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THE ANCIENT WESTERN NORTH AMERICAN MARGIN: AN ALPINE RIFT MODEL FOR THE EAST-CENTRAL CANADIAN CORDILLERA

L.C. STRUIK

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THE ANCIENT WESTERN NORTH AMERICAN MARGIN: AN ALPINE RIFT MODEL FOR THE EAST-CENTRAL CANADIAN CORDILLERA

Abstract

East-central British Columbia is divided into five terranes. They were imbricated by thrusts, metamorphosed, and translated by strike-slip faulting during the Mesozoic and earliest Tertiary. The three eastern terranes (east to west; Rocky Mountain, Cariboo and Barkerville) consist of metamorphosed upper Proterozoic to Triassic immature sand, silt, mud, and carbonate deposited in fluvial to marine shelf conditions. Westward, oceanic pillow basalt, ribbon chert and less clastic and ultramafic rocks of the upper Paleozoic Slide Mountain terrane underlie Triassic and Lower Jurassic subduction-generated basalt and fine grained clastic rocks of Quesnel terrane. The three eastern terranes were not separated by ridge-formed ocean crust but by physical barriers. Between four of the terranes, the barriers are considered to be rift-generated horsts. The horsts are remnants of crust which was thinned in three places. They formed during Proterozoic rifting and their shape and elevation were altered with subsequent rifting during the earliest Cambrian and the latest Devonian. Changes in the shape and height of the horsts controlled sediment transport. Remnants of rifted continental crust underlie Slide Mountain and Quesnel terranes. These remnants may have contaminated the volcanics, and controlled the basal detachment of Slide Mountain terrane. Within Quesnel terrane, a crustal remnant supported shallow-water deposition and may have localized the Triassic east-directed subduction. The margin of western North America is reconstructed from a 276 km long structural cross-section through the central Canadian Cordillera, from the eastern edge of the Rocky Mountain foothills in Alberta to the Quesnel Arc of the Intermontane Belt near Horsefly, B.C. The reconstructed Triassic section and the structure section have the same area of crust. The reconstruction is 802 km long; compared to today's geography, its western end would be in the Pacific Ocean off Vancouver Island. An implication of the reconstruction is that the North American margin was compressed between two converging sialic blocks. The sedimentary rocks, the sialic crystalline basement and the mantle were detached from each other and thickened independently during the compression.

Résumé

Le centre-est de la Colombie-Britannique peut-être divisé en cinq terranes distincts au point de vue stratigraphie et structure. Les terranes sont imbriqués par du chevauchement, métamorphisés et marqués par un faillage à décrochement horizontal au cours du Mésozoïque et le tout début du Tertiaire. Les trois terranes de l'est (direction est-ouest; Rocheuses, Cariboo et Bakerville) sont constitués de sables, de silts, de boues et de carbonates jeunes, métamorphisés datant du Protérozoïque supérieur au Trias; ces matériaux se sont déposés dans des milieux fluviaux et de plateaux continentaux (milieux marins). En direction ouest, des basaltes en coussins formés dans des milieux marins, des cherts rubanés et en moins grande quantité des roches clastiques et ultramafiques du terrane de Slide Mountain du Paléozoïque supportent des basaltes générés par la subduction et des roches clastiques à grains fins du terrane de Quesnel datant du Trias et du Jurassique inférieur. Les trois terranes de l'est n'ont pas été séparés par la crête océanique issue de la croûte à l'exception de barrières physiques. Entre quatre de ces terranes sont considérées comme des zones de fracture ayant donné naissance à des môles. Ces môles sont des vestiges crustaux provenant de la croûte réduite; elle a été effectivement réduite à trois endroits. Les môles formés au cours de la phase de fracturation protérozoïque où leur configuration et leur élévation furent altérées pendant une phase de fracturation subséquente qui eut lieu au tout début du Cambrien et à la toute fin du Dévonien. Les modifications de la configuration et de l'élévation des môles ont contrôlé le transport des sédiments. Les vestiges de la croûte continentale défoncée sont sous-jacents aux terranes de Slide Mountain et de Quesnel. Ces vestiges portent à croire qu'ils ont contribué à la contamination de la croûte par les roches volcaniques et contrôlé la séparation à la base du terrane de Slide Mountain. À l'intérieur du terrane de Quesnel, un vestige crustal est recouvert par une sédimentation d'eau peu profonde et qui peut avoir localisé la subduction triassique en direction est. La marge *de l'ouest nord-américain est reconstituée à partir d'un profil structural de 276 km de long à travers le centre de la Cordillère canadienne, elle est réalisée à partir du prisme oriental qui s'étend des foothills des Rocheuses en Alberta jusqu'à l'arc de Quesnel de la zone intermontagneuse près de Horsefly en Colombie-Britannique. La reconstitution du profil triassique et du profil structural occupe la même surface crustale. La reconstitution a 802 km de long; en la comparant à ce qu'elle représenterait dans le paysage actuel, son extrémité ouest serait nettement l'océan Pacifique au delà de l'île Vancouver. Une implication structurale de la reconstitution se situe au niveau de la marge nord-américaine, cette dernière a été compressée entre deux blocs convergents de la croûte sialique. Les roches sédimentaires, les roches cristallines, sialiques du socle et le manteau ont été partout détachés des autres et se sont épaissis indépendamment au cours de la phase de compression.*

INTRODUCTION

Recent work in the North American Cordillera has emphasized the differences between fault-bounded blocks of stratigraphy. As a consequence the Cordillera has been subdivided into terranes (Jones and Silberling, 1984). But, to define a terrane is not to determine the geological history of the Cordillera. To infer the stratigraphic and structural evolution of the orogen, the palinspastic distribution and links between the terranes must be interpreted. In east-central British Columbia, five fault-bounded terranes have been distinguished by their unique stratigraphy (Fig. 1; Struik, 1986; 1987). In this paper I interpret the palinspastic geology of those terranes. Facies and tectonic links are postulated between the terranes and the terranes are interpreted as products of intermittent Precambrian and Paleozoic rifting of western North America's continental margin and from Triassic subduction of oceanic crust beneath that margin. The Cordillera of central British Columbia is the result of Mesozoic transpression of the Triassic margin between the converging sialic crustal masses of North America and Stikine Terrane.

The palinspastic interpretation explains how three eastern terranes, which extend the length of the Canadian Cordillera, can have different stratigraphic sequences yet all be deposited along the western North American margin. It also shows how western terranes of oceanic or transitional crust and subduction-generated volcanics can be part of that margin.

The procedure is to present some general statements about the paleogeography of terranes and how they could come together. From these generalities I will show that the terranes of the east-central Cordillera were probably separated by highlands rather than oceans — the situation postulated for the Triassic continental margin of the Tethys which became compressed into the Alps. Trumpy's (1960) model for the Alps will be used as a model for the Cordilllera, however the specifics of the margin and its history will be modified by using concepts developed since Trumpy's palinspastic reconstruction. The modifications will be discussed, then the stratigraphy of the terranes summarized, and then the Triassic palinspastic cross-section described. Finally the reconstruction of the Precambrian to Paleozoic western Canadian margin will be discussed by relating the stratigraphy of the eastern Cordilleran terranes to the possible tectonic events that created them.

APPROACH TO PALINSPASTIC RECONSTRUCTION

Because terranes, by definition, are fault-bounded and have no stratigraphic links, it is impossible to know their prefaulting position. However, with a series of assumptions and deductions it is possible to make a reasonable reconstruction. To proceed we need to know what separated the terranes to permit them their distinct stratigraphies, how far apart they were, and what brought them together.

What can separate terranes such that they develop different stratigraphy? 1) *a wide ocean*, 2) *a large distance*, or 3) *a topographic high*. Wide oceans separate source rocks and depositional basins. Large distances on the same continent could separate source rocks. Topographic highs separate the basins but could provide common source rocks.

If a wide ocean separates the terranes then remnants of an intervening ocean should be found between or on the two terranes after they come together. The ocean remnants will be as ophiolite, or subduction-generated melange or magmatism. In some cases the terranes could be transported across oceans on transform faults and therefore have no record of subduction between them. In the east-central Canadian Cordillera the three eastern terranes are mainly sedimentary and nothing suggests they were separated by an ocean.

If a large distance separates the terranes developed on the same continent then they could be brought together by thrust or strike-slip motion. The motion may be recorded by paleomagnetism and possibly by matching the terrane sediments to their source. Strike-slip faults along the length of the eastern Cordillera (Roddick, 1967; Gabrielse, 1985; Struik, 1985) may have translated the terranes of central British Columbia many hundreds of kilometres from the south (Monger and Ross, 1985). As the extent of those motions is poorly constrained,

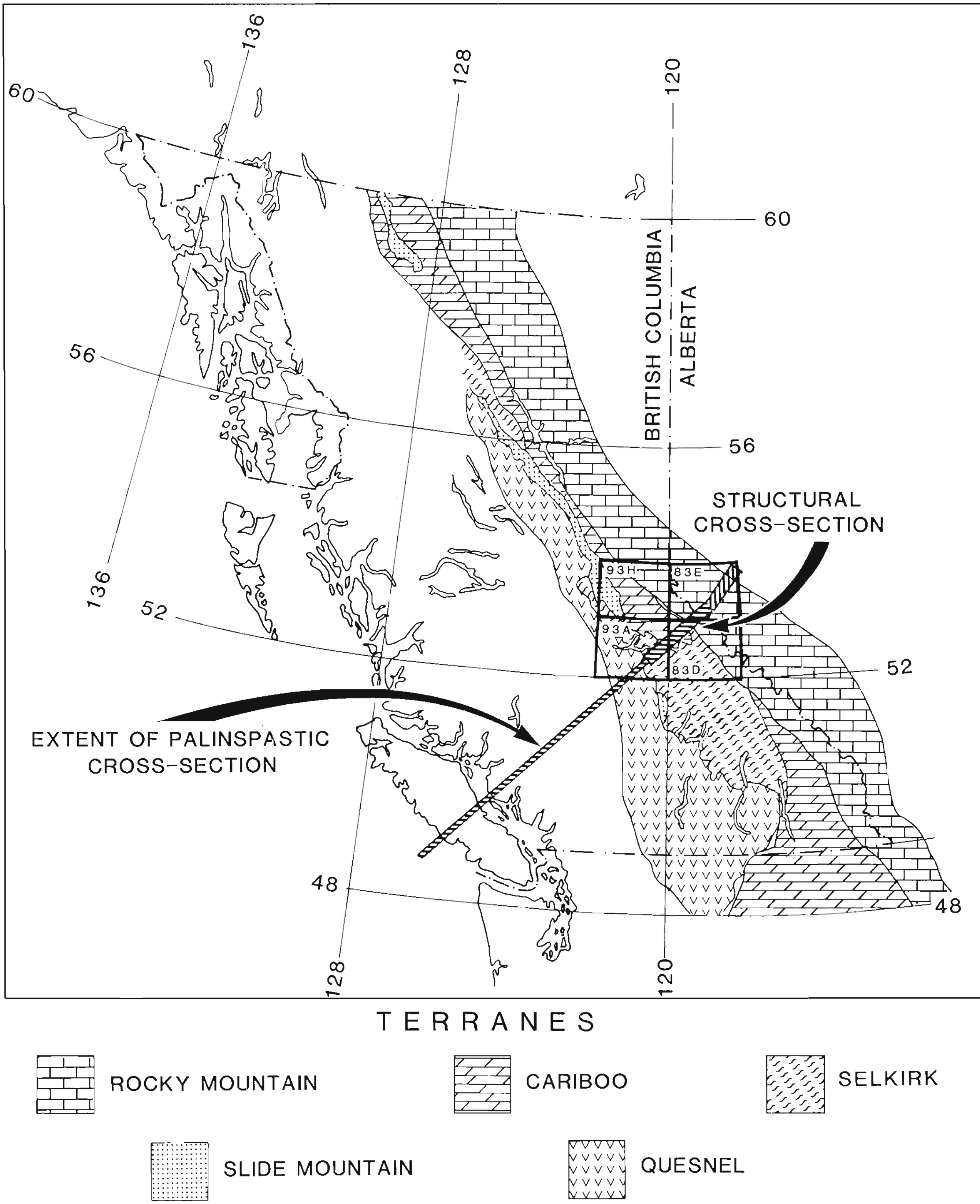

Figure 1. Distribution of the stratigraphic terranes of central British Columbia and Alberta, their correlatives throughout the Canadian Cordillera, and location of the structure section of Figure 2.

rigorous paleogeographic reconstructions are impossible. However, the terranes of the eastern Cordillera extend from Alaska south into the southwestern United States (Struik and Orchard, 1985). If up to 1000 km of dextral strike-slip is restored between the terranes then the place order of the terranes along an east-west transect through east-central British Columbia would be the same before and after restoration. Therefore, at the scale of the eastern Cordilleran terranes, strike-slip displacement does not affect the form of the palinspastic cross-section.

If a topographic high separates the terranes, the highland could consist of continental fragments or chains of volcanic islands built on oceanic or continental crust. The basins developed on either side of the highlands may become juxtaposed by thrusting or strike-slip. With thrusting the highland is overridden by the contents of the basins. The terranes of the central Canadian Cordillera are stacked thrust sheets with large displacements. Nowhere is it possible to unequivocally match rocks between adjacent sheets and thereby determine displacement. The different histories and lack of continuity between the terranes implies they developed independently. Three of the terranes do not have intervening thrust sheets that could represent oceanic crust that was between them during deposition. If not separated by an ocean basin, and, as argued earlier, excluding strike-slip, then the terranes must have been separated by highlands.

Within the nappes of the Alps, elongate zones with comparable stratigraphic history classed as "realms" or "facies belts" (example: Brianconnais realm) contained "platforms" of thin sedimentary sequences (example; Brianconnais platform). Trumpy outlined five facies belts or realms "each with a different geological history" (1960, p.852). The definition of the realms is essentially the same as that used for terranes in the central Canadian Cordillera (Struik, 1986). For the Swiss Alps, Trumpy (1958, 1960) suggested Triassic to mid-Cretaceous extension of the crust formed horsts and basins that controlled the deposition of sediments and mafic igneous rocks and produced the facies realms. Thin sedimentary sequences were deposited on the horsts (platforms) and the adjacent basins filled with thicker accumulations. Mafic igneous rocks (ophiolite sequences) formed within some of the wider and deeper basins. The depositional sequences and their attenuated basement were the southern continental margin of Cretaceous Europe. To explain the distribution and history of Cordilleran terranes, I apply the Alpine concept of extension-generated horst-separated basins.

However, since Trumpy drew the palinspastic cross-sections for the Alps in 1960, much work has been done on extended continental margins. From some of the recent work and from the differences between the Cordillera and the Alps, we can build a continental margin model that is more applicable to the Cordillera but which maintains the essence of the early Alpine model. The geometry and dynamics of the Cordilleran model are here isolated and discussed separately as they modify and build on the Alpine precurser.

Geometry

Shape and dimension of the horsts, extension fault style, and area balancing of the crust define the geometry of the Cordilleran continental margin model. Modern palinspastic reconstructions for the Alps are partly based on seismic profiles through Atlantic continental margins (Trumpy, 1980; Debelmas et al., 1983; Tricart, 1984). They show extended continental crust forming blocks separated by deep basins. The blocks (Trumpy's 'horsts'), or ribbon continents (Van der Linden, 1979, 1985) are as long as the Swiss Alps. They produce 'two-sided' basins (rather than sedimentary wedges) or are separated by oceanic crust. A basin can be floored and bounded by continental crust or by attenuated continental crust intruded by mafic igneous rocks. It is filled with sediment derived initially from both sides. Linear basins parallel to the edge of the continent and bounded by highlands (horsts, ribbon continents) are well displayed in seismic profiles for the east coast of Newfoundland (Enachescu, 1986; Keen et al., 1986;). For the eastern Cordilleran reconstruction, four terranes (realms) formed in two-sided basins separated by horsts (ribbon continents) and the fifth terrane was deposited on a horst. No oceanic crust is represented.

The choice of extension fault geometry for the model is arbitrary, because any shear process can produce horsts and basins. Lithosphere undergoing extension will neck and thin by brittle faulting and ductile flow. Wernicke (1985) suggested that stretching can be evenly distributed (pure-shear), be confined to discrete fault and flow zones (simple-shear), or be some combination of the two. Distributed stretching exhibits an upper brittle zone thinned by listric faults that root on a lower ductile zone. The ductile zone thins by rock flow and may be intruded by subvertical mafic dykes. Discrete-zone stretching confines relative motion between blocks to a low-angle fault in the brittle part of the crust, which at ductile depths passes into a zone of flow. Wernicke suggested the two end members of stretching could be distinguished by fault history and isostatic response of the bounding lithosphere. In the Cordillera, the extension faults are not sufficiently exposed to determine their history and deducing the isostatic response from the sedimentary record is premature.

A four-layer stretching model with brittle-ductile transitions in both the crust and mantle (Houseman and England, 1986) can accommodate pure or simple shear extension. Such a case, with two levels of detachment, is presented for the Orphan Basin off eastern Canada (Keen et al., 1987) where the regional stratigraphy strongly supports a simple shear model. Because all stretching models, two-layer, four-layer, pure shear, or simple shear, can produce crustal horsts and grabens, the deep crustal geometry as drawn in the Cordilleran Triassic palinspastic reconstruction is not constrained. With these uncertainties, the extension faults for the Cordilleran model are drawn listric to the Moho following Trumpy's reconstruction for the Alps (1980, fig. 15, p. 41) and Keen et al. (1986) for the Grand Banks of eastern Canada. The style of stretching is adapted from the simple shear model of lithospheric extension (Wernicke, 1985; Lister et al. 1986).

Palinspastic cross-sections to illustrate the extensional history of the ancient western Canadian margin are derived from a structural cross-section through the central Rocky and Cariboo mountains (modified after Campbell et al., 1982) (Fig. 2, 5B). Line and area balancing of the sedimentary rock sequence and the crystalline continental crust (craton), combined with approximations of the minimum sizes for some basins that cannot be balanced, control the length and form of the Triassic palinspastic reconstruction (Fig. 5A). The depth to the top of crystalline basement in each basin is taken from the sum of the stratigraphic thicknesses in that basin. The schematic topography of the top of the basement follows the topography of simply sheared crust (Wernicke, 1985). The crystalline craton of the western margin of North America may be an extension of the Canadian Shield, but it may include different rocks.

The area of crystalline basement in the palinspastic cross-section (Fig. 5A) is equal to that in the structural cross-section (Fig. 2, 5B). The equality assumes that craton is conserved (Helwig, 1976). In the line of the structure section, conservation can be demonstrated because craton is not exposed and therefore was not eroded away and nothing has been added by intrusion of fractionated mantle or magma generated from subducting oceanic crust. The Quesnel Lake Orthogneiss (Montgomery, 1985) and Hobson pluton (Pigage, 1977) are the only exposed intrusives in the line of section. The Quesnel Lake Orthogneiss is included in the area of the crust because it is Devonian (Mortensen et al., 1986) and therefore part of the Triassic craton. The Jurassic Hobson pluton is not included; the extent of its parents and relatives to depth is unknown. Triassic subduction-generated sialic intrusives under Quesnel terrane in the westernmost part of the section are included as part of the Triassic craton. Area balancing the craton has constrained the size of the continental fragments of the ancient western Canadian margin.

Dynamics

The Alpine model must be modified because the pre-collision history of the western margin of Canada is much longer than Alpine history (approximately 1150 million years longer). Alpine extension-related sedimentation started in the Triassic and ended in the mid-Cretaceous with compression-related sedimentation. Compression continued through to the Miocene (Tricart, 1984). Cordilleran extensional sedimentation began in the Middle Proterozoic and, except for some disputed events, continued until the Triassic. Compression-related deposition in the eastern Cordillera continued from the Triassic to the Eocene.

Instantaneous or rapid extension of the crust and upper mantle produces a basin (initial subsidence) underlain by elevated hot mantle. The hot mantle cools causing further subsidence (thermal subsidence) (McKenzie, 1978). For normal-thickness lithosphere, thermal equilibrium will return after 150-200 Ma when thermal subsidence will stop (McKenzie, 1978). Thompson et al. (1987) pointed out the incompatibility of the prolonged deposition in the Cordillera with the relatively short thermal subsidence time resulting from one instantaneous extension event. They suggested four extension events. The three younger may coincide with those suggested for the central Canadian Cordillera where the earliest sedimentary sequence (middle Proterozoic) is missing (Struik, 1986).

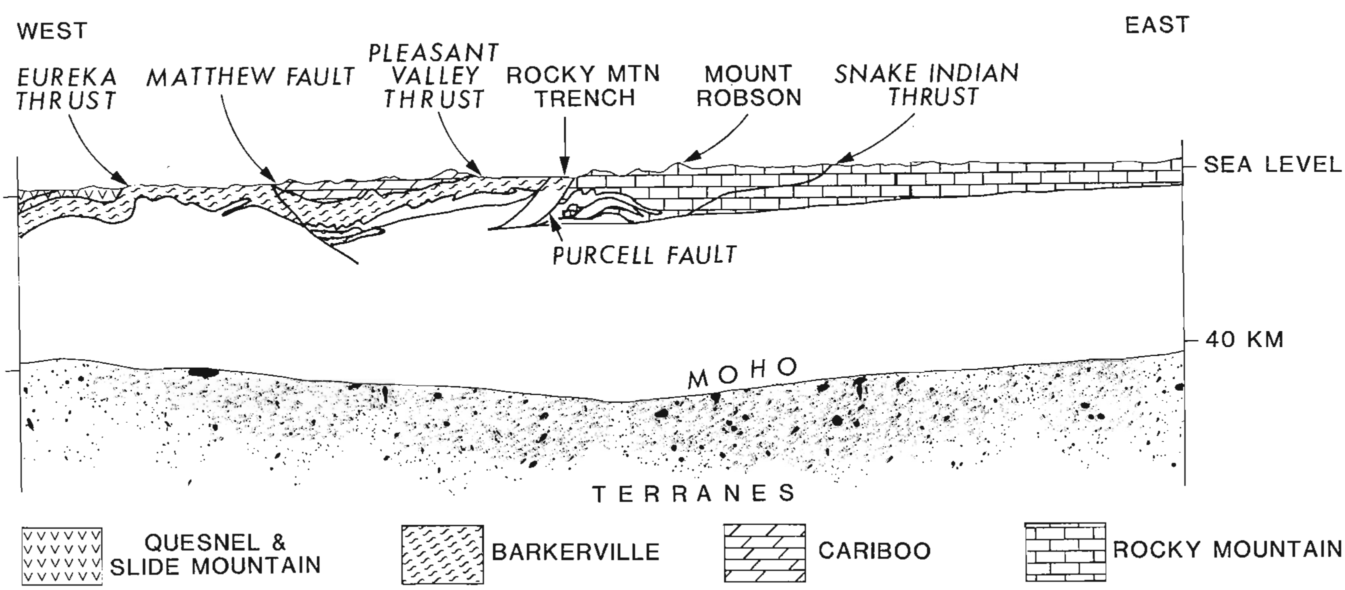

Figure 2. Structure section through east-central British Columbia and west-central Alberta as modified from Campbell et al. (1982).

How can the continental margin be rifted repeatedly without a collisional event? The solution to this problem may be that the margin suffered a series of incomplete extensional events which did not produce an intervening oceanic crust until the last event in the Late Devonian. Incomplete continental rifting before the Late Devonian also explains the absence of Proterozoic and lower Paleozoic ophiolites. The first record of oceanic crust as ophiolite is in the Permo-Carboniferous Cache Creek Group (Monger, 1984).

I propose that the extension history along the line of section began with the formation of a two-sided rift basin in the Proterozoic when continental extension ceased before complete rifting. This process was repeated, beginning in the latest Proterozoic; it may have been interrupted in the Ordovician and Silurian and may have terminated in the Devonian. In Late Devonian, extension began again and resulted in complete continental separation, and the production of an ocean basin. Sediments are assummed to be derived from highlands generated by stretching.

TERRANE STRATIGRAPHY

'Terrane' is used here as 'realm' was used by Trumpy (1980) for the Alps. Some of the terranes may be better considered subdivisions of realms — Trumpy's belts.

In the central Canadian Cordillera, westward from Alberta into British Columbia, terrane stratigraphy changes from Hadrynian to Mesozoic continental shelf and off-shelf sediments (Rocky Mountain, Cariboo and Selkirk terranes), to upper Paleozoic ocean basin basalts and ribbon cherts (Slide Mountain terrane) and to Mesozoic subduction-generated volcanics and sediments (Quesnel terrane) (Struik, 1986). The Rocky Mountain terrane is a geographically differentiated area of North America terrane and no further distinction is intended. Rocky Mountain is separated from Cariboo terrane by the Purcell Fault, Cariboo from Selkirk by the Pleasant Valley Thrust, Quesnel from Selkirk by the Eureka Thrust and Slide Mountain is thrust onto both Selkirk and Cariboo along the Eureka and Pundata thrusts (Fig. 2; Struik, 1986).

An upper Proterozoic sequence, mainly of grit and shale, occurs in the three easternmost terranes and comprises the oldest sedimentary rocks of central British Columbia (Fig. 3). Basement of orthogneiss and paragneiss underlies the Selkirk sequence but is not exposed in the Rocky Mountain terrane and has been detached from the Cariboo terrane (Struik, 1986). The contact between the basement and Selkirk terrane is a shear zone (Morrison, 1982). Each of Rocky Mountain, Cariboo and Selkirk terranes contain comparable upper Proterozoic basal units (Fig. 3). Correlations between the lower parts of the late Proterozoic of Rocky Mountain and Cariboo terranes have been made by Carey (1984), Pell (1984), Murphy (1985), and Carey and Simony (1985). The late Proterozoic has been considered a period of rifting and basin formation in the Rocky Mountain terrane (Stewart, 1972; 1976; Sears and Price, 1978; Monger and Price, 1979; Gabrielse, 1985). Rifting is thought to have happened at approximately 900 (Miller et al., 1973) to 850 Ma (Stewart, 1972) but may be as young as 725 Ma (Evenchick, 1983).

Lower Paleozoic sequences in the eastern terranes are dominated by carbonate and shale (Rocky Mountain), shale (Cariboo), and grit (Selkirk) (Fig. 3).

Upper Paleozoic rocks occur in all terranes, but in central British Columbia those of Quesnel terrane are not exposed. The upper Paleozoic of the three eastern terranes consists mainly of thin sequences of clastics. In addition, Rocky Mountain terrane supports a widespread Lower Carboniferous carbonate succession (Fig. 3). The Slide Mountain terrane in contrast consists of mainly pillow basalt and ribbon chert (Fig. 4).

The Triassic is represented by clastic rocks in the Rocky Mountain terrane, limestone and shale in Cariboo terrane and volcaniclastic rocks in Quesnel terrane (Fig. 3, 4).

TRIASSIC PALINSPASTIC RECONSTRUCTION

The Triassic palinspastic reconstruction includes five depositional basins; four are separated by three cratonic horsts and the fifth is build on a horst. The basins are now represented by the terranes of the central Canadian Cordillera. The cratonic horsts represent ribbon continents created by extension of the western North American margin. They are manifested as arches in the sedimentary record where adjacent sedimentary sequences thin toward the arch and where parts of the sequence are missing.

Rocky Mountain Basin (Fig. 5)

The reconstructed shape of the basin is constrained by sediment thickness, by the geometry of large-scale folds and thrusts, and by crystalline basement thrust sheets in the core of the Yellowhead Culmination south of Mount Robson (Campbell, 1968; Campbell et al., 1973; Campbell, 1978; Mountjoy, 1980; Campbell et al. 1982; Struik, 1986). The horst between the Rocky Mountain and Cariboo Mountain (Cariboo) basins is represented by the McBride Arch (Young, 1969, 1979). The arch was postulated because upper Proterozoic and lower Paleozoic strata of both the Cariboo and Rocky mountains thin toward the Rocky Mountain Trench (Campbell et al., 1973). The cratonic block of McBride Arch is not exposed. It may be detached from overlying sediment and be incorporated in the thickened crust. The structure of the stretched craton is patterned on the model of a simply sheared lithosphere with sub- and intra-crustal detachments (Wernicke, 1985). The craton from the east to the first extension fault is illustrated as thinning to the west (Fig. 5). For that section, Stockmal and Beaumont (1987) drew craton of constant thickness. Because the area of

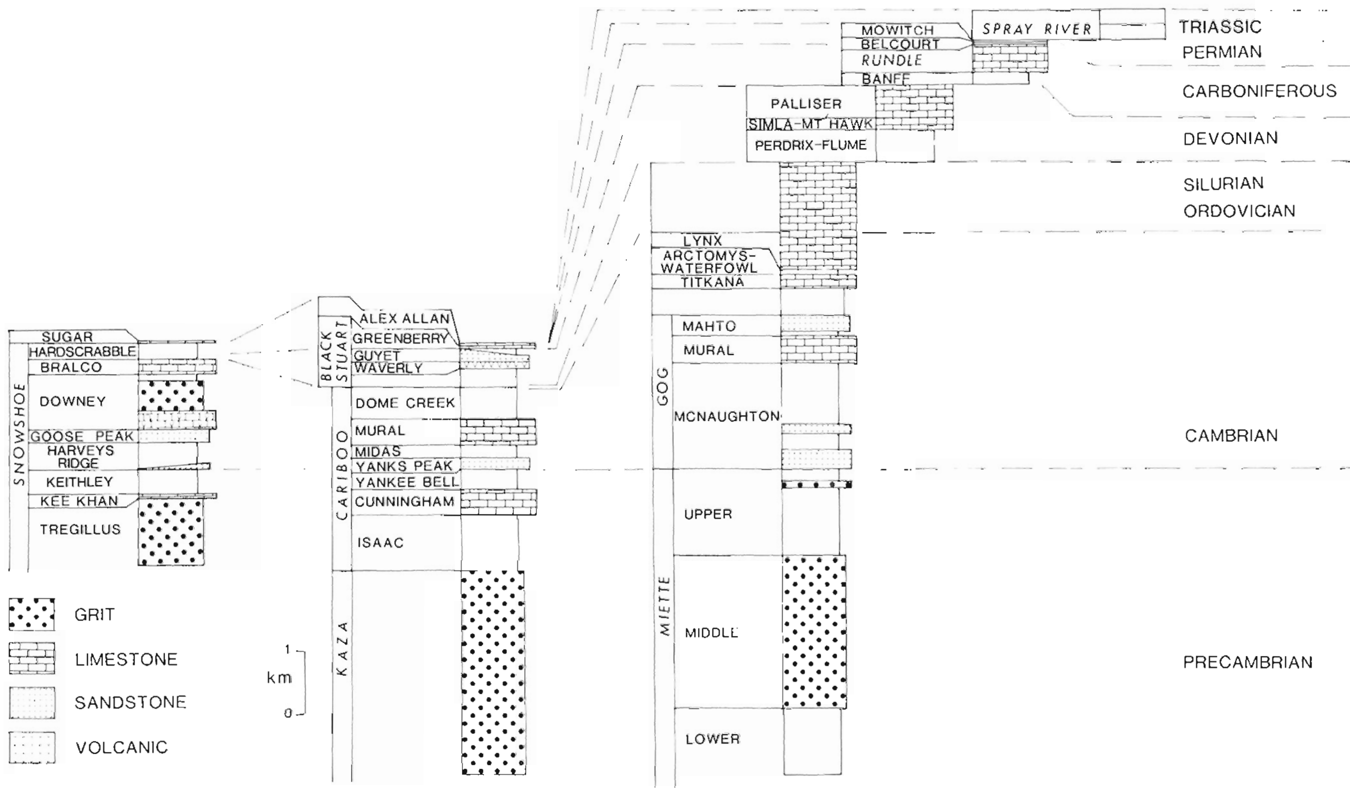

Figure 3. Stratigraphy of Rocky Mountain, Cariboo, and Selkirk terranes. The Rocky Mountain terrane section is a composite of measured sections; components of the composite are shown offset in the column. For Rocky Mountain terrane, the Precambrian to Ordovician component is from Campbell et al. (1973), the Devonian section is from Geldsetzer (1982), the Permian-Carboniferous section is from Bamber and Macqueen (1979, section 8) and Mamet et al. (in press, section 5), and the Triassic section is from Gibson (1974). The Cariboo terrane section is from Campbell et al. (1973) as modified by Struik (1987). The Selkirk terrane section is from Struik (1985, 1987). Names in italics are groups, others are formations or informal divisions. Fine-grained clastic units are left unpatterned.

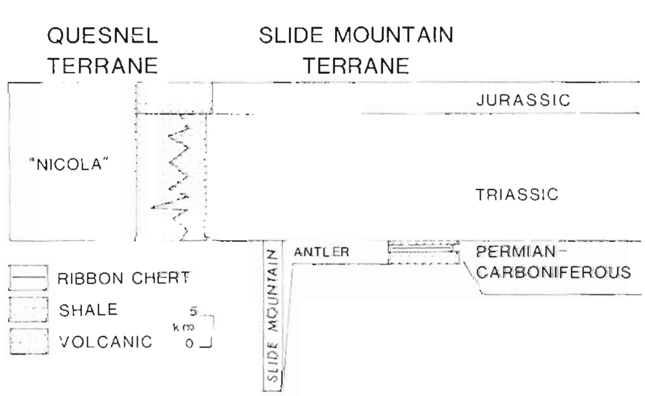

Figure 4. Stratigraphy of Quesnel and Slide Mountain terranes. Quesnellia stratigraphy is from Struik (1985) and Slide Mountain Terrane stratigraphy is from Struik and Orchard (1985).

craton for the palinspastic cross-section is set, then the thinner craton in the east permits thicker horsts in the west. A westward thinning craton under the Rockies balances the westerly thickening sediments. The craton may be thinner in the west because it was stretched, or more likely, because the top was eroded when the graben edges rose during initial stretching.

Cariboo Basin (Fig. 5)

The thickness of strata and the structural geometry of folds and thrusts constrain how Cariboo Basin is drawn (Campbell, 1968; Campbell et al., 1973; Struik, 1986). The thickness of the lowest unit (Kaza Group) is estimated because its base is not exposed. The base and therefore the basement are assumed to be approximately 500 m below the present stratigraphic position of the Pleasant Valley Thrust. The width of the basin is not constrained

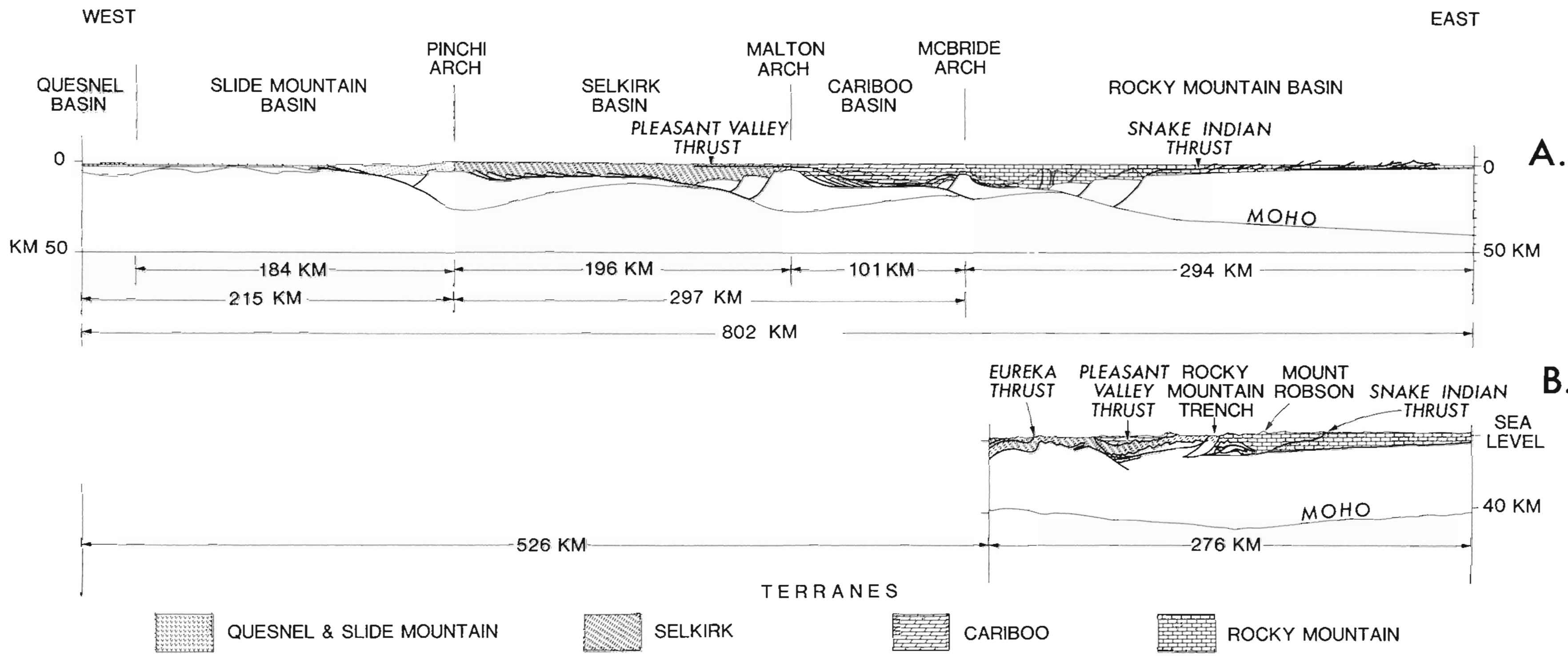

Figure 5. A) Triassic, pre-Columbian Orogen, palinspastic cross section derived from the structural cross section of Figure 2, which is included as B) for a scaling reference.

because thicknesses are estimated and there is no continuous marker to determine shortening. The shape of the cratonal fragment under Cariboo Basin is stylized following the simple shear extension model of Wernicke (1985). Units thin toward the western edge of the basin, as they thin toward the eastern edge, the McBride Arch, and because of the similarity, a horst or arch is proposed for the western boundary. The western horst, referred to as Malton Arch, is drawn with a deep root to approximate isostatic balance. The top of the horst between Cariboo and Selkirk basins may be exposed as the Malton (Morrison, 1982), Bulldog, and Blackman gneisses (McDonough and Simony, 1984). Although the Malton Gneiss may be separated from the Bulldog and Blackman gneisses by a strike-slip fault, all underlie the eastern exposures of Selkirk terrane.

Selkirk Basin (Fig. 5)

The size of the Selkirk Basin is estimated from the thickness of the Snowshoe Group (Struik, 1986), from the depth to basement, and from a minimum length determined from the present extent of Selkirk terrane in central British Columbia (Struik, 1986). Depth to basement was determined from the combined thickness of the Snowshoe Group (Fig. 3) and a hypothetical underlying Precambrian stratigraphy. Rocks older than those exposed could correlate with the lower and middle Miette Group (Fig. 3) of Rocky Mountain Basin and is assumed to have a similar thickness. The length was estimated because the shortening is unconstrained.

The shape of the craton under the basin is modelled after the geometry of simple shear extension. The craton is thinner than that of Cariboo Basin and ?Cambrian volcanics are assumed to have leaked from the mantle upward through the thinned crust.

The western horst that separates Selkirk Basin from the upper Paleozoic Slide Mountain Basin presumably lay west of, or at, the westernmost exposures of Selkirk terrane. Archeocyathid-bearing limestone near Quesnel (Struik, 1984) may be the westernmost Selkirk terrane. The Quesnel locality borders the Pinchi Fault west of which there is no Selkirk terrane, not only in central British Columbia, but for some distance to the northwest and southeast as well. For that reason the horst is hereafter called the Pinchi Arch although the position of the Pinchi Fault may have nothing to do with the ancient edge of Selkirk terrane.

Slide Mountain Basin (Fig. 5)

The depth of the basin is controlled by the thin basalt and ribbon chert sequences at the type area of the Slide Mountain Group at Sliding Mountain (Struik and Orchard, 1985). The length of the basin in the cross-section is estimated at twice the present east-northeast width of Slide Mountain Group in the structural depression through Prince George and McBride map areas 150 km northwest of the structure section. The shortening estimate (100 per cent) is a minimum, because locally a stack of three to four thrust sheets repeats nearly the entire known section of the group (Struik and Orchard, 1985).

The ribbon chert and abundant tholeiitic pillow basalt of Slide Mountain terrane are typical of the upper two layers of an ophiolite, generally considered to represent obducted oceanic crust devoid of sialic material. However, local felsic igneous rocks, with zircons that contain Precambrian cores (P. van der Heyden, personal communication, 1986), were likely contaminated by continental crust. Therefore, in the cross-section the crust under Slide Mountain Basin contains thin fragments of extended "North American" craton.

Quesnel Basin (Fig. 5)

The minimum palinspastic cross-section length of the Quesnel Basin is 1.5 times the present deformed exposures. The thickness is approximately 2 to 3 km. Upper Paleozoic mixed fragmental volcanics, clastics and limestones (Harper Ranch Group), are covered by Triassic fragmental basalts. Basement to upper Paleozoic and Triassic Quesnel terrane may have consisted of lower Paleozoic sedimentary rocks like those of Selkirk terrane deposited on Precambrian crystalline cratonal rocks. In the cross-section the lower Paleozoic and Precambrian basement is undifferentiated as craton. The cratonal basement would have been a ribbon continent supporting a platform for shallow water sedimentation (M.J. Orchard, personal communication, 1986) of the upper Paleozoic Harper Ranch Group; deep ocean deposits formed by extension on the flanks of the platform. During extension, the formation of regional platforms the size of Quesnellia appears confined to continental fragments (compare to those of the Pacific Ocean, Nur and Ben-Avraham, 1983). A Precambrian and Paleozoic Quesnellia continental fragment may have locallized Triassic volcanism by providing a lithological discontinuity with ocean crust along which a thrust could propogate (subduction).

Summary

The Triassic palinspastic cross-section (Fig 5), derived from 276 km of structural section through part of central Alberta and British Columbia, is 802 km long. From the reconstruction, the shortening of the margin is 526 km or 191 per cent. As the method of reconstruction minimizes the shortening, it is safe to approximate the shortening as 200 per cent. The width of the individual basins (their cross-section length) varies from 100 to 300 km; Rocky Mountain Basin is 294 km, Cariboo Basin is 101 km, Selkirk Basin is 196 km, and Slide Mountain Basin is 184 km wide. Quesnel Terrane extends west of the structural cross-section and is therefore unconstrained, being represented by a width of 30 km. The Triassic Quesnel Terrane island arc could have been as wide as 120 km. The present Japanese island arc is 3 to 4 times that width.

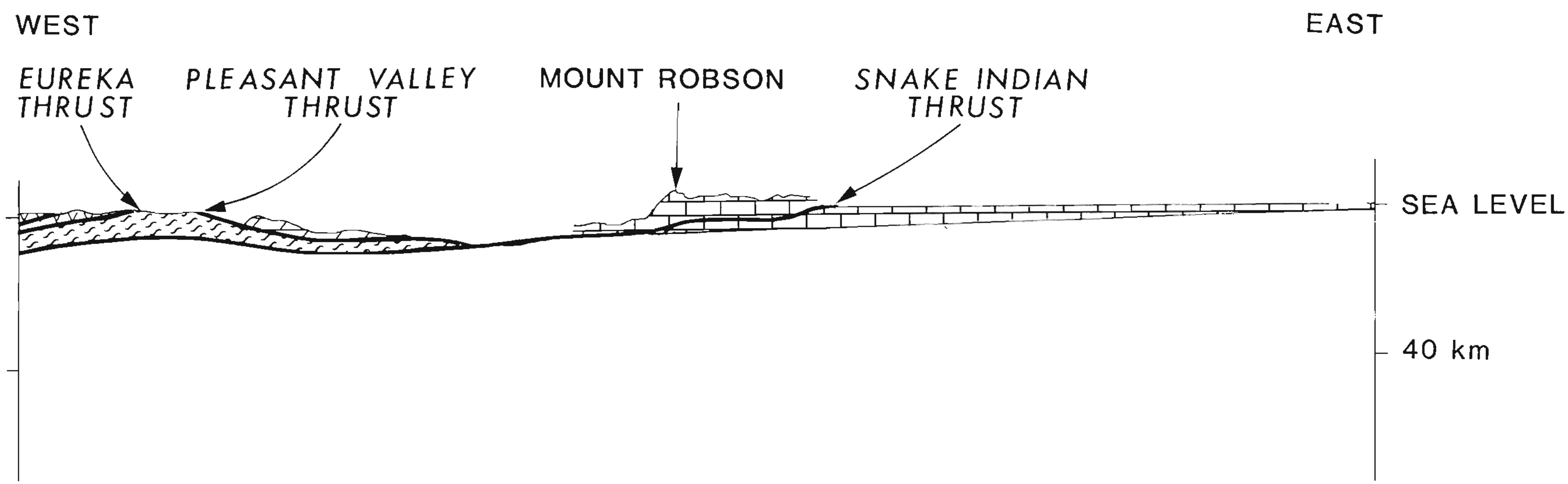

Figure 6. Configuration of a detachment of the sedimentary cover from the crystalline basement as depicted by partial reconstruction of the structure section of Figure 2. Displacement on faults east of the Snake Indian Thrust, and in the region of the Rocky Mountain Trench has been removed. Those faults are younger than the Pleasant Valley and Snake Indian thrusts. The continuity of the Pleasant Valley and Snake Indian thrusts with their opposing senses of motion suggests that the stratigraphic sequences in the thrust sheets were completely detached from the basement during compression.

PROTEROZOIC AND PALEOZOIC HISTORY OF EXTENSION

Earlier in this paper I proposed that the upper Proterozoic and Paleozoic stratigraphic successions of the east-central Canadian Cordillera were deposited during three or more extension events, and that upper Paleozoic sediments were deposited during the extension and separation of a continental block (Siberian or Chinese platforms) from the North American plate. The separation formed an intervening upper Paleozoic oceanic crust. I now introduce palinspastic cross-sections of the latest Proterozoic and Middle Devonian. They show the continental margin after some or all thermal balance has been obtained following extension, and just before further extension (Fig. 7). The following discussion highlights parts of the stratigraphic history which outline the extension history of the margin. The discussion is divided into three time periods; 1) the late Proterozoic, 2) lower Paleozoic, and 3) upper Paleozoic.

Summary of proposed extension history

The upper Proterozoic sequence was deposited in a basin created by extension. Like the proposed extension event for the mid-Proterozoic (McMechan, 1981; Eisbacher, 1981; Thompson et al., 1987), the late Proterozoic extension is presumed to have stopped before the continent split. This resulted in a two-sided basin with laterally continuous stratigraphy and two source terrains on the opposite sides of the basin (Fig. 7). The east side of the basin is the North American craton of today and the west side could have been the Siberian platform (Sears and Price, 1978).

Like the upper Proterozoic sedimentary sequences, the lower Paleozoic sequences may have been deposited into a depression created by extension that did not lead to continental separation. Extension began in the latest Proterozoic and earliest Cambrian and may be the event described by Bond and Kominz (1984) from the Rocky Mountain terrane stratigraphy (Thompson et al., 1987). Arches (horsts, ribbon continents) formed in the lowest Paleozoic, separated depositional basins, and created the different stratigraphy of the three eastern terranes (Fig. 7). Unconformities in the Ordovician and Silurian may be related to interruptions of basin subsidence produced by further minor extensions of the margin.

The upper Paleozoic succession was deposited during extension and splitting of the previously stretched North American craton. Stretching began in the Late Devonian with deposition of the Slide Mountain terrane pillow basalt and ribbon chert, Cache Creek terrane oceanic crust, and clastic rocks throughout Quesnel, Selkirk, Cariboo and parts of Rocky Mountain terranes (see also Gordey et al., 1987). The craton is thought to have separated completely because upper Paleozoic oceanic crust was formed (Cache Creek terrane). It is the last widespread extension event before presumed changes in plate motions caused convergence between North America and the Cache Creek oceanic crust. The convergence resulted in subduction of Cache Creek terrane eastward under Quesnel terrane in the Triassic and the collision of sialic land masses during the Jurassic (Monger, 1984).

Precambrian extension

Precambrian grit, shale and conglomerate of the three eastern terranes record two basic, yet important details; 1) the existence of a highland that supplied sediment; and 2) a water-filled depression into which the eroded material was deposited. These features imply a mechanism that depresses one area adjacent to another that rises. Such a situation exists when the crust is compressed or extended. The two types of deformation can be distinguished by their *syndepositional* faults; compression will be accompanied mainly by thrust faults and extension mainly by extension faults. Compression and extension faults may be generated at the same time during strike-slip faulting.

The late Precambrian depression (Windermere, 800 to 600 Ma) was probably rift-generated because the sediment fill was deposited during extension faulting in the northern Rocky and Mackenzie mountains (Taylor et al., 1979; Eisbacher, 1981). The Precambrian highlands that provided the eroded material for the sediments is presumed to have been formed by the same extension. Like the Gulf of Suez (Kohn and Eyal, 1981; Steckler and ten Brink, 1986), the graben edges along the extending North American margin are considered to have been uplifted for tens of millions of years. Subsidence and graben-edge uplift is postulated to control the deposition of coarse-grained sediments. The effects of sea level changes on the sediments deposited in basins play a subordinate role to that of crustal interactions from plate motions (Hubbard et al., 1985).

Some mathematical models of the stretching process assume instantaneous stretching followed by subsidence due to cooling. However, the coincidence of extension faulting and basin fill deposition (for examples see Eisbacher, 1981; Hubbard et al., 1985) suggests that stretching was protracted. Sediment fill of the Precambrian (and younger) extension consists of three sequences postulated to represent *initial stretching, graben-edge uplift* and *thermal subsidence*.

The **initial stretching sequence** may consist of the basal mud and silt exposed only in the Rocky Mountain basin as the lower Miette Group (Mountjoy, 1970; Carey and Simony, 1985).

The **graben-edge uplift sequence** consists of coarse sand and conglomerate and, as the name implies, was derived from the rising hills that formed boundaries to the deepening basin. An equivalent coarse-grained facies occurs in each of the three eastern terranes; middle Miette Group in the Rocky Mountain terrane, Kaza Group in the Cariboo terrane and Tregillus succession of the Snowshoe Group in the Selkirk terrane (Fig. 3). The con-

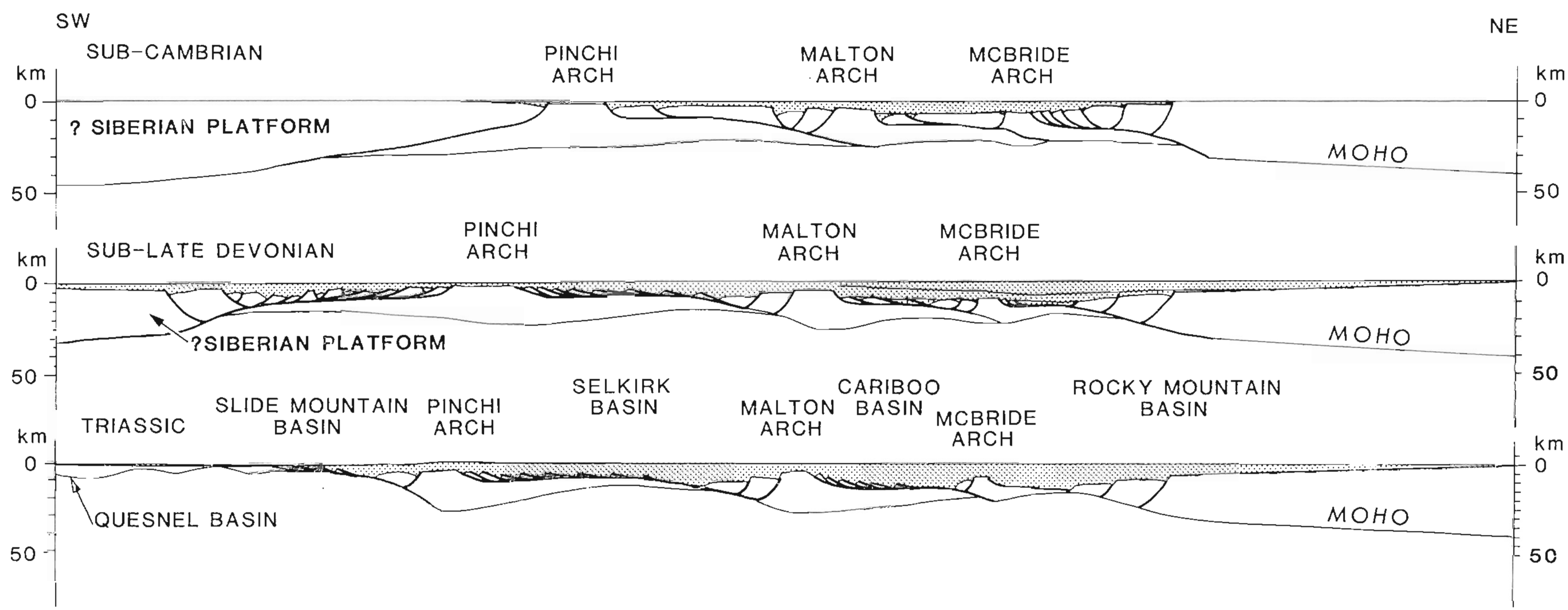

Figure 7. Palinspastic reconstructions of the structural cross-section of Figure 2 for the latest Proterozoic, Middle Devonian, and Triassic (same as Fig. 5A). The Malton and McBride arches develop during and after the latest Proterozoic extension and control the deposition of strata during the lower Paleozoic. The ?Siberian platform does not completely separate from the attenuated North American craton until the Late Devonian, when Slide Mountain Basin is generated. The datum of the sub-Late Devonian section is locally drawn below older Devonian stratigraphy where those older rocks are undifferentiated from the upper Devonian. Constraints on the thickness of the units comes from the palinspastic section of Campbell et al. (1982), and from Struik (1985, 1987).

tinuity is attributed to similar subsidence, possible interconnection of the basins, and a similar source for the clastics from both the eastern and western sides of the basin (Fig. 7). The immaturity of the sands and conglomerate throughout the sequence implies that their source was mountainous and near the basin shoreline. The material has been interpreted as turbiditic (Carey and Simony, 1985; Murphy, 1985), which could account for the wide distribution of the sequence throughout the basin.

The **thermal subsidence sequence** consists of mud and carbonate and represents a decrease in the elevation of the source terrain and continued subsidence of the basin. The decrease in the elevation of the source terrain was a consequence of erosion of the hills having been faster than their uplift and the subsequent cooling and subsidence of the lithosphere supporting it. Lithosphere cooling is also responsible for the continued basin subsidence. The erosion of the hills was gradual as recorded in the gradation from the coarse-grained sedimentary rocks of the graben-uplift sequence to the fine-grained sedimentary rocks of the thermal subsidence sequence. In the Rocky Mountain terrane the fine-grained clastics are the upper Miette Group below the Byng Formation (Ediacaran age, Hofmann et al., 1985), in Cariboo terrane they are the Isaac Formation of the Cariboo Group and in Selkirk terrane they are apparently missing or represented by the Kee Khan marble of the Snowshoe Group (Fig. 3).

Isaac Formation rock is generally finer grained than that of the upper Miette Group and may represent the westward fining of sediments derived entirely from an eroding highland east of the Rocky Mountain basin. The same westward fining may be represented by westward increasing carbonate in the upper part of the Isaac Formation.

The lack of Isaac Formation equivalent mud in Selkirk terrane may be due to: 1) a western highland that supplied coarse clastics into the Selkirk basin during Isaac Formation time, or 2) Selkirk basin was itself high during Isaac Formation time. In the second possibility, the upper contact of the Tregillus succession was an erosional or hiatal unconformity. Any material removed could have been shed to the east into the westernmost extent of the paleo-Isaac Formation. Each possibility requires that facies of the western Isaac Formation are controlled by a western highland.

The upper Proterozoic basin is considered a continuous trough between a western and eastern highland (Fig. 7).

Latest Proterozoic-earliest Cambrian extension

Latest Proterozoic-earliest Cambrian extension accounts for renewed coarse-grained clastic deposition and its coincidence with predicted rifting as determined from subsidence curves of lower Paleozoic stratigraphy (Bond and Kominz, 1984). The coarse-grained sediments abruptly or gradationally overlie the fine-grained facies of the upper Proterozoic thermal subsidence sequence. For the line of section, references to syndepositional extension faults of basal Cambrian age have not been found. If uppermost Proterozoic extension was active such growth faults should have existed.

The Late Proterozoic (Windermere) stratigraphic sequences were described as deposited during three extension-driven tectonic periods: initial stretching, graben-edge uplift and thermal subsidence. The sub-Cambrian event can be described in the same terms.

The **initial stretching sequence** of fine-grained sediment is either missing, or more likely, is superimposed on the thermal subsidence sequence of the earlier upper Proterozoic extension. In Rocky Mountain terrane, it is postulated to consist of the shale and siltstone of the uppermost Miette Group and the limestone of the Byng Formation. In Cariboo terrane, it may consist of the limestone and shale of the uppermost Isaac Formation and the limestone of the Cunningham Formation. In Selkirk terrane, it may consist of the phyllite and marble of the Kee Khan succession of the Snowshoe Group.

The **graben-edge uplift sequence** has correlative units in each of the three eastern terranes. In Rocky Mountain terrane the sequence consists of the McNaughton Formation of Lower Cambrian sandstone and shale. In Cariboo terrane the sequence consists of the Yankee Belle and Yanks Peak formations of ?Proterozoic and Lower Cambrian siltstone and sandstone. In Selkirk terrane the sequence may be represented by the Keithley succession of Snowshoe Group. The base of the Yankee Belle Formation near the Trench and the McNaughton Formation east of the Trench are disconformable and indicate local erosion (Young, 1969, Campbell et al., 1973, Young, 1979).

The most pronounced stratigraphic variation between the Rocky Mountain and Cariboo terranes starts at the base of the Yankee Belle Formation. The difference is maintained until the Lower Cambrian Mural Formation. The difference results from the relative rise of the McBride Arch at the Rocky Mountain Trench (Campbell et al., 1973). The thinning of the Yankee Belle to Mural formations at the McBride Arch (Trench) suggests that the arch subsided more slowly than the basins flanking it. A slower subsidence rate implies that it was cooler and therefore was perhaps thicker than the crust underlying the flanking basins with their thicker sediment accumulations (Fig. 7).

Further discontinuity at the McBride Arch, marked by the erosional unconformity at the base of the Lower Cambrian Yanks Peak Formation of Cariboo terrane, suggests renewed uplift of the arch. This was possibly at the beginning of the Early Cambrian (Fritz, 1984; Fritz and Crimes, 1985) and may reflect further attenuation of the North American margin.

The Pinchi Arch between Selkirk and Cariboo terranes began to form during the latest Proterozoic. It is marked by the westward decrease in thickness of the upper Proterozoic and Cambrian formations of Cariboo terrane. During the Cambrian it was sufficiently developed to separate coarse-grained sandstone and greywacke of Selkirk terrane from the shale and limestone of Cariboo terrane.

The **thermal subsidence sequence** started in the Early Cambrian (Bond and Kominz, 1984) and is marked by a decrease in the grain size of clastic sediments and a larger percentage of carbonate. The grain-size decrease results from subsidence of the source terrain. In Rocky Mountain terrane, the base of the sequence consists of the Mural Formation limestone. In Cariboo terrane, shales of the Midas Formation, under the Mural Formation, initiate the sequence. By Mural Formation time (late Early Cambrian) there appears to be continuity of deposition between the Cariboo and Rocky Mountain basins. Campbell et al. (1973) recognized that the Lower Cambrian carbonates of the Rocky and Cariboo mountains contain similar stratigraphy. The content of sand and mud in the Mural Formation decreases continuously from east to west.

In Selkirk terrane, stretching may have continued or started again in the late Early Cambrian because limestones of that age are interbedded with mafic and intermediate volcanics and are overlain by coarse-grained sandstones (Downey succession, Fig. 3). Alternatively, the volcanics and sandstones could represent compression, but no record of such activity is known for the Cambrian of the Canadian Cordillera. The age of the Downey succession is assigned by correlation with the Lower Cambrian Tshinikan Marble of the Eagle Bay Formation (Schiarizza, 1986) of Selkirk terrane south of Mahood Lake (Struik, 1986). The Tshinikan Marble, like the Downey, consists of limestone that is bounded and variably interlayered with fragmental basalt.

Grits of the Downey succession record an uplifted and eroded Cambrian and possibly younger highland west of the Selkirk Basin. The clastics must be derived from the west because the Lower Paleozoic sections of both Cariboo and Rocky Mountain terranes do not contain coarse clastic rocks.

It is possible that the Bralco marble of Selkirk terrane is also Lower Cambrian and that it was thrust onto the Downey succession internally within Selkirk terrane. The Bralco marble has affinities to the Mural Formation in its stratigraphic characteristics and the rift controlled break between eastern "clean" limestone and western limestone and volcanic may be between the Bralco and Downey successions of the Snowshoe Group of Selkirk terrane. Should this hypothesis be broadly correct, then the concept of a well-defined three basin development of the outer margin of the craton is an oversimplification.

Lower Paleozoic subsidence was interrupted in the Ordovician. Within Cariboo terrane, the Ordovician represents a sharp discontinuity in sedimentation. Struik (1980) described the Little Diastrophism of possible Lower or Middle Ordovician time which may have contributed to the unconformity between the Black Stuart Group and underlying Cambrian and older Cariboo Group. In Rocky Mountain terrane, the same event may be marked by the Middle Ordovician Monkman Formation incursion of sandstone (exposed east of the section of Fig. 3, Campbell et al., 1973) or the early Ordovician inflection in the thermal subsidence curves determined by Bond and Kominz (1984). The relationship between the Ordovician unconformity at the base of the Black Stuart Group (Cariboo terrane) and the age of the Downey succession grit of the Snowshoe Group (Selkirk terrane) is unknown.

Several unconformities probably interrupt deposition in the Black Stuart Group sequence (Cariboo terrane): during the Early Silurian, the latest Silurian, and part of the Early or Middle Devonian. The unconformity in the Early or Middle Devonian is deduced from the karst features within the Lower Devonian chert-carbonate unit of the Black Stuart Group (as pointed out by M. Dubord and H. Geldsetzer, personal communication, 1983). The Ordovician to Devonian sequence of the Cariboo Mountains is much thinner than that of the Rocky Mountains and is dominated by siliceous, black, fine-grained clastics (Fig.3).

Middle Paleozoic extension and Upper Paleozoic continental separation

Middle Paleozoic tectonism is marked by clastic influxes in Rocky Mountain, Cariboo and Selkirk terranes, by explosive volcanism in Cariboo terrane, by granitic intrusions in Selkirk and Rocky Mountain terranes and by the deposition of pillow basalt and ribbon chert sequences of Slide Mountain terrane. Slide Mountain Basin formed by rifting west of Selkirk Basin. The deep Slide Mountain Basin, as indicated by the consistent lithology, was maintained throughout the Permo-Carboniferous. Sedimentation was minimal throughout this period (Struik and Orchard, 1985).

By themselves the clastic influxes and granitic intrusions of the terranes east of Slide Mountain terrane do not define a unique tectonic environment. The intrusives vary in composition from calc-alkaline to alkaline, a chemical variation that, when geographically distributed, could result from subduction-generated volcanism (Condie, 1982, p. 133). Neither the composition, the age range, nor the distribution of Paleozoic intrusives is well understood, however most of the known Devono-Mississippian intrusives are alkaline, ranging from tonalite to carbonatite, and are found mainly in Rocky Mountain and Selkirk terranes (Pell, 1986a,b,c,). In isolation, such rocks are attributed to continental rifting (Condie, 1982, p. 139). The mid-Paleozoic intrusives of Rocky Mountain terrane consist of exotic mafic diatreme breccia pipes (Pell, 1986a) and various alkalic intermediate plutons and related carbonatites attributed to rifting (Pell, 1986b). Within Selkirk terrane the Devono-Mississippian Quesnel Lake orthogneiss (Mortensen et al., 1987) is younger than the inception of the Slide Mountain rift basin. Chemically, it is calc-alkaline to alkaline (Montgomery, 1985). Also in Selkirk terrane, at Blue

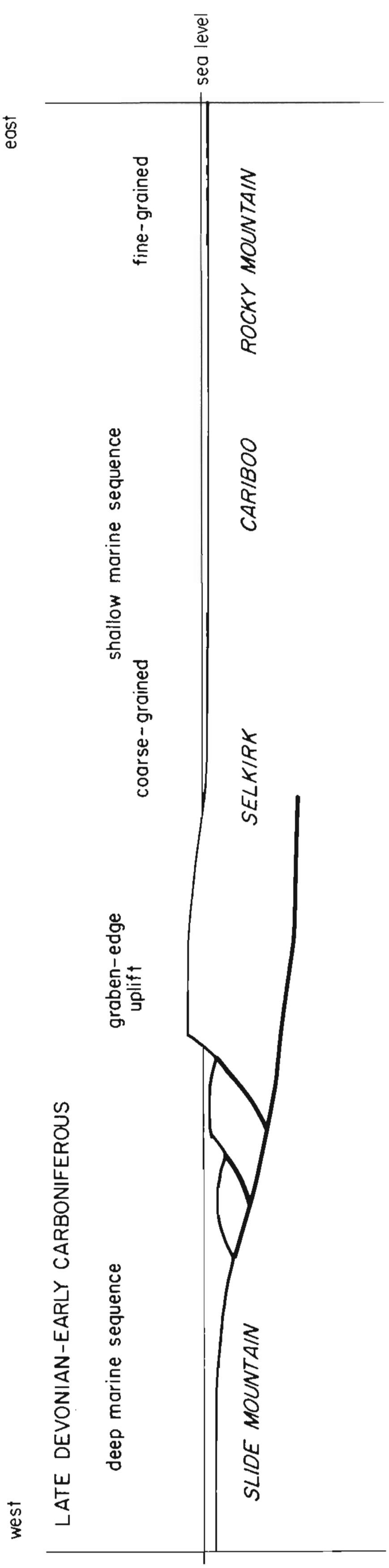

Figure 8. Possible topography of the area during the Late Devonian and Early Carboniferous. The configuration is stylized after a profile from southwest to northeast across the Gulf of Suez (Slide Mountain), Arabian Peninsula (western Selkirk) and Persian Gulf (eastern Selkirk and Cariboo and Rocky Mountain). Sediments eroded from the graben-edge uplift are transported west as coarse debris into the graben and east as progressively finer material into the shallow continental sea.

River (Pell, 1986b) and near Valemount (D. Murphy, personal communication, 1986), Devono-Mississippian carbonatite and tonalite may represent rift-related intrusives coincident in age with the Quesnel Lake Orthogneiss.

The **initial stretching sequence** may be represented by Upper Middle Devonian extrusives (Waverly Formation, Fig. 3), shales and minor limestone of Cariboo terrane (Struik, 1986). It is unknown in Selkirk terrane, possibly because the rocks are not well dated. In Rocky Mountain terrane, the time of initial stretching may be represented by the sub-Frasnian unconformity (Geldsetzer, 1982).

The **graben-edge uplift sequence** consists of the Upper Devonian and Lower Carboniferous clastics of the five terranes. In central Rocky Mountain terrane, Lower Carboniferous black shales of the Exshaw Formation unconformably overlie an eroded sequence of Upper Devonian shallow-water carbonates (Geldsetzer, 1982). The fine-grained clastics are presumably the eastern equivalents of the uppermost coarser clastics of Cariboo terrane (Guyet Formation) and indicate highlands to the west, possibly in the western region of Selkirk terrane. The highland should be within the Selkirk and possibly Cariboo terranes, because to the west, Slide Mountain Basin had formed a deep depression and would not have been a clastic source. The shape of the highland may have been like the Arabian Peninsula east of the Red Sea Rift where the uplift has an abrupt high scarp along the graben edge and gradually decreases in elevation to the east toward the Persian Gulf. Applying the geometry to the latest Devonian Cordillera, the highest elevations of the graben edge were along the west coast of Selkirk terrane overlooking the Slide Mountain basin. Rivers draining to the east from the highlands deposited sediment into a Persian Gulf-like sea covering eastern Selkirk, Cariboo and Rocky Mountain terranes (Fig. 8).

The continuity of the Devono-Mississippian clastic sequence through Cariboo and Rocky Mountain and possibly Selkirk terranes suggests that the McBride arch at that time was depressed and did not promote the independent development of facies. The faunal distinction in the Early Carboniferous between the age equivalent Greenberry Formation limestone of Cariboo terrane and Rundle Group limestone of the Rocky Mountain terrane (Orchard and Struik, 1985) may be one of environment or latitude.

Clastics rocks from the western Selkirk terrane scarp deposited into Slide Mountain Basin may be preserved as part of the lower Fennel Formation of the Slide Mountain Group in southern British Columbia (Schiarizza and Preto, 1984). In Quesnel terrane, the Upper Devonian and Early Carboniferous sediments (Harper Ranch Group) (M. Orchard, personal communication, 1986) may form a platform for the Triassic Quesnel Basin in central British Columbia. The platform was bound to the east by Slide Mountain Basin and to the west by a graben and the Siberian platform (where Siberian platform is used loosely to be the continental mass that eventually rifted away from North America). The graben, during the Late Devonian and Early Carboniferous, was underlain by either continental material or young spreading ridge, similar to the Red Sea today; this was the incipient Cache Creek ocean. The Harper Ranch platform was isolated and emergent and its sediments were derived from the platform itself. Upper Devonian sediments of the platform contain a shallow water fauna and transported plant material (M. Orchard, personal communication, 1986). The Harper Ranch platform (ribbon continent) may have been supported by the hot material rising on its flanks into the Cache Creek and Slide Mountain rifts (graben-edge uplift on both sides of the platform).

The **thermal subsidence sequence** may have begun in the Early Carboniferous. Stretching presumably stopped when the Cache Creek oceanic crust began to grow from a spreading ridge. The oldest Cache Creek Group in southern British Columbia is dated from exotic blocks as Upper Carboniferous (Orchard, 1984). In northern British Columbia the oldest Cache Creek Group is Lower Carboniferous (Monger, 1977). Because the oldest parts of the Cache Creek oceanic crust were probably lost by Triassic subduction, the maximum age of the oceanic crust is unknown. Ocean spreading may have started before the Early Carboniferous; if it did, the graben-edge uplift sequence was deposited coincident with the thermal subsidence sequence as described here.

The uplift generated by the stretching continued to shed clastics during the Late Devonian and Early Carboniferous. During the Late Tournaisian and Early Visean, limestone units of Cariboo and Rocky Mountain terranes signal a decline in the influx of clastics, presumably a result of erosional decline of former uplifts.

In Rocky Mountain, Cariboo and Slide Mountain terranes, the latest Carboniferous is missing beneath a Lower Permian erosional unconformity (McGugan et al., 1968; Bamber and MacQueen, 1979; Orchard and Struik, 1985; Struik and Orchard, 1985), suggesting regional pre-Permian shallow uplift. Within Rocky Mountain terrane a Lower Permian diatreme breccia pipe (Grieve, 1985; Pell, 1986c) was intruded during this uplift. The upper Paleozoic in general consists of thin deposits separated by many hiatuses and disconformities, possibly the result of thermal equilibrium following passive subsidence occasionally interrupted by relatively minor plate adjustments.

MESOZOIC SUBDUCTION AND COLLISION

The Triassic successions are thickest in the Quesnel and Rocky Mountain terranes. The most complete record is in the Rocky Mountain terrane where siliciclastic and carbonate deposits span the Triassic age range (Gibson, 1974). To the west, and during the Early and Middle Triassic, the subsidence recorded by the Rocky Mountain terrane sediments is replaced by possible uplift (shallow highland) within Cariboo and perhaps Selkirk terranes. During Middle and Late Triassic, and Early Jurassic, basalts of Quesnel terrane were generated by subduction (Monger, 1984) of the upper Paleozoic Cache Creek terrane seafloor beneath fragments of rifted North American craton outboard of the Slide Mountain Basin.

The subduction of Cache Creek terrane suggests new relative motion between the Cache Creek and North American plates. Instead of approximately coincident motion of the two during the Permian and Upper Carboniferous (resulting in passive subsidence) they began to converge. Convergence of plates generally results in compressive tectonics. The formation of a back-arc basin is the exception to this. No Triassic back-arc basin appears to have formed in eastern British Columbia. With no extension, the Triassic sequences in Cariboo and Rocky Mountain terranes must have been deposited in a basin created by compression. The collapse of the western margin of North America began when a sialic crust riding with the Cache Creek terrane collided into the Triassic Quesnel arc and its sedimentary and crystalline basement.

CONCLUSIONS

The Precambrian to Tertiary geological history of east-central British Columbia consists of extension of the North American craton during the late Proterozoic, lowest Cambrian, Ordovician(?) and Devonian, subduction of an upper Paleozoic oceanic crust during the Triassic and a collision of cratonal masses during the Jurassic to early Tertiary. The intermittent extensions of the craton produced basins separated by horsts of unextended or only partly extended craton. The horst-bounded basins are represented by three stratigraphically distinct sediment-dominated terranes and a basalt— and chert-dominated terrane. The stretching of the cratonic margin culminated in successful rifting away of the ?Siberian platform and related fragments during the Devonian. Rifting produced the Cache Creek oceanic terrane and the inboard Slide Mountain terrane. Quesnel terrane consists of Paleozoic ?rift-generated sediments deposited onto a cratonal fragment overlain by a Triassic subduction-generated volcanic edifice. During the Triassic the "Cache Creek ocean" closed by subduction beneath the rifted fragments of the North American margin. The subsequent transpression of the extended and sediment-filled margin and its associated island arc (Quesnellia) was driven by the Jurassic collision of Stikine terrane carried on the Cache Creek plate. The collision resulted in the shortening of the Triassic margin by independent and decoupled deformation of the upper mantle; Precambrian cratonic crust; Precambrian, Paleozoic and Triassic sedimentary cover; and the volcanic terranes of Slide Mountain and Quesnel.

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