BLACKFEET RESERVATION

List of Topics

OVERVIEW

BLACKFEET INDIAN RESERVATION

Blackfeet Nation

TRIBAL HEADQUARTERS: Browning, Montana
GEOLOGIC SETTING: Southern Alberta Basin

General Setting

The Blackfeet Reservation is located in northwestern Montana and includes most of Glacier County. On the north it borders the Canadian Province of Alberta. On the west it shares a border with Glacier National Park. The Badger Two Medicine portion of the Lewis and Clark National Forest borders on the southwest. Other natural boundaries include Birch and Cut Bank Creeks. Elevations vary from a low of 3400' in the southeast to a high of over 9000' at Chief Mountain on the northwest boundary.

Major railroads and highways serving the Reservation include Burlington Northern Railroad's main east/west line. This is paralleled by U.S. Highway #2, and is bisected by U.S. Highway #89 at Browning, the administrative center for the Reservation. Great Falls, Montana, an air traffic center, is approximately 125 miles to the southeast, and Calgary, Alberta, Canada is approximately 210 miles to the north.

Mineral Ownership and Leasing

The Blackfeet Reservation contains 1,525,712 acres, with the mineral estates divided as follows. Approximately 41.8% of the minerals is tribally owned. Another 31.3% is owned by allottees, and the remaining 26.9% is owned by fee owners.

A Mineral Assessment Program is currently operating under a three-year plan to evaluate and further define the oil and gas potential of the Reservation. This program also assists the Tribe in the evaluation of new leasing, operating and joint venture agreements. New leases, other mineral exploration, and development agreements are designed in accordance with the 1982 Indian Mineral Development Act, and the rules and regulations contained in 25 CFR. Companies are welcome to negotiate with the Blackfeet Tribal Business Council for any type of lease or joint venture agreement which will satisfy both parties.

Seismic Data

Seismic data from past seismic surveys are available from several seismic brokerage firms. The Tribe has purchased seismic data for some portions of the Reservation and are in the process of reprocessing the data using technology of today. Information on conducting new seismic operations can be obtained from the BIA or the Blackfeet Tribe.

Most of the leases and other types of agreements currently in effect on the Reservation are in areas now under production. This leaves a large portion of the Reservation's minerals available for leasing.

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Petroleum Exploration and Development

The first commercial oil discovery in Montana was made in the spring of 1903 in the Swift Current Valley, just west of the Reservation in what is now Glacier National Park (Darrow, 1955). This discovery was made by a prospector named Sand D. Somes who was looking for copper ore in the Swift Current Valley, now covered by the water of present day Sherburne Lake near Many Glaciers Lodge (Douma, 1953). His interest in oil developed in 1902 when he found pools of oil when cleaning out his workings after blasting. This early production came from a depth of 500'. By 1906, twelve wells had been drilled, six of which produced oil (Darrow, 1955). The best oil well, completed during the spring of 1906, had an initial production of 60 barrels of oil per day. Although production from this oil field was short lived, it marked the beginning of the petroleum industry in Montana.

Just off the Reservation's eastern edge, along the west flank of the Sweetgrass Arch, random drilling led to the discovery of gas in 1926 and of oil in 1929 (Chickering, 1958; Del Monte, 1958). By the early 1930's, development drilling had extended the known limits of this field onto the reservation.

The Cut Bank Field, which extends from Townships 31 to 36 North, in Ranges 5 and 6 West, produced 164,499,336 barrels of oil through December 1992 (Montana Oil and Gas Conservation Division, 1993), with annual production of oil still over 740,000 barrels, and nearly 3 million cubic feet of gas. Approximately 25 percent of the Cut Bank Field area lies within the Reservation. When production began to decline in the mid 1940's due to the pressure decline of the solution gas drive (Chickering, 1958), secondary recovery operations were initiated. The secondary recovery methods used were chiefly waterfloods, which resulted in an increase of production by the early 1950's. The Montana Oil and Gas Annual Review for 1992 lists 11 secondary recovery projects in the Cut Bank Field. All of these are listed as waterfloods, with six of them listed as being idle. Oil and/or gas production is found in the following formations within the Cut Bank field area: Blackleaf, Bow Island, Dakota, Kootenai (Moulton, Lander, Sunburst, and Cut Bank sands), and the Madison Group. So far, secondary recovery operations have been limited to the Cut Bank sands, Lander sand and the Madison Formation.

Other oil and/or gas fields on or near the Reservation include Big Rock, Blackfoot Shallow Gas, Bradley, Little Rock, Blackfoot, East Glacier, Landslide Butte, and Reagan. Inactive or abandoned fields include Two Medicine Creek, and Blackfoot East. Cumulative production from these fields through 1992 is 11,381,868 barrels of oil (Montana Oil and Gas Conservation Division, 1992 Annual Review). Two of these fields, Blackfoot and Reagan, have active secondary waterfloods. Annual gas production plus associated gas produced from these fields for 1992 was approximately 815,000 mcf.

Only limited exploration and development drilling has taken place within the Reservation boundaries during the past ten years. The most recent drilling activity involves the use of horizontally drilled wells, by Unocal, in the Cut Bank Airport Unit. The use of horizontal wells in conjunction with secondary recovery methods should result in a higher percentage of the original oil in place being recovered.

Geology

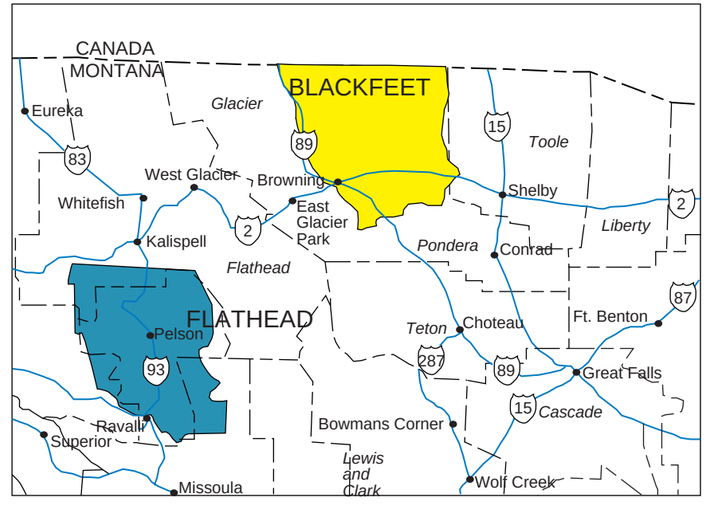
The Blackfeet Indian Reservation occupies a portion of the southern Alberta Basin. Tectonically, the area can be divided into three provinces: the Disturbed/Overthrust Belt on the west, the Foreland Basin in the central portion, and the Sweetgrass Arch on the east. The stratigraphy of the Reservation is generally characterized by the clastic section of the Cretaceous-Jurassic and the carbonates of the Mississippian-Devonian. On the Reservation, production exists in formations within the Cretaceous, Jurassic, and the Mississippian. Of these three provinces, only the Sweetgrass Arch has received more than a very limited amount of exploration.

The Disturbed/Overthrust Belt is a zone of northerly, closely-spaced, sub-parallel thrust faults and folds with some known normal faults. The large scale structural dislocation of these sub-parallel thrust faults may result in older reservoir rocks overlying younger source rocks, or in the fracturing of source rocks to create a reservoir. This geologic province extends from the Brooks Range in Alaska southward to Central America. In Alberta, Canada this belt contains a number of large fields including Pincher Creek and Waterton Lakes. There is limited production of oil and gas from the Disturbed Belt portion of the Reservation near East Glacier. The primary reservoir rocks in this region would be the Mississippian carbonates - limestones and dolomites - which are productive to the south of the Reservation at the Blackleaf Canyon Field. Other potential reservoirs would include the sands of the Cretaceous and the carbonates of the Devonian.

The Foreland Basin is represented by a relatively undeformed wedge of Mesozoic and Paleozoic rocks that vary in thickness from approximately 5,000' on the east to 14,000' on the west. Although the Cretaceous, Jurassic, and the Mississippian portions of the geological section have a high potential for oil and gas production, the Devonian should also be considered as having significant undiscovered hydrocarbon potential. It is this Foreland Basin broad shelf that, during the Devonian, was the site of the deposition of reef-type rocks and sediments that have shown production to the north in the Alberta Basin. Production from the Devonian section also occurs in the Kevin-Sunburst area of the Sweetgrass Arch. Although highly productive of oil and gas in Canada, exploration for the Devonian on the Reservation has been insignificant.

The Sweetgrass Arch portion of the Reservation contains most of the existing production. This production occurs in the clastic sediments of the Cretaceous and Jurassic sections, and in the carbonates of the Mississippian.

In contrast to the structurally complex Disturbed/Overthrust Belt, the Sweetgrass Arch structure is controlled by the generally westward dipping flank of the Sweetgrass Arch. The largest producing field, the Cut Bank Field, is the result of a stratigraphic trap in the Kootenai Formation. Some localized structural irregularities occurred along the west flank of the Sweetgrass Arch. Reagan Field is developed on one of these localized structural irregularities. Of the three geological provinces, only the Sweetgrass Arch has received more than limited exploration. However, even in this highly productive area of the Sweetgrass Arch the full potential of the geologic section has not been adequately tested.



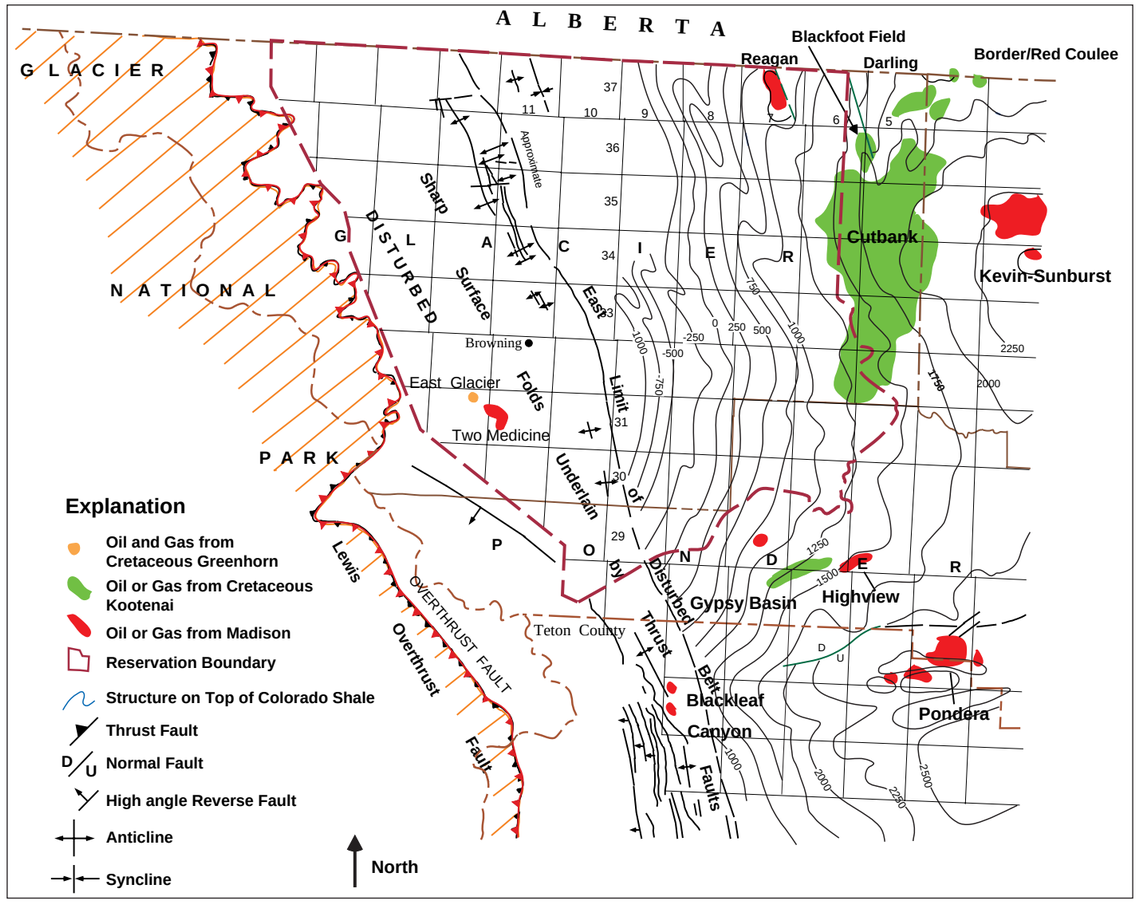


Figure BF-2.1. General structure map of reservation and surrounding region.

GENERAL PRODUCTION INFORMATION

U.S.G.S Geologic Province: North Central Montana

Tectonic Province: Sweetgrass Arch, Foreland Basin, Montana Disturbed Belt

Overall Production: 440 MMBO and 1.1 TCFG
from U.S.G.S. Play Production Province

No. of Fields: 170 discovered fields
58 greater than 1 MMBO or 6 BCFG

Fields Within Reservation Boundaries - (1995 Cummulative Production)

1941 **Reagan**	9.3 MMBO, 15 MMcfd, 54 wells
1955 **Two Medicine**	9.3 MMBO, 15 MMcf, 54 wells
1926, 1929 **Cutbank**	167.3 MMBO, 317 MMcf
(est. 20% within boundary)	447 wells oil, 235 wells gas

EARLY EXPLORATION ON THE BLACKFEET RESERVATION

Oil and gas was discovered in Montana in the late 19th century as oil seeps, in what is now Glacier National Park. The first Montana well in this area was drilled in October of 1901, and achieved a depth of 1450 feet in 1902. Gas was flared from a "sand unit" at a depth of 720 feet.

Swift Current Valley was the scene of the first commercialoil production in 1902. Early copper prospectors, among them Sand D. Soomes, is credited with the discovery of oil seeps during mining operations. By 1906, the field had six producing wells. With the establishment of Glacier National Park in 1910, oil exploration was suspended.

Early exploration on the Sweetgrass Arch, to the east of the reservation culminated in gas and oil discoveries in the late 1920's. January 1931, heralded the discovery of Cutbank Field, which is one of the largest in the Rocky Mountains. Twenty percent of this "giant" field is within the reservation boundaries.

Exploration during the late 1920's led to the discoveries in the Mississippian Madison with Pondera Field. Other discoveries throughout the 1930's and 40's led to both Cretaceous and Madison production. The 1950's saw a flurry of activity in the Montana disturbed belt which led to the discoveries of East Glacier/Two Medicine and Blackleaf Canyon. In 1980, Williams Exploration and Milestone Petroleum tested the "A" Thrust Sheet at Blackleaf Canyon and discovered gas with rates as high as 5.1 MMcfd.

NEARBY FIELDS

1956 Blackfoot - 1.6 MMBO, 3.0 MMcf, 8 wells oil, 7 wells gas
1958 Graben Coulee - 2.4 MMBO, 63 wells oil
1958 Red Creek - 6.5 MMBO, 1.2 MMcf, 18 wells oil
1954 Darling - 70,000 BO (Abn'd)
1929 Border - 497,000 BO, 346,000 Mcf, 1 well oil, 1 well gas
1929 Old Border - 798,450 BO, 7 wells oil
1954 Gypsy Basin - 504,783 BO, 3.1 MMcf, 4 wells total
1976 Highview - 101,477 BO, 741,600 Mcf, 7 wells total
1958, 1980 Blackfeet Canyon - 33,748 BO, 7.0 MMcf, (Abn'd)
Other small fields with no current production

PLAY TYPES ENCOUNTERED

Conventional
1) Fractured/Folded Anticline Mississippian Carbonate Play (2807)
2) Jurassic-Cretaceous Sandstone Play (2808)
3) Mississippian/Devonian Carbonate Play (2805)
4) Montana Disturbed Belt-Imbricate Thrust Play (2701)

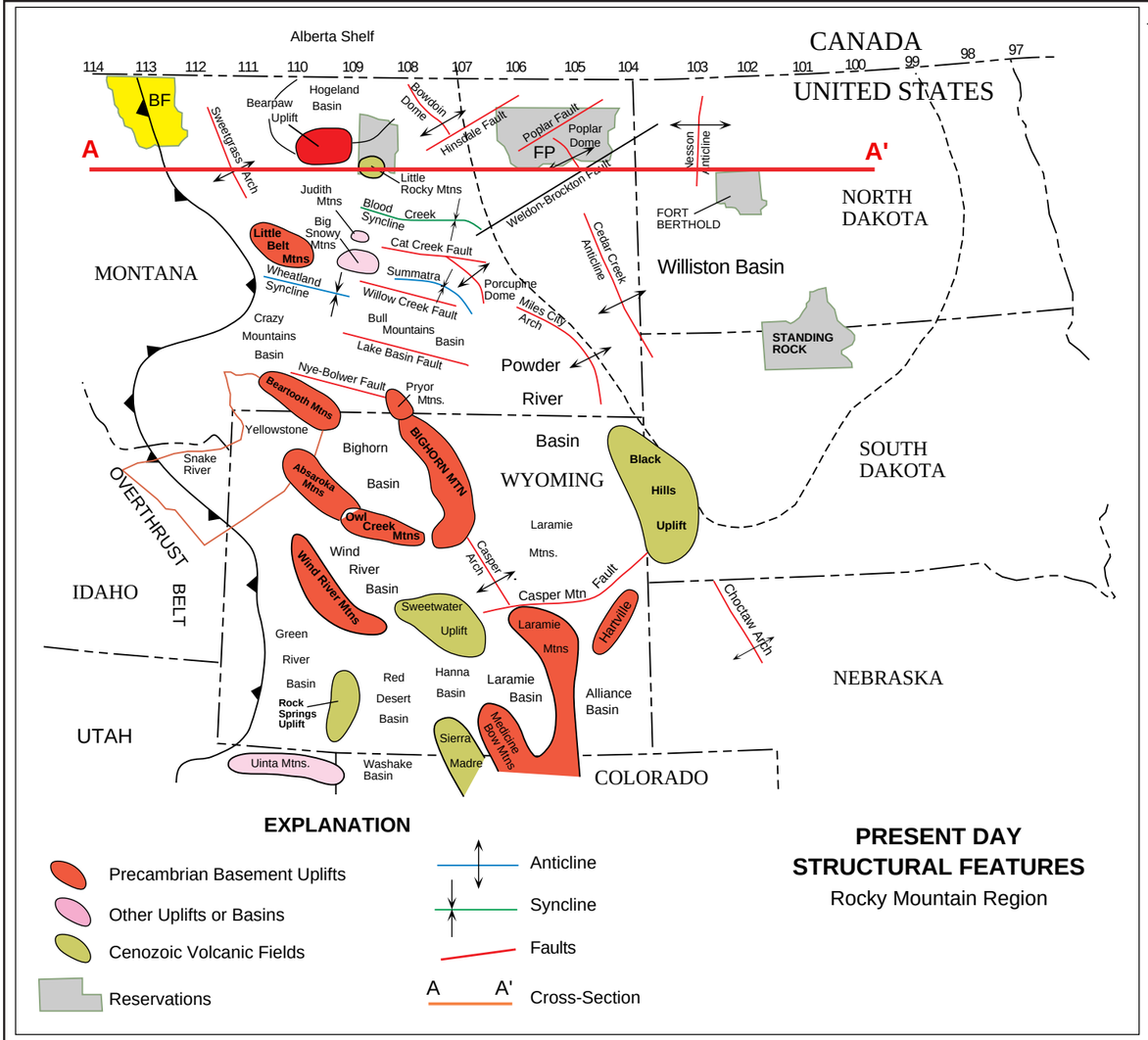
Unconventional or Hypothetical
5) Fractured Bakken (2804)
6) Cambrian Sands (2802)
7) Shallow Biogenic Gas (2810, 2811, 2812)

PRODUCING HORIZON LEGEND

S = Source Rock

ERA	SYSTEM	SERIES	COLOR CODE	WILLISTON BASIN	POWDER RIVER BASIN	WESTERN WYOMING SOUTHERN MONTANA	WESTERN & NORTHERN MONTANA
CENOZOIC	TERTIARY			Fort Union	White River Wasatch Fort Union	Green River Wind River Wasatch Fort Union	Fort Union
MESOZOIC	CRETACEOUS	UPPER		Fox Hills Judith River Eagle Niobrara Greenhorn	Lance Teckla Mesaverde Teapot Parkman Sussex Shannon Niobrara Frontier	Lance Fox Hills Mesaverde Cody Shannon Niobrara Frontier	Hell Creek Judith River Clagget Eagle Telegraph Creek Niobrara Greenhorn Frontier (S)
		LOWER		Dakota Group	Mowry Muddy Dakota Fall River Lakota	Mowry Muddy Bear River Dakota Cloverly	Blackleaf Bow Island Kootenai Cat Creek Moulton Sunburst (S) Cut Bank
	JURASSIC			Morrison Ellis Group Swift Reirdon Piper Nesson	Morrison Sundance Canyon Springs Gypsum Spring	Gannet Morrison Sundance Stump-Preuss Twin Creek	Morrison Ellis Group Swift Reirdon Sawtooth
	TRIASSIC			Spearfish	Chugwater Spearfish	Nugget Chugwater Ankareh Thaynes Woodside	
PALEOZOIC	PERMIAN			Minnekahta Opeche	Goose Egg	Dinwoody Phosphoria Park City	
	PENNSYLVANIAN			Minnelusa Amsden Tyler	Minnelusa	Weber Tensleep Amsden Darwin	Amsden Tyler
	MISSISSIPPIAN			Big Snowy Group Heath Otter Kibbey Madison Group Charles Mission Canyon Lodgepole	Madison Englewood	Madison Mission Canyon Lodgepole	Big Snowy Group Heath Otter Kibbey Madison Group Sun River Charles Mission Canyon Lodgepole (S)
	DEVONIAN			Bakken Three Forks Nisku Duperow Souris River Dawson Bay Winnipegosis	Jefferson	Jefferson Darby	Three Forks Nisku Duperow Souris River (S)
	SILURIAN			Interlake	Interlake		
	ORDOVICIAN			Stonewall Stony Mountain Red River	Big Horn Winnipeg	Big Horn	Red River
	CAMBRIAN			Winnipeg Deadwood	Deadwood	Gallatin Gros Ventre Flathead	Emerson Flathead

Figure BF-2.2. Producing Horizon Legend (after Geomap Executive Reference Map,1983).



◀ **Figure BF-3.1.** Present day structural uplifts and basins, Fort Peck Reservation and location of regional cross-section A-A' (modified after Peterson 1987).

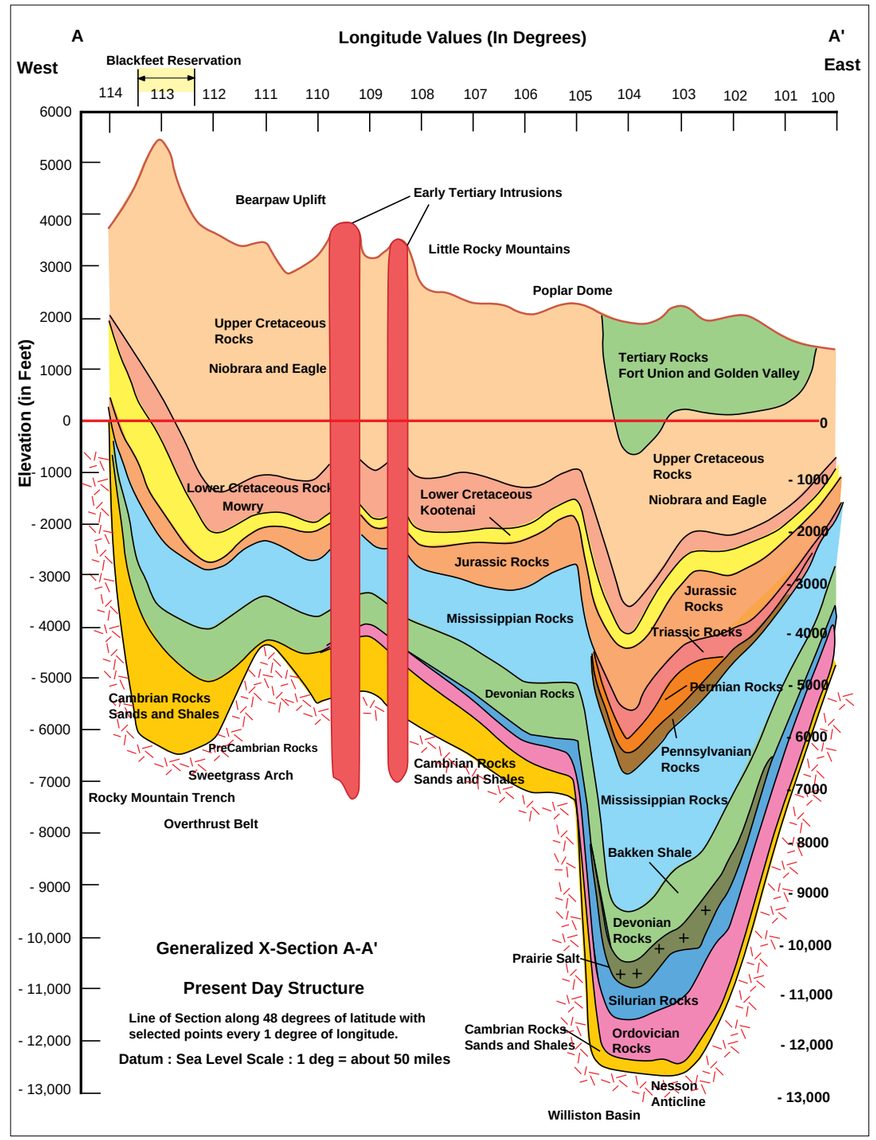


Figure BF-3.2. Generalized cross-section A-A', present day structure.

Regional Geology

The Blackfeet Reservation lies within three distinct geologic provinces, the Montana Disturbed Belt to the west, the Foreland Basin in the center, and the Sweetgrass Arch to the east (see tectonic map and structure cross-section A-A'). The Mesozoic section, composed of Cretaceous and Jurassic rocks is predominatly sand and shale. The Paleozoic section is Mississippian and Devonian in age and is mainly carbonates. The Cambrian section is mainly composed of coarse-grained clastics.

Proven hydrocarbon production (see correlation chart and type log), is mainly from Lower Cretaceous Blackleaf and Kootenai sandstones, although some production is from Upper Cretaceous Greenhorn. Oil and gas is also produced from Jurassic age Swift and Sawtooth sands. Paleozoic production is from the Madison Sun River Dolomite and the Devonian Nisku.

Geologic History

A generalized structural cross-section (see cross-section A-A', Figure BF-3.2) summarizes present day tectonic provinces and older paleostructure. The cross-section uses rock thickness values from each of the geologic periods. The section runs along the 48 degree latitude line and values were selected at one degree longitude intervals.

The western end of the section, near the Blackfeet Reservation is dominated by high relief (greater than 5000 feet). The Cretaceous and older Paleozoic section is about 11,000 feet thick. Major basement uplifts, such as the Sweetgrass Arch and Bearpaw Uplift, influenced sedimentation throughout geologic time.

The eastern side of the cross-section is dominated by the Williston Basin, a stabel cratonic depocenter which has more than 15,000 feet of sediments. The Fort Berthold Reservation is located near the depocenter and is within close proximity to Nesson Anticline, a major oil producing structure.
Between these two tectonic provinces lie the Fort Peck and the Fort Belknap Reservations, Fort Peck is on the western flank of the Williston Basin and is dominated by Poplar Dome, a Laramide age structure, while Fort Belknap is between Bowdoin Dome and Bearpaw Uplift.

A paleo cross-section attempts to show what the subsurface geolgy may have looked like within that time interval. For the sake of space, only the particular interval is shown; no rocks older than it are illustrated. The rock units above the interval have not yet been deposited; the top of the section is the datum. The datum is flat, representing the paleo ground surface.

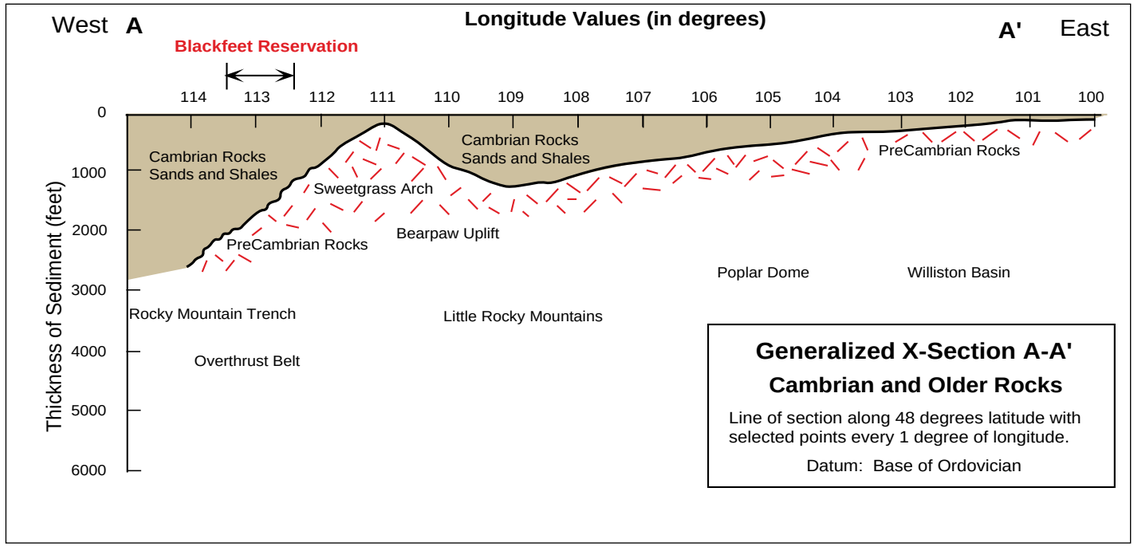


Figure BF-4.1. Generalized time slice cross-section of Cambrian paleo-topography along line of section A-A".

Cambrian Geologic History

Precambrian age supracrustal sedimentary rocks (Superbelt) are buried in the western part of the reservation and extend into Glacier National Park. These rocks are estimated to be from 900 to 1400 million years old.

During Cambrian time, a major seaway existed in western Montana and eastern Idaho (see cross-section A-A' Figure BF-4.1 and map of the Cambrian). This seaway gradually transgressed from west to east across eastern Montana and the Dakotas. The major source of coarse-grained clastics was to the east (from the Sioux Arch) and graded into shales and limestones to the west. Thickness of the Cambrian varies from over 2000 feet at the reservation to less than 100 feet thick at the eastern edge of the Williston Basin.

Between these two tectonic provinces lie the Fort Peck and the Fort Belknap Reservations. Fork Peck is on the western flank of the Williston Basin and is dominated by Poplar Dome, a Laramide age structure, while Fort Belknap lies between Bowdoin Dome and the Bearpaw Uplift.

To better illustrate the geologic history of the region, which has been influenced by all of these tectonic provinces, a series of paleo cross-sections are shown. Each section summarizes a particular time interval; Cambrian and older rocks, Ordovician to Triassic and Cretaceous to Jurassic. Since Tertiary sediments are present only in the Williston Basin, no paleostructure section is shown.

A paleo cross-section attempts to show what the subsurface geology may have looked like within that time interval. For the sake of space, on the particular interval is shown; no rocks older than it are illustrated. The rock units above the interval have not yet been deposited; the top of the section is the datum. The datum is flat, representing the paleo ground surface.

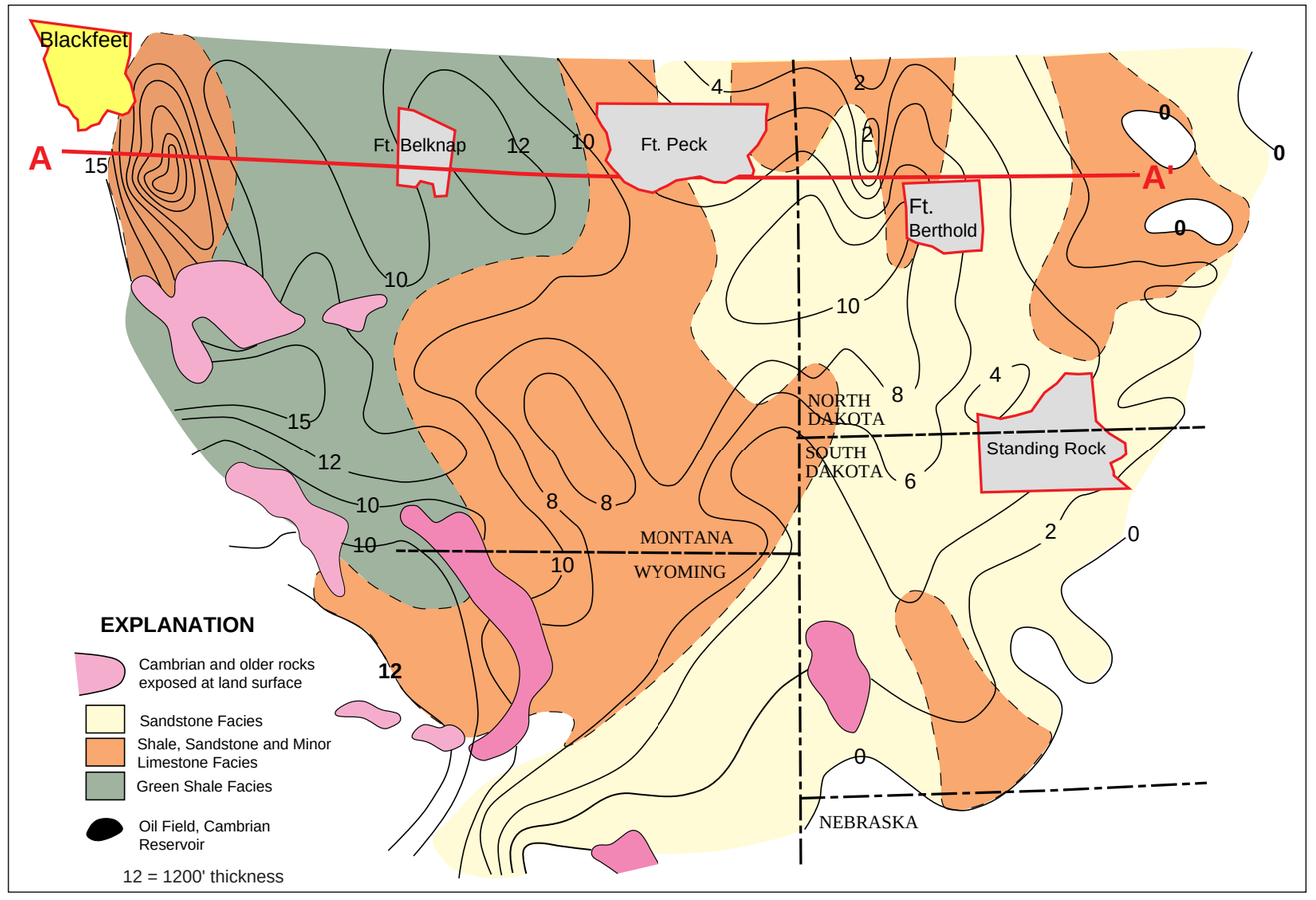


Figure BF-4.2. Thickness of Deadwood and equivalent rocks. Blackfeet Reservation, location of analog fields and location of regional cross-section A-A' (modified after Peterson, 1987).

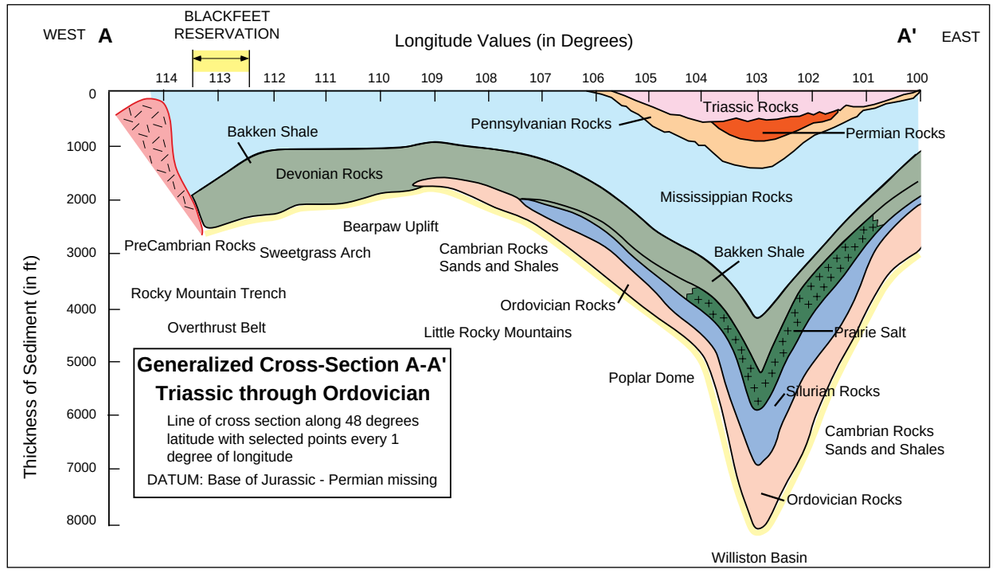


Figure BF-5.1. Generalized cross-section A-A', line of section along 48 degrees of latitude with selected points every 1 degree of longitude (after C.W. O'Melveny, 1996).

Ordovician to Triassic Rocks

From late Cambrian through most of the Paleozoic, the Williston Basin on the east side of the cross-section was the dominant receiver of sediments (see cross-section A-A', Figure BF-5.1). The Williston is a major, stable, cratonic basin, and is characterized by shallow, marine sediments. Ordovician and Silurian rocks were deposited in a tidal flat, cyclic carbonate and evaporite sequence. At the end of Silurian time, a regional unconformity extended across the Williston and to the west. There are no Ordovician or Silurian rocks within the reservation boundaries.

Devonian rocks are widespread across the area. The Devonian is characterized by cyclic evaporite and carbonate units including the Prairie Salt sequence in the Williston. The Prairie's western edge was dissolved away during late Devonian time, and caused the formation of several hydrocarbon traps. Deposition of marine shales and limestones continued throughout Devonian time, culminating with the Bakken Shale. The Bakken, and it's Alberta equivalent, the Exshaw, is a black, organic-rich shale, which is thought to be the main source rock for the Madison oil throughout the region. Devonian rocks including the Bakken are about 700 feet thick at the reservation. The Bakken/Exshaw varies from 10 feet thick to more than 50 feet thick in this area (Figure BF-5.2).

By Mississippian time, the Williston Basin to the west was continually depositing limestones and evaporites in a shallow, marine shelf environment. Most of the producing reservoirs in the Williston Basin area are from these cyclic marine shales, limestone/dolomite porosity zones and evaporite seal sequences. Eventually, the Charles Salt would cover the entire basin and part of eastern and central Montana. By late Mississippian time, deposition was mainly shales and mudstones confined to the central Williston and the Big Snowy trough in Central Montana.

A smaller depocenter of Mississippian rocks existed west of the Sweetgrass Arch and Bearpaw uplift which were positive features in Mississippian time. Total thickness of Mississippian rocks within Reservation boundaries is about 1500 feet.

A major unconformity at the end of Mississippian time led to widespread erosion and karstification. Pennsylvanian sediments are confined to the center of the Williston and in central Montana south of the reservation. Tyler sands and shales are present in the Williston. No Pennsylvanian rocks occur west of longitude 106 degrees along the line of section.

Permian deposits are confined to the central Williston and are predominantly sand/shale and evaporite sequences. A major unconformity at the end of Permian time has removed any evidence of these rocks west of longitude 104 degrees. Triassic rocks are confined to the center of the Williston and are not present on the Blackfeet Reservation.

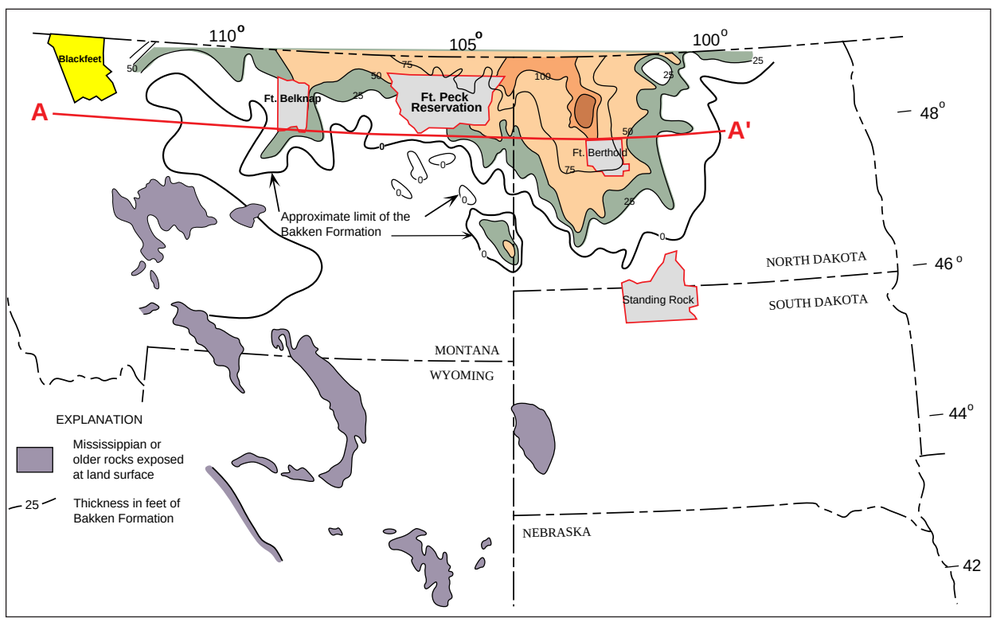


Figure BF-5.2. Map showing thickness of Bakken Rocks, facies, location of analog fields, Blackfeet Reservation and location of regional cross-section A-A' (modified after Peterson, 1987).

Jurassic to Cretaceous Rocks

In Jurassic time, the Williston was still the major depocenter for clastic and marine/evaporite sediments. The western edge of the cross-section shows that the Jurassic was fairly thin, implying that the Sweetgrass Arch and Bearpaw Uplift were still positive features (see cross-section A-A', Figure BF-5.1). Fluvial sands from the eroding highlands filled paleovalleys cut in the exposed Mississippian rocks. Thickness of Jurassic rocks is estimated to be about 500 feet thick.

Early Cretaceous time saw the development of the Thrust sheets in western Utah and eastern Idaho. The Sevier Orogenic event created a major mountain front which formed an asymmetrical basin with the long axis at the present Idaho-Montana border. Sediment from the western highlands were continually deposited at the foot of the mountain front. Deposits were mainly composed of Mississippian and older rocks, with some Cretaceous aged volcanic rocks. This material was carried by rivers and deposited eastward into the Cretaceous seaway (Lower Cretaceous, Kootenai formation). Deposition continued, becoming more marine (Mowry shale, Blackleaf sandstone).

By Upper Cretaceous time, volcanic activity increased. Fluvial deposits continued to carry sediments to the eastern inland seaway. This seaway covered most of eastern Montana, and the great plains from Texas to the Arctic Circle. Extensive chalk (Niobrara Formation) was deposited in the Williston southeast into South Dakota, Nebraska and Colorado.

By the end of the Upper Cretaceous, mountain building began in western Montana with increasing volcanic activity and thrust faulting. Fluvial deposition increased due to uplift and erosion and resulted in the deposition of nearshore and continental sands (Eagle/Judith River/Foxhills). Cretaceous units are abundant on the reservation. Estimated thickness of Cretaceous rocks is greater than 7200 feet.

Tertiary and Younger

Tertiary time saw the erosion of older Cretaceous rocks and is characterized by fluvial deposition. Swamps existed in Paleocene and Eocene time in the central Williston, which formed coal deposits at the end of the Eocene. Western Montana apparently had no Tertiary deposition while central and eastern Montana had deposition of some continental sediments.

Quaternary time was a period of major continental ice sheets extending into North Dakota and Montana. Alpine glaciers existed in Montana's western mountains. Extensive glacial lakes were present along the ancestral Missouri River and its tributaries.

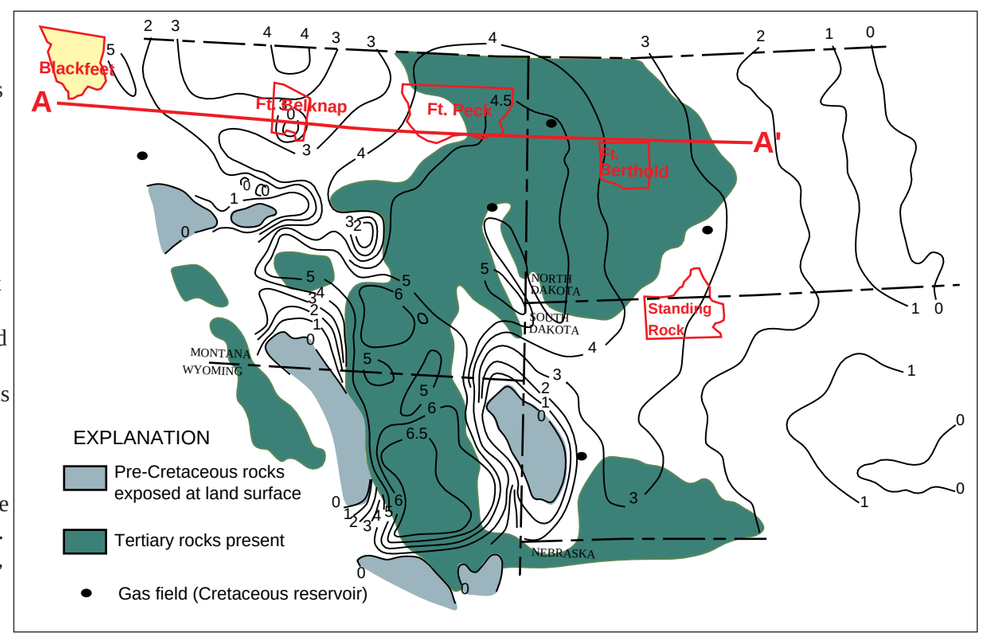
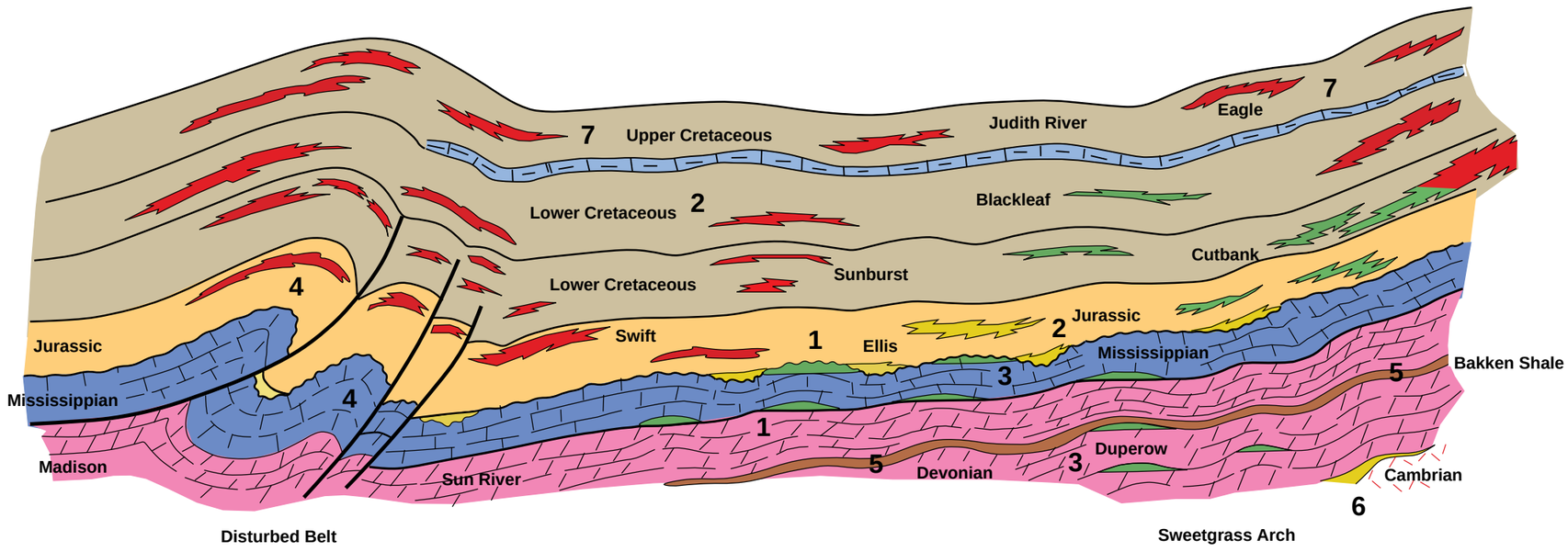


Figure BF-5.3. Map showing general distribution of Cretaceous and Tertiay rocks, Blackfeet Reservation and location of regional cross-section A-A'.



PLAY TYPES - Explanation

1. Folded and Fractured Mississippian Carbonates (2807)
2. Jurassic / Cretaceous Sands (2808)
3. Mississippian / Duperow (2805)
4. Imbricate Trust Sheets (2701)
5. Fractured Bakken (2804)
6. Cambrian Sands (2802)
7. Shallow Biogenic Gas (2811, 2812)

Sandstone
Shale
Shales, sands, and siltstones
Gas
Oil
Thrust Faults
Chalk
Limestone
Dolomite
Igneous / Metamorphics
Sandstone Lenses
Unconformity

Figure BF-6.1. Schematic diagram of play types Blackfeet Reservation

Reservation: Blackfeet
Geologic Province: North Central Montana, Sweetgrass Arch, Montana Disturbed Belt
Province Area: North Central Montana (62,500 sq. miles), Thrust Belt (41,400 sq. miles)
Reservation Area: 2385 sq. miles (1,525,712 acres)

Total Production (by province-1996)

	North-Central Montana	Disturbed Belt
Oil:	440 MMBO	
Gas:	1.1 TCFG	6 BCFG
NGL:	192 MBNGL	33,000 BNGL

Undiscovered resources and numbers of fields are for Province-wide plays. No attempt has been made to estimate number of undiscovered fields within the Fort Berthold Reservation

Play Type	USGS Designation	Description of Play	Oil or Gas	Known Accumulations	Undiscovered Resource (MMBOE) Field Size (> 1 MMBOE) min, median, mean	Play Probability (chance of success)	Drilling depths	Favorable factors	Unfavorable factors
Fractured, folded anticlines in Mississippian Carbonates **1**	2807	folded structures, porosity controlled by matrix or fractures.	Both	49.32 MMBO 21,506 MMCFG 585 MBNGL (numbers include Mississippian and Devonian Play)	**Median:** 9 MMBO (9 fields @ 1MMBO) **Field Size (>1 MMBOE)** 1 MMBO(min) 3 MMBO(median) 1.2 MMBO(max) **No. of undiscovered fields (> 1 MMBOE)** 3 (min) 9 (median) 17 (max) 9.4 (mean)	1 not estimated	1,000-6700 ft	1) confirmed play 2) structure detected on seismic 3) source / reservoir rocks exists 4) thermally mature	1) lack of well control 2) rough topography 3) porosity may vary
Jurassic, Cretaceous sandstones **2**	2808	stratigraphic traps; discontinuos sands, updip pinchouts. Fluvial and nearshore sandstones.	Both	134 MMBO 318 BCFG 9 MMBNGL (most from Cutbank)	**Median:** 30 MMBO (15 fields @ 2 MMBO) **Field Size (>1 MMBOE)** 2 MMBO(min) 20 MMBO(median) 5.3 MMBO(max) **No. of undiscovered fields (> 1 MMBOE)** 6 (min) 15 (median) 28 (max) 15.8 (mean)	1 not estimated	1,000-4,000 ft	1) confirmed play 2) source / reservoir rock exists 3) thermally mature 4) shallow drilling targets 5) probably many fields	1) lack of well control 2) seismic may not detect strat traps 3) porosity may vary
Mississippian and Devonian carbonates **3**	2805	1) Jurassic / Mississippian unconformity traps 2) Devonian Structural Traps	Both	(see numbers from Miss.)	**Median:** 48 MMBO (12 fields @ 4 MMBO) **Field Size (>1 MMBOE)** 3 MMBO(min) 21 MMBO(median) 4.8 MMBO(max) **No. of undiscovered fields (> 1 MMBOE)** 3 (min) 12 (median) 21 (max) 12 (mean)	1 not estimated	1300-7000 ft	1) confirmed play 2) source / reservoir rocks exist 3) thermally mature 4) structure detected on seismic	1) deeper drilling depths 2) Devonian contains nitrogen gas 3) porosity unknown for Devonian rocks

Table BF-6.1. Play summary chart.

Reservation: Blackfeet
Geologic Province: North Central Montana, Sweetgrass Arch, Montana Disturbed Belt
Province Area: North Central Montana (62,500 sq. miles), Thrust Belt (41,400 sq. miles)
Reservation Area: 2385 sq. miles (1,525,712 acres)

Total Production (by province-1996)	North Central Montana	Disturbed belt
Oil:	440 MMBO	
Gas:	1.1 TCFG	6 BCFG
NGL:	192 MBNGL	33,000 BNGL

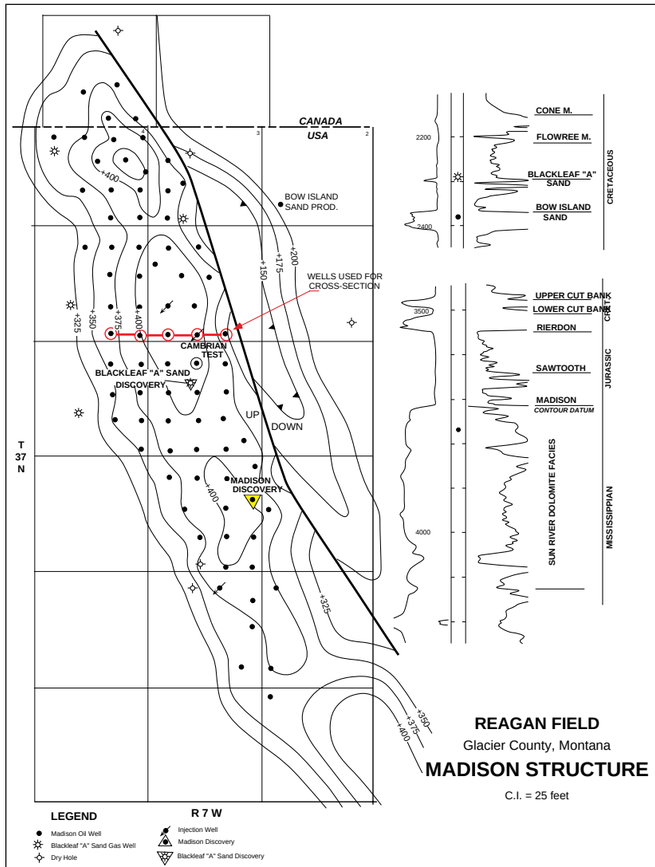
Undiscovered resources and numbers of fields are for Province-wide plays. No attempt has been made to estimate number of undiscovered fields within the Fort Berthold Reservation

Play Type	USGS Designation	Description of Play	Oil or Gas	Known Accumulations	Undiscovered Resource (MMBOE) Field Size (> 1 MMBOE) min, median, mean	Play Probability (chance of success)	Drilling depths	Favorable factors	Unfavorable factors
Montana Disturbed Belt; Imbricate Thrust Sheets **4**	2701	Thrusted units forming shallow and deep anticlines	Mainly gas	No total available from United States Geological Society	**Median:** 900 BCFG (10 fields @ 90 BCFG) **Field Size (>1 MMBOE)** 90 BCFG(median) 366.2 BCFG(max) **No. of Undiscovered Fields (>1 MMBOE)** 5 (min) 10 (median) 115 (max) 5 (mean)	0.5 not estimated	3000-19,000 ft.	1) confirmed play 2) source / reservoir rocks exists 3) thermally mature 4) structure detected on seismic	1) small accumulations to date 2) seismic intensive 3) maybe thermally over mature (some Nitrogen Gas)
Fractured Bakken **5**	2804	Bakken / Exshaw shale high organic content, thermally mature; fractured reservoir	Oil	Not applicable	Not estimated 18,000 BO / sp. mi. 47,520 BO / sq. mi. 5328 sq. mi. untested	0.25 0.2	5,000-10,000 ft.	1) Bakken exists 2) thermally mature 3) structures and flexures exist	1) no existing production within province 2) source rock unknown 3) thermal maturity unknown 4) lack of deep well control
Cambrian Sands **6**	2802	Coarse sands trapped as pinchouts or on deeper structures	Both	Not applicable	**Median:** 2 MMBO (2 fields @ 1 MMBO) **Field Size (>1 MMBOE)** 1 MMBO (min) 5 MMBO(median) 1.3 MMBO(max) **No. of Undiscovered fields (> 1 MMBOE)** 1 (min) 2 (median) 4 (max) 1.1 (mean)	0.5 not estimated	1,700-7000 ft.	1) reservoir rock exists 2) structures exist 3) structure detected on seismic	1) no exciting production within province 2) source rock unknown 3) thermal maturity unknown 4) lack of deep well control
Shallow Biogenic Gas **7**	2811 2812	Accumulation in Upper Cretaceous units; Eagle, Judith River, Niobrara	Biogenic Gas	504,000 MMCFG from numerous fields in province	**Median:** 280 BCFG (14 fields @ 20 BCFG) **Field Size (>1 MMBOE)** 20 BCFG(median) 27.4 BCFG (max) **No. of Undiscovered fields (> 1 MMBOE)** 5 (min) 14 (median) 26 (max) 14 (mean)	1 0.50-0.70	700-3000 ft.	1) source rock / self source 2) reservoir rock exists 3) shallowing drilling depths 4) occasional gas shows	1) size of accumulation unknown 2) porosity decreases with depth 3) exposed to atmosphere possible leakage 4) tracking mechanism

Table BF-7.1. Play summary chart.

Conventional play type

Unconventional/Hypothetical play type



REAGAN FIELD
Glacier County, Montana
MADISON STRUCTURE
C.I. = 25 feet

EAST-WEST CROSS SECTION
REAGAN FIELD

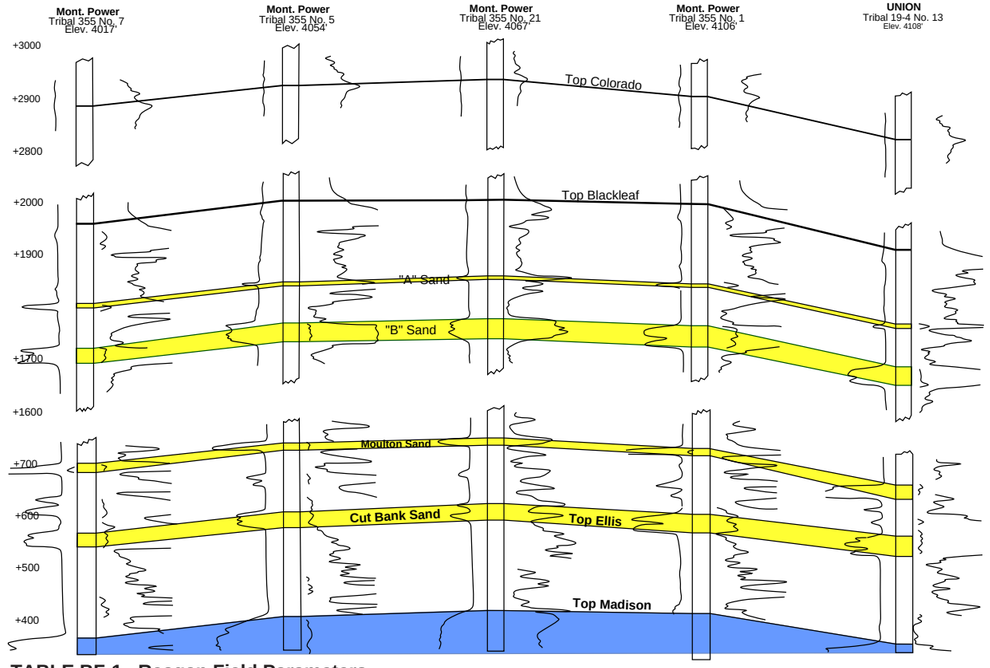
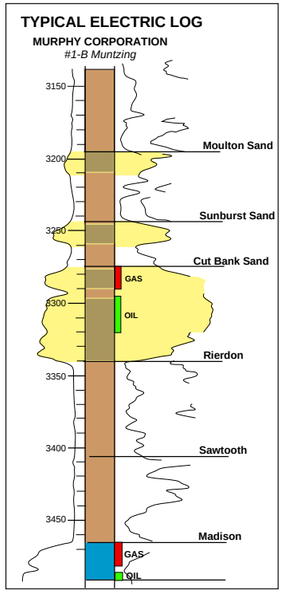


TABLE BF-1. Reagan Field Parameters

Formation:	Madison	**Average Depth:**	3900 ft. (+375)
Lithology:	Dolomite	**Porosity:**	12%
Oil/Gas Column:	52 foot oil column 68 ft. gas column (original)	**Permeability:**	10 md
		Other Shows:	Blackleaf "A" Sand, Madison
Average Net Pay Thickness:	20 feet		

Figure BF-8.1. Source rock along the Sweetgrass Arch is thought to be the black, organic Bakken/Exclaw shale or marine Lodgepole limestone. Source rocks on the Arch are considered mature, while those in the Montana disturbed belt are overmature. Typical traps are folded Madison rocks, with enhanced fracture porosity.



Blackfeet Field Type Log
Glacier County, Montana
Cutbank Sandstone
Madison Sun River Dolomite

◀ **Figure BF-8.2.** Type log from the Blackfoot Field showing production from both Madison carbonates and from younger karst-related sandstone deposits.

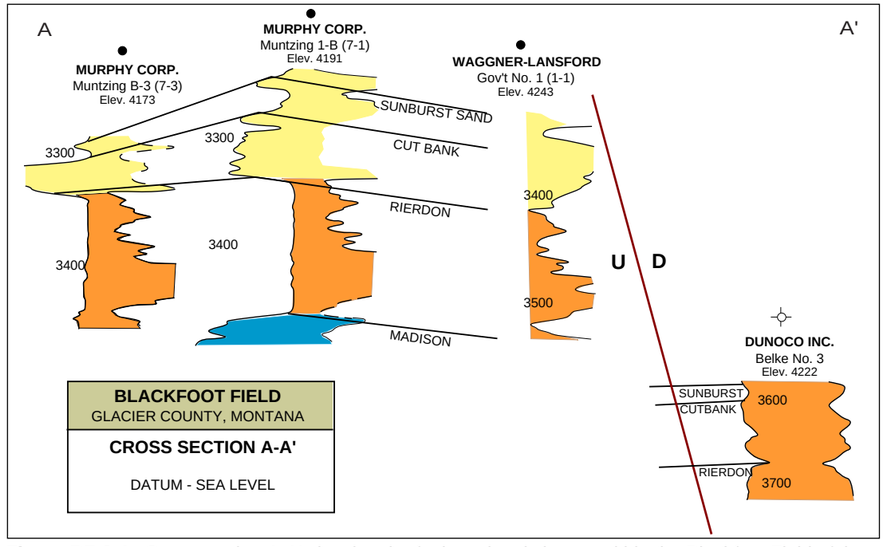


Figure BF-8.4. Cross-section A-A' showing the fault-assisted closure within the Blackfoot Field of the Cut Bank sandstone.

PLAY TYPE 1

Fracture / Folded Anticline Mississippian Carbonate Play

General Characteristics - This play consists of folded or fractured Madison limestones or dolomites. Reservoir rock consists of either (1) sub-tidal carbonate beds with enhanced porosity zones due to dolomitization or (2) paleokarst porosity that developed during post-Mississippian erosion. Source rock along the Sweetgrass Arch is thought to be the black, organic rich Bakken /Exchaw shale, or marine Lodgepole limestone.

Source rocks on the Arch are considered mature, while those in the Montana disturbed Belt are overmature. Typical traps are folded Madison rocks, with enhanced fracture porosity.

ANALOG FIELDS (*) denotes fields within the Reservation boundaries)

Reagan Field *	(Sweetgrass Arch)	9.3 MMBO, 15 MMcf	54 wells
Blackfeet Field	(Sweetgrass Arch)	1.6 MMBO, 3.0 MMcf	8 wells oil, 7 wells gas
Gypsy Basin	(Sweetgrass Arch)	504,783 BO, 3.1 MMcd	4 wells
Red Creek	(Sweetgrass Arch)	6.5 MMBO, 1.2 MMcd	18 wells oil

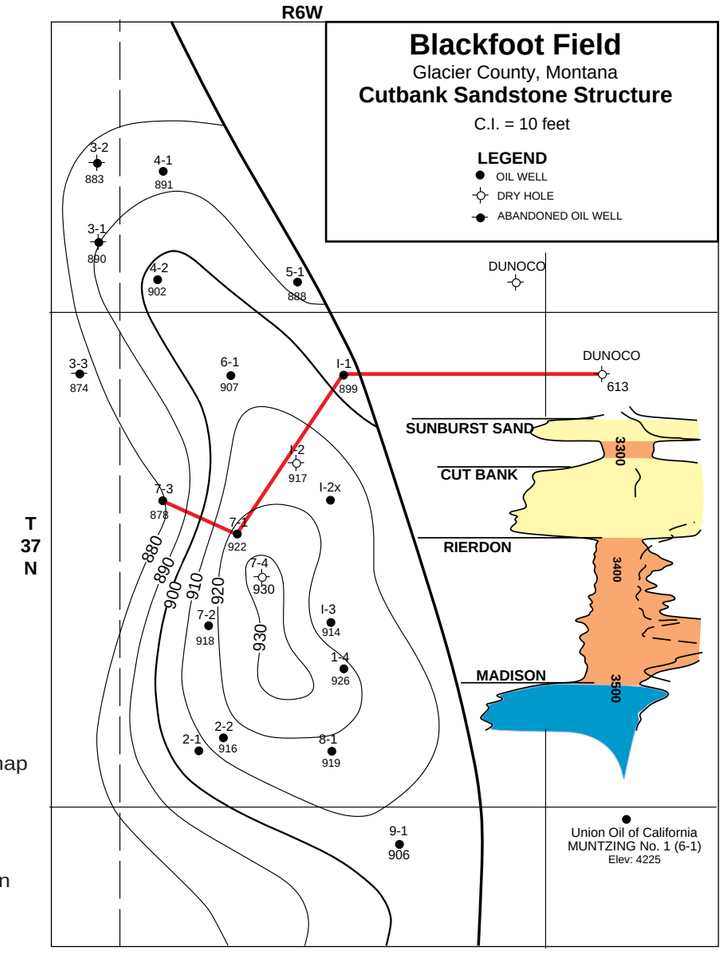
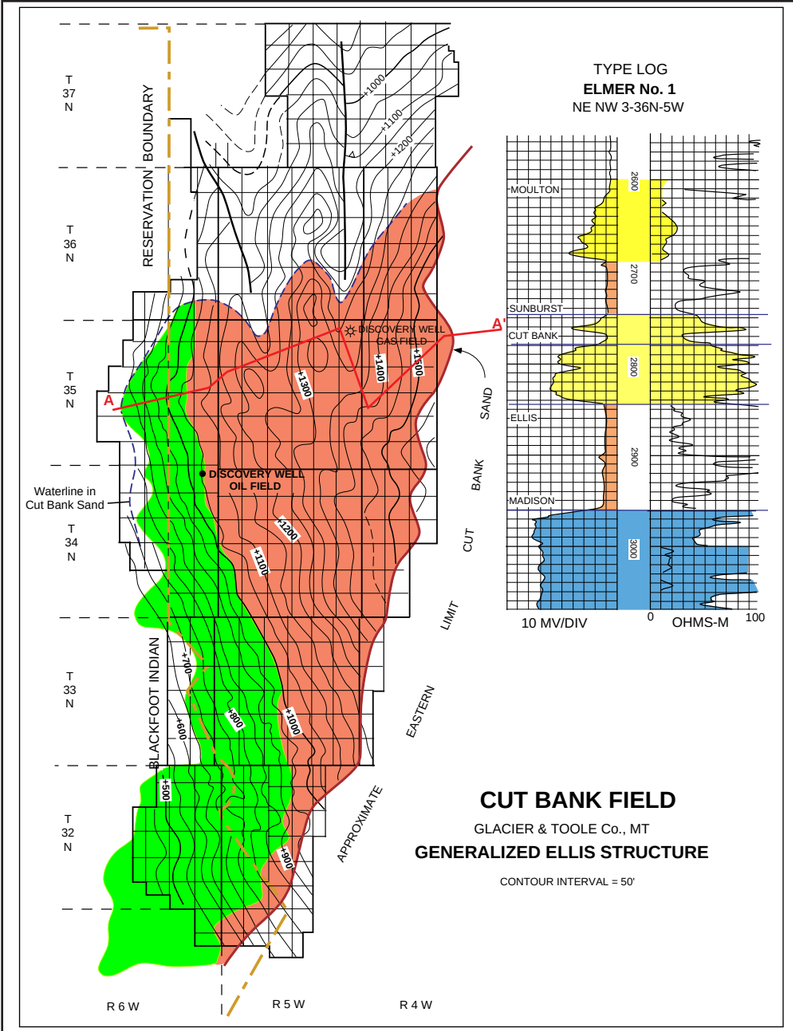


Figure BF-8.3. ▶ Structure contour map of Blackfoot Field. Datum is top of Cut Bank sandstone. Shows position of cross-section A-A' in Figure BF-8.4.



◀ **Figure BF-9.1.** Structure map of the Cut Bank Field, showing the structural and stratigraphic position of Cut Bank sandstone deposits related to underlying Karst development within the Madison carbonates (after T.G. Cully, Montana Geological Society, 1984).

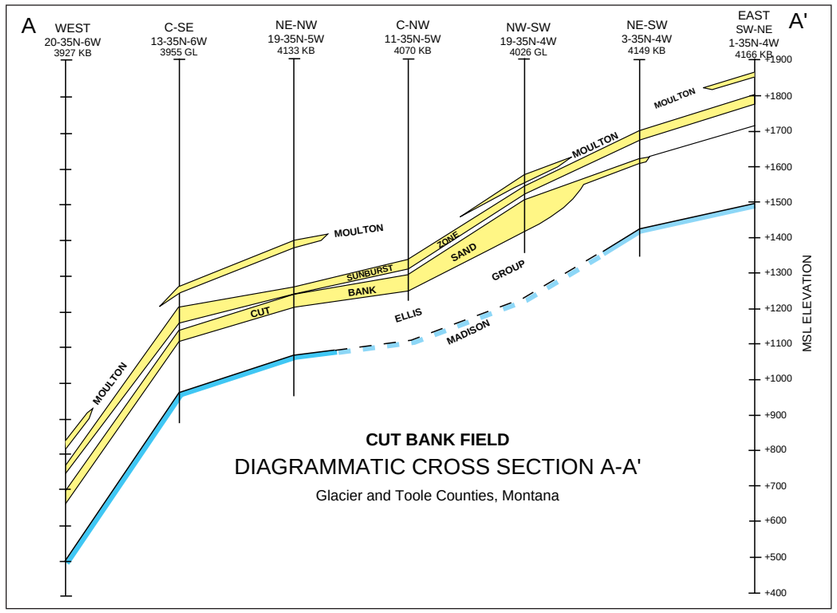


Figure BF-9.2. Cut Bank Field diagrammatic cross-section A-A' showing discontinuous nature of sandstone development across structure (after T.G. Cully, Montana Geological Society, 1984).

Cut Bank Field Parameters

Formation:	Cretaceous Cut Bank Sandstone Colorado Group sands (Moulton, Sunburst, Lander) Mississippian Madison
Lithology:	Cretaceous Cut Bank Sandstone, blanket sand which pinches out updip
Average Depth:	3900 feet (+375)
Porosity:	Moulton: 19-20% Sunburst: 14-24% Lander: 18-24% Cut Bank: 12-19%
Permeability:	Moulton - 200 md Sunburst - not known Lander - 827 md Cut Bank - 110 md Madison - not known
Oil/Gas Column:	52 foot oil column 68 foot gas column (original)
Average Net Pay Thickness:	Variable with formation

SW Cut Bank Field Parameters

Formation:	Cut Bank
Lithology:	Cretaceous Cut Bank Sandstone, blanket sand which pinches out updip
Average Depth:	3900 feet (+375)
Porosity:	Moulton: 19-20% Sunburst:14-24% Lander: 18-24% Cut Bank: 12-19% Madison: 10%
Permeability:	Cut Bank: 1 to 450 md
Oil/Gas Column:	Information not available
Average Net Pay Thickness:	27 feet

PLAY TYPE 2

Jurassic/Cretaceous Sandstone Play

General Characteristics - This play is the major producing interval on the Sweetgrass Arch. Stratigraphic in nature, typical traps are discontinuous fluvial sandstones in the Jurassic Sawtooth and Swift formations. Sandstones in the Cretaceous Kootenai and Blackleaf intervals are also productive.

Several traps are blanket sandstones that pinchout in an updip position along structural trends. Numerous smaller fields are probably present on the flanks of the Sweetgrass Arch and the Kevin-Sunburst Dome. Source rock is thought to be Cretaceous marine shales which are thermally mature across the region.

Analog Fields (*) denotes fields which lies within the Reservation boundaries)

Reagan Field *	(Sweetgrass Arch)	Sunburst and Cut Bank Sands
Blackfoot Field	(Sweetgrass Arch)	Cut Bank Sands
Cut Bank*	(Sweetgrass Arch)	Cut Bank sands (est 15% with boundary)167.3 MMBO, 317 MMcf, 447 wells oil, 235 wells gas
Kevin Sunburst	(Sunburst Dome)	Cumulative production (1985) 74.9 MMBO more than 79.5 MMcf (1963) Nisku (1 well), Madison (795 wells) Swift (25 wells)
Soberup Coulee	(Sweetgrass Arch)	21,853 Mcf (abn'd)
Gypsy Basin	(Sweetgrass Arch)	Sunburst Sand

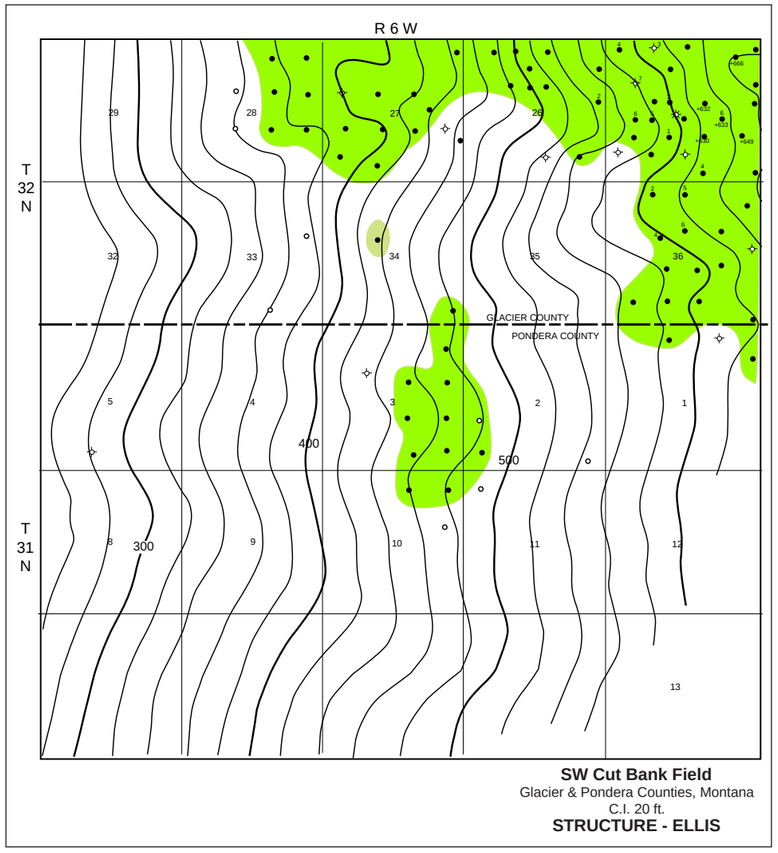


Figure BF-9.3. SW Cut Bank Field showing stratigraphic pinch-outs in the updip direction which correspond to the distribution of production (after W.L. Foley, Montana Geological Society, 1981).

PLAY TYPE 3

Devonian / Mississippian Carbonate Play

General Characteristics - Very little Devonian production has been found to date. Probably found on structures, and numerous shows have been recorded on deep tests at Kevin-Sunburst Gypsy Basin and Highview Fields. A Mississippian play on the Madison unconformity surface is also a distinct possibility. Corresponds to the same United States Geological Survey play classification.

Analog Fields (*) denotes fields within Reservation

Gypsy Basin (Sweetgrass Arch)	504,783 BO, 3.1 MMcf, 4 wells contain shows in Devonian rocks
Kevin-Sunburst Blackleaf Canyon	Contains 1 Devonian Nisku producer
Pondera Field (Sweetgrass Arch), 1984	22.5 MMBO, 224,702 Mcf, 361 wells

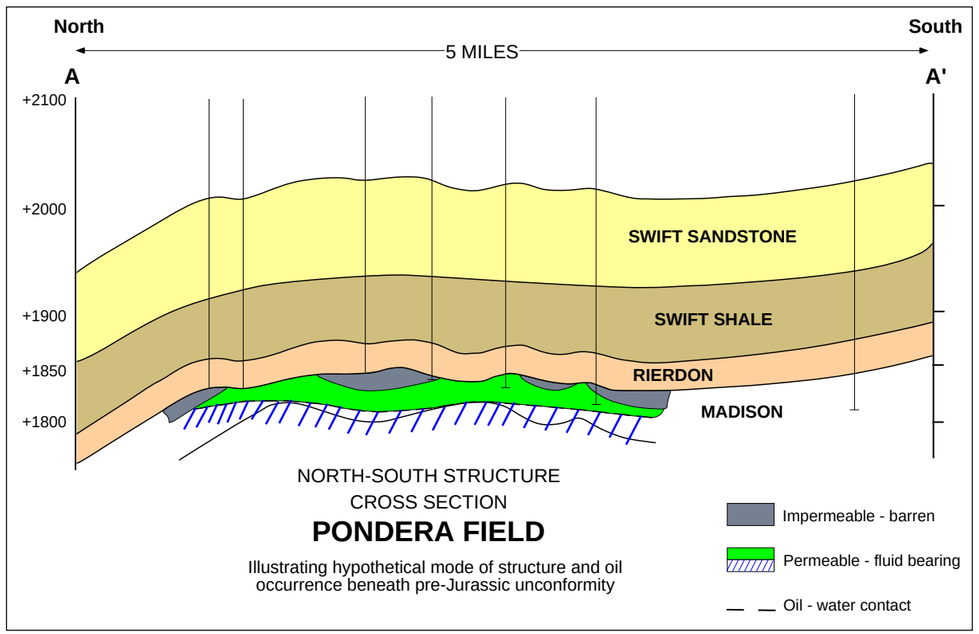


Figure BF-10.1. North-south structure cross-section, Pondera Field showing position of permeable, karsted Madison carbonates.

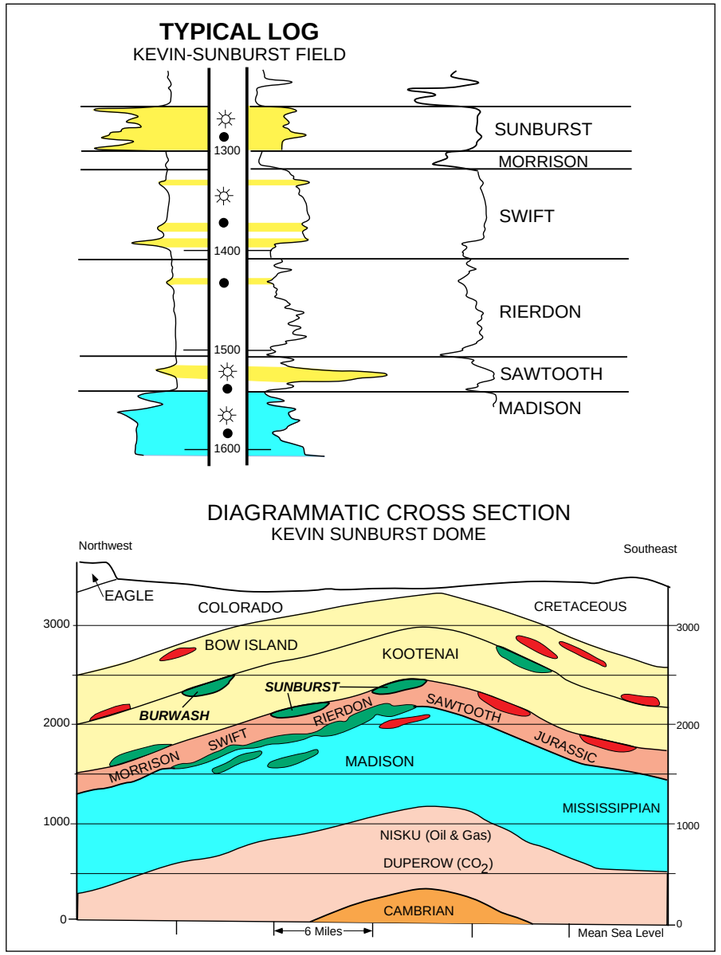


Figure BF-10.2. Typical log, Kevin-Sunburst Field and diagrammatic cross-section. Shows both the Karst-related (Madison) distribution of sandstone reservoirs and development of channel-related (Cretaceous) sandstone horizons (from Montana Geological Society, 1985).

Pondera Field Parameters

Formation:	Mississippian Sun River
Lithology:	Light gray to buff, finely crystalline to sugary dolomite, 140ft. thick
Average Net Pay Thickness:	10 feet
Other shows:	Bow Island Sand Kootenai channel sands, Sun River
Average Depth:	1950 feet (+1820 msl)
Porosity:	14%
Permeability:	82 md
Oil/Gas Column:	70 to 100 foot oil column

This field is a pre-Jurassic truncation of folded Mississippian rocks, and part of a Laramide structural terrace.

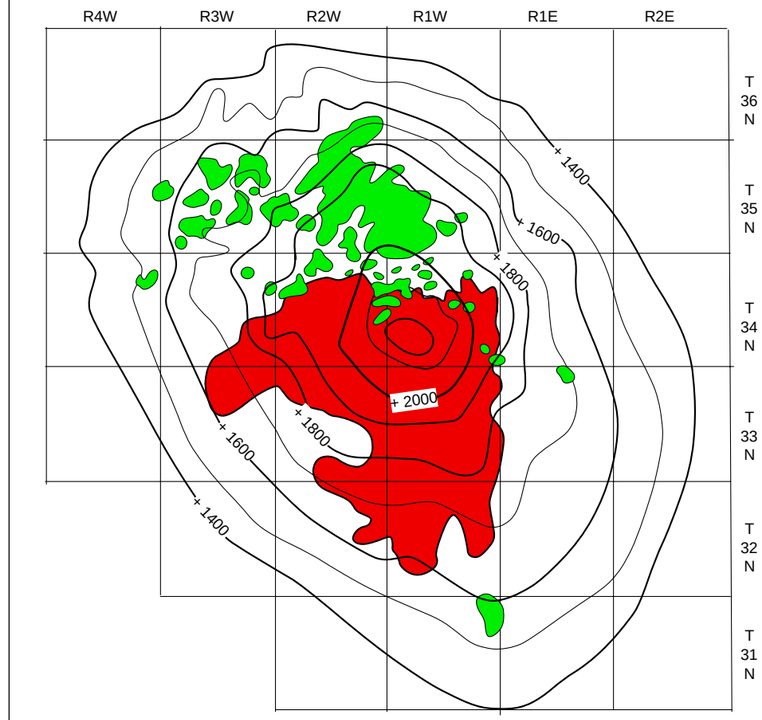


Figure BF-10.3. Kevin-Sunburst Dome (after Montana Geological Society, 1985).

Kevin-Sunburst Field Parameters

Formation:	Mississippian Madison
Lithology:	Dolomitic limestone, varies from dense, to coarse crystalline to intragranular to vuggy to fracture porosity. Secondary porosity also is important locally
Average Net Pay Thickness:	10 feet porosity
Other shows:	Bow Island Sand Burwash, Sunburst Swift, Reirdon, Sawtooth, Madison, Nisku, Duperow
Average Depth:	1500 feet (+2000 msl)
Porosity:	20%
Permeability:	variable
Oil/Gas Column:	from +1400 to 2150 feet in the Madison

This field has numerous pay zones with both a structural and stratigraphic influence. While the Kevin Sunburst Dome does not exist on the reservation, the local variations in reservoir rock make smaller structural and stratigraphic traps likely possible.

PLAY TYPE 4

Montana Disturbed Belt - Imbricate Thrust

General Characteristics - Imbricate, or angled thrust sheets and corresponding anticlines between the Lewis Thrust Sheet, and the eastern edge of the Disturbed belt summarize this play. Only three known fields exist in this province: the East Glacier and Two Medicine complex and Blackleaf Complex.

Potential reservoir rock is dolomitized Mississippian limestone between 200 and 500 feet thick. Permeability is low which may explain the small accumulation found. Lower Mississippian and Devonian rocks may have fractured reservoirs. Jurassic and Cretaceous sandstones may produce.

Source rock is thought to be either (1) the Flood member of the Cretaceous Blackleaf formation (43 - 168 feet thick) with 1.1 % total organic carbon (TOC); (2) shale member of the Jurassic Swift formation (6 - 32 feet thick) with 1.1 % TOC; or (3) Devonian Bakken/Exshaw organic rich shale (10 - 40 feet thick) averaging 0.97 % TOC.

Depths to potential reservoirs vary from 19,000 feet on the western side to less than 3000 feet on the eastern side. Carbon dioxide gas has been found in the equivalent rocks in Canada. Some carbon dioxide has been found in smaller structures in the Disturbed Belt.

Analog Fields (*denotes field inside Reservation boundaries)

Two Medicine	11,510 BO	275,000 Mcf (Abn'd)	(Montana Disturbed Belt)
Blackleaf	33,748 BO	7.0 MMcf (Abn'd)	(Montana Disturbed Belt)

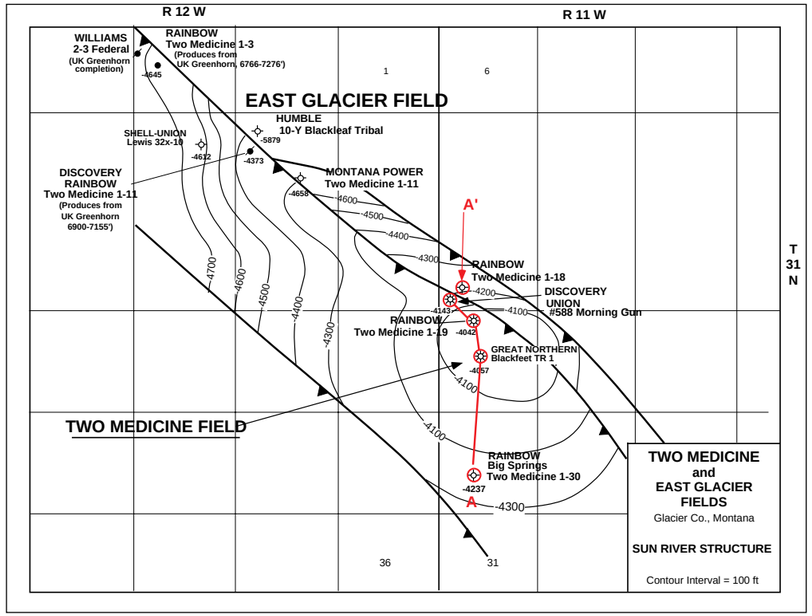


Figure BF-11.1. Two Medicine and East Glacier Fields (after James W. Garner, Montana Geological Society, 1985).

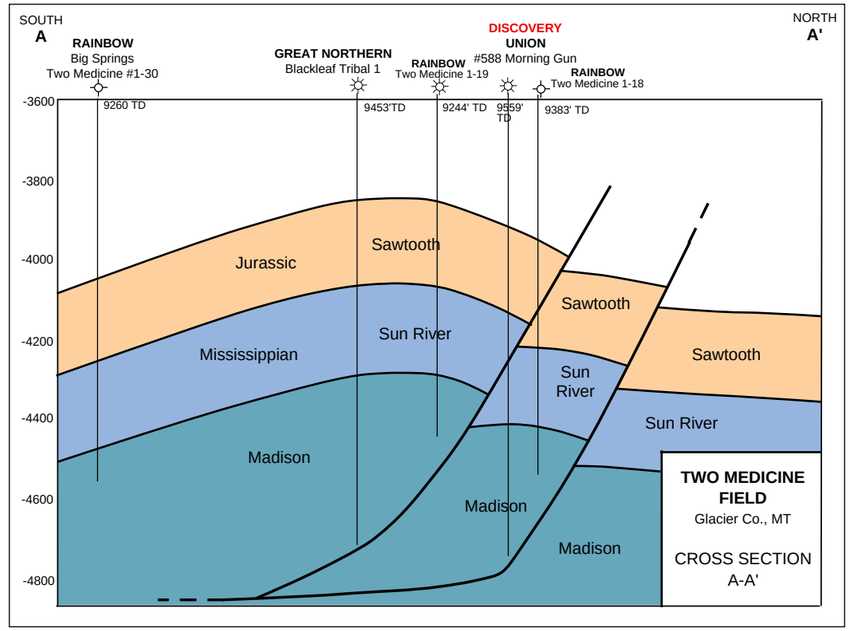
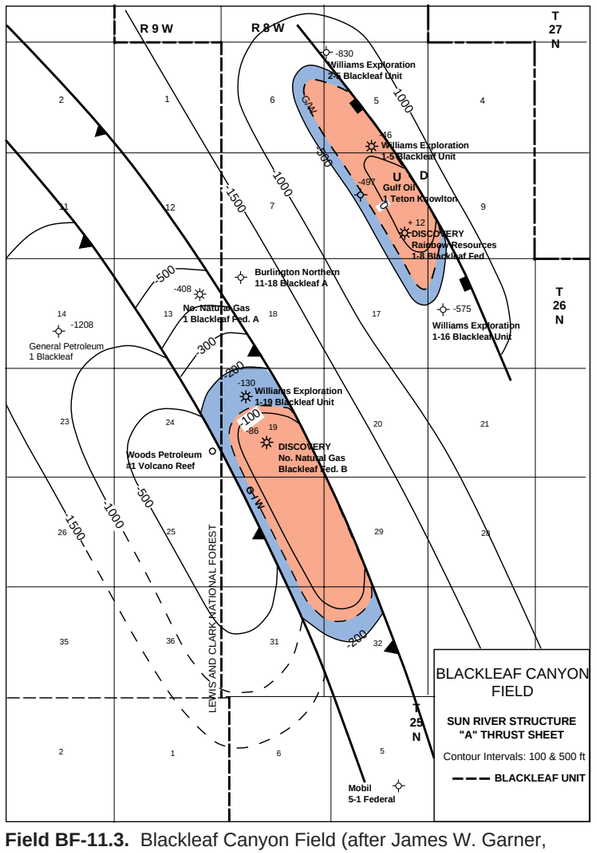


Figure BF-11.2. Two Medicine Field (after James W. Garner, Montana Geological Society, 1985).



Field BF-11.3. Blackleaf Canyon Field (after James W. Garner, Montana Geological Society, 1985).

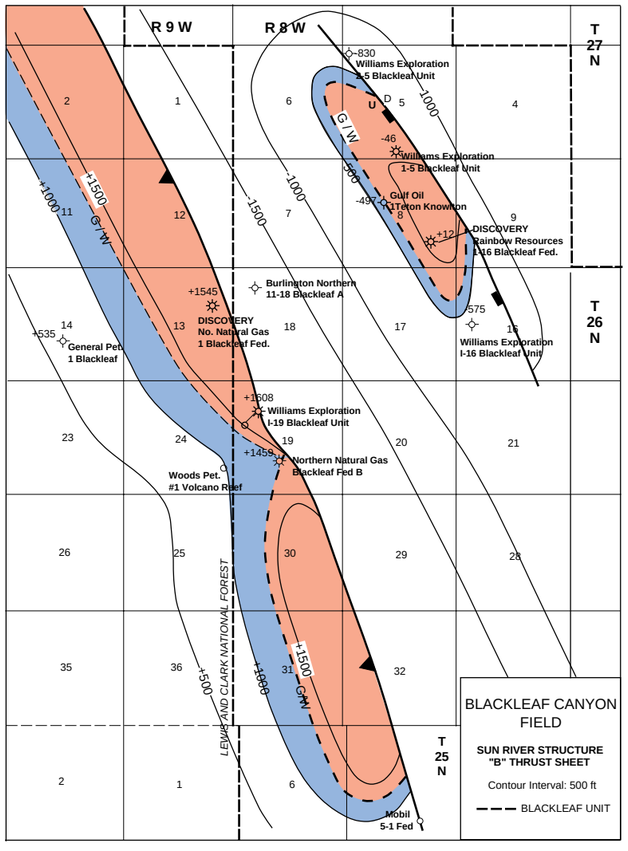


Figure BF-11.4 Blackleaf Canyon Field (after James W. Garner, Montana Geological Society, 1985).

Blackleaf Canyon Field Parameters

Formation:	Mississippian Sun River
Lithology:	West Sun River dolomite, continuous, 450 feet East Sun River, 420 feet
Average depth:	West Sun River "A" thrust sheet 3900 feet. (+1537 feet MSL) West Sun River "B" thrust sheet 5700 feet (-200 feet MSL) East Sun River 5028 feet (-28 feet MSL)
Porosity:	West Sun River 3.5% matrix porosity East Sun River 3.5% matrix porosity
Permeability:	not known
Oil/Gas Column:	West Sun River "A" (100 feet MSL) West Sun River "B" (350 feet +1450 MSL) East Sun River 350 feet (-450 feet MSL)
Average Net Pay:	Sun River 350 feet thick

Two Medicine Field Parameters

Formation:	Cretaceous Greenhorn, Mississippian Sun River
Lithology:	*Greenhorn* - fractured sandstone and shale, 600 feet. Continuous except when faulted *Sun River* - fractured dolomite, 225 feet Continuous except when faulted
Average Depth:	*Greenhorn* - 7000 feet (-2000 feet MSL) *Sun River* - 8800 feet (-4050 MSL)
Porosity:	*Greenhorn* - 15% *Sun River* - 9% average matrix
Permeability:	not known
Oil/Gas Column:	*Greenhorn* - 375 feet (water contact not known) *Sun River*- 125 feet (water contact not known)
Average Net Pay:	*Greenhorn* - 100 feet *Sun River* - 90 feet

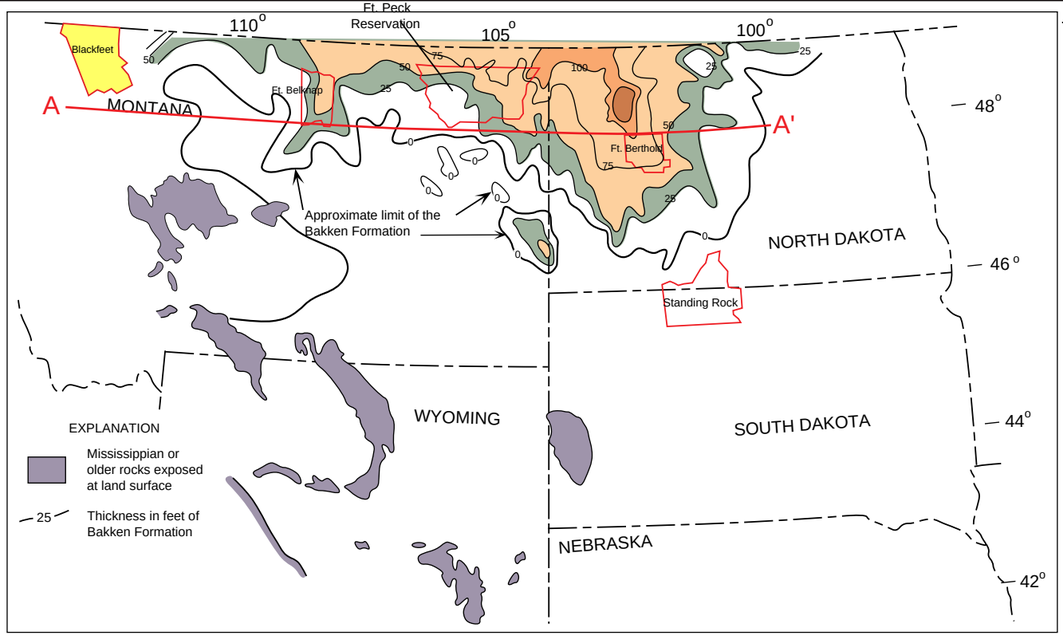


Figure BF-12.1. Thickness of Bakken formation (uppermost Devonian and lowermost Mississippian) (modified after Peterson, 1981,1984).

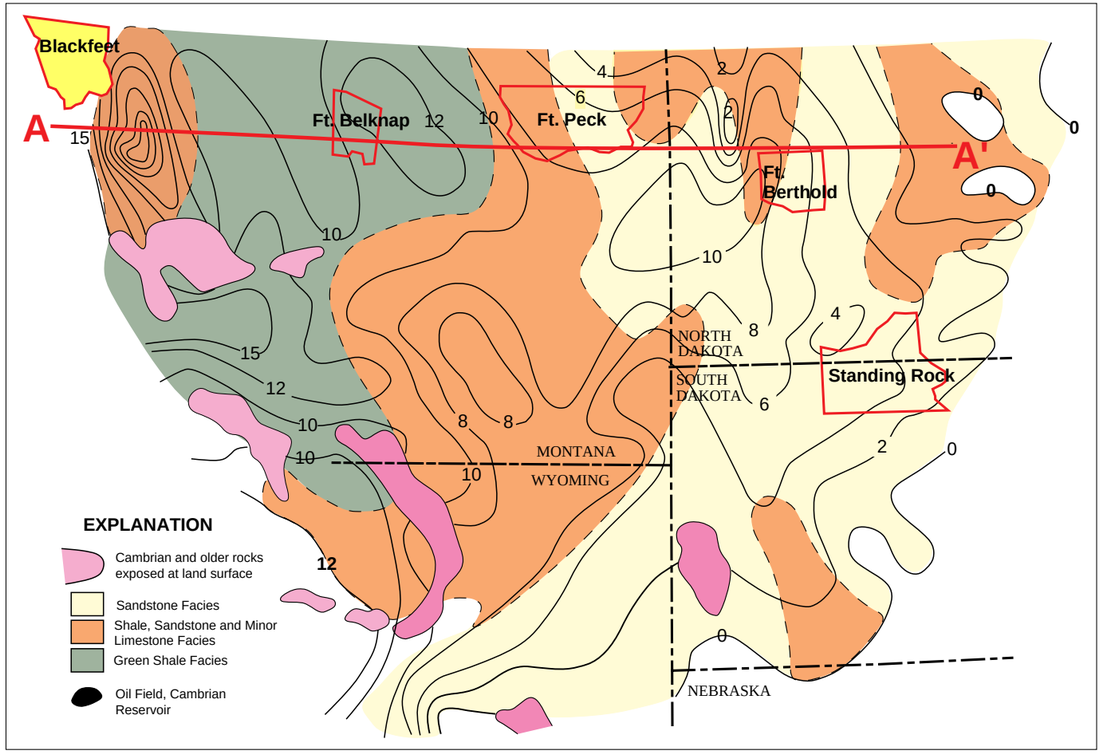


Figure BF-12.2. Thickness of Deadwood and equivalent rocks, location of analog fields. Blackfeet reservation and location of regional cross-section A-A' (modified after Peterson, 1981, 1984).

PLAY TYPE 5
Fractured Bakken Shale Play

General Characteristics - The Devonian Bakken, one of the probable source rocks for the Madison, is an organic rich marine shale, regionally equivalent to the Alberta Shelf, Exchaw shale. The Bakken is considered to be thermally mature across the Sweetgrass Arch, and varies from less than 10 feet thick to over 75 feet thick in the northern portion of the Blackfeet Reservation. Depths vary from 1500 to 6000 feet deep. Fractures would occur along hinge lines in the basin or on the crests of structures.

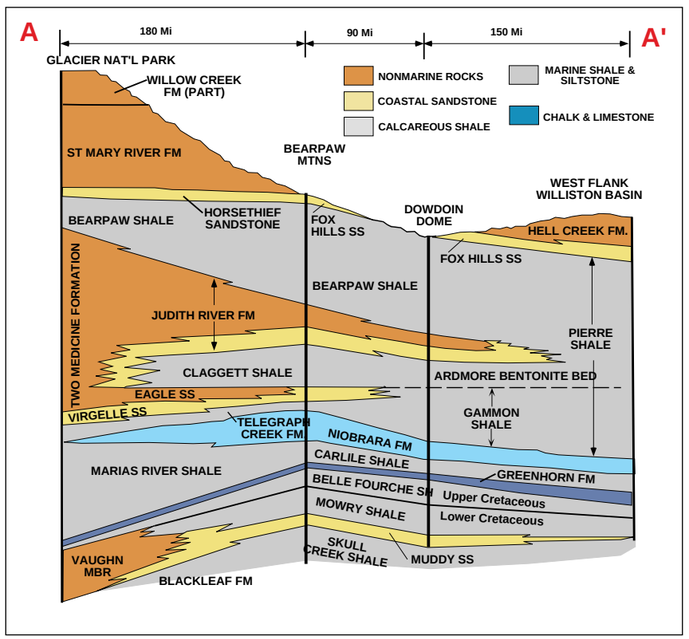


Figure BF-12.3. Thickness of Bakken formation (uppermost Devonian and lowermost Mississippian), in feet (modified after Peterson, 1981,1984).

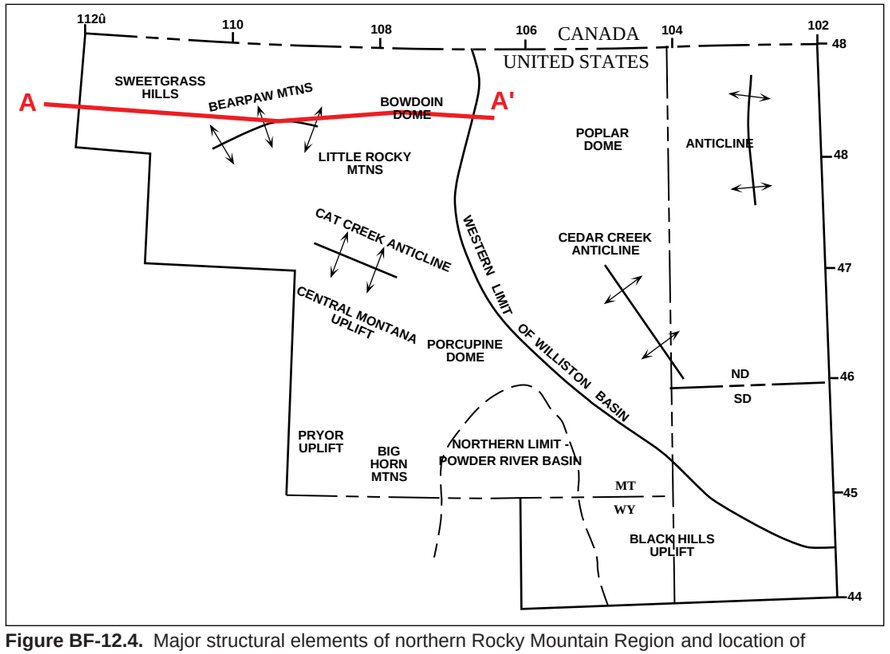


Figure BF-12.4. Major structural elements of northern Rocky Mountain Region and location of Cretaceous cross-section (after Rice and Shurr, 1980).

PLAY TYPE 6
Cambrian Sandstone Play

General Characteristics - Cambrian sandstones are more than 2000 feet thick in the Disturbed belt part of the Reservation. Reservoir rocks are quartz and lithic sandstones from the Flathead formation. Depth to Cambrian is between 3000 and 8000 feet. Source rock is thought to be dark gray marine shales in the Cambrian Gordon formation. No information is available on source rock organic content or thermal maturity. Traps could be structural closures or pinch-outs.

PLAY TYPE 7
Biogenic (Low, Medium, High Potential) Gas Play

General Characteristics - Shallow biogenic (methane rich) gas produces at Bowdoin Dome and Cedar Creek Anticline from the Cretaceous Eagle and Judith River sandstones. Traps are stratigraphic and consist of coarse clastic sands grading to fine sands and silts. Methane is generated soon after burial and is preferentially trapped in the coarse facies. The reservoirs are shallow and tight and look poor on well logs. A pay section may not yield gas shows when drilled. "Sweet spots" on structural highs (with paleothinning) probably localized better reservoirs. This potential for traps in fine grained reservoir rocks also exists.

BLACKFEET RESERVATION

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