FORT BERTHOLD RESERVATION

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REFERENCES
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 reservoirs 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 Allocated 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. Rawling of the U.S. Geological Survey, sandstone reservoirs in the Mississippian Crazy horse formation and the lower Cretaceous Antelope formation make up the major sources of oil and gas fields in the area. Examination of additional producing fields indicates that the oil is trapped in sands, and that the gas is associated with the oil. The Williston Basin, which encompasses the Reservation, has a long history of petroleum development. According to George Long of the Bureau of Land Management (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.

**Fort Berthold Indian Reservation** is comprised 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 valley. 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, 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 parallelising 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 Plahsen's Butte near Mandaree. The reservation is within the Northern Great Plains Physiographic Province and may be divided into two physiographic segments: (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. South of the lake, glacial drift covers the lake, glacially scoured. north of the lake the glacial 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, deep-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 unreserved 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 (9th Cir. July 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 Oct 29, 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**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Acreage</th>
<th>Percentage</th>
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<tr>
<td>Diminished Reservation</td>
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<td></td>
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<tr>
<td>Tribally-owned lands</td>
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<td>Allotted lands</td>
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<td>Government-owned land</td>
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<td>Privately owned (alienated) land</td>
<td>55,865.14</td>
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<td>Subtotal</td>
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<td>Reservoir Taking Area</td>
<td>152,399.95</td>
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<tr>
<td>Homestead (ceded) Area</td>
<td>353,792.59</td>
<td>36.08</td>
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<tr>
<td>Total area of reservation</td>
<td>908,574.54</td>
<td>100.00</td>
</tr>
</tbody>
</table>

**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 MMBBO 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 MMBBO 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 Pinch 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. Producing horizon legend. Many of the potential reservoir intervals can be correlated into Wyoming and Montana. Howev

Producing Horizon Legend (after Geomap Executive Reference Map, 1983)

Fields within reservation boundaries

1996 cumulative production. Parentheses indicates discovery year

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

Nearby fields

(1955) Blue Buttes - 46 MMBBO, 29.2 Mmcf, 44 wells total
(1957) Bear Den - 1.5 MMBBO, 1.7 Mmcf, 2 oil wells, 1 gas well
(1952) Croff - 1.8 MMBBO, 4.1 Mmcf, 3 wells total
(1982) Squaw Creek - 195 MMBBO, 328,546 Mcf, 1 well total
(1982) Mandaree - 160 MMBBO, 147,325 Mcf, 2 wells total
(1995) Lucky Mound - 1.4 MMBBO, 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).
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, biherms/reef or sabkha deposits. Cyclic sedimentation of marine, limestones/dolomites, 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-2.1. 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-2.2. 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-2.3. Generalized time-slice cross-section A-A’. Triassic through Ordovician. Line of section along 48 degrees latitude with selected points every 1 degree longitude. Datum is the base of Jurassic. Permian missing (from C.W. O’Melveny, July 1996).
removed any evidence of these rocks west of longitude 104 degrees. Pennsylvanian 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 initial 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 2400 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 area.

**Geologic History - Ordovician to Triassic**

By Mississippian 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 prone 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. Pennsylvanian 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 Pennsylvian time has
Petroleum Systems

Accumulations of hydrocarbons owe their genesis to several critical factors: generation and migration from source intervals, structural/stratigraphic trapping mechanisms, porous reservoir 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 source rocks. 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 tied 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 undecovered oil resource may be present in Ordovician and Silurian strata. This source interval is largely restricted to the southern and central portions of the basin.

Lodgepole: 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 70 mya (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.

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 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/Lodgepole: Most of the larger structures in the Williston Basin contain mixtures of Lodgepole (Madison) and Bakken oils with the latter at very low saturations (see Figures 2.2 and 2.3 below). Most of the structures in the Williston Basin contain mixtures of Lodgepole (Madison) and Bakken oils with the latter at low relative concentrations.

Potential in Winnipegospe & Lodgepole  
HC saturation  
< 2%  
2 - 5%  
5 - 10%  
10 - 80%  
> 80%  
Prairie salt horizon  
OMa  

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 70 mya (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 rocks with relatively low initial yields; 8 kg BChA rock. However, large volumes of oil have been discovered tied 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 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.

Petroleum Systems
Fort Berthold Reservation
North Dakota

Figure FB-5.1: Schematic Diagram of Play Types - Fort Berthold Reservation

Play Types - Explanation
1. Madison Structure Play
2. Madison Shoreline/Truncation Play
3. Mississippian Lodgepole
4. Ordovician Red River Play
5. Devonian Mica/Crescent Play
6. Silurian Interlake Play
7. Pennsylvanian Tyler-Heath Play
8. Pre-Red River Gas
9. Fractured Bakken Play
10. Shallow Microbial Gas Play

The diagram and summary charts are color-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.

Table FB-5.1: Play Summary Chart

<table>
<thead>
<tr>
<th>Play Type</th>
<th>Oil or Gas</th>
<th>Description of Play</th>
<th>Known Accumulations</th>
<th>Undiscovered Resource (MMBOE)</th>
<th>Drillings Depths</th>
<th>Favorable Factors</th>
<th>Unfavorable Factors</th>
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</thead>
<tbody>
<tr>
<td>Madison, structure</td>
<td>1</td>
<td>Coal measure, primary and secondary porosity</td>
<td>Fresh</td>
<td>High</td>
<td>3,000 - 12,000 ft</td>
<td>1) Folded structures, primary porosity</td>
<td>1) Lack of well control</td>
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<tr>
<td>Madison Shoreline/Truncation Play</td>
<td>2</td>
<td>Coal measure, carbonate, multiple shoreline cycles</td>
<td>Fresh</td>
<td>High</td>
<td>3,000 - 12,000 ft</td>
<td>1) Folded structures, primary porosity</td>
<td>1) Lack of well control</td>
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<tr>
<td>Mississippian Lodgepole</td>
<td>3</td>
<td>Coal measure, carbonate, multiple shoreline cycles</td>
<td>Fresh</td>
<td>High</td>
<td>3,000 - 12,000 ft</td>
<td>1) Folded structures, primary porosity</td>
<td>1) Lack of well control</td>
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<tr>
<td>Ordovician Red River Play</td>
<td>4</td>
<td>Coal measure, carbonate, multiple shoreline cycles</td>
<td>Fresh</td>
<td>High</td>
<td>7,000 - 12,000 ft</td>
<td>1) Folded structures, primary porosity</td>
<td>1) Lack of well control</td>
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<tr>
<td>Play Type</td>
<td>USGS Designation</td>
<td>Description of Play</td>
<td>Known Accumulations</td>
<td>Undiscovered Resource (MMBOE)</td>
<td>Play Probability</td>
<td>Drilling Depth</td>
<td>Favorable factors</td>
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<tr>
<td>Niobrara</td>
<td>3102</td>
<td>Cyclic evaporite-carbonate sequences. Structural and stratigraphic products. Reworked atypical and productivity.</td>
<td>1545 MMBR, 12.7 MMBOE</td>
<td>No well control, 15 MBOE</td>
<td>high</td>
<td>8,200 - 12,500 ft</td>
<td>1) confirmed play, production within reservoir 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful 5) lack of well control 6) rough topography</td>
</tr>
<tr>
<td>Fractured Bakken</td>
<td>3111</td>
<td>Organic rich shale, marly siltstone, fractured, thermally mature oil shale</td>
<td>No information available</td>
<td>Oil shows from Sanish sandstones</td>
<td>0.2 (20%)</td>
<td>7,500 - 11,100 ft</td>
<td>1) confirmed play, production within reservoir 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful 5) lack of well control 6) rough topography</td>
</tr>
<tr>
<td>Nisku and Duperow</td>
<td>3105</td>
<td>Cyclic evaporite-carbonate sequences. Structural and stratigraphic products. Reworked atypical and productivity.</td>
<td>95 MMBR, 20.6 MMBOE</td>
<td>No well control, 15 MBOE</td>
<td>high</td>
<td>8,200 - 12,500 ft</td>
<td>1) confirmed play, production within reservoir 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful 5) lack of well control 6) rough topography</td>
</tr>
<tr>
<td>Silurian</td>
<td>3108</td>
<td>Playfair and rensselen sandstones. Microbial gas. Reservoir may be marine. Microbial gas may be present.</td>
<td>120.5 MMBR, 20.8 BCFG</td>
<td>No well control, 15 MBOE</td>
<td>high</td>
<td>5,000 - 8,200 ft</td>
<td>1) Thermally mature source rocks 2) source rocks and reservoir present 3) shallow drilling depths 4) production within reservation</td>
</tr>
<tr>
<td>Ordovician</td>
<td>3107</td>
<td>Clastic sequences, fluvial and nearshore-biostromal sandstones. Large, faulted structures.</td>
<td>No oil and gas available</td>
<td>Oil shows from Sanish sandstones</td>
<td>resident</td>
<td>10,000 - 18,280 ft</td>
<td>1) confirmed play, production within reservoir 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful 5) lack of well control 6) rough topography</td>
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<tr>
<td>Post Madison</td>
<td>3109</td>
<td>Playfair and rensselen sandstones. Microbial gas. Reservoir may be marine. Microbial gas may be present.</td>
<td>120.5 MMBR, 20.8 BCFG</td>
<td>No well control, 15 MBOE</td>
<td>high</td>
<td>5,000 - 8,200 ft</td>
<td>1) Thermally mature source rocks 2) source rocks and reservoir present 3) shallow drilling depths 4) production within reservation</td>
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<tr>
<td>Williston Basin</td>
<td>1406</td>
<td>1406 MMBR, 1725 BCFG, 192 MBNGL. Niobrara limestone and other shallower carbonates.</td>
<td>No oil and gas available</td>
<td>Oil shows from Sanish sandstones</td>
<td>resident</td>
<td>10,000 - 18,280 ft</td>
<td>1) confirmed play, production within reservoir 2) thermally mature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful 5) lack of well control 6) rough topography</td>
</tr>
</tbody>
</table>

Table BR-6.1. Play type summaries.
Fort Berthold Reservation
North Dakota

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 sub divided into several producing horizons (see cross-section 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. Once oil generation and migration is modeled to begin in the Late Cretaceous.

Blue Buttes Field Structural Cross-Section

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

Play Type 1
Folded Structure - Mississippian Carbonate Play

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.

Figure FB-7.3. Antelope field cross-section (after 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

Antelope Field Parameters

Formation: Mississippian Madison
Lithology: Limestones, 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: Sarah, Duperow, Interlake.
Other information: contains 4.7% H2S

Analog Fields

(*) denotes fields within Reservation

Antelope*: 33 MMBO 16.9 Mmcf
(includes Bakken, Duperow, and Interlake)

Blue Buttes: 45 MMBO 29.3 Mmcf
(includes Duperow, Interlake, and Red River)

Bear Den: 1.4 MMBO 1.5 Mmcf
(Madison, Duperow)

Coff: 1.7 MMBO 4.0 Mmcf
(Madison, Duperow)

Mississippian Madison
Formation:

Conventional Play Type 1
Folded Structure - Mississippian Carbonate Play

Other information:

Other shows: Kibbey sandstone, Kibbey limestone and Charles Formation

Average net pay: variable

Oil/gas column: oil 280 feet

Permeability: 0.1-8 md, average is 3 md

Porosity: averages 7.7%

Lithology: Interbedded limestones and dolomites.

Formation:

Antelope Field Parameters

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: Sarah, Duperow, Interlake.

Other information: contains 4.7% H2S
**Analog Fields**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaza*</td>
<td>- 2.6 MMBO, 1.7 Mmmcf out of 20 wells, 3-4 MMBO ultimate (Bluell)</td>
<td>Sperr et al, 1993</td>
</tr>
<tr>
<td>Wabek*</td>
<td>- 5.1 MMBO, 3.6 Mmmcf, out of 18 wells, 6-7 MMBO ultimate (Sherwood)</td>
<td>Sperr et al, 1993</td>
</tr>
</tbody>
</table>

---

**PLAY TYPE 3**

**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, Nessan, Bluell, Sherwood, Mohall, Glaburn, 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:** 7300-7500 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

---

**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
WILLISTON BASIN
Lodgepole Buildups

West

East

Montana
Trough
basin
shelf
slope

Grainstone-packstone beds on flanks of mound
Bryozoan-crinoid buildup facies (potential hydrocarbon reservoir)
Mudstone-wackestone core facies of mound
Wackestone-packstone buildup facies

Explanation
- Grainsone-packstone beds on flanks of mound
- Bryozoan-crinoid buildup facies (potential hydrocarbon reservoir)
- Mudstone-wackestone core facies of mound
- Wackestone-packstone buildup facies

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, BR=Brider Range, BS=Big Snowy Mountains, D=Dickinson Lodgepole Field, S=Saskatchewan (modified from Burke and Lasemi, 1995).

Dickinson Field, Lodgepole Formation Williston Basin

R 97 W

R 96 W

T 140 N

20' Contour Interval

Dickinson Field Lodgepole Parameters

Formation: Mississippian Lodgepole
Lithology: primarily fossiliferous grainstones with minor amounts of dolomite boundstones, packstones
Average depth: 5000 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-9.3. Isopach map of lower Lodgepole at Dickinson Field (after Burke and Lasemi,1995).

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

Playing 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.

CONVENTIONAL PLAY TYPE 3
Mississippian Lodgepole Waulsortian Mound Play

Fort Berthold Reservation
North Dakota
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. Cycle deposits of carbonate, evaporite, and organic rich shale provide reservoir, source, and seal. Major accumulations are found on structural noses such as Nessan 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.

Antelope Field Parameters
Formation: Ordovician Red River
Lithology: black to dark gray dolomite, limestone 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

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 164 BOPO, API 58
2928 Mcfgpd-discovery well

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. Shows trend of anticline development and production.

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

**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 H₂S

**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 H₂S

**Analog Fields**
- **Antelope:** 39 MMBO, 14.9 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)
- **Croz:** 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).

**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.

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**PLAY TYPE 5**

**Conventional Play Type 5**

- **Index map**
- **Topics**

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**Fort Berthold Reservation**

**North Dakota**

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**PAGE 12 of 18**
**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).

**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.

**CONVENTIONAL PLAY TYPE 6**

**Pre-Prairie (Winnipegosis/Interlake Play)**

**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.

**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

**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

**Pre-Prairie (Winnipegosis/Interlake Play) 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.

**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

**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
**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
Figures FB-14.1 and FB-14.2 show the Winnipeg production correlated with anticlinal fold trends to the southeast.

**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).

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

**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).

**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:** variable, 12-14% density log porosity
- **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 formation, (based on Richardson Field core, Gulf Oil Leviathan 1-21-B)

**Taylor Field Parameters**
- **Formation:** Ordovician Winnipeg and Cambrian Deadwood
- **Lithology:** Interbedded shales and sandstones Sandstone consists of very fine grained quartz
- **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 MMCFGPD, 57.9 API. Cumulative production (1995) 128,730 BO, 5.3 MMCF.

**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.**
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.

**Antelope Field Parameters**

<table>
<thead>
<tr>
<th>Formations</th>
<th>Bakken shale/Sanish sandstone interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lithology</td>
<td>sandstone, dolomitic, brown, friable, slightly argillaceous</td>
</tr>
<tr>
<td>Average depth</td>
<td>10,525 feet</td>
</tr>
<tr>
<td>Pore size</td>
<td>7.4 average</td>
</tr>
<tr>
<td>Permeability</td>
<td>low, changes across structure with the sand/silt content</td>
</tr>
<tr>
<td>Oil/Gas column</td>
<td>no information</td>
</tr>
<tr>
<td>Average net pay</td>
<td>variable</td>
</tr>
<tr>
<td>Other formations</td>
<td>Mission Canyon, Devonian and Winnipegosis</td>
</tr>
<tr>
<td>with shales</td>
<td></td>
</tr>
<tr>
<td>Other information</td>
<td>Discovery well was Woodrow Star-Tribal, see DD T112N R94 W; 560 BPI (1983)</td>
</tr>
</tbody>
</table>

**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 Messimer, 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.

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. Areas 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. Areas within 3000 feet or less of burial should contain chokes 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).
General References

Fort Berthold Reservation


Fort Berthold Reservation-Fields and Articles


Fort Berthold Reservation - Map References

Executive Reference Map 334, 1985 edition. Extended Area, Northern Rocky Mountains, Geomap Company.


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