OVERBURDEN OR QUATERNARY STRATIGRAPHY FIREBAG RIVER; NORTHEASTERN ALBERTA: PRELIMINARY REPORT

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SUMMARY

Requests received have shown a need for information on the overburden stratigraphy in the McMurray oil sand area. The Firebag River is the only place the stratigraphy is well exposed. This report describes the river and preliminary stratgraphic data collected during summer 1982.

The Firebag River flows westward from Saskatchewan through northeastern Alberta to join the Athabasca River north of Fort McMurray.

The eastern quarter of the river flows through high relief, drumlinized terrain, the central portion through undulating moraine and the western quarter through undulating glaciofluvial terrain.

The Firebag River is about 160 km long and falls from about 550 m in Saskatchewan to about 225 m at the Athabaska River. Channel character is meandering except for a short central segment through wetlands where it is relatively straight. The incised alluvial plane increases downstream from 3 to 30 m deep and from 0.5 to 3 km wide.

About 27% of the precipitation leaves as surface runoff; annual extremes of discharge, measured near the mouth, range from 201 m3/sec daily maximum to 4.2 m3/sec daily minimum. Observations by the authors indicate river level varied from 2 to 4 m during spring of 1982 and 0.1 to 2 m during the summer. The river bed is armoured with cobbles and boulders; sand is present mainly at the junction with tributary streams and on point bars. During 1982, about 60% of the lower 2/3 of the river was choked with aquatic vegetation.

Within Alberta, the Firebag River flows first over subcrops of the Clearwater Formation and downstream of this subcrops of the McMurray Formation, the Waterways Formation and other undivided Devonian strata.

The overburden stratigraphy is exposed on the lower two thirds of the river section and the central third was examined. Seven stratigraphic units have been recognized in the field on the basis of their texture, structure, bitumen content, colour and stratigraphic position.

The units and their most diagnostic properties are, starting from the base: Unit 1 – silty sand till, black in colour; Unit 2 – silty sand till with a strong bitumen odor and appearance; Unit 3 – silty sand till with no bituminous odor or appearance; Unit 4 – sand till with no bituminous odor or appearance; Unit 5 – medium to fine grained sand; Unit 6 – Pink sediment; Unit 7 – sand with minor gravelly sand layers.

Unit 2 is correlated with Unit B of Fenton and Dreimanis (1976) and the Firebag Till of McPherson and Kathol (1977). No other correlations are presently possible.

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INTRODUCTION

Background

Requests received by the staff of the Quaternary-Environmental Section of the Alberta Geological Survey have shown a need for information on the overburden stratigraphy in the McMurray oil sand area. A few observations by the first author during the mid 1970°s have shown a similarity between some of the units in the McMurray area and along the Firebag River. This, combined with the fact that the Firebag River is the only place the overburden stratigraphy is well exposed, initiated this project.

The purpose of the study is to obtain information on (1) the overburden or Quaternary stratigraphy to the top of the McMurray Formation and (2) the nature of the Firebag River itself.

The purpose of the report is to describe the river and preliminary stratgraphic data collected during summer 1982.

The Firebag River lies within the boundaries of the Bitumount map sheet Alberta and the Lloyd Lake map sheet Saskatchewan (Figure 1, and NTS 74E and 74F) and flows westward to join the Athabasca River.

The eastern quarter of the river flows through high relief, rolling, drumlinized terrain (Bayrock, 1971). The central portion flows through low relief, gently undulating terrain, originally called outwash (Bayrock, 1971) but later identified as moraine (Bayrock and Reimchen 1974). The western quarter is situated in low relief gently, undulating glaciofluvial sand and gravel (Bayrock, op. cit.).

The vegetation consists of a narrow band of 25 to 30 m tall spruce adjacent to the river beyond which are highlands covered by predominantly jackpine and minor poplar alternating with muskeg filled lowlands. Much of the terrain has been repeatedly burned by forest fires.

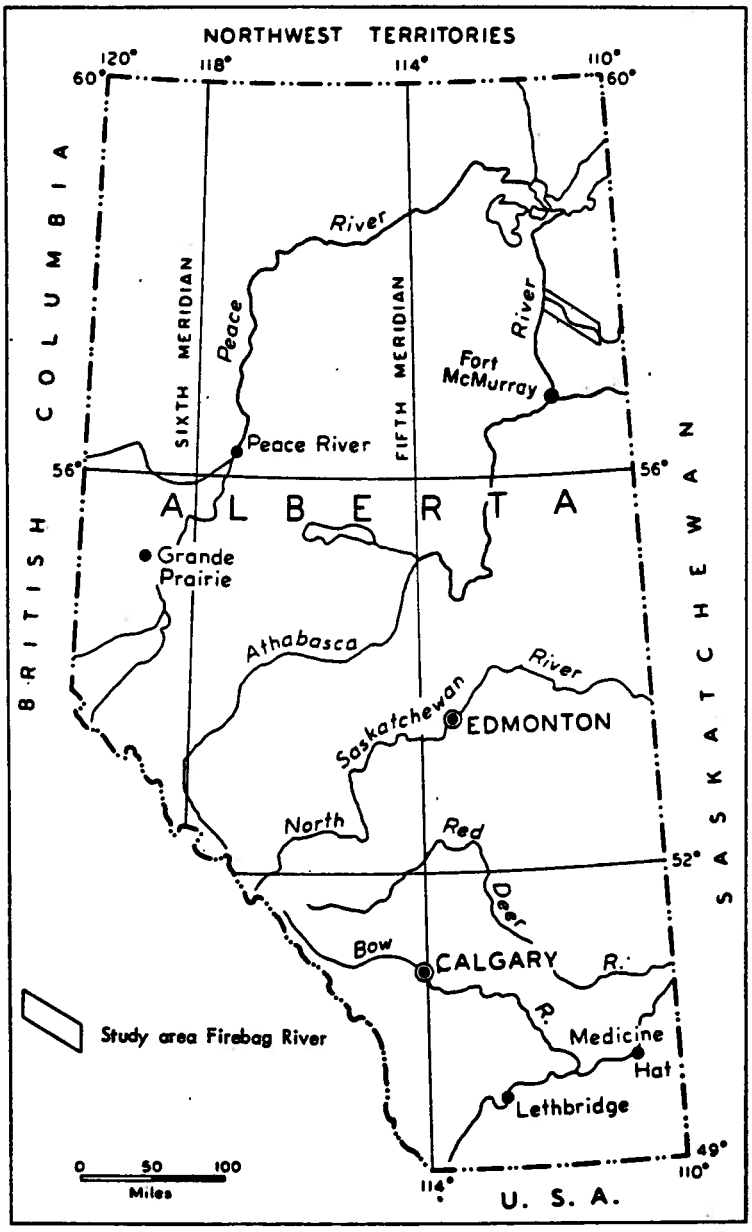


Figure 1. Location of Firebag River study area northeastern Alberta.

NATURE OF THE RIVER

The Firebag River is about 160 km long. The river rises in Saskatchewan at about 550 m and enters the Athabasca at about 225 m with an average gradient, within Alberta, of 2.66 m/km. The character is predominantly meandering except in Tp 95 and 96 R 3W4 where the river flows through wetlands and the channel is relatively straight. The Firebag has incised most of its channel forming an alluvial plain (Bayrock, 1971) 3 to 10 m below the surrounding land surface in the upper reaches and 15 to 230 m below in the lower reaches. The plain varies from about 0.5 km wide in the central part to 3 km wide near the mouth (Bayrock, 1971).

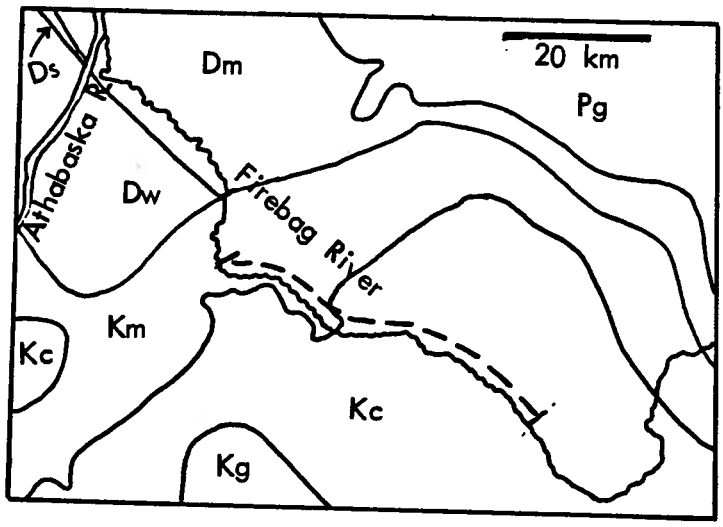
Between 1971 and 1981 about 27% of the estimated precipitation left the Firebag River basin as surface runoff (Hudson, 1982). Annual extremes of discharge measured occasionally at a station near the mouth range from 201 m3/sec maximum daily discharge (16 May, 1981) to 4.2 m3/sec daily minimum (25 October, 1981 in Hudson, op. cit.).

The bed of the river is armoured with cobbles and boulders of Athabasca sandstone, carbonate, igneous and metamorphic rock. Sand is present mainly where other streams feed into the river and on point bars. During the summer of 1982 subaqueous vegetation up to 2 m in length that covered much of the bottom, with the exception of the deeper pools of the meander bends, made downstream progress in the Zodiac boat nearly impossible. Observations from helicopter suggest that about 60% of the part of the river studied was choked with these weeds growing in water from 30 cm to more than 1.5 m deep.

River level varies from 2 to 4 m during spring runoff, based on height of ice scour and driftwood, to 0.1 to 2 m during the summer. Deep pools († 3 m) are present at the meander bends with shallow reaches between the bends. The bottom of the shallow reaches consists of alternating longitudinal channels and ridges about 1 m wide and 3 to 10 m long. Ice scour during the spring removed the bark from trees growing on the flood plain up to a height of 1.3 m.

BEDROCK GEOLOGY

Within Alberta the Firebag River flows first over subcrops of the Clearwater Formation and, downstream of this, subcrops of the McMurray and Waterways Formation and undivided Devonian strata (Fig. 2). With the exception of the McMurray these formations are below river level and not exposed. The undivided Devonian strata consist of limestone, gypsum and anhydrite and the Waterways Formation of limestone and argillaceous limestone. The McMurray Formation , consists of oil impregnated quartzose sandstone and silty shale, and the Clearwater Formation of dark gray silty shale and siltstone (Carrigy and Green, 1965).



Study area 1982 ⊢—–⊣

Bedrock Geology

CRETACEOUS

Kg Grand Rapids Formation: Fine grained sandstone, siltstone and shale

Kc Clearwater Formation: dark gray silty shale, siltstone

Km McMurray Formation: quartzose sandstone, siltstone; oil impregnated

DEVONIAN

Dw Waterways Formation: argillaceous limestone and gray shale

Ds Slave Point Formation: grey and brown limestone dolomitic limestone

Dm Middle Devonian (undivided): includes brown dolomite, gypsum, anhydrite

PRECAMBRIAN

Pg Granitic plutonic rocks

From M. A. Carrigy and R. Green, 1965

Figure 2 showing the portion of Firebag River surveyed in 1982 and the bedrock geology of the area.

QUATERNARY STRATIGRAPHY

The overburden stratigraphy is exposed in a number of geologic sections as far upstream as Tp 96 R 3W4. One third of the river downstream of S 13, Tp 95, R 3 was examined completely by moving downstream in a boat. The portion downstream to about S 33, Tp 98 R 7 was surveyed using a helicopter to land at the best exposed sections and overflying the remaining portions of the river. The geologic sections downstream of the point will be examined next year.

Seven stratigraphic units have been recognized in the field on the basis of their texture, structure, bitumen content, colour and stratigraphic position.

Starting from the base they, and their most diagnostic property, are (1) till black in colour; (2) till with a strong bitumen odor; (3) till similar to (2) but without a bitumen odor; (4) till composed mainly of sand (in contrast to Unit 2 and Unit 3); (5) sand; (6) silt and clay with a pink colour and (7) sand.

Unit 1: Silty sand till, black in colour. Little is known about this unit because it is inaccessible in the first geologic section because the section is nearly vertical and almost inaccessible in the second because of a thick cover of colluvium. In the first section, where this unit is well exposed, the contact with the underlying McMurray Formation and the overlying bituminous till are both sharp. Unit 1 is less than 1.5 m thick.

Unit 2: Silty sand till with a strong bitumen odor and appearance. Colour is grayish brown to olive brown on a fresh surface. Well developed joints are generally iron stained to a depth of about 3 m from the top of the unit. Joints separate till into shards 2 to 5 cm on a side. This unit, which is the most common till unit, is exposed in about one half of the section.

The basal contact with Unit 1 or the McMuarry Formation is sharp. In one section the lower metre of this till contains fragments of pink coloured silt and clay. The upper contact with Unit 3 is sharp. Unit 2 ranges in thickness from 0 to 15 m in thickness.

Unit 3: Silty sand till with no bituminous odor or appearance. Well developed joints divided the till into shards 2 to 5 cm on a side. Colour is dark grayish brown to olive brown on a fresh surface. The contact with unit 2 is generally marked by a layer of sand. The contact with unit 4 is sharp. Thickness of Unit 3 ranges from 0 to 9 m.

Unit 4: Sand till with no bituminous odor or appearance. Massive with only a few poorly developed horizontal joints. Colour is dark grayish brown to grayish brown on a fresh surface. The till forms dry vertical

faces that are very hard. In places, sand lenses are present in the lower metre.

Unit 4 is recognized in only two sections. The lower contact is sharp with silty sand till of unit 3 in the first section. The lower contact is interlayered with sand and silt in the second section. The upper contact is a pebble lag at the base of sand in the first section and a sharp contact with pink silty clay in the second section.

Unit 5: Medium to fine grained sand. The sand is clean (free of silt and clay), well sorted, and clast free except for a boulder lag at base. The upper contact, with the overlying sediment of Unit 6, is sharp. Unit thickness varies from 0 to 2 m.

Unit 6: Pink sediment. In the upstream half of study area this unit is generally clay to silty clay that is less than a metre thick. The easternmost section, however, is interbedded clayey, silty sand and silty sand.

In the downstream portion, unit 6 is more variable in both thickness and composition. The unit ranges from 0 to over 10 m thick and includes layers and irregular masses of grayish brown silt and fine grained sand.

Unit 7. Sand with minor gravelly sand layers. The sand is generally medium grained and clean. In downstream sections cross beds of reworked oil sand fragments are present. This unit is less than 2 m thick in the upsteam half of the area and 10 to 15 m thick in the downstream portion.

Lower contact is generally covered by thick colluvium. Where visible, it is sharp and in one section marked by a gravel filled channel. The upper surface is usually a gravel lag.

CORRELATION WITH PREVIOUS WORK

Unit 2, the " bitumen till", is correlated with Unit B of Fenton and Dreimanis (1976) and the Firebag Till of McPherson and Kathol (1977). No other correlations are presently possible.

FUTURE WORK

The authors will be returning to the Firebag River during the summer of 1983 to describe and sample the sections on the downstream third of the river. Also the stratigraphically more significant sections examined last year are to be revisited to collect detailed information and to try and sample the less accessible portions of these sections. The laboratory analyses on all samples must be completed.

This data will be incorporated in the final stratigraphic synthesis and report.

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