

**GEOLOGICAL PROVINCES**

Hope and Ashcroft map areas comprise two distinct geological and physiographic provinces, the Intermontane Belt to the east, and the Coast and Cascade belts to the west, with the boundary delineated by the north northwest trending Passayten and Fraser faults. The Intermontane Belt is a region of relatively low topographic and structural relief, with mainly subvolcanic and metamorphic grade rocks exposed across its entire width. By contrast, the Coast and Cascade belts have high topographic and structural relief; a tract of amphibolite grade rocks, exposed between Harrison Lake and Fraser River, is flanked by greenschist and lower grade rocks on east and west. The boundary between Coast and Cascade belts is placed at the Fraser River, with the Coast Belt to the north and west of it, and the Cascade Belt to the east and south.

**TERRANES OF HOPE-ASHCROFT MAP AREA**

Pre-Late Mesozoic rocks of Hope and Ashcroft map areas can be subdivided into at least six lithotectonic terranes (Figures A, B). Each terrane has a distinctive geological record provided by its dated lithologies, and in some cases by characteristic faunal associations and mineral deposits. Each is bounded by major faults, and original geographic relationships of presently contiguous terranes containing coeval rocks are unknown or uncertain. In Paleozoic and early Mesozoic time there is no basis for assuming any stratigraphic continuity across the entire region. Linkages between terranes can be established at various times throughout the Mesozoic and by mid-Cretaceous time all terranes were together.

For example, oldest rock units of the Quesnellian terrane are the Ordovician to Triassic Apex Mountain Complex and the Devonian to Permian Harper Ranch Group. Stratigraphically overlying both is the Upper Triassic Nicola Group, above which is the Lower and Middle Jurassic Ashcroft Formation. This succession is lithologically and faunally different from the structurally disrupted Pennsylvanian to Middle Jurassic Cache Creek Complex which flanks it to the west. The distinctly different Permian faunas of the Harper Ranch Group and Cache Creek Complex suggests that during the Permian the two terranes were separated by distances of possibly thousands of kilometres.

The oldest rocks exposed to the highly deformed and disrupted Ordovician through Triassic Apex Mountain Complex exposed in the southeastern corner of Hope map area. These rocks include strata that appear to have been deposited in an oceanic setting, and were probably deformed prior to deposition of the Nicola Group.

The Devonian through Permian Harper Ranch Group possibly represents a basinal facies related to a volcanic arc, and is overlain, 20 km east of Kamloops, by volcanic rocks of the Nicola Group. The Upper Triassic Nicola Group comprises a variety of volcanic and sedimentary facies (Figure A) which, with at least partly comagmatic Late Triassic - Early Jurassic intrusions, formed a west-facing magmatic arc. The Mount Lyton Complex comprises gneiss, amphibolite, mylonite and granitic rock that may represent deeper parts of the Nicola arc.

The non-volcanic clastic Lower and Middle Jurassic Ashcroft Formation unconformably overlies the Nicola Group 5 km northeast of Ashcroft and has an eastern proximal facies derived in large part from the Nicola Group and associated intrusions, and a western distal facies Intermontane Belt. Cache Creek terrane

The Pennsylvanian through Middle Jurassic Cache Creek Complex is not an orderly stratified succession. Rather it is highly disrupted, and probably consists of several discrete elements, all of which probably formed in oceanic settings. The eastern part is a melange composed of Permian and Pennsylvanian carbonate blocks, together with blocks of chert, basalt, minor gabbro and ultramafic rock, in an argillite-chert matrix of mainly Late Triassic age. The central belt contains a large, mainly mid to late Permian carbonate, and the western belt is of Permian to Middle Jurassic age and contains argillite, chert, and volcanoclastic rock. Speculatively, the eastern part of the Cache Creek Complex represents the subduction complex complementary to the Nicola arc.

**Coast-Cascade belts: Methow-Tyauhton terrane**  
The Methow-Tyauhton terrane comprises a basal ophiolite (Spider Peak Formation and associated ultramafics) of probable Triassic age, which is overlain by the predominantly fine-grained clastic Lower and Middle Jurassic Ladner Group, with its volcanic-rich facies, the Dewdney Creek Formation. Above the Ladner Group, is the Late Jurassic succession ("Thunder Lake sequence"), but in the north partly coeval strata form the thicker, Upper Jurassic-Lower Cretaceous Relay Mountain Group. Uppermost are thick upper Lower Cretaceous-lower Upper Cretaceous fine to coarse clastics of the partly coeval Spences Mountain and Pasayten Groups. The latter contain detritus from, respectively, Quesnellian and Bridge River groups, thus linking these terranes together by about mid-Cretaceous time.

**Coast-Cascade belts: Bridge River Terrane**  
The Permian (?) to Middle Jurassic Bridge River Complex (west of Fraser River) and the correlative Permian to Jurassic Hozomeen Complex (east of Fraser River), which together form the Bridge River terrane, resemble the largely coeval Cache Creek Complex in their disrupted nature and their probable deposition in an ocean basin, but differ from the Cache Creek mainly in the absence of large carbonate bodies.

**Coast-Cascade belts: Chilliwack terrane**  
South of Fraser River and on the west side of the high-grade metamorphic core of the Cascades is a Devonian to Jurassic sequence, that, although complexly folded and faulted, retains its stratigraphic integrity. Oldest rocks are the Devonian to Permian Chilliwack Group which probably represents an Upper Paleozoic arc or arcs. In general lithological association, age range and faunas, the Chilliwack group most resembles the Harper Ranch Group of the Intermontane Belt. Stratigraphically above the Chilliwack are clastic rocks of the Upper Triassic and Lower Jurassic Cultus Formation, (possibly representing distal basinal parts of an arc), and Upper Jurassic clastics possibly correlative with the Kent Formation north of Fraser River.

**Coast-Cascade belts: Harrison Lake terrane**  
North of Fraser River and west of Harrison Lake, is a well-preserved Middle Triassic to Lower Cretaceous succession. Lowest is the Camp Cove Formation of Middle and Late Triassic age, which comprises siliceous argillite and mafic volcanics. Unconformably above it is the thick Lower and Middle Jurassic Harrison Lake Formation of mainly intermediate but locally felsic volcanics, above which are Middle and Upper Jurassic shales of the Mysterious Creek Formation, and overlying volcanics of the Billhook Creek Formation. These may represent different facies of a long-lived Jurassic arc. Uppermost are Upper Jurassic(?) and Lower Cretaceous clastic rocks and volcanics of the Peninsula and Brokenback Hill Formations.

The Harrison Lake Formation contains a basal conglomerate with limestone clasts containing fossils that resemble those in Permian limestone of the Chilliwack Group, suggesting a possible stratigraphic tie between Harrison Lake and Chilliwack terranes in late Early Jurassic time.

**Coast-Cascade belts: metamorphic rocks and possible protoliths**  
The high-grade metamorphic rocks between Harrison Lake and Fraser River are of uncertain protolith age, but may in part be correlative with dated rocks in lower grade, less metamorphosed regions east and west. Greenschist grade, mafic to intermediate volcanics and dark pelites of the Silolium schist resemble rocks of the Upper Triassic Cadwallader Group, exposed along strike 70 km to the north northwest. The structurally overlying Cogburn schist, which ranges from greenschist to amphibolite grade, lithologically resembles the Hozomeen and Bridge River complexes to the east and north, or the Pennsylvanian to Jurassic Elbow Lake Formation to the south in Washington State. Structurally highest are amphibolite grade rocks of the Settler schist, which are derived predominantly from pelite but include minor pillow basalt and chert. Less metamorphosed dated equivalents may be either (1) Triassic and Jurassic rocks (Spider Peak Formation, Ladner Group) of the Methow-Tyauhton terrane to the east, or (2) the Jurassic(?) Shuksan metabasalt and Darrington phyllite along strike to the south in Washington State. Associated gneissic rocks appear from preliminary U-Pb studies to be of three ages: (1) Late Triassic (gneiss of Hornet Creek); (2) mid-Cretaceous (gneiss of Mount Brokenridge, which is roughly coeval with the main episode of metamorphism and intrusion in the area); and (3) early Tertiary Custer gneiss.

**Post-mid Cretaceous stratified units**  
These rocks are entirely continental and preserved mainly in structural depressions. They include mid- to early Late Cretaceous arc volcanics of the Spences Bridge Group, Eocene arc volcanics of the Kamloops and Princeton groups, Eocene sedimentary rocks, the Oligocene-Miocene Coquihalla volcanics and the extensive Miocene-Pliocene "plateau basalts", as well as scattered minor Pleistocene and Recent flows. With the exception of the younger basalts, granitic intrusives accompany the volcanics.

**REGIONAL STRUCTURAL EVOLUTION**

**PRE-LATE TRIASSIC STRUCTURES**  
The Apex Mountain Complex in southeastern Hope map area, is more deformed than contiguous Upper Triassic rocks, suggesting pre-Late Triassic deformation, although the relationship between the two is recognized nowhere within the map area. Support for this conclusion comes from the Salmon River valley, (4 km east of eastern boundary of the Ashcroft sheet, lat. 50°22'), where Triassic strata of the Nicola Group unconformably overlie deformed and metamorphosed rocks of the Chapman Group, a possible equivalent of (part of) the Apex Mountain Complex.

**LATE TRIASSIC-EARLY JURASSIC DEFORMATION**  
The eastern belt of the Cache Creek Complex features melange composed of blocks of various lithologies in a sheared matrix. It is possible that some of this fabric is in part of latest Triassic-earliest Jurassic age, as similarly deformed Cache Creek rocks to the north near Williams Lake are cut by 200 Ma granitic rocks. Faults containing hydrothermal minerals in the central Guichon batholith are dated at about 200 Ma. Foliated felsic and amphibolite rocks of the Mount Lyton Complex are dated with U-Pb methods as (218-250 Ma), and the rocks are cross-cut by 210 Ma granitic rock. Speculatively, these structures are related to early Mesozoic subduction/arc activity: structures in the Cache Creek perhaps formed in an accretionary complex, those in the Guichon Batholith in the upper part of the upper plate, and those in the Mount Lyton Complex in the lower part of the upper plate.

**JURASSIC AND CRETACEOUS DEFORMATION**  
Most uniquely Cordilleran crust was created in Jurassic to earliest Tertiary time, probably by structural stacking of rock units on discrete thrust faults and by folding and flow in a generally contractional regime, and by addition of mantle-derived magmatic rock to the crust. The result of these processes was that Intermontane Belt crust thickened and became non-marine by late Middle Jurassic time (ca. 160 Ma) and Coast-Cascade Belt crust thickened and became non-marine by mid Cretaceous time (ca. 100 Ma). The following discrete structural events can be distinguished; their locations are indicated on Figure C.

(1) Middle Jurassic structures  
Northeast of Kamloops, southwest-verging structures, including overturned folds and possible faults, and an increase from greenschist to upper greenschist grades from southwest to northeast, appear to be related to evolution of the flanking Omineca Belt to the east. The structures are congruent with southwest-verging, probable Middle Jurassic structures to the east near Adams Lake, which are interpreted as "backfolds" in the complex structural evolution of the Omineca Belt.

(2) Late Jurassic structures  
West-dipping foliations within the Eagle Plutonic Complex, and congruent, flanking west-dipping foliations in amphibolite and greenschist-grade meta-volcanics of the Nicola Group to the east may be deeper structural equivalents of high-level, subgreenschist grade structures to the north near Cache Creek. There, rocks of the Cache Creek terrane are thrust eastwards over Quesnellia. Detailed mapping and structural studies of the Eagle Plutonic Complex by C. Green (B.C.) have shown that much of the Complex is Late Jurassic (ca. 155 Ma) in age. Studies by W.B. Travers in the north indicate that, deformation is probably not much later than final, late Middle Jurassic deposition of the Ashcroft Formation. The probable transition between the two sets of structures is concealed by overlapping mid-Cretaceous Spences Bridge Group strata.

(3) Cretaceous structures  
In the southwestern part of Hope map area, northwest-verging (south of Fraser River) and southwest-verging (east of Harrison Lake) thrust faults and folds are the northerly continuation of structures on the west side of the Cascade Belt in Washington State. Structures north of Fraser River are syn-metamorphic and both involve, and are intruded by, late Early Cretaceous (ca. 104 Ma) Spuzzum intrusions. Near Harrison Lake, the fabric associated with these structures is cut by the north northwest trending Harrison Fault, which features a strong sub-horizontal stretching fabric. On Mount Brew, 10 km southwest of Lillooet, lower Lower Cretaceous rocks of the Relay Mountain Group (ca. 130 Ma) contain a large (ca. 3 km amplitude) southwest-verging isoclinal recumbent syncline, that is cut by an Eocene (47 Ma) pluton.

The narrow structural high of the Mount Lyton-Eagle complex, and the complementary structural depression to the east containing the mid-Cretaceous Spences Bridge Group, formed in late Early to early Late Cretaceous time. The Mount Lyton-Eagle structural high is bounded on the west by the Pasayten Fault. Late Early Cretaceous to mid-Cretaceous conglomerates of the Jackass Mountain Group contain eastward-derived clasts probably derived from the Eagle Complex. Local dyke swarms of early Late Cretaceous age (85 Ma) cut mid-Cretaceous strata immediately west of the fault, and are oriented parallel with it. These features indicate that in about mid-Cretaceous time the Pasayten Fault was a normal fault, downdropping Methow-Tyauhton strata to the west.

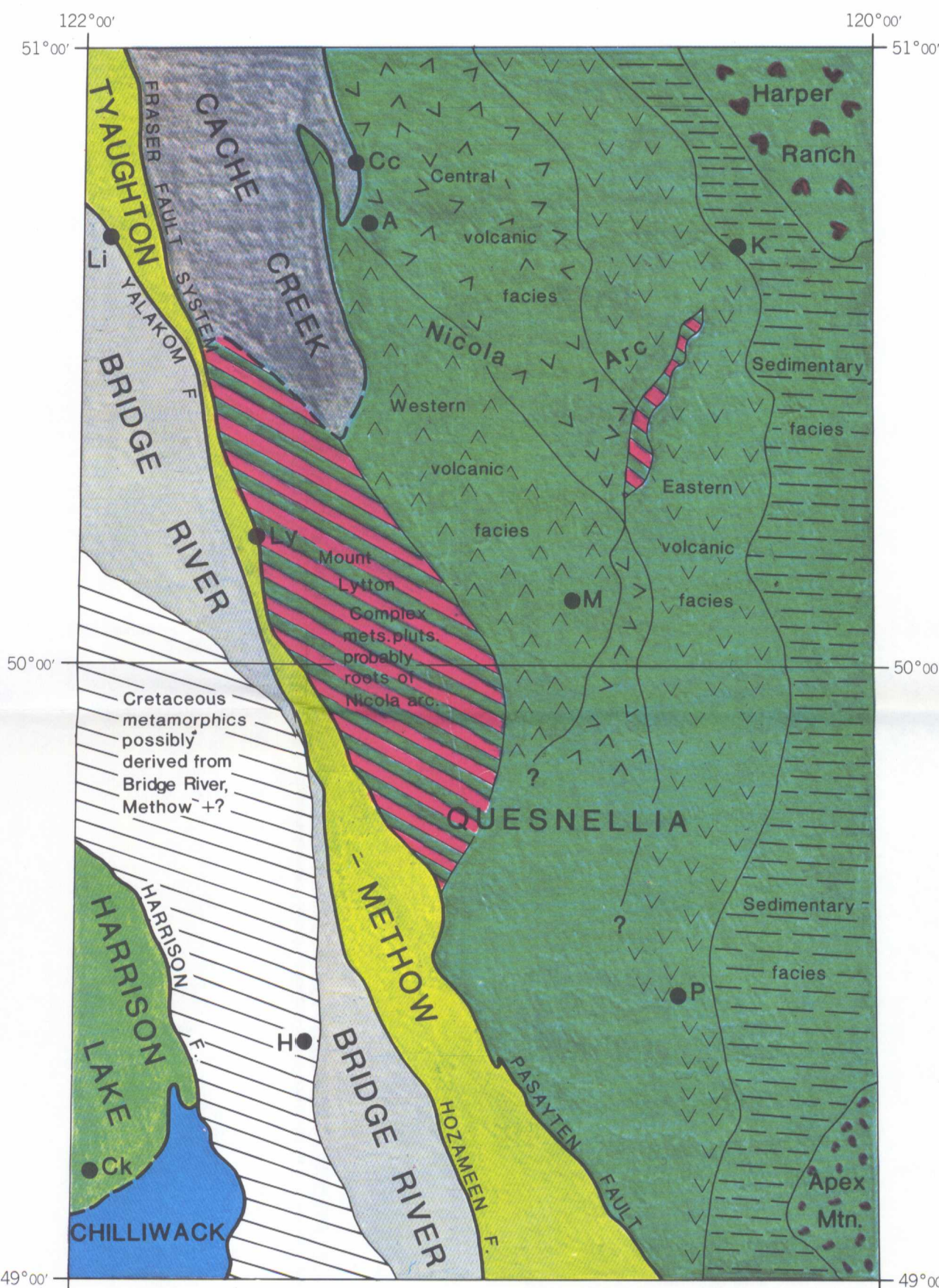
Within the Methow-Tyauhton terrane, the east-verging Chuwantaw Fault, places Jurassic strata over mid- and early Late Cretaceous rocks of the Pasayten Group and is cut by the Eocene Needle Peak pluton, thus establishing Late Cretaceous, pre-48 Ma shortening in this area.

**TERTIARY DEFORMATION**  
The structural record for much of the Paleogene suggests that crustal thinning predominates, in contrast to the Jurassic-earliest Tertiary structural record. This style is most clearly seen in the "Basin and Range" style extensional Eocene deformation of the Okanagan region and east of it. In Hope and Ashcroft map areas, transension possibly related to wrench faulting is the dominant mode of Tertiary deformation, and may be slightly younger than the 55-50 Ma extensional structures to the east.

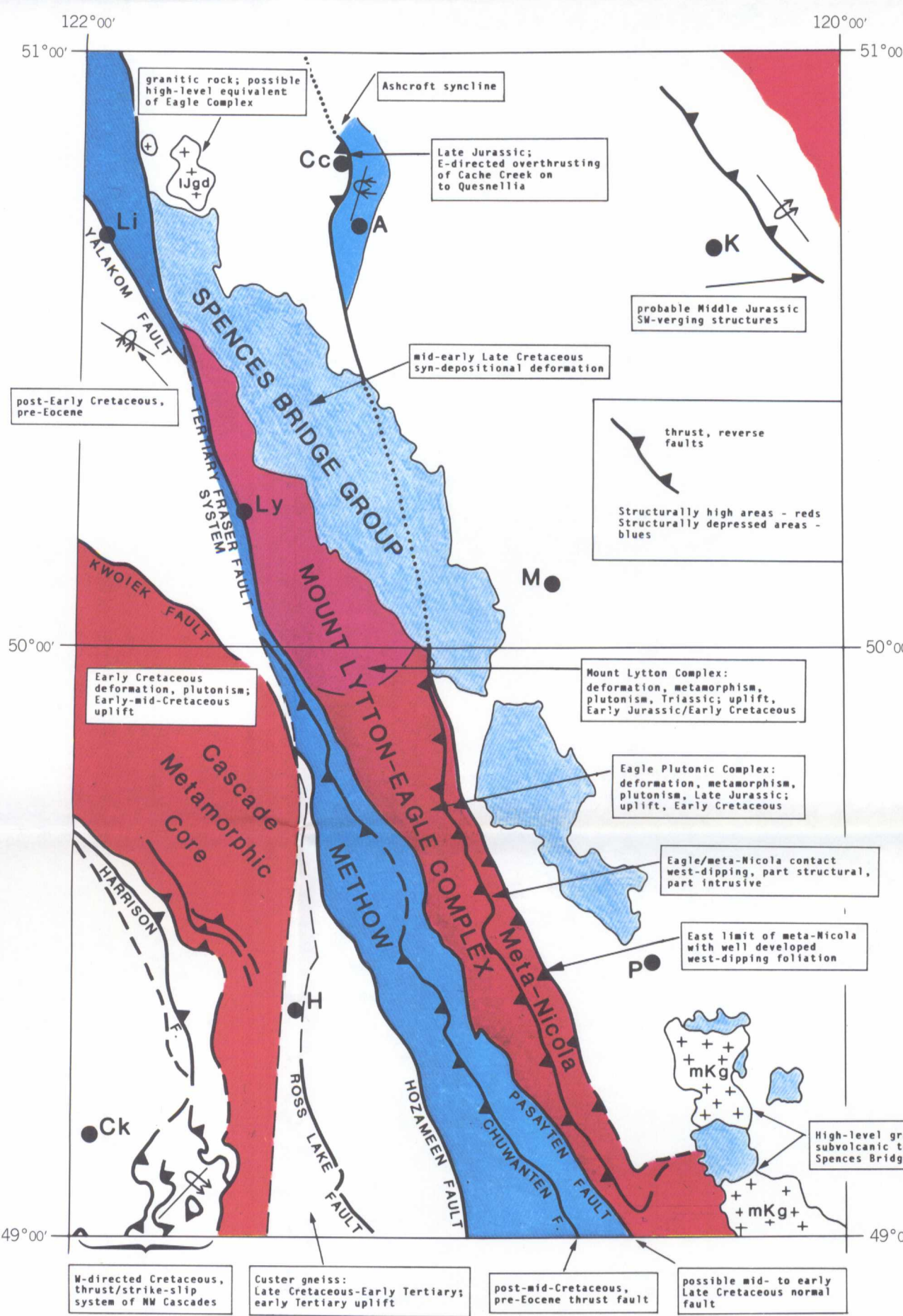
(1) Paleogene structures  
The major Tertiary structure is the Fraser fault system, and its southern extension, the Straight Creek Fault in Washington State. As shown in the inset map of Figure D, this fault system dextrally offsets older structures by 80-100 km. Its geometric relationship with north-northwest trending reverse faults, and north-northeast trending normal faults, both of which involve Eocene rocks, fit the classical wrench fault pattern. Movement probably occurred after 47 Ma, the age of an Eocene pluton overlain by the Phair Creek Fault, a splay of the Fraser fault system southwest of Lillooet, and before 35 Ma, (the oldest date from the cross-cutting Chilliwack Batholith in Washington State). Transension appears to have affected much of the Intermontane Belt. There is dextral movement on the Lornex Fault, the Princeton basin has developed as a transensional basin according to McMechan, and the Nicola Batholith and accompanying high-grade metamorphic rocks, forms a related roset or core complex, as suggested by Ewing.

Several workers propose that the Ross Lake Fault is an Eocene normal fault and/or a dextral strike-slip fault, a suggestion partly based on Tertiary ages from the Custer gneiss and the correlative Skagit gneiss in Washington. This assumption is reasonable on structural grounds, as greenschist grade rocks of the Hozomeen Complex or Olivine Peak east of Hope, structurally overlie foliated pegmatitic rocks that pass downwards into Custer gneiss in the bottom of Fraser canyon.

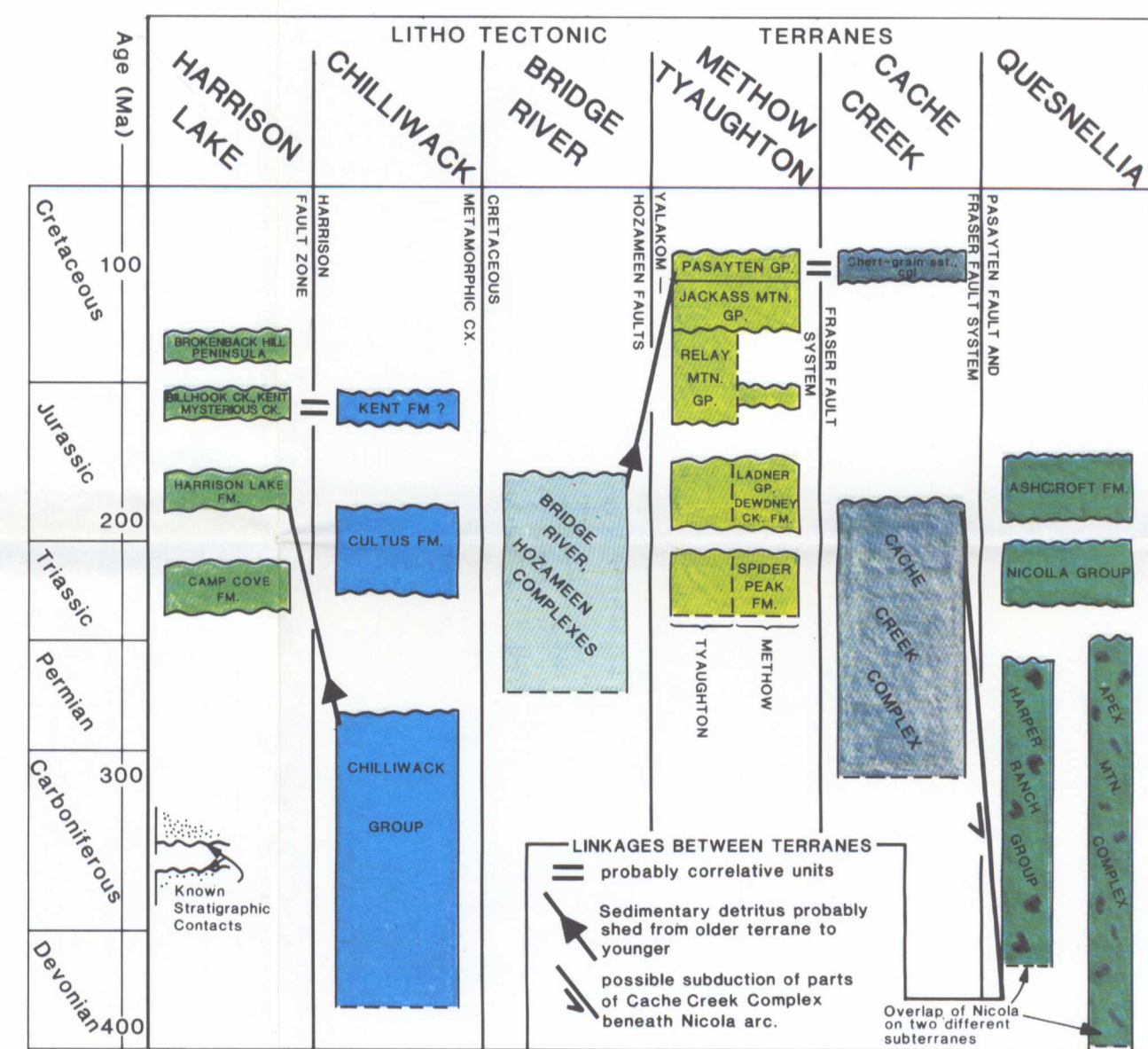
(2) Neogene (?) structures  
A set of northeast trending faults, which includes the long-recognized Coquihalla Fault, show both vertical and predominantly dextral movements. Similarly orientated linears and small faults in the Coast Belt and a fault south of Chilliwack may be related features. The Coquihalla Fault clearly post-dates emplacement of the Needle Peak pluton (48 Ma), and may post-date extrusion of the Oligocene-Miocene (22 Ma) Coquihalla volcanics, which are apparently juxtaposed against it across the fault. As noted by Haugerud, there is apparent dextral offset of the Ross Lake Fault across a northeast elongated apophysis of the Oligocene Chilliwack Batholith. The northeast elongation of Oligocene granite near Doctor's Point on Harrison Lake may be due to the same structural control.



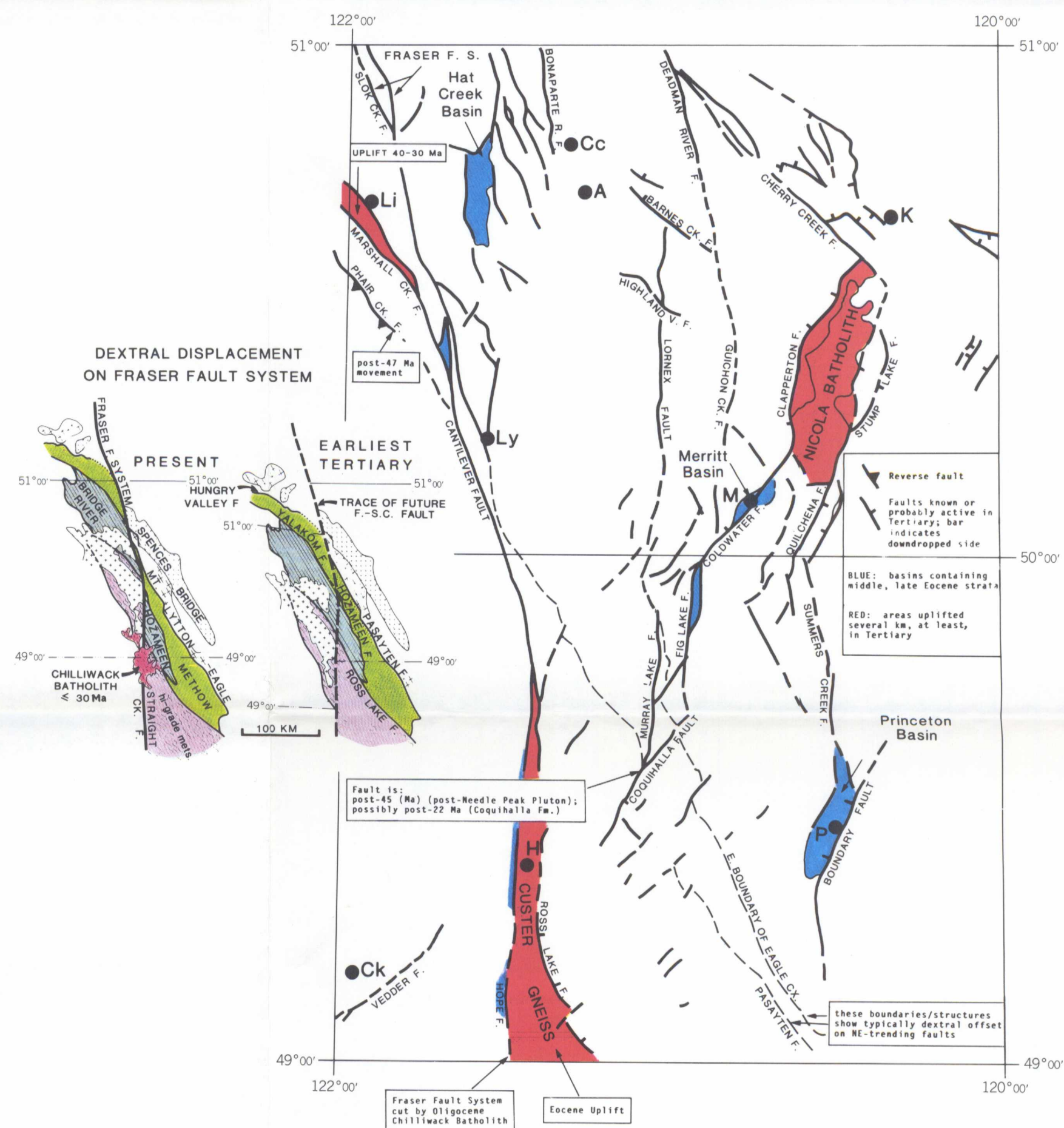
**Figure A: Distribution of terranes and major, terrane-bounding faults in Hope and Ashcroft map areas. Facies within the Upper Triassic Nicola Group, which characterizes Quesnellia, are shown. Principal settlements: A, Ashcroft; H, Hope; K, Kamloops; Li, Lillooet; Ly, Lytton; M, Merritt; P, Princeton; Cc, Cache Creek; Ck, Chilliwack**



**Figure C: Jurassic and Cretaceous structural elements in Hope and Ashcroft map areas**



**Figure B: Rock units of terranes in Hope and Ashcroft map areas, showing known and possible linkages between terranes**



**Figure D: Tertiary structural elements in Hope and Ashcroft map areas**

**Figure 2. Descriptive notes and figures to accompany Map 41-1989 and Map 42-1989 of the Hope Ashcroft map areas, southwestern British Columbia**

Scale 1:1 000 000 - Échelle 1/1 000 000

Kilometres 25 0 25 50 75 Kilometres

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Any revisions or additional geological information known to the user would be welcomed by the Geological Survey of Canada

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