OTTAWA

60-01-04-136

60-1-4-73-5

Amoco Canada
Petroleum Company Ltd.
Bentall Building
444-7th Avenue S.W.
Calgary, Alberta T2P OY2

APPENDIX I

MEMORANDUM

August 8, 1973

Mr. A. L. Benson
Bentall Building--7th Floor

Attention: Mr. I. R. Halladay

PALYNOLOGIC ANALYSIS OF SAMPLES FROM:

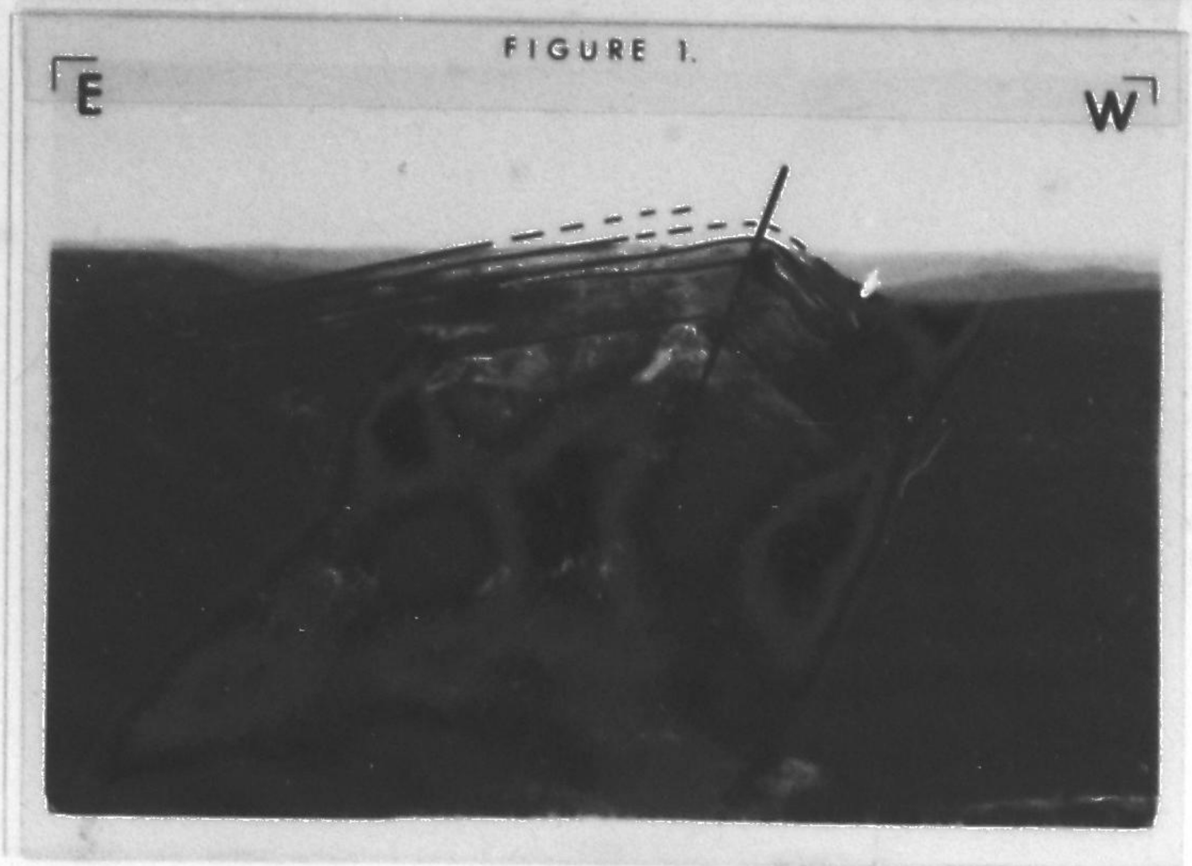
01-5-73	LSD 60 DEG 2 MIN N 124 DEG 41 MIN W	Y.T.
03-3-73, 03-4-73, 03-6-73	LSD 60 DEG 5 MIN N 124 DEG 48 MIN W	Y.T.

Five outcrop samples were processed for palynologic analysis to determine their ages. Each sample yielded residues mainly of black organic débris with some poorly preserved palynomorphs. Sample #1 from the outcrop 03-3-73 yielded minor amounts of Densosporites and Granulatisporites. These palynomorphs indicate an age which is probably Mississippian. No age determination can be made on the other four samples.

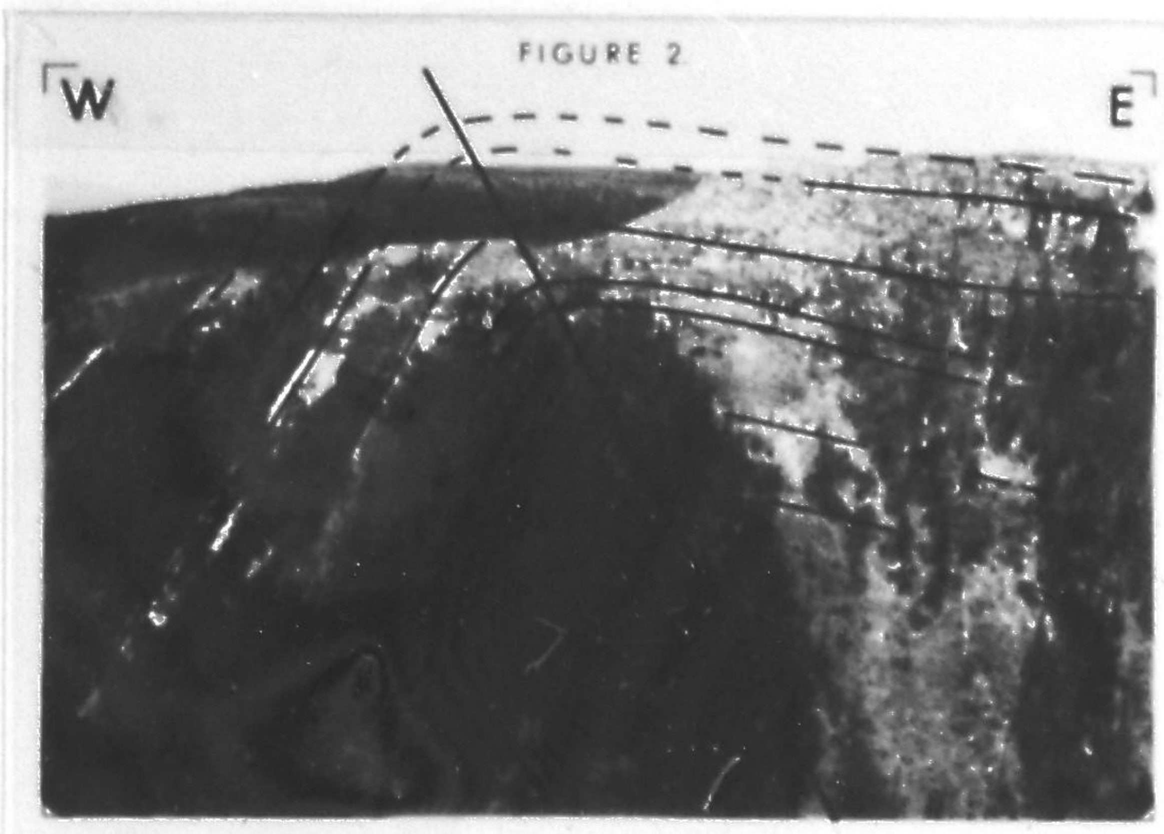
The shales of 03-3-73 and 03-4-73 are rated as having fair hydrocarbon generating capability whereas those of 01-5-73 and 03-6-73 are of good quality. The residues consisted mainly of organic débris resembling sapropel, cuticular fragments and minor amounts of palynomorphs. This composition indicates that the source beds are gas generating. The carbonization stage (on a scale of seven) is 6 which is equivalent to past peak generation in the 03-6-73. However, in the 03-3-73, 03-4-73 and 01-5-73, the carbonization stage is 5 which corresponds to peak generation for gas.

E. A. Marongelo

EAM:kt-11
CC: C. O. Grasdal, IBM Building--8th Floor
C. A. Polluck, IBM Building--8th Floor



<u>FIGURE 1.</u> MERRILL <u>V</u> ANTICLINE. BRITISH COLUMBIA - YUKON BORDER RUNS THROUGH VALLEY IN FOREGROUND.



<u>FIGURE 2</u>. DICKIE ANTICLINE.

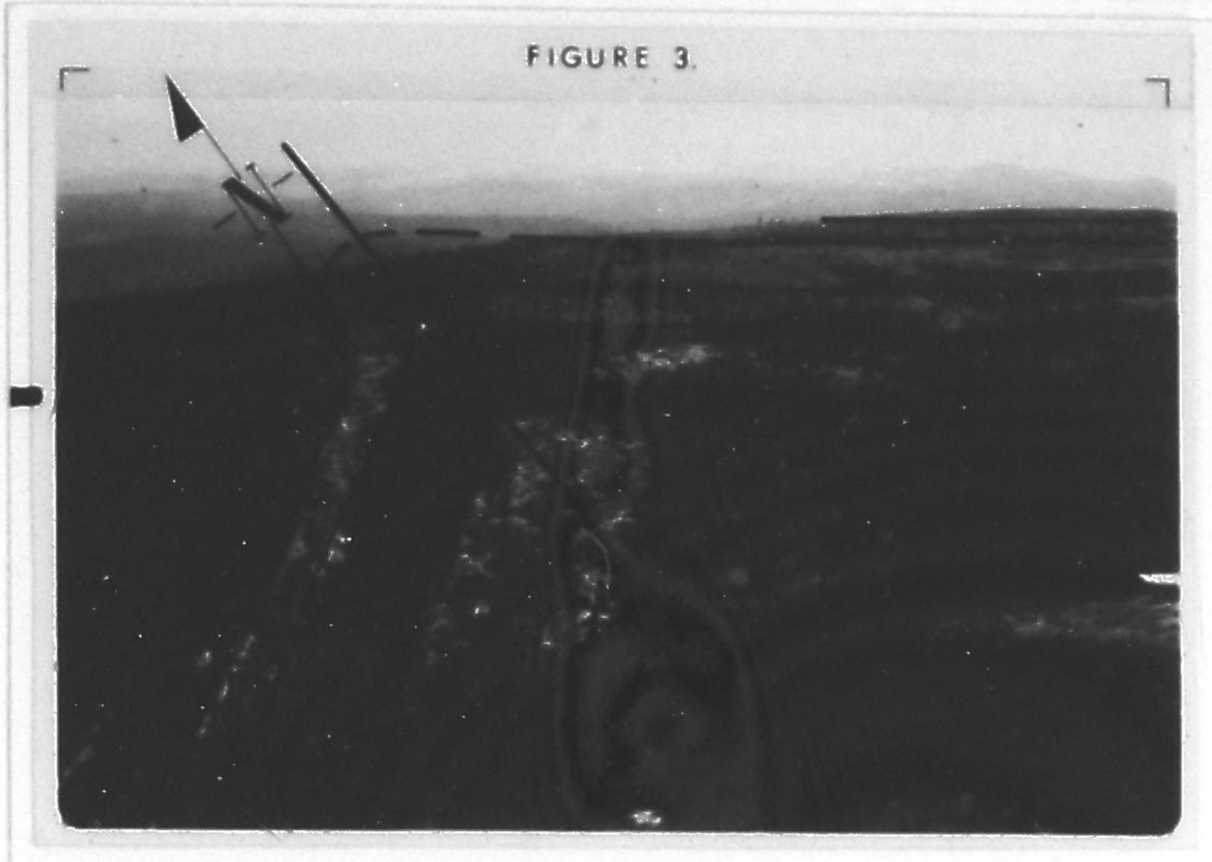


FIGURE 3. SPRUCE ANTICLINE

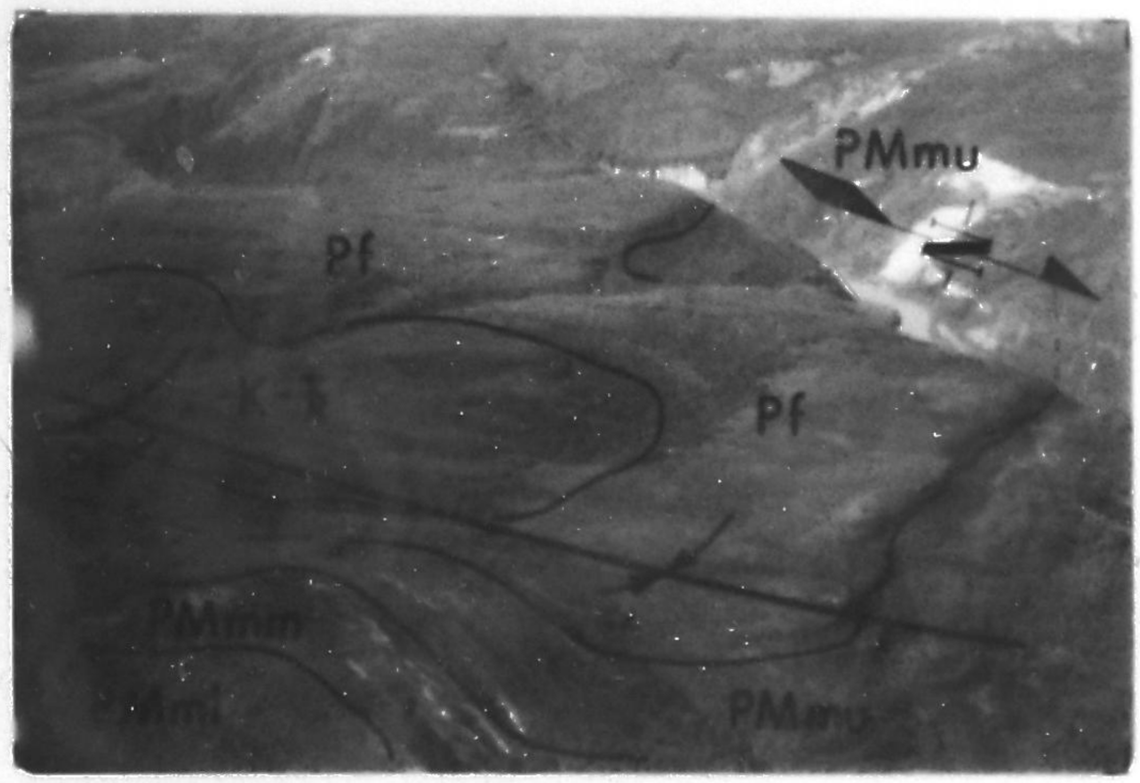


FIGURE 4. POPLAR SYNCLINE. THE BEAVER RIVER IS SEEN AT RIGHT.

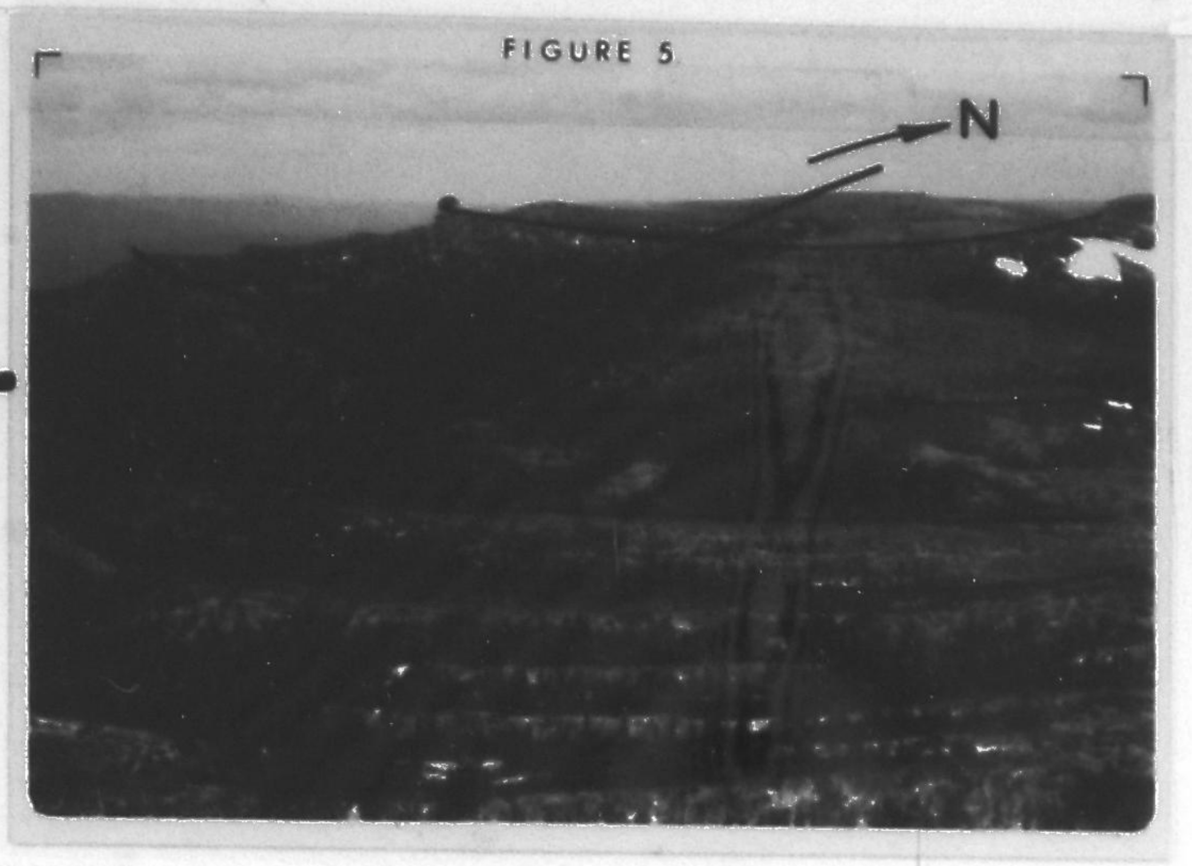


FIGURE 5. PINE TREE SYNCLINE.

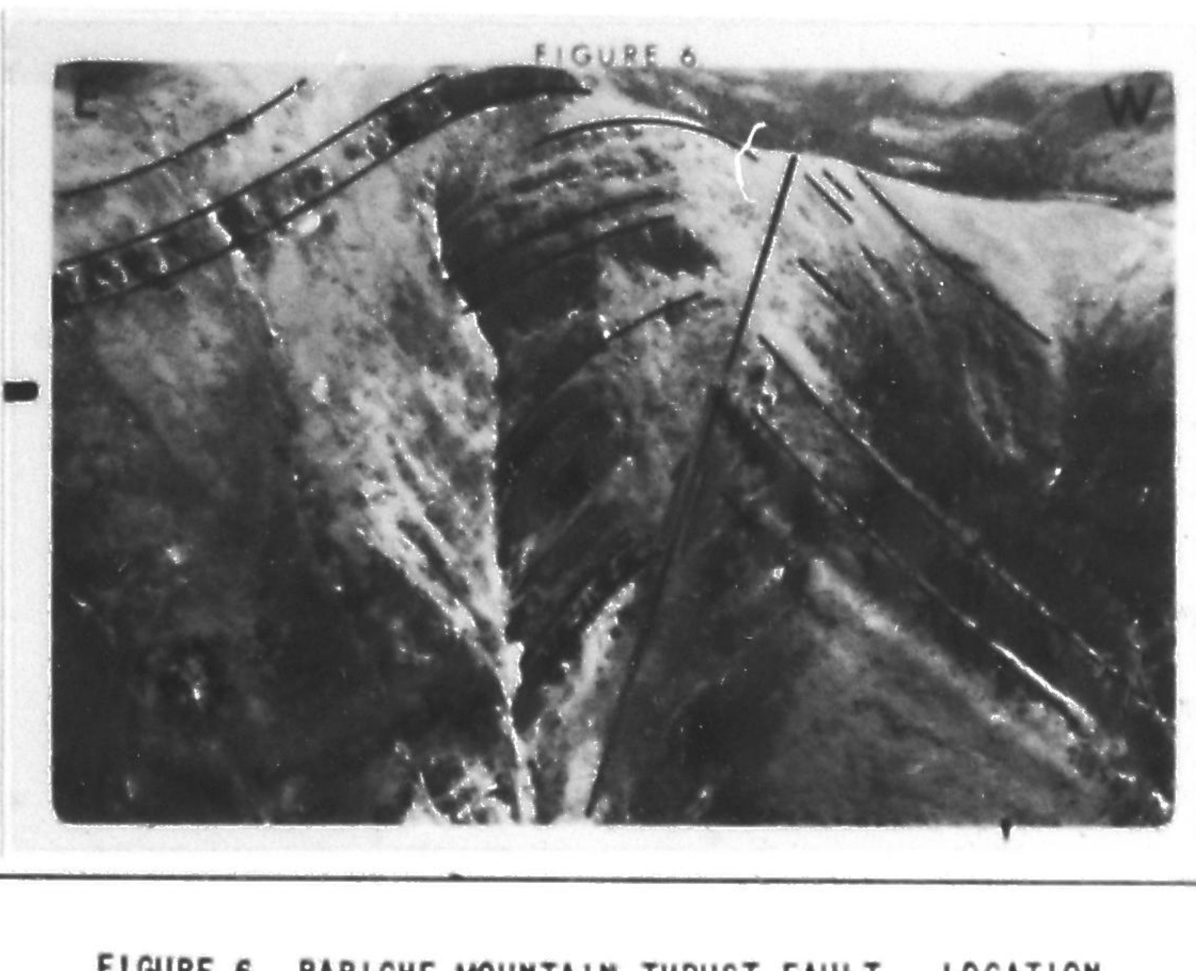
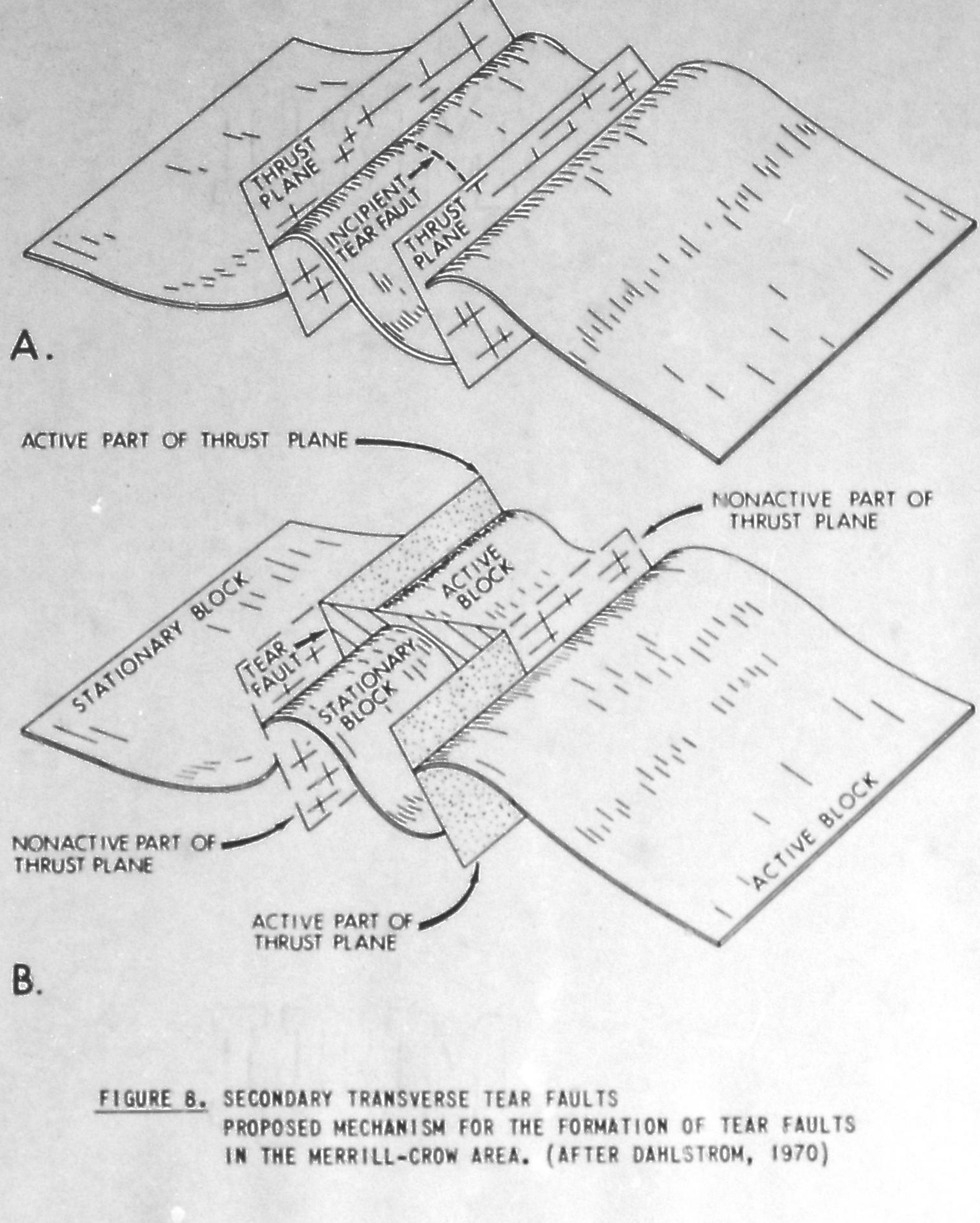


FIGURE 6. BABICHE MOUNTAIN THRUST FAULT. LOCATION IS JUST WEST OF BABICHE MOUNTAIN.



<u>FIGURE 8.</u> SECONDARY TRANSVERSE TEAR FAULTS
PROPOSED MECHANISM FOR THE FORMATION OF TEAR FAULTS
IN THE MERRILL-CROW AREA. (AFTER DAHLSTROM, 1970)

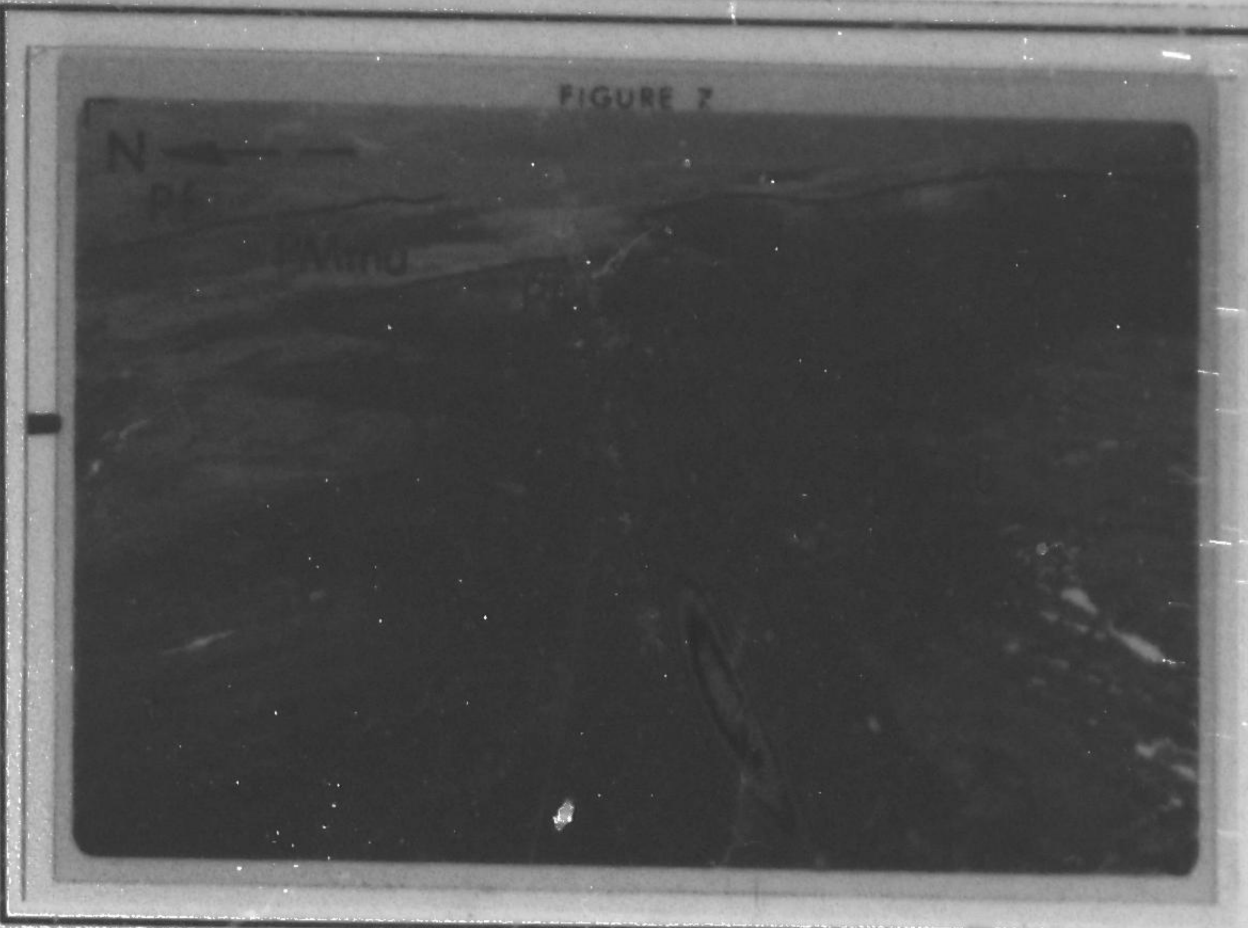


FIGURE 7. CROW THRUST FAULT LOCATION IS JUST EAST OF MOUNT MERRILL.

FIGURE 9. TEAR FAULT NEAR BEAVERCROW MOUNTAIN.

FIGURE 10. MOUNT MERRILL AND DICKIE TEAR FAULTS. MERRILL III.

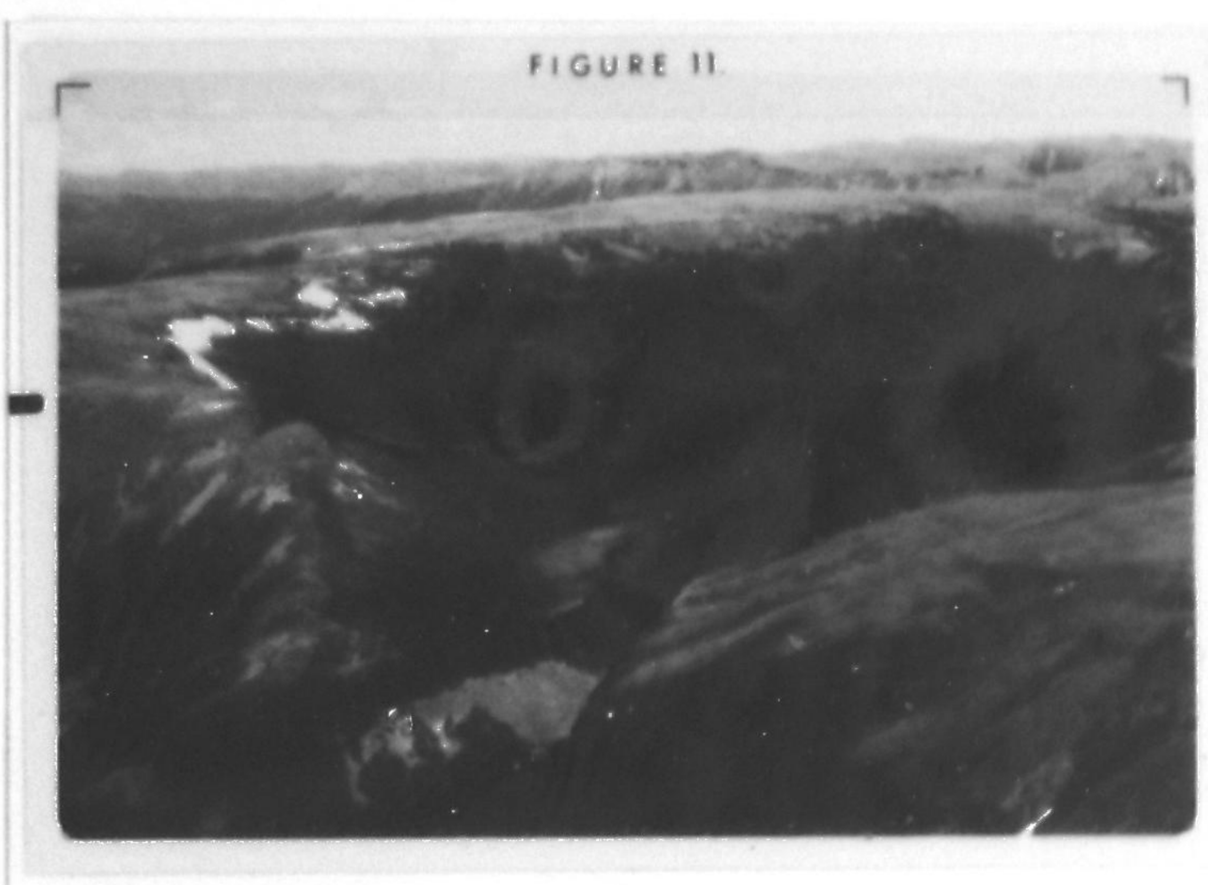
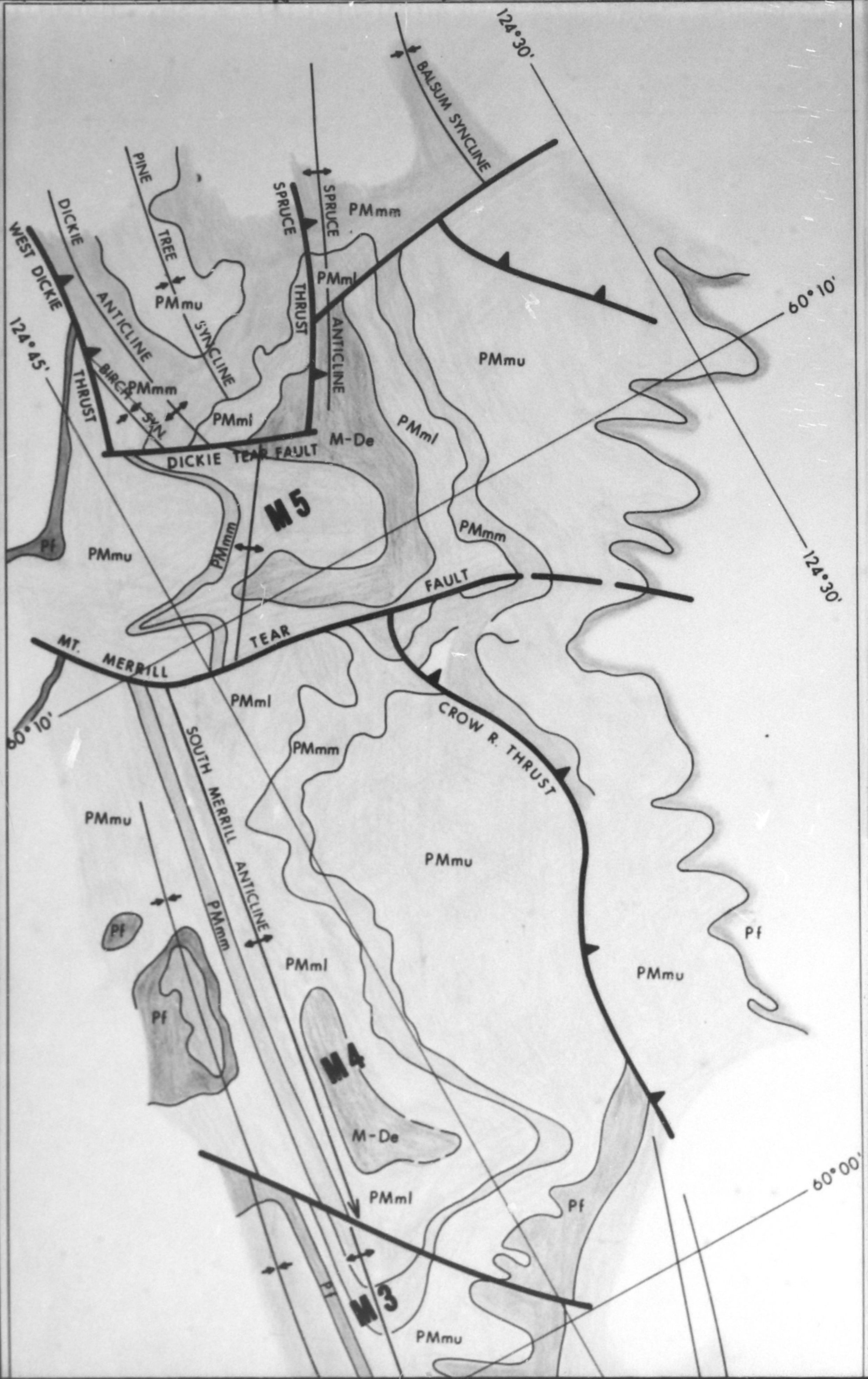
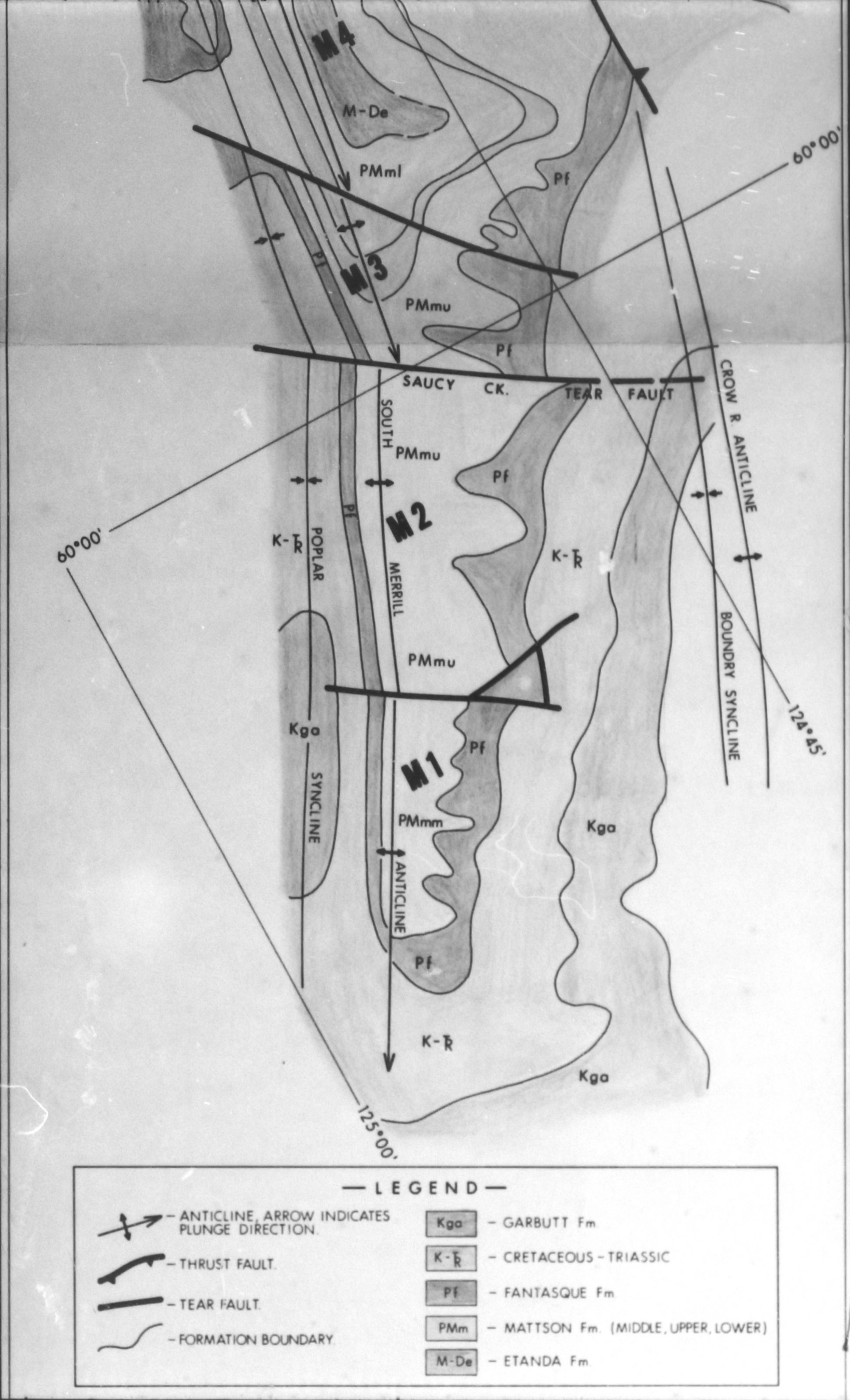
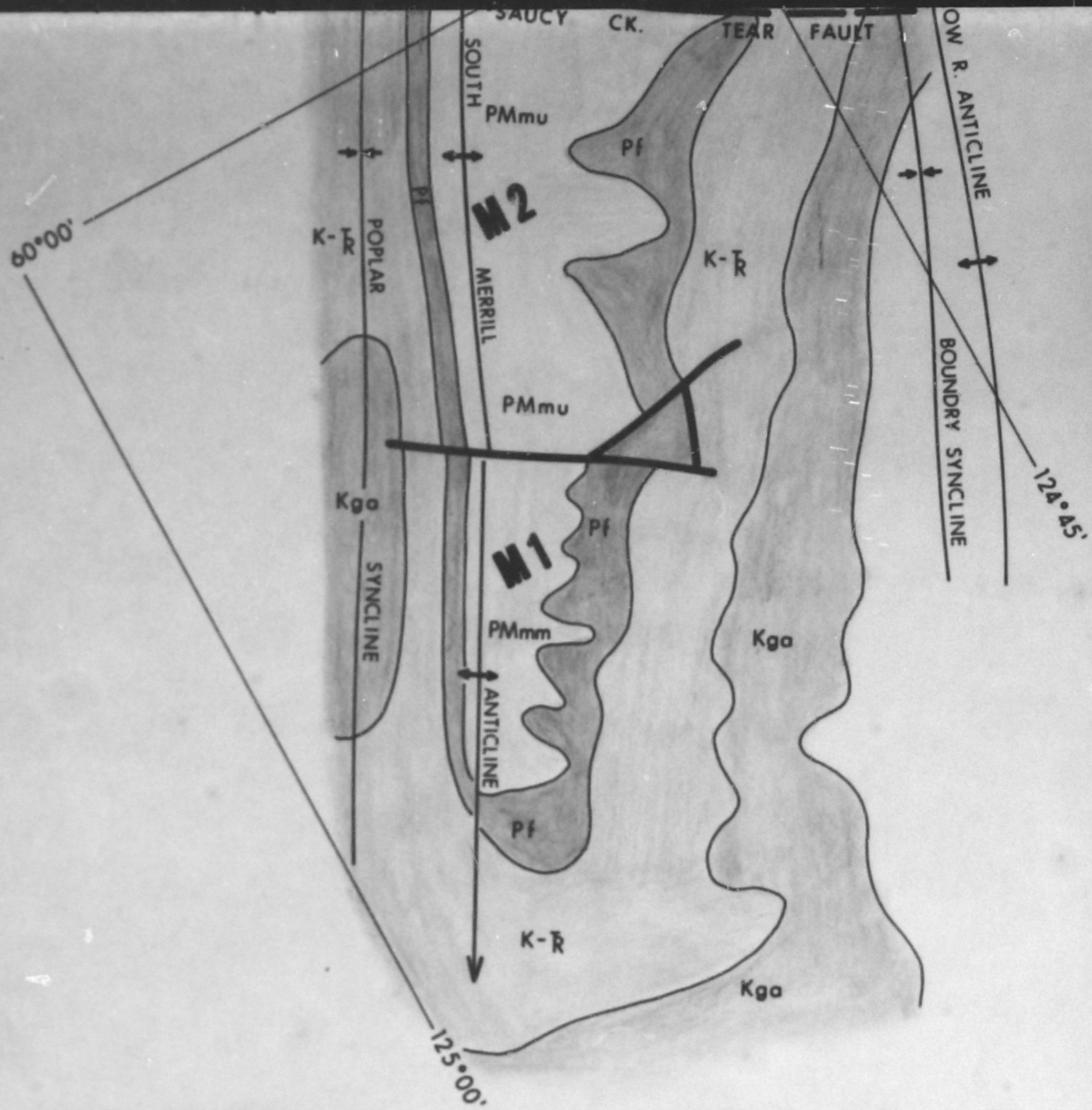


FIGURE 11. TEAR FAULT. NORTH END OF MERRILL III.



124°30'
BALSUM SYNCLINE
PINE TREE SYNCLINE
DICKIE ANTICLINE
WEST DICKIE THRUST
SPRUCE THRUST
SPRUCE ANTICLINE
PMmm
PMml
PMmu
60°10'
124°45'
BIRCH SYN
DICKIE TEAR FAULT
M-De
M5
Pf
124°30'
FAULT
TEAR
MT. MERRILL
60°10'
SOUTH MERRILL ANTICLINE
CROW R. THRUST
M4
60°00'
M3


M4
M-De
PMml
M3
Pf
PMmu
Pf
Pf
60°00'
SAUCY CK. TEAR FAULT
SOUTH
PMmu
Pf
M2
K-TR
POPLAR
MERRILL
PMmu
K-TR
CROW R. ANTICLINE
BOUNDRY SYNCLINE
60°00'
Kga
SYNCLINE
M1
Pf
PMmm
ANTICLINE
Pf
Kga
K-TR
Kga
124°45'
125°00'
— LEGEND —
– ANTICLINE, ARROW INDICATES PLUNGE DIRECTION.
– THRUST FAULT.
– TEAR FAULT.
– FORMATION BOUNDARY.
Kga – GARBUTT Fm.
K-TR – CRETACEOUS - TRIASSIC
Pf – FANTASQUE Fm.
PMm – MATTSON Fm. (MIDDLE, UPPER, LOWER)
M-De – ETANDA Fm.



— LEGEND —

- ANTICLINE, ARROW INDICATES PLUNGE DIRECTION.
- THRUST FAULT.
- TEAR FAULT.
- FORMATION BOUNDARY.

Kga	– GARBUTT Fm.
K-TR	– CRETACEOUS - TRIASSIC
Pf	– FANTASQUE Fm.
PMm	– MATTSON Fm. (MIDDLE, UPPER, LOWER)
M-De	– ETANDA Fm.

Amoco Canada Petroleum Company Ltd.

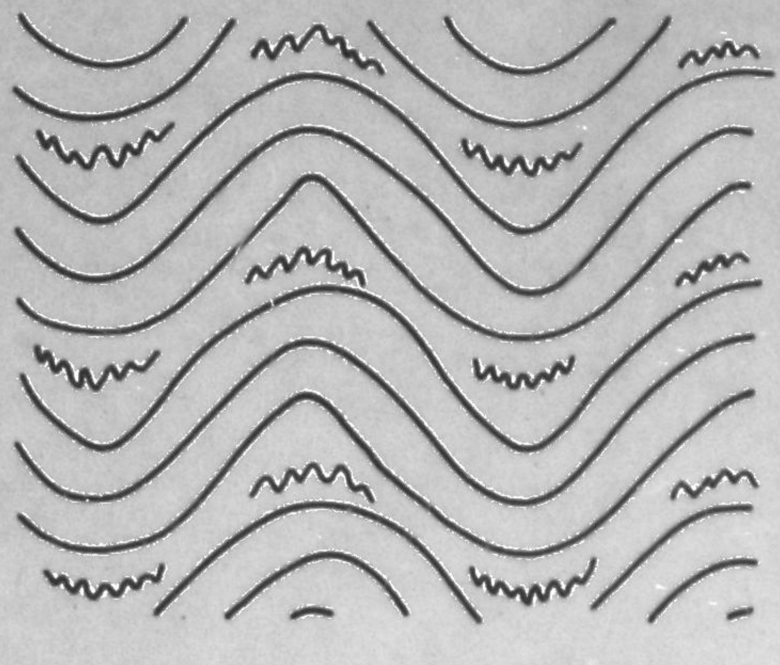
SOUTH MERRILL - CROW RIVER STRUCTURES

SKETCH MAP OF SOUTH MERRILL ANTICLINE

G.R. 73-15.	Compiled By: J. R. TAYLOR.
Figure No: 12.	Date: SEPT., 1973.

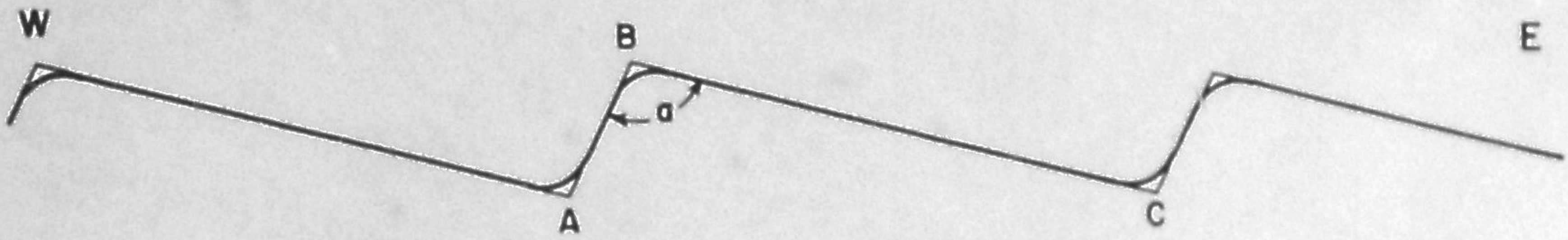
L.O.S.

FIGURE 13.



PSEUDO- SIMILAR FOLDING PRODUCED BY CONCENTRIC FOLDING WITH MULTIPLE PARTIAL DETACHMENTS (AFTER DAHLSTROM, 1970).

FIGURE 14.



ASSYMETRY: FOLDS HAVE "S" CONFIGURATION

(AS OPPOSED TO "Z" CONFIGURATION ).

INTERLIMB ANGLE = α

LIMB RATIO $\frac{BC}{AB}$

SKETCH OF RIGHT SECTION OF TYPICAL FOLD ILLUSTRATING ASSYMETRY.

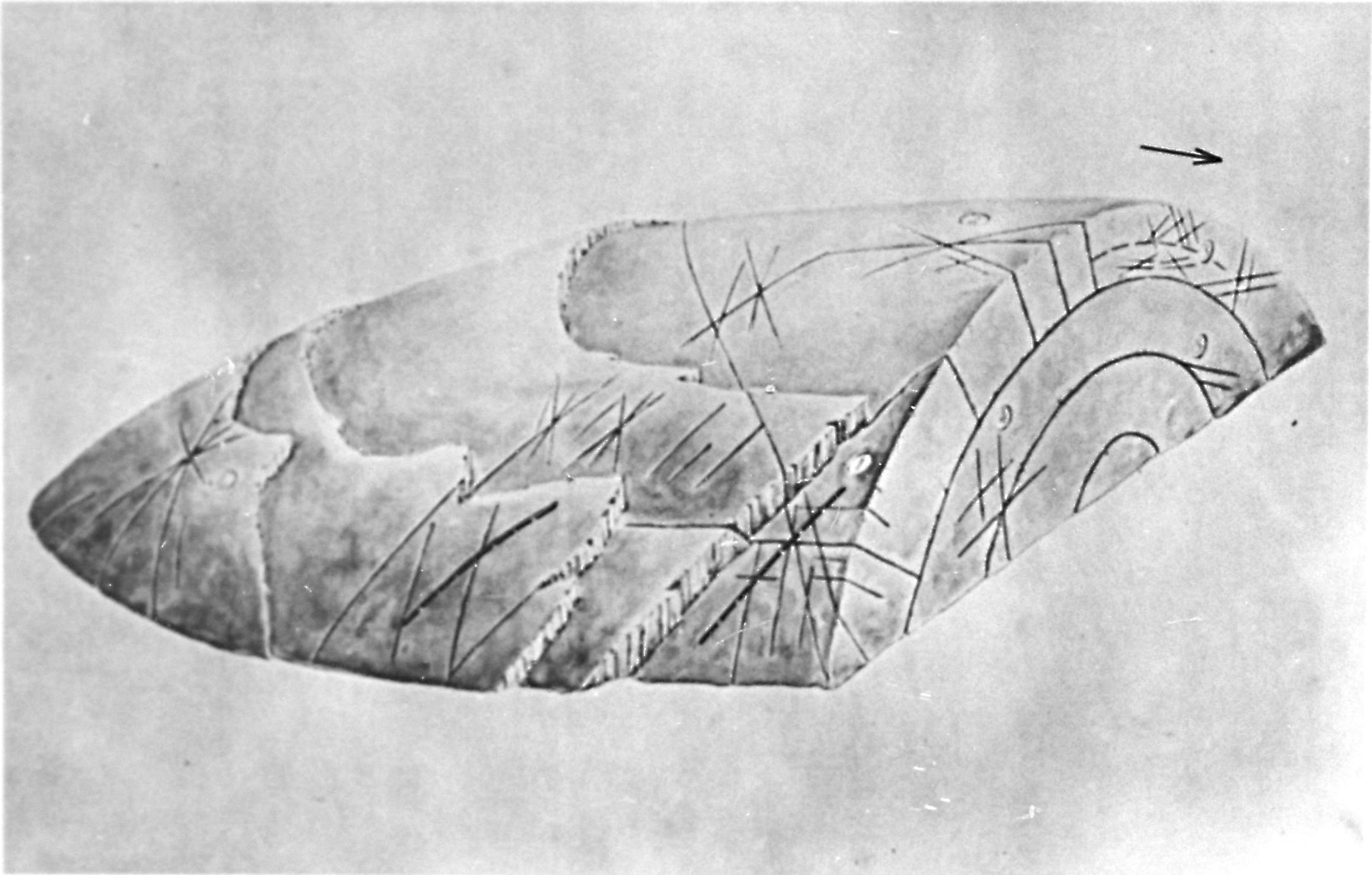


Figure F 15 - Schematic illustration of the fracture sets found on a fold. Note angle of Type I shear fracture and direction of axial trace (arrow) - after Stearns, 1973.

SOUTH MERRILL-CROW RIVER STRUCTURES

YUKON TERRITORY - BRITISH COLUMBIA

LIST OF FIGURES

TABLE OF CONTENTS

INTRODUCTION

The South Merrill - Crow River structures are located in the southeastern Yukon Territory and Northeastern British Columbia. The purpose of this report is to review the surface geology of the South Merrill - Crow River area based on a field check of the area undertaken by the writer during June 6 - 20, 1973.

STRUCTURAL GEOLOGY

1. Surface geological sketch map

Figure 12 is the surface geological map compiled from field work. The map includes data collected in June, 1973, and attitudes believed to be reliable from previous Amoco Canada and Geological Survey reports (Koch, 1960; Douglas and Norris, 1959). Figure 12 significantly updates previous interpretation of the Merrill - Crow River area. Traverses and spot checks in structurally critical areas have solved geologic problems posed in earlier work. Division of the Mattson Formation into three mappable market horizons has contributed to the detection of important structural displacements previously unrecognized in the field.

2. Structural Elements

The project area has undergone moderately intense deformation involving Lower Cretaceous sedimentary rocks. The effective structures observed in the area are:

A. folds
B. low angle reverse faults (thrust faults)
C. transverse tear faults

This characteristic assemblage has had the net effect of structural shortening across the mapped area.

A. Folds

All folding oberserved within the project area exhibits geometrics and orientations which are listed below.

(a) Concentric - the sandstone beds of the Mattson Formation appear to maintain thickness throughout all parts of the fold. Lack of control on the thickness of the Etanda Formation does not allow us to make a similar statement about the shales. The cause of the thickening and thinning in the Etanda in adjacent areas is incompletely understood. Folds may actually adopt some type of pseudo-similar fold mechanism (Figure 13) produced by concentric folding with multiple partial detachments (Dahlstrom, 1970).

(b) Cylindrical - every surface on the fold structure contains a line parallel to the hinge line. This line is the fold axis.

(c) Rectilinear - fold hinges appear to be linear.

(d) Plane - axial planes are not curved.

(e) Harmonic - major changes in fold form are not expected at the level of the Middle Devonian carbonate. The principle lower decollement surface probably occurs in Precambrian argillites (Stearns and Ambrose, 1972).

(f) High Limb Ratio - the ratio of the length of the east limb to the length of the west limb exceed 10:1 (Figure 14).

(g) Open Folds - the interlimb angle is approximately 110° (Figure 14).

(h) Asymmetrical - all folds are S-shaped asymmetrical towards the west (Figure 14).

(i) Axial traces generally trend NNE.

Examples of this pervasive fold style are illustrated in Figure 1-5.

B. Low Angle Reverse Faults (Thrusts)

Low angle reverse faults occur throughout the area and are commonly recognized from repeated members of the Mattson Formation. Thrust faults generally trend NNE and faults planes appear to dip eastward and are interpreted to flatten with depth. Thrust faulting appears to be intimately associated with asymmetric concentric folds suggesting that folding and thrusting are part of the same shortening mechanism. Examples of prominent thrust faults are shown in Figure 6 and 7.

C. Transverse Tear Faults

Recognizable tear faults occur in the South Merrill - Crow River area. These occur transverse to folding and to thrust faulting. Tears are readily seen in steep dipping beds, however in gently dipping strata such as the east flanks of folds, they become very difficult to detect. The tear faults occur as linear or very slightly curvilinear zones of dislocation as indicated by structural discontinuity across the fault. Tear faults are probably near vertical and the amount of displacement is variable (Figure 8).

Transverse tear faults cut the South Merrill Anticline, in a direction oblique to the fold axes. This fault direction appears to correspond to shear fracture of Stearns' Type 1 (Stearns, 1972, see Figure 15). Fold forms on opposite sides of faults may be quite different. The Dickie Tear Fault separates a strongly folded lower wavelength area on the north and the broad open fold of Merrill III on the south. Thus, the assumption that folding took place before transverse faulting cannot be made, since this would simply have displaced the two blocks relative to each other. Transverse tear faulting may be related to the curvilinear nature of the structural trends and mountain ranges which are seen in the entire Liard Area.

Tear faults probably extend to depth and involve Middle Devonian rocks. Examples of tear faults are shown in Figures 9-11.

3. <u>Structures</u>

A. Anticlines

Anticlines mapped at surface are:

(a) South Merrill Anticline
(b) Crow River Anticline
(c) Spruce Anticline
(d) Dickie Anticline

(a) South Merrill Anticline

The South Merrill Anticline is a large surface structure located south of Mount Dickie and traceable SSW across the Crow River. Shaly sands and black shale of predominantly Mississippian age are exposed in the core. Resistant siliceous sandstone of the Middle Mattson Formation form long flank and plunge ridges at an elevation of up to 4,000 feet above sea level. The fold is asymmetrical towards the west. The South Merrill Anticline is divided into sements by transverse tear faults. For convenience, these segments have been designated M1 through M5 (Figure 12).

Fold segment M1 plunges, 05°/SSW. Segment M2 has no detectable plunge at surface. Segment M3 plunges south as evidence by bedding altitudes and outcrop pattern. Segment M4 plunges gently southward. No detectable plunge exists on the surface of segment M5. Note the change in style between segments. The west fold limb becomes less steep from M4 to M5. Changes such as this undoubtedly will be reflected in the configuration of the fold at carbonate level.

(b) Crow River Anticline

The Crow River Anticline is a surface structure recognized between the Crow River and the Beaver River. Upper Mattson Formation calcareous sandstone is exposed in the core at Beaver River. Resistant Fantasque Formation chert occurs on the flank and defines the plunge at the Yukon - British Columbia border. The fold is asymmetrical towards the west and plunges 05° south. Dip measurements on the west limb, along the Beaver River are 70° and the rocks show evidence of brecciation. The east limb dips are 10 - 15°. Just north of the Beaver River the shortening mechanism appears to change from folding to thrust faulting and the Crow River Anticline proper disappears. Whether this juncture occurs at a tear fault or not could not be determined.

(c) Spruce Anticline

The Spruce Anticline is located south of the LaBiche River and west of the Mount Dickie. It expose Lower and Middle Mattson Formation in its core. It is assymetic towards the west. The west limb dips 55+° while the east limb has a dip of 10 - 20°. The fold plunges gently north.

(d) Dickie Anticline

The Dickie Anticline is located west of Mount Dickie. It exposes Etanda Formation in its core and exhibits the fold geometry typical of the area. The west limb dips 50° - 70°, while the east limb dips 10°. The fold plunges gently north.

B. Synclines

Synclines mapped in the field are:

(a) Boundary Syncline
(b) Poplar Syncline
(c) Balsam Syncline
(d) Pine Tree Syncline
(e) Birch Syncline

Geometry of synclines in the South Merrill assumes a standard pattern. The east limbs are steep, 50 - 70°, while west limbs are more gently dipping, 10 - 20°. The Boundary and Poplar Synclines, located in the southern part of the area, plunge gently south and expose Lower Cretaceous rocks in their cores. The Balsam, Birch and Pine Tree Synclines, located west of Mount Dickie, expose Lower or Middle Mattson Formation and do not exhibit a pronounced plunge direction.

C. Thrust Faults

Well developed and important thrust faults in the area are:

(a) Crow River Thrust
(b) Spruce Thrust
(c) West Dickie Thrust

Several other minor thust faults have been mapped.

(a) Crow River Thrust

The Crow River Thrust can be traced from the Yukon - British Columbia border north to just east of Merrill Mountain. It appears to plunge south while at the same time it gains throw northward. At its north end it places Lower Mattson on Upper Mattson. The Crow River Thrust appears to terminate at the Mount Merrill Tear Fault.

(b) Spruce Thrust

The Spruce Thrust is located just east of Mount Dickie. At its south end it appears to place Mississippian - Devonian Etanda on Lower Mattson Formation. It appears to plunge north and may merge with the Spruce Anticline.

(c) West Dickie Thrust

The West Dickie Thrust is located west of Mount Dickie. The Middle Mattson Formation is placed on Triassic - Lower Cretaceous sands and shales.

D. Transverse Tear Faults ("Cross" faults)

Major Transverse Tear Faults occurring in the area are:

(a) Mount Merrill Tear
(b) Saucy Creek Tear
(c) Dickie Tear

(a) Mount Merrill Tear Fault

The Mount Merrill Tear Fault is located just north of

Mount Merrill. It is recognized as a slightly curvilinear offset of steeply dipping Mattson Formation beds transverse to strike. The throw on this fault appears to be variable along strike with the structurally higher side on the north.

(b) Saucy Creek Tear Fault

The Saucy Creek Tear Fault runs along Saucy Creek, south of the Yukon - British Columbia border.

(c) Dickie Tear Fault

The Dickie Tear Fault is located south of Dickie Mountain. The structurally higher side appears to be on the south.

REFERENCES

Dahlstrom, C. D. A., 1970: Structural Geology in the eastern margin of the Canadian Rocky Mountains, Bull. Canadian Petroleum Geol. v. 18, no. 3, pp. 332-406.

Douglas, R. J. W., and Norris, D. K., 1959: Fort Liard - LaBiche map areas, Northwest Territories and Yukon, Geol. Surv., Canada Paper No. 59-6.

Koch, N. G., 1960: Surface geology of the Liard Plateau area of the Northwest Territories, Amoco Canada Geol. Rpt. FXD-54.

Oburn, R. S., 1968: North Park, Colorado - an oil and gas province, in Beebee, B.W., ed Natural Gases of North America, Amer. Assoc. of Petrol. Geol., pp. 840-855.

Reese, D. L., 1968: Gas fields of Rock Springs Uplift, Sweetwater Country, Wyoming, in Beebee, B.W., ed Natural Gases of North America, Amer. Assoc. of Petrol. Geol., pp. 803-816.

Stearns, D. W., 1973: Seminar on Structural Geology: Field Guidebook, Amoco Production Company, Research Department, Tulsa.

Stearns, D. W., and Ambrose, R., 1972: Structural model for the Liard fold belt, Amoco Canada unpublished rpt., not transmitted.

Waldschmidt, W. A., 1948: Gramp's Field, Archuleta County, Colorado in Howell, J. V., ed Structure of Typical American Oil Fields, v. 3, Amer. Assoc. of Petrol. Geol., pp. 110-131.