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, 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 Fort Berthold Reservation possesses all the requisites for commercial petroleum development. According to an oil and gas study authorized by Joe H. Rawlings for the Williston Basin Petroleum Research Institute (Ripe) and the local public producing oil fields. Other fields were recently discovered on the Reservation while drilling the Bakken and Mission Canyon formations. This multiplicity of geologic structures augments 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 Fort Berthold Reservation comprises parts of Dunn, McKenzie, McLean, 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 northern segments.

Although reservoir waters somewhat impede travel between the four land segments, most of the reservation is accessible over 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.

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.

The reservation area north of Lake Sakakawea is part of the Coteau Slope, which has both erosional and glacial landforms with glacial predominate. Gentle slopes characterize 50 to 80 percent of the area and local relief ranges from 200 to 200 feet. The Little Missouri Badlands lie adjacent to the Little Missouri River south and west of Lake Sakakawea as well as a few restricted areas along the Missouri River. They consist of rugged, deeply-eroded, scablands in which gentle slopes characterize only 20 to 50 percent of the area and local relief 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.

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 (9th 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>
<thead>
<tr>
<th>Classification</th>
<th>Acreage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diminished Reservation Area</td>
<td>57,954.20</td>
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<tr>
<td>Tribally-owned lands</td>
<td>360,418.57</td>
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<tr>
<td>Government-owned land</td>
<td>164.09</td>
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<tr>
<td>Privately owned (alleged) land</td>
<td>55,865.14</td>
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<tr>
<td>Subtotal</td>
<td>474,422.00</td>
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<tr>
<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>
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<tr>
<td>Total area of reservation</td>
<td>1,530,574.54</td>
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</tbody>
</table>

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 MMBO and 1.69 TCFG from undiscovered resources in conventional plays. Multiple episodes of maturation and migration occurred during Pernian-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 Green River. 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.

**Nearby fields**

- **1955** Blue Buttes - 46 MMBBO, 29.2 Mmcf, 44 wells total
- **1957** Bear Den - 1.5 MMBBO, 1.7 Mmcf, 2 gas wells
- **1952** Croft - 1.8 MMBBO, 4.1 Mmcf, 3 wells total
- **1981** Spotted Horn - 108 MBO, 36.234 Mmcf, Abandoned
- **1982** Squaw Creek - 195 MBO, 328,546 Mmcf, 1 well total
- **1982** Mandaree - 160 MBO, 147,324 Mmcf, 2 wells total
- **1996** Lucky Mound - 1.4 MMBBO, 890, 670 Mmcf, 18 wells total

**Producing Horizon Legend**

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 located 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 depositional system 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 fluviatile sandstone deposits. The carbonate and evaporite units are mainly tidal flat, sabkha/deep marine carbonates 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 lime 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 to 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 depositional system 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 eastern 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.
removed any evidence of these rocks west of longitude 104 degrees. Pennsylvanian rocks are 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 evaporite 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 Mourey/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 uplifted 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 deposits during the Palaeocene and Eocene. Coal deposits of the Fort Union and equivalent rocks are the result. These sediments can be up to 1700 feet thick across the reservation. Alpinian glaciers existed in Montana during Quaternary time and extensive glacial lakes and ice sheets covered the reservation area.

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).

Figure FB-3.4. Generalized cross-section A-A' - Cretaceous and Older Rocks. Line of cross-section 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. 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.

Figure FB-3.5. Geologic History - Jurassic to Cretaceous

By Mississippian time, the western portion of the Williston basin was continuously receiving carbonates and evaporites in a shallow, marine shelf environment (see Figure FB-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. Pennsylvanian sediments are confined to the center of the Williston basin area and are predominantly sandstone/shale and evaporite sequences. As the Williston basin became filled to base level, only shallow marine/shallow 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 unexplored 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 are all present in the preservation area.

**Ordovician Winnipeg shale** - A very organic-rich shale that exudes richness values of the Bakken shale in source cores. 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 actively restricted to the southern and central portions of the basin.

**Silurian strata** - This source interval is aerally restricted to the southern and central portions of the Williston Basin where undiscovered oil resource may be present in Ordovician and Silurian strata. 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 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.

**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 pyrolysia 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.

**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 pyrolysia 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 changes many of the Devonian shales found in some of the Mississippian-aged sequences.
### Play Types - Explanation

1. **Madison Structure Play**
   - **Description**: An oil or gas play characterized by Madison structure play type.
   - **Drilling Depth**: 3,000 - 12,000 ft
   - **Favorable Factors**:
     - Thermally mature source rocks
     - Source rocks and reservoir present
     - Seismic delineation is useful
   - **Unfavorable Factors**:
     - Rough topography
     - Lack of well control

2. **Red River Play**
   - **Description**: A play characterized by Red River play type.
   - **Drilling Depth**: 3,000 - 12,000 ft
   - **Favorable Factors**:
     - Thermally mature source rocks
     - Source rocks and reservoir present
   - **Unfavorable Factors**:
     - Rough topography
     - Lack of well control

3. **Cretaceous Play**
   - **Description**: A play characterized by Cretaceous play type.
   - **Drilling Depth**: 3,000 - 12,000 ft
   - **Favorable Factors**:
     - Thermally mature source rocks
     - Source rocks and reservoir present
   - **Unfavorable Factors**:
     - Rough topography
     - Lack of well control

4. **Pennsylvanian Tyler-Heath Play**
   - **Description**: A play characterized by Pennsylvanian Tyler-Heath play type.
   - **Drilling Depth**: 3,000 - 12,000 ft
   - **Favorable Factors**:
     - Thermally mature source rocks
     - Source rocks and reservoir present
   - **Unfavorable Factors**:
     - Rough topography
     - Lack of well control

### 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.

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### Table: Play Summary

<table>
<thead>
<tr>
<th>Reservation: Fort Berthold</th>
<th>Geologic Province: Central Williston Basin</th>
<th>Total Production (by province-1996): Williston Basin 1490 MMBO</th>
<th>Undiscovered resources and numbers of fields for Province-wide plays: No attempt has been made to estimate number of undiscovered fields within the Fort Berthold Reservation</th>
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<tbody>
<tr>
<td>Play Type</td>
<td>Total Production (MMBO)</td>
<td>Undiscovered Resource (MMBOE)</td>
<td>Play Probability</td>
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<tr>
<td>Madison Structure Play</td>
<td>3101a</td>
<td>both</td>
<td>490 MMBO</td>
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<tr>
<td>Red River Play</td>
<td>3101b</td>
<td>both</td>
<td>610 MMBO</td>
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<tr>
<td>Cretaceous Play</td>
<td>3101c</td>
<td>both</td>
<td>850 MMBO</td>
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<tr>
<td>Pennsylvanian Tyler-Heath Play</td>
<td>3101d</td>
<td>both</td>
<td>1000 MMBO</td>
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### Reservation: Fort Berthold Total Production (by province-1996) Williston Basin 1496 MMBD 1725 BCFG 192 MMBGL

<table>
<thead>
<tr>
<th>Play Type</th>
<th>USGS Designation</th>
<th>Description of Play</th>
<th>Oil or Gas</th>
<th>Known Accumulations</th>
<th>Undiscovered Resource (MMBOE) Field Size (&gt; 1 MMBOE) min, median, mean</th>
<th>Play Probability Chance of success</th>
<th>Drilling depths</th>
<th>Favorable factors</th>
<th>Unfavorable factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Niisku and Duperow</td>
<td>3108</td>
<td>Cyclic evaporite-carbonate sequences. Structural and stratigraphic traps. Reticulated porosity and permeability.</td>
<td>Bulk</td>
<td>M10 MMBBO 150 BCFG 12.7 MMBGL</td>
<td>1</td>
<td>high</td>
<td>8,000 - 12,500 ft</td>
<td>1) confirmed play, includes self-sealed reservoir 2) normally immature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful</td>
<td>1) lack of well control 2) rough topography</td>
</tr>
<tr>
<td>Silurian Winnipegosis and Interlake</td>
<td>3109</td>
<td>Cyclic evaporite-carbonate sequences. Structural and stratigraphic traps. Primary and secondary porosity. Structural and unconformity-related traps.</td>
<td>Bulk</td>
<td>M10 MMBBO 150 BCFG 12.7 MMBGL</td>
<td>1</td>
<td>medium-high</td>
<td>8,000 - 12,500 ft</td>
<td>1) confirmed play, includes self-sealed reservoir 2) normally immature source rocks 3) source rocks and reservoir present 4) seismic delineation is useful</td>
<td>1) lack of well control 2) rough topography</td>
</tr>
<tr>
<td>Post Madison Penn. Tyler/Health</td>
<td>3108</td>
<td>Fluvial and interdistributary sandstones.</td>
<td>Bulk</td>
<td>M10 MBBG 20.8 BCFG</td>
<td>1</td>
<td>medium-high</td>
<td>5,500 - 8,000 ft</td>
<td>1) thermally mature source rocks 2) source rocks and reservoir present 3) shallow drilling depths</td>
<td>1) No production within reservation 2) rough topography 3) lack of well control 4) diapiric events within reservoir 5) reserves may be in place</td>
</tr>
<tr>
<td>Ordovician Pre-Red River Play</td>
<td>3107</td>
<td>Clastic sequences, fluvial and nearshore-blanket sandstones. Large, faulted structures.</td>
<td>NGL and few BTU gas unavailable</td>
<td>M10 MBBG 3 field @ 10 MBBG</td>
<td>1</td>
<td>medium</td>
<td>10,000 - 16,000 ft</td>
<td>1) confirmed play, production within reservoir 2) source rocks and reservoir present 3) shallow drilling depths 4) reservoir continuity is problematic</td>
<td>1) lack of well control 2) rough topography 3) lack of well control 4) lack of well control 5) thermal maturity 6) lack of well control</td>
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<tr>
<td>Fractured Bakken</td>
<td>3111</td>
<td>Organic rich shale, marine dolomite, fractured, thermally mature oil shale</td>
<td>Bulk</td>
<td>M10 MBBG 20.8 BCFG</td>
<td>1</td>
<td>low</td>
<td>5,500 - 9,000 ft</td>
<td>1) confirmed play, production within reservoir 2) source rocks and reservoir present 3) shallow drilling depths 4) seismic delineation is useful</td>
<td>1) lack of well control 2) rough topography 3) lack of well control 4) lack of well control 5) areal extent may be small</td>
</tr>
<tr>
<td>Niobrara Microbial Gas Play</td>
<td>3112</td>
<td>Netted sandstone and microfacies with microbialite microfacies.</td>
<td>Microporous gas</td>
<td>M10 MBBG 20.8 BCFG</td>
<td>1</td>
<td>medium-low</td>
<td>7,000 to 11,000 ft</td>
<td>1) confirmed play, production within reservoir 2) thermally immature source rocks 3) fractures present 4) seismic delineation is useful</td>
<td>1) lack of well control 2) rough topography 3) lack of well control 4) lack of well control 5) areal extent may be small</td>
</tr>
</tbody>
</table>

Table BR-6.1: Play type summaries.
**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-section above), 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.

**Antelope 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
- **Other information**: contains 4.7% H2S

**Blue Buttes Field Structural Cross-Section**

*Note: Only Madison penetrations shown*

**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

**Index Map**

- **Antelope Field**
- **Charles Field**
- **Kibbey Field**
- **Madison Field**
- **Lodgepole Field**
- **Bakken Field**

**Structural Cross Section - Antelope Field**

*Note: Only Madison parameters shown*
**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-8.1.** Sherwood shoreline trend and position of major oil fields (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, peloidal, intraclastic and composite wackestone-grainstone
- **Average depth**: 7300-7500 feet
- **Porosity**: Intergranular, vugular, intraparticle; 6-16%
- **Permeability**: No information
- **Oil/Gas column**: At least 100 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, peloidal, 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-8.2.** Structure map of the Sherwood subinterval - Plaza and Wabek 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).

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

West

East

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).

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

CONVENTIONAL PLAY TYPE 3
Mississippian Lodgepole Waulsortian Mound Play

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.

Dickinson Field Lodgepole Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formation</td>
<td>Mississippian Lodgepole</td>
</tr>
<tr>
<td>Lithology</td>
<td>primarily fossiliferous grainstones with minor amounts of dolomite</td>
</tr>
<tr>
<td></td>
<td>boundstones, packstones</td>
</tr>
<tr>
<td>Average depth</td>
<td>5000 feet</td>
</tr>
<tr>
<td>Porosity</td>
<td>9-10% mound core</td>
</tr>
<tr>
<td></td>
<td>up to 15% in mound flanks</td>
</tr>
<tr>
<td>Permeability</td>
<td>variable, up to 460md</td>
</tr>
<tr>
<td>Oil/Gas column</td>
<td>no information</td>
</tr>
<tr>
<td>Average net pay</td>
<td>at least 50 feet</td>
</tr>
<tr>
<td>Other shows</td>
<td>no information</td>
</tr>
</tbody>
</table>

Dickinson Field, Lodgepole Formation

Williston Basin

Fort Berthold Reservation
North Dakota

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).

CONVENTIONAL PLAY TYPE 3
Mississippian Lodgepole Waulsortian Mound Play

Mississippian Lodgepole Formation

Lithology: primarily fossiliferous grainstones with minor amounts of dolomite boundstones, packstones
Average depth: 5000 feet
Porosity: 9-10% 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
**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

**Antelope Field Parameters**

- **Formation:** Ordovician Red River
- **Lithology:** black to dark grey 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:** only
- **Average net pay thickness:** 10 feet
- **Other shows:** Minnelusa and Charles Formations
- **Cumulative production:** (1995) 94 MBO, 1.15 Mmcf

---

**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.
**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**

- **Antelope**
  - 39 MMBBO, 18.9 Mmcf (includes Bakken, Duperow, and Interlake)

- **Blue Buttes**
  - 45 MMBBO, 28.3 Mmcf (includes Duperow, Interlake, and Red River)

- **Bear Den**
  - 1.4 MMBBO, 1.5 Mmcf (includes Madison, Duperow)

- **Croff**
  - 1.7 MMBBO, 4.0 Mmcf (includes Madison, Duperow)

**Bear Den Field Parameters**

- **Formation**: Devonian Duperow
- **Lithology**: microcrystalline dolomite with fair microsucreasitic porosity
- **Average depth**: 11,300 feet
- **Porosity**: variable, microsucreasitic
- **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

**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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**Page 12 of 18**

**Devonian Nisku - Duperow Play**
**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 (3707 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:** Madison, Duperow, Sanish
- **Other shows:**
  - Madison, Duperow, Sanish

**Conventional 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).
- **Figure FB-12.2.** Example of wireline log through Silurian interval in Blue Buttes Field.
- **Figure FB-12.3.** Example of Antelope Field wireline log in the Silurian interval.
- **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.
**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.

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**Dickinson Field Parameters**

- **Formation:** Pennsylvania Tyler
- **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-13.1. Thickness of Upper Mississippian - Lower Pennsylvanian Big Smoky 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 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.

---

**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

---

**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 MMCFGPD, 57.9 API. Cumulative production (1995) 128,730 BO, 5.3 MMCFG.

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**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).
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 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.

UNCONVENTIONAL 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**

<table>
<thead>
<tr>
<th>Formation</th>
<th>Bakken/shale/Sanish sandstone interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lithology</strong></td>
<td>sandstone, dolomitic, brown, friable, slightly argillaceous</td>
</tr>
<tr>
<td><strong>Average depth</strong></td>
<td>10,525 feet</td>
</tr>
<tr>
<td><strong>Porosity</strong></td>
<td>7.4 average</td>
</tr>
<tr>
<td><strong>Permeability</strong></td>
<td>low, changes across structure with the sand/shale content</td>
</tr>
<tr>
<td><strong>Oil/Gas column</strong></td>
<td>no information</td>
</tr>
<tr>
<td><strong>Average net pay</strong></td>
<td>variable</td>
</tr>
<tr>
<td><strong>Permeability</strong></td>
<td>low, changes across structure with the sand/shale content</td>
</tr>
<tr>
<td><strong>Other information</strong></td>
<td>Discovery well was Woodrow Star-Tribal, see 21 T102N R 94 W 550 BCPD (1983)</td>
</tr>
</tbody>
</table>

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

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

United States

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. Areas within 3000 feet or less of burial should contain chalcedony 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-16.6. Type logs for Niobrara producing well, Beecher Island area, Kansas Nebraska No. 1-32 Whombie, sec. 32, T2S, R43W (after Lockridge and Sholle, 1978).

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).

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.
## General References

### Fort Berthold Reservation


### Fort Berthold Reservation-Fields and Articles


REFERENCES


Fort Berthold Reservation - Map References


Indian Land Areas, 1992, United States Department of the Interior-Bureau of Indian Affairs.


Fort Berthold Reservation - Map References


Indian Land Areas, 1992, United States Department of the Interior-Bureau of Indian Affairs.


