An overview of the Geology of the Rocky Mountains between the Athabasca and North Saskatchewan Rivers

PREPARED FOR

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by

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INTRODUCTION

The purpose of the field trip is to examine the major structural and stratigraphic features of the Foothills and Front Ranges of the Canadian Rocky Mountains along the Athabasca and North Saskatchewan Rivers, and of the eastern Main Ranges between these rivers. This guidebook does not attempt to present a systematic account of the geology of the Rockies between the Athabasca and North Saskatchewan Rivers. It focuses instead on those aspects of the geology to be examined at the various stops. For an account of the history of Jasper and of the first geological studies, see Hargreaves (1955). The first day's route follows Highway 16 west to Yellowhead Pass During the second day, the route follows Highways 93 from Jasper to Saskatchewan Crossing, 11 from Saskatchewan Crossing to Red Deer, and 2 from Red Deer to Edmonton.

INTERIOR PLATFORM

From Edmonton to Hinton and from east of Rocky Mountain House to Edmonton, the route is in the Interior Platform. The topographic surface along the route rises from Edmonton to Obed, just east of Hinton, which is higher than Yellowhead Pass. Surficial deposits include the preglacial Saskatchewan gravels, glacial till (Laurentide in the northeast, Cordilleran in the southwest), fluvio-lacustrine silts and clays and postglacial aeolian sands. River diversion associated with these deposits is a common phenomenon: the North Saskatchewan at Edmonton, the Pembina 97 km west of Edmonton and the Athabasca at Hinton all flow in narrow valleys eroded in the last 12000 years.

The Paleozoic carbonates and shales and Mesozoic clastics of the Interior Platform dip gently southwest. Bedrock along the route varies from Upper Cretaceous in the northeast to Paleocene in the west. Sub-bituminous coal is abundant near the top of the Cretaceous and is strip-mined near Lake Wabamun (60 km west of Edmonton). Petroleum and natural gas fields crossed by the route include (1) the Acheson oilfield 10 km west of Edmonton (Devonian reef), and (2) the Edson gasfield 204 km west of Edmonton (Mississippian pinch out beneath the sub-Cretaceous unconformity). The Precambrian crystalline basement underlying the sedimentary succession is an extension of the Churchill Province of the Canadian Shield.

THE ROCKY MOUNTAINS

The Rocky Mountain stratigraphic succession is a thicker and more complete equivalent of that in the Interior Platform. Between Highways 11 and 16 it is divisible into miogeoclinal and clastic-wedge sequences of Hadrynian to Middle Jurassic and Late Jurassic to Paleocene age, respectively. These sequences differ from those west of Calgary: for example, the Fairholme Group is generally shalier, the Rundle and Rocky Mountain Groups are thinner and more condensed, the Spray River Group is thicker and contains evaporites, the coal measures of the upper Kootenay Group are replaced by the marine to continental shales and sandstones of the Nikanassin Formation, and strata equivalent to the lower Blairmore Group lie in the coal-bearing Luscar Group. The Precambrian basement may continue uninterruptedly from the Interior Platform to the Rocky Mountain trench: at Jasper and Saskatchewan Crossing it is at about 6 km below sea-level. During orogenesis, the strata were detached from this basement, displaced to the northeast, shortened and thickened. Most of the displacement, shortening and thickening occurred by means of movement along NE-verging thrusts.

The Rocky Mountains along Highways 11 and 16 are divisible mainly on the basis of age of exposed strata into Foothills, Front Ranges and Main Ranges. These divisions are, however, also structurally and physiographically distinct because structure is dependent on stratigraphy, and topography is both stratigraphically and structurally controlled. The Foothills expose Devonian to Paleocene strata belonging to the miogeoclinal and clastic wedge sequences. The Front Ranges expose a thicker and more complete miogeoclinal succession but , except for the easternmost thrust-sheets, lack clastic-wedge strata. The Main Ranges expose mainly Hadrynian and a still thicker and more complete Cambrian to Mississippian succession. The traces of major thrusts form the boundaries between the three divisions. These thrusts, like all others in the Rockies, die out along strike so on a regional scale the boundaries between the Foothills, Front Ranges and Main Ranges are gradational. The three-fold division results mainly from a progressive change in the stratigraphic position of the basal detachment zone, from Devonian to Middle Cambrian to Hadrynian beneath the Foothills, Front Ranges and Main Ranges. Along Highways 11 and 16, these divisions differ from their counterparts west of Calgary. The Foothills in gerneral lack closely spaced imbricate thrust sheets, and buckle folds are more abundant in the Front Ranges. The Main Ranges along Highway 16 expose only Proterozoic strata at road level.

DAY 1

FOOTHILLS ALONG HIGHWAY 16

Between Hinton and Jasper, Highway 16 follows the Athabasca valley along which the Foothills are poorly exposed (Irish, 1944, 1965; Lang, 1947). Prominent are strata belonging to the Upper Cretaceous to Paleocene Saunders Group which consists of up to 3,600 m of molasse . It is divisible into six cyclothems (Jerzykiewicz, 1985; Jerzykiewicz & Sweet, 1986; Mack & Jerzykiewicz, 1989). Each cyclothem consists of a lower sequence of stacked channel sandstones and an upper sequence of mudstones with coal seams. Seams at the top of the fifth cyclothem were mined at Hinton and are still mined at Coal Valley, 60 km to the southeast. The Entrance Conglomerate lies at the base of the fifth cyclothem. It will be examined at **STOP 1,** 1 km south of Highway 16 on Highway 40. The cyclothems in the Saunders Group may be similar to those in Foreland Thrust-and-Fold Belts such as the southern Pyrenees (Puigdefabregas et al., 1986), and be related either to movement along individual NE-verging thrusts in the Front and Main Ranges or to major cycles in the evolution of the triangle zone (Charlesworth et al., 1987).

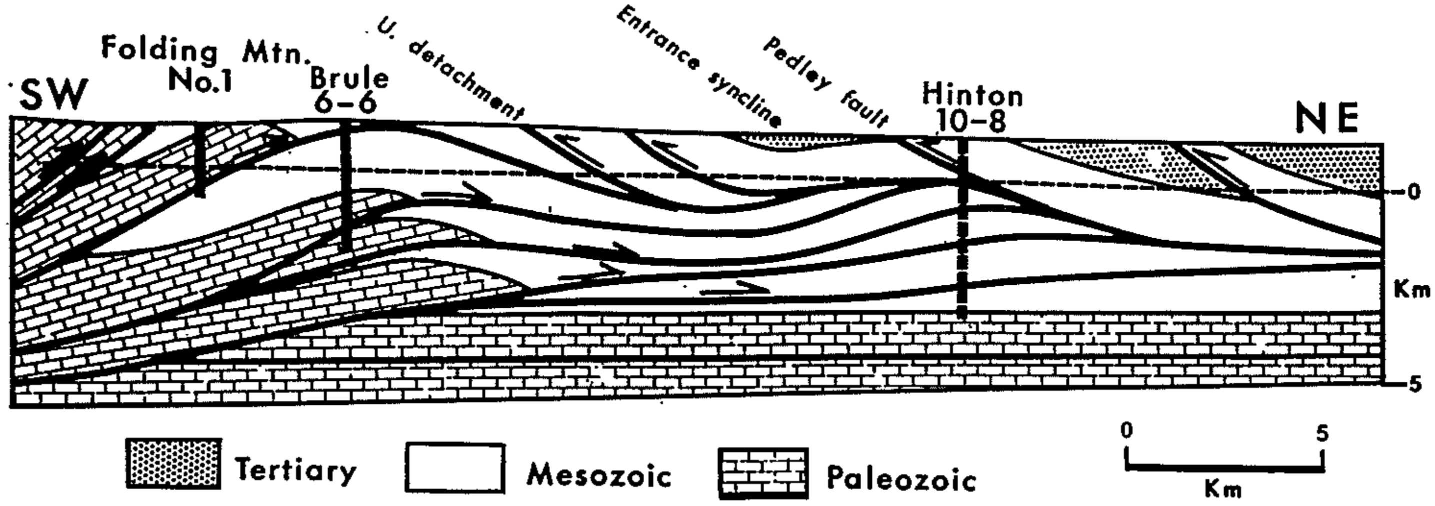

Fig. 1. Cross-section of the Foothills near Highway 16 (from Jones, 1982). The Paleozoics cropping out southwest of the Folding Mountain anticline belong to the Boule thrust-sheet.

PERIOD OR EPOCH	GROUP OR FORMATION		THICKNESS (m)
Lower Cretaceous	Luscar Group	Sandstone, fine grained; greenish grey siltstone:; shale; coal.; Cadomin Conglomerate at base.	600 ±
	Disconformity		
Lower Cretaceous and Jurassic	Nikanassin Fm	Sandstone; siltstone; silty mudstone dark grey.	300 to 600
Jurassic	Fernie Group	Shale, black and dark grey, concretionmary	200 to 300
	Disconformity		
Triassic	Whitehorse Fm	Carbonate, breccia, red mudstone, gypsum.	30 to 450
	Sulphur Mountain Fm.	Siltstone; thinbedded silty mudstone	200 to 300
	Disconformity?		
Permian and/or Pennsylvanian	Rocky Mountain Formation	Massive grey chert; cherty brown sandstone	0 to 70
	Disconformity		
Mississippian	Mt. Head Fm	Dolomite, dense, cherty, medium bedded.	80 to 120
	Turner Valley Fm	Dolmite, brown, porous, caarse grained.	50 to 120
	Shunda Fm	Limestone, dark grey, fine grained, thin bedded.	60 to 110
	Pekisko Fm	Limestone, light grey, crinoidal,coarse grained	35 to 90
	Banff Formation	Linestone and calcareous shale, dark brown, thin bedded.	150 to 230
	Disconformity		
Devonian	Palliser Formation	Limestone, dark grey, massive, fine crystalline, dolomitic.	200 to 275
	Sassenach Formation	Sandstone, fine grained; siltstone, silty shale, silty carbonates.	30 to 200
	Mount Hawk Formation	Limestone, brown grey, argillaceous; and brown calcareous shale.	75 to 90
	Perdrix Fm	Shale, black fissile, thin limestone interbeds	60 to 100
	Maligne & Flume Fms	Limestone, dark grey, thin-bedded,argillaceous, limestone, brown, cherty, with stromatoporoids.	50 to 75
	Sub Devonian Unconformity		
Lower Ordovician	Survey Peak Formation	Limestone; calcareous shale; greenish-grey intraformational conglomerate.	0 to 500
Upper Cambrian	Lynx Formation	Carbonates, silty, thin-bedded, argillaceous; intraformational conglomerate.	300 to 730
Middle Cambrian	Arctomys Fm	Shale, silty, red and green; siltstone, brown.	200 to 250
	Pika Fm	Limestone, calcareous; shale, thin-bedded.	150 to 200
	Titkana Fm	Limestone, dark grey, massive dolomitic.	150 to 250
	Shale Unit	Shale, green and red; argillaceous limestone. Limestone, dark grey, resistant.	430 to 550
Lower Cambrian	Gog Fm	Sandstone, light grey; quartz, cross-bedded, fine to coarse grained, massive.	1200 to 1800
	Disconformity		
Proterozoic Hadrynian	Miette Group	Shale & phyllite, grey; sandstone, conglomeratic poorly sorted; carbonate, arenaceous, algal markings	1750 ±

Fig. 2. Stratigraphic column for the Front and Main Ranges along Highway 16 (E.W. Mountjoy, in Campbell et al., 1976).

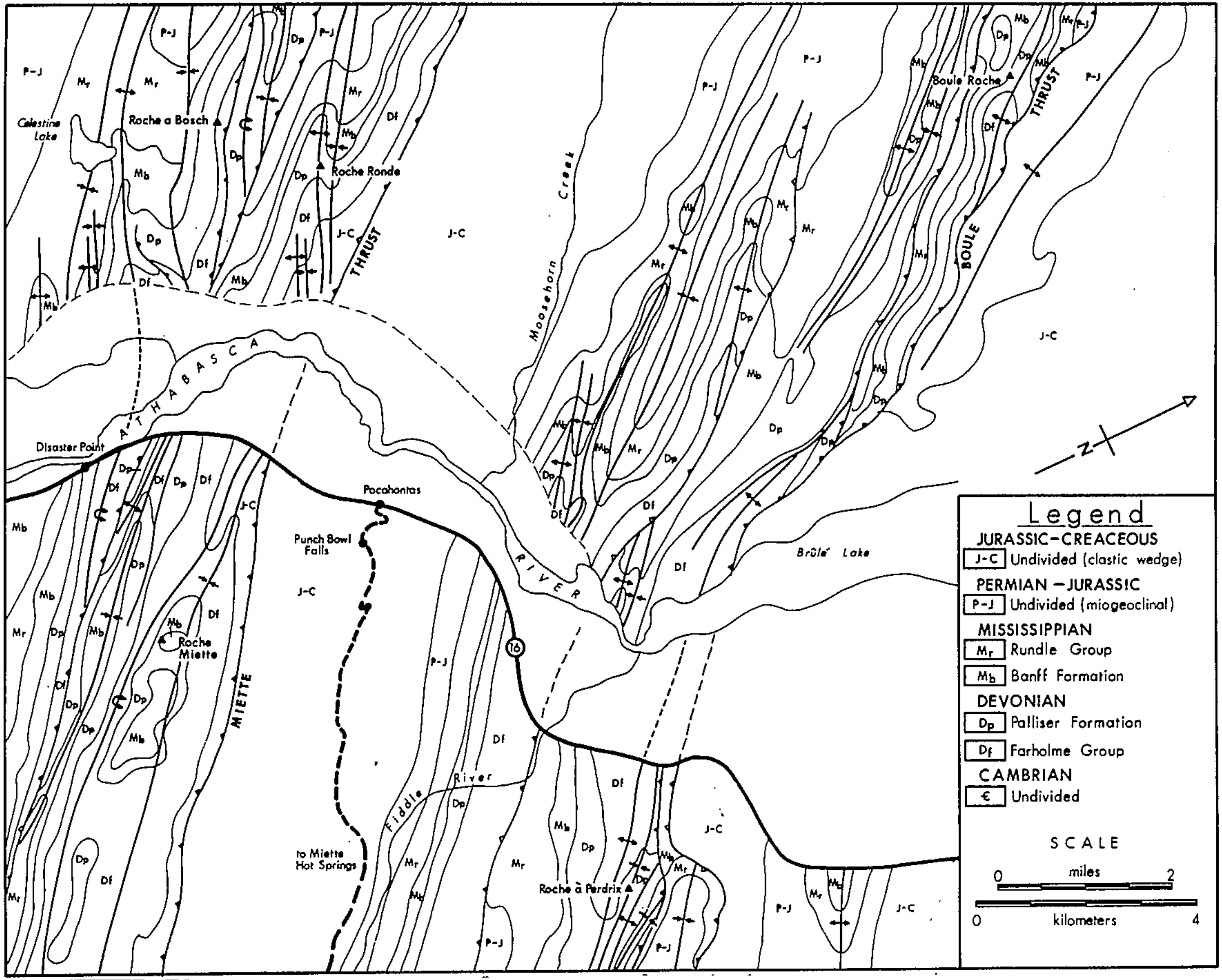

Fig. 3. Geological map of the Boule thrust-sheet and adjacent areas near Highway 16 (after Mountjoy, 1960, 1961; O'Brien, 1960).

Coal also occurs in the Lower Cretaceous Luscar Group (Langenberg & McMechan, 1985). It used to be mined at Brule, on the northwest side of the Athabasca River valley, and there has been some recent exploration near Folding Mountain on the southeast side of the river.

Northeast-verging blind thrusts ending at depth against SW-verging thrusts characterize the structure of the Foothills (Fig. 1). Folding Mountain exposes Mississippian strata in an anticline above the highest of the NE-verging thrusts. Northeast-dipping Paleocene strata in the southwest limbs of the Alberta and Entrance synclines are apparently related to movement along SW-verging thrusts.

FRONT RANGES ALONG HIGHWAY 16

The Front Ranges along Highway 16 consist of five thrust thrust-sheets. From northeast to southwest, these units, the Boule, Miette, Greenock, Colin and Chetamon thrust-sheets, expose a progressively thicker and more complete Cambrian to Jurassic miogeoclinal succession (Fig. 2). Clastic-wedge strata are confined to the Boule thrust-sheet. Recognition of structure in the Paleozoics of the Front Ranges is facilitated by the Palliser - Banff - Rundle stratigraphic trinity. The Palliser Formation is cliff-forming and consists of white-weathering limestone, the Banff Formation is more argillaceous and recessive, and the Rundle Group is mainly carbonate and cliff-forming.

The Boule and Perdrix Ranges expose Upper Cambrian and younger miogeoclinal strata of the **Boule thrust-sheet** north and south of Highway 16, respectively (Fig. 3). The Paleozoics die out within 50 km of Highway 16, so the Boule thrust-sheet could be placed in the Foothills. Clastic-wedge strata belonging to the Boule thrust-sheet crop out in the valleys of Moosehorn Creek and the Fiddle River southwest of the Boule and Perdrix Ranges. Coal in the Luscar Group was mined from 1911 to 1921 at Pocahontas on the Grand Trunk Pacific Railway.

Folds and thrusts superimposed on the southwest dip of the Boule thrust-sheet are well displayed on Roche a Perdrix (Fig. 4), where the buckling of Fairholme strata in the core of a prominent anticline is characteristic of flexural-slip folds, and in the Boule Range (Figs. 5 & 6) which will be viewed from the bridge over the Fiddle River (STOP 2).

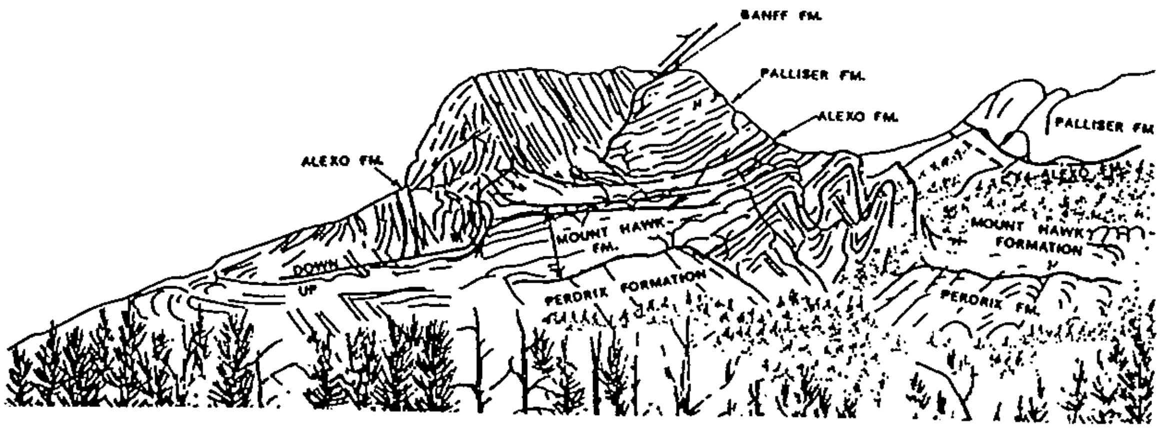

Fig. 4. Roche a Perdrix (R.A. Price with E. Hernando, in Price et. al, 1972).

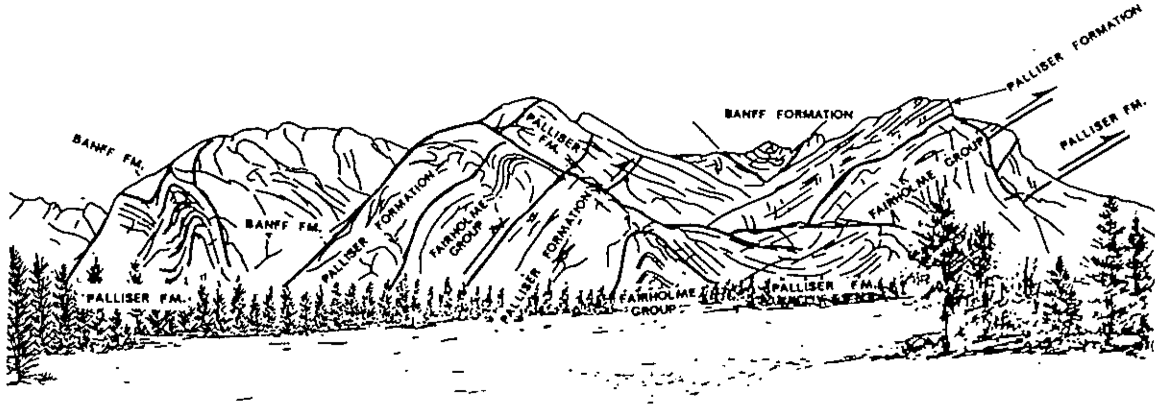

Fig. 5. Boule Range (R.A. Price with E. Hernando, in Price et al., 1972).

At **STOP 3,** Punchbowl Falls, just south of Pocahontas, Upper Jurassic sandstone, siltstone and coaly shale of the Nikanassin Formation are overlain by the 6m thick Cadomin Conglomerate.

Situated in the northeastern part of the **Miette thrust-sheet** and underlain by Paleozoics is the Miette Range and its continuation north of the Athabasca River, the Bosche Range (Fig. 3). The Miette thrust dies out some 40 km to the southeast and is replaced almost on strike by the McConnell thrust. At **STOP 4,** 1 km west of Pocahontas, disharmonically folded Middle Cambrian and Devonian strata can be seen on Roche Miette (Fig. 7) and Roche Ronde (Fig. 8). The conspicuous folds in Upper Paleozoic strata northwest of **STOP 5** at Disaster Point are essentially parallel in style (Figs. 3 & 9). Small-scale structures such as bedding-plane slickenside striae in the Palliser and pressure-solution cleavage in the Banff Formations are conspicuous in roadside outcrops. The poorly exposed southwestern part of the Miette thrust-sheet, extending along the valleys of the Rocky and Snake Indian Rivers, is underlain mainly by folded and faulted Upper Paleozoic to Jurassic miogeoclinal strata.

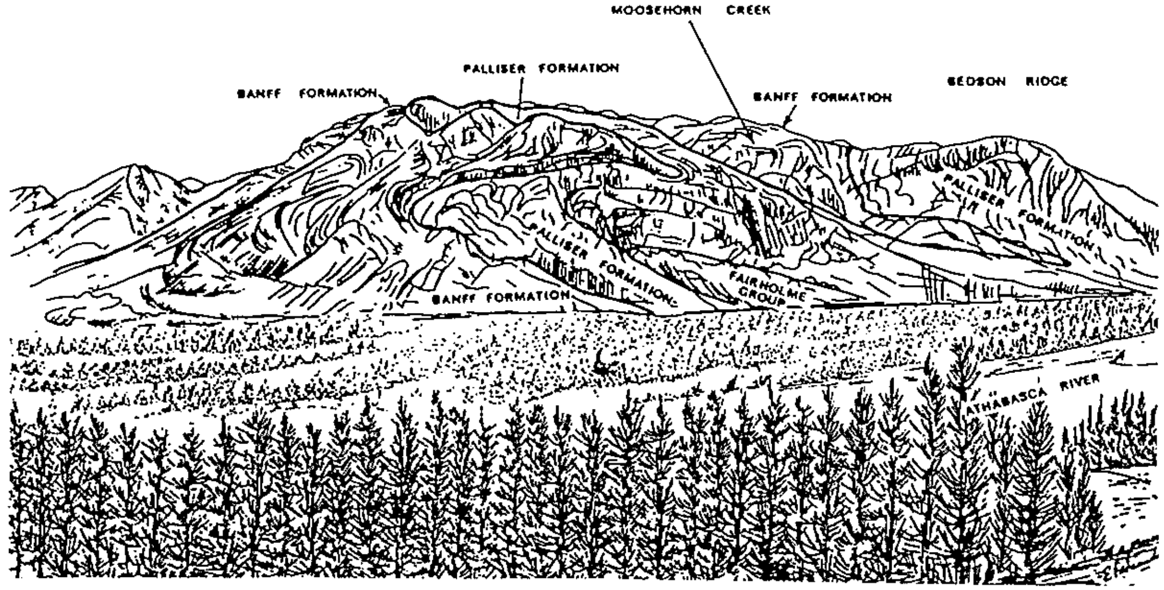

Fig. 6. Northwesterly plunging parallel folds in the Boule Range viewed from Pocahontas (R.A. Price with E. Hernando, in Price et al., 1972).

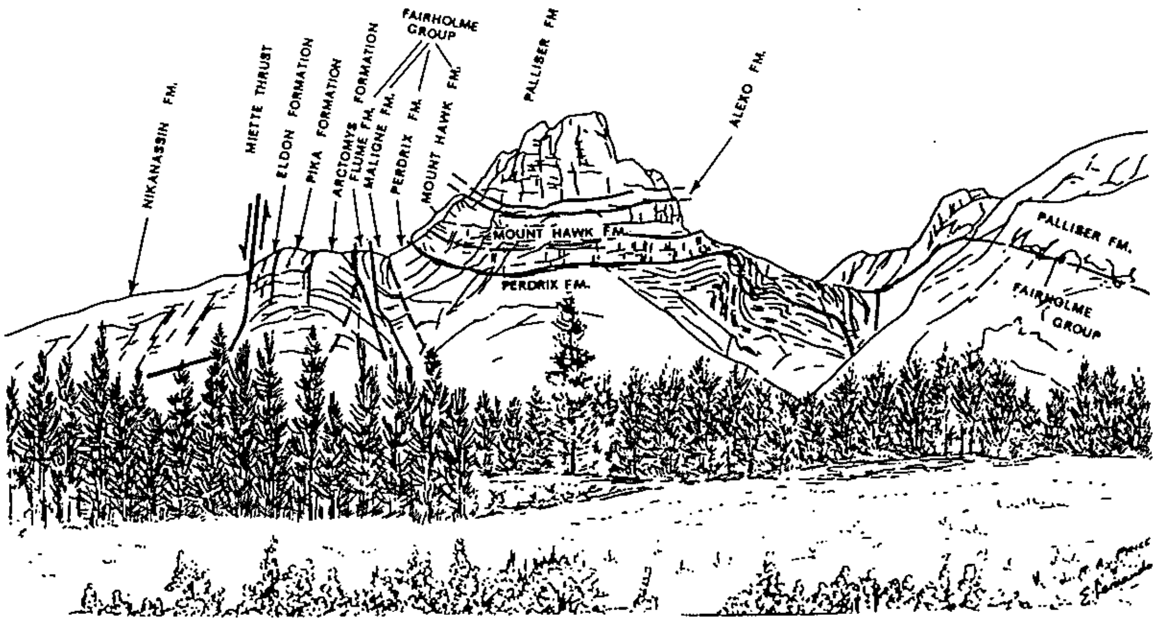

Fig. 7. Roche Miette (R.A. Price with E. Hernando, in Price et al., 1972).

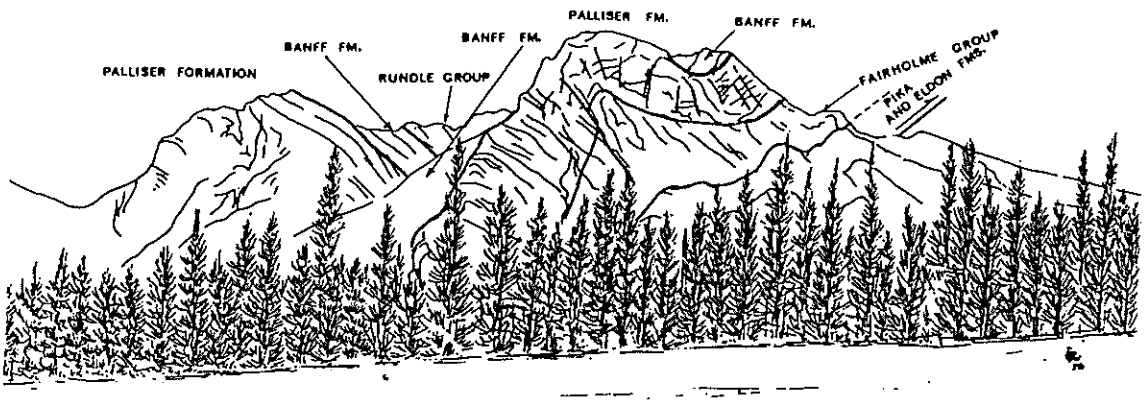

Fig. 8. Roche Ronde (R.A. Price with E. Hernando, in Price et al., 1972).

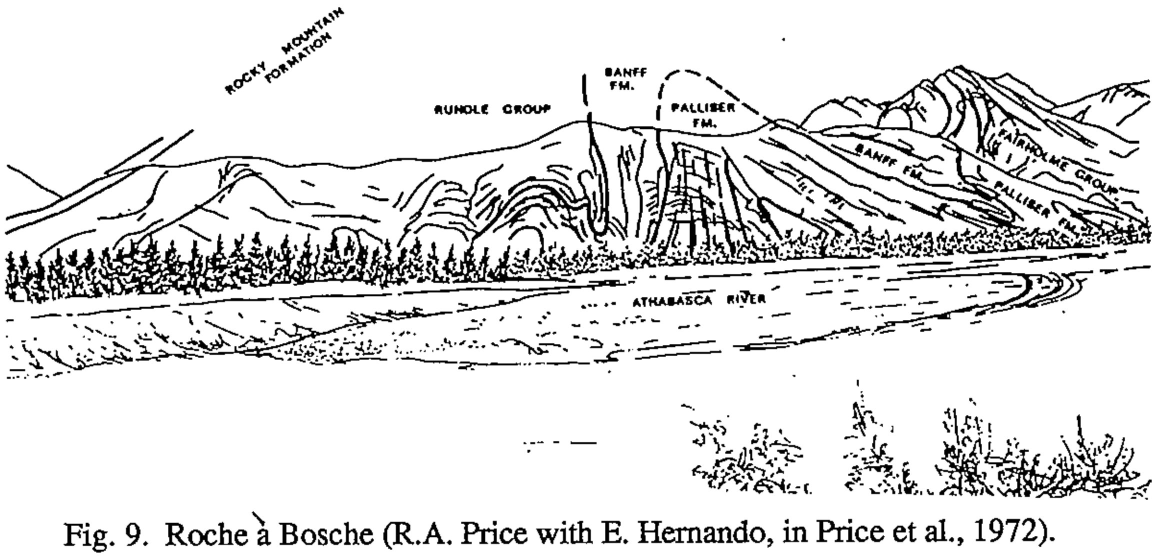

Fig. 9. Roche à Bosche (R.A. Price with E. Hernando, in Price et al., 1972).

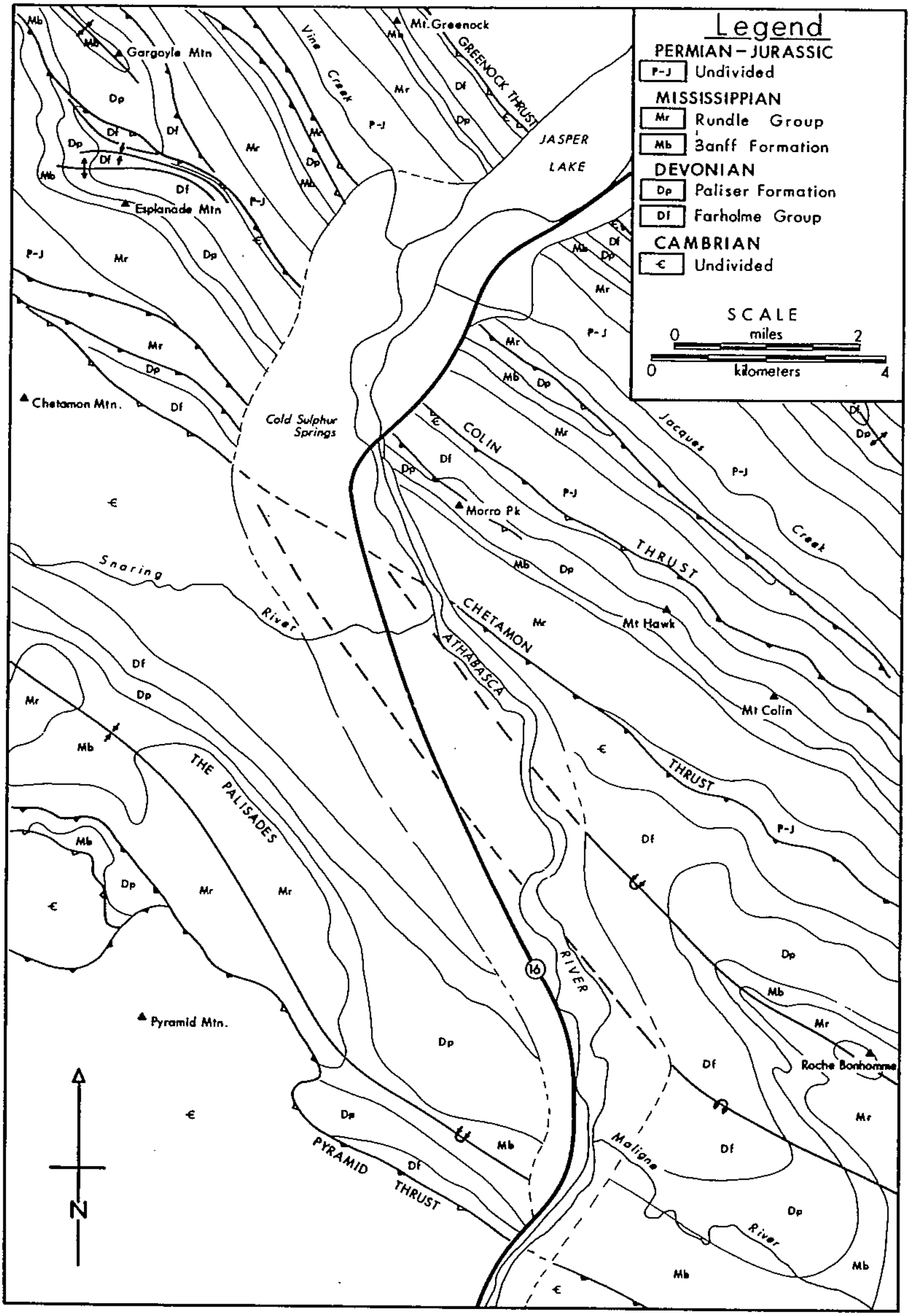

Fig. 10. Geological map of the Greenock, Colin and Chetamon thrust- sheets near Highway 16 (after Mountjoy, 1960; Mountjoy & Price, 1985).

The **Greenock thrust-sheet** is largely steeply dipping and homoclinal (Fig. 10). At **STOP 6,** 21 km west of Pocahontas, the top pf the Rundle Group is represented by (1) buff-weathering platy dolostones, (2) 3 m of dolostone with Tetracamera and ostracods, 3 m of grey dolostone with some dark chert and (4) 1 m of dolostone and sandstoine breccia. The Permian Rocky Mountain (Ishbel) Group rests unconformably on the Mississippian and comprises (5) 27 m of massive chert with subordinate sandstone. This unit is overlain by (6) 14 m of sandstone with subordinate chert of Permian and/or Triassic age and by (7) fine clastics of the Triassic Spray River Group (McGugan & Rapson, 1961, 1963).

The **Colin thrust-sheet** is homoclinal southeast of the Athabasca River. From **STOP 6,** a splay of the Colin thrust can be seen to daylight between Gargoyle and Esplanade Mountains. At **STOP 7,** Cold Sulphur Springs (Fig. 10), 22 km west of Pocahontas, strata belonging to the lower Fairholme Group are well exposed. The springs emerge near the top of stromatoporoidal carbonates of the Flume Formation which rest disconformably on Cambrian carbonates and are overlain by 100 m of poorly exposed shales and argillaceous limestones of the Perdrix Formation. Overlying the Perdrix are 60 m of Mount Hawk argillaceous limestones, nearly 100 m of silty and argillaceous limestones of the Sassenach (Alexo) Formation, and 250 m of micritic Palliser limestones.

The **Chetamon thrust-sheet** exposes some 3,500 m of miogeoclinal strata ranging in age from Cambrian to Triassic (Fig. 10). Beneath the Fairholme Group are about 2000 m of Lower Paleozoic strata that include some Lower Cambrian Gog quartzites. West of the Athabasca River, strata in the thrust sheet lie in an overturned syncline whose northwest limb crops out on Chetamon Mountain (Gog to Lynx, Fig. 11) and in the Palisades (Lynx to Banff). East of the river, Upper Cambrian strata some 1500 m stratigraphically above the Lower Cambrian directly overlie the Chetamon thrust and the thrust-sheet is affected by an anticline - syncline pair: the syncline is well displayed on Roche Bonhomme (Fig. 12). These folds may be fault-bend folds related to a hangingwall frontal ramp connecting hangingwall flats in the Lower and Upper Cambrian, and may have become tighter and overturned due to later buckling. These relationships can be seen from **STOP 8,** the bridge over the Snaring River.

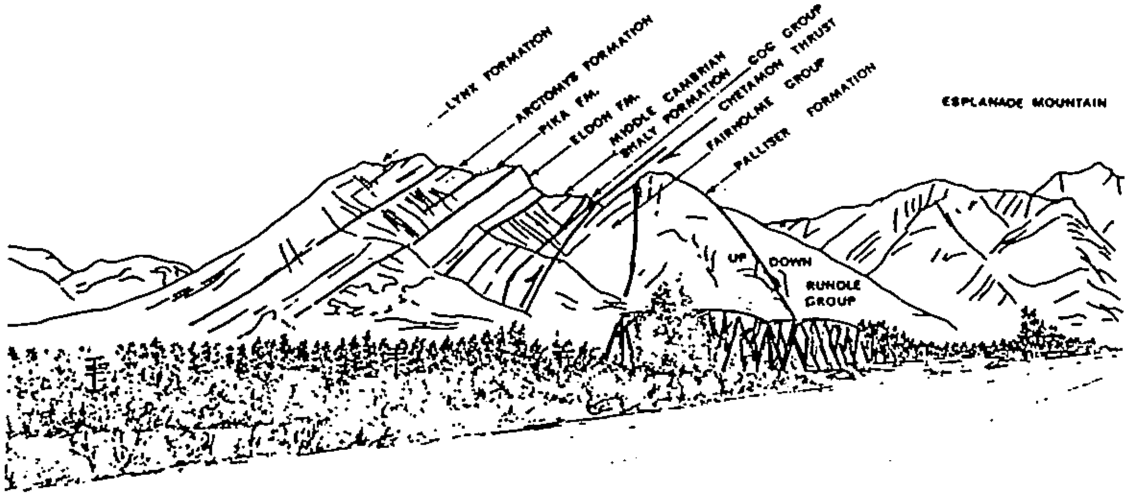

Fig. 11. Chetamon Mountain (R.A. Price with E. Hernando, in Price et al., 1972).

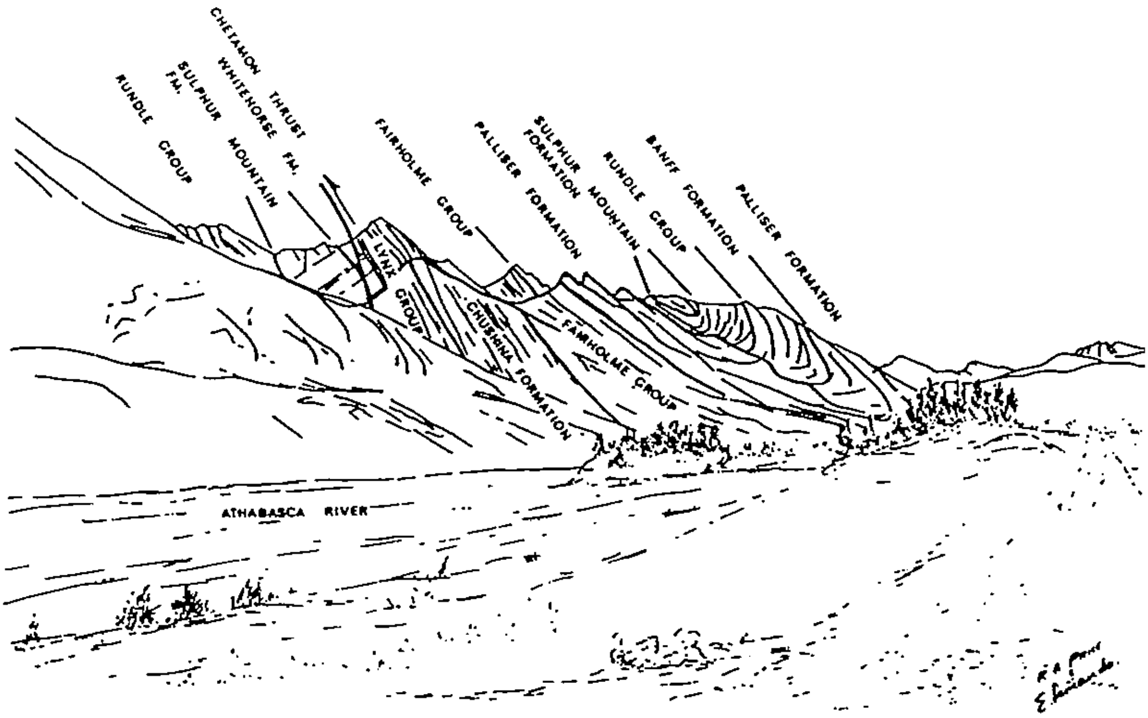

Fig. 12. Roche Bonhomme (R.A. Price with E. Hernando, in Price et al., 1972).

EASTERN MAIN RANGES ALONG HIGHWAY 16

The boundary between the Front and Main Ranges along Highway 16 is the Pyramid thrust which superimposes clean, crossbedded sandstones mapped as Miette by Mountjoy & Price (1985) on overturned (?) shales of the Perdrix (?) Formation. To the northwest, the Pyramid thrust dies out and is replaced by the Snaring thrust as the boundary fault.

Jasper and Yellowhead Pass are in the largest structural culmination to affect the Main Ranges in the southern Rocky Mountains (Fig. 13). For this reason, although quartzites of the cliff-forming Gog Group and overlying Lower Paleozoic carbonates and shales are visible from Highway 16, all outcrops at road level between Jasper and the Rocky Mountain trench belong to the underlying recessive Miette Group of late Proterozoic (Hadrynian) age. The structural trend changes from WNW-ESE in the culmination to NW-SE on either side.

The Miette Group is divisible into three parts of which the middle and upper crop out between Jasper and Yellowhead Pass. The upper Miette Group, over 600 m thick, consists mainly of turbidites represented by slates and siltstones, and was placed in the upper member of the Wynd Formation by Charlesworth et al. (1967). The contact between the Miette and Gog Groups is sharp and known locally to be disconformable (Teitz & Mountjoy, 1985). This unconformity may be associated with a rifting event at the end of the Hadrynian identified by Bond & Kominz (1984). Some red beds at the top of the Miette Group may be related to this event.

The middle Miette Group is apparently divisible into three major units, two grits and a slate. From bottom to top, these units were originally named the Meadow Creek Formation, Old Fort Point Formation, and the lower member of the Wynd Formation (Charlesworth et al., 1967).

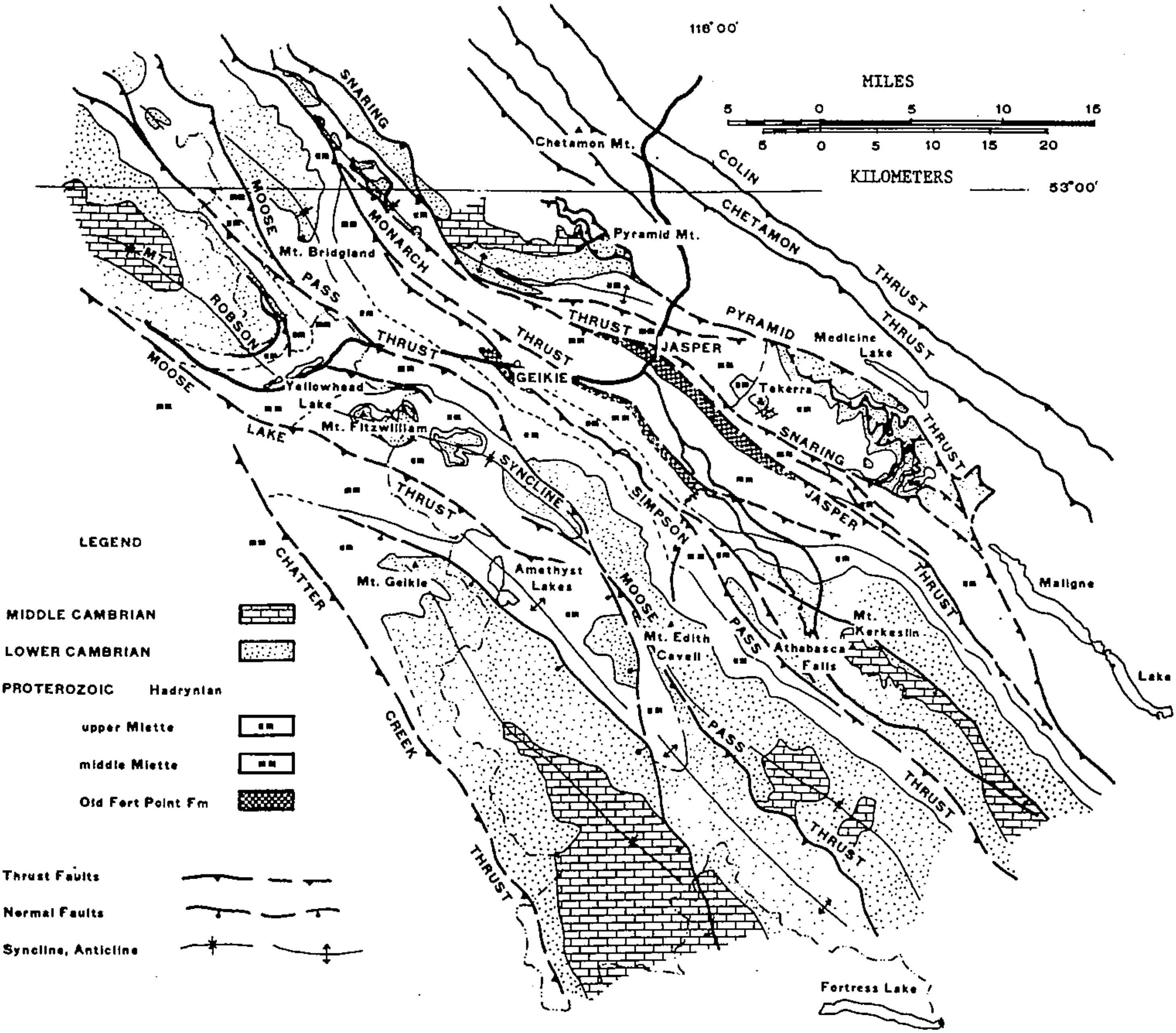

Fig. 13. Geology of the Jasper area (E.W. Mountjoy, in Campbell et al., 1976).

The 300 m thick Old Fort Point Formation is made up mainly of fine-grained varicoloured terrigenous and calcareous turbidites and slates and, particularly in the east, breccias representing submarine debris flows (Dechesne, 1989). Within this formation are some purple siltstones overlain by rhythmic limestones and varicoloured slates which are in turn overlain by black slate with dark limestone and sandy limestone breccia. These beds correlate with a triad of distinctive lithologies, namely chloritic siltstone, rhythmic marble-siltstone and carbonaceous-sulphidic pelite, that has been traced over 35000 sq.km (uncorrected for postdepositional shortening) on both sides of the Rocky Mountains trench, and that may represent a eustatic rise in sea-level (Ross & Murphy, 1988).

The upper grit of the middle Miette Group comprises 750 m of interbedded sandy and slaty units, up to 100 m thick, representing proximal and distal turbidites. The former consist largely of feldspathic sandstones with graded bedding, local crossbedding and, mainly at the bottoms of graded beds, rip-up clasts; the greenish colour of the sandstones is due to chlorite which with muscovite has replaced the original argillaceous matrix. The slaty units are mainly slates displaying graded bedding, micro-crossbedding and related features. The lower grit of the middle Miette Group crops out only rarely (Dechesne & Mountjoy, 1988).

From the structural standpoint, Paleozoic strata in the Main Ranges are characterized by widely spaced thrusts, normal faults and gentle folds (Fig. 13). Within the Yellowhead culmination the Miette Group has been deformed on a much smaller scale to produce closely spaced buckle folds with axial-plane slaty cleavage (Figs. 14 & 15); thrusts and normal faults are also present (Fig. 16). Two main deformational phases have been recognized in the Main Ranges near Jasper by Dechesne & Mountjoy (1988). The first, which produced large gentle folds in Lower Paleozoic strata, small tight folds with axial-plane cleavage in the Miette Group, and low-angle thrust-faults, occurred during the peak of metamorphism (quartz-albite-chlorite-muscovite subfacies of the greenschist facies). The second phase was associated with post peak-metamorphism upright folds and steep thrusts.

The relative importance of folding and thrusting in Miette strata is unclear. Between Jasper and Yellowhead Lake, just west of Yellowhead Pass, Charlesworth et al. (1967) identified only minor faults in Miette strata and found the Old Fort Point Formation in four inliers whose northeastern boundaries are in wide panels of strata dipping either steeply northeast or southwest overturned. The failure of such major structures as the Simpson Pass, Monarch and Moose Pass thrusts to cut strata at road level between Jasper and Yellowhead lake was assumed to result from their being splays of a detachment zone in upper Miette strata separating gently folded Lower Paleozoics from tightly folded middle Miette and older strata (H.A.K. Charlesworth in Price et al., 1972). Price & Mountjoy (1970), E.W. Mountjoy in Campbell et al. (1976), Mountjoy & Price (1985) and Dechesne & Mountjoy (1988), however, have traced major faults from the Gog Group, where they are responsible for most of its shortening, into the middle Miette Group where folding is responsible for at least 50% shortening. This author finds it difficult to envisage how major thrusts belonging to the first deformational phase can propagate through strata experiencing ductile deformation leading to folds with amplitudes of at 1 km, why the stratigraphic throw of these thrusts in the middle Miette is so small, and why thrusts cutting Gog and younger strata do not enter a zone of detachment in the upper Miette Group.

At **STOP 9,** Old Fort Point, the stratigraphy and structural style of the Old Fort Point Formation in the Jasper inlier as well as the geological setting of Jasper Town can examined (Figs. 13 & 14). To the northeast is Roche Bonhomme in the Chetamon thrust sheet of the Front Ranges. The trace of the Pyramid thrust crosses Highway 16 just north of Jasper. To the north, Pyramid and Cairngorm Mountains expose NE-dipping Gog and Upper Miette strata. The shale break half way up Pyramid Mountain contains the trace of the Snaring thrust so the upper part of the mountain is a klippe bound by the Snaring and Pyramid thrusts (Fig. 16). To the west, Whistler's Mountain is underlain by middle and upper Miette Group strata. To the south Mount Edith Cavell displays upper Miette and Gog strata in the northeast limb of the Mount Robson syncline, and Mount Kerkeslin exposes Lower and Middle Cambrian strata in a gentle syncline in the footwall of the Simpson Pass thrust. To the southeast,Tekarra Mountain exposes the contact between the Miette and Gog Groups. The trace of the Jasper thrust, with a minimum displacement of 5 km, runs just southwest of Old Fort Point (Mountjoy & Price, 1985) where both footwall and hangingwall strata are close to the base of the Old Fort Point Formation.

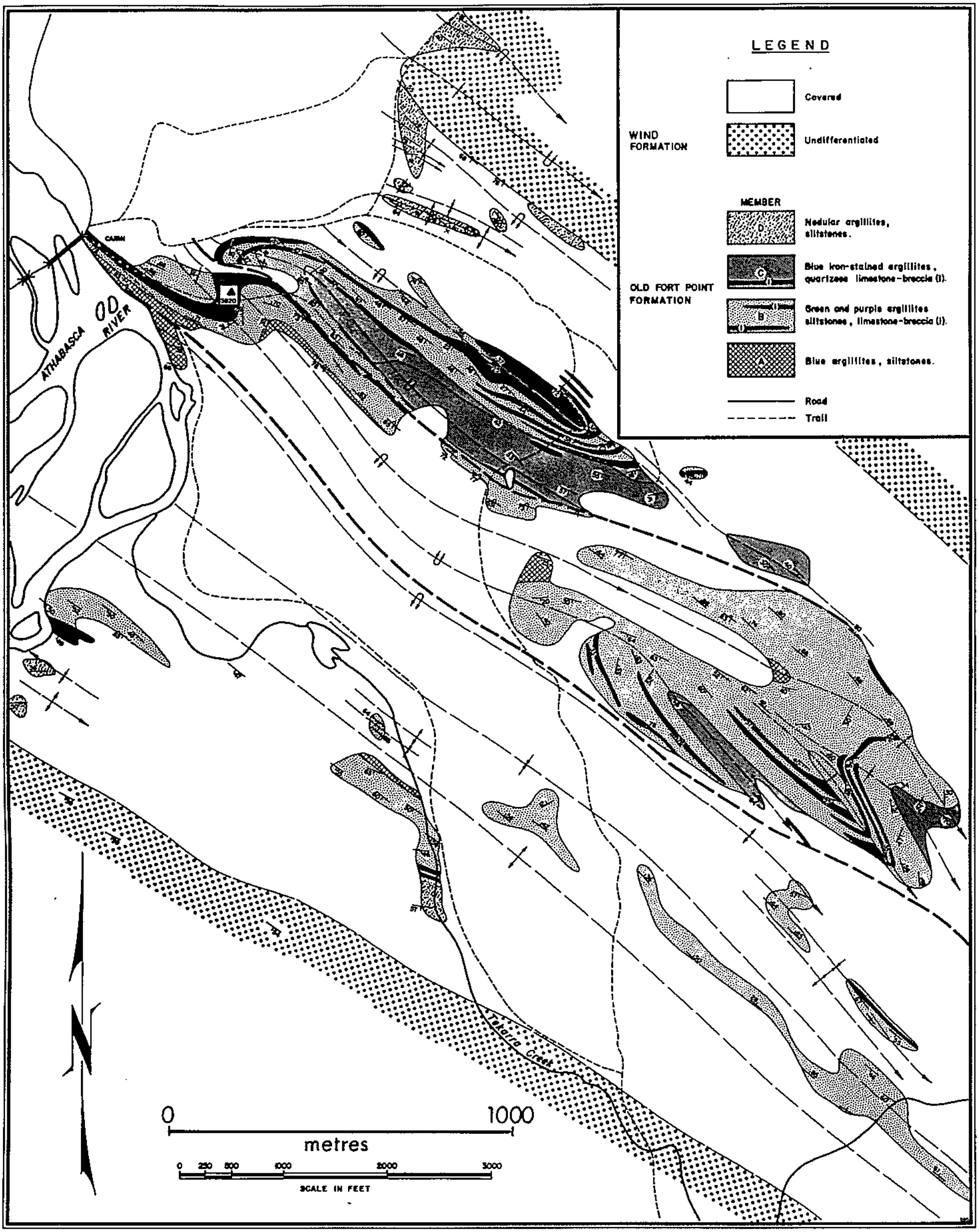

Fig. 14. Geological map of Old Fort Point (Charlesworth et al., 1967).

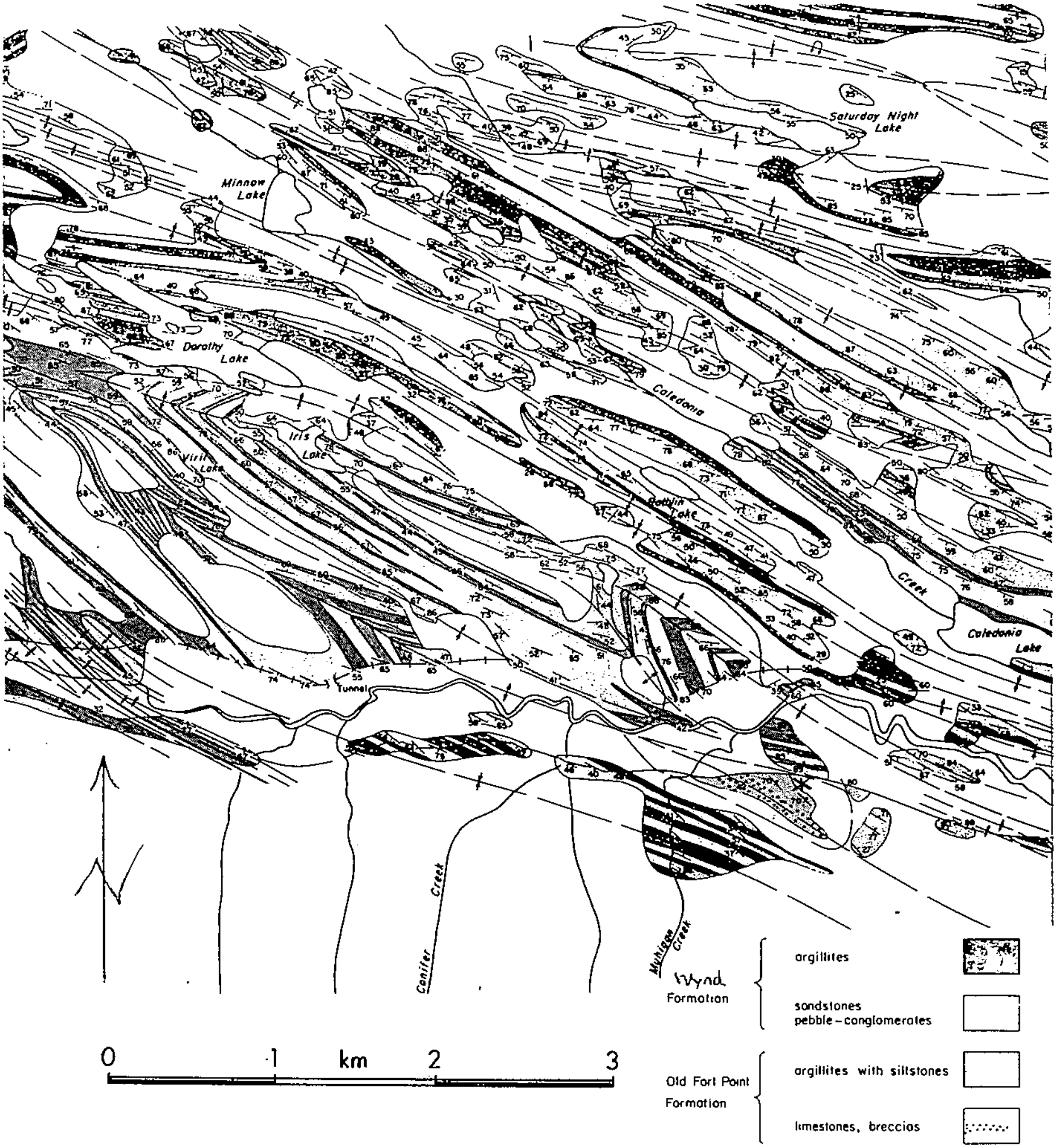

Fig. 15. Geological map of an area between between Jasper and Geikie. The location of STOP 11 is indicated by an asterisk. The trace of the Monarch thrust has been mapped by Dechesne & Mountjoy (1988) as passing through Viril Lake.

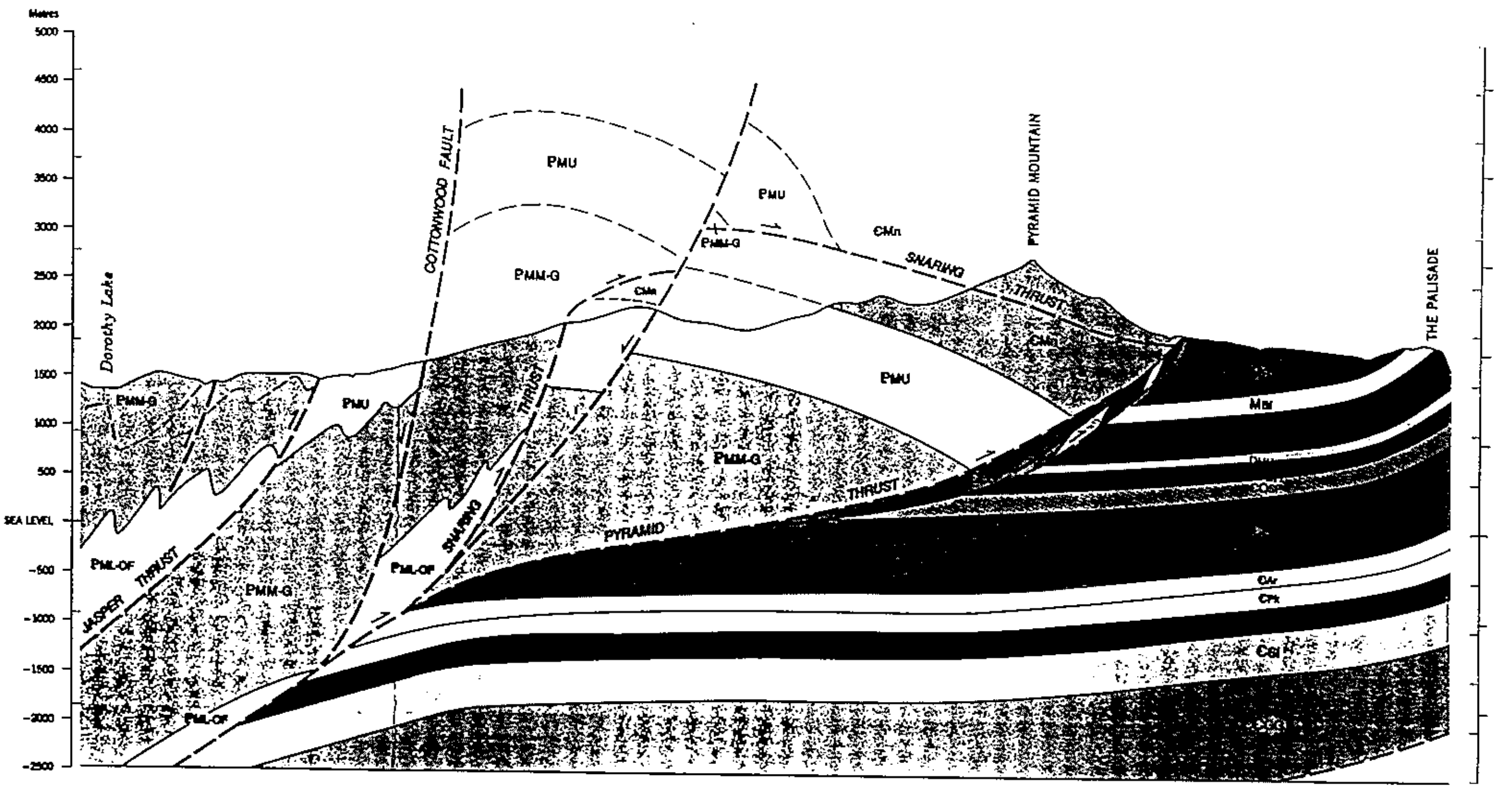

Fig. 16. Geological cross-section through Pyramid Mountain (Mountjoy & Price, 1985).
OF - Old Fort Point Formation. MM - Middle Miette Group (Lower Wynd Formation).
MU - Upper Miette Group (Upper Wynd Formation).

Highway 16 west of Jasper follows the valley of the Miette River, the type locality of the Miette Formation (Walcott, 1913) subsequently raised to group status by Mountjoy (1962). At **STOP 10,** the bridge over the Miette River, strata belonging to the upper part of the middle Miette Group will be examined.

At **STOP 11,** in the Muhigan Creek inlier, 10 km west of the Miette River bridge, Old Fort Point stratigraphy and the second-phase Monarch thrust will be examined (Figs. 15, 17 and 18). In the immediate footwall of the Monarch thrust, slates have quartz veins and folded cleavage and conglomerate has two generations of quartz veins: the first generation of veins is subvertical and boudinaged; the second generation veins are en echelon and are not boudinaged, which suggests that there were two episodes of deformation on the thrust (Dechesne & Mountjoy, 1988).

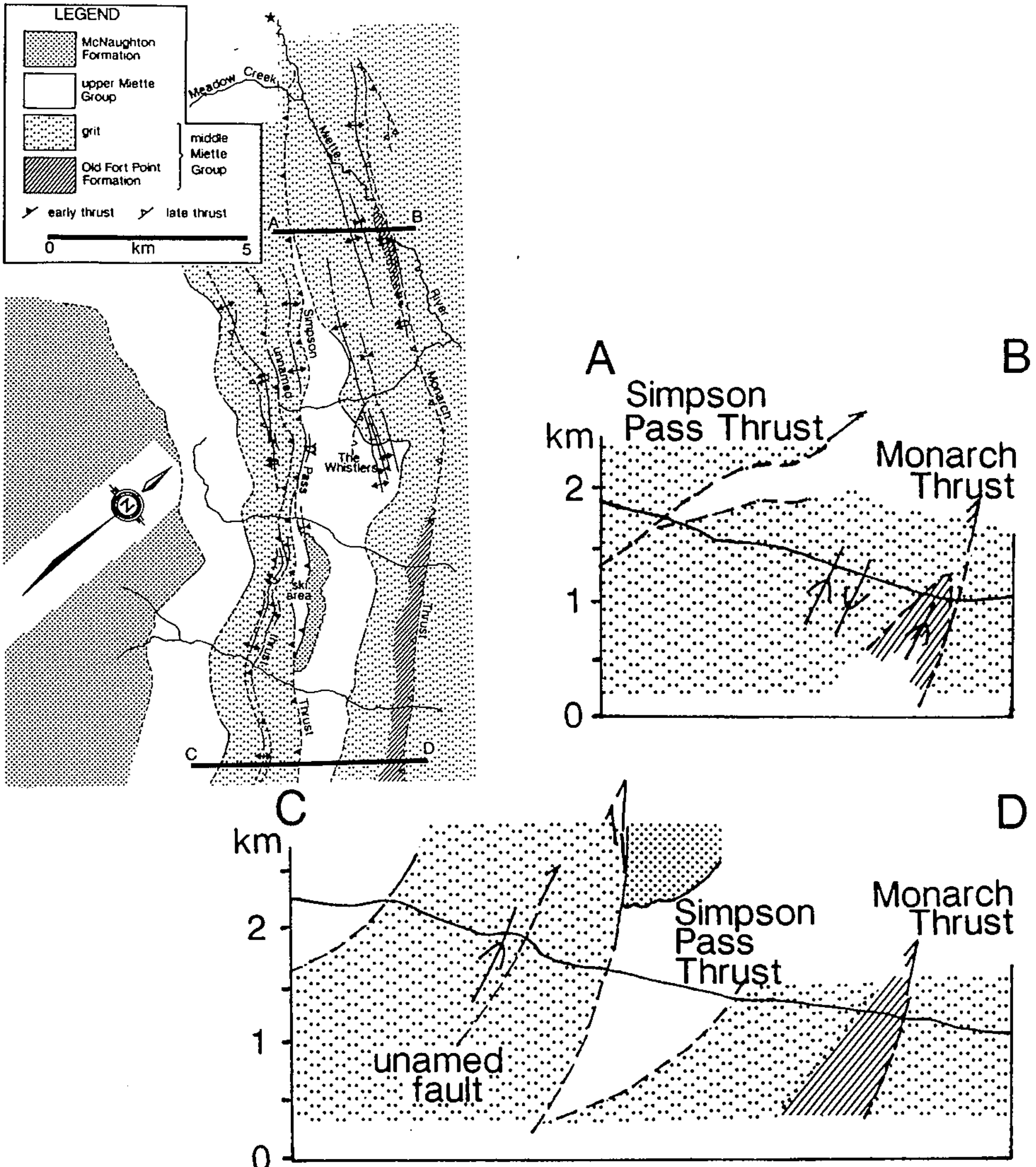

Fig. 17. Geological map and cross-sections of The Whistlers area (Dechesne & Mountjoy, 1988). STOP 11 lies on section line AB.The upright folds near The Whistlers are late folds. All other folds shown are early early folds associated with the early faults. The asterisk indicates the location of the outcrop sketch of Figure 18. In the cross-sections, arrows with single heads denote represent early faults, those with double heads early faults. All folds are associated with the first deformational phase except the upright folds near The Whistlers. AB and CD are the lines of the cross-sections in Figure 17. The * indicates the location of the outcrop sketch of Figure 18.

At **STOP 12,** in the Meadow Creek inlier, 14 km west of the Miette River bridge, Old Fort Point stratigraphy and structure will be examined and the location of the first-phase Simpson Pass thrust discussed (Fig. 18). At **STOP 13,** 25 km west of the Miette River bridge, turbidites at the base of the upper Miette Group will be examined. At **STOP 14,** Yellowhead Lake, 32 km west of the Miette River bridge, Old Fort Point strata in the Yellowhead Lake inlier will be examined and the zone of disharmony separating Gog and Middle Miette strata viewed.

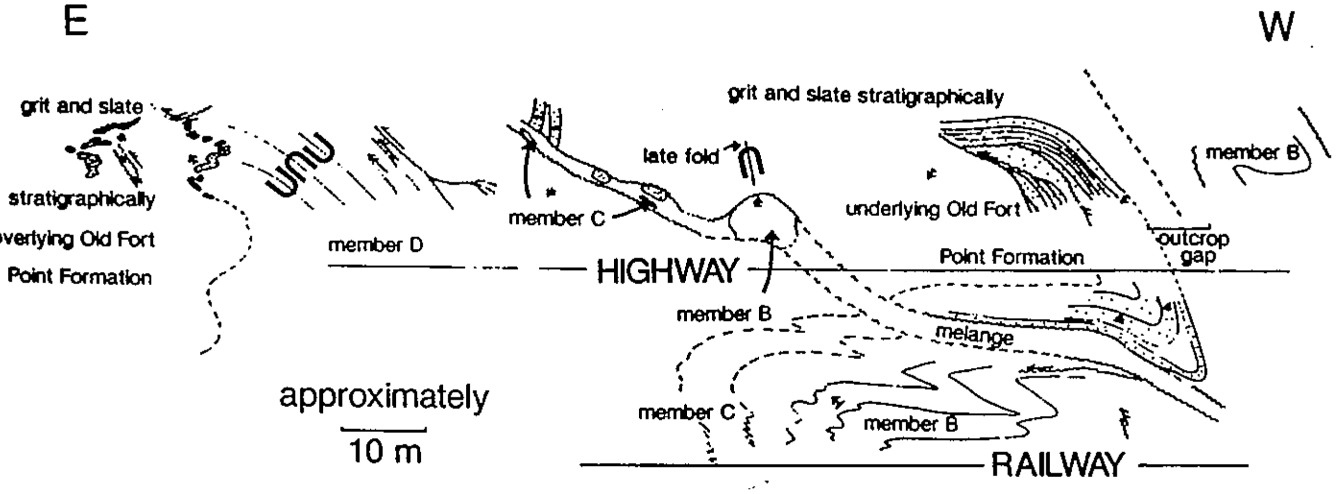

Fig. 18. Composite field sketch of the area denoted by an asterisk in Figure 17 (Dechesne & Mountjoy, 1988). The scale varies slightly across this view. Arrows with single heads represent early faults whereas those with double heads denote late faults. The melange occurs within an early large fault zone and the upper contact with the Old Fort Point Formation is not exposed.

DAY 2

MAIN RANGES BETWEEN JASPER AND SASKATCHEWAN CROSSING

Jasper is situated in a large plunge culmination and the surrounding peaks expose strata no younger than Lower Cambrian. Travelling SE towards Saskatchewan Crossing, the route crosses a major plunge depression where strata as young as Mississippian are preserved. Exposures of the Precambrian Miette Group are limited to the Jasper region, and for the most part Paleozoic strata dominate the landscape.

The stratigraphic column in the Main Ranges between Jasper and Saskatchewan Crossing consists of more than 1000 m of Precambrian strata belonging to the Miette Group, 1000 to 2000 m of the Lower Cambrian Gog Group, mainly quartzites, and about 8000 m of younger Paleozoic strata, mainly carbonates with subsidiary shales (Fig 19). The structural style of this immensely thick, competent succession is characterized by large open folds, thrusts and normal faults.

Between Jasper and Mount Kerkeslin, the route is underlain mainly by Miette strata. At **STOP 1,** about 25 km south of Jasper, there is normally a good view to the W of Mount Edith Cavell (Figs. 13 & 20), where Gog quartzites are separated from the Upper Miette Group by thin carbonates stratigraphically equivalent to the Byng Formation of the Mount Robson area (Teitz & Mountjoy, 1985). To the S, Mount Hardisty exposes the Miette-Gog contact and is separated from Mount Kerkeslin by the Mount Coleman normal fault.

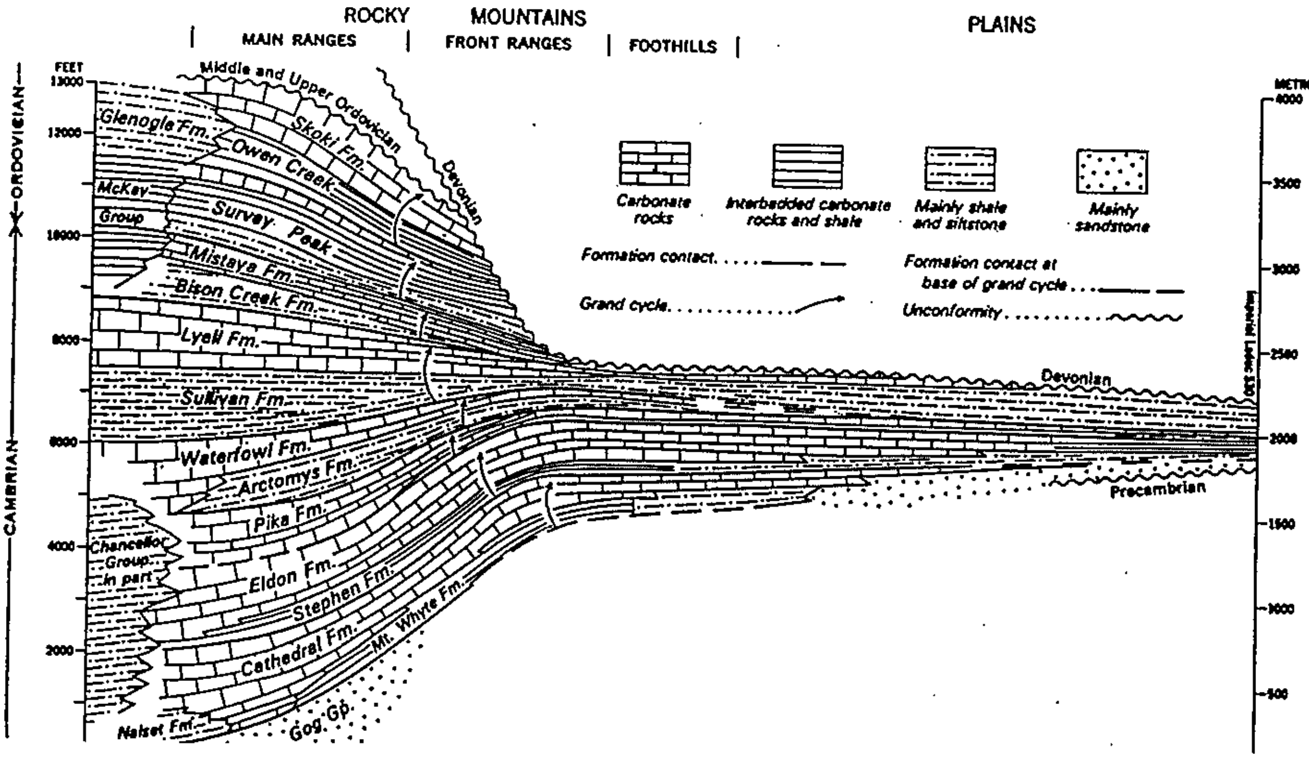

Fig. 19. Schematic restored Cambro-Ordovician stratigraphic succession in the Main Ranges (after J.D. Aitken in Wheeler, et al., 1972).

At **STOP 2,** Athabasca Falls (km 31), there is a good view of Mount Kerkeslin with a northern facies of the Lower and Middle Cambrian (Fig. 21). At the base, the Gog Group is made up of the McNaughton Quartzite, the archaeocyathid- and trilobite-bearing Mural Limestone, and the Mahto sandstone and shale. It is overlain by the Peyto Limestone with characteristic red bands. The Middle Cambrian is represented by shaly limestones, equivalent to the Mount Whyte and Cathedral Formations of the southern facies, and by carbonates of the Titkana (Eldon) Formation which form the top of the mountain. High up on the W slopes, an overturned syncline, most of whose W limb has been eroded, may lie in the immediate footwall of the Simpson Pass thrust (Fig. 21).

At **STOP 3** (km 50.5), there is normally a good view to the SW of Mount Christie and, to the SE, of the Winston Churchill Range. Mount Christie is structurally continuous with Mount Edith Cavell and is underlain by the Simpson Pass thrust. To the SE, along the highway, there is an end on view of the Winston Churchill Range. As we travel SE, the Simpson Pass thrust and a higher imbrication can be seen to repeat the Gog Group (Fig. 22). In the footwall of the Simpson Pass thrust, NE-dipping Middle Cambrian strata lie in the hangingwall of the Mount Coleman normal fault, strata in whose footwall dip SW). The NE dips above the normal fault may result from its listric nature (Fig. 22).

Near Sunwapta Falls (km 53.5), there are good road cuts of Middle Cambrian carbonates with calcite veins. Farther S, the Endless Chain Ridge E of the highway exposes SW-dipping Gog quartzites in the footwall of the Coleman normal fault and in structural continuity with those on Mount Hardisty. West of the highway, in the Winston Churchill Range, there is a dip slope of Middle Cambrian carbonates in the hangingwall of the Coleman normal fault; the rubbly peaks farther SW are Gog above the Simpson Pass thrust. At km 74.5 the route crosses a rockslide with boulders of Gog quartzite from the Endless Chain Ridge, where bedding is approximately parallel to the topographic surface. The prominent mountain to the SE is Tangle Ridge with Lower Paleozoic strata cut by the Coleman normal fault.

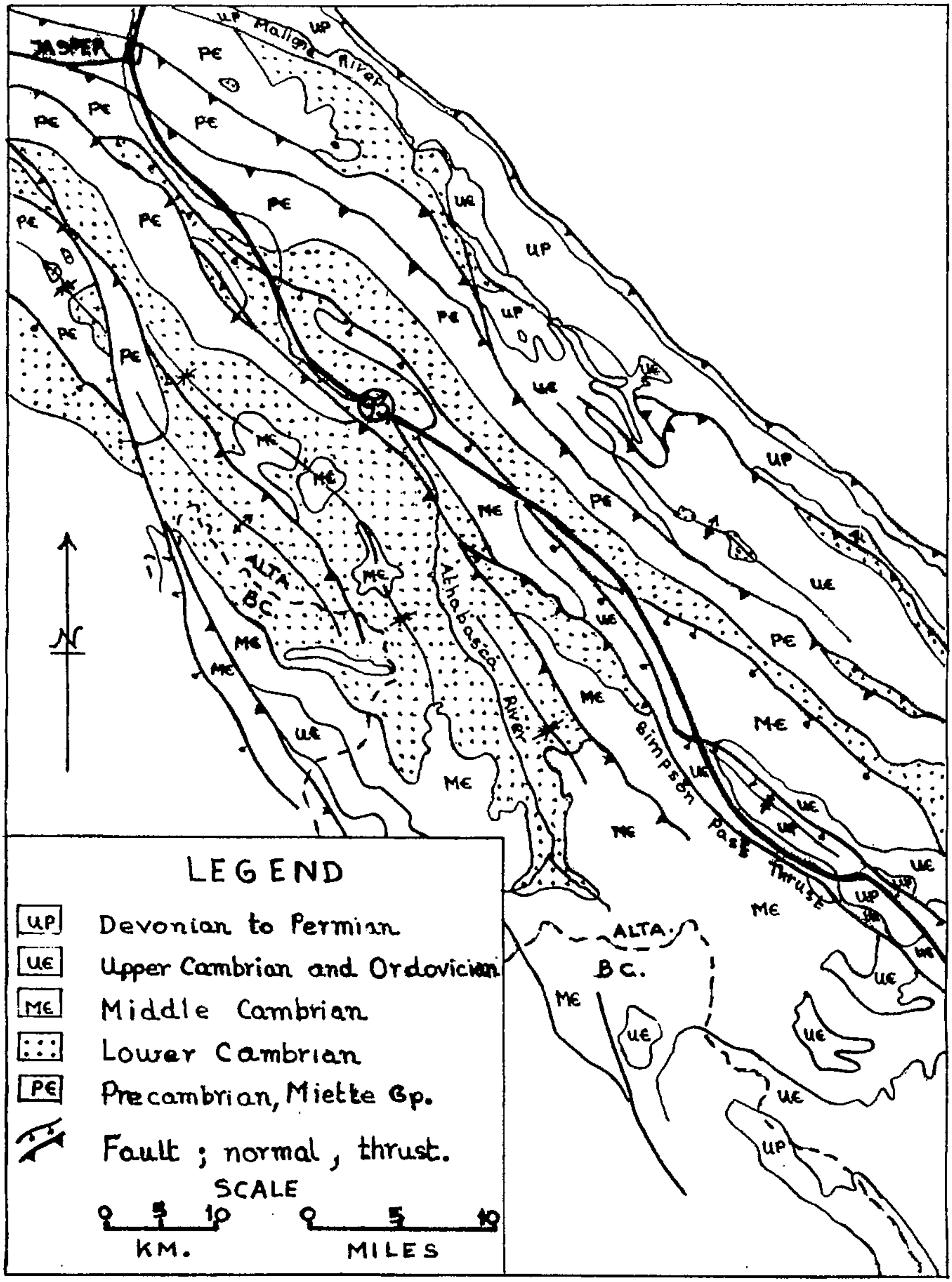

Fig. 20. Geological map of the northern part of the eastern Main Ranges along Highway 93 in Jasper National Park (after Price & Mountjoy, 1970).

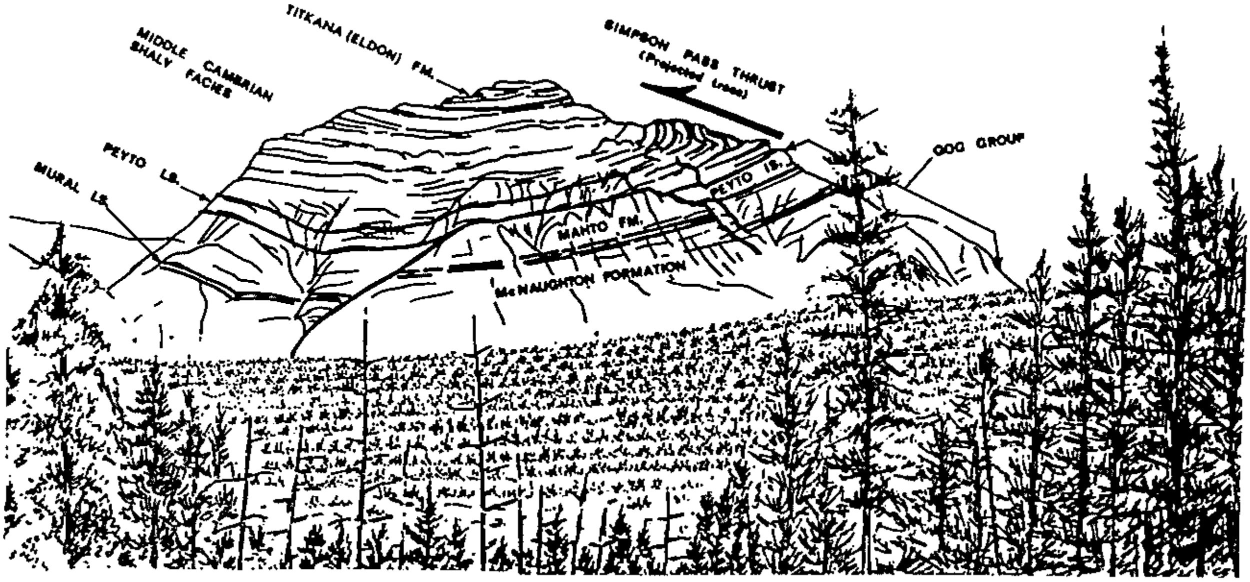

Fig. 21. Sketch of Mount Kerkeslin from Athabasca Falls
(R.A. Price with E. Fernando, in Price et al., 1972).

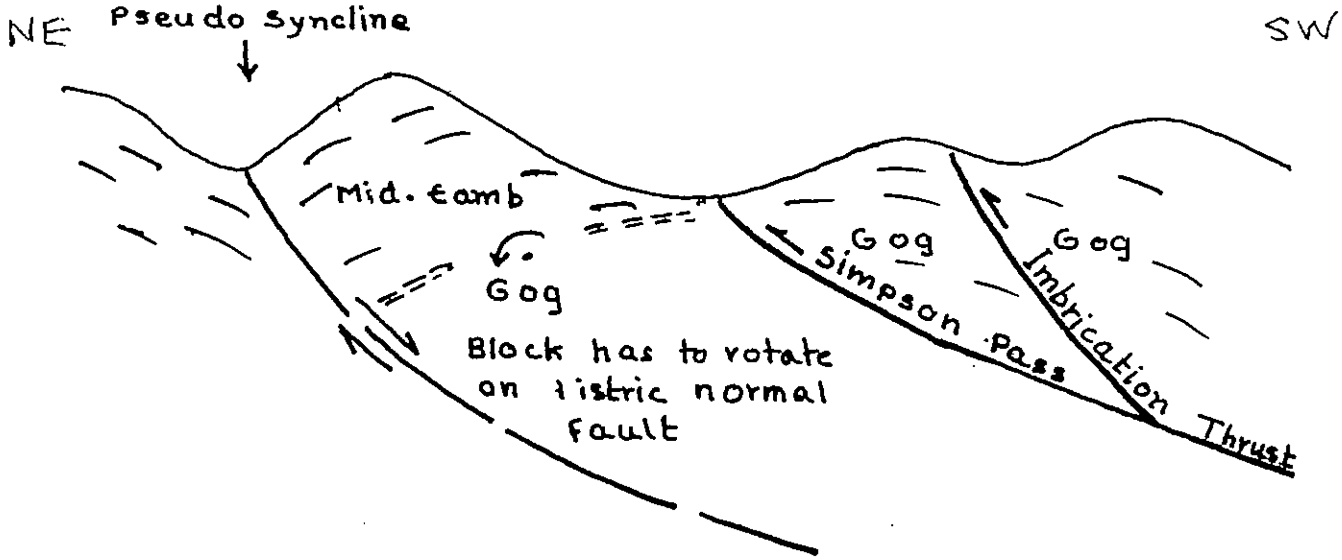

Fig. 22. Schematic structural cross-section showing the field relations SE of STOP 3
(P.S. Simony, P.S. in Simony & Charlesworth, 1976).

At **STOP 4** (km 80.0), the NE-dipping panel of Middle Cambrian strata cropping out in the Winston Churchill Range is absent and the Simpson Pass thrust overlies SW-dipping Lower Paleozoics. In the hangingwall of the thrust is an anticline, overturned to the NE and cored by Gog quartzites. The castellated peaks are carved out of Middle Cambrian strata in the SW limb of this fold.

At **STOP 5** (km 89.0), the SW-dipping Mount Coleman normal fault on Tangle Ridge can be viewed (Fig. 23). Carbonates of the Upper Cambrian Lyell Formation in the hangingwall are juxtaposed against carbonates of the Middle Cambrian Eldon Formation in the footwall. What appear to be fault-drag folds in the Lyell Formation suggest that the hangingwall moved up. This relationship, observed elsewhere in the Rockies, and the fact that some normal faults change laterally into thrusts suggest that many normal faults originated as thrust faults. Across the Sunwapta River to the SW, Middle Cambrian strata in the haningingwall of the Simpson Pass thrust overlie Upper Cambrian strata, including red and green shales of the Arctomys Formation.

Fig. 23. Sketch of the NW end of Tangle Ridge from Highway 93 (R.A. Price with E. Fernando, in Price et al., 1972).

At km 103.0, by the Stutfield Glacier viewpoint, there is a good view to the NW of the anticline above the Simpson Pass thrust whose displacement here is small. On the E side of the road, road cuts in fractured limestones of the Survey Peak Formation display a small anticline-syncline pair plunging NE at 40 deg.

At **STOP 6** (km 105.7), near the Mount Kitchener viewpoint, strata of the Ordovician Outram Formation in the immediate footwall of the Simpson Pass thrust display cleavage, several sets of en echelon gashes filled with calcite, and intense fracturing. A large rockslide from the lower part of the Middle Cambrian succession above the thrust produced a temporary dam along the Sunwapta River.

At **STOP 7** (km 112.2), the Athabasca glacier, which has been retreating throughout the 19th century, can be seen to flow E from the Columbia icefield through a valley eroded in gently NE-dipping, Middle Cambrian strata of Eldon and older strata. These beds lie in the hangingwall of the Simpson Pass thrust in whose footwall are strata ranging from the Upper Cambrian Arctomys Formation to the Mississippian Rundle Group. The structure of the footwall is characterized by a major syncline cut by the Mount Coleman normal fault. To the SE, the route follows the SW limb of the syncline whose core is exposed on Nigel Peak (Fig. 24). A short distance to the SE, at km 117.9, the route crosses the boundary between Jasper and Banff National Parks, coincident here with the watershed between the Mackenzie and Saskatchewan drainage basins.

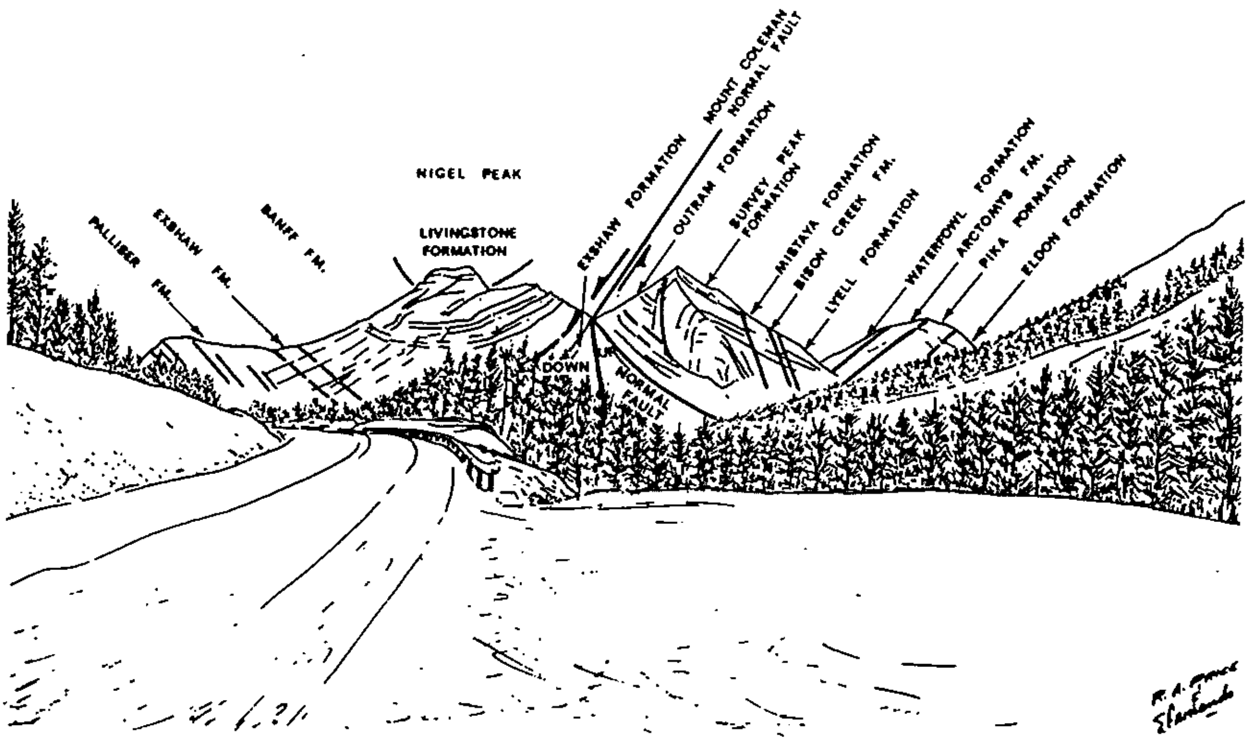

Fig. 24. Sketch of relations across the Mount Coleman normal fault at Nigel Peak (R.A. Price with E. Fernando, in Price et al., 1972).

At **STOP 8**, Cirrus Mountain viewpoint (km 126.5), the Mount Coleman normal fault is clearly visible on the NE face of Cirrus Mountain (Fig. 25). Note the great thickness of Upper Paleozoic strata, almost twice that in the Foothills. The Fairholme Group here has a reefal facies distinct from the shaly off-reef facies to the N.

Farther to the SE, the NW slope of Mount Wilson comes into view (Figs. 26, 27). It displays cyclic repetitions of carbonate and shale typical of the Lower Paleozoic in the Main Ranges.

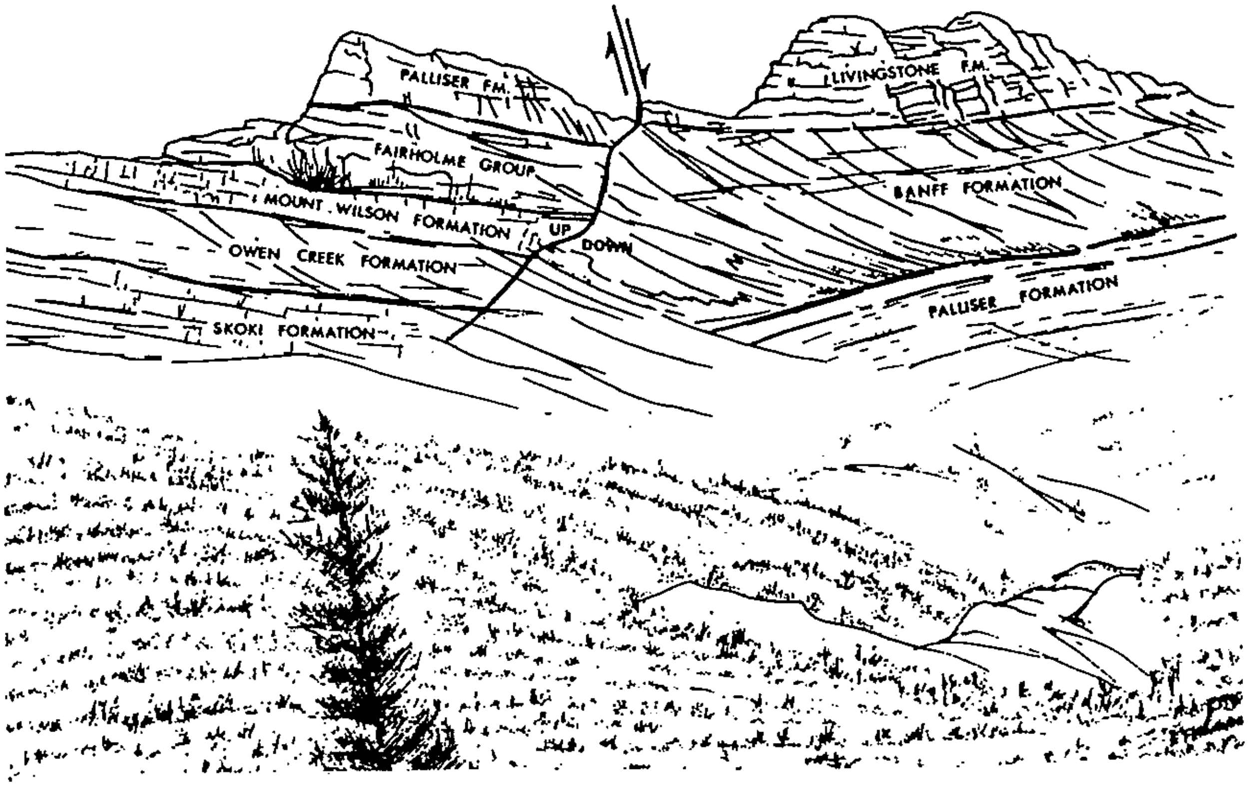

Fig. 25. Sketch of the N slopes of Cirrus Mountain from Highway 93
(R.A. Price with E. Fernando, in Price et al., 1972).

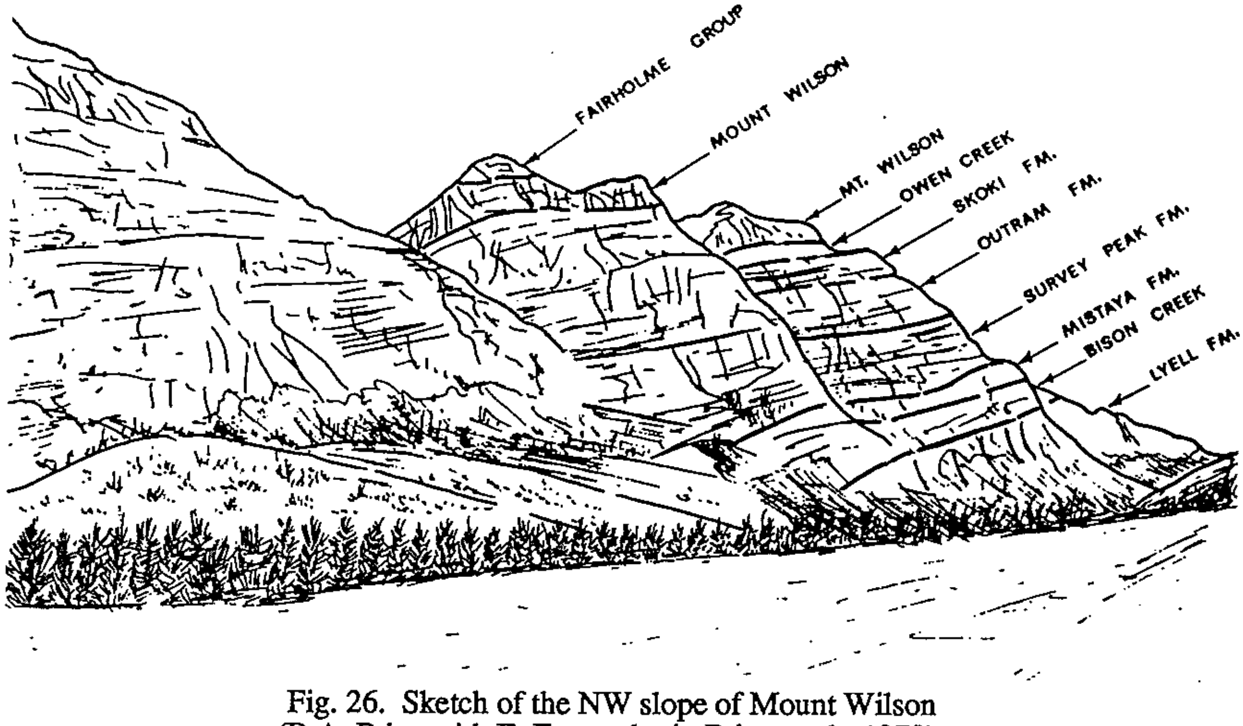

Fig. 26. Sketch of the NW slope of Mount Wilson
(R.A. Price with E. Fernando, in Price et al., 1972).

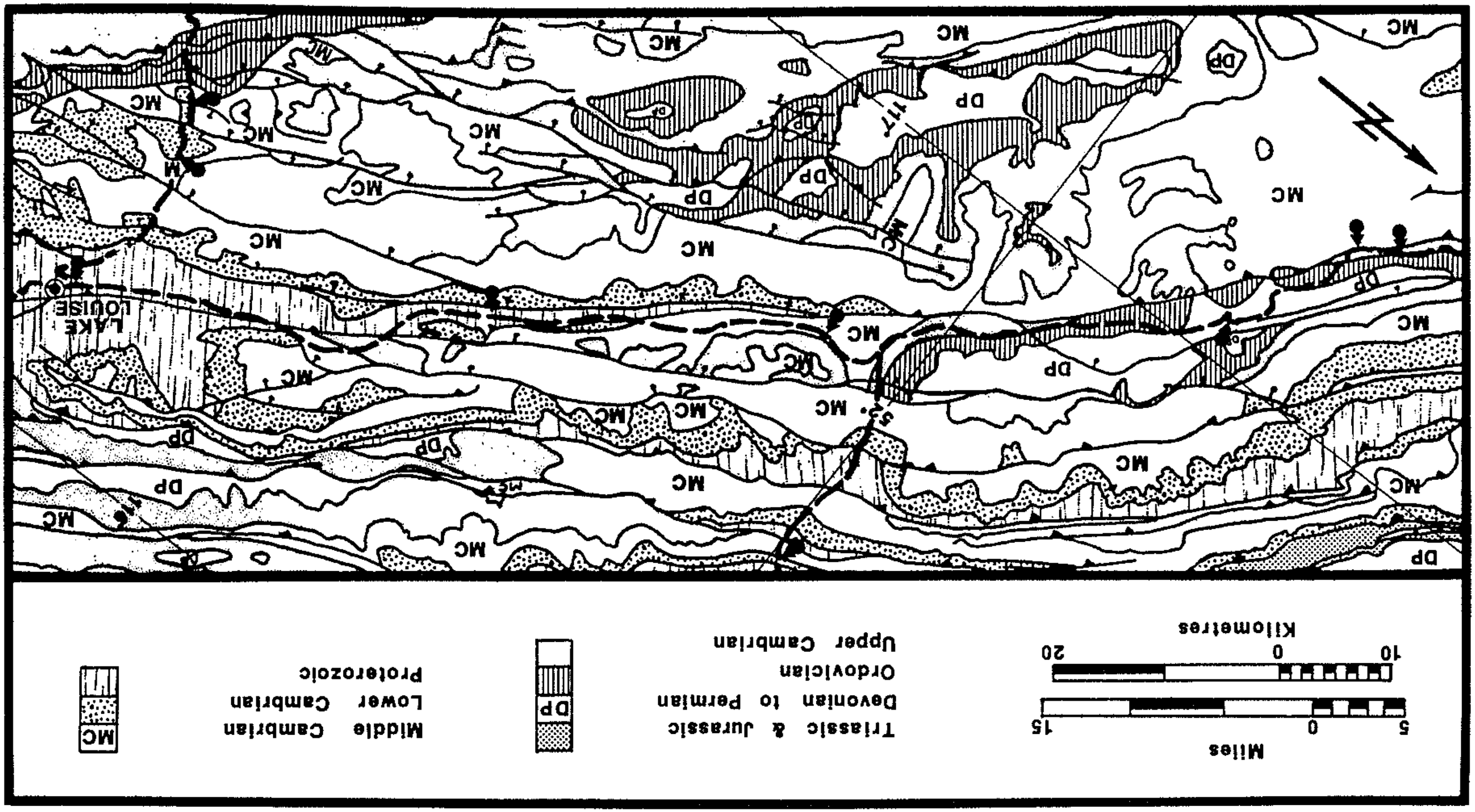

Fig. 27. Geological map of the eastern Main Ranges along Highwayy 93 in Banff National Park. (after Price & Mountjoy, 1970).

East of **STOP 9**, at Saskatchewan Crossing (km 163.2), there is a good view of Mount Wilson (Fig. 28). The youngest strata belong to the Upper Devonian Fairholme Group which is underlain by 60 m of dolostone belonging to the Upper Ordovician Beaverfoot Formation and by 170 m of cliff-forming quartzite belonging to the Ordovician Mount Wilson Formation. Below the quartzites are the Owen Creek (180 m of dolostone), Skoki (170 m of resistant dolostone) and Outram (260 m of limestone and shale) formations. Within the underlying Survey Peak Formation (400 m of limestone and grey-green shale) is the Cambro-Ordovician boundary. The lower part of the mountain consists of the Upper Cambrian Mistaya (100 m of resistant carbonate), Bison Creek (190 m of shaly limestone and calcareous mudstone) and Waterfowl (carbonate) Formations. To the SE there is a good view of Upper Cambrian and Ordovician strata on Mount Murchison (Fig. 29). The Upper Cambrian Mistaya Formation is cut by several small mormal faults.

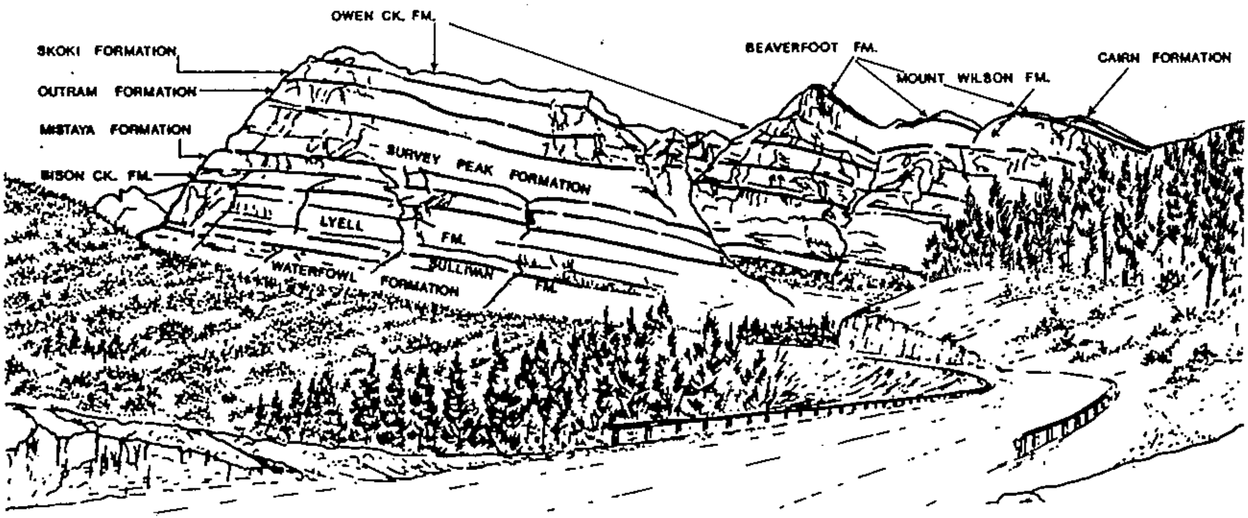

Fig. 28. South face of Mount Wilson from Highway 93
(R.A. Price with E. Fernando, in Price et al., 1972).

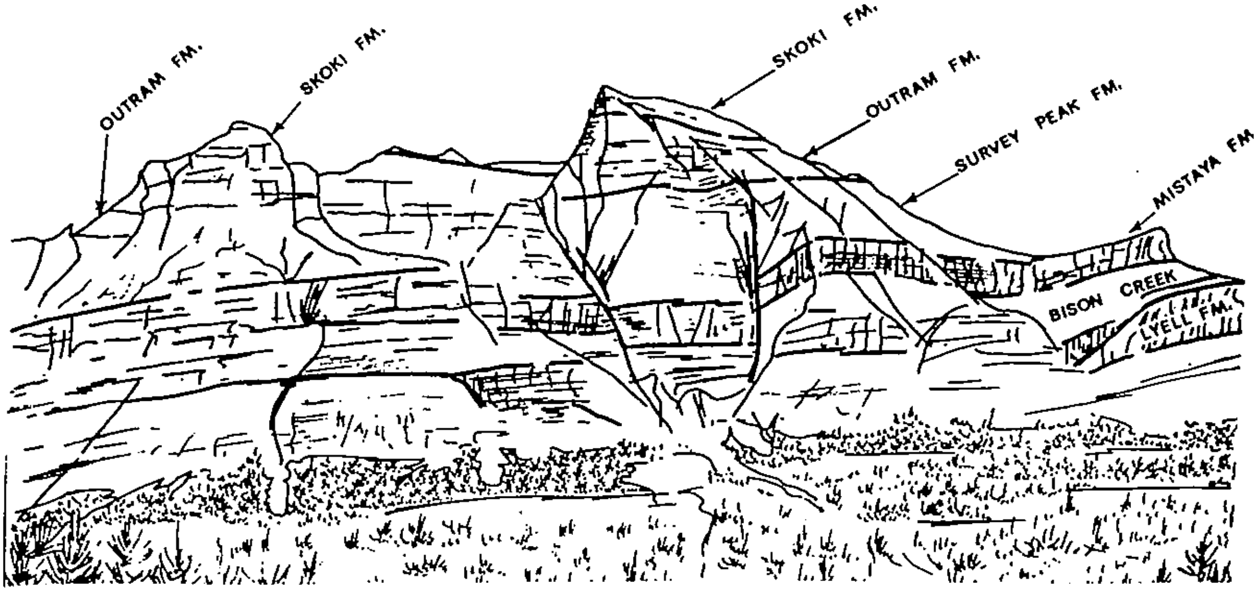

Fig. 29. Sketch of the NW slope of Mount Murchison
(R.A. Price with E. Fernando, in Price et al., 1972).

MAIN RANGES ALONG HIGHWAY 11

Along Highway 11, the route between Saskatchewan Crossing and Whirlpool Point lies in the Main Ranges (Figs. 30 & 31). At km 3.5, there is a good view to the N and S of the pseudo syncline produced by the Pinto Lake normal fault, which juxtaposes the Ordovician Mount Wilson Quartzite against the Middle Cambrian Eldon Formation. To the E, the route crosses the traces of the Pipestone Pass,Johnston Creek and Bourgeau thrusts, each of which superimposes Precambrian Miette on Middle Cambrian and younger strata. The boundary between the Main and Front Ranges, normally the trace of the most easterly thrust to carry Precambrian and Lower Cambrian strata, can be considered to coincide with the trace of the Bourgeau thrust. To the SE, along Highway 1, this thrust is in the Front Ranges, so the boundary between the Main and Front Ranges is here demonstrably gradational.

At **STOP 10,** Whirlpool Point (km 20.8), road cuts expose strata in the Bourgeau thrust sheet belonging to the Lower Cambrian Gog Group (quartz sandstones with shale interbeds), Middle Cambrian Mount Whyte Formation (green shale with interbeds of limestone and siltstone), and Middle Cambrian Cathedral Formation (limestones, dolostones and breccias). The trace of the Bourgeau thrust crosses the highway 0.5 km to the E. To the W, there is a good view of the relationships across the Pinto Lake normal fault (Fig. 32). The fault crossing the E slope of the mountain S of the North Saskatchewan River and E of Mount Murchison is a normal fault that reverses its sense of movement as it is traced to the NW (Fig. 30).

FRONT RANGES ALONG HIGHWAY 11

The Front Ranges along Highway 11 consists only of the McConnell and Sulphur Mountain thrust-sheets (Fig. 30). In a low ridge N of **STOP 11** on Kootenay Plains (km 23.6), the contact between carbonates of the Mississippian Rundle Group and siltstones of the Triassic Spray River Group in the Sulphur Mountain thrust-sheet is visible. The Mississippian is thrust over Triassic strata which, with the underlying Paleozoics, are folded into a large anticline-syncline pair that involves the overlying Bourgeau thrust. These relationships, consistent with the "piggy-back" sequence of thrust development characteristic of foreland thrust and fold belts, can be seen partly from here and partly from another stop a short distance to the to the NE, where a klippe of Middle Cambrian strata belonging to the Bourgeau thrust sheet can be seen to rest on carbonates of the Triassic Whitehorse Formation belonging to the Sulphur Mountain thrust sheet.

At **STOP 12,** at the bottom of the the hill (km 31.6), there is a good view of a prominent anticline-syncline pair in Devonian and Mississippian strata. At the level of the Palliser Formation, the fold is very tight and contains the tip line of a thrust whose dispacement increases to the NW.

The David Thompson Resort (km 44.1) is close to the trace of the Sulphur Mountain thrust that places Cambrian over Triassic strata. The Cambrian crops out at the bridge over the Cline River, where the route turns NE and enters the structurally complex McConnell thrust sheet. To begin with, we go down section from the Triassic to the Banff. At **STOP 13,** km 47.3, anticlinally folded Banff and Rundle strata are thrust over the Triassic. To the SE, the same anticline is cored by Fairholme strata.

Triassic strata NE of the anticline viewed at STOP 13 are underlain by dark cherts and siltstones of the Permo-Carboniferous Rocky Mountain Group which in turn rest on Mississippian and Devonian strata. These beds have been thrown into a series of spectacular folds visible both to the SE and NW from **STOP 14** (km 50.8, at the beginning of the guard rail). These folds probably owe their existence to the shaly nature of the Fairholme Group.

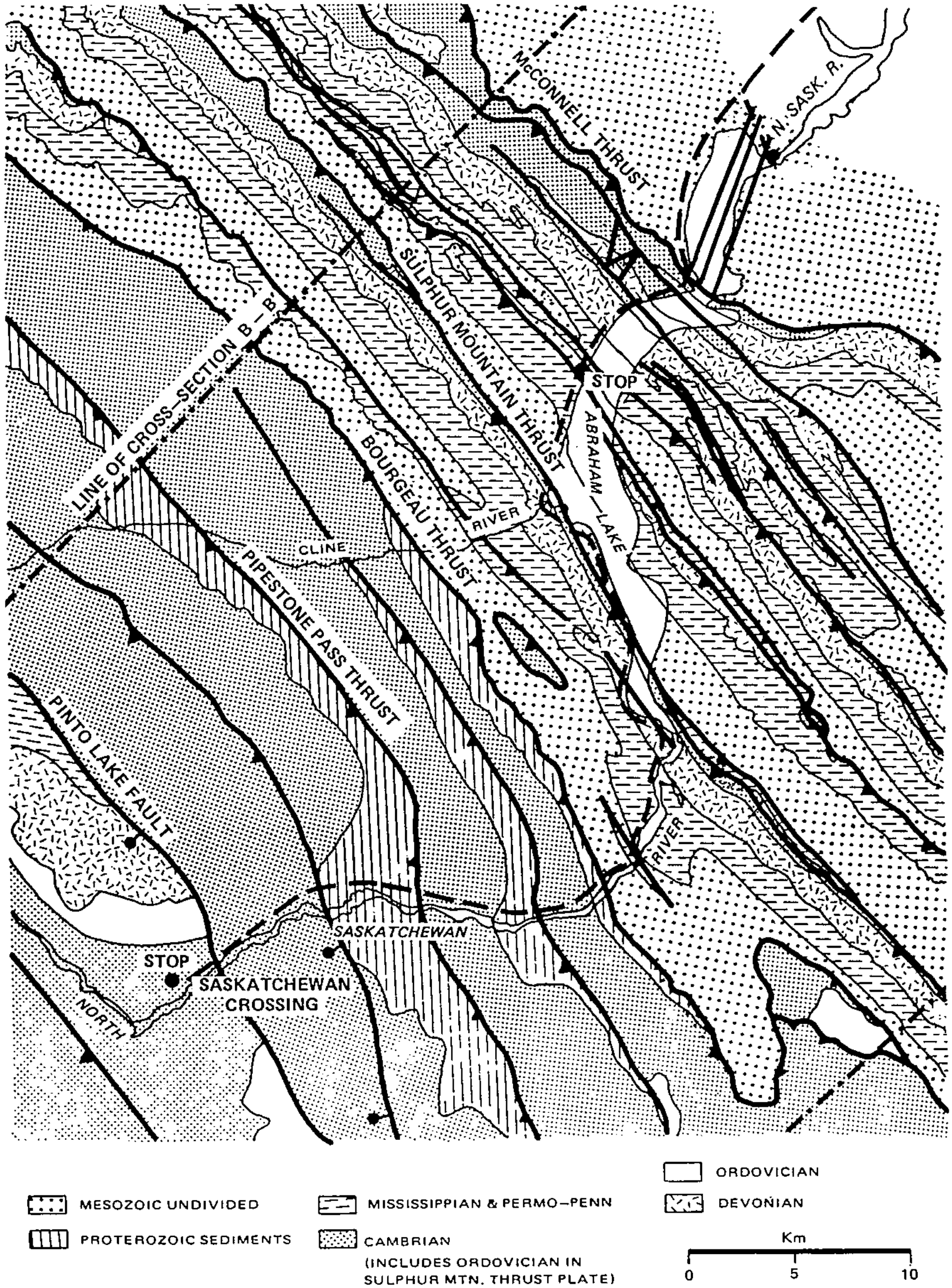

Fig. 30. Geological map of the Main and Front Ranges along Highway 11 (after Verrall, 1968; Price & Mountjoy, 1970).

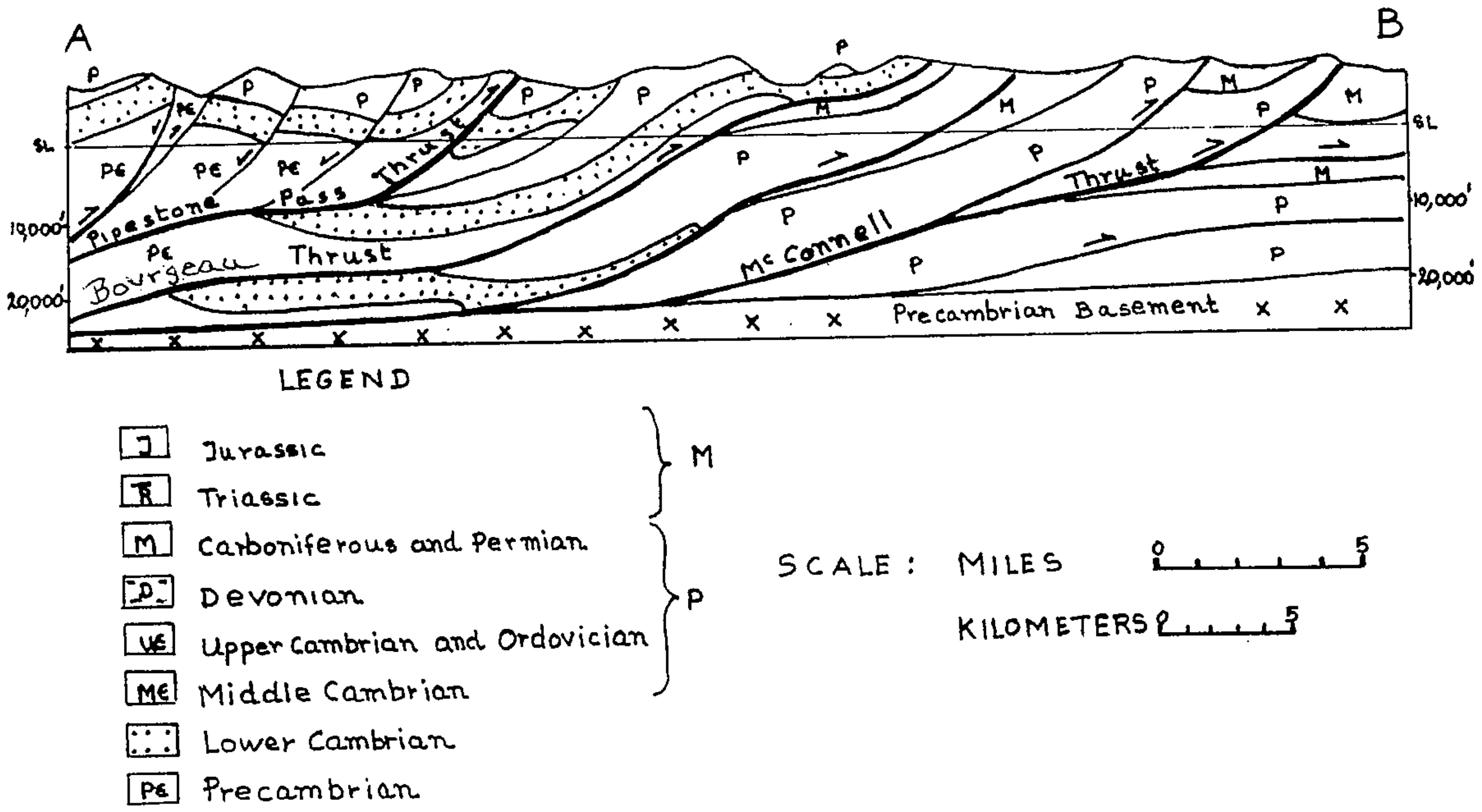

Fig. 31. Geological cross-section of the eastern Main Ranges and Front Ranges SE of Highway 11 (after Verrall, 1968).

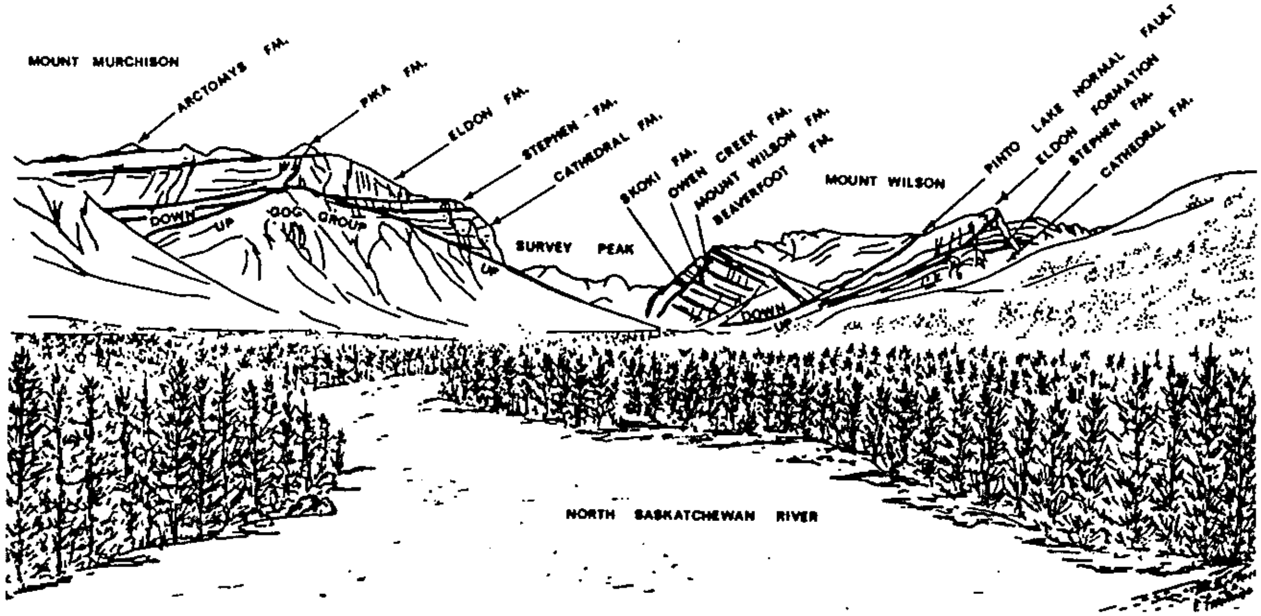

Fig. 32. Sketch of the view up the North Saskatchewan River from Whirlpool Point (R.A. Price with E. Fernando, in Price et. al., 1972).

At **STOP 14**, Windy Point (km 54.5), complexly deformed Cambrian and Devonian strata in the hangingwall of the McConnell thrust sheet overlie complexly deformed coal-bearing strata of the Lower Cretaceous Luscar Group.

FOOTHILLS ALONG HIGHWAY 11

The Foothills along Highway 11 consist largely of the Brazeau and Bighorn (Cripple Creek) thrust sheets (Figs. 33 & 34). Paleozoic strata belonging to the Brazeau thrust sheet crop out in the Brazeau Range. In the Bighorn thrust sheet, the Paleozoic strata cropping out in the Bighorn Range NW of Highway 11 end to the SE against a NE-striking fault, the "Bighorn tear". This fault was interpreted by Douglas (1956) as a wrench fault such that displacement along it plus displacement along the Bighorn thrust SE of the tear was equal to displacement along the Bighorn thrust NW of the tear. Another interpretation is that the Bighorn tear is a hangingwall drop fault across which displacement along the Bighorn thrust does not change (Fig. 34). Time permitting, these relationships will be examined at the last stop of the day.

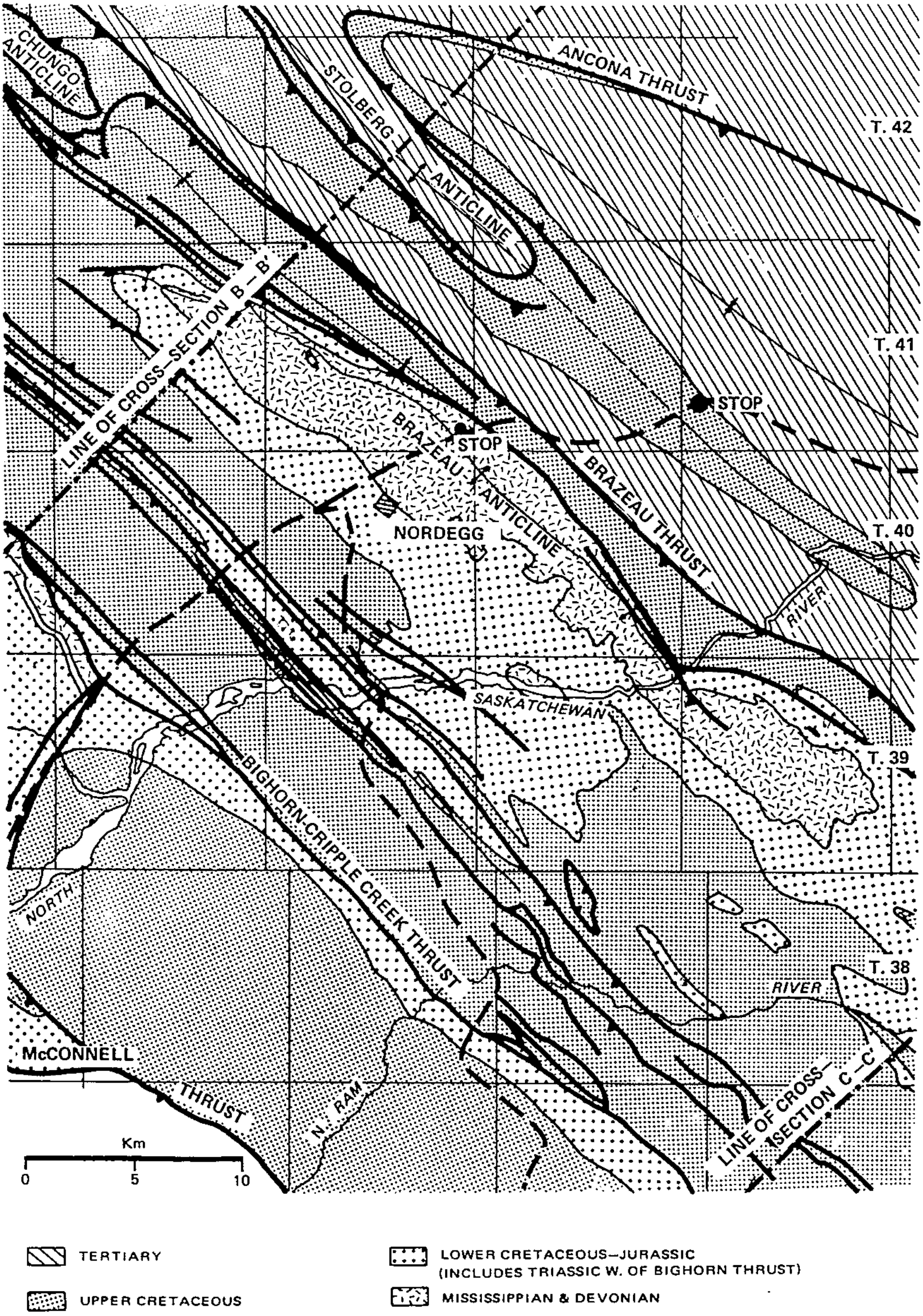

Fig. 33. Geological map of the Foothills along Highway 11 (after Verrall, 1968).

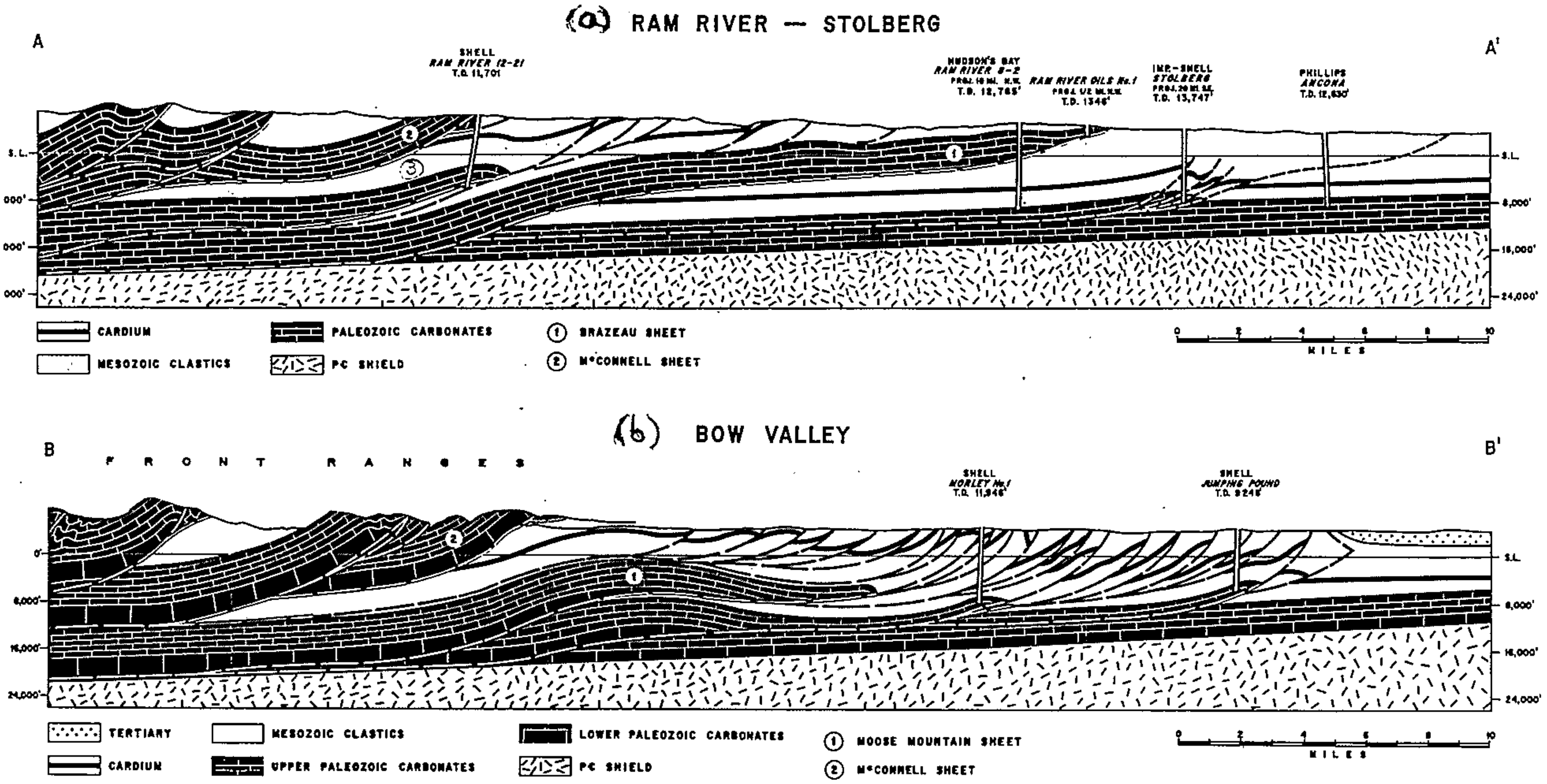

Fig. 34. Geological cross-sections of the Foothills (Bally et al., 1966). (a) The Ram River - Stolberg section is about 10 km SE of Nordegg; 1 - Brazeau thrust-sheet, 2 - McConnell thrust sheet, 3 - Cripple Creek thrust-sheet. (b) The Bow Valley section.

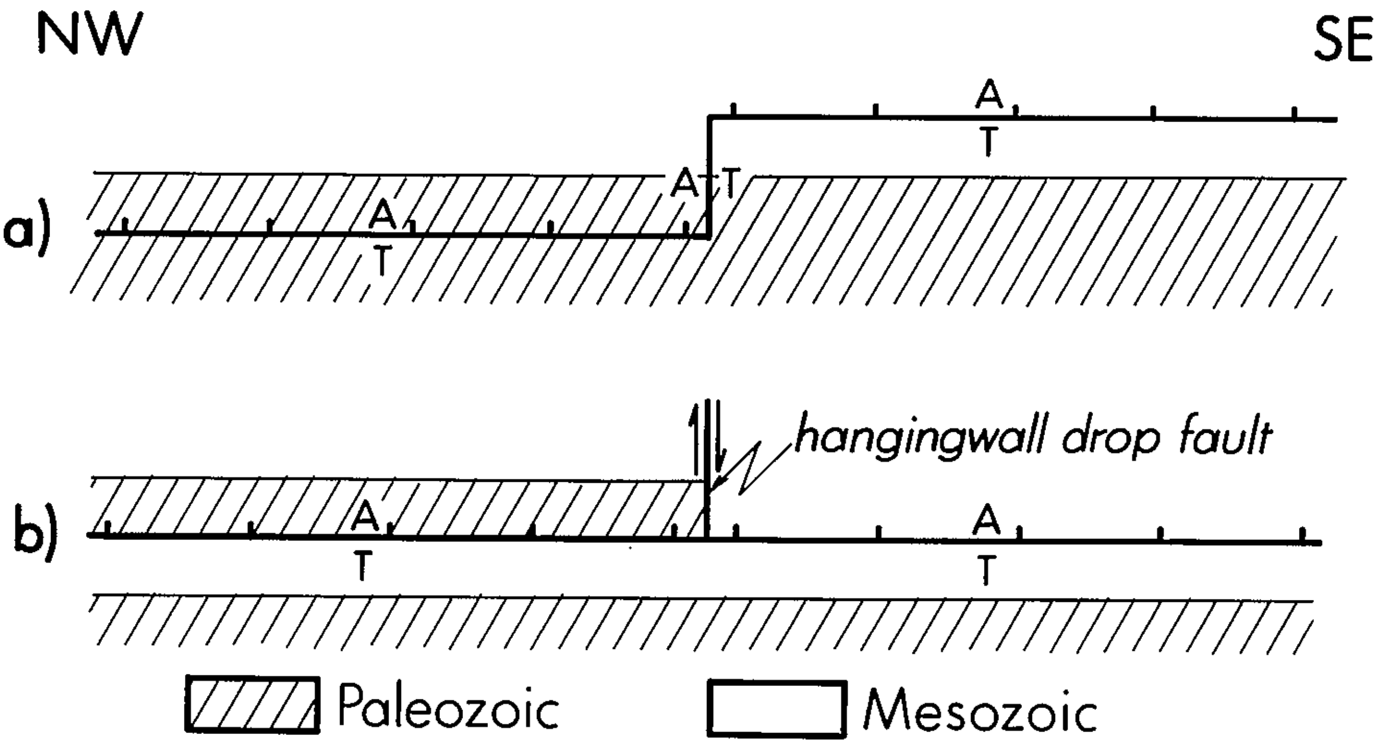

Fig. 35. Schematic hangingwall sequence diagrams showing how the "Bighorn tear" may have developed on the assumption that it is a hangingwall drop fault. A - away, T - towards.

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