MAR 19690075: NORTHEASTERN ALBERTA

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SUMMARY REPORT
PHOTOGEOLOGICAL STUDY
WITH INTEGRATED AEROMAGNETIC DATA

ATHABASCA RIVER AREA
NORTHEASTERN ALBERTA

prepared for

ATLANTIC RICHFIELD COMPANY

prepared by

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MARCH, 1969

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

ROBERT H. FRANTZ, Consulting Geologist

SUMMARY REPORT of PHOTOGEOLOGICAL STUDY WITH INTEGRATED AEROMAGNETIC DATA ATHABASCA RIVER AREA NORTHEASTERN ALBERTA

INTRODUCTION

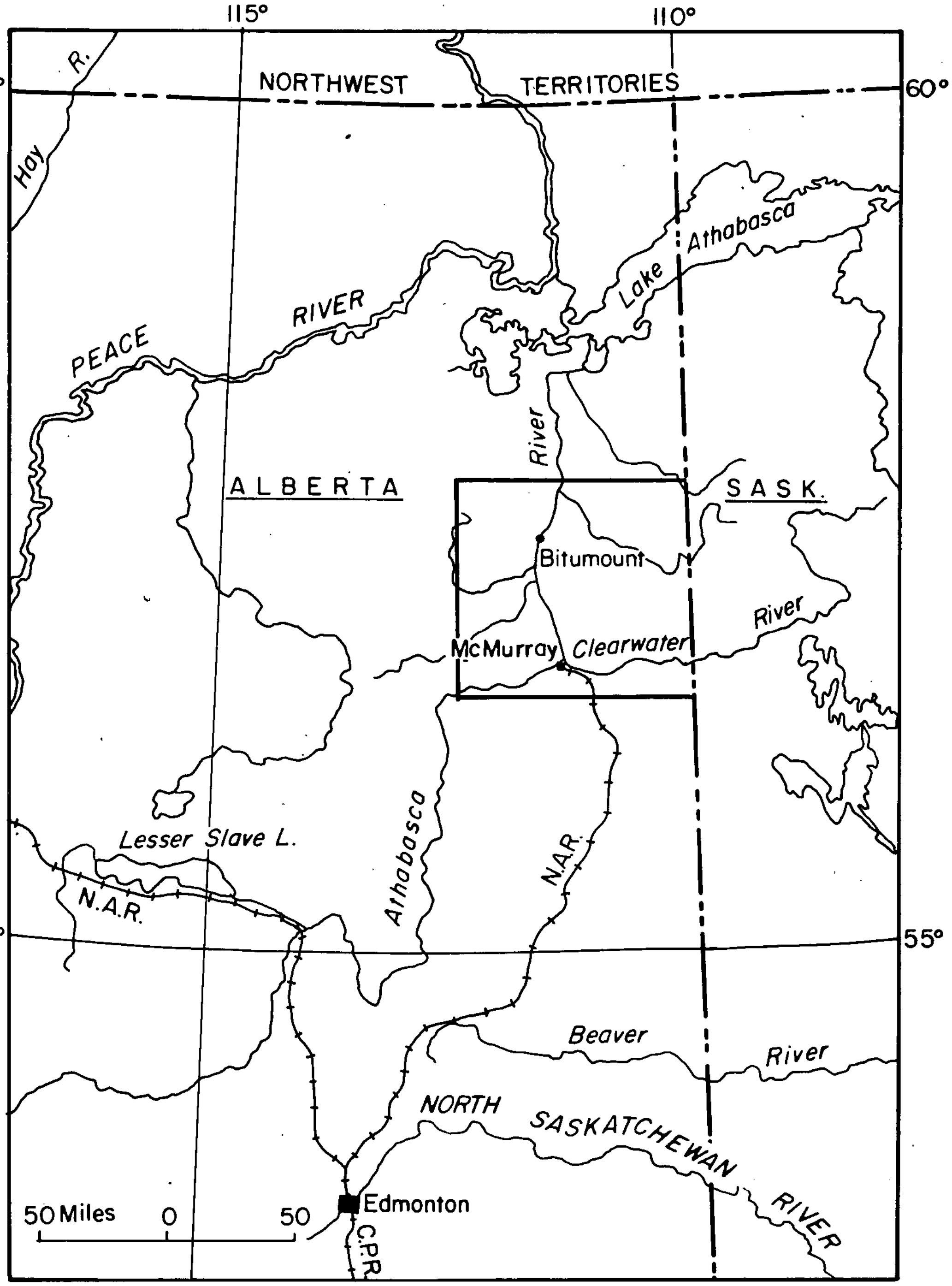
This report presents the results of a combined photogeological, geomorphic and aeromagnetic study of the Athabasca River Area, Northeastern Alberta.

The project was authorized by Mr. J. S. MacDonald acting for Atlantic Richfield Company hereinafter referred to as The Company.

The project area is shown on the Index Map, Figure 1 on page 2 of the report. It comprises all of Townships 88 through 101; Ranges 1 through 16 west of the Fourth Meridian; and includes the Company's permits Alb 1663 through 1669.

The objectives of the project were to delineate by Photogeologic, geomorphic and aeromagnetic methods, any structural and stratigraphic features related to salt collapse and to outline possible surface exposures of salt or sulphur.

The work was conducted by Robert H. Frantz, P. Geol., Consulting Geologist.



INDEX MAP
showing
PROJECT LOCATION

Fig. 1

MAPPING TECHNIQUES

Detailed photogeological and geomorphic information was delineated on the aerial photographs and transferred to a work base.

Important structural features were then selected from the work base.

Important structural features were then transferred to the mosaic overlays.

The selection of important features included the grouping of many minor folds into fold swarms. Numerous other anticlines and synclines which did not belong to any particular fold swarm were mapped separately.

These structural features were then compared with the available aeromagnetic data and correlations or partial correlations were noted. Generalized structural form lines depicting culmination and depression of fold axes were added to this.

The folds, fold swarms, aeromagnetic correlations and generalized structural form lines are shown on Figure 2 and sheets 1 through 9.

The fractures used were selected on the basis of a 'herringbone' pattern which appears to dominate in the area. Interpreted positive and negative areas common to this fracture system together with key fractures and faults and aeromagnetic correlations are shown on Figure 3 and sheets 1 through 9.

Published fold axes and formation boundaries, the latter in some instances modified were incorporated in to the project and appears on Figures 2 and 4 and sheets 1 through 9.

Features or areas interpreted to be common to sulphur deposits were derived from the data of Figures 2 and 3 and sheets 1 through 9. These features and their relationship to The Company Holdings are shown on Figure 4.

The positive structural areas and hinge lines are shown on Figure 5. The features define the areas of least structural collapse.

The project area is to a large extent mantled. Considerable geomorphic interpretation was used. Scattered exposures of bed rock do, however, exist throughout the area and much of the interpreted data was projected from outcrops where features could be delineated.

GEOLOGICAL SETTING

The project area lies along the east flank of the Western Canada Sedimentary Basin. It also lies within the Elk Point (Evaporite) Basin as restricted to the Middle Devonian Period.

The general slope of the Precambrian surface is approximately 23 feet per mile to the west and southwest.

A west dipping wedge of Devonian and possible older strata rests unconformably on the Precambrian erosion surface. This wedge may also have been influenced by the Tathlina High to the northwest and the Peace River Arch to the southwest. Some thinning of Middle Devonian strata toward these anomalous areas may be anticipated.

Within the area the Middle Devonian comprises Elk Point Group undivided; the La Loche Formation as restricted to the Clearwater River Valley; and the Devonian Waterways formation. The latter is made up of the Firebag, Calumet, Christina and Moberly members.

To the west, Devonian rocks are truncated and progressively overlapped by the Lower Cretaceous strata. The Lower Cretaceous is comprised mainly of the 'lower' beds of the McMurray Formation. These beds are of fluviatile origin. Air photo evidence indicates an unconformity and possible presence of 'upper' McMurray beds approximately 20 miles west of Fort MacKay. Numerous small folds, terraces, faults and fractures are present. (Fig. 2) The folds at first, appear heterogeneous in plan, but on close inspection a definite pattern does evolve. Large areas of structural culmination and depression accompany the fold pattern. (Fig. 5)

Local hinge lines are also present. (Fig. 5) These hinge lines are based on the pattern of minor folds. They indicate a broad east-west trending trough, or subsidence centering near the settlement of Bitumount. This trough is complicated by a local positive area north and east of Bitumount.

Both pre-McMurray and post-McMurray folding is indicated. In the northeastern part of the project area, folds within the Precambrian parallel those within the Middle Devonian. The Middle Devonian folds in the same area are in turn parallel to those of the Lower Cretaceous. This may be due to draping of Palezoic beds over structurally evolved topography of the Precambrian or to post-McMurray folding which also affected the basement rock. Devonian folds on the Clearwater and Athabasca Rivers have been truncated prior to McMurray deposition. They are, however, at least superficially, parallel to the unconformity seen on exposures along the Athabasca River. The indication here is that post-McMurray folds may be due in part to draping over a structurally controlled pre-McMurray erosion surface.

A dominant 'herringbone' fracture pattern is interpreted for the area. (Fig. 3) This fracture pattern indicated broad northerly trending structurally positive and negative features. These structural trends appear to culminate south of the project area and depress in the vicinity of the north project boundary. The south culmination may be structurally controlled by the Peace River Arch.

The mechanics of folding, faulting and fracturing is probably related to both draping over Precambrian structurally controlled topography and to removal by solution of salts of the Elk Point Group.

STRATIGRAPHY

Recent detailed stratigraphic information relating to the project area has been presented by A. W. Norris, 1963, (1)., L. P. Tremblay, 1960, (2)., and C. E. B. Conybeare, 1966, (3). Repetition of this data is not deemed necessary for this summary report.

In some instances the formation boundaries have been arbitrarily modified from those shown by Norris, (Fig. 3). Memoir 313 and Tremblay, 1960. These modifications were made so that the formation boundaries would conform more closely to the structural configuration as interpreted on the aerial photographs. The major modifications occur on those boundaries present in the northeastern part of the area.

The Table of Formations on the following page is taken directly from Memoir 313.

(1) Memoir 313, Devonian Stratigraphy of Northeastern Alberta and Northwestern Saskatchewan, Geological Survey of Canada, 1963.
(2) Map 16, 1961. Geology; Firebag River Area Alberta and Saskatchewan
(3) Origin of Athabasca Oil Sands, Bulletin of Canadian Petroleum Geology; Vol. 14, No. 1 March 1966.

TABLE OF FORMATIONS *

Era	Period or epoch	Formation and thickness (feet)	Member and thickness (feet)	Lithology
Mesozoic	Lower Cretaceous	McMurray		
		Unconformity		
Palaeozoic	Upper Devonian	Waterways 702	Mildred[2] 140[1]	Argillaceous limestone and shale
			Moberly 200± [1]	Clastic limestone, argillaceous limestone, and some shale
			Christina 90± [1]	Argillaceous limestone, limestone, shale, and some sandy limestone, and sandstone
			Calumet 102± [1]	Resistant fine-grained and clastic limestone, argillaceous limestone, and some shale
			Firebag 170± [1]	Shale and argillaceous limestone
		?Unconformity		
	Middle Devonian	Livock River 5.5-?13[1]		Limestone, some dolomite, in places brecciated and associated with shale
			Unconformity	
		Elk Point Group: First Salt[2] ?0-777+		Anhydrite, rock salt, dolomite, siltstone, and shale
		Elk Point Group: Methy 110+		Dolomite, calcareous dolomite, minor gypsiferous dolomite; in part brecciated
		Elk Point Group: McLean River 60+		Shale, sandy and silty shale, dolomite, sandy and calcareous dolomite
	Middle Devonian or earlier	La Loche 3+ 19-95[1]		Arkosic sandstone, gritty conglomeratic sandstone, some anhydrite and gypsum, and minor dolomite
		Unconformity		
Precambrian				

[1] Thickness in subsurface
[2] Not exposed

* From Memoir 313
Devonian Stratigraphy of Northeastern Alberta and Northwestern Saskatchewan
A.W. Norris
1963

PHOTOGEOLOGIC - AEROMAGNETIC CORRELATION

The majority of the data presented on the photogeologic maps are represented by a variety of indicators on the aeromagnetic maps.

Those structural features having good or partial magnetic correlation are indicated on the photogeological maps (Sheets 1-9)

Features with good magnetic correlation are in complete or nearly complete agreement with aeromagnetic data.

Features having partial magnetic correlation are, in general, reliable indicators; but are, in some instances, of a subtle nature.

Surface geologic and aeromagnetic data indicate that many structural features present at the surface continue to basement ; or, at least, coincide with structural features of the basement. The surface structural features although represented by magnetic indicators do not always represent the dominant trend of the aeromagnetic maps.

SULPHUR OCCURRENCES

In the Northwest Territories and northeastern Alberta sulphur is known to occur as deposits around springs and gas seeps especially in the Devonian; and in the vicinity of fault zones; or areas of intense fracturing. It occurs as stringers, beds, and cavity infillings in various types of rocks. It also occurs as disseminated sulphur in shale.

The Elk Point evaporite deposits of the Middle Devonian contain large quantities of calcium sulphate and salt beds. It is considered to be the principal source of the sulphur.

CONCLUSIONS

Sulphur in aqueous solution is presumed to have migrated along major fractures and faults either to be trapped by impervious beds or be deposited at the surface.

Subsurface sulphur deposits can be anticipated especially where impervious rocks are present to act as a trap for ascending solutions. A barrier of this type is probably present within the project area where Cretaceous siltstones and shales unconformably overlie, truncated Devonian rocks.

Areas in the vicinity of collapse structures where both salt and anhydrite are present in the subsurface are considered to be particularly favourable for the accumulation of sulphur. Here salts in solution may react chemically with calcium sulphate under conditions of low electro-chemical voltage and a low pH factor to form free sulphur and calcite.

The presence of Elk Point evaporites overlain by impervious shales of the Cretaceous in the vicinity of an area of structural collapse provides the key for determining those areas most favourable for the accumulation of sulphur deposits in the sub-surface.

The Composite Map of Areas of Interest (Fig. 4) shows the areas of greatest structural collapse with respect to those depressions directly related to the plunge of folds. It also depicts areas of collapse related to faults and fractures.

Fig. 5, Positive Structural Areas and Hinge Lines, defines the areas of least structural collapse as based on culminations related to the fold pattern. It also defines a broad east-west trending area of collapse based on the presence of local hinge lines.

The Company Holdings are shown on Figures 4 and 5. Their relationship to conditions favourable for sulphur deposition from aqueous solution is shown in the table on the following page.

All of the Company Holdings lie in areas which appear favourable for the deposition of sulphur from solution.

The Permits relative one to another can be graded using criteria from the table on the following page. 4.0 relates to a maximum favourable condition for sulphur deposition.

Permit Alb. 1663 - 3.6
Alb. 1664 - 4.0
Alb. 1665 - 2.4
Alb. 1666 - 2.6
Alb. 1667 - 3.0
Alb. 1668 - 3.6
Alb. 1669 - 2.6

Another excellent area within the project but not a Company Holding includes Township 97, Range 11 and Township 98, Ranges 11 and 12 West of the Fourth Meridian.

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Robert H. Frantz, P. Geol. (Alta.)
[redacted]

Date March 25, 1969

TABLE FOR GRADING OF COMPANY HOLDINGS
based on data presented on Figures 4 and 5

Conditions favourable for Sulphur deposition	Permit No. Alb. 1663	Alb. 1664	Alb. 1665	Alb. 1666	Alb. 1667	Alb. 1668	Alb. 1669
1. Depression or flank of depression formed by reverse plunge of fold axis. A Depression (collapse area) B Flank of depression.	A & B 4	A & B 4	B-1	B-3	A & B 2	B-2	A-2
2. Depression or flank depression formed by hinge lines. A Depression B Flank of depression.	B - 2	A - 4	A - 2	A - 3	B - 2	A - 2	B - 2
3. Depression or flank of depression formed by fault and fracture pattern. A Depression B Flank of depression.	A & B 4	A & B 4	B - 3	B - 2	A - 4	A - 4	B - 3
4. Presence of areas of intense fracturing.	4	4	2	1	3	4	2
5. Presence of Elk Point evaporites in the subsurface overlain by impervious shales of the Lower Cretaceous (includes the presence of numerous ponds springs and sink holes at the surface for permit 1665.).	4	4	4	4	4	4	4
Total Points	18	20	12	13	15	18	13
Average of Point	3.6	4.0	2.4	2.6	3.0	3.6	2.6

Permits graded by a relative point system. 4.0 is maximum.

CERTIFICATE OF QUALIFICATION

I, ROBERT H. FRANTZ, of the City of Calgary, in the Province of Alberta, Hereby Certify:

1. That I am a consulting geologist actively engaged in both petroleum and mining exploration.

2. That I am a graduate of the University of New Mexico, Albuquerque, New Mexico (1951) in Geology with a minor in Engineering, and have been practicing my profession for the past seventeen years, and that I am a member of the Professional Engineers of Alberta.

3. That I have no direct or indirect interest in the properties of Atlantic Richfield Company in the Alb. Permits Nos. 1663 through 1669 in the Athabasca River Area of Northeastern Alberta and which property is the subject of my report dated March 25, 1969, nor do I expect to receive any interest either directly or indirectly in the property nor in the securities of the company holding this property.

4. That the accompanying report dated March 25, 1969 is based on a photogeological interpretation, conducted by myself, of the property.

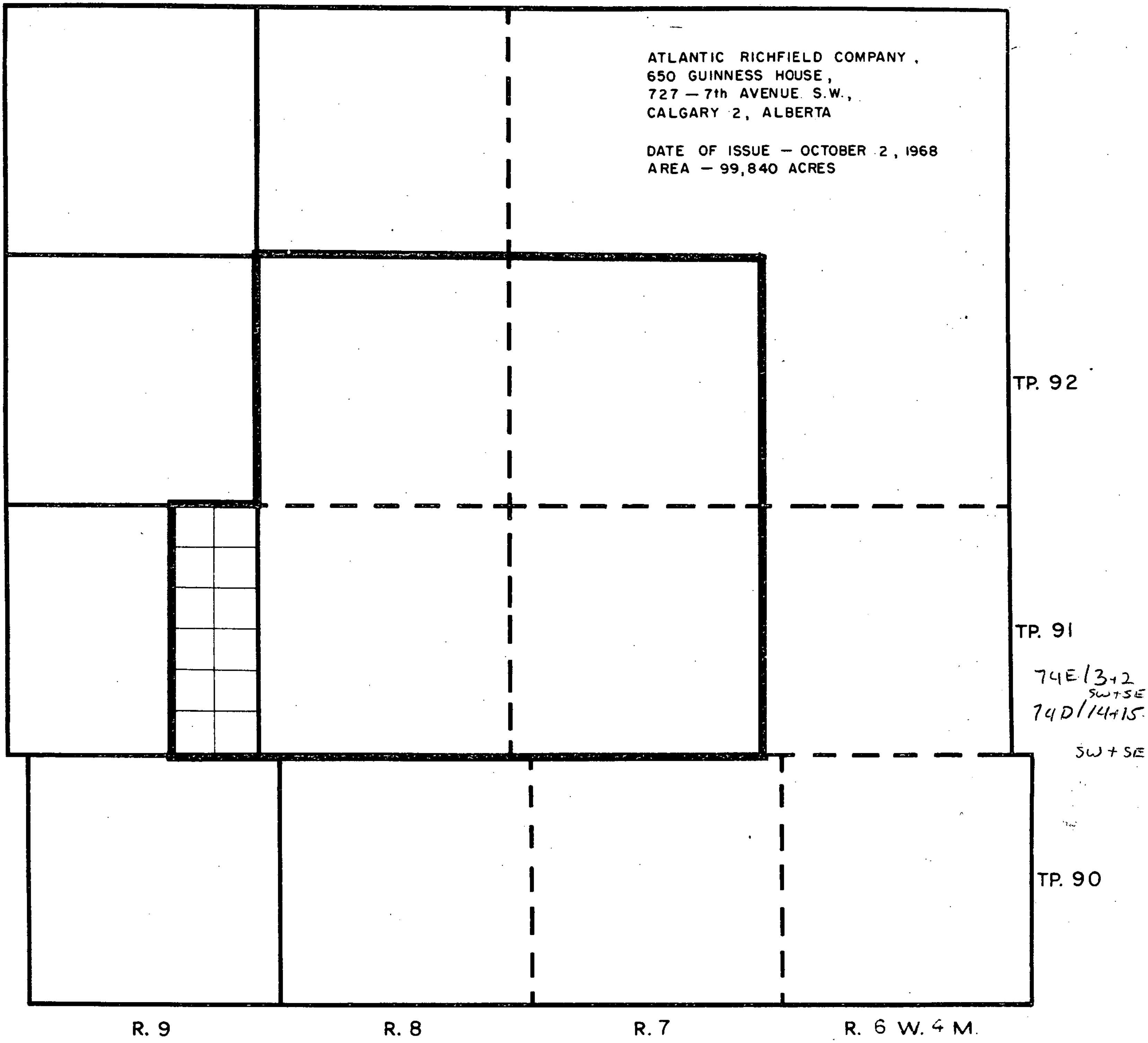
ROBERT H. FRANTZ, P. GEOL.

[redacted]

100 Glacier Drive S.W.
Calgary, 8, Alberta.

March 25, 1969

SULPHUR PROSPECTING PERMIT No. 194



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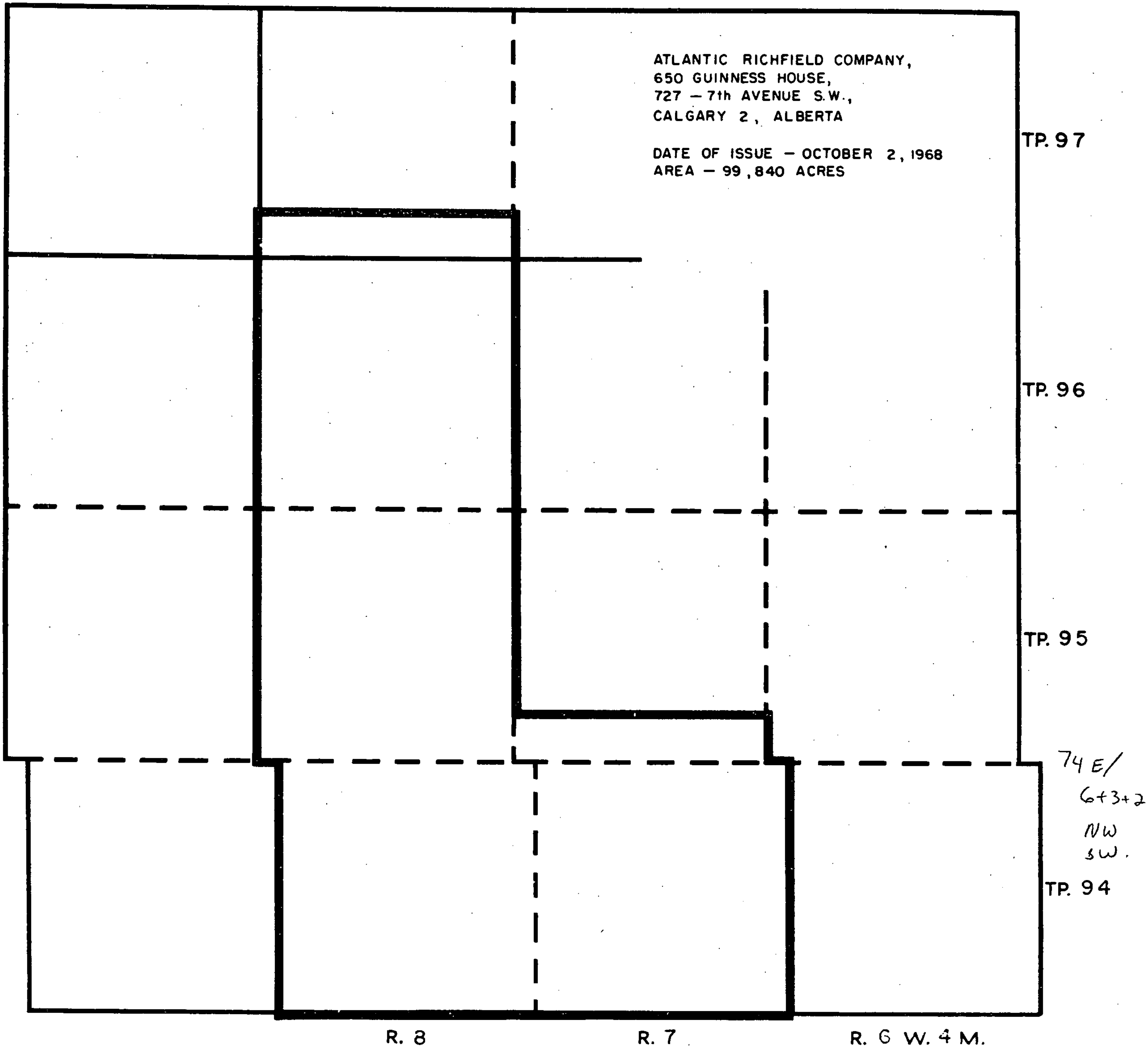

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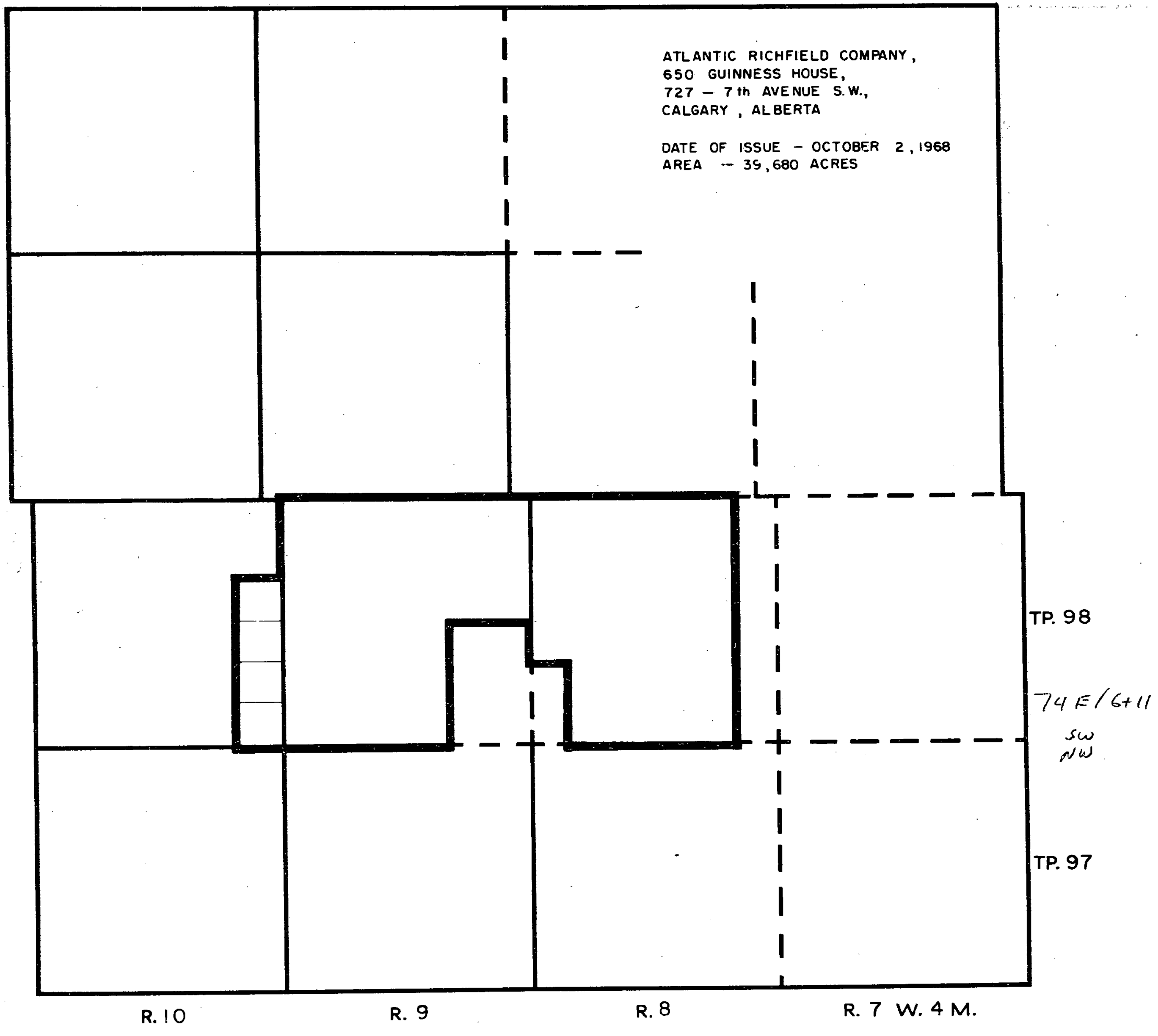

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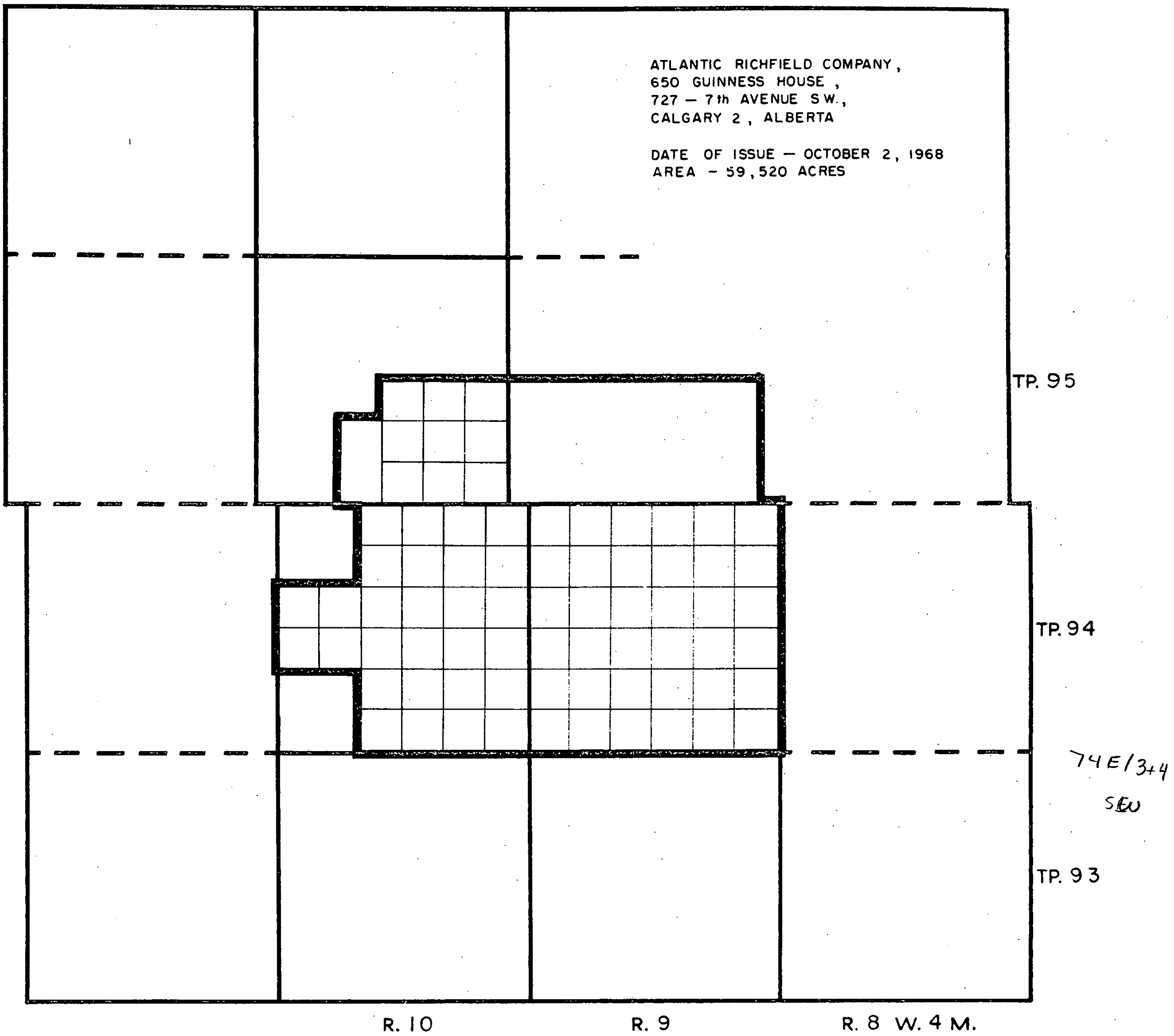

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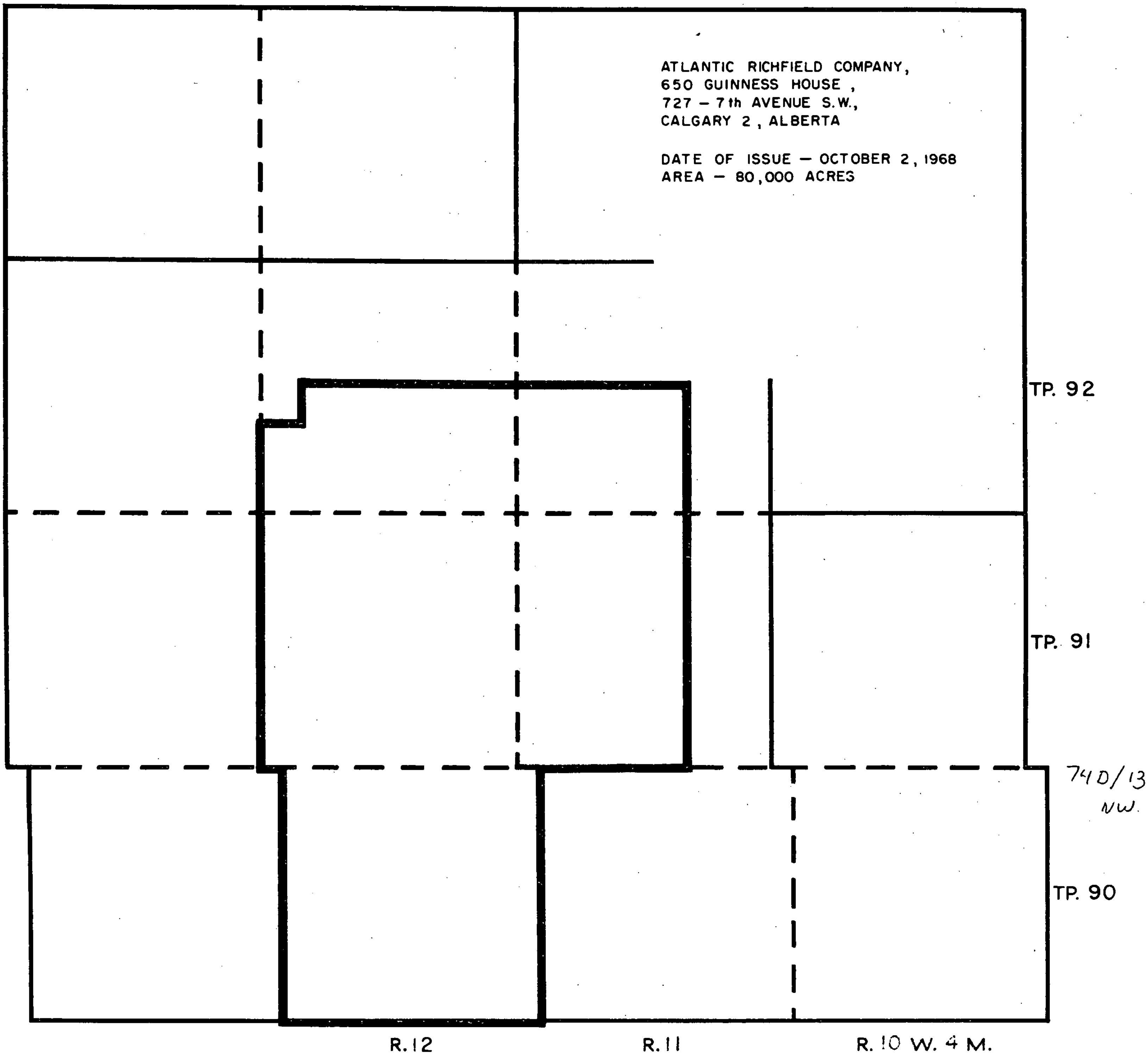

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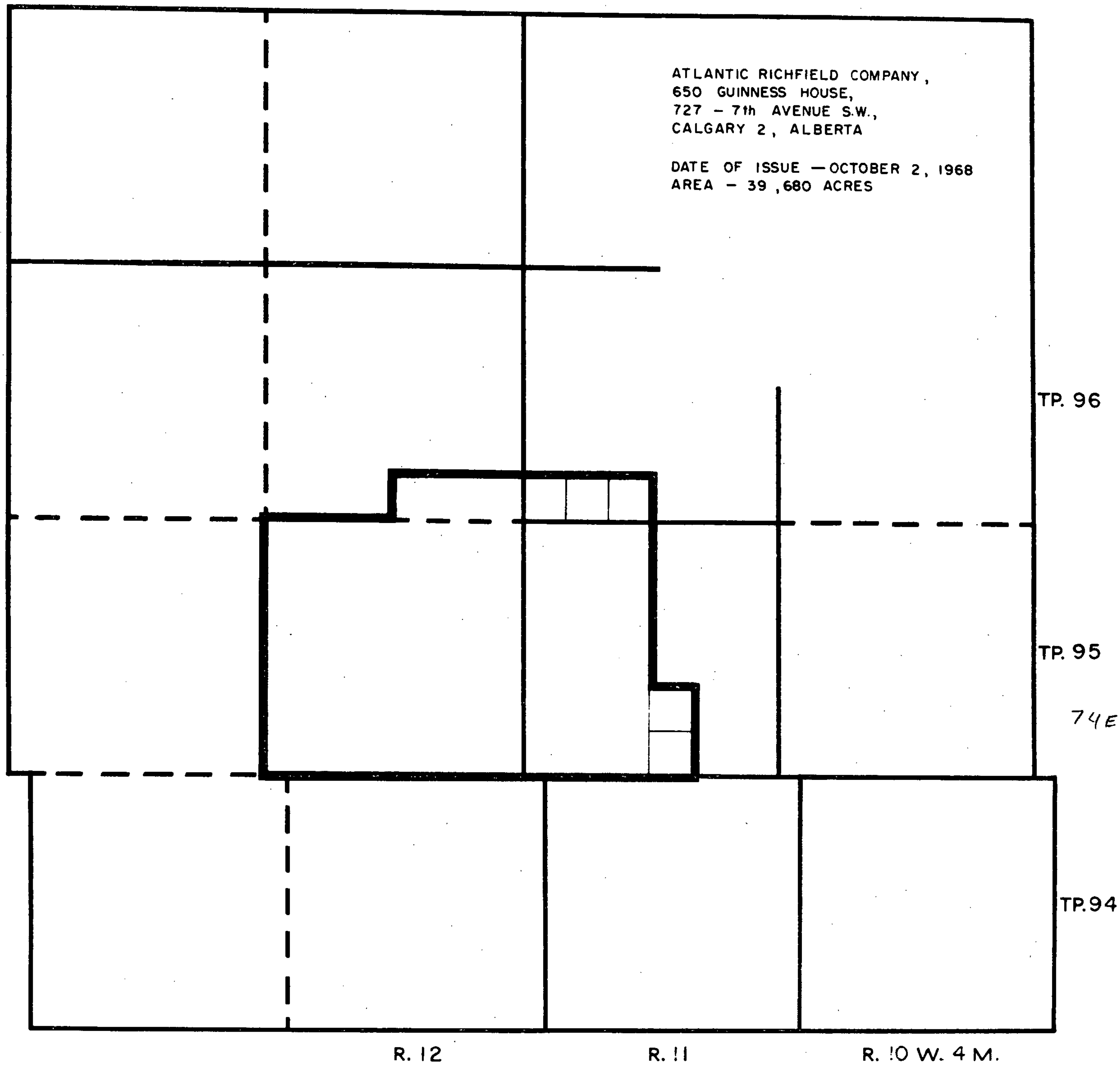

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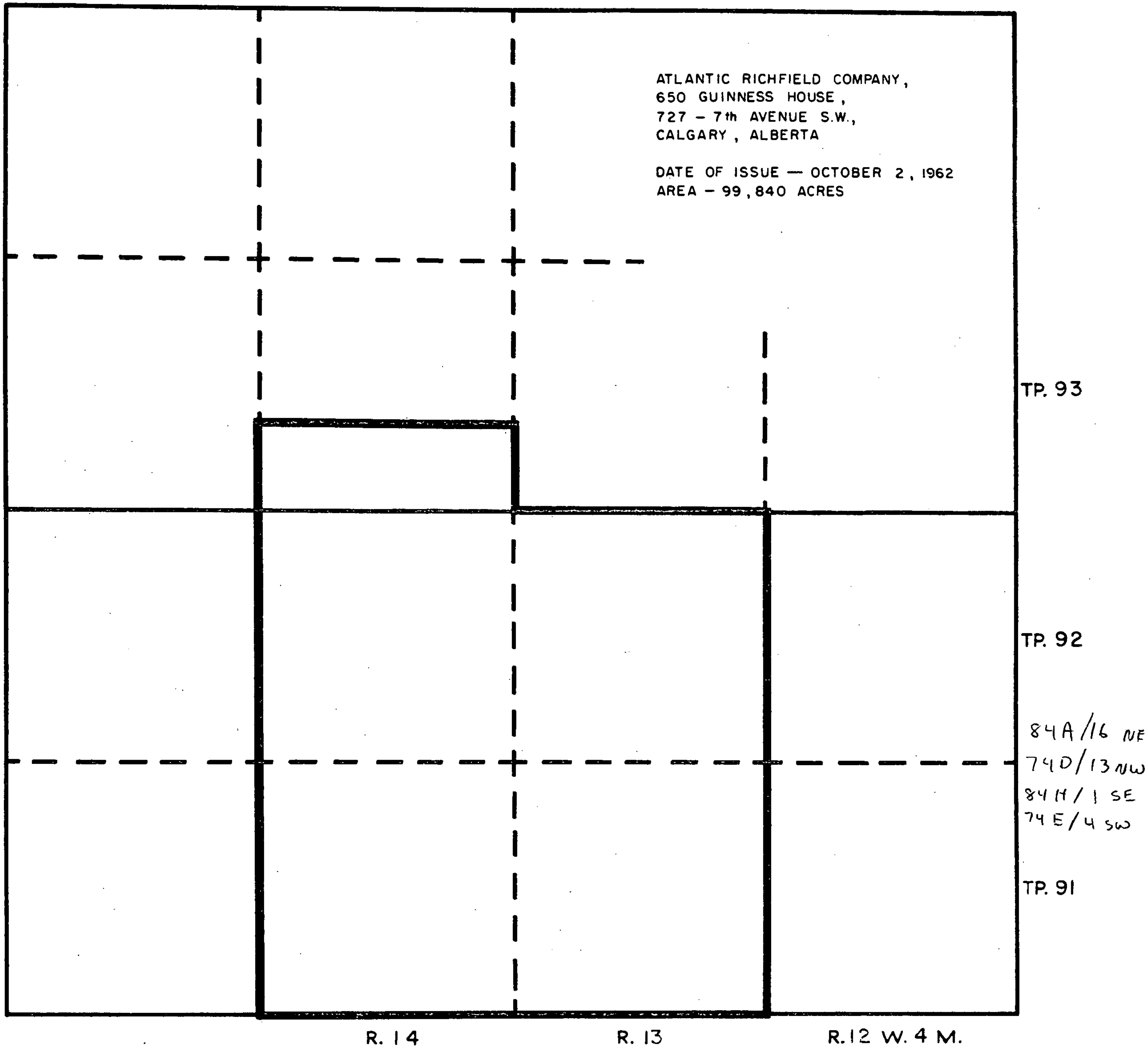
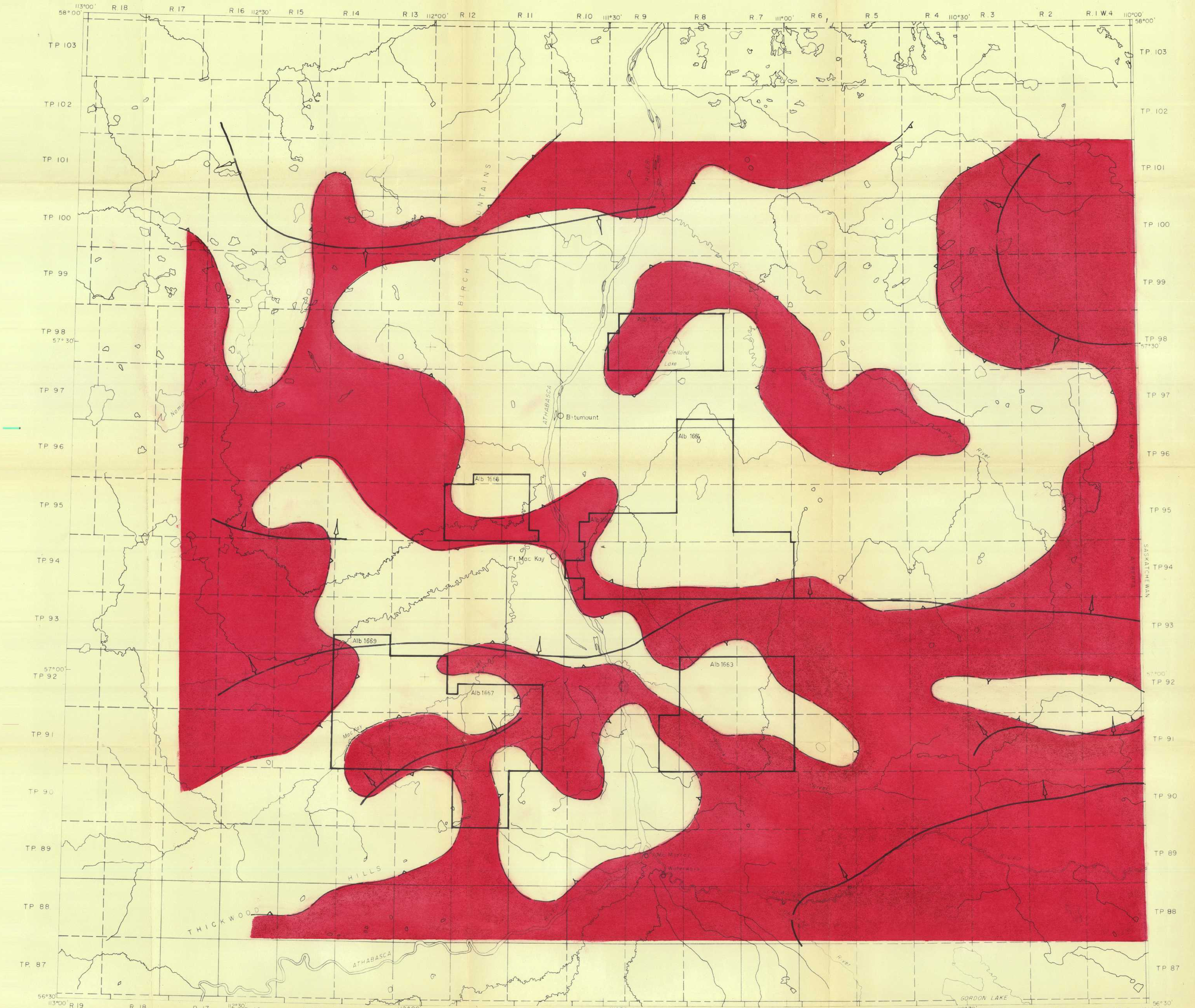
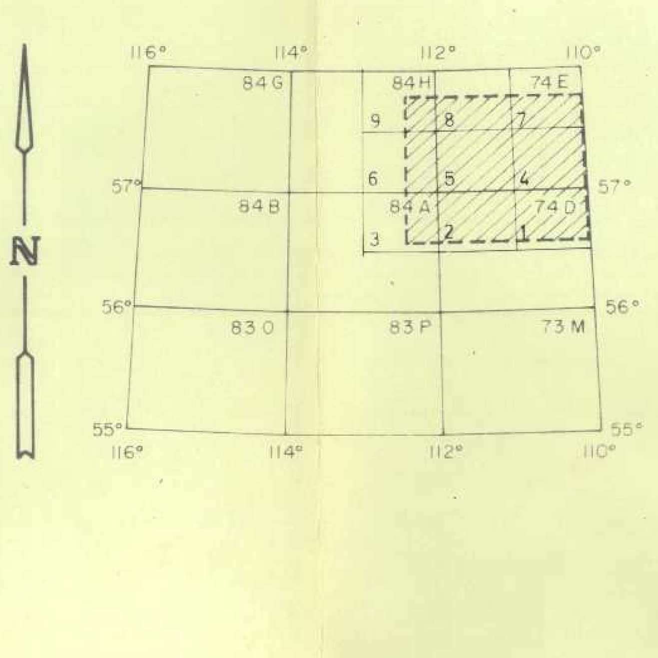




1369 0075

FIGURE 5



LEGEND

Structural form line

Hinge line

Positive structural area

Outline of sulphur permit areas

POSITIVE STRUCTURAL AREAS AND HINGE LINES

(EVOLVED FROM FOLD PATTERNS OF FIGURE 2)

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

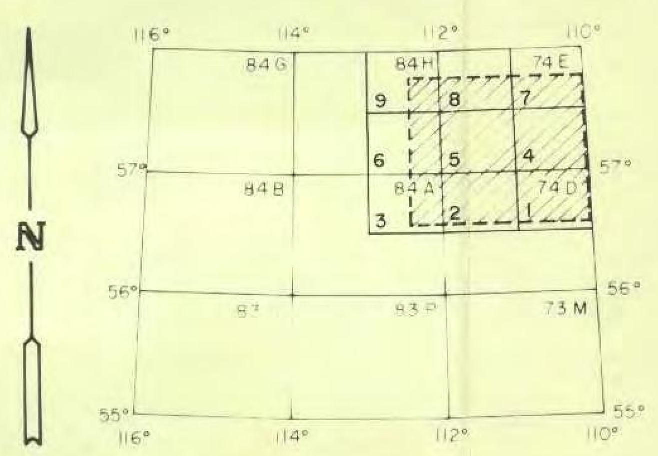
PREPARED BY

ROBERT H. FRANTZ P. GEOL

CALGARY, ALBERTA

MARCH 1969

0 5 10 15 20 Miles



FEATURES OR AREAS COMMON TO SULPHUR DEPOSITS

F Major fault

Depression related to plunge of folds

Negative (collapse) area related to fracture pattern (Interpreted)

Fr Areas of maximum fracturing

Belt of ponds, springs, sinkholes and slump

Formation boundary

U Unconformity

Outline of sulphur permits

LOWER CRETACEOUS

Kl Undivided

UNCONFORMITY

DEVONIAN

Dw Waterways Formation

MIDDLE DEVONIAN

Dm Elk Point Group, Undivided

UNCONFORMITY

PRECAMBRIAN

P€ Undivided

The structural data utilized in the make up of this map, are for the most part supported by magnetic indicators

19690075

FIGURE 4

COMPOSITE MAP OF AREAS OF INTEREST

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

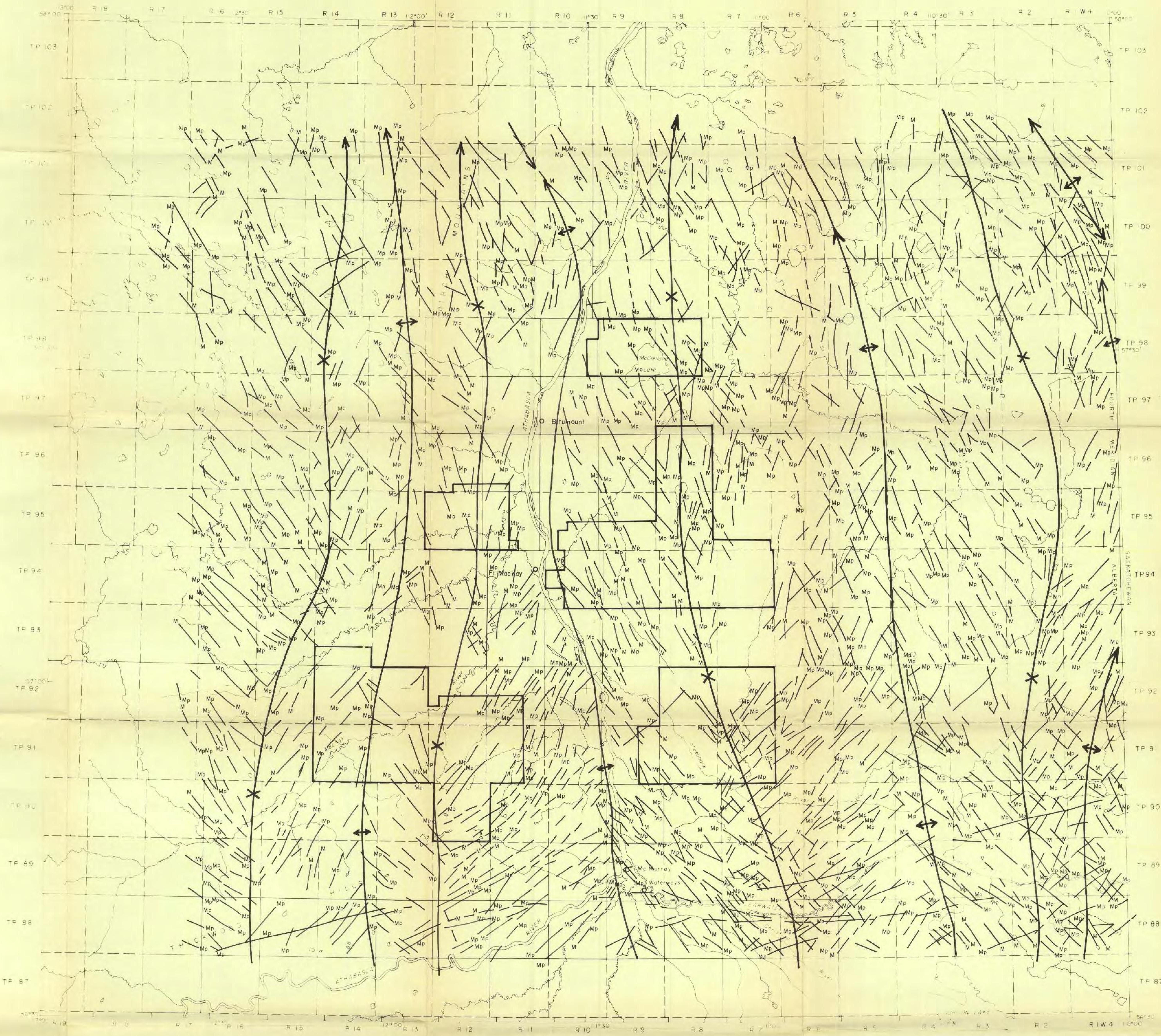
PREPARED BY

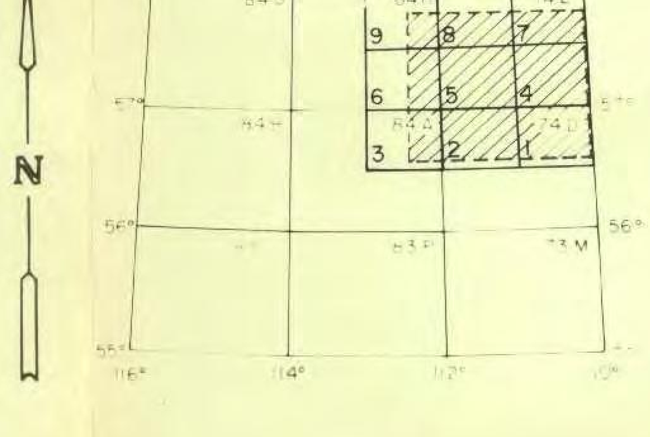
ROBERT H FRANTZ P GEOL

CALGARY, ALBERTA

MARCH 1969

5 0 5 10 15 20 Miles





LEGEND

F	Major fault
	Fault or fracture
	Positive axis
	Negative axis (Collapse structure)
M	Magnetic correlation , p partial
	Outline of sulphur permit areas

Interpretation based on selected fractures

FIGURE 3

STRUCTURE MAP

(DERIVED FROM SELECTED FAULTS AND FRACTURES)

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

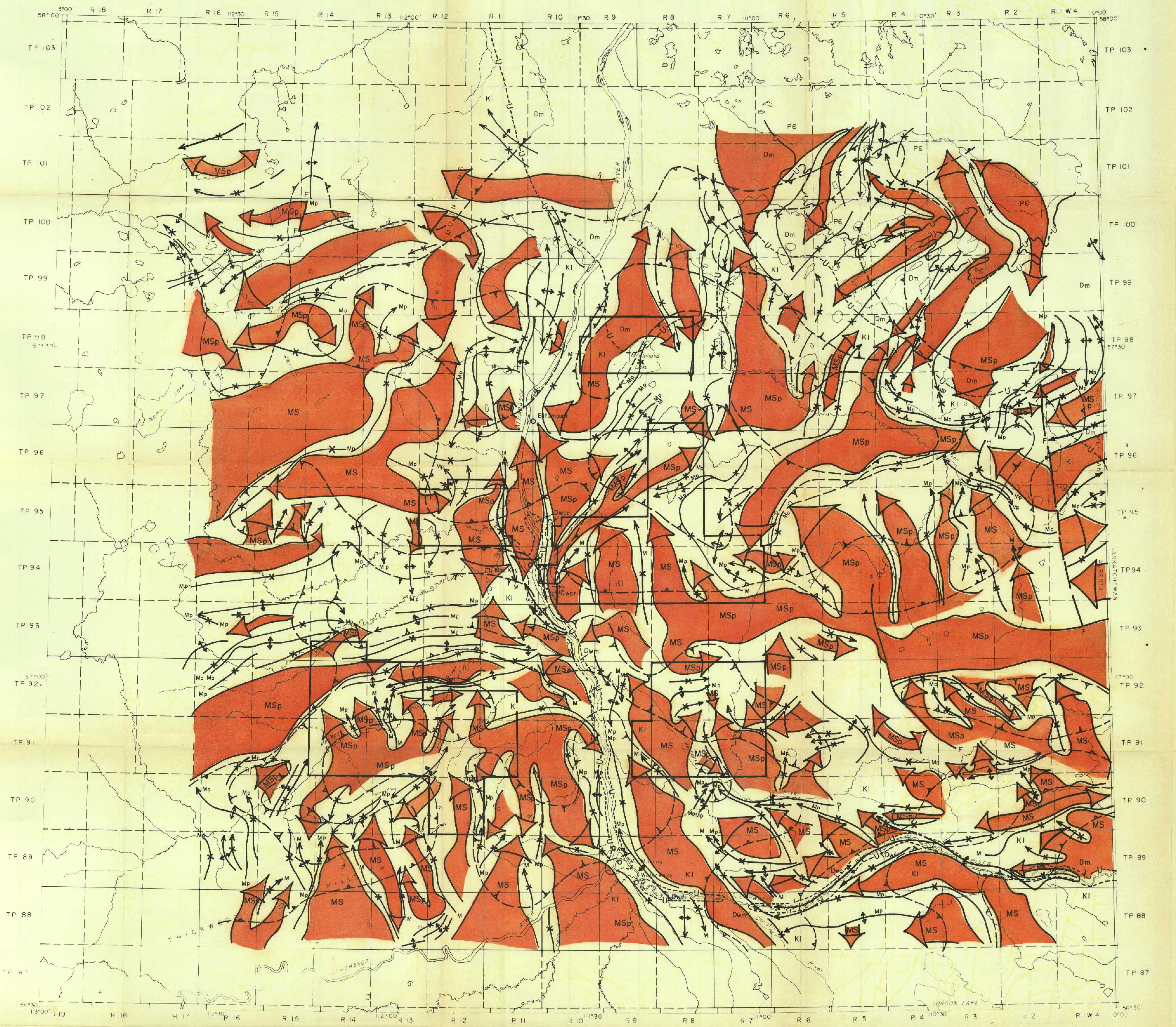
PREPARED BY

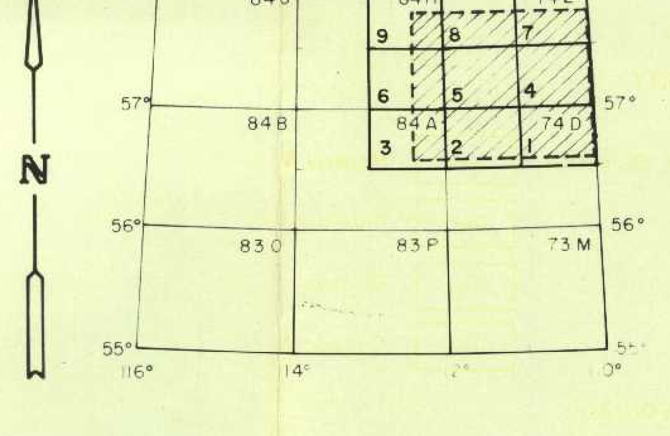
ROBERT H FRANTZ P GEOL

CALGARY, ALBERTA

MARCH 1969

5 10 Miles





LEGEND

F — Major fault

Anticline ⎤
⎬ Arrow denotes plunge direction
Syncline ⎦

Fold swarm (Comprised of numerous small folds Arrow denotes plunge direction)

Structural form line (Arrow denotes dip direction Ticks denote depression or subsidence area)

—U— Unconformity

-------- Member boundary

M Magnetic correlation

MS Fold swarm with magnetic correlation (p) partial correlation

Outline of sulphur permit areas

LOWER CRETACEOUS

Kl Undivided

UNCONFORMITY

DEVONIAN

Dw Waterways Formation

Dwm Moberly Member

Dwcr Christina Member

Dwc Calumet Member

Dwf Firebag Member

MIDDLE DEVONIAN

Dm Elk Point Group, Undivided

UNCONFORMITY

PRECAMBRIAN

PЄ Undivided

FIGURE 2 1969 0075

STRUCTURE MAP

SHOWING

FOLD PATTERNS AND STRUCTURAL FORM LINES

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

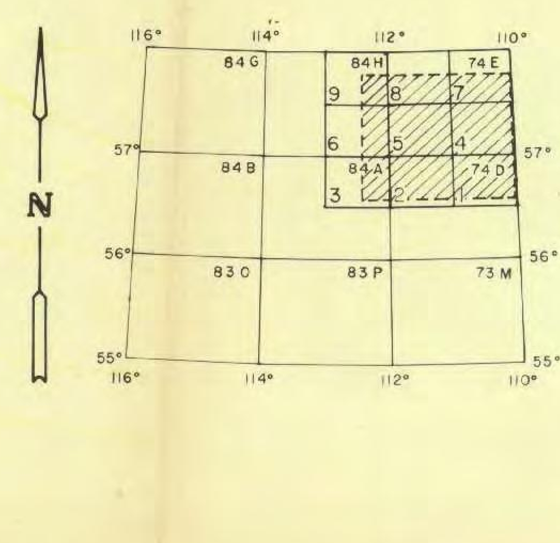
PREPARED BY

ROBERT H FRANTZ P GEOL

CALGARY, ALBERTA

MARCH 1969

5 0 5 10 15 20 Miles



LEGEND

F — Faults or fractures. F denotes major fault

Anticline / Syncline — Arrow denotes plunge direction

Fold swarm (Comprised of numerous small folds Arrow denotes plunge direction)

Structural form line (Arrow denotes dip direction Ticks denote depression or subsidence area)

—U— Unconformity

-------- Member boundary

P Published data

M Magnetic correlation

MS Fold swarm with magnetic correlation — (p) partial correlation

Published dip or component, with or without degree of dip

LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation	Dwm	Moberly Member
		Dwcr	Christina Member
		Dwc	Calumet Member
		Dwf	Firebag Member

MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

P€	Undivided

19690075

SHEET 5

PHOTOGEOLOGICAL MAP
WITH
INTEGRATED AEROMAGNETIC DATA
ATHABASCA RIVER AREA
NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

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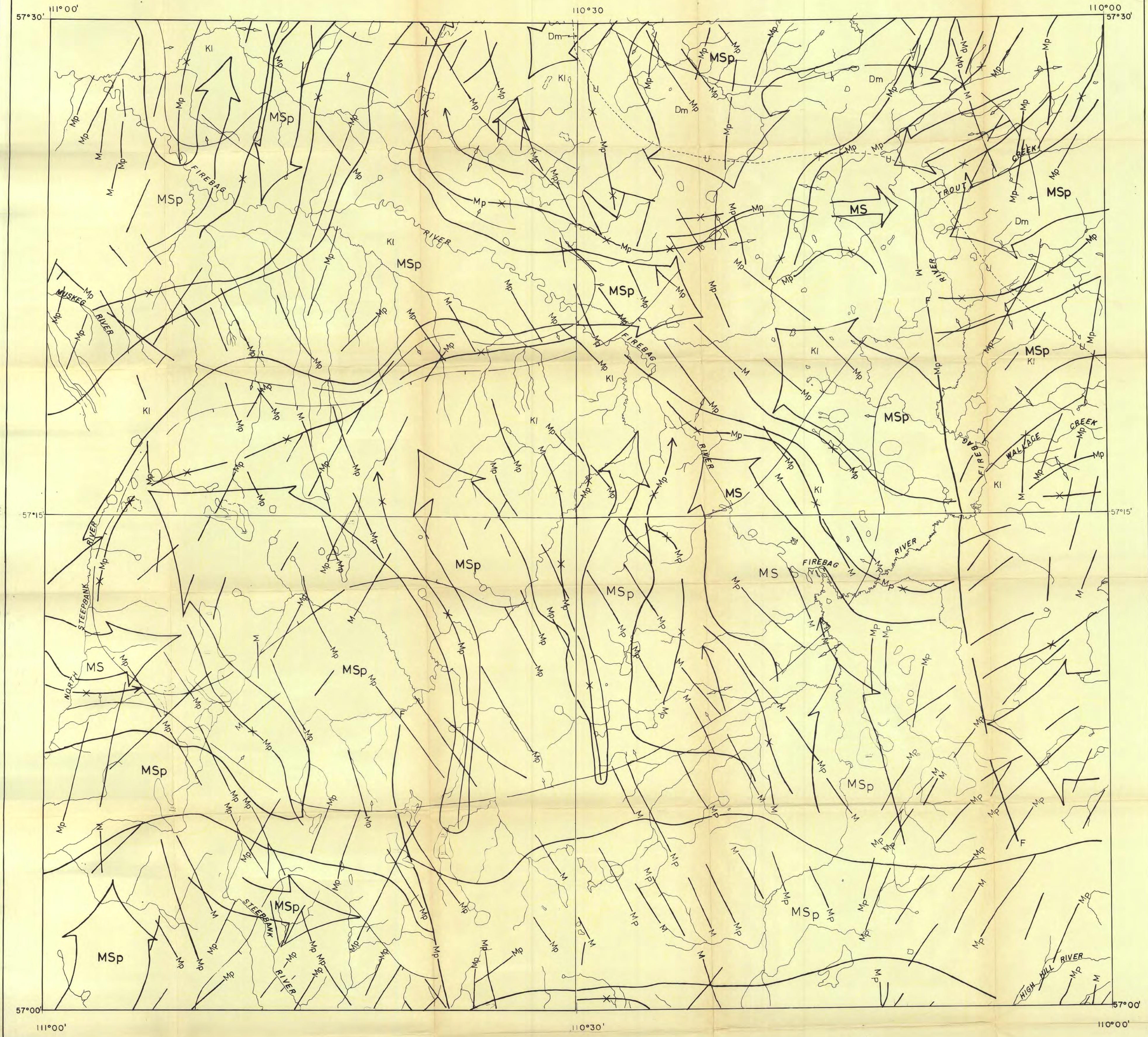
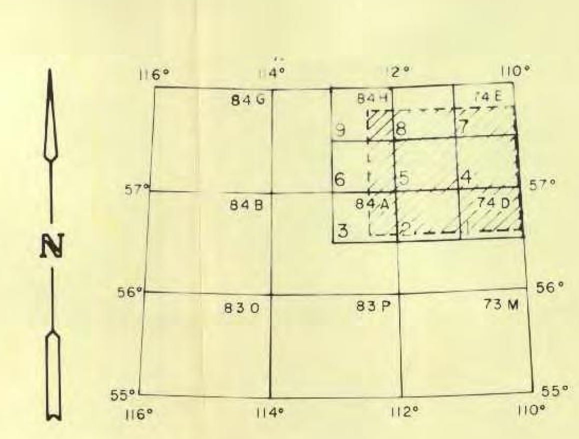
CALGARY, ALBERTA

MARCH 1969

0 1 2 3 4 5 Miles





LEGEND

F Faults or fractures. F denotes major fault

Anticline, Syncline — Arrow denotes plunge direction

Fold swarm (Comprised of numerous small folds Arrow denotes plunge direction)

Structural form line (Arrow denotes dip direction Ticks denote depression or subsidence area)

—U— Unconformity

-------- Member boundary

P Published data

M Magnetic correlation

MS Fold swarm with magnetic correlation — (p) partial correlation

Published dip or component, with or without degree of dip

LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation
Dwm	Moberly Member
Dwcr	Christina Member
Dwc	Calumet Member
Dwf	Firebag Member

MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

P€	Undivided

17690075

SHEET 4

PHOTOGEOLOGICAL MAP
WITH
INTEGRATED AEROMAGNETIC DATA
ATHABASCA RIVER AREA
NORTHEASTERN ALBERTA

PREPARED FOR

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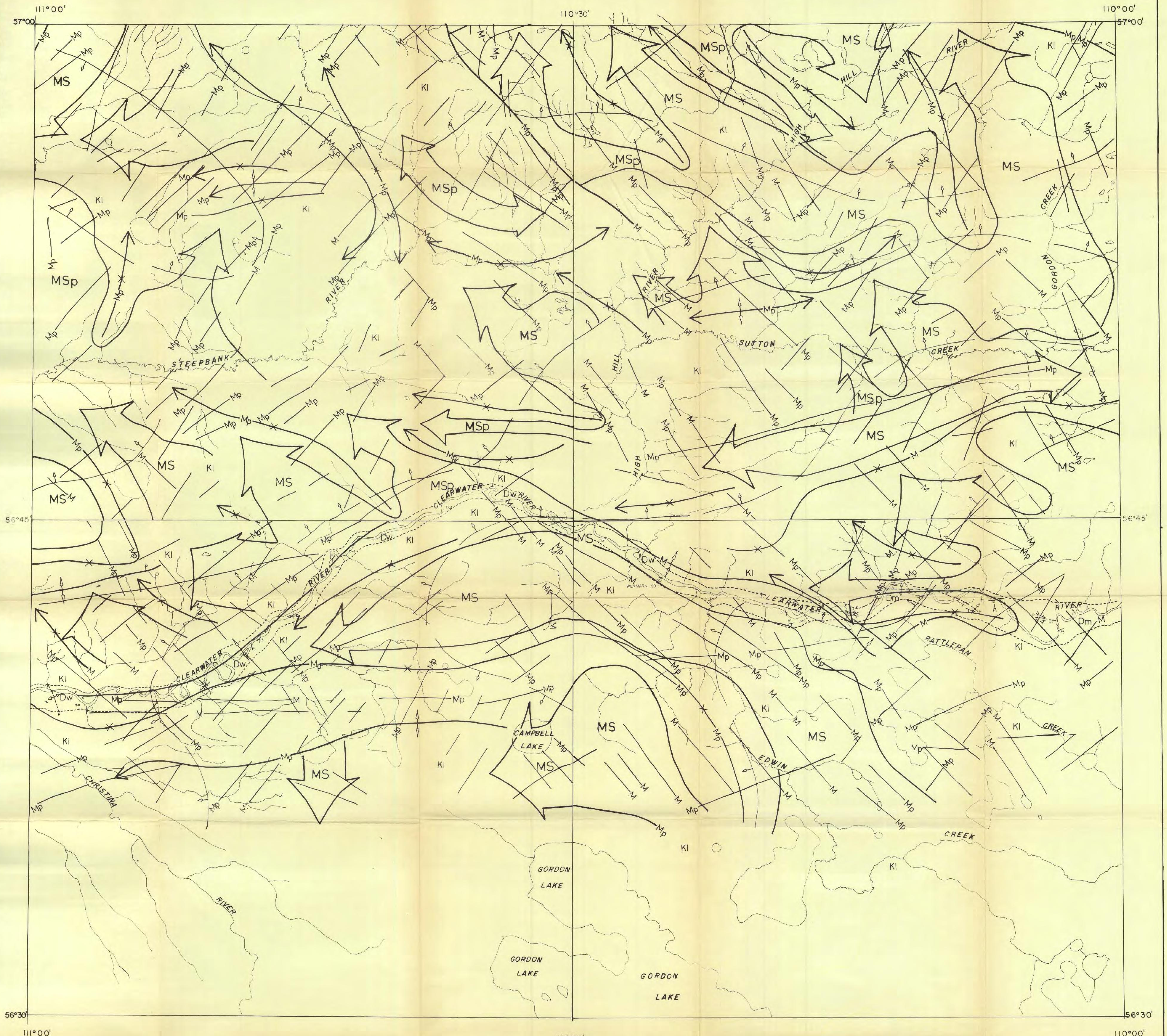
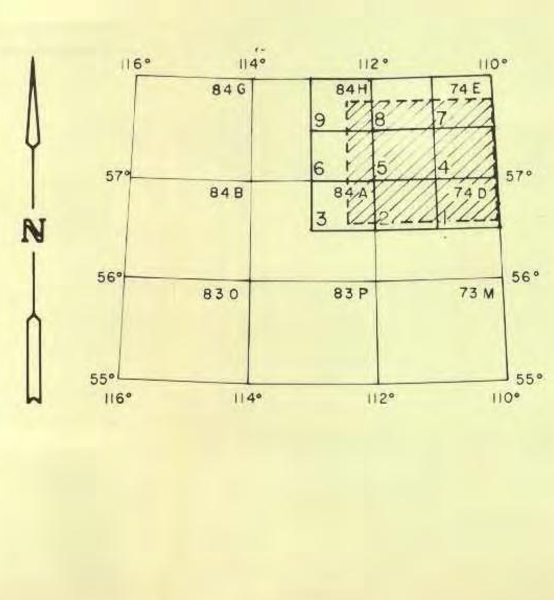
1 0 1 2 3 4 5 Miles





LEGEND

F	Faults or fractures. F denotes major fault
	Anticline / Syncline — Arrow denotes plunge direction
	Fold swarm (Comprised of numerous small folds. Arrow denotes plunge direction)
	Structural form line (Arrow denotes dip direction. Ticks denote depression or subsidence area)
—U—	Unconformity
--------	Member boundary
P	Published data
M	Magnetic correlation
MS	Fold swarm with magnetic correlation — (p) partial correlation
5	Published dip or component, with or without degree of dip.

LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation	Dwm	Moberly Member
		Dwcr	Christina Member
		Dwc	Calumet Member
		Dwf	Firebag Member

MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

P€	Undivided

19690075

SHEET 3

PHOTOGEOLOGICAL MAP
WITH
INTEGRATED AEROMAGNETIC DATA
ATHABASCA RIVER AREA
NORTHEASTERN ALBERTA

PREPARED FOR

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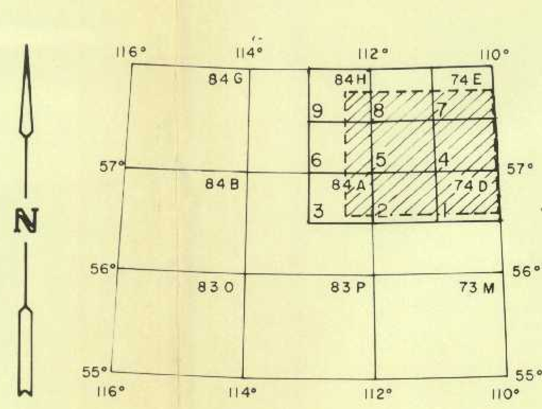
1 0 1 2 3 4 5 Miles



LEGEND

F — Faults or fractures. F denotes major fault

Anticline, Syncline — Arrow denotes plunge direction

Fold swarm (Comprised of numerous small folds. Arrow denotes plunge direction)

Structural form line (Arrow denotes dip direction. Ticks denote depression or subsidence area)

—U— Unconformity

-------- Member boundary

P Published data

M Magnetic correlation

MS Fold swarm with magnetic correlation — (p) partial correlation

Published dip or component, with or without degree of dip.

LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation	Dwm	Moberly Member
		Dwcr	Christina Member
		Dwc	Calumet Member
		Dwf	Firebag Member

MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

P€	Undivided

19690075

SHEET 2

PHOTOGEOLOGICAL MAP WITH INTEGRATED AEROMAGNETIC DATA

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

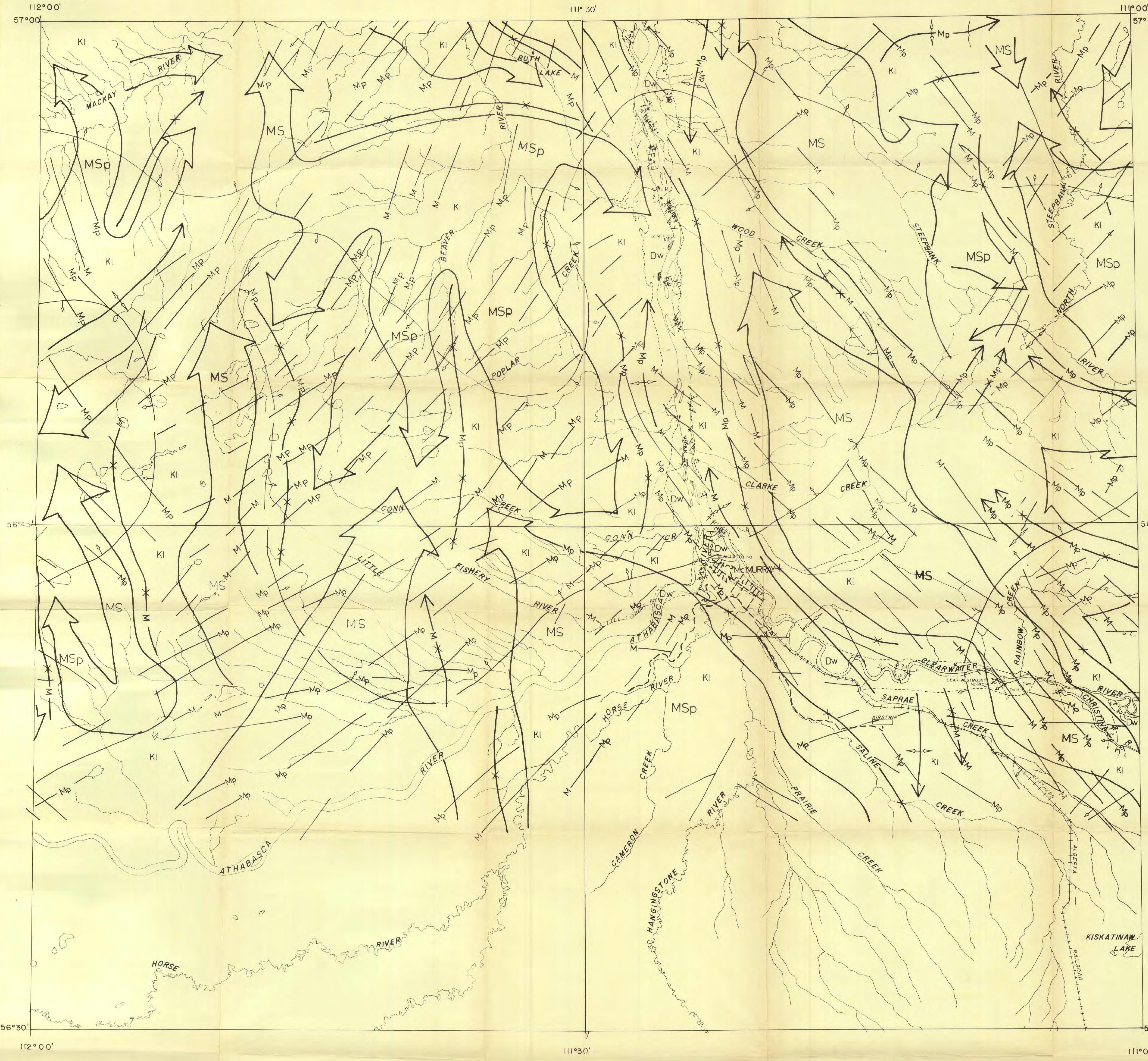
ATLANTIC RICHFIELD COMPANY

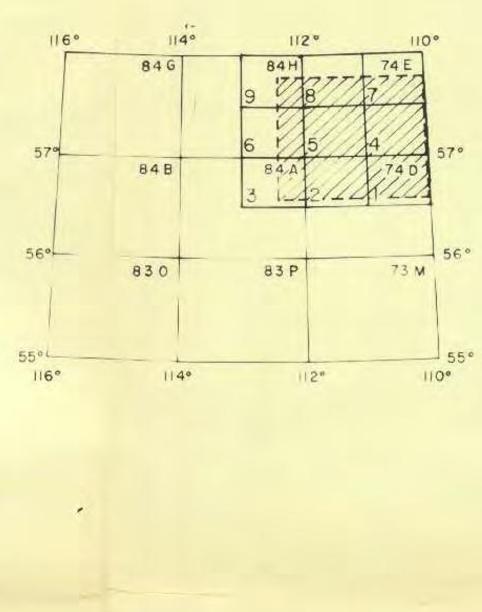
PREPARED BY

ROBERT H FRANTZ P. GEOL
CALGARY, ALBERTA

MARCH 1969

1 0 1 2 3 4 5 Miles





LEGEND

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-------- Member boundary

P Published data

M Magnetic correlation

MS Fold swarm with magnetic correlation — (p) partial correlation

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LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation	Dwm	Moberly Member
		Dwcr	Christina Member
		Dwc	Calumet Member
		Dwf	Firebag Member

MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

P€	Undivided

19690075

SHEET I

PHOTOGEOLOGICAL MAP
WITH
INTEGRATED AEROMAGNETIC DATA
ATHABASCA RIVER AREA
NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

PREPARED BY
ROBERT H FRANTZ P. GEOL
CALGARY, ALBERTA
MARCH 1969

1 0 1 2 3 4 5 Miles

1969 0075

SHEET 9

PHOTOGEOLOGICAL MAP

WITH

INTEGRATED AEROMAGNETIC DATA

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

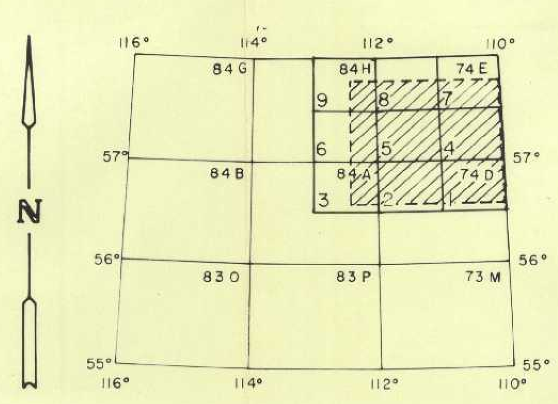
PREPARED BY

ROBERT H FRANTZ P. GEOL

CALGARY, ALBERTA

MARCH 1969

1 0 1 2 3 4 5 Miles



LEGEND

F	Faults or fractures. F denotes major fault
	Anticline / Syncline — Arrow denotes plunge direction
	Fold swarm (Comprised of numerous small folds Arrow denotes plunge direction)
	Structural form line (Arrow denotes dip direction Ticks denote depression or subsidence area)
—U—	Unconformity
--------	Member boundary
P	Published data
M	Magnetic correlation
MS	Fold swarm with magnetic correlation — (p) partial correlation
5	Published dip or component, with or without degree of dip.

LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation	Dwm	Moberly Member
		Dwcr	Christina Member
		Dwc	Calumet Member
		Dwf	Firebag Member

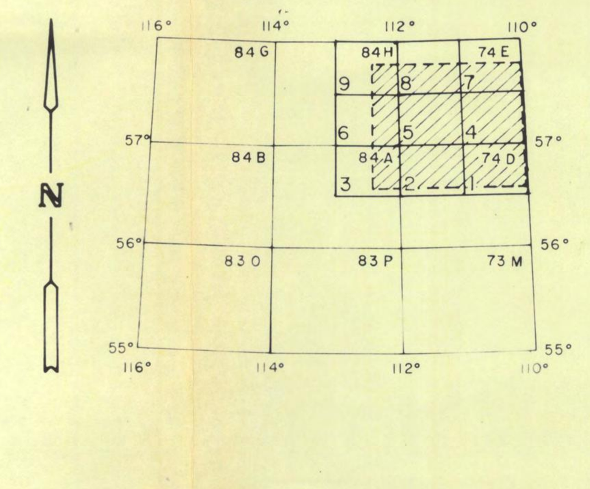
MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

P€	Undivided



LEGEND

F — Faults or fractures. F denotes major fault

Anticline / Syncline — Arrow denotes plunge direction

Fold swarm (Comprised of numerous small folds Arrow denotes plunge direction)

Structural form line (Arrow denotes dip direction Ticks denote depression or subsidence area)

—U— Unconformity

-------- Member boundary

P Published data

M Magnetic correlation

MS Fold swarm with magnetic correlation (p) partial correlation

5 Published dip or component, with or without degree of dip.

LOWER CRETACEOUS

Kl Undivided

UNCONFORMITY

DEVONIAN

Dw Waterways Formation

Dwm Moberly Member

Dwcr Christina Member

Dwc Calumet Member

Dwf Firebag Member

MIDDLE DEVONIAN

Dm Undivided

UNCONFORMITY

PRECAMBRIAN

P€ Undivided

19690075

SHEET 8

PHOTOGEOLOGICAL MAP WITH INTEGRATED AEROMAGNETIC DATA

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

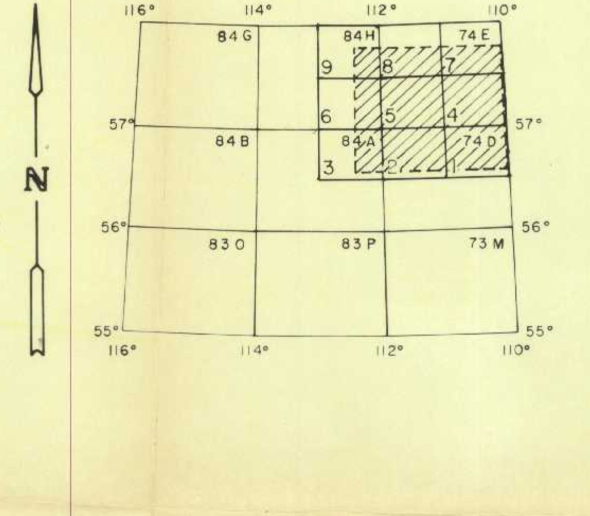
PREPARED FOR

ATLANTIC RICHFIELD COMPANY

PREPARED BY
ROBERT H FRANTZ P. GEOL
CALGARY, ALBERTA

MARCH 1969

1 0 1 2 3 4 5 Miles



LEGEND

F	Faults or fractures. F denotes major fault
	Anticline / Syncline — Arrow denotes plunge direction
	Fold swarm (Comprised of numerous small folds Arrow denotes plunge direction)
	Structural form line (Arrow denotes dip direction Ticks denote depression or subsidence area)
—U—	Unconformity
--------	Member boundary
P	Published data
M	Magnetic correlation
MS	Fold swarm with magnetic correlation — (p) partial correlation
	Published dip or component, with or without degree of dip.

LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation	Dwm	Moberly Member
		Dwcr	Christina Member
		Dwc	Calumet Member
		Dwf	Firebag Member

MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

PЄ	Undivided

19690075

SHEET 7

PHOTOGEOLOGICAL MAP WITH INTEGRATED AEROMAGNETIC DATA

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

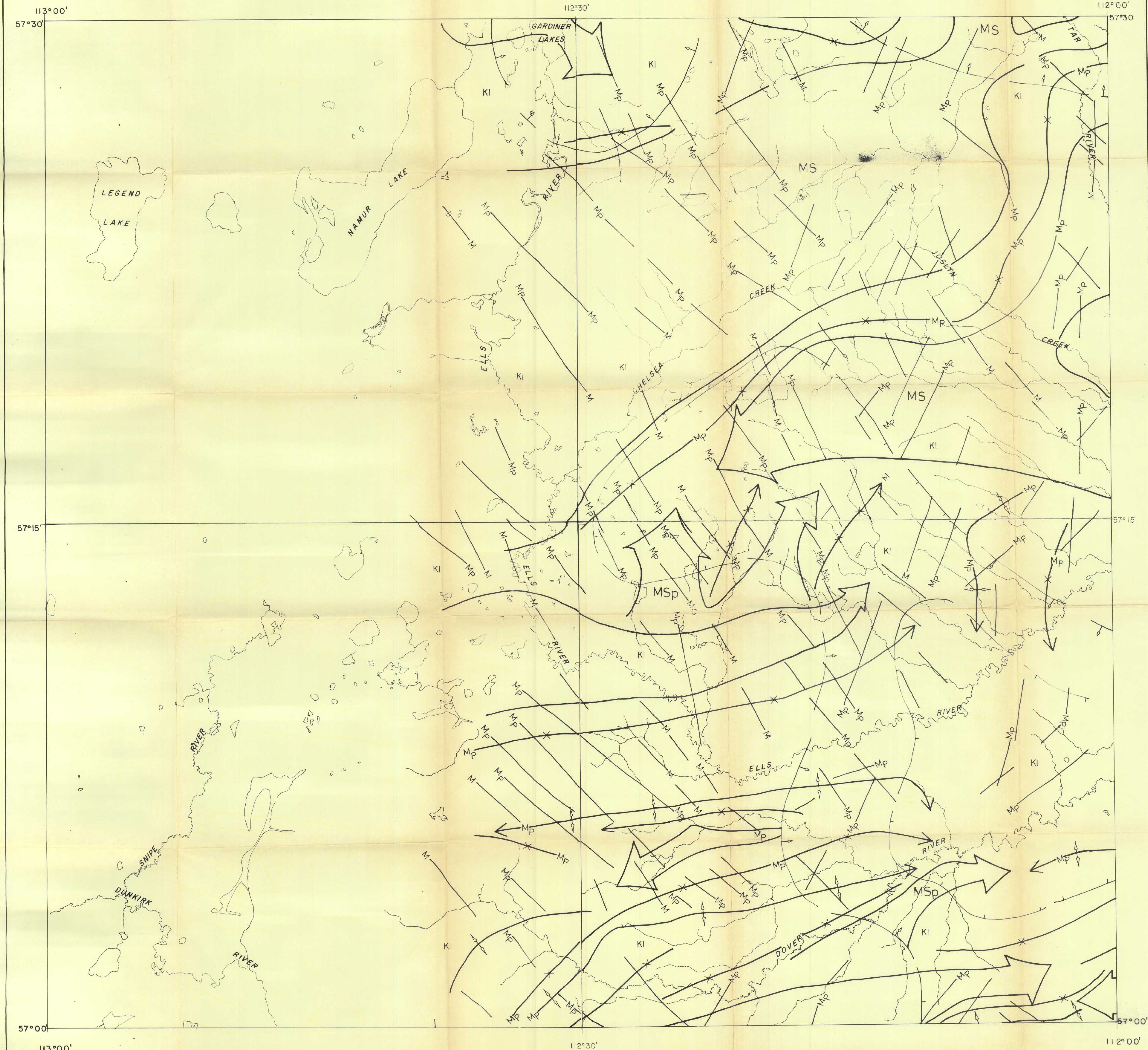
PREPARED BY

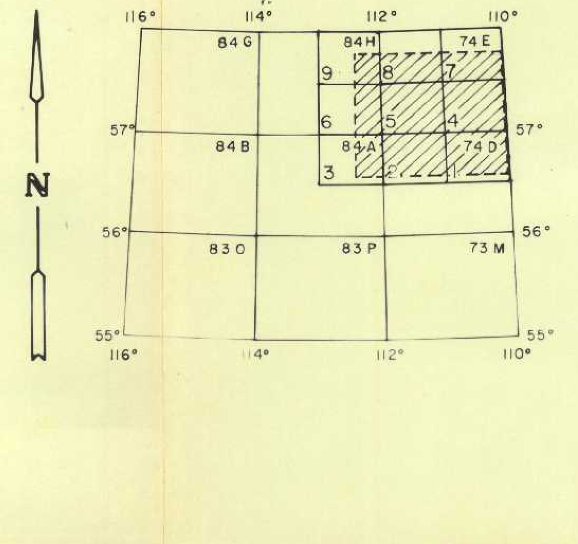
ROBERT H FRANTZ P. GEOL

CALGARY, ALBERTA

MARCH 1969

1 0 1 2 3 4 5 Miles





LEGEND

F	Faults or fractures. F denotes major fault
	Anticline / Syncline — Arrow denotes plunge direction
	Fold swarm (Comprised of numerous small folds Arrow denotes plunge direction)
	Structural form line (Arrow denotes dip direction Ticks denote depression or subsidence area)
—U—	Unconformity
--------	Member boundary
P	Published data
M	Magnetic correlation — (p) partial correlation
MS	Fold swarm with magnetic correlation — (p) partial correlation
	Published dip or component, with or without degree of dip.

LOWER CRETACEOUS

Kl	Undivided

UNCONFORMITY

DEVONIAN

Dw	Waterways Formation	Dwm	Moberly Member
		Dwcr	Christina Member
		Dwc	Calumet Member
		Dwf	Firebag Member

MIDDLE DEVONIAN

Dm	Undivided

UNCONFORMITY

PRECAMBRIAN

P€	Undivided

19690075

SHEET 6

PHOTOGEOLOGICAL MAP WITH INTEGRATED AEROMAGNETIC DATA

ATHABASCA RIVER AREA

NORTHEASTERN ALBERTA

PREPARED FOR

ATLANTIC RICHFIELD COMPANY

PREPARED BY
ROBERT H FRANTZ P. GEOL
CALGARY, ALBERTA

MARCH 1969

1 0 1 2 3 4 5 Miles