurassic rocks that Schiarizza *et al.* (1995) correlate with Methow Terrane. Therefore, despite the stratigraphic ambiguity in its type area, it seems probable that the Relay Mountain Group overlaps Methow, Cadwallader and Bridge River terranes. Relay Mountain rocks in the northern exposure belt do not include an Upper Callovian - Lower Oxfordian turbidite unit that is present at the base of the group in the south, are generally coarser grained and include abundant non-marine sequences intercalated with shallow marine strata. This apparent southeastward trend away from the basin margin may continue farther south into deeper marine clastic rocks of the Cayoosh assemblage.

The upper part of the Tyaughton - Methow basin consists of thick sequences of synorogenic clastic sedimentary rocks that were deposited during mid-Cretaceous

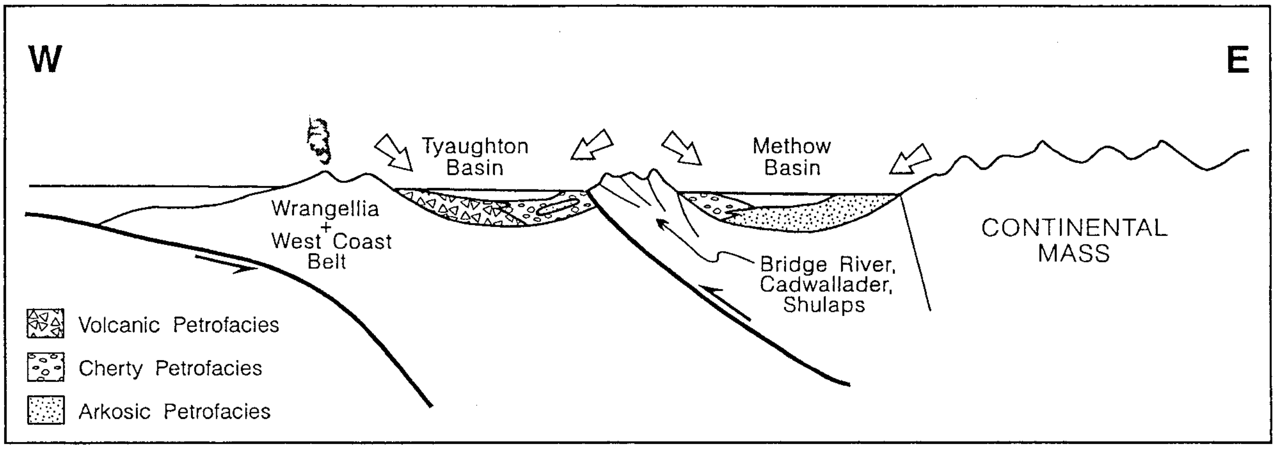

Figure 6. Schematic summary of the tectonic setting and inferred sediment sources of the mid-Cretaceous Tyaughton and Methow Basins, after Garver (1989, 1992).

contractional deformation. The Methow and Tyaughton portions of the basin were separated by a tectonically uplifted topographic high that shed detritus into both flanking basins (Figure 6; Garver, 1989, 1992). The Methow basin, represented mainly by the Jackass Mountain Group, received chert-rich detritus derived from Bridge River Terrane exposed in this topographic high, as well as thick accumulations of arkosic sediment that were derived from a newly uplifted plutonic and metamorphic source terrain to the east. Coeval rocks within the Tyaughton basin are represented by the Taylor Creek Group and overlying Silverquick conglomerate, which were deposited above the Bridge River Complex in the Bridge River area, and above the Relay Mountain Group farther to the northwest. These mid-Cretaceous rocks have been subdivided into 6 informal interfingering units that represent 3 distinct petrofacies (Garver, 1989, 1992; Schiarizza et al., 1993a,c,d). The cherty petrofacies was sourced from uplifted Bridge River Complex exposed within the topographic high to the east, the volcanic petrofacies was derived from volcaniclastic strata to the west, and the arkosic petrofacies was derived from the same source as the thick accumulation of arkosic sediments in the Methow basin to the east (Garver, 1992, Garver and Brandon, 1994).

Although there is no exposed stratigraphic contact between the mid-Cretaceous clastic rocks of the Tyaughton - Methow basin and Cadwallader Terrane, the mid-Cretaceous rocks of the Tyaughton basin do contain detritus that can be linked to Cadwallader Terrane, as well as ophiolitic detritus that was presumably derived from the Shulaps and Bralorne-East Liza complexes (Garver, 1989, 1992). These observations, as well as the present position of Cadwallader Terrane, structurally above the Tyaughton basin and Bridge River Terrane, suggest that Cadwallader Terrane and associated ophiolitic rocks occurred mainly within the tectonically uplifted zone that separated the Tyaughton and Methow basins (Figure 6).

Structural Geology of the Bridge River Area

The structure of the Taseko - Bridge River area is dominated by a system of northwest to north-trending faults that reflect a complex history of mid-Cretaceous to Tertiary contractional, strike-slip and extensional deformation. The oldest map-scale structures include systems of mainly southwest-vergent thrust faults that have been mapped within several discontinuous belts extending from the southeastern Camelsfoot Range to Big Creek (Figure 7). Where dated, the thrust faults are mid to early Late Cretaceous in age, as are other well-dated contractional fault systems in the southeastern Coast - north Cascade orogen (McGroder, 1989, 1991; Rusmore and Woodsworth, 1991b, 1994; Journeay and Friedman, 1993). Later deformation was dominated by dextral strike-slip faulting, which occurred in latest Cretaceous through Eocene time. Dextral faults are the most prominent and continuous structures in the map area, and include the Castle Pass fault and the Yalakom - Marshall Creek - Relay Creek fault system. Extensional faults, such as the Mission Ridge fault (Coleman, 1990), are locally important and are spatially and temporally associated with dextral strike-slip systems.

The Cretaceous and Tertiary structures which dominate the map pattern of the region are superimposed on older structures which are generally not well understood. The oldest recognized structures are synplutonic faults and ductile shears within plutonic knockers of the Shulaps serpentinite mélange, that formed during Permian construction of Shulaps oceanic crust (Calon *et al.*, 1990; Archibald *et al.*, 1991a). Early structures also include outcrop-scale brittle faults that pervade the Bridge River Complex, leading to a pronounced lenticularity of lithologic units. Much of this deformation, as well as that recorded in penetratively deformed blueschist-facies rocks, is attributed to deformation within an accretion-subduction complex. This deformation was apparently operative, perhaps episodically, from the Middle Triassic to at least the late Middle Jurassic, when the Bridge River Complex was depositionally overlain by clastic sedimentary rocks of the Cayoosh assemblage and(?) Relay Mountain Group. These early deformational events remain poorly understood, however, in large part due to the pervasive nature of Cretaceous and Tertiary structures.

Cretaceous Contractional Structures

The most extensive thrust belt in the area is the Gun Creek - Elbow Mountain thrust belt, which extends from Big Creek southeastward to Gun Lake (Figure 7). The lowest structural level comprises Relay Mountain and Taylor Creek groups imbricated by southwest-vergent thrust faults that are best displayed in a northwest-trending belt near Elbow Mountain. Within this zone, thrust faults are defined by younger-over-older relationships between three mappable units of the Relay Mountain Group, as well as by repetition of faunal zones in the richly fossiliferous middle unit of the group (Jeletzky and Tipper, 1968; Tipper, 1978; Umhoefer *et al.*, 1988). West of Big Creek, the rocks deformed in the thrust belt are unconformably overlain by relatively undeformed Cenomanian Powell Creek volcanics, which constrain the timing of thrusting and related deformation to the mid-Cretaceous. The imbricated Tyaughton basin rocks are structurally overlain by thrust-imbricated Cadwallader Terrane and Bralorne-East Liza Complex in the southeastern part of the Gun Creek - Elbow Mountain system. Imbricated Cadwallader Terrane and Bralorne-East Liza Complex are also found in the Liza Lake, Shulaps and Camelsfoot thrust belts farther east, but there they are in thrust contact with underlying Bridge River Complex, and are themselves structurally overlain by the Shulaps Ultramafic Complex.

Thrust faults of the Gun Creek - Elbow Mountain thrust belt are truncated to the east by a system of east to northeast-dipping reverse and reverse-sinistral faults referred to as the Eldorado fault system. These faults commonly reverse the stacking order that is prevalent elsewhere in the area, such that they juxtapose Bridge River Complex above Cadwallader Terrane and Bralorne-East Liza Complex. They are the northern continuation of the fault system which includes the Bralorne and Pioneer mines, where mesothermal reverse-sinistral shear veins formed between 91 and 86 Ma (Leitch *et al.*, 1991a). This is the youngest contractional fault system that is well dated in the area, although Cenomanian or younger northeast-vergent folds and thrust faults within the North Cinnabar system a short distance to the east (Figure 7) may be of the same age (Garver, 1991).

The Cretaceous contractional structures in the Bridge River area are schematically summarized in Figure 8. The southwest-vergent thrust faults exposed in different parts of the map area are thought to comprise segments of the same Cretaceous thrust belt that has been disrupted and deformed by later contractional and strike-slip-related structures. The persistent stacking order that is apparent wherever these early

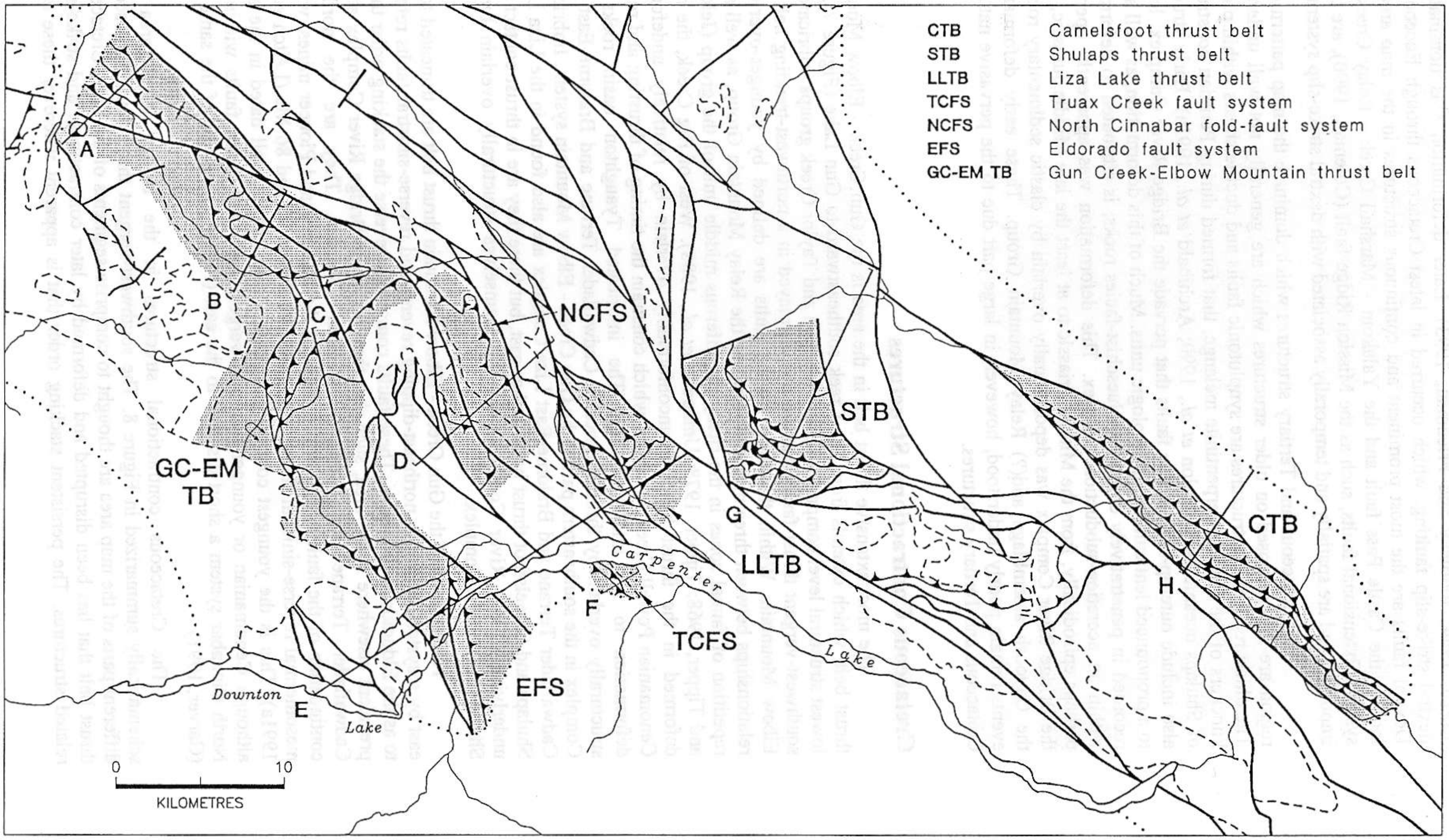

Figure 7a. Cretaceous contractional fault systems in the Taseko - Bridge River map area.

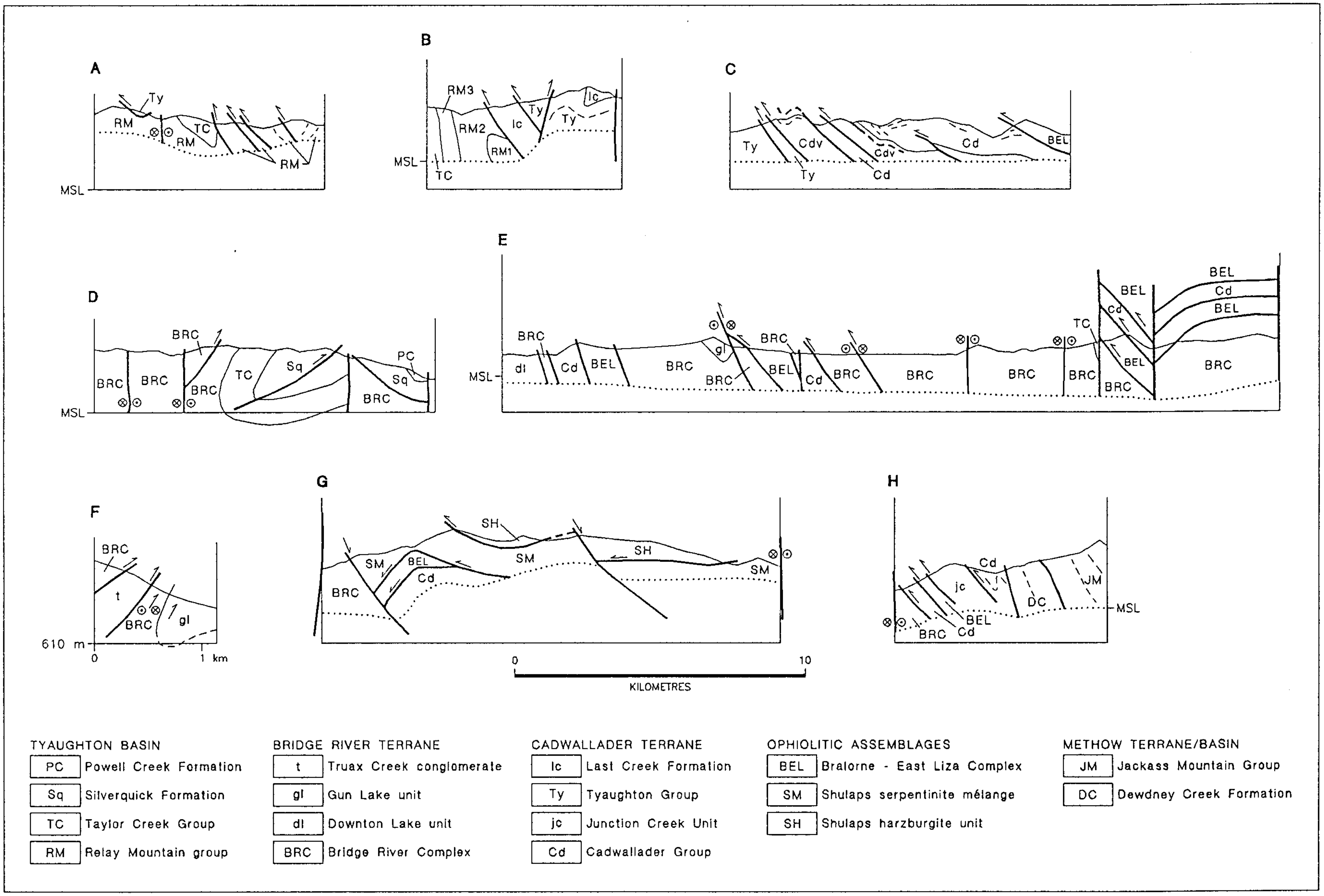

Figure 7b. Cross sections to accompany Figure 7a.

structures are recognized suggests that, prior to this late deformation, imbricated Cadwallader Terrane and Bralorne-East Liza complex comprised a large composite thrust sheet that lay above footwall Bridge River Complex and Tyaughton basin across much of the map area. Higher structural levels of this thrust system are only exposed in the Shulaps Range, where the Shulaps Complex rests above the imbricated Cadwallader Group and Bralorne-East Liza Complex.

The Bridge River Terrane and Tyaughton basin, in the footwall of the thrust system, underwent a protracted series of deformations that culminated in the well dated structures of the Elbow Mountain thrust belt, which deform Albian and older rocks of the Relay Mountain and Taylor Creek groups, and are overlapped by the Cenomanian Powell Creek formation. Older structures are inferred, as detritus in the Taylor Creek Group records uplift and erosion of the underlying Bridge River Complex and Relay Mountain Group, as well as source terrains to the west and east (Garver, 1989). Still older deformation is documented by an angular unconformity that locally separates Hauterivian shales from underlying Jurassic rocks of the Relay Mountain Group near Lorna Lake (Schiarizza *et al.*, 1993d), as well by a 130 Ma date from the first step of a Ar-Ar step-heating age spectrum for Bridge River blueschists, which may reflect heating due to thrust loading in Early Cretaceous time (Archibald *et al.*, 1990).

The invariable association of Bralorne-East Liza Complex imbricated with Cadwallader Terrane as a composite, widespread thrust sheet suggests that their initial imbrication occurred independently of their final emplacement above footwall Bridge River Complex and Tyaughton basin. This is eorroborated by the truncation of earlier structures within both Relay Mountain Group and Cadwallader Terrane by the thrust fault which separates them in the Gun Creek - Elbow Mountain thrust belt. The assembly of the Cadwallader Terrane/Bralorne-East Liza thrust slices postdates Lower Cretaceous (Valanginian or older) siltstone that is imbricated with them in the Camelsfoot thrust belt. Their encroachment or emplacement over the footwall terranes is reflected by detritus derived from ophiolitic rocks and Cadwallader terrane in Albian - Cenomanian rocks of the Tyaughton basin, and thrust faults related to their final emplacement are truncated by the 92 Ma Mount Dickson batholith north of Downton Lake (Figure 7). Imbrication and emplacement of the Cadwallader Terrane and Bralorne-East Liza Complex is therefore broadly constrained to the same Early to mid-Cretaceous time interval as deformational episodes within the Bridge River Complex and Tyaughton basin. Emplacement of the Shulaps Ultramafic Complex above Cadwallader Terrane and Bralorne-East Liza Complex, forming the highest structural level recognized in the southwest-vergent thrust stack, is also inferred to have occurred within this time interval, coincident with the imbrication of the Bralorne-East Liza Complex (equivalent to crustal elements of the Shulaps ophiolite) with Cadwallader Terrane.

Northeast-dipping reverse-sinistral faults of the Eldorado fault system apparently represent the final episode within the protracted period of southwest-directed contractional deformation. These faults were active between 91 and 86 Ma, when they cut the already assembled thrust stack, and locally reversed the stacking order established during earlier thrusting by placing Bridge River Complex above Cadwallader Group and Bralorne-East Liza Complex. Movement along the reverse(?)-sinistral Camelsfoot fault may have accommodated juxtaposition of Methow basin against previously imbricated Cadwallader terrane in a similar fashion farther to the east. Northeast-vergent contractional structures that occur east of the Eldorado fault system also cut earlier southwest-directed thrust faults. They may comprise backthrusts in the hangingwall of the Eldorado system. The generally steep, ramp-like nature of the Eldorado fault system, the component of sinistral movement, and the association with northeast-vergent backthrusts, may all reflect accommodation to the progressive thickening of the thrust-faulted crust, perhaps buttressed by intrusion of 92 Ma granodiorite along the eastern margin of the Coast Plutonic Complex.

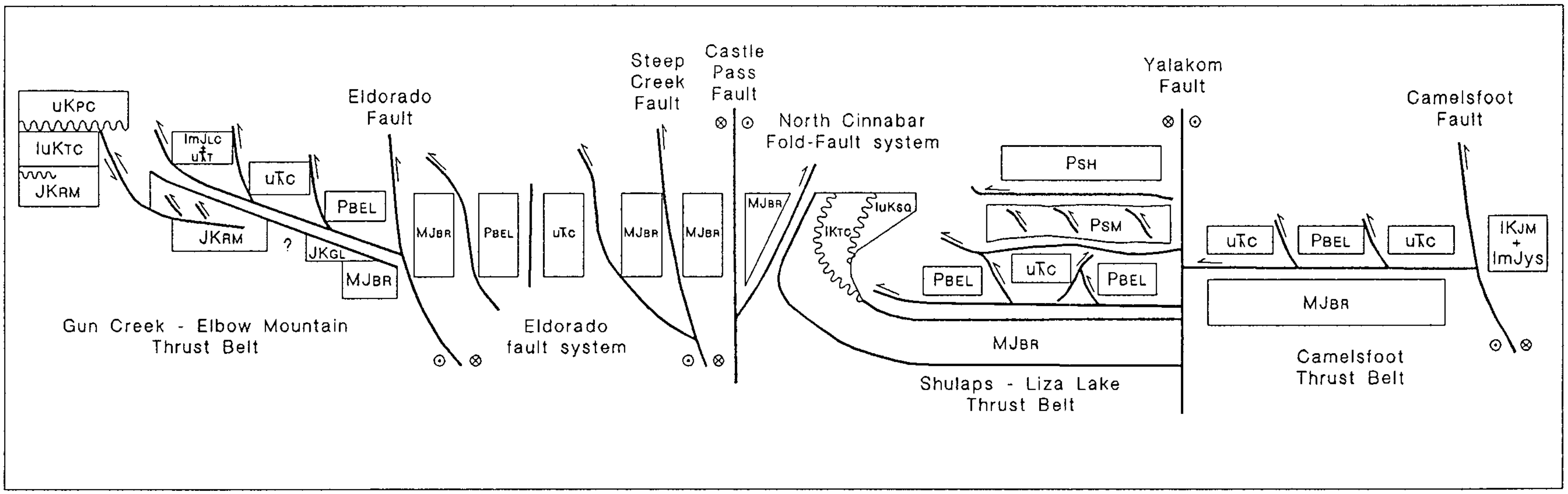

Figure 8. Schematic summary of relationships across Cretaceous contractional structures in the Taseko - Bridge River map area. Abbreviations: **uKPC**, *Powell Creek formation;* **luKSQ**, *Silverquick formation;* **luKTC**, *Taylor Creek Group;* **JKRM**, *Relay Mountain Group;* **JKGL**, *Gun Lake unit;* **MJBR**, *Bridge River Complex;* **lmJLC**, *Last Creek formation;* **uTT**, *Tyaughton Group;* **uTC**, *Cadwallader Group;* **PBEL**, *Bralorne-East Liza Complex,* **PSM**, *Shulaps serpentinite mélange unit;* **PSH**, *Shulaps harzburgite unit;* **lKJM**, *Jackass Mountain Group;* **lmJys**, *Dewdney Creek Formation*

Late Cretaceous - Early Tertiary Dextral Fault Systems

Most of the major through-going northwest-trending fault systems within the Taseko - Bridge River area were the locus of dextral strike-slip movement (Figure 9). These faults cut the mid-Cretaceous contractional structures described above, as well as some early Tertiary volcanic and plutonic rocks, but are overlapped by Neogene plateau basalts of the Chilcotin Group.

The earliest dextral movement documented within the Bridge River area occurred on the Castle Pass fault system, which truncates older contractional structures of the Eldorado and North Cinnabar fold-fault systems. Most of the movement on the Castle Pass system fault predated intrusion of the 67 Ma Eldorado pluton (Garver, 1991), and therefore was Late Cretaceous in age. Movement may have also occurred along other dextral faults in the area at this time but is not proven. Of particular interest in this regard is the evidence for Late Cretaceous deformation within the northern Shulaps Range, where a suite if dioritic dikes is associated with local prograde metamorphism of Shulaps serpentinite mélange. Foliation within the prograde metamorphic aureoles is congruent with that of the surrounding serpentinite mélange and the dikes are commonly boudinaged within the plane of this foliation. They therefore predate some movement within the mélange, but because they caused prograde metamorphism of previously serpentinized ultramafic rock, and at one locality cut the foliation in a penetratively deformed metasedimentary knocker, are interpreted to have been intruded relatively late in the deformational history of the mélange (Archibald *et al.*, 1989; Calon *et al.*, 1990). These dikes are assigned a Late Cretaceous age based on Ar-Ar plateau dates of 77±11 Ma from a boudinaged dike near the Yalakom fault, and 70.27±5.25 from a small plug 4 kilometres to the south (Archibald *et al.*, 1989, 1990; D Archibald, unpublished data). These dates are significantly younger than the latest well-dated phases of Cretaceous contractional deformation outside the complex (*i.e.* 91-86 Ma movement along the Eldorado fault system), and may relate to a Late Cretaceous phase of transpressional deformation along the adjacent Yalakom fault.

Most of the dextral strike-slip faults in the area have evidence for Eocene movement along them. The largest of these structures is the Yalakom fault, which was the locus of more than 100 kilometres of dextral offset (Tipper, 1969; Kleinspehn, 1985; Riddell *et al.,* 1993). Movement along the Yalakom fault is linked to dextral transpressive deformation documented within adjacent Bridge River schists and associated rocks of the Shulaps - Mission Ridge metamorphic belt, which occurred before and during intrusion of the Mission Ridge pluton and associated dikes, which yield 48.5 to 46.5 Ma (Middle Eocene) crystallization ages (Coleman and Parrish, 1991). The Fortress Ridge fault, which offsets the Castle Pass fault, was active during part of this same time interval, and may have been linked to the Yalakom fault through the transpressive structures of the Shulaps Range. The Fortress Ridge system dies out to the northwest, but was apparently linked with the en echelon Chita Creek fault farther west via a left-stepping transfer zone marked by a zone of relative uplift near Lorna Lake. Each of these en echelon fault strands is intruded by granodiorite plutons near its termination, and each of these plutons has yielded 44 Ma Ar-Ar cooling ages (Archibald *et al.*, 1989), identical to a K-Ar cooling date obtained from the Mission Ridge pluton (Woodsworth, 1977).

The youngest dextral faults in the area include the Marshall Creek fault and splays that emanate from it, including the Red Mountain fault and the Quartz Mountain fault system (Figure 9). The initiation of movement along the Marshall Creek fault may have caused the development of a right-stepping transfer zone between it and the northwestern part of the Yalakom fault. This reorganization is presumed to have been responsible for an abrupt change from transpressional to extensional deformation within the intervening Shulaps - Mission Ridge metamorphic belt. This led to the exhumation of greenschist to amphibolite facies Bridge River schists beneath an extensional fault system that included the northeast-dipping Mission Ridge fault (Coleman and Parrish, 1991). Continued deformation led to the development of the Red Mountain fault, which splays from the Marshall Creek fault and cuts both the Mission Ridge and Yalakom faults, and

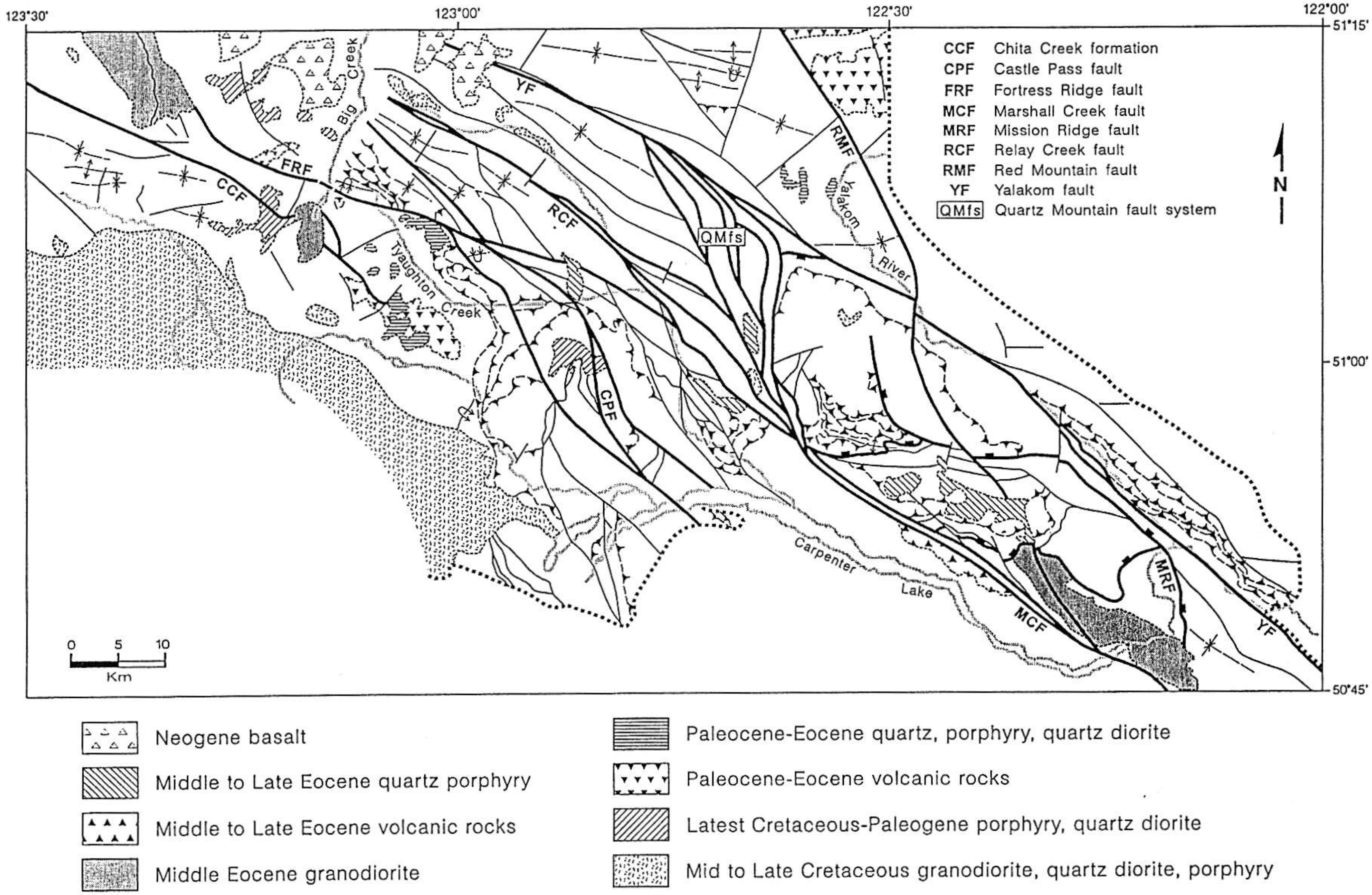

Figure 9. Late Cretaceous - Paleogene dextral strike-slip fault systems in the Taseko - Bridge River map area.

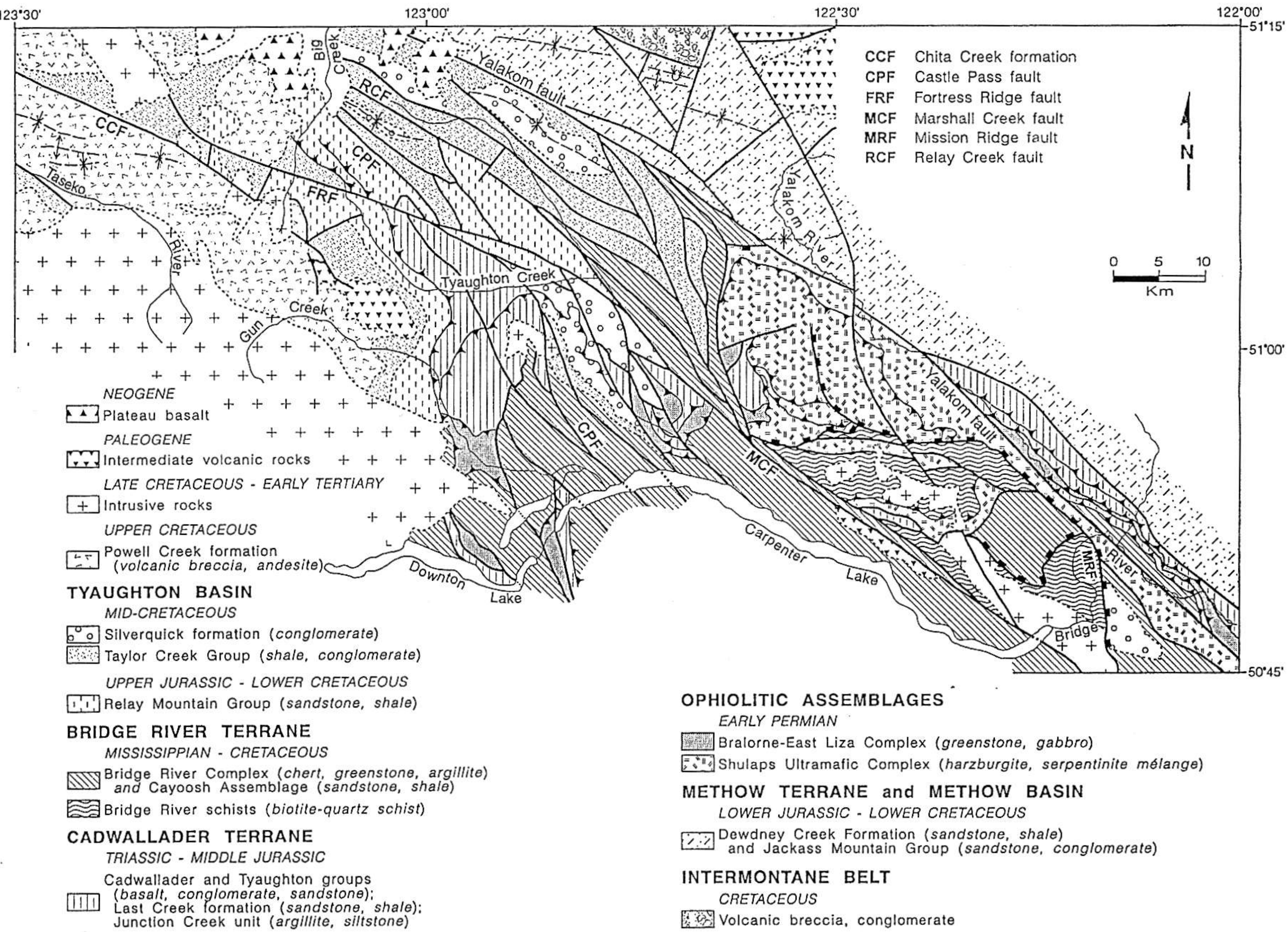

Figure 2. Simplified geologic map of the Taseko-Bridge River area of the southwestern Coast Belt, after Schiarizza et al. (1993 a,b,c,d).

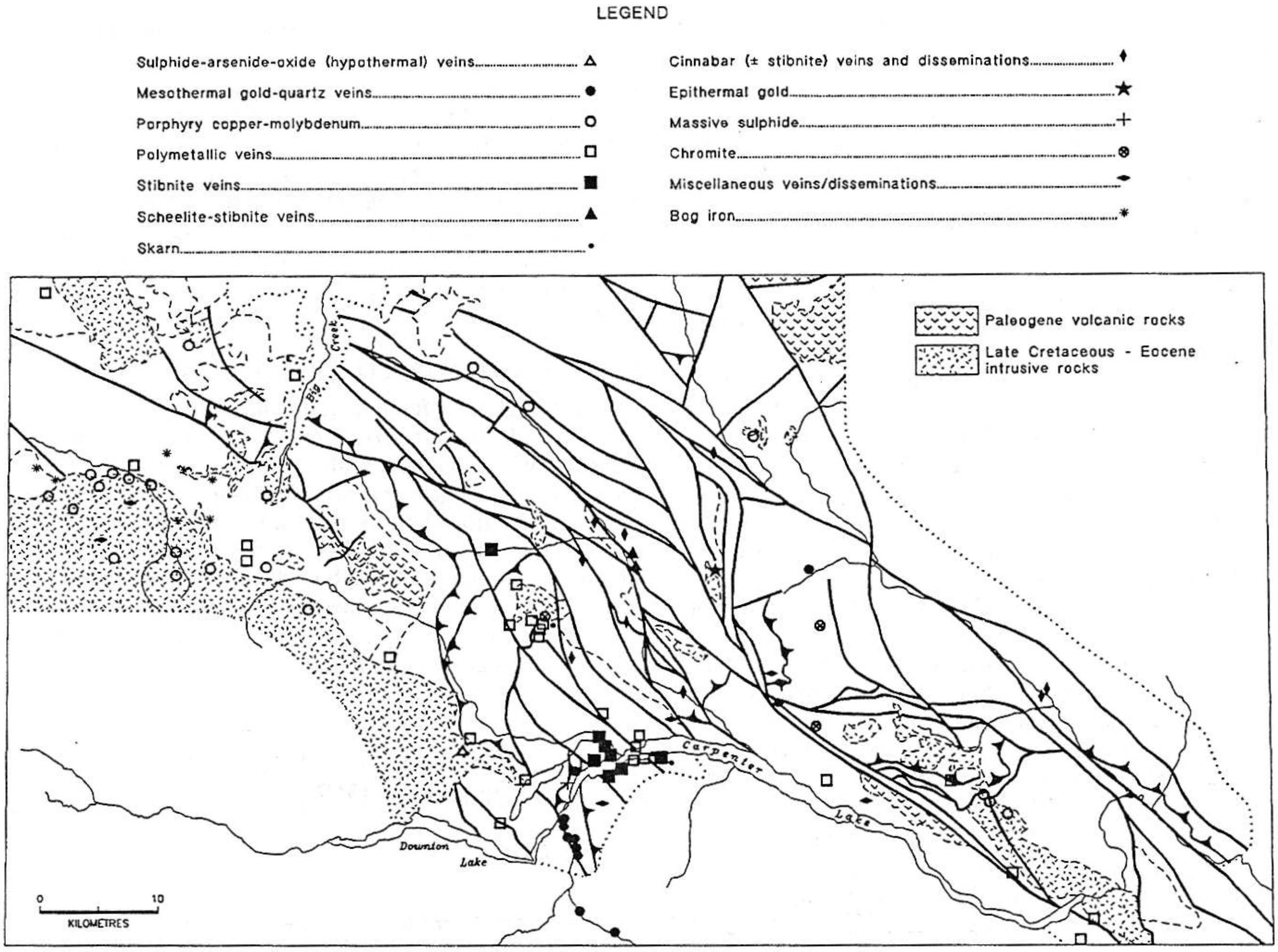

Figure 33. Metallic mineral occurrences (excluding placer gold) in the Taseko - Bridge River map area.

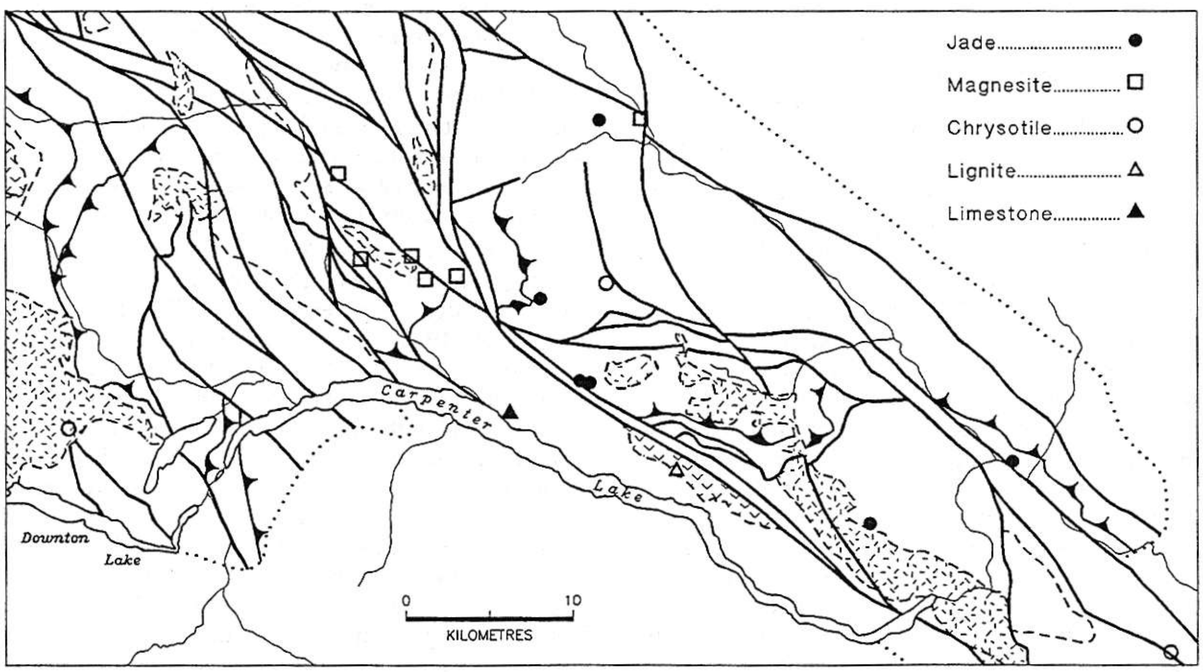

Figure 34. Nonmetallic mineral occurrences in the Taseko - Bridge River map area.

strand of the Yalakom fault is about a kilometre to the west, but a subsidiary fault is mapped along the Yalakom River between the two occurrences. Mineralization is hosted by greenstone and greenstone breccia of the Bralorne-East Liza Complex. It comprises cinnabar veinlets and disseminations that are generally within or adjacent to narrow stringers of white dolomite that occur within broader zones of brownish-weathering ankeritic carbonate alteration (Stevenson, 1940).

The Manitou occurrence is on the slopes directly northwest of lower Mud Creek, within the Bridge River Complex near the north end of the lens enclosed by the Relay Creek fault system. The property produced 543 kilograms of mercury from 141 tonnes of ore in 1938 and 1939. Stevenson (1940) reports that the best mineralization is within 2 northwest-striking shear zones, where cinnabar occurs mainly along foliation and shear surfaces cutting Bridge River greenstone. It also occurs within calcite veins and amygdules, and as disseminated grains within greenstone. The Mugwump prospect is located about 3 kilometres northwest of the Manitou. Here cinnabar and stibnite occur mainly within conglomerates of the Dash formation along the southwest side of the southern strand of the Relay Creek fault system. Cinnabar and stibnite occur together in quartz veinlets, and also as disseminated grains and thin smears on fracture surfaces (Lammle, 1974). Wallrock alteration is characterized by abundant quartz, carbonate and pyrite, and less common hematite, limonite and clay minerals.

The Silverquick mine, which produced 3241 kilograms of mercury between 1955 and 1965 (McCammon, 1965; Robinson, 1966), is on the south side of Tyaughton Creek, 4 kilometres northeast of Eldorado Mountain. Cinnabar mineralization is hosted by highly fractured and faulted conglomerates of the Silverquick formation on the west side of a strand of the Fortress Ridge fault system. The cinnabar is accompanied by quartz, calcite, limonite and clay; it occurs as disseminated grains, streaks and small lenses within brecciated conglomerate, as smears on faults, and in the mud of gouge seams (McCammon, 1965).

SCHEELITE-STIBNITE VEINS

Scheelite-stibnite veins occur at the Tungsten King and Tungsten Queen prospects, which are located just east of Tyaughton Creek along a major strand of the Relay Creek fault system. The Tungsten Queen produced 7896 kilograms of tungsten from 55 tonnes of ore in 1953. The veins occupy branched fractures within listwanite-altered ultramafic rocks comprising chalcedonic quartz, ankerite, mariposite and relict serpentinite. The veins are up to 8 centimetres wide and well banded: scheelite is followed inward from vein walls by chalcedonic quartz, coarse crystalline comb-quartz and finally by a central band of stibnite (Stevenson, 1943). There are no obvious alteration selvages along vein margins. Feldspar porphyry dikes are common within this part of the fault zone, but are not directly adjacent to the veins. Diamond drilling on the Tungsten Queen prospect (Sadlier-Brown and Nevin, 1977) sampled scheelite and stibnite concentrations carrying up to 480 ppb gold within altered ultramafic rocks. These rocks also contain up to 133 ppm arsenic and 17 ppm mercury (Appendix 11).

The symmetric mineral banding, the comb-textured quartz and the branching veins suggest a moderate to high level environment of emplacement. Scheelite is typically indicative of a high-temperature hydrothermal environment, but stibnite is characteristically a low-temperature mineral. Their presence together in the same veins, but in a zonal arrangement that indicates different times of formation, suggests that the veins formed in a rapidly changing temperature regime. Abundant syn-faulting feldspar porphyry dikes intruded along this segment of the Relay Creek fault may have provided a short-lived heat source.

DISSEMINATED (EPITHERMAL) GOLD

At Big Sheep Mountain gold and silver values are associated with vuggy quartz seams with rare disseminated to massive tetrahedrite, and with limonitic pitch-coated fractures within and adjacent to argillically-altered feldspar and quartz-porphyritic rhyolite that caps a feldspar porphyry pluton (Dawson, 1982b). Disseminated pyrite and pyrrhotite are widespread throughout the pluton. Rare amethyst veinlets are reported in altered rhyolite. The limited amount of information regarding the style of mineralization at Big Sheep Mountain suggests a high level or epithermal environment.

METALLOGENY OF THE TASEKO LAKES-BRIDGE RIVER AREA

INTRODUCTION

Woodsworth *et al.* (1977) noted an asymmetric metal and mineral zoning pattern within the Bridge River mining camp, comprising two northwesterly-trending belts of gold-bearing vein deposits (Bralorne and Minto) within a larger zone of antimony minerals, which is succeeded to the northeast by a mercury zone. They suggested that the pattern resulted from mineral deposition under a regional thermal gradient decreasing outward from the eastern margin of the Coast Plutonic Complex. Implicit in their model is the assumption that most mineral deposits formed during a single period of mineralization that coincided with the latest cooling of the northeastern side of the Coast Complex, which they thought occurred at about 50 Ma.

The model of Woodsworth *et al.* (1977) predated most of the geochronologic database presently available for the Taseko - Bridge River area (*e.g.* McMillan, 1983; Archibald *et al.*, 1989, 1990, 1991a,b; Leitch *et al.*, 1991a; Coleman and Parrish, 1991; Parrish, 1992). It also predated development of a regional tectonostratigraphic framework, and an understanding of the kinematics and timing of the complex system of faults in the area. These issues have been the focus of the present study; this allows a more comprehensive understanding of regional metallogeny in the context of the area's complex structural and magmatic evolution. The major metallic mineral deposits in the Taseko - Bridge River area are schematically summarized in Figure 35. They formed over a protracted interval during mid-Cretaceous to mid-Tertiary time, coincident with several pulses of igneous activity within an evolving structural regime that generated

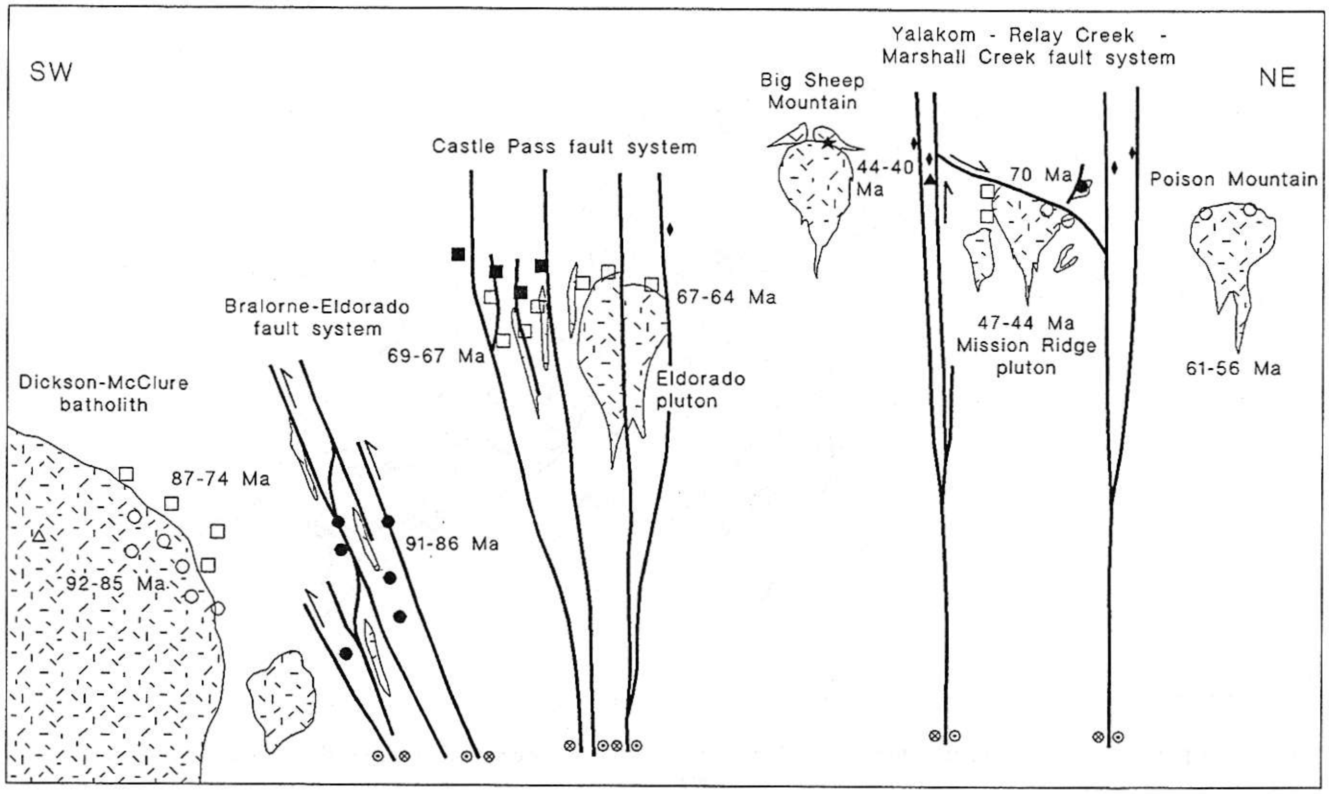

Figure 35. A schematic summary of the distribution and structural and plutonic controls of metallic mineral occurrences along a southwest - northeast transect from the Dickson - McClure batholith to the northeast side of the Yalakom fault. Symbols as in Figure 33.

contractional, transpressional, transcurrent and transtensional structures. The zonal pattern noted by Woodsworth *et al.* (1977) is in part expressed by a general easterly progression from mesothermal to epithermal mineralization within vein deposits. It is supported by the trend of decreasing fluid-inclusion homogenization temperatures in vein quartz (Maheux *et al.*, 1987), indicating a general trend toward higher level metal deposits to the east. This trend is coincident with a general eastward-younging in the age of mineralization, although there are major inconsistencies, particularly when porphyry occurrences are considered (*e.g.* the upper Relay Creek porphyry occurrences, in the northeastern part of the map area, are apparently the oldest deposits in the region). Leitch *et al.* (1989) interpreted the mineralization in terms of a single protracted but episodic mineralizing event coinciding with emplacement of granitic rocks during early Late Cretaceous to Early Tertiary time, and related the eastward-younging to movement of the magmatic front of the Coast Plutonic Complex eastward with time. The present study corroborates this general pattern, but emphasizes the role of faults in localizing both intrusive rocks and mineral deposits. The structural regime evolved from mainly compression and sinistral transpression in the early Late Cretaceous, to dextral strike-slip and local transtension and transpression in latest Cretaceous through Eocene time.

METALLOGENIC EVOLUTION

MID TO EARLY LATE CRETACEOUS

Mineral occurrences of probable mid-Cretaceous age are known only in the vicinity of upper Relay Creek, where they occur within and adjacent to a swarm of hornblende feldspar porphyry dikes and small plugs. The intrusions are spatially associated with the Taylor Creek volcanics, and a single Ar-Ar date suggests that they may be cogenetic. The porphyry-style mineralization includes disseminations of chalcopyrite and molybdenite, as well as disseminations and blebs of pyrite, pyrrhotite and sphalerite that contain low-grade gold. Carbonate alteration is widespread throughout both intrusive and country rocks, and is locally accompanied by propylitic, argillic and quartz-pyrite alteration. Similar hornblende feldspar porphyry intrusions occur near Dash Hill, about 10 kilometres east of the upper Relay Creek occurrences (Figure 36). Carbonate alteration is common in both the intrusions and the adjacent Taylor Creek Group, suggesting that there may also be potential for mineralization in this area.

The early Late Cretaceous was very important in the metallogenic evolution of the Taseko - Bridge River area, as this time period saw the deposition of mesothermal gold-quartz veins of the Bralorne-Pioneer system, as well as mineral deposits within and peripheral to the Dickson - McClure batholith (Figure 36).

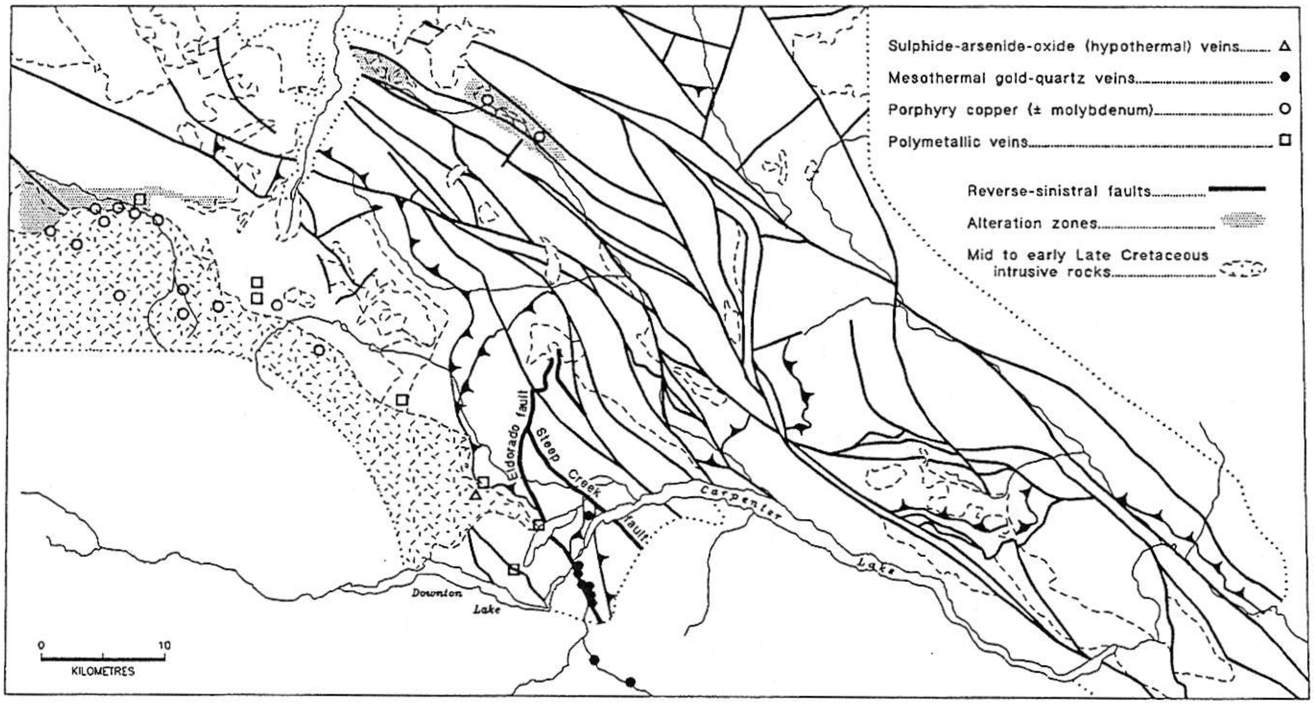

Figure 36. Map showing the distribution of mid to early Late Cretaceous mineral occurrences, along with associated structures and plutonic rocks.

Bralorne-style gold-quartz veins are associated with early late Cretaceous reverse-sinistral faults related to the Eldorado fault system. These faults formed late in the protracted period of Cretaceous contractional deformation that caused imbrication and juxtaposition of the diverse Paleozoic-Mesozoic tectonic elements of the area. All of the major Bralorne-style vein systems cut diorite and greenstone of the Bralorne-East Liza Complex; thus the Bralorne diorite has traditionally been the focus of exploration activity in the region. Recent dating indicates that the diorite is much older than the mineralization and was simply a suitable host for vein formation. A shift in exploration focus to the Late Cretaceous transpressional fault systems that control the mineralization might be fruitful. It is suspected, for instance, that the Camelsfoot fault is a similar structure; it may be an offset extension of the East Hozameen fault system, which controls mesothermal vein mineralization in the Coquihalla River area (Ray, 1986).

The available dating indicates that intrusion, cooling and mineralization associated with the Dickson - McClure batholith was essentially coincident with the Bralorne-style mesothermal veins. The batholith itself contains numerous porphyry occurrences, and a single hypothermal sulphide-arsenide-oxide vein occurrence. The porphyry occurrences pass outward into vein occurrences in the adjacent country rock that are known for 40 kilometres along the northeastern contact of the pluton. In the Battlement Creek area, mineral assemblages in an extensive alteration zone directly north of the batholith suggest conditions transitional between porphyry and epithermal environments.

LATEST CRETACEOUS TO PALEOCENE

Latest Cretaceous to Paleocene intrusions and associated mineral occurrences are concentrated along the dextral-slip Castle Pass fault system between Carpenter Lake and Tyaughton Creek, and may in part have been controlled by a prominent extensional bend in the fault system (Figure 37). Mineral occurrences are mainly polymetallic and stibnite veins, including the past-producing Minto and Congress mines, but the belt also includes skarn and mercury showings. Polymetallic vein and porphyry occurrences that occur along the general strike of the belt west of Big Creek are also associated with porphyry intrusions that may be of this age.

Ribboned gold-quartz veins at the Elizabeth-Yalakom prospect are in Late Cretaceous Blue Creek porphyry, and may also have formed during this time period. The textures of the veins suggest that they developed in a compressional or transpressional regime, similar to that operative during deposition of the older Bralorne-Pioneer vein system. The structural setting of the Elizabeth-Yalakom prospect has not been established, but it is speculated that the mineralization may have been coincident with the early stages of transpressional deformation associated with the Yalakom fault system.

LATE PALEOCENE AND EOCENE

The Eocene structural history of the area was one of dominantly dextral strike-slip, with transpressive and transtensional regimes developed locally along fault bends and steps. The strike-slip faults were the focus of major hydrothermal activity, as evidenced by the abundant listwanite and carbonate alteration along them. Most of the listwanites

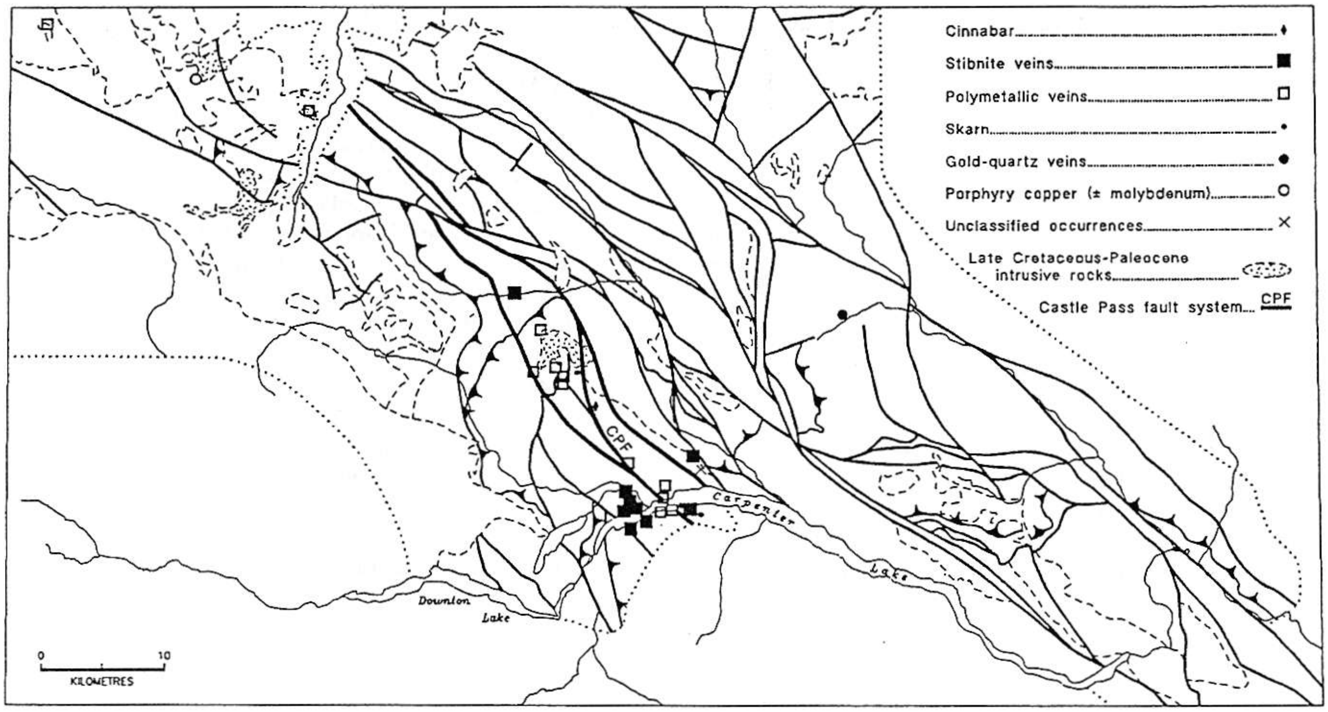

Figure 37. Map showing the distribution of Late Cretaceous to Paleocene mineral occurrences, along with associated structures and plutonic rocks.

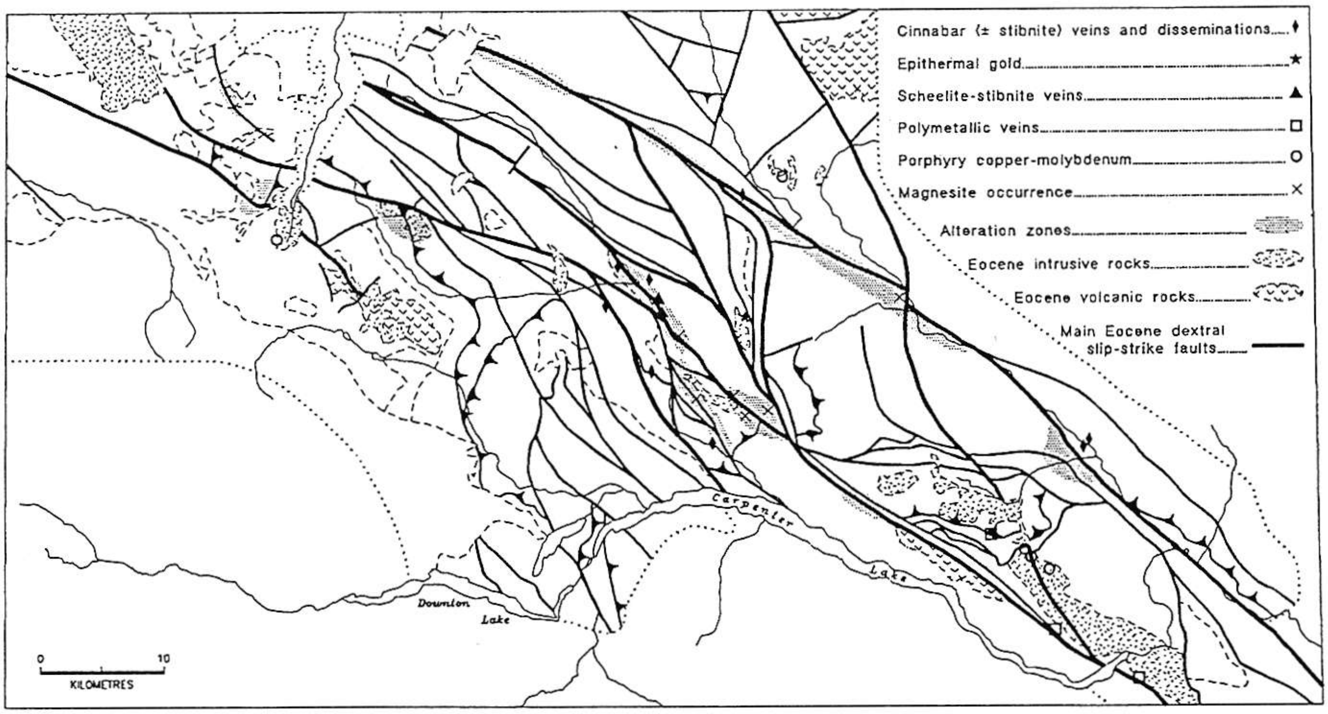

Figure 38. Map showing the distribution of late Paleocene to Eocene mineral occurrences, along with associated structures and plutonic rocks.

are anomalous in mercury and antimony, and a number of cinnabar±stibnite mineral occurrences, some with past production, occur along strands of the Yalakom, Relay Creek and Fortress Ridge fault systems (Figure 38). Higher temperature scheelite-stibnite veins along the Relay Creek fault system may have been localized in an area of synchronous intrusions.

Intrusion and associated porphyry mineralization at Poison Mountain was late Paleocene to early Eocene in age. This is the only mineral occurrence in the area northeast of the Yalakom fault, and as it predates much of the Eocene dextral strike-slip on the fault, may have originated a considerable distance northwest of the mineral occurrences on the other side of the fault.

Porphyry intrusions associated with the Mount Sheba volcanic complex are apparently of early Eocene age (Archibald *et al.*, 1989; Appendix 7). One of these, which intrudes the Relay Mountain Group and Last Creek formation on the north side of Tyaughton Creek, is largely carbonate-clay-altered and, together with associated rhyolite, contains local zones of silicification and pyrite-arsenopyrite mineralization. The alteration and sulphide concentrations may be broadly coeval with the plutonic-volcanic complex or, alternatively, may relate to the younger Fortress Ridge fault system.

Three Middle Eocene granodioritic plutons were localized within the Yalakom - Fortress Ridge - Chita Creek dextral fault system. The Lorna Lake and Mission Ridge plutons have associated porphyry mineralization, and the Mission Ridge pluton is also associated with peripheral polymetallic veins. An extensive alteration zone west of the Lorna Lake stock may also be of this age but; alternatively, may be related to the 64 Ma Dorrie Peak stock. The largest of the three Middle Eocene intrusions, the Beece Creek pluton, contains no known mineral occurrences but is locally altered and may warrant further exploration.

Epithermal-style mineralization at Big Sheep Mountain is associated with a plutonic-volcanic stock that was intruded into a large extensional transfer zone between the Marshall Creek and Yalakom faults. This zone is a major dilational jog that may have considerable potential for additional epithermal mineralization.

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