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GEOLOGY OF MISSION RIDGE, NEAR LILLOOET, BRITISH COLUMBIA (92I, J)

By Meg Coleman
Carleton University
and Ottawa-Carleton Geoscience Centre

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INTRODUCTION AND REGIONAL SETTING

The purpose of this study is to determine the geometry and timing of movement on internal and bounding structures of the Bridge River terrane in the vicinity of one segment of the 1988 LITHOPROBE southern Cordilleran transect, near Lillooet, British Columbia (Figure 1-12-1). Specifically, the orientation of the major faults (Yalakom, Marshall Creek and others) is addressed in order to assist in interpreting the seismic reflection data collected in 1988. The tectonic history of rock units at the boundary of the Coast plutonic complex and the Intermontane Belt between 50° and 51° north latitude is highly enigmatic. An already complex history of Mesozoic accretion and probable Eocene extension is obscured by Tertiary strike-slip faulting, involving northward movement of more outboard allochthonous terranes during and/or after accretion.

The Bridge River terrane, composed mainly of Middle Triassic to Middle Jurassic chert, argillite, basalt, minor limestone, alpine-type ultramafic rocks and their metamorphosed equivalents (Roddick and Hutchison, 1973; Monger, 1977; Potter, 1986), lies immediately to the west of the Yalakom fault, a major strike-slip fault (Figure 1-12-1). This terrane has no clear connection to either Terrane I or II of Monger *et al.* (1982). A recent study by Potter (1986) suggests that the Bridge River terrane was formed during the mid-Mesozoic on the western margin of Terrane I, after accretion of Terrane I but prior to accretion of Terrane II.

Near Lillooet, the northwest-trending Yalakom fault separates Jura-Cretaceous Tyaughton basin sediments on the east from the Bridge River Group on the west. The Bridge River Group is deformed by both high-angle and low-angle northwest-trending faults, which are superimposed on an already complex internal structure.

Recent studies in the area include Potter (1983, 1986), which involved detailed mapping of the southern Shulaps Range including the Shulaps ultramafic complex; a detailed structural analysis of fractures within the Lillooet Group adjacent to the Fraser fault by Miller (1988); and fission-track dating of the Mission Ridge pluton by Parrish (1983) which revealed significant rapid Oligo-Miocene uplift. Gold placer operations are currently active along the Yalakom and Bridge rivers.

LITHOLOGY

BRIDGE RIVER GROUP

The Bridge River Group, bounded to the northeast by the Yalakom fault and to the southwest by the low-angle Mission Ridge fault (Figure 1-12-2), is a chaotic mélange of ribbon chert, greenstone, pillow basalt, minor greywacke, limestone olistoliths and narrow serpentinite zones. It has a thickness of 2.5 to 4.5 kilometres in this structural panel (Figure 1-12-3).

Layers of grey radiolarian chert, 1 to 5 centimetres thick, are separated by argillite layers 1 to 10 millimetres thick. Fault-bounded blocks of chert have multiple, randomly oriented slickenside surfaces. These blocks are usually in fault contact with similarly deformed blocks of the previously mentioned lithologies. In the southern Shulaps Range, Potter (1986) found chert in depositional contact with limestone, greenstone and sandstone. Radiolaria from chert found along

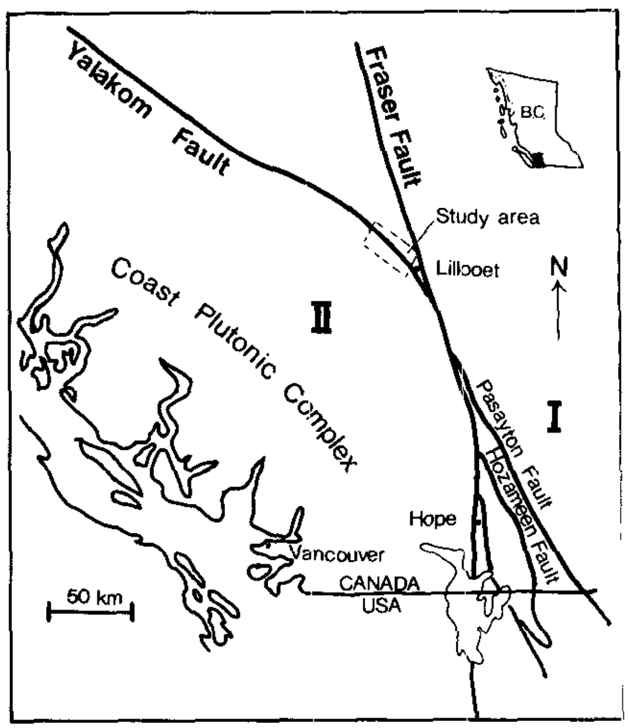

Figure 1-12-1. Map of southwestern British Columbia with study area and major structural features. I and II refer to Terrane I and Terrane II of Monger *et al.*, (1982).

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1988, Paper 1989-1.

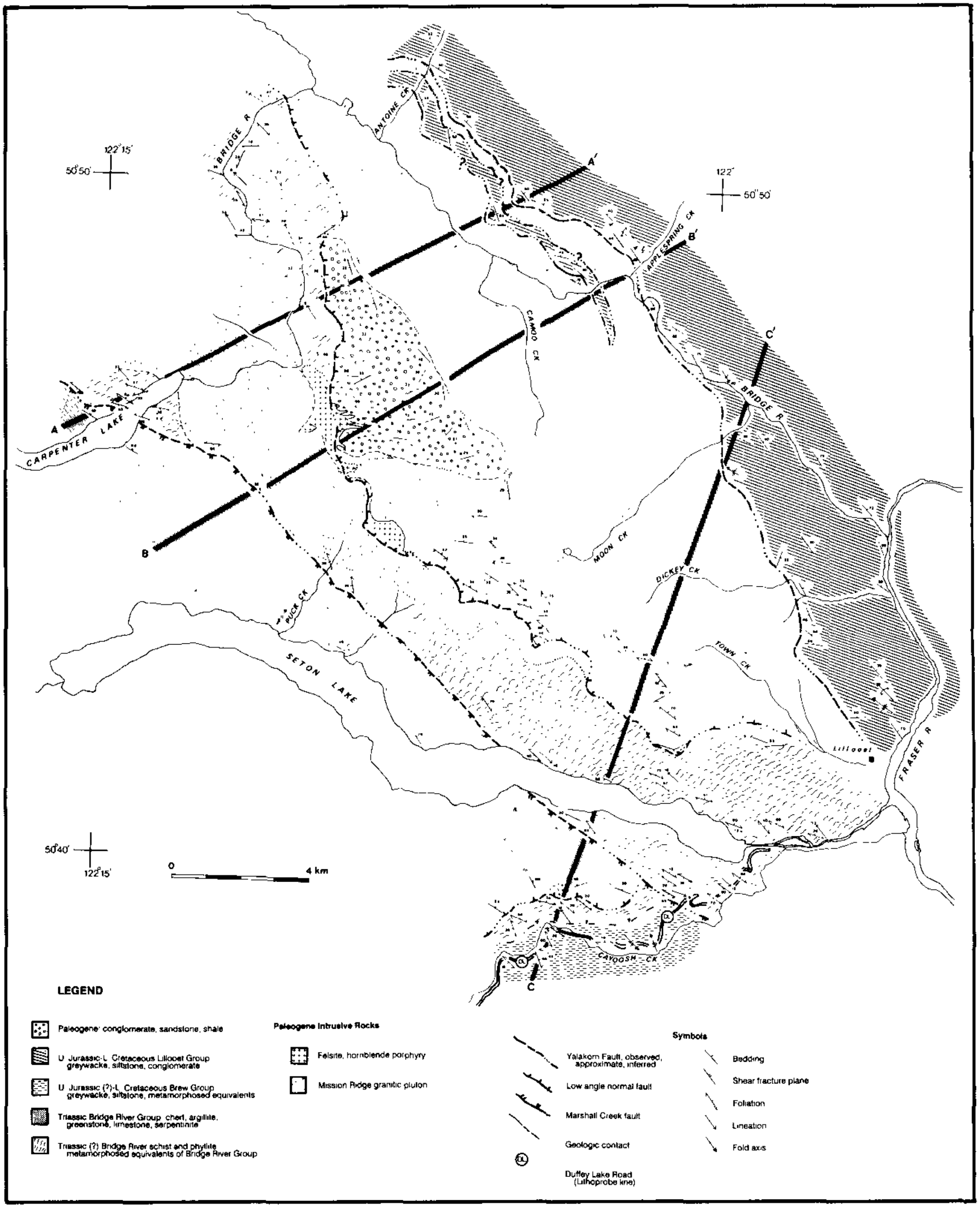

Figure 1-12-2. Geological map of Mission Ridge area. Local relief is more than 2200 metres and accounts for the arcuate trace of some of the major faults.

the Bridge River and Carpenter Lake range from Middle Triassic to Middle Jurassic in age (Potter, 1986; J.W.H. Monger, personal communication, 1988).

Greenstones range from well-preserved pillow basalts to highly sheared and chloritized slickensided blocks. Serpentinized ultramafic rocks occur in discontinuous northwest-trending strands along the Bridge River. Limestone is present as lens-shaped olistoliths as large as 20 metres in diameter, and as 50-metre-thick layers laterally continuous for up to 2 kilometres.

BRIDGE RIVER SCHIST AND PHYLLITE

Metamorphosed equivalents of the Bridge River Group include well-foliated and lineated metachert, phyllite and chlorite schist cut by abundant syntectonic and postdeformational pegmatitic and granitic intrusives (Plates 1-12-1 and 1-12-2). Metamorphic grade is lower greenschist to lower amphibolite facies.

The metacherts are mylonitic, characterized by layers of quartz, 2 to 10 millimetres thick, separated by micaceous pelitic laminations, 1 to 5 millimetres thick. Phyllite contains muscovite, biotite and minor garnet. Chloritized foliated greenstone and greenschist occur in layers 2 to 15 metres thick, and as boudins 2 to 3 metres wide surrounded by metachert and phyllite. Attenuated layers of light grey calcite marble, 1 centimetre to 2 metres thick, occur locally.

Plate 1-12-2. Foliated late syntectonic granitic dyke in Bridge River schist and phyllite.

LILLOOET GROUP

The Lillooet Group consists of marine siltstones, argillites and conglomerates of volcanic provenance. The Lillooet Group has a minimum thickness of 850 metres with ages based on paleontological data which range from Late Jurassic to Early Cretaceous (Duffell and McTaggart, 1952; Trettin, 1961; Jeletsky, 1971).

Plate 1-12-1. Bridge River schist and phyllite cut by several syntectonic and postdeformational dykes.

In the southeast part of the map area the Lillooet Group consists predominantly of interbedded (1 to 10 centimetres thick) argillite and fine-grained sandstone layers with crossbedding, graded beds and load structures. Beds of coarse-grained greywacke with occasional argillaceous rip-up clasts occur throughout this part of the unit.

Northwest of Applespring Creek, adjacent the Yalakom fault, the Lillooet Group consists predominantly of coarse-grained greywacke with beds of conglomerate. The distinctive conglomerate beds are lenticular, average 10 metres in thickness and 50 metres in length, and are comprised of a limestone matrix and about 75 per cent clasts. The clasts include macrofossil-bearing limestone, granitic rocks and green dacite with feldspar phenocrysts. The clasts are rounded and range from pebble size to cobbles 30 centimetres in diameter. Similar lenses of conglomerate in the Late Triassic Cadwallader Group have been interpreted by Rusmore (1987) as filled channels. Samples of the limestone cobbles were collected for fossil dating. This occurrence of conglomerate is on strike with similar lithologies to the north along the Bridge River described by Leech (1953), but taken together, are in a different geographic area than that of the Cadwallader Group, although they may be correlative.

BREW GROUP

The Early Cretaceous Brew Group is estimated by Duffell and McTaggert (1952) to be at least 2500 metres thick; it includes argillite, quartzite, conglomerate and metamorphic derivatives of these rocks. Within the map area, along the Duffey Lake road, metagreywacke with rip-up argillaceous clasts is recumbently folded. The metagreywacke is of greenschist metamorphic grade and muscovite defines the foliation.

PALEOGENE SEDIMENTS

Overlying the Bridge River Group is a section of well-bedded conglomerate, black shale and coarse-grained sandstone 1500 metres thick. The conglomerate consists of about 70 per cent rounded clasts, up to 15 centimetres in diameter, within a coarse-grained sandy matrix. The clasts are mostly Bridge River Group lithologies with locally abundant clasts of cream-coloured felsite. None of the clasts were derived from the Bridge River schists, phyllites or associated granitoid intrusives, presently exposed immediately to the west (Figure 1-12-2). Black shales, up to 10 metres thick, locally contain fossil *Metasequoia* stems and were collected for palynologic dating.

PALEOGENE INTRUSIVE ROCKS

MISSION RIDGE PLUTON

An elongate, foliated coarse-grained pluton, termed the Mission Ridge pluton, ranges in composition from granite to diorite and intrudes the Bridge River schist and phyllite (Figure 1-12-2). In the northwest quadrant of the map area, it crosscuts the foliation of the country rock and has a weak foliation with the same orientation. The emplacement of the pluton is interpreted to be late synkinematic. Two dykes of similar composition to the Mission Ridge pluton and with the same structural relationship to the Bridge River schist and phyllite, have yielded Eocene preliminary uranium-lead zircon ages (P. van der Hyden, personal communication, 1988).

FELSITE

A leucocratic felsite, in part hornblende phyric, intrudes Paleogene sediments, Bridge River Group, Bridge River schist and phyllite, and the Mission Ridge pluton. It is similar in appearance to the felsite clasts in the Paleogene sediments, although it is not necessarily the source of the clasts.

STRUCTURE

The following section describes major fault boundaries and internal structures of the previously described rock units in an east-to-west sequence (Figure 1-12-2).

YALAKOM FAULT

The north-northwest-trending Yalakom fault separates the Lillooet Group in the eastern hangingwall from the older Bridge River Group in the footwall. Careful field mapping along its trace indicates it dips 40 ± 10 degrees east. It merges with the north-trending Fraser fault near Lillooet and extends at least 250 kilometres to the northwest with an estimated Late Cretaceous/Early Tertiary right-lateral strike-slip displacement of 70 to 190 kilometres (Tipper, 1969; Monger, 1985). Rocks of the Lillooet and Bridge River groups are both brittly deformed at the fault boundary. Within the southeast part of the map area the fault is characterized by narrow zones of rusty weathering, fuchsite-bearing, hematized fault breccia. The exact sense of displacement on the fault is at present uncertain.

INTERNAL STRUCTURE OF THE BRIDGE RIVER GROUP AND PALEOGENE SEDIMENTS

The Paleogene sediments are in probable conformable contact with the underlying, highly disrupted Bridge River Group, although the contact is not well exposed. The Paleogene sediments are folded into a northwest-trending, northwest-plunging syncline which is truncated by the Mission Ridge fault.

MISSION RIDGE FAULT

The Bridge River Group and Paleogene sediments are separated from the underlying Bridge River schist and phyllite and the Mission Ridge pluton by a northeast-dipping low-angle normal fault which steepens to the south (Figure 1-12-2), here termed the Mission Ridge fault. The northwest part of this fault within the map area dips 20 ± 5 degrees and truncates both bedding and broad folds within Paleogene sediments in the hangingwall, as well as foliated footwall rocks (*see* cross-section A-A′ and B-B′, Figure 1-12-3). A felsite, described previously, intrudes both the hangingwall and footwall but is also fractured by the fault and is therefore interpreted to have been emplaced during the last stages of faulting.

To the southeast the fault steepens to a 42 ± 5 degree dip (*see* cross-section C-C′, Figure 1-12-3), where a lower level of the fault zone is exposed; Bridge River Group rocks display a penetrative foliation parallel to the fault plane, particularly in the south.

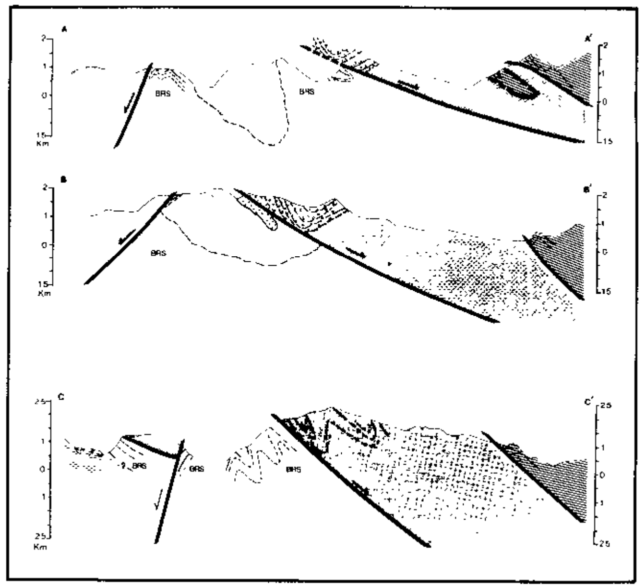

Figure 1-12-3. Cross-sections A-A′, B-B′ and C-C′, from corresponding lines on geologic map of study area. Patterns refer to legend of Figure 1-12-2. BRS refers to Bridge River schist and phyllite; MCF, Marshall Creek fault; MRF, Mission Ridge fault; YF, Yalakom fault. No vertical exaggeration.

INTERNAL STRUCTURE OF BRIDGE RIVER SCHIST AND PHYLLITE

Pervasive foliation and isoclinal folds deformed by asymmetric folds record at least two stages of penetrative deformation, in part accompanied by significant shear strain. Foliation has a consistent northwest strike with shallow northeast dips. Lineation trends northwest with a shallow plunge. Asymmetric shear bands within various lithologies indicate a consistent northwest-over-southeast sense of shear (Plate 1-12-3).

Plate 1-12-3. Shear bands in greenschist of Bridge River schist and phyllite with southeast-directed sense of shear.

MARSHALL CREEK FAULT

The Marshall Creek fault dips 50 to 70 degrees southwest, juxtaposing the Bridge River schists and the lower grade Bridge River Group (Figure 1-12-2).

In the southernmost part of the map area the Marshall Creek fault truncates a low-angle fault. This low-angle fault is similar to the Mission Ridge fault in that it juxtaposes footwall Bridge River schist and phyllite and hangingwall Bridge River Group. The low-angle fault is interpreted to be part of the Mission Ridge fault and restoration of it from cross-section C-C' (Figure 1-12-3) gives an estimated 3.5-kilometre component of normal displacement on the Marshall Creek fault. This component probably increases to the north. Further to the southeast the Marshall Creek fault juxtaposes the Bridge River schist and phyllite with the Brew Group (Figure 1-12-2).

DISCUSSION AND CONCLUSIONS

The sequence of tectonic events in this area is incompletely understood, but some important relationships have been observed which place important constraints on the geometry, timing and kinematics of the major fault boundaries. Uranium-lead dating of intrusions (in progress) will place tighter limits on ages of faulting, plutonism and ductile strain.

The Mission Ridge fault east of the Mission Ridge pluton truncates southeast-directed mylonitic rocks, probable Eocene intrusions and Paleogene sediments. Assuming a normal geothermal gradient, at least 12 kilometres of Paleogene displacement is necessary to juxtapose upper greenschist facies rocks of the Bridge River schist and phyllite with subgreenschist rocks of the Bridge River Group and Paleogene sediments.

West-verging folds within the Lillooet Group have axial traces parallel to the Yalakom fault and may be related to (in part oblique?) thrusting; however, this folding event has not been definitely linked to faulting. Fifty kilometres northwest of Lillooet, where the Yalakom fault is close to vertical, structures including synthetic and antithetic faults fit a model for dextral movement and transpression (Glover *et al.*, 1988).

The Marshall Creek fault, which displaces the Mission Ridge fault, may extend as much as 150 kilometres northwest from where it is truncated by the Fraser fault near Lillooet, if the correlation of the Marshall Creek fault with the Relay Creek fault (Glover *et al.*, 1988) is valid. Glover *et al.* have estimated 8 kilometres of right-lateral displacement on the Relay Creek fault by restoring truncated units of Late Jurassic Relay Mountain Group. Post-Eocene displacement on the Marshall Creek fault may involve both a strike-slip component and normal movement.

It is evident from relationships within the Bridge River terrane that several episodes of deformation have taken place since the beginning of the Eocene. All are relevant to placing better constraints on the age of major dextral transcurrent movement on the Fraser – Straight Creek fault system. Although each of these episodes may not have involved either major amounts of displacement, or large spans of time, they certainly reveal a complex Tertiary tectonic history. We must first be able to "undo" this more recent deformation in order to clarify older accretionary aspects of the Bridge River terrane.

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