KINUSEO MAPPING AND COMPILATION PROJECT (93I/14, 15; 93P/03)

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KEYWORDS: Coal geology, Kinuseo, Bullmoose, Goodrich sandstone, Shaftesbury Formation, Kaskapau Formation, Cardium Formation, Muskiki Formation, Badheart Formation, Puskwaskau Formation.

INTRODUCTION

The Kinuseo mapping and compilation project is a continuation of the 1986 Bullmoose mapping project (Kilby and Wrightson, 1987a,b,c). The objective is to produce 1:50 000-scale geologic maps of the Kinuseo Falls and Kinuseo Creek areas, 93I/14 and 93I/15 (Figure 4-6-1). The maps will include data collected in the field during July and August 1987, together with a significant amount of data compiled from other sources. All of the data will be compiled into a computer processible format for distribution.

In addition to the compilation and mapping in the Kinuseo areas, additional work was carried out in the Bullmoose Creek area (93P/03). Several parts of the Open File 1987-6 map were modified as a result of this re-examination. This paper discusses the mapping in the Kinuseo areas and the revisions to the Bullmoose mapping.

LOCATION

The project area encompasses about 1640 square kilometres in the Northeastern British Columbia Coal Development (Figure 4-6-1). The map area straddles the Rocky Mountain foothills and overlaps onto the Front Ranges to the southwest. This study examines only those strata underlying the foothills. Elevations range from 2800 to 6800 metres. Vegetation varies from alpine tundra to mature stands of pine

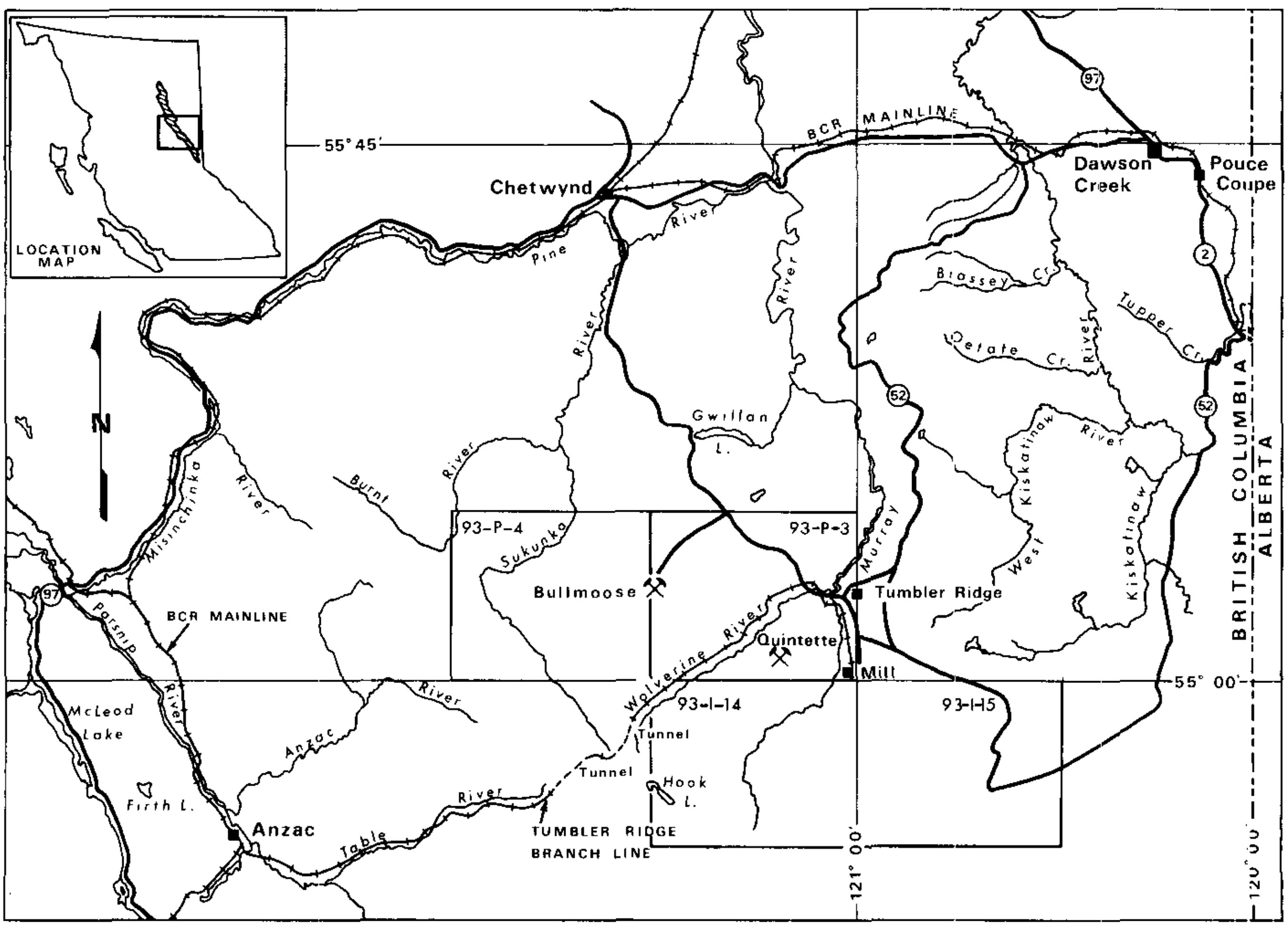

Figure 4-6-1. Study area location map.

British Columbia Ministry of Energy, Mines and Petroleum Resources, Geological Fieldwork, 1987, Paper 1988-1.

SERIES	GROUP	MAP SYMBOL	FORMATION	THICKNESS IN METRES	LITHOLOGY
UPPER CRETACEOUS		uKw	WAPITI	1000	Non marine interbedded conglomerate, sandstone, mudstone and coal
UPPER CRETACEOUS	SMOKY	uKp	PUSKWASKAU	210	Concretionary grey marine shale; coarsens upward to marine sandstone (Chungo)
UPPER CRETACEOUS	SMOKY	uKb	BADHEART	10	Marine and non marine quartz sandstone
UPPER CRETACEOUS	SMOKY	uKm	MUSKIKI	65	Grey marine shale; rust weathering; concretionary
UPPER CRETACEOUS	SMOKY	uKc	CARDIUM	40	Marine and non marine sandstone; conglomerate in upper part
UPPER CRETACEOUS	SMOKY	uKk	KASKAPAU	750	Dark grey marine shales; interbedded sandstone and shale in lower part
UPPER CRETACEOUS	SMOKY	uKd	DUNVEGAN	475	Marine and non marine sandstone, shale and coal
LOWER CRETACEOUS	FORT ST. JOHN	Ksh	SHAFTESBURY	400	Dark grey marine shale, locally silty with sideritic concretions; minor conglomerate and sandstone. Includes the Goodrich sandstone
LOWER CRETACEOUS	FORT ST. JOHN	Kbc	BOULDER CREEK	120	Fine grained, well-sorted sandstone; massive conglomerate; non marine sandstone and mudstone and coal
LOWER CRETACEOUS	FORT ST. JOHN	Kh	HULCROSS	100	Dark grey marine shale with sideritic concretions
LOWER CRETACEOUS	FORT ST. JOHN	Kg	GATES	130	Fine-grained, marine and non marine sandstones; conglomerate; coal; shale and mudstone
LOWER CRETACEOUS	FORT ST. JOHN	Km	MOOSEBAR	130	Dark grey marine shale with sideritic concretions; glauconitic sandstone and pebbles at base
LOWER CRETACEOUS	BULLHEAD	Kge	GETHING	375	Fine to coarse-grained, brown, calcareous, carbonaceous sandstone; coal, carbonaceous shale, and conglomerate
LOWER CRETACEOUS	BULLHEAD	Kcd	CADOMIN	40	Massive conglomerate containing chert and quartzite pebbles and sandstone
LOWER CRETACEOUS	MINNES	JKm	UNDIFFERENTIATED	1700	Thinly-thickly interbedded, shale, sandstone, siltstone and coals
JURASSIC		Jf	FERNIE	700	Black marine shale

Figure 4-6-2. Stratigraphic table (modified after Stott, 1983).

and spruce. Three major drainage systems, the Kinuseo Creek, the Flatbed Creek and the Murray River, crosscut the regional structural trend. These water courses follow U-shaped valleys carved during the Pleistocene glaciation. Access is provided by one paved highway (No. 24), one gravel highway (No. 52) and numerous forestry and coal company access roads.

DATA

A large amount of surface and subsurface data is available for this project. The complete database includes 13 465 outcrop stations with orientation data, 473 coal company boreholes, 45 oil and gas wells and 6858 topographic points digitized from 1:50 000 NTS maps. Much of the previously existing outcrop data was collected from coal company exploration maps on file with the ministry by contract personnel under the Canada/British Columbia Coal Data Acquisition Program. Coal exploration borehole data were obtained from assessment reports on file with the Geological Survey Branch and oil and gas well information was obtained from the Petroleum Resources Division of the Ministry of Energy, Mines and Petroleum Resources in Victoria. A portion of the Kinuseo Creek map sheet was compiled from detailed deposit modelling work conducted during the 1987 field season (Wrightson, this volume). Fieldwork concentrated on the poorly mapped regions within the study area and zones of structural complexity.

Microcomputers are being used for data storage, processing and data displays. For a review of the procedures used and a description of the hardware and software utilized during the project see Kilby and Wrightson (1987a).

STRATIGRAPHY

The foothills within the study area are underlain by Jurassic and Cretaceous marine and nonmarine strata. The

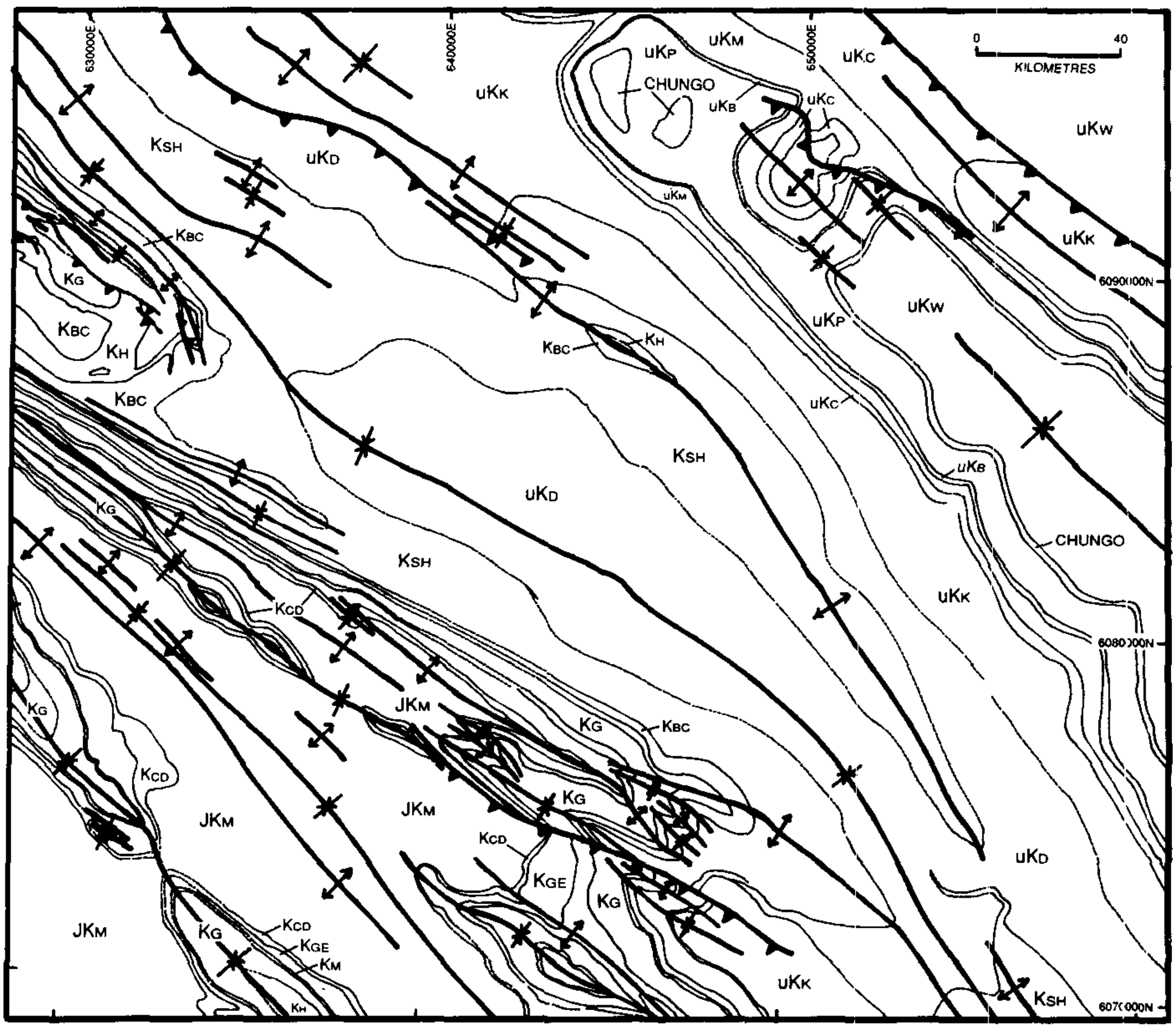

Figure 4-6-3. Kinuseo Falls map sheet (93I/14).

regional stratigraphy has been investigated by Stott (1967, 1968, 1973 and 1982). The formations and their approximate thicknesses are summarized in Figure 4-6-2. Descriptions of formations within the Minnes, Bullhead and Fort St. John groups and the Dunvegan Formation are included in Kilby and Wrightson (1987) and are not repeated here. One difference in the Fort St. John Group in the Kinuseo areas is described below.

The Goodrich sandstone, part of the Fort St. John Group, forms a mappable unit in the Bullmoose area and has formation status there (Kilby and Wrightson, 1987a). The sandstone, which separates similar marine shales of the Hasler and Crusier formations, exhibits a regional thinning to the south. In the Kinuseo areas, the Goodrich sandstone is composed of a poorly exposed thin sandstone which cannot be mapped on the surface or in the subsurface at a scale of 1:50 000. Because this sandstone is unmappable within the study area, the Hasler, Goodrich and Crusier formations have been combined as the Shaftesbury Formation.

SMOKY GROUP

Kaskapau Formation

The Kaskapau Formation is largely composed of dark grey marine shale. The contact with the underlying Dunvegan Formation is thought to be unconformable. Sandstone horizons several metres thick are present near the base of the shale. At the top of the formation, interbedded sandstones and shales grade into the overlying Cardium Formation. The Kaskapau Formation is generally recessive, outcropping only along river valleys and roadcuts.

Cardium Formation

The Cardium Formation consists of a lower marine sandstone and an upper nonmarine sandstone and mudstone sequence. Conglomerates are also locally present near the top of the formation. The sandstones often exhibit extensive bioturbation. Contact with the overlying Muskiki Formation

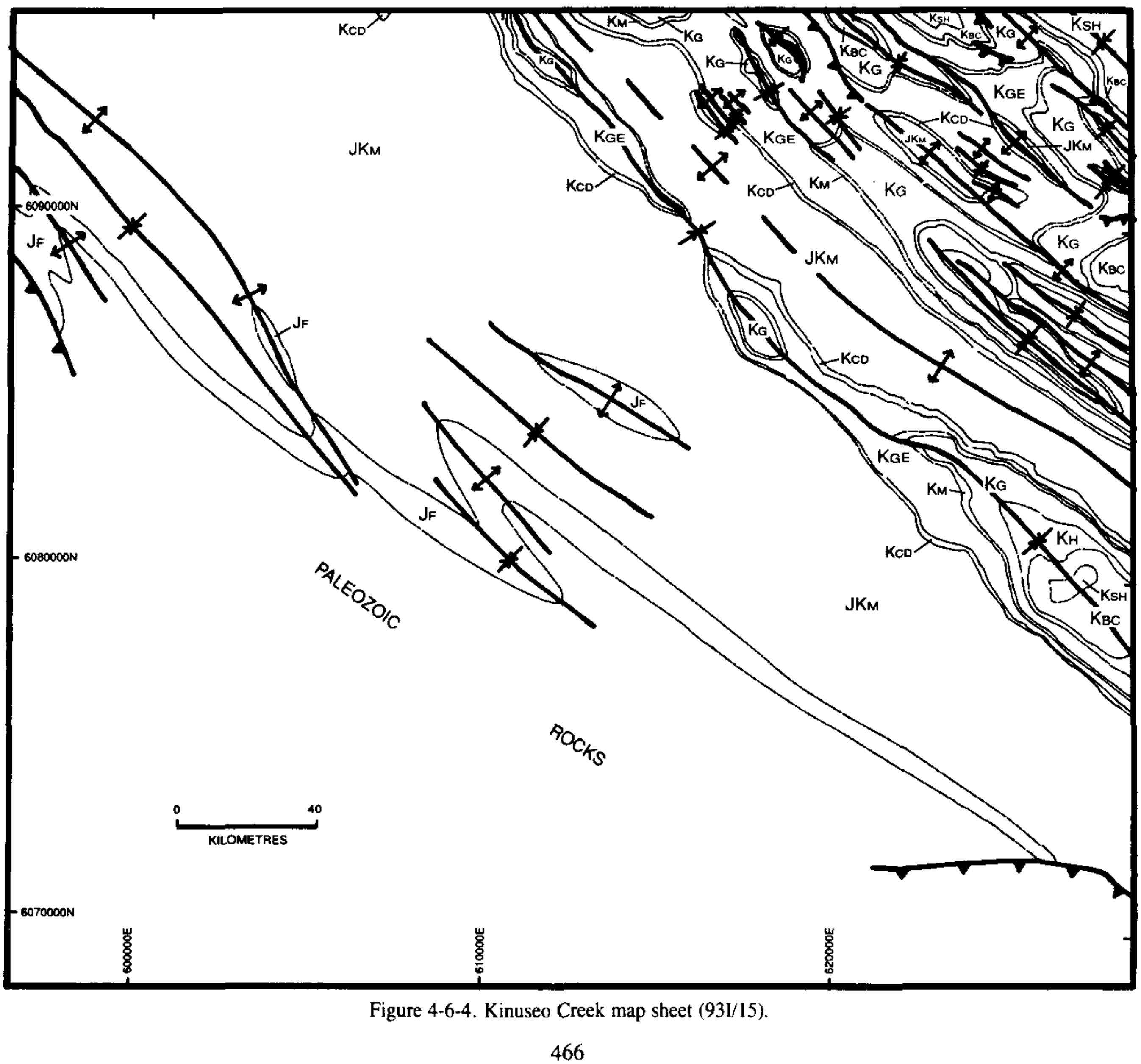

Figure 4-6-4. Kinuseo Creek map sheet (93I/15).

is abrupt and is characterized by the presence of a thin and discontinuous pebble-lag conglomerate.

Muskiki Formation

The Muskiki Formation is a monotonous sequence of rusty weathering, concretionary, grey marine shales. The shales grade upwards into siltstones which underlie the Badheart Formation.

Badheart Formation

The Badheart Formation is a marine to nonmarine sequence of sandstones which are very similar to the sandstones of the Cardium Formation.

Puskwaskau Formation

The Puskwaskau Formation is a rusty weathering marine shale unit. The shales are concretionary and coarsen upwards. The unit is locally capped by fine-grained sandstones. These sandstones, where present, are given member status within the Puskwaskau Formation and are known as the Chungo member.

Wapiti Formation

The nonmarine Wapiti Formation is composed of fining-upward sandstone sequences interbedded with mudstone and some coal.

STRUCTURE

The study area straddles the foothills structural province. Deformation and shortening have been accommodated largely by the development of northwest-trending box and chevron folds. The lack of marker horizons within the Fernie Formation and the Minnes Group prevented the detailed delineation of structure in areas underlain by these strata. In the inner foothills, large synclines characterized by steeply dipping limbs which expose strata of the Bullhead and Fort St. John Groups are separated by narrow complex anticlines (Figure 4-6-3). Folds in the outer foothills are broad open structures characterized by gently dipping limbs (Figure 4-6-4).

No major thrust faults cross the area. The Bullmoose thrust, a prominent structure to the north (Kilby and Wrightson, 1987b) dies out just north of the Murray River. Minor thrust faults, with displacements of less than 500 metres, are evident in the Babcock Mountain area and in the outer foothills near Thunder Mountain. In addition many of the shale sequences have acted as zones of detachment and exhibit complex internal folding and faulting not evident in the enclosing strata.

ECONOMIC GEOLOGY

Coal prospects within the study area, dominantly in the Gates Formation, have proved to be economically viable. Quintette Coal Mines Ltd. has recently begun mining coal seams included in the Gates Formation from the Shikano pit.

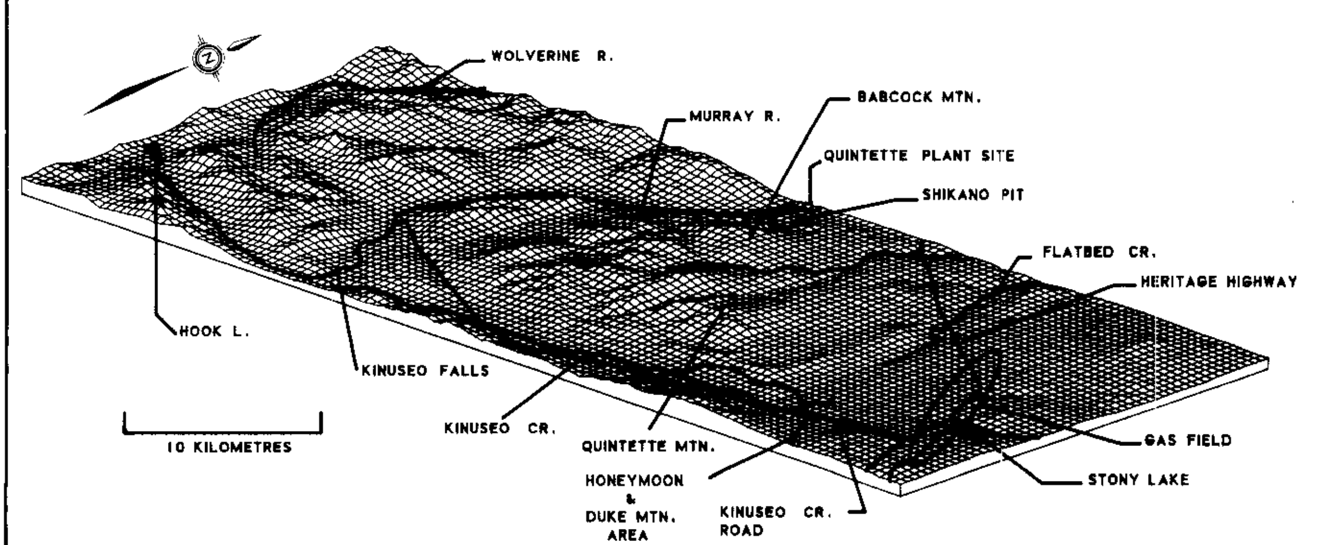

Figure 4-6-5. Isometric view of study area, showing location of infrastructure, major developments and geographic features.

Potential coal mines have been identified on Babcock Mountain and in the Honeymoon syncline – Duke Mountain area (Figure 4-6-5).

Oil and gas exploration has identified several gas pools present beneath the outer foothills. These reservoirs, apparently associated with blind thrusts, have also proved economically viable.

BULLMOOSE PROJECT — REVISIONS AND ADDITIONS

The Bullmoose project was a mapping and compilation project carried out during the 1986 field season. The areas covered in that survey were 93P/03 and 93P/04 (Figure 4-6-1). The style of the project was similar to the Kinuseo project. Due to the large areas covered and the heavy reliance on previous workers' interpretations, some problem areas were detected. These areas were addressed during the 1987 field season as part of the Kinuseo project.

A portion of the Tumbler Ridge map sheet, 93P/02, was examined to provide continuous coverage of the Upper Cretaceous Smoky Group strata between the Bullmoose and Kinuseo project areas.

The Bullmoose project emphasized mapping the Minnes Group strata, rather than the strata above the coal measures, once the coal-measure mapping was complete. Severe folding and lack of mappable units within the Minnes Group resulted in difficulties in interpretation. Little emphasis was placed on mapping the strata above the Boulder Creek Formation, which resulted in errors in the map published as Open File 1987-6; these errors have now been corrected (Figure 4-6-6).

The Kinuseo project concentrated on the strata above the coal measures to maximize useful information from the resources available.

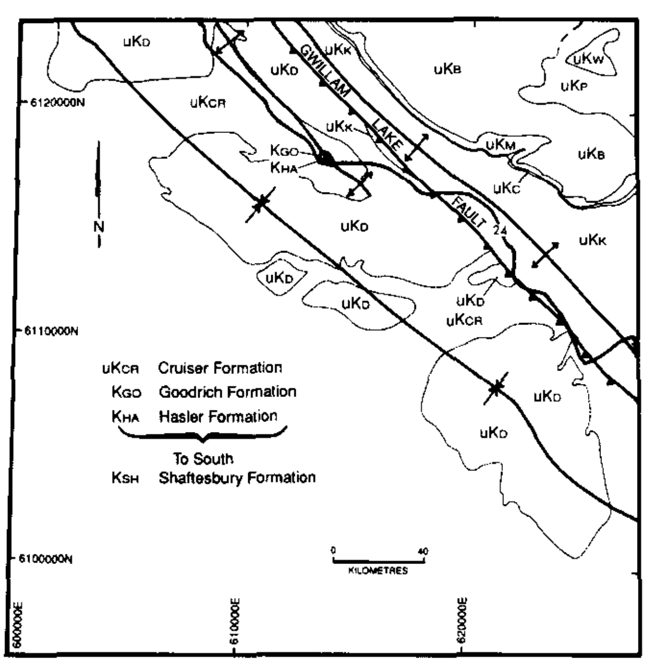

Figure 4-6-6. Eastern portion of the Bullmoose Creek map sheet (93P/3) showing revisions to Open File 1987-6.

Problems with the Bullmoose open file map were detected by the authors as well as coal industry geologists working in the area. We are grateful for the interest and attention paid to the project by these individuals and hope this style of input will continue and result in a superior final geological interpretation.

GWILLAM LAKE FAULT

The Gwillam Lake fault is a regional thrust fault which cuts across the eastern part of the Bullmoose Creek map sheet. D.F. Stott described this structure in 1968. Detailed mapping with a different interpretation of the structure was done by P. Jones in 1959. The authors have adopted the latter interpretation without field evidence of their own. Stott's interpretation was confirmed (Figure 4-6-6) by field data collected during 1987 and a different interpretation of the stratigraphy east of the fault. Along the fault trace on maps 93P/03, 93P/02 and 93I/15, Kaskapau Formation strata form the footwall, and Dunvegan and/or Kaskapau strata are found in the hangingwall. The fault is believed to terminate a short distance south of a road exposure at 6103700N 631000E in the Tumbler Ridge map area (93P/02) and is represented by broad folds in the Kinuseo Creek map area.

SMOKY GROUP STRATA

Open File 1987-6 shows a large exposure of Kaskapau Formation strata east of Bullmoose Creek. This interpretation was consistent with both major compilation sources used: Stott, 1982 and Jones, 1960. Formational thickness calculations, airphoto interpretation and field examination have resulted in a reinterpretation of the interval to include all of the Smoky Group. Cardium, Muskiki, Badheart and Puskwaskau strata are all found on Mount Bergeron. Wapiti strata are also interpreted on the eastern edge of the map sheet (Figure 4-6-6). These upper Cretaceous rocks can be traced through the Tumbler Ridge map sheet, along Tumbler Ridge, to the Kinuseo Creek map sheet where they cover much of the eastern half of the area.

BULLMOOSE THRUST – A FOLDED THRUST FAULT NEAR THE MESA PIT

Placement of the Bullmoose thrust fault through the Mesa pit on Open File 1987-6 drew valid criticism as no large displacement fault had been encountered during the extensive exploration activity in the area. Detailed examination of the area has led to a slight revision of the original interpretation (Figure 4-6-7). It is still felt that the Bullmoose fault runs through the Mesa pit area but not as one discrete fault and with less displacement than in areas to the north. The displacement in the pit area occurs along a large number of minor faults, forming a duplex zone in the coal-bearing Gates Formation. Above the Gates Formation, all the displacement is confined to a narrow fault zone, the Bullmoose thrust fault. This fault is recognized on the Mesa pit access road, a short distance east of the pit, where it is east dipping and displaces the Boulder Creek Formation. Displacement is about 425 metres which corresponds to the sum of the displacements seen along faults such as the Mesa fault zone and Sheriff faults in the Mesa pit. The upper detachment zone of the Mesa pit duplex zone was located below a competent Gates conglomerate unit. As the fault cuts up-section through this conglomerate, it remains a discrete zone with a fault to bedding angle of 30 degrees as it cuts though the Hulcross, Boulder Creek and Hasler formations.

A thin coal seam near the base of the repeated Boulder Creek Formation was sampled on either side of the thrust (Figure 4-6-7). The hangingwall sample had a significantly higher mean random vitrinite reflectance than the sample from the same seam in the footwall ($\bar{R}m$ 1.21 versus $\bar{R}m$ .79). At present the only plausible explanation for this large rank difference is tectonic heating due to the proximity of the hangingwall sample to the fault. However it must be noted that there is a significant maceral difference between the two samples. The higher rank, hangingwall sample is vitrinite rich while the footwall sample is rich in micrinite. More detailed sampling will be required to ascertain the cause of this rank and maceral variance.

COAL OCCURRENCES IN OTHER THAN GATES AND GETHING STRATA

Coal seams were sampled from the Boulder Creek, Dunvegan, Kaskapau and Wapiti formations during the field season.

A basal Wapiti seam outcrops in a roadcut along Highway 52 just east of Quality Creek in the Tumbler Ridge map area. It is 90 centimetres thick and had a $\bar{R}m$ value of .55. At this location the seam contains a 3-centimetre, altered volcanic-ash band or tonstein. X-ray diffraction mineralogical analysis has shown this rock to be kaolinite with a trace of quartz. This locality contains an excellent exposure of the Chungo member of the Puskwaskau Formation.

A 10-centimetre coal seam occurs within the marine shales of the Kaskapau Formation along Bullmoose Creek at 6118300N 615600E. The coal has a $\bar{R}m$ value of .64. Maceral examination showed it to contain vitrinite with about 1 per cent liptinite (sporinite and cutinite), 1 to 2 per cent pyrite, and much less than 1 per cent inertinite. The contacts of the seam are slightly slickensided but it is not thought to be tectonically implaced. The coal possibly originated as a raft of vegetation which was washed out to sea.

Four occurrences of lower Dunvegan coals were sampled. All occurrences are in or near the hangingwall contact with the Gwillam Lake fault in the Bullmoose Creek and Tumbler Ridge map areas. Seam thicknesses ranged from 10 centimetres to 1.5 metres. Mean random reflectance ($\bar{R}m$) values range from .67 to 1.03.

SUMMARY

The foothills within the study area are divisible into inner and outer regions. The inner foothills are characterized by large folds with steeply dipping limbs which expose the Fort St. John Group, including the economically interesting coal measures of the Gates Formation, and older strata. A folded thrust fault has been documented in this zone to the north, in the Bullmoose Creek map area. Strong evidence of tectonic heating associated with faulting is also presented. The outer foothills are characterized by broad open folds with gently dipping limbs. Blind thrust faults beneath the outer foothills area are associated with economically viable gas pools.

The Kinuseo mapping and compilation project will provide 1:50 000 mapping coverage of the 93I/14 and 93I/15 map sheets together with updates to Open File 1987-6. Processing of the large quantity of structural data available for this project is being facilitated by the use of microcomputers. The resulting database will aid further, more detailed studies.

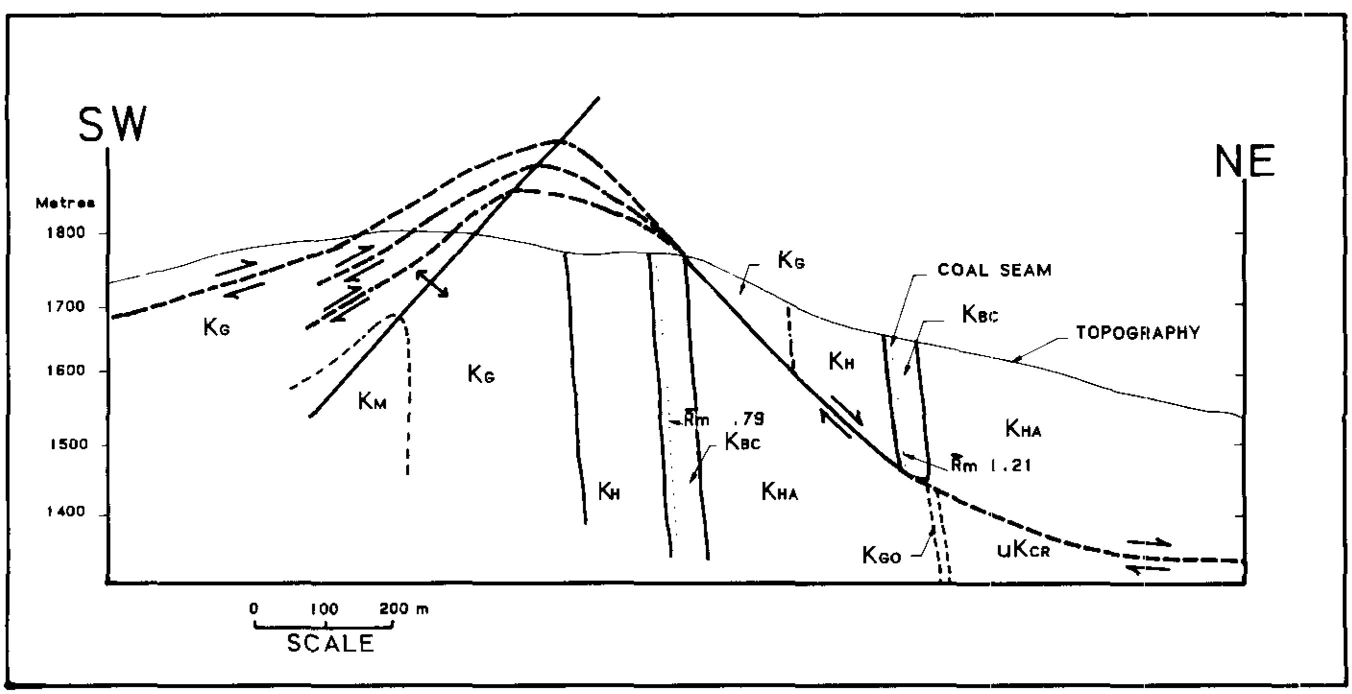

Figure 4-6-7. Cross-section through the Mesa pit area, showing folded thrust fault and Boulder Creek coal sample locations with $\bar{R}m$ values.

ACKNOWLEDGMENTS

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