GEOLOGY OF DUKE AND HONEYMOON PIT AREAS, MONKMAN COAL DEPOSIT, NORTHEAST BRITISH COLUMBIA COALFIELD* (93I/15)

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KEYWORDS: Coal geology, Monkman coal deposit, computer modelling, Minnes Group, Bullhead Group, Fort St. John Group, Smoky Group.

INTRODUCTION

Coal licences were initially acquired on the Monkman property by McIntyre Mines Limited in 1970. Exploration mapping and drilling programs have been conducted over a 17-year period by McIntyre Mines Limited, Canadian Superior Exploration Ltd., Pacific Petroleums Ltd. and Petro-Canada Inc. The Monkman project is a joint venture between Petro-Canada, Mobil Oil Ltd., Smoky River Coal Ltd. and Sumitomo Corporation, with Petro-Canada acting as operator.

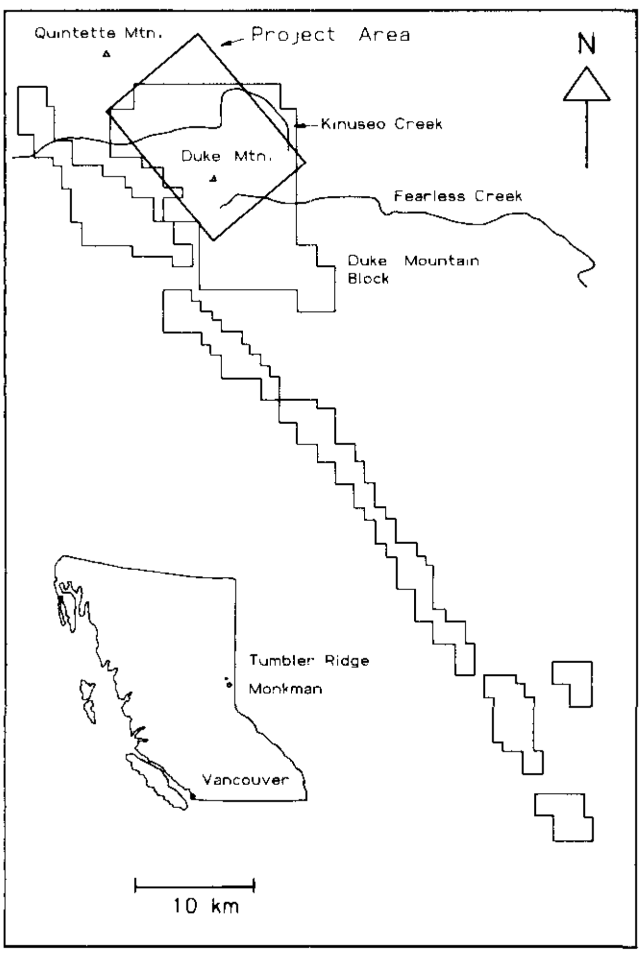

Figure 4-7-1. Study area location map with Monkman property coal licences.

The joint venture group has presented a proposal to the provincial government for an open-pit mine capable of producing 3 million tonnes per year of metallurgical coal. This proposal has obtained Stage II approval. The objectives of the author's project are to provide a detailed geological interpretation of the proposed mine area and to develop a computer-based model of the coal deposit. Information built into the model will be used to calculate coal reserves and stripping ratios. An assessment of the coal deposit will be available to the provincial government at the time that a mining project is initiated at Monkman. Methodology and computer technology developed during this project will be used to model and assess other coal deposits and to assist with the interpretation of structural geology.

LOCATION AND ACCESS

The Monkman coal deposit is located in the southern part of the Northeast British Columbia Coalfield approximately 30 kilometres southeast of the Quintette mine and 35 kilometres southeast of Tumbler Ridge (Figure 4-7-1). The project area covers 140 square kilometres in the inner foothills region of the Rocky Mountains. The Monkman property consists of 169 coal licences which cover 39 587 hectares. The Duke Mountain Block, in which Duke and Honeymoon pits are located (Figure 4-7-2), encompasses 20 745 hectares. Coal licences owned by Petro-Canada mark the northern boundary of the study area and Fearless Creek marks the southern boundary. Kinuseo Creek valley cuts across the northern part of the area. The valley contains up to 100 metres of unconsolidated overburden (Figure 4-7-2) which covers part of the proposed Duke and Honeymoon pits. Elevations vary from 950 metres in the valley floor of Kinuseo Creek to 1742 metres at the top of Duke Mountain. Vegetation ranges from spruce forests to alpine tundra.

Access into the Monkman area is via the Monkman Highway, a dry-weather road which parallels Kinuseo Creek and extends to just west of Kinuseo Falls on the Murray River. The Monkman Highway can be reached by gravel roads from Tumbler Ridge; Elmworth, Alberta; or from Dawson Creek along the Heritage Highway. An airstrip near Thunder Mountain permits access by light plane. Numerous coal exploration roads, petroleum industry access roads and seismic lines provide excellent access to most parts of the project area.

FIELDWORK

Prior to the 1987 field season, all pertinent open file coal assessment reports were examined. Geological maps of the area were used to obtain digitized outcrop information. A computer-based outcrop database was designed to store the

* This project is a contribution to the Canada/British Columbia Mineral Development Agreement.

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

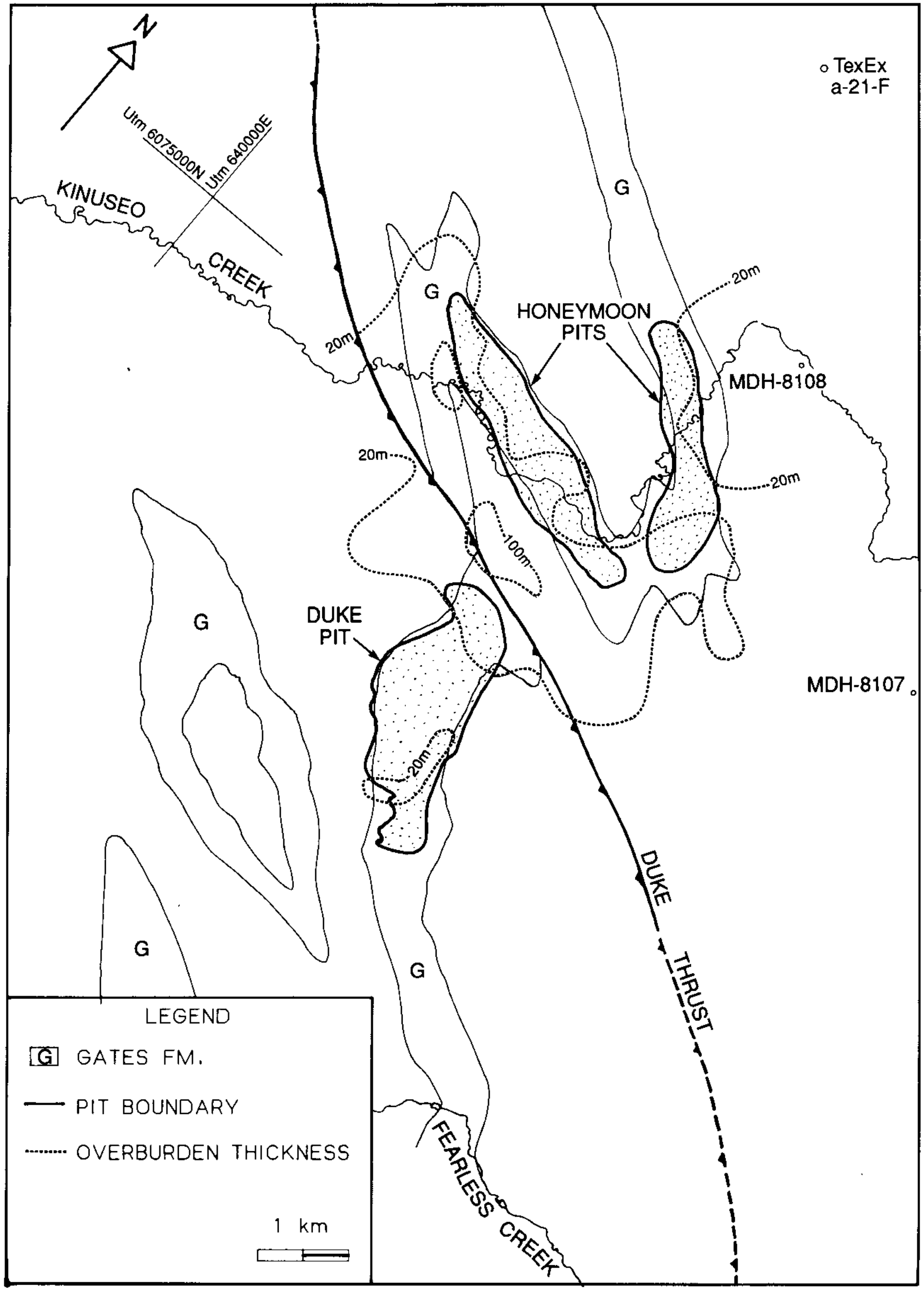

Figure 4-7-2. Subcrop map of the Gates Formation showing unconsolidated overburden thickness and Duke and Honeymoon pits.

information. Once completed, outcrop maps were produced and examined to identify areas which lacked data and to indicate areas with structural complexities or interpretation problems. Subsequent field mapping concentrated on collecting additional outcrop data at these locations and verifying the information over the remaining parts of the map sheet. New data were plotted on topographic maps at a scale of 1:5000. Airphotos at a scale of 1:40 000 were used to produce enlargements at a scale of 1:10 000. Outcrop information was also plotted on the photo enlargements.

Field mapping was conducted in conjunction with mapping carried out by W. Kilby and S. Johnston (1988) on NTS map sheets 93I/14, 93I/15 and 93P/02 at a scale of 1:50 000. Some outcrop data in the southeast corner of the geology map (Figure 4-7-3) is from this source. Information from 1955 outcrop data points and 211 drill holes was examined and incorporated into the geological interpretation.

METHODOLOGY AND DATA HANDLING

Computer-based methods have been used extensively to assist with data handling and display. Orientation parameters describing the geological structural features were calculated using computer-based numerical procedures (Charlesworth *et al.*, 1976).

Cross-sections were constructed by projecting outcrop and drill-hole data down plunge onto planes of cross-section. Assuming that the folded surfaces approximate cylindricity, the data can be reliably projected parallel to the fold axis. Lack of data, or poor distribution of orientations along both limbs and across the hinge zone of a fold, may result in unreliable fold axes orientations. In these cases an appropriate projection axis or fold axis orientation may be obtained by visually best-fitting the data by trial and error, using several different projection orientations.

Thick unconsolidated overburden covers parts of both the Duke and Honeymoon pit areas. Visual best-fit fold axes orientations were determined in these areas.

General data-handling methods are similar to those described by Kilby and Wrightson (1987). Drill-hole data have been incorporated into this study in a computer processible format. Information was divided into primary, secondary and tertiary categories and entered into three independent raw data files. Primary data consist of drill-hole identification, location (easting, northing and elevation), overburden thickness, total depth and original hole orientation measured as the hole trend and plunge. Secondary data consist of drill-hole deviation data entered as the measurement depth, the hole trend and the deviation measured in degrees from vertical. Tertiary data consist of the drilled depths and the identifying names of the horizons of interest. The raw data files were then processed to yield three additional files containing the data in formats ready to be processed or plotted on maps or cross-sections. Primary data for each drill hole are stored as separate records with indexing information used to locate the specific secondary and tertiary data for that hole. Secondary and tertiary data are stored in separate files as eastings, northings and elevations in format ready for posting to maps or cross-sections. Each entry is an independent record. Data points can be referenced and retrieved based upon locational parameters, drill-hole identification, or stratigraphic horizon.

Outcrop data were digitized using a GTCO digitizer connected to a Compaq portable 286 computer. Database maintainance and data processing and display were managed on a Wyse pc286 computer. Peripheral devices included a Houston Instrument DMP-52 plotter and an Epson FX-286e printer.

Database construction and maintainance were performed using the Geological Analysis Package of Cal Data Ltd. Display of the geological data was facilitated by the Structural Analysis module of the Geological Analysis Package, with a number of modifications by the author. Structural analysis of the outcrop data and drill-hole information processing was performed with programs written by the author. Outcrop data were digitized from geological maps using programs written by W. Kilby. Figures were produced using the ECAD computer-aided drafting program.

STRATIGRAPHY

Strata exposed in the area range from the Lower Cretaceous to Jurassic Minnes Group, to the Upper Cretaceous Kaskapau Formation. The stratigraphy in the area has been described extensively by Stott (1968 and 1982) and others. Descriptions of sedimentology and depositional environments are beyond the scope of this study and are not included here. Table 4-7-1 summarizes each formation in terms of a general description and the thickness specific to the Monkman location. Thicknesses and descriptions were obtained from outcrop information, coal exploration drill holes and petroleum industry exploration wells. Texaco Exploration Canada Ltd. drilled an exploration well, TexEx Flatbed a-21-F/93-I-15, in the northeast corner of the map area (Figure 4-7-3). The entire stratigraphic sequence, from the Minnes to the Kaskapau, is penetrated by this hole. Brief descriptions of the stratigraphy follow.

MINNES GROUP

The Minnes Group consists of both marine and nonmarine strata ranging in age from Jurassic to Early Cretaceous. Lithologies include interbedded sandstones, siltstones and shales with minor coal seams.

BULLHEAD GROUP

CADOMIN FORMATION

The Cadomin Formation unconformably overlies the Minnes Group. It is approximately 45 metres thick and consists of two bands of chert and quartzite conglomerate separated by sandstone. The conglomerate framework is poorly sorted and ranges from grit to cobble-size fragments. The Cadomin Formation is easily mappable with prominent ridges often indicating its outcrop.

GETHING FORMATION

Gething strata consist of 140 metres of interbedded sandstone, siltstone, shale and coal. Lenticular conglomerate

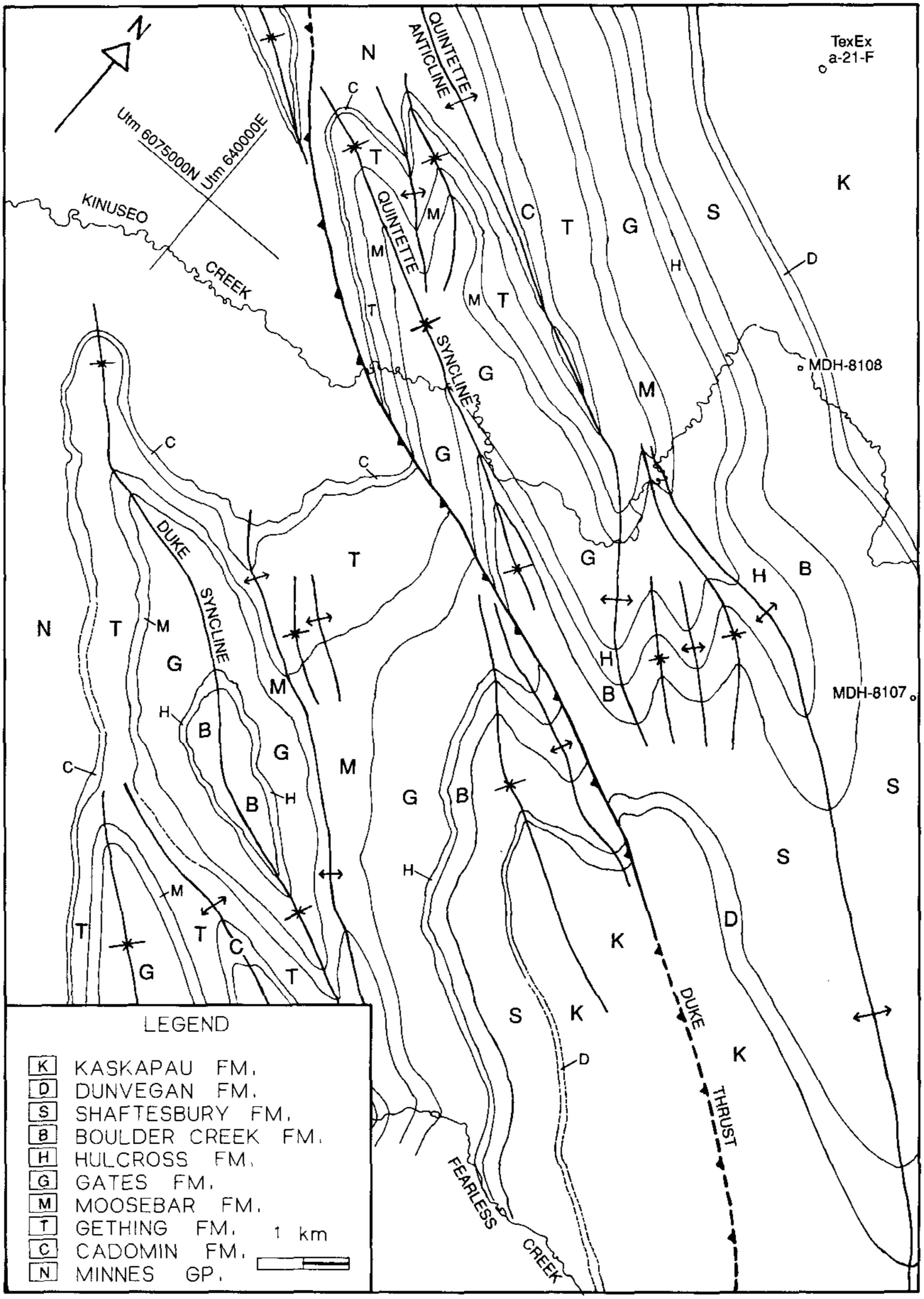

Figure 4-7-3. Geology of the Monkman coal deposit in the Duke and Honeymoon area.

TABLE 4-7-1
STRATIGRAPHIC COLUMN, MONKMAN AREA

SERIES	GROUP	FORMATION	THICKNESS IN METRES	LITHOLOGY
UPPER CRETACEOUS	SMOKY	KASKAPAU	400	Dark grey marine shales; interbedded sandstone and shale in lower part
		DUNVEGAN	30	Non-marine sandstone, some shale and coal
LOWER CRETACEOUS	FORT ST. JOHN	SHAFTESBURY	250	Dark grey marine shale, locally silty with sideritic concretions; minor conglomerate and sandstone. Includes the Goodrich sandstone
		BOULDER CREEK	90	Fine-grained, well sorted sandstone; massive conglomerate; non-marine sandstone and mudstone and coal
		HULCROSS	80	Dark grey marine shale with sideritic concretions
		GATES	250	Fine-grained, marine and non-marine sandstones; conglomerate; coal; shale and mudstone
		MOOSEBAR	120	Dark grey marine shale with sideritic concretions; glauconitic sandstone and pebbles at base, coarsens up, Torrens member at top
	BULLHEAD	GETHING	140	Fine- to coarse-grained, brown, calcareous, carbonaceous sandstone; coal, carbonaceous shale, and conglomerate
		CADOMIN	45	Massive conglomerate containing chert and quartzite pebbles and some sandstone
JURASSIC	MINNES	UNDIFFERENTIATED	1700	Thinly-thickly interbedded, shale, sandstone, siltstone and coals

bands are often found in the lower third of the Gething. In the Monkman area the coal seams are generally poorly developed and are of little economic interest.

FORT ST. JOHN GROUP

Moosebar Formation

The Moosebar Formation is about 120 metres thick. A thin glauconitic conglomeratic band marks the lower contact. This is overlain by bioturbated marine mudstone followed by a series of coarsening-up cycles. The Torrens member, which lies at the top of the Moosebar Formation, is a well-sorted beach sand 20 metres thick.

Gates Formation

The Gates Formation is comprised of approximately 250 metres of interbedded sandstone, siltstone, shale, coal and some conglomerate. Twelve coal seams, identified from oldest to youngest as B1 to B12, are distributed throughout the formation. Well-developed coal seams are present in the Gates Formation from just north of Bullmoose Creek southwards into Alberta.

Potentially mineable coal reserves have been identified in seams B1 to B9 in the Monkman area. Seams B3 and B4 are of most economic interest and constitute the majority of the coal reserves estimated by Petro-Canada in Duke and Honeymoon pits.

Hulcross Formation

Interbedded marine shale and siltstone, with some fine-grained sandstone, make up the Hullcross Formation. It is approximately 80 metres thick.

Boulder Creek Formation

The Boulder Creek Formation compises from 70 to 90 metres of conglomerate, sandstone, siltstone, shale and minor coals. The lowermost 30 metres consist of pebble conglomerate which is overlain by a finer grained interval. The upper 5 metres may be either pebble conglomerate or sandstone.

Shaftesbury Formation

To the northwest, the Shaftesbury Formation is differentiated into the Hasler, Goodrich and Cruiser formations, but these divisions have not been recognized in the vicinity of the Monkman deposit (Stott, 1982). The Shaftesbury Formation may be closely examined with outcrop data in the southeastern quadrant of the map sheet, in coal exploration drill holes MDH-8107 and MDH-8108 and in TexEx Flatbed a-21-F/93-I-15. The Boulder Creek Formation is overlain by 35 to 65 metres of marine shales, silty shales and thin fine-grained sandstones. Above this lies up to 18 metres of marine sandstone. TexEx a-21-F intersects two coarsening-up offshore-bar sandstones which are probably a marine equivalent to the Goodrich Formation. Marine sandstones in a similar stratigraphic position were located at several outcrops. Drill holes MDH-8107 and MDH-8108, however, did not intersect a recognizable sandstone horizon even though they are interpreted to have penetrated the lower portion of the Shaftesbury Formation. The sandstone interval is overlain by about 170 metres of marine shales. The top of these shales marks the top of the Shaftesbury Formation. Discontinuity of the marine sandstone interval makes mapping difficult and prevents division of the Shaftesbury Formation.

SMOKY GROUP

Dunvegan Formation

The Dunvegan Formation consists of 30 metres of argillaceous fluvial sandstones with minor amounts of shale and coal.

Kaskapau Formation

The Kaskapau Formation is comprised of about 400 metres of recessive, dark, marine shales with minor sandstone interbeds near the base.

STRUCTURE

Folds in the Monkman area generally display narrow hinge zones and planar limbs. Major structures are continuous along strike for several kilometres. Along strike the folds are characterized by variations in fold axis trend and plunge. Fold structures tend to die out with abrupt terminations. Duke syncline, Quintette syncline and Quintette anticline (Figure 4-7-3) display these characteristics.

At the north end of the map sheet Quintette anticline has a calculated trend and plunge of 113°/5°. Along strike to the southeast the fold axis orientation changes to 118°/2° and then to 125°/5°. Further south, outcrop data are rare where thick overburden covers Kinuseo Creek valley. Calculated fold axis orientations cannot be determined in this area. Numerous coal exploration drill holes are present in the valley and the continuation of the anticline was examined using these data. Visual best-fit fold axis orientations continue to increase in both trend and plunge to the southeast to maximums of 141°/11°. Rapid but consistent changes in trend, accompanied by an increase in plunge of macroscopic folds, may be indicative of a termination of the fold. Cross-sections further south show no indication of the continuation of Quintette anticline. Fold terminations will be examined in the next field season and outcrop data will be numerically analysed to determine if the folds display conical geometry.

At the northern end of Quintette syncline, the orientation of the fold axis is 121°/20°. To the southeast, the orientation gradually changes to 130°/2°. With the exception of the north end, orientation data are poorly distributed around the syncline.

Outcrop information is abundant along both limbs and across the hinge zone of Duke syncline. Calculated fold axis orientations were determined for four distinct segments or domains along the trend of the structure. At the north end, the fold axis trend and plunge are 313°/0°. The trend and plunge change to 125°/5° in the north-central part of the structure and shallow slightly to 124°/2° in the south-central portion of the fold. At the south end of Duke syncline the fold axis orientation changes dramatically to a trend of 290° and a plunge of 15°.

In the extreme northwest corner of the map sheet Duke thrust fault displaces Minnes strata over the Cadomin Formation in Quintette syncline. The western limb of the syncline is vertical to slightly overturned. Along strike to the southeast the fault cannot be traced by outcrop data, due to the overburden in Kinuseo Creek valley. Drill-hole information indicates continuity of the thrust to the southeast, where it is indicated by the positions of Dunvegan outcrops.

ECONOMIC GEOLOGY

Major economic interest in the area is in the Monkman coal deposit which contains large reserves of metallurgical coal. The deposit has reached an advanced stage of exploration and engineering planning and has received Stage II approval from the provincial government. Further development awaits tightening in the slack world coal markets.

Gas from Mississippian to Jurassic sediments is exploited to the east and north of the study area.

AKNOWLEDGMENTS

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