FORT BERTHOLD RESERVATION

List of Topics

OVERVIEW
FORT BERTHOLD RESERVATION
The Three Affiliated Tribes

Tribal Headquarter: New Town, North Dakota
Geologic Setting: Williston Basin

Introduction

The Fort Berthold Indian Reservation is located in west-central North Dakota approximately thirty miles southwest of the city of Minot. The Reservation contains portions of Dunn, McKenzie, McLean, Mercer, Mountrail and Ward Counties and includes an area of about 1,530 square miles or 980,000 acres. These lands are located 15 miles east of the center of the Williston Basin, a geologic area where undiscovered accumulations of oil and gas may be located.

Several studies have been published over the years which indicate high potential for undiscovered oil and gas reserves on the Fort Berthold Reservation. There has been past interest exhibited by oil companies, however, high royalties, high lease acquisition costs, inability to assemble large blocks of acreage, rights to seismic data, Tribal Employment Rights Office (TERO) regulations, taxes, and a 100 percent signature requirement imposed by the federal statute on Trust lands have served as deterrents to oil and gas exploration on the Reservation. The 100 percent signature requirement regulation has made exploration on Tribal Allotted Lands nearly impossible to carry out due to the high fragmentation caused by heirship. The Tribes are currently working to correct these problems to open the door for future gas and oil exploration and development. The Three Affiliated Tribes are striving to work closer with oil companies to make oil and gas exploration on Fort Berthold competitive with lands outside of the Reservation.

The Fort Berthold Reservation possesses all the requisites for commercial petroleum development. According to an oil and gas study authorized by Joe H. Rawlings, source rocks and reservoir caprock combinations are in evidence from the Antelope field located near the northwest corner of the Reservation. This field produces both oil and gas from four different zones. The relatively new Plaza field, located near the east exterior boundary, is also a major producing oil field. Other fields were recently discovered on the Reservation while drilling the Bakken and Mission Canyon formations. This multiplicity of geologic structures argues the presence of the many deep traps. Regardless of the development of these fields, much of the Reservation has not been explored for accumulations of oil and gas.

The Williston Basin, which encompasses the Reservation, has a long history of production. Much of the oil in this area was sourced by the organically rich Bakken Formation. New horizontal drilling technology has made production from Bakken source rocks possible. A report written for the Bureau of Indian Affairs by Susan Race Wager, states that the Fort Berthold Reservation is favorably located for exploration in the Bakken Formation.

According to George Long of the Bureau of Land Management (BLM), there have been 571 tests for oil and gas on or immediately adjacent to the Fort Berthold Reservation resulting in a total of 392 producing wells and 179 plugged and abandoned wells; a 69% success ratio. The majority of these 179 plugged and abandoned wells did report oil and gas shows. Of special interest, there appears to be production potential in the Mississippian Charles Formation which has been bypassed in all of the wells drilled except those few that are too shallow to reach the Charles Formation located in the Mission Canyon.

Water saturation calculations were made on 60 wells to evaluate possible bypassed production in the Mississippian Charles Formation. Possible oil and gas production was indicated in 52 of these 60 wells. According to the BLM, there are approximately 10 formations proved to be productive in the Fort Berthold area. Of further note, the facies distribution during lower Mississippian time strongly suggests that Lodgepole trends are present on the Fort Berthold Indian Reservation (USGS).

The Three Affiliated Tribes have purchased seismic data from lines located in the western portion of the Reservation, which may be examined by parties interested in oil and gas exploration. Some of the seismic data will be reprocessed and may be correlated with borehole logs. Sections and data tapes reside with the Division of Energy and Minerals Resources of the Bureau of Indian Affairs located in Denver, CO.

Area Location and Access

Fort Berthold Indian Reservation comprises parts of Dunn, McKenzie, McLean, Mercer, Mountrail, and Ward Counties in west-central North Dakota (Figure 1), near the confluence of the Missouri and Little Missouri River valleys. Total area is about 1,530 square miles, approximately 11 percent of which is covered by waters impounded by Garrison Dam (Lake Sakakawea). The lake divides the reservation into four distinct areas, here referred to as the western, southern, eastern, and north-central segments.

Although reservoir waters somewhat impede travel between the four land segments, most of the reservation is accessible over a system of State highways and local roads. Rail service is provided to the northern part of the reservation by the Soo Line Railroad. A main east-west line of the Burlington Northern passes within 7 miles of the reservation, roughly paralleling the southern boundary.

Physiography

The Fort Berthold Indian Reservation includes land that ranges from rugged badlands to rolling plains. Altitudes range from about 1,850 feet at Lake Sakakawea to over 2,600 feet on Phaelen's Butte near Mandaree. The reservation is within the Northern Great Plains Physiographic Province and may be divided into four physiographic units: (1) the Coteau Slope; (2) the Missouri River trench (now flooded); (3) the Missouri Plateau; and (4) the Little Missouri Badlands. South of Lake Sakakawea the reservation has a bedrock surface with scattered areas of glacial drift. North of the lake, glacial deposits predominate and only patches of bedrock crop out. The landscape reflects this distribution of sediments: south of the lake, hills and badlands are common; north of the lake the glaciated topography is mainly undulating to rolling.

The reservation area north of Lake Sakakawea is part of the Coteau Slope, which has both erosional and glacial landforms with glacial predominating. Gentle slopes characterize 50 to 80 percent of the area and local relief ranges from 50 to 200 feet. The Little Missouri Badlands lie adjacent to the Little Missouri River south and west of Lake Sakakawea as well as in a few restricted areas along the Missouri River. They consist of rugged, deeply-eroded, hilly land in which gentle slopes characterize only 20 to 50 percent of the area and local relief is commonly over 500 feet. Areas other than badlands south and west of the lake are part of the Missouri Plateau. In these areas, gentle slopes characterize about 50 to 70 percent of the area and local relief ranges from 300 to 500 feet.

The Missouri and Little Missouri Rivers and their larger tributaries have cut deeply into the bedrock and glacial deposits of various compositions. The Missouri River is 300 to 500 feet below the upland plain. Near the western boundary of the reservation, the Little Missouri River has eroded a channel more than 600 feet deep. Occasional ridges and bare buttes extend as much as 400 feet above the plain.

Land Status

The Fort Berthold Indian Reservation was established by the Fort Laramie Treaty of September 17, 1851, for the Arikara, Mandan, and Hidatsa Tribes of Indians who later united to form the Three Affiliated Tribes. Executive Orders and Congressional Acts have limited the reservation to its present boundaries. The act of June 1, 1910, 36 Stat. 455, opened unallotted and unsold reservation lands to non Indians, thus creating the "ceded and diminished lands" boundary. It was assumed by many that only the remaining lands comprised the Fort Berthold Indian Reservation. A Federal appeals court (8th Cir. 1972), however, ruled that the 1910 Act did not change reservation boundaries and that the "homestead" (ceded) area remained a part of the reservation (City of New Town vs. United States, 454 F 2d 121) Public Law 437 and the Act of July 31, 1947 (amended October 29, 1947) made provision for lands inundated by the Garrison Dam reservoir. Table 1 summarizes the present extent of land holdings on the Fort Berthold Indian Reservation. Most of the north and northeast part of the reservation (the homestead area) is in private ownership. Land status data are from Bureau of Indian Affairs records.

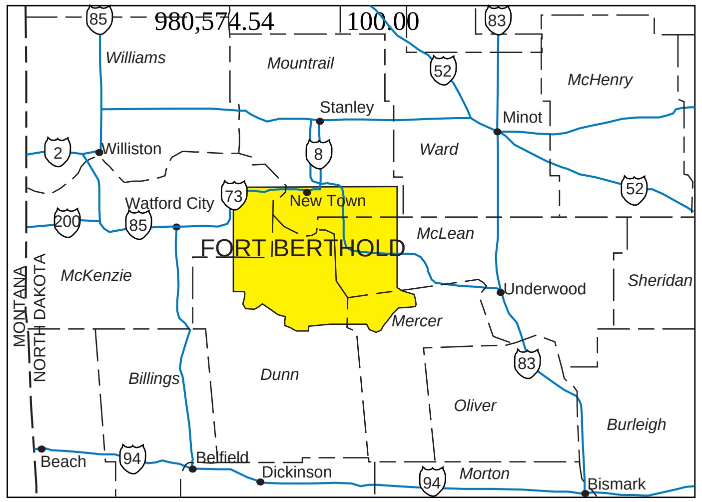
Nearly 54 percent of the reservation's subsurface mineral rights are owned by the Three Affiliated Tribes. Mineral rights in the diminished reservation area are all tribally owned with the exception of 164.09 acres owned by the Federal government. The Tribes also retain mineral ownership for 110,623.13 acres of the homestead area. Lands in the Garrison reservoir area were severed.

TABLE 1 - Summary of land ownership, Fort Berthold Indian Reservation, N. Dakota

Classification	Acreage	Percentage of total
Diminished Reservation Area		
Tribally-owned lands.	57,954.20	5.91
Allotted lands	360,438.57	36.76
Government-owned land	164.09	0.01
Privately owned (alienated) land	55,865.14	5.70
Subtotal	474,422.00	48.38
Reservoir Taking Area	152,359.95	15.54
Homestead (ceded) Area.	353,792.59	36.08
Total area of reservation.	980,574.54	100.00

Contacts

Inquiries concerning oil and gas leases on the Fort Berthold Reservation may be directed to the Three Affiliated Tribes Natural Resources Department - telephone (701) 627-3627 or the Bureau of Indian Affairs, located in New Town, North Dakota - (701) 627-3741.



INTRODUCTION
Fort Berthold Reservation

Williston Basin

Over 700 MMBO have been produced from the Williston Basin, one of the largest cratonic basins in North America. The reservation is ideally situated for numerous exploration targets within this basin. Several source rock horizons, including the world renown Bakken Formation, contribute to the prolific nature of the basin.

The Williston Basin contains an estimated mean value of 650 MMBO and 1.69 TCFG from undiscovered resources in conventional plays. Multiple episodes of maturation and migration occurred during Permian-Cretaceous time from these source intervals. Understanding the trapping mechanisms and migration pathways are critical to successful future exploration within the reservation area. Carbonate reservoirs in Paleozoic formations have been the primary focus of hydrocarbon exploration. Recent exploration targets include microbial gas in Cretaceous sediments and deep Paleozoic sandstone intervals.

Early Exploration in the Williston Basin and Fort Berthold Reservation

Early discoveries were made on large surface structures such as Nesson and Cedar Creek Anticlines, and Poplar Dome. The Williston Basin is distinctive among other Rocky Mountain basins because of its continuous basin subsidence and burial history throughout Paleozoic and Mesozoic time. Large volumes of clastic and carbonate sediments have been preserved.

Since the late 1940's, industry has found more than 960 fields and the basin has undergone multiple exploration cycles. The Williston Basin covers more than 143,000 sq. miles and Fort Berthold reservation covers about one percent of that total (1530 sq. miles). Most of the reservation is unexplored.

Gas was discovered at Cedar Creek Anticline in 1916; oil was discovered on Nesson Anticline in 1951. Nesson is located about 50 miles northwest of the reservation boundary. Antelope Field, a southeast plunging anticline, was discovered in 1953 and extends onto the reservation. Plaza and Wabek Fields, part of the Mississippian shoreline trend, were discovered in the 1980's. Condensate and gas were discovered in the Winnipeg and Deadwood Formations at Antelope Field in 1992.

Fort Berthold Reservation
GENERAL PRODUCTION INFORMATION

U.S.G.S. Geologic Province - Williston Basin (031)
Tectonic Province - Williston Basin

Fields within reservation boundaries

1996 cumulative production. Parentheses indicates discovery year

(1953) **Antelope** - 41 MMBO, 19.2 Mmcf, 30 oil wells, 2 gas wells
(1989) **Plaza** - 2.9 MMBO, 3.9 Mmcf, 20 wells total
(1982) **Wabek** - 5.4 MMBO, 3.9 Mmcf, 18 wells total

Nearby fields

(1955) **Blue Buttes** - 46 MMBO, 29.2 Mmcf, 44 wells total
(1957) **Bear Den** - 1.5 MMBO, 1.7 Mmcf, 2 oil wells, 1 gas well
(1952) **Croff** - 1.8 MMBO, 4.1 Mmcf, 3 wells total
(1981) **Spotted Horn** - 108 MBO, 36,234 Mcf, (Abn'd)
(1982) **Squaw Creek** - 195 MBO, 328,546 Mcf, 1 well total
(1982) **Mandaree** - 160 MBO, 147,325 Mcf, 2 wells total
(1990) **Lucky Mound** - 1.4 MMBO, 890, 670 MCF, 18 wells total

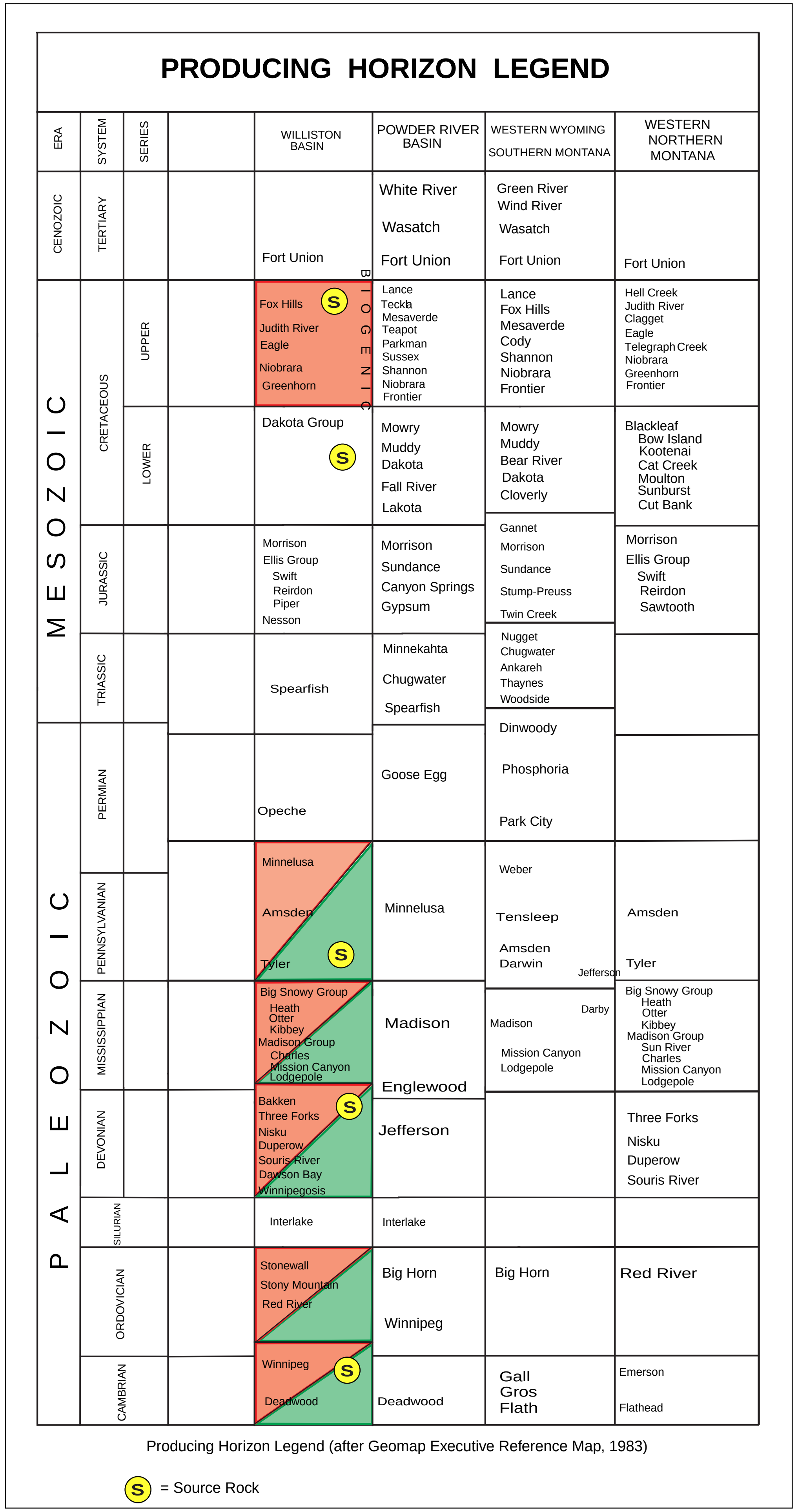


Figure FB-1.1. Producing horizon legend. Many of the potential reservoir intervals can be correlated into Wyoming and Montana. However, the Williston Basin is unique among other Rocky Mountain basins for its thick package of Paleozoic age carbonate sediments. While the other basins are known for their numerous clastic potential reservoir intervals, the Williston Basin is known as a carbonate province (modified after Seventh International Williston Basin Symposium Guidebook, 1995). ▶

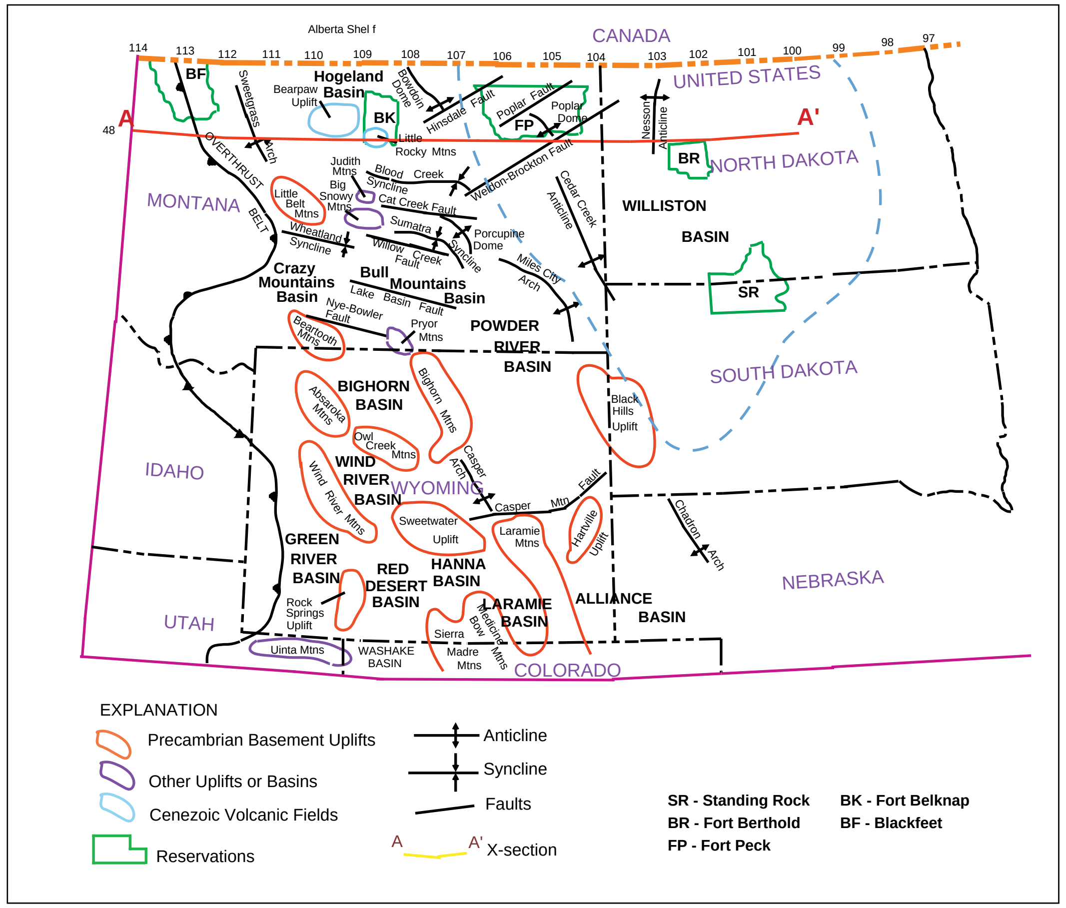


Figure FB-2.1. Present day structural features of the northern Rocky Mountain region. Includes major fault zones, uplifts, basins, and reservation areas (modified after Peterson, 1987).

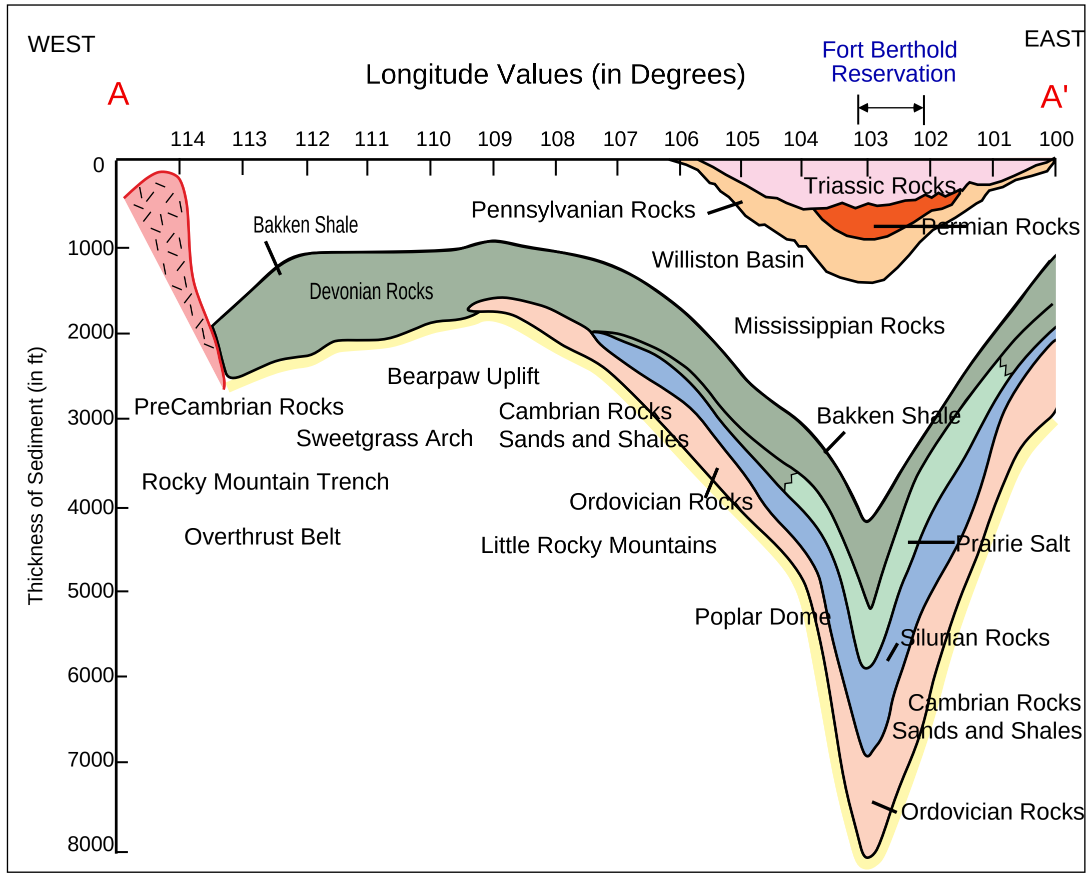


Figure FB-2.3. Generalized time-slice cross-section A-A'. Triassic through Ordovician. Line of section along 48 degrees latitude with selected points every 1 degree of longitude. Datum is the base of Jurassic, Permian missing (from C.W. O'Melveny, July 1996).

REGIONAL GEOLOGY

The Fort Berthold Reservation is situated near the deepest part of the Williston Basin (see Fig. FB-2.1 A-A' and associated cross-sections). During the Paleozoic and early part of the Mesozoic, the basin was a stable, cratonic depocenter which received over 15,000' of sediments. Fort Berthold reservation is located within the depocenter, near a major structural feature called the Nesson Anticline, which produces a significant percentage of hydrocarbons within the basin.

Predominantly a carbonate depocenter in the Paleozoic, the basin is also interbedded with clastics and evaporites. The clastic intervals are composed of marine, organic rich shales which are the principal source rocks for the basin. In addition, some of the clastic intervals also include nearshore marine or fluvial sandstone deposits. The carbonate and evaporite units are mainly tidal flat, bioherm/reef or sabhka deposits. Cyclic sedimentation of marine shales, limestones/dolomite, and anhydrites or salt are indicative of the Paleozoic section within the Williston Basin.

Potential reservoir intervals can be formed in the limestone or dolomite via primary or secondary porosity mechanisms. Porosity may be intergranular, vuggy, intercrystalline or fractured or combinations of all types depending on structural position and depositional environment.

Geologic History - Cambrian and older rocks

Precambrian age supracrustal sedimentary rocks are present in western Montana and extend into Glacier National Park (see Fig. FB-2.1). These rocks are estimated to be from 900 to 1400 million years old. No Precambrian rocks are exposed on the Fort Berthold Reservation.

During Cambrian time, a major seaway existed in western Montana and eastern Idaho (see Figs. FB-2.2 & 2.4). This seaway gradually transgressed from west to east across eastern Montana and the Dakotas. The dominant source of coarse-grained clastics was to the east (from the Sioux Arch) and gradually changed into shales and limestones to the west. Thickness of the Cambrian rocks varies from over 2000 feet in the Montana Disturbed Belt to less than 100 feet along the eastern edge of the Williston Basin. Cambrian sediments buried under the Fort Berthold Reservation are about 300-600 feet thick and composed predominantly of coarse-grained sandstone.

Geologic History - Ordovician to Triassic

A major depocenter evolved along the eastern edge of the Williston Basin which was a stable, marine shelf area throughout much of the Paleozoic (see Fig. FB-2.3). Ordovician and Silurian rocks were deposited mostly in a shallow tidal flat environment which resulted in alternating cycles of limestone/dolomite, marine shales, and evaporites. By the end of Silurian time, a regional lowstand resulted in a basin-wide unconformity separating Silurian and Devonian rocks. This unconformity influenced the development of vuggy, karsted, carbonate sediments adjacent to this horizon. Present-day thickness of Ordovician and Silurian rocks in the reservation area are 1200 feet and 1000 feet , respectively.

Deposition during Devonian time proceeded much as it had in the Silurian except for the development of highly organic-rich shales within the carbonate intervals. Within the reservation boundaries, Devonian sediments are about 1700 feet thick and include the regional Prairie Salt (500-700'), and the Bakken Shale (70-100'). The Prairie Salt forms a regional seal for the older intervals and has been mobilized/dissolved out of this section near the western edge of the basin (105 degrees longitude). The Bakken Shale is thought to be one of the primary source intervals for Mississippian and younger production.

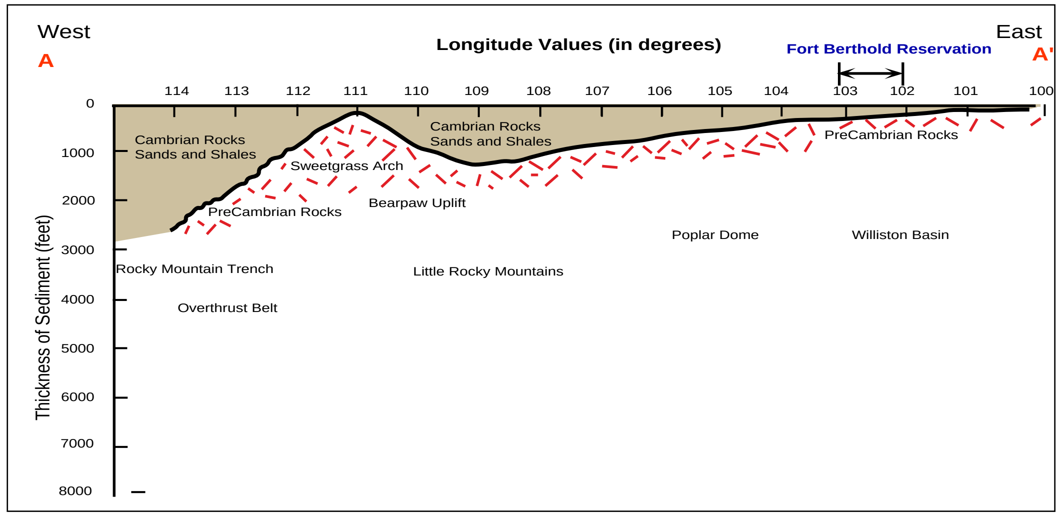


Figure FB-2.2. Generalized time-slice cross-section along A-A'. Line of section along 48 degrees latitude with selected points every 1 degree longitude. Datum is base Ordovician.

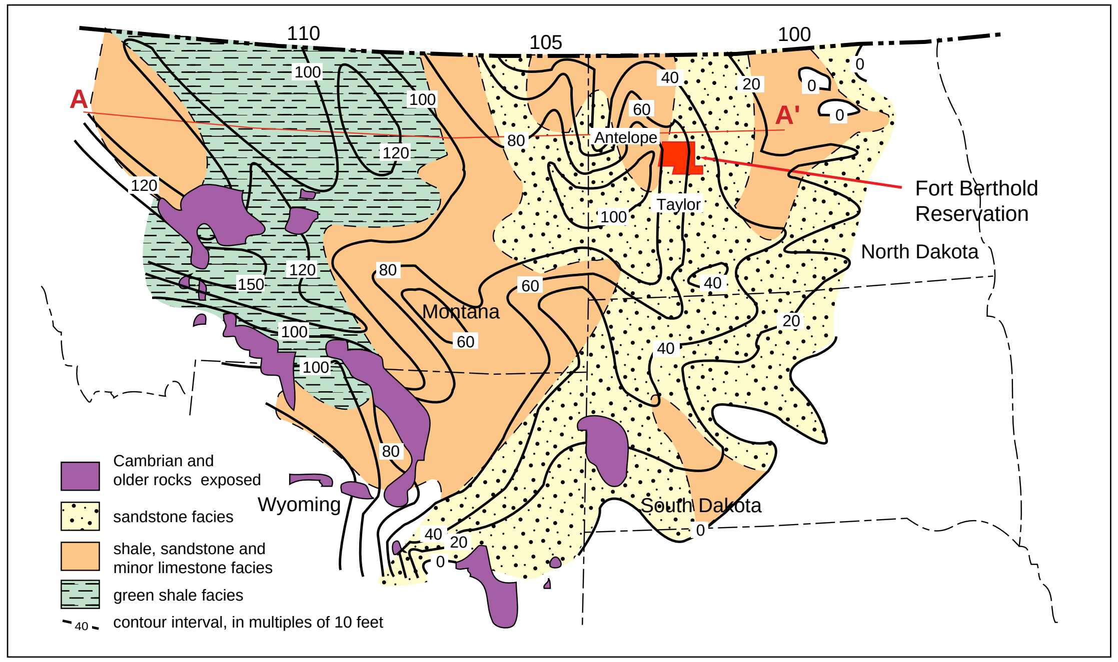


Figure FB-2.4. Map showing thickness of Cambrian-aged Deadwood and equivalent rocks along with facies information, location of analog fields from Cambrian sediments, location of reservation, and location of regional cross-section A-A' (modified after Peterson, 1987).

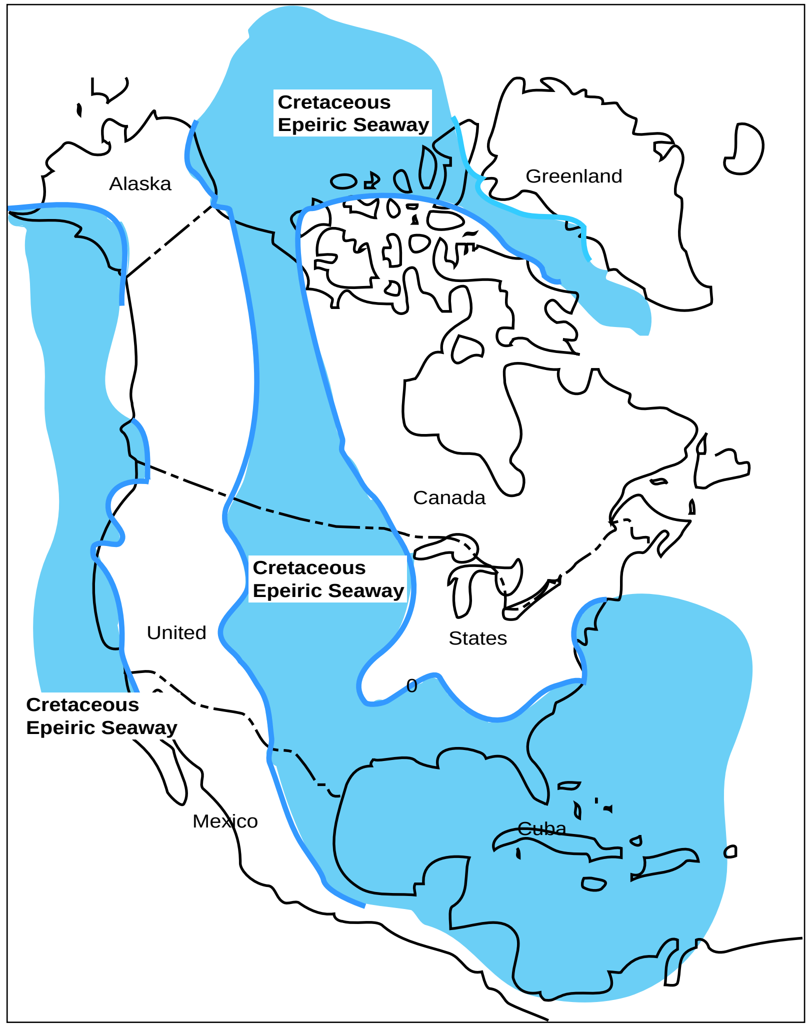


Figure FB-3.3. Paleogeographic map of North America during Late Cretaceous time, showing the extent of the Cretaceous seaway (after Rice and Shurr, 1980).

GEOLOGIC HISTORY (continued)

Geologic History - Ordovician to Triassic

By Mississpppian time, the western portion of the Williston Basin was continuously receiving carbonates and evaporites in a shallow, marine shelf environment (see Figure BF-3.1). Most of the producing reservoirs in the basin are from these cyclic marine shales, limestone/dolomite porosity horizons, and evaporitic carbonate sequences. Eventually, the Charles Salt horizon would cover the entire basin and part of eastern and central Montana. By late Mississippian time, deposition of shales and mudstones were mainly confined to the central Williston area and the Big Snowy trough in central Montana. Total thickness of Mississippian rocks within the reservation boundaries is about 2400-2800 feet.

Another major lowstand at the end of the Mississippian time led to widespread erosion and karstification of the underlying carbonate intervals. Pennsylvanian sediments are confined to the center of the Williston basin and central Montana. Pennsylvanian rocks are about 400 feet thick.

Permian deposits are confined to the central Williston basin area and are predominantly sandstone/shale and evaporite sequences. As the Williston basin became filled to base-level, only shallow marine/terrestrial sediments were deposited. This also resulted in numerous unconformities in this horizon. A major unconformity at the end of Permian time has removed any evidence of these rocks west of longitude 104 degrees. Permian rocks within the reservation are about 500 feet thick. Triassic-aged sediments are also present and of continental origin. Estimated thickness of Triassic rocks across the reservation are about 400-500 feet thick.

Geologic History - Jurassic to Cretaceous

A tectonic structural reorganization of the North American continent occurred during Jurassic-Cretaceous time. This resulted in a major change in depocenter position of the Williston basin, shifting from the east to the western side (Figure 4.3). The inital pulses of the Sevier and later Laramide thrusting resulted in dominantly clastic deposition in the Cretaceous Seaway during this time (Figure 4.4).

Thickness of Jurassic rocks across the reservation area are estimated to be about 1200 to 1400 feet thick and are comprised of a complex mixture of nearshore marine, fluvial, and evaporitic deposits. Early Cretaceous-aged continental/fluvial sediments are about 300-400 feet thick. Provenance for these sediments are thought to have been from the southeast in what is present day South Dakota.

The Mowry/Skull Creek Formation is about 400-500 feet thick within the reservation area and was deposited in a transgressive marine sequence which extended from western Montana eastward into the Dakotas; from Texas northward into Canada. Numerous clastic sandstone deposits are present within this sequence and are the result of variations in sea level and clastic influx into the seaway.

During Upper Cretaceous time thrusting and crustal loading from the west had subsided enough to allow the re-establishment of carbonate deposition within the seaway. Extensive chalk deposits of the Greenhorn/Niobrara Formations were deposited as well as thousands of feet of marine carbonate/clastic shale. Upper Cretaceous rocks in the area are more than 2500 feet thick. As the Laramide Orogeny and associated thrusting began to exert influence, nearshore marine and fluvial sandstones began depositing along the shorelines of the seaway.

Geologic History - Tertiary and Quaternary

As the orogenic uplifts of the Laramide Orogeny occurred during Late Cretaceous to Tertiary time, older Cretaceous rocks were uplifted and eroded. Only the central portion of the Williston preserved the swamp/peat deposits during the Paleocene and Eocene. Coal deposits of the Fort Union and equivalent rocks are the result. These sediments can be up to 1750 feet thick across the reservation. Alpine glaciers existed in Montana during Quaternary time and extensive glacial lakes and ice sheets covered the reservation area.

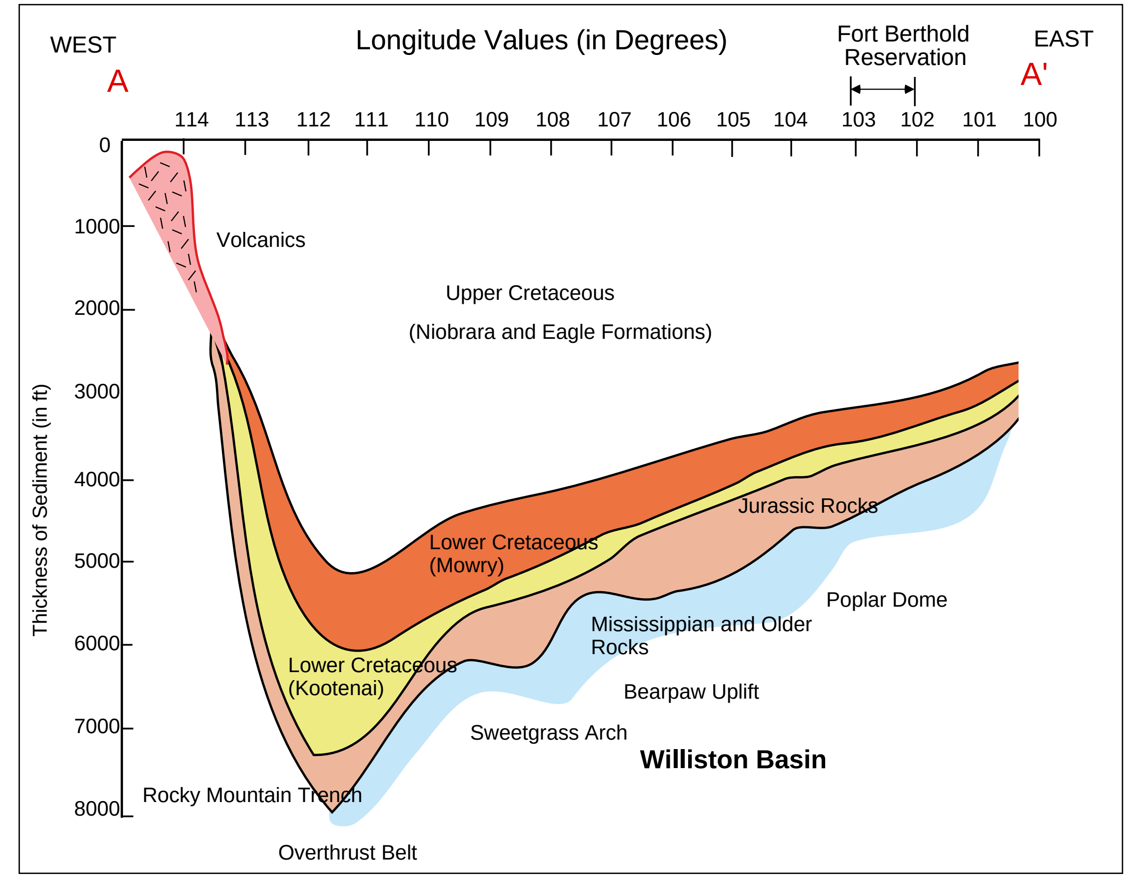


Figure FB-3.2. Generalized cross-section A-A' - Cretaceous and Older Rocks. Line of cross-section along 48 degrees latitude with selected points every 1 degree of longitude. Datum located at the top of the Cretaceous.

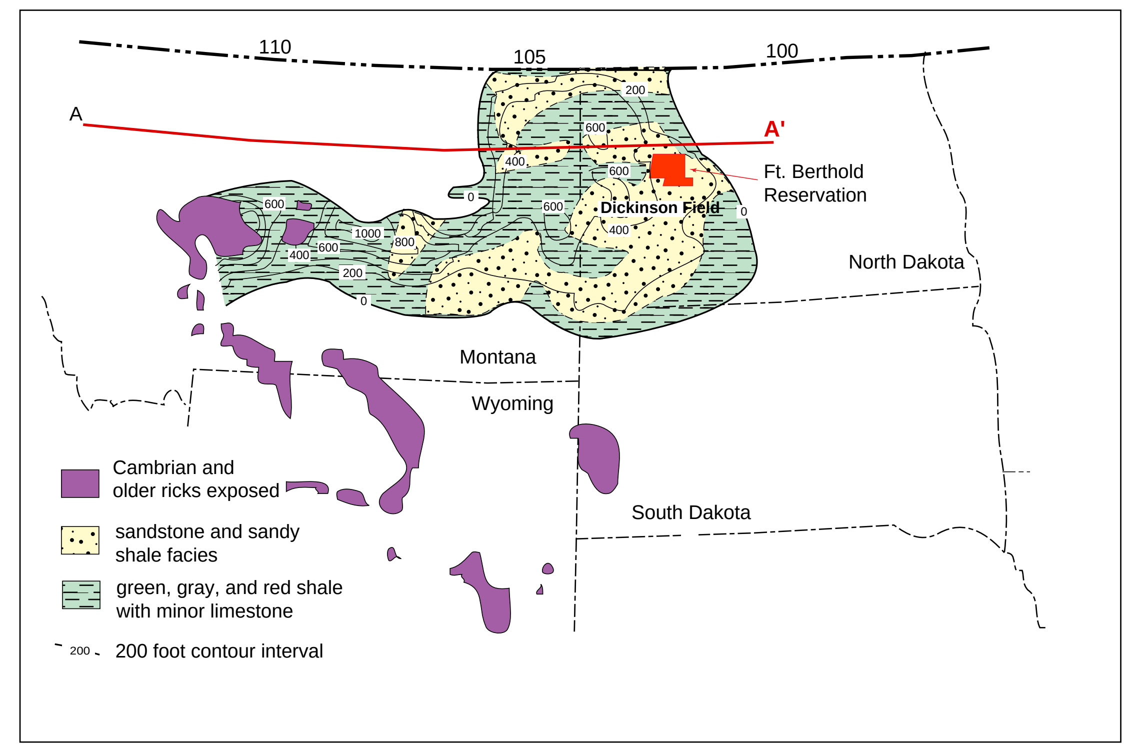


Figure FB-3.4 Isopach map showing thickness and facies distribution of late Mississippian and Pennsylvanian sediments of the Tyler and Big Snowy Group suite of rocks. Location of Fort Berthold Reservation, any analog fields, and older basement rocks also shown (modified after Peterson, 1987).

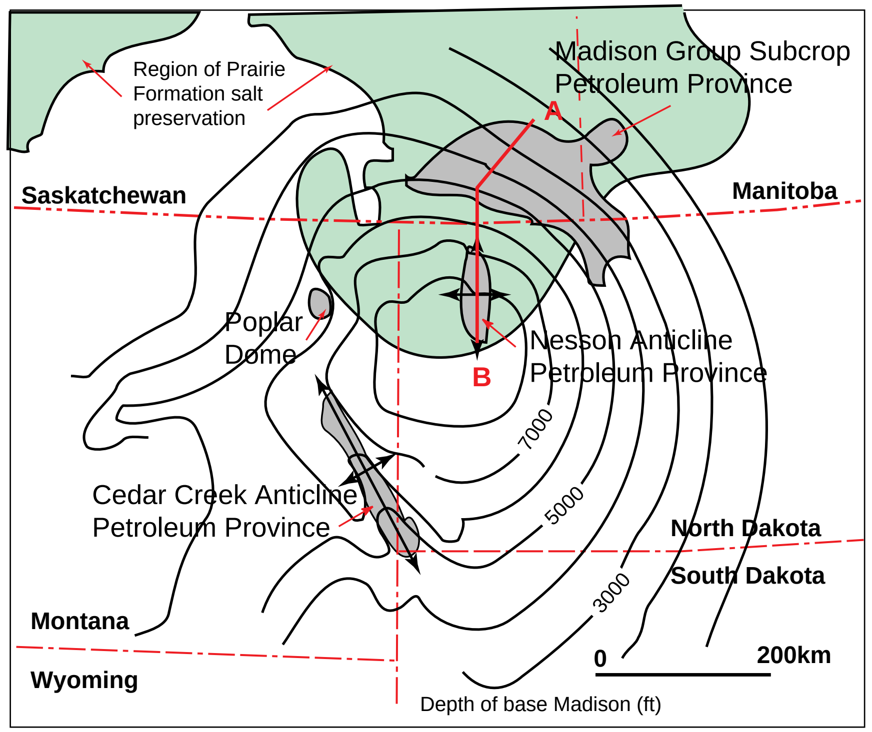


Figure FB-4.1 - Location of the Williston Basin with major petroleum provinces and line of section for burial history diagrams indicated. Structural contours are drawn on the base of the Madison Group (after J. Burrus, K.Osadetz, S. Wolf, et al, 1995).

Petroleum Systems

Accumulations of hydrocarbons owe their genesis to several critical factors: generation and migration from source intervals, structural/stratigraphic trapping mechanisms, porous reservior rocks, and the appropriate timing of formation/generation of these factors. At least four petroleum systems are present within the Williston Basin with numerous underexplored potential hydrocarbon exploration targets. This discussion focuses on the source intervals.

Source rocks: Generation and Expulsion

At least four source intervals have contributed to the hydrocarbon generation and accumulation patterns within the Williston Basin and all are present in the reservation area.

Ordovician Winnipeg shale - A very organic rich shale which exceeds richness values of the Bakken shale in some cases. This interval first entered the oil window in latest Cretaceous/Paleocene time. Peak generation and expulsion occurred between 55-38 mya and some generation continues today. Oils typed to this source are found in the Cedar Creek anticline, eastern Montana, and western North Dakota. However, structures which formed in latest Eocene or after (such as the Nesson Anticline) could not trap the oil migrating from this source. This suggests that much of Winnipeg- sourced oil migrated to the northeastern flank of the Williston Basin where undiscovered oil resource may be present in Ordovician and Silurian strata. This source interval is aerally restricted to the southern and central portions of the basin.

Bakken Shale - Known as a world-class source interval, the Bakken has an average of 11.33 wt. % organic carbon. Oil generation was probably initiated about 75 mya with initial expulsion occurring about 70mya (late Cretaceous). Calculations based on pyrolysis data suggest that between 92.3 - 110 billion barrels of oil have been generated from the Bakken. Except for a few fields utilizing the Bakken as the reservoir, significant volumes of Bakken sourced oil have not been discovered to date. Some researchers suggest that most of the expelled Bakken oil is probably lost into the drainage system, where it remains dispersed, at very low saturations (see Figures 2.2 and 2.3 below). Most of the larger structures in the Williston Basin contain mixtures of Lodgepole (Madison) and Bakken oils with the latter at low relative concentrations.

Lodgepole source interval - This zone contains predominantly carbonate source horizons with relatively low initial yields; 8 kg HC/t rock. However, large volumes of oil have been discovered typed to this source interval, especially within the Nesson Anticline Petroleum Province. This horizon seems to be geographically restricted to the central and southern portions of the Williston Basin. It appears that migration and trapping efficiencies were much higher in this horizon when compared to the Bakken. This may be due to advantageous timing of structure development relative to expulsion/migration.

Winnipegosis source interval - The rich, basinal carbonate horizons within this unit (47 kg HC/t rock) are restricted to a starved, Devonian which begins along the northern end of the Nesson anticline and continues north into Canada. This interval charges many of the Waulsortian mounds found in some of the Mississippian-aged sequences.

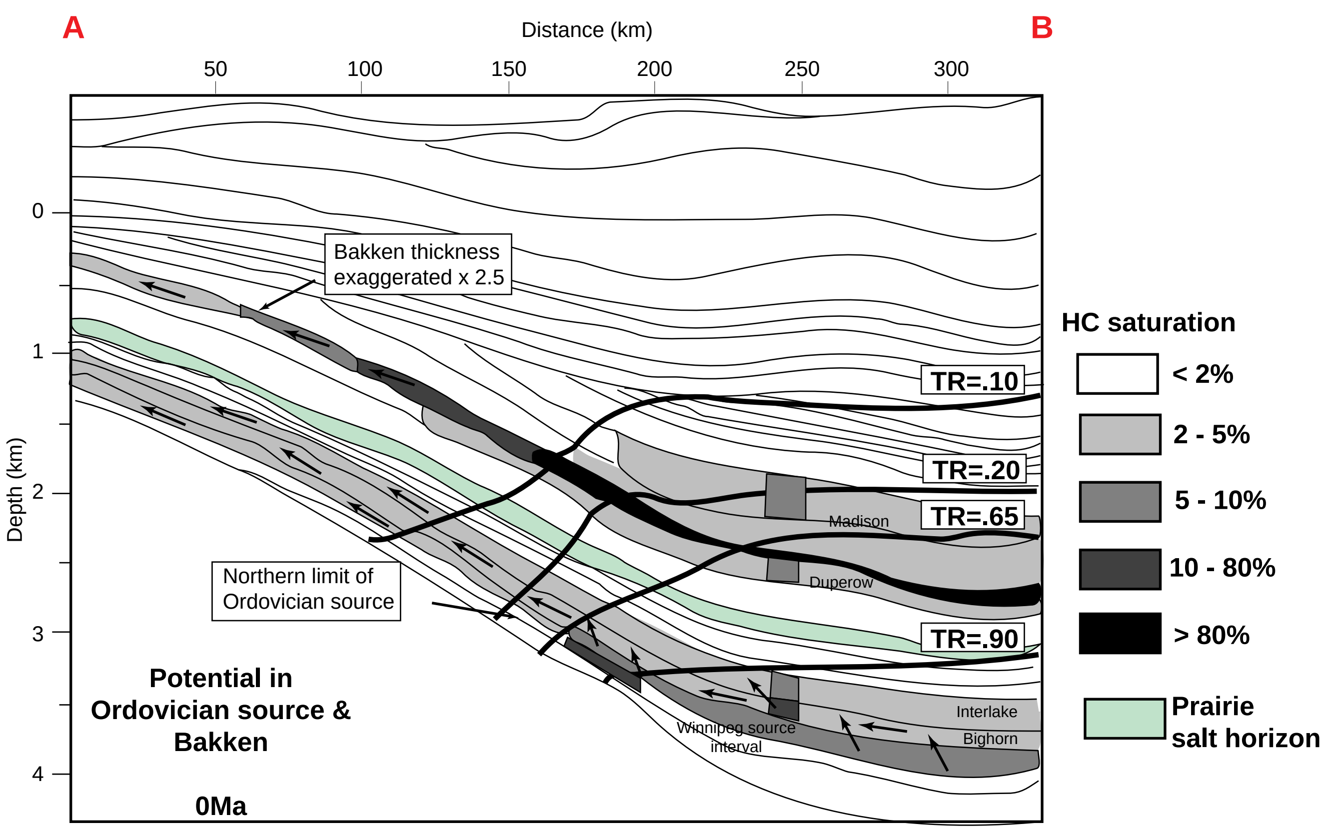
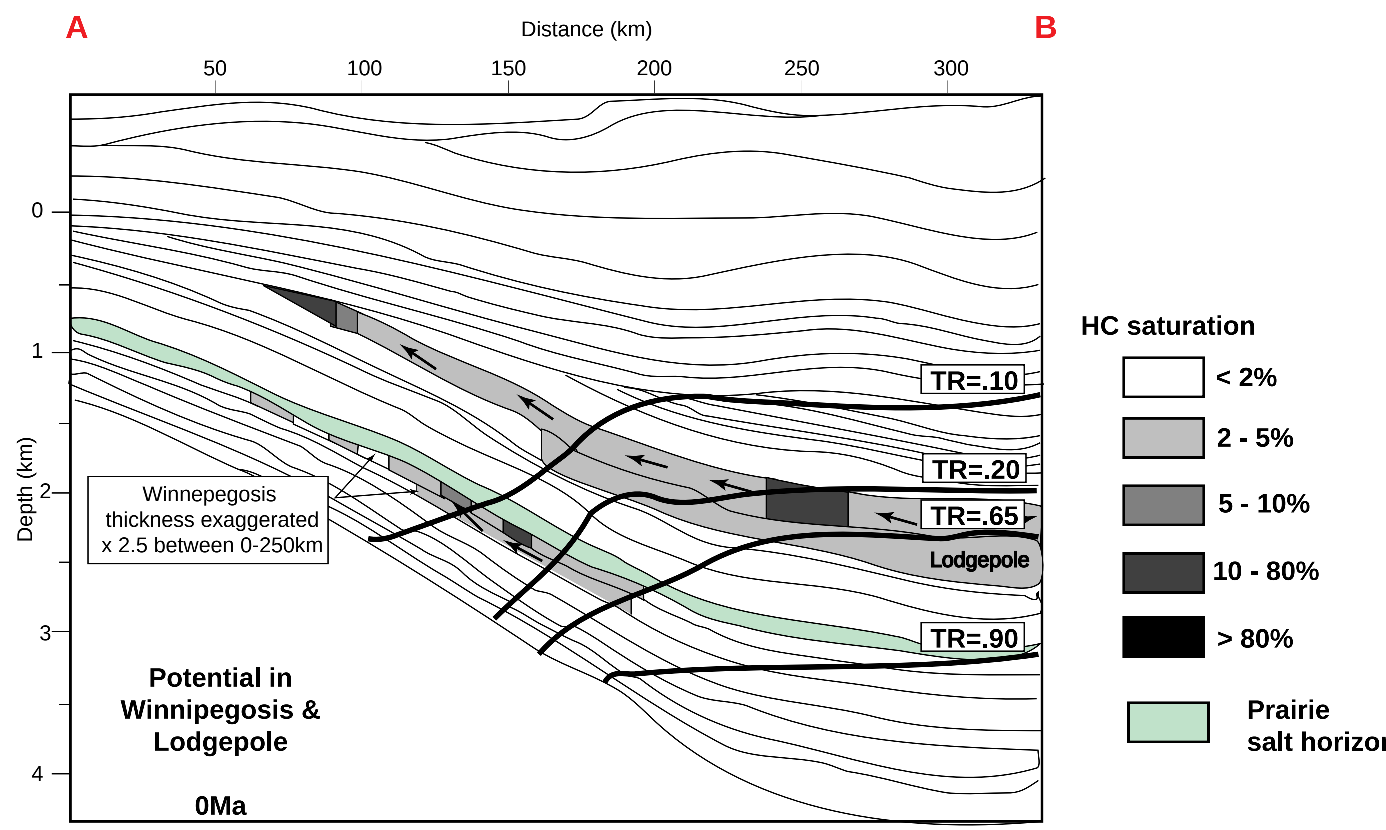


Figure FB-4.2 - Burial history model with patterns of transformation ratio (TR) at the present and distribution of oil saturations, calculated using a finite model, two-dimensional computer model that simulates oil generation, expulsion, and migration. Generation kinetics determined by experimental data from Williston Basin source rocks. Thermal history model constrained by both present temperature and source rock maturity data. Saturations compared to known patterns of hydrocarbon accumulation within the basin. Saturations between 2-5% represent dispersed oil; saturations above 10% represent oil accumulation or depleted source rocks. Arrows show patterns of active oil migration (after J. Burrus, K. Osadetz, S. Wolf, et al., 1995)



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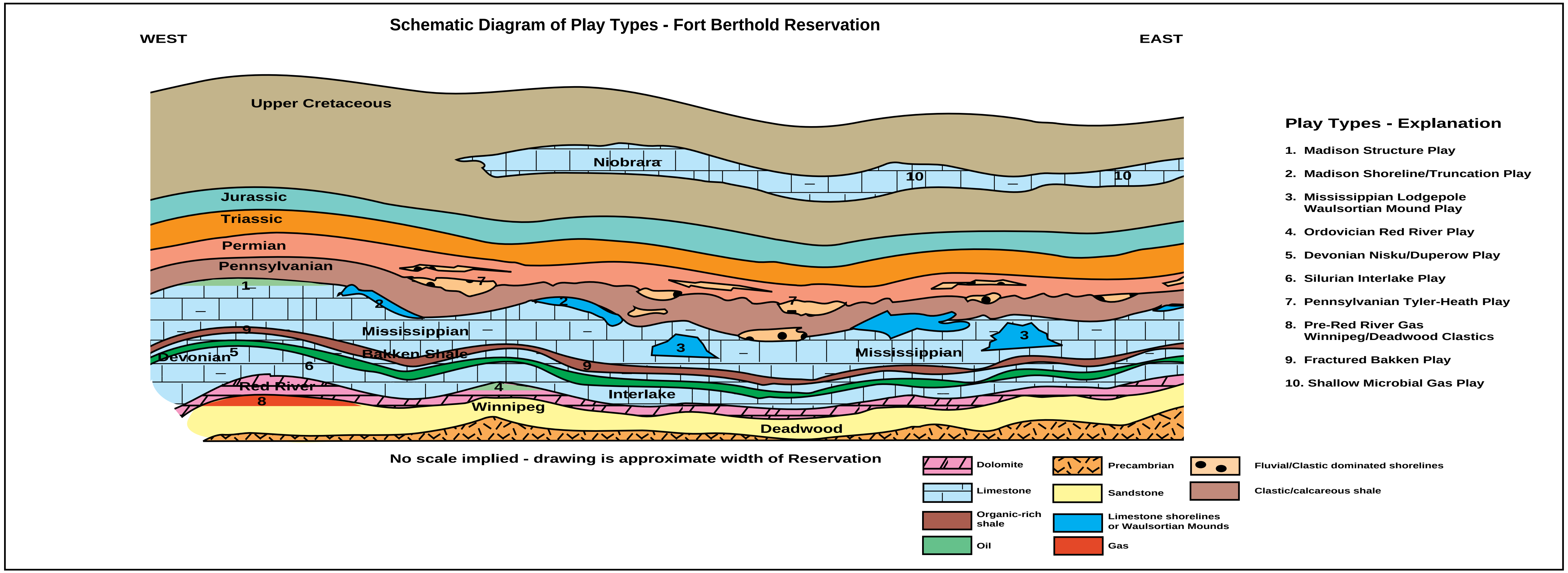


Figure FB-5.1. Schematic diagrams of play types at Blackfeet Reservation

Play Summary

The diagram and summary charts are coded to the play type number and provide a quick reference to the discovered and undiscovered resource for the reservation area. Also listed are USGS (1996) risk estimates and designations for each of the play types. A qualitative brief review of the summary aspects of each play are also shown.

Reservation:	**Fort Berthold**			**Total Production (by province-1996)**	**Williston Basin**	**Undiscovered resources and numbers of fields are for Province-wide plays. No attempt has been made to estimate number of undiscovered fields within the Fort Berthold Reservation**			
Geologic Province:	**Central Wiliston Basin**			**Oil:**	**1496 MMBO**				
Province Area:	**Williston Basin (143,000 sq. miles)**			**Gas:**	**1735 BCFG**				
Reservation Area:	**1530 sq. miles (980,000 acres)**			**NGL:**	**192 MBNGL**				
Play Type	**USGS Designation**	**Description of Play**	**Oil or Gas**	**Known Accumulations**	**Undiscovered Resource (MMBOE)**	**Play Probability (chance of success)**	**Drilling depths**	**Favorable factors**	**Unfavorable factors**
Madison, structure **1**	3101a	folded structures, primary and secondary porosity in carbonates	Both	878 MMBO 916.5 BCFG 77.9 MMBNGL (numbers include 1, 2,& 3)	**Median:** 600 MMBO(30 fields @ 20MMBO) **Field Size (> 1 MMBOE)** 2 MMBO (min), 20 MMBO (median), 5.3 MMBO(mean) **No. of undiscovered fields (> 1 MMBOE)** 9 (min) 30 (median) 60 (max) 31.9 (mean) numbers include plays 1, 2, & 3	1 high	3,000 - 12,000 ft	1) confirmed play; excellent production within reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful	1) lack of well control 2) rough topography 3) porosity and facies may be highly variable
Madison shoreline/ truncation play **2**	3101b	Cyclic evaporite/ carbonate sequence, structure/stratigraphic updip pinchout, multiple shoreline cycles	Both	878 MMBO 916.5 BCFG 77.9 MMBNGL (numbers include 1, 2,& 3)	**Median** of 600 MMBO (30 fields @ 20MMBO) **Field Size (>1 MMBOE)** 2 MMBO(min) 20 MMBO(median) 5.3 MMBO(mean) **No of undiscovered fields (> 1 MMBOE)** 9 (min) 30 (median) 60 (max) 31.9 (mean) numbers include plays 1, 2, & 3	1 high	3,000 - 12,000 ft	1) confirmed play; excellent production within reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) trend extends into reservation 5) mostly shallow drilling depths	1) lack of well control 2) rough topography 3) porosity and facies may be highly variable 4) seismic may not be able to delineate shoreline trends
Miss. Lodgepole/ Waulsortian Mound play **3**	3101c	Mound buildups; 'reefs', small but prolific structures; excellent porosity and permeability	Both	878 MMBO 916.5 BCFG 77.9 MMBNGL (numbers include 1, 2,& 3)	**Median** of 600 MMBO (30 fields @ 20MMBO) **Field Size (>1 MMBOE)** 2 MMBO(min) 20 MMBO(median) 5.3 MMBO(mean) **No of undiscovered fields (> 1 MMBOE)** 9 (min) 30 (median) 60 (max) 31.9 (mean) numbers include plays 1, 2, & 3	1 high	3,000 - 12,000 ft	1) confirmed play; trend probably extends to reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic may be very useful	1) lack of well control 2) rough topography 3) small areal extent, may be difficult to explore for
Ordovician Red River Play **4**	3102	Cyclic evaporite/ carbonate sequence, structure/stratigraphic updip pinchouts; multiple shoreline cycles	Both	188.3 MMBO 555.7 BCFG 70.5 MMBNGL	**Median** of 250 MMBO (25 fields @ 10 MMBO) **Field Size (>1 MMBOE)** 2 MMBO/10 BCFG(min) 10 MMBO/35 BCFG(median) 2.1 MMBO/11.7 BCFG(mean) **No of undiscovered fields (> 1 MMBOE)** 5 (min) 25 (median) 50 (max) 26 (mean)	1 high	7,000 - 12,000 ft	1) confirmed play; production within reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic useful in locating structures	1) lack of well control 2) rough topography 3) possible small exploration targets

Table FB-5.1. Play summary chart

Reservation:	**Fort Berthold**	**Total Production (by province-1996)**	**Williston Basin**	**Undiscovered resources and numbers of fields are for Province-wide plays. No attempt has been made to estimate number of undiscovered fields within the Fort Berthold Reservation**
Geologic Province:	**Central Williston Basin**	**Oil:**	**1496 MMBO**	
Province Area:	**Williston Basin (143,000 sq. miles)**	**Gas:**	**1735 BCFG**	
Reservation Area:	**1530 sq. miles (980,000 acres)**	**NGL:**	**192 MBNGL**	

Play Type	USGS Designation	Description of Play	Oil or Gas	Known Accumulations	Undiscovered Resource (MMBOE) Field Size (> 1 MMBOE) min, median, mean	Play Probability (chance of success)	Drilling depths	Favorable factors	Unfavorable factors
Nisku and Duperow **5**	3103	Cyclic evaporite/carbonate sequences. Structural and stratigraphic pinchouts. Excellent porosity and permeability	Both	160.5 MMBO 159.2 BCFG 12.7 MMBNGL	**Median** 250 MMBO (25 fields @ 10 MMBO) **Field Size (> 1MMBOE)** 2 MMBO/10 BCFG 10 MMBO/60 BCFG 2.1 MMBO/13.1 BCFG **No.of undiscovered fields (> 1 MMBOE)** 9 (min) 25 (median) 60 (max) 26.9 (mean)	1 high	8,000 - 12,500 ft	1) confirmed play; production within reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful	1) lack of well control 2) rough topography
Silurian Winnipegosis and Interlake **6**	3105	Cyclic evaporite/ carbonate sequence, erosional surfaces. Primary and secondary porosity. Structural and unconformity related trapping mechanisms	Both	55.5 MMBO 180 MMCFG 24.8 MMBNGL	**Median** 225 MMBO (15 fields @ 15 MMBO) **Field Size (> 1MMBOE)** 3 MMBO/15 MCFG(min) 15 MMBO/90 MMCFG(median) 3.3 MMBO/19.7 MMCF(mean) **No. of undiscovered fields (> 1 MMBOE)** 5 (min) 15 (median) 25 (max) 15 (mean)	1 mod.- high	8,000 - 12,500 ft	1) confirmed play; production within reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic useful in prospect delineation	1) lack of well control 2) rough topography
Post Madison Penn. Tyler/Heath **7**	3106	Fluvial and nearshore sandstones with structural closures. Traps may also occur as discontinuous sandstone lenses.	Both	133.5 MMBO 28.8 BCFG	**Median** 16 MMBO (8 fields @ 2 MMBO) **Field Size (> 1MMBOE)** 2 MMBO 10 MMBO 2.1 MMBO **No of undiscovered fields (> 1 MMBOE)** 4 (min) 8 (median) 15 (max) 8.6 (mean)	1 mod.-high	5,500 - 9,000 ft	1) Thermally mature source rocks 2) source rocks and reservoir present 3) shallow drilling depths	1) No production within reservation 2) rough topography 3) lack of well control 4) depositional area within reservation may be marine instead of shoreline
Ordovician Pre-Red River Play **8**	3107	Clastic sequences, fluvial and nearshore blanket sandstones. Large, faulted structures	NGL and low BTU gas	no information available	**Median** 50 BCFG (5 fields @ 10 BCFG) **Field Size (> 1MMBOE)** 10 BCFG 25 BCFG 13.1 BCFG **No. of undiscovered fields (> 1 MMBOE)** 1 (min) 5 (median) 20 (max) 7.3 (mean)	1 moderate	10,000 - 16,000 ft	1) confirmed play; production within reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic useful in locating structures 5) high volume reserves	1) lack of well control 2) rough topography 3) low BTU, contains nitrogen
Fractured Bakken **9**	3111	Organic rich shale, marine siltstone; fractured; thermally mature oil shale	Both	No information available Oil shows from Sanish sandstones	not estimated 70.3 MMBO/ sq. mile generated hydrocarbons 56.24 MMCFG/ sq. mile generated hydrocarbons Area of play = 8185 sq. miles 7806 sq. miles untested	1 0.2 (20%)	7,500 - 11,100 ft	1) confirmed play; production within reservation 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful	1) lack of well control 2) rough topography 3) Probable narrow bands of potential fractured reservoir zones
Niobrara Microbial Gas Play **10**	3113	Niobrara limestone and other shallow reservoirs, self-sourced; porosity decreasing with increasing depth. Large volume accumulations possible	Microbial gas	Only production to date is from Cedar Creek Anticline and Bowdoin dome. These fields are from shallow Eagle Formation sandstones, not Niobrara.	not estimated 180 MMCFG/160 acres (median) 256 MMCFG/160 acres (mean) Area of play = 55,000 sq. miles 29,958 sq. miles untested (mean)	1 0.5 (50%)	500 - 4500 ft	1) large volume play 2) shallow drilling depths 3) accumulations in structural traps, seismic may be useful in delineation of traps	1) lack of well control 2) rough topography 3) reservoir continuity is problematic 4) areal extent may be small

Table BR-6.1. Play type summaries.

Conventional play type

Unconventional/Hypothetical play type

Summary of Plays (continued)

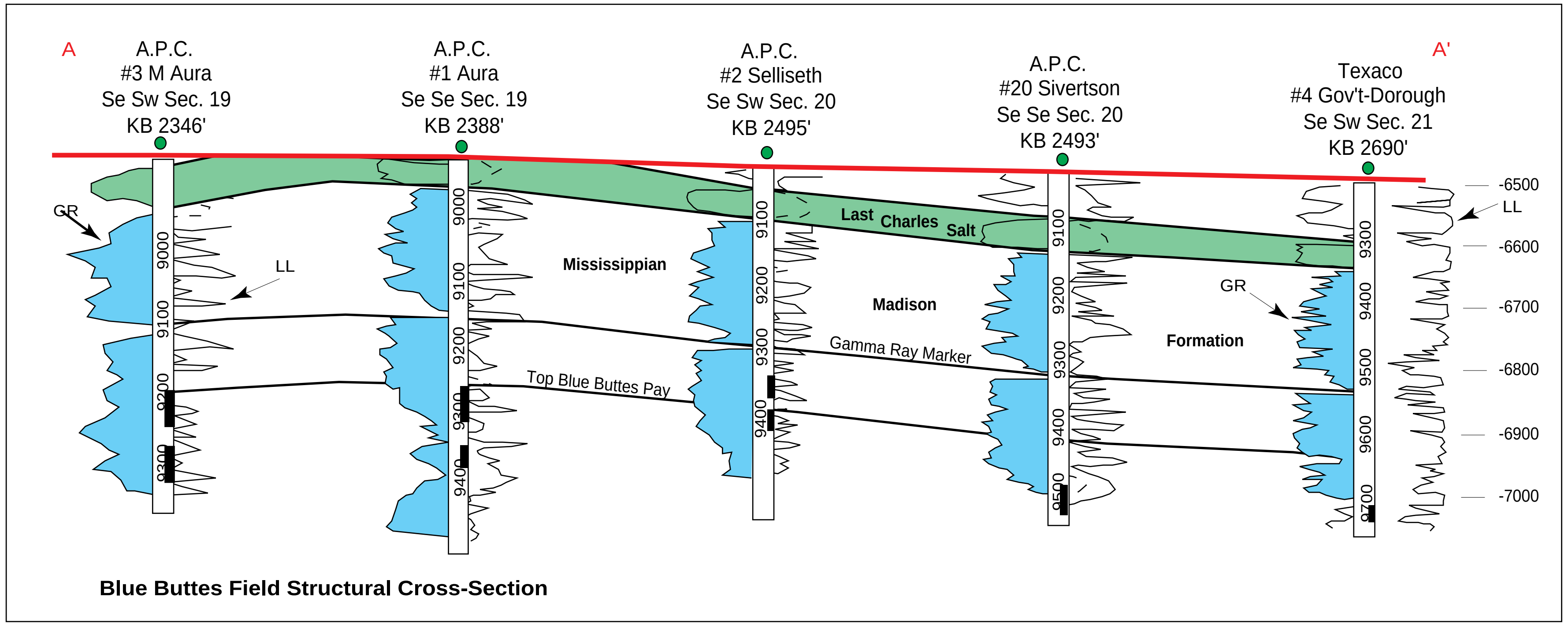


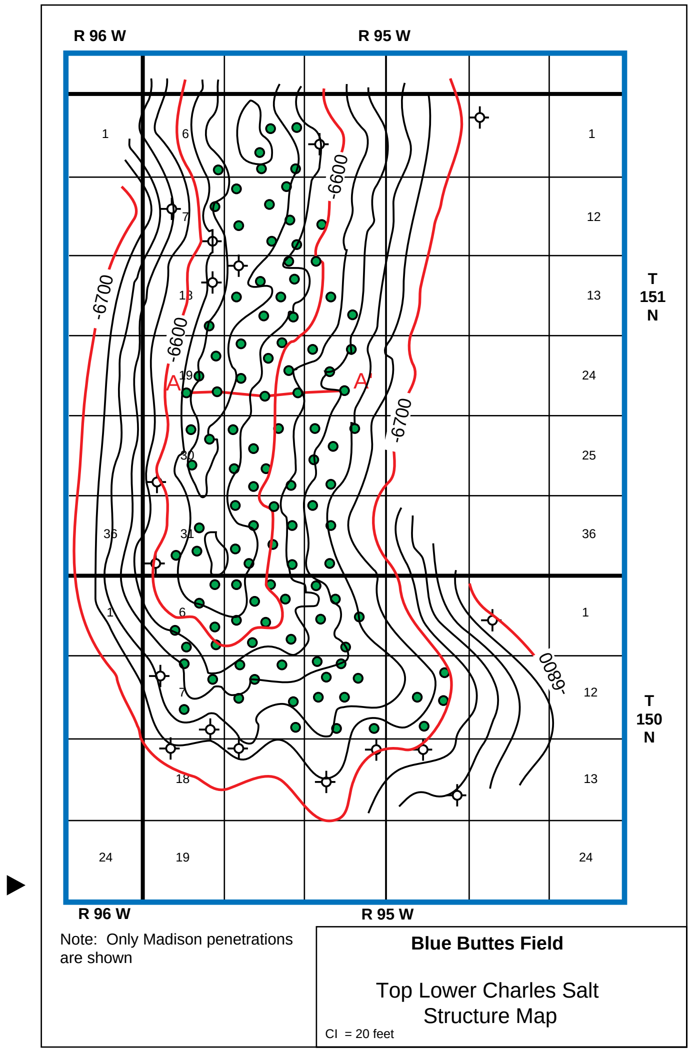
Figure FB-7.1. Blue Buttes Field structural cross-section (after Connelly, North Dakota Geological Society, 1962).

Blue Buttes Field Parameters

Formation:	Mississippian Madison
Lithology:	Interbedded limestones and dolomites.
Average depth:	9200 feet (in reservation area)
Porosity:	averages 7.7%
Permeability:	0.1-8 md, average is 3 md.
Oil/gas column:	oil 280 feet
Average net pay:	variable

Other Formations with shows: Kibbey sandstone, Kibbey limestone and Charles Formation

Figure FB-7.2. Structure contour map ▶ of Blue Buttes Field showing location of cross-section A-A'. Structure on top of Lower Charles Salt.



PLAY TYPE 1

Folded Structure - Mississippian Carbonate Play

General Characteristics - The Mississippian Madison play is primarily a structural play combined with superimposed facies/porosity changes and pinch-outs. This play is the dominant hydrocarbon producer in the Williston basin. The Madison is subdivided into several producing horizons (see cross-sections below), based on porosity zones. These zones are overlain by evaporite or shale seals. The Charles Salt horizon is a regional evaporite seal which overlies most of the Madison Formation.

Reservoir rocks are generally dolomitized carbonate rocks with either algal, oolitic, crinoidal, or micritic components. Source rocks are thought to be either of Bakken origin or cyclic marine shales within the evaporite-carbonate cycle. Onset of oil generation and migration is modeled to begin in the Late Cretaceous.

Analog Fields

(*) denotes fields within Reservation

Antelope* - (includes Bakken, Duperow, and Interlake)	39 MMBO	18.9 Mmcf
Blue Buttes - (includes Duperow, Interlake, and Red River)	45 MMBO	28.3 Mmcf
Bear Den - (Madison, Duperow)	1.4 MMBO	1.5 Mmcf
Croff - (Madison, Duperow)	1.7 MMBO	4.0 Mmcf

Antelope Field Parameters

Formation:	Mississippian Madison
Lithology:	Limestone, brown, dolomitic, fossil fragments, occasional chalky horizons.
Average depth:	9100 feet (in reservation area).
Porosity:	4.7% gross, intergranular, vuggy
Permeability:	info. not available
Oil/gas column:	highly variable
Average net pay:	variable
Other shows:	Sanish, Duperow, Interlake.
Other information:	contains 4.7% H2S

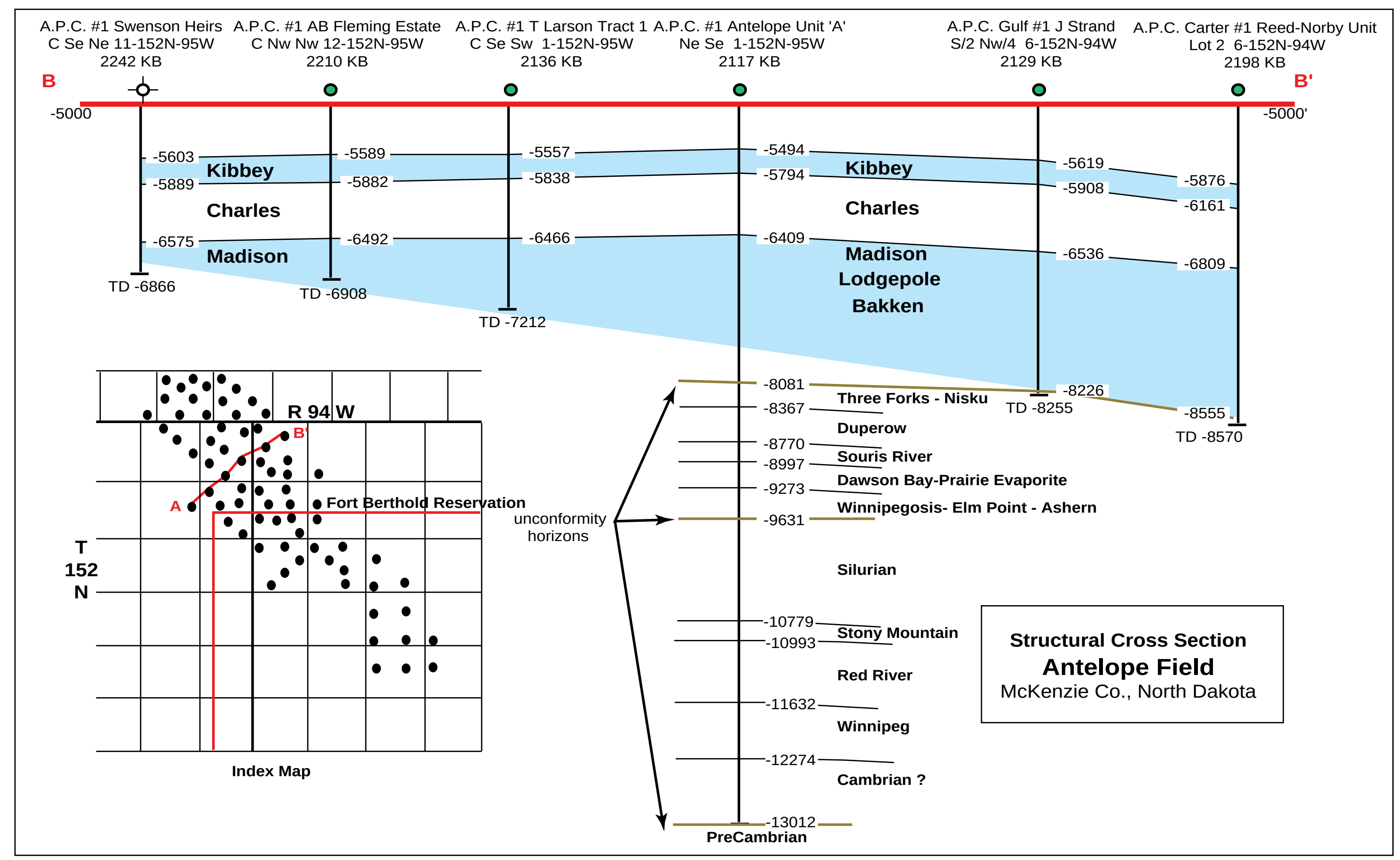


Figure FB-7.3. Antelope field cross-section (after North Dakota Geological Society, 1962).

Analog Fields

(*) denotes fields which lie within reservation

Plaza* - 2.6 MMBO, 1.7 Mmcf out of 20 wells, 3-4 MMBO ultimate (Bluell)

Wabek* - 5.1 MMBO, 3.6 Mmcf, out of 18 wells, 6-7 MMBO ultimate (Sherwood)

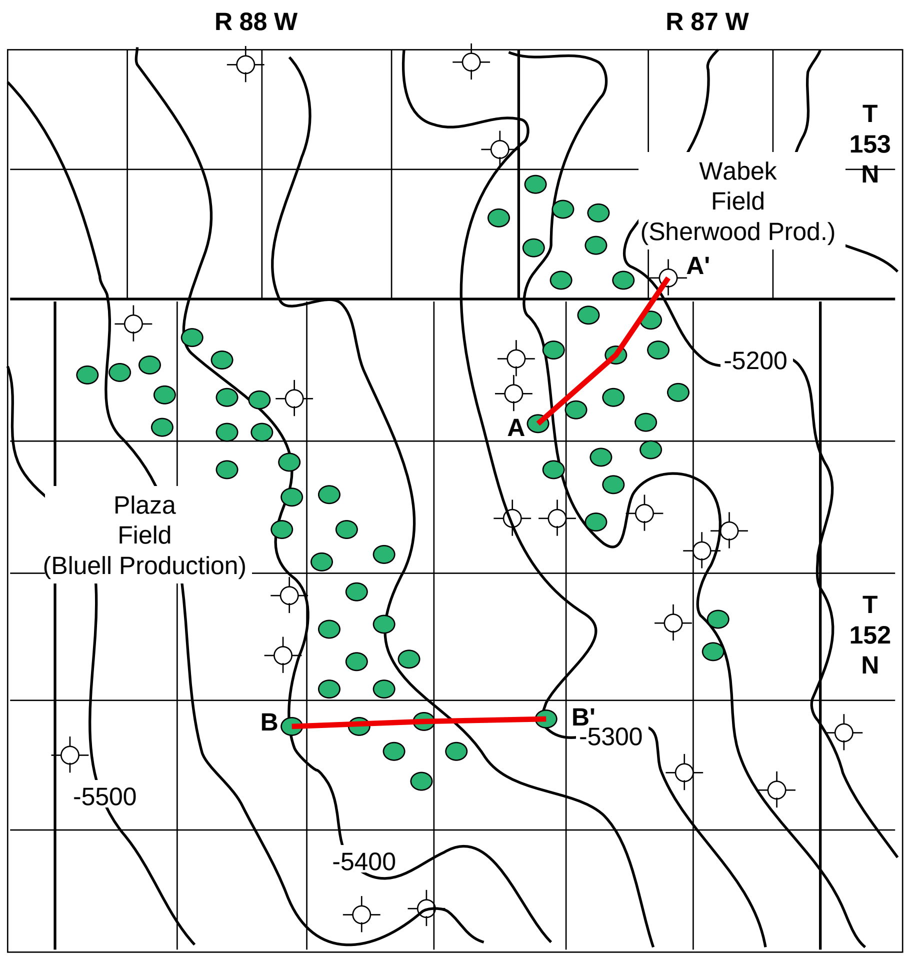


Figure FB-8.2. Structure map of the Sherwood subinterval - Plaza and Wabek fields (after Sperr et al, 1993).

Wabek Field Parameters

Formation:	Mississippian Mission Canyon Sherwood subinterval
Lithology:	Light brown-brown, peloidal, oolitic, pisolitic intraclastic and composite wackestone-grainstone
Average depth:	7300-7500 feet
Porosity:	intergranular, vugular, intraparticle 6-26%, ave.=10%
Permeability:	no information
Oil/Gas column:	at least 100 feet
Average net pay:	26 feet

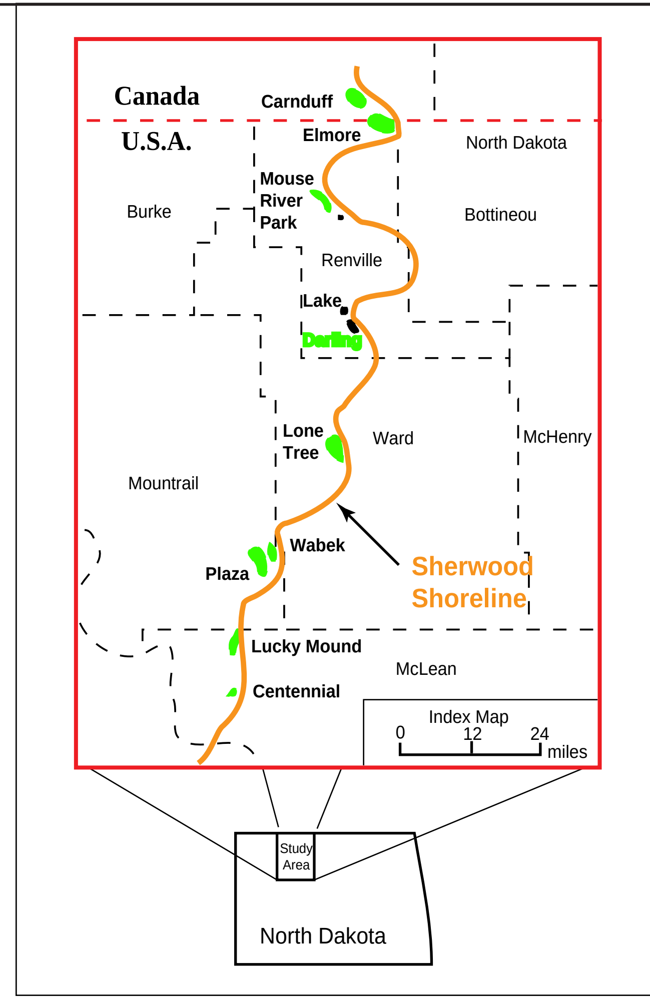


Figure FB-8.1. Sherwood shoreline trend and position of major oil fields (after Sperr et al, 1993).

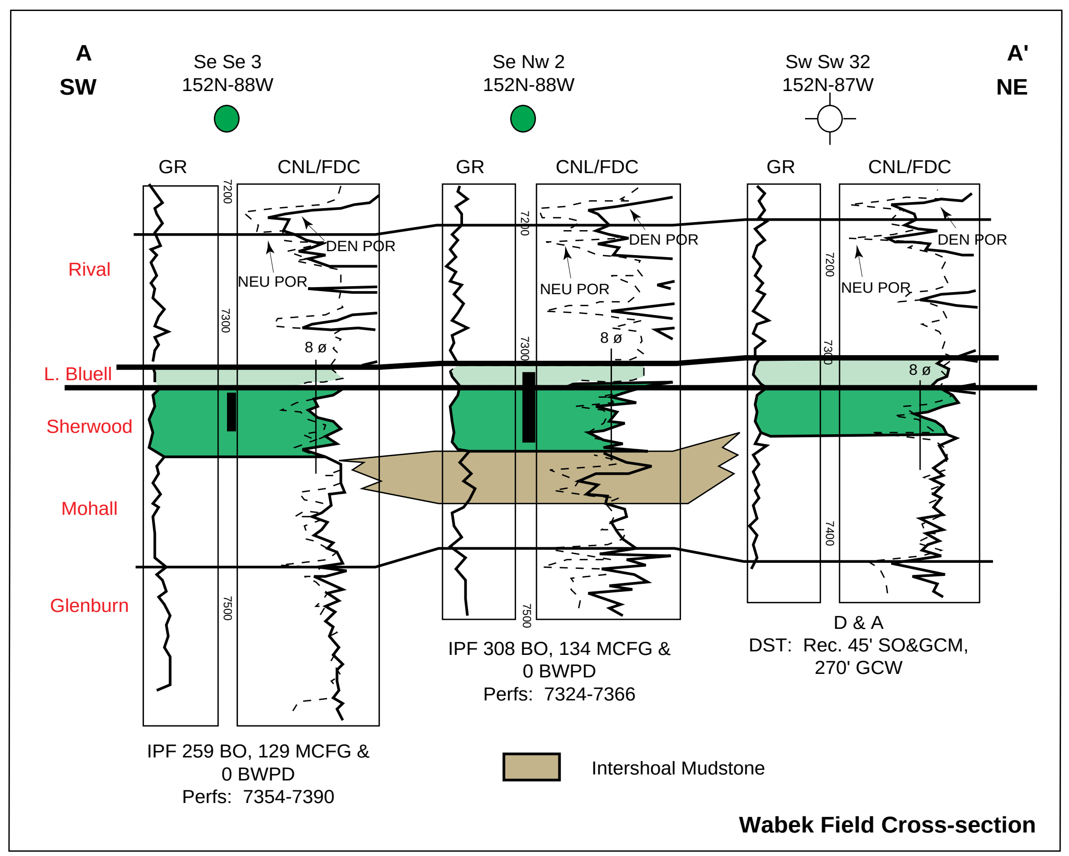


Figure FB-8.3. Wabek Field cross-section showing position of productive interval. Datum is top of Sherwood horizon (after Sperr et al, 1993)).

PLAY TYPE 2

Mississippian Shoreline Play

General characteristics - This play is an extension of the northeast shelf play which produces from Sherwood and Bluell porosity cycles. In an eastward direction the Mississippian interval subcrops the following formations: Midale, Nesson, Bluell, Sherwood, Mohall, Glenburn, Landa, Wayne, and Lodgepole. Reservoirs are dolomitized carbonates of either algal, oolitic, or bioherm banks along the shoreline trend. The updip seal can either be an evaporite or a shale. Source rocks are likely contained within the Bakken or other marine shales within the evaporite sequence.

Plaza Field Parameters

Formation:	Mississippian Mission Canyon, Bluell subinterval
Lithology:	Light brown-brown, peloidal, oolitic pisolitic, intraclastic and composite wackestone-grainstone
Average depth:	7400-7500 feet
Porosity:	intergranular, vugular, intraparticle; 6-16%
Permeability:	no information
Oil/Gas column:	at least 120 feet, no oil/water contact known
Average net pay:	6 feet

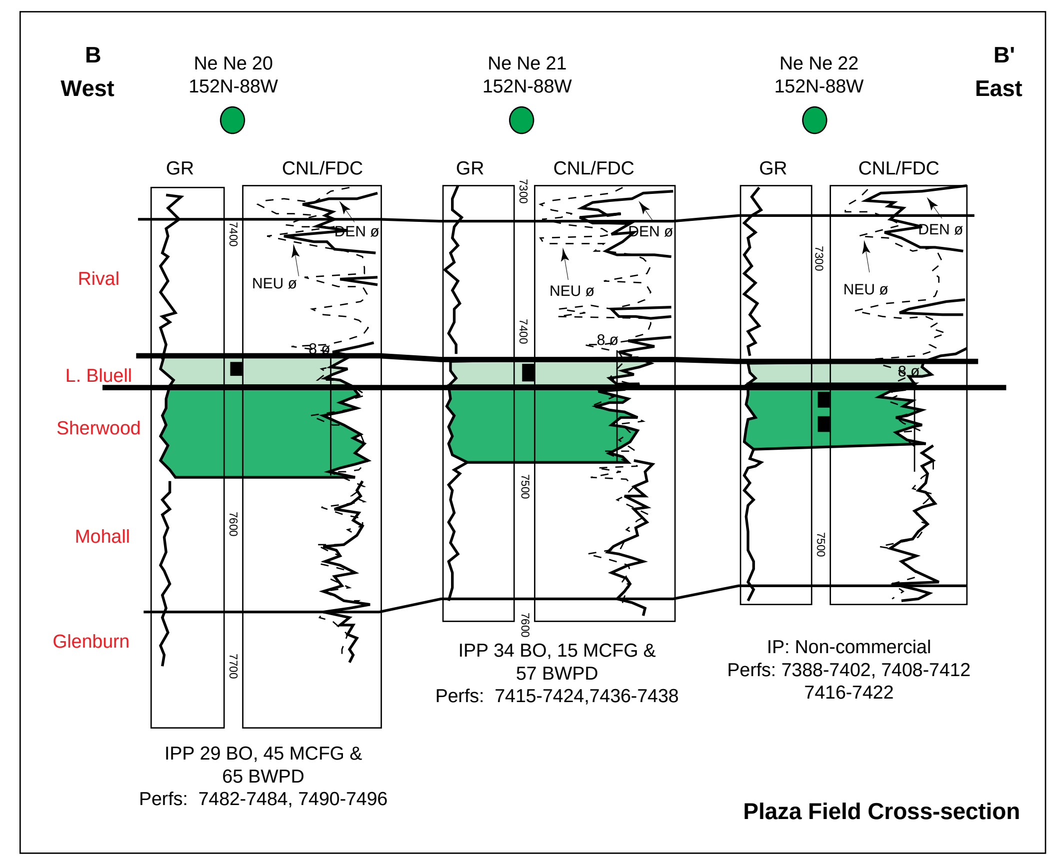


Figure FB-8.4. Plaza field cross-section showing position of productive interval. Datum is top of Sherwood horizon (after Sperr et al, 1993).

PLAY TYPE 3
Mississippian Lodgepole Waulsortian Mounds

General Characteristics - No production has been established within the reservation, however, there is a productive trend in neighboring Stark County. Similar mounds have been found in outcrop in the big Snowy Mountains, Montana.

Waulsortian facies within the Lodgepole formation are lens-like buildups of massive limestone with abundant crinoid and bryozoan fragments. Potential reservoir intervals are boundstones whose framework constituents consist of crinoids, bryozoans, and lesser amounts of mollusks and corals. Inter and intra-particle porosity is the result of leaching and alteration of these particles.

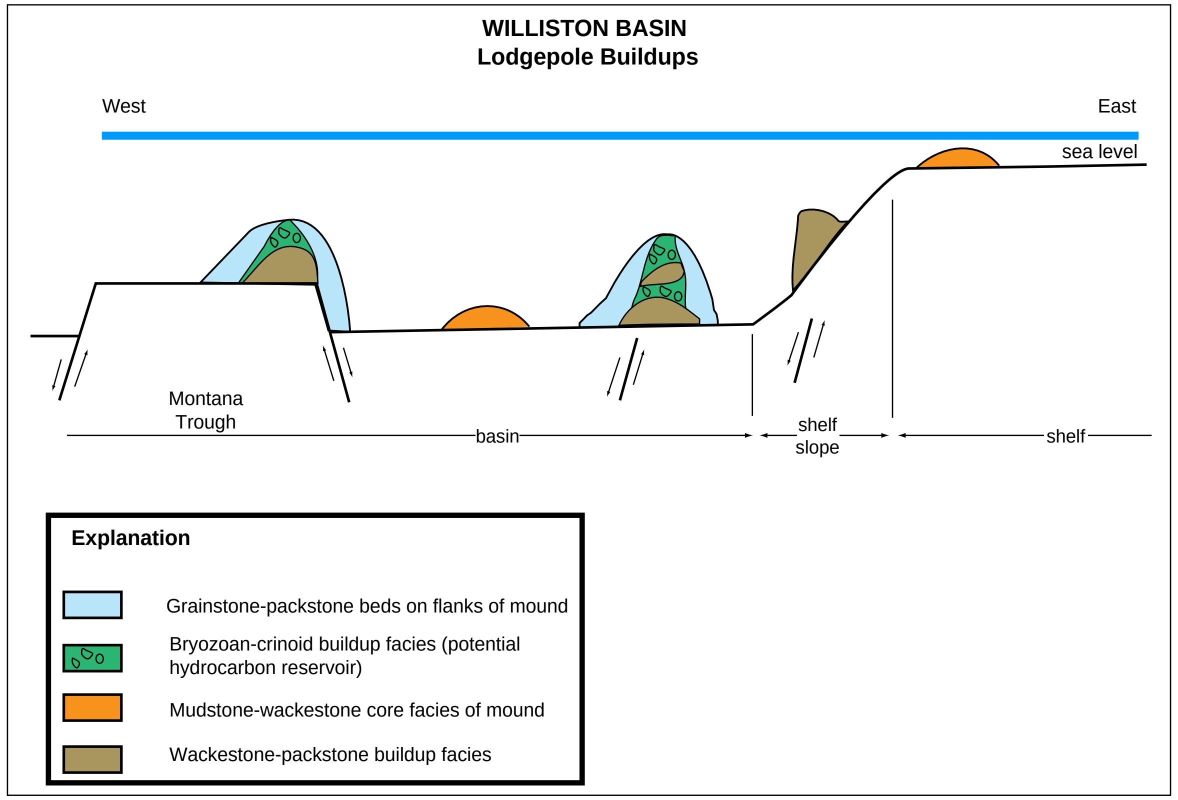


Figure FB-9.1. Diagrammatic cross-section of Waulsortian Mounds within the Williston Basin, shows facies distribution and general location within the basin (after Burke and Lasemi, 1995).

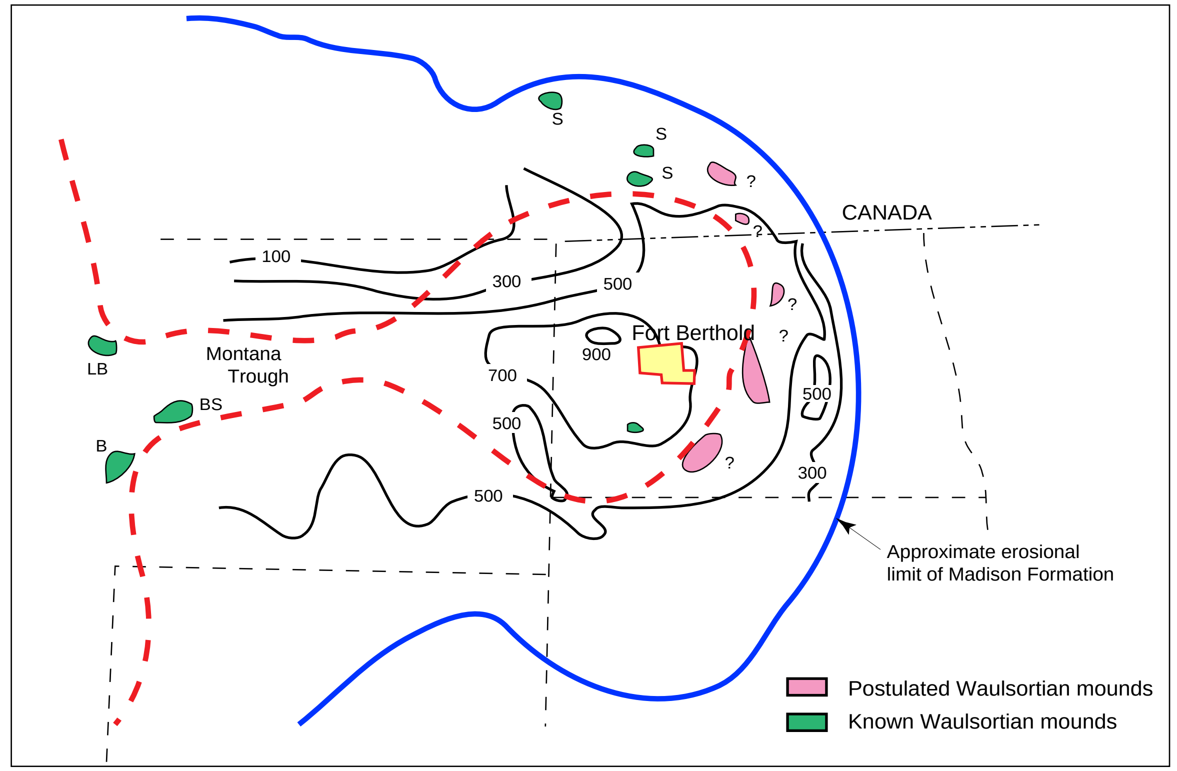


Figure FB-9.2. Generalized isopach map (c.i.=200') of the Lodgepole Formation, Williston Basin in relation to the Fort Berthold Reservation. LB=Little Belt Mountains, B=Bridger Range, BS=Big Snowy Mountains, D=Dickinson Lodgepole Field, S=Saskatchewan (modified from Burke and Lasemi, 1995).

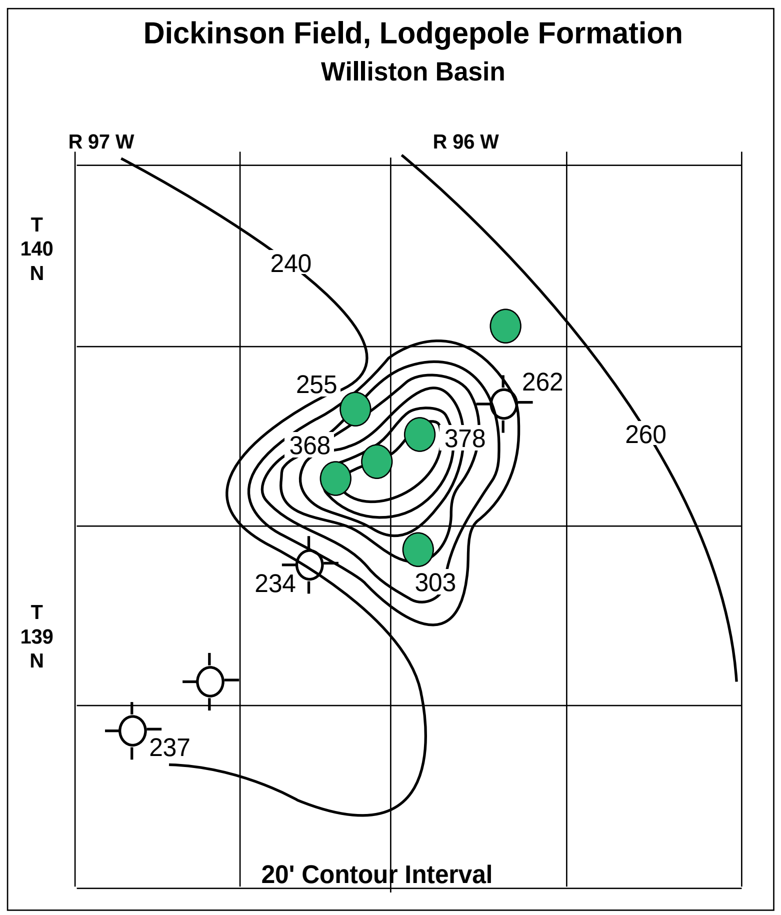
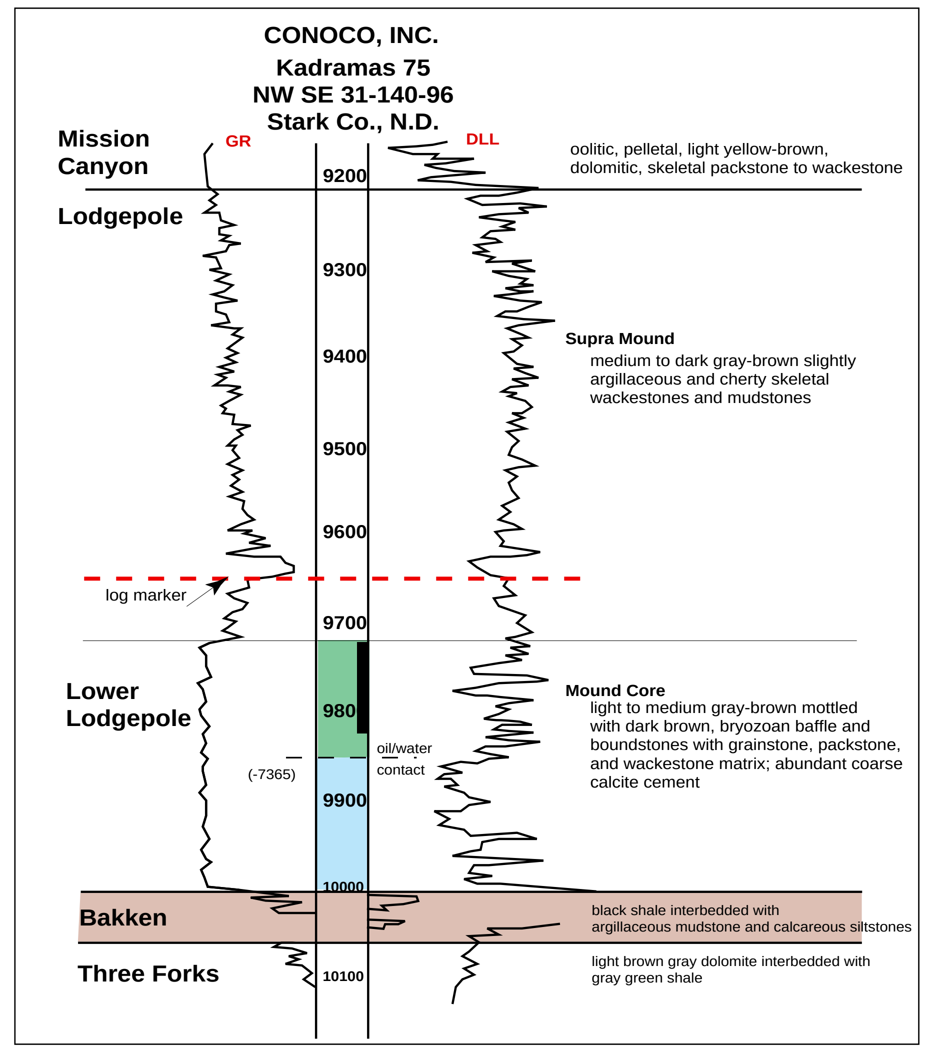


Figure FB-9.3. Isopach map of lower Lodgepole at Dickinson Field (after Burke and Lasemi,1995).

Dickinson Field Lodgepole Parameters

Formation:	Mississippian Lodgepole
Lithology:	primarily fossiliferous grainstones with minor amounts of dolomite boundstones, packstones
Average depth:	9800 feet
Porosity:	9.4-10% mound core up to 15% in mound flanks
Permeability:	variable, up to 460md
Oil/Gas column:	no information
Average net pay:	at least 50 feet
Other shows:	no information



◄ **Figure FB-9.4.** Generalized Lodgepole section depicting Waulsortian Mound Buildup (after Burke and Lasemi, 1995).

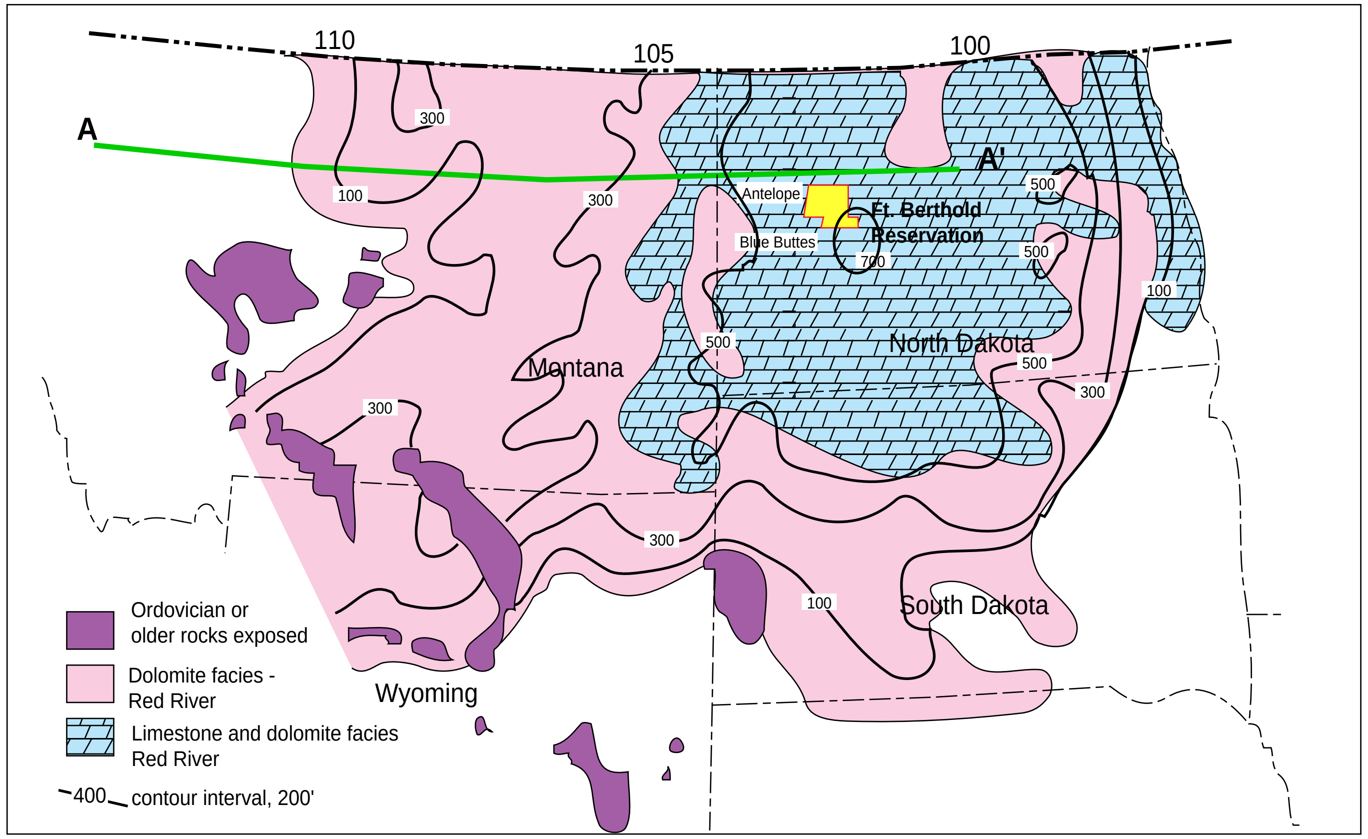


Figure FB-10.1. Map showing thickness of Ordovician Red River Formation within the Williston basin and surrounding area, location of analog fields and reservation, and location of regional cross-section A-A' (modified after Peterson, 1987).

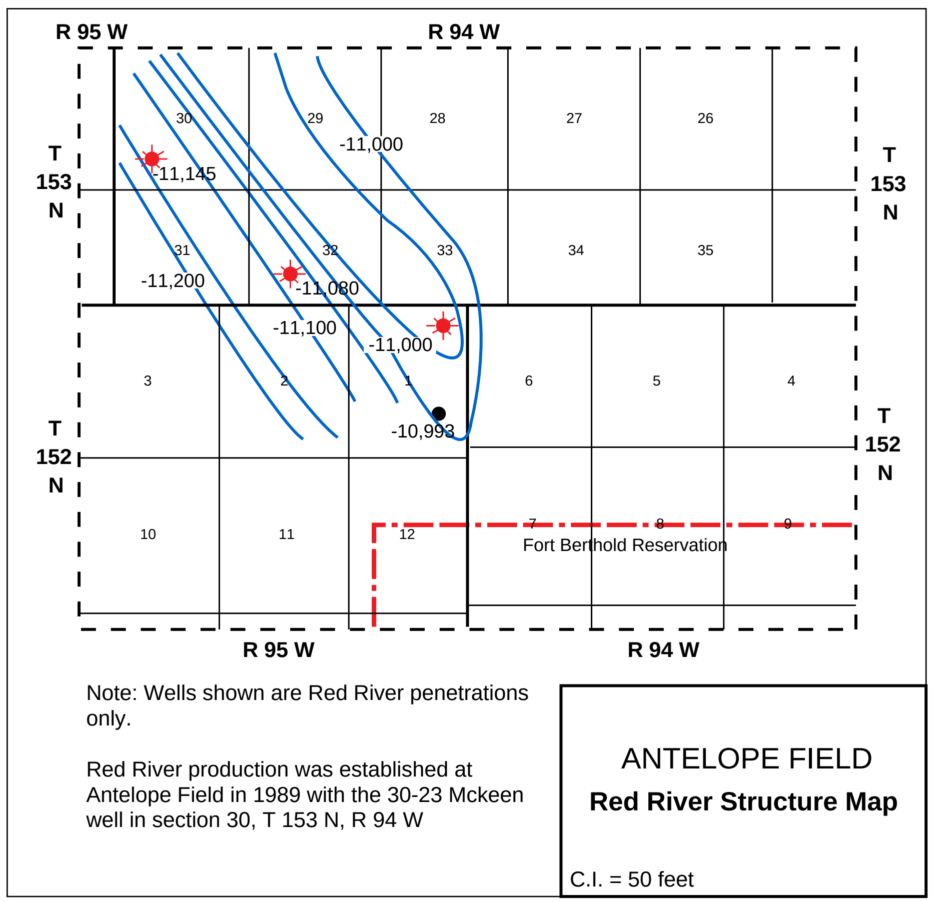


Figure FB-10.2. Structure contour map of the Red River Fm., Antelope Field. Contours show the general trend of anticline/fold development.

PLAY TYPE 4

Ordovician Red River Play

General Characteristics: This is the second most productive formation in the Williston basin. Reservoirs are dolomite intervals and dolomitic limestones formed from bioclastic mounds and tidal flat deposits. Cyclic deposits of carbonate, evaporite, and organic rich shale provide reservoir, source, and seal. Major accumulations are found on structural noses such as Nesson and Cedar Creek Anticlines. Smaller fields are found in fold structures draped over basement fault blocks, or small carbonate mounds.

The source intervals are thermally mature to overmature at the basin center, and become somewhat immature along the basin flanks. Winnipeg shale and marine shales in the Red River Formation are thought to be the primary source of the reservoir oil. Hydrocarbon generation and migration is estimated to have begun in late Paleozoic time.

Blue Buttes Field Parameters

Formation:	Ordovician Red River
Lithology:	black to dark gray dolomite, limestone very fine grained to crystalline occasionally sucrosic texture
Average depth:	-11,300 MSL
Porosity:	9.8%
Permeability:	1.0 md
Oil/Gas column:	unknown
Average net pay thickness:	23 feet
Other shows:	Kibbey Sandstone, Kibbey Limestone Charles Formation
Other information:	Initial IP 564 BOPD, API 58 2928 Mcfgpd-discovery well

Antelope Field Parameters

Formation:	Ordovician Red River
Lithology:	black to dark gray limestone/dolomite very fine grained to crystalline Occasionally sucrosic texture
Average depth:	13,480-13,490 feet
Porosity:	12% log density porosity
Permeability:	not known
Oil/Gas column:	no information
Average net pay thickness:	10 feet
Other shows:	Minnelusa and Charles Formations
Cumulative production: (1995)	94 MBO, 1.15 Mmcf API 56.2, IP 113 BC, 1452 Mcfgpd

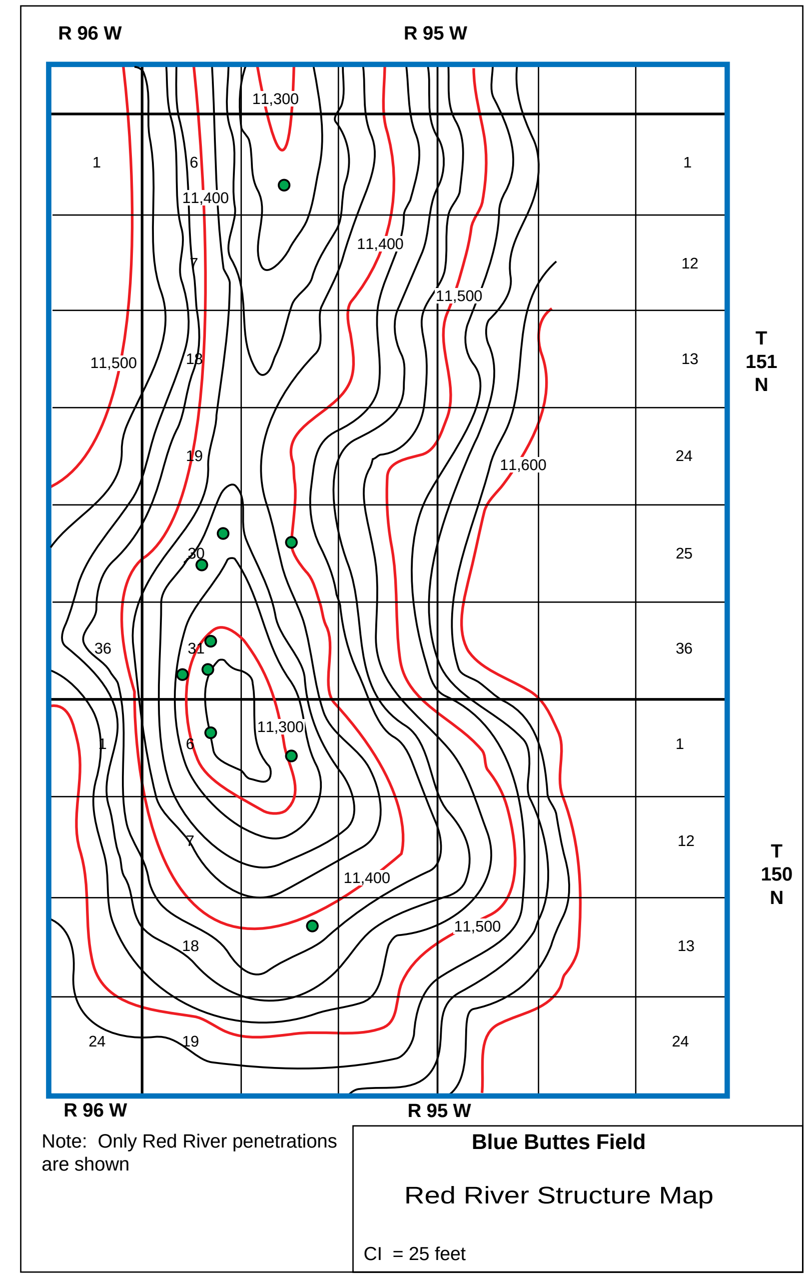


Figure FB-10.3. Red River Structure Map - Blue Buttes Field. Shows trend of Anticline development and production.

PLAY TYPE 5

Devonian Nisku-Duperow Play

General Characteristics- This play consists of a carbonate evaporite sequence interbedded with cyclic marine shales. Reservoir rocks are typically dolomite or dolomitized limestone. Source rock for the oil is thought to be from the Bakken interval which is mature-overmature in the central portion of the basin and immature on the flanks. Oil migration and generation are estimated to have begun in early to late Cretaceous time.

Traps are gentle folds and closures related to carbonate bank deposition on paleohighs or shelf areas. These paleostructures are present on regional structural trends such as the Nesson Anticline and Antelope Anticline.

Analog Fields

(*) denotes fields which lie within Reservation

Antelope*-	39 MMBO, 18.9 Mmcf (includes Bakken, Duperow, and Interlake)
Blue Buttes -	45 MMBO, 28.3 Mmcf (includes Duperow, Interlake, and Red River)
Bear Den -	1.4 MMBO, 1.5 Mmcf (includes Madison, Duperow)
Croff -	1.7 MMBO, 4.0 Mmcf (includes Madison, Duperow)

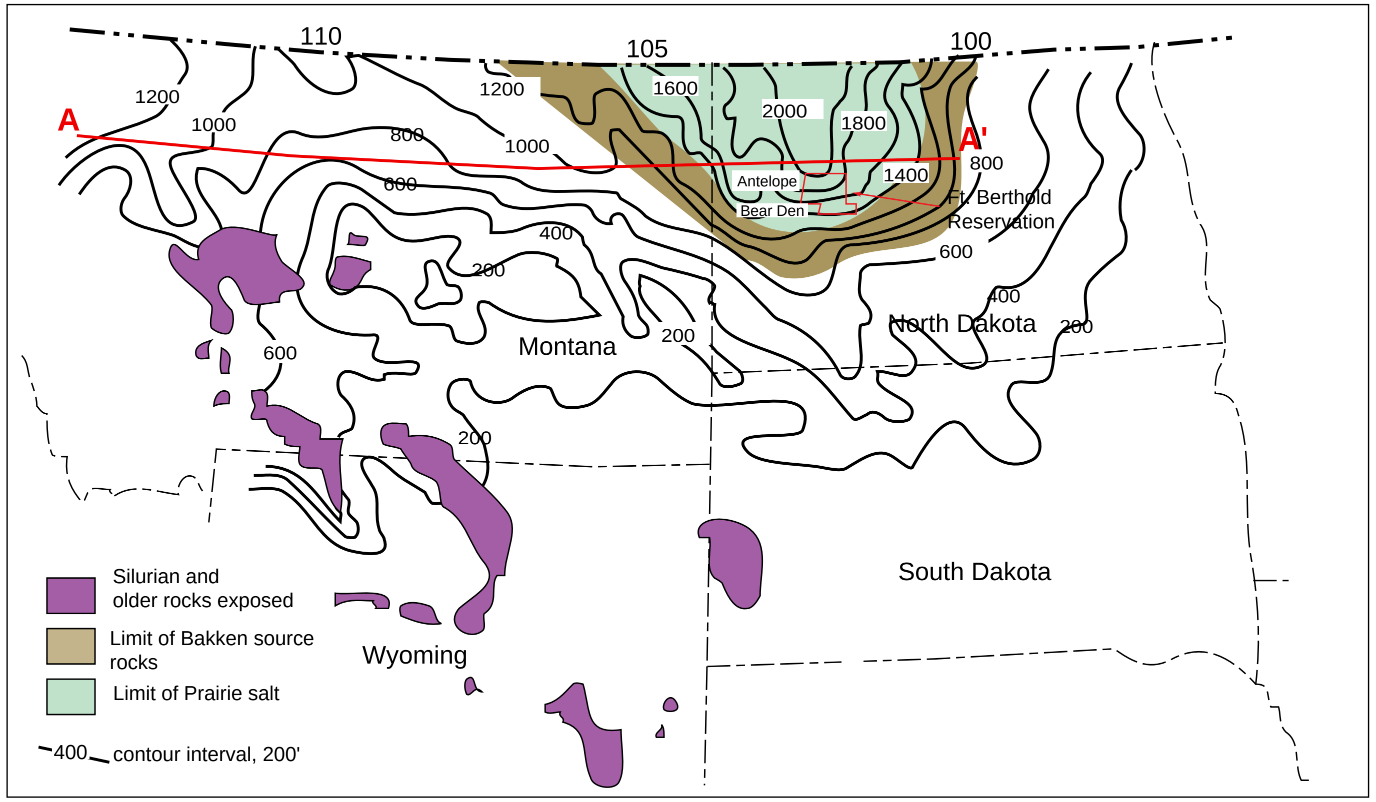


Figure FB-11.1. Map showing thickness of Devonian rocks, limit of Prairie salt, limit of Bakken source rock, location of analog fields and reservation, and location of regional cross-section A-A' (modified after Peterson, 1987).

Bear Den Field Parameters

Formation:	Devonian Duperow
Lithology:	microcrystalline dolomite with fair microsucrosic porosity
Average depth:	11,300 feet
Porosity:	variable, microsucrosic
Permeability:	not known
Oil/Gas column:	variable
Average net pay thickness:	13 feet
Other info:	no H_2S

Antelope Field Parameters

Formation:	Devonian Duperow
Lithology:	dolomite, brown, finely crystalline, granular to vugular limestone intervals, fossiliferous
Average depth:	10,750 feet
Porosity:	variable, granular, vuggy
Permeability:	not known
Oil/Gas column:	variable
Average net pay thickness:	variable
Other shows:	Madison, Interlake, Sanish
Other information:	No H_2S

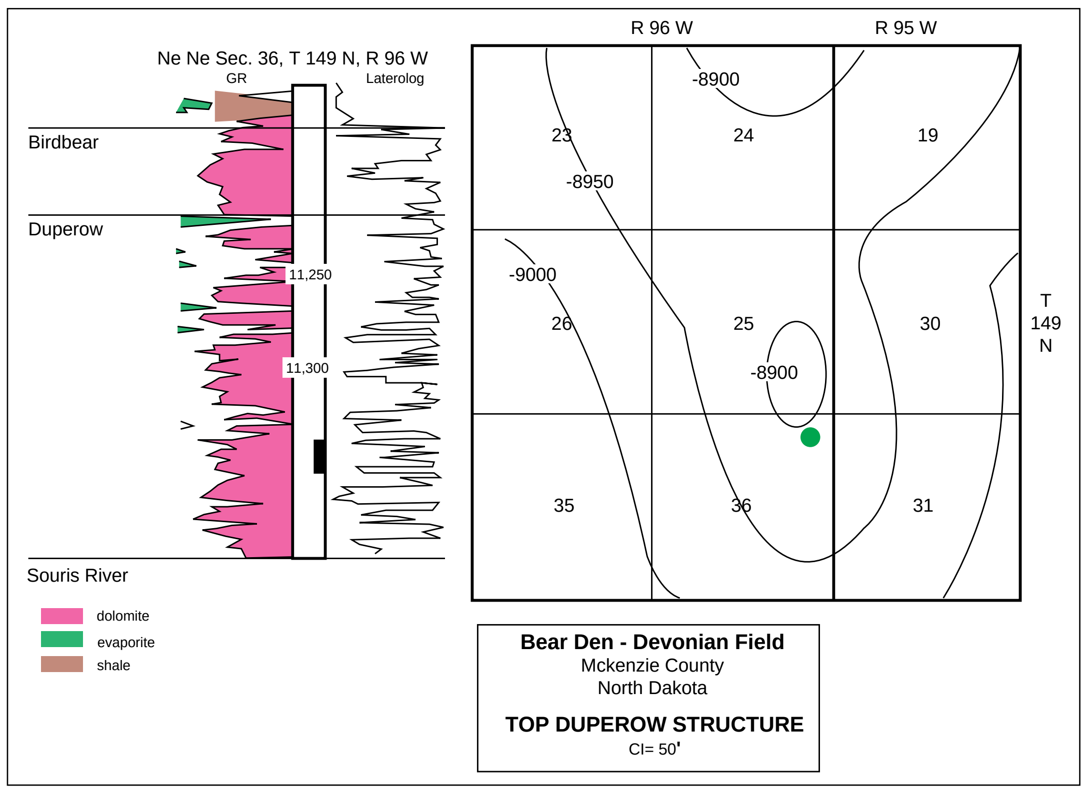


Figure FB-11.2. Bear Den - Devonian Field. Shows position of dolomitic intervals relative to the interbedded evaporite seals. Productive interval indicated in black.

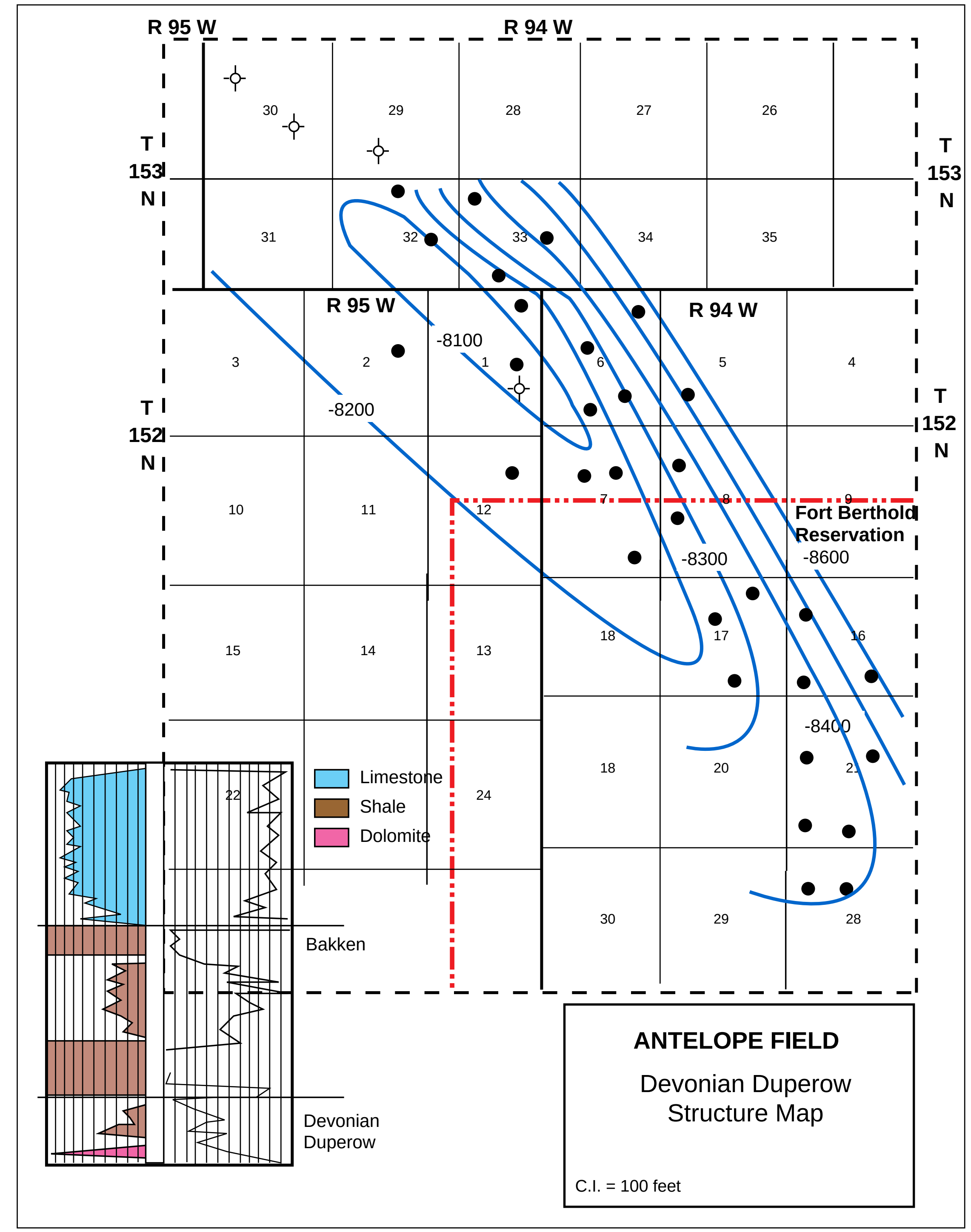


Figure FB-11.3. Structure map of Antelope Field. Shows general anticlinal fold trend to the southeast. Inset shows position of Bakken relative to Duperow Formation.

PLAY TYPE 6

Pre-Prairie (Winnipegosis/Interlake Play)

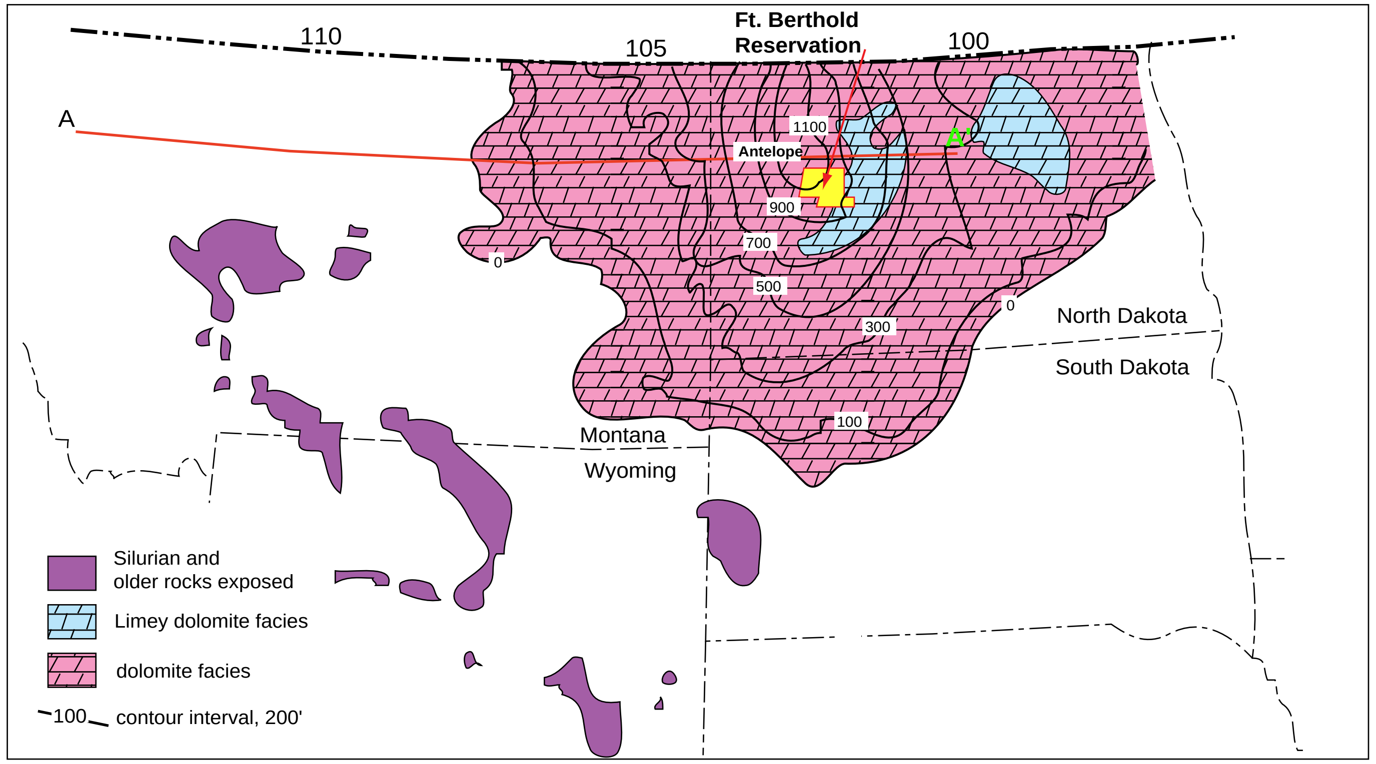


Figure FB-12.1. Map showing thickness of Silurian Interlake Formation, facies type, location of analog field and reservation, and location of regional cross-section A-A' (modified after Peterson, 1987).

General Characteristics - Regional carbonate units of lower Devonian and Silurian age are overlain by the Prairie Evaporite which acts as a seal rock. Typical reservoirs in the Winnipegosis are reefs or dolomitized carbonate mounds. Unconformity traps are thought to exist in the Silurian Interlake Formation which can result in dolomitized reefs, minor karsting, and dissolution porosity in tidal deposits.

The Ordovician Red River shales are thought to be the source rocks for this play and are thermally mature within the basin center. Typical traps consist of gentle folds with flexure faulting associated with the regional structure. Stratigraphic traps (either pinch-outs or porosity variations) may exist as well.

Antelope Field Parameters

Formation:	Silurian Interlake
Lithology:	dolomite, cream to dark brown possible algal forms, microcrystalline and vugular in part
Average depth:	-9600 feet MSL
Porosity:	variable, granular, vuggy, 7.5%
Permeability:	1.3md
Oil/Gas column:	variable
Average net pay thickness:	variable
Other shows:	Madison, Duperow, Sanish

Blue Buttes Field Parameters

Formation:	Silurian Interlake
Lithology:	Dolomite
Average depth:	12,300 feet (-9967 MSL)
Porosity:	12%
Permeability:	not known
Oil/Gas column:	not known
Average net pay thickness:	30 feet

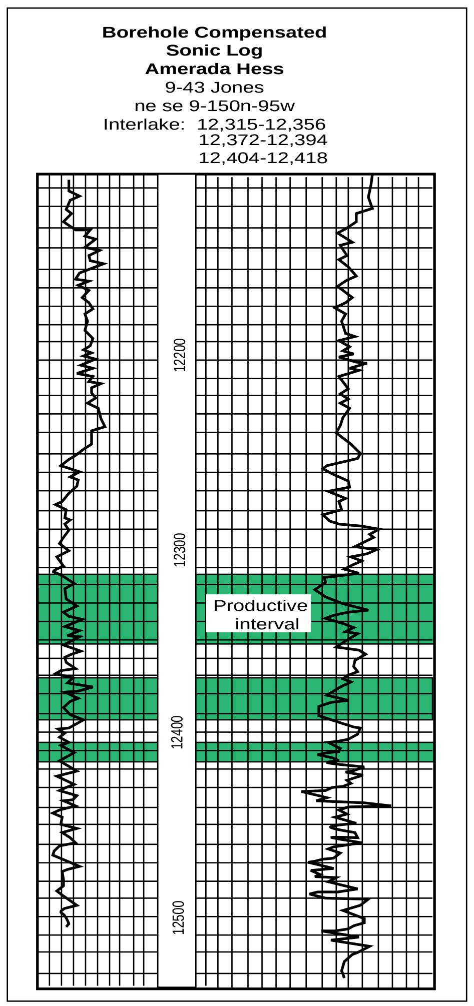


Figure FB-12.2. Example of wireline log through Silurian interval in Blue Buttes Field.

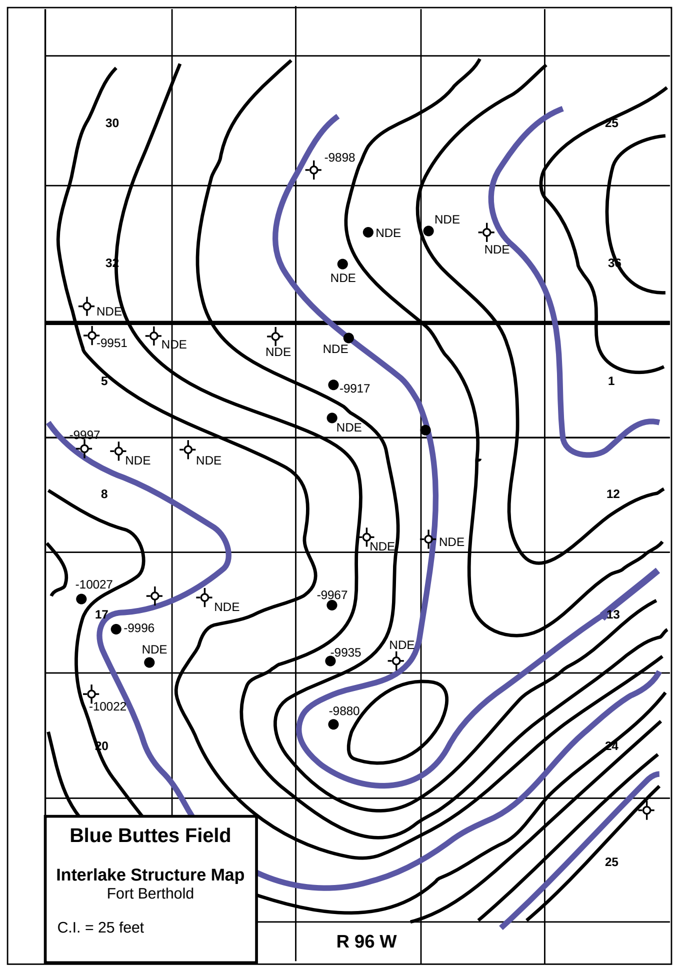


Figure FB-12.3. Structure contour map of Interlake interval, Blue Buttes Field. Shows anticlinal nose development with production located somewhat off structure. This indicates a strong stratigraphic component which assists trapping mechanism.

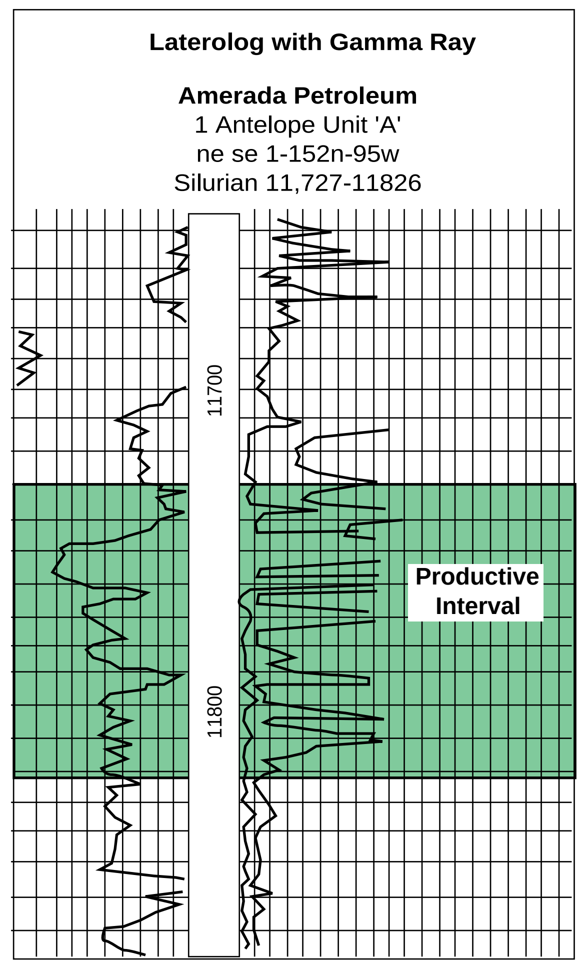


Figure FB-12.4. Example of Antelope Field wireline log in the Silurian interval.

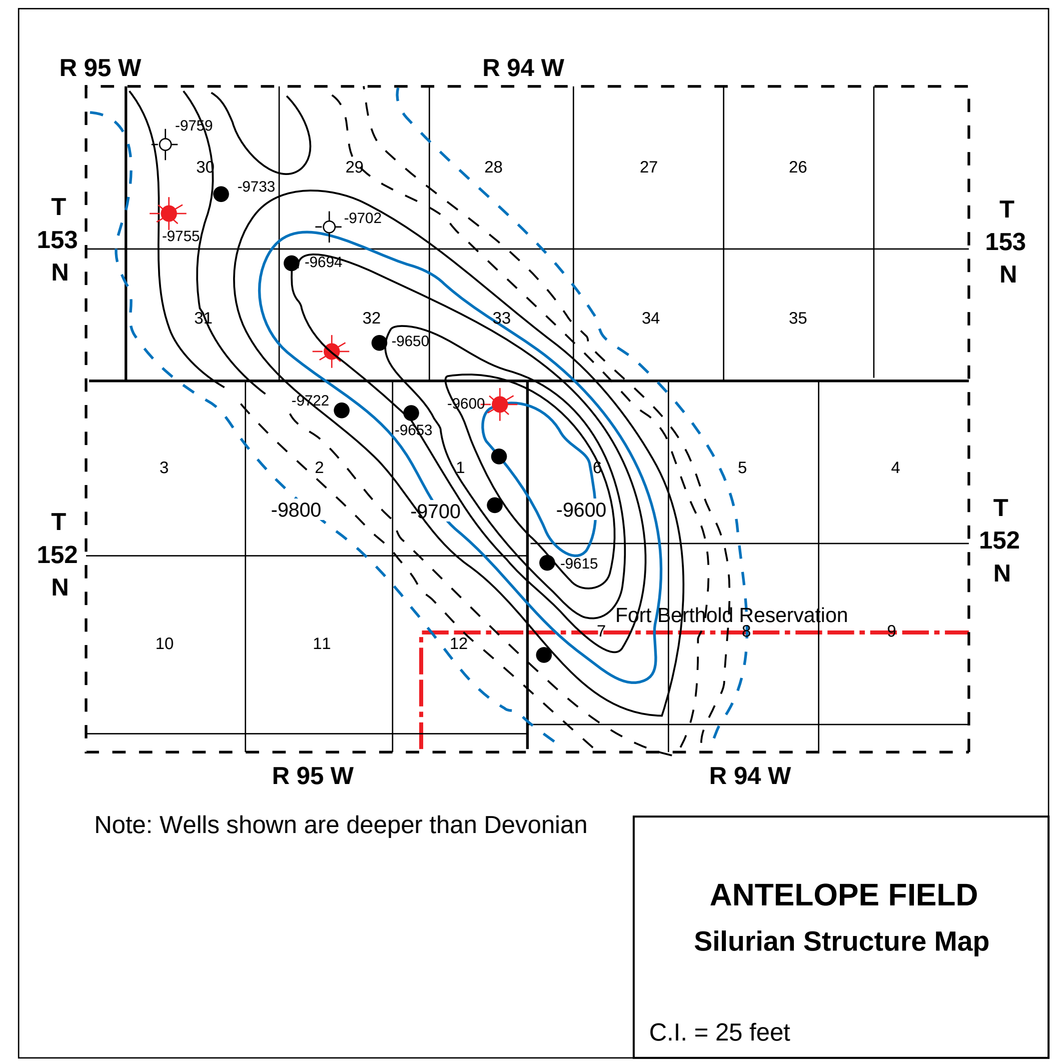


Figure FB-12.5. Silurian structure map, Antelope Field. Shows anticlinal fold trend to the southeast with production strongly coincident with structure.

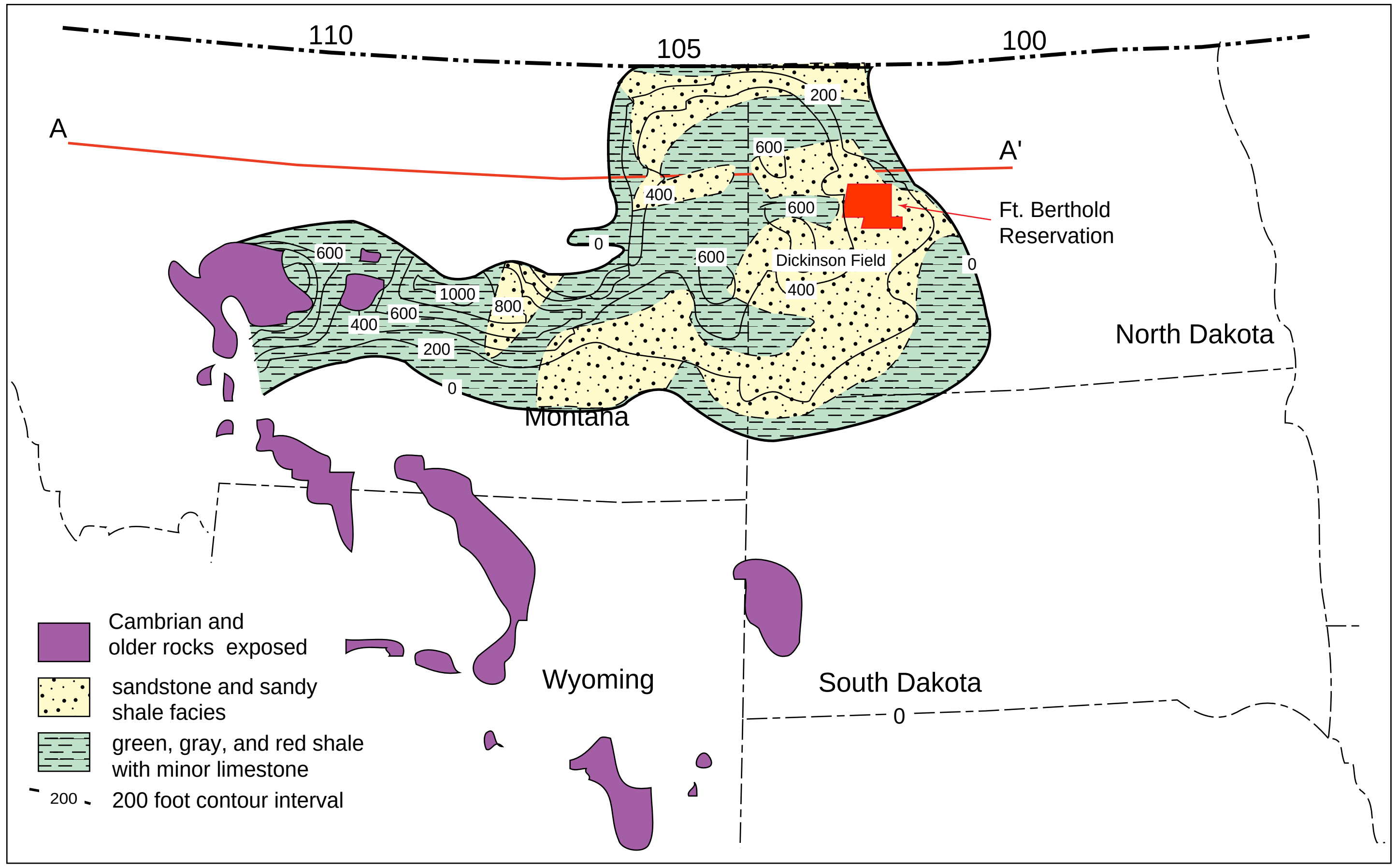


Figure FB-13.1. Thickness of Upper Mississippian - Lower Pennsylvanian Big Snowy Group interval (Tyler-Heath), location of Fort Berthold Reservation, Dickinson Field (analog), and location of regional cross-section A-A' (modified after Peterson, 1987).

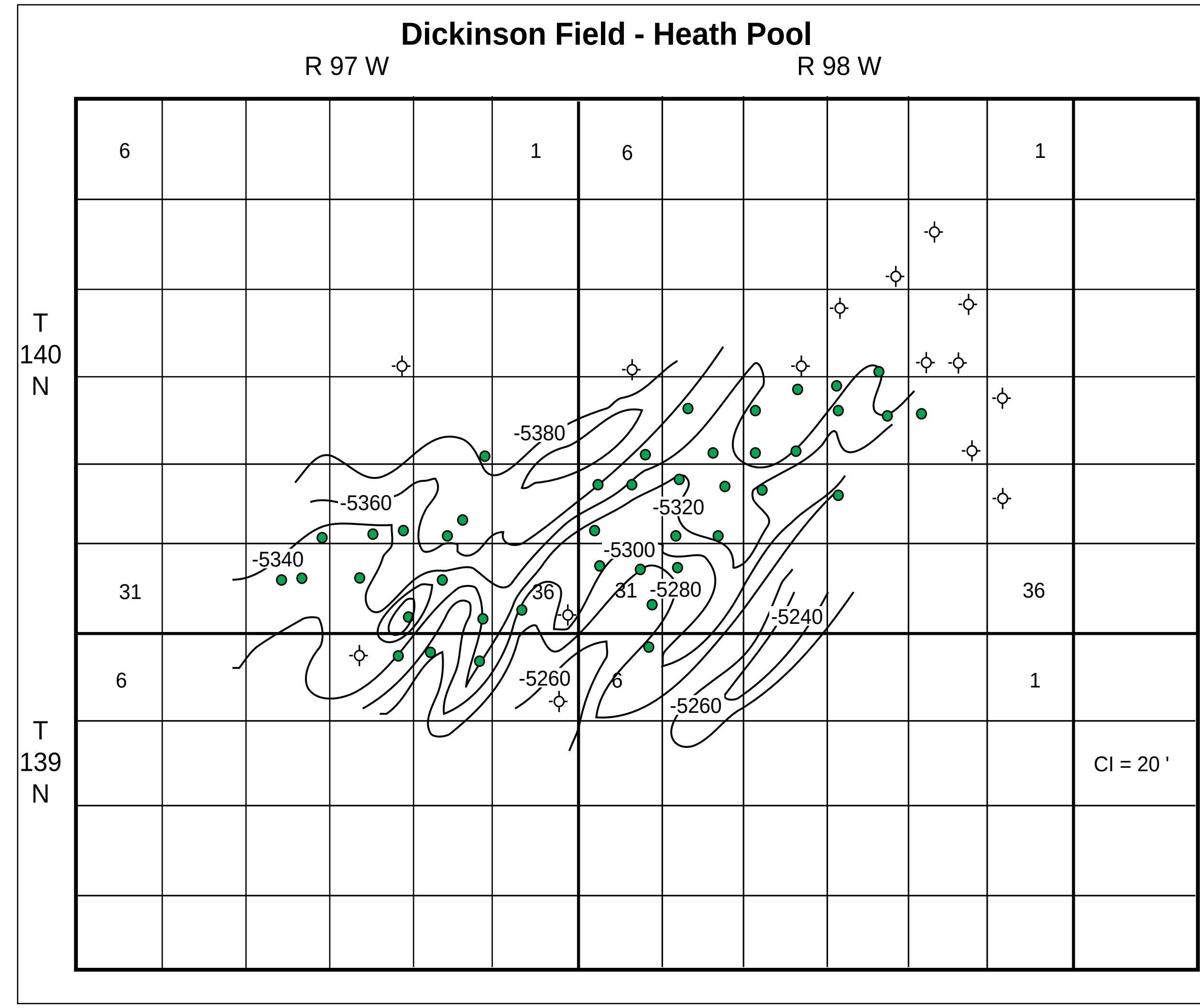


Figure FB-13.2. Structure map of Dickinson Field, top of Heath. Complex structural configuration reflects the depositional patterns associated with fluvial, deltaic and nearshore marine environments (after Williston Basin Field Summaries, 1984).

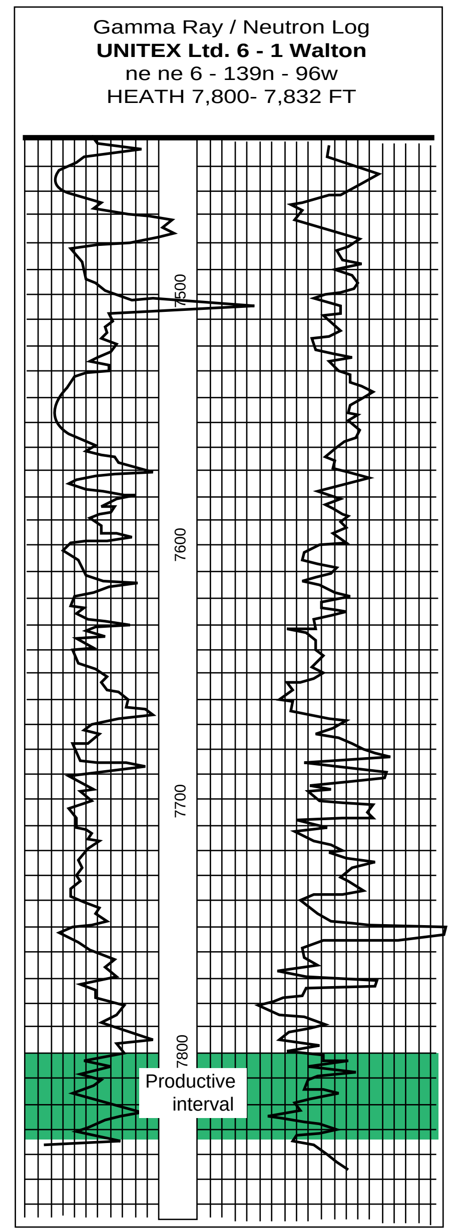


Figure FB-13.3. Well log example from Dickinson Field. Upper Mississippian - Lower Pennsylvanian

PLAY TYPE 7

Post Madison Clastics (Tyler-Heath)

General Characteristics - Regional deposition of fluvial, deltaic, and nearshore marine sandstones and carbonates provides the potential reservoirs for this play type. Dark gray to black, organic rich, marine shales of the Tyler are considered to be the main source rock which charge these reservoirs. The shales are thermally mature in the center of the basin and immature along the flanks. Onset of oil generation and migration is thought to have occurred in late Cretaceous to early Tertiary time.

Lateral discontinuity of potential reservoirs in the well-sorted fluvial and nearshore marine sandstones is the norm. In general, areal extent of reservoirs is limited with possible internal porosity and permeability barriers. Overall porosities may be quite good (10-16%). Tyler sandstones are roughly time equivalent to the Morrow sandstones of the mid-continent.

Dickinson Field Parameters

Formation:	Pennsylvanian Tyler Mississippian Heath
Lithology:	Interbedded sandstones and shales
Average Depth:	7800 feet
Porosity:	12%
Permeability:	194 md
Oil/Gas Column:	not known
Average net pay:	variable
Other Shows:	shows in deeper Mississippian intervals

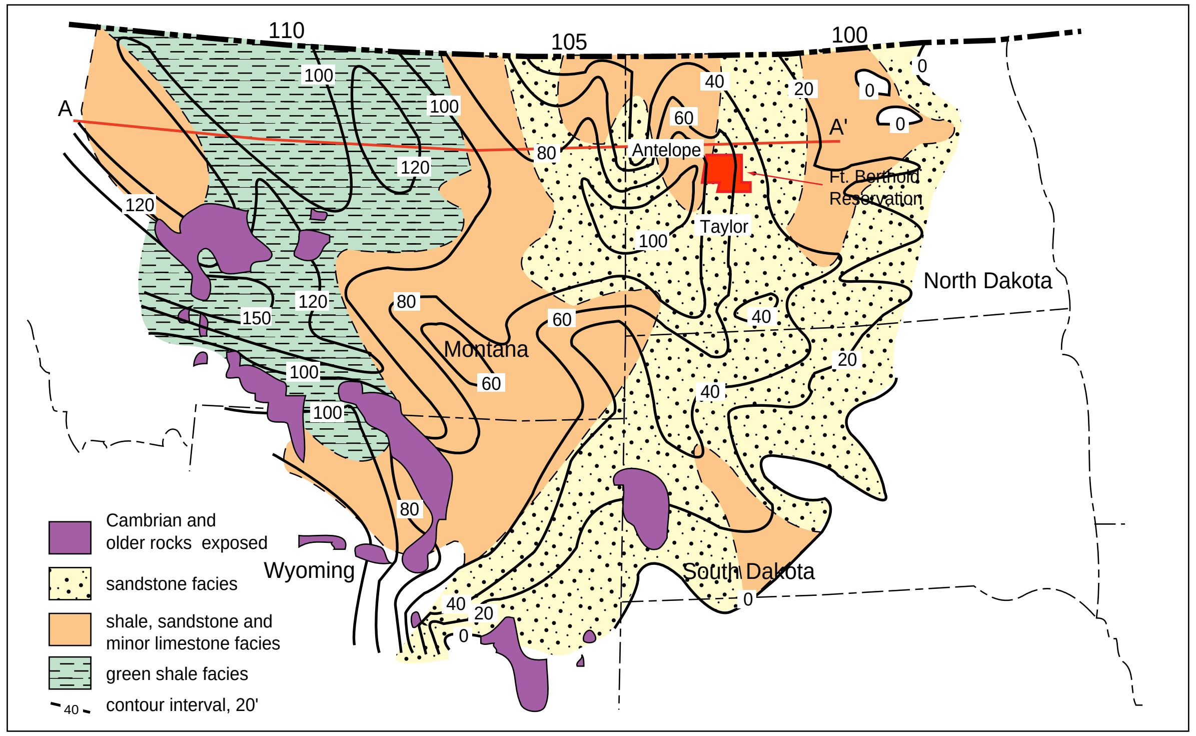


Figure FB-14.1. Thickness of Deadwood and equivalent rocks, location of analog fields, location of reservation, and location of regional cross-section A-A' (modified after Peterson, 1987).

PLAY TYPE 8

Pre-Red River Gas Play

General Characteristics - Production has been established from Ordovician (Winnipeg) and Cambrian (Deadwood) sandstones. These units are located within the thermally mature or overmature hydrocarbon window of the Williston basin. Both gas and condensate are produced.

Reservoir intervals contain a 'clean' quartz sandstone, silica cement, and enhanced fracture porosity. Source rock is considered to be a marine shale either within the Deadwood or the Winnipeg sandstone. Hydrocarbon generation is thought to have occurred in late Cretaceous to early Tertiary time. Traps are generally asymmetric folds associated with major structural fault zones or hinge lines.

Locations of the fields used as analogs for this play type are noted on the regional facies map. Fort Berthold reservation is bracketed by these fields and in an optimum facies position for possible plays of this type to occur within the boundary of the reservation.

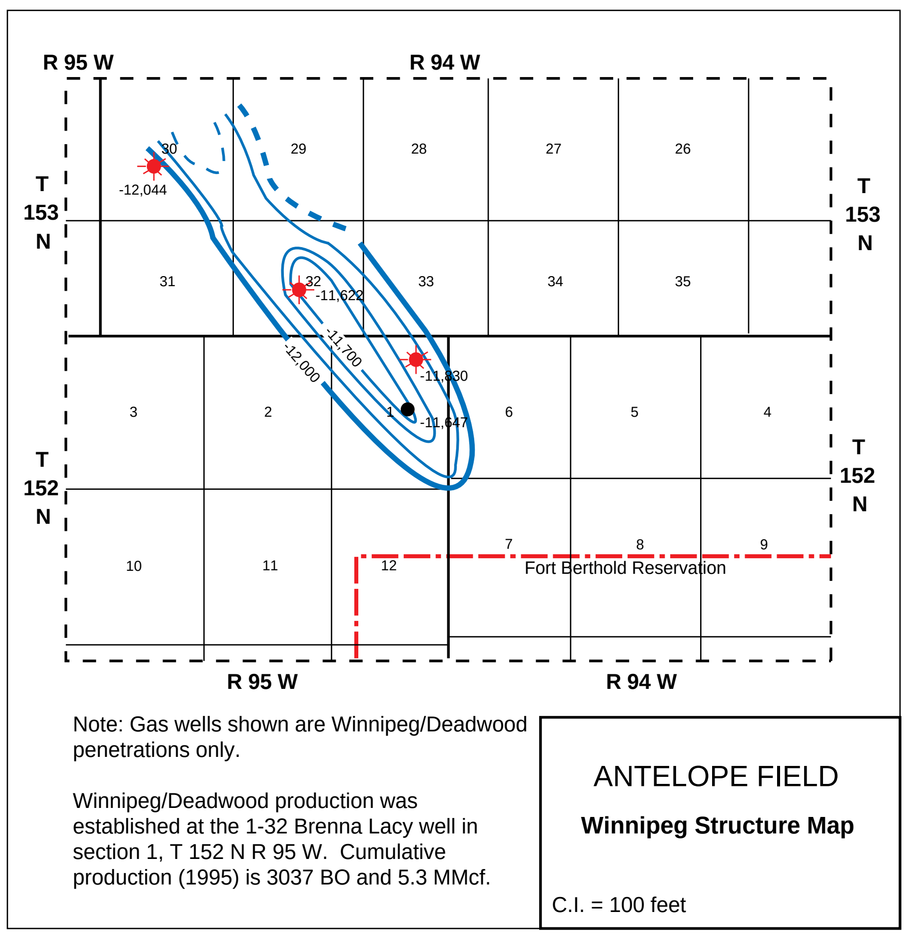


Figure FB-14.2. Structure contour map of the Winnepeg Fm., Antelope Field. Shows Winnepeg production correlated with anticlinal fold trend to the southeast.

Antelope Field Parameters

Formation:	Ordovician Winnipeg and Cambrian Deadwood
Lithology:	very fine to fine grained, occasionally medium grained quartz sandstone, occasionally carbonaceous and pyritic
Average Depth:	13,900 feet
Porosity:	12-18% depending upon interval
Permeability:	no information
Oil/Gas column:	no information
Average net pay:	40-50 feet
Other shows:	no information

Other information: 1-32 Brenna-Lacy (1992) completed in Winnipeg-Deadwood. IPF 8BCPD, 5924 MCFGPD. SI for gas. Cumulative production - (1995) 3037 BO, 5.4 MMCF.

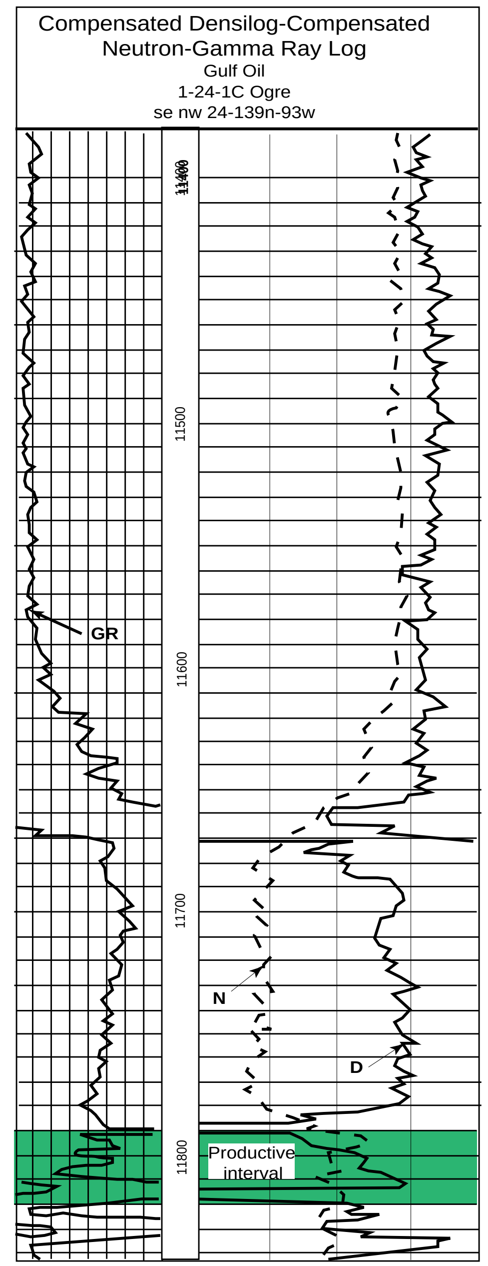


Figure FB-14.3. Example of Winnipeg-Deadwood formation log signature from Taylor field.

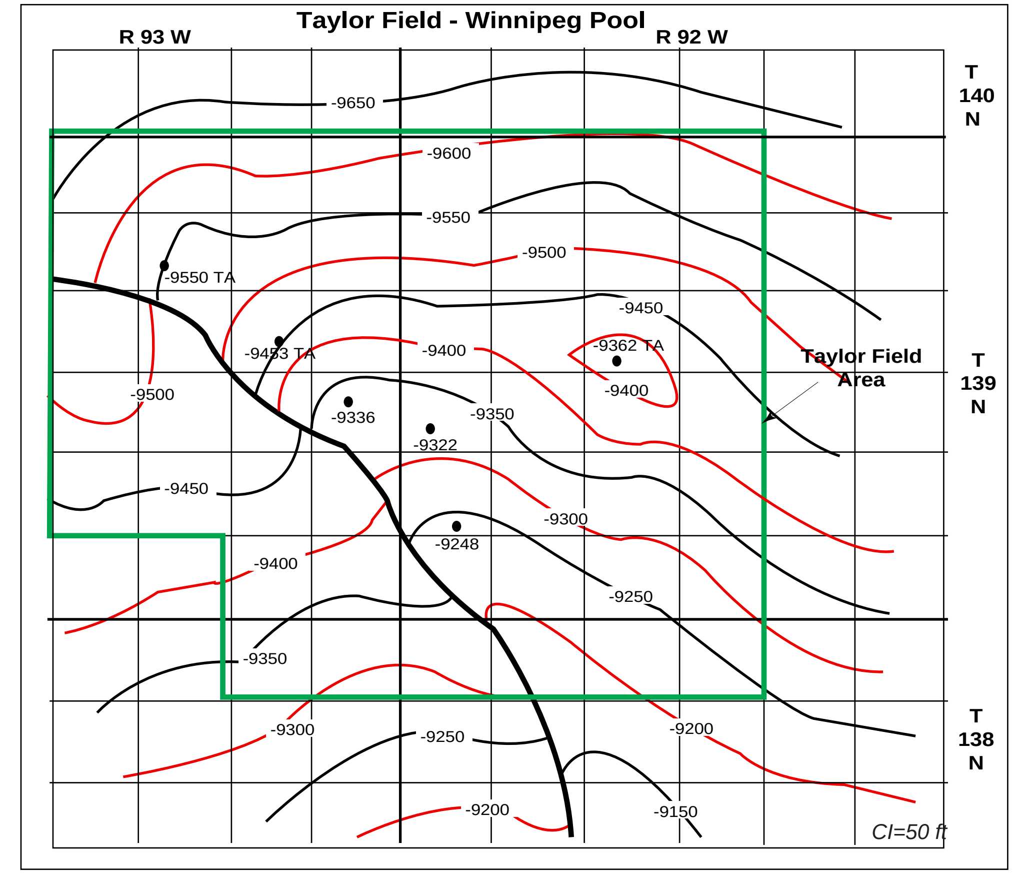


Figure FB-14.4. Taylor Field, Winnipeg Structure. Production strongly correlated to major fault with associated anticlinal nose development to the northwest (from Williston Basin Summaries, 1994).

Taylor Field Parameters

Formation:	Ordovician Winnipeg and Cambrian Deadwood
Lithology:	Interbedded shales and sandstones Sandstone consists of very fine grained quartz (based on Richardson Field core, Gulf Oil Leviathan 1-21-B
Average depth:	11,760-11,780 feet
Porosity:	variable, 12-14% density log porosity
Permeability:	no information
Oil/gas column:	no information
Average net pay:	no information
Other shows:	no information

Other information: Discovery well for Taylor Field, 120 BCPD, 4.54 MMCFPD, 57.9 API. Cumulative production (1995) 128,730 BO, 5.3 MMCF.

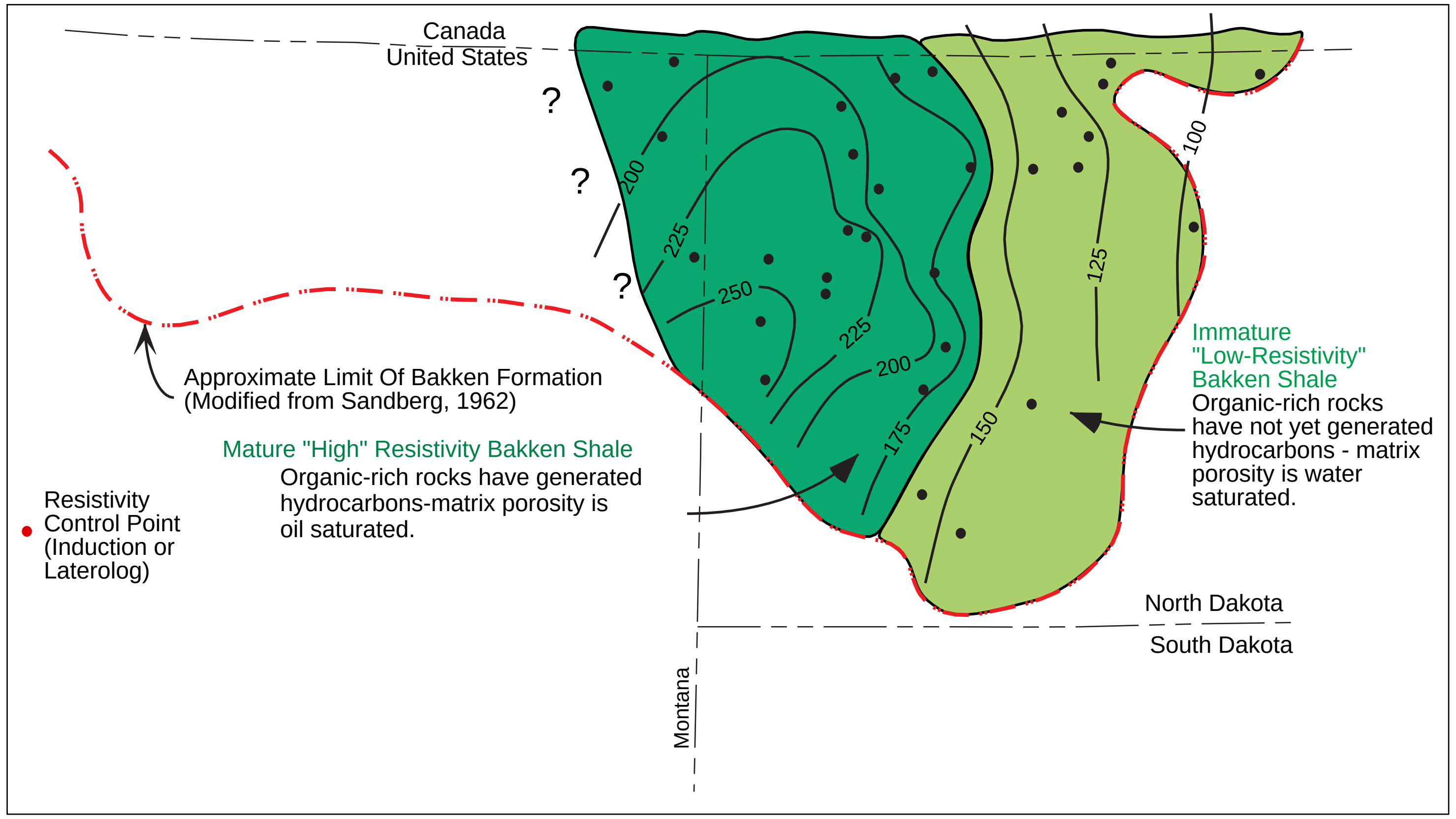


Figure FB-15.1. Areas of "high" and "low" electrical resistivity in Bakken shales, with subsurface isotherm contours (degrees) and interpreted area of source-rock maturity (after Messiner, 1984).

Fort Berthold reservation is ideally situated for mature Bakken production. The Bakken source interval is thought to have generated over 1 billion barrels of oil but production/migration from the interval is problematic. Mechanisms for emplacement outside the Bakken interval are described below in the west/east cross-section. Production within the Bakken must be concentrated in intervals where fractures (original or induced) can remain open to fluid flow.

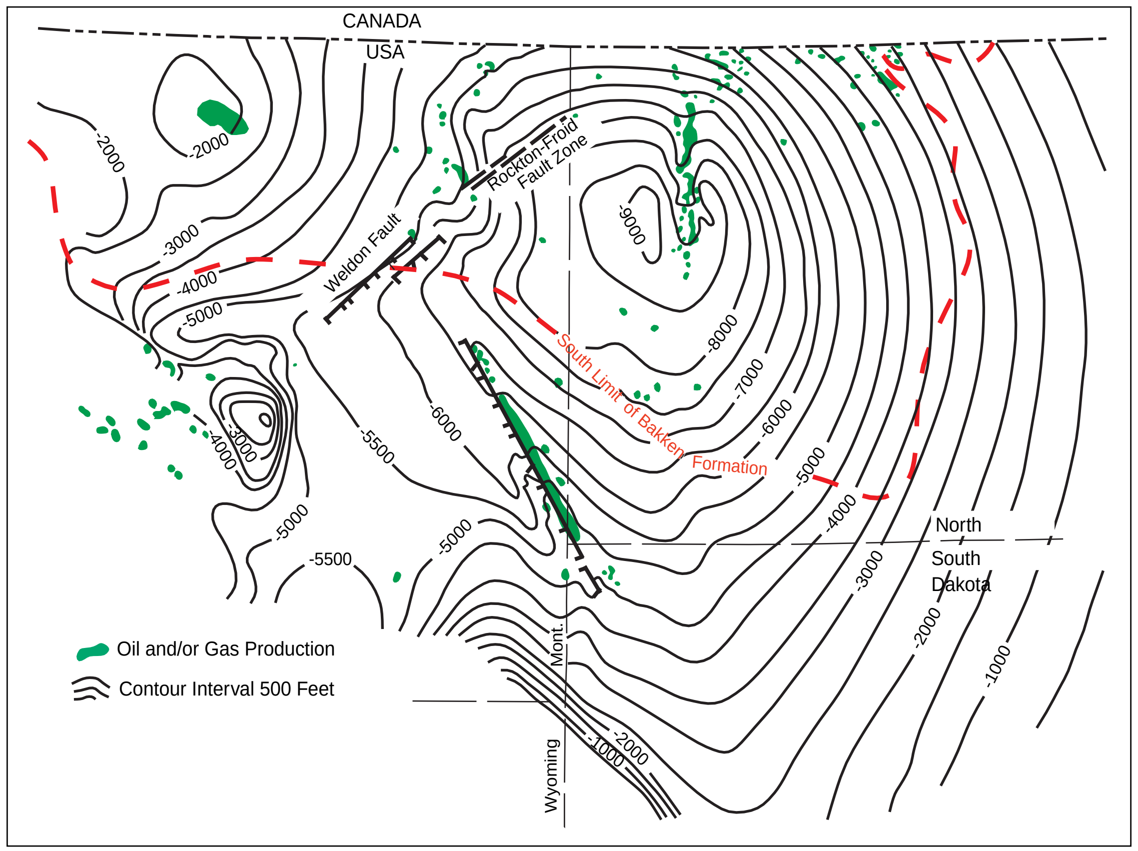


Figure FB-15.2. Williston Basin with structure contours on the base of Mississippian strata and limit of Bakken Formation (after Webster, 1987).

PLAY TYPE 9
Bakken Fairway/Sanish Sand Play

General Characteristics - The fractured Bakken Formation can be subdivided into three distinct rock types. The upper and lower zones are black shale with a high organic matter content. The middle zone is a relatively lean organic shale/siltstone. U.S.G.S. analyses of the Bakken indicates that 11.5-12.1 weight percent of the shale is organic carbon. Evidence suggests that the Bakken has generated hundreds of billions of barrels of oil.

The Bakken Fm, where it exists, is thermally mature (see map). It forms a continuously sourced, self-sealed reservoir. Production is controlled by fractures; matrix porosity and permeability are low. Different fairways are assumed to exist. The areas with the highest potential have elevated thermal maturity, proximity to subcrop, close fracture spacing and proximity to basin flexure hinge lines. Vitrinite reflectance should be greater than 0.9-1.02.

The United States Geological Survey considers Antelope field a special category of Bakken fairway production. The Sanish sand is locally developed, brown, dolomitic, friable, and a slightly argillaceous sandstone with about 6-7% porosity.

Antelope Field Parameters

Formation:	Bakken shale/Sanish sandstone interval
Lithology:	sandstone, dolomitic, brown, friable, slightly argillaceous
Average depth:	10,525 feet
Porosity:	7.4 average
Permeability:	low, changes across structure with the sand/silt content
Oil/Gas column:	no information
Average net pay:	variable
Other formations with shows:	Mission Canyon, Devonian and Winnipegosis

Other information: Discovery well was Woodward Star-Tribal, sw se 21 T152N R 94 W; 550 BOPD (1953)

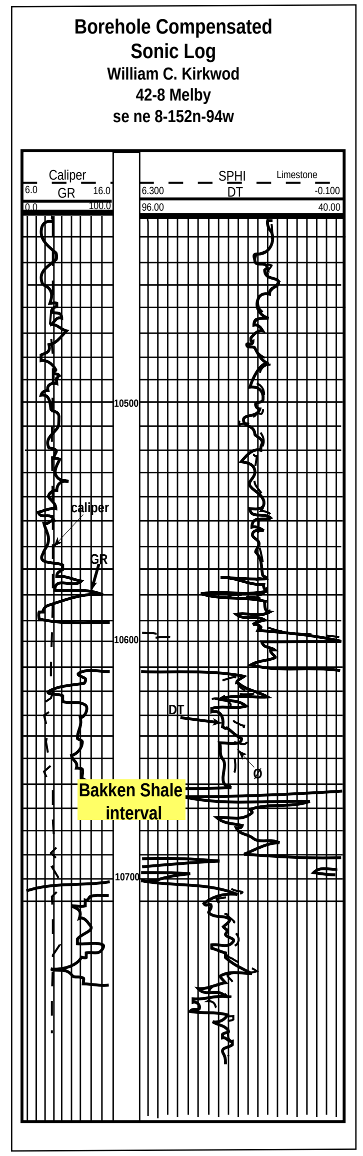


Figure FB-15.3. Example of log signature from Antelope Field showing Bakken shale interval with sand/silt development

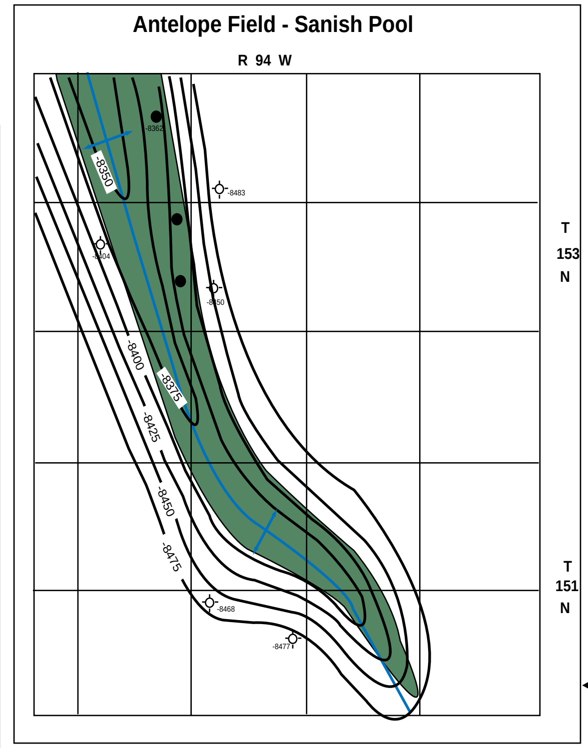


Figure FB-15.4. Structure map of the Sanish Pool, Antelope field (from Williston Basin Field Summaries, 1984).

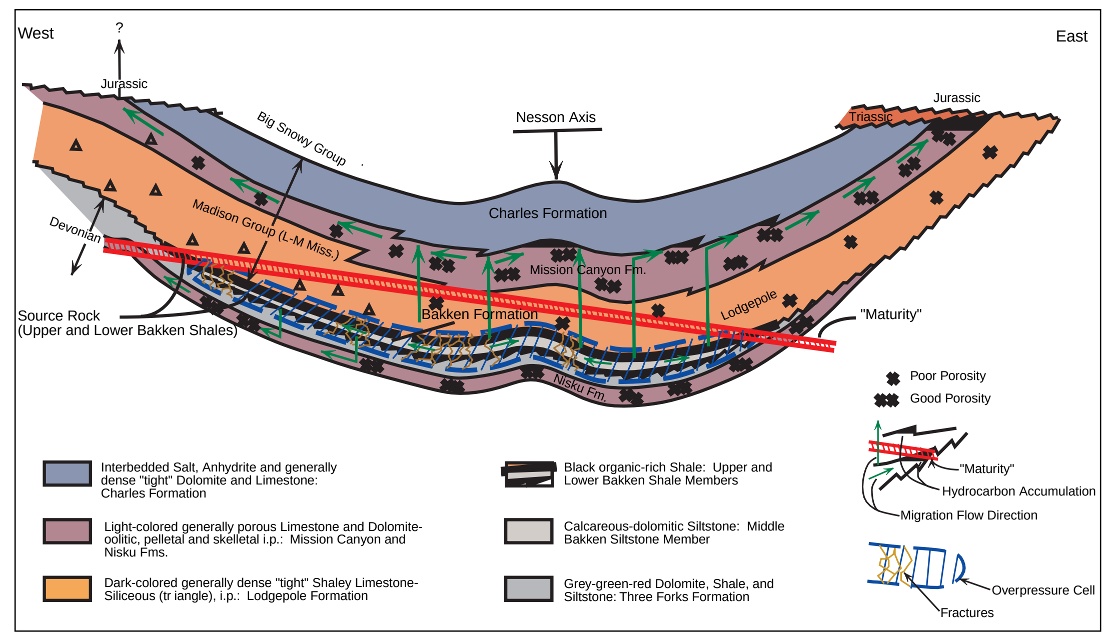


Figure FB-15.5. Schematic east-west section across the Williston Basin showing source-rock maturity, fluid over-pressure, fracture, migration and hydrocarbon accumulation patterns in the Bakken formation and adjacent units (after Messiner, 1984).

PLAY TYPE 10

Niobrara Microbial Gas Play

(Low - High Potential)

General Characteristics - Upper Cretaceous Niobrara is a chalk and calcareous shale that covers most of the western interior from Kansas and eastern Colorado into the Dakotas. It is assumed that a Niobrara gas play similar to the eastern Denver Basin (Beecher Island Field, Goodland Field) exists in the southern Williston basin.

Niobrara production in the Denver Basin is considered a self-sourced, continuous extent gas field. Estimated thickness of the Niobrara would be greater than 100 feet, and depth of burial is less than 1000 feet. Area of subcrop or outcrop might affect gas generation. Areal extent of production might be as small as 25 square miles.

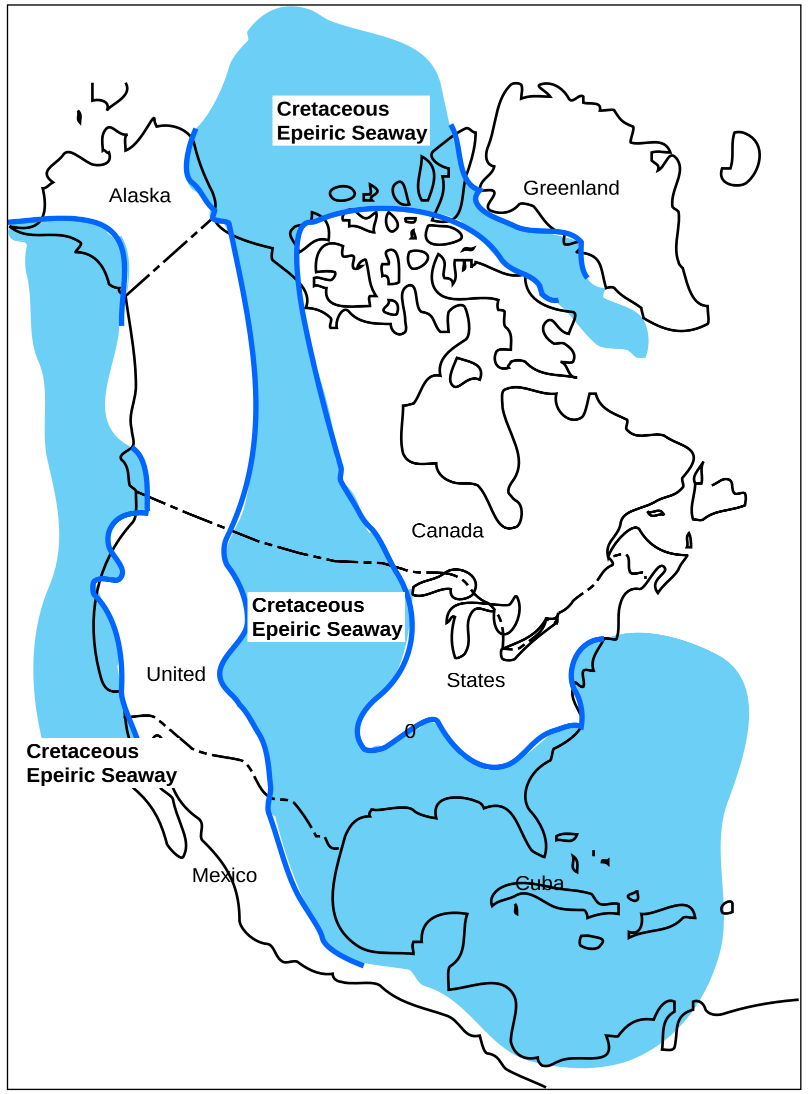


Figure FB-16.1. Paleogeographic map of North America during Late Cretaceous time, showing the extent of the Cretaceous seaway (after Rice and Shurr, 1980).

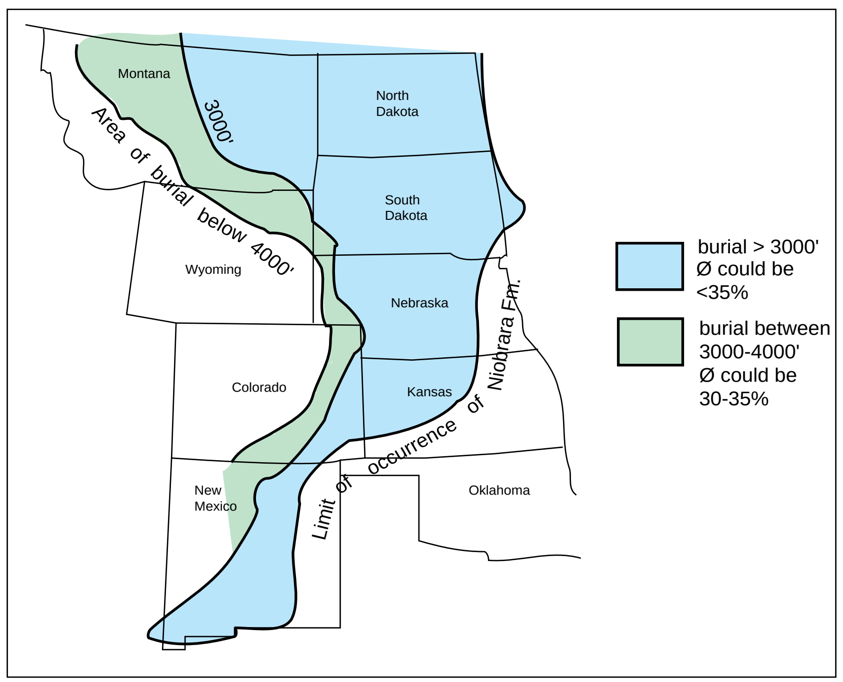


Figure FB-16.2. Map showing depth of burial of the Niobrara Formation. Across reservation area porosity could be <35% (after Rice and Shurr, 1980).

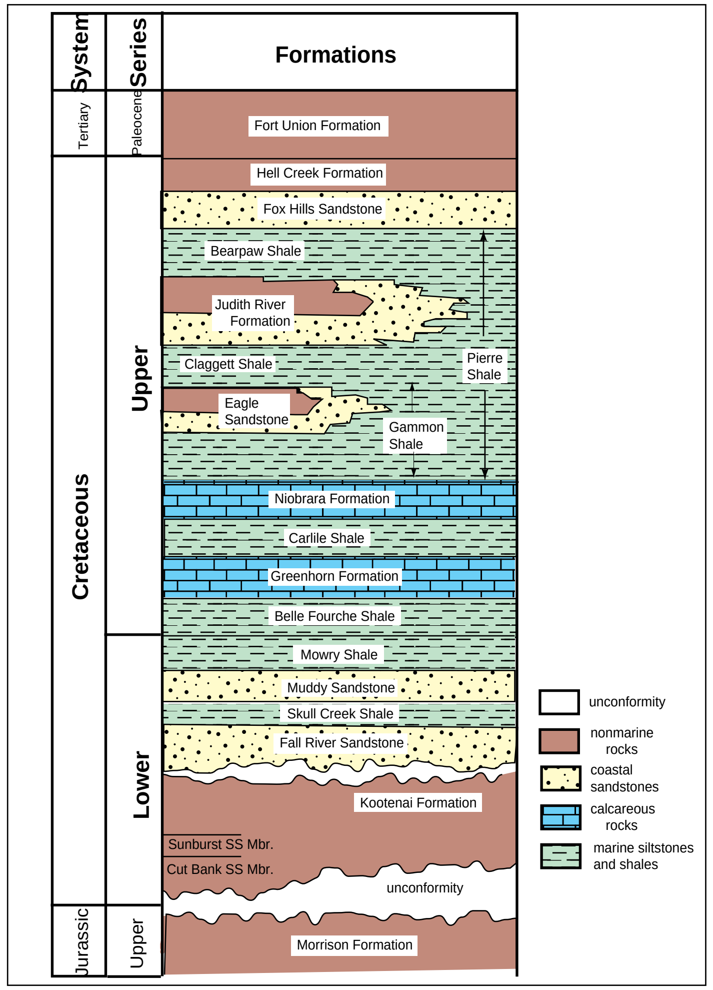


Figure FB-16.3. General correlation chart of Cretaceous rocks (after Rice and Shurr, 1980).

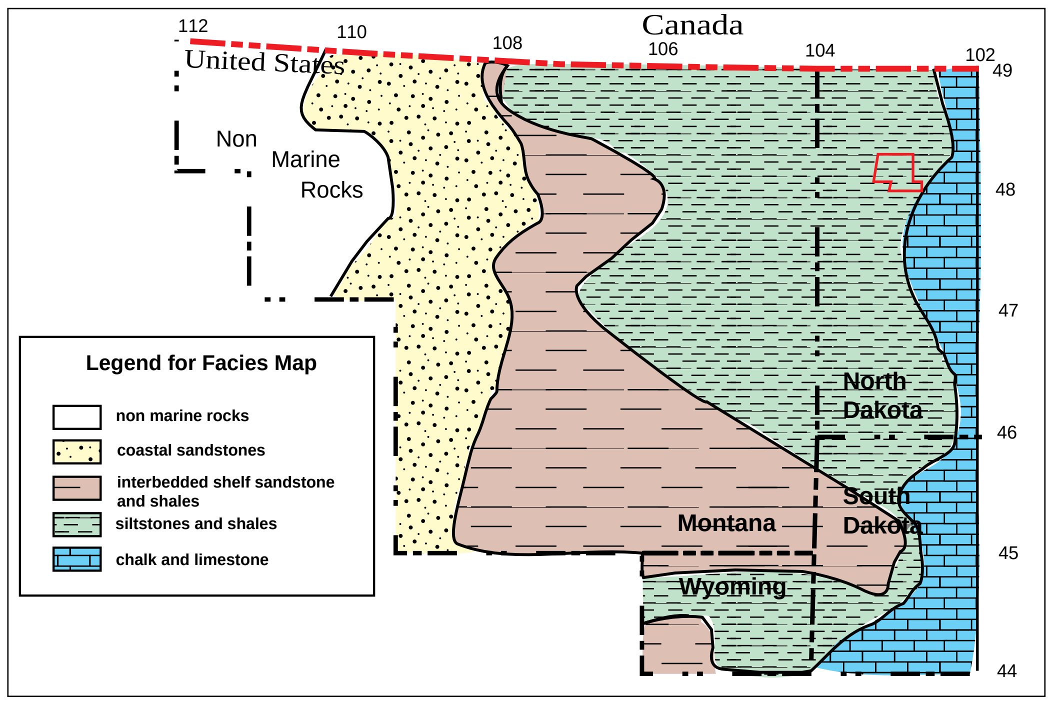


Figure FB-16.4. Regional distribution of diagenetic and petrophysical facies of the Niobrara. Area within 3000 feet or less of burial should contain chalks with porosity greater than 35%. Areas between 3000 and 4000 feet of burial should average 30-35% porosity (after Rice and Shurr, 1980).

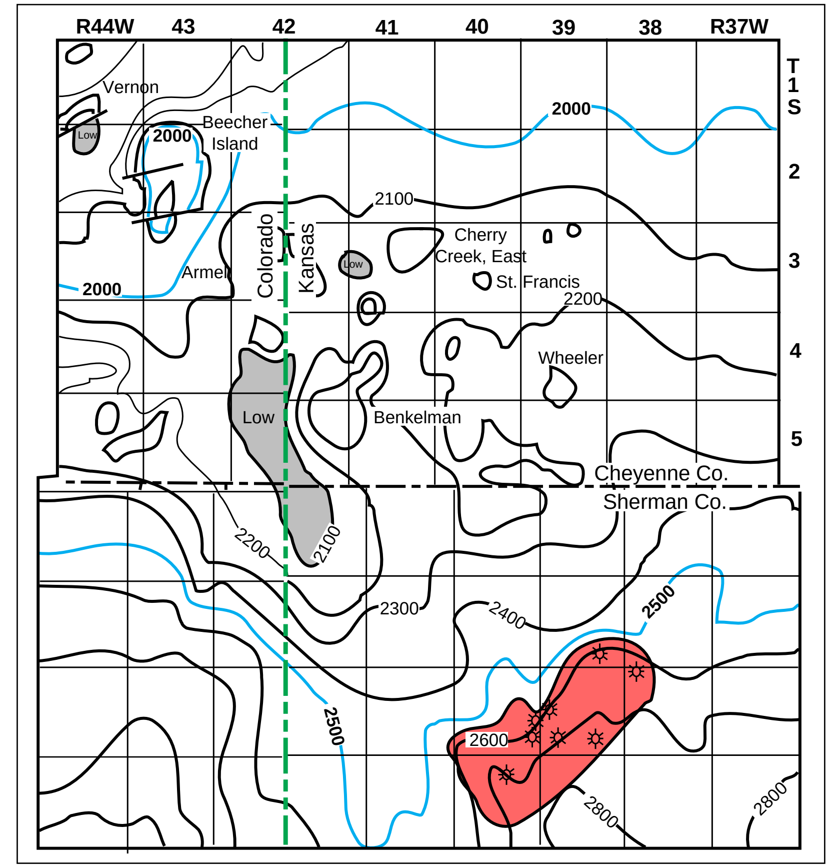


Figure FB-16.5. Structure map on top of the Niobrara Formation, northwestern Kansas showing a Niobrara gas field (in red). Contour interval is 100 feet. Hypothetical or unconventional play for Fort Berthold reservation (after Lockridge and Sholle, 1978).

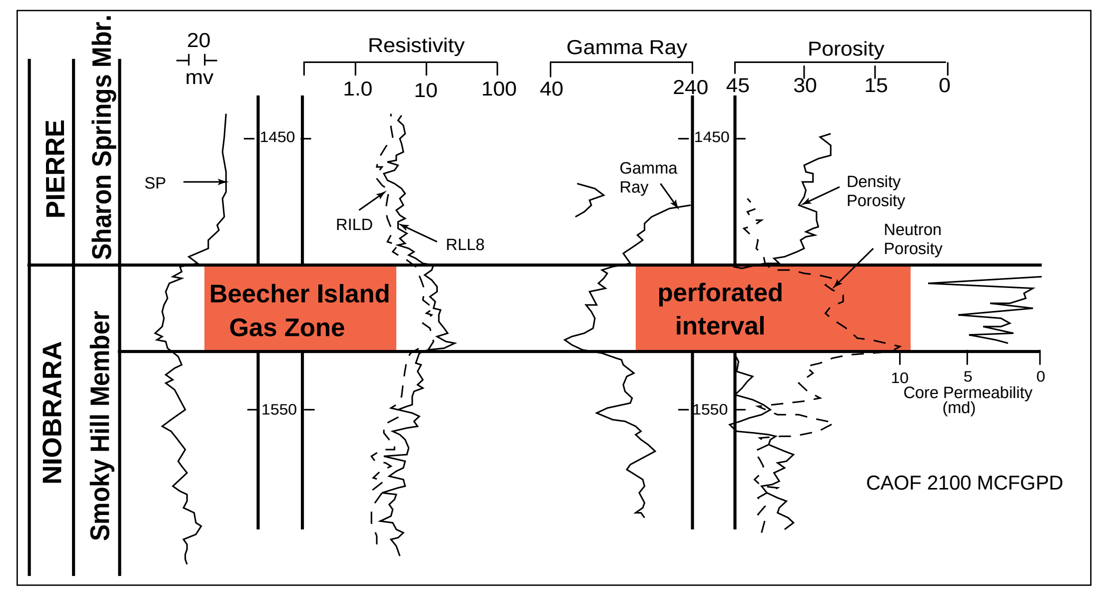


Figure FB-16.6. Type logs for Niobrara producing well, Beecher Island area, Kansas Nebraska No. 1-32 Whombie, sec. 32, T2S, R43W (after Lockridge and Sholle, 1978).

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