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Correlation of Ordovician and Silurian Formations of Eastern Montana

Marvin A. Lanphere

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A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
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ABSTRACT

Correlation charts made from electric log data show the relationship of Ordovocian and Silurian strata in eastern Montana. The Silurian sediments terminate westward in eastern Montana, but the Ordovician sediments are present westward into central Montana.

Formational terminology of the Ordovician and Silurian systems in eastern Montana is not agreed upon by all geologists. The Winnipeg formation overlain by the Red River formation and Stony Mountain formation are the most commonly accepted formation names for the Ordovician sediments. Interlake group is the term applicable to the Silurian strata of eastern Montana.

INTRODUCTION

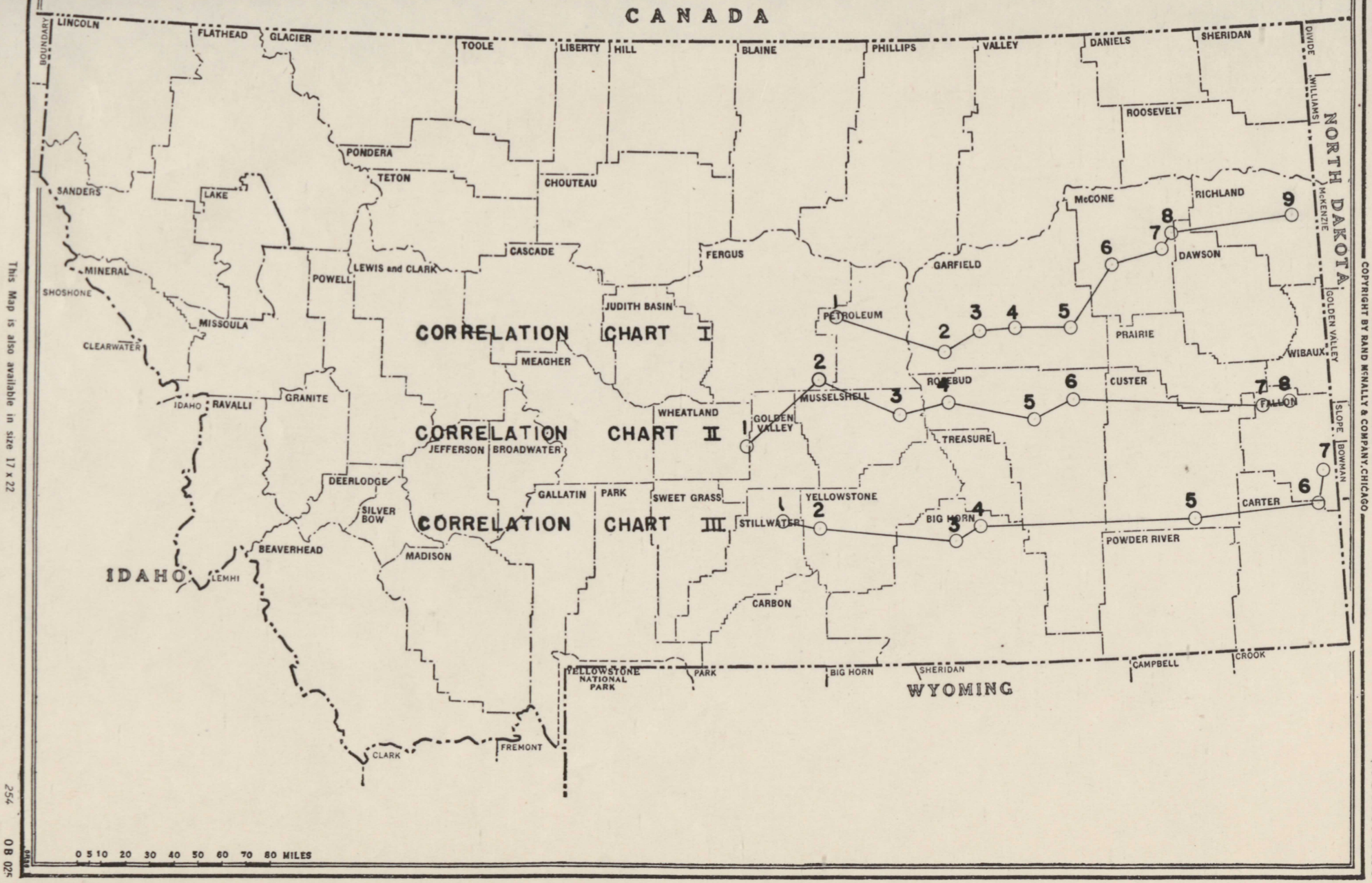
The purpose of this problem is to correlate the Ordovician and Silurian strata of the eastern Montana part of the Williston Basin. It was originally thought that cross sections could be drawn from the western termination, or zero isopach, of Ordovician and Silurian sediments into the Williston Basin proper. The western termination of the Silurian sediments was found on all three cross sections. However, the zero isopach of the Ordovician sediments was

located on only one of the three cross sections.

A secondary objective of the problem was to investigate the terminology applied to Ordovician and Silurian formations in eastern Montana. Formation names have been carried from outcrop sections in Canada, usually Manitoba, to the subsurface formations of the Williston Basin. There has been a great deal of controversy among geologists concerning this subsurface terminology. At present, the controversy cannot be resolved. For the purpose of this report the writer used the terminology accepted by a majority of eastern Montana geologists.

The area under investigation covers a part of the Plains area of eastern Montana. Three cross sections were drawn and correlated from electric log data. The lines of cross sections are shown on the index map of Montana (Plate 1). In general, the sections trend in an east-west direction extending from or near the western termination of Ordovician and Silurian strata to the deeper part of the Williston Basin near the Montana-North Dakota boundary.

Appreciation is extended to Dr. O. D. Blake, of the Montana School of Mines Geology department, for outlining the problem and for his interest and assistance during the study.



STRATIGRAPHY

Ordovician

The basal Ordovician formation in the Williston Basin is the Winnipeg formation, originally defined by D. B. Dowling (1896). According to Hadley et al (1954), the lithology of the Winnipeg formation is as follows:

> Consists of basal sandstone unit with overlying green shale sequence. Locally has some sand in upper shale unit. May contain pyrite and phosphate nodules. Thin limestone beds locally.

A problem exists as to what constitutes the western termination of the Winnipeg formation. This problem will be mentioned later in the report. In the wells where the Winnipeg formation is present its thickness ranges up to 273 ft.

The Red River formation is very widespread and is one of the most consistent formations in the Williston Basin. It was originally named by A. F. Foerste (1929) from quarries along the shores of Lake Winnipeg, Manitoba. Hadley et al (1954) say that the Red River formation, "In outcrop has been divided into three units from top to bottom: Selkirk limestone, Cat Head limestone, and Dog Head limestone. In the subsurface this formation also has a distinctive threefold aspect which for want of correct terminology has been called Unit A, B, and C." However, to the best knowledge of the writer, the threefold division of the Red River formation is not recognized and the corresponding terminology

is not used in eastern Montana.

The lithology of the Red River formation is "Thick bedded crystalline to fragmental limestones and dolomites, sometimes shaly in basal unit and often sandy to cherty in medial unit" (Hadley et al, 1954). In the wells covered by this report, the Red River formation ranges in thickness from 0 to 812 ft.

From outcrops on the west shore of Lake Winnipeg, D. B. Dowling (1901) originally named the Stony Mountain formation. At the outcrop the Stony Mountain formation has been divided into three members. The Stony Mountain shale is the basal member, the Penetentiary dolomite is the medial member, and the Gunton dolomite is the upper member. The subdivisions of the Stony Mountain formation are not generally used in eastern Montana. The term Gunton is occasionally used in eastern Montana, but there is some doubt about the age of the Gunton. Hadley et al (1954) state, "The exact age of the Gunton member is not established and it probably represents the transition from Ordovician to Silurian." Because of this doubt concerning the age of the Gunton member, the writer has placed the Ordovician-Silurian boundary at the top of the Stony Mountain formation as the term is used in eastern Montana. The Stony Mountain formation of Montana is probably correlative with the basal member of Dowling's Stony Mountain formation.

The Stony Mountain formation "In subsurface is primarily

a shale or shaly limestone that is embedded with dark brown to black fossil fragments" (Hadley et al, 1954). The formation is very uniform ranging in thickness from 0 to 102 ft in most of the wells covered by this report, with thicker sections of 161 ft and 210 ft in wells drilled on the Cedar Creek anticline.

Silurian

The Silurian sediments of the Williston Basin belong to the Interlake group originally named by A. D. Baillie (1951) from exposures in the Interlake area of Manitoba. In the type locality, the Interlake group is divided into the Stonewall formation and Units B, C, D, and E in ascending order. In eastern Montana no formation names have been established in subsurface except the Stonewall, which is rarely used; all Silurian strata is usually referred to as Interlake.

The lithology of the Interlake group (Hadley et al, 1954) is

Light colored, cream to white earthy to lithographic limestones and dolomites with local zones of reefoid porosity and permeability. Contains pyrite and thin irregular laminae of green shale. Scattered sand grains.

In the wells included in this report, the thickness of the Silurian strata ranges from 0 to 597 ft.

CORRELATION METHODS

The correlations were made from electric log data with the assistance of stratigraphic "tops" chosen by oil company geologists. Nearly all of the standard electric log curves were used, when available, to choose formation boundaries.

However, in the correlation charts (Plates 2-4) only the normal curve and the lateral or inverse curve have been plotted. This practive was adopted for uniformity because, in several cases, these two curves were the only resistivity measurements made on the wells. Although the spontaneous potential curve is commonly included in electric log correlations, the writer omitted the S.P. curve in this study because, in most cases, it showed insufficient character to be of value in correlation.

The top of the Stony Mountain formation (Ordovician-Silurian boundary) was selected as a base line for the correlation sections, Because the Stony Mountain formation is the most uniform and consistent formation involved in this study, the top of the Stony Mountain was the logical marker to use as a base line.

The most difficult aspect of the problem was choosing electric log "markers" to be used as stratigraphic "tops". A distinct change in lithology produces a good "marker" that will give a sharp reflection on the electric log. A distinct change in lithology will also usually indicate a well-defined stratigraphic boundary. But, the stratigraphic boundaries of the Ordovician and Silurian strata of the Williston Basin are presently the subjects of considerable controversy.

The top of the Winnipeg formation has a characteristic shape on the electric log curves. Well-developed examples of the Winnipeg formation are shown in Shell NPRR #/32-33-"B" (well 7, correlation chart I), in Shell NP #/11-33 (well 8,

correlation chart II), and in California Pennel Unit #/1 (well 7, correlation chart II).

The base of the Winnipeg formation is clearly defined by the characteristic curve marking the top of the Cambrian sediments. The basal Winnipeg is a sand unit while the upper Cambrian is shaly. The base of the Winnipeg formation is marked by a distinct "kick" to the left resulting from the less resistive shale sequence of the uppermost Cambrian strata.

An unsolved problem concerning the Winnipeg formation is just exactly what constitutes the western termination of the formation. West of a line through General Petroleum 5-25-P (well 4, correlation chart I), British-American #/1 NP Fuller (well 5, correlation chart II), and Greer-Delhi Kendrick #/4 (well 4, correlation chart III) the characteristic curve of the Winnipeg formation disappears on the electric log. Whether the formation wedges out or experiences a facies change is not known. Additional work will be necessary in order to solve this problem.

Both the top and the bottom of the Stony Mountain formation are well indicated on the resistivity curves. The Stony Mountain lithologically is quite shaly and, therefore, the formation has a low resistivity. On the resistivity curves the top of the Stony Mountain formation produces a distinct "kick" to the left, and the bottom of the formation produces a "kick" to the right toward the highly resistant carbonate lithology of the Red River formation. If the limestones of the Red River formation contain hydrocarbons,

however, the Stony Mountain-Red River boundary is difficult to determine because the resistivities of the two formations are comparable and a characteristic curve is not produced. Occasionally the resistivity curve marking the Stony Mountain-Red River boundary may be reversed. That is, the top of the Red River formation may be marked by a "kick" to the left instead of to the right. This reversal can be caused by a change in the salinity of the drilling mud with respect to the salinity of a formation's connate water. However, correlations can still be made because the characteristic curve of the Stony Mountain-Red River boundary will be formed although the curve will be reversed in direction.

Concerning the Interlake group, Hadley et al (1954) say, "Great difference of opinion exists as to both top and bottom of this unit as found in the subsurface of the Williston Basin." After research, the writer adopted, for correlation purposes, the Devonian-Silurian boundary that is most commonly used in eastern Montana. This correlation marker is well illustrated in Hodge and Hodge Eggebrecht #/1 (well 8, correlation chart I). Correlations were made using the selected marker although there was some disagreement, in certain cases, with stratigraphic "tops" chosen by other geologists.

A general difficulty concerning this project was the scarcity of information on the Ordovician and Silurian stratigraphy of eastern Montana. Very little deep drilling was done in the area until a few years ago. At present,

deep tests are still few in number and widely separated. Consequently, the information used in this report for correlation purposes is not as detailed as the writer would have liked.

SUMMARY

During the course of this problem certain conclusions have been reached and certain observations can be made from studying the correlation charts (Plates 2-4). These conclusions and observations are stated below.

(1) The formational terminology of the Ordovician and Silurian systems in eastern Montana is not agreed upon by all geologists. In this report the writer adopted the nomenclature that is most widely used. The basal Ordovician is the Winnipeg formation, which is overlain by the Red River and Stony Mountain formations. The top of the Stony Mountain formation is the most generally accepted Ordovician-Silurian boundary. Interlake group is the name which is applicable to the Silurian strata of eastern Montana.

(2) Additional work will have to be done before the problem of the Winnipeg formation can be solved. The writer believes the western termination of the Winnipeg formation is either a "wedge out," which could be caused by either erosion or non-deposition, or a facies change into the Red River formation to the west.

(3) The Ordovician sediments thicken over the Cedar

Creek anticline, as shown in Shell NP #/11-33 (well 8, correlation chart II) and Shell Little Beaver #/33-3 (well 7, correlation chart III). This thickening may be due to structural reasons or it may be normal thickening due to deepening of the Williston Basin. Since no wells to the east of the Cedar Creek anticline are included in this report, the writer will not predict the cause of thickening of the Ordovician sediments.

(4) A peculiar relationship is shown in Greer Otter # 1 in Bighorn county (well 3, correlation chart III). The total thickness of the Ordovician sediments is only 189 ft compared with a thickness of 504 ft in Greer-Delhi Kendrick # 4 (well 4, correlation chart III), which is only 13 miles to the east. The thickness of the Ordovician strata increases again to the west to a total of 344 ft in Cities Service McFarland #1 (well 2, correlation chart III). Some type of structural control is suggested. However, the evidence is not conclusive enough to justify the presence of a structural high in Ordovician time on the information observed in this one well.

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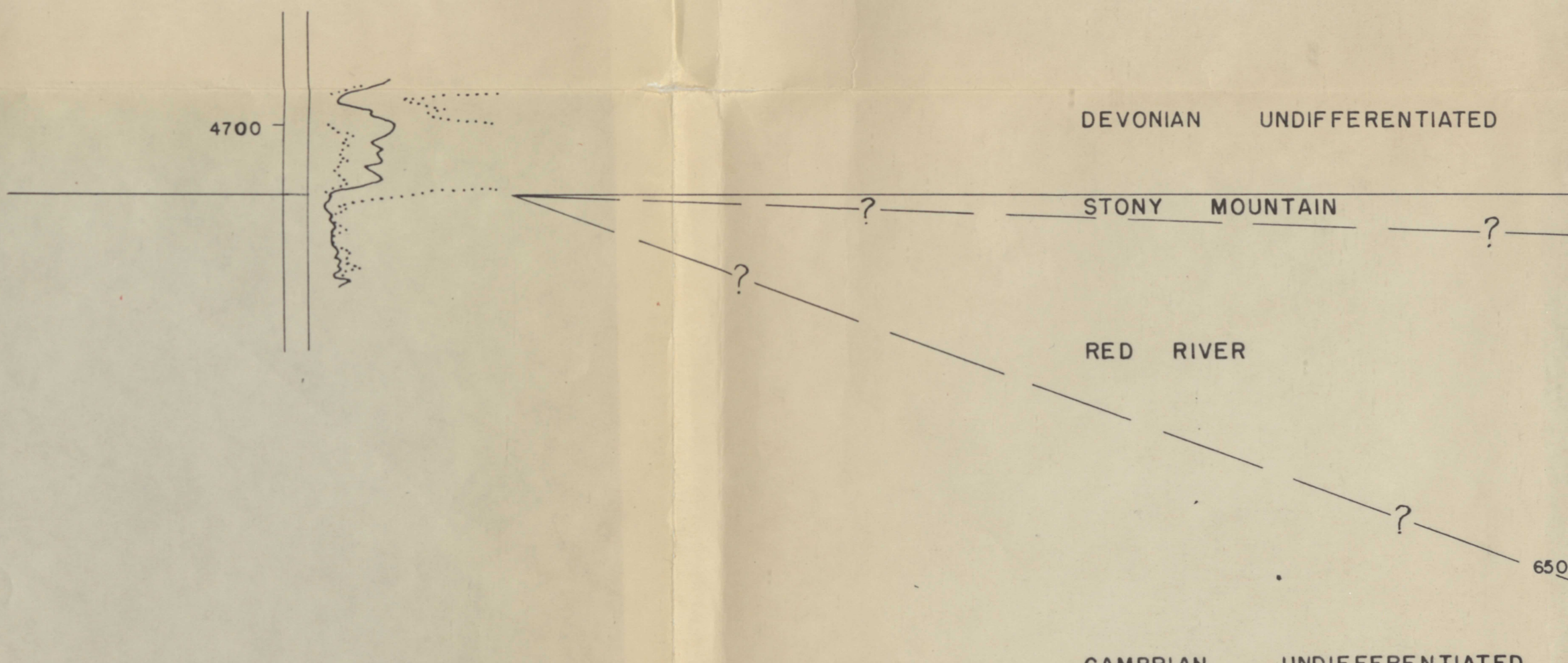
PETROLEUM COUNTY
Amerada Petroleum Corp.
#1 J.E. Burke
25-17N-24E

GARFIE
Amerada
NPR
1-

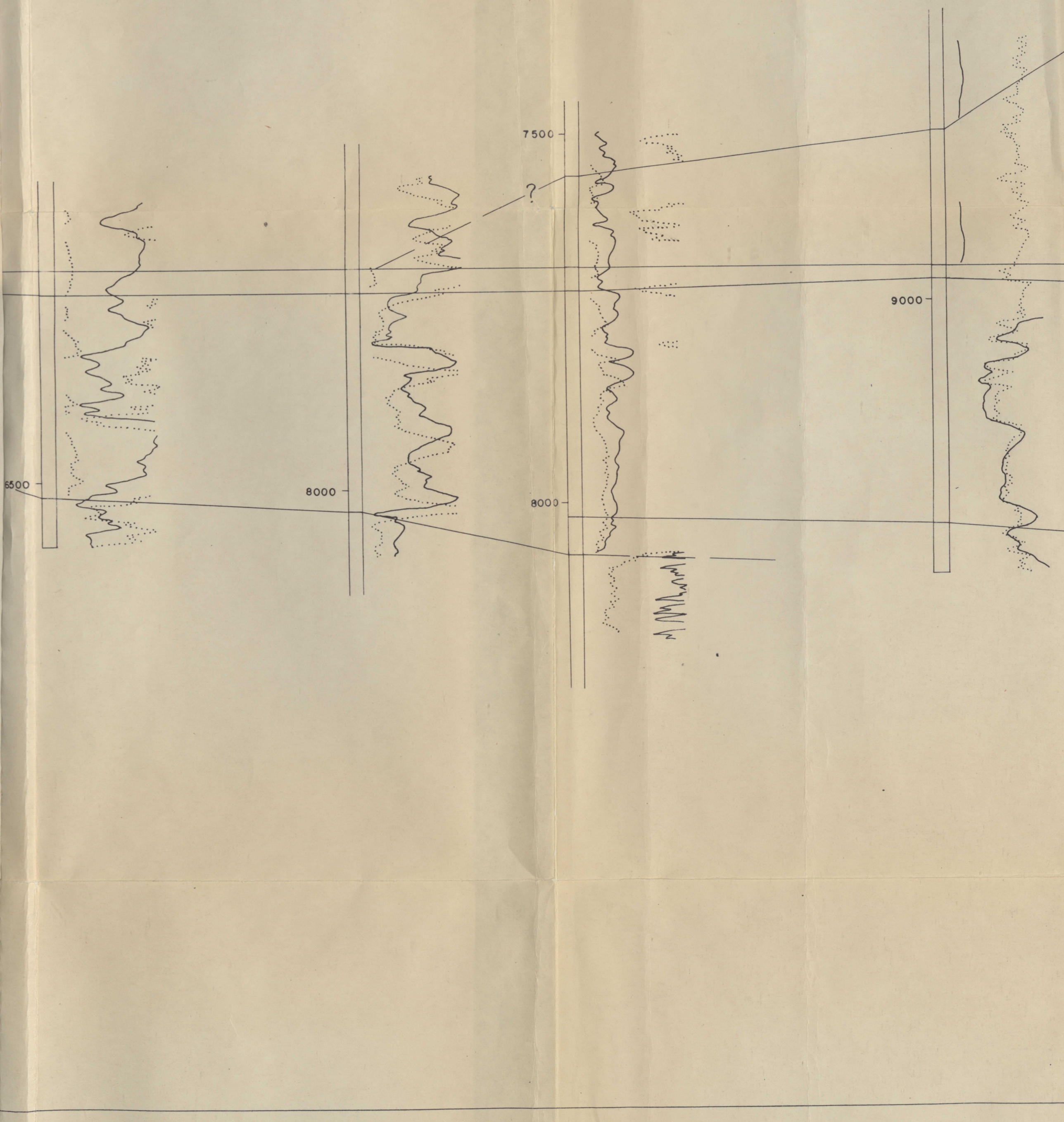
51 mi.



MONTANA SCHOOL OF MINES
MARVIN LANPHERE
1955

CORRELATION CHART I

2	3	4	5
FIELD COUNTY da Petroleum Corp. NPRR "B" #1 1-14N-32E	GARFIELD COUNTY Ralph Lowe Sandquist #1 28-16N-36E	FREEDOM DOME General Petroleum Corp 5-25-P 25-16N-38E	GARFIELD COUNTY Shell Oil Co. Williamson #14-34 34-16N-42E
21 mi.	15 mi.	25 mi.	



6

McCONE COUNTY
Stanolind - Amerada
NPRR #1
5-20N-45E

34 mi.

8500

9000

RED RIVER

WINNIPEG

CAMBRIAN UNDIFFERENTIATED

7

S.W. RICHEY FIELD
Shell Oil Co.
NPRR 32-33-"B"
33-22N-48E

22 mi.

9500

9500

10000

10500

8

McCONE COUNTY
R.V. and R.F. Hodge
Eggebrecht #1
3-23N-49E

18 mi.

9000

9500

9

RICHLAND COUNTY
Sun Oil Co and Phillips Petroleum Co
Dynneson #1
32-24N-58E

53 mi.

DEVONIAN UNDIFFERENTIATED

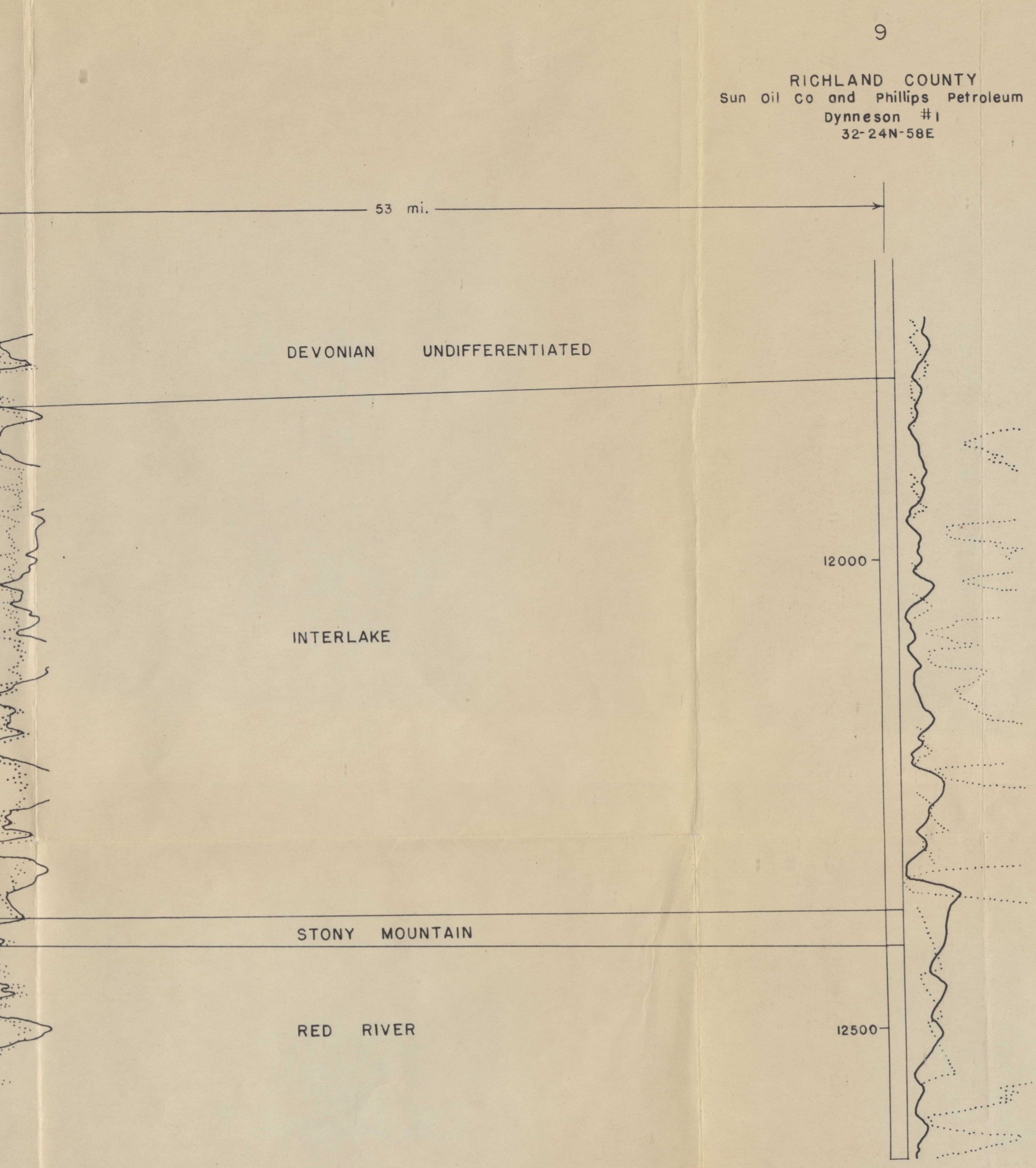
INTERLAKE

12000

STONY MOUNTAIN

RED RIVER

12500



Vertical Scale

500'

400'

300'

200'

100'

0

1

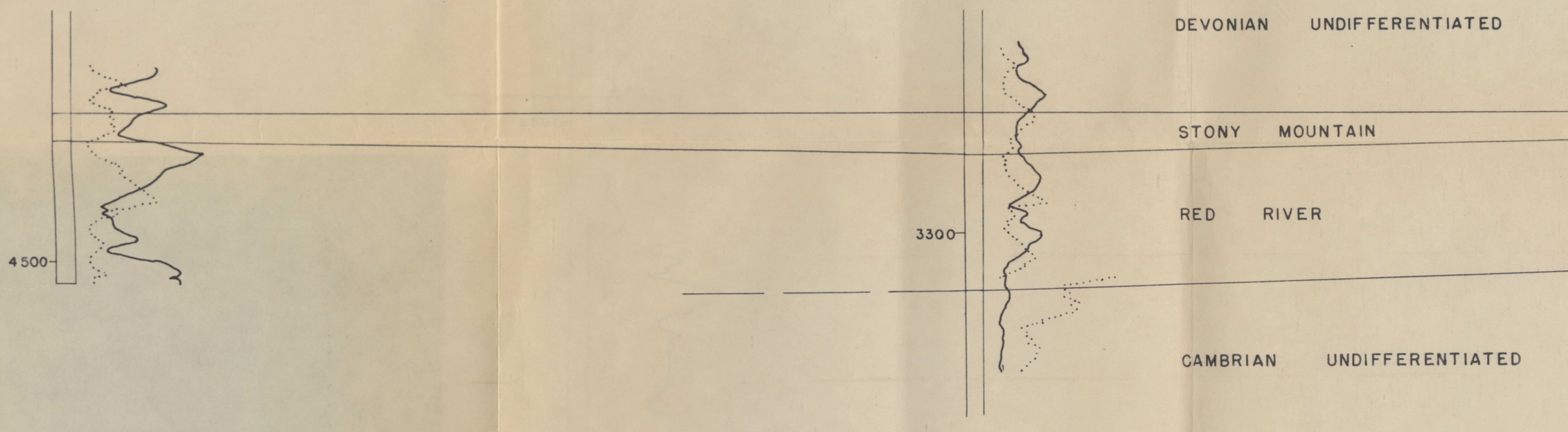
WHEATLAND COUNTY
Mid-Montana Oil Co.
Young #1
13-7N-18E

2

FERGUS COUNTY
Amerada Petroleum Corp.
R. L. Wilden #1
27-13N-23E

46 mi.

40 mi



NTANA SCHOOL OF MINES
MARVIN LANPHERE
1955

CORRELATION CHART

3

MELSTONE FIELD
Amerada Petroleum Corp.
#2 Hougen
23-10N-29E

4

ROSEBUD COUNTY
The Texas Co.
State B #2
36-11N-33E

26 mi

36 mi.

TED

6500

7300

?

Vertical Scale

500'

400'

300'

200'

100'

0

T II

5

ROSEBUD COUNTY
British-American Oil Co.
#1 N.P. Fuller
21-9N-39E

6

ROSEBUD COUNTY
Coden Exploration Co.
Thompson-Nefsy #1
34-11N-42E

22 mi.

85 mi.

7

FALLON COUNTY
The California Company
Pennel Unit #1
15-10N-56E

8

CABIN CREEK FIELD
Shell Oil Co.
N.P. #11-33
33-10N-58E

12 mi.

DEVONIAN UNDIFFERENTIATED

INTERLAKE

STONY MOUNTAIN

RED RIVER

WINNIPEG

CAMBRIAN UNDIFFERENTIATED

9500

8500

10000

9000

10500

1

STILLWATER COUNTY
Superior Oil Co.
Copulos 71-22
22-2N-21E

2

YELLOWSTONE COUNTY
Cities Service Oil Company
McFarland #1
6-1N-24E

3

BIGHORN COUNTY
George J. Greer, Trustee
Otten #1
32-1N-34E

BIG
Gre

15 mi.

63 mi.

13 mi.

6000

6500

5500

DEVONIAN UNDIFFERENTIATED

STONY MOUNTAIN

RED RIVER

CAMBRIAN UNDIFFERENTIATED

MONTANA SCHOOL OF MINES
MARVIN LANPHERE
1955

CORRELATION CHART III

4

BIGHORN COUNTY
Greer-Delhi Oil
Kendrick #4
8-1N-36E

mi. — 95 mi.

?

8500

5

CUSTER COUNTY
Pure Oil Co.
State #1
36-2N-5IE

mi.

56 mi.

8500

9000

9500

?

DEVONIAN UNDIFFERENTIATED

INTERLAKE

STONY MOUNTAIN

RED RIVER

WINNIPEG

CAMBRIAN UNDIFFERENTIATED

6

CARTER COUNTY
Carter Oil Co.
Traweek #1
6-2N-6IE

7

LITTLE BEAVER FIELD
Shell Oil Co.
Little Beaver #33-3
3-4N-6IE