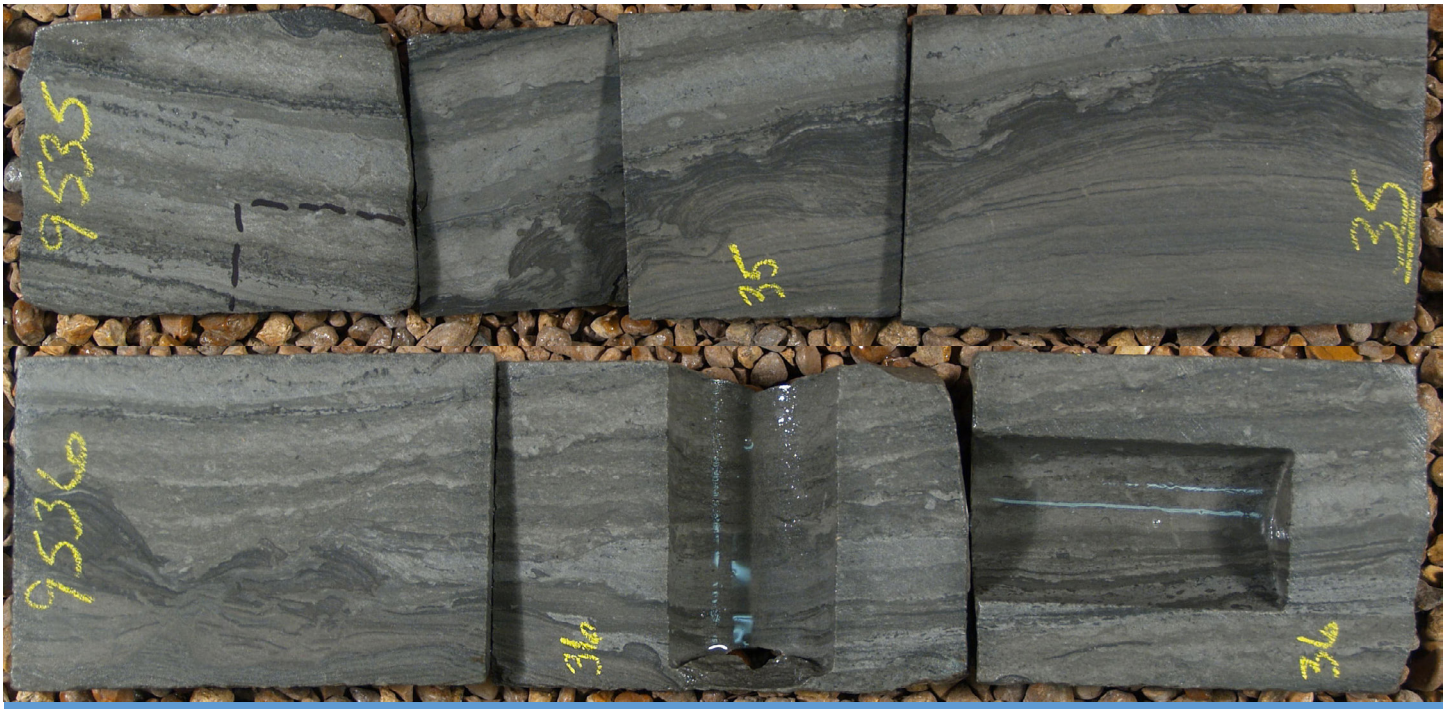
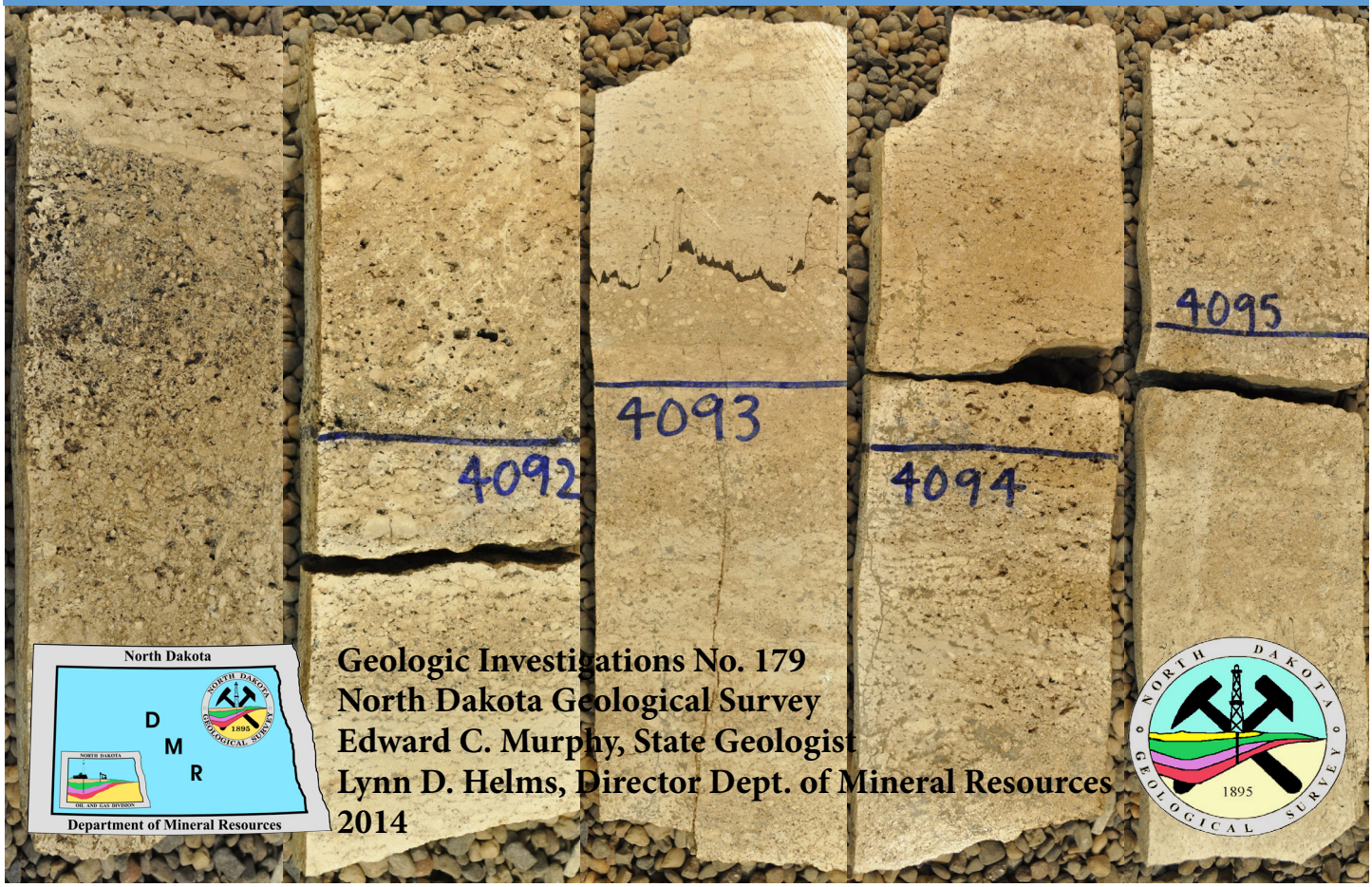


Stratigraphic Core Atlas

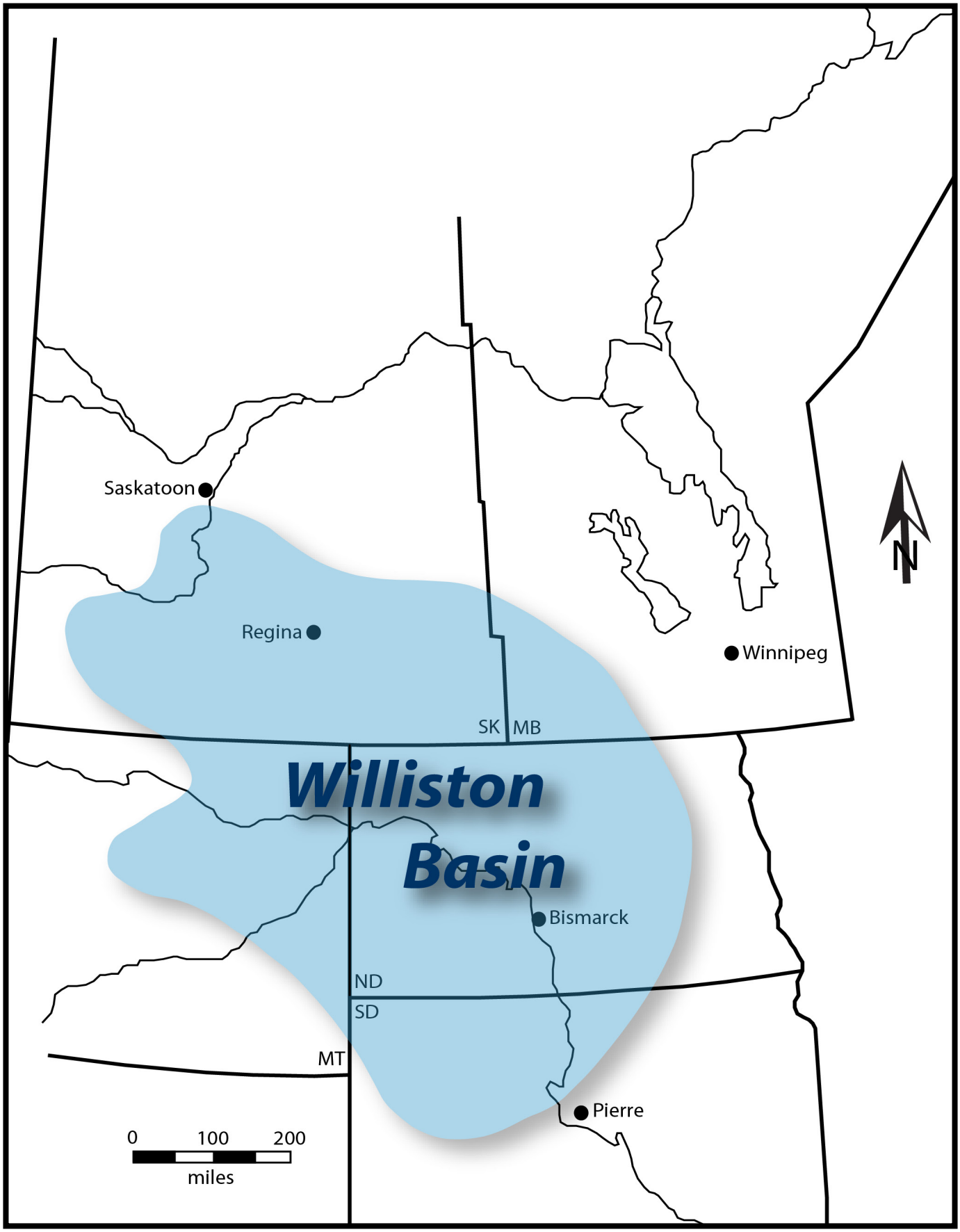
Julie A. LeFever



Geologic Investigations No. 179
North Dakota Geological Survey
Edward C. Murphy, State Geologist
Lynn D. Helms, Director Dept. of Mineral Resources
2014

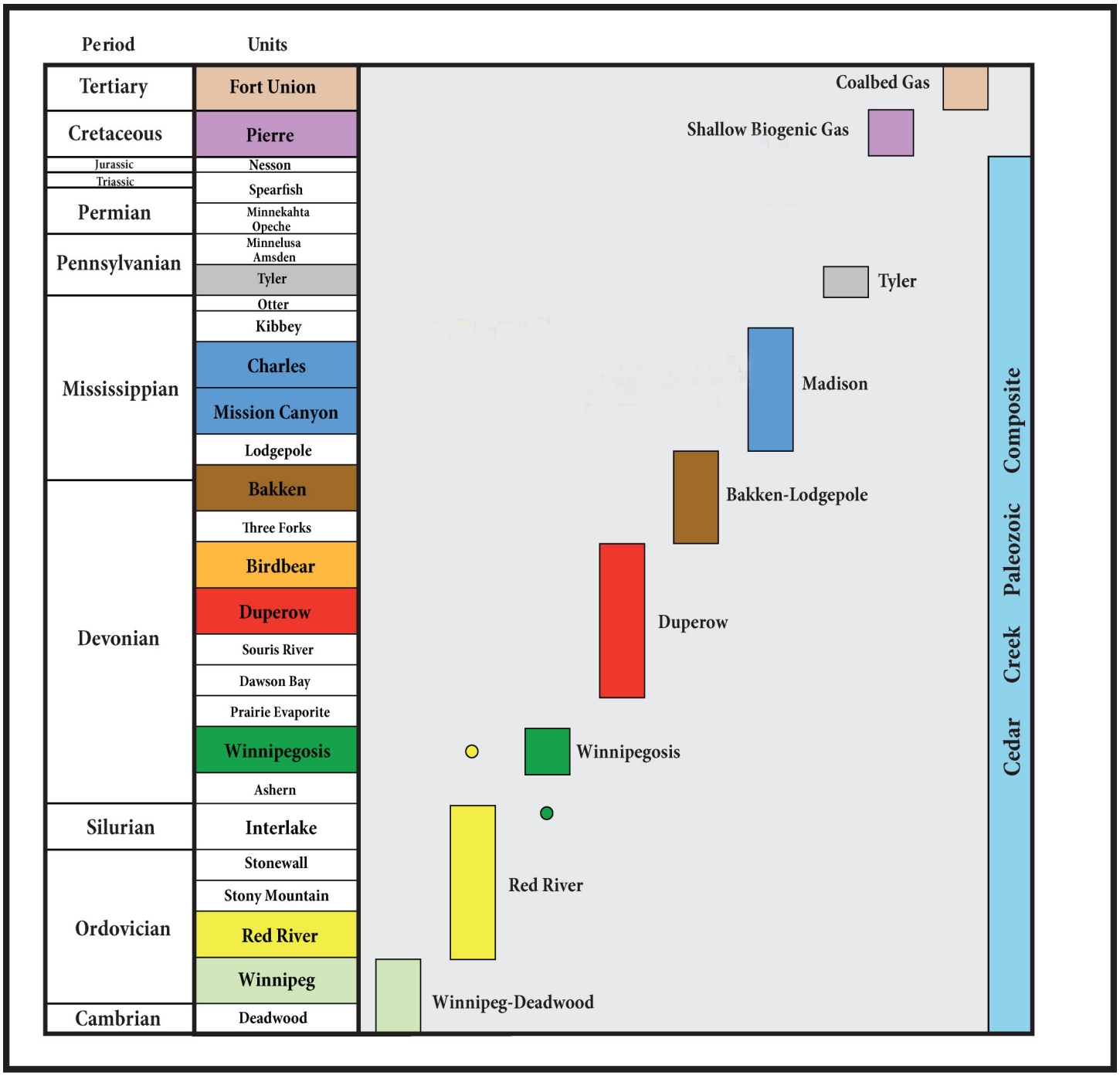
Forward

The intent of this document is to present a brief introduction to the various formations found in the subsurface of the Williston Basin. All of the formations are listed in decending statigraphic order with a brief discription, problems encountered when drilling, a representative log, and a core image. There are recognizable variations in these formation depending location that may not be covered in this volume.

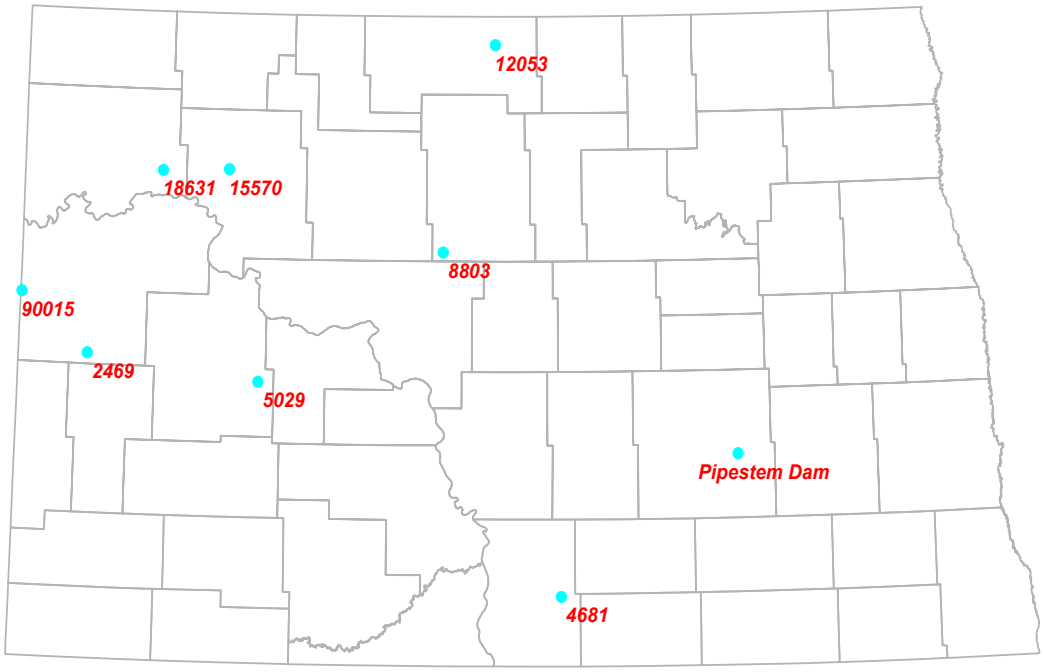


Index map showing the areal extent of the Williston Basin.

Total Petroleum System for the Williston Basin



Stratigraphic column of the Williston Basin showing the petroleum systems and their stratigraphic distribution of the petroleum system fluids. Circles represent minor occurrences of a single oil analysis. Systems without a documented oil source correlation are considered hypothetical and include the Winnipeg, Duperow and Birdbear. The Deadwood petroleum system is speculative because a good oil-prone source rock has not been identified (modified from Lillis, 2013).



API Number/ Well Number	Location	Operator/Name	Formation
	Jamestown, ND	Pipestem Dam	Cretaceous Pierre
33-105-01787-0000 18631	NWNE 15-155-96	Hess Corporation BLOU #12	Cretaceous Niobrara
33-049-00127-0000 8803	NENE 22-151-80	Atlantic Richfield Co. Wunderlich #1	Cretaceous: Niobrara, Greenhorn, Mowry
33-061-00486-0000 15570	SENE 9-155-92	Ceja Corporation Lund #42-9	Cretaceous Carlisle
33-025-00039-0000 5029	NWNE 30-144-91	Texaco, Inc. Rodne #1	Cretaceous Mowry
33-029-00010-0000 4681	SENW 12-132-75	Forest Oil Corporation Bernard Hulm #1	Cretaceous Newcastle
33-053-00422-0000 2469	SENE 15-145-101	Shell Oil Co. & N. Pacific Northern Pacific #32-15	Cretaceous Newcastle
33-053-90015-0000 90015	SENE 10-148-105	Shell Oil Comapny USA #42-10	Cretaceous Inyan Kara
33-009-01786-0000 12053	SWSE 10-162-76	Turtle Mountain Oil & Gas, Inc. Craig #1-10	Traissic Spearfish

Location of the wells for the Cretaceous and Triassic rocks in the following discussion.

Cretaceous Pierre Formation

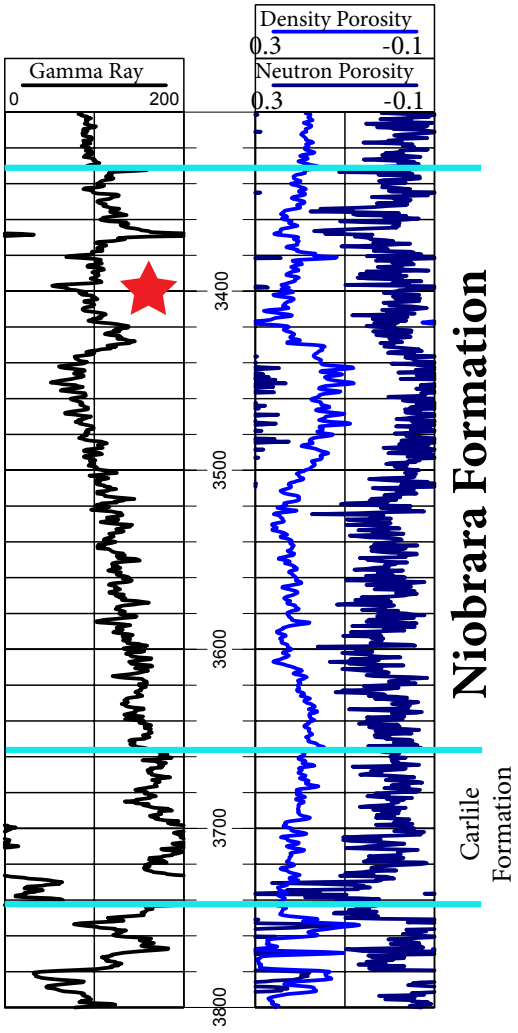
1. Light to dark grey shale, generally non-calcareous, fissile to blocky.
2. Offshore marine deposits
3. 5 members with 4 exposed at the surface in North Dakota. Members include, in ascending order: Gammon, Pembina, Gregory, Degrey, and Odanah. The upper 4 members are exposed at the surface.
4. Ardmore bentonite marks the contact between the Gammon and the Pembina members.
5. Thickness = up to 2300 ft.

Pipestem Dam (Jamestown, ND)

Cretaceous Niobrara Formation

1. Shale, chalk; light to medium grey, upper exposures weather to yellow; calcareous, zones contain limy inclusions or specks that are referred to as the "First White Specks" by drillers and are used to differentiate it from the overlying Pierre Formation, very calcareous or marly zone in the lower part of the unit; laminated and bioturbated strata; some pyritized burrows, marine fossils.
2. Offshore marine deposits.
3. Thickness - up to 250 ft.
4. Porosity 8.7 to 13.4% , averaging 11.2%. Permeabilities range from .07 to 2.6 md.

Hess Corporation
BLOU #12
NWNE 15-155-96



Atlantic Richfield Co.
Wunderlich #1
NENE 22-151-80

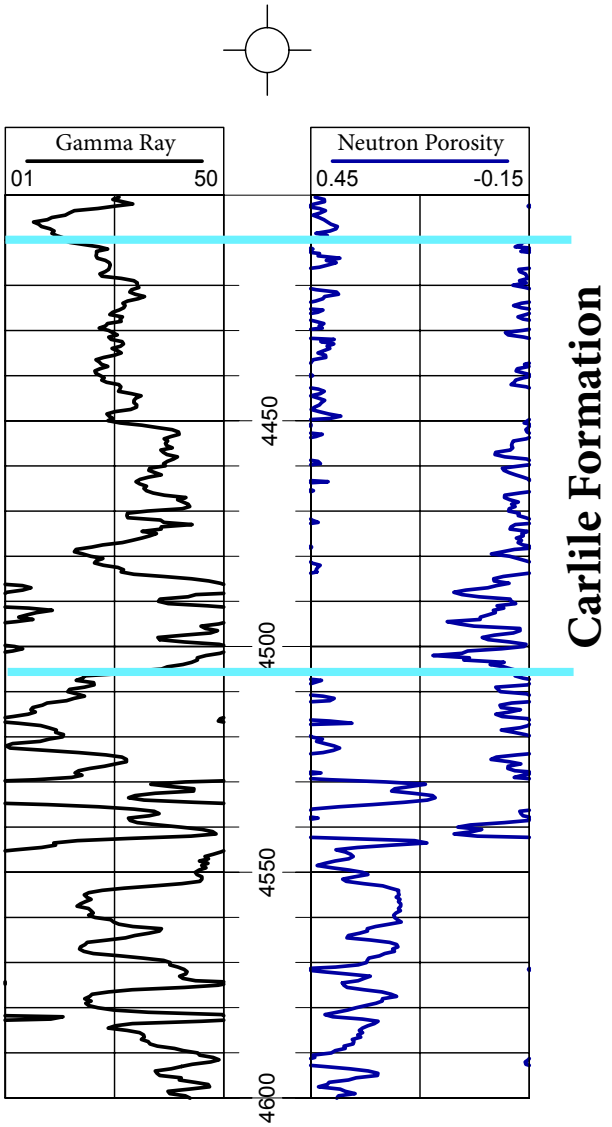
★ denotes location of core.

NOTE: Red, yellow and blue stars denote the approximate position of the core photos on the following pages.

Cretaceous Carlisle Formation

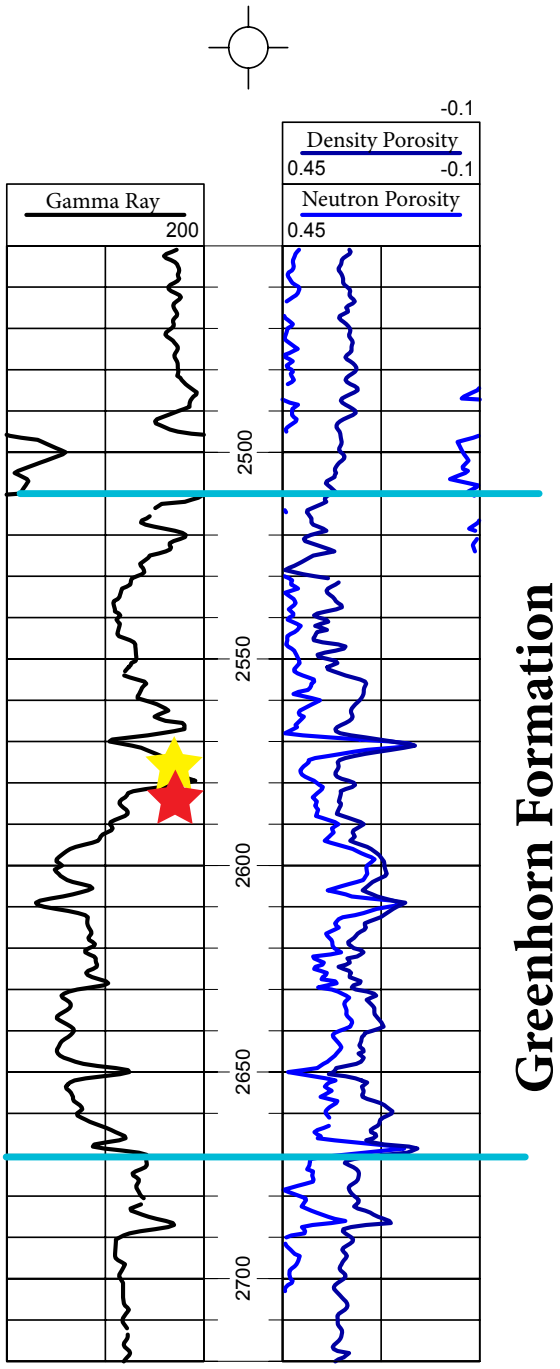
1. Medium grey to black noncalcareous soft shale with bentonite zones.
2. Offshore marine deposits.
3. Thickness - up to 400 ft.

Ceja Corporation
Lund #42-9
SENE 9-155-92

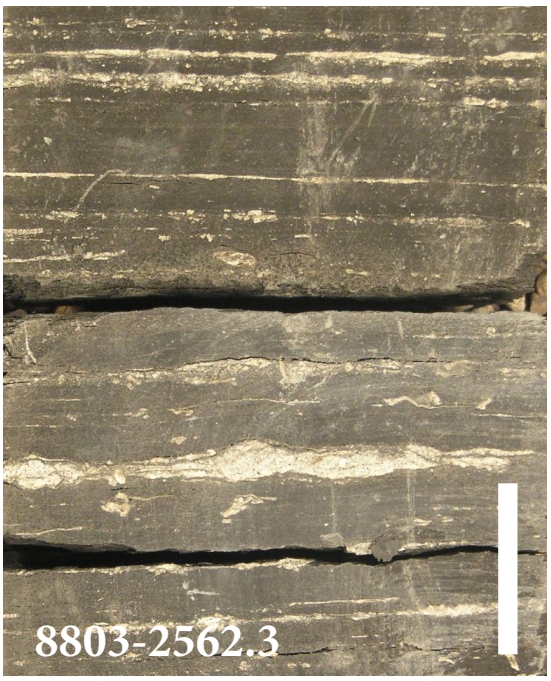


Cretaceous Greenhorn Formation

1. Dark grey shale and thin-bedded shaly limestone referred to as the "Second White Specks".
2. Offshore marine deposits.
3. Thickness approximately 150 ft.
4. Porosities range from 5.8 to 27.9%, averaging 25.1%. Permeabilies range from .03 to .45 md, averaging .16 md.



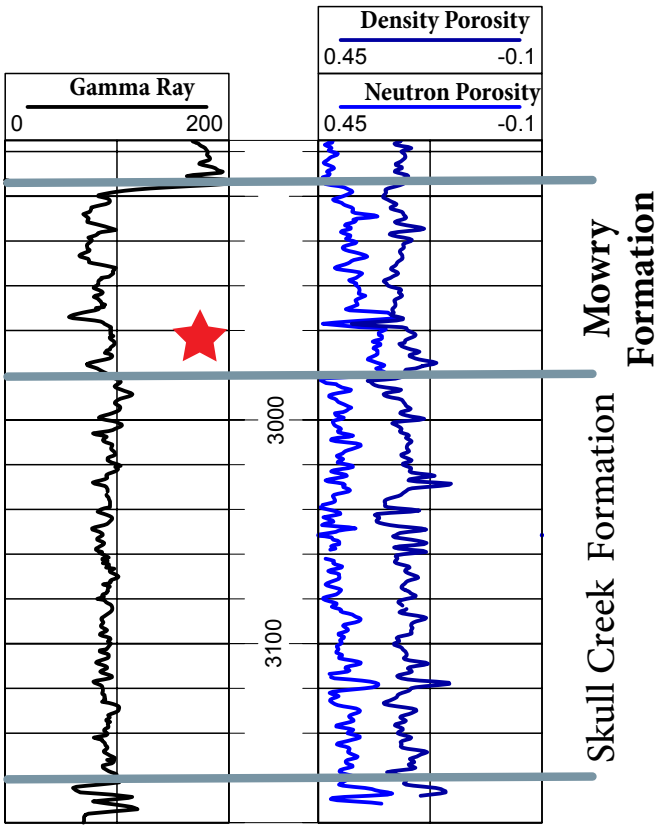
Atlantic Richfield Co.
Wunderlich #1
NENE 22-151-80



Cretaceous Mowry Formation

1. Shale, medium to dark grey, soft, flaky, traces of bluish grey bentonic claystone; top is marked by a persistent bentonite that has a strong response off a gamma-ray log.
2. Offshore marine deposits.
3. Thickness - up to 300 ft.

Atlantic Richfield Co.
Wunderlich #1
NENE 22-151-80

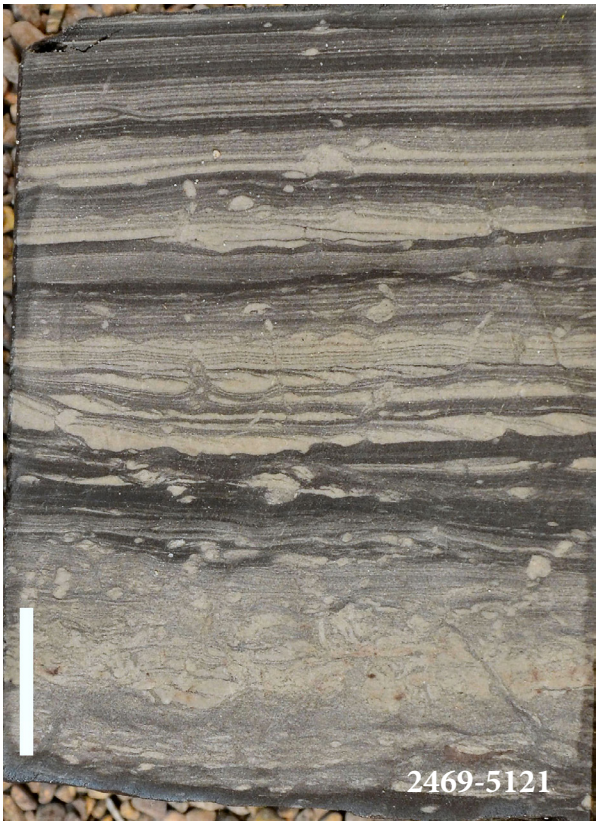


Texaco, Inc.
Rodne #1
NWNE 30-144-91

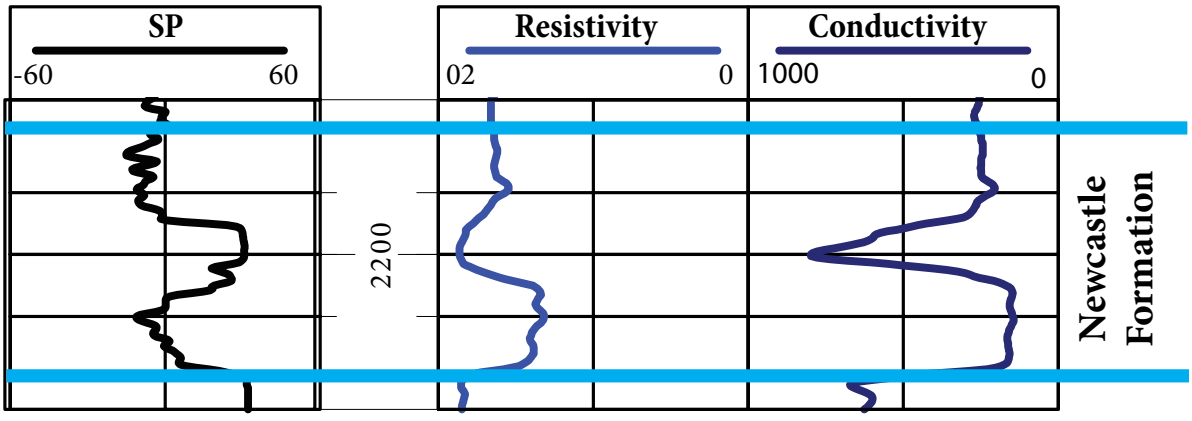
Cretaceous NewcastleFormation

1. Light grey burrowed silstone interbedded with dark grey shale (aka “Muddy”)
2. Nearshore marine deposits
3. Thickness = 250 ft.
4. Log porosity up to 40%

Shell Oil Co. &
NP Railroad
N. Pacific #32-15
SWNE 15-145-101



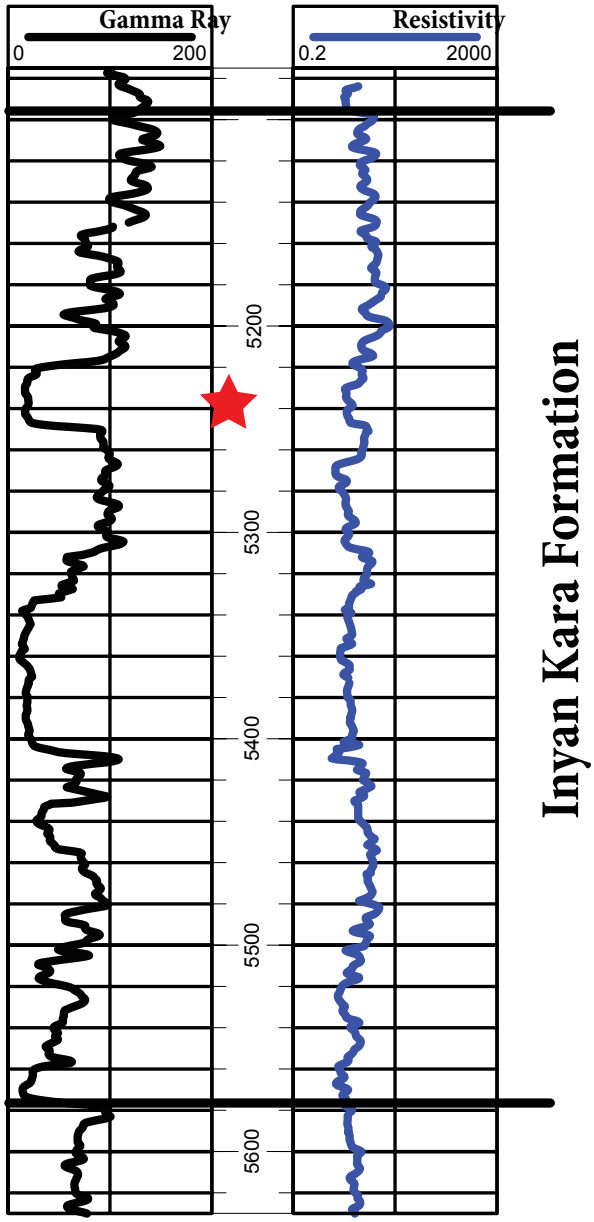
Forest Oil Corporation
B. Hulm #1
SENW 12, T132N, R75W



Cretaceous Inyan Kara Formation

1. Upper portion - Light grey, fine- to coarse-grained sandstone interbedded with grey silty shale. Lower portion - Light grey medium- to coarse-grained sandstone with occassional lenses of clay, bentonitic.
2. Marine to non-marine deposits.
3. Thickness = up to 625 ft.

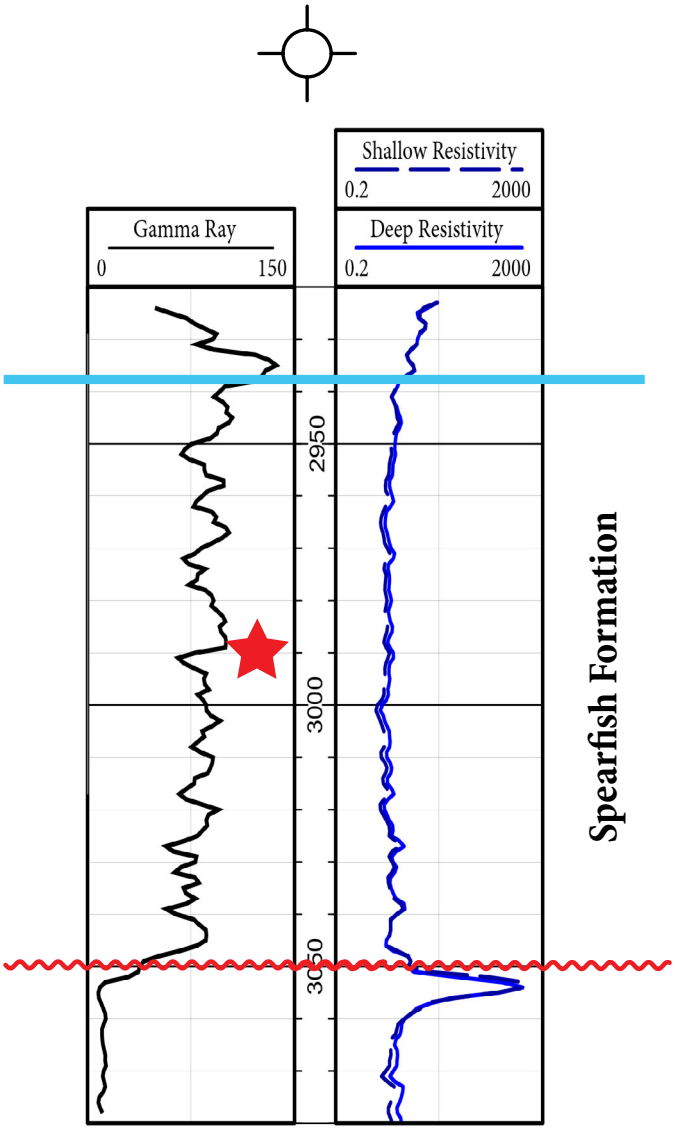
Shell Oil Co.
USA #42-10
SENE 10-148-105

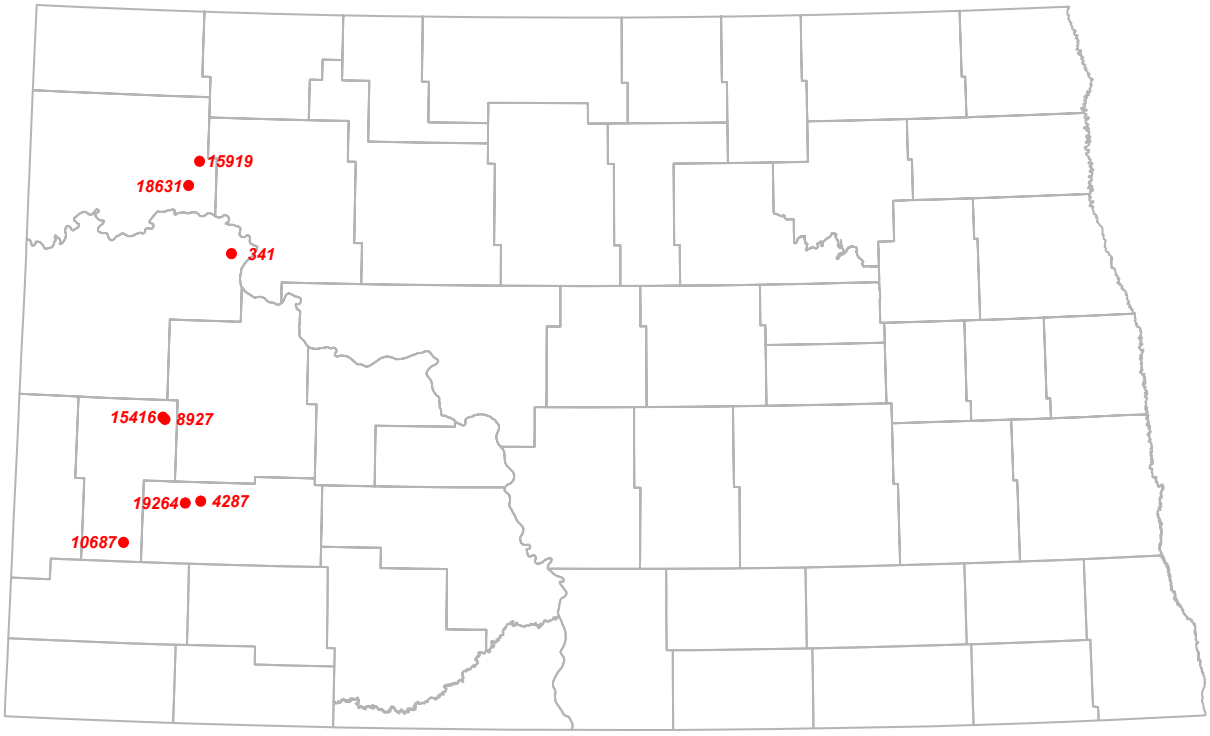


Triassic Spearfish Formation Saude Member

1. Light to reddish brown to dark red fine-grained siltstone to sandstone, may be cemented with calcite and/or anhydrite, anhydrite nodules, frosted grains.
2. Shallow marine deposits.
3. Thickness - up to 220 ft, average play thickness of 20 ft (conventional).
4. Permeabilites range 0.05 to 40 md.
5. Unconventional horizontal target.

Turtle Mountain Gas & Oil, Inc.
Craig #1-10
SWSE 10-162-76





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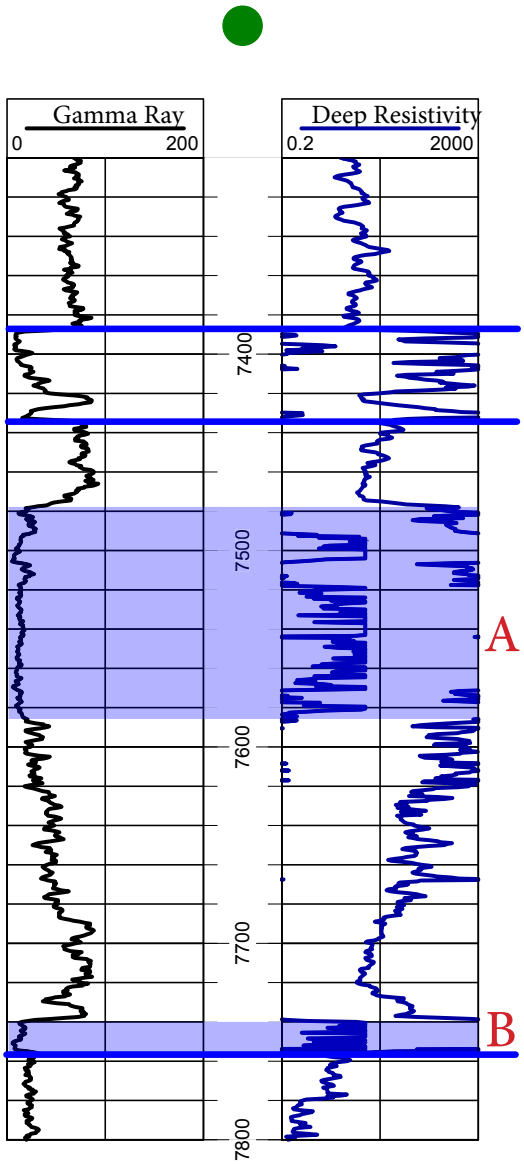
33-007-00748-0000 8927	NESW 33-144-98	Gulf Oil Corp. Romanyshyn #2-33-4B	Permian Opeche
	24-145-88	ANG Coal Gasification Co. Water Disposal #1	Permian Broom Creek
33-089-00588-0000 19264	Lot 2 6-139-97	Fidelity Exploration & Production, Co. Kostelecky #31-6H	Pennsylvanian Tyler
33-089-0004-0000 4287	SENW 36-140-97	Continental Oil Company Karsky-State #1	Pennsylvanian Tyler
33-105-01787-0000 18631	NWNE 15-155-96	Hess Corporation BLOU #12	Mississippian Otter, Kibbey
33-007-00989-0000 10687	SWNE 6-137-100	Union Texas Petroleum Corp. Smith #6-1	Mississippian Otter
33-053-00014-00000 341	SWSE 21-152-94	Stanolind Oil & Gas Corp. Woodrow Starr #1A	Mississippian Otter
33-105-01547-0000 15919	SESE 6-156-95	Murex Petroleum Corp. Susan Kaye #6-7H	Mississippian Madison

Location of the wells for the Permian through Mississippian rocks in the following discussion.

Permian Opeche Formation

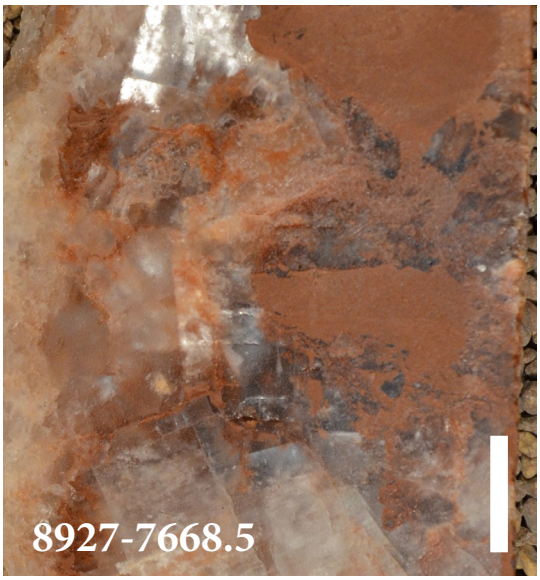
1. Shale to mudstone; reddish orange; silty; slightly dolomitic, contains gypsum and anhydrite laminae up to 200 ft of salt in central basin area; depositional thickness preserved when Minnelusa Formation is present. Contains the A and B salts.
2. Shallow, restricted marine deposits.
3. Thickness - up to 500 ft.

BTA Oil Producers, LLC.
9210 JV-P Knudtson #1
NWNE 32-144-98



Opeche Formation

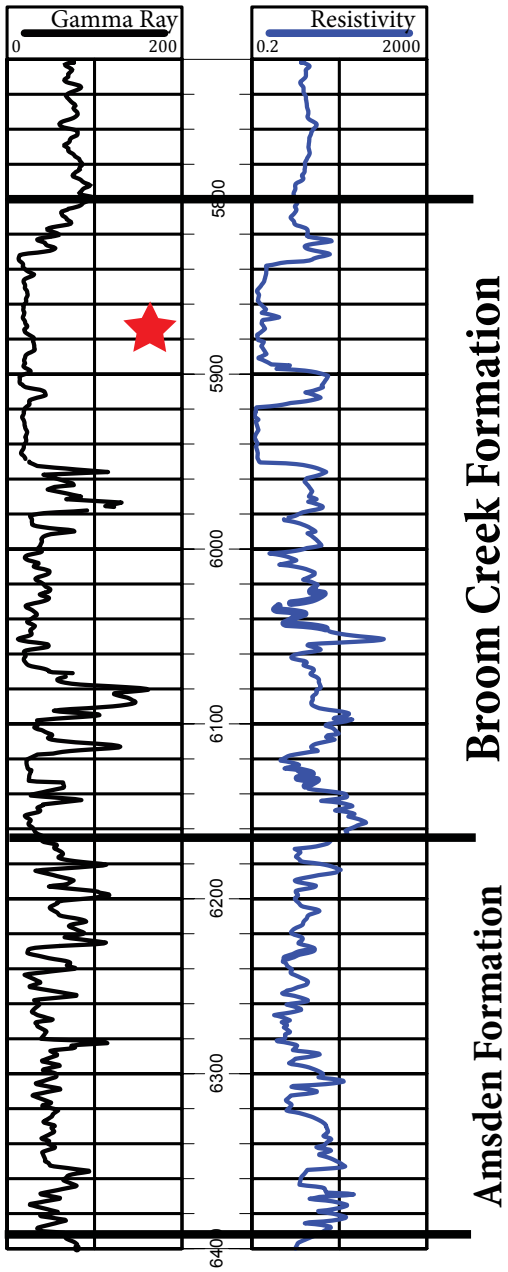
Gulf Oil Corp.
Romanyshyn #2-33-4B
NESW 33-144-98



Permian Broom Creek Formation

1. Grey to reddish orange to brownish red, shaly, fine- to medium-grained sandstone, friable, anhydrite and rip-up clasts at upper unconformable, occasional lenses of clay, bentonitic.
2. Shallow marine deposits.
3. Thickness = up to 375 ft.
4. Nitrogen-bearing, CO2 and Water Injection

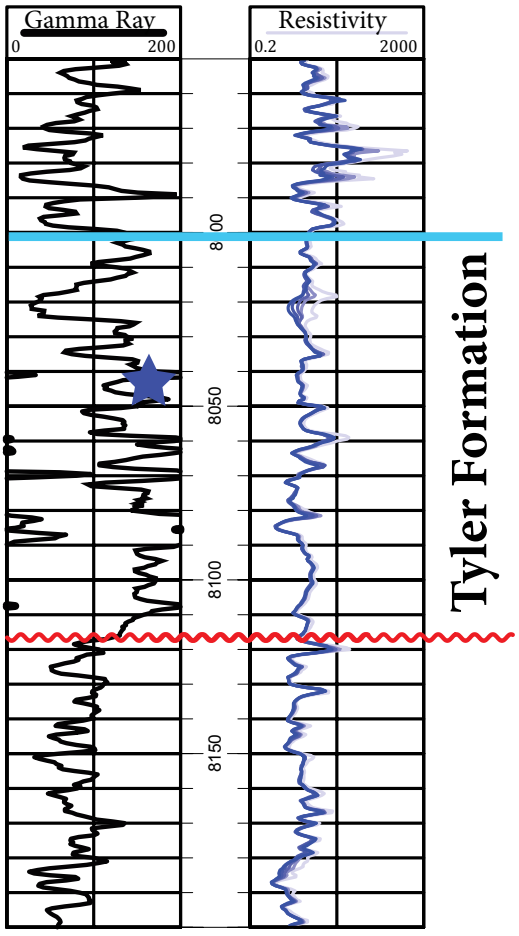
ANG Coal Gasification Co.
Water Disposal #1
24-145-88



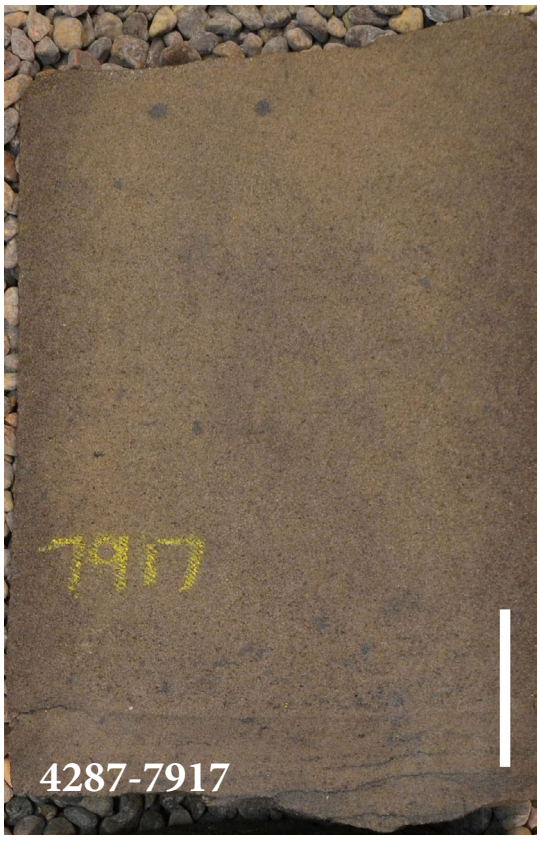
Pennsylvanian Tyler Formation

1. Interbedded sequence of varicolored shale to mudstone, greyish brown to reddish brown, fine- to medium-grained sandstone, and varicolored limestone, coal, fossils locally abundant.
2. Marginal marine deposits, including fluvial channels, barrier islands, swamp and beach deposits.
3. Thickness = up to 270 ft.
4. Porosity - 12 to 20%
5. Conventional and unconventional horizontal target.

Fidelity E & P Co.
Kostelecky #31-6H
Lot 2 6-139-97



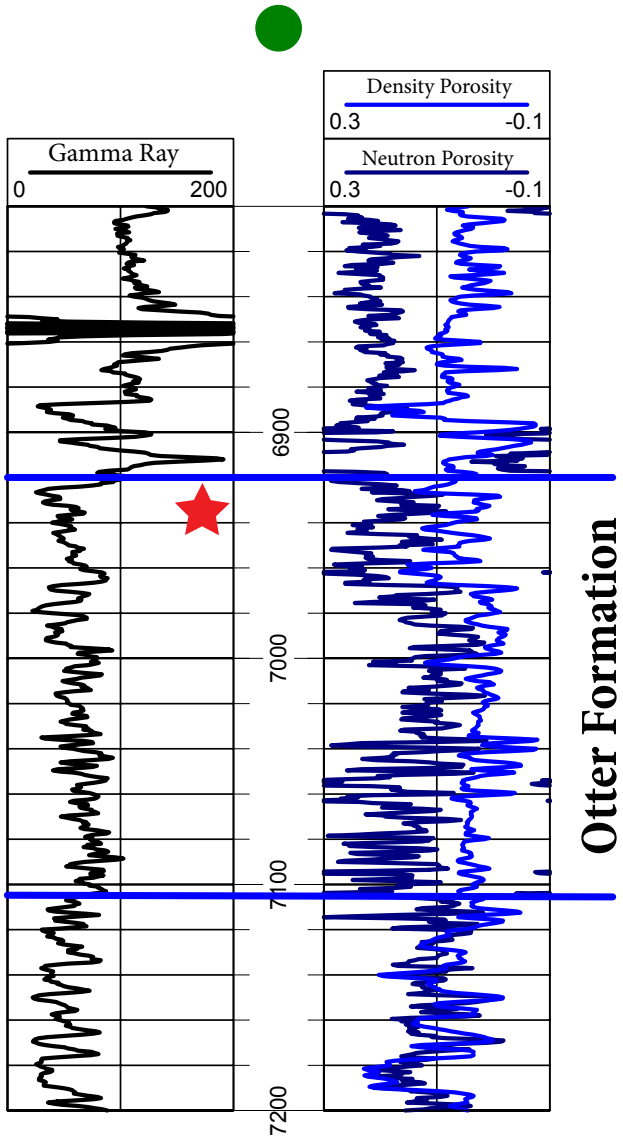
Continental Oil Co.
Karskey-State #1
SENW 36-140-97



Mississippian Otter Formation

1. Greenish grey to reddish grey carbonaceous shale. Shale has variegated colors along the margins. Grey to green, marly limestone is also present. Limestone is thinly bedded. fossiliferous, and oolitic. Upper contact is unconformable.
2. Represents offshore marine deposits.
3. Thickness reaches a maximum of 260 ft.

Hess Corporation
BLOU #12
NWNE 15-155-96

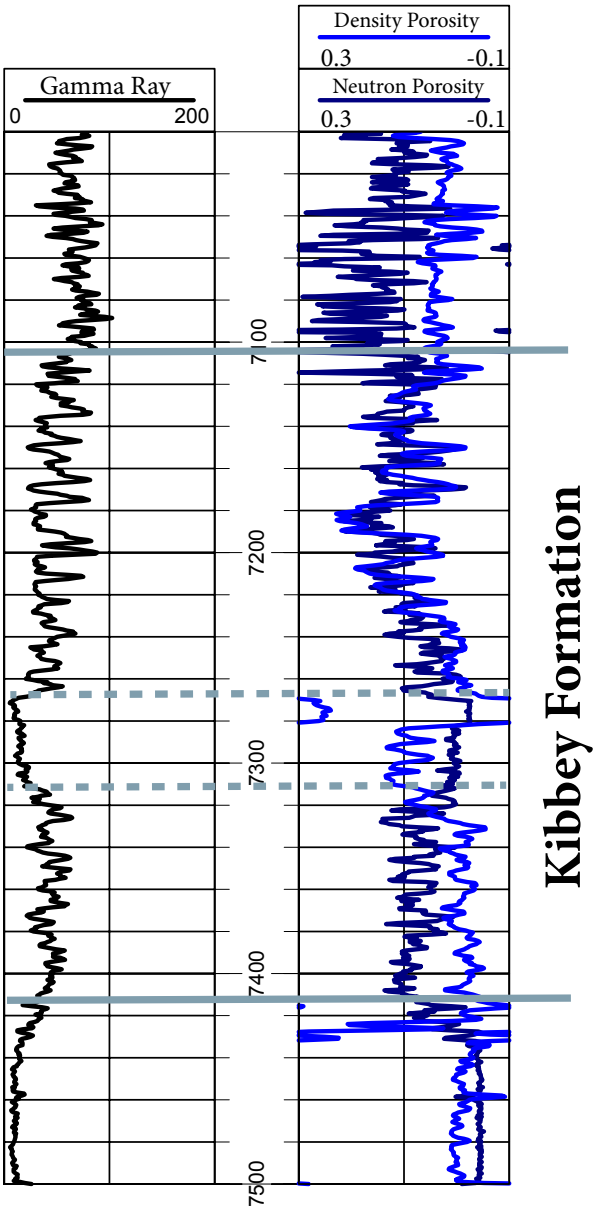


Union Texas Petroleum Corp.
Smith #6-1
SWNE 6-137-100

Mississippian Kibbey Formation

1. Sandstone, light grey to reddish grey, fine-grained to medium-grained, silty. Shale; redddish to variegated; silty, interbedded gypsum. Limestone; white to brown, dolomitic. A persistent limestone bed in the middle of the unit (Kibbey lime) is an excellent marker on wireline logs.
2. Shallow marine deposits.
3. Thickness - to 250 ft.

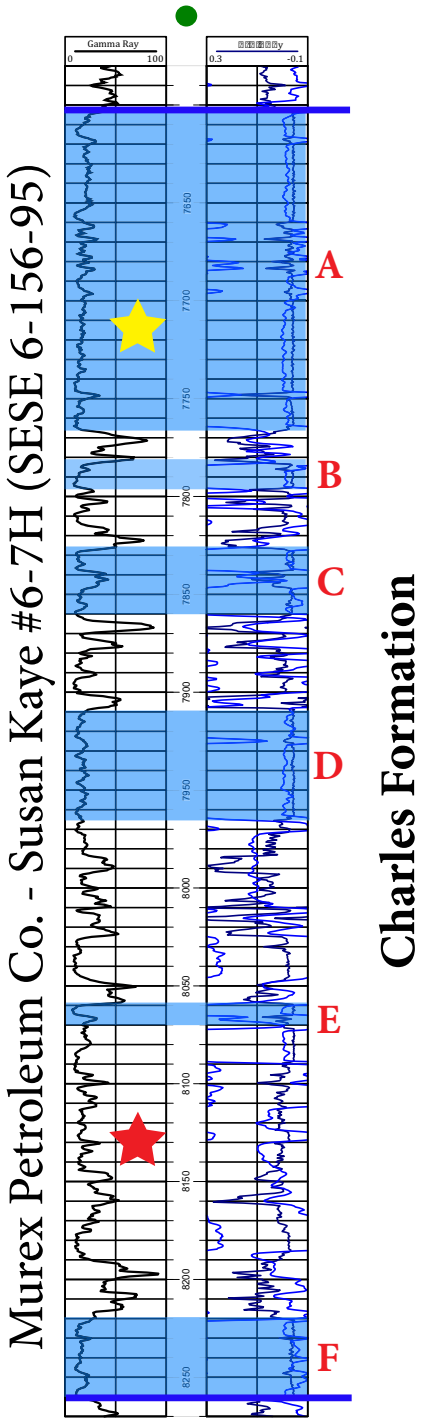
Hess Corporation
BLOU #12
NWNE 15-155-96



Stanolind Oil & Gas, Co.
Woodrow Starr #1
SWSE 21-152-94

Mississippian Madison Group Charles Formation

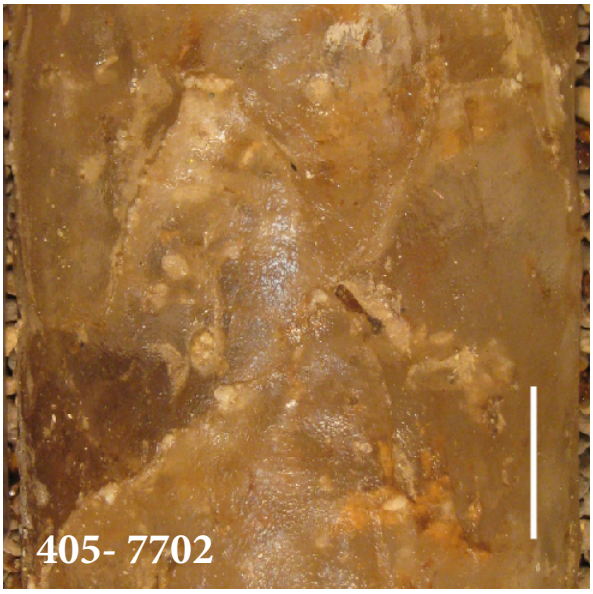
1. The Charles Formation is an interbedded sequence of carboates and evaporites (Salts A-F). Notable marker bed is the Base of the Last Charles Salt.
2. Offshore to nearshore deposits.
3. Thickness = approximately 660 ft.
4. Solution mining of salt, CO2 and water injection.
5. Problems: Fractures resulting in a loss of cement and/or production, salt-initiated collapse of casing.

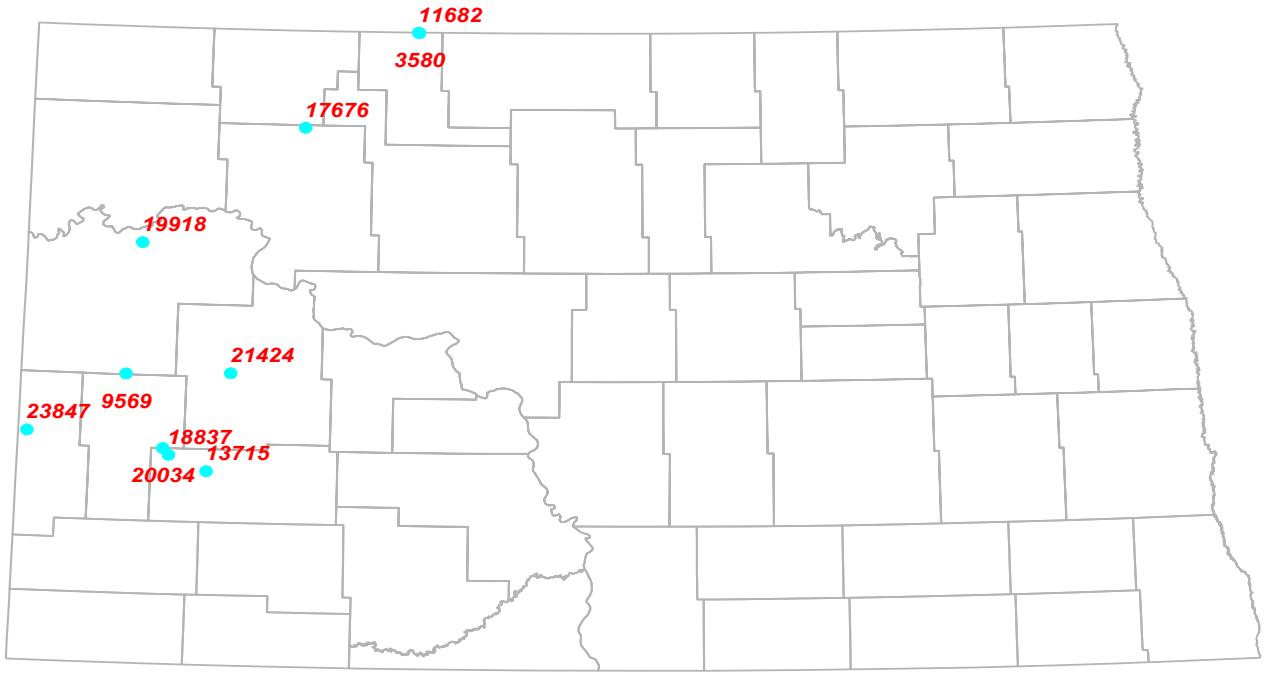


Murex Petroleum Co. - Susan Kaye #6-7H (SESE 6-156-95)

Charles Formation

Amerada Petroleum Corp.
Beaver Lodge Field





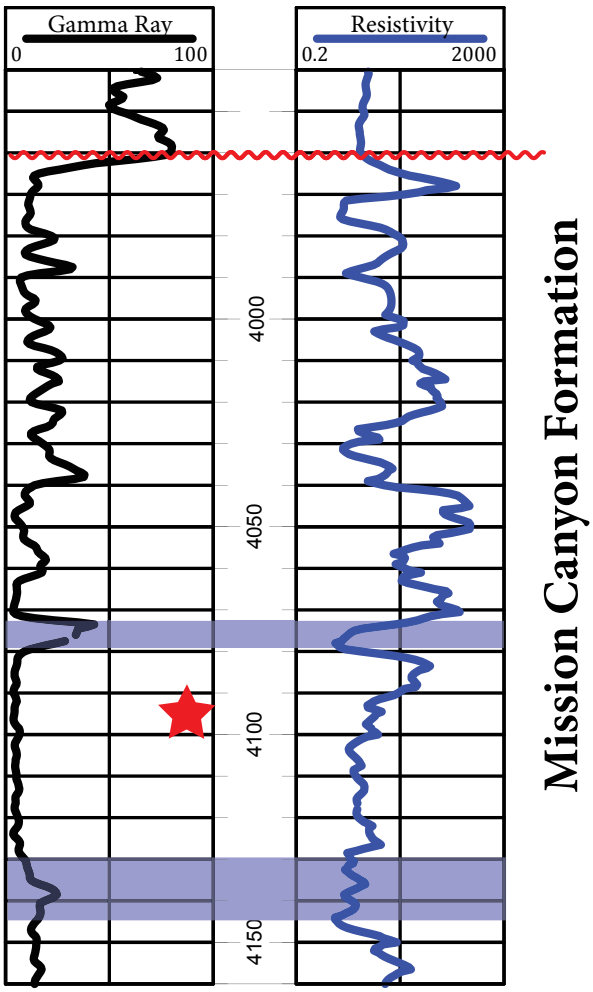
API Number/ Well Number	Location	Operator/Name	Formation
33-075-01056-0000 11682	SWSW 25-164-85	Chandler & Associates, Inc. Rusch #B-2	Mississippian Madison
33-075-00217-0000 3580	Lot 3 25-164-85	Chandler & Associates, Inc. Rusch "B" #1	Mississippian Madison
33-061-00884-0000 17676	SESE 6-158-90	EOG Resources, Inc. Sidonia #1-06H	Mississippian Lodgepole
33-089-00417-0000 13715	NWNW 11-139-97	Duncan Energy Co. Knopik #1-11	Mississippian Lodgepole
33-053-03358-0000 19918	SWSE 22-152-99	Continental Resources, Inc. Charlotte #1-22H	Miss-Dev Bakken, Three Forks
33-089-00586-0000 18837	NWNW 13-140-99	Whiting Oil and Gas Corporation Kubas #11-13TFH	Miss-Dev Bakken, Three Forks
33-025-01453-0000 21424	NESE 27-145-95	Denbury Onshore, LLC. Johnson #43-27WNH	Devonian Birdbear
33-089-00620-0000 20034	Lot 3 3-140-99	Continental Resources, Inc. Debrecen #1-3H	Devonian Birdbear
33-033-00318-0000 23847	SWNE 9-141-105	Whiting Oil and Gas Corp. Stecker #32-9	Devonian Duperow
33-053-01536-0000 9569	SESE 34-145-100	Cities Services Oil Co. Federal #DG-1	Devonian Duperow

Location of the wells for the Mississippian through Devonian rocks in the following discussion.

Mississippian Madison Group Mission Canyon Formation

1. The Mission Canyon Formation is a series of carbonates separated by a series of marker beds that have a significant gamma-ray signature.
2. Offshore to nearshore deposits.
3. Thickness - up to 575 ft.
4. Porosity ranges from 4.7-27%; field averages of 8-15.9%; Permeabilities range from 1-400 md, field averages of 3.4-21 md.
5. Water Injection.

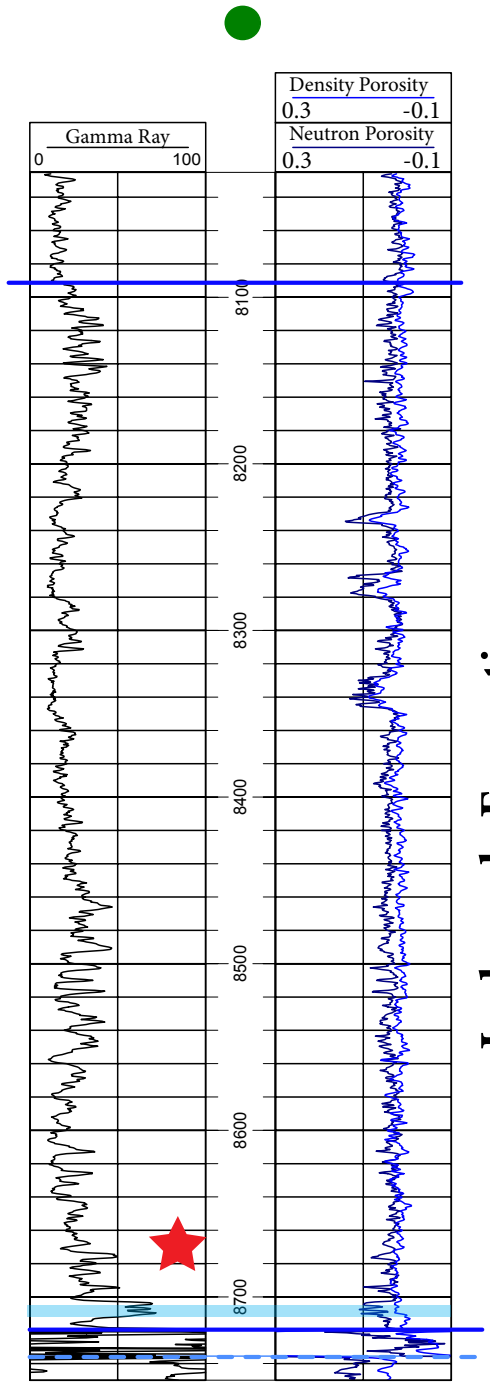
Chandler & Associates, Inc.
Rusch #B-2
SWSW 25-164-85



Chandler & Associates, Inc.
Rusch "B" #1
Lot 3 25-164-85

Mississippian Madison Group Lodgepole Formation

1. Dark grey to brown, light orange or pinkish, dolomitic to cherty to argillaceous limestone. May be fragmental, finely crystalline to granular, oolitic or vuggy to finely intergranular. Roughly equivalent to the Flossie Lake, Witewater Lake, Virden and Scallion subintervals. The Carrington shale facies is present only on the eastern flank of the basin and is equivalent to part of the Scallion subinterval and consisting of a dark grey to red with green mottling clayey, noncalcareous shale. Locally, the Lodgepole contains mud mounds.
2. Thickness - range up to 900 ft.
3. Offshore marine to nearshore.



Lodgepole Formation

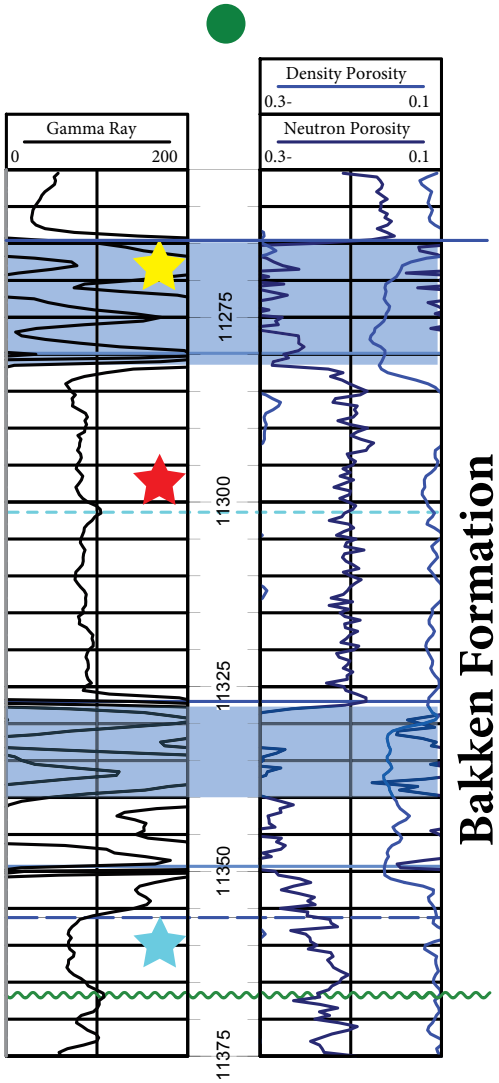
EOG Resources, Inc.
Sidonia #1-06H
SESE 6-158-90

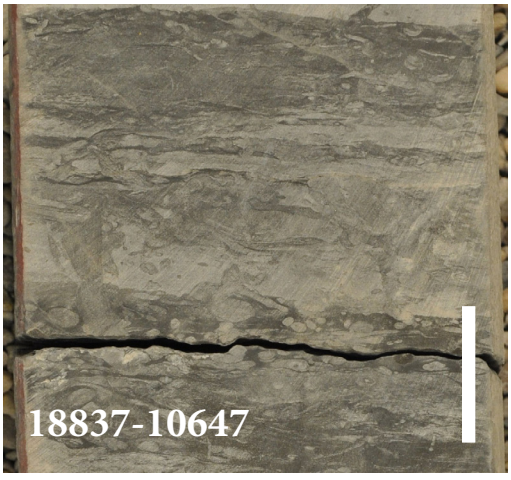
Lodgepole "Mound" - #13715 - NWNW 11-139-97 Duncan Energy - Knopik #1-11

Mississippian - Devonian Bakken Formation

1. Upper and lower black, organic-rich shale, middle light grey to tan mixed sequence of siliciclastics and carbonates. Pronghorn Member is a grey to brown and tan sequence of carbonates, dolostones, and sandstones.
2. Offshore to nearshore deposits.
3. Thickness = approximately 160 ft.
4. Porosity 6 -10%; Permeability - 0.0001 md
5. Conventional and unconventional drilling.
6. *Problems:* Overpressured, fractures, formation damage.

Continental Resources, Inc.
Charlotte #1-22H
SWSE 22-152-99

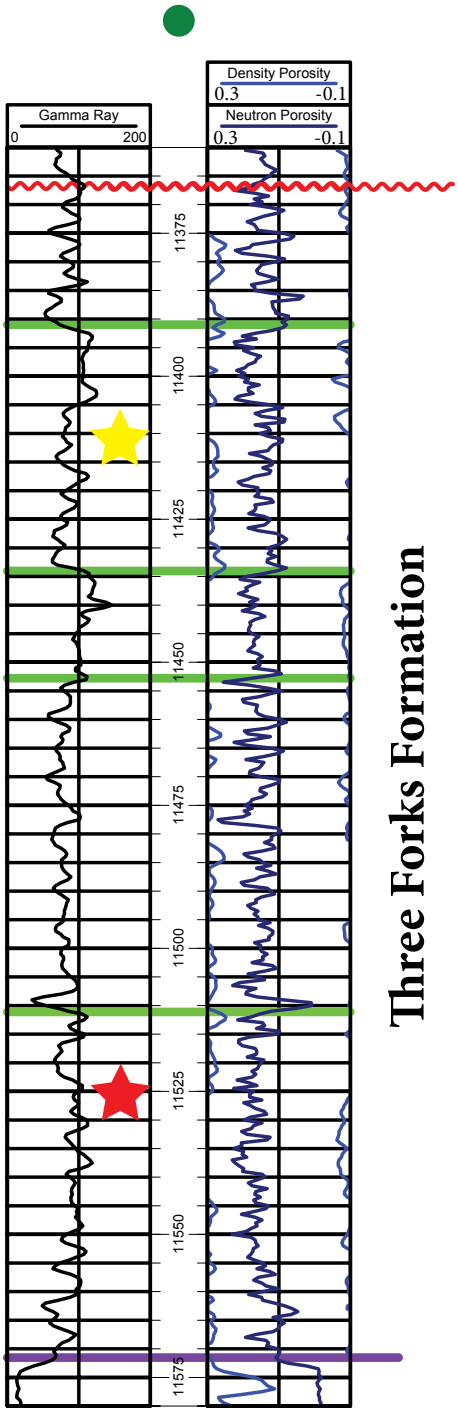




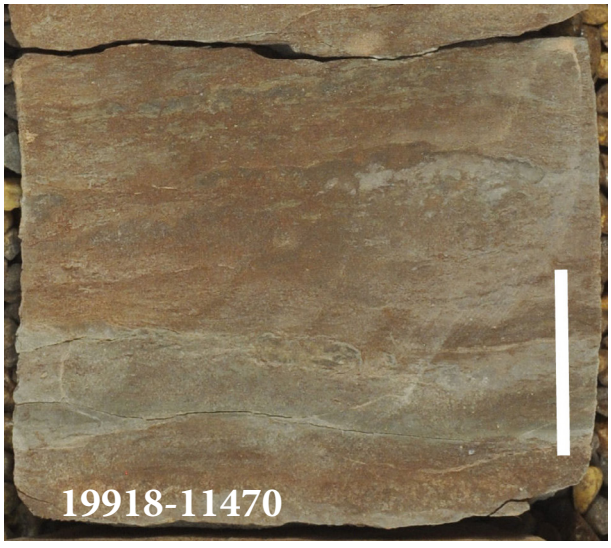
18837 - Whiting Oil & Gas Corp. - Kubas #11-13TFH
NWNE 12-146-99

Devonian Three Forks Formation

1. Upper half - interbedded sequence of apple-green and tan dolomudstones and mudstone; lower half - red silty dolomudstones.
2. Intertidal to supratidal deposits.
3. Thickness = up to 270 ft.
4. Porosities average 6%; Permeabilities range from .01-10 md.
5. Unconventional target - 4 separate targets (informally referred to as the “benches”).



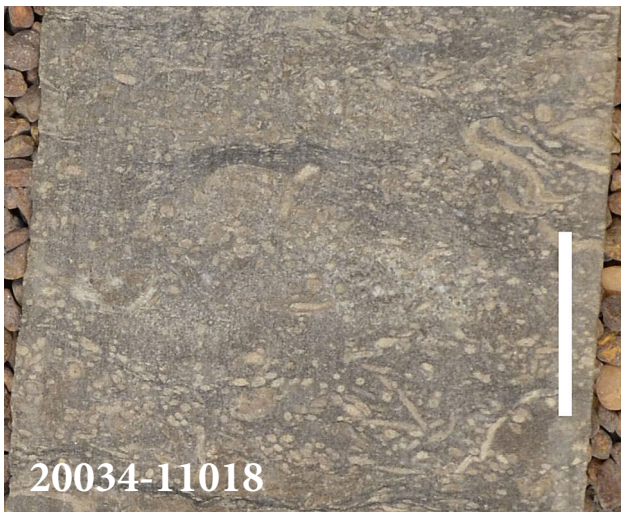
Continental Resources, Inc.
Charlotte #1-22H
SWSE 22-152-99



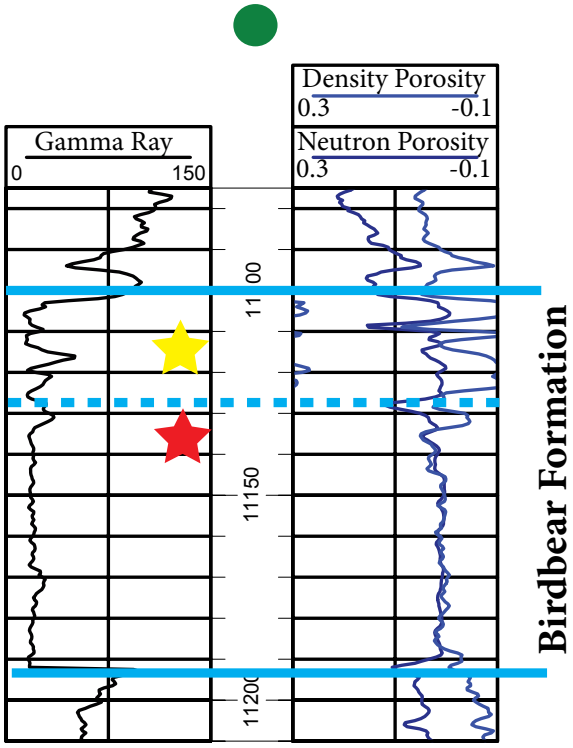
Devonian Birdbear Formation

1. Upper anhydrite section with interbeds of stromatolites and dolostone, overlying limestone.
2. Nearshore marine deposits.
3. Thickness - approximately 150 ft.
4. Porosity 6-10%; Permeability - .0001 md
5. Conventional drilling in the shelf and reefs, horizontal drilling in the thin, upper algal-bearing dolostones.

Continental Resources, Inc.
Debrecen #1-3H
Lot 3 3-140-99



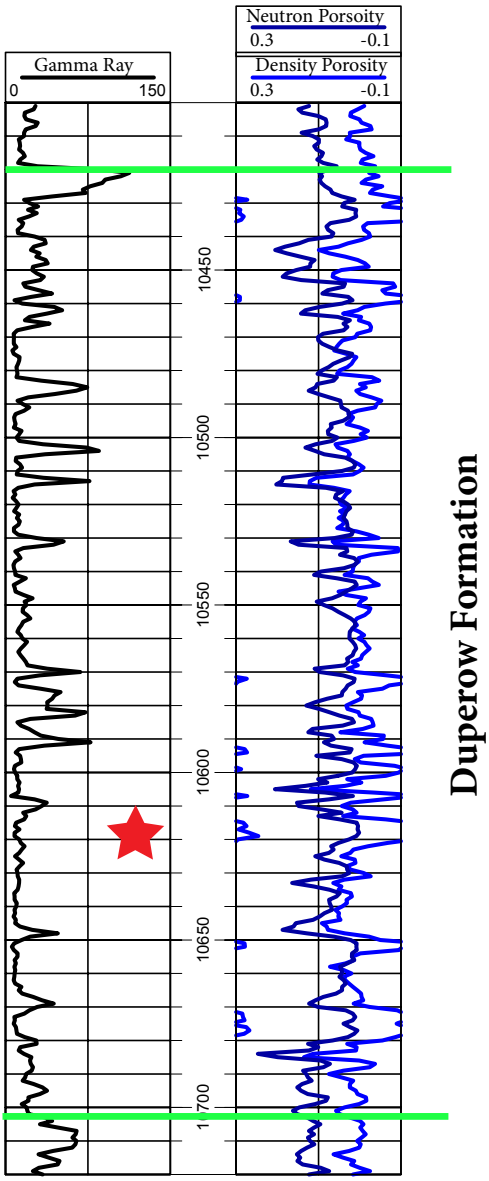
Denbury Onshore, LLC.
Johnson #43-27WNH
NESE 27-145-95



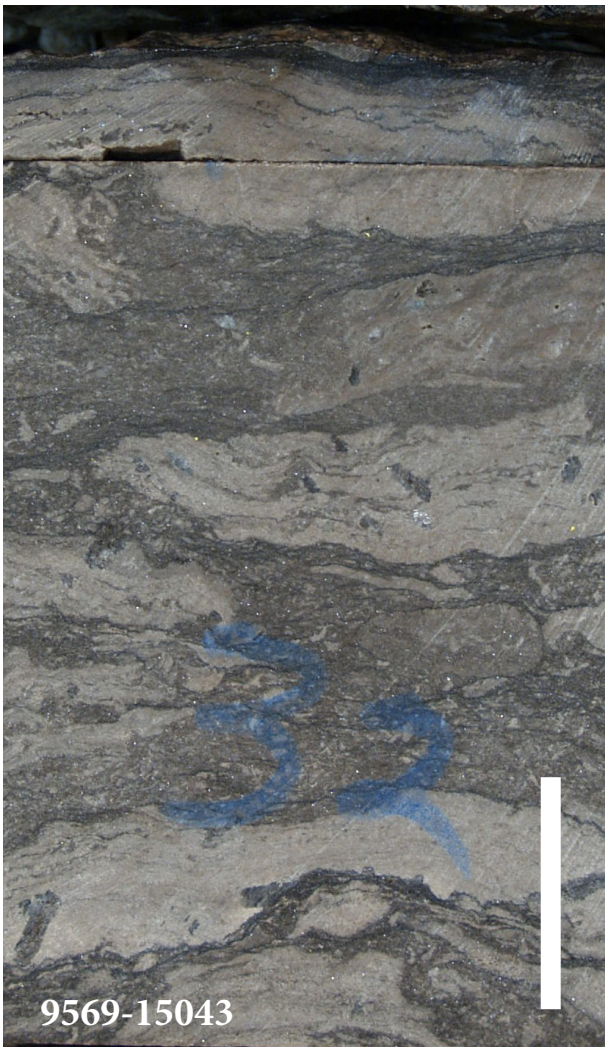
Devonian Duperow Formation

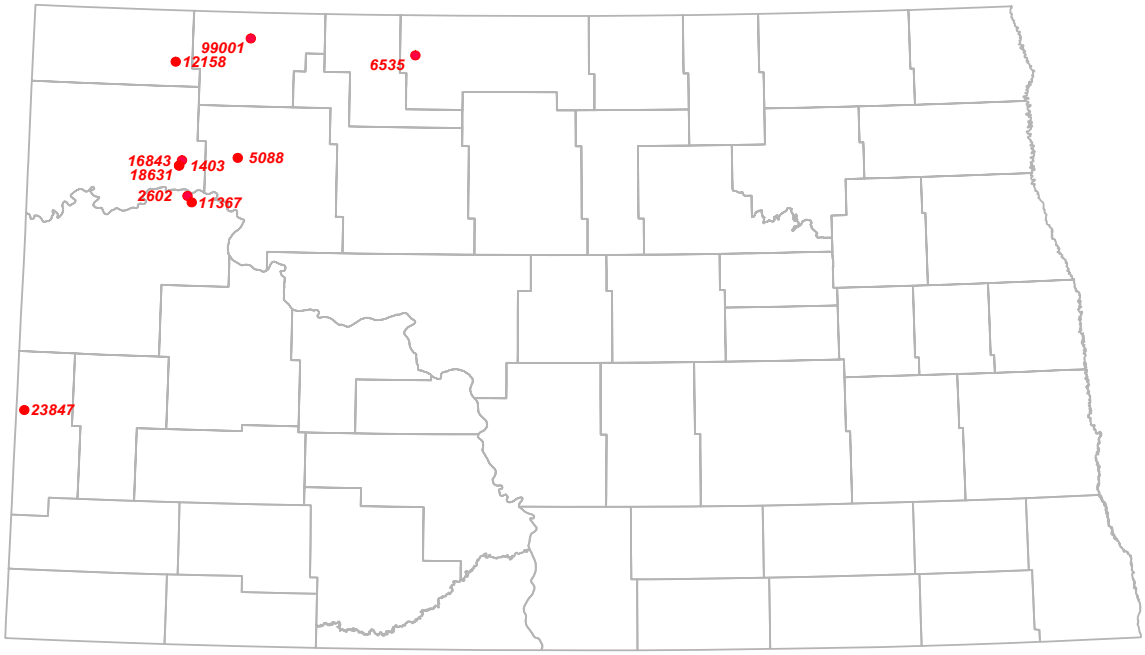
1. Light grey-brown to dark brown crystalline to granular limestone, grey-green to brown microcrystalline to crystalline dolostone, and grey to brown siltstone and grey to brown laminated mudstones with siltstone and sandstone lenses and shale interbeds.
2. Nearshore marine deposits contain approximately a half dozen shoaling-upward sedimentary cycles that begin with fossiliferous, stromatoporoid bank and are capped with anhydrite.
3. Thickness - up to 563 ft.
4. Porosity - 6 to 21%; Permeabilities ranging from 1 to 123 md.

Whiting Oil & Gas Corp.
Stecker #32-9
SWNE 9-141-105



Cities Service Oil Co.
Federal #DG-1
SESE 34-145-100





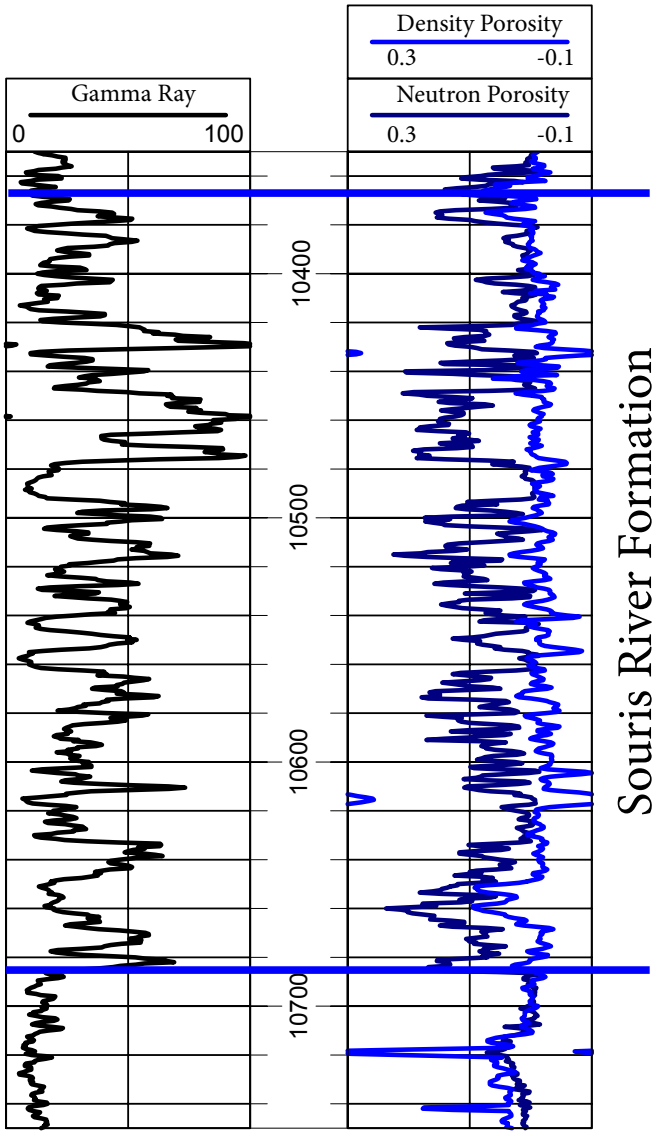
API Number/ Well Number	Location	Operator/Name	Formation
33-105-01787-0000 18631	NWNE 15-155-96	Hess Corporation BLOU #12	Devonian Souris River, Dawson Bay, Ashern
33-105-00519-0000 1403	SWNE 15-155-96	Amerada Petroleum Corp. Boe-Olson #1	Devonian Souris River
33-023-00377-0000 12158	SWSE 19-161-95	Apache Corporation Bakken #19-15	Devonian Dawson Bay
33-105-01657-0000 16843	SWNE 2-155-96	Hess Corporation BLSU D-408C	Devonian Prairie
33-013-99001-0000 99001	SENW 7-162-91	TXL Oil Corp. Lignite TXL Storage Well #1	Devonian Prairie
33-009-01289-0000 6535	NENE 2-161-83	Shell Oil Co. Greek #41-2	Devonian Winnipegosis
33-061-00187-0000 5088	NENW 35-156-93	Shell Oil Co. L Texel #21-35	Devonian Winnipegosis
33-053-00449-0000 2602	C NE 6-153-95	Texaco, Inc. Seth A. Garland #5	Devonian Ashern
33-033-00318-0000 23847	SWNE 9-141-105	Whiting Oil and Gas Corp. Stecker #32-9	Devonian Duperow, Winnipegosis; Silurian Interlake
33-053-02012-0000 11367	SWNW 16-153-95	Amerada Hess Corp. State #16-12	Silurian Interlake

Location of the wells for the Devonian through Silurian rocks in the following discussion.

Devonian Souris River Formation

1. Dolostone and limestone, light to dark grey, grayish brown, crystalline to dense, anhdritic, interbeds of siltstone, claystone and evaporites. Shale, red, occurs at base, referred to as the "First Red Bed".
2. Shallow marine deposits.
3. Thickness - up to 375 ft.

Hess Corporation
BLOU #12
NWNE 15-155-96

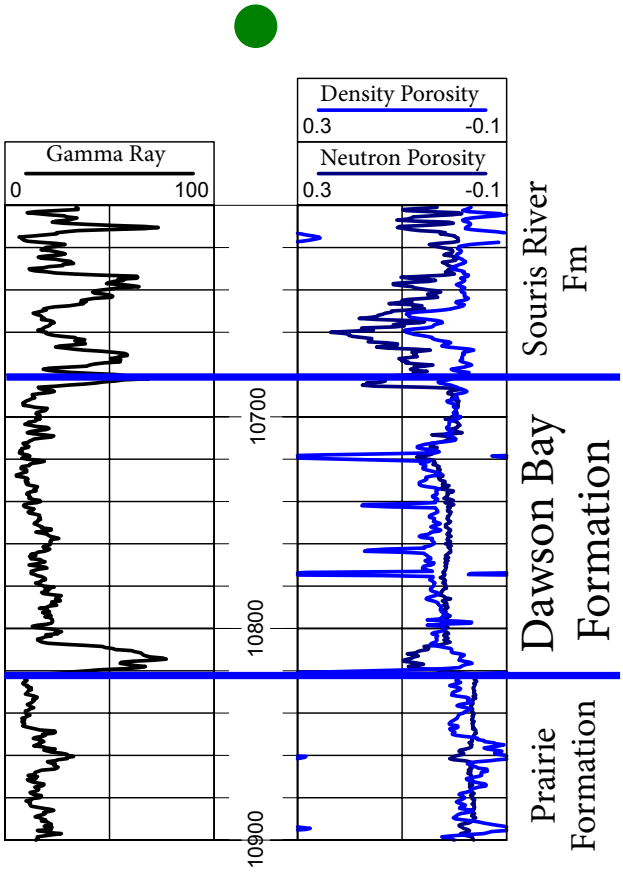


Amerada Petroleum Corp.
Boe-Olson #1
SWNE 15-155-96

Devonian Dawson Bay Formation

1. Dolostone; light grey to light brownish grey with dark red, yellow, yellow-brown to black mottling; variable crystal size; anhydritic, poroous. Limestone; light grey to brownish grey, dense, fossiliferous. Shale predominantly red, some green and grey; dolomitic, occurs at base referred to as the "Second Red bed".
2. Mariginal to nearshore marine deposits.
3. Thickness : up to 190 ft.

Hess Corporation
BLOU #12
NWNE 15-155-96

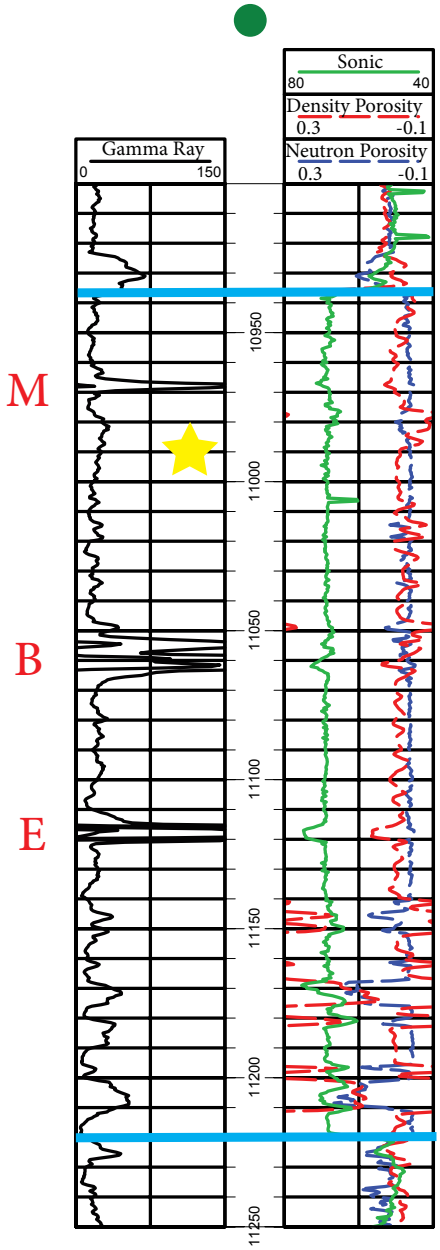


Apache Corporation
Bakken #19-15
SWSE 19-161-95

Devonian Prairie Formation

1. Evaporite, halite, with interbedded lenses of reddish brown siltstone and claystone. Three mineable potash intervals - Mountrail, Belle Plaine, and Esterhazy. Where evaporites are absent consists of mudstone and siltstone interbeds.
2. Shallow restricted marine deposits.
3. Thickness - approximately 650 ft.
4. *Problems*: Washouts leading to casing collapse.

Hess Corporation
BLSU #D-408C
SWNE 2-155-96

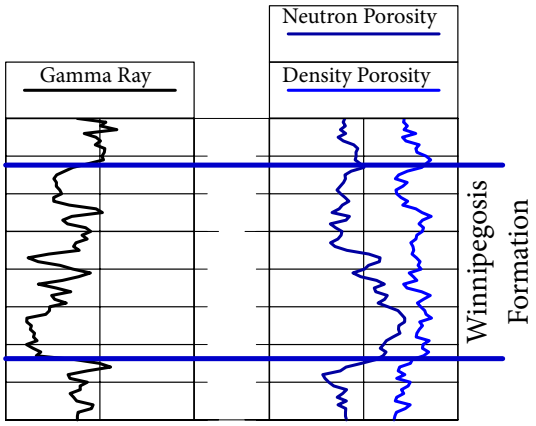


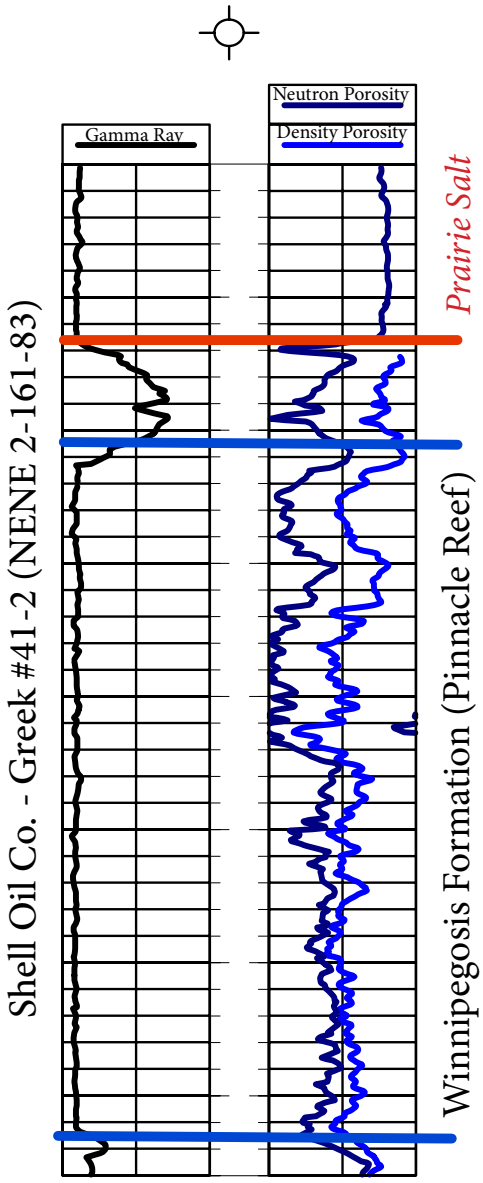
TXL Oil Corp.
Lignite TXL Storage Well #1
SENW 7-162-91

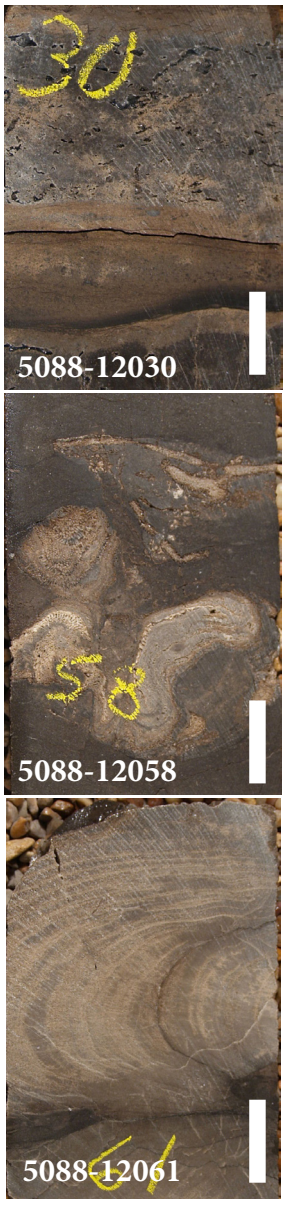
Devonian Winnipegosis Formation

1. Grey, grayish blue, and brown, massive to mottled, laminated limestone and dolostone, grey to light brown, massive to laminated dolomitic mudstone, and nodular and interbedded anhydrite. Formation is fossiliferous with abundant stromatoporoids. The facies that formed adjacet to pinnacle reefs resulted in some Winnipegosis rocks being deposited lateral to Prairie rocks.
2. Offshore to shallow marine deposits.
3. Thickness - up to 220 ft.
4. Porosity - up to 18 %; Permeability up to 20 md.

Whiting Oil & Gas Corp.
Stecker #32-9
SWNE 9-141-105



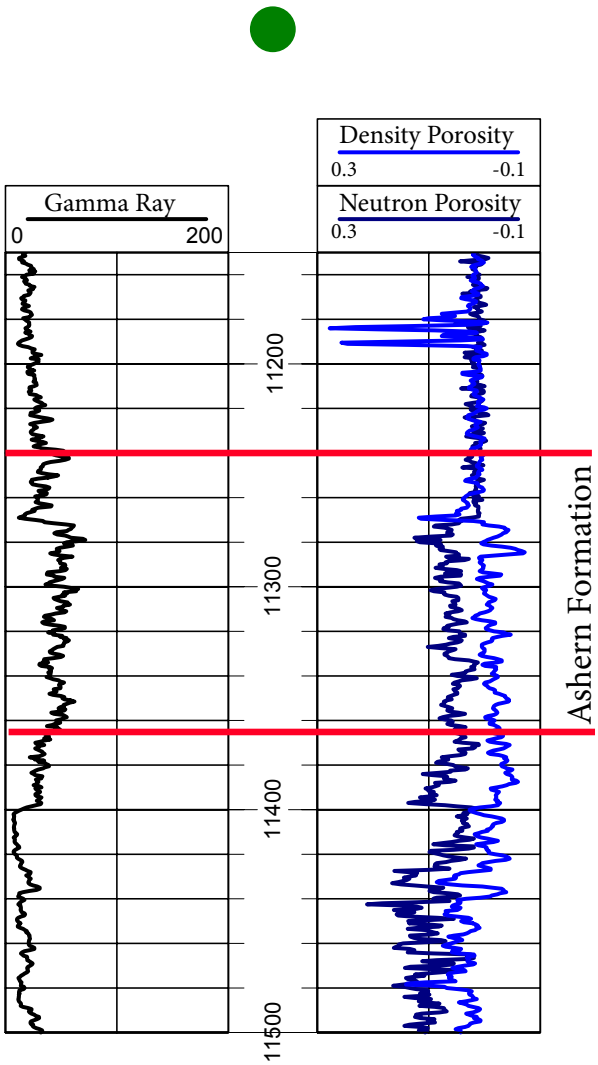




Devonian Ashern Formation

1. Upper two-thirds dolostone, medium to dark grey; argillaceous; microcrystalline and some laminations, anhydrite; some nodular. Lower third: dolostone, light to dark reddish brown; argillaceous microcrystalline, nodular anhydrite; brecciated zone at base. Sometimes referred to as the Third Red bed.
2. Shallow, restricted marine deposits.

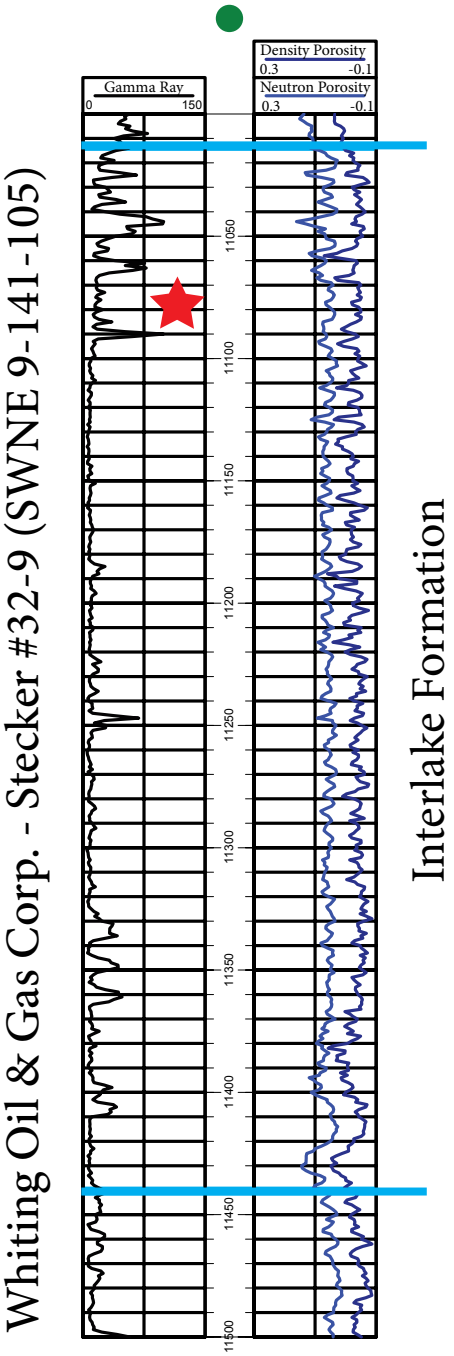
Hess Corporation
BLOU #12
NWNE 15-155-96



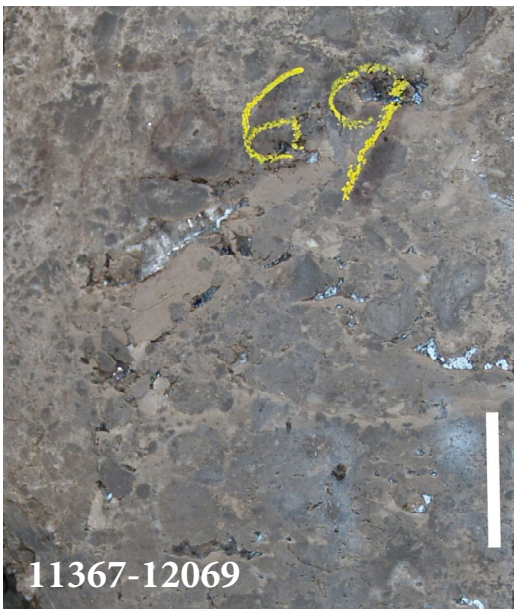
Texaco, Inc.
Seth A. Garland #5
C NE 6-153-95

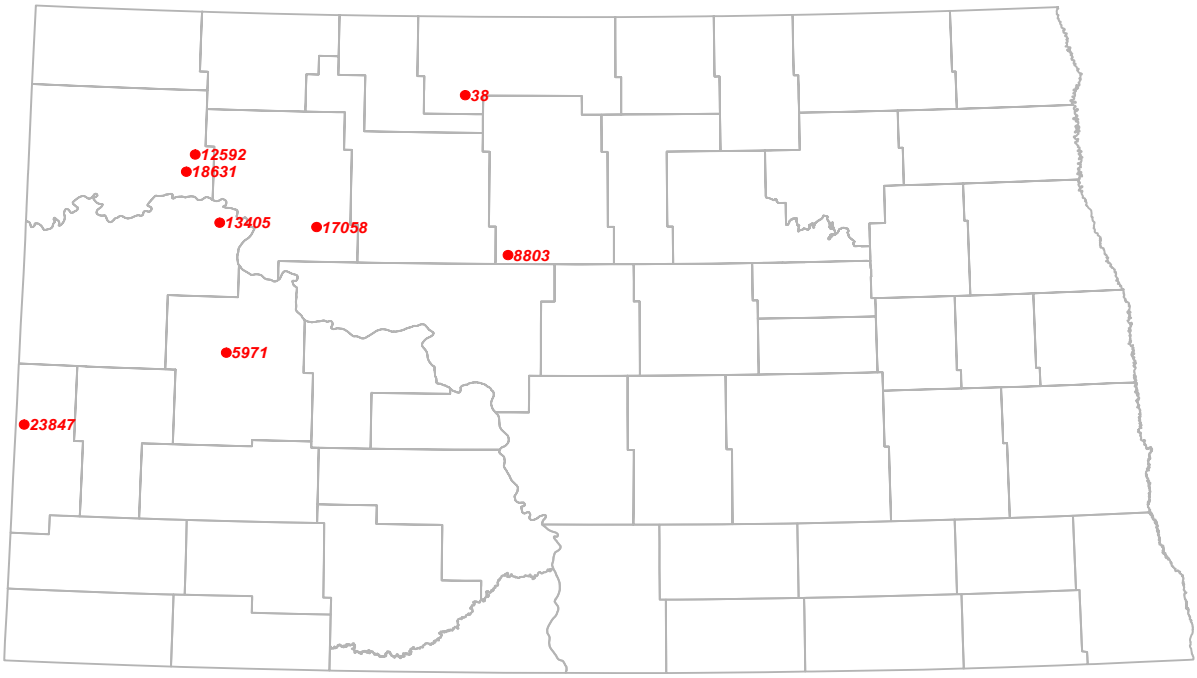
Silurian Interlake Formation

1. Varicolored dolostones, finely crystalline to microcrystalline, massive to laminated, brecciated zones and paleosols.
2. Shallowing upward to non-marine deposits.
3. Thickness - approximately 1,100 ft.
4. Porosity ranges from 8 -28%, averaging 12%; Permeability - highly variable.
5. *Problems*: Salt-plugging in reservoir creating local oi-water contacts, high pour point and salts results in plugging of perforations and chokes, high produced water volumes.



Amerada Hess Corporation
State #16-12
SWNW 16-153-95





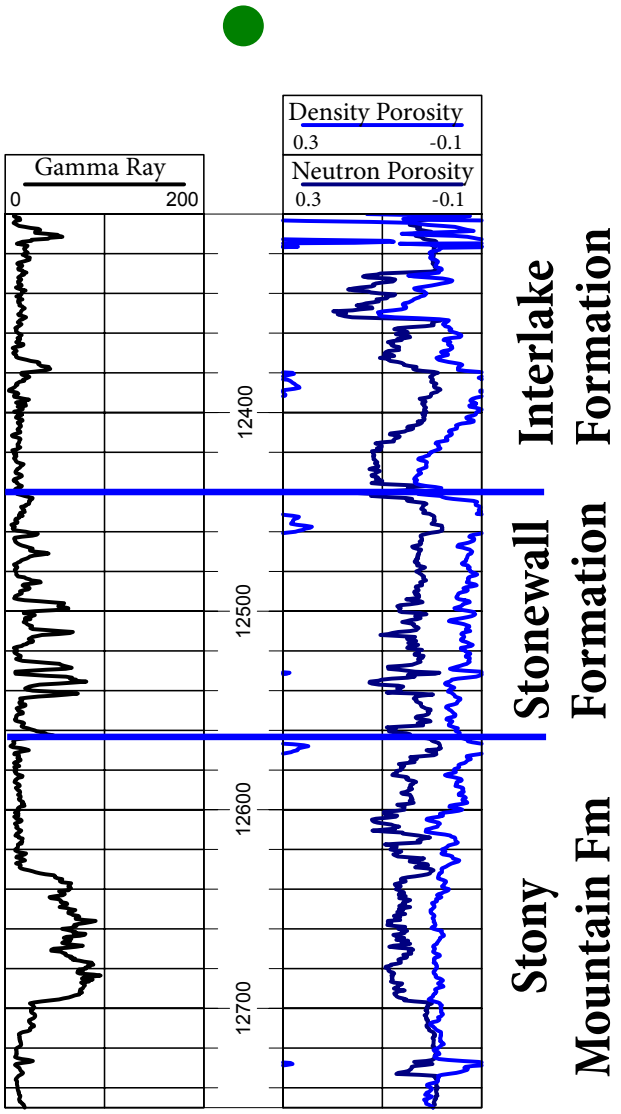
API Number/ Well Number	Location	Operator/Name	Formation
33-105-01787-0000 18631	NWNE 15-155-96	Hess Corporation BLOU #12	Silurian Stonewall
33-009-00002-0000 38	SWSE 31-160-81	California Oil Company Blanche Thompson #1	Silurian Stonewall
33-061-00600-0000 17058	SESW 1-152-90	EOG Resources, Inc. Shell Creek #1-01	Ordovician Stony Mountain, Icebox
33-033-00318-0000 23847	SWNE 9-141-105	Whiting Oil and Gas Corp. Stecker #32-9	Ordovician Red River Winnipeg Group; Cambro-Ordovician Deadwood
33-025-00062-0000 5971	NENW 6-145-94	Amoco Production Co. Grant Carlson #1	Ordovician Red River
33-105-01369-0000 12592	NESW 18-156-95	Amerada Hess Corporation BLOU #7	Ordovician Black Island
33-053-02397-0000 13405	Lot 7 1-152-95	Amerada Hess Corporation Brenna-Lacey 1 #32	Cambro-Ordovician Deadwood
33-049-00127-0000 8803	NENE 22-151-80	Atlantic Richfield Co. Wunderlich #1	Precambrian
		Whiting Oil and Gas Corp. Stecker #32-9	Devonian Duperow, Winnipegosis; Silurian Interlake
33-053-02012-0000 11367	SWNW 16-153-95	Amerada Hess Corp. State #16-12	Silurian Interlake

Location of the wells for the Silurian through Precambrian rocks in the following discussion.

Silurian Stonewall Formation

1. Light to dark greyish brown, finely crystalline, weakly laminated to massive, brecciated, limestone and dolostone. Anhydritic infilling.
2. Shallow marine deposits.

Hess Corporation
BLOU #12
NWNE 15-155-96

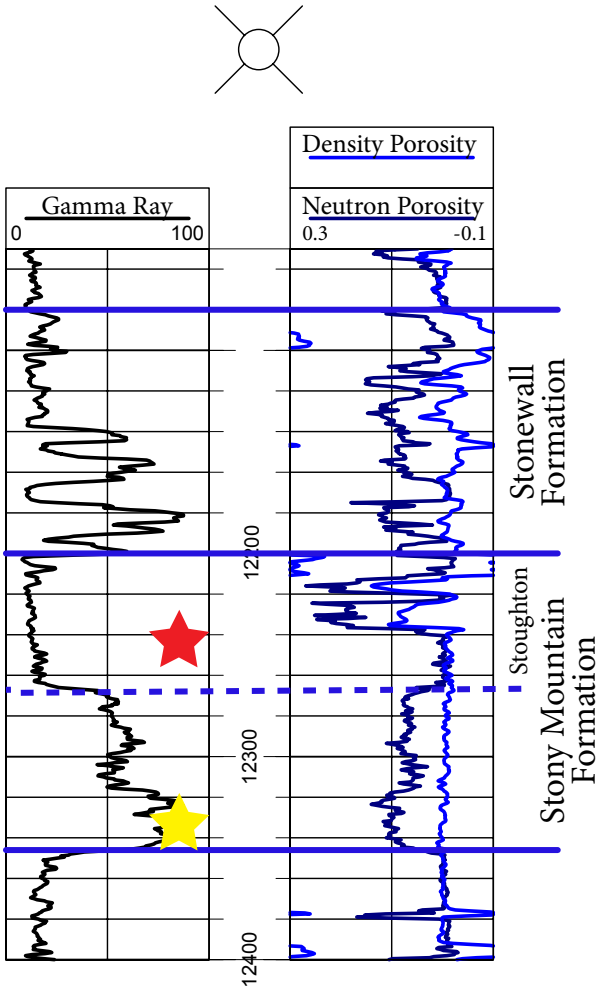


California Company
Blanche Thompson #1
SWNE 15-155-96

Silurian Stony Mountain Formation

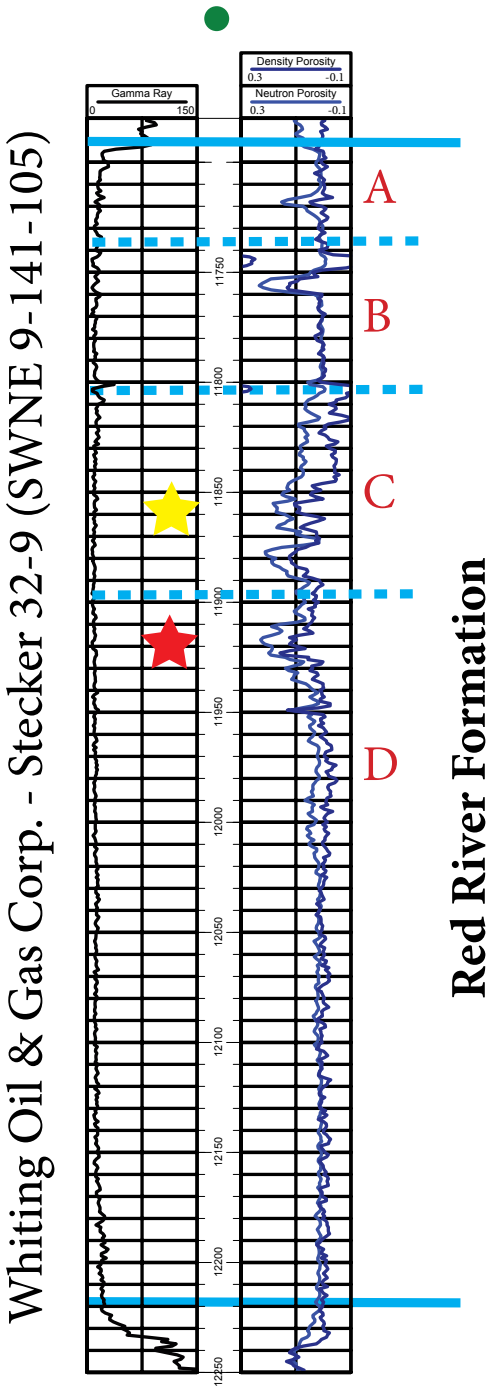
1. Gunton Member: dolostone, yellowish grey to grayish brown, finely crystalline. Limestone grayish brown, fossiliferous, thin anhydrite lenses. Stoughton Member: limestone and shale. Limestone; light bluish grey, olive-grey, to black; clean to agillaceous; interbedded fossiliferous, pyritic. Interbeds of pure limestone, argillaceous limestone and highly calcareous shale. Strong gamma-ray deflection at the base of this member.
2. Shallow marine deposits.

EOG Resources, Inc.
Shell Creek #1-01
SESW 1-152-90

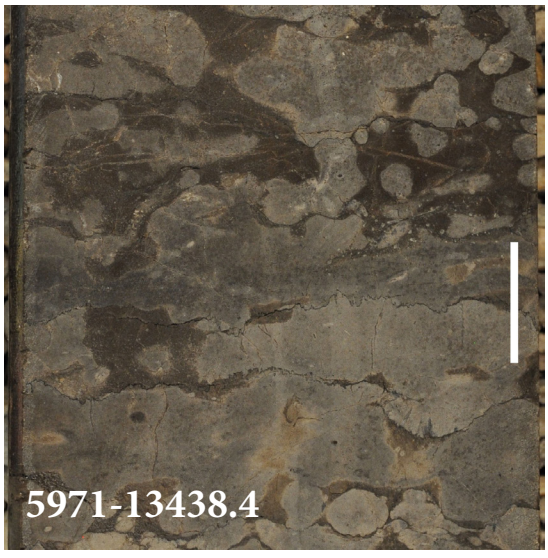


Ordovician Red River Formation

1. Upper third is grey to brown mottled dolomitic limestone, lower two thirds is yellowish grey to brown mottled limestone. Formation is informally divided into four parts - A-D. Each interval consists of bioturbated skeletal limestone that is overlain by a mudstone, capped by an anhydrite and shale.
2. Organic matter and oil sources is "kukersite" (C) with up to 14% TOC.
3. Thickness - approximately 700 ft.
4. Porosity ranges from 6-35%, averaging 12%; Permeability .01-125 md, fracturing and minor tectonic fracturing.



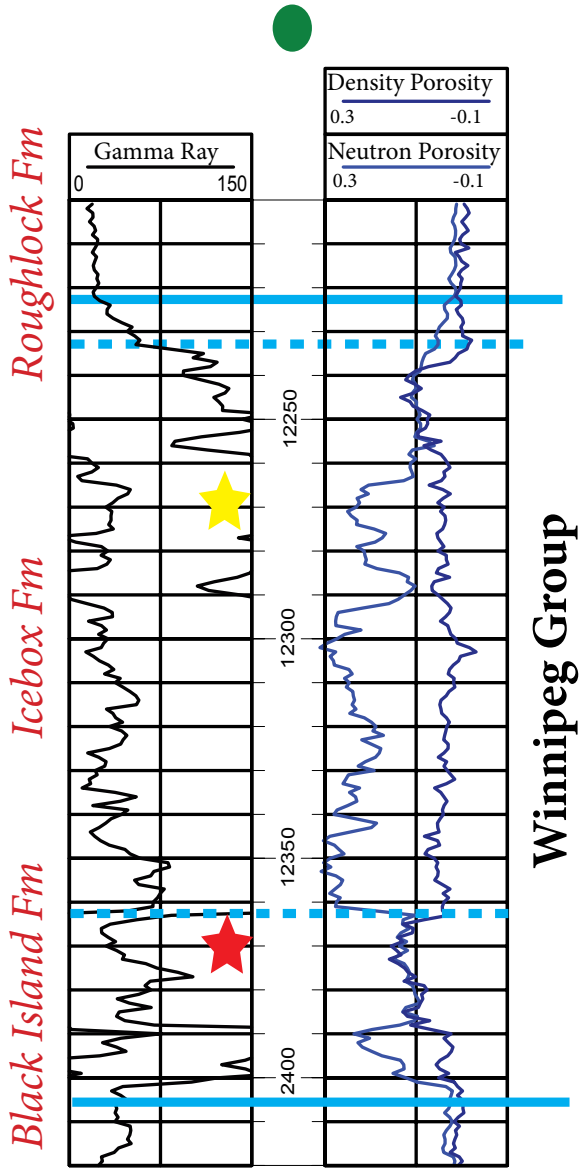
Amoco Producing Co.
Grant Carlson #1
NENW 6-145-94



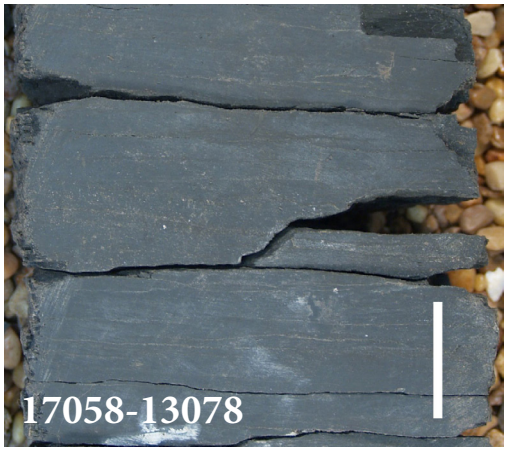
Ordovician Winnipeg Group Roughlock, Icebox, Black Island Formations

1. Three separate formations comprise the Winnipeg Group. The Roughlock is a medium to dark grey calcareous shale. The Icebox is a greenish grey to black shale with isolated sandstone beds. The Black Island is a heavily bioturbated sandstone with shale lenses.
2. Total thickness is approximately 530 ft.
3. Roughlock and Icebox - Offshore marine deposits; Black Island - Shallow marine to fluvial deltaic.
4. Porosity - Black Island - range from 2-11%.
5. Icebox is a source rock and unconventional gas target.

Whiting Oil & Gas Corp.
Stecker #32-9
SWNE 9-141-105



EOG Resources, Inc.
Shell Creek #1-01
SESW 1-152-90
Icebox Formation



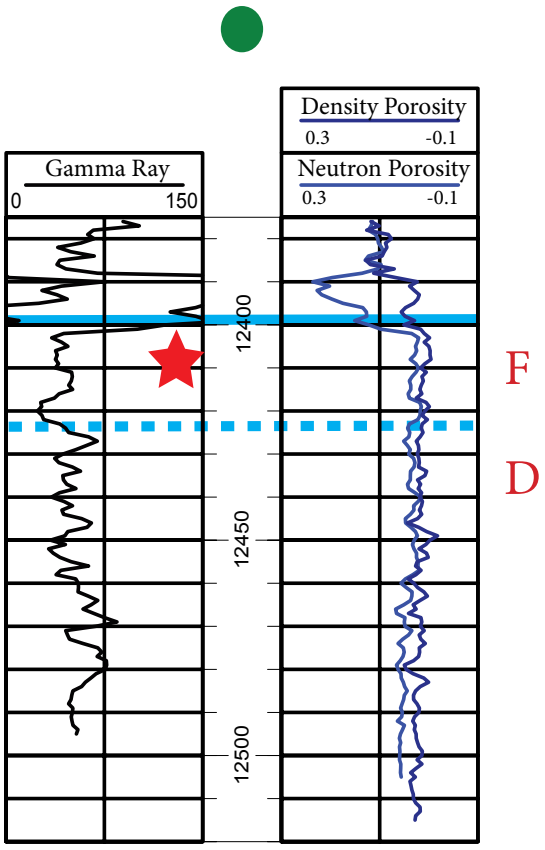
Amerada Hess Corporation
BLOU #7
NESW 18-156-95
Black Island Formation

Cambro - Ordovician Deadwood Formation

1. Predominantly siliciclastic rocks principally quartz arenites, quartz wackes, and siltstones with lesser amounts of carbonate rocks. The formation is divided into 6 (A-F) separate intervals.
2. Thickness is approximately 1000 ft.
3. Marginal marine to offshore.
4. Porosity - up to 7%.
5. Conventional gas-oil condensate.

Amerada Hess Corporation
Brenna-Lacey 1 #32
Lot 7 1-152-95

Whiting Oil & Gas Corp.
Stecker #32-9
SWNE 9-141-105



PreCambrian

Rocks of the Trans-Hudson Orogen underlie the west half of North Dakota. These rocks are remnants of oceanic arc systems that were caught between the Superior and Wyoming cratons when these two microcontinents collided in the Early Proterozoic, 1.9 billion to 1.8 billion years ago. These rocks include granite, granodiorites, biotite-garnet gneiss, charnockite, hornblende schist, monzonite and diabase. The Superior Province is an Archean craton (>2.5 billion years old) that underlies much of eastern North Dakota. Test wells drilled into these rocks have encountered: granites, granodiorites, diorites, chlorite schists (greenstone), granitic metamorphic rocks, stretched pebble conglomerates, porphyritic granodiortie-gneiss, banded gneiss, phyllites, metasedimentary and metavolcanic rocks, adamellites, syenites, banded iron formations, and tuffs. The Wyoming Province undrlies the very southwestern corner of North Dakota on some geologic maps and on others do not extend into North Dakota at all. The Wyoming Province is an Archean craton that formed over 2.5 billion years ago. Rocks encountered in deep test wells in this area include; granites, granite-gneiss, migmatic gneiss, amphibolite, ultramafic rocks, schists, diabases, iron-banded quartzite, and metaconglomerates.

Atlantic Richfield Co.
Wunderlich 1
NENE 22-151-80

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Lillis, P.G., 2013, Review of Oil Families and Their Petroleum Systems of the the Williston Basin: The Mountain Geologist, v. 50, no. 1, p. 5-31.

Murphy, E.C., Nordeng, S.H., Juenker, B.J., and Hoganson, J.W., 2009, North Dakota Stratigraphic Column, North Dakota Miscellaneous Series No. 91, 1 sheet.

U.S. Geological Survey Assessment Team, 2013, Assessment of Undiscovered Oil and Ga Resources of the Williston Basin Province of North Dakota, Montana and South Dakota, 2010; U.S. Geological Suvey Digital Data Series DDS-69-W