# BUTLER RIDGE MAP–AREA, PEACE RIVER DISTRICT (94B/1)

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## INTRODUCTION

Map sheet NTS 94B/1 comprises the study area; it encloses the eastern end of Williston Lake in the Peace River district of British Columbia (Fig. 49). The W.A.C. Bennett Dam is the most prominent landmark in the area.

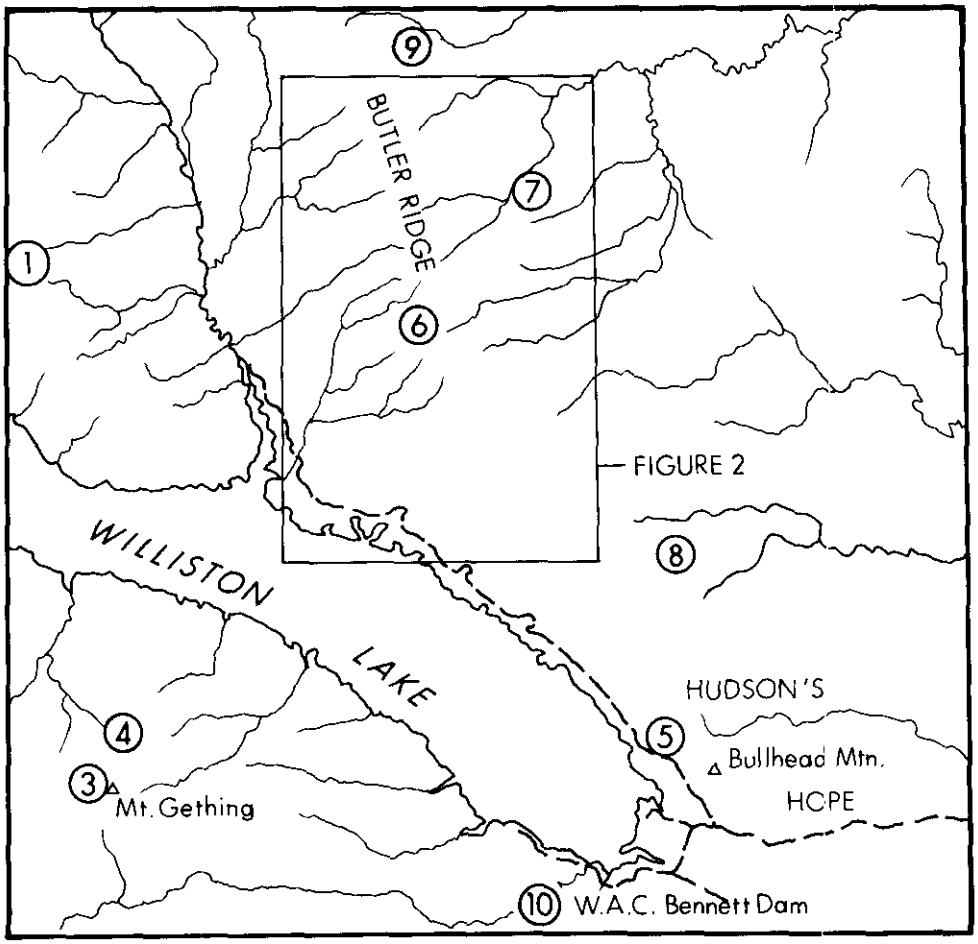


Figure 49. Map showing outline of the project area. Circled numbers refer to locations for which stratigraphic data are available.

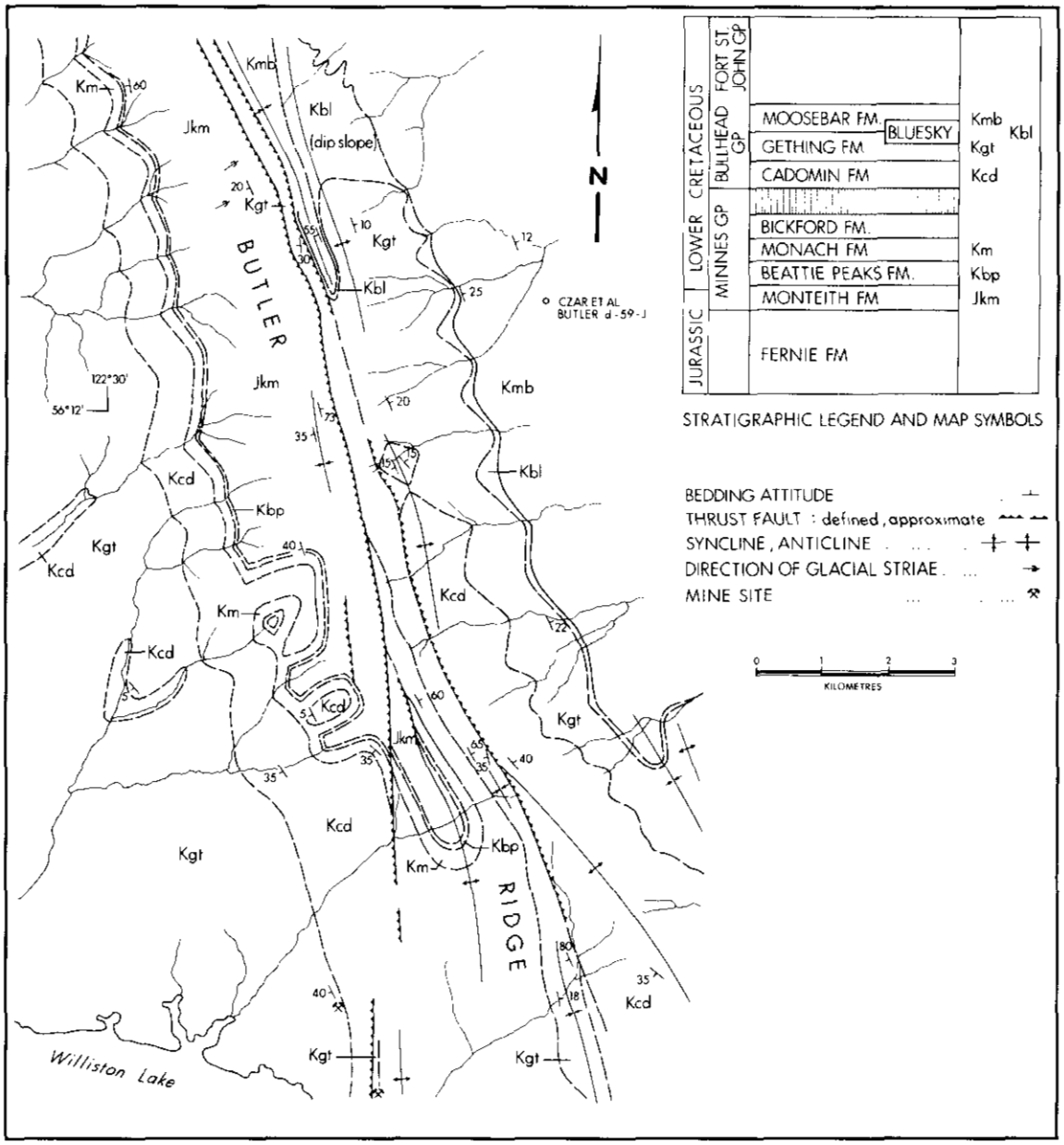


Figure 50. Geology of a portion of map-sheet 94B/1 (mapped at scale 1:50 000).

Fieldwork in 1983 was oriented toward synthesizing the geology from previous work. Previous work includes coal property assessment work by Utah Mines Limited, Hudson's Bay Oil & Gas Company Limited, Amax of Canada Limited, and Cinnabar Peak Mines Ltd. in the areas of Mount Gething, Dunlevy Inlet, Farrell Creek, and Portage Mountain respectively. Data are also available from a number of gas wells drilled in the region.

General stratigraphy and mapping has been done in recent times by Beach and Spivak (1944), Hughes (1964), and Stott (1963, 1968, 1969a, 1969b, 1973), but Beach and Spivak's map remains the only comprehensive compilation of the geology of the area on a 1:50 000 scale.

Beach and Spivak designated strata between the Cretaceous coal-bearing Gething Formation and the Jurassic marine Fernie Formation as the Dunlevy Formation. The term Dunlevy has been discarded and the section divided according to the terminology of Mathews (1946) and Stott (1980) but disputes remain (Hughes 1964).

In the terminology of Stott the Cadomin Formation underlies the Gething Formation. The base of the Cadomin appears to be identifiable and traceable in the map-area. It is marked by a sharp and irregular contact of pebbly arenites with fine-grained, rippled, thin-bedded quartz arenites and siltstones. About 1 centimetre of coal occurs at the contact; there is carbonaceous mottling (rooting ?) below. A similar bedded interval frequently occurs at or very close to the base of the Cadomin Formation as defined by other criteria (*see* following). Recognizing the base of the Cadomin facilitated sorting out the stratigraphy of the underlying Minnes Group.

The stratigraphic sequence must be mapped with caution. The Cadomin Formation and the Minnes Group are both arenaceous sequences; dip-slope exposures are particularly prone to incorrect designation unless a check with a nearby vertical section is made.

Mapping and air-photograph examination outlined folded and faulted strata that give more complex map unit patterns than that presented in previous maps of the area (Fig. 50). For example, dip-slope remnants of the Cadomin Formation are preserved high on the backs of cross ridges to the main Butler Ridge which otherwise is underlain by the Monteith Formation. Deep in the valleys that drain east Mount Gething, the Cadomin Formation is exposed; dips of its contact with the Gething are generally about the same as the gradient of the valley.

## GENERAL STRATIGRAPHY

### MONTEITH FORMATION

The Monteith Formation consists of thick units of white rippled quartz arenite interbedded with grey to tan rippled shales and arkosic wackes. Exposure of the Monteith Formation often form scarps of quartz arenite that exceed several tens of metres in height. Consequently, the Monteith Formation constitutes much of the high and steep exposure on Mount Gething, south Mount Gething (immediately south of the map-area), and Butler Ridge.

Re-examination of a section measured by Beach and Spivak (1944) on the north amphitheatre of Mount Gething indicates that 603 metres of the formation are present. The writer did not observe the base but Beach and Spivak's data suggest that the lowest 25 metres are in the transition beds to shale of the Fernie Formation. It is not always clear, especially in logs, which quartz arenite in contact with shale comprises the top of the Monteith Formation. As a result there are various interpretations of the stratigraphy between the Monteith and Cadomin Formations (for example, Hughes, 1964; Karst, 1981). Compiled thickness data suggest that the formation thins eastward (accompanying table).

COMPILATION OF STRATIGRAPHIC THICKNESS DATA
(*SEE* FIGURE 49 FOR LOCATIONS)

| | FERNIE FORMATION | MONTEITH FORMATION | BEATTIE PEAKS FORMATION | MONACH FORMATION | CADOMIN FORMATION | GETHING FORMATION | BLUESKY |
|---|---|---|---|---|---|---|---|
| | *metres* | *metres* | *metres* | *metres* | *metres* | *metres* | *metres* |
| 1. Quasar et al Dunlevy a-40-L | 100 | 505 | 200 | | ----- | ----- | ----- |
| 2. Rainbow Rocks | ----- | ----- | 210 | | ----- | ----- | ----- |
| 3. Mount Gething – North | ----- | 603 | >120 | ----- | ----- | ----- | ----- |
| 4. Mount Gething -- Northeast | ----- | ----- | ----- | ~100 | ----- | ----- | ----- |
| 5. Butler Ridge – South | ----- | ----- | ~30 | ~120 | ----- | ----- | ----- |
| 6. Butler Ridge – North | ----- | ----- | ~50 | ~125 | ----- | ----- | ----- |
| 7. Czar et al Butler d-59-J | 120 | 415 | 50 | 95 | ~260 | ~325 | 40 |
| 8. FPC – Richfield, Brenot Creek No. 1 | 34 | 382 | 110 | | ----- | ----- | ----- |
| 9. Amax Coal Co. Inc., diamond-drill hole BR-1 | ----- | ----- | ----- | ----- | ----- | 275 | 40 |
| 10. Peace River Canyon | ----- | ----- | ----- | ----- | ----- | 550 | <1 |
| 11. West Cdn Moberly Lake 11-36-80-25 | 120 | 282 | 61 | ----- | 119 | 250 | 6 |

## BEATTIE PEAKS FORMATION

The Beattie Peaks Formation consists of dark, burrowed, and carbonaceous siltstones, ferruginous shales, fine-grained rippled arenites, and quartz arenites. The stratigraphic interval is normally recessive but less so in this map area than to the west. Best exposures comprise the top 125 metres of Beach and Spivaks' section on the west 'table-top' of Mount Gething. To the south, on the South Mount Gething property, Utah Mines considers that about 40 metres of this formation are present. East of Mount Gething the formation is difficult to recognize, both on logs and in section. In the area of Bullhead Mountain it forms a thin (30-metre ?) shaly transitional interval between quartz arenites below and flaggy arenites above, but both lithologies are much interbedded. Its upper contact is sharper on Butler Ridge to the north. The formation thins eastward from the Carbon Creek area (where it is ⩾230 metres); the Butler Ridge/Bullhead Mountain area is probably near the eastern limit where it can be recognized.

## MONACH FORMATION

The Monach Formation consists of massive to flaggy arenite units. Arenite units are ledge forming but these are not as prominent as scarps of the Cadomin or Monteith Formation. Platy crossbedding and general lack of both pebbles and log casts helps to differentiate these arenites from those of the Cadomin Formation, which they otherwise resemble. Some units fine upwards in grain size with flaggy beds overlying a massive base (for example, northwest end of Butler Ridge). At Rainbow Rocks lateral pinching of units is apparent.

Tentative identification of the Monach Formation on Bullhead Mountain was made last year (Legun, 1982); it is apparently confirmed by a section exposed immediately to the south of the highest knob on Butler Ridge where approximately 125 metres of massive and crossbedded arenite (Plate VI) underlie the pebbly Cadomin Formation. Similar flaggy arenites directly underly the Cadomin Formation on the south and west sides of Bullhead Mountain, at Rainbow Rocks, and on the northeast flank of Mount Gething. Coarse-grained quartz arenite is also present and may grade into arenite without an apparent bedding contact. Gamma log data from gas wells indicate that some recessive zones between arenite units are carbonaceous.

Immediately below the Cadomin Formation on the north side of Portage Mountain near the British Columbia Hydro line is an anomalous section consisting of tens of metres of massive coarse quartz arenite

overlain by interbedded quartz arenite, shale, and coal. Bedding dips indicate that this sequence underlies pebbly Cadomin Formation exposed in a road cut leading to the W.A.C. Bennett Dam. This contrasts markedly with arenites immediately to the north on Bullhead Mountain that are apparently in the same stratigraphic position.

It is difficult to judge the thickness variation in the Monach Formation since, together with Beattie Peaks shale, it may form a single upward coarsening sequence. Where a reasonable separation of lithology has or can be made (accompanying table), a thickness not exceeding 125 metres is indicated. This is not a significant change from thicknesses to the west (Mathews, 1946).

Plate VI. Outcrop of cross-bedded Monach Formation arenite, Butler Ridge area.

## CADOMIN FORMATION

The Cadomin Formation is characterized by a series of pebbly arenite units that form scarps or ledges separated by recessive interbeds. This corresponds to a large blocky gamma response on geophysical logs. On the whole units are only sparsely pebbly with pebbles concentrated in lenses near or at the base. Log casts at the base are also typical. Carbonaceous shales and thin coals constitute parts of the recessive intervals. The base of the Formation is distinct and it grades into the Gething 'coal measures' by thinning of arenite units and loss of pebbly aspect.

The Cadomin Formation is well distributed through the map area; a complete section may be present on Butler Ridge above the headwaters of Gravel Hill Creek. Here steep-dipping arenite units are exposed for a considerable distance along strike. They are lens-like and fine upward from conglomerate at the base. This and other characteristics, for example log impressions, suggest a fluvial origin for these units.

Clasts in the Cadomin are up to 5 centimetres in long diameter; no pronounced change in clast size from west to east was noted. A maximum thickness of 260 metres is indicated in Czar et al Butler gas well. Sections measured by Stott and mapping by the writer suggest a thickness of 200+ metres in the map-area.

### GETHING FORMATION

The Gething Formation is a typical 'coal measure' sequence. It consists of interbedded arenites, siltstones, shales, mudstones, and coals; fossil plant material is abundant. The type section is at Peace River Canyon, immediately below the W.A.C. Bennett Dam, on its west side. Interesting features of Peace River Canyon exposures include a preserved tree trunk with annual growth rings (Legun, 1982).

In the map area the Gething Formation is virtually free of conglomerate; on the whole it is distinguishable as a map unit from the Cadomin Formation. Thick units of Cadomin pebbly arenite pass laterally by pinch-out into coal measures of the basal Gething Formation (for example, at old Reschke mine). Thus, positioning of the basal contact varies from place to place. On the east side of Butler Ridge a sudden decrease of prominent sandstone 'ribs' of the Cadomin Formation visible on air photographs marks the mapped contact with the Cadomin Formation. The top of the Gething section is defined by a distinct marker unit called the Bluesky (discussed later).

The thickness of the Gething Formation varies significantly within the map-area. To the northeast coal drill hole BR–1 and gas well data (Czar et al Butler) indicate a thickness of 275 and 325 metres respectively (Bluesky excluded). In the Peace River Canyon, 28 kilometres to the south, it is 550 metres. Just west of the canyon at Mount Gething, Utah Mines calculates that 670 metres of Gething strata were initially deposited. This increases to over 1 000 metres to the west in the Carbon Creek area. Well to the south of the map-area toward Pine River the formation thins again, defining a basin of subsidence between the Peace and Pine Rivers extending east-west. This basin of maximum deposition was outlined by an isopach map of Stott (1968, Fig. 10, p. 31); it appears to be even more trough-like in form west of Moberly Lake.

The thickness of the Bluesky marker unit also varies significantly in the map-area. Lithologically the unit consists of glauconitic chert pebble mudstone to pebbly arenite to well-sorted quartz arenite. Lithologic contrast is strong with the overlying Moosebar shales and underlying Gething coal measures. In the Peace River Canyon area the Bluesky is less than one metre thick and consists of matrix-supported chert pebbles in mudstone. To the north, in the Ruddy Creek area, thickness has increased to 40 metres and it consists of 24 metres of quartz arenite overlain by 17 metres of closely packed pebble conglomerate (diamond-drill hole BR–1). The sequence coarsens upward in 'step-like fashion'. Hughes (1972) separated the quartz arenite from the conglomerate and called it the 'Ruddy Member' of the Gething Formation; however, from gamma log response and physical character (no coal) it is apparent that the conglomerate and the arenite form the same depositional unit.

Beach and Spivak identified *Discranodonta* in the conglomerate at Ruddy Creek. This pelecypod, together with upward coarsening and fair to good sorting of clasts within discrete layers, suggests that the Bluesky unit is of shallow marine origin. The source of the clasts is an enigma.

## COAL GEOLOGY

Though thin coals are present in the Cadomin Formation and carbonaceous zones occur in the Minnes Group, the Gething is the only formation of economic significance. The Gething Formation in the Peace River Canyon area has at least 20 named seams but they rarely exceed 1 to 1.5 metres in thickness. Utah Mines has correlated some with seams underlying its East Mount Gething property (Louise, Milligan, and Riverside seams). The Trojan and Superior seams of the Peace River Canyon area are correlated southward into Bri-Dowling and South Mount Gething properties but their presence north of Williston Lake is in doubt.

Coal outcrops are easily accessed along the Dunlevy Creek Road, the road to W.A.C. Bennett Dam by Portage Mountain, and the road going to Carbon Lake by Mount Gething.

In general, maximum coal seam thickness increases from the Williston Lake area southward to the Pine Pass region, where occasional seams are 4 metres or more thick. The map area probably represents the northern limit of economic coal in the Gething Formation.

In the north half of the map-area, drilling by Amax in 1971 and 1972 did not intersect seams thicker than 1.2 metres. Hudson's Bay Oil & Gas intersected a 3-metre-thick high-ash coal seam in the middle Gething just east of Dunlevy Inlet. On the eastern slopes of Mount Gething the Riverside seam is a maximum 3 metres thick but averages half that thickness.

A coal rank study by Hacquebard (1974) of the Peace River Canyon section indicated that coal reflectance values ranged from 1.05 at the top to 1.36 at the base of the Gething Formation. This indicates that coals in the area are medium to high-volatile bituminous in rank. Company data also indicates that coals in the area are non-coking (low FSI).

## *PRE–CADOMIN UNCONFORMITY: DISCUSSION*

Stott (1969, 1973) considers that the Cadomin Formation lies on Beattie Peaks strata in the Butler Ridge area at Rainbow Rocks and on Bullhead Mountain and that intervening strata, the Monach and Bickford Formations, were removed by erosion. Stott rejects the idea that intervening formations disappear by eastward thinning; he considers the base of the Cadomin Formation to mark a major unconformity with progressive bevelling of underlying formations in a northeast direction. This has been disputed by Hughes who argued that the carbonaceous Bickford Formation, his Brenot Formation, persisted eastward from the Carbon Creek area. The writer agrees with Stott; apparently Hughes' Brenot Formation is based on incorrect identification of the top of the Monteith Formation in the French Petroleum Company – Richfield, Brenot Creek No. 1 well.

Stott's unconformity probably corresponds to the distinct contact observed at the base of the Cadomin lithologic sequence. This unconformity, however, is not as profound as suggested by Stott; the Monach Formation is present and loss of thickness of the Minnes Group is due in part to stratigraphic thinning, not erosion.

## STRUCTURE

As noted by Beach and Spivak (1944), the major structural features of the Peace River foothills are narrow zones of anticlinal folds, commonly broken by high-angle thrust faults, separated by broad synclinal basins of gently folded strata (for example, the Dunlevy syncline). In the map-area, two major fault zones are present. On Butler Ridge Monteith quartz arenites are thrust over the Gething Formation. To the south this major thrust splits into a series of thrusts which have smaller displacement and are separated by tight synclines and anticlines. These tight anticlines open into box-like forms with sharp-kinked limbs. To the north only dip-slope remnants of the Cadomin Formation are preserved high on the 'back' of the thrust plate; to the south, where the structures open up, Cadomin Formation forms the bulk of the exposure of the anticline and syncline pairs.

On the east flank of Mount Gething a major fault thrusts Monteith quartz arenite over Cadomin pebbly arenites. This thrust continues on the east side of south Mount Gething. West of the thrust, strata on Mount Gething and south Mount Gething are flat lying; further west they steepen to the west over a kink fold. This suggests that the structure forming the flat peak tops of both mountains is a box fold with its

east limb overturned above the thrust. Beach and Spivak's map, however, shows the kink on Mount Gething to be a thrust which continues as the thrust on the east flank of south Mount Gething; mapping by the writer suggests that this is incorrect.

## REFERENCES


Beach, H. H. and Spivak, J. (1944): Dunlevy – Portage Mountain Map-Area, *Geol. Geol. Surv., Canada*, Paper, 44–19, 13 pp.

Hacquebard, P. A. (1974): Rank Studies of coals in the Rocky Mountains and Inner Foothills Belt, Canada, *in* Carbonaceous materials as indicators of metamorphism, R. R. Dutcher, P. A. Hacquebard, L. M. Schopf, and J. A. Simon, Eds., *Geol. Soc. America*, Special Paper 153, pp. 75–93.

Hughes, J. E. (1964): Jurassic and Cretaceous Strata of the Bullhead Succession in the Peace and Pine River Foothills, *B.C. Ministry of Energy, Mines & Pet. Res.*, Bull. No. 51.

Karst, R. H. (1981): Correlation of the Lower Cretaceous Stratigraphy of Northeastern British Columbia from Foothills to Plains, *B.C. Ministry of Energy, Mines & Pet. Res.*, Geological Fieldwork, 1980, Paper 1981–1, pp. 78-89.

Legun, A. (1983): Stratigraphy and Sedimentology Notes on the Bullhead Mountain–Peace River Canyon, Carbon Creek Area, Northeastern British Columbia, (93O/15, 16; 94B/1, 2), *B.C. Ministry of Energy Mines & Pet. Res.*, Geological Fieldwork, 1982, Paper 83–1, pp. 93-98.

Mathews, W. H. (1946): Geology and Coal Resources of the Carbon Creek–Mount Bickford Map-Area, *B.C. Ministry of Energy, Mines & Pet. Res.*, Bull. 24, 27 pp.

Stott, D. F. (1963): Stratigraphy of the Lower Cretaceous Fort St. John Group and Gething and Cadomin Formations, Foothills of Northern Alberta and British Columbia, *Geol. Surv., Canada*, Paper 62–39, 48 pp.

Stott, D. F. (1968): Lower Cretaceous Bullhead and Fort St. John Groups, between Smoky and Peace Rivers, Rocky Mountain Foothills, Alberta and British Columbia, *Geol. Surv., Canada*, Bull. 152, 277 pp.

Stott, D. F. (1969): Fernie and Minnes Strata North of Peace River, Foothills of Northeastern British Columbia, *Geol. Surv., Canada*, Paper 67–19, Pt. B, 132 pp.

Stott, D. F. (1969): The Gething Formation at Peace River Canyon, *Geol. Surv., Canada*, Paper 68–28, 30 pp.

Stott, D. F. (1973): Lower Cretaceous Bullhead Group between Bullmoose Mountain and Tetsa River, Rocky Mountain Foothills, Northeastern British Columbia, *Geol. Surv., Canada*, Bull. 219, 228 pp.