NORTH DAKOTA GEOLOGICAL SURVEY CIRCULAR N0. 228

Summary of the Amerada Petroleum Corp. - Signalness Unit #1
Dunn County, North Dakota
Well No. 2400 - Permit No. 2412

by William P. Eastwood
April, 1960

Amerada Petroleum Corp., - Signalness Unit #1 located in SW 1/4, SE 1/4, sec. 10, T. 148N., R. 96W., (2073.7 FEL, 720 FSL), Dunn County, North Dakota. Elevation of K.B. 2394 feet above sea level. Contractor - Noble Drilling Co., Tulsa, Oklahoma.

The drilling permit was issued July 13, 1959. The well was spudded July 15, 1959. Surface casing was set on July 19, 1959. Total depth of 11,660 was reached during the week of September 19-26, 1959. The well was tested and completed as a producer from the Duperow formation on October 23, 1959. Discovery well of Lost Bridge field.

Drill Stem Tests (Johnson Testers):

#1 9402-9456 (Madison) 8-12-59. 4 hour best, 4 1/2" DP, 1500 ft, water cushion, 3/4" opening. Opened tool @ 1:45 A.M., air immediately with weak blow increasing to strong blow in 3 hours, strong blow for remainder of test, no gas to surface, closed tool 5:45 A.M. for 1/2 hour B.H.P. Recovered 2445' fluid: 45' free oil, 32.4 corrected gravity. 8-10% water; 240' gas and oil cut water cushion, est. 5% oil; 1260' gas and mud cut water cushion; 300' gas cut drilling mud, 600' slightly gas cut muddy salt water. IHP-5495#, IFP 805#, FFP 1220#, 10 minutes BHP 2500#, 20 minutes BHP 3525#, 30 minutes BHP 3893#, FHP 5460.

#2 Run #1 9482-9560(Madison) 8-15-59. 4 1/2" DP, 1500' water cushion 3/4" opening. Opened tool 7:50 A.M., air immediately, packers failed. Recovered 1500' water cushion, 900' drilling mud.

Run #2 9466-9560 (Madison) 4 1/2" DP, 1500' water cushion, 3/4" opening. Opened tool 8:15 A.M. air immediately with weak blow for 15 minutes and started losing mud rapidly, shut in tool and trip out of hole. Packer failed. Recovered 1500' water cushion, 780' drilling mud, Temp. 228^0.

Run #3 9458-9560 (Madison) 8-16-59. 3 hour test, 4 1/2" DP, 1500’ water cushion, 3/4" opening. Opened tool 2:00 P.M., air immediately with weak blow for one hour and died. Dead for 1 hour, by-passed fluid, a few weak bubbles and died. Dead for 1 hour, closed tool 5:00 P.M. 1/2 hour BHP. Recovered 1635' fluid: 1500' water cushion, 135' drilling mud, no show oil, gas, or salt water. IHP 5530#, IFP 790#, FFP 830#; 10 minutes BHP 1365#, 20 minutes BHP 1850#, 30 minutes BHP 2330#, FHP 5500#, Temp. 214^0.

#3 9559-9624 (Madison) 8-18-59. 4 hour test, 4 1/2" DP, 1500' water cushion, 3/4" opening. Opened tool 8:10 A.M., air immediately with weak blow for 1 1/4 hour gradually decreasing and died in 2 1/2 hours. Dead for remainder of test, no gas or fluid to surface. Shut in 12:10 P.M. for 1/2 hour BHP. Pulled packer 12:45 P.M. Recovered 2235' fluid: 1320' water cushion, 180' muddy water cushion 735' slightly gas cut drilling mud. No show of oil.

IHP 5490#, IFP 1015#, 10 minutes BHP 1085#, 20 minutes BHP 1137#, 30 minutes BHP 1230#, FHP 5500#, Temp. 218^0.

#4 9614-9700 (Madison) 8-19-59. 3 hour test, 4 1/2" DP, 2000' water cushion, 3/4" opening. Opened 7:00 P.M., air immediately with weak blow gradually decreasing and died in 55 minutes, dead 1 1/4 hour, by-passed fluid, a few weak bubbles and died, dead rest of test. Shut in 10:00 P.M. for 1/2 hour BHP. Pulled packers 10:30 P.M. Recovered 2330' fluid: 1820' water cushion; 180' muddy water cushion; 240' black sulphurous salt water; 90' black sulphurous mud cut salt water. No show of oil. IHP 5431#, IFP 905#, FFP 1030#, 10 minutes BHP 2523#, 20 minutes BHP 3687#, 30 minutes BHP 4053#, FHP 5475#, Temp 219^0.

#5 9735-9800 (Madison) 8-21-59. 2 hour test. 4 1/2" DP, 2000' water cushion 3/4" opening. Opened 3:00 P.M., air immediately with weak blow gradually decreasing and died in 40 minutes, dead 1 1/3 hour, by-passed fluid with a few bubbles and died. Packers failed 2 minutes after tool opened. Recovered 2570' fluid: 1820' water cushion; 180' muddy water cushion; 180' black sulphurous mud cut salt water; 390' drilling mud. No show of oil. IHP 5471#, IFP 907#, FFP 932#, FHP 5532#, Temp. 218^0.

#6 10,977-11,000 (Three Forks, Sanish) 9-9-59. 3 hour test, 4 1/2" DP, 3000' water cushion, 3/4" opening. Opened 7:15 A.M., air immediately with weak blow for 1 1/4 hour, then gradually decreasing and died in 2 hours 10 minutes, dead remainder of test. Shut in 10:15 A.M. for 1/2 hour BHP. Pulled packers 10:55 A.M. Recovered 3390' fluid: 2640' water cushion; 300' slightly gas cut drilling mud; 360' slightly gas cut water cushion; 90' drilling mud. No show of oil. IHP 6250#, IFP 1400#, FFP 1575#, 10 minutes BHP 1625#, 20 minutes BHP 1765#, 30 minutes BHP 1900#, FHP 6210#, Temp. 228^0.

#7 11,425-11,490 (Duperow) 9-15-59. 4 hour test. 4 1/2" DP, 3000' water cushion, 3/4" opening. Opened 1:10 P.M. with air immediately, weak blow for 40 minutes decreasing to very weak for remainder of test, no gas to surface, Shut in 5:10 P.M. for 1/2 hour BHP. Pulled packers 5:45 P.M. Recovered 3910' fluid: 1340' water cushion; 630' highly gas cut water cushion; 1030' highly gas cut muddy water cushion, unloaded; 460' highly gas cut drilling mud; unloaded; 450' highly gas cut drilling mud. No show of oil. IHP 6735#, IFP 145#, FFP 1733#, 10 minutes BHP 2460#, 20 minutes BHP 3315#, 30 minutes BHP 4110#, FHP 6718#, Temp. 254^0.

#8 11,555-11,607 (Duperow) 9-17-59. 4 hour test, 4 1/2" DP, 2600' water cushion, 3/4" opening. Opened 4:30 P.M., air immediately with weak blow increasing to strong blow in 7 minutes, gas to surface in 51 minutes. Not enough gas to measure. No fluid, strong blow remainder of test. Shut-in 8:30 P.M. for 1/2 hour BHP. Pulled packer 9:15 P.M. Recovered 8910' fluid: 360' muddy gas cut water cushion; 1240' heavily gas cut water cushion, unloaded; 6140' free oil, corrected gravity 39.3, unloaded; 1140' gas cut salt water with salt crystals, concentration 346,000 PPM; 30' salt crystals. IHP 6826#, IFP 1023#, FFP 3225#, 10 minutes BHP 4820#, 20 minutes BHP 5120#, 30 minutes BHP 5235, FHP 6795#, Temp. 276^0.

Completion Data:

1. TD 11,660. Acidized open hole 11,635-11,660 with 2000 gallons regular acid. Swabbed 19 1/2 barrels oil, 32 1/2 barrels salt water in 12 hours. Swabbed 15 1/2 barrels oil, 57 barrels salt water and salt crystals in 13 hours. Squeezed open hole with 90 sacks PBD 11,625.

2. PBD 11,625. Perforated 11,428-11,484 with 4 shots per foot, acidized with 2000 gallons regular acid. Swabbed 10 barrels muddy salt water in 2 hours. Swabbed 7 barrels oil and 108 1/2 barrels salt water in 14 hours. Shut in, swabbed 1 1/2 barrels oil, 20 barrels salt water in 10 hours. Squeezed perforations with 95 sacks.

3. Perforated 11,533-11,567 with 4 shots per foot, acidized with 2000 gallons regular acid. Flowed 313 barrels oil, 36 barrels acid and salt water in 24 hours on various sized chokes. T.P. 1250#, GOR 578/1, gravity 41.1°.

Casing and Tubing Record:

4599 feet of 9 5/8" surface casing cemented with 2285 sacks.
11,635 feet of 7" production casing cemented with 1800 sacks. Cement top at 5816.
11,553 feet of 2 7/8" O.D.EuE Tubing.

Cores: None

Mechanical Logs:

Schlumberger Gamma Ray-Laterolog (4598-11655)
Schlumberger Sonic Log (9260-9980; 10870-11030, and 11290-11654).
Lane-Wells Chlorinilog (10,990-11,619).

Readings from Chlorinilog (computed by Lane-Wells)

Depth	Chlorinilog Porosity	Neutron Porosity	Porosity Difference	% Salt Water
11484-506	6	9	3	80
11506-512	17	21	4	45
11512-520	28	34	6	42
11520-530	18	20	2	24
11530-540	8	13	5	92
11540-550	25	29	4	41
11550-556	6	11	5	109
11556-566	20	18	-2	26
11566-572	24	26	2	18
11572-582	15	17	2	28
11582-590	11	13	2	37
11590-594	15	16	1	15
11594-606	26	25	-1	10
11606-619	9	14	5	85

The formation tops were determined by samples and mechanical logs. Color names are those used in the Color Rock Chart of the National Research Council. Limestone petrography terms are those proposed by Folk (1959) Bull. Amer. Assoc. Petroleum Geologists, V. 43, no. 1, pp. 1-38.

FORMATION TOPS

Cretaceous		
	Pierre formation	1620 (sample top)
	Greenhorn formation	4660 (?) (Sample top)
	Mowry formation	4983
	Fall River formation	5384
Jurassic		
	Morrison formation (?)	5695
	Piper lime	6513
Triassic		
	Spearfish formation	6630
Permian		
	Minnekahta formation	7138
	Opeche formation	7179
Pennsylvanian		
	Minnelusa formation	7545
	Amsden formation	7655 (?)
Mississippian		
	Big Snowy Group	8179
	Kibbey lime	8509
	Madison formation	
	Poplar interval	8655
	Ratcliffe interval	9205
	Base Last salt	9280
	Madison undifferentiated	9485
	Base Last anhydrite	9600
	Bakken formation	10883
Devonian		
	Three Forks formation	10931
	Birdbear formation	11208
	Duperow formation	11293

Sample descriptions not corrected for log. In most cases the log averaged about 10 feet.

510-540	Lignite, with very rare to greenish gray, glauconitic, calcareous white medium-grained sandstone and reddish brown siltstone & abundant lost circulation material.
540-570	As above.
570-600	Lignite and rare reddish brown and pale brown siltstone.
600-720	As above.
720-810	As above, rare medium gray, medium to fine grained, glauconitic sandstone and rare medium gray siltstone. Rare molluscan fragments.
810-870	As above.
870-900	Abundant medium to coarse-grained angular and subrounded loose sand grains composed mostly of white and clear quartz with common moderate yellowish green (10GY6/4) translucent grains which may also be quartz. Common lignite and moderate reddish orange (10R6/6) siltstone which are probably cavings.
900-1020	As above.
1020-1110	Abundant lignite with common medium gray, calcareous and siltstone moderate reddish orange common siltstone. Rare molluscan fragments.

1110-1200 As above gray siltstone more common than lignite. Common medium grained, glauconitic, calcareous sandstone.
1200-1260 As above.
1260-1290 Abundant yellowish gray (5Y7/2) non-calcareous shale.
1290-1320 Medium-to-coarse-grained, calcareous, glauconitic sandstone. Common fragments of lignite and reddish brown siltstone. Very rare light olive gray (5Y5/2) to dusky yellow (5Y6/4) fine crystalline (micrite) limestone.
1320-1410 As above.
1410-1470 Common yellowish gray shale and siltstone. Rare sandstone as above. Rare light gray to white very fine-grained sandstone. Common lignite cavings (?).
1470-1620 Lignite.

1620 Top of Pierre formation
1620-1680 Shale, yellowish gray to light gray with rare dark gray fragments. Non-calcareous. Rare molluscan fragments.
1680-1740 Abundant dark gray shale. Lignite and glauconitic sandstone, cavings.
1740-1770 Common angular to subrounded, medium gray to white, medium to coarse, loose quartz sand grains with common lignite and fine-grained very light gray sandstone.
1770-1800 Medium gray to dark gray shale, common sand grains and sandstone as above.
1800-1860 Abundant loose sand grains as above. Common shale and sandstone as above.
1860-1920 Lignite.
1920-1950 Dark gray shale. Rare very light gray glauconitic calcareous sandstone.
1950-1980 Yellowish gray shale with common very light gray glauconitic sandstone as above. Rare molluscan fragments.
1980-2010 Dark gray shale. Rare sandstone and molluscan fragments as above.
2010-2040 Pale yellowish brown shale with common very light gray medium-grained, calcareous sandstone.
2040-2070 Loose sand grains as at 1740-70.
2070-2190 Medium gray to dark gray shale. Rare molluscan fragments.
2190-2310 As above with pale yellowish green (10Y8/2) siltstone. Rare pale yellowish brown (10YR6/2) sublithographic (micrite) limestone.
2310-2550 Medium gray shale. Rare mollusk fragments. Common dark gray shale from 2370-2400. Cornuspira at 2520-50.
2550-2640 Lignite with rare medium gray shale.
2640-2820 Medium gray shale, rare reddish brown sandstone, rare mollusk fragments.
2820-3300 Shale as above, pelsparite limestone at 3030-60. Rare gypsum.
3300-3390 Dark gray shale. Rare dark gray fine-grained friable sandstone with many dark yellowish green (10GY4/4) grains at 3300-3330. Common fine grained very light gray calcareous sandstone 3330-3360. Rare gypsum and mollusk fragments.
3390-3510 Medium gray and dark gray shale.
3510-3620 As above.
3620-4110 Medium gray shale, mollusca fragments rare dark yellowish orange (10YR6/6) siltstone at 3960-4050.
4110-4170 Dark gray shale with abundant white calcareous specks.

4170-4320 Dark gray non-calcareous shale, rare dark gray speckled shale. Rare dark yellowish orange siltstone.
4320-4600 Dark gray shale with rare medium gray shale.
4600-4660 Dark gray shale as above with common very light gray to white fine-grained, limy, glauconitic sandstone.

4660 Top of Greenhorn formation
4660-4720 Dark gray calcareous shale containing small white calcareous specks. Specks are not as numerous as first white specks at 4110.
4720-4780 Dark gray non-calcareous shale with common dark gray calcareous speckled shale.
4780-5080 Dark gray to black, non-calcareous shale.
5080-5290 Dark gray shale. Rare medium gray fine-grained sandstone, rare white calcite nodules at 5110-40 and 5260-90.
5290-5350 Missing.
5350-5380 Medium gray to dark gray shale with rare medium gray fine grained, glauconitic (?) sandstone.

5384 Top of Fall River formation
5380-5410 Dark gray shale.
5410-5560 Abundant dark gray shale with white to very light gray, very fine grained pyritic sandstone.

5695 Top of Morrison formation
5560-5740 Dark gray to medium gray shale, rare sandstone. Quartz grains at 5650-80.
5740-5770 Common large pieces of medium gray to very light gray, glauconitic (?) non-calcareous fine-grained sandstone. Common black shale as above.
5770-5830 Black shale with common sandstone as above.
5830-5950 Abundant sandstone as above, rare shale as above. Rare pale yellowish brown (10YR6/2), sublithographic limestone and pale brown (5YR5/6) shale at 5890-5920.
5950-5980 As above with common very light gray medium grained to fine-grained limy sandstone.
5980-6010 As in 5830-90 above. Rare limy sandstone.
6010-6190 Abundant medium-grained, very light gray calcareous sandstone, common black shale.
6190-6220 Sandstone as above with medium-gray slightly limy siltstone.
6220-6250 Greenish gray (5GY6/1) shale with siltstone and rare sandstone as above.
6250-6280 As above with rare white sublithographic (micrite) limestone.
6280-6310 Missing.
6310-6400 Common moderate brown (5YR4/4) and (5YR3/4), slightly limy shale with gray shale and siltstone as above.
6400-6460 Common very pale orange (10YR8/2) to very light gray to white fine-crystalline (microsparite) limestone containing rare glauconite (?) grains. Abundant medium gray to dark gray shale. Fine-grained limy sandstone at 6430-60.
6460-6490 Medium gray, waxy-appearing limy shale with common fragments of pale yellowish brown (10YR6/2) fine-crystalline to sublithographic (micrite)limestone.

6490-6520 Light red (5R6/6) to pale red (5R6/2) micrite limestone. Rare pale yellowish brown limestone as above. Rare moderate reddish brown (10R4/6) shale and gray shale as above. Rare white fine grained sandstone.
6520-6550 As above with common very pale orange dolomitic micrite limestone.
6550-6580 As above but reddish brown shale more common.
6580-6610 Pale red (5R6/2) to grayish red (5R4/2) pelmicrite limestone. Common pale yellowish brown micrite limestone. Rare reddish brown shale and dolomitic limestone as above.

6630 Top of Spearfish formation
6610-6640 Limestone, sublithographic (micrite) limestone.
6640-6700 As above with moderate reddish brown (10R4/6) sandy shale.
6700-6850 Shale, moderate red (5R4/6), slightly limy, sandy. Rare rounded quartz grains.
6850-7090 As above with rare dark reddish brown shale at 6850-6910. White gypsum in the red shale 7000-7060.
7090-7150 Reddish brown shale as above with white gypsum.

7138 Top of Minnekahta formation
7150-7180 Red shale as above with common very pale orange to white to pale red limestone.

7179 Top of Opeche formation
7180-7210 Abundant gypsum, white with pinkish tinge. Common shale as above.

7230 Top of Opeche salt (by laterolog)
7210-7300 Salt, clear, pinkish tinge, fragments of large crystals.

7300 Base of Opeche salt (by laterolog)
7300-7390 Shale, reddish brown (10R4/6) with salt fragments as above.
7390-7420 Salt with rare reddish brown shale.
7420-7440 Reddish brown shale, dark gray shale (cavings ?) and salt.
7440-7500 Reddish brown shale with rare fine crystalline white salt pasted on it from 7440-70.
7500-7520 Missing.
7520-7540 Salt, clear, pinkish tinge, fragments of large crystals.
7540-7560 Shale, moderate red (5R4/6), silty and sandy.

7545 Top of Minnelusa formation
7560-7590 Pale red (5R6/2), very fine grained, limy sandy dolomite. Shale as above.
7590-7600 Moderate red shale as above. White gypsum and pink dolomite rare. Black shale cavings.
7600-7620 Pale red to moderate pink limy dolomite as in 7560-90.
7620-7650 Sand grains, quartz, coarse, loose, rounded, subspherical.

7655 Top of Amsden formation
7650-7670 Dolomite, pale red and moderate pink as above. Common white and pink gypsum. Rare coarse loose sand grains as above. Common red shale as above.
7670-7690 Sandstone, white, quartzitic, friable, medium grained, slightly limy. Common red shale and dolomite as above.
7690-7700 Fragments of salt crystals and red shale as above.

7700-7710 Sandstone and shale as in 7670-90.
7710-7720 Dolomite, moderate pink (5R7/4) medium crystalline, limy, sandy.
7720-7740 Very pale yellowish brown (10YR6/2) medium to fine grained quartz sandstone with limy dolomite cement.
7740-7770 Sandstone as above with common pale yellowish brown fine-crystalline slightly sandy limy dolomite and dolomitic sandstone.
7770-7820 Moderate pink to pale red sandy dolomite and dolomitic sandstone, medium grained.
7820-7830 As above only color is pale yellowish brown.
7830-7850 As in 7770-7820 above.
7850-7860 Sandstone, very pale orange (10YR8/2) medium grained to fine-grained, friable. Grains are clear, angular to subrounded quartz.
7860-7920 Dolomite, very pale orange, very fine crystalline (micrite ?) tight. Common moderate red shale 7900-10.
7920-7950 Dolomite as above with common moderate yellowish brown (10YR5/4) dolomite, mostly finely crystalline (microsparite) but some is pelmicrosparite with small pinpoint vugs.
7950-7960 As above with common moderate yellowish brown fine crystalline to sublithographic (micrite) limestone.
7960-7990 Abundant limestone as above rare dolomite as above. Rare to common grayish red (5R4/2) silty limestone.
7990-8000 Limestone as above with common very pale orange micrite limestone.
8000-8010 Abundant very pale orange (10YR8/2) fine crystalline (micrite) limestone with common to rare moderate yellowish brown micrite limestone.

8011 Top of Tyler formation.
8010-8030 Very pale orange, microsparite limy dolomite with limestone as above.
8030-8060 Shale, dark yellowish brown (10YR6/6) to dusky yellow (5Y6/4), and very dusky red purple (5RP2/2) with rare light green shale (5G7/4). All shale clayey, waxy-appearing, and splintery. All shale is non-calcareous. Amount of red purple shale increases from 8040-60.
8060-8070 Black to dark gray shale with common to rare shale as above.
8070-8120 Black shale as above. At 8110-8120 rare fine grained, slightly, oil-stained sandstone, faint cut.
8120-8130 Black shale and sandstone as above with rare light gray (N7) siltstone.
8130-8160 Black shale and sandstone as above.
8160-8190 Black shale and sandstone as above with variegated shale as in 8030-60.

8179 Top of Big Snowy group
8190-8200 As above with grayish brown (5YR3/2) micrite limestone.
8200-8210 Grayish brown to dark yellowish brown limestone as above with black and variegated shale as above.
8210-8220 Shale and rare limestone as above with common dark yellowish green clayey calcareous shale.
8220-8240 Dolomite, grayish yellow (5Y8/4) to very pale orange. Black and green shale as above (cavings ?). Dolomite is limy and earthy appearing, very finely crystalline (microsparite).
8240-8260 As above but dolomite rare.
8260-8280 Light gray, fine-crystalline (microsparite) silty limestone. Shale and dolomite as above.

8280-8310 Black shale, common light gray limy shale.
8310-8340 As above with moderate orange pink (5YR8/4) fine grained sandstone and moderate reddish orange (10R6/6) shale (cavings ?).
8340-8350 As above with rare white, fine-grained friable quartz sandstone.
8350-8370 As above with variegated shale cavings.
8370-8510 Abundant white to pale red sandstone as above. Black and variegated shale cavings. Sandstone fine to medium grained and friable. White gypsum at 8470-8480. Sand becomes slightly coarser towards base.

8509 Top of "Kibbey lime"
8510-8520 Shale as above with common white gypsum.
8520-8550 Limestone pale to dark yellowish brown (10YR6/2) sublithographic (micrilimestone). Good secondary porosity in the form of small interconnected (?) vugs beginning at 8540.
8550-8560 Sandstone, white, fine and medium grained, calcareous. With shale and limestone as above.
8560-8580 Abundant black shale rare variegated shale, limestone and sandstone. Rare white gypsum.
8580-8590 As above with common light brown (5YR6/4) medium grained calcareous sandstone.
8590-8600 Black shale and assorted cavings.
8600-8650 As above with quartz fragments and muscovite flakes.

8655 Top of Madison group. First Charles salt. Top of Poplar interval.
8650-8720 Salt. By laterolog the first Charles salt extends from 8658-8800.
8720-8750 Salt as above with black and brown shale. By the laterolog a shaly zone exists from 8710-8730.
8750-8810 Salt, fragments of large crystals.
8810-8820 Dolomite, limy, very pale orange (10YR8/2) microsparite (finely crystalline) apparently fair intergranular porosity.
8820-8840 Salt with rare dolomite as above.
8840-8860 Pale yellowish brown (10YR6/2) microsparite limy dolomite and limy shale, white anhydrite.
8860-8880 As above with common salt.
8880-8890 Common pale yellowish brown to light gray micrite limestone. Limestone has areas where secondary porosity is well developed. Rare dolomite and salt as above. Black shale cavings.
8890-8900 Limestone, medium gray, micrite. Apparently no porosity.
8900-8920 Black and variegated shale with white anhydrite. Probably cavings.
8920-8990 Salt, clear, brownish tinge, fragments of large crystals.
8990-9000 Abundant white anhydrite, rare salt. Black shale cavings.
9000-9020 Limestone, pale yellowish brown, micrite with rare small pellets. Rare white anhydrite. Rare areas of secondary porosity in the form of small interconnected vugs 9010-9020.
9020-9030 As above with common moderate to pale yellowish brown oomicro-sparite. Common moderate to dark yellowish brown micrite with dead oil (?) stain. Rare ostracodes.
9030-9050 Limestone, pale yellowish brown, microsparite, silty with common white anhydrite. Rare pieces of pale yellowish brown microsparite, limy dolomite with inclusions of white anhydrite.
9050-9090 Abundant white anhydrite, rare limestone and dolomite as above. Black shale cavings.
9090-9100 Missing.

9100-9110 As in 9050-90 above.
9110-9120 Medium gray anhydrite.
9120-9130 White anhydrite and common medium gray anhydrite rare microsparite limestone as above.
9130-9140 Limestone, pale to moderate yellowish brown, micrite with rare pelmicrite, rare secondary porosity.
9140-9150 Limestone as above, pelmicrite more common, rare very light gray microsparite limestone with inclusions of white anhydrite.
9150-9170 Limestone, moderate to dark yellowish brown, micrite and pelmicrite. Rare brachiopod fragments.
9170-9180 As above with very light gray microsparite limy dolomite with inclusions of anhydrite.
9180-9190 Limestone and dolomite as above, common white anhydrite.
9190-9200 Mostly black and variegated shale cavings with white anhydrite.

9205 Top of Ratcliffe interval
9200-9210 Limestone, moderate to dark yellowish brown, pelmicrite with rare medium sized intraclasts.
9210-9220 Moderate yellowish brown limestone as above with white and gray anhydrite.
9220-9260 Salt.
9260-9300 Medium gray limy anhydrite.
9300-9310 Light gray to white limy anhydrite. Very rare rare pale yellowish brown micrite limestone with linear algae (?).
9310-9315 Anhydrite as above with pale yellowish brown microsparite limestone and light gray microsparite limy anhydritic dolomite.
9315-9320 As above with very rare oosparite limestone.
9320-9325 Anhydrite as above with common moderate to dark, yellowish brown pelmicrite, secondarily porous limestone.
9325-9345 Badly caved. Black and variegated shale.
9345-9350 White and gray anhydrite. Rare pale yellowish brown microsparite limestone.
9350-9355 White and gray anhydrite.
9355-9360 Anhydrite as above with common very pale orange (10YR8/2) micro-sparite, anhydritic, limy dolomite.
9360-9365 As above with moderate yellowish brown pelmicrite limestone.
9365-9375 Limestone, moderate yellowish brown micrite and pelmicrite, rare small secondary vugs. Good cut.
9375-9390 As above with good secondary porosity, spotty oil stain, good cut. Rare tight oosparite limestone at 9385-90.
9390-9405 Rare limestone as above, common white to gray anhydrite, mostly black shale cavings.
9402-9456 Drill stem test #1. Recovered 45 feet free oil, 240 feet gas and oil cut water cushion, 1260 gas and mud cut water cushion, 30 feet gas cut mud and 600 feet slightly gas cut muddy salt water.
9405-9410 Limestone, moderate yellowish brown pelmicrite. Small dusky yellowish brown pellets in a matrix of pale yellowish brown micrite or microsparite. Fair intergranular porosity, low permeability. Very weak cut.
9410-9420 Limestone, moderate yellowish brown, oopelsparite. Small pseudo-oolites and pellets in a microsparite matrix. Pale yellowish brown to very pale orange pelaparite limestone consisting of small pellets in an anhydritic matrix.

9420-9425 Limestone moderate to pale yellowish brown pelsparite, small pellets in matrix of finely granular calcite and possibly some anhydrite. Good intergranular porosity, numerous pinpoint vugs. Good cut.

9425-9445 Limestone as above with common pale yellowish brown pelmicro-sparite limestone, lightly anhydritic and dolomitic small pellets in a finely granular and dolomitic matrix. Fair porosity, low permeability, very weak cut.

9445-9450 Pelsparite limestone as above. Rare pelmicrosparite limestone.

9450-9456 Limestone, moderate yellowish brown, pelmicrosparite, anhydritic. Small pellets in matrix of calcite or finely crystalline limestone. Slightly anhydritic. Small vugs very rare, low porosity. Very weak cut.

9456-9460 As above, badly caved.

Drill stem test #2

Run #1 9482-9560 failed.

Run #2 9466-9560 recovered water cushion and mud. No oil or gas.

Run #3 9458-9560 recovered water cushion and mud. No oil or gas.

9460-9480 Pelsparite and pelmicrite limestone, as above.

9480-9485 As above, with rare pale yellowish brown micrite limestone and rare white anhydrite.

9485 Top of Madison undifferentiated

9485-9490 Limestone, pale yellowish brown, pelmicrosparite good inter-granular and vuggy porosity.

9490-9510 As above with moderate yellowish brown tight pelsparite limestone.

9510-9525 Badly caved, black shale and white anhydrite.

9525-9540 Common limestone as above with abundant white and medium bluish gray (5B5/1) anhydrite.

9540-9545 Anhydrite as above with common pale yellowish brown, finely granular (microsparite) slightly dolomitic limestone.

9545-9555 Limestone, moderate yellowish brown, tight, pelsparite and pelmicrite.

9555-9565 Badly caved. Black shale, limestone as above and white anhydrite.

Drill stem test #3 9559-9624. Recovered water cushion and slightly gas cut, drilling mud. No show of oil.

9565-9600 Limestone, moderate yellowish brown, peloosparite. Tight. Pellets and small pseudo-oolites in a crystalline calcite and white anhydrite matrix. Rare brachiopod fragments. Becomes more anhydritic towards base.

9600-9624 Limestone as above with common very light gray dolomitic anhydrite and very pale orange microsparite limy dolomite.

9624 Circulated 1 hour. Anhydritic limestone as above. Shale cavings.

Drill stem test #4 9614-9700. Recovered water cushion and black sulphurous salt water, no show of oil.

9624-9635 Peloosparite, anhydritic, limestone as above.

9635-9665 Limestone as above, less anhydritic. Scattered small intergranular pores. Pale yellowish brown pelsparite limestone appearing about 9645 and becoming more toward base.

9665-9700 Pale to dark yellowish brown pelsparite as above, common to rare peloosparite as above.

9700 Circulated sample. As above.

9700-9725 Limestone as above with common dark yellowish brown pelmicrite.

9725-9750 Abundant pale yellowish brown pelmicrosparite. Rare pelmicrite and peloosparite.

Drill stem test #5 9735-9800. Packers failed, recovered water cushion, drilling mud and black sulphurous salt water.

9750-9765 Limestone as above.

9765-9825 Limestone, pale yellowish brown to very pale orange pelsparite and pelmicrosparite. Slightly anhydritic. Rare pseudo-oolites.

9825-9840 As above with common pale yellowish brown peloosparite.

9840-9850 As above, badly caved.

9850-9865 Limestone, pale to moderate yellowish brown intrapelsparite. Tight.

9865-9870 Limestone as above, with pelmicrite.

9870-9875 Limestone, pale yellowish brown, intrapelsparite and pelmicrosparite, coarse pale yellowish brown calcite crystals.

9875-9885 As above with common moderate to dark yellowish brown pelmicrosparite limestone. Small pellets in a finely granular matrix.

9885-9900 Pale yellowish brown as in 9870-75 above with rare granular limestone as above.

9900-9915 As above with common white fine crystalline (micrite) limestone.

9915-9945 Limestone, moderate yellowish brown, intrapelsparite, coarse yellowish brown calcite crystals. Rare dark yellowish brown granular limestone. Very rare pale yellowish brown limy secondary chert.

9945-9955 Limestone, moderate to dark yellowish brown, pelmicrosparite, small pellets in a finely granular matrix.

9955-9965 As above with common pale intrapelsparite as in 9915-45.

9965-9970 Missing.

9970-9975 Pale to moderate yellowish brown intrapelsparite as above.

9975-9995 As above with common dark yellowish brown, fine crystalline limestone. Pelmicrite.

9995-10050 Limestone, pale to dark yellowish brown, Pelsparite and pelmicrite.

10050-10080 Limestone, dark yellowish brown, pelmicrite. Rare pelsparite. Rare brachiopod fragments.

10080-10130 As above with common moderate yellowish brown pelmicrite limestone.

10130-10170 Dark yellowish brown limestone as above with common pale yellowish brown to very pale orange, very fine crystalline (micrite) limestone. Rare moderate yellowish brown pelsparite, very rare brachiopod fragments.

10170-10250 Dark yellowish brown limestone as above, very common to abundant moderate yellowish brown pelmicrite and pelmicrosparite. Rare brachiopod fragments.

10250-10320 Dark yellowish brown micrite and pelmicrite limestone. Rare pale yellowish brown pelsparite.

10320-10360 Dark yellowish brown limestone as above. Rare to common pale yellowish brown pelmicrite and micrite.

10360-10370 Missing.

10370-10390 Limestone as in 10320-60.

10390-10420 As above with common pale yellowish brown intrasparite.

10420-10470 Limestone as above, no intrasparite.

10470-10550 Limestone dark yellowish brown to dusky yellowish brown fine crystalline (micrite and pelmicrite) limestone.

10550-10600 As above with common moderate yellowish brown fine crystalline to finely granular limestone (pelmicrosparite).

10600-10620 As above, no pelmicrosparite.

10620-10680 As above, black and red shale cavings (?).
10680-10810 Limestone as above.
10810-10820 Limestone, as above. Black and red shale cavings.
10820-10850 Limestone as above.
10850-10877 Limestone as above. Black and red shale.
10877 Circulated 1/2 hour. Black shale.

10883 Top of Bakken formation
10880-10885 Abundant black shale, rare limestone as above.
10885-10890 Abundant limestone as above, common black shale.
10890-10935 Black shale, rare limestone, rare pieces of dark gray sandy limestone or carbonate sandstone from 10910-35.

10931 Top of Three Forks formation
10935-10955 Limestone and common shale as above.
10955-10977 Black shale, very rare limestone.
10977 Circulated 1/2 hour as above.
Drill stem test #6 10,977-11,000. Recovered gas cut drilling mud. No oil.
10977-10985 Shale and limestone as above, rare greenish gray limy siltstone, rare green shale which may be cavings.
10985-11000 Shale and limestone as above, common yellowish brown, granular, oil-stained limy dolomite. Resembles a quartz sandstone but the grains are actually dolomite crystals. Rare pieces of white medium grained sandstone. Dolomite is oil-stained, has fair cut, good intergranular porosity and permeability. A few fragments of the dolomite seen associated with greenish gray shale.
11000-11020 Greenish gray non-calcareous shale interbedded and inter-laminated with fine to medium granular yellowish brown limy dolomite. Common black shale and yellowish brown limestone cavings. Rare light pink medium-grained sandstone. No oil stain.
11020-11025 Abundant granular dolomite as above, rare green shale and cavings.
11025-11035 Dolomite as above with common dark yellowish brown to medium gray granular anhydritic limestone.
11035-11055 Common grayish pink (5R8/2) sucrosic dolomite, common granular dolomite and rare limestone as above. Rare moderate yellowish green (10GY6/4) dolomitic shale.
11055-11060 As above with common black and red shale (cavings ?).
11060-11090 Abundant dark greenish gray (5GY4/1) to greenish gray (5GY6/1) granular, subsucrosic dolomite. Rare pink dolomite and limestone as above. Very rare green shale as above.
11090-11100 As above with common light gray fine crystalline limestone.
11100-11120 Dolomite as above with common yellowish green (10GY6/4) shale. Common pink sucrosic dolomite.
11120-11140 As above with common dark yellowish brown limestone. Rare yellowish green shale. Abundant red and black shale at 11130-40.
11140-11150 Abundant dolomite and yellowish green dolomite shale as above. Common white anhydrite.
11150-11210 Abundant moderate reddish brown (10R4/6) fine grained sandstone and yellowish green dolomitic shale common white anhydrite and dolomite as above. Rare dark gray fine-crystalline limestone.

11208 Top of Birdbear formation

11210-11225 Rare reddish brown shale as above, common green shale as above, rare pink sucrosic dolomite, rare dark to dusky yellowish brown fine crystalline limestone. Common yellowish brown granular limy dolomite.

11225-11235 Dolomite moderate yellowish brown, limey, subsucrosic and with very weak cut in carbon tetrachloride with common dark yellowish brown fine crystalline anhydritic limestone.

11235-11245 Abundant limestone as above. Rare dolomite as above. Rare intra-pelmicrosparite limestone.

11245-11265 Abundant pale yellowish brown granular anhydritic limestone, rare dark yellowish brown limestone as above, rare dolomite as above.

11265-11270 As above with rare sublithographic yellowish brown limestone and rare very light gray fine crystalline limestone.

11270-11290 Abundant moderate yellowish brown fine crystalline to sub-lithographic limestone, slightly anhydritic. Rare subsucrosic yellowish brown limey dolomite.

11290-11305 As above with rare to common pale yellowish brown pelmicrite limestone.

11293 Top of Duperow formation

11305-11315 As above with common white anhydrite(?) adhering to the fragments.

11315-11320 Limestone as above with common pale yellowish brown fine crystalline (micrite) limestone are rare white anhydrite. Common black shale cavings.

11320-11345 Limestone pale to moderate yellowish brown fine crystalline (pelmicrite)to sublithographic (micrite). Rare white anhydrite at 11340-45.

11345-11365 Limestone, dark to dusky yellowish brown, sublithographic. Rare pale yellowish brown limestone and white anhydrite. Common anhydrite 11355-65

11365-11385 Limestone, pale yellowish brown, pelmicrosparite, subsucrosic. Rare pale yellowish brown subsucrosic limy dolomite. Common pale to moderate yellowish brown sublithographic limestone. Common white anhydrite. Red and black shale cavings.

11385-11390 Limestone, moderate yellowish brown, sublithographic (micrite) to fine crystalline (pelmicrite). Slightly anhydritic.

11390-11400 As above with common dark yellowish brown sublithographic limestone. Rare moderate yellowish brown finely granular limy dolomite.

11400-11410 Limestone, moderate yellowish brown pelmicrite to micrite. Rare dark yellowish brown sublithographic (micrite) limestone. Common patches of pelsparite in the pelmicrite limestone.

11410-11412 Missing.

11412-11420 Limestone as above.

11420-11428 Limestone, moderate to dark yellowish brown, micrite with common pelmicrite. Rare moderate to light yellowish brown limestone as above.

Drillstem Test #7 11425-11490. Recovered gas cut drilling mud; no oil.

11428-11434 As above with common moderate yellowish brown sublithographic (micrite)limestone.

11434-11438 Moderate and dark yellowish brown limestone, as above. Rare very pale yellowish brown finely granular dolomite.

11438-11444 Dolomite limy, moderate yellowish brown, finely granular to subsucrosic, fair porosity and permeability. No cut. Rare moderate to dark yellowish brown limestone as above. Samples for interval 11440-42 are missing, duplicate samples for interval 11442-44.

11444-11454 Limestone, very pale yellowish brown pelmicrite and moderate to dark yellowish brown pelmicrite and micrite. Common to rare dolomite as above. Rare moderate red limy shale (cavings ?). Common moderate yellowish brown pelsparite limestone with good secondary porosity at 11448-52.

11454-11460 Limestone as above, no dolomite, rare shale. Rare patches of pelsparite.

11460-11466 Limestone, moderate to dark yellowish brown, pelmicrite. With common moderate yellowish brown finely granular to subsucrosic, slightly limy and pyritic dolomite which shows fair cut in carbon tetrachloride. Common pale yellowish brown limestone.

11466-11470 Limestone as above with dark yellowish brown micrite. Rare dolomite as above.

11470-11478 Limestone as above with common to abundant granular to sub-sucrosic limy dolomite as above but with no cut.

11478-11488 Limestone as above, no dolomite.

11488-11494 Common to rare dolomite as above, no cut. Abundant limestone as above.

11494-11512 Limestone, yellowish brown, pelmicrite and micrite as above. No dolomite. Rare brachiopod shell fragments at 11502-04.

11512-11518 Limestone as above with rare granular dolomite.

11518-11528 Common granular to subsucrosic dolomite as above, common limestone as above. Dolomite has very weak cut.

11528-11530 Limestone, as above. Common to rare dolomite as above.

11530-11538 Dolomite, dark yellowish brown, slightly limy subsucrosic to sucrosic, common small vugs, good intergranular porosity, fair cut. Common limestone as above.

11533-11567 Perforated interval, 4 shots per foot.

11538-11546 Limestone as above with rare dolomite as above. White gypsum or anhydrite.

11546-11558 Abundant dolomite as above, rare to common limestone as above.

Drill stem test #8 11,555-11, 607. Recovered gas cut water and 6140 feet of free oil.

11558-11560 Sucrosic dolomite as above with rare to common very finely granular very pale yellowish brown limy dolomite.

11560 Circulation 1/2 hour. Dolomite and limestone as above.

11560-11564 Abundant dark yellowish brown sucrosic, dolomite as above with faint cut and common very pale yellowish brown very finely granular limy dolomite with faint cut.

11564-11576 Abundant dark yellowish brown sucrosic dolomite as above, common moderate yellowish brown micrite limestone, rare pale yellowish brown dolomite. Rare small pyrite masses.

11576-11588 Abundant moderate to dark yellowish brown micrite and pelmicrite limestone, common sucrosic dolomite as above.

11588-11596 Abundant sucrosic dolomite as above, common limestone as above. Weak cut.

11596-11602	Dolomite and limestone as above with common to rare very pale yellowish brown limestone containing medium-sized dolomite crystals.
11602-11604	Sucrosic dolomite and sublithographic limestone as above. No dolomitic limestone. Rare white anhydrite.
11604-11607	Abundant sucrosic dolomite as above, rare limestone as above.
11607	Circulation 1/2 hour. As above.
11607-11610	As above. Lost circulation material.
11610-11612	Common limestone as above, common dolomite as above.
11612-11620	Abundant limestone as above, rare dolomite as above. Limestone becomes slightly lighter in color with depth.
11620-11628	Limestone, moderate yellowish brown, pelmicrite with common fine crystalline, very pale yellowish brown, earthy limestone.
11628-11634	Limestone as above with rare finely granular pale yellowish brown dolomite.
11634-11638	Limestone as above, no dolomite, rare anhydrite (?). Common dark yellowish brown sublithographic (micrite) limestone.
11638-11646	Abundant dark yellowish brown micrite, as above, common pelmicrite as above, rare earthy limestone as above.
11646-11660	Abundant finely granular to subsucrosic pale yellowish brown dolomite. Common dark yellowish brown micrite as above. Rare earthy limestone as above. No cut.
11660	Total depth