GEOLOGY AND MINERAL OCCURRENCES OF THE TYAUGHTON CREEK AREA* (92O/2, 92J/15, 16)

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KEYWORDS: Regional geology, Bridge River complex, Shulaps ultramafic complex, Cadwallader Group, Tyaughton Basin, Taylor Creek Group, blueschist, strike-slip faults, gold veins, stibnite, cinnabar, scheelite.

INTRODUCTION

The Tyaughton Creek map area is centred 185 kilometres north of Vancouver, on the northeastern margin of the Coast Mountains (Figure 1-14-1). It covers about 700 square kilometres of mountainous terrain within the Chilcotin Ranges, north and east of the village of Gold Bridge. Our 1988 mapping program comprises the southeastward extension of the previous two summers' mapping in the Warner Pass (Glover and Schiarizza, 1987; Glover *et al.*, 1987) and Noaxe Creek (Glover *et al.*, 1988a, 1988b) map sheets. It encompasses part of the area covered by reconnaissance geological mapping directed by B.N. Church of this Ministry during mineral deposit studies of the Bridge River mining camp (Church, 1987; Church and MacLean, 1987; Church *et al.*, 1988a, 1988b; Church and Pettipas, 1989, this volume).

This year's program included detailed mapping in the Spruce Lake–Pearson Creek area by J.I. Garver and P.J. Umhoefer as part of their doctoral research at the University of Washington (Garver *et al.*, 1989, this volume). It also incorporated a study of the Shulaps ultramafic complex undertaken by T. Calon of The Memorial University of Newfoundland. Geological mapping and sampling by D.A. Archibald of Queen's University continues a potassium-argon and $^{40}Ar/^{39}Ar$ geochronology study initiated during the 1987 field season; preliminary results of this program are summarized by Archibald *et al.* (1989, this volume).

This is the third year of a 4-year regional mapping project, begun in 1986 and funded by the Canada/British Columbia Mineral Development Agreement. Open File geology and mineral potential maps covering this season's study area will be released in February, 1989.

REGIONAL GEOLOGY

The study area is underlain primarily by Mesozoic sedimentary and volcanic rocks that occur within a structurally complex, northwest-trending belt that flanks the northeastern margin of the Coast plutonic complex (Figure 1-14-1). The area includes several tectonostratigraphic assemblages (Figure 1-14-2) which are described following.

Shulaps Ultramafic Complex: variably serpentinized harzburgite and dunite structurally underlain by serpentinite mélange containing knockers of ultramafic, gabbroic, volcanic and sedimentary rock. It is interpreted by Nagel (1979), Potter (1983, 1986), and T.Calon (personal communication, 1988) as a dismembered ophiolite suite.

Bridge River Complex: imbricated chert, greenstone, gabbro, blueschist, limestone and clastic rocks ranging in age from at least Middle Triassic to Early Jurassic. These rocks, together with the structurally overlying Shulaps ultramafic complex are assigned to the Bridge River terrane by Potter (1983, 1986) and inferred to comprise the remnants of a Mesozoic back-arc basin.

Cadwallader Terrane: greenstone and gradationally overlying Early Triassic sedimentary rocks of the Cadwallader Group, together with Late Triassic clastics and limestone of the Tyaughton Group and overlying Early to Middle Jurassic shale. Trace element geochemistry of Cadwallader greenstones and the composition of Late Triassic clastic sediments suggest derivation from a volcanic arc (Rusmore, 1985, 1987).

Tyaughton Basin: shallow-marine clastic rocks of the Middle Jurassic to Early Cretaceous Relay Mountain Group, and predominantly marine clastics of the mid-Cretaceous Taylor Creek and Jackass Mountain groups. Taylor Creek sediments were in part derived from the adjacent Bridge River complex at the onset of mid-Cretaceous compressional tectonism.

In the Warner Pass map area, weakly deformed Late Cretaceous andesitic volcanics assigned to the Powell Creek volcanics sit above the Taylor Creek Group with pronounced angular unconformity. Late Cretaceous deposits within the Tyaughton Creek area are represented mainly by the coarse, nonmarine Silverquick conglomerate. It overlies the Taylor Creek Group with apparent angular unconformity and passes gradationally upward into andesitic volcanics; these units were subsequently deformed by northerly-directed overturned folds and thrusts.

Mesozoic strata throughout the belt are intruded by Late Cretaceous to Eocene stocks and dykes of felsic to intermediate composition, and are locally unconformably overlain by Eocene volcanic and sedimentary rocks and by Miocene to Pliocene plateau lavas. They are intruded by Late Cretaceous granite to quartz diorite of the Coast plutonic complex along the southwestern margin of the belt.

* This project is a contribution to the Canada/British Columbia Mineral Development Agreement.

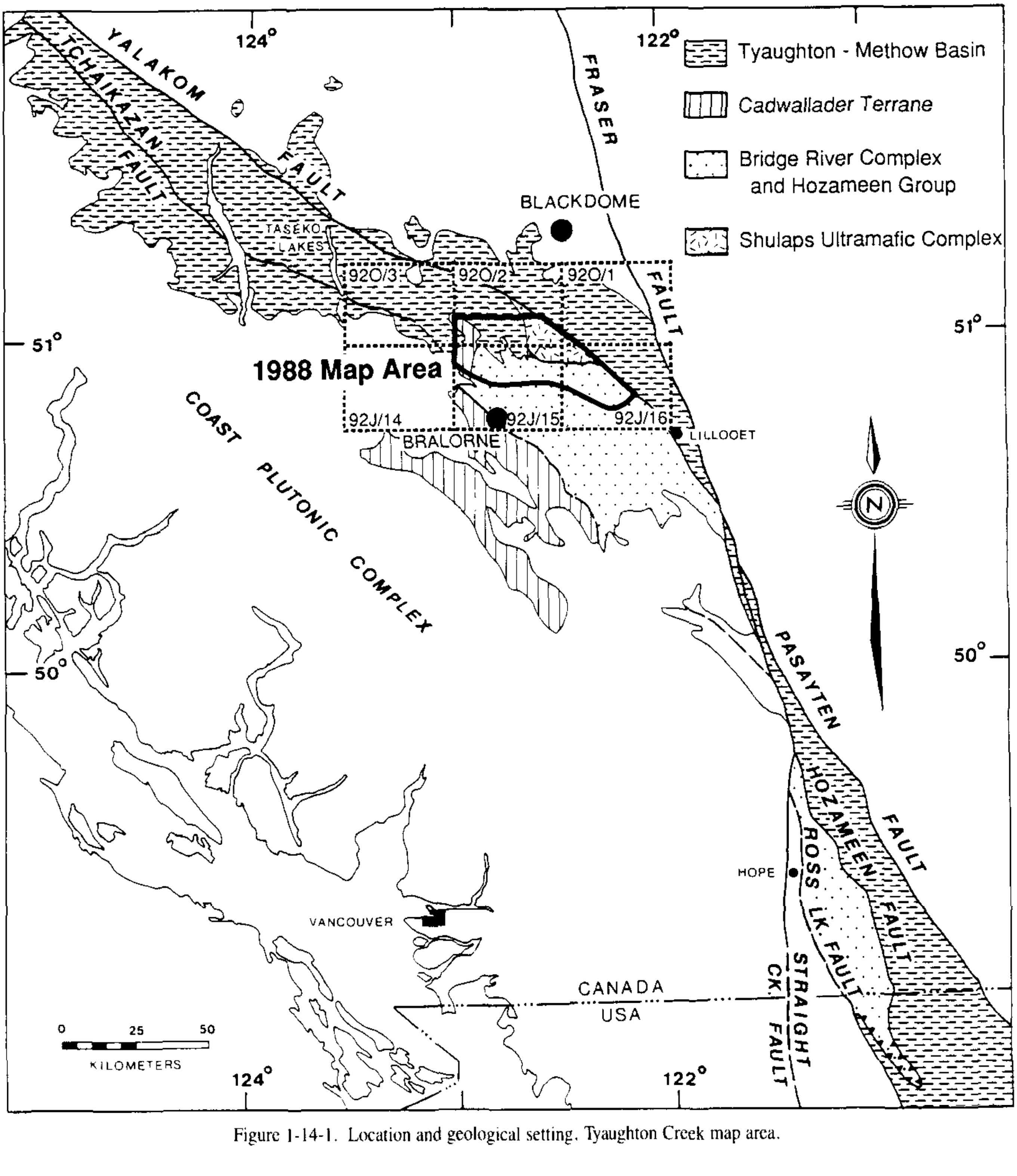

Figure 1-14-1. Location and geological setting, Tyaughton Creek map area.

Mesozoic rocks are offset about 80 kilometres from probable correlatives to the south, where the Hozameen Group and Methow basin correspond to the Bridge River complex and Tyaughton basin respectively. This offset is inferred to be the product of Eocene dextral movement along the north-trending Fraser–Straight Creek fault system (Monger, 1985). Late Cretaceous fragmentation of the belt occurred along northwest-trending dextral strike-slip faults associated with the Yalakom–Hozameen system. This faulting postdated mid-Cretaceous folding and thrusting. Still earlier deformation and metamorphism is recorded locally and may in part be related to the tectonic juxtaposition of the Cadwallader terrane and the Bridge River and Shulaps complexes.

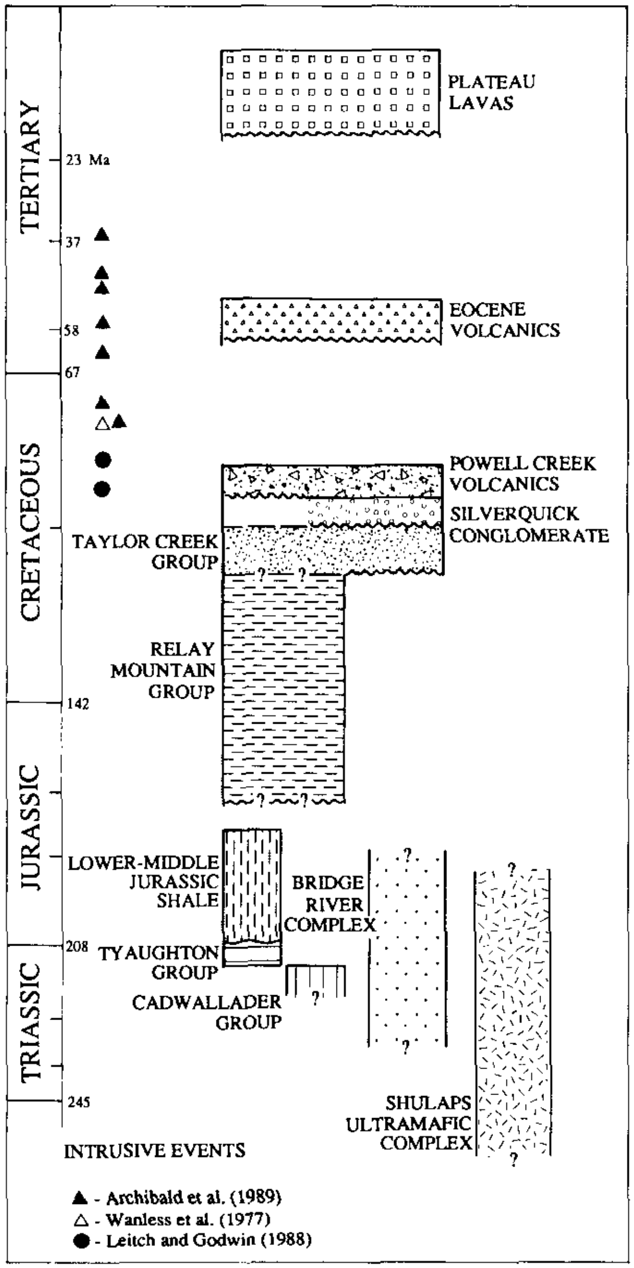

Figure 1-14-2. Tectonostratigraphic assemblages of the Tyaughton Creek map area.

LITHOLOGY

BRIDGE RIVER COMPLEX

The Bridge River complex includes variably metamorphosed and structurally imbricated chert, clastic rocks, limestone, mafic extrusive and intrusive rocks, and serpentinite. It underlies a large portion of the map area between the Shulaps Range and Carpenter Lake (Figure 1-14-3). These rocks were previously assigned to the Bridge River Series by Drysdale (1916) and McCann (1922); to the Bridge River Group by Roddick and Hutchison (1973); and to the Fergusson Series by Cairnes (1937, 1943). They include rocks assigned to the Fergusson Group by Church (1987) and Church *et al.* (1988a, 1988b). In agreement with earlier workers, we also include some greenstone units within the Bridge River complex that Church assigned to the Cadwallader Group. The term "complex" (after Potter, 1983, 1986) is preferred to "Group", because internal structural complexities prohibit measurement of a meaningful type section.

Bridge River rocks within most of the map area comprise prehnite-pumpellyite-grade chert and greenstone, together with lesser amounts of argillite, tuff, limestone, sandstone, conglomerate and gabbro; serpentinite is common along fault zones. Chert is in depositional contact with argillite, greenstone, tuff, limestone and clastic rocks; limestone and greenstone are also in depositional contact. The complex is characterized, however, by a high degree of internal disruption and brittle faulting so that lithologic contacts are commonly faults, and individual lithologic units are traceable for only short distances.

Bridge River chert is generally grey, but also includes red, brown and green varieties. It typically occurs in beds 1 to 10 centimetres thick separated by argillaceous partings, but also occurs as massive pods several metres thick, and as narrow lenses within black argillite. Greenstone is grey-green to chocolate-brown or purplish-brown-weathering metabasalt. It is commonly massive, but also includes pillowed varieties and pillow breccia. It is locally amygdaloidal, and contains rare phenocrysts of plagioclase or altered ferromagnesian minerals. Light grey limestone occurs locally throughout the complex, but is most common in the vicinity of Marshall Ridge. It occurs as thin lenticular beds intercalated in bedded chert; as podiform lenses ranging from a few centimetres to several tens of metres thick within greenstone; and as large olistolith blocks (Potter, 1983) within chert, argillite and coarser clastic rocks. Clastic rocks within the Bridge River complex include chert and volcanic-rich sandstones and chert-pebble conglomerates. These are a relatively minor component locally intercalated with chert and argillite over intervals ranging up to several tens of metres.

Medium to coarse-grained gabbroic rocks occur locally within the Bridge River complex, where they are typically associated with greenstone. At one locality along the Carpenter Lake road, 9 kilometres west of the east end of the lake, gabbro occurs as a sequence of steeply south-dipping sheeted dykes. Individual dykes typically display only one chilled margin, commonly their southern contact.

A distinctive assemblage of structurally interleaved blueschist, greenschist and metachert with thin limestone beds comprises the Bridge River complex near the headwaters of North Cinnabar Creek where it unconformably underlies the Taylor Creek Group; these rocks are described by Garver *et al.* (1989). This belt has been traced intermittently down to and across Tyaughton Lake for about 15 kilometres to the southeast. Blueschist also occurs within an adjacent fault panel at a single locality along Tyaughton Creek, about 7 kilometres east of Tyaughton Lake.

The Bridge River complex northeast of the Marshall Creek fault is represented mainly by phyllites and schists which were penetratively deformed under predominantly greenschist-facies metamorphic conditions. These rocks are structurally interleaved with serpentinite mélange and talc-serpentine-carbonate schist beneath the upper massive

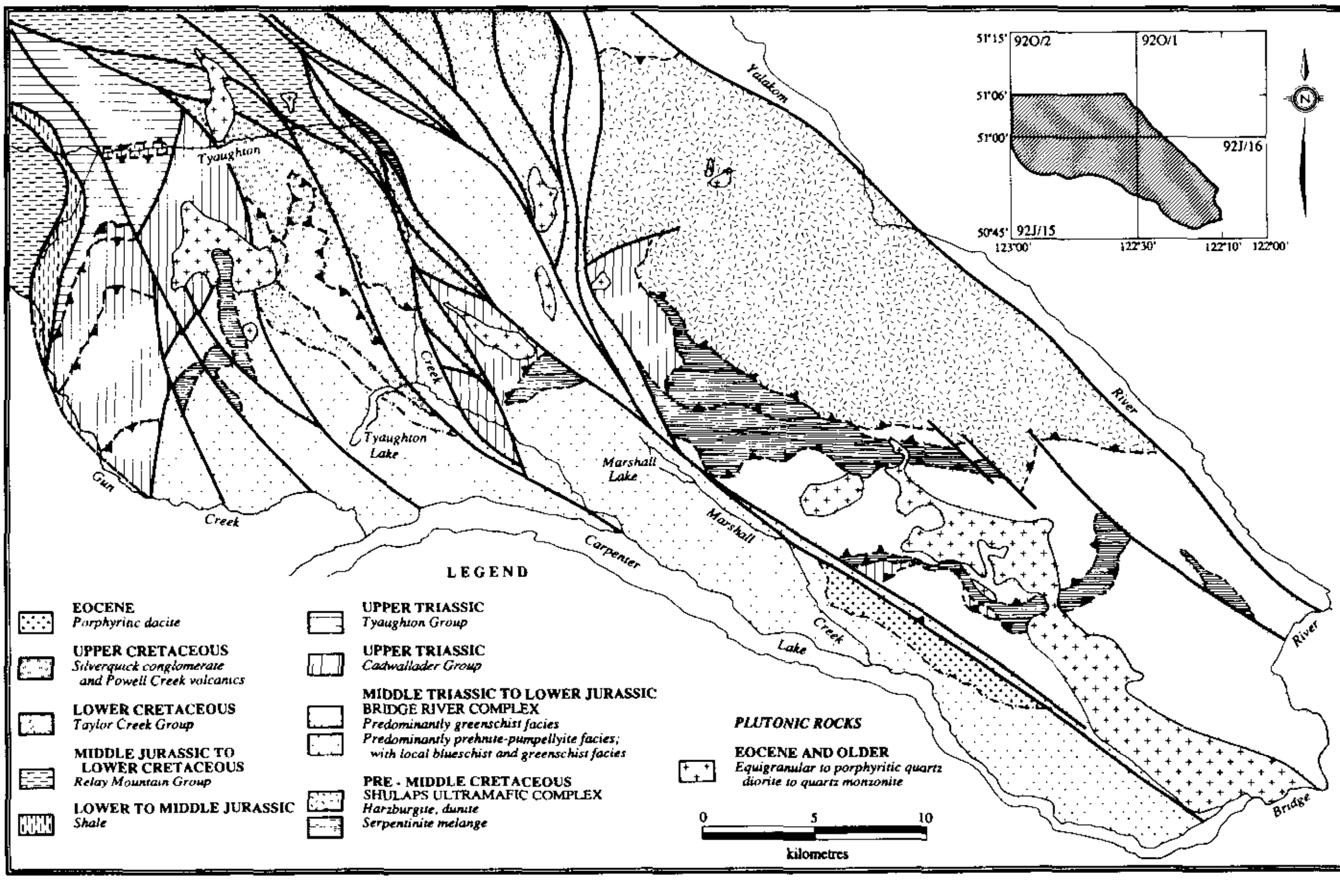

Figure 1-14-3. Generalized geology map, Tyaughton Creek area. Geology east of the Mission Ridge pluton after Potter (1983).

harzburgite unit of the Shulaps ultramafic complex. The most common lithologies are medium to dark grey phyllite, quartz phyllite and biotite-bearing schist derived from argillite and chert, and chloritic schist derived from mafic volcanic rock. These are locally intercalated with crudely foliated phyllosilicate-bearing metasandstone, marble, and chlorite-actinolite-carbonate schists probably derived from impure calcareous sediments. The penetrative cleavage within the phyllites and schists is commonly crenulated. Locally they are structurally imbricated with non-penetratively deformed lithologies similar to those which characterize the Bridge River complex elsewhere within the map area.

The age of the Bridge River complex is presently constrained by Late Triassic conodonts from a limestone pod near the mouth of Tyaughton Creek (Cameron and Monger, 1971), and by Middle Triassic to Early Jurassic radiolarians from twelve localities (seven of them along the Carpenter Lake road within the present map area) between Lillooet and Gold Bridge (Cordey, 1986). To the south correlative Hozameen Group contains Permian to Middle(?) Jurassic strata (R.A. Haugerud, *in* Monger and McMillan, 1984), suggesting that the Bridge River complex may span a wider time range than presently indicated. Preliminary radiometric dates on Bridge River blueschists range from Late Permian to Early Jurassic (Garver *et al.*, 1989); if the older dates are valid they provide evidence of a Paleozoic protolith within the complex. Samples collected during fieldwork are presently being processed for conodonts and radiolaria and may provide further age control.

SHULAPS ULTRAMAFIC COMPLEX

The Shulaps ultramafic complex outcrops in the Shulaps Range and covers the northeastern part of the map area (Figure 1-14-3). It is bounded by the Yalakom fault on the northeast and by Bridge River and Cadwallader Group rocks to the north, west and south. The complex was first studied in detail by Leech (1953), who concluded that it was an intrusive body, emplaced in Late Triassic or Early Jurassic time, and later redistributed, possibly by solid flow, to the west and northwest along fault zones. Later workers (Monger, 1977; Nagel, 1979; Wright *et al.*, 1982) suggested that the Shulaps and Bridge River complexes together constitute a dismembered ophiolite. Potter (1983, 1986) conducted detailed mapping along the southern margin of the complex; he concluded that it had been structurally emplaced while the ultramafic rocks were still hot, and had imparted a dynamothermal metamorphic aureole to underlying Bridge River rocks.

Mapping during the present study was concentrated along the margins of the Shulaps complex, although several traverses were made through the interior of the ultramafic massif. Our mapping was carried out in conjunction with detailed mapping within the complex in the Jim Creek–East Liza Creek area by T. Calon and D. Archibald, who collected samples for radiometric dating.

The Shulaps complex essentially comprises two parts. The structurally highest unit, which makes up the main body of the prominent ultramafic massif, consists of variably serpentinized harzburgite with lesser dunite. The second component consists of serpentinite containing knockers of various rock types, and is termed serpentinite mélange. It sits structurally beneath massive harzburgite along the southwestern margin of the complex, but pinches out within Bridge River rocks to the east. Serpentinite mélange also occurs at a lower structural level, where it is imbricated with Bridge River and Cadwallader Group rocks. It is only locally preserved along the western margin of the complex, where massive harzburgite is juxtaposed against predominantly prehnite-pumpellyite-grade Bridge River rocks across northerly trending faults which may be splays connecting the Marshall Creek and Yalakom fault zones.

Harzburgite within the main mass of the Shulaps complex is locally layered, with layering defined by centimetre-wide bands of orthopyroxenite, and trains of chromite. The layering is interpreted by T. Calon (personal communication, 1988) to be a mantle tectonite fabric. Dunite locally defines layering, but is more common as unoriented pods and lenses, some of which crosscut layering within the harzburgite. Calon suggests that this is indicative of a transitional upper mantle origin.

The upper serpentinite mélange, which locally attains a structural thickness approaching 1000 metres, contains blocks of ultramafic, gabbroic, volcanic and sedimentary rock. The largest knockers, up to hundreds of metres in size, derive from an igneous complex which includes layered ultramafic cumulates, layered gabbro and varitextured gabbro, all cut by swarms of mafic to intermediate dykes. Gabbro at the northwest end of the belt grades into a dyke complex which in turn grades into pillowed volcanic rocks. These volcanics sit structurally above Cadwallader Group rocks, whereas elsewhere in the belt the serpentinite mélange sits above the Bridge River complex.

T. Calon (personal communication, 1988) has noted a crude "knocker stratigraphy" within the serpentinite mélange, such that progressively lower structural levels are dominated by knockers derived from progressively higher structural levels within an ophiolite complex. Sedimentary and volcanic knockers occur from top to bottom of the unit. Most of these comprise Bridge River lithologies, but pebble conglomerates and finer clastic rocks of uncertain origin are also present; some may belong to the Cadwallader Group. The sedimentary and volcanic knockers presumably represent a sampling of the footwall succession across which the Shulaps complex was emplaced.

The structurally lower serpentinite mélange unit was traced from a point 7 kilometres southeast of Marshall Lake, where it is truncated by the Marshall Creek fault, for 10 kilometres to the east, where it is truncated by the Mission Ridge pluton. It apparently continues northeastward from the east margin of the pluton, where it was mapped by Potter (1983) as his "Eastern Imbricate Zone" (Figure 1-14-3). The serpentinite encloses knockers of ultramafic, gabbroic and dioritic rocks similar to those within the upper mélange unit. It is both overlain and underlain by Bridge River rocks, but in two areas is juxtaposed against lenses of Cadwallader Group conglomerates and sandstones along its lower contact. This unit is inferred to be a structural repetition of the upper serpentinite mélange; its occurrence at this lower structural level suggests that emplacement and imbrication of the Shulaps complex was a complex process involving some out-of-sequence thrusting and/or folding.

Serpentinite containing gabbroic, volcanic and sedimentary knockers also occurs 5 kilometres northwest of Marshall Lake and may comprise an offset portion of the Shulaps mélange. Serpentinite containing knockers of mainly Bridge River lithologies occurs within the Bridge River complex south of Eldorado Mountain, close to its contact with the Cadwallader Group (Garver *et al.*, 1989). The intimate association of Cadwallader and Bridge River rocks beneath the Shulaps serpentinite mélange suggests that the Eldorado mélange might be a structural repetition of the same zone. The correlation is consistent with the presence of ultramafic and gabbroic rocks, including the Early Permian Bralorne diorite (Leitch and Godwin, 1988), exposed in close association with both Bridge River and Cadwallader Group rocks south of the Eldorado area (Church *et al.*, 1988a, 1988b).

CADWALLADER GROUP

The Cadwallader Group comprises Upper Triassic sedimentary and volcanic rocks which outcrop in the Eldorado Mountain area, as well as within several fault panels farther to the east. 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 formation status by Roddick and Hutchison (1973), and included within the Cadwallader Group. Rusmore (1985, 1987) was the first to study the group in detail. She concluded that the Noel Formation is not a coherent unit and should be abandoned. Her revised stratigraphy, based on sections west of Eldorado Mountain, comprises 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 group was recognized. The Group was assigned 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) recognize the Pioneer and Hurley formations of Rusmore, but retain the name Noel Formation for black argillite and siltstone locally exposed south of the present study area. They also assign greenstone units to the Pioneer Formation which we, along with previous workers, include within the Bridge River complex. Further confusion as to the status of the Cadwallader Group arises from the fact that volcanic and sedimentary rocks assigned to the group in the Bralorne area are apparently intruded by the Early Permian Bralorne diorite (Leitch and Godwin, 1988).

The divisions of the Cadwallader Group recognized during the present study correspond to those of Rusmore (1985, 1987). The Pioneer Formation consists of green to purplish-weathering, commonly amygdaloidal, pillowed and massive greenstone, and greenstone breccia. The overlying Hurley Formation consists mainly of thin-bedded sandstone and siltstone turbidites, but commonly includes distinctive pebble to cobble conglomerates containing limestone, mafic to felsic volcanic and granitoid clasts. Formational contacts observed by Rusmore east of Eldorado Mountain vary from abrupt to gradational; the latter are marked by a transition zone of intercalated greenstone, bedded tuff, conglomerate, sandstone and minor micritic limestone. A similar gradational contact between the Pioneer and Hurley formations was observed along a northwest-trending ridge 4 kilometres northwest of Liza Lake. The contact between the two formations was not observed elsewhere.

The Cadwallader Group is exposed most extensively in the Eldorado Mountain area, where it occurs as a north-northeast-trending panel separated by faults from the Tyaughton Group to the west and the Bridge River complex to the east. Both Pioneer and Hurley formations also outcrop in Tyaughton Creek canyon, east of Tyaughton Lake, and along a northwest-trending ridge system to the north. In this area the group is juxtaposed against Bridge River complex and Cretaceous rocks across northwesterly trending faults that are splays of the Castle Pass and Relay Creek–Marshall Creek fault systems. The southeastern contact, however, is in part a northwest-dipping shear zone across which the Cadwallader Group apparently sits structurally above a belt of serpentinite mélange.

The Cadwallader Group is also exposed on the northeast side of the Marshall Creek fault where it is juxtaposed against the Shulaps complex and metamorphosed Bridge River rocks. Cadwallader rocks in this area were penetratively deformed under lower greenschist(?) facies metamorphic conditions; fine-grained sediments are typically cleaved and clasts in conglomerate are locally highly flattened. The most extensive exposures occur in the East Liza Creek area, where the Hurley Formation is structurally overlain, across a gently-dipping and locally folded thrust contact, by a pillowed volcanic-dyke-gabbro complex that comprises part of the upper serpentinite mélange. The Hurley Formation also occurs as two lenses structurally beneath the lower serpentinite mélange 10 kilometres southwest of Marshall Lake. These lenses in turn sit structurally above the Bridge River complex.

TYAUGHTON GROUP

The Tyaughton Group, of middle(?) to late Norian age, comprises fluvial to shallow-marine conglomerate, sandstone and limestone. It outcrops in the northwestern corner of the map area, where it occurs within a structurally complex panel on the north and south sides of Tyaughton Creek. The group is subdivided into five distinct units which are described by Glover *et al.* (1988) and Garver *et al.* (1989).

Clastic units within the Tyaughton Group contain mainly intermediate to felsic volcanic detritus. Contacts with the Cadwallader Group are everywhere faults, but the similarity in age and composition suggests that the two groups were originally a coherent sequence, deposited in or near a Late Triassic volcanic arc (Rusmore, 1987).

LOWER TO MIDDLE JURASSIC SHALE

An unnamed unit comprising dark grey calcareous shale together with brown sandstone, siltstone, and minor conglomerate is spatially associated with the Tyaughton Group. It is dated as upper Hettangian to lower Bajocian on the basis of a rich ammonite fauna (Tipper, 1978 and personal communication, 1987), and is inferred to have been deposited disconformably above the Tyaughton Group.

The shale unit outcrops most extensively in the vicinity of Spruce Lake, where it occupies a southeast to south-trending belt along the east side of the Tyaughton Creek fault. It also occurs within a structural window along Tyaughton Creek, and as a northwest-trending fault-bounded sliver within Relay Mountain Group rocks north of the creek, where its extent is too limited to be shown on the geological sketch map (Figure 1-14-3).

RELAY MOUNTAIN GROUP

The Relay Mountain Group comprises Jurassic to Cretaceous shallow-marine strata that are extensively exposed in a northwest-trending belt extending from the northwestern part of the present map area to Big Creek (Glover *et al.*, 1987, 1988b). They are described in detail by Jeletzky and Tipper (1968), who estimated a thickness of 1500 to 2700 metres in sections north of Relay Mountain. The group ranges in age from Callovian (latest Middle Jurassic) to Barremian (Early Cretaceous); detailed subdivisions by Jeletzky and Tipper are based on the rich bivalve and ammonite fauna.

The Relay Mountain Group consists of sandstone, shale and minor conglomerate. Within the map area it crops out in a belt on the west side of the Tyaughton Creek fault, and as several south-tapering fault-bounded wedges that terminate near Tyaughton and Relay creeks.

TAYLOR CREEK GROUP

The Taylor Creek Group, of Albian age, is represented within the study area by the chert-rich Dash conglomerate and conformably overlying shale and micaceous sandstone of the Lizard formation. In the Eldorado Mountain area these rocks sit unconformably above the Bridge River complex and are described by Garver *et al.* (1989). The same units occur as fault slivers along Tyaughton Creek, east and northeast of Eldorado Mountain. They also outcrop extensively in the Big Sheep Mountain area, where they occur within an array of south-tapering fault panels which extend southward from a wide synformal belt exposed between Relay and Lone Valley creeks (Glover *et al.*, 1988a, 1988b; *see* also Figure 1-14-4.)

SILVERQUICK CONGLOMERATE AND POWELL CREEK VOLCANICS

Upper Cretaceous rocks within the Tyaughton Creek area are represented mainly by the Silverquick conglomerate, comprising a lower unit of chert-pebble conglomerates and an overlying unit of interbedded chert-pebble conglomerate, volcanic-pebble to cobble conglomerate and andesitic breccia. These rocks outcrop in several fault panels east of Eldorado Mountain, and are described in more detail by Garver *et al.* (1989). Andesitic breccias and pyroxene-phyric flows of the overlying Powell Creek volcanics occur locally along the west slopes of Tyaughton Creek, due east of Eldorado Mountain. The two units are not separated on the accompanying sketch map (Figure 1-14-3).

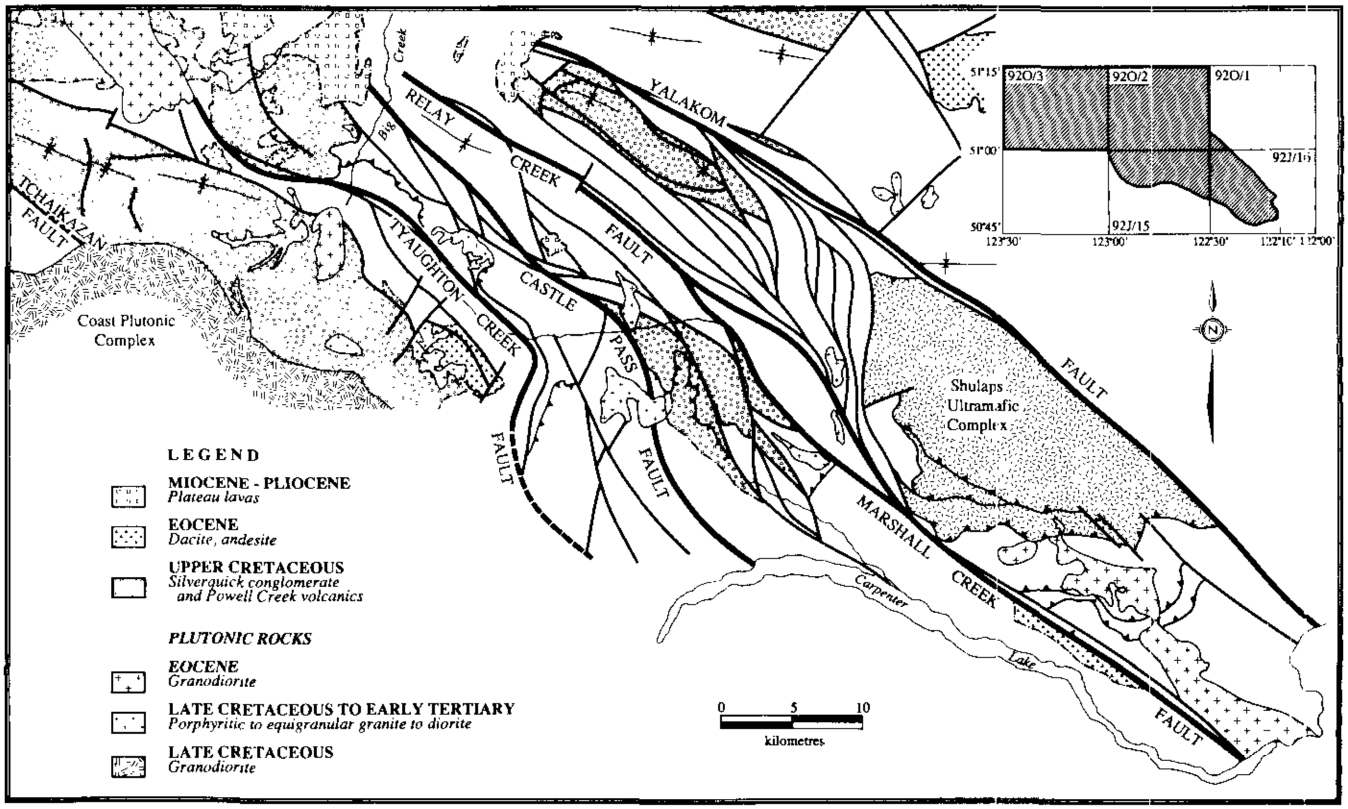

Figure 1-14-4. Major structures of the Taseko–Bridge River area and the distribution of Late Cretaceous and younger rock units.

EOCENE VOLCANIC AND SEDIMENTARY ROCKS

A conspicuous belt of light grey to buff-weathering volcanic flows and breccias outcrops on the slopes northeast of Carpenter Lake, southeast of Hog Creek. The volcanics comprise mainly hornblende, biotite, feldspar and quartz-phyric dacites. They are locally underlain by several tens of metres of conglomerate, sandstone and shale; narrow seams of lignite were reported within the sediments by McCann (1922). The sediments and volcanics dip at shallow to moderate angles northeastward. They sit unconformably above Bridge River rocks to the southwest, and are bounded to the northeast by the Marshall Creek fault. A small patch of similar volcanic rock sits unconformably above the Bridge River complex 2 kilometres north of Liza Lake.

An attempt to date the basal sediments northeast of Carpenter Lake by palynology was unsuccessful; the overlying volcanics were collected for potassium-argon radiometric dating but have not yet been dated. They are provisionally assigned an Eocene age on the basis of their compositional similarity to Eocene rocks elsewhere in the region.

MIOCENE PLATEAU LAVAS

Flat-lying basalt flows (not shown in Figure 1-14-3) cap Castle Peak and several adjacent ridges in the northwestern corner of the map area, where they unconformably overlie rocks of the Tyaughton and Relay Mountain groups. These outliers are erosional remnants of Miocene plateau basalts which cover much of the Chilcotin Plateau to the north (Tipper, 1978).

CRETACEOUS AND TERTIARY INTRUSIVE ROCKS

Intrusive rocks within the Tyaughton Creek area are represented by several mappable plutons and numerous dykes. They are mainly felsic to intermediate in composition, and vary from porphyritic to equigranular in texture. Although few of these rocks are dated within the map area, a similar suite of intrusive rocks to the north and northwest ranges in age from Late Cretaceous to Oligocene (Archibald *et al.*, 1989).

The largest intrusive unit is the Mission Ridge pluton, a markedly elongate body that extends northwesterly from the east end of Carpenter lake for 24 kilometres; it intrudes Bridge River schists and phyllites, as well as both upper and lower serpentinite mélange zones associated with the Shulaps ultramafic complex. The pluton consists mainly of biotite granodiorite in the southeast, but to the northwest passes into predominantly hornblende-biotite-quartz-feldspar porphyry comprising phenocrysts up to several millimetres in size within an aphanitic to fine-grained matrix. Similar porphyry makes up the Hog Creek stock, which intrudes Bridge River schists 1 kilometre west of the north end of the Mission Ridge pluton. Biotite from granodiorite of the Mission Ridge pluton has yielded a potassium-argon age of 44 Ma (Woodsworth, 1977). This date is identical to that recently obtained for two compositionally similar plutons within the Warner Pass map sheet to the northwest (Archibald *et al.*, 1989).

The Eldorado pluton consists of equigranular quartz diorite to granodiorite. It intrudes rocks of the Bridge River complex, the Cadwallader Group and the Taylor Creek Group in the west-central part of the map area, south and west of Eldorado Mountain. Biotite from this pluton has recently yielded a potassium-argon age of 63.7 Ma (K. Dawson, personal communication, 1987). This constrains the timing of movement on the Castle Pass fault which is crosscut by the pluton.

Most other intrusive bodies in the map area are undated hornblende-feldspar, quartz-feldspar, or hornblende-biotite-quartz-feldspar porphyries. These are commonly the locus of moderate to intense carbonate alteration. The Big Sheep Mountain porphyry is of particular interest as it hosts epithermal-style alteration and mineralization. The host porphyry is not yet dated, but sericite from an alteration zone has yielded a potassium-argon age of 27 Ma (Archibald *et al.*, 1989).

Dykes within the area are mainly porphyries with the same range in composition described in the previous paragraph. Dark grey lamprophyres occur locally. A hornblende plagioclase porphyry dyke from within the Yalakom fault zone in the northeastern corner of the area has recently yielded a potassium-argon age of 76 Ma (Archibald *et al.*, 1989). Dykes of similar compsition apparently predate some of the movement along the Shulaps serpentinite mélange, and a suite of hornblende porphyry dykes which intrudes the mélange zone caused local synkinematic metamorphism (Archibald *et al.*, 1989). These and related intrusives will be the subject of further radiometric dating.

STRUCTURE

OVERVIEW

The structure within the map area is dominated by steeply dipping northwest to northerly trending faults which comprise part of a regionally extensive dextral strike-slip system which was active in Late Cretaceous time. Tertiary deformation, probably related to dextral wrench-faulting along the Fraser fault system to the east, is reflected mainly in north to northeast-trending faults, dykes and extensional veins, but also involved predominantly dip-slip movement along earlier-formed northwest-trending structures.

Earlier structural events are recorded within structural blocks separated by major strands of the strike-slip system. Middle Cretaceous compressional deformation is documented in the Taylor Creek Group and younger rocks of the Eldorado Mountain area, where pre-Middle Cretaceous deformation and metamorphism of the underlying Bridge River complex is also recognized. Polyphase folding of the adjacent Cadwallader Group may also reflect mid-Cretaceous and older deformational events. Rocks within the Shulaps block record a complex history of deformation and metamorphism associated with emplacement of the Shulaps ultramafic complex over the Bridge River complex and Cadwallader Group. These events in part predate displacement on the bounding Marshall Creek–Yalakom fault system.

STRIKE-SLIP FAULTS

Figure 1-14-4 shows the main structures within the Warner Pass, Noaxe Creek, Bralorne and Bridge River map areas, as outlined by our past three summers' mapping. The structural pattern is dominated by steep northwest-trending faults inferred to comprise part of a Late Cretaceous dextral strike-slip system. Major through-going faults include, from northeast to southwest; the Yalakom fault, the Relay Creek–Marshall Creek fault system, the Castle Pass fault, the Tyaughton Creek fault and the Tchaikazan fault. Predominantly dextral strike-slip displacement along the system is indicated by kinematic indicators within the fault zones themselves, by the pattern and orientation of subsidiary faults and folds, and by local offset markers (Tipper, 1969; McLaren, 1986; Glover *et al.*, 1988a). Major offset along the Yalakom fault is indicated by the juxtaposition of the age-equivalent, but lithologically distinct Jackass Mountain and Taylor Creek groups; previous workers have postulated 80 to 190 kilometres of right-lateral displacement (Tipper, 1969; Kleinspehn, 1985).

The Yalakom, Tyaughton Creek and Tchaikazan faults cut volcanic and sedimentary rocks of inferred Cretaceous age. The Tchaikazan fault is apparently truncated by 87 Ma granodiorite (McMillan, 1976) of the Coast plutonic complex; the Castle Pass fault is plugged by the 64 Ma Eldorado pluton (Garver *et al.*, 1989); and the Yalakom fault zone is intruded by a 76 Ma hornblende plagioclase porphyry dyke which, although it has brecciated margins, is inferred to postdate major movement along the fault (Archibald *et al.*, 1989). These constraints collectively suggest that most of the movement on the fault system occurred in Late Cretaceous time.

The principal fault strands within the Tyaughton Creek map area are the Relay Creek–Marshall Creek system, the Castle Pass fault and the Tyaughton Creek fault. These are discussed individually in the following paragraphs.

THE RELAY CREEK–MARSHALL CREEK FAULT SYSTEM

The Relay Creek fault extends from Big Creek in the northeastern Warner Pass sheet to the north boundary of the Tyaughton Creek map area as a relatively simple fault which brings steeply dipping, northeast-facing Taylor Creek strata on the northeast against older, generally southwest-facing strata on the southwest. To the south, it bifurcates into two main strands which rejoin near Marshall Lake and continue southeastward as the Marshall Creek fault (Potter, 1983, 1986). These two strands bound a strongly imbricated lozenge of mainly Bridge River rocks, up to 4 kilometres wide, enclosed by younger units.

East of Big Sheep Mountain northerly trending faults which juxtapose the Shulaps complex, Bridge River complex, and Taylor Creek Group are apparently splays off the northern Relay Creek fault strand. These faults merge with the Yalakom system in the Quartz Mountain–Mud Lakes area. The main Relay Creek fault apparently merges with the Yalakom fault in the Big Creek area, 30 kilometres farther to the northwest (Tipper, 1978). The zone between these faults has the form of a large-scale extensional strike-slip duplex, as defined by Woodcock and Fischer (1986). A complex synformal structure defined in 1987 along the southwestern margin of the Yalakom fault, northeast of Relay Creek, may be a negative flower structure within this extensional zone (Figure 1-14-4).

To the southeast the Marshall Creek fault zone (Potter, 1983, 1986) comprises two main fault strands. The northeastern strand separates greenschist facies Bridge River complex, Cadwallader Group and serpentinite mélange on the northeast, from prehnite-pumpellyite-grade Bridge River rocks to the southwest. A parallel fault to the southwest juxtaposes the low-grade Bridge River assemblage against a package of similar Bridge River rocks unconformably overlain by Eocene(?) volcanics. Tertiary motion along this segment is therefore indicated. In the valley of Jones Creek, this Tertiary faulting apparently emplaced Bridge River rocks over the Eocene volcanics along a steep northeast-dipping reverse fault. The two strands apparently merge to the south, where the fault zone may cut the 44 Ma Mission Ridge pluton. Nevertheless, Late Cretaceous movement along the Marshall Creek fault zone is suspected because of its apparent continuation as the Relay Creek and Yalakom faults to the north. The Tertiary movement may represent remobilization of an older fault zone where earlier northwest-trending structures presented a favourable orientation for compressional structures generated during dextral motion along the Fraser fault system (Monger, 1985).

THE CASTLE PASS FAULT

The Castle Pass fault has been traced from the confluence of Graveyard and Big creeks in the Warner Pass map sheet, through the southwestern corner of the Noaxe Creek sheet, to the north shore of Carpenter Lake in the Bralorne sheet. North of the Tyaughton Creek map area it forms the northeastern boundary of the Tyaughton Group. From Tyaughton Creek to the head of Taylor Creek it truncates the Cadwallader Group and the north-northeast-trending fault systems which separate the Cadwallader from the Tyaughton Group on the west and the Bridge River complex to the east. These rocks and structures are juxtaposed against the Taylor Creek Group and Silverquick conglomerate which outcrop east of the Castle Pass fault. Farther south, the Castle Pass fault separates lithologically distinct packages of Bridge River rocks, as described by Garver *et al.* (1989).

The Castle Pass fault is crosscut by the Eldorado pluton south of Eldorado Mountain. Biotite from this pluton has yielded a potassium-argon age of 63.7 Ma (K. Dawson, personal communication, 1987). Movement on the fault must therefore have occurred in the Late Cretaceous, because the fault cuts mid-Cretaceous rocks as well as structures which deform them (Garver *et al.*, 1989).

THE TYAUGHTON CREEK FAULT

This fault extends in a southeasterly direction from Lorna Lake to Tyaughton Creek (Glover *et al.*, 1987, 1988b), then bends to the south through Spruce Lake to Gun Creek, where it separates the Relay Mountain Group from the Lower to Middle Jurasic shale unit to the east. From there it may be continuous with a southeasterly trending system of faults mapped by Church *et al.* (1988b) along Gun Creek. Within the Warner Pass map sheet, offset of an isolated klippe of Tyaughton Group rocks from the main outcrop mass of the group, as well as of an earlier northeast-trending fault, suggests that the Tyaughton Creek fault has been the locus of 8 to 10 kilometres of right-lateral strike-slip movement (Glover *et al.*, 1988a).

The pronounced bend of the Tyaughton Creek fault at Spruce Lake is part of a regional pattern; all faults of the strike-slip system between there and the Yalakom fault display a Z-shaped sygmoidal deflection (Figure 1-14-4). The locus and orientation of this deflection appears to be controlled by the major step in the Marshall Creek system where it bounds the western margin of the Shulaps ultramafic complex and becomes part of the Yalakom system along the southeast margin of the the Relay-Yalakom duplex.

STRUCTURES IN THE ELDORADO MOUNTAIN AREA

The structure of the Eldorado Mountain area is described by Garver *et al.* (1989) and is summarized here. Middle Cretaceous deformation is documented on the east side of the Castle Pass strike-slip fault, where rocks of the Taylor Creek Group and Silverquick conglomerate occur in an overturned panel that formed during northeast-directed folding and associated thrust faulting. The overturned panel, which is cut by the Castle Pass fault, also includes rocks of the Bridge River complex which sit unconformably beneath the Taylor Creek Group. Pre-Middle Cretaceous deformation is indicated by schistosity within Bridge River rocks, which formed under blueschist to greenschist-facies metamorphic conditions. Blueschist, greenschist and prehnite-pumpellyite-grade Bridge River rocks are structurally imbricated beneath the unconformity, and also occur as clasts within the overlying Taylor Creek Group. The imbrication of different metamorphic facies within the Bridge River complex may also have been a pre-Middle Cretaceous event, but may have occurred in conjunction with deposition of the synorogenic Taylor Creek Group.

Polyphase deformation is also documented west of the Castle Pass fault, where Rusmore (1985, 1987) identified two phases of deformation within the Cadwallader Group. The first phase produced upright, northeast-trending folds and associated steep faults; the second phase produced northward-verging folds and thrust faults. The latter event is tentatively correlated with the Middle Cretaceous compressional deformation indicated by the overturned Taylor Creek Group and Silverquick conglomerate east of the Castle Pass fault. The earlier structures are oriented approximately parallel to the systems of faults which bound the Cadwallader Group and separate it from the Bridge River complex to the east and the Tyaughton Group to the west. These structures may be related to pre-Middle-Cretaceous tectonic juxtaposition of the Cadwallader Group and Bridge River complex.

STRUCTURES WITHIN THE MARSHALL RIDGE BLOCK

The Marshall Ridge block comprises Bridge River rocks exposed between the Marshall Creek fault and Carpenter Lake in the southern part of the area, together with imbricated Bridge River, Cadwallader, and Cretaceous rocks along trend to the northwest. Bridge River rocks within this block are predominantly prehnite-pumpellyite grade, and are typically pervaded by outcrop-scale brittle faults and folds. The combined effect of these, and larger scale structures, is to produce a complex array of lenticular blocks which generally prohibits the tracing of individual lithologic units, or even packages of units, for more than a few hundred metres. The structures are highly variable in orientation, but show a preferred northwesterly to northerly trend, parallel to the overall structural grain as defined by the major strands of the Late Cretaceous strike-slip system. This suggests that the fault-induced lenticularity of the Bridge River complex is at least in part a product of Late Cretaceous and younger(?) deformation; this is corroborated by similar complex juxtapositions of lenticular wedges of Cretaceous rocks within the northern part of the Marshall Ridge block. Nevertheless, because this lenticularity characterizes the Bridge River complex throughout the area, even where younger rocks comprise stratigraphically coherent packages, it is probable that in part it records an earlier history of deformation. The presence of blueschists in the Eldorado Mountain block, and at one locality within the Marshall Ridge block, suggests that at least some of this deformation may have occurred within a subduction zone.

The northern part of the Marshall Ridge block is underlain by imbricated Bridge River, Cadwallader and Cretaceous rocks, which occur within a structurally complex zone cut by numerous splays of the Relay Creek–Marshall Creek fault zone, and bounded to the west by a major splay of the Castle Pass fault. The structural imbrication is mainly across steeply-dipping northwest to northerly trending faults which comprise part of the strike-slip system. Gently dipping thrust(?) faults were observed locally and place either Bridge River complex above Cretaceous rocks or Cretaceous rocks above Bridge River complex. These faults are mid-Cretaceous or younger in age; most are thought to be related to the strike-slip faulting, but some may be relicts of the earlier, mid-Cretaceous compressional event.

STRUCTURES WITHIN THE SHULAPS BLOCK

The Shulaps block consists of rocks of the Shulaps ultramafic complex, the Bridge River complex and the Cadwallader Group which are exposed northeast of the Marshall Creek fault and its northerly trending splays east of Big Sheep Mountain. Harzburgite and associated dunite, comprising the main Shulaps massif, sit structurally above serpentinite mélange imbricated with the Bridge River complex and Cadwallader Group.

Rocks within the serpentinite mélange, the Bridge River complex and the Cadwallader Group were penetratively deformed under predominantly greenschist-facies metamorphic conditions. The penetrative fabric commonly observed within metasedimentary and metavolcanic rocks varies from a schistosity to a slaty cleavage. It dips at moderate to high angles to the north or northwest, and is axial planar to east or west-plunging mesoscopic folds. It is locally crenulated and folded about upright folds which are approximately coaxial with the earlier ones. Mylonite occurs locally along Cadwallader and Bridge River contacts with the mélange, and as small knockers within it. Serpentinite commonly displays a penetrative, steeply north-dipping schistosity cut by discrete, more gently north-dipping slip-surfaces spaced several millimetres to several centimetres apart.

The contacts between major lithologic units within the Shulaps block dip mainly north to northeast, in approximate conformity with foliation, and are inferred to be thrust faults. One of these, the contact between the Cadwallader Group and an overlying greenstone-gabbro complex associated with the serpentinite mélange, is exposed north of Marshall Lake. It generally dips gently but is deformed by upright folds; slaty cleavage in the underlying metasediments is axial planar to these folds. The contact itself is marked by a narrow mylonitic zone which is largely obscured by the later slaty cleavage. The contact between Bridge River schists and underlying serpentinite mélange is also folded where it was observed 1 kilometre southwest of Rex Peak. The contact is marked by a mylonitic fabric which appears to grade upward into the schistosity in the overlying schists. It is folded about upright, gently east-plunging, south-verging asymmetric folds; schistosity in talc-serpentine-magnesite schist beneath the contact is axial planar to these folds.

Structures preserved within the Shulaps block record the imbrication and emplacement of the Shulaps ultramafic complex above rocks of the Bridge River complex and Cadwallader Group. Folding of earlier thrust contacts and the presence of polyphase mesoscopic fabrics attest to a complex history of deformation and metamorphism. Synkinematic metamorphism and cleavage development were apparently synchronous with some thrust contacts, but are associated with folds which deform other thrust contacts. Some of the metamorphism, which transformed serpentinite to talc-serpentine-magnesite schists with regenerated olivine porphyroblasts, is of local extent and clearly associated with a suite of intermediate hornblende porphyry intrusives; it is in part synchronous with late folding which deforms an earlier thrust contact and associated penetrative schistosity. Repetition of the serpentinite mélange unit may also be related to relatively late folding and/or thrusting.

The timing of deformation and metamorphism within the Shulaps block is not well constrained. It in part predates displacement on the Marshall Creek fault and associated northerly trending splays, because they separate blocks of contrasting metamorphic grade; these faults were the locus of Tertiary and possibly Late Cretaceus movement. Final cooling after the latest thermal-structural events may be constrained by a preliminary ^{40}Ar-^{39}Ar radiometric date of 73 Ma on hornblende from a metadiabase knocker within the upper serpentinite mélange (Archibald *et al.*, 1989). This event may have been synchronous with strike-slip faulting. The age of the Shulaps complex and its emplacement history are the focus of a radiometric dating program presently in progress.

MINERAL OCCURRENCES

OVERVIEW

The map area straddles the northern part of the Bridge River mining camp, which remains British Columbia's foremost historical gold producer. Most of the gold was produced from mesothermal veins south of the present map area, although important production also came from the Minto and Congress mines along the southern boundary of the area. Mineral occurrences within the map area comprise a variety of vein types, most of them auriferous, together with cinnabar disseminations along major strike-slip faults. In addition, disseminated chalcopyrite occurs locally within mafic dykes of the Shulaps ultramafic complex, and jade and magnesite prospects are associated with altered ultramafic rocks within the Shulaps complex and elsewhere.

Many of the mineral occurences in the area show a clear spatial relationship to plutons or dyke swarms. The available data indicate that igneous intrusion and mineralization within the region spanned a considerable time range between the early Late Cretaceous and Oligocene (McMillan, 1976; Woodsworth *et al.*, 1977; Leitch and Godwin, 1988; Archibald *et al.*, 1989). The major strike-slip faults which cut the area also exert an important control on mineralization. In places the faults are older than and/or contemporaneous with mineralization and have acted to localize metal concentrations. Elsewhere, faults may have played a role in juxtaposing mineral occurrences that were apparently deposited at different structural levels.

A regional metal zoning pattern recognized by Woodsworth *et al.* (1977) comprises, from southwest to northeast, overlapping zones of predominantly gold, antimony and mercury mineralization. The map area coincides with the periphery of the gold zone, much of the antimony zone, and all of the mercury zone. This zonation is in part expressed by a general easterly progression from mesothermal to epithermal mineralization within the Bridge River mining camp. 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.

Metal zonations peripheral to individual plutons do not conform with the regional metal distribution of Woodsworth *et al.* (1977), and stand out as general inconsistancies in the proposed regional metal zonation framework. Local juxtaposition of metal deposits representative of different crustal levels and temperature regimes is also inconsistent with this regional zonation. For example: the Apex mercury prospect within the Yalakom fault is adjacent to the Poison Mountain porphyry copper-molybdenum deposit (Glover *et al.*, 1988); the Elizabeth-Yalakom mesothermal vein prospect is juxtaposed with the Big Sheep Mountain epithermal prospect; and the Wayside mine (mesothermal) is juxtaposed with the Howard and Lou prospects (stibnite veins). These inconsistencies reflect some combination of multiple mineralizing events followed by differential uplift across major structures.

Mineral occurrences are classified according to dominant metallic minerals and the textures and structures of metal concentrations. Their locations are plotted in Figure 1-14-5.

PORPHYRY COPPER-MOLYBDENUM

At the Yalakom prospect, minor chalcopyrite and molybdenite occur as disseminations and in quartz veinlets within carbonate and silica-altered granodiorite of the Mission Ridge pluton. This is the only porphyry-type mineralization presently known in the map area. The 44 Ma date from the Mission Ridge pluton indicates that the mineralization is Eocene or younger in age.

LOW-SULPHIDE GOLD-QUARTZ VEINS

Most of the gold produced in the Bridge River mining camp was from quartz veins that contain only a few per cent sulphide minerals. These veins occupy tension fractures or sheared zones within diorite and greenstone at the Bralorne-Pioneer and Wayside mines south of the map area (Church, 1987; Leitch and Godwin, 1988). Vein quartz is milky and contains a variable amount of calcite, ankerite and disseminated metallic minerals. Much of the quartz is ribboned with laminations and stylolitic partings of chlorite-sericite and inclusions of carbonate-sericite-mariposite-altered wallrock. Metallic minerals are mostly pyrite and arsenopyrite, with lesser sphalerite, galena, pyrrhotite, chalcopyrite, tetrahedrite, stibnite, scheelite, marcasite, molybdenite, native gold and gold tellurides. Sulphide concentrations and native gold tend to coincide along ribboned structures, although both are also within vein quartz. The ratio of gold to silver is generally between 4 and 8:1.

Auriferous veins of the Elizabeth-Yalakom prospect are also of this type. The veins occupy north-trending shears in porphyritic quartz diorite within the central part of the Shulaps ultramafic complex. The diorite is crosscut by various aplitic to porphritic dykes; those observed, however, are not spatially coincident with the auriferous veins. The age of the host diorite intrusion is not known, but it postdates the surrounding ultramafic rocks (of unknown age) as shown by the hydrothermally altered contact zone (Gaba *et al.*, 1988).

HIGH-SULPHIDE AURIFEROUS VEINS (PLUTON-ASSOCIATED)

Veins composed dominantly of arsenopyrite and pyrite, with lesser sphalerite, chalcopyrite, jamesonite, pyrrhotite and only minor quartz occupy shears that may be radial extension fractures peripheral to the 64 Ma Eldorado pluton. A local metal zonation about the pluton is represented by the abundance of arsenopyrite in veins closest to the contact (Pearson, Lucky Jem, Northern Lights 1 and 6) and by base metal sulphide and sulphosalt minerals in veins farther from the pluton (Robson, Lucky Strike).

Gold-bearing veins are also locally associated with the 44 Ma Mission Ridge pluton. These are being actively explored at the Spokane prospect, where pyrite, pyrrhotite and chalcopyrite occur within quartz veins cutting both country rock and intrusive phases along the southwestern margin of the pluton.

SKARNS

The Wide West prospect is a pyrrhotite and minor chalcopyrite skarn within limestone of the Bridge River complex along the margin of the Eldorado pluton. Minor gold is associated with the sulphide concentrations.

SCHEELITE-STIBNITE VEINS

The Tungsten King and Tungsten Queen prospects are located along a major strand of the Relay Creek–Marshall Creek fault system. Here, scheelite-stibnite veins occupy branched fractures within pervasively carbonate and silica-altered ultramafic rocks consisting of chalcedonic quartz, ankerite, mariposite and relict serpentinite. The veins are up to 8 centimetres thick 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 (Stephenson, 1941). There are no obvious alteration selvages

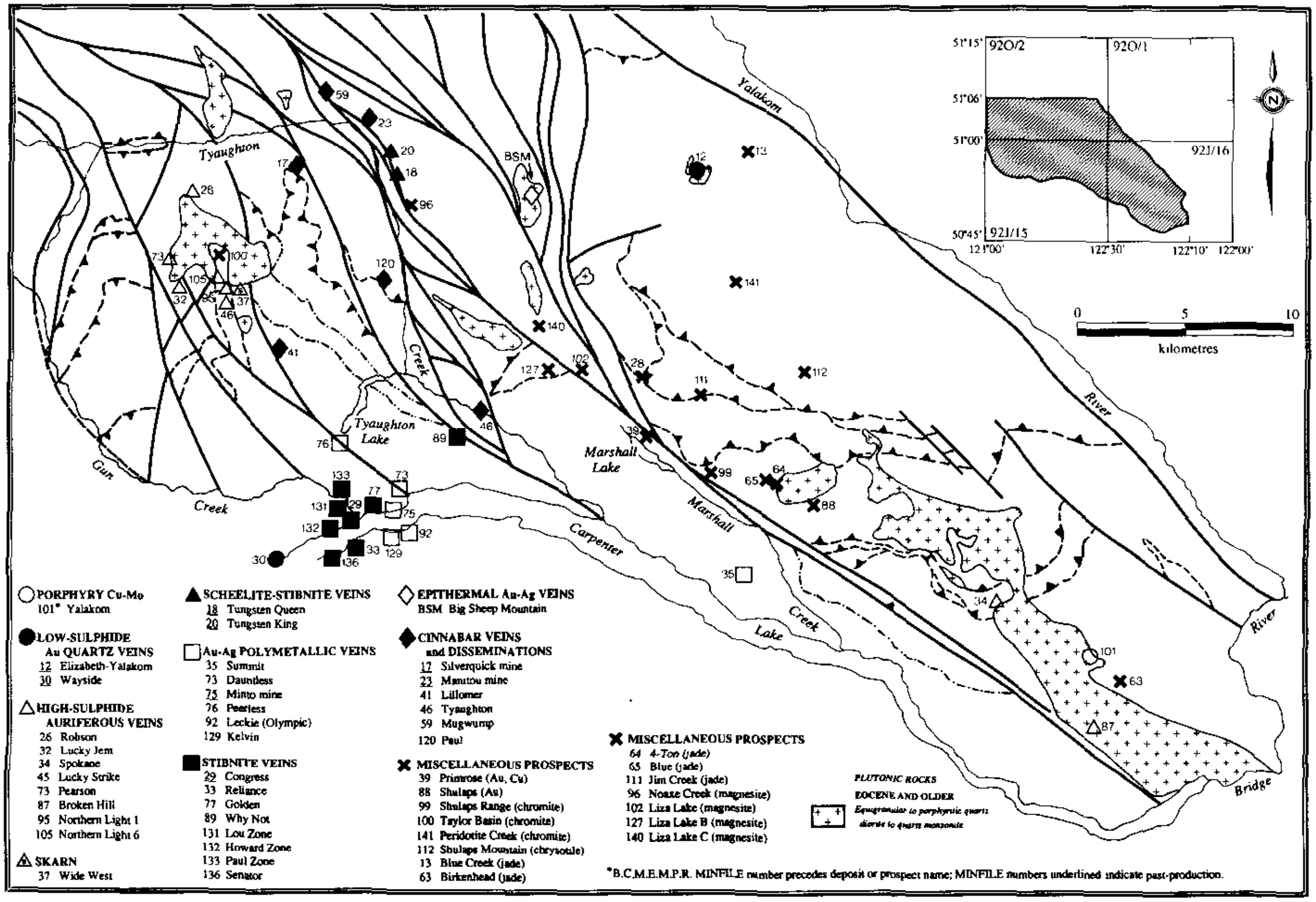

Figure 1-14-5. Mineral occurrences, Tyaughton Creek map area.

along vein margins. Feldspar porphyry dykes parallel the fabric of the altered serpentinite, but are not adjacent to the veins and their participation in mineralization processes is not proven. Diamond drilling on the Tungsten Queen prospect (Sadlier-Brown and Nevin, 1977) sampled scheelite and stibnite concentrations with up to 480 ppb gold within altered ultramafic rocks. These rocks also contain up to 133 ppm arsenic and 17 ppm mercury (Glover *et al.*, 1988b).

Scheelite is typically indicative of a high-temperature hydrothermal environment. The symmetric mineral banding, the comb-textured quartz, and the nature of the branched fractures the veins occupy together suggest a moderate to high-level environment of emplacement. The apparent absence of alteration adjacent to the veins may indicate that metal deposition was coincident with alteration of the serpentinite; the latest and lowest temperature phase (stibnite) occupies the cores to the veins. Cinnabar, reported as minor disseminations in foliated greenstone within 150 metres of scheelite-stibnite veins at the Tungsten Queen prospect (Stephenson, 1941), may be related to a later higher level, lower temperature hydrothermal overprint.

GOLD-SILVER POLYMETALLIC VEINS

Polymetallic veins containing gold and silver occur mainly between Tyaughton and Carpenter lakes, close to the inferred trace of the Castle Pass fault. The Minto vein is by far the largest and the only one to yield economic quantities of metals, namely gold, silver, copper and lead.

The veins occupy shears within foliated greenstone, argillite, chert and serpentinite of the Bridge River complex; they are commonly associated with feldspar porphyry and aplite dykes. Veins contain coarsely crystalline arsenopyrite, pyrite, sphalerite, galena and chalcopyrite together with accessory tetrahedrite, jamesonite, pyrrhotite and bornite. The veins are complex and multiphase; banding is defined by alternating metallic mineral concentrations and quartz-ankerite gangue. Brecciated veins are commonly richer in precious metals. Wallrock alteration is characterized by rare to abundant ankerite and calcite, with lesser sericite, chlorite and mariposite. Gold is closely associated with arsenopyrite; only rarely is gold present as native metal. The ratio of gold to silver is generally between 0.1 and 0.3:1. The close spatial association of veins and dykes suggests a possible genetic relationship. This is probably the case at least for the Minto vein, since it parallels the margin of the "Minto dyke" which is apparently auriferous (J. Miller-Tait, personal communication, 1988).

STIBNITE VEINS

A cluster of stibnite veins cuts Bridge River rocks directly west of the polymetallic veins described in the preceding section. These veins occupy shears within foliated greenstone, and less commonly within sedimentary rocks and gabbro. Feldspar-porphyritic dykes both parallel and crosscut vein structures; dykes range from unaltered to completely altered. Veins consist of quartz, ankerite and stibnite, with lesser pyrite and arsenopyrite. They are discontinuously banded with comb-textured vuggy quartz and are commonly brecciated and discontinuous. Stibnite, pyrite and arsenopyrite are accompanied by sphalerite, tetrahedrite, limonite, marcasite, and cinnabar as irregular and lenticular concentrations that partly replace carbonate-altered wallrock and adjacent dyke rock. Wallrocks are altered for as much as 5 metres away from veins; arsenopyrite and associated gold concentrations are most abundant within these alteration envelopes. The ratio of gold to silver is variable.

Some stibnite veins, such as those at the Congress mine and Golden and Senator prospects, contain an appreciable amount of arsenopyrite and associated gold. Recent discoveries of auriferous stibnite veins are the Howard, Lou and Paul prospects. Veins at the Lou prospect are much like those at the Congress mine. At the Howard and Paul prospects, the veins contain much more arsenopyrite and pyrite. Generally gold is intimately associated with arsenopyrite and metallurgical problems arise in their separation. However, within the upper level drift at the Howard prospect, banded and brecciated, granular, locally vuggy and comb-textured quartz-carbonate veins (with disseminated stibnite and arsenopyrite) locally contain abundant visible gold. Vertical metal zonation is apparent within orebodies at the Congress mine; cinnabar locally accompanies stibnite in the upper levels, whereas with depth, the abundance of pyrite, arsenopyrite and gold increases relative to stibnite (Cairnes, 1937).

EPITHERMAL GOLD-SILVER VEINS

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 argillic-altered feldspar and quartz-porphyritic rhyolite that caps a feldspar porphyry pluton (Dawson, 1982). Disseminated pyrite and pyrrhotite are widespread throughout the pluton. Rare amethyst veinlets are reported in altered rhyolite. The limited data regarding the style of mineralization at Big Sheep Mountain suggests a high level or epithermal environment. Epithermal mineralization in the region is best represented by the Blackdome deposit, 35 kilometres to the northeast (Vivian *et al.*, 1987).

CINNABAR VEINS AND DISSEMINATIONS

Cinnabar occurs as thin fracture-coatings and disseminations in sheared Bridge River and Cretaceous rocks along several strands of the Relay Creek and Castle Pass fault systems. At the Mugwump prospect, cinnabar is in calcite-quartz-pyrite veinlets that contain accessory stibnite. Wallrock alteration is characterized by abundant quartz, carbonate and pyrite, and less common hematite, limonite and dickite. Dyke rocks are not spatially associated with cinnabar mineralization.

Cinnabar mineralization at the Mugwump and Manitou showings occurs along a major strand of the Relay Creek fault system. Farther to the southeast, the fault is occupied by lenticular bodies of quartz-ankerite-calcite-mariposite-magnesite-serpentinite rocks which, at the Tungsten Queen and Tungsten King showings, contain scheelite-stibnite veins that locally carry gold values. The association of cinnabar, stibnite, scheelite, and gold with carbonate and silica-altered ultramafic rocks within and adjacent to a major steeply dipping fault is thought to be a near-surface expression of a Mother Lode type gold deposit (Albino, 1988; Musial, 1988). These observations and comparisons suggest that there may be potential for precious metal mineralization along the Relay Creek–Marshall Creek fault system.

SUMMARY

Much of the Tyaughton Creek map area is underlain by partially coeval rocks of the Bridge River complex, the Cadwallader Group, and the Shulaps ultramafic complex. This report documents the lithological characteristics and distribution of these units, and the nature of the structures which separate them. It also describes elements of an important Late Cretaceous fault system which were traced into the area from the north and west, and provides further information on the structural and stratigraphic relationships of mid-Cretaceous rocks within the region. The results of the study are summarized as follows:

(1) The Bridge River complex comprises structurally imbricated chert, greenstone, limestone, clastic rocks, gabbro and serpentinite; it is at least in part Middle Triassic to Early Jurasic in age. Gabbro occurs locally as sheeted dykes, corroborating the oceanic origin suggested by the predominant lithologies. The local importance of clastic rocks, limestone beds and limestone olistoliths suggests derivation from a topographically diverse basin or basins, as was pointed out by Potter (1983, 1986), who suggested a back-arc or marginal ocean basin setting. Most of the complex is at prehnite-pumpellyite metamorphic grade and is characterized by pervasive brittle faulting. Pre-Middle Cretaceous blueschist-facies metamorphism is documented in the Eldorado Mountain area, and suggests that deformation and metamorphism in part occurred in a subduction zone. Predominantly greenschist-facies metamorphism characterises the Bridge River complex where it is structurally imbricated with the Shulaps ultramafic complex.

(2) The Cadwallader Group comprises pillowed and massive greenstone of the Pioneer Formation and overlying conglomerate, sandstone and shale of the Hurley Formation. It is Late Triassic in age and therefore coeval with parts of the Bridge River complex. In the Eldorado Mountain area it is juxtaposed against the Bridge River complex across north-northeast-trending faults that predate the Castle Pass strike-slip fault and may also predate mid-Cretaceous compressional structures. In the Shulaps Range it is penetratively deformed, metamorphosed, and thrust-imbricated with rocks of the Bridge River complex and Shulaps ultramafic complex.

(3) The Shulaps ultramafic complex includes a harzburgite unit with a mantle tectonite fabric, together with structurally underlying serpentinite mélange which contains elements of the ultramafic cummulate to volcanic section

of an ophiolite assemblage. The serpentinite mélange is thrust-imbricated with rocks of the Bridge River complex and Cadwallader Group. Structures preserved within this thrust zone suggest a complex history of deformation and metamorphism that in part predates movement on the bounding Marshall Creek fault zone. Final uplift and cooling, however, may have been coincident with Late Cretaceous strike-slip faulting on the Yalakom–Marshall Creek system.

(4) The tectonic juxtaposition of the Shulaps ultramafic complex, the Bridge River Complex and the Cadwallader Group represents an important event in the accretionary history of the western Cordillera. Several lines of indirect evidence suggest that the initial juxtaposition occurred in Middle Jurassic time (Potter, 1986; Rusmore, 1987; Umhoefer *et al.*, 1988; Rusmore *et al.*, 1988). The preliminary results of our 1988 mapping program provide only a pre-Middle Cretaceous age for this event; dating presently in progress may provide further constraints.

(5) Deposition of the late Early Cretaceous Taylor Creek Group was coincident with the onset of regional compressional tectonism. Clasts within the Taylor Creek Group provide the first evidence of uplift and erosion of the Bridge River complex, while clasts in the overlying Silverquick conglomerate were derived from both the Bridge River complex and Cadwallader Group. Furthermore, the Taylor Creek Group is the oldest unit within the Tyaughton basin documented to sit unconformably above Bridge River basement. This suggests the possibility that thrust imbrication (and accretion?) of the Bridge River and Cadwallader terranes was predominantly a late Early Cretaceous event.

(6) The map area is cut by a northwest-trending system of dextral strike-slip faults that was active in Late Cretaceous time. Northerly trending splays of the Relay Creek–Marshall Creek fault system connect with the Yalakom fault system to define a large-scale extensional duplex structure. This fault system steps across and bounds the northwestern margin of the Shulaps ultramafic complex at its southeastern end. In contrast to the extensional zone to the northwest, the Shulaps complex may have been deformed and uplifted during Late Cretaceous movement on the bounding strike-slip fault systems.

(7) Metallic mineral concentrations are within or adjacent to strike-slip faults or associated structures, and have a close spatial relationship with plutons or dykes. The age of mineralization seems closely tied to igneous activity between Late Cretaceous and Early Tertiary time. The protracted history of mineralization and plutonism combined with differential uplift across faults has led to the juxtaposition of deposits of contrasting structural level and local inconsistencies in the pattern of regional metal zoning documented by Woodsworth *et al.* (1977).

ACKNOWLEDGMENTS

The authors would like to thank Peter Sajgalik, Teresa Lynch, Kim Safton, Paul Umhoefer, Doug Archibald and Tom Calon for their mapping contributions and good company while in the field. We are grateful to C.J. Potter for showing us through parts of the Bridge River complex, and to him, P. Umhoefer and M.E. Rusmore for continuing discussions on the geology and tectonics of the region. Field trips and discussions with B.N. Church, W.J. McMillan, W.R. Smyth, V.A. Preto and G.R. McKillop of this Ministry helped focus our attention on some of the important geological problems in the area. We would also like to thank Bill Atkinson and Bob Holt of Cariboo-Chilcotin Helicopters Ltd. for safe and punctual helicopter service.

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