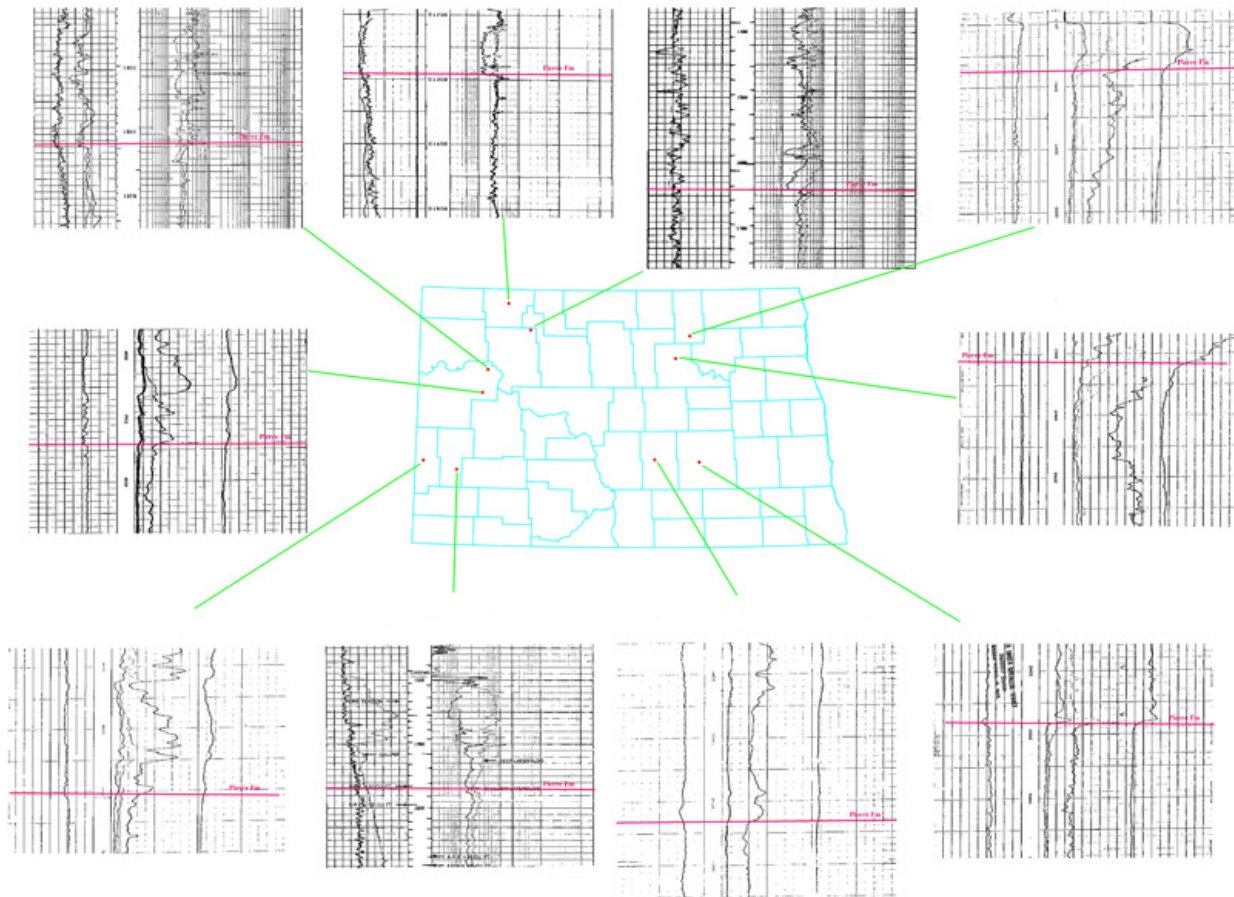


# Reference Logs for Cretaceous Formations in North Dakota

by  
Richard D. LeFever



**REPORT OF INVESTIGATIONS NO. 106**  
**NORTH DAKOTA GEOLOGICAL SURVEY**  
Edward C. Murphy, State Geologist  
Lynn D. Helms, Director, Dept. of Mineral Resources  
2007

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**Department of Geology and Geological Engineering  
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2. Top of the Judith River beds.
3. Top of the Gammon Member and the Niobrara Formation.
4. Top of the Niobrara, Carlile, and Greenhorn Formations.
5. Top of the Greenhorn and Belle Fourche Formations.
6. Top of the Mowry, Newcastle, Skull Creek, and Inyan Kara Formations.
7. Top of the Inyan Kara and Swift Formations.

Digital files of the logs depicted in this report can be viewed on the ND Oil and Gas Subscription site.  
Paper copies of the plates in this report can be obtained from the ND Geological Survey at a cost of \$5 per plate.

## **Introduction**

This document is intended to provide those working in the Cretaceous of the subsurface of North Dakota with a set of reference logs for the major stratigraphic units. The logs were chosen to give coverage across as much of the state as possible, and to convey some idea of the variability in log characteristics which exist.

Although there are numerous publications on the Cretaceous in North Dakota, there are few which provide sufficient examples of the log characteristics of the various units to be useful in a study such as this. The most useful examples are in Rice (1977), Bluemle *et al.* (1986), and Moore *et al.* (1987). Some wells which were part of cross-sections or used as examples in these publications are included on the plates, are highlighted in red, and listed in Table 1.

The approximate stratigraphic equivalencies for the subsurface Cretaceous strata in North Dakota and surrounding states and provinces are shown in Figure 1. Please note that the correlation of the members of the Pierre Formation in North Dakota with the Bearpaw-Claggett interval in eastern Montana is only speculative, as most of the Pierre members cannot be traced with confidence in the subsurface.

## **Pierre Formation**

The Pierre Formation is a noncalcareous shale. The upper contact of the Pierre Formation is with the Fox Hills Formation. The Fox Hills is typically far more sandy or silty than the Pierre, and the contact is usually marked by a sharp increase in resistivity upward (*e.g.*, well 72, Plate 1). On newer logs, where shallow and deep resistivities are distinguished, the contact is often recognizable as a noticeable upward increase in separation of the curves (*e.g.*, well 11541, Plate 1). The Pierre Formation extends over most of North Dakota, although it is absent locally due to glacial erosion. It is exposed along the Cedar Creek anticline in southwestern North Dakota, in the Missouri River Valley south of Fort Yates, along the Pembina Escarpment in the northeast part of the state, and in the lower levels of some drainages. Five members are recognized in North Dakota, four of which are exposed in outcrop in the northeast. Generally, the members are difficult to recognize in the subsurface; the exception is the Gammon Member (below).

Table 1. Previously published wells used in plates.

<u>Well No./ API</u>	<u>Location</u>	<u>Operator and Well Name</u>	<u>Source</u>
72 33-053-00004	SWNE Sec.36 T150N R96W McKenzie County	AMERADA PETROLEUM CORP. N. DAK. B TRACT 1 #1	Rice (1977)
422 33-071-00008	NESW Sec.33 T158N R62W Ramsey County	MCLAUGHLIN INC. WOLFE # 1	Rice (1977)
3981 33-009-00915	SENE Sec.22 T159N R82W Bottineau County	MIDWEST OIL CORP. ARTHUR J. GUNNING #1	Rice (1977)
4727 33-025-00036	SWSW Sec.6 T142N R91W Dunn County	SIGNAL DRILLING & EXPLORATION INC. CARL SIVERTS #1	Rice (1977)
4790 33-009-01034	SESE Sec.20 T159N R81W Bottineau County	UNION OIL COMPANY OF CALIFORNIA ABRA STEEN #1	Bluemle <i>et al.</i> (1986)
7087 33-023-00171	SESW Sec.18 T163N R95W Divide County	SHELL OIL CO. SVANGSTU #24-18	Bluemle <i>et al.</i> (1986)
10571 33-011-00412	SWSW Sec.26 T130N R102W Bowman County	STRIKER PETROLEUM CORP. RUPPERT #1	Bluemle <i>et al.</i> (1986)



### **Judith River beds**

In Montana, the Judith River Formation is a prominent coarser zone in the lower part of the shaly Upper Cretaceous section (fig. 2). Although the Judith River is not recognized as a formal stratigraphic unit in North Dakota, a silty or sandy interval stratigraphically equivalent to the Judith River Formation in Montana is present in many wells in western North Dakota (Plate 2), and is herein referred to as the Judith River beds. It is not recognizable in all wells, and does not appear to occur east of the Nesson Anticline. Where present, it occurs 300-500 ft above the top of the Gammon Member of the Pierre Formation.

### **Gammon Member**

The Gammon Member is the lowest member of the Pierre Formation. It is present over most of the state, and is the only Pierre member that can be consistently identified on wireline logs. The top of the Gammon is considered to be the base of the Ardmore bentonite, a widespread distinctive marker. The Ardmore has a distinctive gamma-ray trace (*e.g.*, well 15182, Plate 3); on logs which lack a gamma-ray curve, the Gammon top is placed at a distinct break on the resistivity curve (*e.g.*, well 422, Plate 3). In older descriptions, and in informal usage, the Gammon in eastern Montana and North Dakota is often called the “Eagle Sandstone”, although that usage is incorrect in this area; the Eagle Sandstone *sensu stricto* occurs only much farther west.

### **Niobrara Formation**

The Niobrara Formation is a calcareous shale, often with white inclusions, referred to by drillers as the “First White Specks”. The unit becomes more calcareous to the east; in eastern North Dakota, it is more chalky than shaly. On wireline logs, the top of the Niobrara Formation is the first significant deflection of the gamma-ray curve below the top of the Gammon Member (*e.g.*, well 7087, Plate 4). Where a gamma-ray curve is not present, the top is picked at a significant deflection in the resistivity curve (*e.g.*, well 422, Plate 4).

### **Carlile Formation**

The Carlile Formation is a noncalcareous shale, and is present in the subsurface over



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Fallon County, Montana

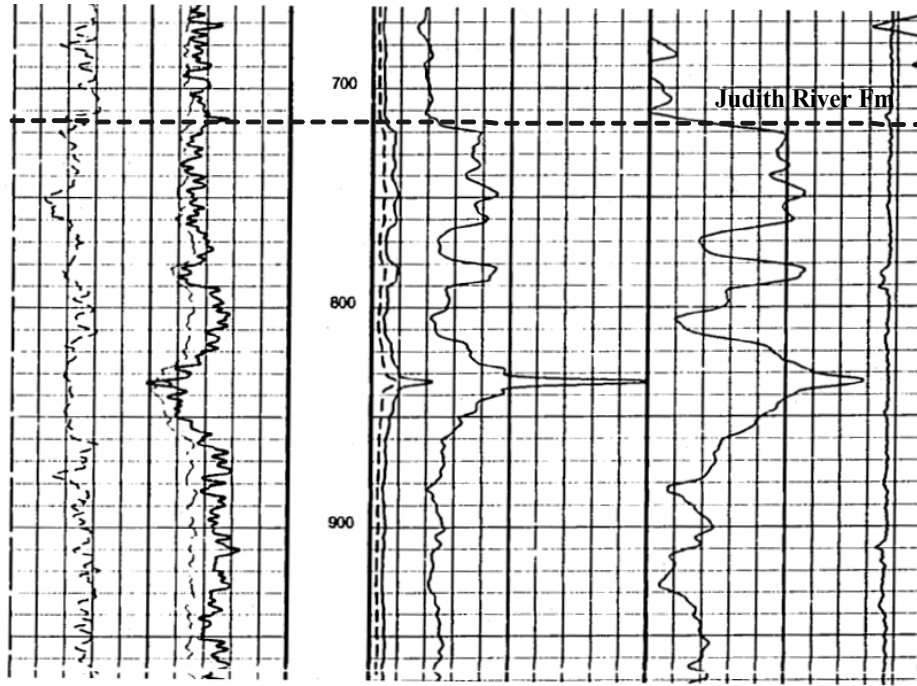


Figure. 2. Judith River Formation in eastern Montana

nearly all of North Dakota. On wireline logs, the top of the Carlile is marked by an abrupt increase in the gamma-ray curve, from the calcareous Niobrara to the shaly Carlile (*e.g.*, well 11541, Plate 4). Where there is no gamma-ray curve, the top is usually picked at a peak on the resistivity curve (*e.g.*, wells 422, 671, Plate 4). To the southwest, the Carlile is lithologically similar to the overlying Niobrara, and the top may be difficult to determine (*e.g.*, well 13223, Plate 4).

### **Greenhorn Formation**

The Greenhorn Formation is a calcareous shale, sometimes referred to by drillers as the “Second White Specks”. It has a distinctive log character, and is one of the few Cretaceous units which can be recognized on a wide variety of logs. At the top of the Greenhorn, the gamma-ray curve declines abruptly from the shaly Carlile into the Greenhorn (*e.g.*, wells 4790, 14926, Plate 5). On logs which lack a gamma-ray curve, the top is usually picked at the top of an abrupt deflection in the resistivity curve (*e.g.*, well 72, Plate 5). On some wells, the gamma-ray deflection may be distinctly separated from the resistivity deflection (*e.g.*, well 8856, Plate 5); in such cases, the top is picked with the gamma-ray curve.

### **Belle Fourche Formation**

The Belle Fourche Formation is a micaceous shale, and is present in the subsurface over nearly all of the state. The top is most easily recognized on the resistivity trace, where there is an abrupt decrease in resistivity from the Greenhorn into the Belle Fourche (*e.g.*, well 72, Plate 5). The lithologic difference between the two formations is often less pronounced on the gamma-ray trace, and may be difficult to recognize.

### **Mowry Formation**

The Mowry Formation marks the top of the Dakota Group (fig. 1). The top of the Mowry is marked by a persistent bentonitic layer, which gives a strong response on gamma-ray curves (*e.g.*, well 3312, Plate 6). Where a gamma-ray curve is not present, the top of the Mowry is typically picked at an abrupt downward decrease in resistivity (*e.g.*, well 3981, Plate 6).

## **Newcastle Formation**

The Newcastle Formation is a sandy and silty unit between the Mowry and Skull Creek shales. The lower contact of the Newcastle is unconformable; the unit was deposited during a significant sea level fall and subsequent transgression. The Newcastle is not present throughout the state; it is generally absent in north and northeastern North Dakota, and locally in the southwest. Where present, the formation is easily recognizable as an interval of lower gamma-ray response (*e.g.*, well 14834, Plate 6). Where no gamma-ray curve exists, the unit appears as a distinct increase on the resistivity log trace (*e.g.*, well 422, Plate 6).

## **Skull Creek Formation**

The Skull Creek Formation is a shale unit which extends across the entire state of North Dakota. The upper contact with the Newcastle Formation (*e.g.*, well 14834, Plate 6) is unconformable. The Skull Creek has log characteristics similar to the Mowry Formation; where the Newcastle Formation is absent, it may be difficult to distinguish the Mowry and Skull Creek (*e.g.*, well 8549, Plate 6).

## **Inyan Kara Formation**

The Inyan Kara Formation consists of sandy and silty intervals, with some shales. The upper part is predominantly marine sandstones, with some shales, while the lower part is primarily nonmarine sandstones and shales. The Inyan Kara is present across the entire state. It represents the initial deposits of the Early Cretaceous transgression, and was deposited on an erosion surface at the top of the Swift Formation (Jurassic). In extreme eastern and southeastern North Dakota, the Swift Formation is absent, and the Inyan Kara is underlain by the Red River Formation (Ordovician). The top of the Inyan Kara is picked at a prominent deflection of the resistivity curve (*e.g.*, well 15541, Plate 7). On newer logs, the deflection often appears as a “sawtooth” pattern, as with well 15541. Where the “sawtooth” pattern is absent (*e.g.*, well 3981, Plate 7), the top is considered to be the first major deflection of the resistivity curve.

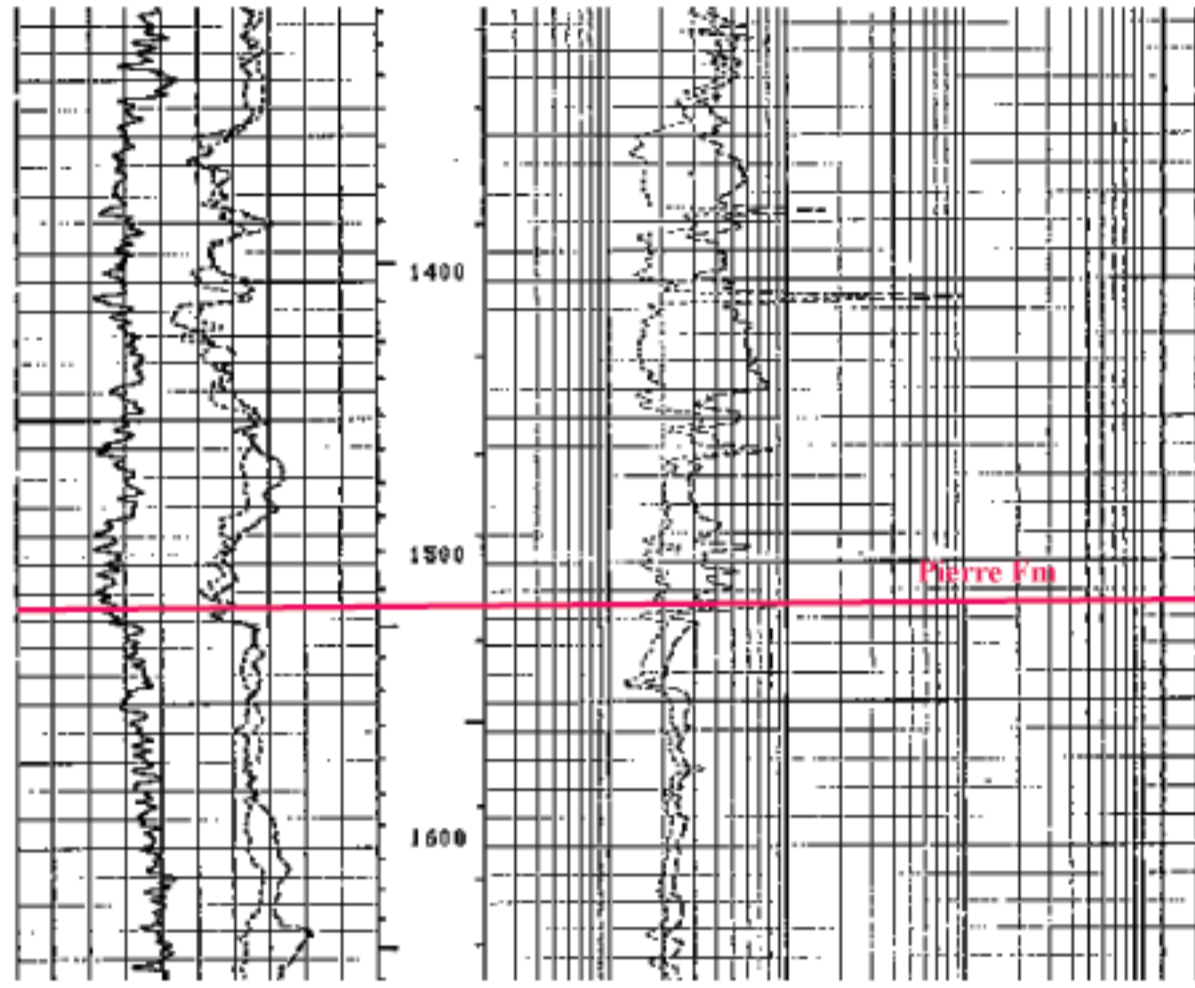
In some wells (*e.g.*, well 14676, Plate 6), there are small deflections evident above the major or “sawtooth” deflection. Some workers label these “Dakota silt”, while the major one is called “Dakota sand”. For consistency, the major deflection is always used here as the Inyan Kara top.

The base of the Inyan Kara is picked at the bottom of the lowest sandy zone, *i.e.*, where the gamma-ray curve abruptly increases to the values typical of the shaly Swift Formation (*e.g.*, well 11541, Plate 7).

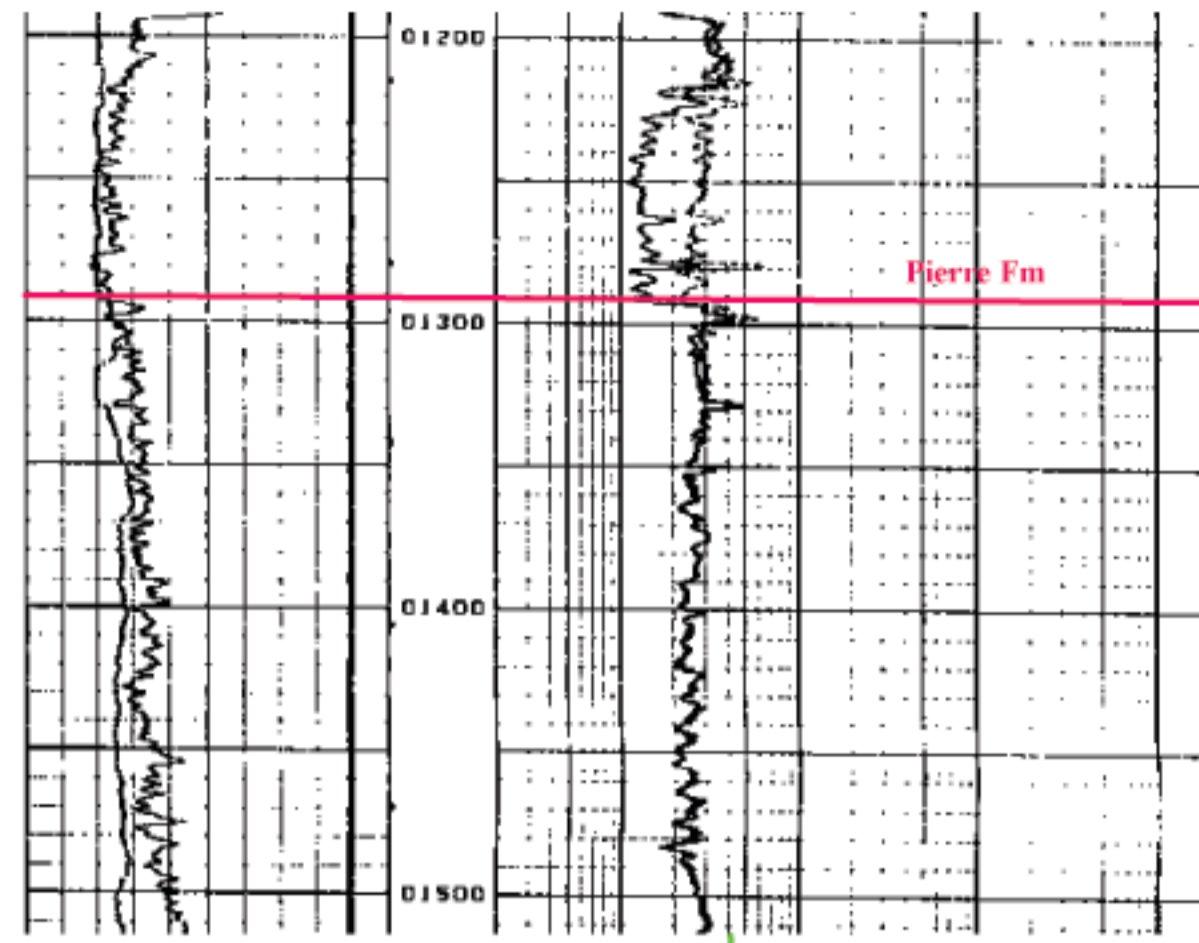
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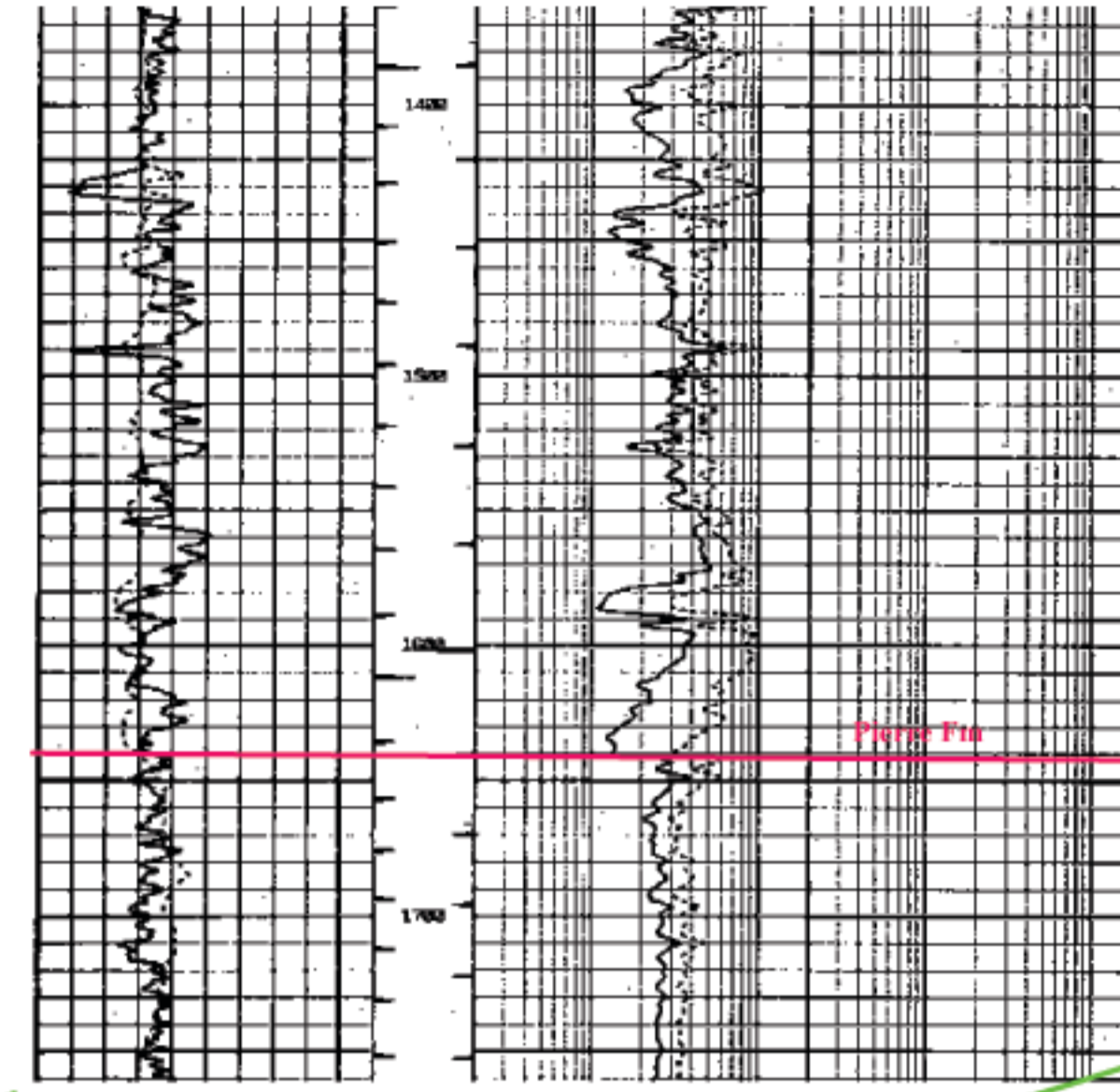
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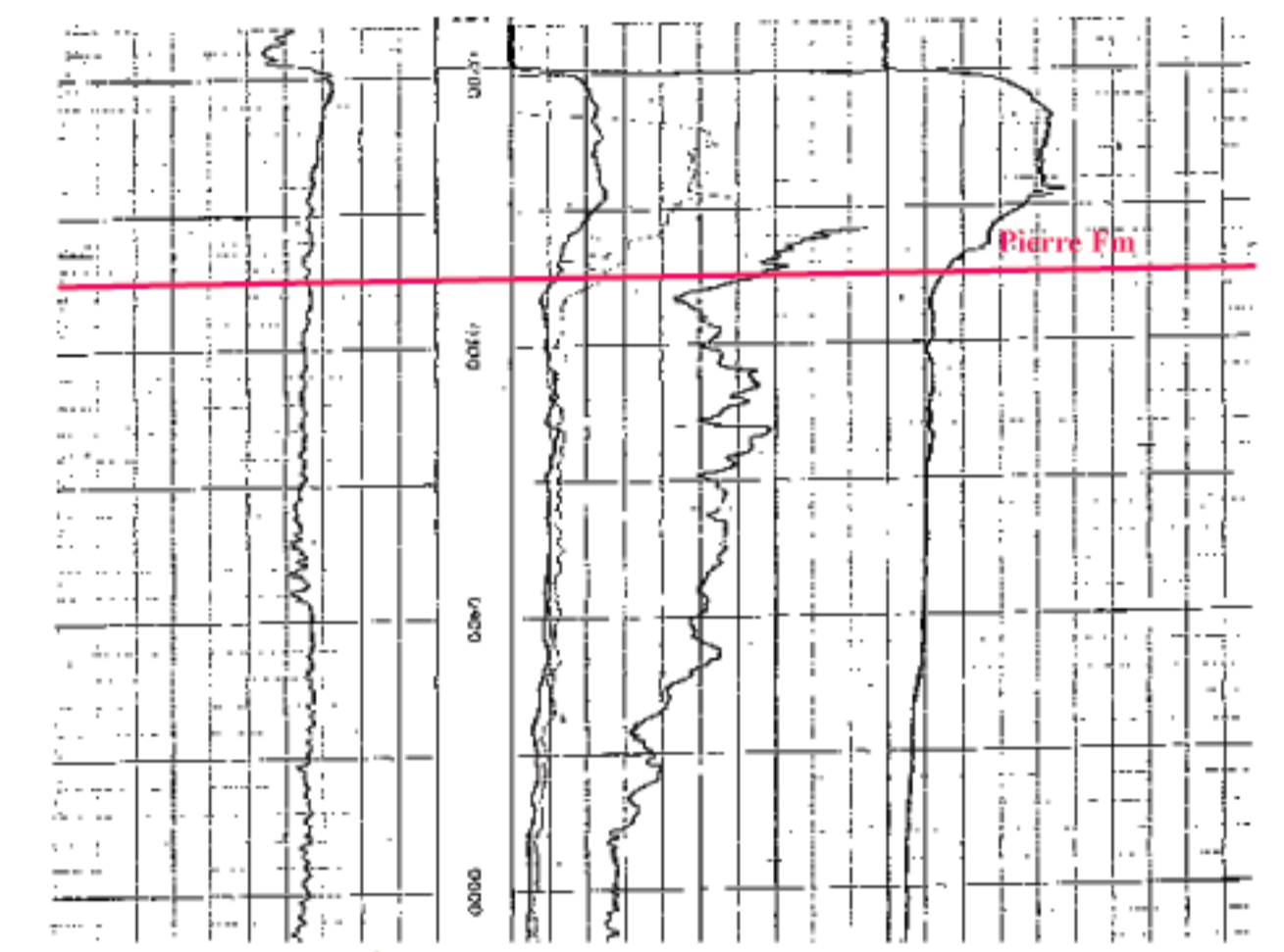
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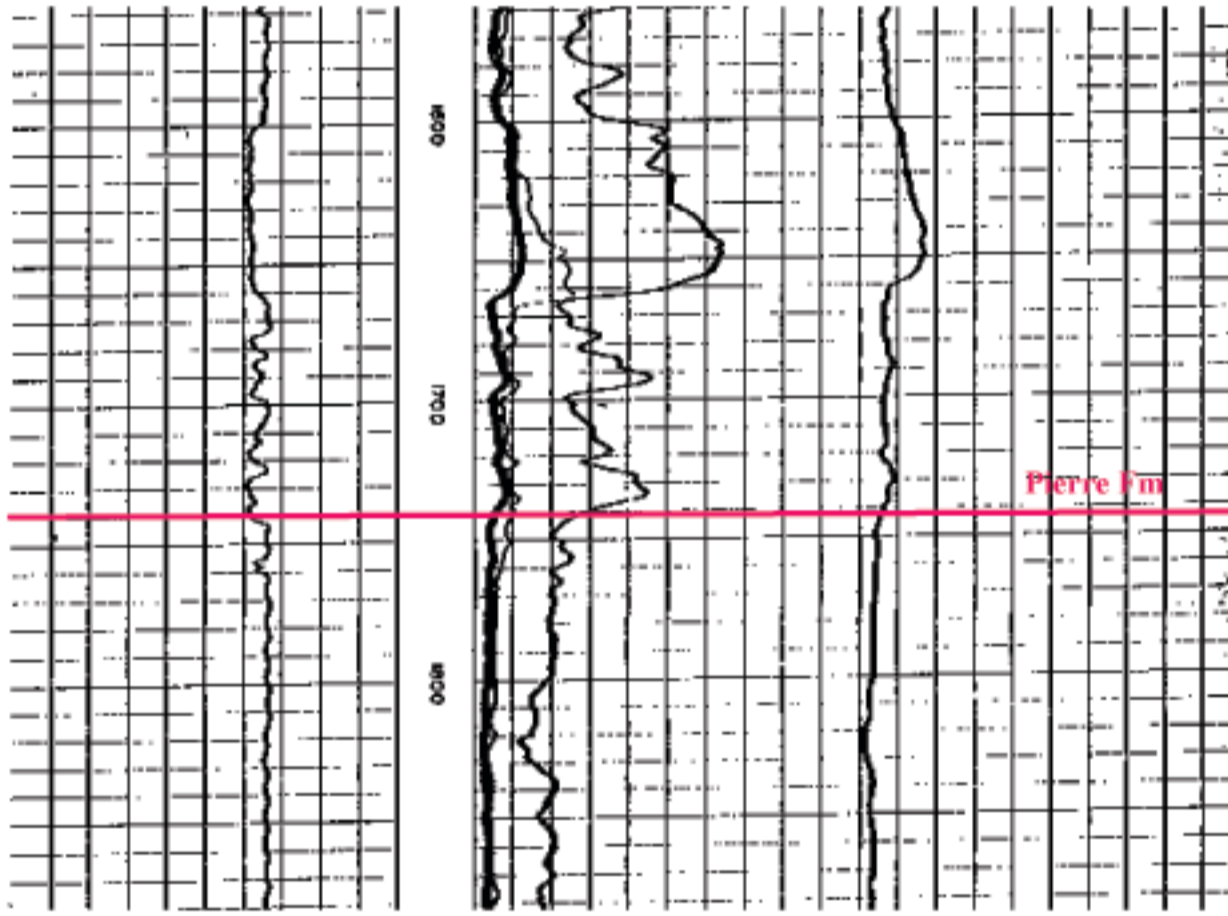
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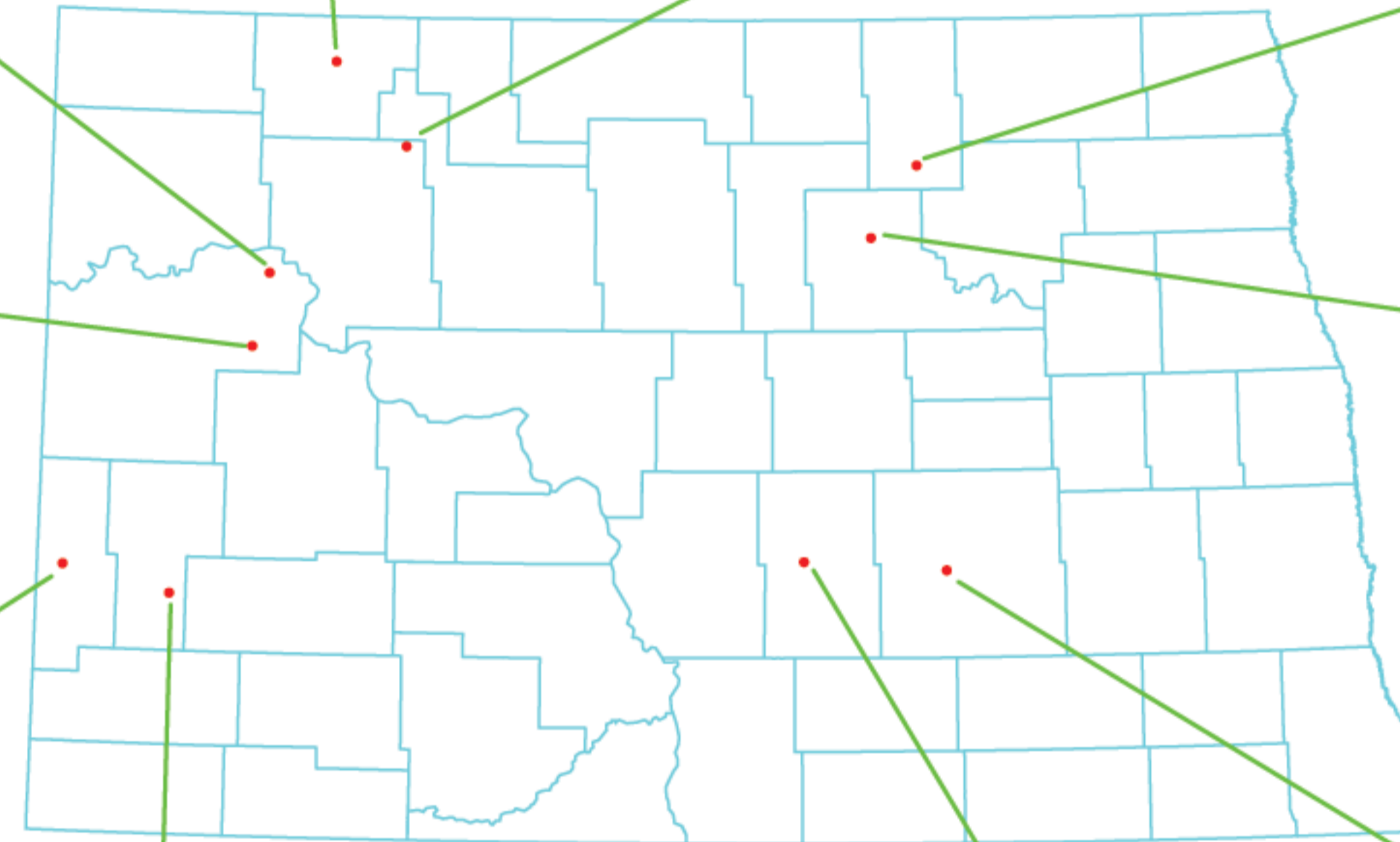
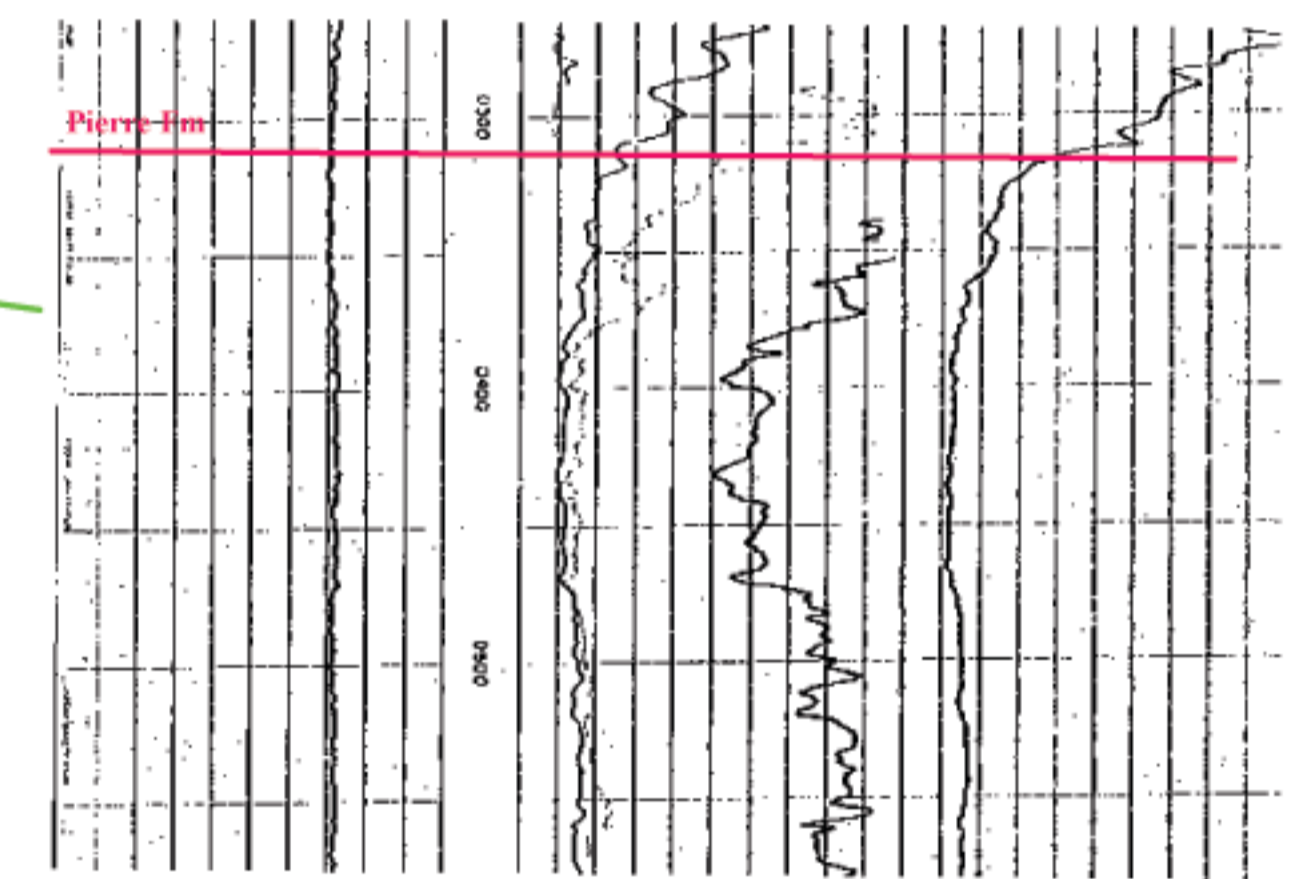
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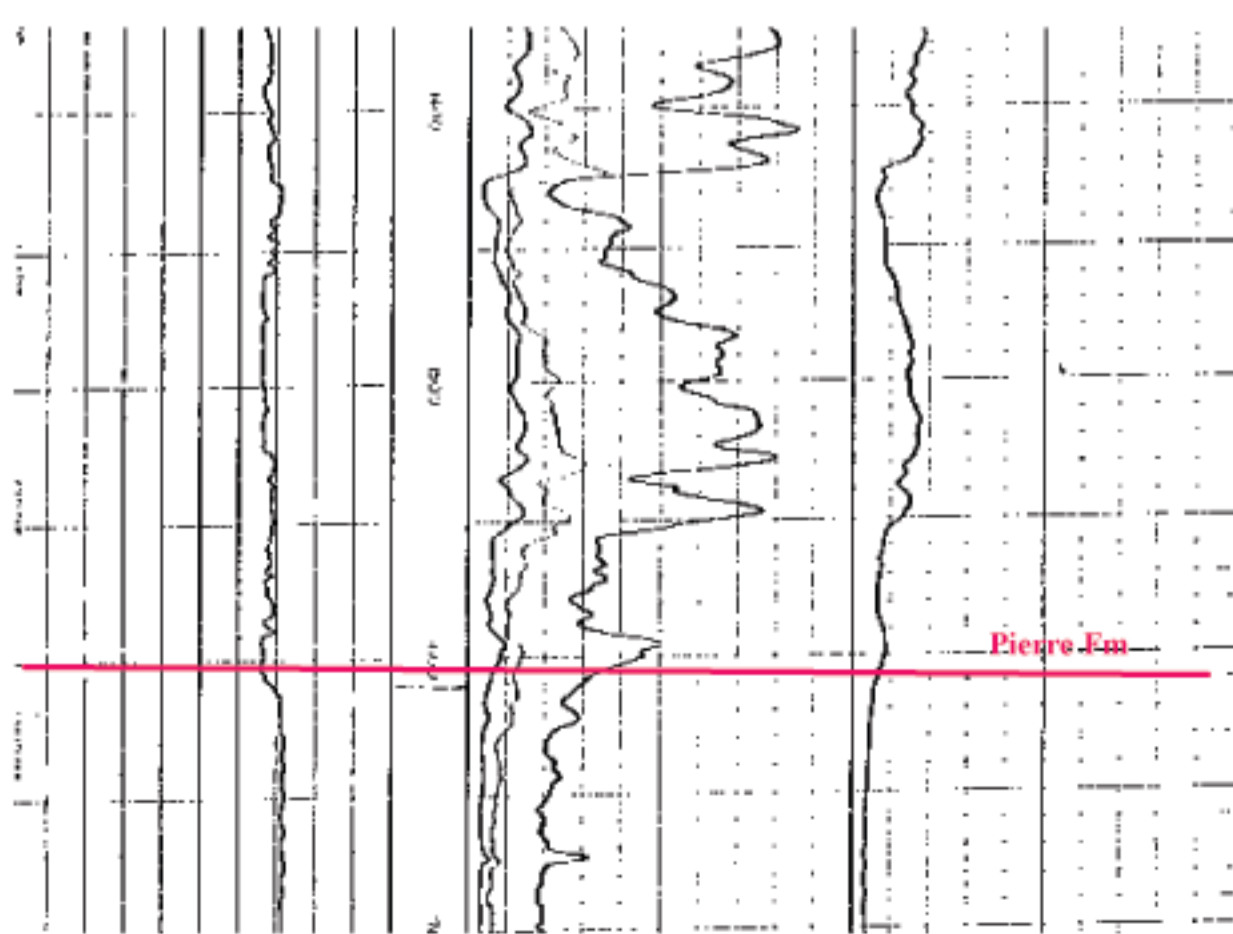
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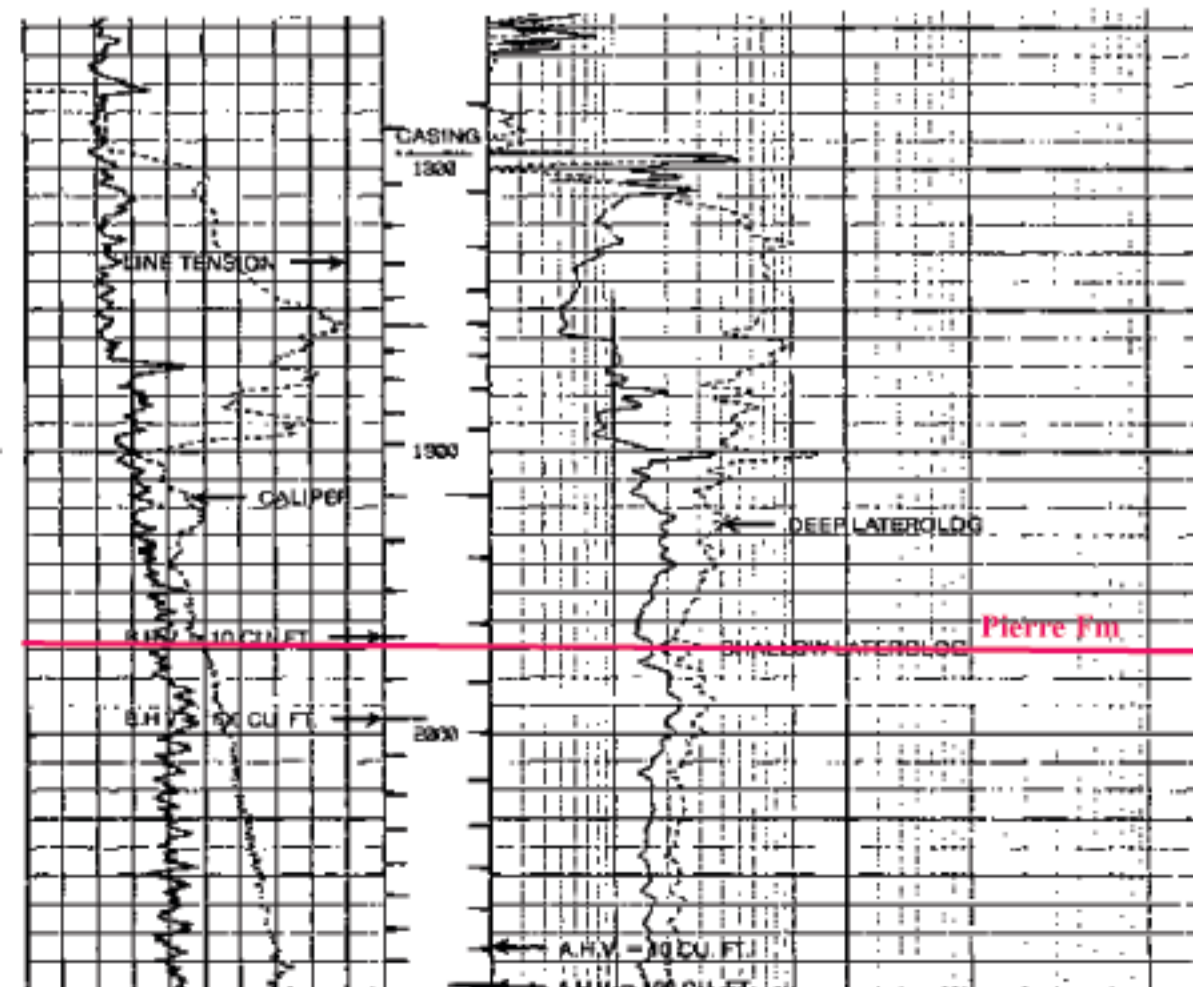
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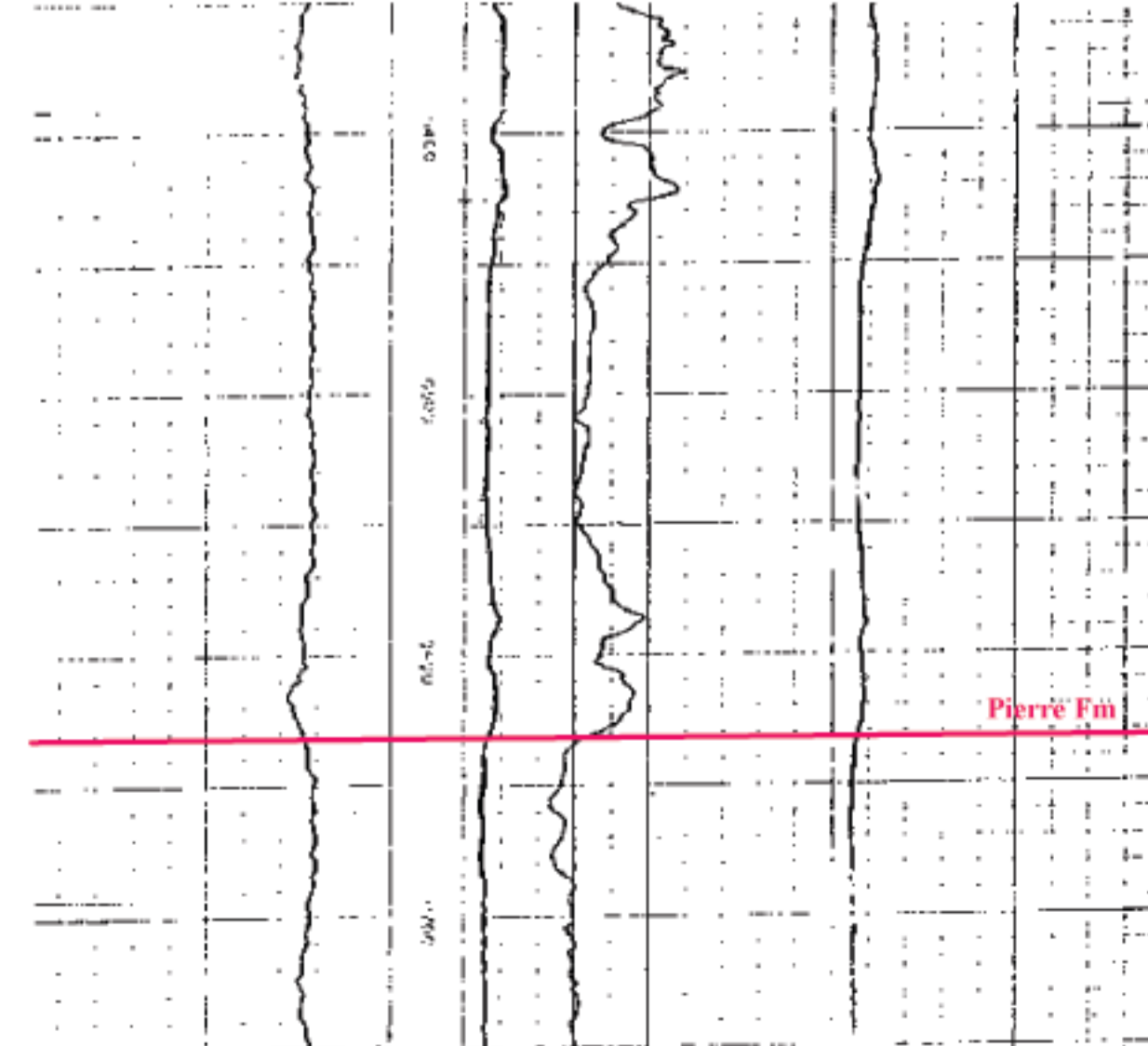
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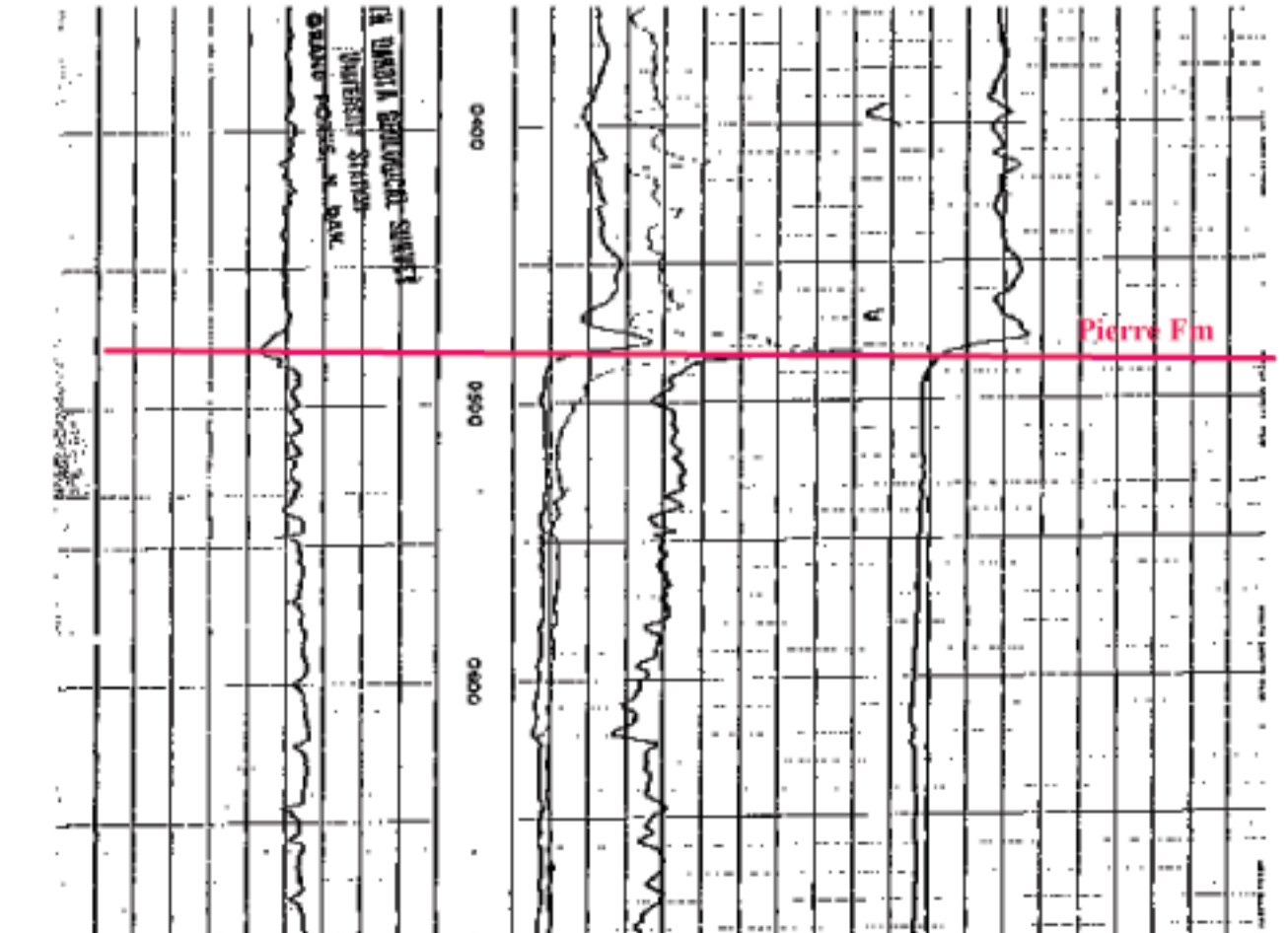
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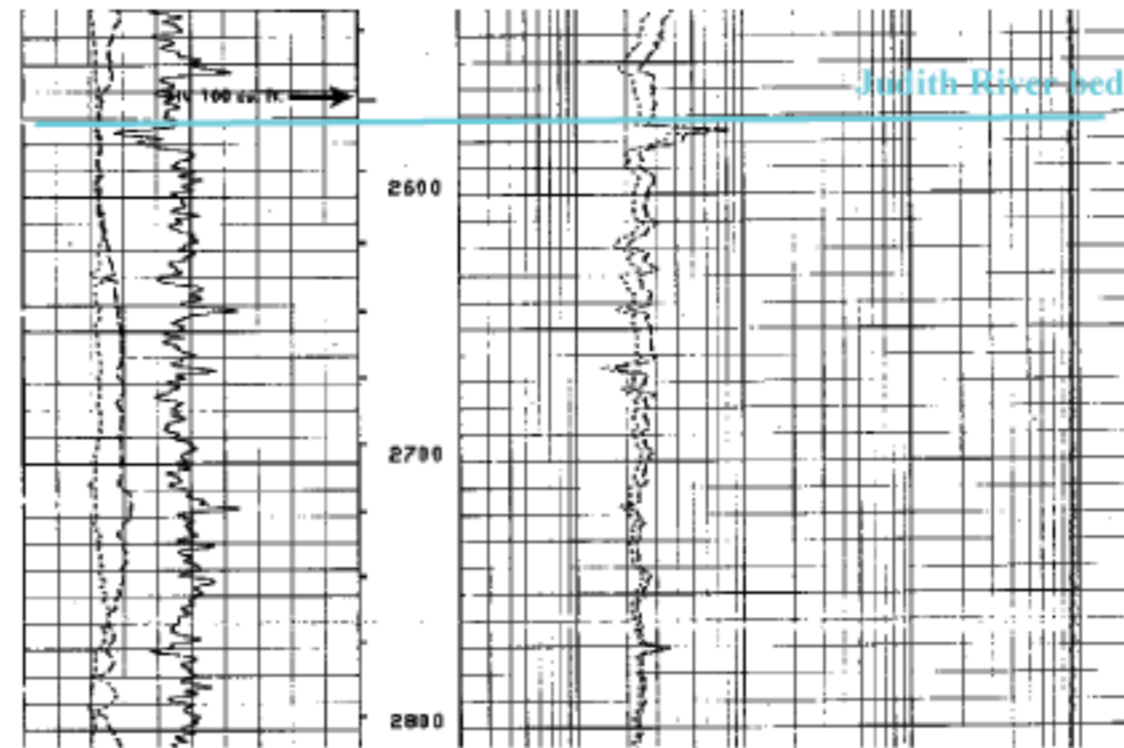
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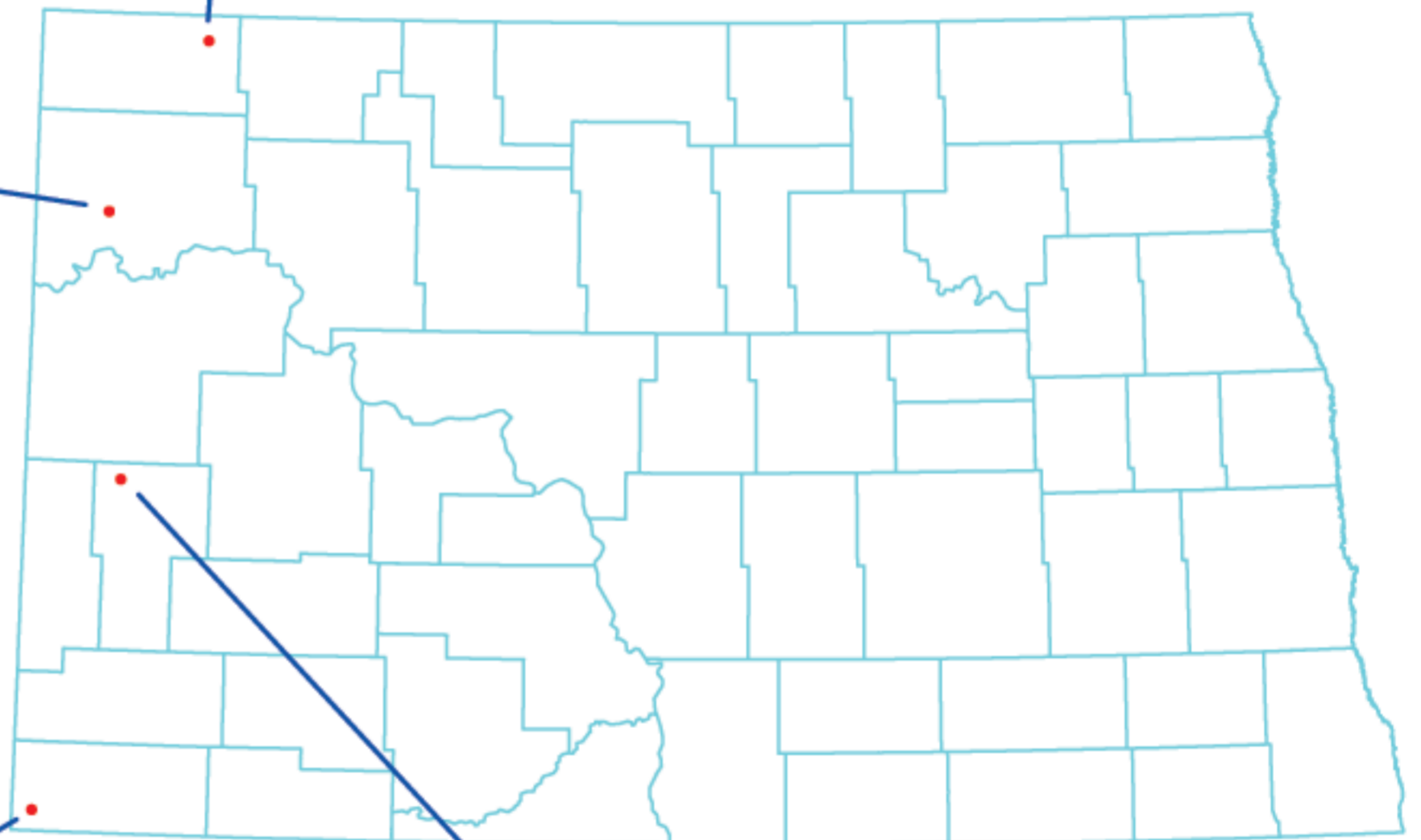
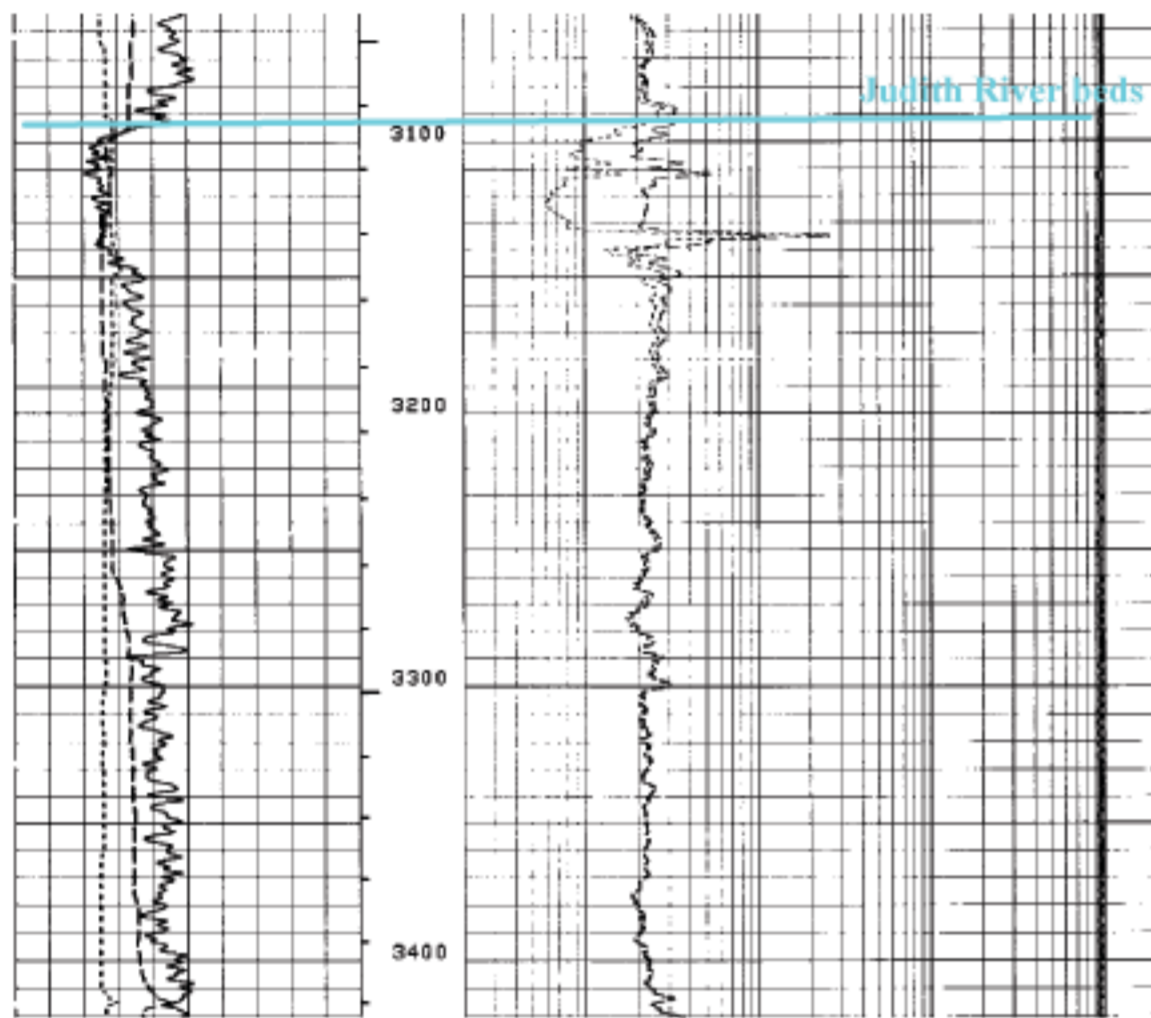
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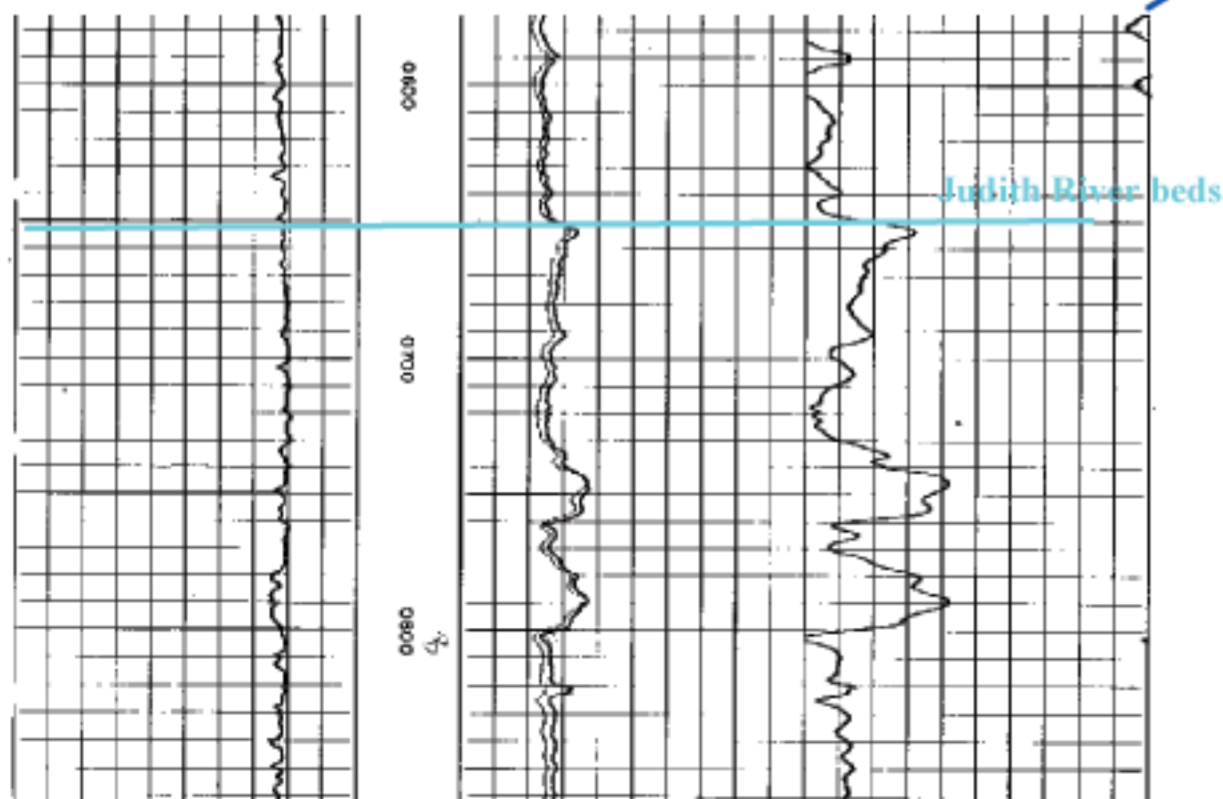
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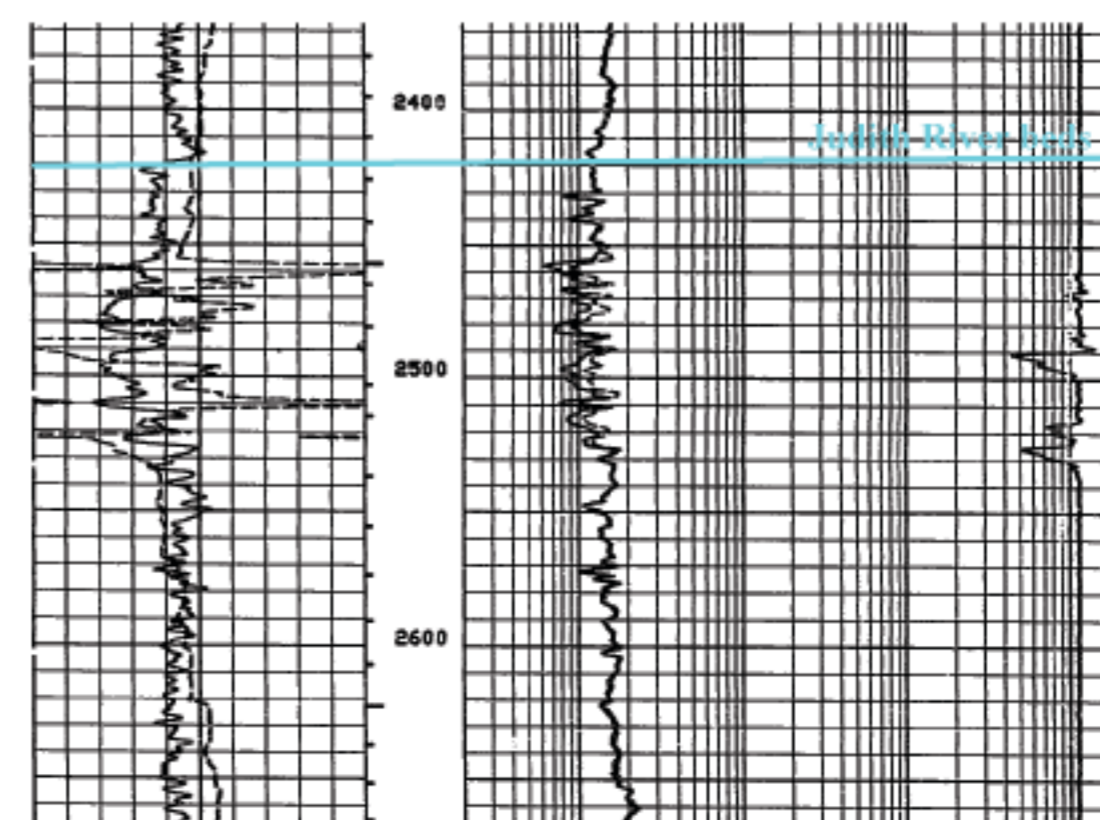
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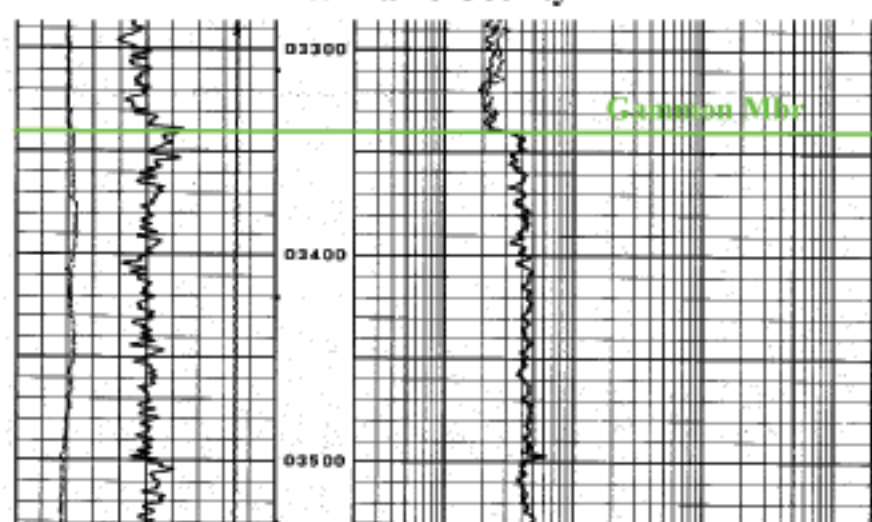
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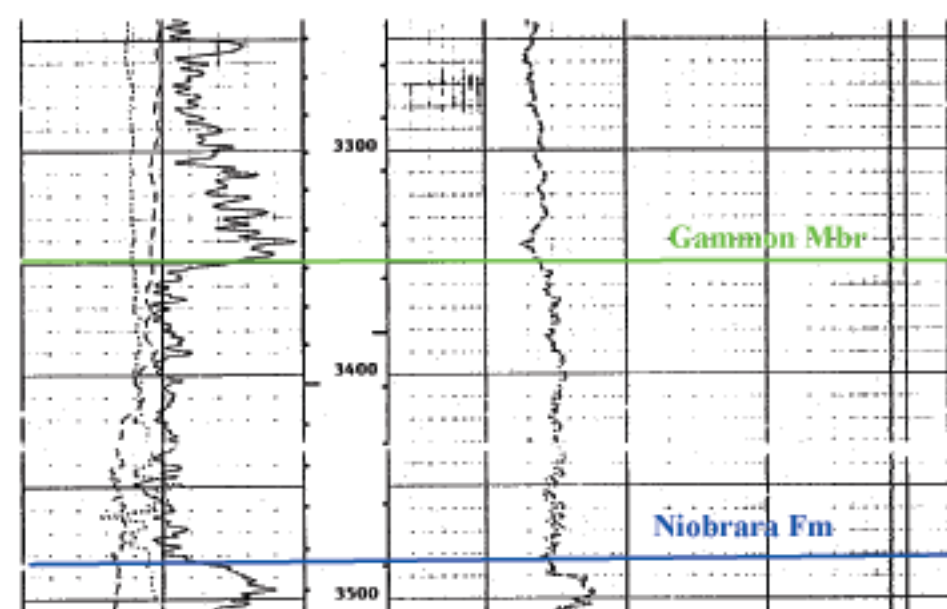
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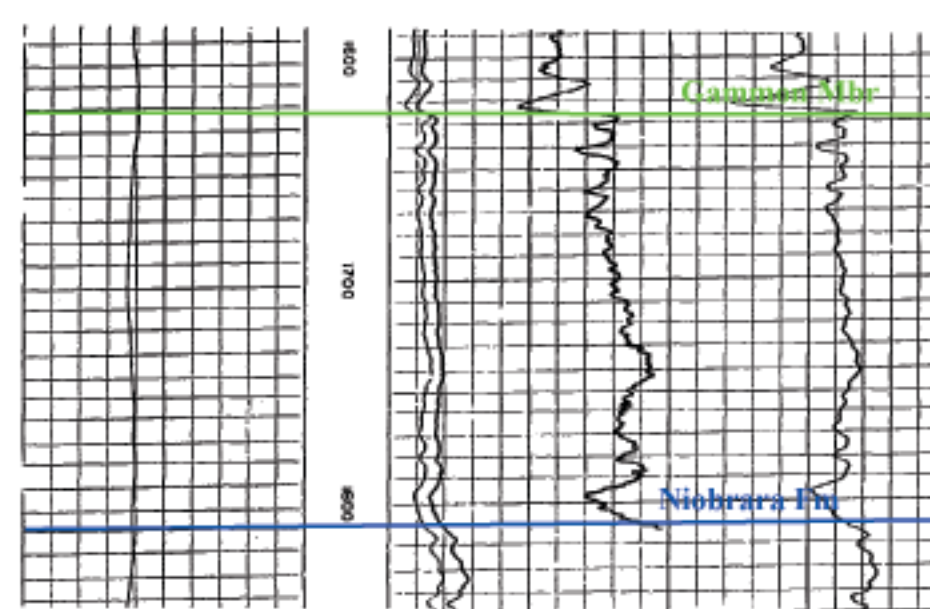
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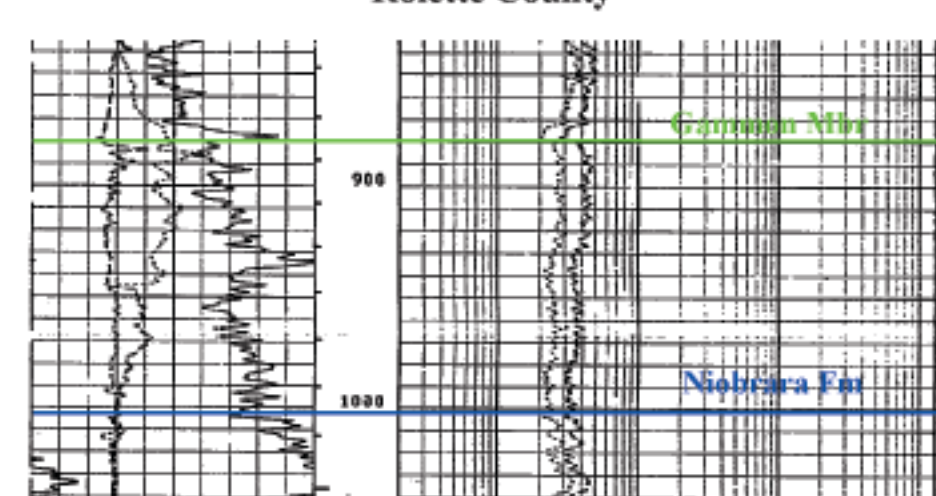
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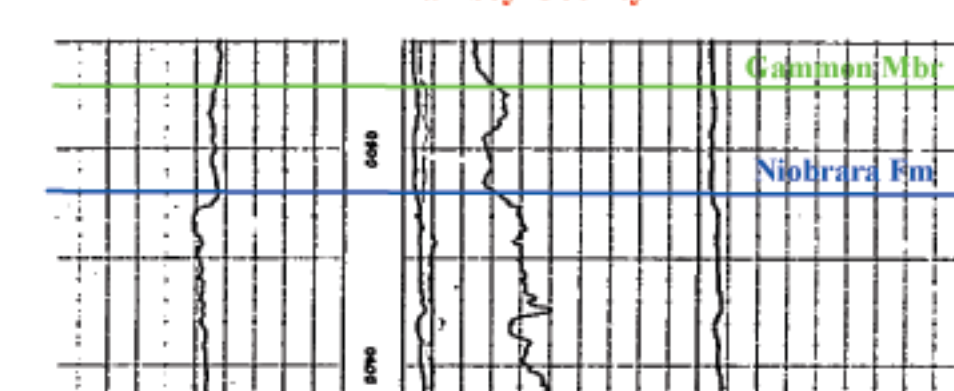
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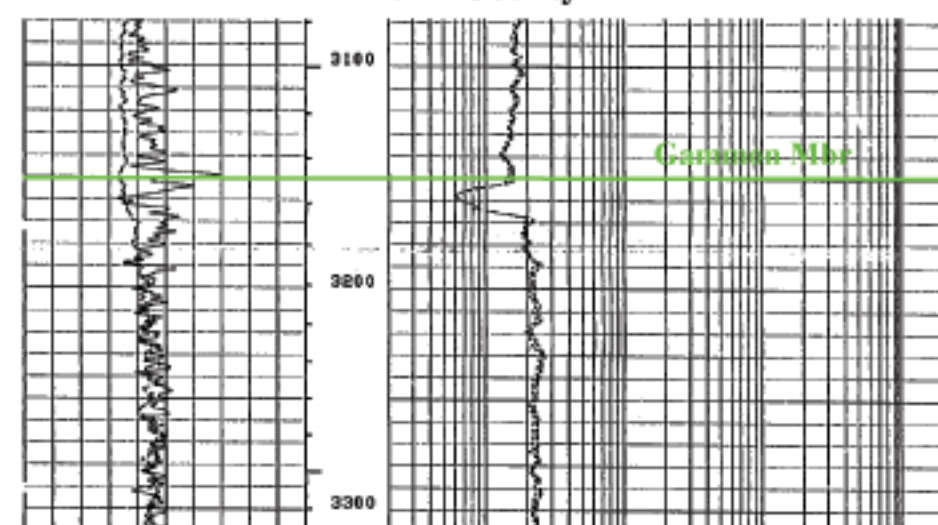
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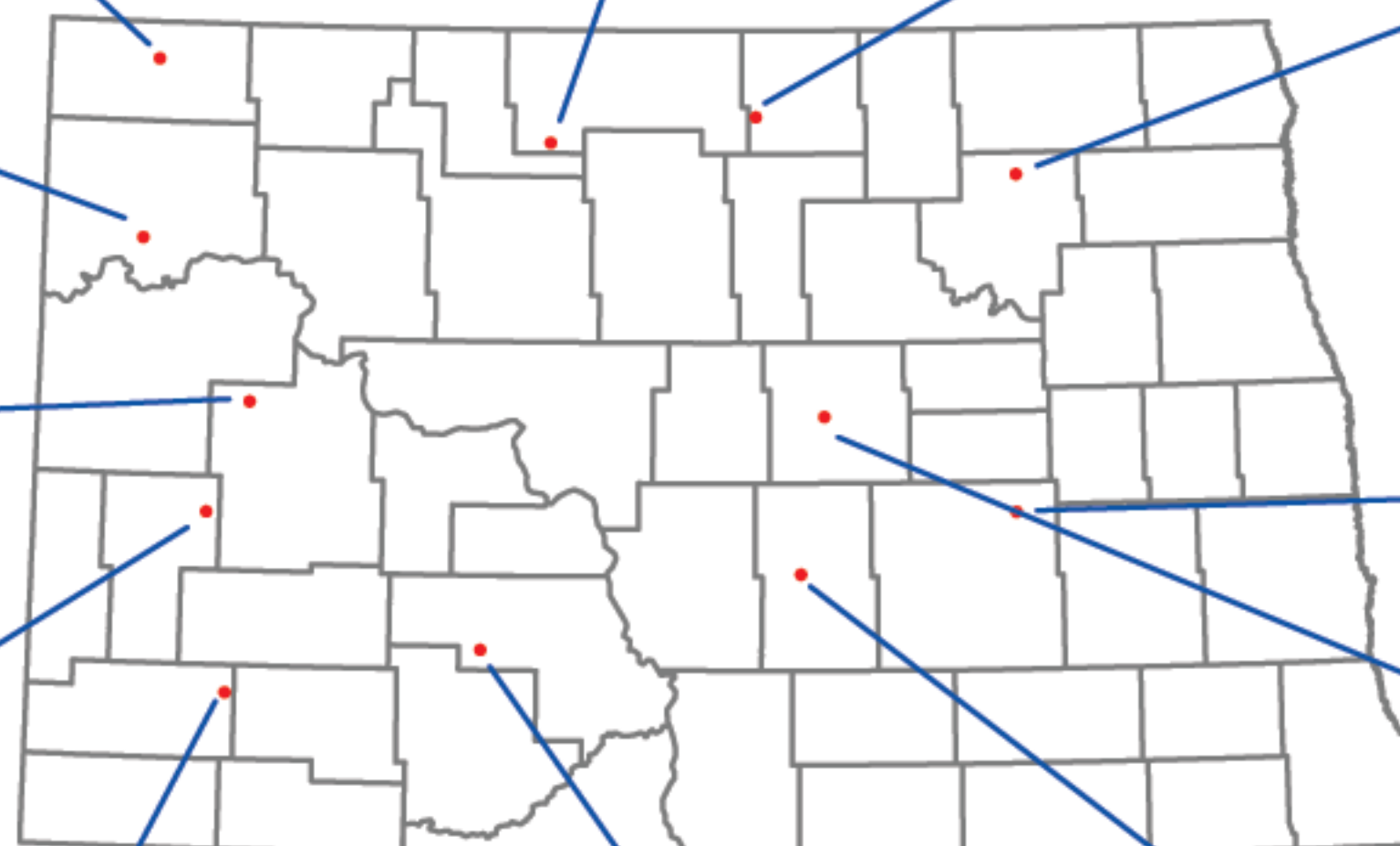
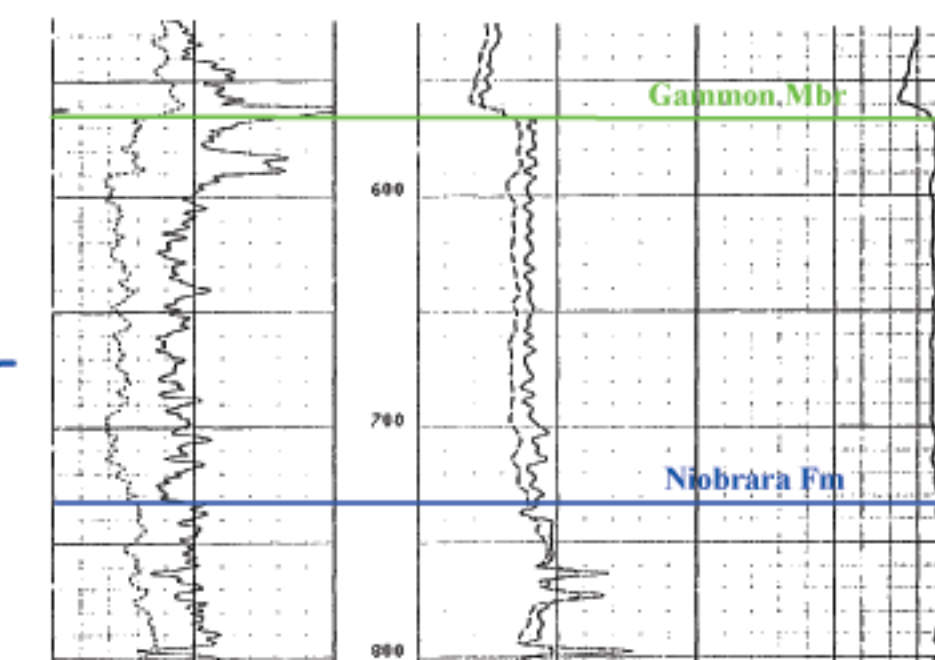
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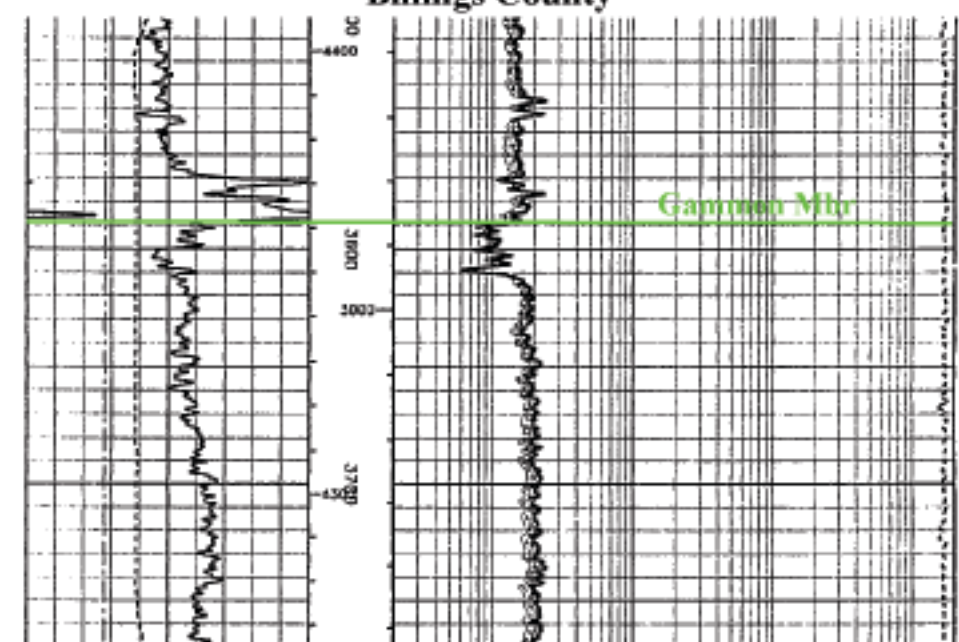
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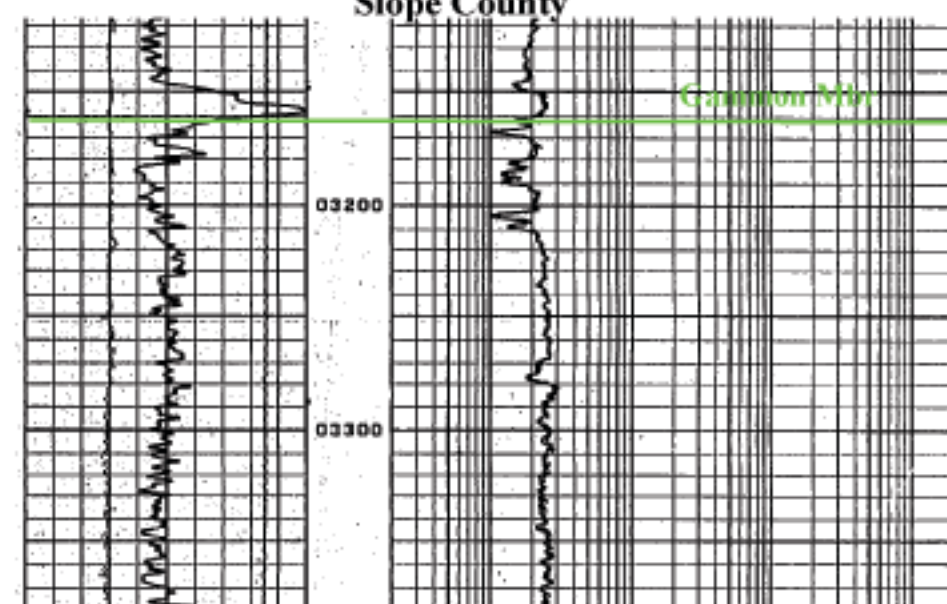
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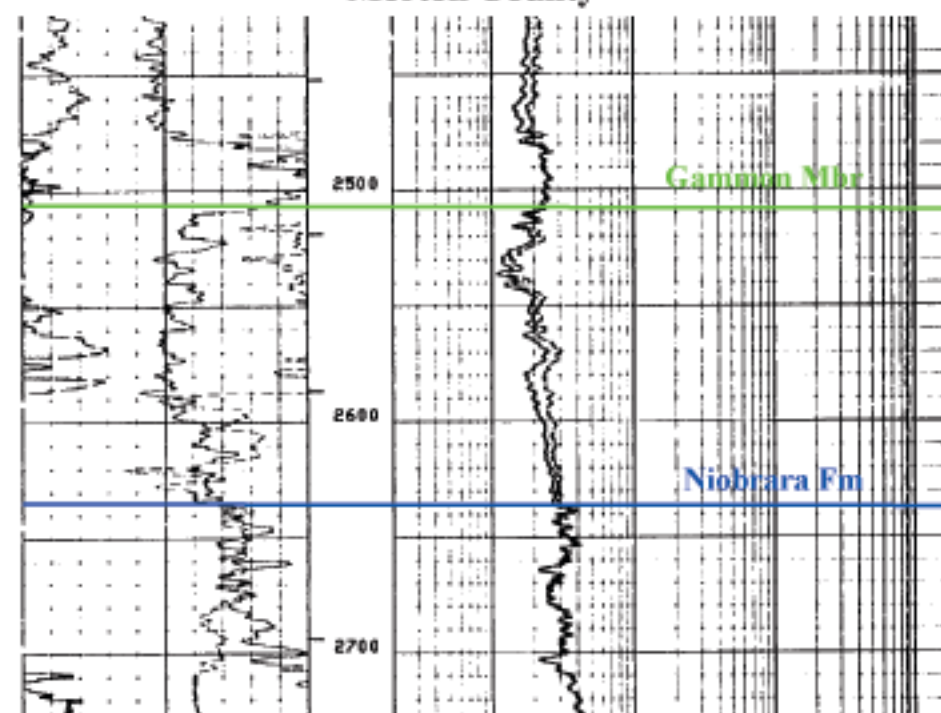
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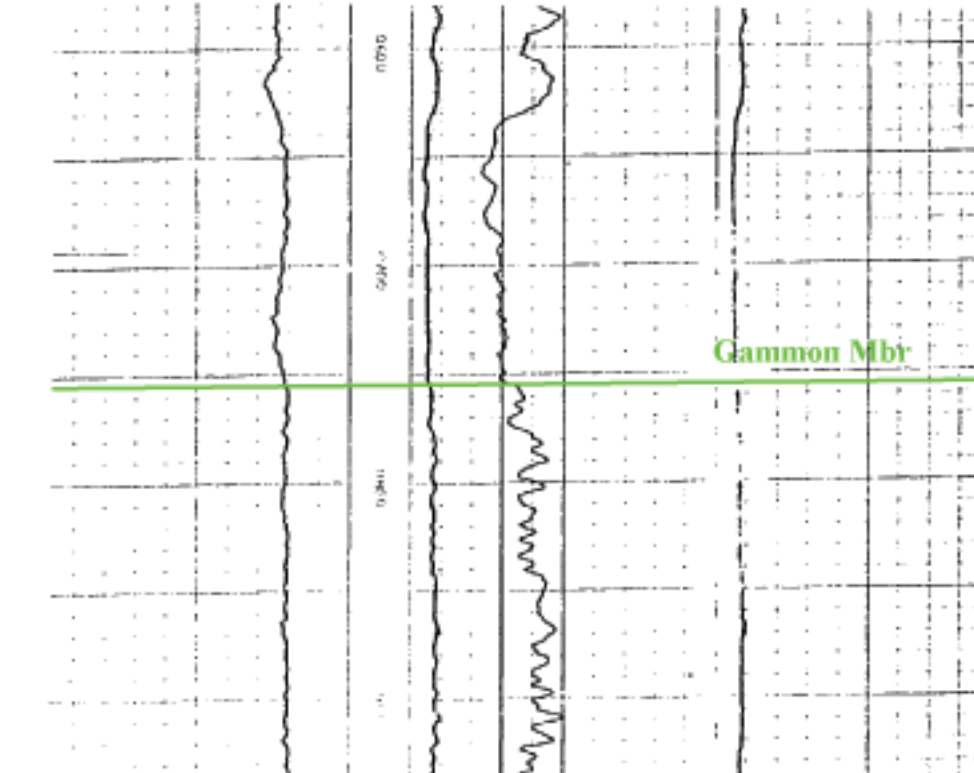
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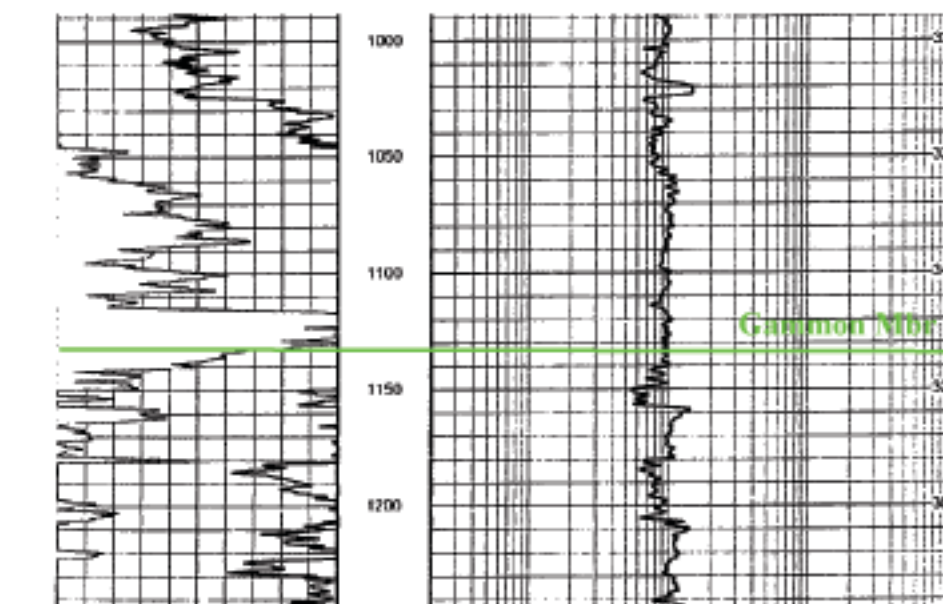
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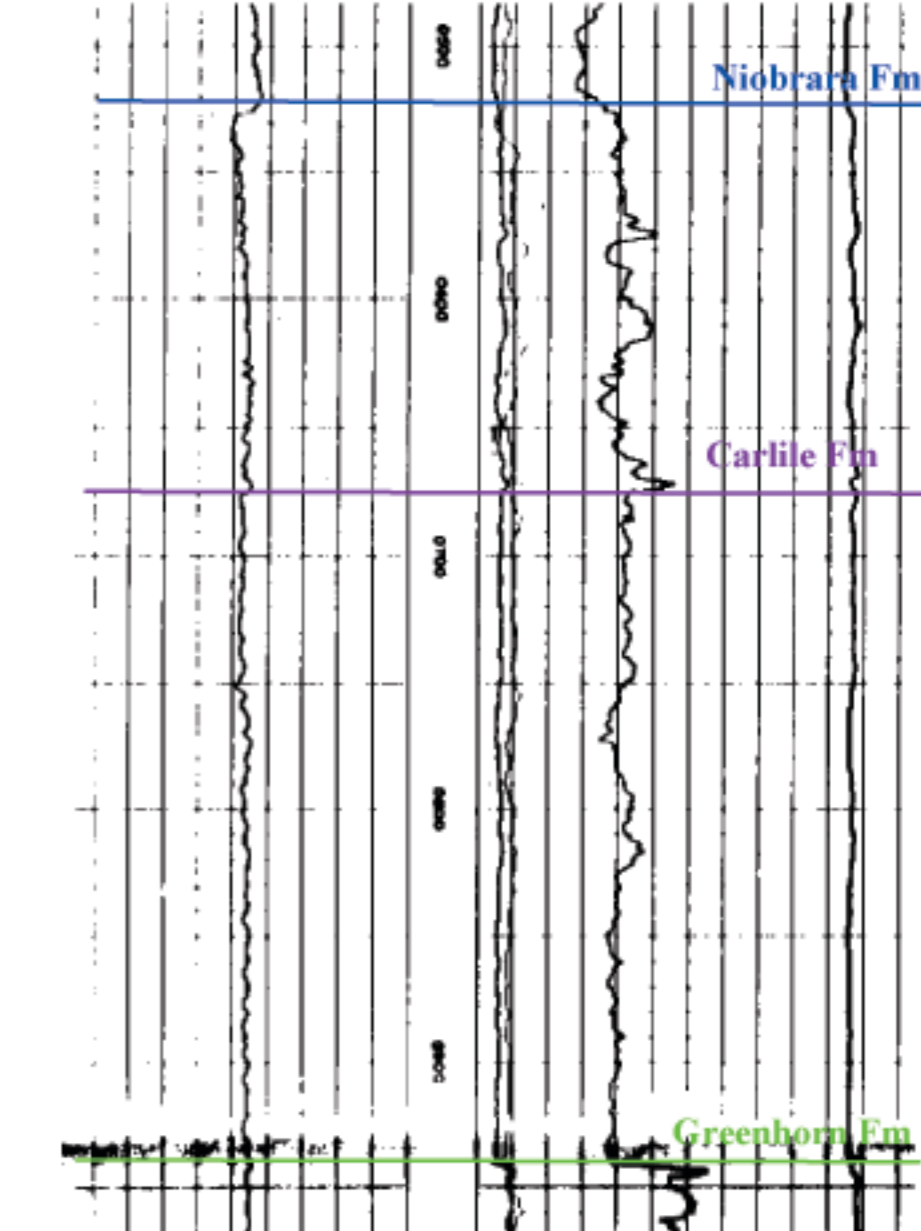
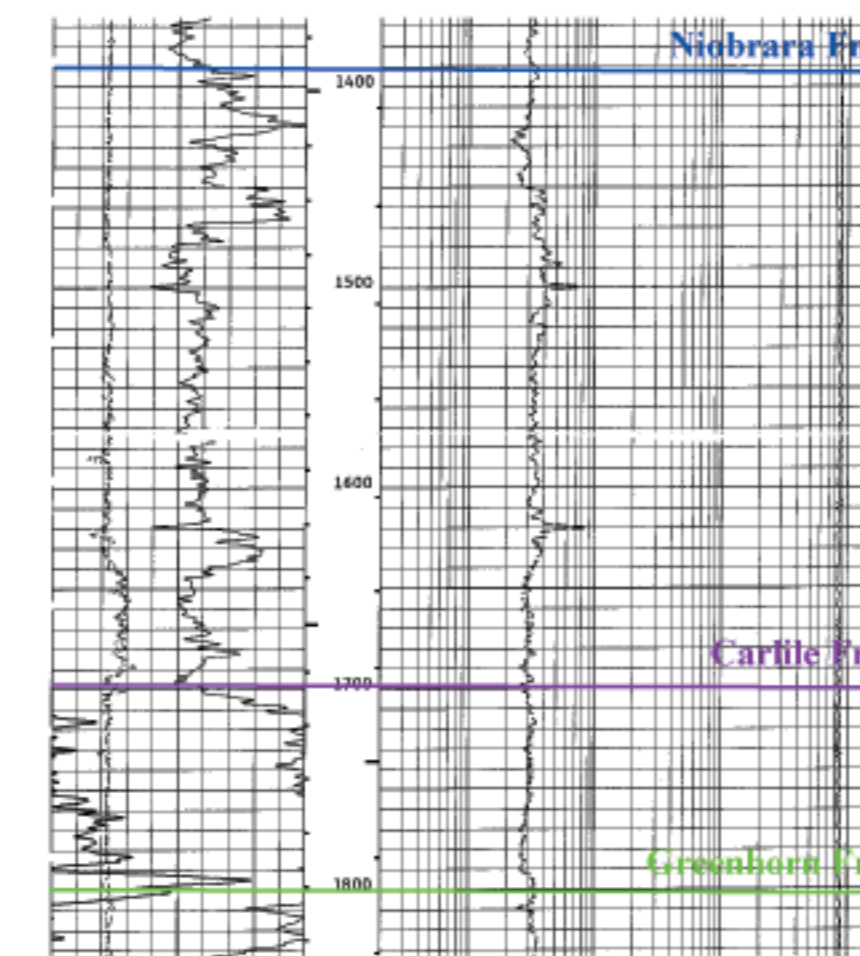
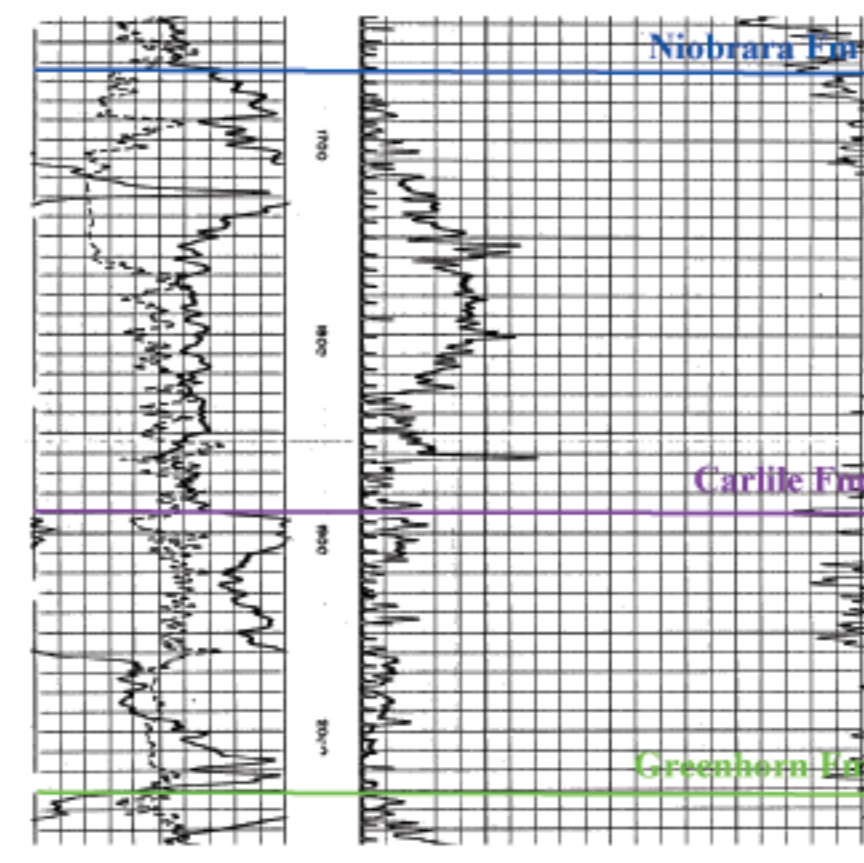
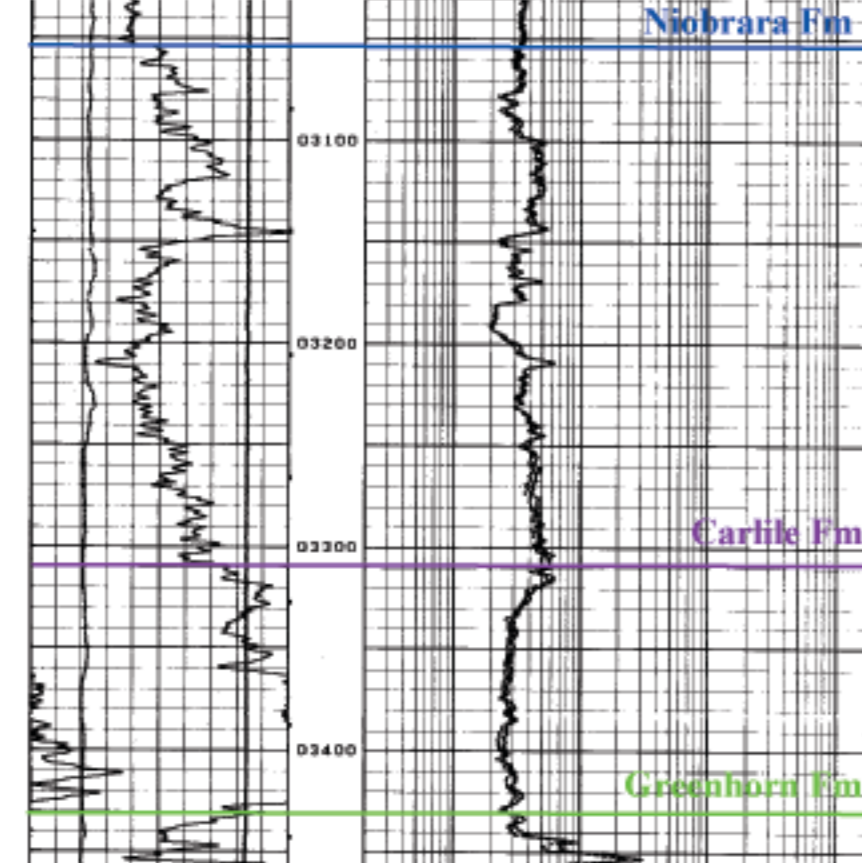
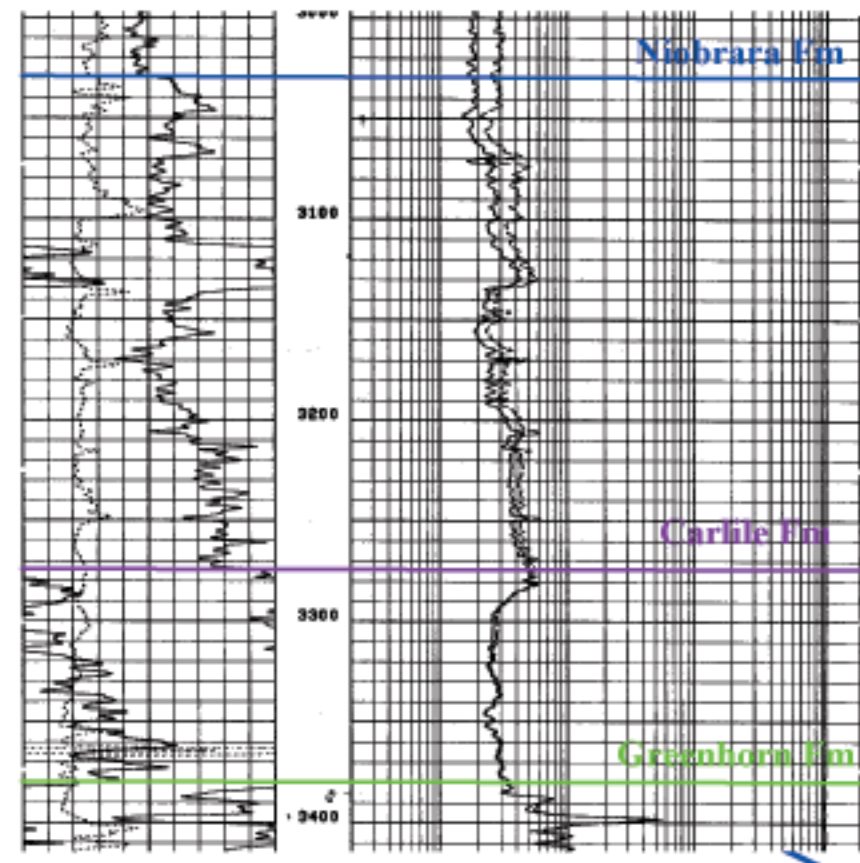
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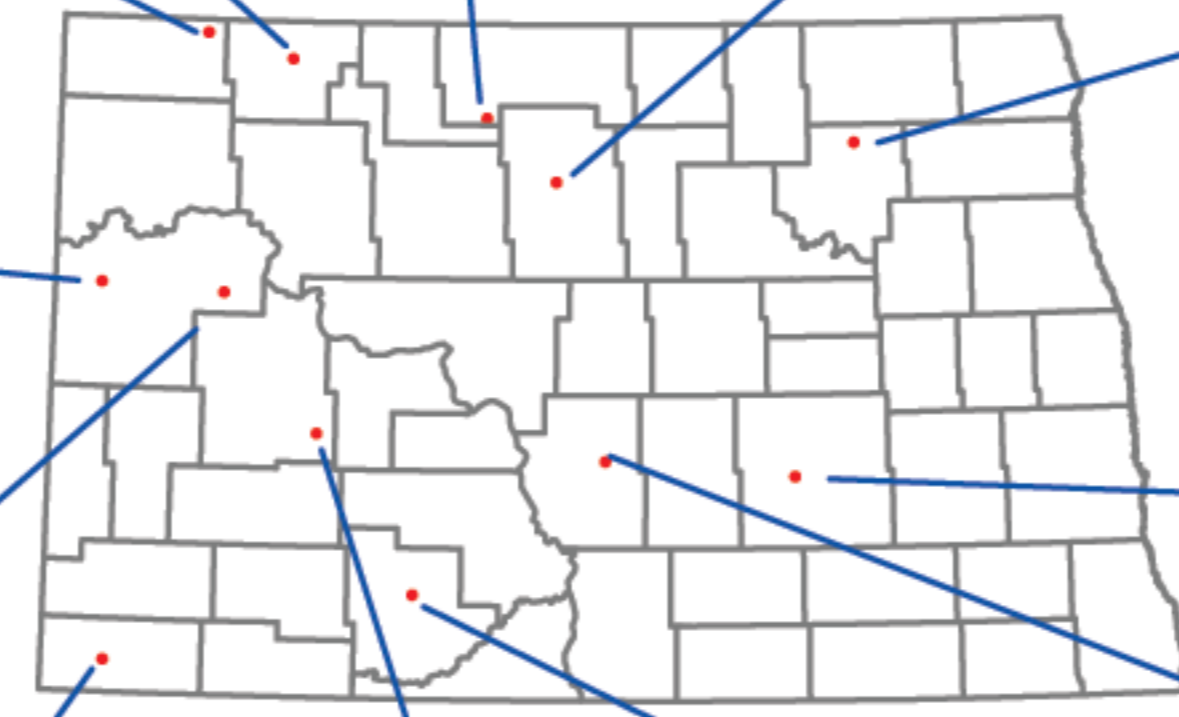
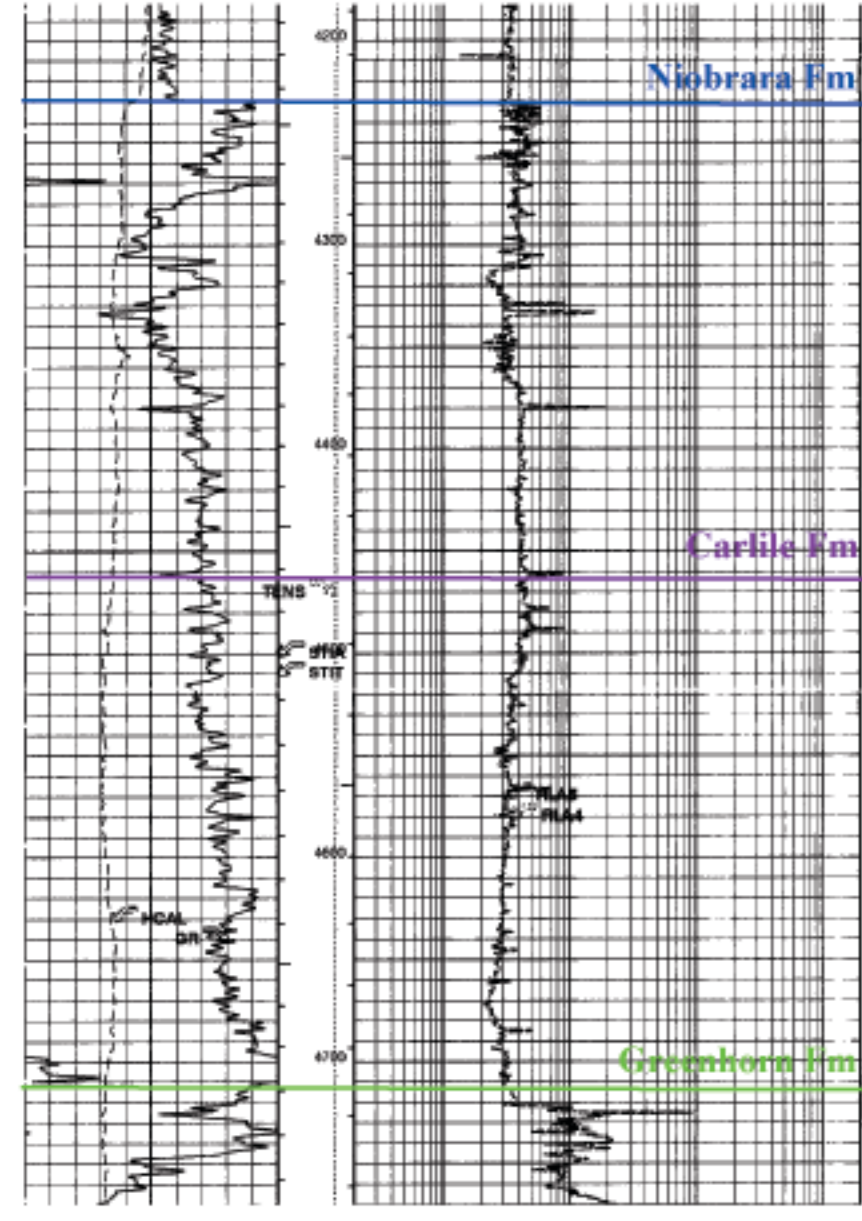
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UNION OIL COMPANY OF CALIFORNIA ABRA STEEN #1  
Bottineau County

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EOG (NEW MEXICO) INC. ERDMAN #1-34  
McHenry County

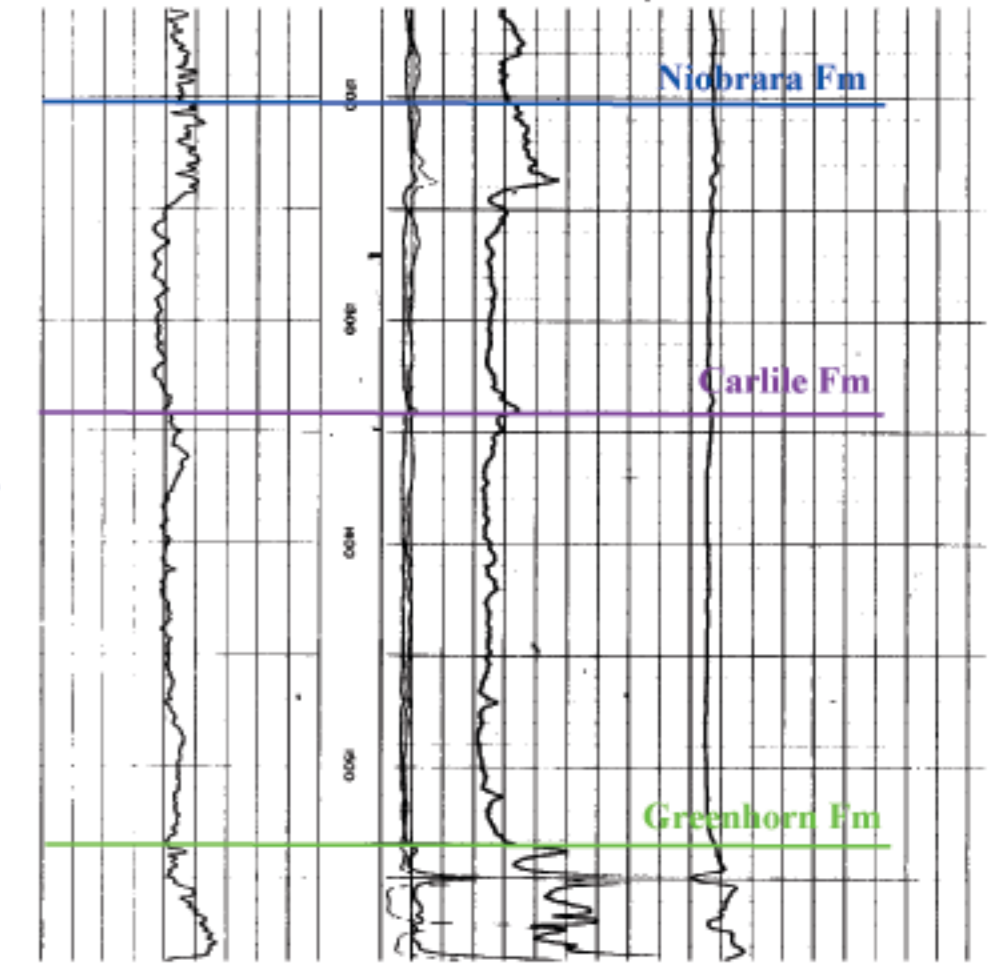
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Ramsey County



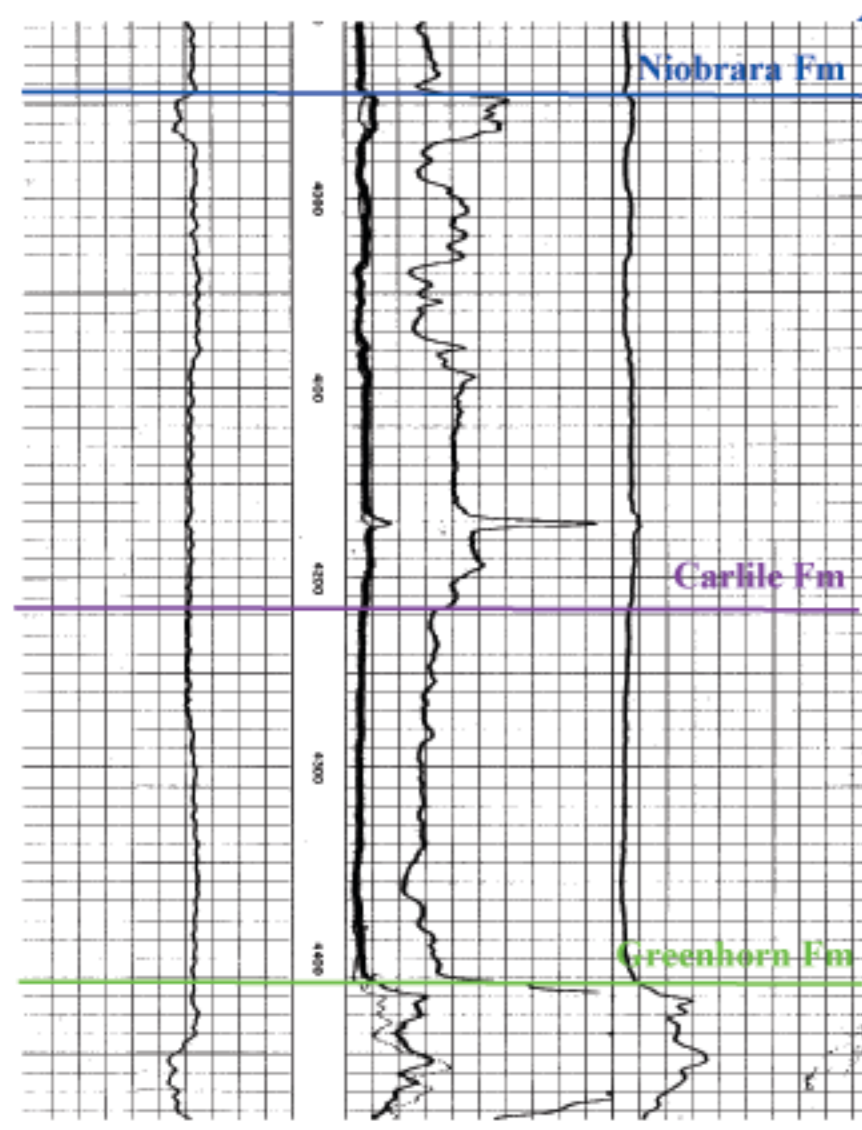
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McKenzie County



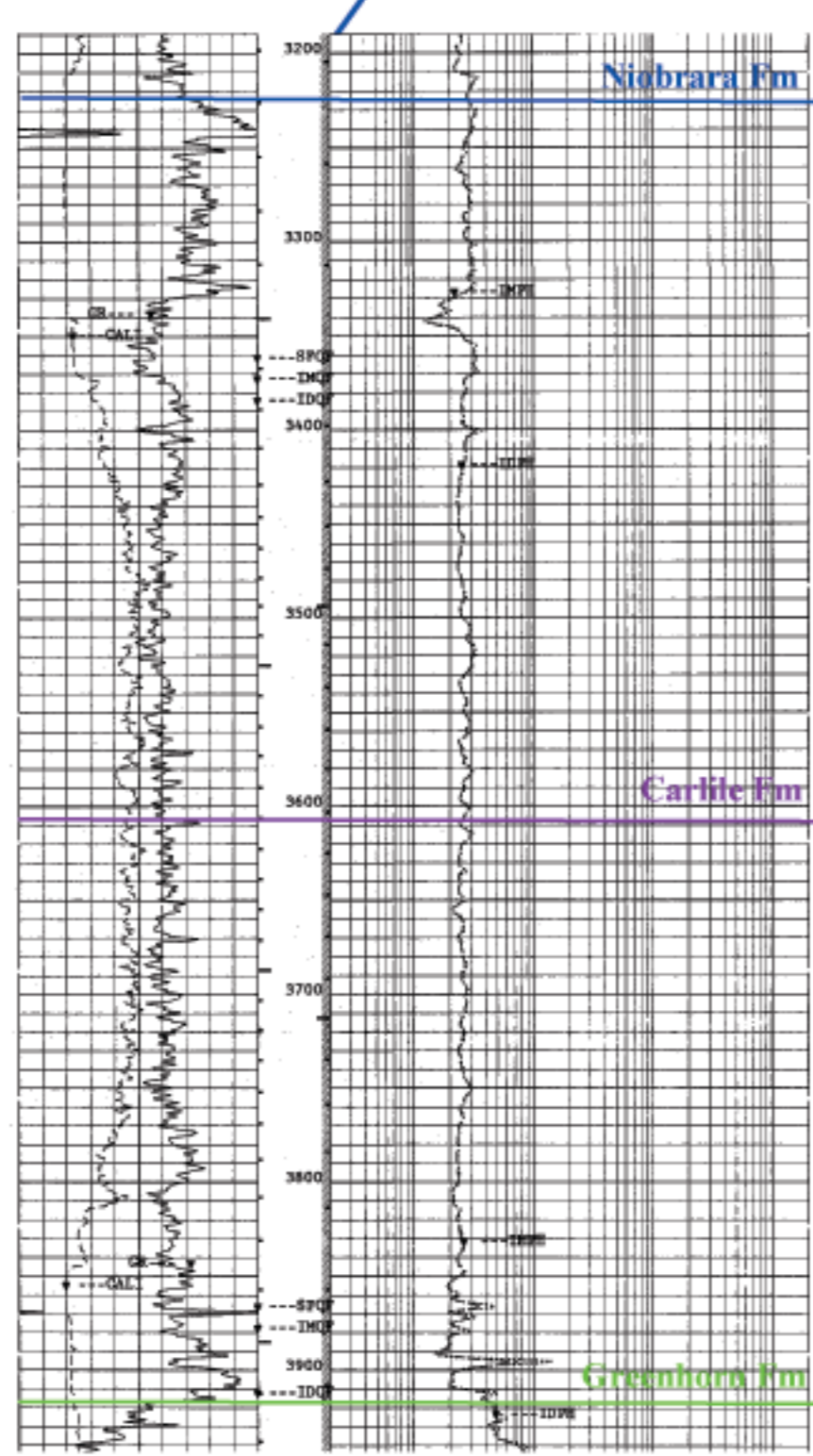
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Stutsman County



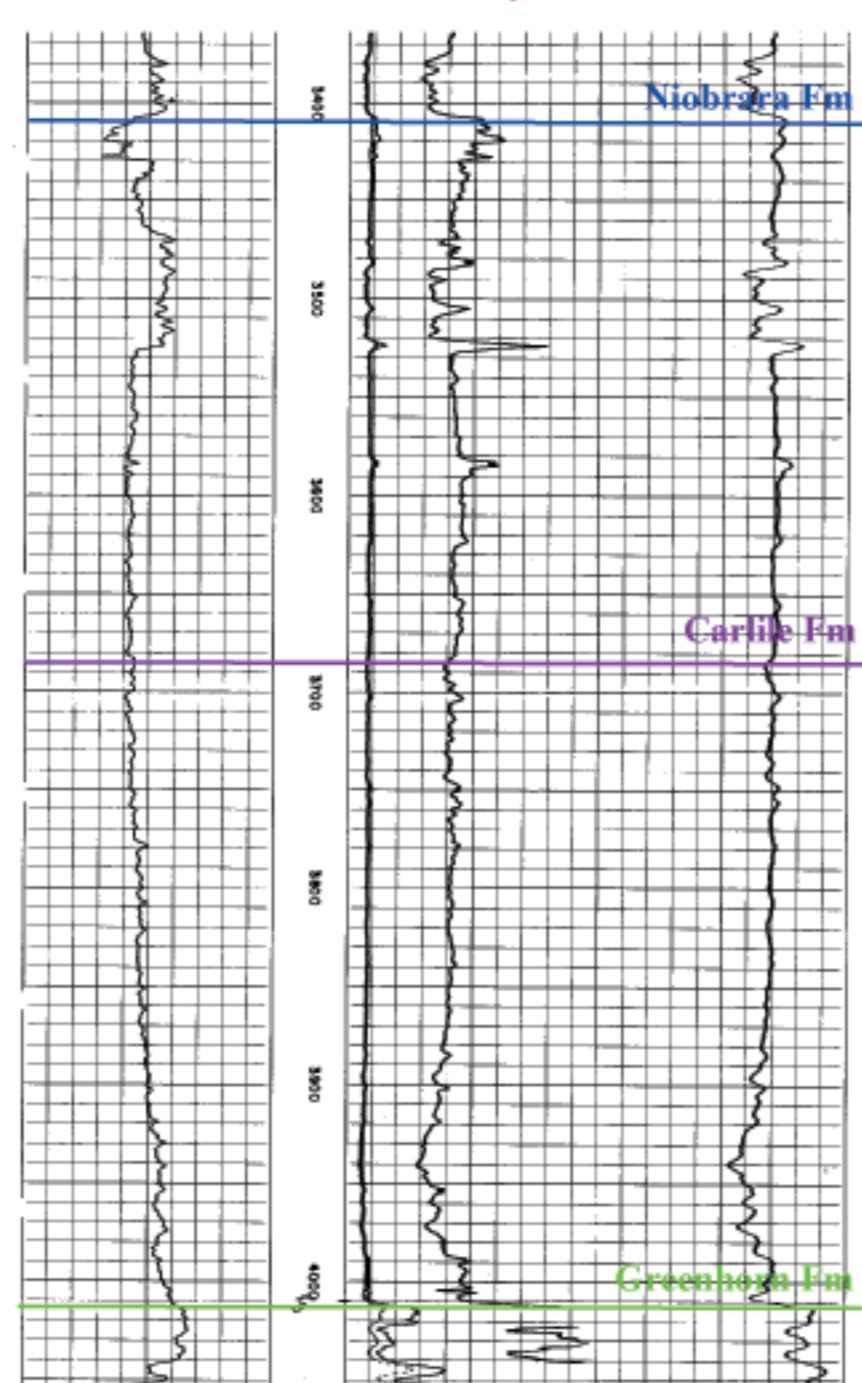
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N. DAK. B TRACT #1  
McKenzie County



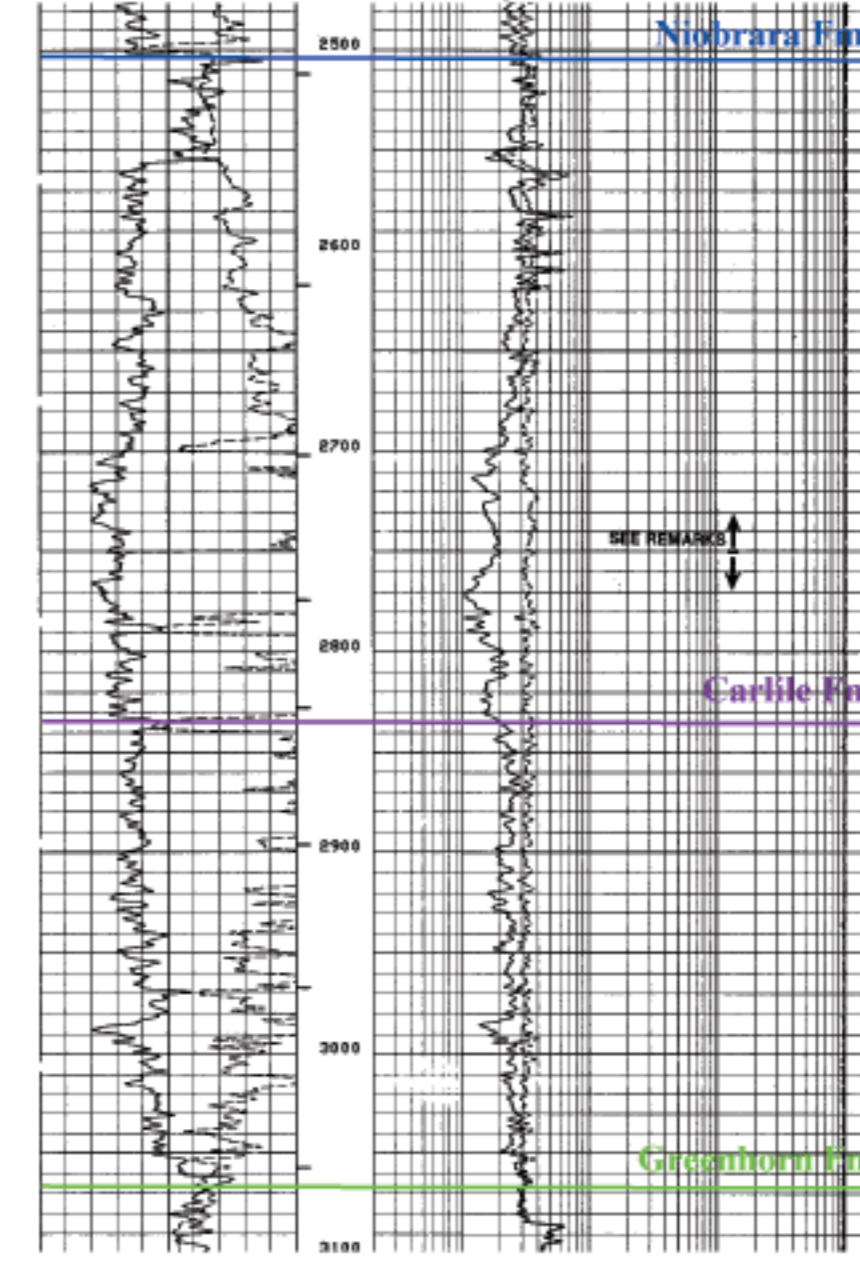
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Bowman County



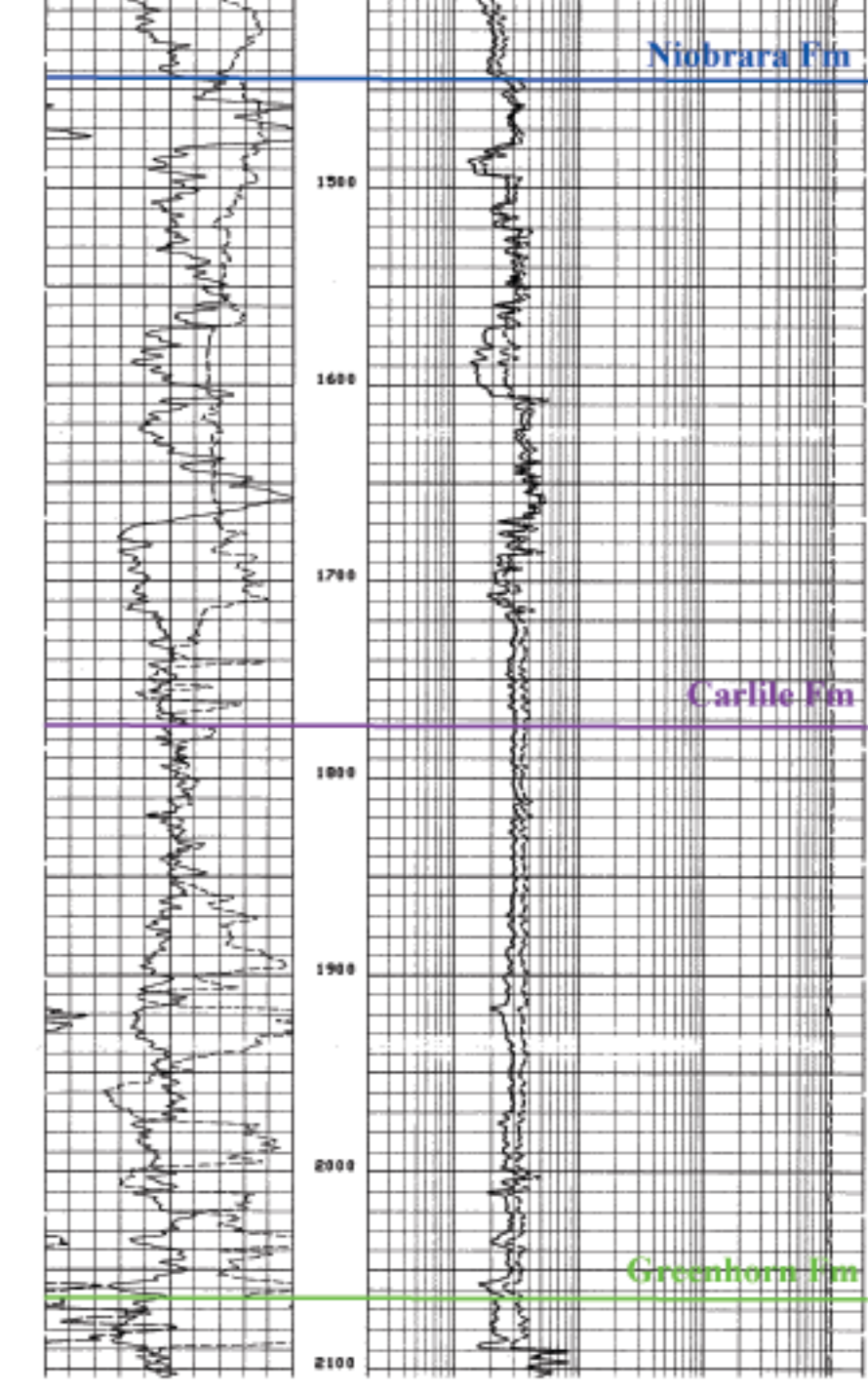
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CARL SIVERTS #1  
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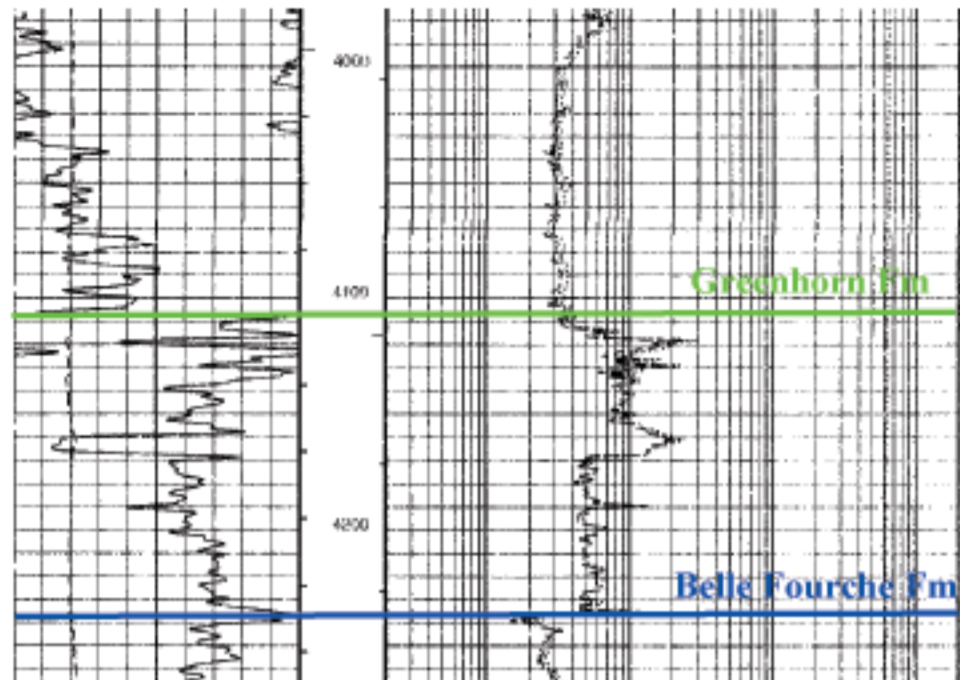


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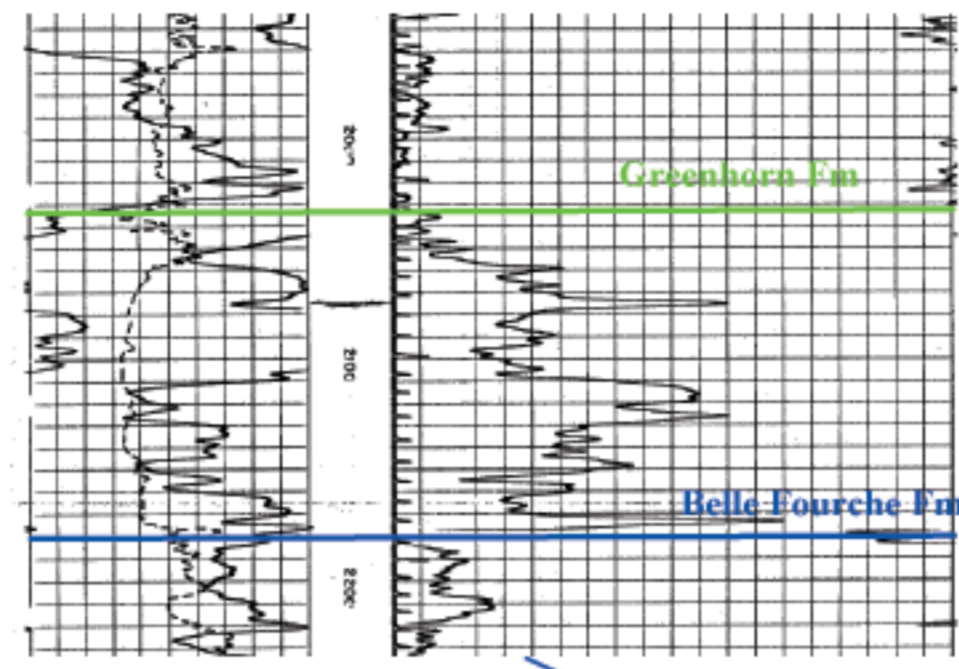




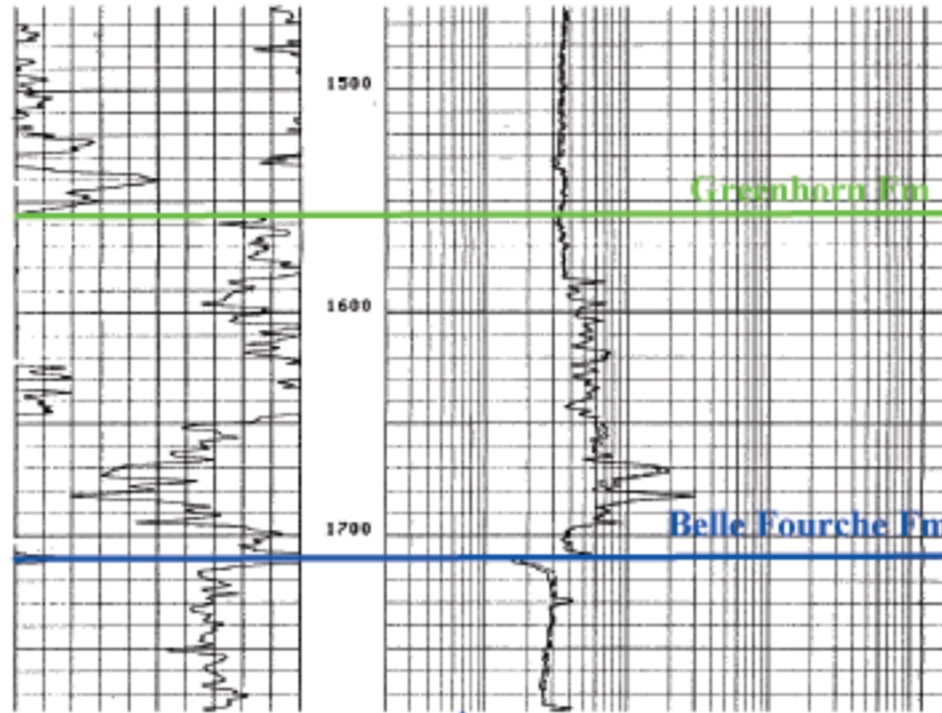
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Divide County



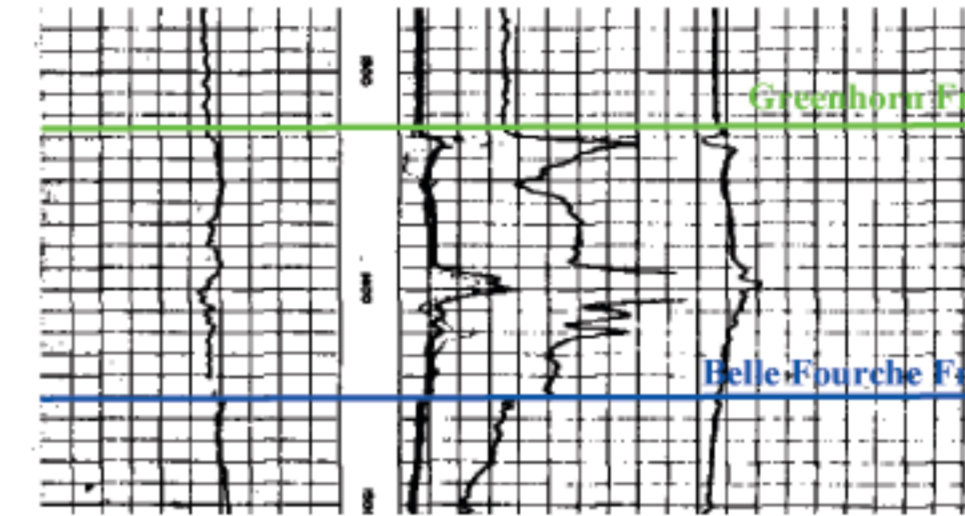
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Bottineau County



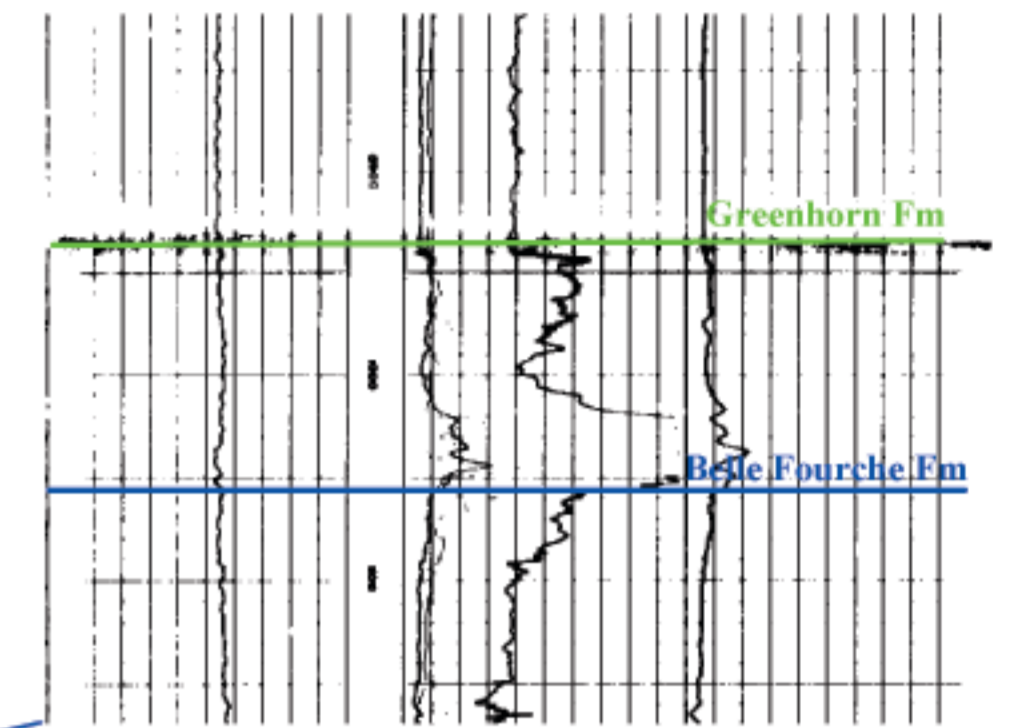
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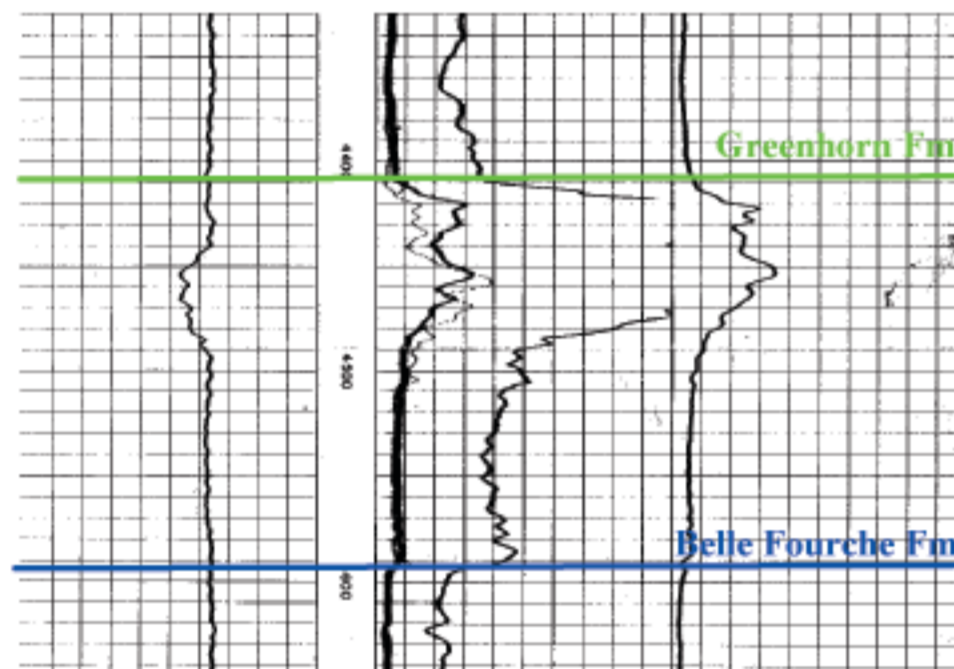
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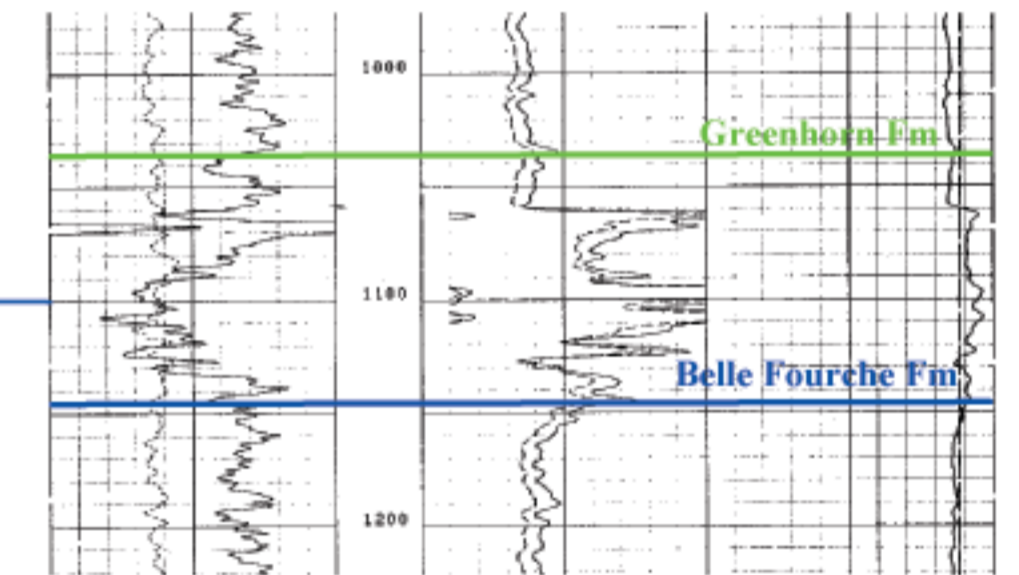
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Ramsey County



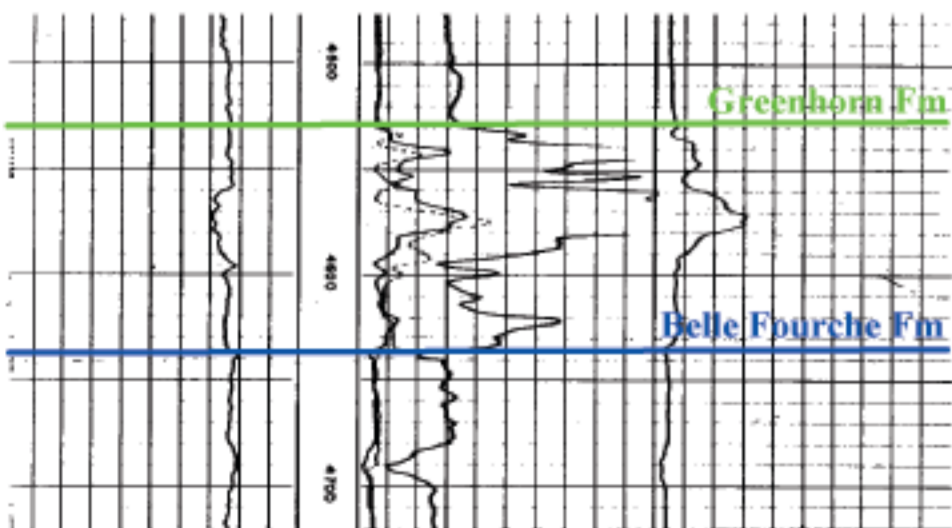
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McKenzie County



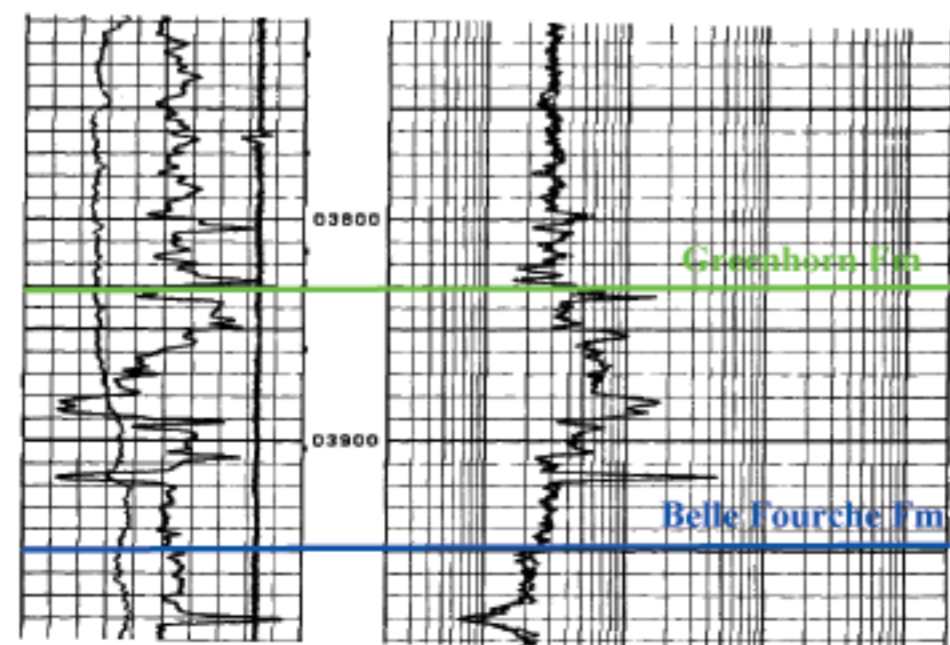
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Stutsman County



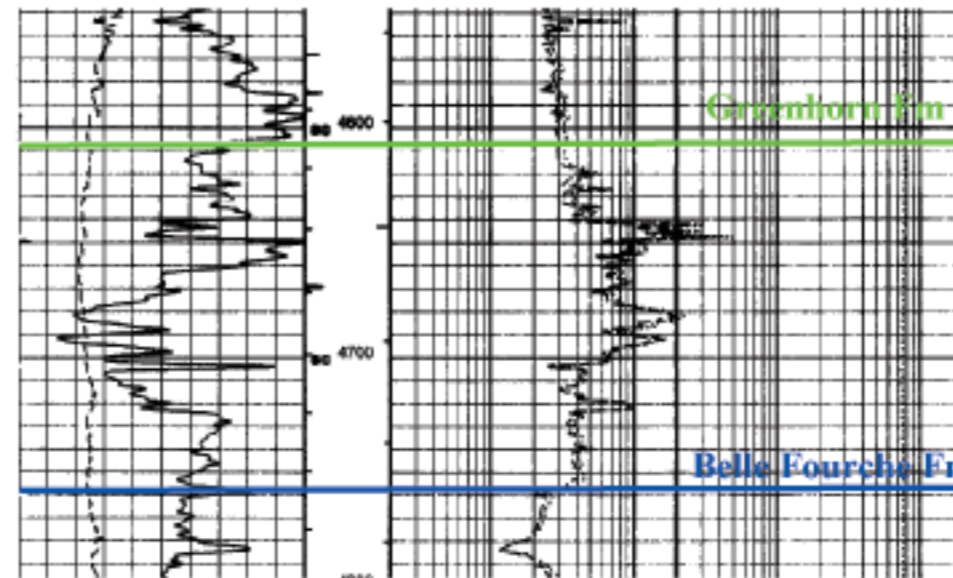
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Golden Valley County



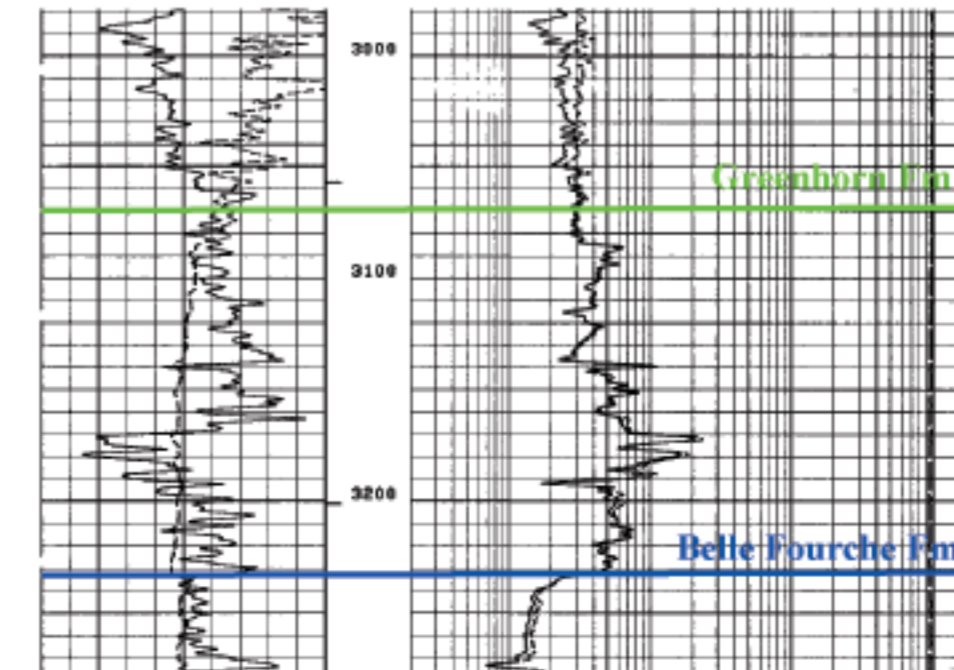
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Bowman County



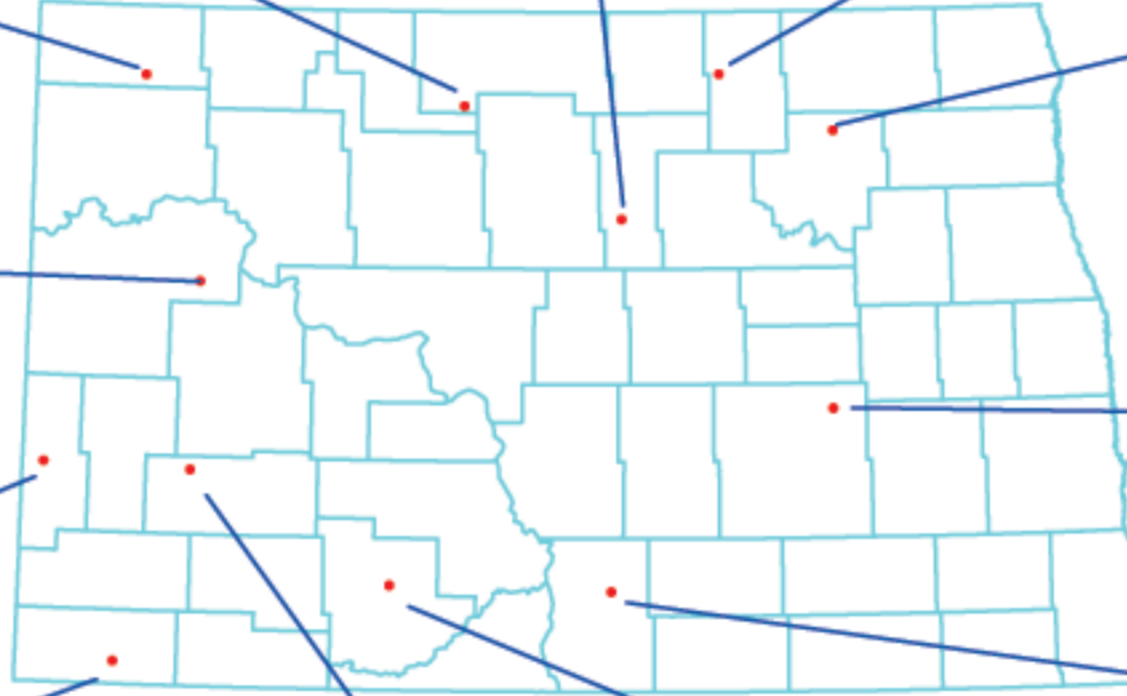
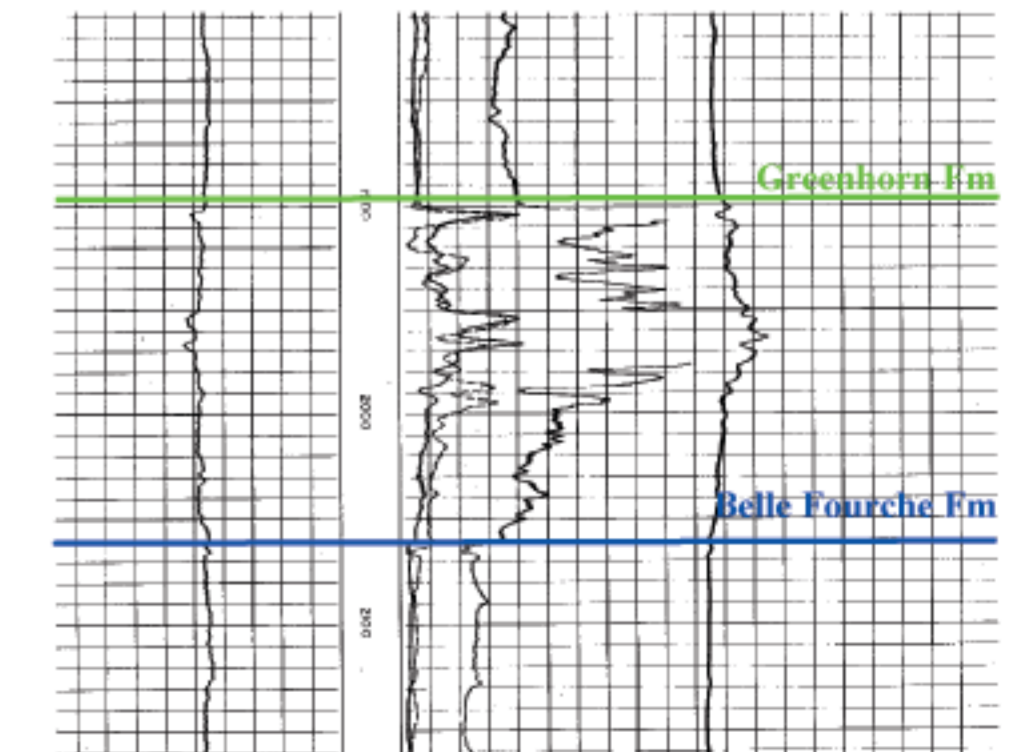
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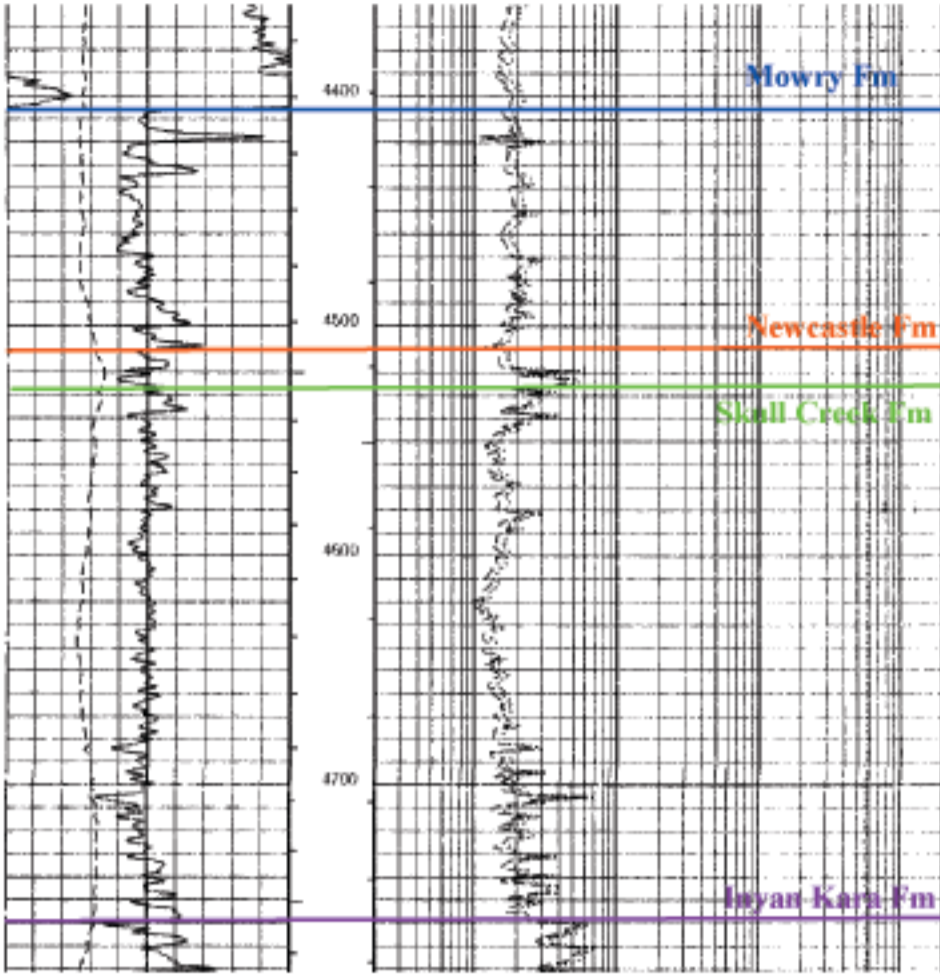
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Grant County



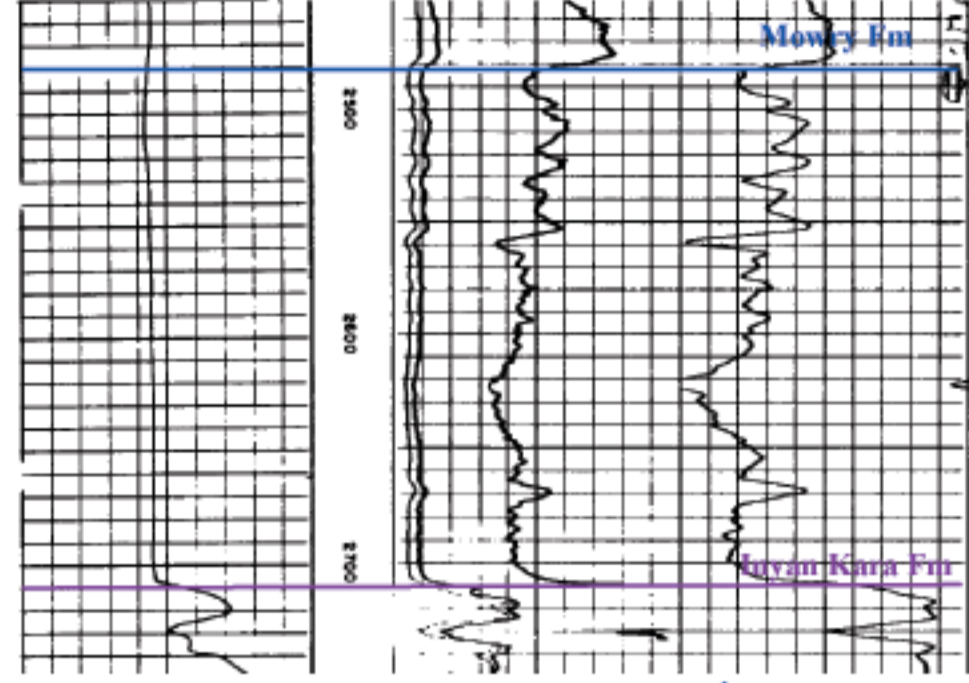
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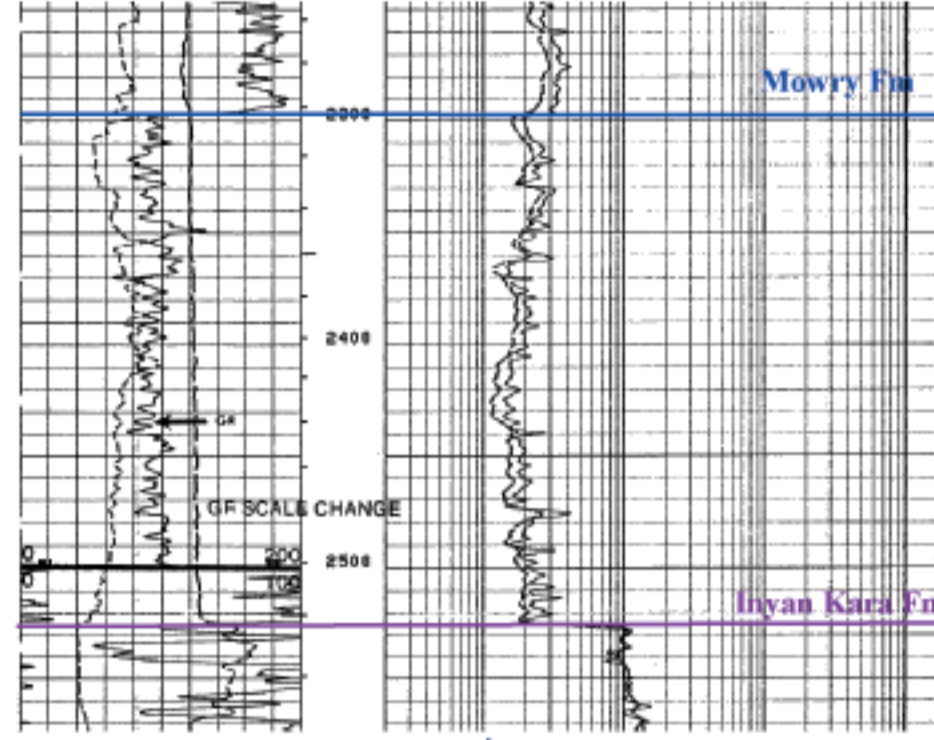
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Divide County



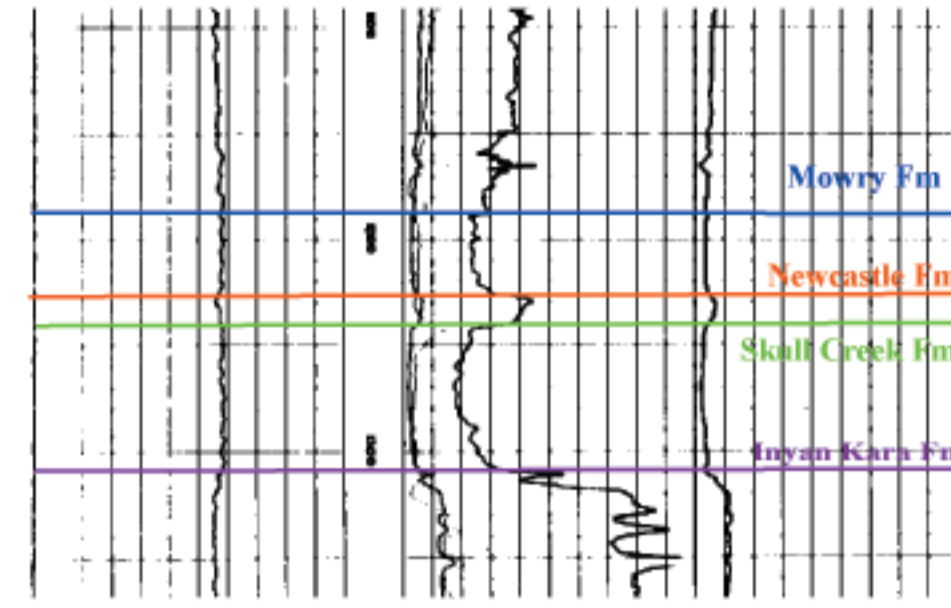
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Bottineau County



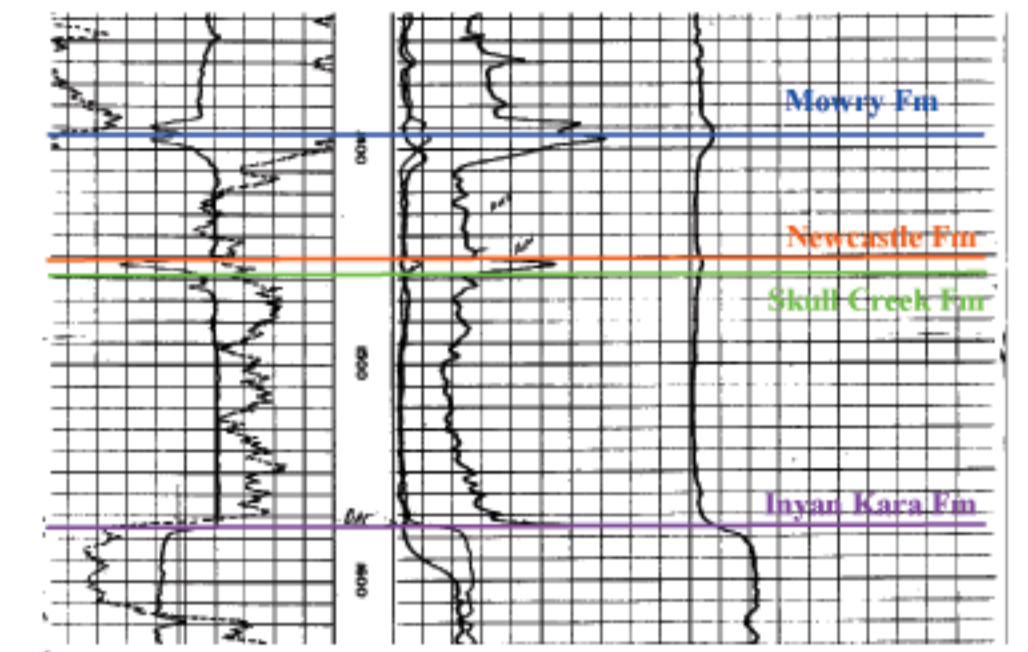
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Sheridan County



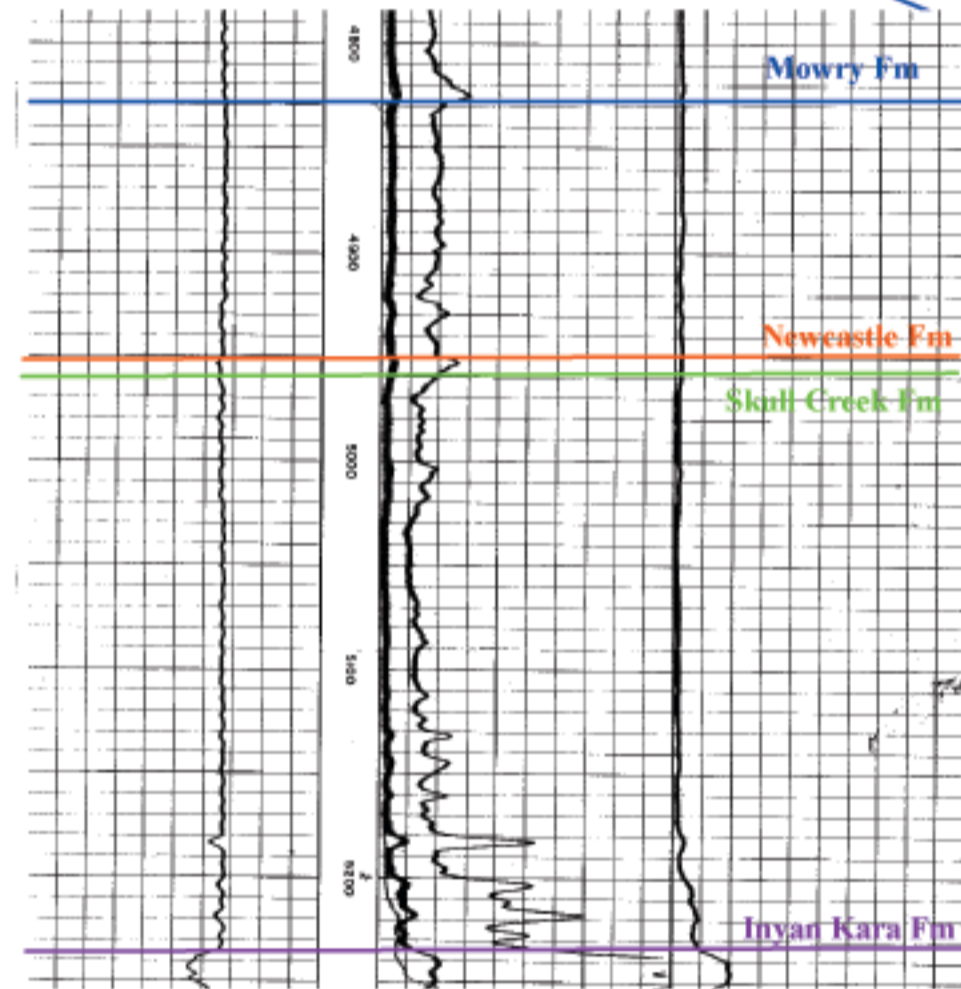
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Ramsey County



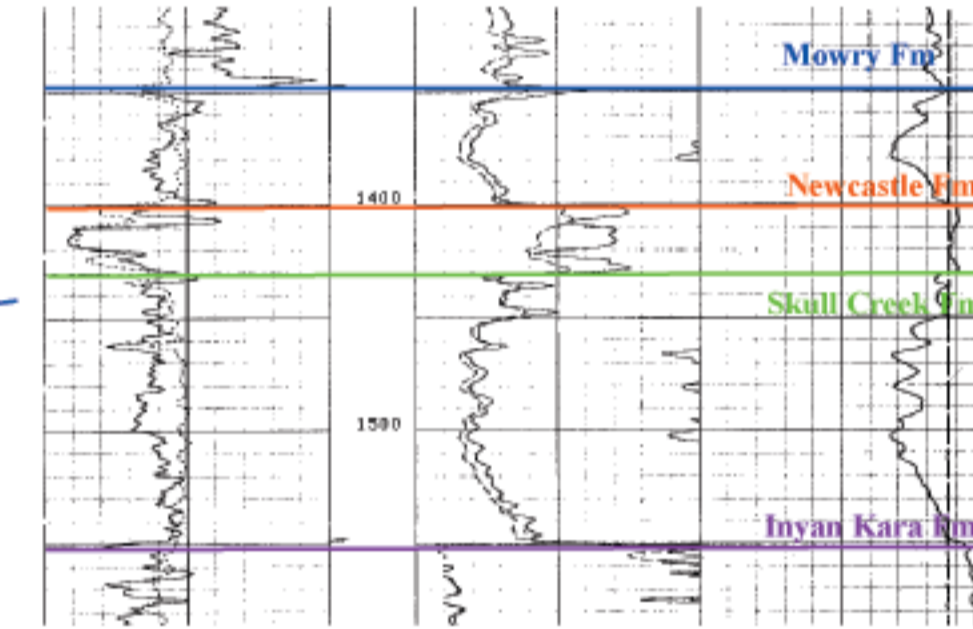
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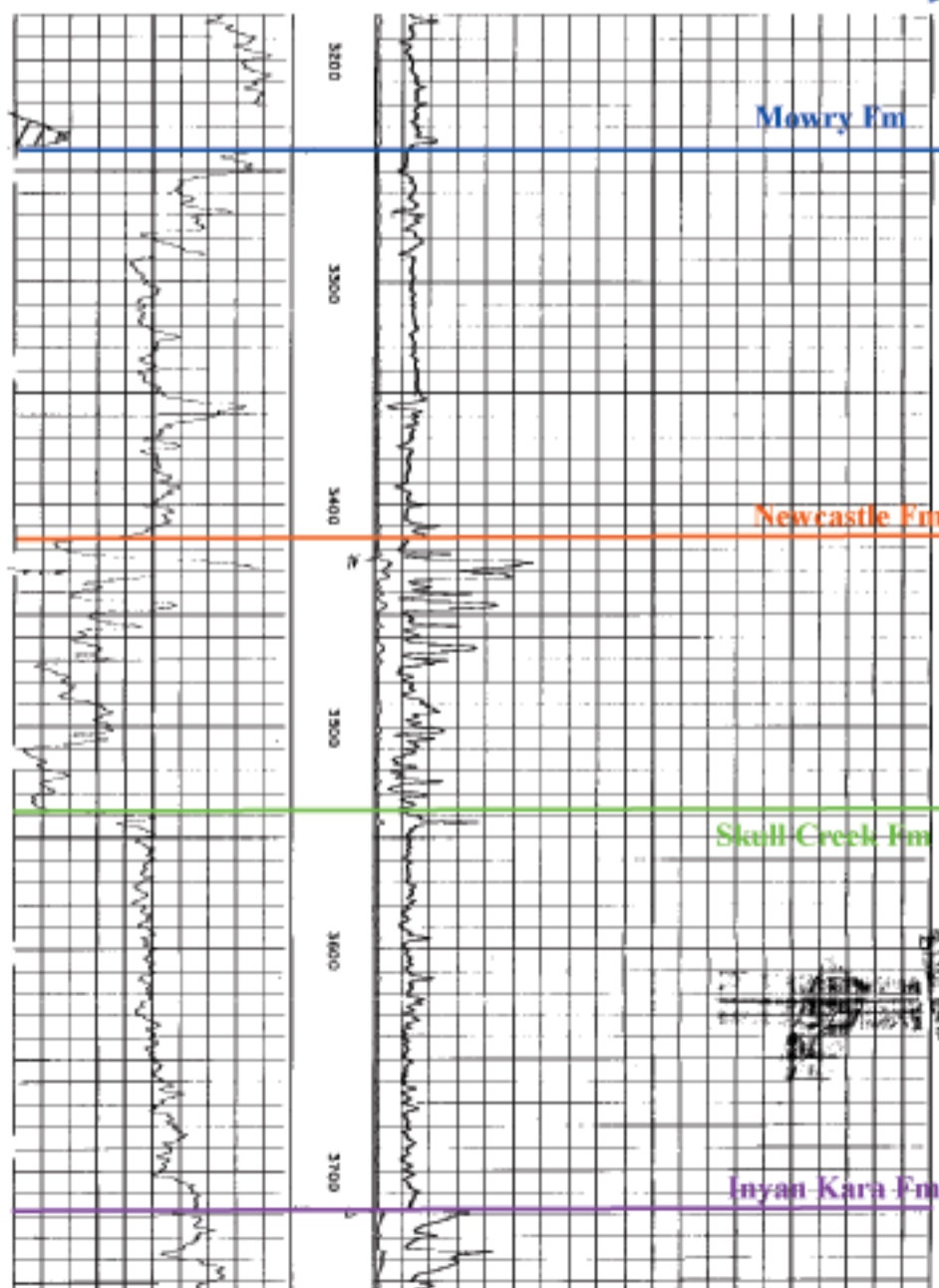
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McKenzie County



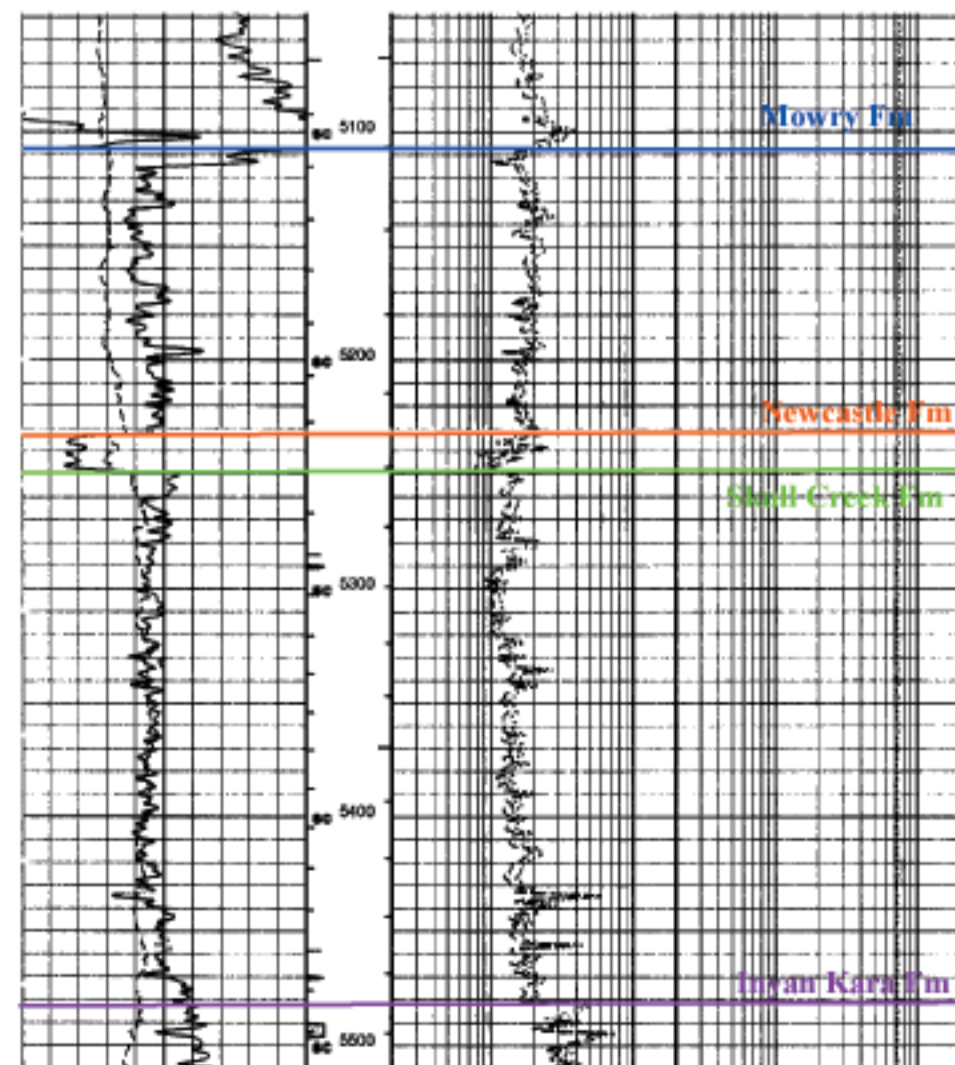
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Stutsman County



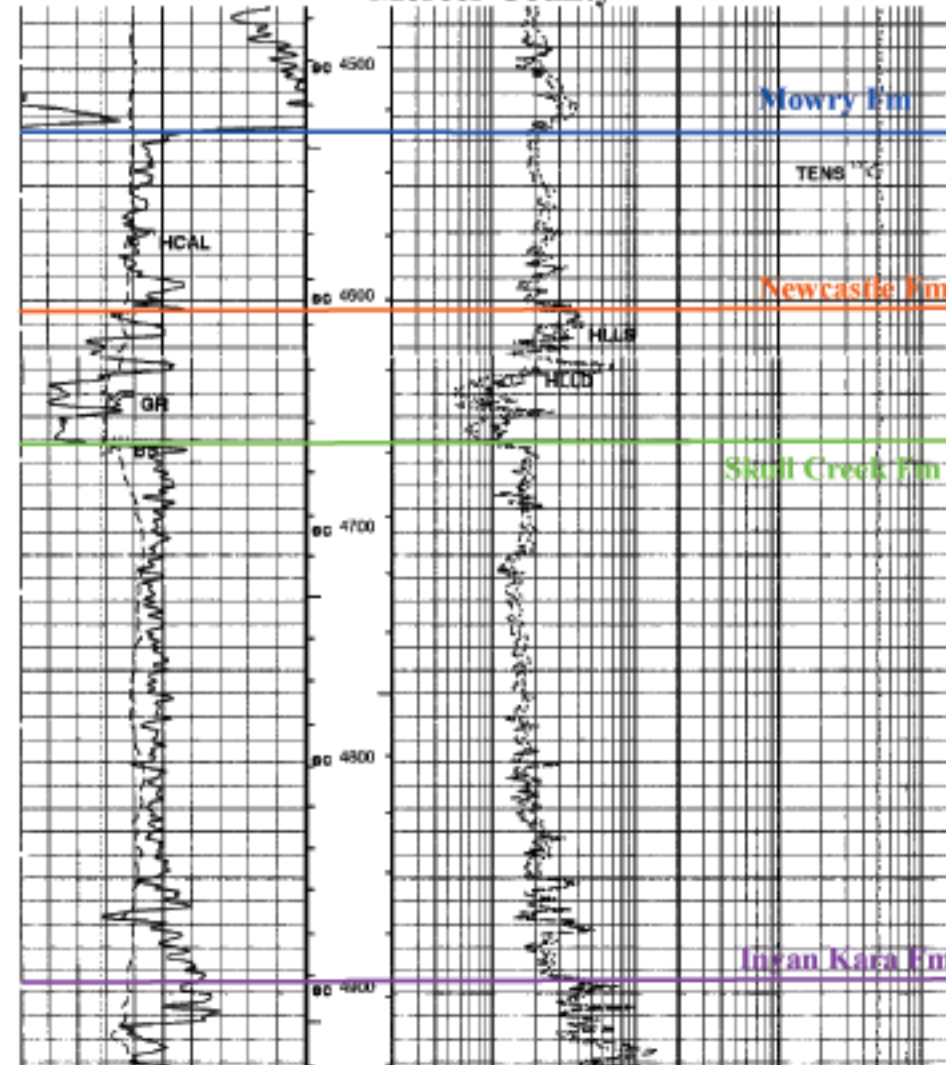
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Bowman County



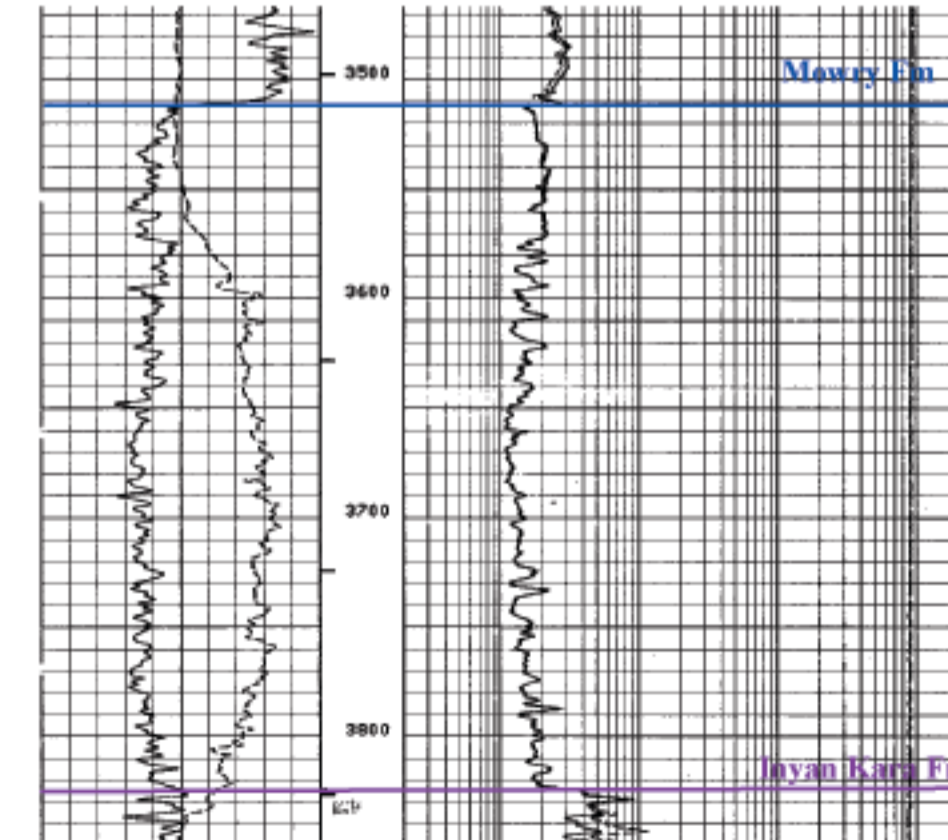
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Stark County



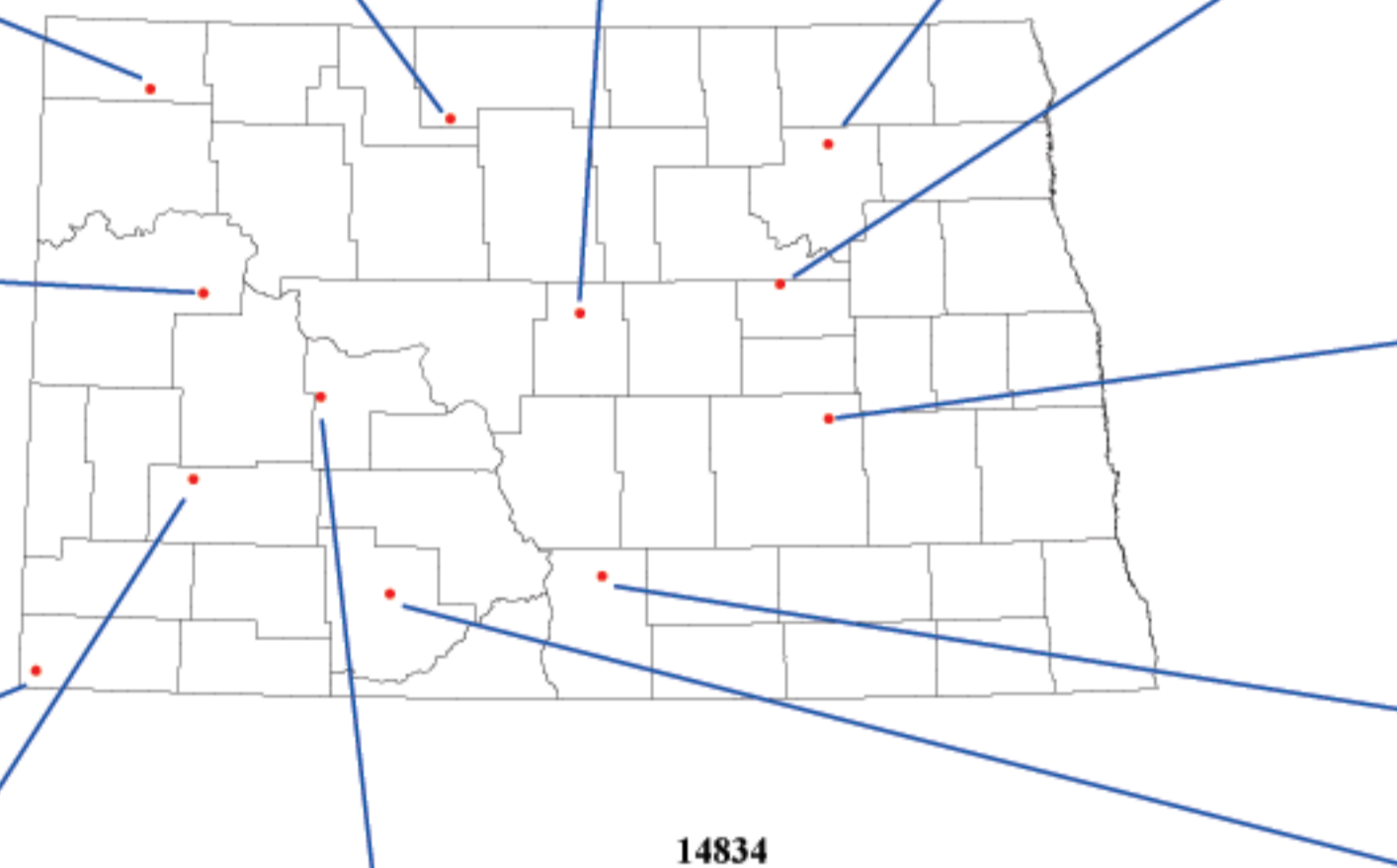
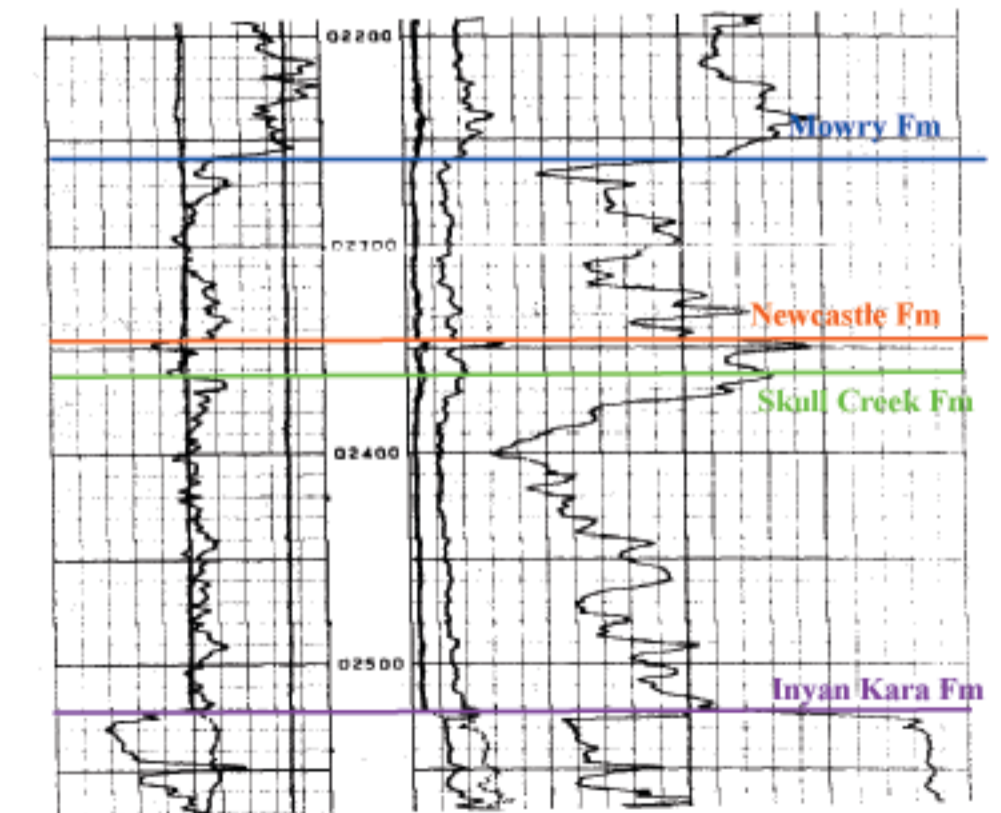
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Mercer County



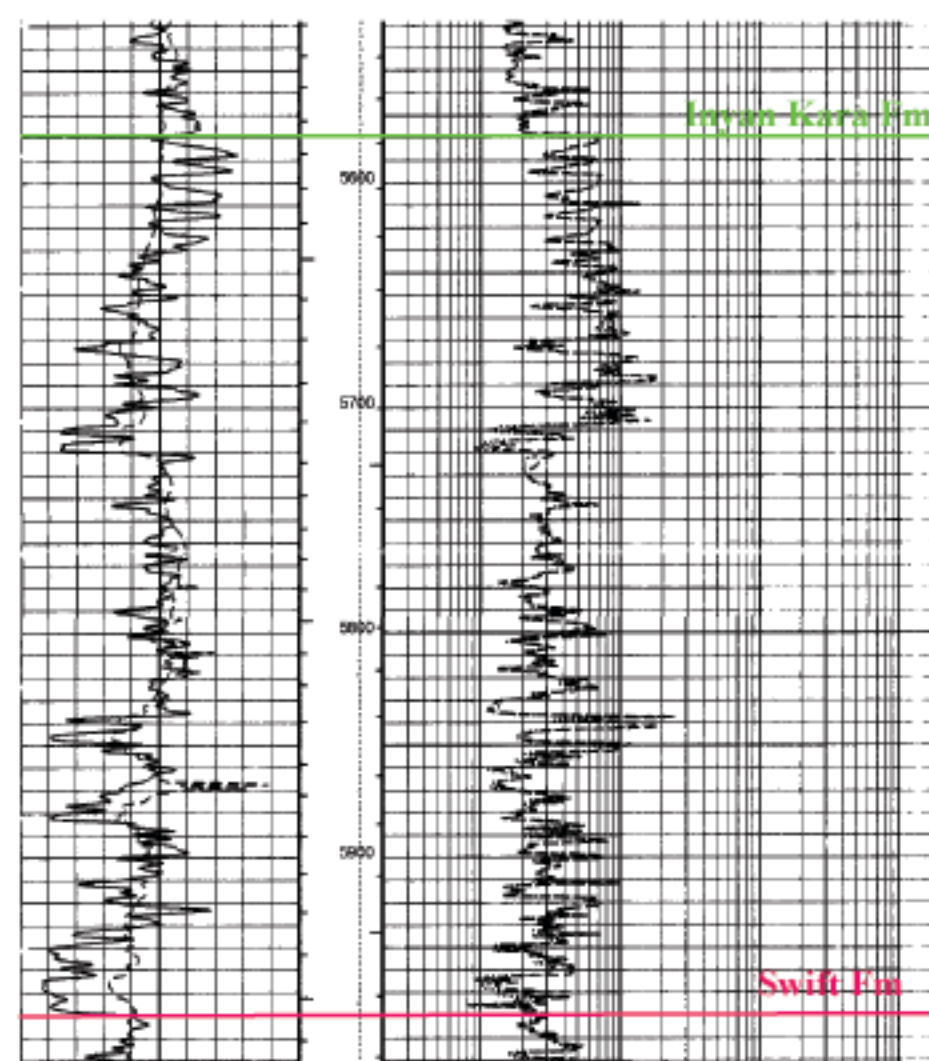
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Grant County



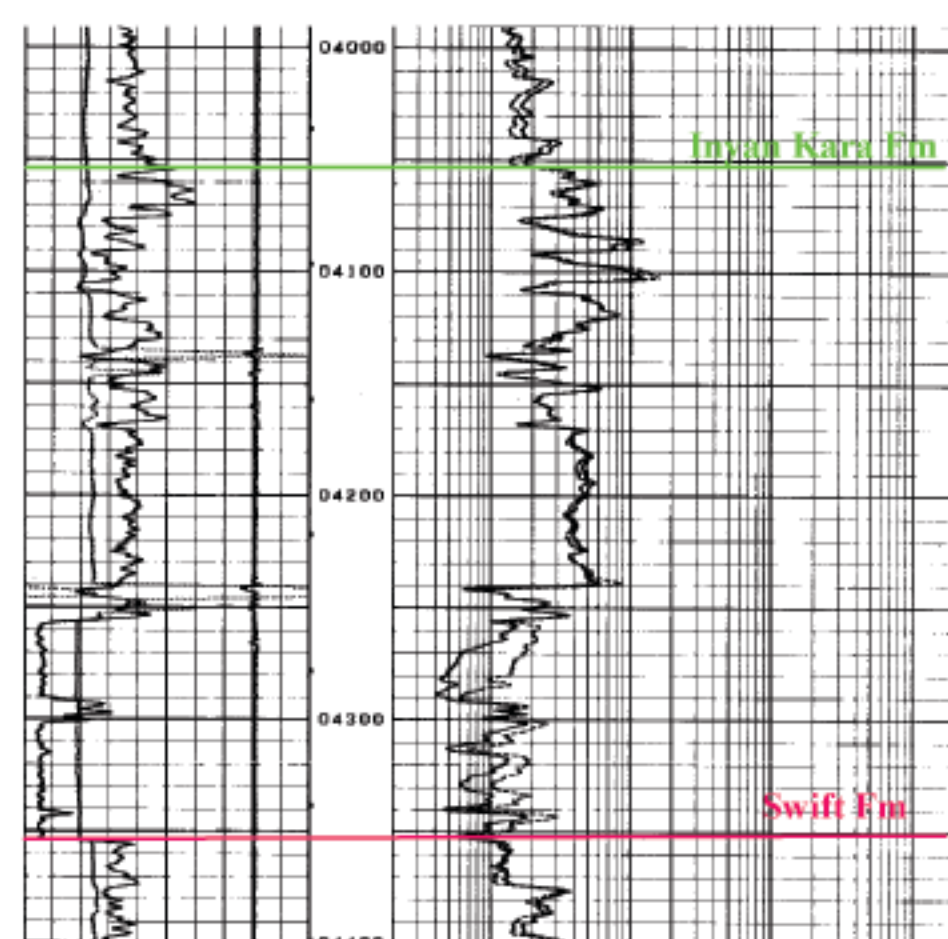
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SOUTHWESTERN ENERGY PRODUCTION CO.  
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Emmons County



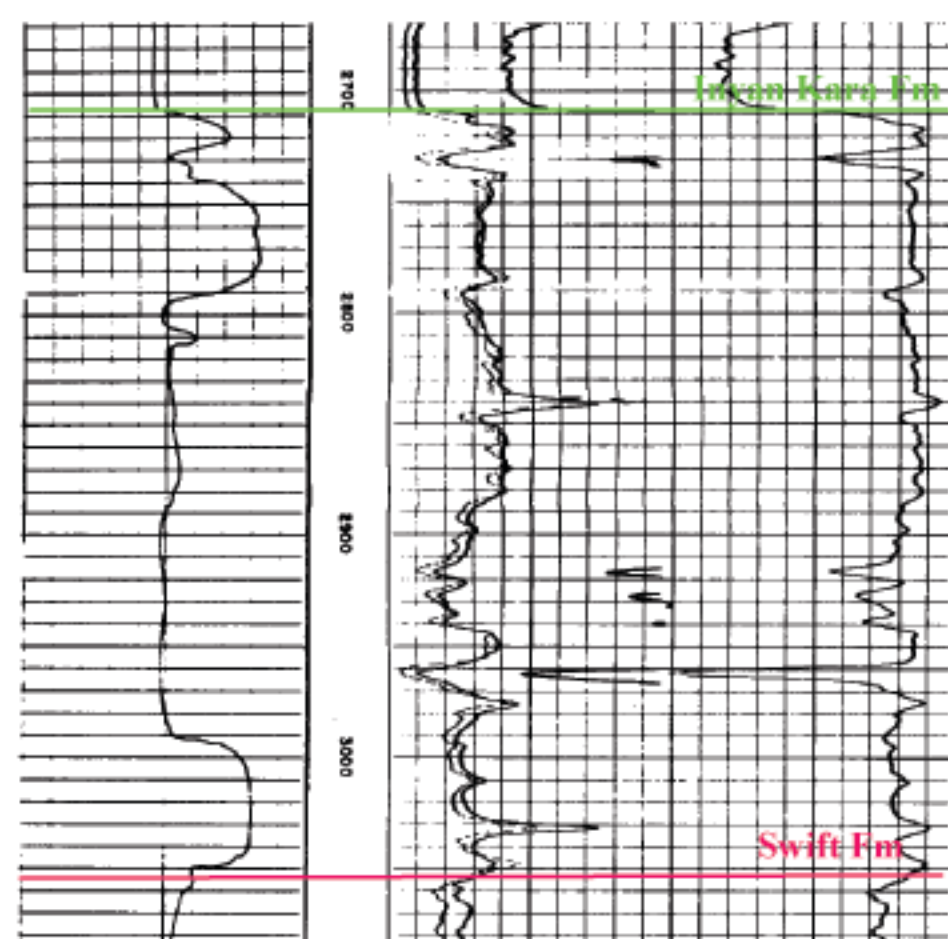
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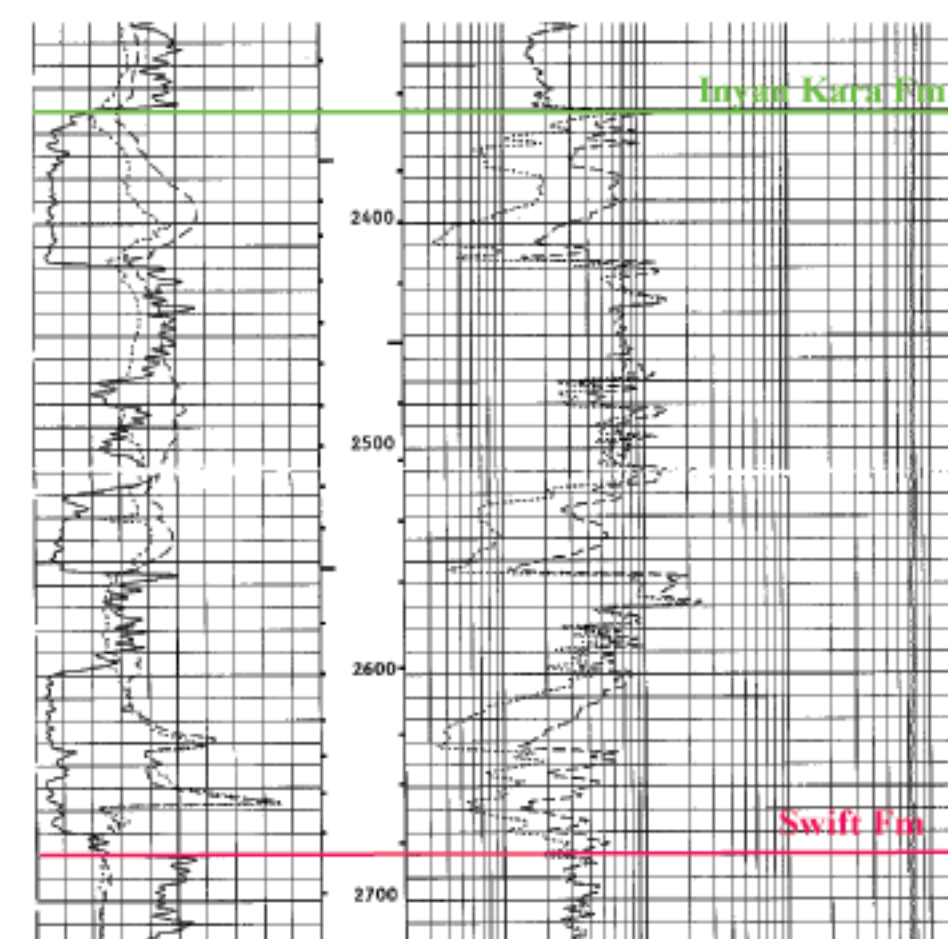
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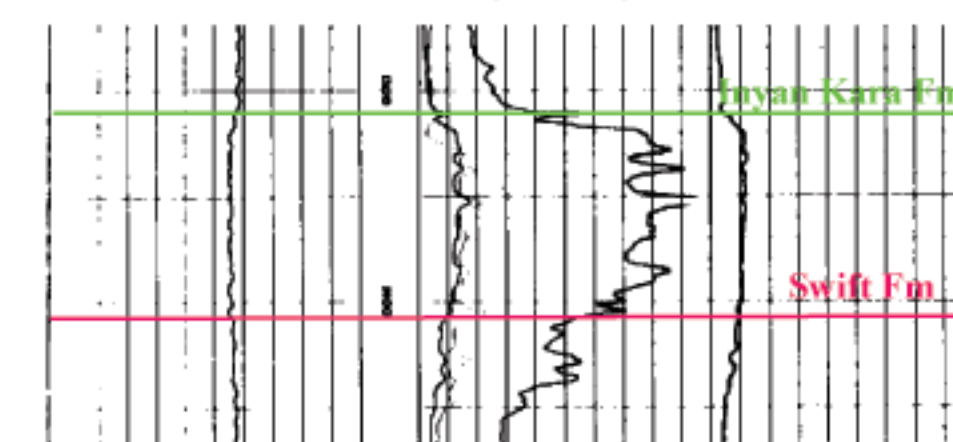
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 Bottineau County



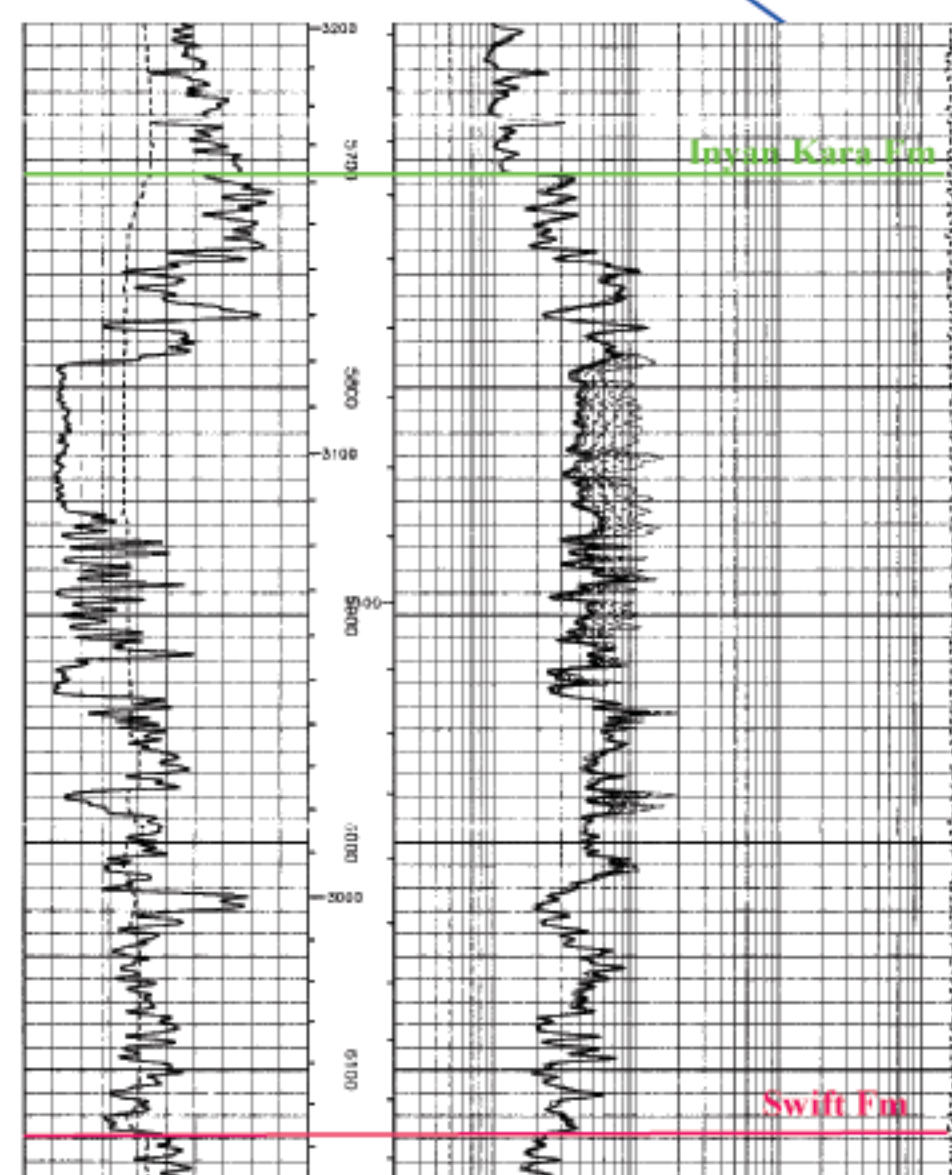
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 McHenry County



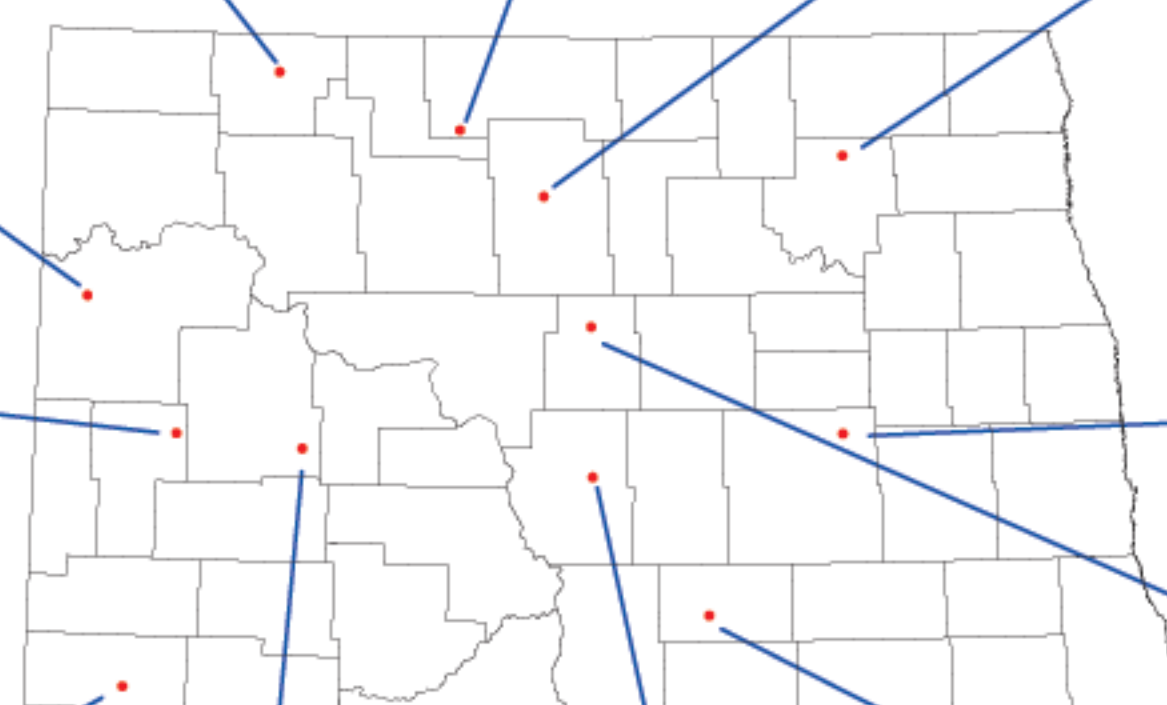
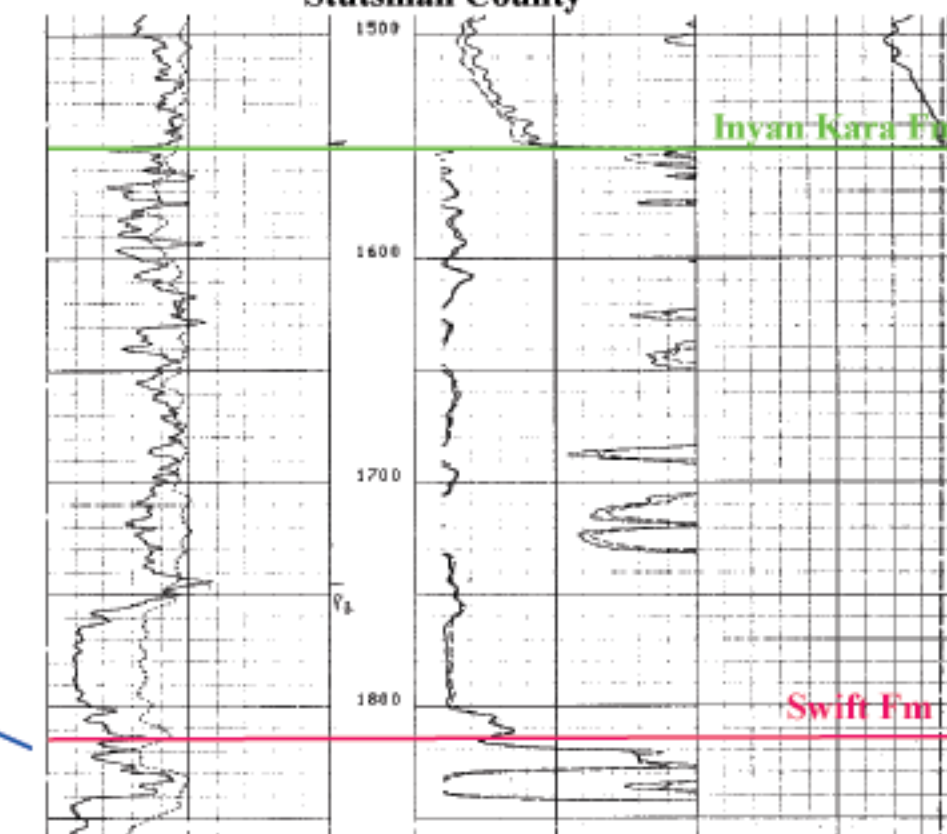
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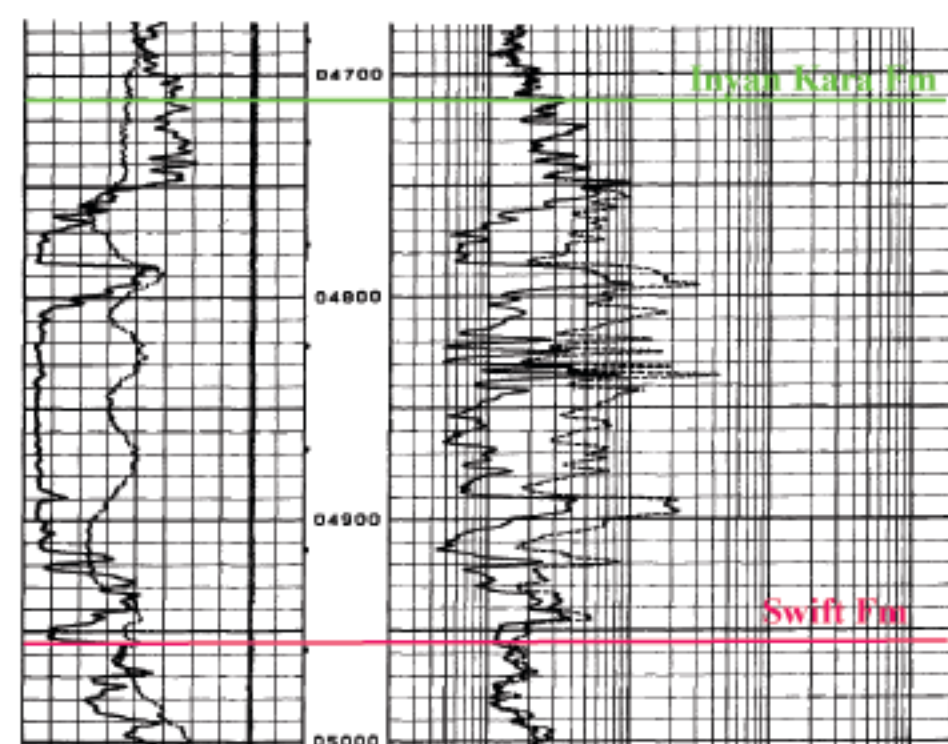
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 Billings County



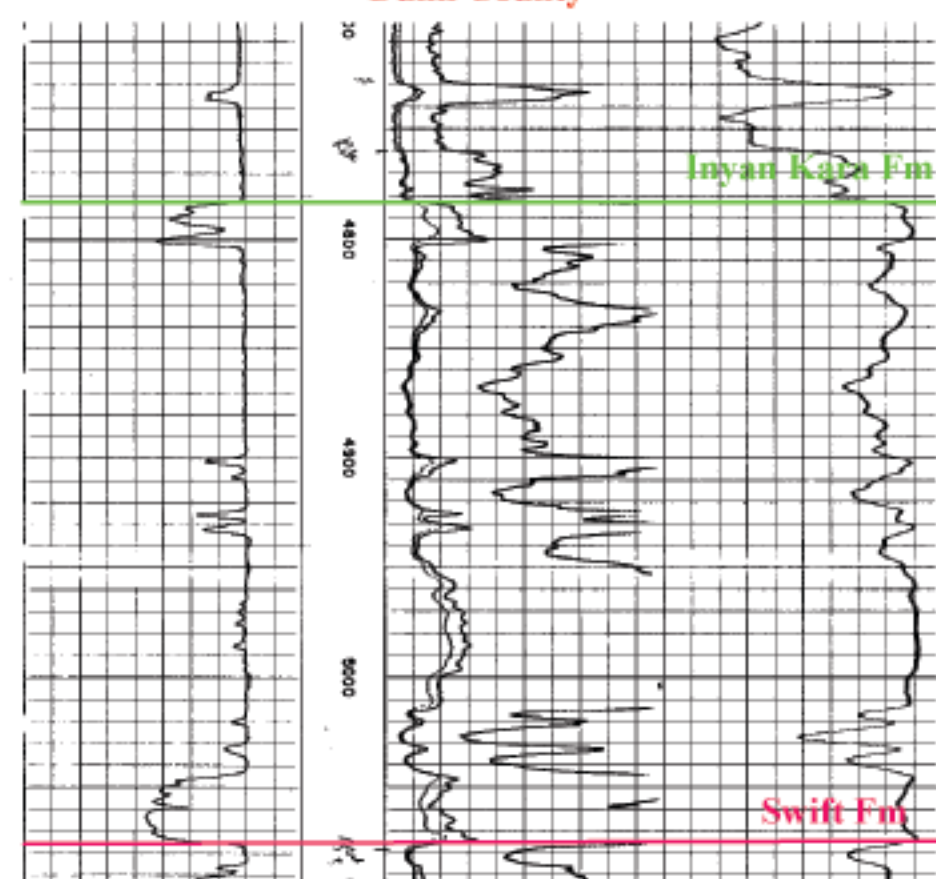
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 Stutsman County



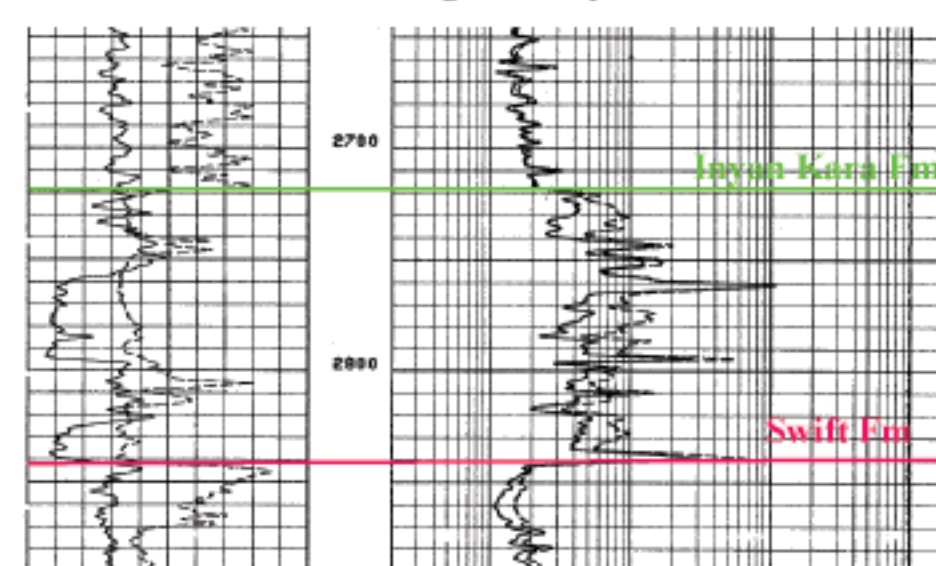
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 Bowman County



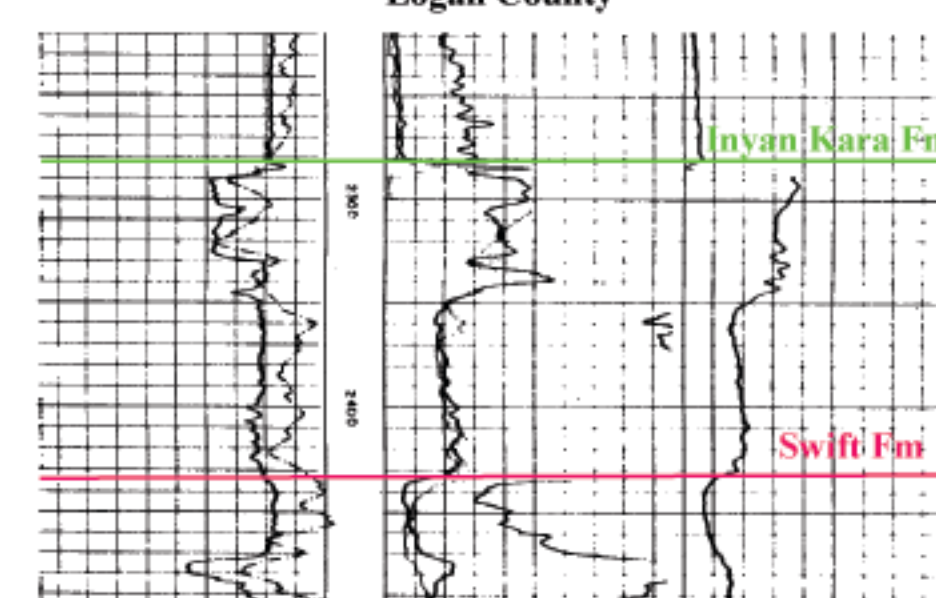
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 SUN OIL CO. T. D. THORSON #1  
 Burleigh County



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 CALVERT DRILLING INC. LEROY BURNSTAD #1  
 Logan County



11826  
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 BALLARD EXPLORATION COMPANY INC.  
 BORCHARDT #1  
 Sheridan County

