Lithostratigraphic and tectonic framework of Jurassic and Cretaceous Intermontane sedimentary basins of south-central British Columbia[1]

Janet Riddell

Abstract: The south-central Intermontane belt of British Columbia has a complex architecture comprising late Paleozoic to Mesozoic volcanic and plutonic arc magmatic suites, marine and nonmarine clastic basins, high-grade metamorphic complexes, and accretionary rocks. Jurassic and Cretaceous clastic basins within this framework contain stratigraphy with hydrocarbon potential. The geology is complicated by Cretaceous to Eocene deformation, dismemberment, and dislocation. The Eocene to Neogene history of the southern Intermontane belt is dominated by non-arc volcanism, followed by Pleistocene to Recent glaciation. The volcanic and glacial cover makes this a difficult region to explore for resources. Much recent work has involved re-evaluating the challenges that the overlying volcanic cover has historically presented to geophysical imaging of the sedimentary rocks in this region in light of technological advances in geophysical data collection and analysis. This paper summarizes the lithological and stratigraphic framework of the region, with emphasis on description of the sedimentary units that have been the targets of hydrocarbon exploration.

Résumé : La ceinture intermontagneuse du centre-sud de la Colombie-Britannique a une architecture complexe (Paléozoïque à Mésozoïque) comprenant des suites magmatiques, volcaniques et d'arcs plutoniques, des bassins clastiques marins et non marins, des complexes à métamorphisme élevé et des roches d'accrétion. Les bassins clastiques du Jurassique et du Crétacé dans ce cadre comprennent une stratigraphie à potentiel d'hydrocarbures. La géologie a été rendue complexe par des déformations, des démembrements et des dislocations du Crétacé à l'Éocène. L'historique de l'Éocène au Néogène de la ceinture intermontagneuse sud est dominé par un volcanisme ne provenant pas d'arcs, suivi d'une glaciation du Pléistocène au Récent. La couverture volcanique et glaciaire de la région complique l'exploration pour des ressources. Étant donné les progrès technologiques dans la collecte et l'analyse de données géophysiques, une grande partie des travaux récents comprenaient la réévaluation des défis que présentait historiquement la couverture volcanique à obtenir une imagerie géophysique des roches sédimentaires de la région. Le présent article résume le cadre lithologique et stratigraphique de la région, mettant l'accent sur la description des unités sédimentaires qui ont été ciblées pour la recherche d'hydrocarbures.

[Traduit par la Rédaction]

Introduction

This paper outlines a lithostratigraphic framework for sedimentary successions of the south-central Intermontane belt, and provides descriptions for the exposed successions, to provide a context for other papers in this Special Issue that deal with specific rock units. The area under discussion in this paper (outlined on Figs. 1 to 13) includes much of the Interior Plateau of British Columbia (Holland 1964) between the Coast Mountains to the west and the Cariboo Highway (Highway 97) to the east, and between latitudes 51°N and 54°N.

The Intermontane belt is the central of the five geomorphogeologic belts of the Canadian Cordillera (Fig. 1 inset). It is characterized by relatively low metamorphic grade and subdued topography, in contrast to the Coast crystalline belt to the west and the Omineca crystalline belt to the east.

The geologic history of the south-central Intermontane belt of British Columbia spans the late Paleozoic to the present and includes the amalgamation of outboard terranes, accretion of amalgamated terranes to North America, and subsequent formation of Jurassic to Tertiary overlap assemblages (Coney et al. 1980; Monger and Price 2002). Mesozoic overlap assemblages consist of the products of subduction-related arc magmatism and sedimentary detritus shed into local basins as North American and allochthonous rocks were uplifted and deformed (Eisbacher 1981; Kleinspehn 1985; Armstrong 1988; Garver 1992; Monger 1997; Marsden and Thorkelson 1992; Bassett and Kleinspehn 1997; Schiarizza et al. 1997; Monger and Price 2002; Evenchick et al. 2007). Extension during the Eocene was accompanied by magma-

Received 5 August 2010. Accepted 2 May 2011. Published at www.nrcresearchpress.com/cjes on 29 June 2011.

Paper handled by Associate Editor Maurice Colpron.

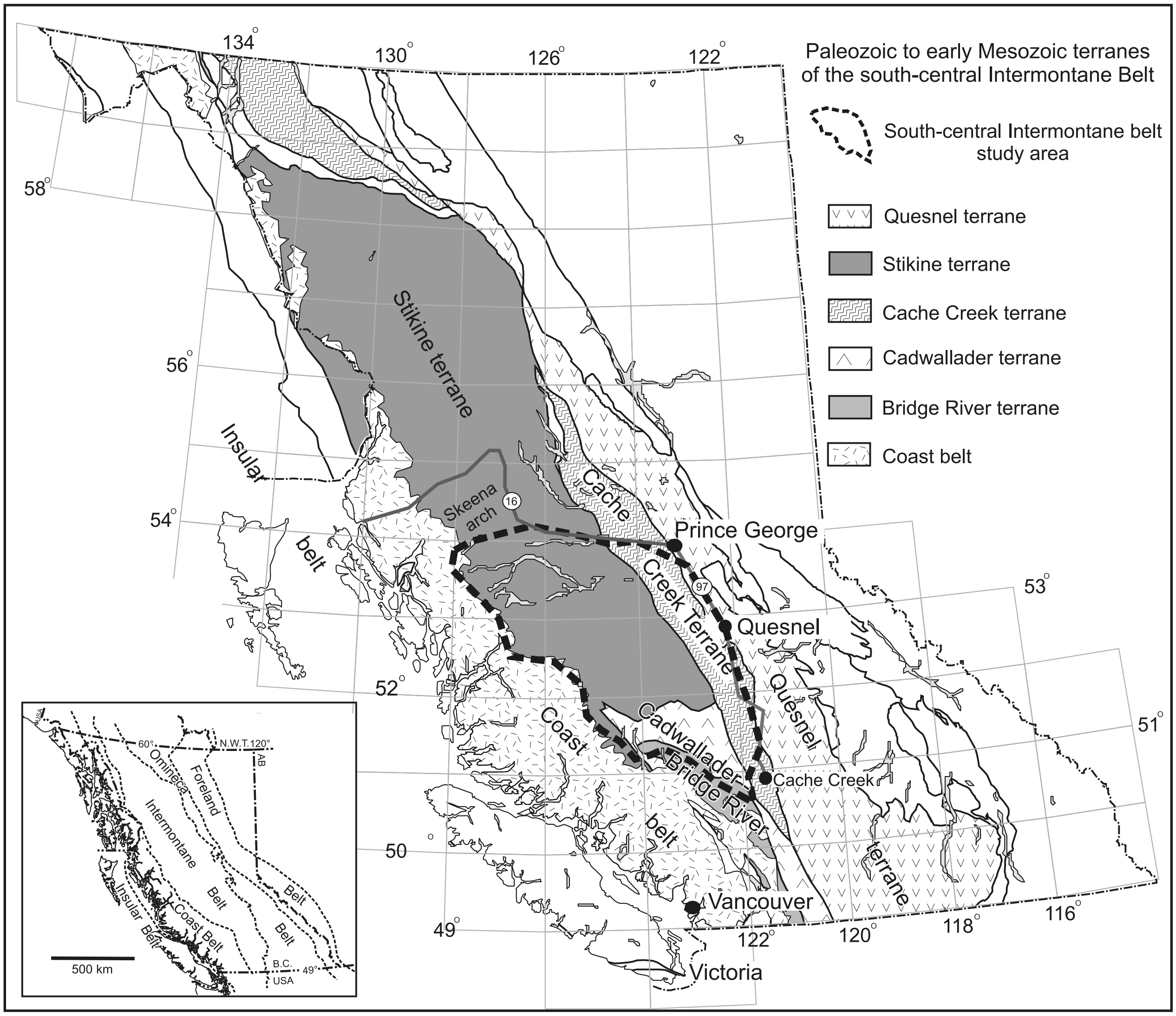
J. Riddell. British Columbia Ministry of Energy, Oil and Gas Division, P.O. Box 9323, Stn. Prov. Govt., Victoria, BC V8W 9N3, Canada.

E-mail for correspondence: (e-mail: Janet.Riddell@gov.bc.ca).

[1]This article is one of a series of papers published in this Special Issue on the theme of *New insights in Cordilleran Intermontane geoscience: reducing exploration risk in the mountain pine beetle-affected area, British Columbia*.

 doi:10.1139/E11-034

Fig. 1. Terranes of the south-central Intermontane belt. Inset: Geomorphologic belts of the British Columbia Cordillera.



tism (Tipper 1963*a*, 1963*b*, 1968; Woodsworth 1980; Armstrong 1988; Diakow and Levson 1997; Diakow et al. 1997; Grainger et al. 2001; Struik and MacIntyre 2001; Diakow 2006), unroofing of metamorphic core complexes (Friedman and Armstrong 1988; Wetherup and Struik 1996), and large-scale dextral strike-slip faulting (Struik 1993; Umhoefer and Schiarizza 1996). Non arc-related volcanism produced widespread blankets of mafic volcanic flows during the Miocene and Pliocene (Bevier 1983*a*, 1983*b*; Mathews 1989; Andrews and Russell 2007) and an east–west chain of Quaternary volcanoes (Bevier et al. 1979; Souther 1984, 1986; Souther et al. 1987; Souther and Souther 1994). The most recent glaciation left abundant unconsolidated till, fluvioglacial and glaciolacustrine deposits (Tipper 1971*a*, 1971*b*, 1971*c*, 1971*d*, 1971*e*; Plouffe and Levson 2001).

Potential hydrocarbon source rocks in the region include Jurassic and Early Cretaceous marine shales. Of special interest are black shales deposited during the Toarcian (latest Early Jurassic), which may represent an important global anoxic event, during which shales with high organic carbon content were deposited widely in oceans throughout the world (Ferri 2011). Voluminous coarse clastic sedimentary successions deposited primarily at the end of the Early Cretaceous are the primary candidates for hydrocarbon reservoir (Hannigan et al. 2001; Hayes 2002; Brown et al. 2008). Hydrocarbon trap-building conditions were optimal during the compressional tectonic regime of the middle to Late Cretaceous, and again during the formation of tensional structures in the Eocene. Hydrocarbon maturation opportunities were created during the mid-Cretaceous and Eocene because of heating related to magmatism and burial by thick sedimentary deposits (Riddell 2010).

The multi-institutional (Natural Resources Canada, British Columbia Ministry of Energy, Mines and Petroleum Resources, Geoscience BC, and participating universities and graduate students) collaborative geoscience efforts of the past 5 years had the goal of facilitating new resource exploration in the region that is suffering negative economic repercussions from the mountain pine beetle infestation that has destroyed vast areas of forest. Important challenges for oil, gas, and mineral resource exploration in the region are the scarcity of exposure of the rock units with high resource prospectivity because of extensive Cenozoic volcanic and Quaternary glacial cover and the hampering effect that the Cenozoic volcanic rocks have on acquisition of high-quality exploration geophysical data.

Hydrocarbon exploration has been carried out sporadically in the region since the 1930s. Several exploration wells were drilled in Tertiary sedimentary rocks along the Fraser River south of Quesnel between 1931 and 1981 (Yoon 1972; Long and Graham 1993). Cretaceous targets in the Nazko River and Redstone areas were explored by several companies in the 1950s and 1960s (Hudson's Bay Oil and Gas Company Report 1960; Pyecroft et al. 1961) and by Canadian Hunter Exploration Limited from 1979 to 1986 (Cosgrove 1981*a*, 1981*b*, 1981*c*, 1982, 1986).

Much of the recent work in the region (Cassidy et al. 2008; Calvert et al. 2009, 2011; Farqhuarson et al. 2011; Hayward and Calvert 2011; Idowu et al. 2011; Kim and Cassidy 2011[2]; Smithyman and Clowes 2011; Spratt and Craven 2011; Talinga and Calvert 2011) has involved re-evaluating the challenges that the overlying volcanic cover has historically presented to imaging rock units in the subsurface (Andrews and Russell 2006; Spratt et al. 2007; Calvert et al. 2009; Hayward and Calvert 2009) in light of technological advances in geophysical data collection, processing, and analysis.

A note on the term "Nechako basin"

The term "Nechako basin" has been used inconsistently over past decades to refer to different tectonic and stratigraphic entities in different locations, resulting in confusion about the distribution of sedimentary rocks and hydrocarbon potential in the region. For example, Tipper and Richards (1976) used the term "Nechako basin" to refer to a Middle and Late Jurassic depocentre receiving detritus shed to the south from the Skeena Arch (Fig. 3*a*). Canadian Hunter Exploration Limited referred to its project area in the Nazko River and Chilcotin plateau region (Fig. 3*a*) as the "Nechako basin" during hydrocarbon exploration and drilling of mid-Cretaceous targets in the early 1980s (Cosgrove 1981*a*, 1981*b*, 1981*c*, 1982, 1986). Koch (1973), Mossop et al. (2004), and others following them, have used the term "Nechako basin" to define most of the south-central Intermontane belt (Fig. 3*b*). This use of the term is especially misleading because it implies that a contiguous sedimentary basin underlies the entire region. Instead, as demonstrated by geological mapping of Tipper (1959, 1960, 1963*a*, 1963*b*, and 1968), Woodsworth (1980), Souther (1984), Roddick and Tipper (1985), Souther (1986), van der Heyden and Metcalfe (1992), Wetherup and Struik (1996), Diakow and Levson (1997), Struik et al. (2000), Diakow (2006), Haggart et al. (2006*b*), Mahoney et al. (2007), Mihalynuk et al. (2009), and others, the region has a complex geologic architecture, including volcanic and plutonic arc magmatic suites and associated sedimentary successions of various (mainly Mesozoic) ages, high-grade metamorphic complexes, and accretionary rocks. Sedimentary successions preserved within this region are localized and cover a far smaller aggregate area than the poorly defined entity that has been known as the "Nechako basin." Publications resulting from recent (i.e., 2004–2011) efforts to improve the geoscience database in the mountain pine beetle-infested area, including articles in this volume, have most commonly used the term "Nechako basin" in the same sense that Canadian Hunter used it in during their exploration program of 1979–1986, that is the Nazko River valley and the Redstone area of the Chilcotin Plateau (Fig. 3*a*).

It is recommended that the use of the "Nechako basin" label be discontinued, and that workers in the region instead provide explicit description of the location and (or) geologic units under discussion.

Lithostratigraphic framework

Paleozoic to mid-Mesozoic terranes

The oldest rocks in the south-central Intermontane belt belong to terranes that amalgamated and accreted to North America from late Paleozoic through the middle Mesozoic (Monger 1997). The study area straddles five terranes; Quesnellia, Cache Creek, Stikinia, Cadwallader, and Bridge River (Fig. 1).

Quesnel terrane (Quesnellia)

Quesnel terrane is exposed along the eastern side of the study area (Figs. 1, 4), where it is in contact with Cache Creek terrane to the west along the Pinchi fault (Struik et al. 1990). In south-central British Columbia Quesnellia (or Quesnel terrane) includes upper Paleozoic arc-related volcanic and clastic rocks of the Harper Ranch sub-terrane overlain by Triassic arc assemblage of the Nicola Group (Monger et al. 1991). Pre-Triassic rocks of Quesnellia are not exposed in the study area (Tipper 1959, 1960; Struik et al. 1990). The Nicola Group is exposed sparsely east of Quesnel (Tipper 1959; Panteleyev et al. 1996), and on both sides of Highway 97 between Quesnel and Prince George (Tipper 1960; Struik et al. 1990), where it includes black phyllite overlain by mafic volcanic rocks dominated by pyroxene-phyric flows and breccias and minor limestone and slate. Late Triassic to Early Jurassic plutons intrude the Nicola Group and host porphyry copper and copper–gold mineralization, notably the Polley stock at the Mount Polley deposit (Meredith-Jones 2009) northeast of Williams Lake. Lower and Middle Jurassic sandstones, conglomerates, and shales lie unconformably on Nicola Group rocks (Panteleyev et al. 1996) south of Quesnel (Fig. 4).

Cache Creek terrane

The Cache Creek terrane (Figs. 1, 2, 5) is an accretionary complex that includes disrupted Carboniferous to Early Jurassic (Orchard et al. 2001) oceanic crustal rocks and subduction mélange; chert, argillite, basalt, greenstone, reef carbonate, and blueschist (Monger and Price 2002). In southern British Columbia, Cache Creek terrane rocks are confined to the eastern part of the Intermontane belt. Cache Creek terrane rocks are sparsely exposed (Tipper 1960; Struik et al. 1990) west of the Highway 97 between Quesnel and Prince George, and include ribbon chert, black argillite, mafic volcanic rocks, limestone, and serpentinite. Thick reef

[2]Unpublished article entitled "Imaging the structure of the Nechako basin using teleseismic receiver functions".

Fig. 2. Geology of the south-central Intermontane belt and hydrocarbon exploration well locations. Adapted from digital geology by Massey et al. (2005).

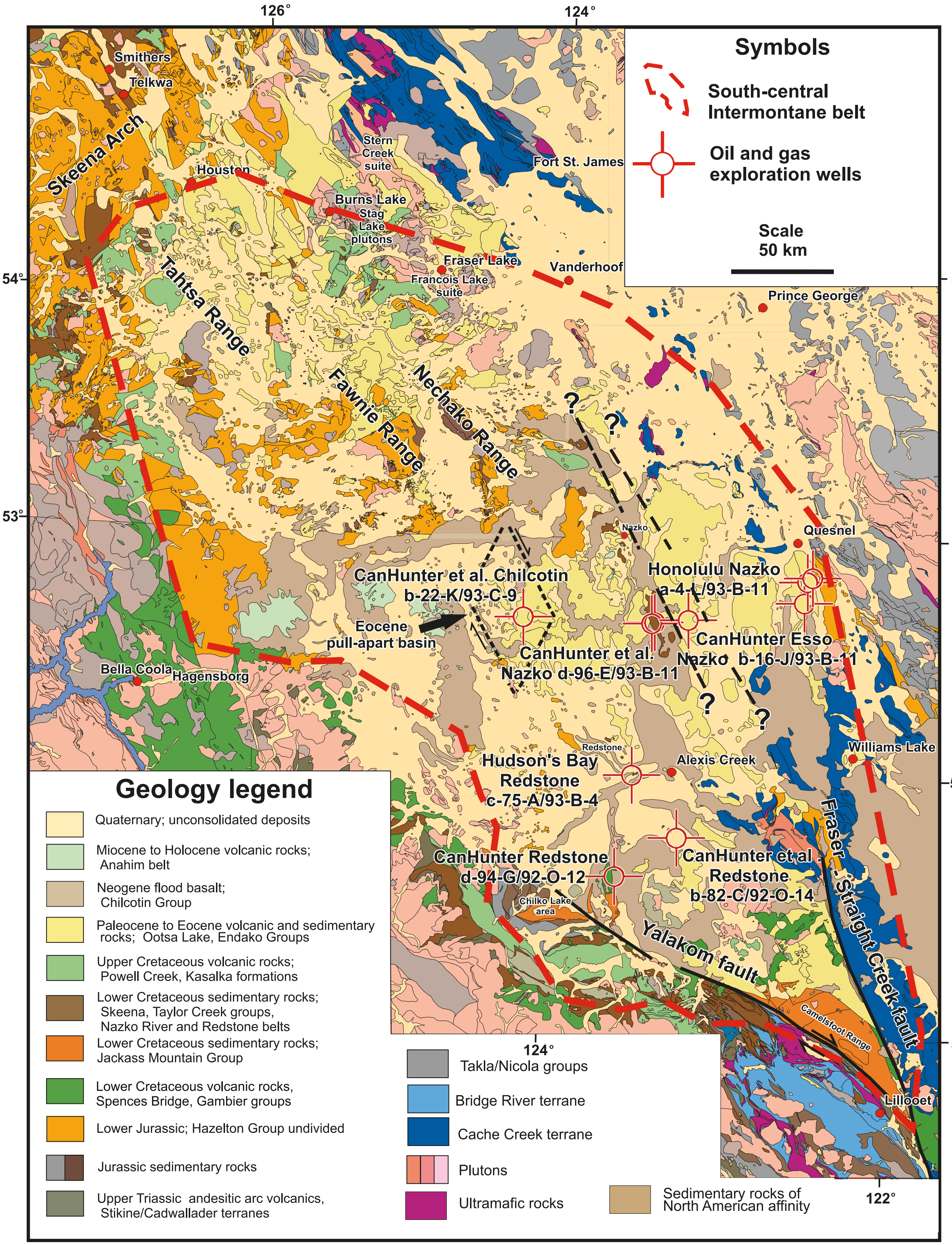
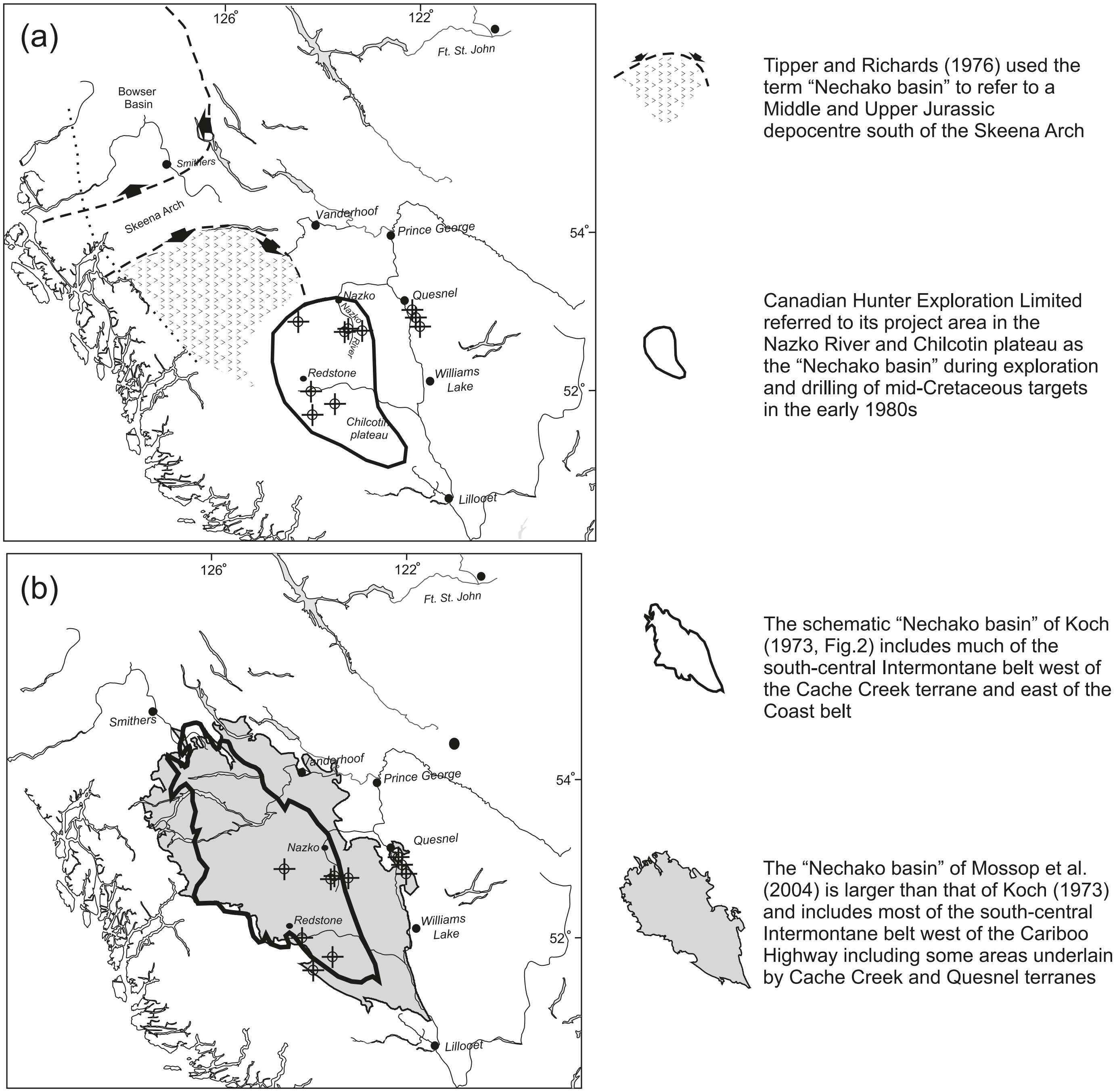


Fig. 3. The term “Nechako basin” has been used inconsistently over past decades to refer to different tectonic and stratigraphic entities in different locations. (*a*) Tipper and Richards (1976) used the term “Nechako basin” to refer to a Middle and Upper Jurassic depocentre receiving detritus shed to the south from the Skeena Arch. Canadian Hunter Exploration Limited referred to its project area in the Nazko River and Chilcotin plateau as the “Nechako basin” during hydrocarbon exploration and drilling of mid-Cretaceous targets in the early 1980s. (*b*) Koch (1973) and Mossop et al. (2004), and others following them, have used the term “Nechako basin” to define most of the south-central Intermontane belt.



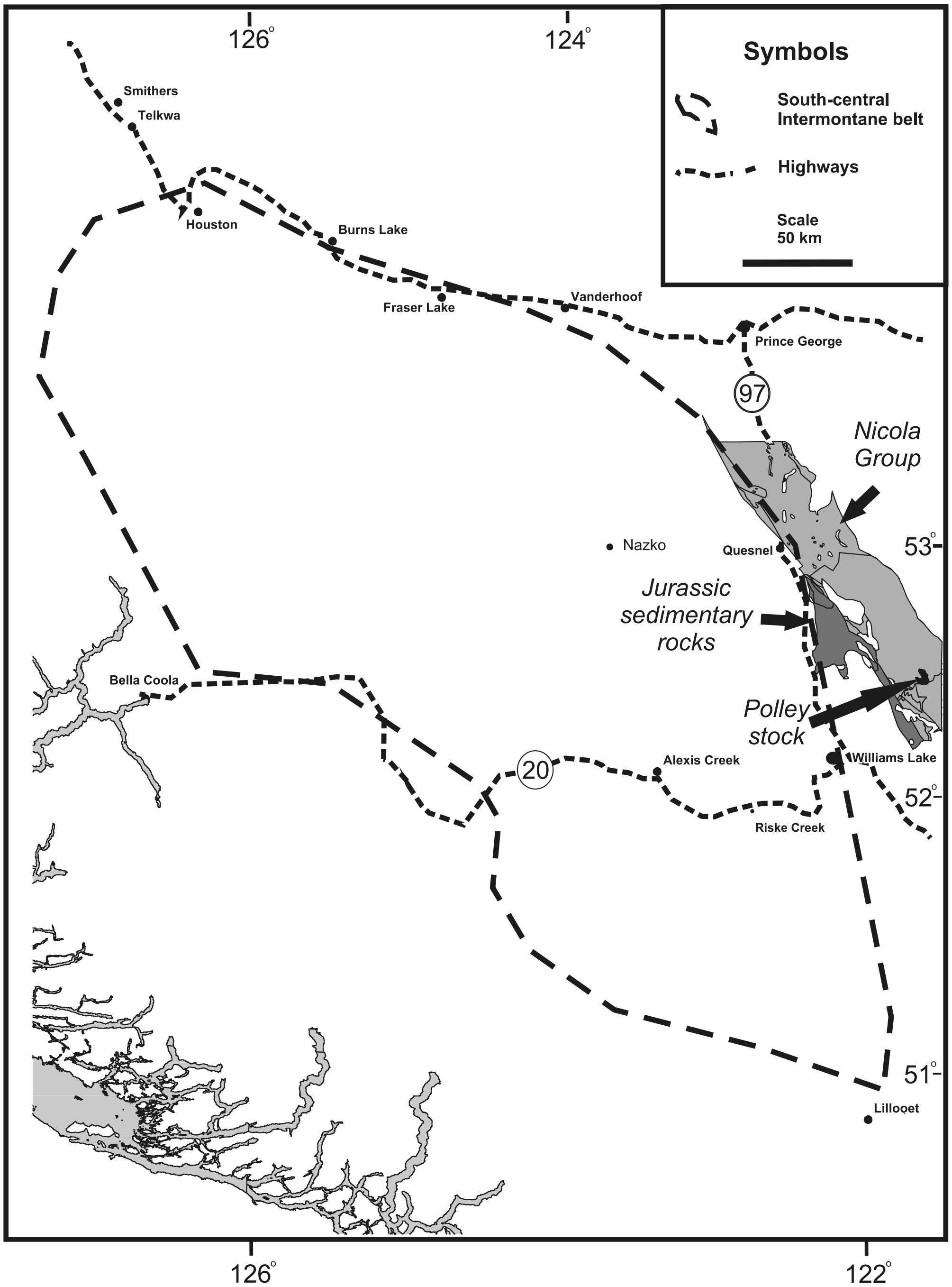
carbonates form abundant and impressive cliff outcrops in many locations along the Fraser River in southern British Columbia. Major plutons intruding Cache Creek rocks in the south-central Intermontane belt include the Late Permian Farwell Pluton (Read 1992) and the Late Triassic Granite Mountain pluton (Ash et al. 1999) north of Williams Lake, which hosts the Gibraltar porphyry copper deposit.

Limited exposures of Jurassic volcanic and sedimentary rocks overlie Cache Creek rocks on both sides of the Fraser Fault (Fig. 5) south of Riske Creek near Williams Lake. They include fossiliferous sandstone and conglomerate, rhyolite, dacite, andesite, and tuff. The regional correlation of these rocks is uncertain (Read 1992).

Stikine terrane (Stikinia)

Stikinia is a large volcanic arc terrane that underlies much

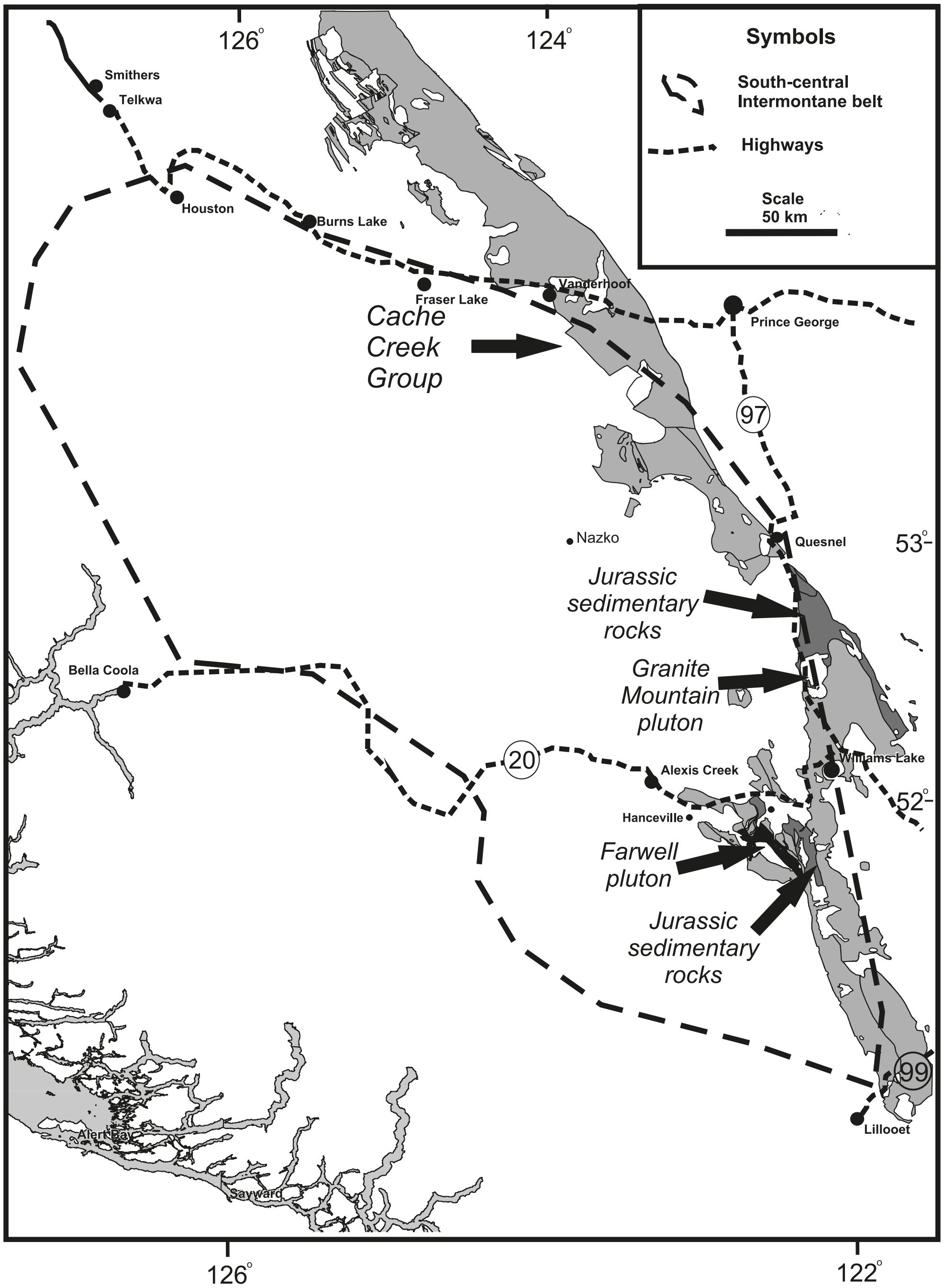
Fig. 4. Distribution of the Quesnel terrane along the eastern edge of the study area. Adapted from digital geology by Massey et al. (2005). The Upper Triassic Nicola Group (light grey) is composed of mafic volcanic rocks. Lower to Middle Jurassic sandstone, conglomerate and shale (dark grey) overlap the Cache Creek and Quesnel terranes south of Quesnel.



of the Intermontane belt (Figs. 1, 6. Its stratigraphy includes Devonian to Jurassic arc volcanic rocks and associated sedimentary rocks (Monger and Price 2002). Stikinia is generally characterized by Permian carbonate units, overlain by Upper Triassic arc volcanic and sedimentary rocks of the Takla Group, in turn overlain by volcanic arc successions of the Jurassic Hazelton Group (Monger et al. 1991). In the south-central Intermontane belt occurrences of pre-Jurassic Stikinian stratigraphy are rare; small isolated outcrops (too small to show on Fig. 6) occur over a limited area in the Tahtsa Ranges (Diakow 2006).

The Hazelton Group includes numerous Lower to Middle Jurassic arc volcanic successions deposited in a marine basin (Thorkelson et al. 1995). It is widely exposed in the south-central Intermontane belt in the Tahtsa Ranges (Woodsworth 1980; Diakow 2006), Nechako and Fawnie ranges (Diakow and Levson 1997), and along the contacts with igneous rocks of Coast belt north of Bella Coola (Haggart et al. 2006*b*;

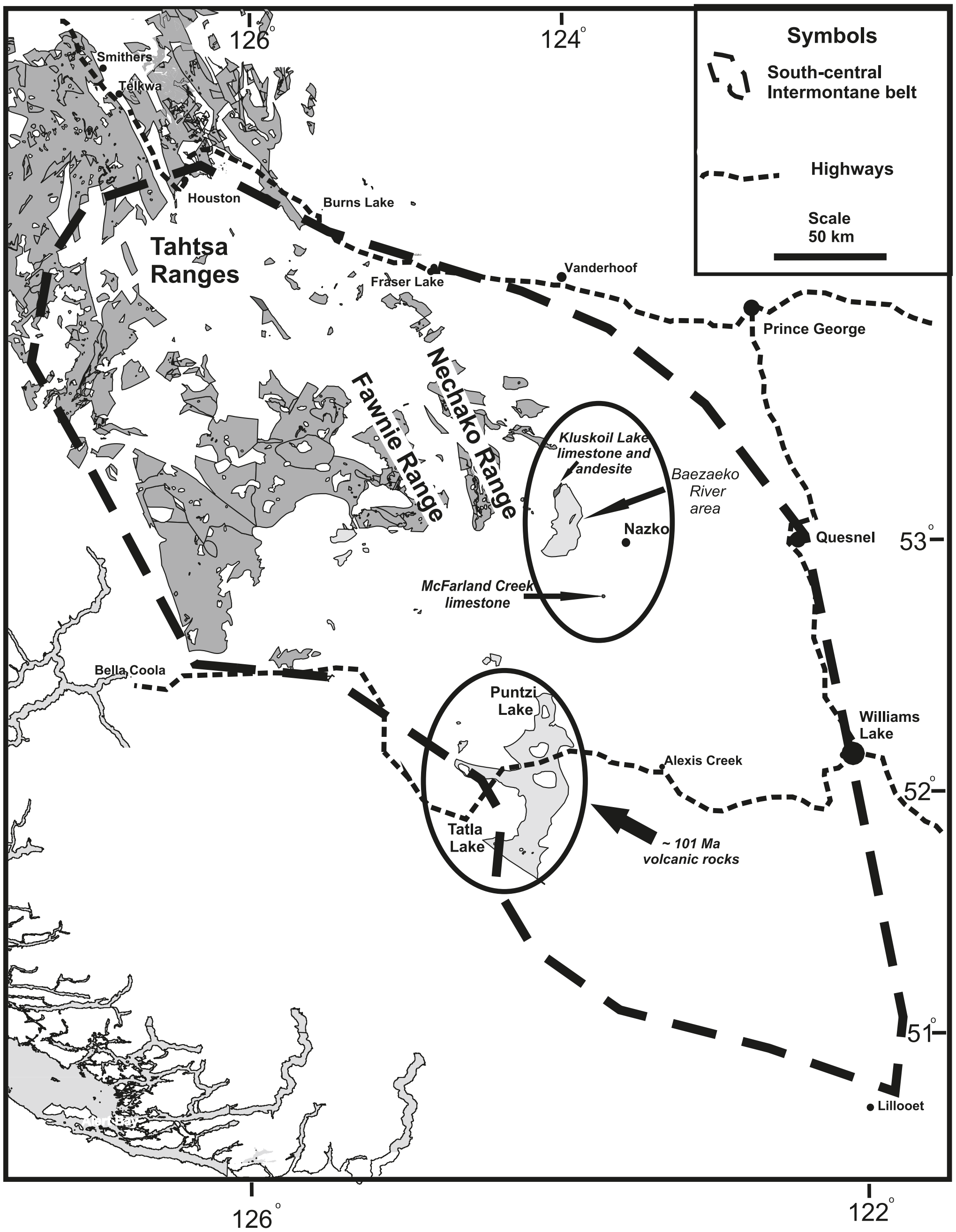
Fig. 5. Distribution of the Cache Creek terrane along the eastern edge of the study area. Adapted from digital geology by Massey et al. (2005). The Cache Creek Group (light grey) includes ribbon chert, black argillite, mafic volcanic rocks, limestone and serpentinite. Lower to Middle Jurassic sedimentary rocks (dark grey) overlap the Cache Creek and Quesnel terranes south of Quesnel and west of Williams Lake.



Mahoney et al. 2007). The most widespread and abundant Hazelton unit is the Telkwa Formation, which is dominated by maroon and green intermediate volcanic flows and breccias. Lesser volumes of marine sedimentary rocks are associated with the volcanic successions, including marine sandstone, siltstone, and mudstone of the Lower Jurassic Nilkitkwa Formation and shallow-water sandstones of the Middle Jurassic Smithers Formation (Diakow 2006). In the uplifted horst of the Fawnie and Nechako ranges (Figs. 2, 6), the Entiako Formation includes Lower to Middle Jurassic mudstones (Diakow and Levson 1997).

In the Fawnie and Nechako ranges (Figs. 2, 8), the Hazelton Group is overlain by late Middle Jurassic to Lower Cretaceous sedimentary rocks of the Bowser Lake Group (Diakow and Levson 1997). These include fine-grained, deep-water successions with a few resistant chert pebble conglomerate beds and light-coloured ash-tuff laminae and minor volcanic rocks. These rocks transition upsection to a younger, coarser,

Fig. 6. Distribution of the Stikine terrane. Adapted from digital geology by Massey et al. (2005). The oldest rocks of Stikinia include in the study area are Permian limestone overlain by Upper Triassic mafic volcanic rocks. These older rocks are sparsely exposed in the study area and do not appear on this map bhecause of scale. Lower to Middle Jurassic Hazelton Group (medium grey) is widely exposed in the north-western part of map; it is dominated by arc volcanic rocks with marine sedimentary successions. Exposures at Kluskoil Lake, Baezaeko River, and McFarland Creek have been included with Stikinia on previous maps, but they are undated and their terrane affinity is unknown. Rocks between Puntzi and Tatla lakes were included with the Hazelton Group on previous maps, but have yielded Early Cretaceous dates, so they are too young to be part of the Hazelton arc. Correlation of these upper Lower Cretaceous volcanic rocks with the Spences Bridge Group has been suggested.

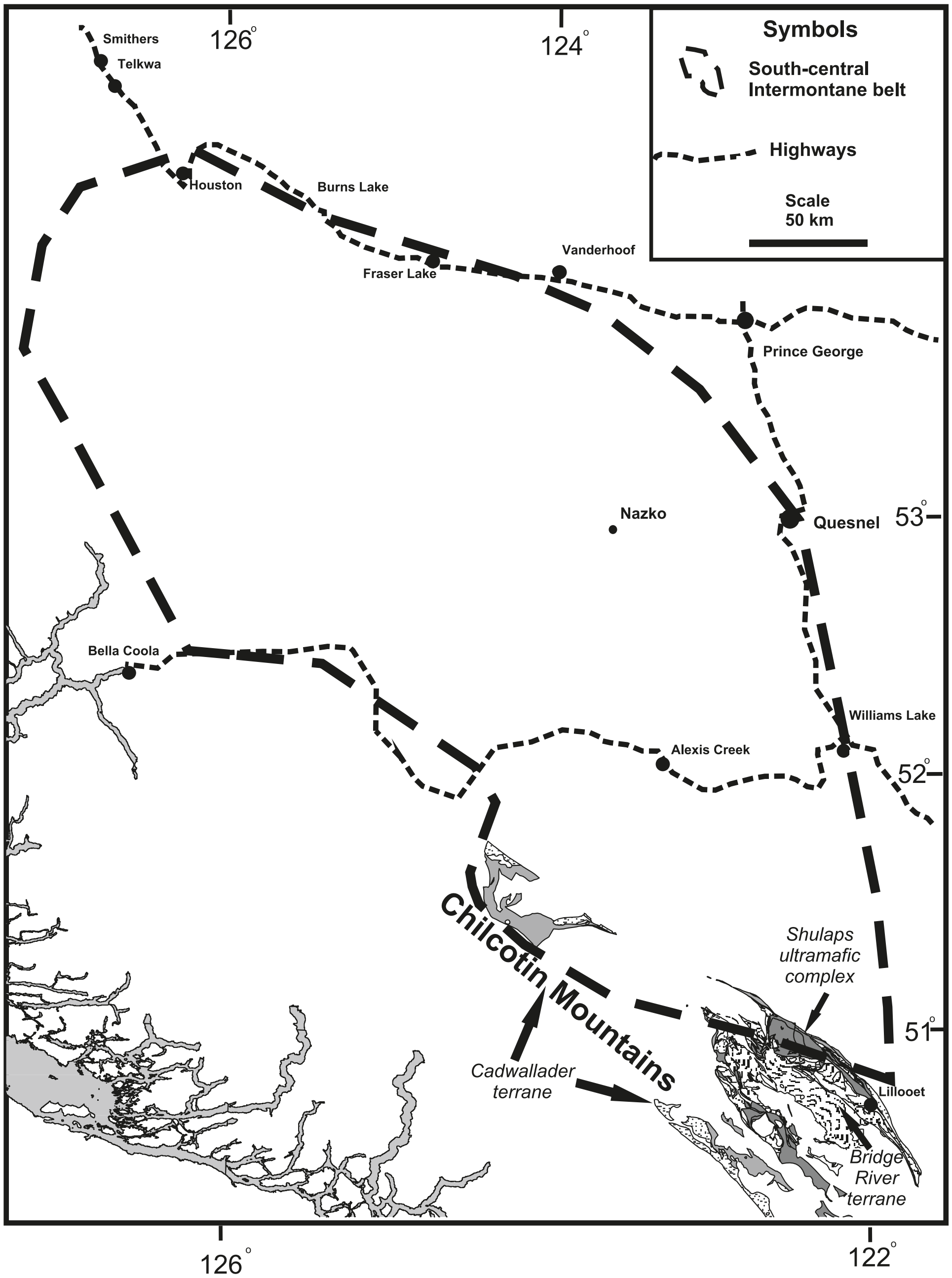


shallow-water succession that includes chert pebble conglomerate and fossiliferous sandstone and siltstone (Diakow et al. 1997). The Late Jurassic Laidman pluton intrudes rocks of the Hazelton and Bowser Lake groups in the Fawnie Range (Diakow and Levson 1997; Friedman et al. 2001).

Stikinian strata are intruded by large plutonic suites (Fig. 2), including the Late Triassic Stern Creek suite (220–215 Ma; Struik et al. 2000; Whalen et al. 2001), the Early to Middle Jurassic Stag Lake plutons near Burns Lake, and the Late Jurassic Francois Lake suite (Struik 1998, Struik et al. 2000; Whalen et al. 2001).

A belt of rocks west of Nazko has been included with Stikinian rocks on compilation maps (Massey et al. 2005; Riddell 2006), but they are undated and their Stikinian affinity is

Fig. 7. Distribution of the Cadwallader terrane, Bridge River terrane, and the Shulaps ultramafic complex. Adapted from digital geology by Massey et al. (2005). The late Paleozoic Shulaps ultramafic complex and other ultramafic rocks are dark grey. Upper Triassic to Middle Jurassic arc volcanic rocks and arc-derived clastic sedimentary rocks of Cadwallader terrane are shown in light grey (marine shales) and stippled pattern (volcanic rocks). Mississippian to Jurassic Bridge River complex is shown in a cloud pattern.



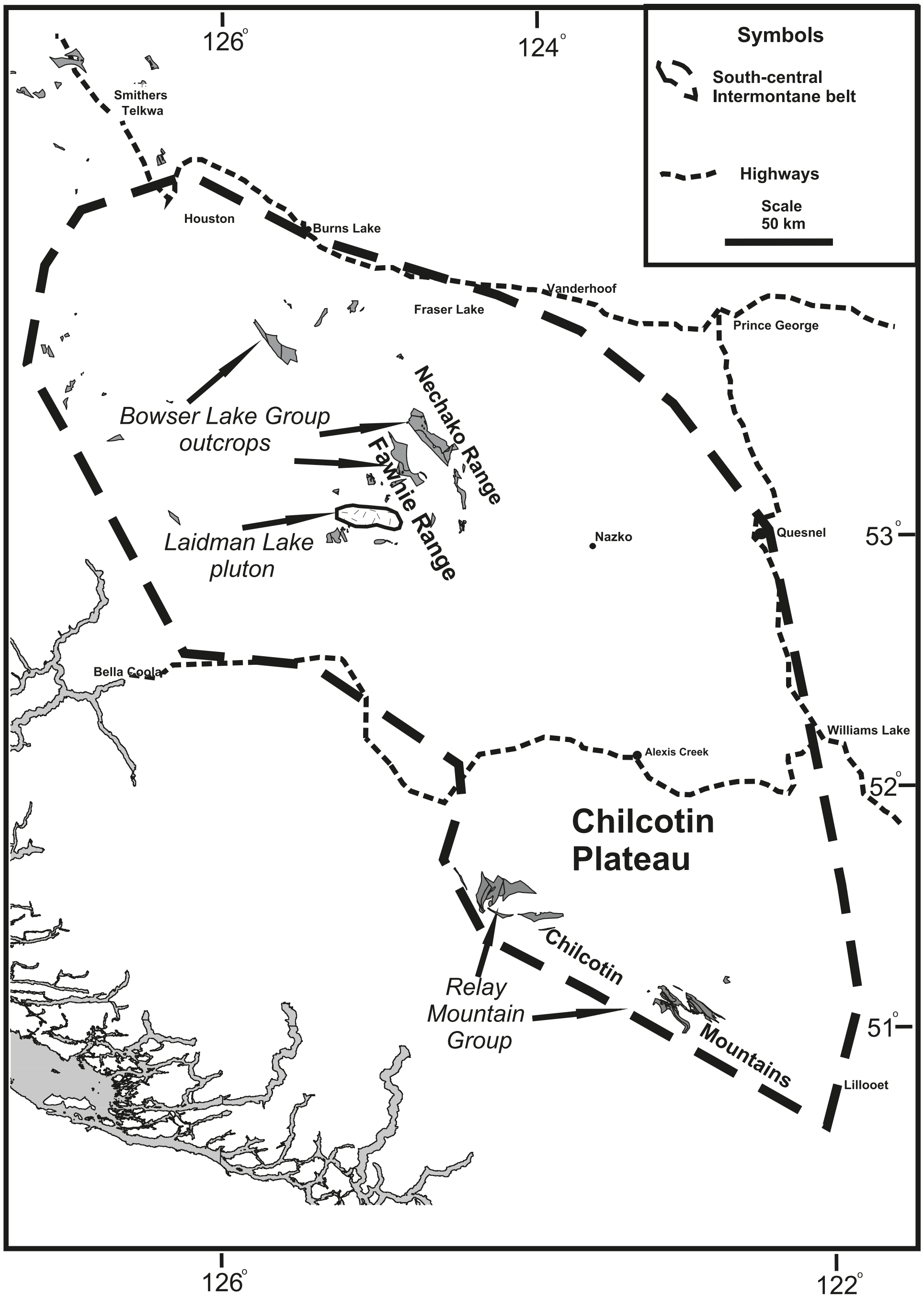
not certain. These rocks (Fig. 6) include limestone and andesite south of Kluskoil Lake (Tipper 1960); andesite, chert pebble conglomerate, and argillite in the Baezaeko River area; and limestone near McFarland Creek (Tipper 1959; Metcalfe et al. 1997).

Andesitic volcanic rocks near Tatla and Puntzi lakes areas (Fig. 6) of the Chilcotin Plateau were tentatively mapped as Hazelton Group (Tipper 1968; Massey et al. 2005; Riddell 2006) and assumed to be part of Stikinia. However, recent U–Pb zircon dating (Riddell 2010) has yielded latest Early Cretaceous ages (~101 Ma) that indicate that these rocks are too young to be part of the Hazelton arc. They are further discussed later in the text.

Cadwallader and Bridge River terranes

The Cadwallader and Bridge River terranes are exposed in the Chilcotin Mountains south of the Yalakom fault (Figs. 2, 7). They are considered part of the eastern margin of the Coast belt (Schiarizza et al. 1997). They are included here because they form basement to Methow–Tyaughton basins, which include units that represent hydrocarbon potential along the southwest edge of south-central Intermontane belt.

Fig. 8. Distribution of upper Middle Jurassic to Lower Cretaceous sedimentary rocks. Adapted from digital geology by Massey et al. (2005). Middle and possibly Late Jurassic rocks of the Bowser Lake Group are exposed in the Nechako and Fawnie ranges. The Upper Jurassic to Lower Cretaceous Relay Mountain Group is exposed in the Chilcotin Mountains on the southern edge of the map area. In both the Bowser Lake Group and the Relay Mountain Group, fine-grained, deeper water shales and siltstones of the Late Jurassic give way into the Early Cretaceous to generally coarser grained, shallower water facies.



The Cadwallader terrane comprises the Cadwallader Group, the Tyaughton Group, and Lower to Middle Jurassic marine sedimentary sequences (Umhoefer 1990). The Cadwallader Group contains Upper Triassic mafic volcanic rocks overlain by sedimentary rocks of the Hurley Formation (Rusmore 1987; Schiarizza et al. 1997). The Tyaughton Group comprises Upper Triassic nonmarine and shallow-marine sedimentary rocks (Umhoefer 1990). Lower to Middle Jurassic marine sedimentary rocks are recognized in several locations in the Chilcotin Mountains, where they have been assigned various local names; the Nemaia, Last Creek (Umhoefer and Tipper 1998), and Junction Creek (Schiarizza et al. 1997) formations. The Cadwallader Group is interpreted as an Upper Triassic volcanic arc and fringing clastic apron (Schiarizza et al. 1997; Umhoefer and Tipper 1998). The Triassic arc volcanic rocks of Cadwallader terrane share broad similarities with Stikinian arc rocks of the same age, and it has been proposed that they could be formerly distal components of the same arc system that were subsequently structurally juxtaposed (Rusmore et al. 1988; Umhoefer 1990; Umhoefer and Tipper 1998).

The Bridge River terrane comprises variably metamorphosed ribbon chert, argillite, clastic rocks, and mafic volcanic and intrusive rocks and greenstone, serpentinite, blueschist, and ultramafic rocks (Potter 1986; Schiarizza et al. 1997). Radiolarians from Bridge River chert range in age from Mississippian to Jurassic and represent a long-lived oceanic domain (Cordey and Schiarizza 1993). The Upper Jurassic to Lower Cretaceous Cayoosh assemblage (Journeay and Mahoney 1994) consists of clastic metasedimentary rocks that unconformably overlie the Bridge River terrane.

The upper Middle Jurassic to Lower Cretaceous Relay Mountain Group overlaps the Bridge River and Cadwallader terranes (Figs. 2, 8). The Relay Mountain Group is well dated by abundant index macrofossils (Umhoefer et al. 2002). It comprises three formations. The Tyoax Pass Formation includes marine shale and sandstone turbidites. It is overlain by the Teepee Mountain Formation, which contains shallow-marine, fluvial, and marginal marine facies. The youngest unit, the Lower Cretaceous Potato Range Formation, includes marine and nonmarine facies and contains west-derived clastic material, marking the first evidence of the arrival of a western margin to the basin. The Potato Range Formation sandstones show greater abundance of tuffaceous clastic material in comparison to the underlying formations, indicating an increase of volcanic arc activity to the west (Umhoefer et al. 2002). As in the Bowser Lake Group further north, in the Relay Mountain Group fine-grained, deeper water shales and siltstones of the Upper Jurassic give way into the Lower Cretaceous to generally coarser grained, shallower water facies.

Amalgamation and accretion

The story of the timing of amalgamation and accretion of the offshore Cordilleran terranes is complex. The direction and speed of plate convergence along the western boundary of North America has varied over the past 190 Ma (Monger 1997), and the unravelling of the resultant collage of terranes is not straightforward (Coney et al. 1980; Monger et al. 1991), but understanding of the evolution of the Canadian Cordillera has progressed because of regional geologic mapping and multidisciplinary analyses conducted over past years. Useful summaries are provided by Monger et al. (1991); Price (1994); Monger and Price (2002); and Evenchick et al. (2007).

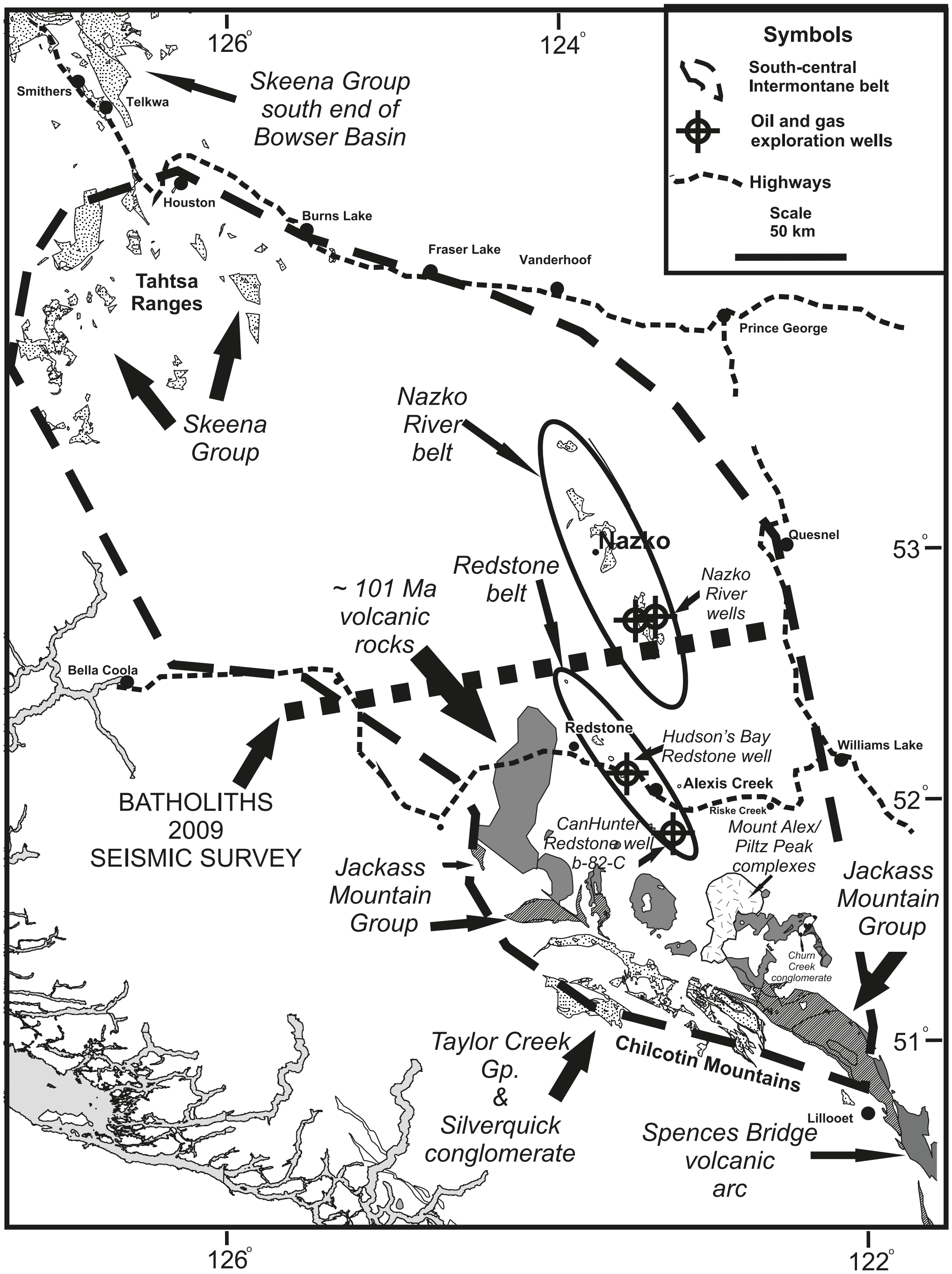
The boundary between the composite Stikinia – Cache Creek – Quesnel terrane and the composite Cadwallader – Bridge River terrane lies in the southern part of the study area. The location and geometry of the boundary between these composite terranes is not well understood because it is hidden beneath younger volcanic and glacial cover.

Quesnel, Cache Creek and Stikine terranes: The amalgamation of the Quesnel, Cache Creek, and Stikine terranes into a larger block, the composite Intermontane terrane (Terrane I of Monger et al. 1982) by the Middle Jurassic is demonstrated by deposition of detritus from Cache Creek terrane on to Quesnel terrane near Quesnel (Panteleyev et al. 1996) and Stikine terrane in the Bowser basin (Ricketts et al. 1992; Evenchick et al. 2007). Accretion of Terrane I to North America by no later than the Early Cretaceous is documented by deposition of metamorphic detritus from the Omineca crystalline belt in Lower Cretaceous deposits on Bowser basin rocks (Monger et al. 1982; Evenchick et al. 2007).

Cadwallader and Bridge River terrane: Mapping by Schiarizza et al. (1997) documented evidence that the Bridge River ocean crust was subducting beneath late Paleozoic ophiolitic rocks of the Shulaps ultramafic complex from the Middle Triassic to the Middle Jurassic. Upper Triassic to Middle Jurassic arc volcanic and arc-derived clastic sedimentary rocks of Cadwallader terrane formed on the overriding plate in response to subduction. The Relay Mountain Group overlaps the Bridge River and Cadwallader terranes, demonstrating a link between them by the late Middle Jurassic. Accretion of this block to the North American continent in the Early to Late Cretaceous is indicated by the incorporation of continental-sourced detritus in the overlapping Tyaughton–Methow basin (Schiarizza et al. 1997).

The latitude at which accretion of the Cadwallader – Bridge River terrane block took place is controversial. Debate has developed because of the apparent incompatibility between the paleomagnetic and the geological data sets along the North American Cordillera (Cowan et al. 1997; Haskin et al. 2003; Haggart et al. 2006*a*). In the Canadian Cordillera paleomagnetic inclination measurements in Upper Cretaceous volcanic rocks that overlie some of the Insular terranes (or Terrane II of Monger et al. 1982) and the Cadwallader – Bridge River terrane block are shallower than they should be had they formed near their present latitudinal positions. The Baja – British Columbia hypothesis (Irving 1985) proposed that rocks of the combined Insular – Cadwallader – Bridge River block were positioned 2000 km or more to the south at ~90 Ma, subsequently migrating northward along the Pacific coast during the Late Cretaceous, to amalgamate with Terrane I before the end of the Cretaceous (Wynne et al. 1995; Irving et al. 1996; Ward et al. 1997; Housen and Beck 1999; Baker et al. 2003; Enkin 2006; among others). However, geological and faunal data indicate links between the Insular and Intermontane terranes by the mid-Cretaceous or earlier (van der Heyden 1992; Haggart and Carter 1994; Monger and Journeay 1994; Monger and Price 1996; Mahoney et al. 1999; Schröder-Adams and Haggart 2006; Smith 2006; among others), and thereby constrain Late Cretaceous displacement amounts to much shorter distances, in the order of a few hundred kilometres. More recently, the paleomagnetic work of Enkin et al. (2006) and Enkin (2006) on Albian to Cenomanian chert pebble conglomerate exposed at the mouth of Churn Creek (Fig. 9) at the Fraser River near Gang Ranch supports the “yo-yo” solution (Mahoney et al. 2001) to the “Baja British Columbia” problem, which suggests the Intermontane and the Insular terranes were amalgamated by the Albian (latest Early Cretaceous) into a huge block, which then travelled south together to the latitude of the Baja Peninsula in the early Late Cretaceous, then migrated north again to its approximate present position by the Eocene. At the Churn Creek site, described by Mahoney et al. (1992) and Riesterer et al. (2001), the Churn Creek conglomerate is deposited on volcanic rocks that are correlated with the Spences Bridge Group (Haskin 2000; Haskin et al. 2003). Contrasting paleomagnetic signatures occur *within* the section (Enkin 2006, fig. 3B): the inclinations of the underly-

Fig. 9. Distribution of mid-Cretaceous sedimentary rocks and arc volcanic sequences. Adapted from digital geology by Massey et al. (2005). The late Early Cretaceous (Aptian to Albian) Skeena Group is exposed in the Tahtsa Ranges south of Houston, where it is dominated by grey and green micaceous feldspathic sandstone, with minor chert pebble conglomerate, and black shale. The Nazko River and Redstone belts are dominantly Albian to Cenomanian chert- and quartz-rich sandstones and chert-pebble conglomerates with interbedded red siltstones. Thicknesses of 1000–2000 m were intersected by wells in the Nazko River and Redstone areas. Aptian–Albian to Cenomanian rocks of the Taylor Creek Group and Silverquick conglomerate include marine, shallow-marine, and nonmarine sedimentary rocks. The Skeena, Nazko River, Taylor Creek, and Silverquick units are shown in stippled pattern. The lower Aptian to Cenomanian or Turonian Jackass Mountain Group (hatched) includes marine and nonmarine feldspathic sandstone and conglomerate. The Albian to Cenomanian Churn Creek conglomerate is a small exposure near the southeast edge of the study area. The Spences Bridge continental volcanic arc was active in the mid-Cretaceous.



ing ~104 Ma (Albian) volcanic rocks indicate formation approximately adjacent to present-day Oregon State), while the inclinations in the overlying Albian to Cenomanian conglomerate indicate deposition at the latitude of northern Mexico.

Late Lower Cretaceous to latest Upper Cretaceous synorogenic basins and magmatism

A large-scale compressional–transpressional tectonic regime was active from the end of the Early Cretaceous (Aptian–

Albian) to the earliest Tertiary during the accretion of the Insular terranes to North America (Monger et al. 1994; Monger 1997; Schiarizza et al. 1997; Monger and Price 2002). Events associated with this regime are expressed along the Intermontane belt as thrust faults and folds and by accumulations of overlap assemblages of synorogenic sedimentary rocks. A transition from dominantly marine to dominantly nonmarine sedimentary deposition occurred by the end of Early Cretaceous as terranes of the Insular belt moved eastward toward the new continental edge, closing the oceans. Shallow-marine and nonmarine clastic deposits of locally derived detritus on angular unconformities are preserved along the Intermontane and Coast belts (Tipper 1959, 1978; Woodsworth 1980; Schiarizza et al. 1997, 2002; Reisterer et al. 2001; Evenchick et al. 2007; Riddell et al. 2007; Haggart et al. 2011). These units were most voluminously deposited in the Albian to Cenomanian, and they represent the most important potential hydrocarbon reservoir units in the region (Brown et al. 2008) as they include abundant coarse-grained intervals of significant thicknesses.

Skeena Group

The Skeena Group of the south-central Intermontane belt is exposed in the Tahtsa Ranges south of Houston (Fig. 9), where it is dominated by grey and green micaceous feldspathic sandstone, with minor chert pebble conglomerate and black shale (Desjardins and Arksey 1991; Bassett and Kleinspehn 1997; Diakow 2006; Riddell and Ferri 2008). The Skeena Group includes sedimentary rocks deposited in marine, shallow-marine, coal-swamp delta, and fluvial environments (Bassett and Kleinspehn 1997). It is inferred to be Aptian to Albian in age and is best exposed in the Bowser basin, where it was deposited in a synorogenic basin on deforming Stikinian and Bowser basin rocks (Evenchick et al. 2007).

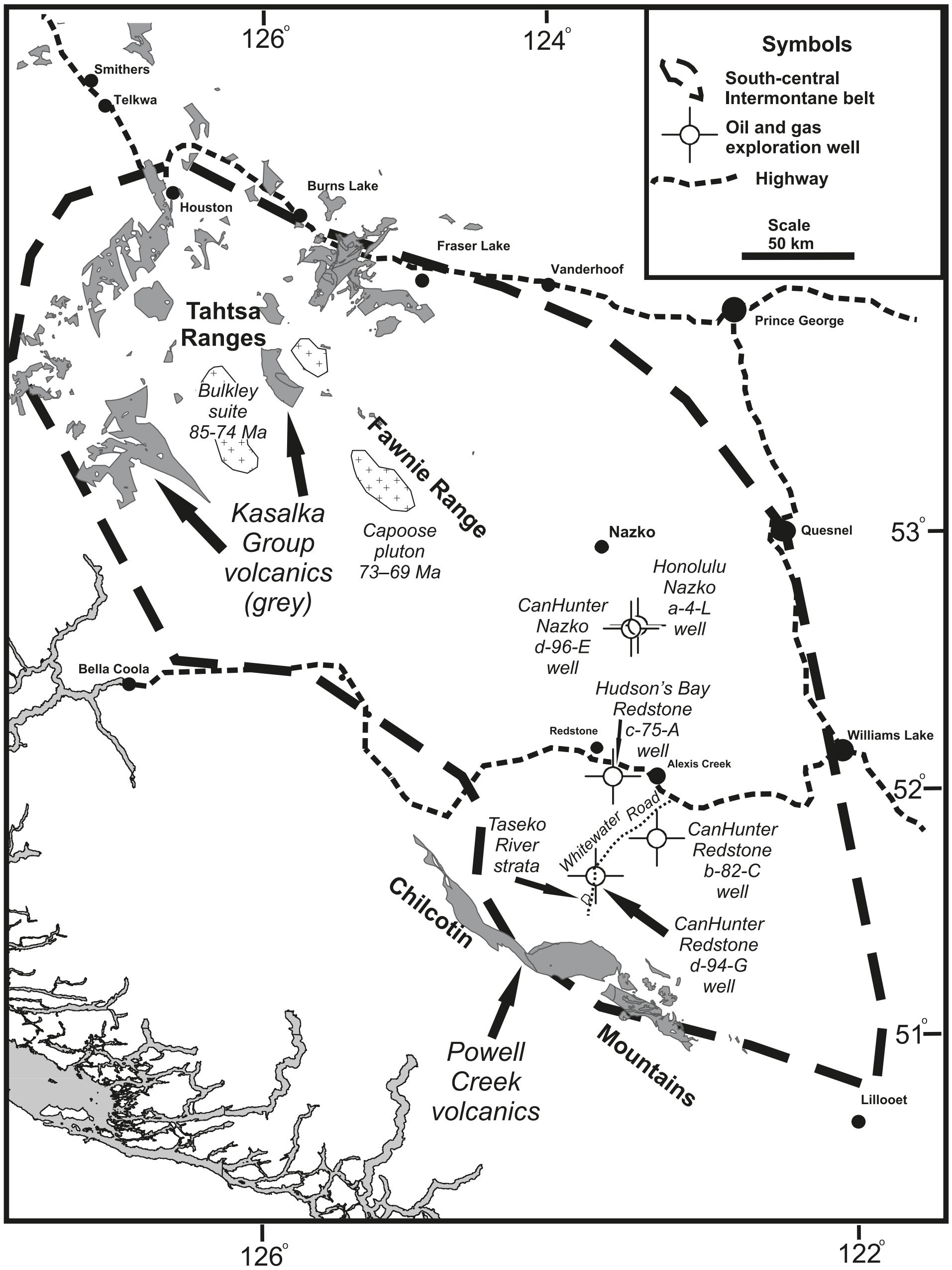
Nazko River and Redstone belts

A succession of latest Lower Cretaceous (Albian) to Upper Cretaceous, mainly nonmarine to shallow-marine sedimentary rocks is exposed in scattered outcrops along a narrow north-northwest trending belt about 70 km west of Quesnel. The belt of rocks, herein referred to as the Nazko River belt (Fig. 9), has been the primary target of most of the hydrocarbon exploration that has occurred in the south-central Intermontane belt, and although no discoveries have occurred, oil staining and bitumen showings at surface (Brown et al. 2008) and in the subsurface (Pyecroft et al. 1961; Taylor 1961; Cosgrove 1981*a*) demonstrate that a petroleum system has been functional in these rocks. The Cretaceous rocks of the Nazko River belt have been the target of much of the hydrocarbon exploration in the region, and distinguishing them from other rocks is the primary aim of recent work on interpretation of reprocessed 1980s Canadian Hunter seismic data (Hayward and Calvert 2011), new Vibroseis seismic data (Calvert et al. 2011) and new magnetotelluric data (Spratt et al. 2011), all of which have had success with imaging these rocks in the subsurface. The Nazko River belt is 10–15 km wide and ~90–150 km long. Outcrops are mostly of tan- to brown-weathering chert- and quartz-rich sandstones with floating chert pebbles and pebble trains, with chert-pebble conglomerate and silt interbeds, and abundant cross-beds (Ferri and Riddell 2006; Riddell et al. 2007). An Albian palynological age from a surface outcrop near the CanHunter Nazko wellsite was reported by Hunt (1992). An outcrop of muscovite-rich sandstone near the Honolulu Nazko wellsite produced a palynological age of Cenomanian to possibly Turonian (Sweet 2008, sample C-467162). Over 2000 m thicknesses of similar rocks were intersected by the Honolulu Nazko (a-4-L/93-B-11) and CanHunter Nazko (d-96-E/93-B-11) exploration wells (Figs. 2, 8, 13; Pyecroft et al. 1961; Cosgrove 1981*a*; Mustard and MacEachern 2007; Riddell et al. 2007). The drilling also intersected intervals of finer grained rock types that do not appear in outcrop, presumably because they are recessive. Many are reddish mudstones, some of which represent paleosols (Mustard and MacEachern 2007). Most palynological ages from well cuttings from these two wells range from middle to late Albian to Cenomanian (Riddell et al. 2007). Taylor (1961) reported Late Cretaceous palynomorphs beneath the mainly Lower Cretaceous rocks in the Honolulu Nazko well. These results were supported by identification of Campanian palynomorphs in greenish shale, sandstone, and siltstone at depths of 2300–2500 m, beneath the Albian to Cenomanian section (Riddell et al. 2007). A lithologically similar unit at 2725–2805 m depth in the CanHunter et al. Nazko (d-96-E) well (Geological Survey of Canada (GSC) sample C-477699) also yielded Campanian palynomorphs (Sweet 2006). This result requires the existence of a thrust fault to place more than 2000 m of Albian to Cenomanian strata over the younger rocks in the subsurface of the Nazko River valley (Fig. 14).

The eastern extent of the Cretaceous rocks of the Nazko River belt under Eocene and younger cover is limited to about 10 km to the east of the Nazko valley by a contact with very different rocks intersected by the the CanHunter Esso Nazko (b-16-J/93-B-11) well (Figs. 2, 14; Cosgrove 1981*b*; Riddell et al. 2007). A north-northwest-striking, near-vertical strike-slip fault (Fig. 2) is interpreted between the wells from reprocessed Canadian Hunter seismic and magnetic data (Hayward and Calvert 2011). At 2–15 km to the west, the Nazko River belt is flanked by a highland of probable pre-Cretaceous limestones and volcanic rocks of uncertain affinity (Fig. 5) at MacFarland Creek (Tipper 1959) and Kluskoil Lake (Tipper 1960). The southern end of the belt is limited by exposures of Cache Creek terrane rocks southwest of Alexis Creek (Fig. 2), but the contact is covered by Eocene and younger rocks. The northernmost recognized exposure of Nazko River belt rocks is about 80 km north of the Nazko River wells (Fig. 2). It is possible that the depositional basin was originally wider but correlative rocks have been separated from the Nazko River belt by faulting, either during the fold and thrust events in the Cretaceous or by Eocene strike-slip faulting related to the Yalakom and Fraser fault systems, or both, leaving the Nazko River belt as a remnant sliver.

Rocks that closely resemble the outcrops in the Nazko River belt occur at surface along a smaller subparallel belt (Redstone belt, Fig. 9) west of the trace of the Nazko River belt. Small isolated outcrops occur east of Redstone, and on the Chilko River south of Redstone. Similar rocks were intersected in the Hudson's Bay Redstone well (c-75-A/93-B-4; Hudson's Bay Oil and Gas Company (1960) well report; Figs. 2, 9, 14). Based on field characteristics, these occurrences directly correlate with the sedimentary rocks of the

Fig. 10. Distribution of Upper Cretaceous rocks. Adapted from digital geology by Massey et al. (2005). The Kasalka and Powell Creek (light grey) continental-arc volcanic sequences are exposed in the north and south parts of the map, respectively. Surface exposures of Upper Cretaceous sedimentary rocks are rare, but relatively thin intervals were intersected by five oil and gas exploration wells.

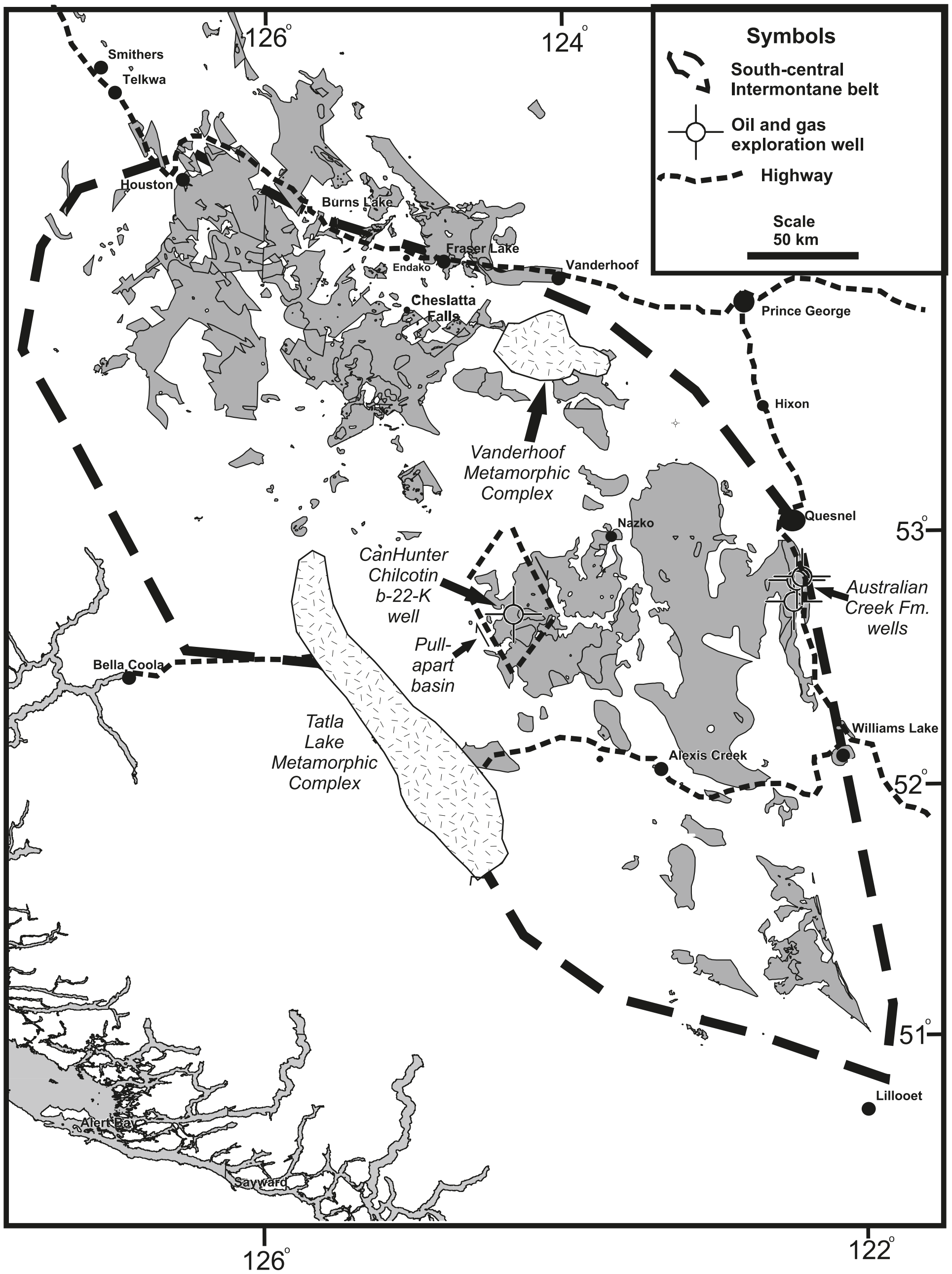


Nazko belt. Surface exposures are dominated by cross-bedded coarse chert-rich salt-and-pepper sandstones with abundant pebble trains, and chert pebble conglomerates and red siltstones. Similar lithological successions at 500–1300 m depth in the Hudson's Bay Redstone (c-75-A/93-B-4) well contain mainly late Albian palynomorphs (Sweet 2006, Riddell et al. 2007). Palynomorphs from the upper 500 section in this well support an age range of late Albian to Cenomanian (A.R. Sweet, written communication 2011).

The regional correlation of the sedimentary rocks of the Nazko River and Redstone belts is not certain. They overlap in age with parts of the Skeena Group to the northwest, the Taylor Creek Group and Silverquick conglomerate, and the Jackass Mountain Group to the south. Their current position near the boundary between Cache Creek and Stikine terrane implies that, like the Skeena Group, they were likely deposited on the composite Intermontane terrane. The Nazko River – Redstone belts are presently separated from the nearest Skeena Group outcrops by over 150 km and by the uplifted older rocks of the Fawnie and Nechako ranges (Figs. 2, 6, 8).

The strata of the Nazko and Redstone belts resemble the Dash and Beece Creek formations of the Taylor Creek Group and the Silverquick conglomerate, coeval units in the Tyaughton basin of the Chilcotin Mountains to the south, and we have previously speculated that they are correlative (Ferri and Riddell 2006; Riddell et al. 2007). Their common

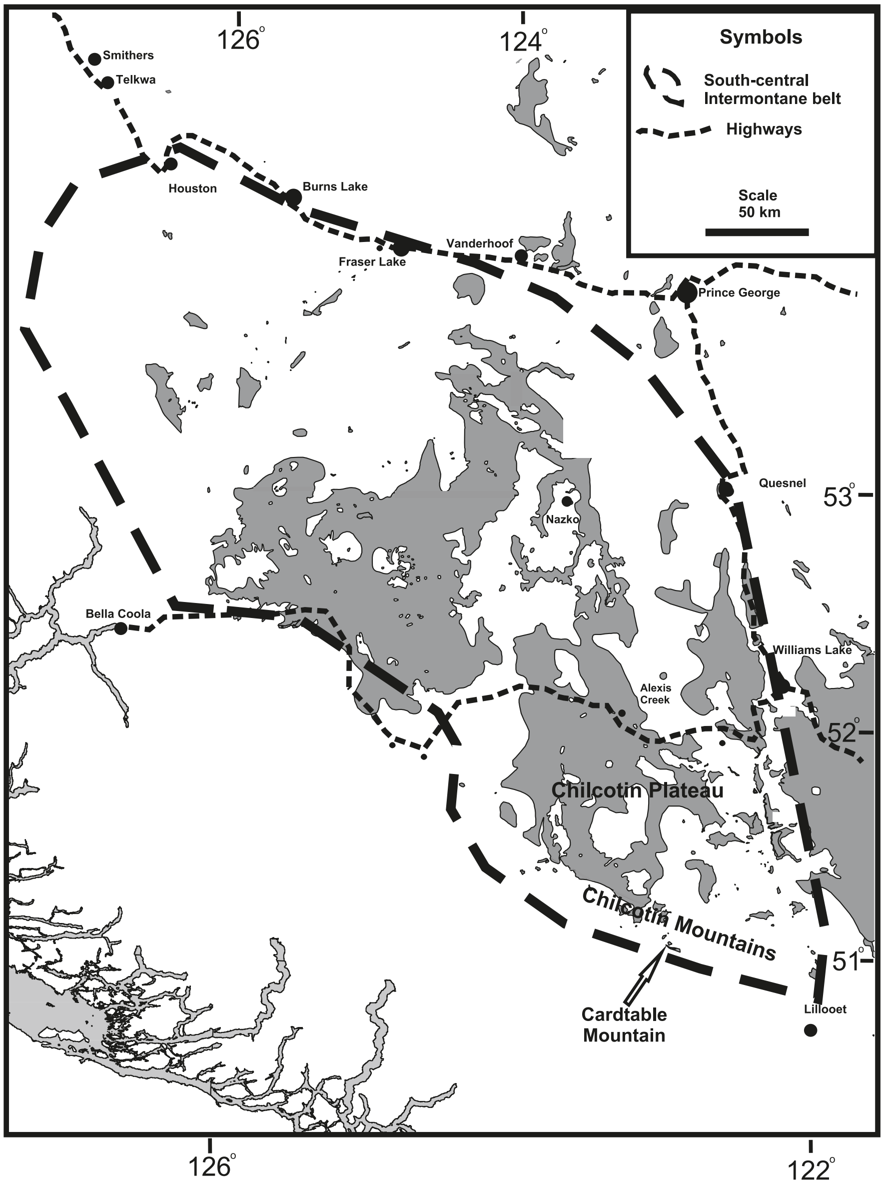
Fig. 11. Distribution of the Eocene Ootsa Lake and Endako groups and related terrestrial sedimentary sequences (grey) and Eocene metamorphic complexes (patterned). Adapted from digital geology by Massey et al. (2005). Felsic volcanic rocks of the Ootsa Lake Group (~53–47 Ma) are the volumetrically dominant lower Eocene formation in the region. Concurrently, unroofing of older plutonic rocks occurred, producing the Tatla Lake and Vanderhoof metamorphic complexes. The CanHunter Chilcotin b-22-K well intersected over 3700 m of Lower Cretaceous flows and volcaniclastic rocks of the Ootsa Lake Group. Four wells were drilled south of Quesnel in the Tertiary "lignite beds" of the Australian Creek Formation to investigate oil and gas potential. The wells intersected 400–500 m of Tertiary sedimentary rocks, with no oil or gas shows, before bottoming out in Cache Creek limestones.



features are chert-rich clastic composition and dominantly shallow-marine to nonmarine depositional environments, including fluvial units and red paleosols. The similarities do not necessarily demonstrate contiguity or proximity of the basins during deposition, but they indicate a similar source terrane (likely an accretionary complex to supply chert clasts) and a mainly nonmarine setting. The source of chert clasts in the Tyaughton basin is the Bridge River terrane (Garver 1989, 1992). The source for chert clasts in the Nazko River and Redstone belts is uncertain, but it may be the Cache Creek terrane, or Bridge River terrane, or both.

The 2009 BATHOLITHS onland seismic refraction survey (Stephenson et al. 2011) crossed the north end of the Redstone belt and the south end of the Nazko Redstone belt (Fig. 9). Velocity modelling indicates depths of 2.5 km of sedimentary rocks beneath the Redstone belt, thickening to 3.3 km under the south end of the Nazko belt (Stephenson et al. 2011).

Fig. 12. Distribution of Neogene Chilcotin Group basalts (grey). Adapted from digital geology by Massey et al. (2005).



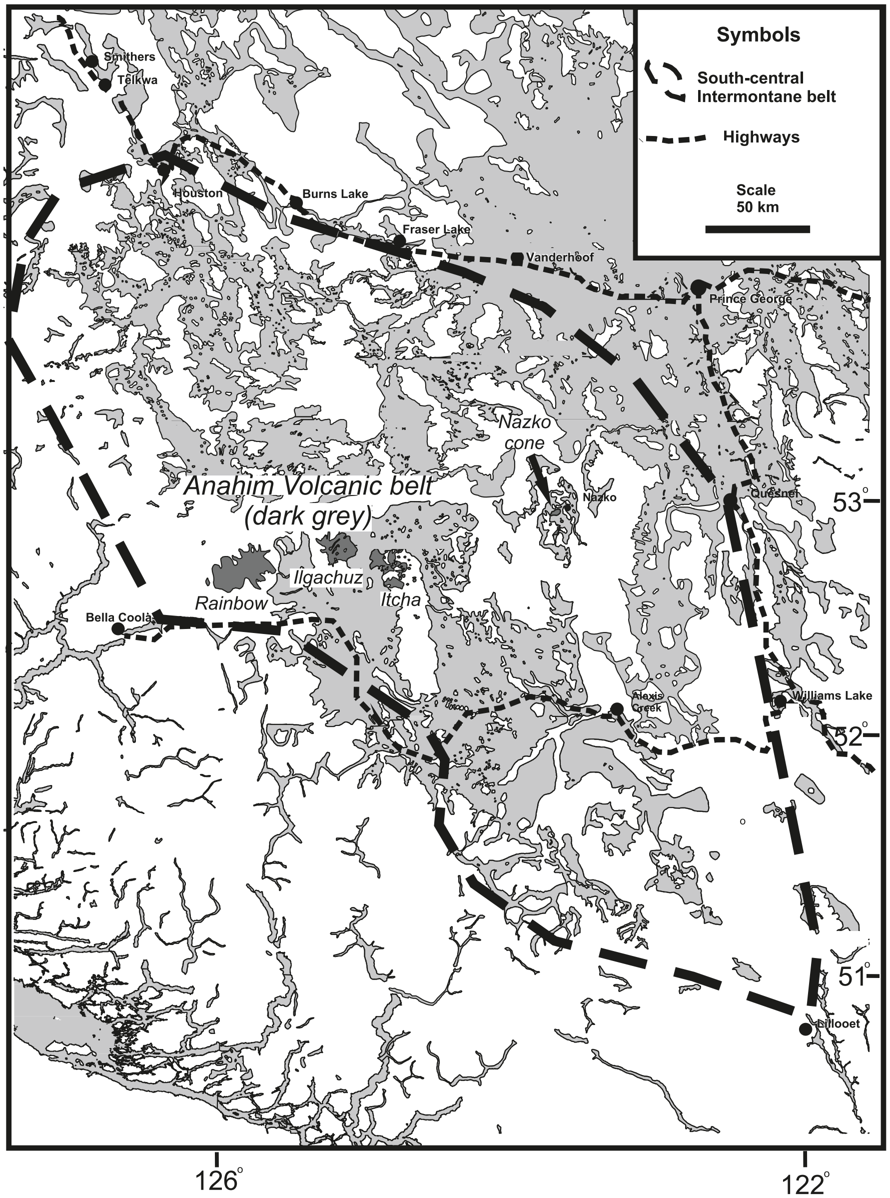
The Cretaceous strata in the Nazko River exploration wells were tentatively correlated with the Jackass Mountain Group by exploration geologists during the Canadian Hunter exploration program of the 1980s (Cosgrove 1981*a*, 1981*b*, 1981*c*).

Sedimentary rocks of the southern Chilcotin plateau

The surface geology of the southern Chilcotin plateau area between Highway 20 and the Chilcotin Mountains (Fig. 2) is dominated by mid-Cretaceous volcanic rocks and plutons, overlain by Eocene volcanic rocks (Tipper 1978; van der Heyden and Metcalfe 1992; Hickson 1993). Albian to Upper Cretaceous sedimentary rocks were encountered in the subsurface (Fig. 14) in two exploration wells drilled by Canadian Hunter, both located south of the Whitewater Road (Fig. 10). The sedimentary sequences in these wells have been assumed to be equivalent to the mainly Albian successions in the Nazko River belt, or the Tyaughton or Methow basins (Cosgrove 1981*a*, 1981*b*, 1986; Ferri and Riddell 2006; Riddell et al. 2007). However, palynological work on well cuttings indicates that for the most part these rocks are Late Cretaceous (Sweet 2006, 2008). Geophysical programs to image these rocks included gravity and seismic surveys along the Whitewater Road (Fig. 10) by Canadian Hunter in the early 1980s (Salt 1981; Riddell 2006; Hayward and Calvert 2009, 2011) and a magnetotelluric survey in 2007 (Spratt and Craven 2011).

The CanHunter et al. Redstone well (b-82-C/92-O-14) (Figs. 9, 10, 14) intersected 200 m of undated volcanic rocks over 1400 m of Upper Cretaceous sandstone, conglomerate, and siltstone, which in turn overlie a depositional contact (Cosgrove 1981*c*) with Early Cretaceous (Riddell et al. 2007) granite (Fig. 14). The upper 1000 m of the sedimentary sequence is maroon to green intermediate volcaniclastic sandstone and conglomerate. The interval between 1210 and 1248 m contains Campanian palynomorphs. Samples from lower in the well, at 1293 and 1710 m depth yielded palyno-

Fig. 13. Distribution of Quaternary glacial deposits (light grey) and volcanic rocks of the Anahim Belt (dark grey). Adapted from digital geology by Massey et al. (2005). The Anahim volcanic belt forms an east–west-trending belt of three large (Rainbow, Ilgachuz and Itcha) and many more small volcanoes across the Interior Plateau from the Coast Belt to Nazko. The volcanoes range in age from 8 Ma to the Holocene. The youngest, Nazko cone, is <1 Ma.

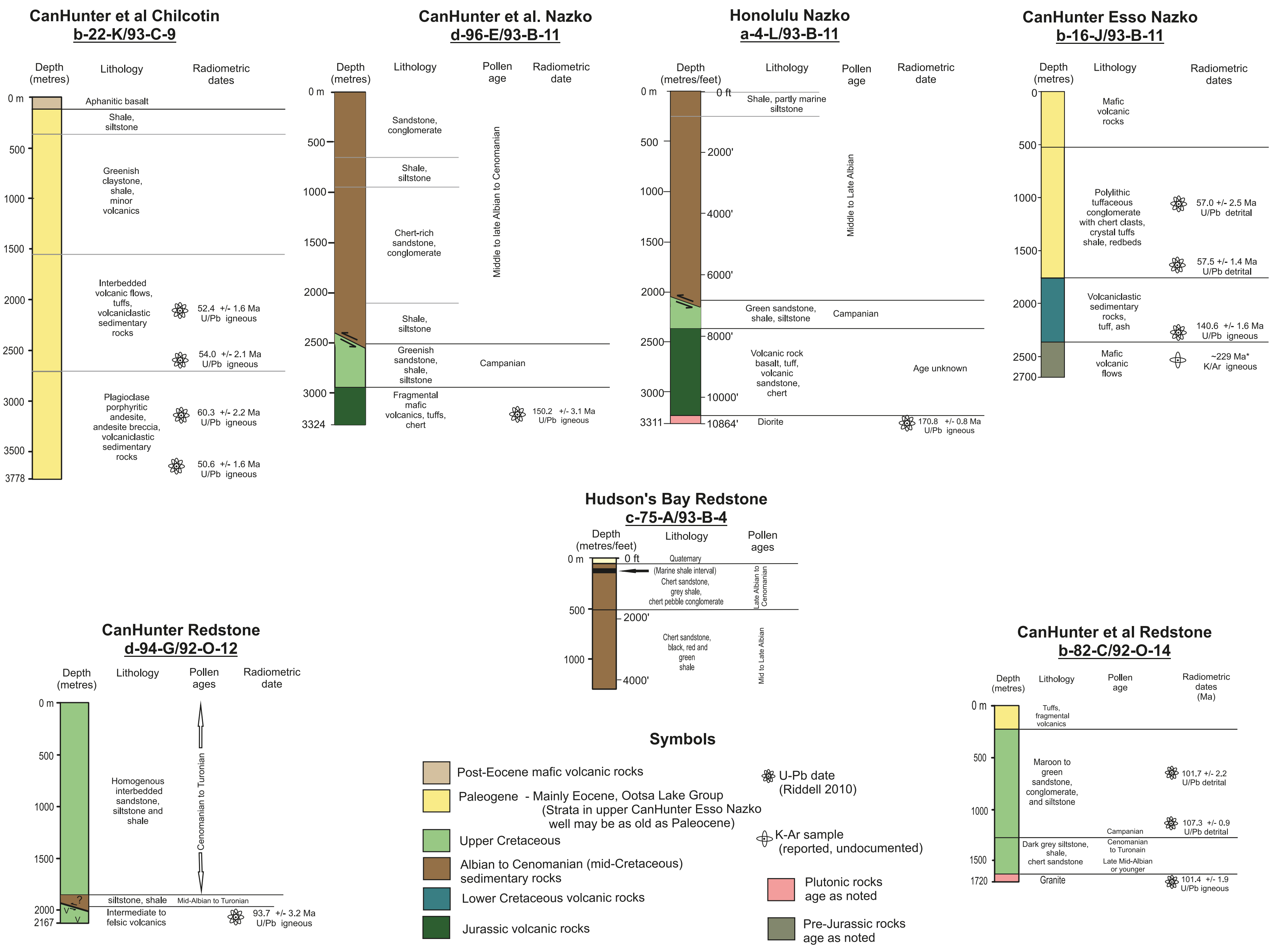


morphs of mostly Cenomanian to possibly Turonian age (Sweet 2006, samples C-467098, C-477759, and C-477760). Well cuttings samples from 1150 and 700 m depths yielded detrital zircons with U–Pb ages of ~107.3 and ~101.7 Ma, respectively (Riddell 2010), indicating a latest Early Cretaceous igneous source terrane. Likely sources of this detrital material are the recently recognized ~101 Ma volcanic belt (Hickson 1993; Riddell and Ferri 2008; Riddell 2010) exposed in the Chilcotin Plateau and described later in the text, and abundant local plutons of similar ages (van der Heyden and Metcalfe 1992; Hickson 1993; Hunt and Roddick 1993).

The CanHunter Redstone well (d-94-G/92-O-14) (Figs. 10, 14) intersected ~2085 m of interbedded sandstone, siltstone, and shale (Cosgrove 1986) of middle Albian to possibly Turonian age (Sweet 2006), overlying earliest Late Cretaceous (~94 Ma, Riddell 2010) intermediate to felsic volcanic rocks (Fig. 14).

The informally named Taseko River strata (Ferri and Riddell 2006) are volcanic-rich sandstones and pebble to granule conglomerates exposed along a bend in the Taseko River north of the Yalakom fault (Fig. 10) near the CanHunter Redstone d-94-G well. Dating of detrital zircons from the section (Enkin et al. 2006) indicates that these rocks are no older than 86 Ma. These strata have been included within the Powell Creek formation by Baker et al. (2003) based on their similar age and similar low-angle paleomagnetic inclinations. This correlation is consistent with the monolithic purple and green andesitic volcanic clast composition of the unit.

Fig. 14. Simplified stratigraphy in seven exploration wells in the south-central Intermontane belt. Adapted from Riddell et al. (2007). Well locations are shown on Fig. 2. Lithologic descriptions simplified from Hudson's Bay Oil and Gas Company (1960) Report, Pyecroft et al. (1961), and Cosgrove (1981*a*, 1981*b*, 1981*c*, 1982, 1986).



Sedimentary rocks of the Tyaughton and Methow basins

The upper Tyaughton basin (Taylor Creek Group and Silverquick conglomerate) and the upper Methow basin (the Jackass Mountain Group) are upper Lower Cretaceous to Upper Cretaceous sedimentary successions deposited unconformably on rocks of the Relay Mountain Group, and locally on Bridge River terrane rocks in the Chilcotin Mountains (Figs. 2, 9). The successions are partly contemporaneous and share a common substrate yet show distinctive characteristics with respect to clast provenance. Garver (1989, 1992) proposed a model in which the Methow and Tyaughton basins originated as a single basin that was separated in Aptian to Albian time into two sub-basins by intrabasinal uplift of the underlying Bridge River terrane during contractional tectonic events related to the Late Cretaceous accretion of the Insular terranes. In this model, the upper Tyaughton basin was supplied with volcaniclastic material from Insular terranes to the west, and chert-rich Bridge River terrane rocks to the east. The Methow basin meanwhile received chert-rich Bridge River detritus from the west, and arkosic material from the North American continental margin to the east.

In the Tyaughton basin, the marine Elbow Pass and Paradise formations are the older parts of the Taylor Creek Group that formed before the tectonic uplift and exposure of Bridge River Group rocks, and clastic material in both is dominantly volcanic in origin. The shallow-marine Dash and Beece Creek formations of the Taylor Creek Group (Schiarizza et al. 1997) and are dominantly conglomeratic units with abundant chert pebbles derived from the Bridge River Group (Garver 1989). The Lizard formation of the Taylor Creek Group is a muscovite-rich arkosic marine turbidite sandstone unit within the Tyaughton stratigraphy that marks a period of eastern-sourced arkosic debris into the Tyaughton sub-basin, and marks the time of a breach of the intrabasinal barrier (Garver 1989, 1992). The nonmarine Silverquick conglomerate overlies Taylor Creek Group and Bridge River terrane rocks. The unit includes sandstone and red to maroon siltstone interbeds. Silverquick conglomerate beds resemble those of the Taylor Creek Group in that they contain abundant chert pebble clasts, but they can be distinguished from Taylor Creek conglomerates by the significant percentages of volcanic and sedimentary clasts, and by the presence of detrital muscovite in the sandstones (Garver 1989) and nonmarine sedimentary structures and microflora (Haggart et al. 2011). The Silverquick conglomerate is overlain conformably and gradationally by the Powell Creek volcanic formation (Garver 1989; Schiarizza et al. 1997).

The Methow basin is represented in the study area by excellent exposures of the Jackass Mountain Group, which occur along the southern edge of the south-central Intermontane belt (Figs. 2 and 9), at the north end of Chilko Lake, and in the Camelsfoot Range north of Lillooet, where they have been studied by Roddick and Tipper (1985), Kleinspehn (1985), Garver (1989), and Schiarizza et al. (1997, 2002) among others. Most recently, work on the stratigraphy, sedimentology and clast provenance was conducted by MacLaurin (2009) at Chilko Lake and by Goodin (2008) in the Camelsfoot Range (Fig. 2). The Chilko Lake and Camelsfoot sequences are correlative and have been separated from one another by about 115 km of dextral strike-slip offset along the Yalakom fault (Fig. 2; Umhoefer and Schiarizza 1996; MacLaurin et al. 2011). The Jackass Mountain Group comprises more than 2000 m of marine and nonmarine feldspathic sandstone and conglomerate ranging in age from early Aptian to Cenomanian–Turonian. Both Goodin (2008) and MacLaurin (2009) conclude that these successions formed in proximity to an eroding volcanic arc and plutonic complex to the east; possibly the ~113 to 97.5 Ma (Thorkelson and Rouse 1989) Spences Bridge volcanic arc (Haskin 2000; Diakow and Barrios 2009), and the Okanagan batholith and (or) Omineca crystalline belt. Garver and Scott (1995) and MacLaurin (2009) document the absence of clastic material from the Bridge River or Shulaps ophiolite into this part of the Methow basin. This implies that another barrier may have further subdivided the Methow basin into yet smaller sub-basins, some of which were shielded from Bridge River – Shulaps material.

Magmatic rocks

Pulses of subduction-related arc magmatism produced igneous rocks and contributed volcanic lithic material to clastic successions from the end of the Early Cretaceous into the Late Cretaceous.

The Lower to Upper Cretaceous (~113–97.5 Ma, Thorkelson and Rouse 1989) Spences Bridge arc overlapped Cache Creek, Quesnel, and Stikine (and (or) Cadwallader; Enkin 2006) terranes across the southern Intermontane belt (Figs. 2, 9).

Andesitic volcanic rocks near Tatla and Puntzi lakes areas of the Chilcotin Plateau (Fig. 9) were tentatively mapped as Hazelton Group (Fig. 6) and appear as such on compilation maps (i.e., Tipper 1968; Massey et al. 2005; Riddell 2006). However recent U–Pb zircon dating has yielded latest Early Cretaceous ages (~101 Ma, Riddell 2010), which indicate that these rocks are too young to be part of the Hazelton arc. They are likely part of a broad but poorly exposed belt (Hickson and Higman 1993) of late Lower Cretaceous volcanic rocks in the Chilcotin Plateau (Figs. 8, 9) in the wedge-shaped area between the Fraser and Yalakom faults. Correlation of these rocks with the Spences Bridge Group has been suggested (Mathews and Rouse 1984; Hickson and Higman 1993; Riesterer et al. 2001; Riddell and Ferri 2008).

Parts of the Mount Alex – Piltz Peak complex (van der Heyden and Metcalfe 1992; Hunt and Roddick 1993) intruded the southern Chilcotin Plateau in the mid-Cretaceous (Fig. 9). Plutons of the 84–64 Ma (Late Cretaceous) Bulkley Intrusive Suite (MacIntyre et al. 1994) intrude the Tahtsa (Diakow 2006) and Fawnie ranges (Diakow and Levson 1997) (Fig. 10). Many other minor igneous events occurred locally, producing small plutons, dikes, sills, flows, and breccias, and contributing ash, tuff, and lithic material to sedimentary successions throughout the region.

The Kasalka Group is a volcanic sequence that includes hornblende-bearing andesite porphyry flows, breccias, and lahars. It ranges in age from 71 to 68 Ma (Diakow 2006) where it is exposed in the Tahtsa Ranges (Fig. 10). Similar volcanic rocks of the Powell Creek formation are exposed in the Chilcotin Mountains (Fig. 10), where they range in age from ~92 to 79 Ma (Schiarizza et al. 1997).

Tertiary post-orogenic rocks

Paleocene to Eocene

A shift in the direction of plate convergence at about

59 Ma (Monger and Price 2002) caused the tectonic regime along the Canadian Cordillera to change from transpressional to transtensional. The transtensional tectonic regime is marked along the southern Intermontane belt by structures of middle Paleocene through Eocene ages, as well as continued and significant Eocene dextral movement along steeply dipping strike-slip structures, such as the Pinchi, Fraser – Straight Creek, Yalakom, and associated faults (Struik 1993; Umhoefer and Schiarizza 1996; Fig. 2), and unroofing of metamorphic core complexes, such as the Wolverine (Struik 1993), Tatla Lake (Friedman and Armstrong 1988), and Vanderhoof (Grainger et al. 2001) complexes (Fig. 11). The initiation of strike-slip movement documented in the Chilcotin Mountains began in the latest Cretaceous, sometime between 70 and 65 Ma, and continued until about 35 Ma (Umhoefer and Schiarizza 1996). Eocene normal faulting is mapped in the south part of the Bowser basin (O'Sullivan et al. 2009) and is inferred from interpretations of magnetic and paleomagnetic data (Lowe et al. 2001) in the Endako region along the northern edge of the study area. Volcanic flows and associated volcaniclastic rocks of the Ootsa Lake Group were deposited widely throughout the region (Fig. 10) between ~53 and 47 Ma (Grainger et al. 2001). Ootsa Lake Group volcanic rocks are dominantly felsic in composition, but mafic flows do occur locally, along with minor sedimentary rocks. They vary considerably in thickness (Metcalfe and Hickson 1994, 1995; Metcalfe et al. 1997) from a few metres to thousands of metres. The CanHunter et al. Chilcotin (b-22-K/93-C-9) exploration well (Figs. 2, 11, 14) was drilled on the centre of a large gravity low (Riddell 2006) in the Baezaeko River area northwest of Redstone (Ferri and Riddell 2006) and intersected over 3700 m of flows and volcaniclastic rocks (Cosgrove 1982) of the Ootsa Lake Group (Riddell et al. 2007) (Fig. 14). Four Paleocene to early Eocene dates were returned from cuttings at depths between 2020 and 3745 m (Riddell 2010). This represents an anomalously thick section of lower Paleogene and younger deposits. Hayward and Calvert (2011) have identified a rhomboidal feature outlined by seismic and gravity data at this location (Fig. 11), which they interpret as an Eocene pull-apart basin. This interpretation is consistent with the anomalous Eocene thickness indicated by the well data.

The Endako Group volcanics are most abundant in the Endako area west of Vanderhoof. They are dominantly mafic in composition. They range in age from 51 to 45 Ma (Grainger et al. 2001), overlapping the Ootsa Lake Group in age.

The Eocene volcanic rocks in the region present challenges to hydrocarbon exploration. They contain considerable variability in texture, composition, and unit thickness (Tipper 1959, 1960, 1963*a*; Metcalfe and Hickson 1994, 1995), making them difficult to incorporate into geophysical models (Hayward and Calvert 2009). Recent work to improve understanding of these rocks has included collection and compilation of new rock property data and mapping (Bordet and Hart 2011).

Upper Eocene to Miocene sedimentary rocks

Deposits of Upper Eocene, Oligocene, and Miocene sedimentary rocks occur in isolated locations around the region. Important occurrences (too small to show on Fig. 11) include the Upper Eocene beds on the Nechako River (Rouse and Mathews 1989), near Nazko (Rouse and Mathews 1988), and adjacent to the Fraser River at several locations north and south of Quesnel (Rouse et al. 1990). These sequences were deposited in humid warm terrestrial environments and comprise sandstone, siltstone, and conglomerate beds, and commonly contain lignite (Rouse and Mathews 1988). The "lignite beds" (Dawson 1877) of the Australian Creek Formation were investigated for oil and gas in the early 1930s (Cockfield 1931), coal (Yoon 1972; Long and Graham 1993), and for diatomaceous earth (Hora and Hancock 1995). Wells were drilled in 1931, 1951, 1952, and 1981 (Fig. 11). They intersected 400–500 m of Tertiary sediments, with no oil or gas shows, before bottoming out in Cache Creek Group carbonates (Hayes 2002).

Miocene to Pliocene basalt

In Miocene to Pliocene time, basalt flows of the Chilcotin Group formed a lava blanket over the southern Interior of British Columbia that is tens of thousands of square kilometres in area (Bevier 1983*a*; Andrews and Russell 2007; Fig. 12). The Chilcotin Group was deposited on a mainly low-relief paleosurface and is generally thin, between 2 sand 15 m (Mathews 1989; Andrews et al. 2011). Because it is so widespread, it has been considered a major impediment to hydrocarbon exploration (Andrews and Russell 2007; Spratt et al. 2007; Hayward and Calvert 2009) because it interferes with seismic imaging of the prospective Jurassic and Cretaceous sedimentary target units in the subsurface.

Geochemical studies of the Chilcotin Group indicate that the basalt has a mantle source, with no contamination or mixing with crustal material (Bevier 1983*a*; Dostal et al. 1996). Thorkelson and Taylor (1989) suggested that the Chilcotin Group lavas were produced by plate-edge volcanism as the Pacific – Juan de Fuca plate boundary subducted beneath the North American plate. The Chilcotin Group is characterized by flat to gently dipping olivine-phyric flows. The basaltic successions range in age from 26 to 1.1 Ma and are generally thin (2–15 m), but thicker successions formed locally in paleovalleys (Mathews 1989). In the most northern part of the region the Chilcotin Group lies close to the present day erosion surface, and it can be observed that the flows pooled around higher standing older rocks. On the Chilcotin Plateau west of Williams Lake the Chilcotin Group forms the distinctive cap rock that rims present-day river valleys. Flat-lying Chilcotin Group flows lie at about 1500 m elevation on the southern Chilcotin Plateau (Hickson and Higman 1993) and ramp up to the south to form caps on some the highest peaks in the Chilcotin Mountains. At Cardtable Mountain (Fig. 12), ~18 Ma Chilcotin basalt (Mathews 1989) overlies Jura-Cretaceous rocks of the Relay Mountain and Taylor Creek Groups (Schiarizza et al. 1997) at an elevation of 2400 m, documenting significant, relatively recent uplift of those mountains. This episode of late Neogene uplift is documented in the Coast Mountains by fission track thermal history studies by Parrish (1983) and Farley et al. (2001).

Quaternary

The Quaternary geological record the south-central British Columbia is dominated by unconsolidated deposits formed during the formation, movement, and melting of the Cordilleran ice sheet. Ice moved across the Interior Plateau in a generally eastward direction from the Coast Mountains and left evidence in the form of till drumlins and rock striations (Holland 1964). Ice dams blocked rivers resulting in the formation of glacial lakes. Deglaciation provided huge volumes of water that transported and redeposited vast amounts of materials as glaciofluvial deposits. Glacial materials cover a large percentage of the south-central Intermontane belt (Figs. 2, 13). Regional scale (1 : 250 000) mapping of Quaternary surficial geology was conducted over much of the region by Tipper (1963*a*, 1971*a*, 1971*b*, 1971*c*, 1971*d*, 1971*e*) and at finer scales by Plouffe and Levson (2001), Plouffe et al. (2001), Ferbey and Levson (2001), Vickers and Ferbey (2009), Ferbey et al. (2009), Ferbey (2010), and Plouffe et al. (2011), among others.

The Anahim volcanic belt (Figs. 2, 13) is an east–west-trending belt of three large (Rainbow, Ilgachuz and Itcha) and many more small volcanoes across the Interior Plateau from the Coast Belt to Nazko (Souther et al. 1987). The volcanoes range in age from 8 to <1 Ma (Souther 1986). The belt cuts across the Cordilleran grain, and the volcanoes get progressively younger toward the east, leading Bevier et al. (1979) to speculate that the volcanoes were produced by a mantle hot spot under the westward-progressing North American plate. They also considered the possibility that the lavas originate from the ridge between the Juan de Fuca and Pacific plates as they subduct under the North American plate.

Summary

Sedimentary rocks that formed in a variety of depositional environments since late Paleozoic time are preserved in the south-central Intermontane belt of British Columbia. Jurassic and Cretaceous clastic basins contain stratigraphy with hydrocarbon potential. Clastic deposition occurred in basins adjacent to the continent and fringing Paleozoic to Early Jurassic island-arc and ocean terranes as plate convergence progressed along the western North American continental margin. Lower to Middle Jurassic sedimentary rocks were deposited in mainly deep-water marine environments and represent potential hydrocarbon source beds, but their distribution in the subsurface is poorly known. Jurassic clastic basins locally included clastic input from active volcanic arcs. In the Middle Jurassic to Early Cretaceous, marine, shallow-marine and nonmarine overlap assemblages were deposited as terranes amalgamated. Starting in the late Early Cretaceous and continuing into the earliest Tertiary a prolonged compressive tectonic regime produced contractional structures, while uplifting and deforming accreted rocks. Sedimentation occurred in tectonically active basins, concurrent with active arc magmatism through the Cretaceous. By Albian time, oceans between the accreting terranes and the continent began to close. Albian to Cenomanian sedimentary successions contain abundant coarse clastic units and represent the most important potential reservoir targets in the region. Where they are well exposed, clastic units are characterized by vertical and lateral heterogeneity in texture and clast content, indicative of their tectonically active depositional setting. Contemporaneous basins may or may not have been continually contiguous, as intervening barriers were intermittently uplifted, exposed and subsequently eroded. The Eocene to Neogene history of the southern Intermontane belt is dominated by non-arc volcanism and minor localized nonmarine sedimentary deposition. A large percentage of the southern Intermontane belt is covered by Pleistocene to Recent glacial deposits. Widespread Cenozoic volcanic rocks and glacial deposits extensively cover the older rocks.

Acknowledgments

The author is grateful to John Garver and Paul Umhoefer for careful and insightful reviews of a previous manuscript. Filippo Ferri provided leadership and insight during fieldwork and research. Larry Diakow kindly shared his experience and knowledge of the region. Jim Haggart, JoAnne Nelson, and Maurice Colpron provided support and advice through the revision process.

References

Andrews, G.D.M., and Russell, J.K. 2007. Mineral exploration potential beneath the Chilcotin Group (NTS 092O, P; 093A, B, C, F, G, J, K), south-central British Columbia: preliminary insights from volcanic facies analysis. *In* Geological fieldwork 2006. British Columbia Ministry of Energy, Mines and Petroleum Resources. pp. 229–238.

Andrews, G.D.M., Plouffe, A., Ferbey, T., Russell, J.K., Brown, S.R., and Anderson, R.G. 2011. The thickness of Neogene and Quaternary cover across the central Interior Plateau, British Columbia: analysis of water-well drill records and implications for mineral exploration potential. Canadian Journal of Earth Sciences, **48**: this issue

Armstrong, R.L. 1988. Mesozoic and early Cenozoic magmatic evolution of the Canadian Cordillera. Geological Society of America, Special Paper 218.

Ash, C.H., Rydman, M.O., Payne, C.W., and Panteleyev, A. 1999. Geological setting of the Gibraltar Mine, South Central British Columbia (93B/8&9). *In* Exploration and mining in British Columbia — 1998. BC Ministry of Energy and Mines. pp. A1–A15.

Baker, J., Enkin, R.J., and Mahoney, J.B. 2003. Late Cretaceous Powell Creek formation along the Taseko River confirm controversial paleomagnetic results from Mount Tatlow and Churn Creek: Further evidence on the Baja–BC model. Geological Association of Canada – Mineralogical Association of Canada, Abstracts with Programs, **28**: 589.

Bassett, K.N., and Kleinspehn, K.L. 1997. Early to middle Cretaceous paleogeography of north-central British Columbia: stratigraphy and basin analysis of the Skeena Group. Canadian Journal of Earth Sciences, **34**(12): 1644–1669. doi:10.1139/e17-132.

Bevier, M.L., Armstrong, R.L., and Souther, J.G. 1979. Miocene peralkaline volcanism in west-central British Columbia — Its temporal and plate-tectonic setting. Geology, **7**(8): 389–392. doi:10.1130/0091-7613(1979)7<389:MPVIWB>2.0.CO;2.

Bevier, M.L. 1983*a*. Regional stratigraphy and age of Chilcotin Group basalts, south-central British Columbia. Canadian Journal of Earth Sciences, **20**(4): 515–524. doi:10.1139/e83-049.

Bevier, M.L. 1983*b*. Implications of chemical and isotopic composition for petrogenesis of Chilcotin Group basalts, British Columbia. Journal of Petrology, **24**(Part 2): 207–226.

Bordet, E., and Hart, C.J.R. 2011. Characterization and structural framework of Eocene volcanic sequences in the Nechako region, central British Columbia. *In* Geoscience BC Summary of activities 2010. Geoscience BC Report 2011-1. pp. 239–254.

Brown, D., Simpson, J., Daniels, H., and Riddell, J. 2008. Petrographic analyses of potential reservoir units of the Nechako region of British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Geology Open File, 2008-09. 110 p.

Calvert, A.J., Hayward, N., and Smithyman, B., and Takam Takougang, E.M. 2009. Vibroseis survey acquisition in the central Nechako Basin, south-central British Columbia (parts of NTS 093B, C, F, G). *In* Geoscience BC Summary of activities. Geoscience BC Report 2009-1. pp. 145–150.

Calvert, A.J., Hayward, N., Spratt, J., and Craven, J.A. 2011. Seismic reflection constraints on upper crustal structures in the volcanic-covered central Nechako basin, British Columbia. Canadian Journal of Earth Sciences, **48**: this issue.

Cassidy, J.F., Al-Khoubbi, I., and Kim, H.S. 2008. Mapping the structure of the Nechako basin using passive source seismology. *In* Geoscience BC Summary of activities 2007. Geoscience BC Report 2008-1. pp. 115–120.

Cockfield, W.E. 1931. Oil possibilities between Soda Creek and Quesnel, Cariboo District, British Columbia. Geological Survey of Canada, Summary Report 1931A. pp. 58A–65A.

Coney, P.J., Jones, D.L., and Monger, J.W.H. 1980. Cordilleran suspect terranes. Nature, **288**(5789): 329–333. doi:10.1038/288329a0.

Cordey, F., and Schiarizza, P. 1993. Long-lived Panthalassic remnant: The Bridge River accretionary complex, Canadian Cordillera. Geology, **21**(3): 263–266. doi:10.1130/0091-7613(1993)021<0263:LLPRTB>2.3.CO;2.

Cosgrove, D.T. 1981*a*. Well history report on CanHunter et al. Nazko d-96-E/93-B-11, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Resources Assessment Report WA 5439.

Cosgrove, D.T. 1981*b*. Well history report on CanHunter Esso Nazko b-16-J/93-B-11, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Resources Assessment Report WA 5444.

Cosgrove, D.T. 1981*c*. Well history report on CanHunter et al. Redstone b-82-CJ/92-O-14, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Resources Assessment Report WA 5680.

Cosgrove, D.T. 1982. Well history report on CanHunter et al. Chilcotin b-22-K/92-C-9, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Resources Assessment Report WA 5702.

Cosgrove, D.T. 1986. Well history report on CanHunter Redstone d-94-G/92-0-12, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Resources Assessment Report WA 6438.

Cowan, D.S., Brandon, M.T., and Garver, J.I. 1997. Geologic tests of hypotheses for large coastwise displacements — a critique illustrated by the Baja British Columbia controversy. American Journal of Science, **297**(2): 117–173. doi:10.2475/ajs.297.2.117.

Dawson, G.M. 1877. Report on explorations in British Columbia. *In* Report of progress for 1875–1876. Geological Survey of Canada. pp. 233–265.

Desjardins, P.J., and Arksey, R.L. 1991. Geology of the Lamprey Creek area (93 L/03). British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 1991-1, map scale 1 : 50 000.

Diakow, L.J. 2006. Geology of the Tahtsa Ranges between Eutsuk Lake and Morice Lake, west-central British Columbia, (parts of NTS 93E/5, 6, 7, 9, 10, 11, 12, 13, 14, and 15). British Columbia Ministry of Energy, Mines and Petroleum Resources, Geoscience Map 2006-5, scale 1 : 150 000.

Diakow, L.J., and Barrios, A. 2009. Geology and mineral occurrences of the mid-Cretaceous Spences Bridge Group near Merritt, southern British Columbia (Parts of NTS 092H/14, 15, 092I/02, 02). *In* Geological fieldwork 2008. British Columbia Ministry of Energy, Mines and Petroleum Resources. pp. 63–79.

Diakow, L.J., and Levson, V.M. 1997. Bedrock and surficial geology of the southern Nechako Plateau, central British Columbia, NTS 93F/2, 3, 6, & 7. British Columbia Ministry of Employment and Investment, Geoscience Map 1997-2, scale 1 : 100 000.

Diakow, L.J., Webster, I.C.L., Richards, T.A., and Tipper, H.W. 1997. Geology of the Fawnie and Nechako Ranges, southern Nechako Plateau, Central British Columbia (93F/2, 3, 6, 7). *In* Interior Plateau Geoscience Project: summary of geological, geochemical and geophysical studies. British Columbia Ministry of Employment and Investment, Paper 1997-2. pp. 7–30.

Dostal, J., Hamilton, T.S., and Church, B.N. 1996. The Chilcotin basalts, British Columbia (Canada): Geochemistry, petrogenesis and tectonic significance. Neues Jahrbuch für Mineralogie, **170**: 207–229.

Eisbacher, G.H. 1981. Late Mesozoic – Paleogene Bowser Basin Molasse and Cordilleran Tectonics, Western Canada. *In* Sedimentation and tectonics in alluvial basins. *Edited by* A.D. Miall. Geological Association of Canada, Special Paper 23.

Enkin, R.J. 2006. Paleomagnetism and the case for Baja British Columbia. *In* Paleogeography of the North American Cordillera: evidence for and against large-scale displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46. pp. 233–253.

Enkin, R.J., Mahoney, J.B., and Baker, J. 2006. Paleomagnetic signature of the Silverquick/Powell Creek succession, south-central British Columbia: Reaffirmation of Late Cretaceous large-scale terrane translation. *In* Paleogeography of the North American Cordillera: evidence for and against large-scale displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46. pp. 201–220.

Evenchick, C.A., McMechan, M.E., McNicoll, V.J., and Carr, S.D. 2007. A synthesis of the Jurassic–Cretaceous tectonic evolution of the central and southeastern Canadian Cordillera: Exploring links across the orogen. *In* Whence the mountains? Inquiries into the evolution of orogenic systems: a volume in honour of Raymond A. Price. *Edited by* J.W. Sears, T.A. Harms, and C.A. Evenchick. Geological Society of America, Special Paper 433. pp. 117–145. doi:10.1130/2007.2433(06).

Farley, K.A., Rusmore, M.E., and Bogue, S.W. 2001. Post-10 Ma uplift and exhumation of the northern Coast Mountains, British Columbia. Geology, **29**(2): 99–102. doi:10.1130/0091-7613(2001)029<0099:PMUAEO>2.0.CO;2.

Farqhuarson, C.G., Craven, J.A., Hurich, C.A., Spratt, J.E., Welford, J.K., and Pilkington, M. 2011. Modelling and investigation of airborne electromagnetic data and reprocessing of Vibroseis data from the Nechako Basin of south-central British Columbia (NTS 093B, C, F, G), guided by magnetotelluric results. *In* Geoscience BC Summary of activities 2010. Geoscience BC Report 2011-1. pp. 275–278.

Ferbey, T., Vickers, K.J., Hietava, T.J.O., and Nicholson, S.C. 2009. Quaternary geology and till geochemistry of the Redstone and Loomis Lake map areas, central British Columbia (NTS 093B/04, 05). *In* Geological fieldwork 2008. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 2009-1. pp. 117–126.

Ferbey, T., and Levson, V.M. 2001. Ice flow history of Tahtsa Lake – Ootsa Lake region (NTS 93E/10, 11, 14, 15, 16). British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 2001-8, map scale 1 : 100 000.

Ferbey, T. 2010. Quaternary geology and till geochemistry of the Nadina river map area (NTS 093/15), west-central British Columbia. *In* Geological fieldwork 2009. British Columbia

Ministry of Energy, Mines and Petroleum Resources, Paper 2010-1. pp. 43–53.

Ferri, F., and Riddell, J. 2006. The Nechako Basin Project: new insights from the southern Nechako Basin. *In* Summary of activities 2006. BC Ministry of Energy, Mines and Petroleum Resources. pp. 93–129.

Ferri, F. 2011. Source rock potential of Lower to Middle Jurassic black clastic sequences of the Intermontane belt. Canadian Journal of Earth Sciences, **48**: this issue.

Friedman, R.M., and Armstrong, R.L. 1988. Tatla Lake metamorphic complex: an Eocene metamorphic complex on the southwestern edge of the Intermontane Belt of British Columbia. Tectonics, **7**(6): 1141–1166. doi:10.1029/TC007i006p01141.

Friedman, R.M., Diakow, L.J., Lane, R.A., and Mortensen, J.K. 2001. New U–Pb age constraints on latest Cretaceous magmatism and associated mineralization in the Fawnie Range, Nechako Plateau, central British Columbia. Canadian Journal of Earth Sciences, **38**: 619–637.

Garver, J.I. 1989. Basin evolution and source terranes of Albian–Cenomanian rocks in the Tyaughton Basin, southern British Columbia: Implications for mid-Cretaceous tectonics in the Canadian Cordillera. Unpublished Ph.D. thesis, University of Washington, Seattle, Wash.

Garver, J.I. 1992. Provenance of Albian–Cenomanian rocks of the Methow and Tyaughton basins, southern British Columbia: a mid-Cretaceous link between North America and the Insular terrane. Canadian Journal of Earth Sciences, **29**(6): 1274–1295. doi:10.1139/e92-102.

Garver, J.I., and Scott, T.J. 1995. Trace elements in shale as indicators of crustal provenance and terrane accretion in the southern Canadian Cordillera. Geological Society of America, **107**(4): 440–453. doi:10.1130/0016-7606(1995)107<0440:TEISAI>2.3.CO;2.

Goodin, J.R. 2008. Sedimentology and stratigraphy of the Lower Cretaceous Jackass Mountain Group, Camelsfoot Range, British Columbia. Unpublished Master’s thesis, Simon Fraser University, Burnaby, B.C.

Grainger, N.C., Villeneuve, M.E., Heaman, L.M., and Anderson, R. G. 2001. New U–Pb and Ar–Ar isotopic age constraints on the timing of Eocene magmatism, Fort Fraser and Nechako River map areas, central British Columbia. Canadian Journal of Earth Sciences, **38**: 679–696.

Haggart, J.W., and Carter, E.S. 1994. Biogeography of latest Jurassic and Cretaceous mollusc and radiolarian faunas of the Insular Belt, British Columbia, suggest minimal northward displacement. Geological Society of America, Abstracts with Programs, **26**(7): A148.

Haggart, J.W., Enkin, R.J., and Monger, J.W.H. (*Editors*). 2006*a*. Strengths and limitations of paleogeographic methods in assessing large-scale displacement within the North American Cordillera. *In* Paleogeography of the North American Cordillera: evidence for and against large-scale displacements. Geological Association of Canada, Special Paper 46. pp. 1–13.

Haggart, J.W., Mahoney, J.B., Woodsworth, G.J., Diakow, L.J., Gordee, S.M., Rusmore, M., and Struik, L.C. 2006*b*. Geology, Bella Coola region (93D/01, /07, /08, /10, /15 and parts of 93D/02, 03, /06, /09, /11, /14, /16 and 92M/15 and /16), British Columbia. Geological Survey of Canada, Open File 5385, map scale 1 : 100 000.

Haggart, J.W., Mahoney, J.B., Forgette, M., Carter, E.S., Schröder-Adams, C.J., MacLaurin, C.I., and Sweet, A.R. 2011. Paleoenvironmental and chronological constraints on the Mount Tatlow succession, British Columbia: first recognition of radiolarian and foraminiferal faunas in the Intermontane Cretaceous back-arc basins of western Canada. Canadian Journal of Earth Sciences, **48**: this issue.

Hannigan, P., Lee, P.J., Osadetz, K.G., Dietrich, J.R., and Olsen-Heise, K. 2001. Oil & Gas Resource Potential of the Nechako-Chilcotin Area, British Columbia. Geological Survey of Canada, British Columbia Ministry of Energy, Mines and Petroleum Resources, GeoFile 2001-6.

Haskin, M.L. 2000. Stratigraphic affinity and tectonic–stratigraphic significance of late Albian volcanic rocks in the Empire Valley – Churn Creek area, south-central British Columbia. Unpublished M.Sc. thesis, Simon Fraser University, Burnaby, B.C.

Haskin, M.L., Enkin, R.J., Mahoney, B.J., Mustard, P.S., and Baker, J. 2003. Deciphering shallow paleomagnetic inclinations: 1. Implications from correlation of Albian volcanic rocks along the Insular/Intermontane Superterrane boundary in the southern Canadian Cordillera. Journal of Geophysical Research, **108**(B4): 3-1–3-18. doi:10.1029/2002JB001982.

Hayes, B. 2002. Petroleum Exploration Potential of the Nechako Basin, British Columbia. B.C. Ministry of Energy and Mines, Petroleum Geology, Special Paper 2002-3.

Hayward, N., and Calvert, A.J. 2009. Eocene and Neogene volcanic rocks in the southeastern Nechako Basin, British Columbia: interpretation of the Canadian Hunter seismic reflection surveys using first-arrival tomography. Canadian Journal of Earth Sciences, **46**(10): 707–720. doi:10.1139/E09-041.

Hayward, N., and Calvert, A. 2011. Interpretation of structures in the southeastern Nechako Basin, British Columbia, from seismic reflection, well log, and potential field data. Canadian Journal of Earth Sciences, **48**: this issue.

Hickson, C.J. 1993. Geology of the northwest quadrant, Taseko Lake map are (92O), west-central British Columbia. Geological Survey of Canada, Open File 2695, map scale 1 : 50 000.

Hickson, C.J., and Higman, S. 1993. Geology of the northwest quadrant, Taseko Lakes map area, west-central British Columbia. *In* Current research, part A. Geological Survey of Canada, Paper 93-1A. pp. 63–67.

Holland, S.S. 1964. Landforms of British Columbia, a physiographic outline. British Columbia Department of Mines and Petroleum Resources, Bulletin No. 48.

Hora, Z.D., and Hancock, K.D. 1995. Quesnel area — Industrial minerals assessment. *In* Geological fieldwork. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1995-1. pp. 395–404.

Housen, B.A., and Beck, M.E. 1999. Testing terrane transport: An inclusive approach to the Baja B.C. controversy. Geology, **27**(12): 1143–1146. doi:10.1130/0091-7613(1999)027<1143:TTTAIA>2.3.CO;2.

Hudson’s Bay Oil and Gas Company. 1960. A report of Hudson’s Bay Redstone c-75-A well. British Columbia Ministry of Energy, Mines and Petroleum Resources. Petroleum and Natural Gas Report 430.

Hunt, J.A. 1992. Stratigraphy, maturation and source rock potential of Cretaceous strata in the Chilcotin-Nechako region of British Columbia. Unpublished Master’s thesis, The University of British Columbia, Vancouver, B.C.

Hunt, P.A., and Roddick, J.C. 1993. A compilation of K–Ar and ^{40}Ar–^{39}Ar ages: Report 23. *In* Radiogenic age and isotopic studies: Report 7. Geological Survey of Canada, Paper 93-2. pp. 127–154.

Idowu, O.A., Frederiksen, A.W., and Cassidy, J.F. 2011. Imaging the Nechako Basin, British Columbia, using ambient seismic noise. Canadian Journal of Earth Sciences, **48**: this issue.

Irving, E. 1985. Whence British Columbia? Nature, **314**(6013): 673–674. doi:10.1038/314673a0.

Irving, E., Wynne, P.J., Thorkelson, D.J., and Schiarizza, P. 1996. Large (1000 to 4000 km) northward movements of tectonic domains in the northern Cordillera, 83 to 45 Ma. Journal of

Geophysical Research, **101**(B8): 17901–17916. doi:10.1029/96JB01181.

Journeay, J.M., and Mahoney, J.B. 1994. Cayoosh Assemblage: regional correlations and implications for terrane linkages in the southern Coast Belt, British Columbia. *In* Current research 1994-A. Geological Survey of Canada. pp. 165–175.

Kleinspehn, K.L. 1985. Cretaceous sedimentation and tectonics, Tyaughton–Methow basin, southwestern British Columbia. Canadian Journal of Earth Sciences, **22**(2): 154–174. doi:10.1139/e85-014.

Koch, N.G. 1973. The Central Cordilleran region. *In* Future petroleum provinces of Canada. Canadian Society of Petroleum Geologists, Memoir 1. pp. 37–71.

Long, D.G.F., and Graham, P.S.W. 1993. Sedimentology and coal resources of the Early Oligocene Australian Creek Formation, near Quesnel, British Columbia. Geological Survey of Canada, Paper 92-11.

Lowe, C., Enkin, R.J., and Struik, L.C. 2001. Tertiary extension in the central British Columbia Intermontane Belt: magnetic and paleomagnetic evidence from the Endako region. *In* The Nechako NATMAP Project of the central Canadian Cordillera. *Edited by* B. Jones. Canadian Journal of Earth Sciences, **38**(4): 657–678.

MacIntyre, D.G., Ash, C., and Britton, J. 1994. Geological compilation, Skeena-Nass area, west-central British Columbia, NTS 93E, L, M; 94D; 103G, H, I, J, P; 104A, B. British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 1994-14, map scale 1 : 250 000.

MacLaurin, C.I. 2009. Sedimentology, stratigraphy, and provenance of the Lower Cretaceous Jackass Mountain Group, Chilko Lake area, British Columbia, Canada. Unpublished Master's thesis, Simon Fraser University, Burnaby, B.C.

MacLaurin, C.I., Mahoney, J.B., Haggart, J.W., Goodin, J.R., and Mustard, P.S. 2011. The Jackass Mountain Group of south-central British Columbia: depositional setting and evolution of an Early Cretaceous deltaic complex. Canadian Journal of Earth Sciences, **48**: this issue.

Mahoney, J.B., Hickson, C.J., van der Heyden, P., and Hunt, J.A. 1992. The Late Albian – Early Cenomanian Silverquick conglomerate, Gang Ranch area; evidence for active basin tectonism. *In* Current research, part A. Geological Survey of Canada, Paper 92-1A. pp. 249–260.

Mahoney, J.B., Mustard, P.S., Haggart, J.W., Freidman, R.M., Fanning, C.M., and McNicoll, V.J. 1999. Archean zircons in Cretaceous strata of the western Canadian Cordillera: The "Baja B.C." hypothesis fails a "crucial test". Geology, **27**(3): 195–198. doi:10.1130/0091-7613(1999)027<0195:AZICSO>2.3.CO;2.

Mahoney, J.B., Enkin, R.J., and Haskin, M. 2001. Paleomagnetic Constraints on Terrane Translation: the Churn Creek Succession in South Central British Columbia. *In* Proceedings, American Geophysical Union, Fall Meeting 2001. Abstract #GP11A-0192.

Mahoney, J.B., Haggart, J.W., Hooper, R.L., Snyder, L.D., and Woodsworth, G.J. 2007. Geology, parts of Chikamin Mountain and Troitsa Lake (93E/06 and 11), British Columbia. Geological Survey of Canada, Open File 5586, map scale 1 : 50 000.

Marsden, H., and Thorkelson, D.J. 1992. Geology of the Hazelton volcanic belt in British Columbia; implications fro the Early to Middle Jurassic evolution of Stikinia. Tectonics, **11**(6): 1266–1287. doi:10.1029/92TC00276.

Massey, N.W.D., MacIntyre, D.G., Desjardins, P.J., and Cooney, R.T. 2005. Digital geology map of British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File 2005-02, map scale 1 : 1 000 000.

Mathews, W.H. 1989. Neogene Chilcotin basalts in south-central British Columbia: geology, ages and geomorphic history. Canadian Journal of Earth Sciences, **26**: 969–982.

Mathews, W.H., and Rouse, G.E. 1984. The Gang Ranch – Big Bar area, south-central British Columbia: stratigraphy, geochronology, and palynology of the Tertiary beds and their relationship to the Fraser Fault. Canadian Journal of Earth Sciences, **21**(10): 1132–1144. doi:10.1139/e84-118.

Metcalfe, P., and Hickson, C.J. 1994. Preliminary study of Tertiary volcanic stratigraphy in the Clisbako River area, central British Columbia. *In* Current research 1994-A. Geological Survey of Canada. pp. 105–108.

Metcalfe, P., and Hickson, C.J. 1995. Tertiary volcanic stratigraphy in the Clisbako River area, central British Columbia. *In* Current research 1995-A. Geological Survey of Canada. pp. 67–73.

Metcalfe, P., Richards, T.A., Villeneuve, M.E., White, J.M., and Hickson, C.J. 1997. Physical and chemical volcanology of the Eocene Mount Clisbako volcano, central British Columbia. *In* Interior Plateau Geoscience Project: summary of geological, geochemical and geophysical studies. Geological Survey of Canada, Open File 3448. pp. 31–61.

Meredith-Jones, S. 2009. MINFILE detail report, Mount Polley. Available from minfile.gov.bc.ca/report.aspx?f=PDF&r=Minfile_Detail.rpt&minfilno=093A++008 [cited 15 December 2010].

Mihalynuk, M.G., Orovan, E., Larocque, J.P., Bachiu, T., and Wardle, J. Geology of the Chilanko Forks and Southern Clusko River Map Areas (NTS 093C\01 & 09 South). British Columbia Ministry of Energy, Mines and Petroleum Resources (BCMEMPR), Open File 2009-6, map scale 1 : 50 000.

Monger, J.W.H. 1997. Plate tectonics and northern Cordilleran geology: An unfinished revolution. Geoscience Canada, **24**: 189–198.

Monger, J.W.H., and Journeay, J.M. 1994. Guide to the geology and tectonic evolutions of the southern Coast Mountains. Geological Survey of Canada, Open File 2490.

Monger, J.W.H., and Price, R.A. 1996. Comment on "Paleomagnetism of the Upper Cretaceous strata of Mount Tatlow: Evidence for 3000 km of northward displacement of the eastern Coast Belt, British Columbia" by P.J. Wynne et al. and on Paleomagnetism of the Spences Bridge Group and northward displacement of the Intermontane Belt, British Columbia: A second look" by E. Irving et al. Journal of Geophysical Research, **101**(B6): 13 793 – 13 799. doi:10.1029/96JB00795.

Monger, J.W.H., and Price, R.A. 2002. The Canadian Cordillera: Geology and tectonic evolution. CSEG Recorder, February 2002. pp. 17–36.

Monger, J.W.H., Price, R.A., and Tempelman-Kluit, D.J. 1982. Tectonic accretion and the origin of the two major metamorphic and plutonic welts in the Canadian Cordillera. Geology, **10**(2): 70–75. doi:10.1130/0091-7613(1982)10<70:TAATOO>2.0.CO;2.

Monger, J.W.H., Wheeler, J.O., Tipper, H.W., Gabrielse, H., Harms, T., Struik, L.C., et al. 1991. *In* Geology of the Cordilleran Orogen in Canada. *Edited by* H. Gabrielse and C.J. Yorath. Geological Survey of Canada, Geology of Canada, no. 4, Part B. Cordilleran terranes, Chap. 8, Upper Devonian to Middle Jurassic assemblages. pp. 281–327.

Monger, J.W.H., van der Heyden, P., Journeay, J.M., Evenchick, C. A., and Mahoney, J.B. 1994. Jurassic–Cretaceous basins along the Canadian Coast Belt; their bearing on pre-Mid-Cretaceous sinistral displacements. Geology, **22**(2): 175–178. doi:10.1130/0091-7613(1994)022<0175:JCBATC>2.3.CO;2.

Mossop, G.D., Wallace-Dudley, K.E., Smith, G.G., and Harrison, J.C. Sedimentary basins of Canada. Geological Survey of Canada, Open File 4673, map scale 1 : 5 000 000.

Mustard, P.S., and MacEachern, J.A. 2007. A detailed facies (sedimentological and ichnological) evaluation of archived hydrocarbon exploration drill core from the Nechako Basin, B.C. *In* The Nechako Initiative — Geoscience update 2007. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Geology, Open File 2007-1. pp. 7–57.

Orchard, M.J., Cordey, F., Rui, L., Bamber, E.W., Mamet, B., Struik, L.C., Sano, H., and Taylor, H.J. 2001. Biostratigraphic and biogeographic constraints on the Carboniferous to Jurassic Cache Creek Terrane in central British Columbia. Canadian Journal of Earth Sciences, **38**(4): 551–578. doi:10.1139/e00-120.

O'Sullivan, P.B., Evenchick, C.A., Osadetz, K.G., Ferri, F., and Donelick, R.A. 2009. Apatite fission track data for seventeen rock samples from the Bowser and Sustut basins, British Columbia. Geoscience BC Report 2009-19 – GSC Open File 6325 – BC MEMPR Petroleum Geology, Open File 2009-05.

Panteleyev, A, Bailey, D.G., Bloodgood, M.A., and Hancock, K.D. 1996. Geology and mineral deposits of the Quesnel River – Horsefly map area, central Quesnel Trough, British Columbia NTS 93A/5, 6, 7, 11, 12, 13; 93B/9, 16; 93G/1; 93H/4. British Columbia Ministry of Employment and Investment, Bulletin 97.

Parrish, R.J. 1983. Cenozoic thermal evolution and tectonics of the Coast Mountains of British Columbia, 1. Fission-track dating, apparent uplift rates, and patterns of uplift. Tectonics, **2**(6): 601–631. doi:10.1029/TC002i006p00601.

Plouffe, A., Bednarski, J.M., Huscroft, C.C., Anderson, R.G., and McCuaig, S.J. 2011. Late Wisconsinan glacial history in the Bonaporte Lake map area, south-central British Columbia: implications for glacial transport and mineral exploration. Canadian Journal of Earth Sciences, **48**: this issue.

Plouffe, A., and Levson, V.M. 2001. Late Quaternary glacial and interglacial environments of the Nechako River – Cheslatta Lake area, central British Columbia. Canadian Journal of Earth Sciences, **38**(4): 719–731. doi:10.1139/e00-111.

Plouffe, A., Levson, V.M., and Mate, D.J. 2001. Till geochemistry of the Nechako River map area (NTS 93F) British Columbia. Geological Survey of Canada, Open File 4166, map scale 1 : 250 000.

Potter, C. 1986. Origin, accretion, and postaccretionary evolution of the Bridge River terrane, southwest British Columbia. Tectonics, **5** (7): 1027–1041. doi:10.1029/TC005i007p01027.

Price, R.A. 1994. Cordilleran tectonics and the evolution of the Western Canada Sedimentary Basin. *In* Geological atlas of the Western Canada Sedimentary Basin. *Compiled by* G.D. Mossop and I. Shetsen. Canadian Society of Petroleum Geologists and Alberta Research Council, Special Report 4, Chap. 2.

Pyecroft, M., Meyers, N.A., and Lowell, K.A. 1961. Well report, Honolulu Nazko #a-4-L NTS 93-B-11. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Resources Assessment Report WA 634.

Read, P.B. 1992. Geology of parts of Riske Creek and Alkali Lake area, British Columbia. *In* Current research, part A. Geological Survey of Canada, Paper 92-1A. pp. 105–112.

Reisterer, J.W., Mahoney, J.B., and Link, P.K. 2001. The conglomerate of Churn Creek: Late Cretaceous basin evolution along the Insular–Intermontane superterrane boundary, southern British Columbia. Canadian Journal of Earth Sciences, **38**: 59–73.

Ricketts, B.D., Evenchick, C.A., Anderson, R.A., and Murphy, D.C. 1992. Bowser basin, northern British Columbia: Constraints on the timing of initial subsidence and Stikinia – North America terrane interactions. Geology, **20**(12): 1119–1122. doi:10.1130/0091-7613(1992)020<1119:BBNBCC>2.3.CO;2.

Riddell, J. 2006. Geology of the southern Nechako basin, NTS 92N, 92O, 93B, 93C, 93F, 93G. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Geology Map 2006-1, scale 1 : 400 000.

Riddell, J.M. 2010. Summary of apatite fission-track analyses and radiometric dates from the Nechako region, British Columbia (NTS 92O, N; 93B, C, F, G, and L) and implications for oil and gas prospectivity. British Columbia Ministry of Energy, Mines and Petroleum Resources, Oil and Gas Geoscience Reports 2010. pp. 123–131.

Riddell, J., and Ferri, F. 2008. Nechako Project Update. British Columbia Ministry of Energy, Mines and Petroleum Resources, Geoscience Reports 2008. pp. 67–78.

Riddell, J., Ferri, F., Sweet, A., and O'Sullivan, P. 2007. New Geoscience Data from the Nechako Basin Project. *In* The Nechako Initiative – Geoscience update 2007. British Columbia Ministry of Energy, Mines and Petroleum Resources, Petroleum Geology Open File 2007-1. pp. 59–98.

Riesterer, J.W., Mahoney, J.B., and Link, P.K. 2001. The conglomerate of Churn Creek: Late Cretaceous basin evolution along the Insular–Intermontane superterrane boundary, southern British Columbia. Canadian Journal of Earth Sciences, **38**(1): 59–73.

Roddick, J.A., and Tipper, H.W. 1985. Geology, Mount Waddington (92N) map area. Geological Survey of Canada, Open File 1163, map scale 1 : 250 000.

Rouse, G.E., Mathews, W.H., and Lesack, K.A. 1990. A palynological and geochronological investigation of Mesozoic and Cenozoic rock in the Chilcotin-Nechako region of central British Columbia. *In* Current research, part F. Geological Survey of Canada, Paper 90–1F. pp. 129–133.

Rouse, G.E., and Mathews, W.H. 1988. Palynology and geochronology of Eocene beds from Cheslatta Falls and Nazko areas, central British Columbia. Canadian Journal of Earth Sciences, **25**(8): 1268–1276. doi:10.1139/e88-122.

Rouse, G.E., and Mathews, W.H. 1989. Palynology of subsurface Cenozoic sediments and pyroclastic rock southwest of Vanderhoof, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological fieldwork 1988, Paper 1989-1.

Rusmore, M.E. 1987. Geology of the Cadwallader Group and the Intermontane – Insular superterrane boundary, southwestern British Columbia. Canadian Journal of Earth Sciences, **24**(11): 2279–2291. doi:10.1139/e87-213.

Rusmore, M.E., Potter, C.J., and Umhoefer, P.J. 1988. Middle Jurassic terrane accretion along the western edge of the Intermontane superterrane, southwestern British Columbia. Geology, **16**(10): 891–894. doi:10.1130/0091-7613(1988)016<0891:MJTAAT>2.3.CO;2.

Salt, W.T. 1981. Gravity Survey of the Chezacut – Chilanko Forks – Chilko River area of the Nechako Basin, Project Number 80-230. BC Ministry of Energy, Mines and Petroleum Resources, Petroleum Natural Gas Report 2395.

Schiarizza, P., Riddell, J., Gaba, R.G., Melville, D.M., Umhoefer, P.J., Robinson, M.J., Jennings, B.K., and Hick, D. 2002. Geology of the Beece Creek–Nuit Mountain area, B.C. (NTS 92N/8, 9, 10; 92O/5, 6, 12). BC Ministry of Energy, Mines and Petroleum Resources, Geoscience Map 2002-3, scale 1 : 100 000 scale.

Schiarizza, P., Gaba, R.G., Glover, J.K., Garver, J.I., and Umhoefer, P. J. 1997. Geology and Mineral occurrence of the Taseko – Bridge River area. British Columbia Ministry of Employment and Investment, Bulletin 100.

Schröder-Adams, C., and Haggart, J.W. 2006. Biogeography of Foraminifera in tectonic reconstructions: Limitations and constraints on the paleogeographic position of Wrangellia, *In* Paleogeography of the North American Cordillera: evidence for and against large-scale displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46. pp. 95–108.

Smith, P.L. 2006. Paleobiogeography and Early Jurassic molluscs in the context of terrane displacement in western Canada. *In* Paleogeography of the North American Cordillera: evidence for and against large-scale displacements. *Edited by* J.W. Haggart, R.J. Enkin, and J.W.H. Monger. Geological Association of Canada, Special Paper 46. pp. 81–94.

Smithyman, B.R., and Clowes, R.M. 2011. Improved near-surface velocity models from the Nechako Basin seismic survey, south-central British Columbia (parts of NTS 93B, C, F, G), part 2: full-waveform inversion. *In* Geoscience BC Summary of activities 2010. Geoscience BC Report 2011-1. pp. 255–264.

Souther, J.G. 1984. The Ilgachuz Range, a peralkaline shield volcanic in central British Columbia. *In* Current research, part A. Geological Survey of Canada, Paper 84-1A. pp. 1–10.

Souther, J.G. 1986. The western Anahim Belt: root zone of a peralkaline magma system. Canadian Journal of Earth Sciences, **23**(6): 895–908. doi:10.1139/e86-091.

Souther, J.G., Clague, J.J., and Mathewes, R.W. 1987. Nazko cone: a Quaternary volcano in the eastern Anahim Belt. Canadian Journal of Earth Sciences, **24**(12): 2477–2485. doi:10.1139/e87-232.

Souther, J.G., and Souther, M.E.K. 1994. Geology, Ilgachuz Range and adjacent parts of the Interior Plateau, British Columbia. Geological Survey of Canada, Map 1846A, scale 1 : 50 000.

Spratt, J., and Craven, J.A. 2011. Near-surface and crustal-scale images of the Nechako basin, British Columbia, Canada, from magnetotelluric investigations. Canadian Journal of Earth Sciences, **48**: this issue.

Spratt, J.E., Craven, J., Jones, A.G., Ferri, F., and Riddell, J. 2007. Utility of magnetotelluric data in unravelling the stratigraphic-structural framework of the Nechako Basin (NTS 092N; 093C, B, G, H), South-Central British Columbia, from a re-analysis of 20-year-old data. *In* Geological fieldwork 2006. British Columbia Ministry of Energy, Mines and Petroleum Resources Paper 2007-1. pp. 395-403.

Stephenson, A.L., Spence, G., Wang, K., Hole, J.A., Miller, K.C., Clowes, R.M., Harder, S.H., and Kaip, G.M. 2011. Crustal velocity structure of the southern Nechako basin, British Columbia, from wide-angle seismic traveltime inversion. Canadian Journal of Earth Sciences, **48**: this issue.

Struik, L.C. 1993. Intersecting intracontinental Tertiary transform fault systems in the North American Cordillera. Canadian Journal of Earth Sciences, **30**(6): 1262–1274. doi:10.1139/e93-108.

Struik, L.C. 1998. Bedrock geology, Fraser Lake, British Columbia. Geological Survey of Canada, Open File 3559, Scale 1 : 100 000.

Struik, L.C., and MacIntyre, D.G. 2001. Introduction to the special issue of Canadian Journal of Earth Sciences: The Nechako NATMAP Project of the central Canadian Cordillera. Canadian Journal of Earth Sciences, **38**(4): 485–494. doi:10.1139/e01-019.

Struik, L.C., Fuller, E.A., and Lynch, T.E. 1990. Geology of Prince George (East Half) map area (93G/E), Descriptive notes and fossil list. Geological Survey of Canada, Open File 2172, map scale 1 : 250 000.

Struik, L.C., Fallas, K., Hrudey, M.G., and Whalen, J.B. 2000. Bedrock geology, Burns Lake, British Columbia. Geological Survey of Canada, Open File 3840, map scale 1 : 100 000.

Sweet, A.R. 2006. Applied research report on 157 samples from the Nechako basin, central British Columbia (NTS 92J/15, 92O/12, 92O/14, 93B/04, 93B/11, 93C/09). Geological Survey of Canada, unpublished Paleontological Report 12-ARS-2006.

Sweet, A.R. 2008. Applied research report on 20 outcrop samples from the Nechako basin, central British Columbia (NTS 92J/15, 92O/02, 12; 93B/11, 13; 93F/08; 93G/05). Geological Survey of Canada, unpublished Paleontological ARS-2008-07.

Talinga, D.A., and Calvert, A.J. 2011. Velocity models from three-dimensional traveltime tomography in the Nechako Basin, south-central British Columbia (Parts of NTS 093B, C, F, G). *In* Geoscience BC Summary of activities 2010. Geoscience BC Report 2011-1. pp. 265–274.

Taylor, N.W. 1961. A report on the Nazko River and Puntzi Permit areas – Interior Plateau, Central British Columbia. Honolulu Oil Corporation, British Columbia Petroleum Resources Branch, Assessment Report 935.

Thorkelson, D.J., Mortensen, J.K., Marsden, H., and Taylor, R.P. 1995. Age and tectonic setting of Early Jurassic episodic volcanism along the northeastern margin of the Hazelton Trough, northern British Columbia. *In* Jurassic magmatism and tectonics of the North American Cordillera. *Edited by* D.M. Miller and C. Busby. Geological Society of America, Special Paper 299. pp. 83–94.

Thorkelson, D.J., and Rouse, G.E. 1989. Revised stratigraphic nomenclature and age determinations for mid-Cretaceous volcanic rocks in southwestern British Columbia. Canadian Journal of Earth Sciences, **26**(10): 2016–2031. doi:10.1139/e89-170.

Thorkelson, D.J., and Taylor, R.P. 1989. Cordilleran slab windows. Geology, **17**(9): 833–836. doi:10.1130/0091-7613(1989)017<0833:CSW>2.3.CO;2.

Tipper, H.W. 1959. Geology, Quesnel, British Columbia. Geological Survey of Canada Map 12-1959, scale 1 inch to 4 miles.

Tipper, H.W. 1960. Geology, Prince George, British Columbia. Geological Survey of Canada Map 49-1960, scale 1 inch to 4 miles.

Tipper, H.W. 1963*a*. Nechako River Map-Area, British Columbia. Geological Survey of Canada, Memoir 324.

Tipper, H.W. 1963*b*. Geology, Nechako River, British Columbia. Geological Survey of Canada, Map 1131A, scale 1 inch to 4 miles.

Tipper, H.W. 1968. Geology, Anahim Lake, British Columbia. Geological Survey of Canada, Map 1202A, scale 1 inch to 4 miles.

Tipper, H.W. 1971*a*. Surficial geology, Prince George, 93G, British Columbia. Geological Survey of Canada, Map 1288A, scale 1 : 250 000.

Tipper, H.W. 1971*b*. Surficial geology, Anahim Lake, 93C, British Columbia. Geological Survey of Canada, Map 1289A, scale 1 : 250 000.

Tipper, H.W. 1971*c*. Surficial geology, Quesnel, 93B, British Columbia. Geological Survey of Canada, Map 1290A, scale 1 : 250 000.

Tipper, H.W. 1971*d*. Surficial geology, Taseko Lakes, 92O, British Columbia. Geological Survey of Canada, Map 1292A, scale 1 : 250 000.

Tipper, H.W. 1971*e*. Surficial geology, Mount Waddington, 92N, British Columbia. Geological Survey of Canada, Map 1291A, scale 1 : 250 000.

Tipper, H.W. 1978. Geology of Taseko Lakes map area, British Columbia. Geological Survey of Canada, Open File Map 534, scale 1 : 125 000.

Tipper, H.W., and Richards, T.A. 1976. Jurassic Stratigraphy and History of North-Central B.C. Geological Survey of Canada Bulletin 270.

Umhoefer, P.J. 1990. Stratigraphy and tectonic setting of the upper part of the Cadwallader terrane, southwestern British Columbia. Canadian Journal of Earth Sciences, **27**(5): 702–711. doi:10.1139/e90-069.

Umhoefer, P.J., and Schiarizza, P. 1996. Latest Cretaceous to early Tertiary dextral strike-slip faulting on the southeastern Yalakom fault system, southeastern Coast Belt, British Columbia. Geological Society of America Bulletin, **108**(7): 768–785. doi:10.1130/0016-7606(1996)108<0768:LCTETD>2.3.CO;2.

Umhoefer, P.J., and Tipper, H.W. 1998. Stratigraphy, depositional environment, and tectonic significance of the Upper Triassic to

Middle Jurassic rocks of the Chilcotin Ranges, southwestern British Columbia. Geological Survey of Canada, Bulletin 519.

Umhoefer, P.J., Schiarizza, P., and Robinson, M. 2002. Relay Mountain Group, Tyaughton-Methow basin, southwest British Columbia: a major Middle Jurassic to Early Cretaceous terrane overlap assemblage. Canadian Journal of Earth Sciences, **39**(7): 1143–1167. doi:10.1139/e02-031.

van der Heyden, P. 1992. A Middle Jurassic to Early Tertiary Andean–Sierran arc model for the Coast belt of British Columbia. Tectonics, **11**(1): 82–97. doi:10.1029/91TC02183.

van der Heyden, P., and Metcalfe, S. 1992. Geology of the Piltz Peak plutonic complex, northwestern Churn Creek map area, British Columbia. *In* Current research, part A. Geological Survey of Canada, Paper 92-1A. pp. 113–119.

Vickers, K.J., and Ferbey, T. 2009. Surficial geology of the Redstone Area (NTS 93B/04). British Columbia Ministry of Energy, Mines and Petroleum Resources, Open File Map 2009-5, scale 1 : 50 000.

Ward, P.D., Hurtado, J.M., Kirschvink, J.L., and Verosub, K.L. 1997. Measurements of the Cretaceous Paleolatitude of Vancouver Island: Consistent with the Baja – British Columbia hypothesis. Science, **277**(5332): 1642–1645. doi:10.1126/science.277.5332.1642.

Wetherup, S., and Struik, L.C. 1996. Vanderhoof Metamorphic Complex and surrounding rocks, central British Columbia. *In* Current research 1996-A. Geological Survey of Canada. pp. 63–70.

Whalen, J.B., Anderson, R.G., Struik, L.C., and Villeneuve, M.E. 2001. Geochemistry and Nd isotopes of the François Lake plutonic suite, Endako batholith: host and progenitor to the Endako molybdenum camp, central British Columbia. Canadian Journal of Earth Sciences, **38**(4): 603–618. doi:10.1139/e00-080.

Woodsworth, G.J. 1980. Geology of Whitesail Lake (93E) map-area, British Columbia. Geological Survey of Canada, Open File 708, scale 1 : 250 000.

Wynne, P.J., Irving, E., Maxson, J.A., and Kleinspehn, K.L. 1995. Paleomagnetism of the Upper Cretaceous strata of Mount Tatlow: Evidence for 3000 km on northward displacement of the eastern Coast Belt, British Columbia. Journal of Geophysical Research, **100**(B4): 6073–6091. doi:10.1029/94JB02643.

Yoon, T.N. 1972. Exploration report of Quesnel coal properties. Master Explorations Limited, British Columbia Department of Mines and Petroleum Resources, Coal Assessment Report, File No. 35.