
STATE OF SOUTH DAKOTA
George T. Mickelson, Governor

STATE GEOLOGICAL SURVEY
E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

No. 57

DEEP BORINGS OF WESTERN SOUTH DAKOTA

by

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Vermillion, South Dakota
August, 1947

ERRATA

| Page | Line | |
|------|------|-----------------------------------|
| 3 | 3* | Insert "from" at the end |
| 5 | 39 | Varved |
| 5 | 7* | First word is <u>lavender</u> |
| 19 | 16 | Gastro-(pods) |
| 32 | 3 | Sphaerosiderite |
| 37 | 21 | First word is <u>Dentalium</u> |
| 52 | 42 | <u>In</u> , not is |
| 64 | 9 | Third word is <u>subangular</u> |
| 97 | 13 | Loosely |
| 97 | 30 | (Octahe-)drons |
| 99 | 40 | Some |
| 100 | 27 | Third word is <u>lithographic</u> |
| 101 | 16 | <u>Laterite</u> |
| 105 | 16 | <u>Bentonite</u> , not pentinite |
| 108 | 8 | Marcasite |

*From bottom of page

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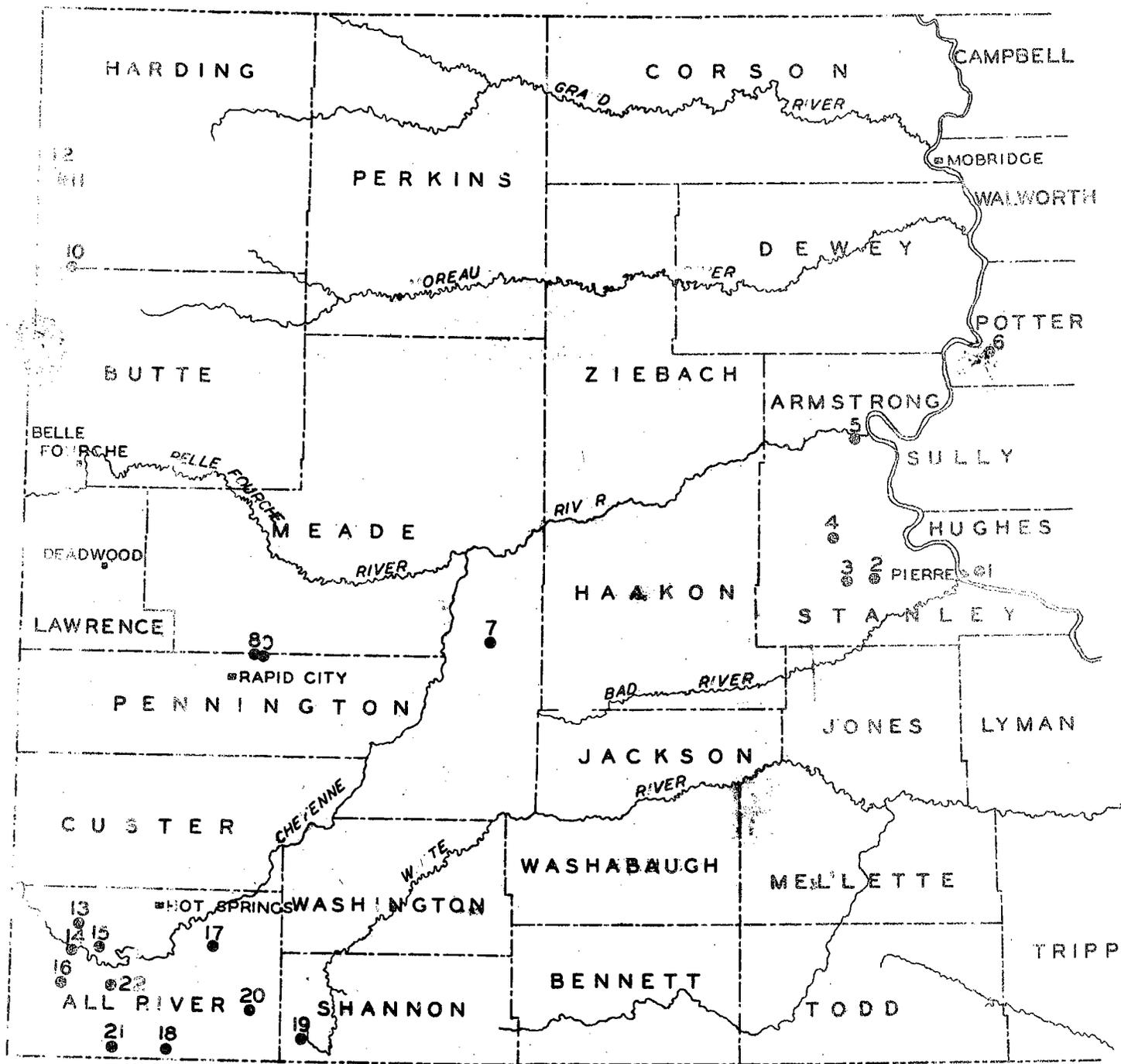
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INDEX MAP OF BORINGS IN WESTERN SOUTH DAKOTA

PLATE I

NUMBERS SAME AS THOSE IN TEXT

| WELL NO. | MISSISSIPPIAN | | | | | | | | | | | CRETACEOUS | | | | | | | | | | | |
|----------|------------------|--------------|----------|-----------|-------------------|---------|----------|-----------|------------------|------------|-----------|----------------|----------|--------|-------|----------------|----------|-----------|---------|----------|--------|-----------|-------|
| | LOWER ORDOVICIAN | | | | MIDDLE ORDOVICIAN | | | | LATER ORDOVICIAN | | | PENN. RED BEDS | | | | UPPER JURASSIC | | | | | | | |
| | Oneota | New Richmond | Shakopee | St. Peter | Black River | Madison | Big Snow | Minnelusa | Opeche | Minnekahta | Spearfish | Sundance | Morrison | Lakota | Fuson | Dakota | Graneros | Greenhorn | Carlile | Niobrara | Pierre | Fox Hills | Lance |
| 1 | 0 | 0 | 57 | 40 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 525 | 0 | 10 | 10 | 100 | 350 | 50 | 320 | 140 | 550 | | |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 145 | 0 | 0 | 0 | 210 | 120 | 90 | 15 | 140 | 270 | 30 | 330 | 150 | 820 | | |
| 3 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 360 | 0 | 0 | 0 | 355 | 60 | 100 | 10 | 40 | 390 | 60 | 255 | 180 | 755 | | |
| 4 | 135 | 230 | 75 | 65 | 45 | 0 | ? | 580 | 0 | 0 | 0 | 215 | 150 | 60 | 105 | 165 | 285 | 40 | 315 | 155 | 1115 | | |
| 5 | 100 | 350 | 30 | 100 | 40 | 0 | ? | 590 | 0 | 0 | 0 | 205 | 95 | 145 | 110 | 35 | 266 | 65 | 365 | 95 | 700 | | |
| 6 | 120 | 340 | 20 | 90 | 10 | 0 | 0 | 370 | 0 | 0 | 0 | 250 | 0 | 90 | 40 | 140 | 260 | 90 | 350 | 120 | 790 | | |
| 7 | | | | | | 170* | ? | 749 | 102 | 40 | 83 | 187 | 160 | 90 | 270 | 80 | 405 | 75 | 320 | 120 | 1807 | 243 | |
| 8 | | | | | | 220* | ? | 675 | 120 | 50 | 280 | 630 | 149 | 44 | 57 | 80 | 850 | 80 | 350 | 110 | 630 | | |
| 9 | | | | | | | | | | | | | | 80 | 100 | 40 | 910 | 90 | 320 | 110 | 690 | | |
| 10 | | | | | | 500 | 530 | 470 | 60 | | | | | | | | | | | | | | |
| 11 | | | | | | 690 | 575 | 440 | 80 | 45 | 535 | 590 | 70 | 72 | 112 | 25 | 1000 | 70 | 390 | 130 | 1730 | 210 | 335 |
| 12 | | | | | | 800 | 605 | 420 | 90 | 42 | 458 | 605 | 125 | 35 | 105 | 75 | 945 | 100 | 440 | 140 | 1780 | 220 | 160 |
| 13 | | | | | | | | 874 | 130 | 75 | 390 | 365 | 320 | 50 | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | 860 | 190 | 50 | 420 | 380 | 70 | 150 | 10 | 90 | | | | | | | |
| 16 | | | | | | 275 | 0 | 1040 | 172 | 54 | 337 | 437 | 150 | 100 | 100 | 162 | 708 | 80 | 200 | | | | |
| 17 | | | | | | 94 | 0 | 784 | 115 | 55 | 305 | 205 | 290 | 140 | 360 | 50 | 775 | 35 | 440 | 60 | 900 | | |
| 18 | | | | | | 165 | 0 | 970 | 120 | 50 | 192 | 423 | 268 | 95 | 87 | 20 | 845 | 30 | 520 | 100 | 1090 | | |
| 19 | | | | | | 0 | 0 | 643 | 335 | 35 | 240 | 255 | 106 | 134 | 160 | 150 | 855 | 30 | | | | | |
| 20 | | | | | | | | 880 | 115 | 35 | 290 | 375 | 220 | 120 | 75 | 70 | 825 | 30 | 570 | 40 | 460 | | |
| 21 | | | | | | | | 685 | 100 | 50 | 200 | 470 | 50 | 130 | 210 | 40 | 780 | 30 | 365 | | | | |

FORMATION THICKNESS IN BORINGS

DEEP BORINGS OF WESTERN SOUTH DAKOTA

by

C. L. Baker

INTRODUCTION

During the last fifteen years about two dozen borings made in the State of South Dakota have reached into or penetrated Paleozoic rocks yielding much new information concerning sedimentary rocks not formerly known beneath the Dakota Basin and extending the knowledge of rock structure, particularly in the rocks beneath the Upper Cretaceous. With one exception--namely, the earliest drilled of these tests, the Gypsy Oil Company Hunter No. 1 in southeastern Pennington County--the holes drilled are in three rather circumscribed areas situated in central South Dakota and on the northern and southern ends of the Black Hills uplift in western South Dakota. The major and deeper part of the Dakota Basin in the northwestern one-fourth of the state has not yet been tested by any drilling.

Cuttings and cores from the tests have been studied and described under the binocular microscope supplemented in some cases by resistivity logs. Since nearly all formations penetrated above the Spearfish red beds cave greatly in the hole during drilling, results cannot be expected to be more than reasonably accurate, being subject necessarily to a considerable amount of individual interpretation.

SUMMARY OF RESULTS

One of the greater Paleozoic depositional basins of North America extended across South Dakota in a northwest-southeast direction. Its eastern margin was the southwestern end of the pre-Cambrian shield with rocks of that age outcropping in the eastern part of the state at present altitudes ranging from 1000 to 1500 feet above sea level. The southwestern margin of the Dakota Paleozoic basin was the northeast end of the Colorado land mass extending from the north end of the present Black Hills uplift south-southeastward to the Chadron or Cambridge arch some

60 to 100 miles east of the southwest corner of South Dakota; on the latter in southwest Shannon County, South Dakota, Pennsylvanian rocks rest directly upon pre-Cambrian and in a distance of 250 miles south-southeastward from the deep borings in Harding County more than 2000 feet of strata ranging from the base of the Middle Ordovician to the top of Mississippian, wedge out against the Colorado land mass. In central South Dakota (Stanley County) on the north flank of a prominent structural ridge plunging northwest, in the 10 miles distance between the Phillips Dakota No. 1 and Lang No. 1 borings, Paleozoic strata thin from 1565 to 200 feet, Ordovician and probably Upper Cambrian strata wedging out, the top of the pre-Cambrian ascending 1600 feet. Similarly from the Carter Dakota No. 1 in western Potter County southward 35 miles to Pierre the Paleozoic decreases from 1430 to probably about 150 feet, the pre-Cambrian ascending 1000 feet. In the southeast corner of South Dakota 372 feet of Middle and Lower Ordovician and Upper Cambrian and 263 feet of overlying Paleozoic, considered Devonian or partly Devonian and Silurian, are present between the pre-Cambrian and the base of the Cretaceous. No boring yet has penetrated the full succession of Paleozoic strata anywhere in the middle of the Dakota depositional basin of Paleozoic time.

The Dakota Paleozoic depositional basin is now the Dakota structural basin in which both Mesozoic and Paleozoic rocks have been downwarped. The greatest known structural relief in the state is two miles (10,500 feet) between outcropping St. Peter sandstone at 5,000 feet altitude in the northern Black Hills and its projection to beneath the trough of the structural basin halfway between the northwest corner of the state and Missouri River where it is estimated to descend to 5500 feet beneath sea level, on the assumption that there is no thickening of the Paleozoic section between western Harding County and the synclinal trough, a supposition which may not be correct. Northeastward down the flank of the Chadron arch from southwestern Shannon County (Amerada Red Eagle No. 1) 125 miles to southeastern Pennington County (Gypsy Hunter No. 1) the base of the Pennsylvanian Minnelusa formation descends 1865 feet, the top of the Dakota sandstone descending about 2000 feet in this distance. A west-northwest plunging arch extending from Chamberlain on Missouri River to northern Haakon County is shown by a lowering of the Dakota sandstone 800 feet between the two places; the crest of this arch dips only 100 feet in a distance of 75 miles between central Lyman and central Stanley counties. The general strike of the rocks from southeastern Pennington County to Campbell County on the Missouri River is northeast. Northward plunging synclines probably flank both sides of the north end of the Chadron arch.

Several unconformities exist in the sedimentary rock successions. There is one between lower Eocene Cenozoic and underlying strata. Another, marked by widespread overlap of the basal Cretaceous on older Mesozoic and Paleozoic, especially on the east flank of the Dakota Basin, lies at the base of the Dakota-Lakota series. The marine Sundance (basal Upper Jurassic) overlaps the underlying red beds on the east basin flank and extends to central South Dakota. The Pennsylvanian Minnelusa formation overlaps wedging out older Paleozoic on both east and west basin flanks. The lower Mississippian Madison (Pahasapa) limestone rests upon varying strata of Ordovician, upper Cambrian and pre-Cambrian age. There is evidence in the central part of the state that the Sioux quartzite area was uplifted at the close of Lower Ordovician (Beekmantown) time and was the source of the widespread St. Peter sandstone at the base of the Middle Ordovician which extends from central South Dakota to the Bighorn Mountains of Wyoming but is absent in the southern half of the Black Hills and to the south of them.

FORMATIONS ENCOUNTERED IN THE DEEP BORINGS

Approximate formation thicknesses in the various borings are shown in the accompanying table.

PRE-CAMBRIAN South of the Black Hills the top of the pre-Cambrian is granitoid or schistose rocks and in central South Dakota it is granite, diorite and quartz monzonite or granodiorite but higher up on the slope of the pre-Cambrian shield in southeastern South Dakota it is Sioux quartzite and argillite.

CAMBRIAN In the three borings farther down the slope of the pre-Cambrian shield in the center of the state is a member of green shale 100 to 125 feet thick, somewhat sandy, and in one hole based by a thin sandstone which may be Upper Cambrian. The Cambrian is absent in borings south of the Black Hills; its horizon is not reached elsewhere.

ORDOVICIAN The typical upper Mississippi Valley Beekmantown section of Oneota, Shakopee and New Richmond occurs in boring lower down the slope in central South Dakota, being overlapped farther up the slope by St. Peter sandstone. The St. Peter is present in all these borings except the Phillips Lang No. 1, the overlying total Paleozoic being there only 150 feet thick. The St. Peter is present in three borings in Harding County north of the Black Hills, in neither of which its full thickness was penetrated. It is there overlain by higher Ordovician, thickening northward 650 feet in Northern Ordnance Government No. 1 to 890 feet in State Royalty No. 1. The basal part of this higher section is

green shale with small black phosphate nodules, in part sandy, 80 to 95 feet thick, of Decorah-Platteville (Black River) age, succeeded by dolomite and limestone containing a few higher Ordovician brachiopods. Part of this upper succession in the two northern wells may be Trenton, the upper part being likely Richmond. It is possible that part or all strata in the thin White-wood outcropping in the Black Hills is Trenton, there being apparently conformable gradation upward from the Decorah-Platteville. Near Galena in the Black Hills the Whitewood rests directly upon St. Peter, the green shale being absent.

MISSISSIPPIAN The lower Mississippian Madison (Pahasapa) limestone wedges out on the Chadron uplift and eastward up the flanks of the west-northwest plunging arch of the pre-Cambrian shield in central South Dakota. It is thickest (500 to 650 feet) in the three Harding County borings in the northwest, where it thickens northward. It is cavernous south of the Black Hills as it is on outcrop. In the western half of the Dakota Basin there is strong probability that the later Mississippian Big Snowy group is present, especially beneath Harding County. In the central basin (Gypsy Hunter No. 1) and in central South Dakota a second laterite or red bed may separate Minnelusa above from Big Snowy beneath, the line of division being at the top of 450 feet of strata in the Gypsy Hunter, leaving an upper 320 feet only as Minnelusa, while in the Phillips Dakota No. 1 boring in northern Stanley County 150 feet below the red bed might be considered to be Big Snowy and 435 feet above it to be Minnelusa.

For the present it appears best to assume that the presence of Big Snowy is doubtful except beneath northwestern South Dakota. In the state's central area Paleozoic rocks above mid-Ordovician are highly variable, probably having gaps and overlaps; only the two northern borings in Stanley County are known to penetrate anhydrite, either of the Minnelusa, Big Snowy or of some other formation.

PENNSYLVANIAN All Black Hills outcrop sections of Minnelusa are misleading since most of the carbonates and virtually all calcium sulphate have been dissolved, leading to very extensive solution collapse and thinning of 200 feet or more, leaving a residue mainly sandstone except for some thin limestones and dolomites in the basal third. A few miles east of outcrops, in the Rapid City Airport borings, most of the upper half of the Minnelusa appears to be anhydrite and the lower half carbonates with actually less sandstone than is present in nearest outcrops. Forty-five miles farther east, in Gypsy Hunter No. 1 boring, there would appear to be considerably more shale and siltstone, relative to carbonate rocks, in the lower half but the record is better than that of

the Rapid City Airport holes, because the lower Minnelusa section was drilled with cable tools after caving Mesozoic was cased off. There remains the possibility that this lower part may be Big Snowy although bituminous and other shales are present in the succession south of the Black Hills, both in outcrop and underground, and underground in central South Dakota. Thickness of so called Minnelusa is only 75 feet more in the Gypsy Hunter than in the Rapid City Airport holes.

The thickest Minnelusa is on the southwest and south sides of the Black Hills, nearer to source of sediments. In Provo Ordinance No. 1 it amounts to 1035 feet, decreasing to 750 feet in Amerada State Agricultural College No. 1. However, a plausible interpretation of the succession in Amerada Red Eagle No. 1, southwest Shannon County, is that the overlying Opeche red beds have there increased to four times their usual thickness, leaving only 570 feet of underlying Minnelusa, mainly carbonates and anhydrite. In the Lance Creek oil field, Wyoming, these strata are called Hartville and considered to be equivalent to Ten Sleep and Amsden. It is possible that the red part of the Amsden is the basal laterite of the Minnelusa. This laterite occurs at the base of the Minnelusa at all but one of the sections of Black Hills outcrops made by the writer and appears likewise in all the borings herein considered; it is the insoluble residue from solution of underlying Madison limestone, produced under warm, moist seasonal rainfall weathering. It contains Mesolobus mesolobus and Chaetetes milleporaceus, diagnostic fossils of low Pennsylvanian. Near the top of the Minnelusa in northern Black Hills outcrops, vicinity of Beulah, Wyoming, associated with some outcropping thin gypsum beds, is a nondescript brachiopod fauna of either Pennsylvanian or Permian age.

RED BEDS Between the Minnelusa and lower Upper (Oxfordian) Jurassic marine Sundance formation intervenes a succession of red siltstone, sandstones, anhydrite and one limestone (Minnekahta) the age or ages of which are unknown, geologic work for 75 years having failed to yield diagnostic fossils. The lower division or Opeche is generally about 100 feet thick and contains at least one bed of calcium sulphate in southwestern Black Hills outcrops. It is succeeded by thin Minnekahta limestone, generally between 30 to 50 feet thick, finely laminated or varied, light pinkish or lavender, in places magnesian, with Paleoniscid fishes and Estheria or Estheria--like brine shrimps, undoubtedly lacustral or lagoonal, grading upwards into calcium sulphate in southwest Black Hills outcrops and an excellent stratigraphic and structural datum plane for strata above the basal Minnelusa unconformity; however, it does not extend as far east as central South Dakota.

Overlying it is another red bed, the Spearfish, containing one or more anhydrite members. Gypsum outcrops in exposures of the red beds on the Black Hills flanks, probably because they are much less permeable than the sandstones and carbonates of the Minnelusa.

MID-MESOZOIC The Sundance is present at least as far east as the State's center, overlapping the lensing out red beds to the east. It is dominantly marine, characterized by glauconite pellets; it is bentonitic and contains one or more sandstone aquifers. At its top, south and southeast of the Black Hills, is a local sandstone, the Unkpapa. Overlying is the Morrison formation, largely varicolored, sombre-hued bentonitic clays and bentonites but in places sandy, overlapped towards the center of the state by the Cretaceous.

CRETACEOUS The Cretaceous formations outcrop over most the Dakota Basin. All Lower and Middle Cretaceous with exception of uppermost Cenomanian appear to be absent. The Lakota, Fuson, Dakota (Fall River) and overlying Thermopolis (Skull Creek) shale are now referred to upper Cenomanian, the base of true upper Cretaceous being taken as the Muddy or Newcastle sandstone. The Dakota and Lakota are mainly sandstones, the Lakota being the coarser and locally containing fine pebbles. The Fuson is largely bentonitic clays and shales with some coal and sandstones. The Thermopolis or Skull Creek is a dark brownish to bluish shale, the coloring matter of which appears to be largely ferrous carbonate. The Minnewaste lens or wedge of chemically precipitated dolomite immediately above the Lakota in southeast Black Hills exposures becomes in descending order limestone, anhydrite and dolomite in the Amerada State Agricultural College boring in northeastern Fall River County. At the top of the Fuson, widespread underground, is an horizon of rhodochrosite or mangano-siderite pellets, medium sand grain in size. Flanking and overlapping upon the pre-Cambrian shield in central South Dakota are various sandstones of the Dakota-Lakota group and some higher ones. True shales in the Upper Cretaceous are confined to the succession below the top of the Sharon Springs basal member of the Pierre.

The bulkiest ingredient of Upper Cretaceous strata is bentonite, sodium bentonite in rocks of Benton and Niobrara age (Colorado group) and calcium bentonite in Pierre, Fox Hills and Lance. The bentonite occurs both in thin pure beds and as admixtures in all the other strata; hence nearly all strata above the red beds cave in drill holes. The Greenhorn is a thin impure limestone, changing to marl north and northeast of the Black Hills, characterized by numerous prismatic Inoceramus shell fragments and Globigerina, above which Carlile, Niobrara and basal Pierre (Sharon Springs) shales and marls are markedly bituminous though mainly impermeable. The facies or tongue of

pure Niobrara chalk, outcropping in Missouri River Valley upstream to Fort Thompson, changes underground to north and west into marl with numerous minute chalky pellets. The clays of the Lance are mainly bentonite.

Copper sulphides and carbonates occur sporadically in sedimentary rocks of the Dakota Basin, oxidation zone carbonates both in Pierre and basal Minnelusa laterite, sulphides more widely distributed. The bronze-colored manganese sulphide (hauerite) is found in the lower half of the Pierre.

PERMEABLE HORIZONS IN WHICH OIL OR GAS SHOWINGS ARE FOUND

Many permeable sandstones, limestones and dolomites occur in the Paleozoic succession; the most widespread aquifers in which are the St. Peter sandstone and the Madison limestone, likely the two greatest aquifers underlying the Dakota Basin. The Sundance has one sandstone or more intercalated in a marine section. More widely known for 65 years are the Dakota-Lakota group of sandstones. Higher up are the Newcastle or Muddy sandstones and a few other thin ones, perhaps localized, in higher Benton, Niobrara, Pierre and Fox Hills.

Good oil showings have been found in South Dakota in St. Peter sandstone, Madison limestone, Minnelusa, Sundance, Unkpapa, the Dakota-Lakota series, the Newcastle or Muddy sandstone and the Niobrara.

DESCRIPTIONS OF WELL CUTTINGS

A. Central South Dakota

1. PIERRE AIRPORT 1, 2130' SNL, 190' WEL. NE. $\frac{1}{4}$, Sec. 35, T. 111 N., R. 79 W., Hughes County. Ground altitude 1708.18', cutting measurements from 1718' altitude.

- 0- 100' Pierre clay, bentonitic, micaceous, gypsiferous, green grey. Haploporella abundant 10'-30', 70'-80', miliolids 70'-80', some manganese oxide coated nodules and nodular tawny clay ironstone
- 100- 110 Sand, medium to coarse
- 110- 375 Clay and mudstone, grey, considerable manganese oxide 160'-70', Haploporella, Textularia, "Cristellaria," 200'-20', mudstone, more compact, light grey, begins at 230', white bentonite at 270'. Globigerina abundant, Textularia and abundant biotite flakes at 320'-30'. Tan clay ironstone, 330'-50'. First shell fragments and hard brown bentonite at 350'-60'. Dark grey dense, fine texture fossiliferous concretionary limestone, containing silt and bentonite, 360'-75'. Much octahedral and red brown to bronzy hauerite (?) and Inoceramus prisms 370'-75'
- 375- 380 Chalk, light grey, impure silty, shale, soft, very dark blue grey to black, bituminous, much iron carbonate
- 380- 410 Mainly grey bentonitic clay, considerable chalk. Small oval brown pellets of clay ironstone
- 410- 430 Clay, a little darker grey
- 430- 550 Mostly cavings (?) of black soft manganese-bearing, partly laminated clay, white bentonite, 490'-500'
- 550- 570 Niobrara chalk, impure, silty, light grey, spotted
- 570- 690 Chalk, marly, spotted grey and white, bituminous, fish remains, chalk pellets flattened along laminae. Purer chalk, 650'-60' and 680'-90' (full of Textularia, Globigerina and "Cristellaria"). The chalk has flakes of biotite and white mica
- 690- 740 Carlile mudstone, dark grey, compact
- 740- 770 Limestone, magnesian, dark grey, dirty, fine-grained with shell fragments
- 770-1010 Shale, dark and light grey. Foraminifera at 830' and from 960' downwards. Particles of cuprite-red hauerite (?) at 880'-90'
- 1010-1060 Greenhorn limestone, grey, spotted, chalky, impure sandstone, light grey, fine-grained, with Inoceramus prisms, some shale, dark blue grey
- 1060-1120 Graneros with light grey sandstone in cuttings, grey fine grained. Impure, limy cement, micaceous, a little serpentine, angular grains, some dark chert and lignite fragments, fish remains

1120-1165 Shale, dark grey
 1165-1180 Sandstone, light grey, fine grained, with sparse
 serpentine
 1180-1205 Shale, dark green grey
 1205-1230 Sandstone, fine to medium grained, biotite flakes
 1230-1320 Shale, as above
 1320-1410 Shale, nearly black, compact, fissile (Thermopolis
 phase), some light brown siltstone
 1410-1510 Dakota sandstone, light brown, fine to medium grained
 some arkosic and angular below 1440'
 1510-1520 Manganosiderite pellets, small
 1520-1530 Lakota grit, quartzose, poorly cemented, subround
 to subangular
 1540-1560 Sundance sandstone, fine grained, glauconitic, at
 1600'-30' sandstone is cream colored, changing to
 light brown, 1630'-40', both are fine grained
 1670-1720 Siltstone, carmine and brown
 1720-1730 Clay, light green, bentonitic
 1770-1800 Sandstone, glauconitic, fine grained
 1800-1810 Sandstone, dark grey, fine grained, pyritic and
 glauconitic
 1810-1820 Sandstone, light grey, fine grained
 1830-1840 Sandstone, coarse, subangular to subround. Water
 flowed 1100 gal. per minute, temperature 109° F.,
 shut-in pressure 350 lbs. per sq. in.
 1850-1860 Sandstone, grey, fine grained, lignite fragments
 1866-1875 Sandstone, coarse, bentonitic
 1875-1895 Claystone, green drab, bentonitic, pyrite-cemented
 sandstone, some lignite and alabaster. Quartzite
 and granite pebbles reported, 1865'-1900' and 1935'-
 40'.
 1895-1915 Sandstone, brown, fine grained, porous, cemented
 with pyrite, 1895'-1905'
 1925-1935 Sandstone, fine to coarse, angular
 1935-1945 Siltstone and mudstone, maroon, purple, lavender
 and pink, some chert pebbles
 1945-2015 Bentonite, hard, light brown grey, mottled with
 purple, mudstone and siltstone, bentonitic, purple,
 stained tan and yellow. Particle of native copper
 2015-2025 Bentonite, sandy
 2025-2035 Bentonite, varicolored, with plagioclase and ben-
 tonite
 2035-2055 Basal Sundance, with small pebbles of chert and
 quartz
 2055-2065 Minnelusa (?) sandstone and mudstone, maroon, sand-
 stone is brown, fine, densely cemented, angular to
 round
 2065-2075 Sandstone, brown, dolomite and pyrite cement
 2075-2095 Sandstone, brown, medium to coarse, angular
 2095-2115 Bentonite
 2115-2125 Grit, coarse, to conglomerate, fine, quartz and
 chert pebbles. The Minnelusa (?) sandstones are
 water-bearing

- 2125-2135 Limestone, very dark grey, fine texture, grades down into black and grey shale
- 2165-2195 Limestone, dark blue grey, finely crystalline, and brown-grey, lithographic
- 2195-2215 Limestone, brown, fossiliferous, some bentonite, butternut brown
- 2215-2255 Grit to fine conglomerate, quartzose
- 2255-2260 Laterite, Indian red, mottled with grey
- 2260-2275 Pahasapa (Madison) limestone, cream, finely crystalline, imperfect oolites. Top probably at 2252'. Combined flow of water from sands between 1865' and 2252', most of which came from the lower sand, was about 2200 gal. per minute, shut-in pressure 290 lbs. per sq. in., temperature 117° F.
- 2275-2285 Limestone, yellow brown, finely crystalline
- 2285-2315 Limestone, cream, porous, sandy at base
- 2315-2325 Age unknown, sandstone, coarse, angular, shale, lavender and terra cotta
- 2325-2335 Limestone, cream to dove, lithographic
- 2335-2365 Dolomite (Lower Ordovician (?)), light brown grey, sugary, porous, with quartz grains, becomes sandier downwards. Vein calcite 2355'-2365'
- 2365-2370 Sandstone, grey, silty, some shale, red pebbles of chert and a few of granite, one of which was at least three-fourths inch across.

Water encountered between 2338' and 2370' flowed 200 gals. per minute, bottom hole pressure 1350 lbs. per sq. in., shut-in pressure, 345 lbs. per sq. in., temperature 102° F.

Noteworthy in the above are the unusual number of sandstones in the Upper Cretaceous, the probable wedging out of Fuson and Morrison, the occurrence of marine Sundance so far east with a great amount of sandstone, the presence of only 200' of Minnelusa (?) and of only 55' of Pahasapa and the very thin possible Ordovician. The facts may possibly be interpreted as caused by secular upwarps of the southwest part of the pre-Cambrian nucleus at various times from early Paleozoic to mid-Cretaceous.

It is possible that the sandstone from 1170' to 1320' depth is the type Dakota and perhaps equivalent to the Muddy or Newcastle.

2. PHILLIPS PETROLEUM CO. LANG 1, Center NE. $\frac{1}{4}$ SE. $\frac{1}{4}$ Sec. 26,
T. 5 N., R. 28 E., Stanley County. Altitude 1982'.

| | |
|------------|----------------------------------------------------------------------------------------------------------------|
| 0- 220' | No cuttings |
| 220- 250 | <u>Pierre</u> clay, bentonitic, grey to green grey, a little white chalk, details as below: |
| 250- 280 | Foraminifera |
| 340- 360 | Hauerite (?), a little red clay |
| 400- 430 | A little white clay |
| 610- 820 | Sharon Springs shale (?), very dark blue grey, bituminous, <u>Textularia</u> , 790'-820' |
| 820- 850 | <u>Niobrara</u> marl, chalky, grey, foraminifera |
| 850- 880 | Chalk, impure |
| 880- 910 | Chalk, impure, and chalky marl |
| 910- 970 | No cuttings |
| 970-1000 | <u>Carlile</u> limestone, dark grey, sand, fine |
| 1150-1180 | <u>Textularia</u> in blue grey shale |
| 1300 | <u>Greenhorn</u> limestone, grey, sandy, with many <u>Inoceramus</u> prisms |
| 1330 | <u>Graneros</u> clay, dark blue grey |
| 1450 | Sandstone, grey, fine grained |
| 1480 | Clay, bentonite, light grey |
| 1510 | Minute chunks of asphalt in dark blue grey shale, more abundant, 1540'-70' |
| 1600-1630 | <u>Dakota</u> sandstone, light grey, fine grained, micaceous, siltstone, dark grey, dolomitic cement |
| 1630 | Shale, very dark blue grey |
| 1660-1695 | Sandstone, grey |
| 1695-1725 | Shale, dark blue grey |
| 1725-1740 | Sandstone, buff, fine grained, micaceous |
| 1740 | Manganosiderite pellet horizon |
| 1755-1770 | Sandstone, light brown, fine grained-- <u>Lakota</u> |
| 1770-1815 | Sandstone, cream, well sorted |
| 1830-1845 | Sandstone, light brown grey, medium grained, angular to subround, poorly sorted, larger grains in silty matrix |
| 1905-1920 | Clay, bentonitic, light blue grey-- <u>Morrison</u> |
| 1920-1935 | Bentonite, light grey, with biotite, some clay, brown |
| 1935-1950 | Clay, red brown |
| 1950-1980 | Clay, green grey |
| 1980-1995 | Siltstone, dark brown red, carmine-specked |
| 1995-2010 | Shale, dark blue grey |
| 2010-2025 | Siltstone, dark grey, limy |
| 2025-2040 | <u>Sundance</u> sandstone, dark grey, very fine, glauconitic |
| 2040 | Sandstone, medium grained, glauconite, in part stained with heavy black oil |
| 2080-2085+ | Shale, black, very bituminous |
| 2085-2100 | Sandstone, grey, medium grained, and shale, black, bituminous |
| 2100-2115 | Gypsum, white satin spar, clay, light green grey, bentonitic |

2115-2130 Clay, as just above
 2130-2145 Sandstone, coarse to gritty, pyrite cement, sub-
 round, etched grains
 2145-2160 Sandstone, fine, cemented with chalcopyrite, black
 manganese oxide
 2165 Siltstone, light grey, bentonitic
 2175-2190 Siltstone, light grey, bentonitic, some clay and
 sand
 2190-2205 Shale, dark grey
 2205-2220 Sandstone, medium grained
 2220-2235 Conglomerate of quartz and abundant quartzite,
 lignite and selenite
 2235-2250 Minnelusa limestone, magnesian, cream buff, very
 fine grained, dolomite crystals in calcite matrix,
 chert, light grey white, milky
 2250-2260 Shale, black
 2260-2275 Limestone, dolomitic, grey, silty, fine sugary
 2275-2280 Limestone, light brown, calcite veined
 2280-2285 Limestone, cream, fine texture, dull lustre
 2285-2290 Shale, black, and sandstone, fine (cavings?)
 2295-2310 Limestone, as last above, silty below
 2315-2320 Siltstone, cream
 2325-2330 Bentonite, light grey and terra cotta
 2330-2335 Limestone, light brown grey and pink, lithographic,
 bentonite, light green
 2335-2340 Limestone, light brown grey and pink, lithographic,
 bentonite, white
 2340-2345 Clay, red brown (terra cotta), bentonitic
 2345-2350 Limestone, cream and pink, lithographic, mudstone,
 dark terra cotta
 2350-2355 Mudstone, terra cotta, tawny, grey and brick red,
 shale, brick red
 2355-2375 Clay, bentonitic, mottled salmon and grey, tawny
 and brown at base, alabaster
 2375-2380 Limestone, light brown, very fine, nodular
 2380-2385 Sioux quartzite, pink, coarsely crystalline, iron
 oxide, blue black. Large grains sand with quartzite
 matrix
 2385-2390 Argillite, black, sericitic
 2390-2403 Quartzite, pink
 2403-2408 Quartzite, lavender
 2408-2435 Quartzite, lavender and pink

3. PHILLIPS PETROLEUM CO. STATE SCHOOL LAND 1, 330' S. and 330'
W. From NE. corner of NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ of SE. $\frac{1}{4}$, Sec. 36, T. 5 N.,
R. 27 E., Stanley County. Altitude 1854'.

| | |
|-------------|-------------------------------------------------------------------------------------------------------------------|
| 0- 755' | No cuttings, <u>Pierre</u> clay |
| 755- 845 | <u>Niobrara</u> marl, spotted chalky, laminated, flattened light grey chalk discs in darker grey marl, bituminous |
| 845- 905 | Marl, less chalky |
| 905- 935 | Marl, with chalky fragments |
| 935- 965 | <u>Carlile</u> shale, dark blue grey, bentonitic |
| 965- 995 | Shale, medium grey, sandstone, fine grained, biotitic |
| 995-1055 | Shale, medium grey |
| 1055-1085 | Shale, medium grey, foraminifera |
| 1085-1100 | Shale, darker grey |
| 1100-1130 | Shale, darker grey, foraminifera |
| 1130-1190 | Shale, black, bituminous |
| 1190-1250 ? | <u>Greenhorn</u> limestone, made up of <u>Inoceramus</u> prisms and <u>Globigerina</u> , sandy |
| 1260-1320 | <u>Graneros</u> shale, black and dark grey, bituminous, some with chalky spots |
| 1320-1350 | Siltstone, light grey |
| 1380-1440 | Some sandstone, grey, fine grained |
| 1530-1560 | Some bentonite, light brown |
| 1590-1620 | Bentonite |
| 1640-1650 | Bentonite, also at various depths down to 1740 |
| 1640-1660 | <u>Dakota</u> sandstone, red brown, angular, fine grained, ferruginous, mostly well cemented |
| 1660-1670 | Sand, fine, angular |
| 1680-1690 | Manganosiderite (or rhodochrosite) pellets, sometimes cement small quartz grains |
| 1690-1700 | Sandstone, very light grey, very fine, lignite fragments |
| 1750-1760 | Sandstone, grey, fine grained, much bentonite 1750'-1890' |
| 1760-1780 | Sand, fine with some large grains, angular to sub-angular, a little glauconite, copper sulphides |
| 1780-1790 | Sandstone, brown and grey, fine and medium grained interbedded, selenite |
| 1790-1810 | <u>Morrison</u> clay, light green grey, bentonitic |
| 1810-1830 | Shale, blue grey, selenite |
| 1830-1840 | Bentonite, white |
| 1840-1850 | Shale, light and dark grey, also blue grey, silty |
| 1850-1860 | <u>Sundance</u> sandstone, grey, fine grained, biotite and white mica, glauconitic |
| 1870-1890 | Clay, light green grey and red brown, silty |
| 1920-1940 | <u>Sundance</u> , with large glauconite nodules |
| 1940-1950 | Clay, drab, bentonitic |
| 1950-1970 | Sandstone, dark grey, fine grained, clayey and siltstone, some glauconite, some of which is yellow brown |

1970-1980 Sandstone, medium grained, angular, glauconitic
 1980-2000 Mudstone, grey, brown grey, salmon and terra cotta, bentonite
 2000-2010 Concretions, maroon, ferruginous
 2010-2040 Sandstone, marcasite cemented
 2040-2080 Sandstone, light grey, fine grained, with much pyrite cement
 2080-2120 Bentonite, varicolored
 2120-2140 Bentonite, brick red and tan
 2140-2150 Bentonite, light grey, compact, flaky
 2150-2160 Sand grains, all sizes, satin spar
 2160-2165 Bentonite, green grey, translucent, compact, satin spar
 2165-2185 Sand, all size grains from grit to fine, subround to subangular
 2175-2200 Siltstone, sandy, salmon, mottled with grey, some white kaolin or bauxite, some fibrous to splintery, unctuous to dull lustre
 2205-2225 Minnelusa dolomite and magnesian limestone, dove and light grey, very fine texture
 2225-2230 Dolomite, darker grey, vuggy, fine crystals
 2230-2235 Limestone, dolomitic, medium grey, fine rhombic, calcite veins, chert, brown grey
 2235-2240 Sandstone, light grey, fine grained, limy cement
 2240-2245 Chert, light grey
 2245-2255 Dolomite, light dove grey, texture fine powdery, some calcite, probably sandy
 2255-2280 Sandstone, light grey, fine grained, angular to subround, probably in part dolomite cemented
 2280-2285 Chert, dark blue grey
 2285-2295 Limestone, magnesian, grey, fine sugary
 2295-2305 Limestone, magnesian, lighter grey
 2305-2315 Dolomite, black to dark blue grey, flaky, clayey
 2315-2320 Bentonite, light grey
 2320-2325 Bentonite, light sea green, silty
 2325-2330 Dolomite, dove, with coarsely crystalline rhombohedral and scalenohedral calcite
 2330-2355 Dolomite, brown cream, fine sugary, calcite veins
 2355-2385 Sandstone, cream, very fine, dolomite cement, much clay, bentonitic
 2385-2405 Dolomite, light brown, fine grained, silty, much clay, bentonitic, salmon, grey and green
 2405-2425 Clay (?), varicolored, mostly light green and grey
 2425-2435 Shale and clay, red, bentonite, lavender, sandy, red, purple, tawny, brown and green bentonite continues down to 2490'
 2435-2440 Limestone, grey, fine texture, fossils, small dolomite rhombs
 2440-2460 Mostly varicolored clay
 2460-2470 Dolomite, cream and light pink, fine texture
 2480-2495 Shale, red and maroon

2495-2505 Sandstone, cream, with about one-half limestone, coarse to medium quartz grains scattered through limestone, some grit size, some limestone, lithographic

2505-2515 Limestone, dark blue grey, very fine grained, clayey

2515-2520 Limestone, dove, lithographic

2520-2525 Limestone, dove, fine sugary, fossils

2525-2530 Shale, black

2540-2555 Limestone, dove, lithographic

2555-2565 Shale, black

2565-2588 St. Peter grit, largely pink-coated grains, some smaller grains, subround to subangular, some grains one-fourth inch across, fragments of coarse Sioux quartzite

2588-2595 Sand, St. Peter

2595-2600 Shale, yellow and brown yellow, some grey mottling, bentonitic

2600-2605 Sand, fine grained, angular to subangular, dark brown red bentonite matrix, sand grains coated brown red, poorly sorted, some red shale

2605-2610 Sandstone, light red brown, fine grained, poorly sorted, angular to subangular

2610-2620 Limestone, dolomitic, light brown grey, fine sugary

2620-2625 Kaolin, impure white, dolomite, light brown grey, vuggy, very small rhombs

2625-2595 Conglomerate, grit and sandstone

2695-2767 Sioux quartzite

4. PHILLIPS PETROLEUM CO. DAKOTA 1, Center NW. $\frac{1}{4}$ NW. $\frac{1}{4}$, Sec. 16,
T. 6 N., R. 27 E. Altitude 2177'; cuttings measured from
2186'. 4000' casing run.

| | |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0- 307' | No cuttings, <u>Pierre</u> , surface casing to 307' |
| 307- 315 | <u>Pierre</u> clay, grey, bentonitic, considerable chalk, light grey |
| 315- 325 | Some bentonite, white, biotitic |
| 325- 330 | "Cristellaria," <u>Ammodiscus</u> |
| 330- 335 | A little alabaster, foraminifera |
| 355- 360 | Bentonite, white, biotitic |
| 435 | Rhodochrosite or manganosiderite pellets, light brown |
| 450- 475 | Clay, brownish, very bentonitic, clay ironstone concretions |
| 455 | <u>Globigerina</u> |
| 490- 520 | Concretions, tan and brown, very dense texture, manganiferous |
| 520 | Clay, grey, limy, biotite flakes |
| 545 | <u>Ammodiscus</u> |
| 565 | <u>Inoceramus</u> prisms |
| 605- 640 | Bentonite in large quantity |
| 645- 735 | Clay, lighter grey, bentonitic. Abundant bentonite to 850'. <u>Inoceramus</u> prisms |
| 735- 780 | Bentonite, light brown, grey, some sandy and ashy beds |
| 795 | First shell fragments other than <u>Inoceramus</u> |
| 790- 850 | Gumbo, very sticky |
| 855- 885 | Concretions, grey septarian, calcium carbonate |
| 885- 985 | Shale, very dark blue grey, bituminous, many fish fragments |
| 985-1040 | Marl, chalky, spotted two shades of grey, bituminous |
| 1040-1075 | Shale, grey, becoming darker at 1055', shell fragments, <u>Textularia</u> |
| 1075 | Bentonite, grey, with small cinnabar--crimson dots of magnetic iron oxide |
| 1100 | Clay, light tawny, silty, with dots as above |
| 1115-1120 | Some marl, dark grey, chalky |
| 1185-1270 | <u>Niobrara</u> marl, chalky grey, with black shale, laminated. Chalk is bituminous, both shale and chalk have a glossy partial film darker and more bituminous, softer than above, 1220'-70', less chalk below 1265' |
| 1295 | Bentonite |
| 1310 | Chalcopyrite |
| 1315-1340 | Some sandstone, grey, fine grain, fish remains and glauconite |
| 1380 | Siltstone, light green grey |
| 1430 | Mudstone, light grey |
| 1585-1625 | <u>Greenhorn</u> limestone, packed with <u>Inoceramus</u> prisms, light, has numerous fine sand grains 1610'-25' |

1625 Bentonite, white, top Graneros shale
 1640 Shale, dark blue grey, bituminous, sandstone, light grey, fine, limy
 1670 Sandstone, light grey, fine, fish scales
 1685 Shale, black, with alum
 1695 Shale, grey, with small chalky spots
 1700-1710 Bentonite, bluish
 1725 Shale, lighter grey, with Inoceramus prisms and thin interlaminae of fine light grey sandstone, Globigerina
 1760-1765 Shale, black, bituminous
 1785-1790 Bentonite, light grey
 1825-1830 Bentonite, light grey
 1835-1840 Bentonite, tan
 1870 Shale, dark blue grey
 1910-1915 Dakota sandstone, grey, fine, Resistivity log indicates sandstones at 1912', 1965'-85', 2000'-2110' (interbedded with shale), 2170'-85' and 2235'-45'; cuttings are very poor, mainly cavings
 1915-1920 Sandstone, light grey, medium grain, angular, dark chert grains
 1920-1925 Clay, bentonitic, light green grey
 1935-1940 Ironstone, brown
 1955-1960 Clay, light green grey, bentonitic
 1970-1975 Shale, dark brown grey
 1975-1980 Sandstone, light brown grey, coarse to fine
 1985-1990 Bentonite, light blue grey
 2005-2015 Siltstone, light brown
 2015-2025 Sandstone, light brown, fine grained, very silty
 2050-2065 Shale becomes very dark blue grey, possibly some fine sandstone
 2065-2070 Siltstone, dark maroon, rhodochrosite pellet horizon
 2070-2075 Sandstone, fine angular, light grey (base Dakota)
 2075 Fuson bentonite, drab
 2095-2115 Shale, black and dark blue grey
 2115-2125 Shale, grey, silty, clay ironstone, brown
 2125-2130 Siltstone, light yellow brown, micaceous
 2130 Shale, grey, ashy, micaceous and bentonitic
 2140-2145 Sandstone, light grey, cone-in-cone
 2145-2150 Sandstone, light grey, medium grained, angular
 2160-2165 Mudstone, purplish, bentonite, drab
 2165 Siltstone, light yellow brown, shale, grey, silty, sandstone, light brown, medium grained, angular, ferruginous
 2175-2180 Clay ironstone, brown
 2180-2185 Lakota sand, loose, coarse, subround to subangular, partly pitted
 2185-2190 Sandstone, brown grey, fine to medium, angular
 2190-2195 Sandstone, lighter grey
 2195-2200 Bentonite, light grey and blue grey
 2200-2215 Sandstone, light brown grey, fine to coarse, angular, micaceous, carbonaceous, poorly sorted, much brown sandy clay ironstone 2205'-10'

2215-2225 Shale, dark blue grey
 2235-2240 Concretions and sandstone as above, grit size, black and dark brown, rounded chert, base Lakota
 2240-2275 Shale, dark blue grey
 2275-2280 Shale, black
 2280-2290 Shale, brown red (terra cotta) and drab, bentonite
 2415 Sandstone, grey, fine, angular, poorly sorted
 2410-2435 Glauconitic Sundance clay
 2435-2445 Bentonite, drab and light grey fine sandstone, 2435'-40'
 2460-2465 Sandstone, light grey, very fine grained, micaceous
 2474 Sandstone, pyrite-cemented, coarse, angular
 2565 Mudstone, drab, soft, micaceous
 2585-2590 Limestone, cream, sandstone, grey, fine, mudstone, bright red, bentonite, very light grey
 2595-2605 Shale, grey
 2605-2610 Sandstone, light grey, fine, angular
 2610-2625 Sandstone, light grey, fine, angular, and clay, green grey, bentonitic
 2625-2655 (Minnelusa) limestone, magnesian, light pink and cream, fine sugary sandstone, coarse, considerable glauconite nodules in cavings, also some large quartz grains in white limy matrix
 2665-2670 Bentonite, green grey
 2670 Limestone, magnesian, buff and cream
 2680-2690 Sandstone, cream, fine to medium, interbedded with limestone, cream, fossiliferous, vuggy, with small dolomite crystals
 2690-2695 Shale, black, bituminous
 2698 Sandstone, coarse, subangular, glauconitic, limestone, magnesian, buff, vuggy
 2720 Limestone, magnesian, cream, very fine sugary
 2725 Much chert, light grey milky, in limestone as just above
 2735-2750 Anhydrite, white and grey, in dolomite, light brown, dull, very fine texture
 2750-2770 Dolomite, brown grey, very silty, sugary
 2770-2775 Much chalcedony, white to blue, milky, and much calcite
 2775-2785 Sandstone, grey, fine grained, very vuggy, limy cement
 2785-2800 Anhydrite, white, light blue and light brown grey, silty, dolomite, fine sugary, with chert, blue grey, 2795'-2800'
 2800-2805 Dolomite, grey and brown, finely crystalline, very cavernous
 2805-2810 Anhydrite, light grey to white, in dolomite, light brown
 2810-2820 Limestone, magnesian, light cream grey, cavernous, fine grained, with spots of dolomite
 2820-2825 Anhydrite, white, light grey and blue, chert, light grey, milky

2825-2830 Limestone, dolomitic, light brown grey, small rhombs in finer limestone matrix
 2830-2835 Shale, brick red, bentonitic
 2835-2840 Anhydrite and limestone, dolomitic, light brown
 2845-2850 Limestone, dolomitic, grey, fine texture
 2850-2855 Limestone, light brown, very sandy, fine quartz grains
 2855-2860 Anhydrite, white
 2860-2865 Limestone, dolomitic, light brown, some sandy, rest very fine and dense
 2865-2880 Anhydrite and limestone, dolomitic, fine, dense powdery texture, not sandy
 2880-2910 Shale, purple and maroon, tawny yellow and brown, bentonitic, some shale, sandy and siltstone
 2910-2960 Clay, salmon, mottled with grey, and sea green, sandy and silty, bentonitic, ostracods and gastropods in lower part
 2960-2980 Grit size fragmentary quartz, chert, jasper and limestone
 2980-3000 Bentonite, tan, pink and lavender
 3000-3005 Clay, salmon (or light brick red), mottled with brown grey
 3005-3010 Pebbles, mostly of grey limestone
 3010-3015 Small Spirifer
 3015-3020 Limestone, cream, fine sugary to lithographic
 3020-3060 Clay, varicolored, quite pebbly
 3060-3065 Limestone, cream, finely crystalline, fossils, secondary calcite
 3075-3085 Limestone, grey, finely crystalline, Nummulostegina and ostracods
 3085-3095 Limestone, darker grey, fossils
 3095-3100 Limestone, dark blue grey, with some black shale
 3100-3105 Limestone, dove, fine powdery texture
 3105-3115 Limestone, cream grey, fine powdery texture
 3115-3120 Shale, black, bituminous, hard, fissile
 3120-3130 Limestone, spotted with two shades of grey, fine grained
 3130-3140 Shale, black, bituminous, finely fissile
 3140-3145 Sandstone, buff, fine grained, poorly sorted, subangular to subround
 3145-3150 Shale, black, bituminous, hard, finely fissile
 3150-3155 Limestone, black, bituminous, clayey
 3160-3165 Claystone, salmon, and sandstone, coarse, light grey, angular, pyrite cement, with plant fragments replaced by covellite and chalcopyrite
 3165-3182 Claystone, salmon, limy, bentonitic matrix, and clay, brown drab
 3185-3190 Clay, yellow brown and lavender, bentonitic, partly laminated, limestone, cream and pink, fine texture
 3190-3195 Limestone, cream and pink, fine powdery texture, Productus

3195-3205 Clay, light green grey, bentonitic, sandy and silty
 3205-3210 Pahasapa (Madison) limestone, cream to light brown,
 fine granular
 3210-3235 Limestone, creamy white to light blue grey, fine
 sugary, grey above, flaky
 3235-3240 Limestone, creamy white, fine sugary, imperfect
 oolites, flaky
 3240-3245 Limestone, pink, dull, porous, small rhombs, flaky
 3245-3255 Limestone, light cream to pinkish and dove, fine
 sugary powdery texture
 3255-3260 Limestone, pink, distinct small crystals
 3260-3265 Limestone, light dove, powdery to fine crystalline,
 vuggy
 3265-3275 Limestone, magnesian, light brown grey, honeycombed
 3275-3285 Limestone, light brown to cream, lithographic to
 fine crystalline
 3285-3295 Limestone, magnesian, grey, fine crystalline
 3295-3300 Limestone, dolomitic, grey, porous, with small
 dolomite rhombs
 3300-3320 Limestone, cream, oolitic
 3320-3340 Limestone, cream, oolitic, with scattered dolomite
 rhombs
 3340-3352 Limestone, dolomitic, grey, porous, small dolomite
 rhombs
 3352-3362 Limestone, cream, oolitic
 3362-3373 Limestone, dolomitic, grey and cream, small rhombs
 3373-3395 Limestone, cream and grey, oolitic, passing down
 into grey dolomite
 3395-3405 Dolomite, grey, rhombic
 3405-3530 Limestone, cream, imperfectly oolitic, partly
 lithographic, partly with dolomite rhombs
 3530-3555 Dolomite, cream, vuggy, limy, fossils, rhombic
 3555-3595 Dolomite, cream, with milky white chert
 3595-3630 Dolomite, cream, chert, opaque white with fine dots
 3630-3675 St. Peter grit, with finer sand matrix, etched,
 subround grains, some silt
 3675-3695 Dolomite, grey, very porous, medium to coarse rhombs
 3696-3705 Grit
 3705-3725 Shakopee dolomite, light grey
 3725-3740 Dolomite, grey and light green grey, finely crystal-
 line
 3740-3795 New Richmond sand, coarse
 3795-3815 Grit, subround, etched grains, some glauconite
 3815-3820 Oneota dolomite, cream and dove, finely crystalline
 3820-3910 Dolomite, light grey brown, porous fine to medium
 rhombs
 3910-3935 Dolomite, light grey brown, porous fine to medium
 rhombs, sandy
 3935-4035 Dolomite with bluish white milky chert
 4035-4045 Dolomite, with some large quartz grains
 4045-4065 Sandstone, grey, coarse, abundant matrix of dolomite

4065-4075 Shale, green, chloritic and bentonitic
4075-4080 Conglomerate, quartzose
4080-4125 Shale, green, chloritic and bentonitic, with
interbeds of coarse grey sandstone
4125-4160 Shale, pistachio green, epidotic
4160-4165 Conglomerate
4165-4180 Shale, as last above, sandy
4180-4206 Pre-Cambrian granite, quartz, pink potash feldspar,
muscovite, biotite

5. CARTER OIL CO. STRATIGRAPHIC TEST 2, Center SE. $\frac{1}{4}$, Sec. 12,
T. 9 N., R. 27 E., Stanley County. Altitude 1764'.

| | |
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| 0- 80' | Sand, various sizes, coarse to fine, angular to subangular, some frosted grains, rose quartz, dark flint, calcite crystals. Some quartz grains polished and partly rounded. Some milky white, most transparent and colorless. Some bentonite, green and light grey, selenite flakes and schist fragments. Pierre clay below 65' |
| 80- 765 | Pierre clay, bentonitic, green grey, mudstone, somewhat compact, bentonitic, biotite flakes, clay ironstone, yellow to brown, <u>Inoceramus</u> and ammonite, all above 150'. <u>Haploporella</u> common, 150' to -60', some chalk, light grey, 200'-10', siltstone with clay ironstone cement, 250'-70', <u>Globigerina</u> at 270', <u>Haploporella</u> and considerable white biotitic bentonite, 300'-20', <u>Lituonella</u> , <u>Haploporella</u> and other poorly preserved foraminifera at 320'-50', round disks possibly plants, 250'-320', <u>Dorothea</u> , very small "Cristellaria" and <u>Haploporella</u> common at 360'-70', "Cristellaria", <u>Vidalina</u> and <u>Glomospira</u> at 390'-400', clay ironstone, 400'-10', <u>Dentalium</u> , "Cristellaria" and chalky particles, 410'-30', <u>Vidalina</u> , 430'-40', darker brown grey than above and below, with fish remains, bituminous and laminated, 510'-40', <u>Pulvinulinella</u> , 560'-70', white bentonite, 530'-70', small round pyritized organic balls and <u>Vidalina</u> at 570'-80', pyrites <u>Haploporites</u> , 620', considerable white bentonite, 630'-40', marl, grey, with white chalk particles, 640'-50', chalk, spotted marl and "Cristellaria", 670'-80', <u>Haploporites</u> , 730'-40', marl, dark blue grey with very small chalk particles, bituminous, transitional to Niobrara, 740'-65' |
| 765- 860 | Niobrara marl, chalk spotted, bituminous, flattened chalk particles, fish remains, less chalky in lower part, <u>Robulus</u> and <u>Pullenia</u> |
| 860- 870 | Bentonite, rather firm, grey white |
| 870- 890 | Carlile clay, blue grey, <u>Robulus</u> , <u>Globorotalia</u> , <u>Polyphragma</u> |
| 890- 900 | Clay ironstone concretions |
| 900- 920 | Clay becoming darker |
| 940- 990 | <u>Valvulina</u> (?) |
| 990-1000 | Sandstone, light grey, fine |
| 1030-1070 | Mudstone, medium green grey, very bentonitic, numerous biotite flakes, dwarfed foraminifera |
| 1100-1110 | <u>Haploporites</u> |
| 1150-1160 | <u>Hyperammonoides</u> |
| 1180-1190 | Considerable light grey bentonite |

1125-1290 Greenhorn limestone, light grey, translucent, crystalline, full of Inoceramus prisms and fish remains, some grey ashy marl, Globigerina, some glass shards and bentonite flakes, mudstone, dark blue grey, bentonitic, with Textularia and nonionid at base

1290-1300 Graneros mudstone, dark blue grey, bentonitic

1300-1310 Bentonite, grey white

1310-1320 Ammodiscoides, Haploporites

1320-1330 Chalk with small dark specks, Glomospira, miliolid

1340-1350 Bentonite, grey white, Globigerina, Orbulina

1360-1370 Cribrobulimina

1380-1400 Globigerina, Elphidium, Orbulina, light grey, fine grained sandstone, limy cement

1400-1410 Limestone, sandy, oolitic, glauconitic

1440-1560 Lower Graneros shale, dark and bituminous

1560-1570 Sandstone, light grey, fine, glauconitic

1570-1590 Dakota sandstone, grey, coarse, angular, felspathic and with other minerals from crystalline rocks, some recrystallized quartz, lignite fragments and mica flakes, limy cement, porous, rolled detrital pyrite, top Dakota probably at 1556'

1600-1610 Bentonite, white

1660-1670 Fuson bituminous coal, coking, bright shiny lustre with woody fusain structure

1670-1700 Shale, dark blue grey

1700-1720 Sandstone, brown, micaceous and lignitic, Inoceramus prisms, bentonite, light grey green

1720-1730 Sandstone, brown grey, coarse, porous, micaceous, angular, lignite, carbonaceous shale, silicified wood

1730-1740 Clay ironstone, brown, concretionary

1740-1770 Siltstone, very light grey, hard, micaceous, clay ironstone (?), dark purple, some small jasper and quartz pebbles

1780-1790 Clay, green grey, bentonitic, sandstone, yellow brown, coarse

1830-1840 Considerable sandstone, base Lakota, 1845'

1850-1860 Morrison bentonite, light grey blue

1860-1890 Dolomite, light brown, finely crystalline

1890-1910 Mudstone, light blue grey

1910-1940 Some sandstone, white, very fine grained

1940-1960 Sundance sandstone, grey, with specks of glauconite

1960-1980 Mudstone, grey

1980-2020 Abundant glauconite nodules

2020-2040 Limestone, light grey, fine grained

2040-2080 Sandstone, light grey, fine grained, limy cement

2080-2120 Sandstone, light grey, medium grained, some polished sub-angular grains of grit size, mica, "black sand," lignite fragments

2120-2130 Some red brown concretionary aggregates

2130-2150 Siltstone, dark cherry red, conglomerate with iron oxide cement, some pebbles of brownish wine color, matrix of small silty pellets and quartz grains, vesicular material partly filled with concentric mineral

2145-2170 Minnelusa sandstone, brown, fine grained, insoluble cement

2170-2180 Possibly siltstone, crimson, sandy

2180-2190 Sandstone, grey, medium grained, angular to subround, porous

2190-2240 Siltstone, sandy, to sandstone, fine silty, salmon

2240-2250 Sandstone, light grey to light salmon pink, medium grained, angular to subround, poorly sorted, some large grains, grains pitted, little or no cement

2250-2260 Sandstone, fine grained in part

2260-2270 Sandstone, with some coarse rounded dolomite grains, claystone, terra cotta

2270-2280 Sandstone, pink, fine grained, poorly sorted, some large grains, limy cement

2280-2290 Limestone, pink to white, sandy in part, very finely crystalline

2290-2300 Limestone, cream, cavernous, some stained red and pink, finely crystalline, with a little chert and some quartz crystals

2300-2320 Dolomitic limestone, cream, fine grained, opaque, a little chert, 2310'-20'

2310-2330 Sandstone, light grey, angular, fine grained, poorly sorted

2330-2350 Limestone, magnesian, cream, very fine texture, milky chert and milky vein quartz

2350-2370 Siltstone, brown grey, very limy, micaceous, some sand grains

2370-2380 Limestone, magnesian, grey, with white spots, perhaps altered oolitic, cavernous, silty, a mixture of limestone and dolomite

2380-2400 Anhydrite, white and light grey

2400-2410 Anhydrite, white and blue grey, with mixed limestone and dolomite, with some quartz sand below

2410-2430 Limestone, dolomitic, cavernous, light brown grey, sponge spicules, anhydrite fillings

2430-2445 Shale, black, very bituminous

2445-2450 Limestone, magnesian, light blue grey, very fine sugary, some dark grey chert

2450-2480 Anhydrite, blue grey and white, with dolomite, cream, porcellaneous, light milky chert and bi-pyramidal quartz, 2460'-80'

2480-2490 Dolomite, limy, light grey, finely crystalline, with translucent chert

2490-2500 Sandstone, grey, coarse, subangular to subround, some citrine and brown, white, and grey chert grains, poorly sorted, some frosted grains, really a fine grit

2500-2510 Pleurotoma, albite, almandite and bipyramidal quartz

2510-2540 Dolomite, light brown grey, fine sugary, limy, dolomite crystals in limestone

2540-2550 Clay, bentonitic, light green grey, tawny yellow and pink, silty

2550-2560 Dolomite, light to medium grey, medium-sized crystals, apparently partly sandy

2560-2570 Mudstone, bentonitic, salmon pink to terra cotta and tawny yellow, glauconitic, gastropods and ostracods, limestone, light grey, crystalline

2570-2580 Bentonite, varicolored

2580-2610 Bentonite, predominantly pink

2610-2625 Limestone, cream, lithographic, capulid gastropod

2625-2640 Clay, bentonitic, tawny yellow and dark brown red, lavender, purple and bright green

2640-2645 Limestone, medium grey, fossiliferous, nodular

2645-2670 Shale, black and dark grey, bituminous, limy, chalcopyrite

2670-2680 Limestone, dove to medium grey, very fine texture

2680-2690 Shale, dark blue grey and black, bituminous, ostracods

2690-2700 Limestone, medium grey, fine, small specks pyrite, fossiliferous

2700-2708 Shale, black, shiny, hard and tough, bituminous, much chalcopyrite

2708-2720 Sandstone, light grey, fairly coarse, pyrite cement, angular to subround, poorly sorted

2720-2730 Limestone, dark blue grey, fine texture, sandy and clayey

2730-2735 Sandstone, coarse to medium, recrystallized quartz common

2735-2760 Pahasapa (Madison) limestone, magnesian, cream, very fine sugary, some small vugs, light grey chert

2760-2770 Limestone, cream, coarser than above

2770-2780 Limestone, cream, lithographic, fossiliferous

2780-2790 Limestone, dove grey, fine sugary

2790-2800 Limestone, light brown grey, porcellaneous or lithographic

2800-2810 Limestone, light grey, fine sugary

2810-2830 Limestone, dove (light brown grey), dense, finely crystalline

2830-2840 Limestone, dove (light brown grey), a little more porous and coarser crystalline

2840-2860 Limestone, light brown, quite porous, crystalline

2860-2880 Limestone, light brown, fine sugary, fossiliferous

2880-2890 Limestone, grey and light brown, full of small round cavities

2890-2910 Limestone, brown, dense with local calcite crystals, fossiliferous, imperfect oolites

2910-2940 Limestone, interbedded brown, oolitic, and grey, sugary, full of holes

- 2940-2970 Limestone, grey, dolomite crystals in fine ground-mass
- 2970-3030 Limestone, dolomitic, grey, fine sugary, porous, oolites at base
- 3030-3160 Limestone, light brown, fine, dense, oolitic in part. At 3058' texture becomes fine sugary. Stylolites and fossils. At 3110' becomes largely oolitic with pores. Below 3130' it is again dense to fine sugary and fossiliferous. Dolomite rhombs in calcite
- 3160-3260 Limestone, dolomitic, medium brown, sugary, porous and vuggy, dolomite rhombs, fossils. Bituminous at 3210'
- 3260-3300 St. Peter sandstone, light grey, coarse, with grains of all sizes, subangular to round, some frosted grains. Coarse grains scattered through white finer matrix. Pink sand grains fairly common (likely derived from Sioux quartzite), very small glauconite spots
- 3300-3340 Shakopee dolomite, light brown, perfect rhombs with open spaces between, some vugs filled with anhydrite, lower 10' slightly bituminous
- 3340-3350 Sandstone, grey, fine to coarse, unsorted, small specks glauconite
- 3350-3400 Dolomite, brown cream, rhombs with vugs partly filled with anhydrite, compound dogtooth spar crystals. Bituminous, 3380'-3400', where texture is fine sugary
- 3400-3430 New Richmond sandstone, coarse, gritty, angular to subround, frosted, glauconitic, some jasper and rose quartz grains, some recrystallized
- 3430-3440 Oneota dolomite, brown grey, sugary
- 3440-3450 Limestone and dolomite mixed, grey, medium sized crystals
- 3450-3460 Dolomite, finely crystalline, dense, interbedded with sandstone, coarse, subround to angular
- 3460-3500 Dolomite, light brown, fine sugary
- 3500-3590 Dolomite, dove, a little larger size crystals, vuggy, with some dry hydrocarbon stylolites
- 3590-3620 Dolomite in limestone matrix, light brown, some fine sand grains
- 3620-3640 Limestone, light brown and grey, rough crystalline texture, white chert, secondary calcite
- 3540-3660 Sandstone, light brown grey, fine apparently interbedded with cherty limestone
- 3660-3700 Abundant chert, light blue grey, limestone, light grey, silty, fossiliferous
- 3700-3780 Limestone, light brown, fine texture, chert less abundant, fossils common including small orthid brachiopods, small black chert or phosphate pebbles, considerable sand, 3740'-80'
- 3780-3880 Shale, upper 20' light green, rest dark green, sandy and silty above, chloritic and bentonitic
- 3880 Pre-Cambrian diorite, plagioclase, hornblende, biotite, hornblende in part chloritized

6. CARTER OIL CO. STRATIGRAPHIC TEST 1, Center NE. $\frac{1}{4}$ NW. $\frac{1}{4}$, Sec. 34, T. 118 N., R. 78 W., Potter County. Altitude 1865'.

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| 0- 10' | Pierre clay, bentonitic, green-grey, white satin spar gypsum |
| 10- 790 | Pierre clay, bentonitic, with details as follows: much selenite, 60'-70', satin spar and some fine sand 80'-90', quartz, jasper, chert, hornblende, rose quartz, grossularite or andradite, almandite, biotite, chlorite, serpentine, potash and plagioclase feldspar and fragments of holocrystalline igneous at 90'-100' may be cavings from the surface. <u>Inoceramus</u> prisms, 90'-100' and 140'-50', some sandstone, 140'-50', shell fragments, 180', chalk, light grey, with <u>Haploporella</u> and <u>Ammodiscus</u> , 265'-70', mudstone, blue grey, 310'-420', greenish bentonite, 420'-50', small oval tan concretions, 580'-90', light tan brown limestone concretions and hauerite (?), 590'-700', Sharon Springs shale, very dark blue grey, bituminous, 710'-90' |
| 790- 910 | <u>Niobrara</u> , marl, grey, chalk-specked, bituminous, brownish, more compact and chalkier, 830'-40' |
| 910-1240 | <u>Carlile</u> shale, dark grey, with silty grey limestone, 980'-90', chalk, light cream-grey, small black dots, 1030'-40', sandstone, grey, fine, biotitic, 1040', brown iron carbonate, 1170', shale nearly black, 1200'-40' |
| 1240-1250 | <u>Greenhorn</u> limestone, grey, sandy, porous, crystalline, packed with <u>Inoceramus</u> prisms and fish remains |
| 1250-1260 | Bentonite, light green grey, <u>Cribrobulimina</u> |
| 1260-1330 | Limestone, light and dark grey, coarsely crystalline, bituminous, with flattened pyrite pebbles, <u>Globigerina</u> , <u>Inoceramus</u> prisms, fish remains |
| 1330-1380 | <u>Graneros</u> marl, chalky, dark grey, spotted, bituminous |
| 1380-1390 | Bentonite, light grey |
| 1400-1510 | Sandstone, light grey, fine grained, biotite and a little glauconite, limy cement, fish remains |
| 1510-1590 | Shale, dark blue grey, bituminous |
| 1590-1730 | <u>Dakota</u> sandstone, medium grained, subround to sub-angular, little cement, apparently nearly all sandstone, 1640'-1730' |
| 1730-1760 | <u>Fuson</u> shale, dark blue grey, bituminous |
| 1760-1770 | Manganosiderite (or rhodochrosite) pellets in loose sand |
| 1810-1850 | <u>Lakota</u> (?), mostly sandstone with considerable mudstone, light green grey, bentonitic, some interbeds of white bentonite with small quartz and biotite fragments |
| 1850-1900 | Sandstone, brown grey, arkosic, fine grained |
| 1900-1910 | <u>Sundance</u> sandstone, light grey, glauconitic, mudstone with <u>Haploporella</u> |

1910-1930 Some bentonite, light green, sandy
 1930-1940 Sandstone, light brown and grey, fine grained, micaceous
 1940-1950 Limestone, rich brown
 1950-1990 Sandstone, mostly, medium grained, brown siltstone cemented with iron carbonate
 1990-2000 Sandstone, grey, fine grained, part with much glauconite
 2000-2010 Clay ironstone, dark brown grey, fine texture, nodular
 2010-2040 Sandstone, dark grey, fine grained, glauconitic, micaceous, partly quartzite, 2030'-40'
 2040-2070 Clay ironstone, dark brown, fine sugary texture, probably some bentonite, brown, 2050'-70'
 2070-2110 Sandstone, brown to grey, medium to coarse well-polished grains, subangular to subround, limy cement, also pyrite cement, high porosity, abundant lignite fragments
 2110-2120 Sandstone, grey and brown, coarse
 2120-2150 Residual soil of cream to light brown kaolin or bauxite with maroon to crimson mottlings, silty to sandy, some small pebbles. Lowest 10' is partly pink and lavender, bentonite, orange, tan and yellow, 2130'-40'. Probably top of Paleozoic (Minnelusa (?)) or basal Sundance.
 2150-2200 Minnelusa sandstone, cream, poorly sorted, medium grained, subangular to subround, limy cement to porous
 2200-2220 Sandstone, as above, but with some jasper grains, stained with yellow ochre
 2220-2235 Clay, brown red, bentonitic
 2235-2240 Considerable milky chert, weathered selenite, siltstone, pink
 2240-2250 Siltstone, dove, magnesium-calcium carbonate cement, with some shale, dark blue grey, bituminous
 2250-2260 Siltstone and fine sandstone, light grey, recrystallized quartz
 2260-2270 Shale, black, very bituminous
 2270-2300 Limestone, magnesian, light brown grey, sugary, porous
 2300-2310 Dolomite, light brown grey, fine sugary
 2310-2320 Limestone, magnesian, cream to light dove, fine sugary
 2320-2330 Sandstone, white, fine grained, limy cement
 2330-2340 Mudstone and siltstone, maroon
 2340-2360 Cavings but perhaps in light grey limestone
 2360-2370 Bentonite, light grey, green grey, pink and yellow, small nautiloid
 2370-2380 Limestone, cream, lithographic, calcite fillings of vugs
 2380-2400 Bentonite, pink yellow, brown, light green and light grey

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| 2400-2420 | Limestone, light grey and cream streaked, lithographic, much secondary calcite |
| 2420-2435 | Limestone, dark blue grey, bituminous, fine powdery texture |
| 2435-2445 | Shale, black, bituminous, limy |
| 2450-2470 | Limestone, cream, lithographic to powdery texture, chalcopyrite |
| 2470-2500 | Limestone, finely crystalline and vuggy, magnesian in lower beds |
| 2500-2520 | Limestone, cream, obscurely oolitic, porous, finely crystalline, possible unconformity |
| 2520-2570 | <u>Pahasapa</u> (Madison) (?) limestone, magnesian, light brown, crystalline, very porous and vuggy, dolomite rhombs in calcite matrix. Some conglomerate, dark brown bituminous streaks and stains, porosity decreases downwards |
| 2570-2600 | Limestone, light dove, very dense, minute dolomite rhombs |
| 2600-2620 | Dolomite, grey, very vuggy, crystalline |
| 2620-2640 | Limestone, light brown and grey, obscurely oolitic, very fine, ostracods |
| 2640-2645 | Limestone, cream, oolitic |
| 2645-2655 | Limestone, dark grey, fine, porous and vuggy |
| 2655-2670 | Limestone, light brown grey, large oolites with pores between, secondary calcite, alabaster, 2665' |
| 2670-2690 | Limestone, grey, coarse, abundant sand grains |
| 2690-2700 | Dolomite, dark grey, fine sugary, calcite matrix |
| 2700-2750 | Dolomite, grey, crystalline, considerable fine sand and silt |
| 2750-2910 | Limestone, cream, oolitic in part, porous, lithographic to crystalline, looks like Madison |
| 2910-2930 | Limestone, cream, medium sized crystals, porous and vuggy |
| 2930-2990 | Limestone, light brown, crystals in fine powdery matrix |
| 2990-3000 | Siltstone, salmon, some claystone, brick red |
| 3000-3010 | Sand, loose, coarse, unsorted, subround to subangular, <u>St. Peter</u> (base of mid-Ordovician) |
| 3010-3050 | <u>Shakopee</u> (Lower Ordovician) dolomite, dark brown, coarsely crystalline, very porous |
| 3050-3070 | Dolomite, white and light green grey, fine sugary, with scattered large sand grains |
| 3070-3080 | Dolomite, light green grey, fine sugary |
| 3080-3091 | Dolomite, brown, fine sugary, vuggy |
| 3091-3100 | Dolomite, grey, fine sugary, with scattered small and larger quartz grains |
| 3100-3120 | <u>New Richmond</u> sandstone, grey and green grey, grains fine to coarse |
| 3120-3200 | <u>Oneota</u> dolomite, light brown grey, sugary, vuggy, secondary quartz crystals |
| 3200-3270 | Dolomite, darker brown, secondary quartz crystals |

- 3270-3320 Dolomite, light brown, milky white chert, secondary quartz crystals
- 3320-3380 Dolomite rhombs in calcite crystals, light blue chert, some siltstone
- 3380-3440 Limestone, cream, fine texture, white matrix of abraded calcite crystals
- 3440-3460 Limestone, cream, with fine detritus
- 3460-3490 Shale, light dull green, bentonitic, some fine sandstone in upper and numerous small quartz grains below
- 3490-3560 Shale, dull green, unctuous, bentonitic, flaky, hard, probably chloritic
- 3560-3580 Sandstone, grey, porous, poorly sorted, varying size grains, finer above
- 3580-3611 Pre-Cambrian granodiorite or quartz-monzonite, extensively chloritized, contains quartz, biotite, plagioclase, some orthoclase, hornblende; feldspars are kaolinized

B. Central Western South Dakota

7. GYPSY OIL CO. HUNTER 1, NE. $\frac{1}{4}$ SW. $\frac{1}{4}$, Sec. 28, T. 3 N., R. 16 E., Pennington County, altitude 2956.8'. Nine-inch casing set at 4513', cable tools 4573'-5001'. See Littlefield, M.S., "Log of Wildcat Well in Pennington County, South Dakota," Am. Assoc. Petroleum Geologists Bull., vol. 23, No. 8, August, 1939, pp. 1234-1237.

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| 0- 243' | No cuttings. <u>Fox Hills</u> formation |
| 243- 560 | No cuttings. <u>Pierre</u> bentonitic clay |
| 560-2050 | <u>Pierre</u> clay, bentonitic, grey green, with some white chalky layers, selenite, fine mica flakes, small serpentine particles, shell fragments, including <u>Inoceramus</u> |
| 640& 710 | <u>Robulus navarroensis</u> , <u>Dorothea</u> (?) at 640' |
| 750- 760 | Abundant shell fragments, hauerite (?) |
| 760- 770 | Chalcopyrite, <u>Robulus</u> , abundant <u>Inoceramus</u> prisms |
| 810 | <u>Robulus</u> |
| 830 | <u>Robulus</u> , <u>Globigerina</u> , many shell fragments |
| 840- 850 | Part with very small quartz grains, noted also higher up, fine greywacke sand, chalcopyrite, many shell fragments |
| 850- 860 | A little milky chert |
| 900- 910 | <u>Dorothea</u> , <u>Globigerina</u> , <u>Robulus</u> |
| 920 | <u>Dorothea</u> , and considerable calcite |
| 960- 970 | <u>Robulus</u> |
| 980 | <u>Robulus</u> , <u>Globigerina</u> |
| 990 | <u>Dorothea</u> |
| 1020 | Some light grey limestone |
| 1040 | Some greywacke sandstone with andesite fragments, brown siltstone |
| 1090 | <u>Haplophragmoides</u> |
| 1140 | <u>Robulus</u> |
| 1170 | <u>Globigerina</u> , <u>Textularia</u> , <u>Haplophragmoides</u> , some brown limestone concretions |
| 1180 | <u>Dorothea</u> , <u>Dentalina</u> |
| 1200 | Brown septarian concretion |
| 1210 | <u>Haplophragmoides</u> , <u>Dorothea</u> , <u>Globigerina</u> |
| 1230 | <u>Nodogenerina</u> |
| 1280 | Considerable brown clay ironstone |
| 1330 | <u>Dorothea</u> |
| 1340 | Somewhat limier, <u>Globigerina</u> |
| 1360 | <u>Robulus</u> , echinoid spine, <u>Haplophragmoides</u> , <u>Globigerina</u> , <u>Dorothea</u> |
| 1410 | <u>Haplophragmoides</u> |
| 1420 | <u>Textularia</u> , <u>Globigerina</u> |
| 1430 | <u>Robulus</u> , <u>Haplophragmoides</u> , <u>Textularia</u> , <u>Globigerina</u> , <u>Dorothea</u> and Miliolid, sandstone, grey, medium grain with black particles |
| 1450 | <u>Haplophragmoides</u> , <u>Dorothea</u> , <u>Globigerina</u> , small pearl and <u>Chara</u> seeds, limestone, light grey, very dense, some with cone-in-cone structure |

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| 1480 | <u>Dorothea</u> |
| 1490 | <u>Cribrostomoides</u> |
| 1500 | <u>Dorothea</u> , cone spaerosiderite, some hauerite (?) |
| 1520 | <u>Globigerina</u> |
| 1530 | <u>Globigerina</u> , <u>Robulus</u> , <u>Textularia</u> , <u>Dorothea</u> |
| 1550 | <u>Globigerina</u> , <u>Robulus</u> , <u>Textularia</u> |
| 1560 | Chalk, light brown |
| 1584-1590 | <u>Ammodiscus</u> |
| 1590 | <u>Textularia</u> |
| 1602-1604 | Core of mudstone, dark grey, very fine, compact |
| 1610 | <u>Haplophragmoides</u> |
| 1630 | <u>Haplophragmoides</u> , <u>Dorothea</u> |
| 1660 | Top of <u>Sharon Springs</u> shale, dark grey, bituminous, serpentine pellets common, <u>Dorothea</u> , abundant <u>Chara</u> seed |
| 1670 | <u>Dorothea</u> , <u>Globigerina</u> , some sandstone and light grey limestone |
| 1680 | <u>Robulus</u> , <u>Globigerina</u> |
| 1690 | <u>Haplophragmoides</u> , brown clay ironstone, very dark grey marl |
| 1700 | <u>Ammodiscus</u> , <u>Dorothea</u> , <u>Textularia</u> , nonionid, some fine grit, black elliptical pebbles, fish remains, bituminous grey marl |
| 1730 | Nonionid (" <u>Cristellaria</u> "), <u>Textularia</u> , <u>Dorothea</u> |
| 1740 | Nonionid (" <u>Cristellaria</u> "), <u>Ammodiscus</u> , <u>Globigerina</u> |
| 1750 | Some small flattened chalk pellets, serpentine or glauconite pellets common |
| 1760 | <u>Robulus</u> , <u>Textularia</u> , <u>Globigerina</u> , <u>Vidalina</u> , <u>Polyphragma</u> , flaky, fissile shale of two tones of dark blue-grey. Considerable biotite occurs in the Sharon Springs |
| 1790 | <u>Dentalina</u> , a little light grey, fine grained, limy sandstone |
| 1820 | Some limestone, fine texture, light grey |
| 1830 | Limestone more abundant |
| 1860 | <u>Dorothea</u> |
| 1900-1910 | Chalk-spotted marl |
| 1910 | <u>Dorothea</u> |
| 1920 | <u>Textularia</u> , miliolid |
| 1930 | <u>Robulus</u> |
| 1940 | <u>Textularia</u> |
| 1950 | " <u>Cristellaria</u> ," <u>Robulus</u> , <u>Globigerina</u> , <u>Dorothea</u> |
| 1980 | <u>Vidalina</u> , <u>Globigerina</u> |
| 2010 | <u>Vidalina</u> , <u>Globigerina</u> , <u>Robulus</u> |
| 2040 | Many small concretionary nodules of serpentinous clays, as usual, there is much caving material in the Pierre cuttings |
| 2050-2090 | <u>Niobrara</u> marl, dark grey, chalk-spotted, <u>Robulus</u> , <u>Globigerina</u> |
| 2090-2110 | About half chalk, rest is marl |
| 2110 | Permanganate-appearing substance |

2130-2160 Some particles nearly pure chalk
 2160-2170 Less impure but solid chalk, Globigerina
 2170-2250 Carlile marl, dark blue grey, somewhat flaky,
 bituminous, fish remains and Inoceramus
 2250-2260 Robulus, Dorothea, some sandstone, light grey,
 micaceous
 2260 Dorothea
 2270 Globigerina, some sandstone, light grey, fine,
 limy
 2290 Shale very dark, nearly black, fine mica flakes,
 considerable limy sandstone, light grey, fine to
 medium, micaceous, biotite, hornblende, greywacke,
 foraminifera
 2390 Shale is dark blue-grey
 2410 Sandstone as at 2290'
 2460 Shale is dark blue-grey
 2500-2520 Greenhorn shale, almost black, with some flattened
 chalk pellets and fish remains
 2520-2563 Same but chalk particles very fine
 2563-2575 Limestone, light grey, chalky and clayey, crystal-
 line, spotted two shades grey, partly oolitic,
 (Globigerina)
 2575-2610 Graneros mudstone, bentonitic, flaky but not lami-
 nated
 2610 Color lighter
 2620 Vidalina, Globigerina, Dorothea
 2630 Shale again dark with small chalk spots
 2770 Some coarsely crystalline limestone with phlogopite
 2810 Shale very dark blue grey, Thermopolis (Skull
 Creek) facies
 2920 Some brown clay ironstone
 2950 Some siltstone, light grey
 2980-3010 Dakota sandstone, light grey, very fine, silty
 3010-3060 Increase in amount of sandstone
 3060 Shale dark blue grey, sparse manganosiderite pellets.
 Reported base Dakota at 3082'
 3100-3160 Sandstone, creamy white, medium grained, porous,
 subangular
 3160-3170 Limestone brown, with sponge spicules, siderite
 3170-3230 Fuson shale, dark blue grey. Casing run to 3209'
 3130-3240 Bentonite, dark green, pellets in dark blue grey
 mudstone
 3240-3280 Sandstone, fine grained with green bentonite matrix
 3280-3330 Shale, dark blue grey
 3330-3390 Lakota sandstone, light buff, medium grained,
 micaceous, angular, porous
 3390-3410 Shale, dark blue grey
 3410-3420 Sandstone, grey-white, medium grained, angular,
 porous, white ashy matrix, micaceous. Some re-
 crystallized quartz, some large quartz grains partly
 rounded and frosted, a few pieces hornblende. Base
 coarser sandstone, more prevalently recrystallized

3420-3440 Morrison mudstone, light grey green, bentonitic, micaceous, and silty
 3440-3450 Mostly bentonite, dull light green with spots and streaks of dark green
 3450-3460 Some siltstone, terra cotta, with sand grains, more abundant sandstone, fine grained and unsorted, light green, some drab bentonite with numerous quartz grains
 3460-3470 Sandstone, buff, fine grained, angular
 3470-3480 Sandstone, large quartz grains, angular, some mudstone light green grey bentonite
 3480-3540 Sandstone, non-limy, buff to light grey, poorly sorted, angular, some recrystallized, becomes finer below
 3540-3550 Bentonite, light green, compact, conchoidal fracture
 3550-3570 Bentonite, as just above but some light grey, full of quartz grains
 3570-3580 Mudstone, bentonitic, 3 shades of light green, some sandstone, bentonitic, some large subround etched grains, matrix partly limy, a little limestone
 3580-3600 Sundance sandstone, light grey, medium grained, angular, porous, glauconitic
 3600-3730 Siltstone, light grey, glauconitic
 3730-3767 Sandstone, buff, fine grained, glauconitic, grey below
 3767-3836 Spearfish sandstone, salmon, fine silty, angular. Color very light red brown
 3836-3850 Sandstone, light grey
 3850-3950 Anhydrite, white, and siltstone, dull brown red
 3950-3980+ Minnekahta limestone, dense, buff, somewhat magnesian, cavernous limestone--anhydrite mixture, some finely pisolitic
 3980+--4000 Opeche siltstone, dark red brown
 4000-4010 Limestone--anhydrite, light grey
 4010-4082 Siltstone, red brown, anhydrite at base
 4082-4120 Minnelusa limestone, cream to light pink, magnesian, lithographic, becoming silty at base
 4120-4130 Limestone, bentonitic, lavender, fine grained
 4130-4140 Some anhydrite, mostly light pinkish brown fine grained limestone, silty, with small crystals of anhydrite
 4140-4150 Anhydrite, white to pinkish
 4150-4170 Limestone, dolomitic, brown buff, fine texture anhydrite, some pink, and sandstone
 4170-4190 Limestone, dolomitic, cream, porcelain texture
 4190-4200 Limestone, magnesian, light brown grey, fine texture, anhydrite, grey and white
 4200-4220 Sandstone, salmon, fine grained, angular, white anhydrite
 4220-4280 Perhaps all anhydrite, light grey and white, perhaps, at 4250'-60' some sandstone, salmon fine

4280-4300 Sandstone, light grey and pink, medium grained, angular, poorly sorted, larger grains rounded and **etched**, and dolomite, dark pink

4300-4330 Dolomite, pink, fine texture, anhydrite, white and grey

4330-~~4360~~ Siltstone, brown red or dark salmon, somewhat limy

4360-4380 Siltstone, dark **red-vermillion**, finer, shale, red, with light green-grey splotches

4380-4400 Shale, red, green-splotched, interbedded with sandstone, red, silty, micaceous, angular

4400-4420 Shale, lavender

4420-4430 Sandstone, brown, fine grained, silty, poorly sorted, limy, some white

4430-4450 Limestone, dolomitic, fine texture, brown pink, and anhydrite, white

4450-4470 Sandstone, cream, medium grained

4470-4480 Sandstone, grey, medium grained, poorly sorted, angular, somewhat limy

4480-4490 Anhydrite, grey and white, dolomite, grey-brown, fine sugary

4490-4500 Sandstone, light grey, fine, poorly sorted with some large rounded frosted grains

4500-4520 Shale, black, extremely bituminous, very small mica flakes

4520-4530 Limestone, magnesian, brown grey, fine sugary, siltstone, grey

4530-4575 Limestone, magnesian, grey, fine granular

4575-4591 Limestone, dolomitic, dove grey, fine granular

4591-4605 Limestone, grading down into darker color, then to siltstone and at base to shale, shiny black, very bituminous

4605+~~4611~~ Sandstone, light grey and white, fine, limy, recrystallized, chert, dark brown and grey

4611-4622 Sandstone, light grey, fine, angular, limy

4622-4630 Limestone, magnesian, very light grey, fine texture, with a little shale, light green. The limestone is an intermixture of dolomite and calcite crystals

4630-4641 Sandstone, light grey, very fine grained, limy

4641-4652 Shale, grey, light green and lavender, bentonitic, underlain by limestone, magnesian, very light grey, fine texture

4652-4661 Dolomite, cream to light grey, finely crystalline

4661-4671 Mudstone and siltstone, dark dull purple-red, blotched, light grey green

4671-4683 Mudstone, red, green and grey

4683-4693 Siltstone, light green grey, limy

4693-4710 Anhydrite, white

4710-4722 Limestone, magnesian, light grey, fine texture to amorphous, shale, light green, bentonitic

4722-4729 Mudstone, butternut brown with grey laminae

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| 4729-4739 | Limestone, very dark blue grey, clayey |
| 4739-4751 | Limestone, medium grey, fine granular, glauconitic, some shale, black and dark grey, bentonitic |
| 4751-4760 | Limestone, light dove grey, lithographic |
| 4760-4768 | Some bentonite, dark dull lavender |
| 4768-4775 | Shale, black |
| 4775-4790 | Bentonite, dark grey, and limestone, grey |
| 4790-4810 | Limestone, dove grey, lithographic to fine granular, calcite veins |
| 4810-4817 | Sandstone, lavender, with light grey bands, some grit size |
| 4817-4823 | Laterite, dark Indian red, bentonitic, and sandy |
| 4823-4830 | Sandstone, white, medium grained, non-sorted, some large frosted subround grains |
| 4831-4856 | <u>Pahasapa (Madison)</u> limestone, light dove grey, lithographic to fine granular |
| 4856-4872 | Limestone, as above, but with considerable light milky chert |
| 4872-4917 | Limestone, with a little chert, calcite veins |
| 4917-4924 | Limestone, some light brown with small dolomite crystals |
| 4924-4955 | Limestone, magnesian, light brown, with small dolomite crystals, some pink, probably rest is cream or buff |
| 4955-4975 | Limestone, with some larger dolomite rhombs |
| 4975-5001 | Limestone, dolomitic, brown, finely crystalline, porous, with small dolomite crystals |

Fresh water rose 1400' in one hour from Dakota sandstone at 3041' depth. Fresh water rose 2300' in one hour from Lakota sandstone at 3325' depth. Fresh water rose 3000' in 15 minutes from Morrison sandstone at 3461' depth. One-half bailer of water per hour from Minnelusa limestone at 4520'-4580' depth. Fresh water rose 3850' from top of Madison Pahasapa limestone of 4855'-72' depth. Fresh water rose 4000' from Madison magnesian limestone at 4934' depth.

C. Eastern Flank, Black Hills

8. RAPID CITY AIRPORT 2, 1480' EWL, 2438.8' SNL, Sec. 13, T. 2 N., R. 8 E., Pennington County, Altitude 3210.4'.

See also Gries, J.P., Two Deep Water Wells Near Rapid City, S. Dak., Am. Assoc. Petroleum Geologists Bull., vol. 27, No. 5, pp. 646-50, May, 1943.

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| 0- 290' | No cuttings |
| 290- 350 | <u>Pierre</u> bentonitic clay, medium blue-grey, bentonitic and muscovitic, with thin streaks and nodules of limestone with hauerite (manganese sulphide?). Fish remains, white bentonite with phlogopite, 340'-50', considerable dark grey limestone, 300'-10', cone-in-cone concretions, <u>Inoceramus</u> prisms and shell fragments. Much organic matter replaced by pyrite and marcasite. Shark's teeth. Chalcopyrite |
| 350- 360 | Limestone, dark blue-grey, earthy. Shot-like pyrite |
| 360- 370 | Hauerite (?), chalcopyrite |
| 370- 420 | Clay, blue grey |
| 420- 430 | Limestone, very muddy, dark grey |
| 430- 530 | Mudstone, dark-grey, more compact than higher up <u>talium</u> and <u>Globigerina</u> at 450'. Hauerite (?) in balls, pipe concretions and replacing <u>Inoceramus</u> prisms at 470'-80', <u>Cristellaria</u> at 480'-90', much manganosiderite at 500'-20', <u>Globigerina</u> and <u>Dentalium</u> at 510'-20', chalcopyrite at 520'-30' |
| 530- 570 | Marl, grey, spotted with white chalk pellets |
| 570- 630 | Chalcopyrite rather abundant. Sulphides replacing hydroids and bryozoa at 610'. Rest of interval blue-grey clay |
| 630- 700 | <u>Niobrara</u> marl, spotted with chalk pellets, bituminous |
| 700- 840 | <u>Niobrara</u> marl, spotted chalky, bituminous, dark grey, bentonitic with biotite flakes. The chalk pellets, as usual in the borings, are flattened parallel to the laminae. Infant ammonites (goniatite stage) at 820'-30'. At the base is limestone, hard, medium grey, dense, finely crystalline and bentonitic |
| 840- 860 | <u>Carlile</u> mudstone, bentonitic, micaceous, with a little chalk, medium grey worn <u>Globorotalia</u> , <u>Robulus</u> and <u>Globigerina</u> , with some fine sand, 850'-60' |
| 860- 870 | Sandstone, greywacke, biotitic, medium grained, light grey |
| 870- 900 | Marl, sandy and chalky, grey |
| 900- 910 | Mostly grey bentonite |
| 910-1000 | Some sandstone, medium grained, light grey, with biotite and glauconite, lime cement, angular grains, some black chert grains. Probably the interval is largely dark grey shale |

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| 1000-1050 | Cement from casing obscures cuttings |
| 1050-1160 | Siltstone, dark blue-grey, with small white chalk pellets. Some laminae limy |
| 1160-1170 | Siltstone with <u>Globigerina</u> and <u>Inoceramus</u> prisms |
| 1170-1190 | Siltstone with some fine-grained medium grey sandstone |
| 1190-1270 | <u>Greenhorn</u> marl, speckled with chalk pellets, <u>Inoceramus</u> prisms |
| 1270-1290 | Some sandstone with large quartz grains. Numerous <u>Globigerina</u> , a little chalcopyrite |
| 1290-1390 | Marl, bentonitic, chalk-specked, dark grey. Many <u>Globorotalia</u> and <u>Globigerina</u> . The Greenhorn contains some light grey limestone and glauconite, also hauerite (?) and chalcopyrite or bornite. At 1250' light grey sandy limestone has interbeds of finely laminated black bituminous bentonitic shale and rare malachite. Probably mainly dark blue grey shale below 1300' and may more properly be uppermost Graneros. |
| 1390-1530 | <u>Graneros</u> shale, bentonitic, limy, dark blue-grey. Some black shale at 1450' |
| 1530-1700 | Shale, mostly dark brown grey but some dark blue grey, with varying amounts of bentonite |
| 1700-1750 | Shale, silty, becoming darker progressively downwards than that above |
| 1750-1780 | Shale, mostly dark brown grey |
| 1780-1800 | Mudstone, bentonitic, medium grey |
| 1800-1830 | Mudstone, dark brown grey, flaky |
| 1830-1850 | Sandstone, light grey, extremely fine (Newcastle) |
| 1870-1890 | No cuttings |
| 1890-2120 | Shale, dark blue grey (Thermopolis or Skull Creek) |
| 2120-2200 | <u>Dakota</u> (Fall River) sandstone, grey, fine |
| 2200-2257 | <u>Fuson</u> shale and bentonite, dark grey |
| 2257-2301 | <u>Lakota</u> water-bearing sandstone, orange, coarse, sub-angular at 2281', light grey bentonite, 2295' |
| 2301-2320 | <u>Morrison</u> siltstone, dark grey, and sandstone, light brown grey, medium |
| 2320 | Some sandstone |
| 2400-2410 | Clay, green |
| 2410-2420 | Sandstone, grey, medium grain |
| 2430-2440 | Sandstone, grey, fine |
| 2450 | <u>Sundance</u> sandstone, light grey and bentonite, light grey-green |
| 2470-2500 | Sandstone, light grey, and bentonite, light grey. Much light grey bentonite, 2480' |
| 2670 | Some glauconitic sandstone and lavender bentonitic clay. Ostracods at 2680' |
| 2710 | Limestone, oolitic, glauconitic, light grey |
| 2730-2750 | Sandstone, glauconitic, light grey, fine grained |
| 2820 | Sandstone, fine |
| 2900 | Siltstone, lavender |

2950 Sandstone, glauconitic, light grey, with siltstone interlaminae, Morrison and Sundance, except as noted above, are difficulty determinable because of caving. There is considerable of the usual Sundance grey-green bentonitic clay

3080-3130 Spearfish siltstone, salmon

3130 Increase in amount of silty fine salmon sandstone

3140-3170 Siltstone, salmon

3170-3190 Anhydrite

3200-3360 Siltstone, salmon

3360-3410 Minnekahta limestone, light grey, pink-tinted, lithographic

3410-3460 Opeche siltstone, dark brown red

3460-3470 Some anhydrite

3470-3480 Siltstone, red

3480-3490 Sandstone, dark brown red, fine grained, a little lighter than just above, some white and grey anhydrite

3510-3520 Siltstone, dark brown red

3520-3530 Basal Opeche sandstone, unsorted, coarse to fine grains, rounded to angular, large grains rounded and frosted

3530-3540 Minnelusa anhydrite, finely crystalline, light grey and white

3540-3560 Sandstone, cream white, limy, medium to fine, poorly sorted

3560-3570 Sandstone, cream, coarse, angular grains

3580-3590 Limestone, brown grey, fine texture, and anhydrite, fine, grey

3590-3620 Anhydrite, cream white, finely grained, some faintly pink

3620-3650 Cavings

3650-3670 Siltstone and claystone, dark brown red

3680-3710 Anhydrite, cream and grey, granular to fine crystalline, some yellow and pinkish, some dolomite and coarse green sandstone. At 3700' some pink and orange medium grained sandstone. At 3740' and below some white sandstone

3750-3760 Anhydrite, white to light grey and pink, finely crystalline, some limestone

3780-3790 Some sandstone, coarse, white, limy or dolomitic cement, subrounded grains

3790 Considerable dark brown red siltstone (cavings?)

3800-3810 Anhydrite, grey, irregularly stained pink

3810-3845 Mostly sandstone, coarse white

3845-3848 Anhydrite, grey, stained brick red

3850-3860 Sandstone, medium grained

3860-3870 Sandstone, grey

3870-3880 Anhydrite, grey, and siltstone, bright brick red

3880-3890 Anhydrite, cream, dense to fine crystalline

3890-3910 Anhydrite, cream, and sandstone, fine, pink,

| | |
|-----------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 3910-3920 | Anhydrite, cream, and siltstone, bright brick red |
| 3920-3950 | Probably mostly cavings, possibly largely anhydrite |
| 3950-3980 | Shale, dark dull maroon, sandstone, pink to grey, medium to fine grained, some coarse, dolomite, dark pink, finely crystalline, some cavernous |
| 3980-4000 | Some limestone, cream, porcellaneous, with milky chert |
| 4000-4010 | Limestone, light grey, fine, dense, perhaps some sandstone |
| 4010-4050 | Limestone, light brown grey, dense, with some Paris green bentonitic shale |
| 4050-4060 | Limestone, magnesian, medium grey, dense |
| 4060-4070 | Some sandstone |
| 4070-4080 | Limestone, as last above |
| 4080-4090 | Limestone, cream, lithographic |
| 4090-4100 | Sandstone, cream, medium grained, angular to rounded |
| 4100-4140 | Dolomite, light creamy brown grey, dense, a little white chert |
| 4140-4150 | Dolomite, light brown, sandy |
| 4150-4160 | Some shale, maroon and bright green, large dolomite rhombs |
| 4160-4185 | Dolomite, cream to pink, porous to lithographic, some large rhombs |
| 4185-4190 | Top of laterite zone, Kaolin or bauxite, white, limy. Leached zone |
| 4190-4195 | Grit, quartzose, angular and rounded, chert fragments and dark red sandy clay |
| 4195-4205 | Laterite, largely siltstone, maroon, with white and light grey spots. Some is Indian red (turgite). Some chert and large quartz fragments |
| 4205-4215 | <u>Pahasapa (Madison)</u> limestone, cream, lithographic, light milky chert |
| 4215-4250 | Limestone, cream, showing crystals |
| 4250-4310 | Limestone, cream, with milky chert |
| 4310-4350 | Limestone, light brown grey, some pinkish, dense fine texture, calcite veined. Some magnesian and dolomitic, small secondary dolomite rhombs |
| 4350-4425 | Limestone, dolomitic, light pink to grey, small rhombs with open spaces between; matrix is calcite |

Static level of Madison water 4100' above sea level, temperature 121° F. Rapid City Airport 1 boring penetrated 400' of Madison limestone.

9. RAPID CITY AIRPORT 3, Pennington County

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|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0- 80' | No cuttings |
| 80- 100 | Terrace gravel and pebbles of quartz, chert, schists, sandstone, limestone, concretionary iron oxide and quartzite |
| 100- 130 | <u>Pierre</u> bentonitic clay, green grey, very small mica flakes, small limy nodules, <u>Inoceramus</u> prisms and foraminifera, some silt |
| 130- 140 | Some fine light grey sandstone and small serpentine particles |
| 140- 150 | Some chlorite and biotite flakes in the marl |
| 150- 440 | Marl, as above. Shell fragments at 200'-220'. Very limy with bornite replacing shell matter at 240'-70'. Bentonitic siltstone at 270'. First pure light grey bentonite with broken fish bones at 290'. Foraminifera at 310'. A little brown grey limestone at 330'. Copper sulphide and fish scales at 370'. Some fine sand and silt at 420'. Light brown ironstone concretions at 435'-45' |
| 440- 450 and | A little spotted chalky marl. Chalcopyrite. Remainder of interval bentonitic marl |
| 620- 630 | |
| 710- 760 | Marl, spotted chalky, chalk pellets rather sparse in bituminous Sharon Springs shale |
| 760- 790 | Sharon Springs dark blue grey bituminous shale |
| 790- 900 | <u>Niobrara</u> marl, flattened chalk pellets in bentonitic bituminous clay |
| 900- 940 | <u>Carlile</u> shale, dark blue grey |
| 940- 950 | Bornite fairly common as a cement. Some grey limestone, <u>Belemnitella</u> |
| 960- 970 | Considerable silt and fine sand |
| 970- 980 | Shark tooth in shale |
| 980-1010 | Shales, dark grey, fine sandy with biotite and epidote, chert and muscovite. Sandstone in whitish spots (tuffaceous) |
| 1010-1060 | No cuttings |
| 1060-1150 | Mostly cavings. Perhaps some sandstone, 1100'-1150' |
| 1150-1160 | Some very dark blue grey shale, probably continues to 1190' |
| 1190-1220 | <u>Greenhorn</u> (at least in part) shale, limy to chalky, dense, laminated, very dark grey, sandy and with some sandstone |
| 1220-1260 | Apparently typical <u>Greenhorn</u> . Packed <u>Inoceramus</u> prisms. <u>Globigerina</u> especially in thin light grey bituminous limestone films |
| 1260-1270 | More limestone than just above |
| 1270-1280 | <u>Inoceramus</u> fragments common |
| 1290-1310 | Some sandstone, glauconitic, limy, light grey, biotitic, also <u>Globigerina</u> and <u>Inoceramus</u> prisms, limestone. <u>Belemnitella</u> |

1310-1380 Graneros shale, dark blue-grey, bentonitic
 1380-1400 Shale, dark grey, with minute chalk particles,
 fish scales
 1400-1450 Shale, dark grey, with fish remains
 1450-1460 Numerous Globigerina
 1460-1470 Bentonite, whitish grey
 1470-1490 Shale, as above, but more fissile from here downwards
 1490-1510 Considerable light grey impure limestone with fish
 remains
 1510-1520 Sandstone, limy cement, light grey, Globigerina
 1530-1540 Shale, dark blue grey, with much broken fish remains
 1540-1550 Some limestone, largely of broken Inoceramus prisms
 1550-1660 Shale, dark blue grey, broken fish skeletal fragments,
 very fine mica flakes, some coarse flaky brown grey
 bentonite layers
 1660-1840 Shale apparently more bentonitic, not so dense and
 fissile as above. Globigerina and fish remains
 1840-1890 Shale, dark blue-grey, apparently more alkaline than
 usual
 1890-1920 Newcastle (Muddy) sandstone, light buff, fine,
 porous, angular to subround, micaceous and carbo-
 naceous
 1920-2220 Thermopolis (Skull Creek) shale, dark blue grey
 and light brown, bentonitic
 2220-2250 Dakota sandstone, fine and bentonite, purple
 2250-2260 Sandstone, fine brown red
 2260-2360 Fuson shale, dark blue grey
 2360-2380 Lakota sandstone, coarse, angular, drab bentonite
 2410-2440 Sandstone, dark grey, fine to coarse, angular to
 subangular, partly recrystallized
 2440-2510 Shale, Morrison (?), dark blue grey, flaky, consi-
 derable drab bentonite, Ostracods at 2460'-80'

D. North of Black Hills

10. NORTHERN ORDNANCE GOVERNMENT 1, 660' NSL, 660' WEL, SE. $\frac{1}{4}$,
 Sec. 32, T. 15 N., R. 2 E., Harding County. Altitude of
 ground 3322', derrick floor 3326'

| | |
|-----------|--------------------------------------------------------------------------------------------------------------------------------|
| 0-4800 | No cuttings |
| 4800-4860 | <u>Opeche</u> siltstone, brown red, some anhydrite, white |
| 4860-4890 | <u>Minnelusa</u> cream and pink dolomite, fine granular, and sandstone, secondary anhydrite |
| 4890-4900 | Mudstone, brown red, green splotched, sandstone, pink, fine to medium, angular to subround, coarse white and salmon grit |
| 4900-4910 | <u>Minnelusa</u> limestone, dolomitic, cream, powdery texture, porous, dull lustre |
| 4910-4920 | Dolomite, pink, cream and lavender, finely crystal- line, sandstone, white and pink, fine grained |
| 4920-4940 | Dolomite and anhydrite, light buff and white, pink tinted, lithographic texture |
| 4940-4950 | Dolomite, anhydrite and milky chert |
| 4950-4980 | Dolomite, buff, fine granular, pink tinted, sec- ondary anhydrite |
| 4980-5020 | Dolomite, buff, anhydrite, with some siltstone, lavender, dolomitic, bentonitic, flaky, green mottled |
| 5020-5040 | Sandstone, cream, fine to medium grained, porous, subangular, some coarser etched grains |
| 5040-5060 | Sandstone, light red brown, (salmon), fine to medium grained, porous, subangular, with coarser etched grains |
| 5060-5070 | Dolomite, light grey, lavender tinted, fine powdery sugary |
| 5070-5090 | Dolomite, light grey, and pink, fine powdery sugary, sandy, sandstone, white |
| 5090-5100 | Sandstone, cream, pink stained, fine grained |
| 5100-5130 | Dolomite, cream and partly pink, fine powdery granular texture, some sandstone, light pink, 5110'-30' |
| 5130-5150 | Dolomite, cream and light brown, splotched with pink |
| 5150-5160 | Sandstone, light pinkish grey, fine grained, dolo- mite cement |
| 5160-5180 | Dolomite, light grey, pink tinted, fine granular, some sandy |
| 5180-5220 | Dolomite, lavender tinted, fine granular, some sandy, and fine grey sandstone |
| 5220-5230 | Dolomite, pink, fine granular |
| 5230-5240 | Dolomite, coarser, rhombic, cream and pink, some bipyramidal quartz crystals |
| 5240-5260 | Dolomite, pink, cream and dove |
| 5260-5270 | Dolomite, cream, splotched with pink, fine sand- stone |
| 5270-5280 | Sandstone, dark pink, fine grained, color caused by bright red bentonite |

5280-5320 Shale, bright brick red, purple, yellow brown and lavender, bentonite, light grey and green grey, splintery, increasing amount of sandy siltstone downwards

5320-5330 Bentonite, lavender and grey

5330-5340 Anhydrite, grey and pink

5340-5350 Anhydrite, cream and shale

5350-5360 Anhydrite, pinkish cream, crystalline, vuggy

5360-5380 Anhydrite, pinkish cream, dense fine grained

5380-5400 Dolomite, cream, pink stained, dense fine grained

5400-5420 Dolomite, light grey

5420-5430 Anhydrite, light grey

5430-5440 Mainly anhydrite, cream and light grey, and dolomite

5440-5450 Dolomite, cream

5450-5470 Mainly anhydrite, light brown grey, vuggy

5470-5500 Dolomite, cream and light dove, pink tinted, fine sugary

5500-5510 Dolomite, cream and light dove, coarsely crystalline

5510-5530 Dolomite, light dove

5530-5540 Anhydrite, lavender and light grey, shale, carmine and purple

5540-5560 Dolomite, cream, light grey, shale, some pinkish stained, bottom of abundant red shale cavings, 5550'

5560-5570 Dolomite, cream and pink, lithographic, and anhydrite

5570-5580 Anhydrite, light grey, pink and cream, very fine grained

5580-5590 Anhydrite, cream and light blue grey

5590-5600 Dolomite, light grey, fine crystalline

5600-5610 Limestone, partly magnesian, brown cream, vuggy, finely crystalline, dolomite rhombs in calcite, fossils, anhydrite veined

5610-5620 Dolomite, rather dark brown, rhombic, very cavernous

5620-5630 Possibly Pahasapa (Madison) limestone, altered oolitic, very cavernous

5630-5640 Dolomite, light brown, rhombic, cavernous, secondary white anhydrite replacements

5640-5650 Limestone, light grey and brown, oolitic

5650-5700 Dolomite, light brown, cavernous, rhombic, small cream spots, oolites replaced partly by dolomite, which cements them, some anhydrite filled cavities, mostly oolitic limestone below 5670'

5700-5710 Limestone, magnesian, dove, finely crystalline, vuggy, common white spots anhydrite, small dolomite rhombs

5710-5720 Dolomite, brown, vuggy, crystalline

5720-5740 Limestone, cream to light dove, fine sugary texture, partly oolitic; fossils

5740-5760 Dolomite, brown, some white and brown spotted, oolitic, rhombic, vuggy, stylolites

5760-5790 Dolomite, dove, some secondary white anhydrite fillings, some recemented breccia

5790-5800 Anhydrite, white and light grey, fine powdery texture

5800-5820 Anhydrite, light buff, some pink stained, lithographic texture

5820-5830 Dolomite, buff, sugary, very cavernous, altered oolites, some dark brown red shale (cavings?)

5830-5840 Limestone, light brown, shale, red

5840-5850 Anhydrite, light dove and white spotted, lithographic

5850-5860 Dolomite, buff, cavernous, fine sugary

5860-5900 Madison (Pahasapa) (?) limestone, brown, rhombs in finer limestone matrix, fine sugary, oolitic in part, fossils

5900-5930 Limestone, dolomitic, brown grey, fine textured rhombs, with small creamy spots of calcite, cavernous, altered oolitic, perhaps some shale, magenta, 5910'-30'

5930-5960 Limestone, magnesian, cream buff, spotted, many small dolomite rhombs connecting oolites, fossils, oolites more dissolved and more spotted, 5950'-60'

5960-6010 Dolomite, medium grey, very small crystals, a little secondary anhydrite, 5990'-6000'

6010-6020 Limestone, light dove, somewhat fragmental, fragments cemented by coarser calcite, otherwise fine lithographic texture

6020-6040 Dolomite, as at 5960'-6010', with a little purplish stain

6040-6050 Dolomite, light grey, greenish shade, quite silty

6050-6060 Limestone, light grey, fossiliferous, secondary dogtooth spar and rhombs, some oolites spotted white and grey, dolomite rhombs

6060-6070 Dolomite, light brown, sugary rhombic, with small cavities

6070-6110 Dolomite, light grey brown, more cavernous, medium sized rhombs, vitreous lustre, partly finer sugary crystals, likely recrystallized

6110-6130 Same but a lighter grey brown and with smaller rhombs

6130-6180 Dolomite, as at 6070'-6110'

6180-6220 Dolomite, light brown, medium sized rhombs, quite vuggy

6220-6290 No cuttings

6290-6310 Dolomite, as above, with small amount of chert, light grey, milky

6310-6330 Siltstone and claystone, light green grey and dark blue grey, dolomitic and bentonitic

6330-6340 Dolomite, light grey, very finely crystalline

6340-6350 Dolomite, light green, very finely crystalline

6350-6360 Sandstone, light grey, fine to medium, subangular to subround, some etched grains, chert grains various shades of grey, very poorly sorted, dolomitic cement

- 6360-6390 Later Ordovician (?) dolomite, light and dark grey, fine amorphous, grading down into light dove lithographic, shale, very dark blue grey, hard, silty
- 6390-6430 Dolomite, light dove, amorphous, lithographic
- 6430-6440 Dolomite, medium grey, claystone, medium grey
- 6440-6460 Limestone, magnesian, medium grey, quite fine texture, somewhat clayey
- 6460-6470 Dolomite, medium grained, fine sugary, some secondary anhydrite, 6470'-80'
- 6470-6490 Dolomite, light dove grey, pink splotched, finely crystalline
- 6490-6500 Dolomite, brown grey (dark dove), large rhombs, probably recrystallized, vuggy
- 6500-6520 Dolomite, cream, dove near top, coarse rhombs, vuggy
- 6520-6570 Dolomite above grades down into finer grained, with fine porcellaneous texture, stylolites
- 6570-6650 Dolomite, dark dove (light brown grey) rather small rhombs, some vugs, a little lighter dove below 6620'
- 6650-6900 Dolomite, buff and light dove, finely crystalline, some spots of large crystals, stylolites. May be Bighorn (upper Ordovician) which possibly may begin at 6360' though the 6360'-6650' interval may be Niagaran or Devonian
- 6900-6930 Mostly dolomite, dull greenish, impure, passing down into magnesian limestone, some shale, dolomitic
- 6930-6940 Siltstone to fine sandstone, grey green, limy and dolomitic cement
- 6940-6990 Decorah-Platteville (Black River) shale, dull Lincoln green, fissile, bentonitic, chloritic, black phosphate nodules from 6460' down, up to one-half inch size, some siltstone, green, at base very dark grey, purple, lavender and brown shale
- 6990-7010 St. Peter sandstone, grey, some greenish, fine grained
- 7010-7038 Sandstone, white, medium grained, porous, subangular, partly recrystallized, grains originally etched, recrystallized. Top may be at 7017'

11. NORTHERN ORDNANCE CORP. HARDING SCHOOL LAND 1, Center SW.
 $\frac{1}{4}$ SW. $\frac{1}{4}$, Sec. 1, T. 17 N., R. 1 E., Harding County.
 Altitude 3430'.

| | |
|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0- 75' | <u>White River</u> Oligocene sand, medium, angular, mica- ceous, with dark chert, green garnet and vermiculite particles |
| 75- 100 | <u>Hell Creek</u> sand, fine grained, and clay, bentonitic, grey green, carbonaceous, biotitic |
| 100- 130 | Clay, green grey, bentonitic |
| 130- 140 | Clay, dark grey, bentonitic, lignitiferous |
| 140- 170 | Clay, dark grey, bentonitic, with light green small serpentine nodules, some silt and fine sandstone |
| 170- 180 | One fossil shell |
| 170- 220 | Same with more serpentine pellets, fossils, very bentonitic 75'-220' |
| 220- 230 | Clay, as above |
| 260- 290 | Foraminifera , rather abundant at 280'-90' |
| 290- 310 | Shell fragments |
| 310- 320 | Cone-in-cone concretions, foraminifera and abundant serpentine nodules |
| 320- 340 | Clay, very bentonitic |
| 340- 350 | <u>Inoceramus</u> prisms, biotite flakes, fine sand |
| 350- 360 | Pyritized plant spores |
| 380- 390 | Sand, fine |
| 390- 400 | Many <u>Inoceramus</u> prisms, much fine sand |
| 400- 410 | Aragonite |
| 410- 420 | <u>Fox Hills</u> sand, fine, many biotite flakes |
| 420- 430 | Sand, fine grained, angular, numerous light green glauconite nodules |
| 430- 450 | Same with foraminifera |
| 470- 480 | Clay, with foraminifera |
| 480- 490 | Sand, fine, angular, foraminifera, biotite |
| 490- 510 | Sand, fine, angular, glauconite |
| 510- 520 | Clay, grey, bentonitic |
| 520- 560 | Grit to fine sand grains, subround, etched, some chert grains, light green glauconite |
| 560- 580 | Clay, grey , foraminifera and shell fragments |
| 580- 590 | Sand, medium with some coarse grained |
| 590- 620 | Conglomerate and grit, pieces up to one-half inch, some of chert and ironstone, mostly of quartz, more or less angular, some pebbles well rounded and polished, a few pebbles of sandstone and limestone |
| 620- 630 | <u>Pierre</u> sand, fine, angular |
| 630- 650 | Clay, green grey, very bentonitic, foraminifera |
| 650 | Beginning of pure bentonite beds, casing run at 715' |
| 930 | Clay, as in succession above, shell fragments and <u>Inoceramus</u> prisms |
| 960- 970 | Sand, fine to medium, with black chert, biotite and a little glauconite |

990- Foraminifera, small olivine particles
 1060 Sand, fine
 1130 White mica flakes commoner from here down
 1260 Bentonite, light grey
 1280-1300 Shale, dark grey
 1390-1410 Concretions, dark, limy
 1481-1499 Core, 6 inches of clay ironstone, light brown con-
 cretionary, following considerable fine angular
 sand, biotite, vermiculite, serpentine, a little
 olivine, milky chert, some bentonitic clay,
 cemented by iron oxide
 1510-1530 Sandstone, limy cement, fine grained, with quartz,
 serpentine, white chert and a few olivine particles
 1560 Foraminifera
 1620 Considerable fine sand, angular, with olivine and
 light green glauconite
 1640 Concretion, brown grey
 1660-1670 Limestone, light grey
 1670-1680 Sandstone, fine grained, arkosic
 1700-2100 Usual clay with pure bentonite and concretions
down to 2050', with following details
 1700 Limestone concretions, light and brown grey, some
 sandstone, grey, with subangular serpentine particles,
 some septarian aragonite
 1740 Concretions, tan and dark brown, with vein aragonite
 and calcite
 1750-1760 A little azurite (hydrous copper carbonate)
 1760-1770 Foraminifera
 1770-1780 Copper sulphide, either bornite, covellite or oxi-
 dized chalcopyrite, bronze color, tarnishing to
 covellite and chalcopyrite. Fills fossil shell
 1780 Robulus
 1980 Sandstone, greywacke, with some chlorite
 2030-2040 Olivine and chlorite
 2040-2120 Sandstone, light grey, greywacke, fine grained, ser-
 pentine, biotite
 2120 Some vermiculite
 2160-2170 Dorothea (also occurs much higher)
 2170 Sand, fine, with biotite and serpentine
 2210-2220 Chalk, light grey, soft
 2220 Bentonite, light milky grey with biotite flakes, a
 few foraminifera
 2250 Fish remains commoner than higher up
 2280 Dorothea
 2350 Niobrara, Beaver Creek chalky member, shale, dark
 grey, speckled with soft chalk in minute flattened
 blebs, really a shaly marl, bituminous
 2370 Malachite (hydrous copper carbonate)
 2450 Sandstone, grey, fine, angular, many biotite flakes
 2470 Chalk marl with foraminifera
 2480 Chalk marl with Globigerina, base Niobrara (?)

2490 Bornite
 2510 Sandstone, fine
 2520-2610 Azurite and bornite, chalky marl with shale, dark grey
 2580 Textularia
 2608-2623 Core of silty greywacke sandstone with thin inter-
 films of dark grey shale, considerable biotite and
 vermiculite, plant fragments, mostly clay near bottom
 2623-2630 Marl, chalky, foraminiferal
 2650 Bentonite, pure, brown and yellow
 2750 Sandstone, with serpentine and small black chert
 particles
 2800-2810 A little white chalky material
 2810-2870 Sandstone, angular, fine grained, interbedded with
 shale, dark blue grey, bituminous, malachite at
 2830'-40', chalcopyrite 2860'-70'
 2870-2940 Shale, dark blue grey, and limestone, light grey,
fragmental, sandy, packed with Globigerina and
 broken Inoceramus prisms. Azurite 2920'-30'
 2940-3080 Shale, dark blue grey, with some chalk and pure
 bentonite, Globigerina common, thin sand laminae,
 some limy films containing sand grains and Ino-
ceramus prisms. The Greenhorn may be from 2960'
 to 3050' where the impure limestone appears to be
 more abundant. Azurite at 3020'-30'
 3080-3500 Much bentonite, some pure, fish remains
 3080 Bentonite, light brown grey, biotite and vermicu-
 lite, Globigerina common
 3110 Azurite
 3150-3180 Shale, blue grey
 3180 Azurite, brown iron carbonate nodules, in shale,
 flaky, slaking, very bentonitic
 3220 Azurite
 3240 Shale, dark blue grey, with silty laminae, fissile,
 micaceous, azurite, bornite
 3280-3290 Sandstone, grey, fine grained, interbedded with
 dark grey chalky and bentonitic shale, Globigerina
 3290-3300 Sandstone, grey, fine grained, with some limestone
 and much biotite
 3330-3340 Azurite, fish scales, some creamy chalk
 3340-3380 Bornite, interbedded laminated sandstone and shale,
 biotite flakes common, Textularia at 3370'
 3380-3420 Shale, dark blue grey, flaky, fish scales
 3420-3440 Limestone, grey, sandy, fossiliferous
 3480-3500 Bentonite, milky, brown, sandstone and shale inter-
 bedded
 3600-3630 Muddy (?) sandstone, cream-buff, fine to medium
 grained, angular to subangular, soft, porous. This
 is possibly the Dakota sandstone.
 3630-3740 Some beds of bentonite, milky, yellow
 3630-3640 Sandstone, medium grained, angular
 3650-3680 Shale, dark grey, very small chalk spots, foramini-
 fera

3680-3700 Clay ironstone, light brown, considerable brown
grey bentonite, fish scales

3710 Azurite

3710-3910 Shale, dark blue grey, quite flaky and bentonitic,
fish scales, bones and spines

3910-3917 Core of mudstone, compact, dense, very dark blue
grey, "ripple"-laminated, very fine mica flakes

3929-3948 Core: upper 5½', mudstone with bentonite specks
3', siltstone, grey, lenticular, with
laminated darker grey muddier
sediment
lower 4½', mudstone, dark blue grey, finely
laminated

3941½-3948 Core: Dakota, upper 4' 10", siltstone to fine
sandstone, light grey
in thin lenses, inter-
laminated with finer,
darker grey
lower 1' 2", sandstone, light grey,
fine grained, mica-
ceous, bentonitic, chlo-
ritic, angular, porous

3948-3966 Core, sandstone, light grey, with lignitic plant
fragments, fine grained

3966-3970 Bentonite, green drab

3970-4050 Sandstone and shale, as overlying, biotite, white
mica and chlorite flakes

4050-4075 Shale, dark blue grey, biotite

4075-4078 Core, mudstone, dark grey

4078-4079 Lakota sandstone, light grey to white, medium grained,
angular, much lignitiferous material, bentonitic

4079-4085 Sandstone, light grey, coarser

4085-4150 Sandstone, light to dark grey, fine to coarse, some
chert and biotite, lignitic, recrystallized

4150-4180 Morrison lignitic shale and sand, clay, light grey,
bentonitic

4180-4220 Shale, dark blue grey and bentonite

4220-4235 Sundance bentonite, lavender, terra cotta, grey and
green, sandstone, grey, fine grained, glauconitic,
angular, Pachyteuthis (Belemnites) found in cavings
lower down

4240-4250 Azurite and bornite rather common, bentonite, vari-
colored

4250-4270 Bentonite, grey, lavender, terra cotta

4270-4310 Bentonite, varicolored

4310-4330 Bentonite, green, grey, etc.

4330-4470 Bentonite, grey and brown, abundant

4330-4340 Limestone, cream, finely crystalline, in part sandy

4340-4400 Some strata of glauconitic sandstone, bentonite
green, sandy, at 4380'-90'

4400-4430 Sandstone, light grey, fine grained, glauconitic,
angular grains, limy

4450-4460 Gryphaea
 4460-4510 Bentonite, pure, brown, grey and lavender
 4510-4530 Sandstone, light grey, fine grained, glauconitic, siltstone, dark grey
 4530-4540 Sandstone, light grey, fine grained, bentonite, white, Pachyteuthis
 4540-4550 Sandstone, light grey, fine grained
 4550-4590 Sandstone, as above, shale, green grey, bentonitic
 4590 Sandstone, below to 4750' pure bentonite in the cuttings
 4750 Siltstone, terra cotta, shale, green grey, and sandstone, grey, fine grained
 4786-4810 Limestone, cream, lithographic, shale, light green, flaky, bentonitic
 4810-4840 Spearfish (?) siltstone, red brown
 4840-4860 Anhydrite, white, magnesian limestone, light brown, lithographic
 4860-4865 Limestone, light brown with anhydrite, very fine lithographic, mudstone, red brown bentonite, sandstone, glauconitic, light green grey
 4865-4870 Sandstone, coarse, ferruginous
 4875 Pachyteuthis in cavings
 4910 Sandstone, grey, unusually large glauconite pellets, limestone, magnesian, white, soft powdery, siltstone, light green grey, bentonite, lavender, some medium sized well polished grains and white and black mica in sandstone
 4980-5345 Spearfish siltstone, salmon, with sand grains. Top of Spearfish may be at 4810', cavings obscuring formation below
 5345-5350 Minnekahta limestone, dolomitic, cream, fine sugary, anhydrite white, alabaster
 5380 Same but limestone cream, grey, pink and light brown
 5390-5470 Probably Opeche red beds, mostly cavings
 5470-5500 Minnelusa dolomite, buff, very fine sugary, porous, some light pink, sandstone, coarse, grey, mostly cavings
 5500 Bentonite, pink, hard, flaky, mostly cavings
 5520-5530 Dolomite and sandstone, red, coarse, mostly cavings
 5530-5580 Dolomite, pink and grey, fine sugary, sandstone, pink and grey, coarse to medium, limestone, sandy, mostly cavings
 5580-5605 Dolomite, cream, fine sugary, some full of sand grains
 5605-5620 Sandstone, grey and pink, fine to medium grained
 5620-5660 Dolomite, pink and grey, fine powdery
 5660-5670 Sandstone, white, fine, subround
 5670-5710 Sandstone, cream and pink, fine grained and dolomite, cream and pink
 5720-5730 Dolomite, cream, grey, with sandstone
 5730-5760 Sandstone, cream, fine grained, some quite limy, dolomite, cream and pink

5760-5790 Dolomite, cream and pink, some light brown grey, fine texture
 5790-5860 Dolomite, cream, buff and pink, fine powdery, vein calcite
 5860-5910 Siltstone, bright red, grading to tan, mostly dull brown red in lower half. Some sandstone and grit
 5910-5920 Big Snowy (?) limestone, cream and light grey, lithographic
 5920-5970 Limestone, grey, pink stained and streaked, lithographic, calcite-veined, largely cavings
 5970-6000 Large calcite rhombs in finer matrix
 6000-6020 Siltstone, red, limestone, pink, dolomite, light grey
 6020-6070 Anhydrite and dolomite mixed, fine sugary, minute dolomite rhombs, calcite, some sand grains, crystallized quartz crystals at 6040'-50', mostly cavings
 6070-6080 Limestone with dolomite rhombs, porous, dull, powdery
 6080-6150 Limestone, as above fossiliferous, some larger rhombs, anhydrite zone with carbonate interbeds and mixtures, 6000'-6220'
 6150-6200 Some oolites, limestone, cream buff, coarser than above, fossils
 6200-6220 Anhydrite, white and brown grey, light blue grey, dull, dolomite, light brown, lithographic
 6220-6240 Anhydrite, light brown grey, chert, blue
 6240-6270 Madison (?) dolomite, spotted grey, coarsely crystalline calcite
 6270-6280 Limestone, more oolitic downwards, more coarsely crystalline, quite porous, stylolitic
 6280-6290 Limestone, oolitic
 6290-6400 Small dolomite rhombs in calcite matrix, fossiliferous
 6400-6465 No cuttings
 6465-6485 Cavings
 6485-6520 Dolomite, white to dove
 6520-6525 Limestone, buff, porous, dolomite rhombs in calcite matrix with anhydrite, light blue grey, wholly crystalline, oolites and imperfect oolites with pore spaces between
 6525-6600 Limestone, cream, lithographic, anhydrite, some oolitic, also finely crystalline, rhombic, fossils
 6600-6760 Limestone, light brown grey, finely crystalline, vuggy, dolomitic rhombs in white fine limestone matrix; limestone, white, chalky
 6760-6790 Limestone, light brown grey with dolomite rhombs
 6790-6815 Limestone, light brown grey, fine sugary
 6815-6900 Pahasapa (Madison) limestone, cream buff, crystalline, imperfectly oolitic, fossils
 6900-6990 Limestone, buff, recrystallized with vestigial oolites, a little sandstone, fine grained, pink, fossils, malachite, some chert, some limestone, porcellaneous

6990-7045 Limestone, some magnesian, fossils.
7045-7085 Dolomite, white, chalky, limestone, magnesian, cream to dove, finely crystalline, chert, milky white

7085-7110 Limestone, pink
7110-7125 Limestone, pink, with small specks of green clay
7125-7175 Dolomite, mostly, conglomerate, pink, ferruginous, coarse sand grains, limestone pink

7175-7220 partly pinkish dolomite
7220-7250 Limestone, cream, finely crystalline, flaky
7250-7275 Limestone, cream, and pink
7275-7295 Limestone, magnesian, cream and lavender, lithographic

7290-7295 Dolomite, cream, porcellaneous, stylolitic
7295-7430 Limestone and dolomite, very fine grained, light blue grey and brown, conglomerate at 7375' may be base of Madison.

7430-7495 Limestone, becomes light grey brown, some cream, very fine dense, mostly dolomite

7495-7500 Limestone, dolomitic, light brown, rhombic
7500-7540 Limestone, dolomitic, buff to light brown, very little milky chert

7540-7545 Limestone, cream
7545-7560 Limestone, cream, dull, fine powdery texture, dense, lithographic

7560-7630 Dolomite, light brown (dove) and cream, a little coarser than just above, contains anhydrite

7630-7750 Dolomite, dove, more coarsely crystalline, rhombic, stylolitic, limestone, soft white chalky
7750-7755 A little milky chert

7755-7760 Dolomite, pink, fine rhombic
7760-7890 Dolomite, dove, spotted, pink, fine rhombic
7890-7895 Brachiopod
7895-7905 Shale, dark Lincoln green, unctuous, flaky and splintery, with some quartz and black phosphate grains (Decorah ?)

7905-7980 Shale, green and purple, some very bentonitic and green, cores from 7919'-62' are shale, dark green, chloritic, dense compact, conodont (Belodus compressus); cores from 7962'-66' shale, dark grey, siltstone, green grey, with thin shale lenses, black phosphate and sand grains at 7965'-66' is medium grey bentonite

7980-8000 St. Peter sandstone, pure white, medium to coarse grained, subrounded, calcite cement, etched grains in part recrystallized

12. STATE ROYALTY PETROLEUM CO. 1, 100' NW. of center, SW. $\frac{1}{4}$, NE. $\frac{1}{4}$, Sec. 35, T. 18 N., R. 1 E., Harding County. Altitude 3267.5'

References: Decker, C.E., Viola Well Core from South Dakota, Am. Assoc. Petroleum Geologists Bull., vol. 26, 1942, pp.123-35; Furnish, W.M., Barragy, E.J., and Miller, A.K., Ordovician Fossils from Upper Part of Type Section of Deadwood Formation, Am. Assoc. Petroleum Geologists Bull, vol. 20, 1936, pp. 1329-41.

| | |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0- 160' | <u>Lance</u> |
| 160- 380 | <u>Fox Hills</u> |
| 380- 540 | <u>Pierre</u> bentonitic clay |
| 540- 760 | <u>Pierre</u> bentonitic clay, light green grey, <u>Inoceramus prisms</u> , clay ironstone concretions, very small mica flakes, shell fragments, hauerite (bronzy "pyrite"), some fine sand, more forams below 720' |
| 760- 800 | With some fine angular grains of sand and small dark brown grains, perhaps of volcanic rock |
| 800- 900 | Clay, bentonitic, light green grey, small flakes biotite, muscovite, chlorite or vermiculite, small serpentine nodules, occasional fragment of olivine, fine angular quartz grains, fish and shell fragments and <u>Inoceramus</u> prisms |
| 900-1020 | Clay, bentonitic, green grey, biotite and chlorite, clay ironstone concretions, fine quartz silt, shell fragments and <u>Inoceramus</u> prisms |
| 1020-1100 | Less sticky clay from here down, but forams very rare |
| 1100-1150 | Fish remains more common and clay in part darker. First pure, bentonite, 1110' |
| 1150-1260 | No cuttings |
| 1260-1270 | As last above |
| 1270-1280 | Sandstone, grey, fine grained serpentinous greywacke. Resistivity log indicates sandy zone 1315'-1365' |
| 1280-1420 | Clay as above, clay ironstone concretions |
| 1420-1440 | Sand, fine grained |
| 1440-1620 | Usual clay, clay ironstone concretions |
| 1620-1680 | Clay has considerable vein calcite |
| 1680-1700 | Considerable sand |
| 1700-1720 | Some limestone, light grey, impure |
| 1720-1730 | Tan clay ironstone |
| 1730-1740 | Bentonite, grey |
| 1740-1750 | Bentonite, light yellowish or greenish grey, flaky |
| 1780-1810 | Bentonite and concretions, shell fragments |
| 1810-1840 | Some serpentinous greywacke |
| 1840-1850 | Considerable fine sandy |
| 1850-1890 | Clay, as usual |
| 1890-1900 | Fine sandy |
| 1900-2070 | Fish and shell fragments, ironstone concretions, a small portion with small chalky particles |

2070-2080 Core of clay, light green grey, laminated, very bentonitic, small chalky particles

2080-2160 Clay, as usual, with some purer bentonite

2160-2300 Niobrara darker chalky marl, with small flattened chalky particles

2300-2390 Carlile shale, light green grey

2390-2400 Some fine sand with abundant biotite flakes

2400-2410 Chalcopyrite

2430-2480 Sandstone, light grey, fine grained, greywacke, calcite cement, considerably biotite, more prevalently sandstone 2450'-2470'

2480-2540 Shale, blue grey, chalcopyrite

2540-2550 Large amount of dogtooth spar

2570-2580 More limy, much secondary calcite, Inoceramus prisms

2610-2620 Malachite

2630-2640 Pyritized Inoceramus prisms

2650-2660 Calcitized aggregates of Inoceramus prisms--Greenhorn (?)

2660 Black bituminous shale begins and increases downwards

2710 Sand, fine, biotitic, interlaminated with black shale

2730-2740 Globigerina common

2740-2760 Greenhorn abundant broken Inoceramus prisms, probably a sandy crystalline limestone, some serpentine fragments and Globigerina

2760-2800 Shale, dark grey, bituminous

2800-2810 Bornite

2810-2840 Limestone, light grey, impure, Globigerina, broken Inoceramus prisms, some serpentine fragments. Chalcopyrite at 2820'-30', base Greenhorn (?)

2840-2850 Chalcopyrite, less limestone, fish remains

2850-2870 Some limestone

2870-2940 Graneros shale, dark grey, some limestone

2940-2970 Shale, black, bituminous, fissile, compact

2970-2980 Chalcopyrite, shell fragments

3000-3010 Chalcopyrite

3020-3080 Chalcopyrite, black shale

3080-4650 No cuttings, but resistivity log and geologist's record indicate that Graneros black and dark grey shale continues to 3415' depth, Muddy or Newcastle sandstone with shale interbeds occurs at 3415'-55', then black (Thermopolis) shale to 3785', Dakota sandstone, white, fine grained, 3785'-3860', Fuson shale, black, and interbedded grey and tan fine grained sandstone, from 3860'-3965', Lakota sandstone, white, fine grained, 3965'-4000', Morrison clay from 4000'-4125' and upper Sundance clay and sandstone, 4125'-4650'

4650-4660 Sundance limestone, dove, lithographic, in part originally oolitic, cavings of light green fine grained glauconitic sandstone, light green, yellow green and brown bentonitic clay

4660-4670 Much grey and a little lavender bentonite
 4670-4700 Considerable clay, greenish yellow, drab and lavender, silty and bentonitic, some varicolored and spotted, a little terra cotta silt
 4700-4710 Limestone, clayey and silty, soft amorphous, chalky, with some dolomite and secondary anhydrite
 4710-4720 Mudstone, lavender, limy, bentonitic
 4720-4730 Limestone, brownish dove, lithographic
 4730-4810 Spearfish siltstone, dark brown red, splotched with light grey, secondary anhydrite
 4810-4820 Sandstone, dark brown red, very silty, fine to coarse grained, secondary anhydrite
 4820-4904 Siltstone, dark brown red, some anhydrite. Sandstone, 4825'-40' below which siltstone is either sandy or contains sandstone interbeds
 4904-4914 Core. Siltstone, dark brown red, with small mica flakes
 4914-5110 Siltstone, dark brown red, partly sandy, fine grained sand
 5110-5188 Siltstone, salmon, full of small sand grains
 5188-5230 Minnekahta thin white anhydrite at top. Remainder limestone, light grey and pink, fine texture, dull lustre, soft. Finely crystalline and more compact 5200'-30', deep pink color, 5210'-20', lower 15' silty and light brown
 5230-5320 Opeche siltstone, dark brick red, some fine sand and secondary anhydrite. Some coarse sand grains 5310'-20'
 5320-5340 Sandstone, white and light grey, pink stained, fine and medium grained, angular, recrystallized
 5340-5410 Siltstone, brick red, possibly cavings
 5410-5425 Minnelusa dolomite, dove grey, lavender splotched, lithographic
 5425-5435 Core of sandstone, pink and light grey, angular, medium grained
 5435-5440 Dolomite, dove, lithographic, partly sandy
 5440-5445 Dolomite, lavender, grey spotted, fine granular
 5445-5450 Dolomite, grey, lavender tinted, fine granular, secondary anhydrite
 5450-5460 Sandstone, cream, coarse to medium, etched, sub-round, insoluble cement
 5460-5470 Sandstone as above, with dolomite, light brown, lavender
 5470-5480 Dolomite, dove, fine crystalline, with larger secondary rhombs
 5480-5500 Sandstone, cream, lavender tinted, coarse to medium, etched, subround, dolomite cement, some bipyramidal quartz
 5500-5505 Dolomite, cream, lavender tinted, fine granular to lithographic
 5505-5510 Dolomite, lavender, fine granular

5510-5515 Dolomite, cream, lithographic, milky chert
5515-5520 Sandstone, cream, lavender tinted, fine grained, dolomite cement
5520-5530 Dolomite, cream, sandy, lavender stained, some sandstone as overlying
5530-5535 Sandstone, fine grained, cream, lavender tinted, dolomite cement
5535-5545 Dolomite, dove, lavender stained, fine dense, mostly lithographic, white chert and anhydrite
5545-5550 Sandstone, cream, fine grained, angular
5550-5567 Core: Dolomite, dove, lavender stained, fine, dense, and shale, purple
5567-5576 Dolomite, cream, some lavender tinted, porcellaneous, dull, milky chert
5576-5578½ Core: Mostly white anhydrite but some dolomite, pink and dove, dense, with calcite veinlets
5586-5593 Core: Dolomite, light pink grey, lithographic to fine granular, cuttings of fine rhombic dolomite
5593-5600 Core: Dolomite, light lavender and cream, fine rhombic, some very light green bentonite
5600-5605 Core: dolomite, pink, cemented breccia and light grey lithographic, anhydrite, white
5605-5610 Core: dolomite, purplish, earthy, and light grey, also mudstone, purple, dolomitic, cuttings largely bentonite, light lavender and light green, shaly
5610-5627 Dolomite, pink and cream, dense lithographic to fine granular, some secondary anhydrite, **stylolites**, also noted higher up
5627-5630 **Same** as last except some is pink and coarse rhombic
5630-5635 Core: anhydrite, white and grey, coarsely crystalline
5635-5645 Core: dolomite, dark lavender, fine grained to coarse rhombic
5645-5652 Core: mudstone, dull cochineal red, some grey dolomite, crystalline, top of laterite zone
5652-5662 Core: bentonite, sandy, yellow brown, pink, grey and lavender
5662-5684 Sandstone, cream, medium to coarse grained, etched, subangular, some is lavender and light green, some fine grained but mostly coarse, some bentonite, light sea green, splotched with lavender
5684-5694 Sandstone, white and red brown, cross bedded, coarse, angular, with some black chert grains, the matrix is laterite
5694-5704 Core: siltstone, dull brown red, sandy, mottled with a lighter shade
5704-5709 Core: siltstone, salmon, with bleached spots of buff, mostly continuous cores from 5709'-7511'
5709-5714 Mudstone, lavender, purplish and and bright brick red, anhydrite, pinkish, grey, yellow, sandy bentonitic clay. Some red siltstone and sandy mudstone, grey bentonite, red sandstone with bentonitic matrix

- 5714-5724 Sandstone, cream to buff, medium to coarse angular, limy cement, grains partly recrystallized, also core of coarse to medium white sandstone, also buff sandstone, including some bentonite and brick red fine siltstone
- 5724-5734 Core same sandstone and some lavender siltstone, also grit, brick red and buff, with secondary anhydrite, bentonitic red, lavender and yellow mudstone
- 5734-5740 Core mudball conglomerate, green in purple matrix of silt and fine sandstone, also lavender siltstone and pink-stained grey sandstone with unassorted grains of all sizes.
- 5740-5750 Limestone, light grey, pink and lavender-stained, very fine texture, a little anhydrite (overlapping samples 5740'-62')
- 5740-5747 Core purplish, lavender and green bentonitic mudstone, purple-stained light grey dolomite, bipyramidal quartz crystals
- 5750-5760 Limestone as at 5740'-50' with a little intermixed anhydrite
- 5747-5757 Core, same as cuttings, with some light greenish anhydrite fillings
- 5757-5762 Core of same dove limestone with secondary anhydrite and green and purple shale interbeds, coarse subangular sand in green bentonite
- 5762-5770 Same as last
- 5770-5780 Same with some light grey sandy dolomite, some oolitic, also medium-sized dolomite rhombs in white powdery limestone matrix
- 5780-5790 Same (core) with purple and magenta hard siltstone concretion, cuttings of anhydrite and silty and sandy dolomite
- 5790-5807 Core streaked lavender, purple and green light fine grained limestone, with a little anhydrite, some coarse and fine grey and pink limestone and pink siltstone in cuttings
- 5807-5812 Core pink and green-grey mottled mudstone and anhydrite, fine, white, pink-tinged
- 5812-17-22 Core anhydrite, light greenish, pinkish and white
- 5822-5840 Core anhydrite, white
- 5840-50-60-70 Cuttings and cores of limestone, medium grey, finely crystallized with small dolomite rhombs in core fragments of white anhydrite and pink and cream spotted soft powdery dull dolomite, anhydrite and dolomite with interbedded pink-stained anhydrite
- 5870-5878 Intermixture of anhydrite and dolomite, small rhombs dolomite in anhydrite ground mass, buff, core has also dove and purple-splotched dolomite and some secondary anhydrite.
- 5878-5884 Same as just above
- 5884-5891 Core light buff limestone with coarser dolomite rhombs

5892-5897 Limestone, light buff
 5902-5907 Limestone, buff, porous, altered oolitic and altered fossils, cavernous, also same as just above
 5907-5917 Limestone, buff, fine, dull, stylolitic, oolitic, some with dolomite rhombs
 5917-5927 Limestone, light brown-grey, porous, many dolomite rhombs
 5927-5932 Limestone, rhombs of dolomite in white finer matrix
 5932-5937 Limestone dove, fine rhombs in white matrix
 5937-5978 Dolomite, dove, fine rhombic
 5978-5995 Limestone, dove, coarsely crystalline
 5995-6000 Limestone finely crystalline with much secondary calcite
 6000-6005 Limestone with light grey anhydrite
 6005-6109 Anhydrite and dolomite, white, dove, brown, grey, pink, lavender, lavender-brown, light and dark blue-grey, varicolored, some limestone 6005'-16'. Some spotted dolomite may have been originally oolitic. It has larger crystals in a finer matrix. Lower anhydrite is darker grey.
 6109-6113 Limestone, oolitic, vuggy, dove, Madison (?)
 6113-6129 Limestone, finer, vuggy, dove, porous
 6129-6144 Limestone, dove, dolomite rhombs in calcite matrix 6134'-44', oolitic and vuggy
 6144-6149 Limestone dove, oolitic
 6149-6159 Limestone dove, dolomitic, finely crystalline, vuggy
 6161-6169 Dolomite, fine rhombic, vuggy, dove or buff
 6169-6177 Limestone, oolitic, buff
 6177-6182 Limestone and dolomite, buff
 6182-6294 Limestone, buff, finely crystalline, stylolitic
 6294-6300 Dolomite, dove, finely crystalline
 6299-6304 Dolomite, dove, finely crystalline with light grey anhydrite
 6304-6345 Anhydrite, light grey, light bluish grey and dove, a little dolomite
 6345-6376 Dolomite, dove, finely crystalline, very vuggy
 6376-6381 Dolomite, dove, finely crystalline, limy
 6381-6388 Limestone, oolitic, buff
 6388-6391 Dolomite, light brown, fine crystals
 6391-6396 Dolomite rhombs in cream powdery calcite
 6396-6409 Limestone, oolitic, cream-buff
 6409-6416 Limestone, oolitic, Schuchertella, and white coarse anhydrite
 6416-6434 Dolomite, dove, finely crystalline, porous, with anhydrite
 6436-6456 Dolomite, brown-grey, fine rhombic, stylolites with anhydrite
 6456-6466 Dolomite, light grey, finer
 6466-6476 Dolomite, light grey, finer, with light grey coarser limestone
 6476-6486 Dolomite, light brown, sugary, with light grey coarser limestone

6495-6501 Limestone, spotted cream and light brown, altered oolites, porous

6501-6511 Limestone, light and medium grey, stylolitic

6511-6521 Limestone, light and medium grey, dolomite, light grey fine, anhydrite, grey-white

6521-6530 Limestone grey, magnesian, lavender stained

6530-6560 Dolomite, light grey to purple, finely crystalline and grey stylolitic limestone 6540'-60'

6560-6580 Limestone, grey, medium crystals and dolomite, grey and purple with large anhydrite-filled cavities

6580-6589 Both limestone and dolomite as above, limestone fossiliferous, light grey, stylolitic

6589-6593 Limestone, grey, stylolitic, medium crystals, also cream, oolitic, very porous

6585-6595 CORRECTED DEPTH--Limestone, grey, stylolitic, fine sugary dolomite, lavender-tinged light grey

6595-6605 Limestone, light grey, medium crystals, in part lavender-stained

6605-6615 Limestone, light grey, purple-stained, fine, some fairly coarse, grey, purple-specked, some pink-stained stylolitic

6615-6625 Limestone and dolomite, cream and light grey, lavender-stained, also limestone, coarsely crystalline altered oolitic

6630-6638 Limestone and dolomite, light brown, fine, porous

6638-6643 Dolomite, light brown, fine, sugary and limestone, cream to light brown

6643-6648 Limestone, light dove, finely crystalline

6648-6652 Dolomite, purple-tinged grey, fine sugary, stylolitic

6652-6664 Limestone, dolomitic, fine sugary, light grey,
Productus

6664-6669 Limestone, light brown-grey, fine

6669-6672 Limestone, buff, fine

6672-6676 Limestone, cream-buff and dolomite, white, powdery, very porous

6676-6686 Limestone, light dove, sugary, light grey chert

6686-6696 Limestone and dolomite, light dove, sugary

6696-6701 Limestone light dove, sugary and dolomite, fine, grey, stylolitic

6701-6708 Limestone, and dolomite, light grey, sugary

6708-6710 $\frac{1}{2}$ Limestone, light brown-grey, medium crystals and dolomite, cream

6710 $\frac{1}{2}$ -6713 Limestone, light grey, fine and dolomite, light brown very porous, sugary

6713-6723 Dolomite and limestone, light dove and cream, very porous, chert, white, porous

6723-6733 Dolomite dull brown-grey, vuggy

6733-6740 Dolomite and limestone, light dove, porous, limestone is oolitic

6740-6749 Limestone, magnesian, limy, dove, sugary

6749-6756 Dolomite, limy, dove, sugary, also cream colored, chert, fine, opaque, porous

6757-6761 Dolomite and limestone, light grey and brown, sugary

6767-6801 Dolomite, grey-brown and cream, medium rhombic porous with white anhydrite fillings

6801-6815 Dolomite, light brown-grey, fine, with white anhydrite fillings, white porous chert, thin shelled brachiopods

6815-6820 Dolomite, light and medium grey, fine sugary

6820-6828 Dolomite, darker grey, sugary, white decomposed chert

6828-6832 Dolomite, light brown, fine sugary

6832 $\frac{1}{2}$ -6837 Dolomite, medium grey, fine sugary, anhydrite fillings

6837-6841 Dolomite, light brown, fossils, white decomposed chert, sponge spicules

6841-6846 Dolomite, light grey, anhydrite fillings, sponge spicules

6846-6852 Dolomite, light grey, cream amorphous chert, sponge spicules

6852-6855 Limestone, light grey and cream

6855-6858 Dolomite, light grey stylolites, large amount anhydrite, cream and light grey

6858-6861 $\frac{1}{2}$ Anhydrite, very fine, stylolites, light brown-grey, perhaps mixture of dolomite and anhydrite

6861 $\frac{1}{2}$ -6874 $\frac{1}{2}$ Dolomite, brown-grey, sugary and white anhydrite with cream amorphous chert below 6865'

6874 $\frac{1}{2}$ -6876 $\frac{1}{2}$ Dolomite, grey sugary and cream amorphous chert

6876 $\frac{1}{2}$ -6884 $\frac{1}{2}$ Dolomite, grey sugary and cream amorphous chert with sponge spicules and secondary anhydrite

6884 $\frac{1}{2}$ -6887 Limestone, grey, fine, stylolitic

6887-6889 Limestone, grey, fine with cream amorphous dull chert

6889-6914 Dolomite, pink-stained light grey, medium crystals, glauconite specks 6889'-94'

6914-6933 $\frac{1}{2}$ Dolomite, grey and purple, fine, some pink and vuggy, glauconite specks 6914'-19', with mudstone, purplish, sericitic, partly silty

6933 $\frac{1}{2}$ -6934 $\frac{1}{2}$ Dolomite, pink, with white anhydrite cavity fillings

6934 $\frac{1}{2}$ -6940 Dolomite, light pink to lavender with large to small etched sand grains and small pebbles, possibly basal Englewood

6940-6945 Dolomite, buff and cream, fine sugary, vuggy

6945-6949 Dolomite, buff and cream, light greenish and grey, dark green and purple fine mudstone and siltstone, some fairly light green, chloritic

6949-6961 Dolomite, light brown-grey, vuggy sugary with larger secondary crystals

6961-6965 Dolomite, grey and cream, fine sugary to powdery, dull

6965-6986 Dolomite, pinkish, but mostly dolomitic green and lavender silty hard mudstone

6986-7002 Dolomite grey, cream and lavender, fine, lower 5' green and purple specked

7002-7009 Dolomite, light grey sugary with white anhydrite fillings

7009-7025 Dolomite cream, fine, vuggy, Zygospira, 7022'-25'

7025-7030 Cream sugary, porous, fine secondary anhydrite

7030-7047 Bighorn dolomite, cream, vuggy, stylolites, with Zygospira modesta, diagnostic for Richmond **Upper Ordovician**

7047-7057 Dolomite, fine, cream and light grey

7057-7066 Dolomite, fine, cream and light grey, partly oolitic, with light green "meta"-bentonite

7066-7076 Dolomite, fine, cream **and** light grey and large chunk anhydrite, very fine dense cream

7076-7101 Dolomite, some purple and pink stained, cream, dense

7101-7114 Mudstone, light green, light grey, green-grey, purple, lavender, grey, dark grey, cream, probably mixed with dolomite, stylolites, purple and green anhydritic shale, 7101'-12'

7114-7165 Dolomite, buff, greenish, lavender, light brown, dark grey, dense, fine, **fossils**, 7136'-45'

7165-7200 Dolomite, medium grey, dense, fine, some secondary anhydrite

7200-7214 Dolomite, lavender and light grey green, dense, fine, some coarser **and** crystalline

7214-7232 Claystone, dolomitic, lavender, purple and green, anhydrite cement

7232-7242 Claystone, dolomitic, same, white anhydrite cavity fillings

7242-7278 Dolomite, light grey-green, lavender-stained, lower 7' cream-brown and light pink with fine cream-buff dolomite. A little light green unctuous bentonite 7247'-53'

7278-7302 Dolomite, large rhombs, some anhydrite, cavernous, light lavender, brown and grey

7302-7312 Limestone, fine light brown, Zygospira, mudstone, finely laminated, grey, purple stained

7312-7320 Limestone, magnesian, cream, fine and mudstone, dolomite, light grey and purple, fossils

7320-7325 Limestone, magnesian, light grey, with a little anhydrite

7325-7337 Dolomite, light cream, faintly laminated, vuggy, lower half **with** minute veinlets

7337-7371 Dolomite, light cream and light brown-grey, sugary with some light brown-grey limestone 7337'-55', wavy laminae 7347'-55', considerable secondary anhydrite 7361'-68'

7371-7376 Limestone, cream, medium crystals, small rhombs dolomite

7376-7485 Dolomite, light brown and grey some pink-stained, stylolitic, porous to sugary and dense, some secondary anhydrite, some rhombic, also light brown-grey limestone, fine dense, 7456'-64'

- 7485-7488 Limestone, cream, fine matrix with smaller dolomite rhombs and larger calcite crystals
- 7488-7501 Dolomite, limy, light brown-grey, fine sugary
- 7501-7514 Limestone, light dove to brown-grey, fine sugary, fossils, stylolitic. Strophomena at 7508'-11' Mainly cuttings 7514'-7908' T.D.
- 7514-7625 Limestone, cream to dove, **finely crystalline**, partly pink-stained
- 7625-7640 Limestone, pink, fine rhombs
- 7640-7689 Limestone, less uniformly pink
- 7689-7710 Limestone, light and medium grey, finely crystalline
- 7710-7720 Limestone, darker grey, silty, finely crystalline
- 7720-7730 Middle Ordovician dark grey limestone, very fine to medium crystalline. Contains oldest known fish scales and Mid-Ordovician graptolites
- 7730-7740 Decorah-Platteville shale, dark blue-grey grading down into green chloritic. Basal limestone may contain small brown chert pebbles and fine sand grains
- 7740-7745 Shale, chloritic, bentonitic, green, with scattered small quartz grains and black phosphate grains, apparently a little fine light grey sandstone at upper contact
- 7745-7777 Decorah-Platteville shale, Lincoln green, bentonitic, chloritic, fine sandy and black phosphate grains, some rolled and rounded and fine pebble size
- 7781-7783 Some green siltstone
- 7781-7785 Green shale has some sandstone, white, fine to medium, subround to subangular
- 7785-7820 Green shale, darker green grey, some sandstone, white, coarse, angular
- 7820-7903 St. Peter (Lower Ordovician) sandstone, cream, poorly cemented, porous, grains medium to coarse, angular to subround, partly recrystallized. Saturated with light yellow oil at 7820'. Angular pink feldspar fragments from 7876' downwards
- 7903-7908 Sandstone, arkosic, with abundant fresh pink potash feldspar, muscovite, some bornite. Sand grains angular to subangular, coarse to fine. Some grit, quartzose, T.D.

E. South of Black Hills

13. BELL OIL CO. BELL (CLEVELAND STONE QUARRY) 1, NW. corner
Sec. 8, T. 8 S., R. 3 E., Fall River County. Drilled with
cable tools.

| | | |
|------|-----|----------------------------------------------------------------------------------------------------------------------|
| 0- | 30' | Gravel, pebbles and <u>Lakota</u> sandstone, buff, coarse to fine, angular |
| 30- | 40 | Sandstone, fine grained, angular, with light green bentonitic matrix |
| 40- | 50 | Sand, cream, coarse to fine, etched, recrystallized, angular to sugangular |
| 50- | 60 | <u>Morrison</u> sand, fine, with bentonitic matrix, lavender, light grey and light green |
| 60- | 70 | Sandstone, light green to cream buff, white ashy matrix, fine to silt size grains, angular, bentonitic matrix |
| 70- | 80 | Sandstone, light grey, shale, dark brown grey, bituminous, bentonitic, some silty, hard and tough |
| 80- | 90 | Shale, as just above, with interlaminae of siltstone, lighter grey |
| 90- | 100 | Shale, brown, bentonitic, bituminous, with sandstone, fine to medium, angular grains |
| 100- | 140 | Sand, grey, medium to fine, angular to subround, bentonite, medium grey, silt grey, considerable sand recrystallized |
| 140- | 165 | Siltstone, grey and brown, very bentonitic, grades down into sandstone and grey bentonite |
| 165- | 185 | Sandstone, grey, medium to fine, subangular to subround, some recrystallized, some etched, some vein selenite |
| 185- | 190 | Bentonite, light green grey and medium grey |
| 190- | 200 | Shale, dark brown grey, bituminous, sandstone, grey, fine |
| 200- | 220 | Sandstone, cream, fine, siltstone, dark grey, shaly |
| 220- | 230 | Bentonite, light blue grey |
| 230- | 240 | Sandstone, light grey, fine, shale, black, bituminous |
| 240- | 260 | Bentonite, light blue grey, chalcopryrite and some shale, grey, 250'-60' |
| 260- | 270 | Limestone, light dove grey, fine powdery texture, bentonite, cream, <u>Chara</u> seeds |
| 270- | 280 | Bentonite, light dove, limy. Ostracods and <u>Chara</u> fruits |
| 280- | 290 | Bentonite, light blue grey, silty and sandy, sand size particles of chert, grey and brown, limestone and quartz |
| 290- | 310 | Bentonite, cream, grey, light green grey, dense, limy, Ostracods |
| 310- | 320 | Bentonite, same colors, but sandy |
| 320- | 330 | Mudstone, bentonitic, dove and light green grey, limy, limestone, bentonitic, light dove |
| 330- | 350 | Mudstone, and siltstone, light grey green, bentonitic |
| 350- | 370 | Sandstone, cream grey, fine, poorly sorted, white limy cement, angular to subround, some etched |

370- 380 Sundance siltstone, light green and lavender, mica-
 ceous, glauconitic
 380- 440 Bentonite, light grey, biotitic, glauconite in small
 subround particles
 440- 450 Siltstone, grey, glauconitic, with shaly bentonite
 450- 480 Sandstone, grey, fine, angular, glauconitic, Pachy-
teuthis (Belemnites), shaly bentonite increasing in
 amount downwards
 480- 585 No cuttings
 585- 615 Sandstone, light grey, fine, angular milky chert,
 brown ironstone, selenite, authigenic quartz
 618- 630 As just above but glauconitic
 630- 640 Sandstone, light grey, very fine, limy cement, ben-
 tonite, light grey
 640- 650 Siltstone, light grey, glauconitic
 650- 700 Mudstone, green grey, bentonitic
 700- 710 Siltstone to fine sandstone, brown grey, limy cement
 710- 725 Limestone, grey, sandy and ashy, bentonite, grey
 green, platy
 725- 735(?) Sandstone, cream, with some coarse etched grains
 735- 775 Spearfish siltstone, claystone and sandstone, brown
 red, some green
 775- 785 Anhydrite
 785- 840 Mudstone, salmon, some sandstone, white, some an-
 hydrite and gypsum
 840- 940 Anhydrite in large amount in red siltstone
 940-1125 No cuttings
 1125-1170 Minnekahta limestone, buff, very fine texture, some
 anhydrite and gypsum
 1170-1180 Same with a little translucent chert
 1180-1200 Limestone, cream, pink and lavender, fine powdery
 texture
 1200-1210 Opeche siltstone, dull red brown, limy
 1210-1220 Siltstone, bright brick red, some sandstone and
 cream anhydrite
 1220-1280 No cuttings
 1280-1330 Siltstone, sandstone and mudstone, bright brick red,
 a little anhydrite, etched sand grains
 1330-1390 Top Minnelusa (Converse) sandstone, brown buff,
 fine, angular to subround, gypsiferous
 1390-1400 Anhydrite, brown grey
 1400-1440 No cuttings
 1440 Sandstone, brown red, fine, angular, siltstone,
 brown red
 1460 Same with anhydrite, brown grey
 1480-1500 Anhydrite, brown grey and white, some fossiliferous
 limestone with milky chert, sand
 1510-1520 Sand, fine, subangular, some anhydrite
 1520-1540 Anhydrite, grey, cream, brown, silty
 1540-1550 Sandstone, buff, fine grained
 1550-1560 Sandstone, buff, fine grained with anhydrite

1560-1570 Anhydrite, pinkish and cream
1570-1580 Anhydrite, with red sandy clay
1580-1615 No cuttings
1615-1630 Sandstone, brown red, siltstone and anhydrite, some large clear quartz fragments, milky chert
1630-1674 Sandstone, brown red to buff, fine to medium, angular to subround, etched, poorly sorted
1675-1690 Anhydrite, buff, stained with pink
1690-1700 Sandstone, fine, anhydrite, siltstone, brown red
1700-1715 Anhydrite, cream and grey, very fine
1715-1725 Anhydrite, cream, well crystallized
1725-1737 No cuttings
1737-1748 Sandstone, light grey, poorly sorted fine to medium, limy cement, anhydrite, claystone, grey, bentonitic, shale, black, bituminous, selenite and satin spar
1748-1752 Siltstone, chocolate to yellow brown, lavender and grey, micaceous
1752-1755 Clay, chocolate, clay ironstone, yellow brown and red brown, anhydrite, grey chert, shale, brown grey and butternut brown, fissile, considerable bornite
1755-1759 As above with shale, dark grey, very fissile
1759-1764 As above with considerable shale, black, bituminous, siltstone, grey
1764-1766 Bentonite, dark purple and medium blue grey, siltstone, brown and red, shale, butternut brown and black, bituminous, anhydrite, white and blue grey
1766-1787(?) Same but more brown grey anhydrite
1787-1798 About as above with some quartz and milky chert
1798-1807 Mostly shale, grey, chocolate brown and black, bituminous
1812-1818 Some chert, milky
1818-1856 Anhydrite, grey, white and blue grey
1856-1866 Anhydrite, dove and cream
1866-1896 "Leo" sandstone, cream, fine grained, etched, angular to subround, poorly sorted
1896-1900 Anhydrite, grey and blue grey
1900-1910 Shale, black, micaceous, very bituminous
1910-1920 Sandstone, fine angular to subround, partly etched
1920-1937 Anhydrite, light grey, bituminous shale 1731'-37'
1937-1945 Sandstone, grey, fine, anhydrite cement
1945-1949 Anhydrite, grey, bituminous shale, black
1949-1953 Sandstone, light grey, fine, interbedded with shale, medium grey
1953-1958 Same but shale is black bituminous
1958-1970 Anhydrite, grey
1970-1998 Anhydrite, grey, black bituminous shale and grey sandstone
1998-2005 Sandstone, cream, fine grained
2005-2011 Anhydrite, dove

2011-2018 Anhydrite, grey, with chert, dark blue grey
 2018-2028 Sandstone, cream, fine grained
 2028-2038 Anhydrite, grey and white, sandstone, translucent
 chert
 2038-2045 Sandstone, grey, fine grained
 2045-2084 Anhydrite, grey to 2068', cream, 2068'-84', sandy
 2076'-84'.
 2084-2120 Anhydrite, cream, recrystallized in part, with
 etched sand, grades down into dolomite, fine sandy
 and silty
 2120-2132 Siltstone, cream buff, clay, green, brown red
 2132-2142 Dolomite, buff, translucent and milky pinkish chert
 abundant
 2142-2158 Same with clay, light salmon and green grey, bento-
 nitic
 2158-2170 Claystone and siltstone, purple and green grey,
 bentonitic
 2170-2181 Claystone and siltstone, purple, green, grey, brown
 red
 2181-2204 Same with some small fragments of cream crinoidal
 limestone, sand grains, 2195'-2204'

14. BURLINGTON RAILROAD WELL, Edgemont, Fall River County

| | |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 530- 600' | <u>Lakota</u> sandstone, grey, medium grained, angular to subround |
| 600- 620 | Sandstone, darker grey, medium grained, angular to subround |
| 640- 642 | Sandstone, grey, medium grained, angular to subround, bentonite, grey, white and lavender, chalcopryrite and chalcocite |
| 970-1000 | <u>Morrison</u> sandstone, fine grained, with clayey matrix, terra cotta and light grey mixed |
| 1020-1040 | |
| 1160-1174 | <u>Sundance</u> sandstone, fine grains, some citrine quartz and brown chert grains in light grey bentonitic matrix, mudstone, light grey green |
| 1174-1190 | Sandstone, light grey to buff, fine grained, angular |
| 1223-1230 | Siltstone, light grey to buff |
| 1230-1237 | <u>Spearfish</u> mudstone, salmon and deeper red |
| 1237-1250 | Mudstone, salmon |
| 1250-1270 | Mudstone, salmon |
| 1410-1430 | Anhydrite and red beds |
| 1450-1490 | Siltstone, salmon |
| 1720-1850 | Mudstone, salmon, silty |
| 2303-2325 | <u>Minnelusa</u> anhydrite, white and grey, limestone, grey, a little chert, sandstone, grey, medium grained, angular, a little black shale, chalcopryrite |
| 2325-2352 | Anhydrite and limestone, grey, some chert, small sand grains, chalcopryrite |
| 2352-2400 | Same as last, chalcopryrite |
| 2400-2440 | Sandstone, fine grained, anhydrite, limestone, chalcopryrite |
| 2440-2465 | Chalcopryrite, shale, black, sandstone, very fine grained, anhydrite intercrystallized with limestone |
| 2465-2490 | Considerable milky white chert, fine quartzose sandstone, brown grey limestone, sandstone, medium to coarse, rounded grains, mostly light grey brown cherty limestone |
| 2516-2537 | Sandstone, red brown, fine angular grains |
| 2537-2572 | Sandstone, brown |
| 2572-2595 | Sandstone, buff, fine angular grains |
| 2641-2648 | Mudstone, purplish, sandstone, medium subround to subangular grains, limestone, grey, fine textures |
| 2730-2764 | Mudstone, purplish, (<u>laterite</u>), sandstone, fine grained, a little white bentonite, chalcopryrite. |
| 2920 | This well obtained its water in the upper Pahasapa limestone at 2980' depth. The railroad well at Minnekahta penetrated anhydrite-bearing Minnelusa from 990'-1342'. |

15. CONTINENTAL OIL CO. STATE 1, 2310' SNL, 2273' EWL, Sec. 36,
T. 8 S., R. 3 E., Fall River County. Altitude 4046'.

| | |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 0- 30' | <u>Dakota</u> sandstone, cream, medium sized angular grains |
| 30- 70 | No cuttings |
| 70- 90 | Sandstone, as at 0'-30' |
| 90- 100 | Siltstone, dark grey, sandy |
| 100- 130 | Sandstone, buff and cream, fine grained, selenite veins |
| 130- 250 | Sandstone, as above with some pink potash feldspar grains, brown or grey, poorly sorted, some siltstone, <u>Lakota</u> |
| 250- 280 | <u>Morrison</u> siltstone, dark and lighter grey, laminated |
| 280- 290 | Siltstone with interbedded sandstone, light grey, fine grained, bentonite, light grey and green |
| 290- 310 | Siltstone, grey |
| 310- 320 | Siltstone, grey, some sandy, limy cement, bentonite, light grey |
| 320- 330 | <u>Sundance</u> limestone, light grey, fine texture, dense |
| 330- 350 | Siltstone, green grey, glauconitic, grades to fine sandstone, chalcopryrite with pyrite |
| 350- 370 | Sandstone, light grey, medium grained, subangular to subround |
| 370- 380 | Siltstone and mudstone, medium grey |
| 380- 430 | Chalcopryrite, diminutive <u>Porocystis</u> -like organism (<u>Cymopolia</u> ?) marcasitized, a little blue chert, organisms, 420'-30' |
| 430- 440 | Sandstone, light grey, glauconitic, fine grained |
| 440- 480 | Sandstone, light grey, glauconitic, fine grained, same fossils as above, 470'-80' |
| 480- 510 | Siltstone, terra cotta, chalcopryrite, same fossils as above |
| 510- 530 | Bentonite, grey and green, sandstone, salmon, medium grained |
| 530- 540 | Bentonite with phlogopite, algal fruits |
| 540- 600 | Sandstone, very light grey, fine grained, bentonite, white, sandy, 550'-60', sandstone, glauconitic and micaceous |
| 600- 650 | Sandstone, as above, chalcopryrite |
| 650- 700 | Sandstone, as above |
| 700- 730 | <u>Spearfish</u> sandstone, salmon, grading to siltstone downward |
| 730- 810 | Siltstone, salmon, gypsiferous, sandstone, light grey, medium grained |
| 810- 930 | Siltstone, salmon, anhydrite |
| 930-1060 | Anhydrite, white, fairly coarsely crystalline, pink stained, 1030'-60' |
| 1060-1120 | Siltstone and mudstone, salmon, some anhydrite, es- pecially at 1070'-80' |
| 1120-1170 | <u>Minnekahta</u> limestone, light grey, white and pink, fine dense, some anhydrite |
| 1170-1200 | <u>Opeche</u> mudstone, dark brown red, darker red than the <u>Spearfish</u> |

1200-1250 Same with anhydrite, white, fine, dense, some grey spots, some sandstone
 1250-1325 Sandstone, dark brown red but lighter than siltstone above, some siltstone
 1325-1360 Sandstone, red brown, fine to medium grained, siltstone, dark brown red
 1360-1380 Minnelusa sandstone, red and light grey, some white anhydrite
 1380-1460 Anhydrite, white, grey, pink, crystalline with dolomite and magnesian limestone, some of the latter light grey and dense
 1460-1480 Limestone, light grey, very finely crystalline
 1480-1540 Limestone, dolomitic, light grey, with chert, light grey and milky, chalcopyrite, anhydrite, foraminifera, 1500'-10'
 1540-1620 Anhydrite, white and pink
 1620-1650 Sandstone, brown, medium grained, limestone, glauconitic, grey and pink, anhydrite
 1650-1690 Limestone, brown and pink, fine texture, anhydrite, white
 1690-1760 Sandstone, mostly
 1760-1770 Limestone, dark grey, a little anhydrite
 1770-1780 Sandstone, limestone, dark grey, earthy, a little anhydrite
 1780-1790 Anhydrite, dark brown grey, chert
 1790-1820 Sandstone, much limestone, dark grey, earthy, shale, very dark grey
 1850-1880 Shale, very dark grey, anhydrite, brown grey
 1880-1890 Sandstone, some recrystallized, anhydrite, dark grey, chalcopyrite
 1890-1910 Shale, dark grey, anhydrite, dark brown grey
 1910-1930 Sandstone and anhydrite
 1930-1940 Chalcopyrite, mostly siltstone, light grey, considerable chert, bipyramidal quartz crystals
 1940-1960 Sandstone, fine grained
 1960-1980 Anhydrite, dark grey, limestone, light grey, considerable chert, dark blue grey, shale, black
 1980-2000 Limestone, light grey, fine granular
 2000-2010 Sandstone, grey, fine grained
 2010-2030 Sandstone, light grey, fine grained, much limy cement, quartzitic, abundant milky chert
 2030-2070 Sandstone, with limestone, dark brown grey and chert, white
 2070-2090 Sandstone, light grey, very fine grained, some dark brown red
 2110-2140 Sandstone, buff, fine-grained, with limestone, 2130'-40', lavender, light grey, pink, fine texture
 2140-2150 Sandstone, grey, limestone, white, very fine texture
 2150-2170 Laterite, mudstone and siltstone, sandy, green grey, dark grey, brown, yellow, purple, some sandstone, buff, and limestone, white

2170-2220 Siltstone and mudstone, sandy, purple, becomes quite limy at 2180', bentonitic, light green and grey spots

2220-2238 Pahasapa (Madison) limestone, buff, light grey, white, lithographic texture, lost circulation which led to abandonment

16. **BLACK HILLS ORDNANCE DEPOT, PROVO, U.S. WAR DEPT. 1, 1060.7'**
 NSL, 304.7' WEL, SE. $\frac{1}{4}$, Sec. 3, T. 10 S., R. 2 E., Fall River
 County. Altitude, concrete base, ground, 3655.1', top of
 rotary table 3663.6', top of Kelly bushings, 3664.5'. For-
 mation depths measured from 3664.5' altitude.

- 0- 10' Carlile shale, weathered, dark olive green or drab,
 bentonitic, large amount of eolian angular flaky
 quartz sand, fine, some grains coarse, frosted, sub-
 angular
- 24- 34 Shale, dark blue grey, bentonitic, gypsiferous and
 limy
- 44- 50 Shale with calcite veinlets
- 50- 70 Shale with sandstone, medium grey, biotitic, chlo-
 ritic, fine angular, lime cement, fish scales
- 70- 100 Shale, dark grey, bentonitic, compact
- 200- 280 Greenhorn marl, dark grey, very minutely laminated,
 much speckled with chalky and translucent lime-
 stone, hard, some very fine quartz sand, fish re-
 mains. Greenhorn limestone reported down to 380',
 alternating with dark shale
- 380- 700 Graneros (Belle Fourche) shale, dark grey, limy
 and silty streaks and bentonite, white, 680'-90'
- 700- 850 Mowry shale, dark brown grey, fish scales
- 850- 870 Nefsky shale, limy, bentonite
- 870- 890 Newcastle sand, light grey, very fine grained,
 water-bearing
- 890-1088 Thermopolis (Skull Creek) shale, very dark grey,
 with bentonite, phlogopite, silt and sand
- 1088-1115 Dakota (Fall River) sandstone, light grey, fine to
 medium grained, micaceous, marcasite
- 1115-1175 Sandstone, light grey, fine to medium, hard, angu-
 lar, shale, dark grey, bentonitic, sandstone at
 1140'-58'
- 1175-1250 Sandstone, light grey and white, fine to medium
 hard, bentonite, white, shale, dark grey, sandy,
 bentonitic
- 1250-1350 Clay, dull purple and dark grey, very bentonitic,
 sandstone, coarse
- 1350-1370 Lakota sandstone, light grey, porous, limy cement,
 poorly sorted coarse to fine grains, subround to
 subangular
- 1370-1390 Sandstone with clay, purple, sandy
- 1390-1450 Sandstone, white, coarse
- 1450-1470 Morrison clay, light grey, brown and lavender,
 silty
- 1470-1500 Clay, grey, silty
- 1500-1560 Bentonite, light grey, green and brown, some sand-
 stone, light grey, fine, clay, grey
- 1560-1590 Clay, dark grey, and bentonite, hard, light grey
 and light green

1590-1600 Clay, dark grey
 1600-1640 Sundance sandstone, light grey, fine to medium, limy glauconitic, shale, dark grey
 1640-1685 Shale, dark blue grey
 1685-1735 Sandstone, light grey, fine, glauconitic, micaceous, limy, milky white chert
 1735-1810 Sandstone, light grey, fine, mainly clay, terra cotta, purple, dark grey, bentonitic, light green bentonite
 1810-1860 Sandstone, light grey, fine grained, limy glauconitic
 1860-1880 Clay, terra cotta, sandstone, light grey
 1880-1950 Shale, dark blue grey, some nearly black, silty and sandy
 1950-2000 Sandstone, light grey, fine grained, glauconitic
 2000-2037 Sandstone, cream, medium to coarse grained, porous, large grains rounded and etched, limy cement, glauconitic, vein calcite, some milky chert
 2037-2160 Spearfish siltstone, sandy salmon, micaceous
 2160-2374 Zone of anhydrite, white and light grey, interbedded with siltstone and mudstone, brown red and sandstone, mostly fine grained and silty
 2374-2428 Minnekahta limestone, magnesian and dolomite, light grey and brown, fine, dense, with some anhydrite, some stained pink. Base Minnekahta may be at 2408'
 2428-2480 Opeche sandstone, red-coated, fine grained
 2480-2560 Siltstone, dark dull brown red, some sandy
 2560-2570 Anhydrite, grey, sandstone, dark red, mostly fine grained, mudstone, red
 2570-2600 Sandstone and mudstone, red, some anhydrite
 2600-2620 Minnelusa sandstone, pink and light grey, medium grained, subangular
 2620-2654 Anhydrite, white and pink, a little sandstone, white
 2654-2670 Mostly sandstone, pink and white, angular, medium grained, chalcopryrite, nodule of chalcocite, considerable limestone, magnesian, brown grey
 2670-2690 Limestone, brown grey, specked with dark grey, finely crystalline
 2690-2720 Sandstone, white and buff, limestone and dolomite, as above, increased pink sandstone, 2710'-20'
 2720-2730 Limestone, probably magnesian, cream, very finely crystalline to porous
 2730-2770 Apparently only cavings
 2770-2840 Sandstone, limestone, white and anhydrite grey, pink and dull lavender
 2840-2850 Some shale, maroon, otherwise as overlying
 2850-2880 Anhydrite, pink, purple and grey, shale, maroon, sandstone, pink and grey
 2880-2920 Same, with limestone, predominantly magnesian
 2925-2935 Red marker, shale, dull purple to maroon, flaky
 2935-2960 Like from 2880'-2920' but more limestone, grey, sandstone, medium grained, less anhydrite

2960-3030 Sandstone, light grey, fine to medium, shale, very dark grey, hard, fissile, limestone, earthy, brown grey, fine grained, a little white anhydrite, limestone predominates, with considerable pink staining, some chalcopyrite in sandstone, some calcite, dark brown grey

3030-3040 Shale, nearly black, fissile, hard, mostly limestone, light grey dense

3040-3060 "Leo" sandstone, white, medium coarse, subangular, show of oil and gas

3060-3070 Shale, dark brown black, chalcopyrite

3070-3090 Chalcopyrite, milky chert, limestone mostly

3090-3110 Bipyramidal quartz, mostly limestone

3110-3150 Limestone with a little milky white chert, abundant at 3130'-40', sandstone, limy, siltstone

3150-3170 Sandstone, light grey, medium grained, subangular to subround, limy cement, limestone, light brown grey, finely crystalline, anhydrite, white

3170-3175 Limestone, medium brown grey, some oolitic, some with quartz grains, a little white anhydrite, some white chert, most limestone porous, some very fine textured

3175-3180 Mostly sandstone

3180-3200 Limestone, as above, some silty, a little white chert

3200-3210 Sandstone, with limestone and anhydrite

3210-3220 Limestone

3220-3240 Sandstone, some grey and white chert

3240-3250 Sandstone, white, medium grained, porous

3250-3260 Limestone, sandstone, chert, milky

3260-3295 Sandstone, white, fine grained, limy cement, porous

3295-3330 Limestone, silty and sandy, sandstone, limy, fine grained, a little anhydrite

3330-3340 Sandstone, white, fine, limestone, light grey, dense

3340-3370 Sandstone, cream, very fine grained, limy cement, siltstone, dark purple and lavender, 3350'-70'

3370-3390 Limestone, light grey, very fine, dense, some sandstone and lavender siltstone

3390-3420 Chalcopyrite mixed with pyrite, mostly sandstone, buff and grey, **very** fine, limestone, light grey, with considerable chert

3420-3470 Some chert, grey and white, much siltstone, lavender, sandstone, limestone, echinoid spines

3470-3500 Increase in chert, siltstone, lavender, spotted with light green grey to white

3500-3510 Same, mudstone, purple and lavender, some silty, limestone, light grey, lithographic, chert, white translucent

3510-3560 About half limestone and chert, small brown chert pebbles in sandstone, echinoid spines, chalcopyrite, some limestone finely crystalline, mudstone with limy spots, organic

3560-3570 Considerable limestone stained pink to purplish, mostly very dense fine granular

3570-3590 Mudstone, dull purple, flaggy to finely laminated, sandstone, red, subround grains, horn coral

3590-3630 Mudstone, yellow, with abundant ostracods

3630-3640 Grit or conglomerate of brown grey chert, malachite and azurite

3640-3660 Pahasapa (Madison) limestone, white and pink, with large calcite rhombs

3660-3675 Limestone, white to pink, recrystallized, large rhombic crystals in finer matrix

3675-3685 Limestone, white to pink, as just above, with sandstone, white, rather coarse, limy matrix, some translucent chert, malachite, 3680'-85'

3685-3740 Same limestone, white, dense, chalcopyrite, otherwise as overlying

3740-3750 Same limestone marbleized, mostly pink, some vein quartz

3750-3780 Part of limestone has finer crystals than from 3640'-3750'

3780-3800 Limestone, light cream, fine grained, cavernous

3800-3880 Mixture of dolomite and limestone, light grey, fine textured, drusy, some silt size quartz fragments, 3830'-35'

3880-3890 Limestone, light grey and (mostly) very pink, medium grained, a little sandstone, white, coarse

3890-3900 Sandstone, coarse, angular to subangular, some grains corroded, some nearly perfect crystals, singly and in cluster, disintegrated from underlying granite

3900-3915 Sandstone as overlying, with particles of brown phyllite or mica schist, shale, green

3915-3999 Pre-Cambrian biotite granite

Water from Dakota sandstone, 1085'-1158', rose 660' in 15 minutes, bottom hole pressure, 360 lbs. (?)

Water from upper Lakota sandstone, 1271'-1345', rose 660' in 12 minutes, bottom hole pressure 360 lbs. (?)

Water from red Sundance sandstone, 1728'-1775', rose 1215' in 18 minutes, bottom hole pressure, 700 lbs. (?)

Flowing Water from upper part basal Sundance 1964'-2010', rose 1680' in 9 minutes, bottom hole pressure, 1000 lbs.

Flowing Water from basal Sundance sandstone, 1964'-2039', rose 2027' in 23 minutes, bottom hole pressure, 975 lbs.

Water from sandy zone Minnelusa sandstone, 2609'-2654', rose 270' in 15 minutes, bottom hole pressure, 160 lbs.

Flowing Water from upper Madison, 3652'-3698', rose 3300' in 25 minutes, bottom hole pressure, 1900 lbs.

Flowing Water from lower Madison, 3781'-3825', rose 3785' in 34 minutes, bottom hole pressure, 1975 lbs.

Artesian Flow Water from Madison, 3628'-3828' was 120 gals. per minute, temperature, 139° F.

17. AMERADA PETROLEUM CORP., SOUTH DAKOTA AGRICULTURAL COLLEGE
 1, 330' N. and 330' E. of SW. corner SE. $\frac{1}{4}$, Sec. 27, T. 8
 S., R. 7 E., Fall River County. Altitude 3366'.

| | |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0- 775' | No cuttings, <u>Pierre</u> clay |
| 775- 800 | Marl, chalk speckled, medium grey, <u>Globigerina</u> , <u>Inoceramus</u> , fish remains |
| 800- 830 | Shale, dark blue grey, bituminous, chalk pellets, Sharon Springs |
| 830- 840 | Shale, black |
| 840- 900 | <u>Niobrara</u> marl, grey, much chalk, <u>Globigerina</u> and fish remains |
| 900- 950 | <u>Carlile</u> shale, dark blue grey, a few chalk pellets, bituminous, biotite, fish remains |
| 950-1020 | Shale, black, bituminous, small chalk spots, pure bentonite beds |
| 1020-1050 | Shale, blue grey, chalk spotted, concretions and bentonite beds |
| 1050-1060 | " <u>Cristellaria</u> " |
| 1060-1070 | Shale, black, bituminous |
| 1070-1080 | Copper sulphide and hauerite (?) in a pyritic zone |
| 1080-1100 | Sandstone, grey, fine grained |
| 1120-1150 | Sandstone, grey, fine grained, limy cement, biotite, carbonaceous, fish fossils |
| 1150-1180 | Shale, grey, dark |
| 1180-1190 | Sandstone, with dark chert and medium grained sand particles |
| 1190-1240 | Shale, dark blue grey, iron carbonate concretions, fish fossils |
| 1240-1290 | Shale, black |
| 1290-1300 | Shale, black, bituminous, <u>Globigerina</u> |
| 1340-1375 | <u>Greenhorn</u> limestone, grey, packed with <u>Inoceramus</u> prisms, interbedded with chalky marl, <u>Globigerina</u> |
| 1375-1410 | <u>Graneros</u> shale, dark blue grey, small flattened chalk pellets |
| 1410-1600 | Shale, black, slightly bituminous, small flattened chalk pellets, fish fossils, bentonite, 1580'-90' |
| 1600-1690 | Shale, dark blue grey to black, bentonite, <u>Globi-</u> <u>gerina</u> , fish fossils |
| 1690-1700 | Sandstone, grey, fine grained |
| 1790-1890 | Shale, dark blue grey, clay ironstone |
| 1890-1920 | Muddy or Newcastle sandstone, grey, fine grained, angular, limy cement |
| 1970-2000 | Sandstone, red stained and shale, purple, "rusty" beds |
| 2110 | Sandstone , grey, fine grained, impermeable, dirty, some with glauconite and selenite |
| 2150-2200 | <u>Dakota</u> sandstone, light grey, fine to medium grained, porous, subangular to subround, carbonaceous, mica- ceous, some large quartz grains, lignite, 2180'-85' |
| 2200-2210 | Manganosiderite or rhodochrosite pellets |
| 2210-2229 | Sandstone, light green, fine grained |

2229-2239 Sandstone, light grey, fine to medium grained, porous, angular to subround, carbonaceous, partly recrystallized, some siltstone, red

2239-2265 Cement and cavings, some sandstone

2265-2270 Fuson shale, sandy shale and siltstone, dark grey

2270-2285 Sandstone, light grey, fine grained

2285-2300 Shale, grey, bentonitic

2300-2310 Sandstone, light grey, fine to medium, subangular to subround, partly recrystallized, porous

2310-2315 Shell fragments

2325-2350 Shale, various shades grey, bentonitic, some sandy, coal

2350-2370 Shale, various shades grey and lavender, bentonite, coal

2370-2375 Sandstone, medium to coarse, porous, limy cement, subangular to subround

2385-2390 Brown platy magnetic iron oxide, shales as above

2390-2420 Sandstone, as at 2370'-75', partly recrystallized, etched grains, some blue grey chert particles

2420-2430 Conglomerate, unusual quantity of bluish and milky chert fragments, grit

2430-2435 Sandstone, fine to medium, spotted light grey, very light grey cement, bentonite, angular to subround, good permeability

2435-2440 Minnewaste limestone, light grey and cream

2440-2445 Limestone, cream grey, oolitic

2445-2450 Chert, bluish and milky, much bentonite, grey

2450-2455 Limestone, light and dark grey mixed, also cream, finely crystalline

2455-2485 Anhydrite, bluish white, some impure, clay, dark grey, bentonitic and silty

2485-2495 Dolomite, light dove, dense, very fine grained, silt particles with anhydrite fillings

2495-2510 Sandstone, light grey, fine grained, limy cement

2510-2520 Shale, dark grey

2520-2530 Limestone, medium grey, very fine grain

2530-2555 Mudstone, green grey and drab, bentonitic

2555-2560 Mudstone, brown drab and dark grey, carbonaceous, bentonitic

2560-2635 Lakota sandstone, light grey, fine to medium, mostly recrystallized, some shale, grey, sand grains angular to subangular, porous, some carbonaceous material

2635-2700 Perhaps mostly shale, dark chert particles and large quartz grains

2700-2720 Morrison mudstone, dark and medium grey, green grey, brown grey, bentonitic

2720-2725 Siltstone, light red brown, perhaps some lignite

2725-2730 Siltstone or fine sandstone, brown red, brown, yellow, quartzitic

2730-2740 Clay, dove and light green grey, bentonitic

2740-2770 Sandstone, light grey, buff and cream, fine grained, partly recrystallized, nonrounded, porous, some finer micaceous laminae

2770-2805 Sandstone, partly quartzitic, light brown and very light grey, cement is chert or chalcedony
 2805-2810 Mudstone, light yellow and leek green, very small dark spots, bentonitic
 2810-2815 Sandstone, as at 2740'-70'
 2815-2820 Perhaps mainly mudstone
 2820-2830 Sandstone, light brown grey, quite fine grained
 2830-2835 Bentonite, green grey, sandy
 2835-2845 Clay or mudstone
 2845-2850 Grit, quartzose
 2850-2865 Sand, light salmon, clayey
 2865-2870 Sand, poorly sorted, fine, partly rounded, in matrix of salmon clay
 2870-2875 Clay (?)
 2875-2900 Sandstone, buff, grey, pinkish, fine grained, partly rounded, Unkpapa
 2900-2990 Clay, light green grey, sandy, some with silt laminae
 2990-3005 Sundance bentonite, oily green, hardened, siltstone, greenish, glauconitic
 3005-3010 Sandstone, grey, fine, glauconitic
 3010-3025 Cavings
 3025-3030 Small globular marcasitized "golf ball" organisms
 3030-3050 Sandstone, glauconitic, limy, fine to medium, finer below
 3055-3065 Sandstone, light grey, glauconitic, fine grained, porous
 3065-3070 Clay (?)
 3070-3080 Sandstone, as last above, siltstone, light green grey, limestone, grey, silty
 3080-3145 Mudstone, mostly light green grey, bentonitic, siltstone, 3125'-30'
 3145-3150 Mudstone, chocolate, bentonitic, sandy
 3150-3155 Caliche
 3155-3165 Sandstone, light salmon, fine to medium grained
 3165-3170 Sandstone, light grey, glauconitic
 3170-3195 Sandstone, cream, fine grained, sparsely glauconitic
 3195-3200 Spearfish mudstone, brown red
 3200-3215 Sandstone, cream, fine grained, bentonite, brown and drab
 3215-3225 Sandstone, light salmon, fine grained, mudstone, brown red
 3225-3250 Sandstone, light salmon, pink, mudstone and siltstone, salmon
 3250-3275 Anhydrite
 3275-3280 Mudstone, red
 3280-3335 Siltstone, dark salmon
 3335-3350 Anhydrite, cream, stained pink
 3350-3360 Siltstone, salmon
 3360-3370 Sandstone, salmon, fine grained with larger frosted subround grains, unsorted
 3370-3380 Anhydrite, cream, some pink stained

3405-3415 Anhydrite, light grey
 3425-3430 Limestone, buff, lavender-stained, fine powdery texture
 3430-3450 Siltstone, dark brown red
 3450-3455 Sandstone, dark brown red, unsorted coarse to fine, siltstone
 3460-3465 Mudstone, dark brown red
 3465-3500 Siltstone, etc., salmon, with light grey to white spots
 3500-3505 Minnekahta limestone, buff, fine powdery texture
 3505-3520 Limestone, pink-stained cream, fine granular
 3520-3529 Limestone, light pink brown, fine granular
 3545-3555 Limestone, purplish, fine granular
 3555-3565 Opeche siltstone and fine sandstone, light brown
 3565-3575 Siltstone, brown red (?)
 3575-3580 Possibly limestone, buff, fine texture
 3580-3585 Dolomite, brown cream, fine texture
 3585-3620 Limestone, pink cream, fine texture
 3620-3630 Shale, brown and dark purple
 3630-3645 Sandstone, light salmon, fine to medium, poorly sorted, limy cement, anhydrite above
 3645-3660 Cavings
 3660-3670 Siltstone, salmon
 3670-3695 Minnelusa sandstone, light salmon, fine grained
 3695-3705 Sandstone, cream buff, medium grained, limy cement, angular to subround
 3705-3735 Anhydrite, light grey, brown mottled
 3735-3755 Sandstone, light salmon and grey, fine to medium, poorly sorted, dolomitic cement
 3755-3800 Dolomite, brown grey, fossiliferous, brachiopods, medium sized crystals, porous
 3800-3815 Anhydrite, light and medium grey
 3815-3830 Sandstone, cream and buff, fine to medium, dolomite cement
 3830-3850 Dolomite, grey, fine powdery texture, grading downward into limestone
 3850-3855 Limestone and anhydrite
 3855-3860 Sandstone, light pink brown, fine to medium texture, dolomitic limestone cement
 3860-3870 Dolomite, light brown grey, fine powdery texture
 3870-3895 Anhydrite, pinkish above, grey below
 3895-3910 Sandstone, cream, and light pink, medium and coarse, poor sorting, dolomitic cement
 3910-3930 Anhydrite, cream and grey
 3930-3935 Dolomite, brown grey, fine powdery, mixed with anhydrite
 3938 Lost circulation
 3940-3945 Dolomite, anhydrite, purple mudstone
 3945-3950 Possibly sandstone, cream and pink
 3950-3965 Limestone, dark grey, splotched with lighter grey, fine powdery, passing downwards to dolomite

3965-3970 Dolomite, dark grey, splotted with lighter grey, fine powdery, passing downwards to anhydrite
 3970-3980 Anhydrite, grey and brown grey, and dolomite
 3980-4010 Dolomite, medium and dark grey, fine powdery texture, larger secondary crystals
 4010-4040 Sandstone, light grey, fine to medium grained, etched, subangular to subround, dolomite cement, glauconite (?)
 4040-4045 Dolomite, brown grey, fine powdery texture, larger secondary crystals
 4045-4060 Sandstone, light grey, medium grained, etched, subangular to subround, dolomite cement
 4060-4065 Shale, black, very bituminous
 4065-4070 Anhydrite and dolomite mixed
 4070-4075 Possibly black shale
 4075-4085 Dolomite, dark grey, fine sugary
 4085-4090 Sandstone, medium grey, fine grained, dolomite cement
 4090-4095 Core of dolomite
 4095-4100 Shale, dark blue grey limy, possibly hydraulic limestone
 4100-4115 Dolomite, dove grey, fine powdery, brittle, flaky
 4115-4130 Same with intermixed anhydrite and bluish and smoky translucent chert
 4130-4135 Dolomite and anhydrite mixed
 4135-4150 Sandstone, cream, fine grained, cement probably mostly siliceous, some quartzite
 4150-4155 Dolomite, medium grey, intermixed with anhydrite, in part sandy
 4155-4170 Sandstone, light bluish grey, fine to medium grained, poorly sorted, etched, nonround, dolomite cement
 4170-4175 Shale, black, bituminous
 4175-4180 Sandstone, as at 4155'-70', quartzitic, chert fragments
 4180-4185 Dolomite, brown dove, lithographic
 4185-4200 Limestone, dolomitic, brown grey, very fine powdery texture, dense, flaky, a little chert
 4200-4215 Dolomite, grey, fine powdery texture
 4215-4220 Shale, black, bituminous
 4220-4240 Dolomite, light grey, fine powdery texture
 4240-4250 Dolomite, light grey, fine sugary
 4250-4255 Anhydrite, light grey
 4255-4280 Dolomite, light grey
 4280-4295 Dolomite, light brown grey, vuggy, a little coarser, some rhombic
 4295-4305 Dolomite, brown, rhombic, with a little chert
 4305-4320 Dolomite, cream grey, with fine sand, vuggy, rhombic, tinged with pink
 4320-4325 Sandstone, cream and pink, angular, fine to medium grains, dolomitic, milky chert
 4325-4340 Dolomite, deep pink or rose, fine rhombic to powdery, vuggy, sandy and less pink below
 4340-4350 Sandstone, light pink, fine grained, dolomitic cement

4350-4355 Grit size grains of quartz, carnelian and feldspar,
 some chert, subangular to subround, many chatter marks
 4355-4360 Sandstone, cream, fine grained
 4360-4365 Bentonite or bauxite, greenish white
 4365-4375 Lateritic clay, brown red, mottled with grey
 4375-4415 Laterite, sandy, maroon to purplish, also clay,
 spotted grey and light green, some bentonite or
 bauxite, some bright green is either hydrous iron
 or nickel silicate, some clay like pipestone, hard,
 red, lustrous, also lavender
 4415-4420 Some cream chert, much cream fine sandstone
 4420-4454 Laterite, more sandy, some tan and brown
 4454-4465 Pahasapa (Madison) limestone, cream, flaky, brittle,
 extremely fine powdery texture, small secondary cal-
 cite crystals
 4465-4475 Same with vugs and geodes, pink stained, secondary
 rhombic dolomite crystals
 4475-4482 Same with altered oolites
 4482-4488 Core of dolomite
 4495-4520 Limestone, cream, partly altered oolites and part
 very fine texture
 4520-4543 Dolomite, pink stained, rhombic, vuggy, cavernous,
 part coarsely crystalline
 4543-4548 Cored dolomite, lost circulation and hole

18. AMERADA PETROLEUM CORP. PERRY MOODY 1, center NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ NE. $\frac{1}{4}$, Sec. 8, T. 12 S., R. 6 E., Fall River County, 1651' W. and 330' S. of NE. corner Sec. 8. Altitude 3650'.

| | |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0- 340' | No cuttings |
| 340- 360 | <u>Pierre</u> clay, green grey, bentonitic, fine mica flakes, some biotite, silty, foraminifera, <u>Inoceramus</u> prisms, in part limy, brown ironstone concretions |
| 360- 370 | Clay, lime cemented |
| 410- 420 | Considerable biotite flakes, brown ironstone concretions |
| 460- 480 | Clay micaceous and silty |
| 500- 510 | Clay partly lime cemented |
| 510- 520 | <u>Inoceramus</u> and concretions |
| 520- 580 | Clay silty and carbonaceous, to fine sandy |
| 630 | More silty than above |
| 670- 680 | Shell fragments, much bentonite to 690' |
| 680- 700 | Some sandstone, grey, fine grained, bentonitic |
| 700- 720 | Some of the clay is darker grey |
| 720- 730 | Limestone, grey, clayey |
| 730- 740 | Clay with hauerite (?) and selenite |
| 740- 750 | Clay ironstone |
| 800- 820 | Limestone, dark grey, fine texture, clayey |
| 820- 830 | <u>Saracenaria</u> |
| 830 | Some concretionary ironstone |
| 870- 890 | Brown ironstone, shell fragments |
| 890 | Semi-shale, darker grey than above, limy, with concretions |
| 920- 950 | Darker and bituminous clay |
| 950 | Clay, chocolate, bentonitic, concretions, dark brick red |
| 1020-1090 | Sharon Springs shale, dark blue grey to black, bituminous, fish remains |
| 1090-1190 | <u>Niobrara</u> marl, chalk speckled, bituminous, chalk particles flattened along laminae, more marl than chalk |
| 1190-1250 | <u>Carlile</u> shale, dark blue grey and black, bituminous, some chalk spotted marl |
| 1250-1260 | Increase in chalk speckled marl |
| 1260-1280 | Mostly chalk speckled marl, grey, fish remains |
| 1280-1290 | Even more chalky |
| 1290-1310 | Less chalky |
| 1310-1320 | More chalky, first <u>Globigerina</u> , here abundant |
| 1320-1350 | Less chalky |
| 1350-1360 | Shale, black and dark blue grey, some chalky marl |
| 1360-1380 | Fine sand and much biotite, some coarse angular sand, <u>Globigerina</u> |
| 1380-1400 | Considerable sandy light grey chalk with many <u>Globigerina</u> , a little volcanic ash, light green, blue grey chert fragments |
| 1400-1440 | Shale, blue grey, a little gypsum |

1450-1460 Limestone, clayey and silty, fine texture
 1460-1480 Sand, fine, and silt, light grey, Globigerina
 1500-1510 Sandstone, coarse, angular, with dark grey chert particles
 1510-1520 Shale, blue grey, some ironstone, brown
 1520-1690 Shale, very dark blue grey, with light grey siltstone laminae, bituminous, some fine sandstone, small particles either glauconite or green volcanic ash, fish fragments
 1690-1710 Shale, dark blue grey, with small amount of disseminated chalk, Globigerina
 1710-1740 Greenhorn limestone, light grey, many Inoceramus prisms, foraminifera, purer cream limestone, 1720'-40', fine powdery texture
 1740-1760 Graneros shale, dark blue grey, some small chalk spots, foraminifera
 1760-1810 Marl, chalky
 1810-1840 Bentonite, brown grey, impure, shale with small amount of chalk, Globigerina
 1840-2130 Shale, dark blue grey, minute chalk particles, bentonite, cream, 1860'-70', mudstone, purplish brown (perhaps ironstone), 1870'-80'
 2130-2140 Sandstone, grey, fine grained
 2160-2180 Muddy or Newcastle sandstone, light grey, fine grained, porous, carbonaceous, poorly sorted angular to sub-angular
 2190-2200 Sandstone, some reddish, cemented with chalcopyrite
 2210-2220 Shale, brown red and blue grey, Inoceramus
 2240-2250 Limestone, light brown, impure
 2250-2260 Shale with fish scales, bentonitic, brown, lavender, purple
 2280-2300 Some sandstone, grey
 2300-2310 Sandstone, light grey, fine grained, below which is shale, blue grey and purple
 2460-2461 A very little sandstone
 2461-2462 Shale more purplish than usual, selenite and satin spar
 2466-2467 Bentonite, light blue
 2490-2499 Shale, black, Inoceramus prisms, some purplish and blue grey, partially black below
 2513-2514 Shale, terra cotta and brown, bentonitic
 2514-2570 Occasional siltstone in the shale
 2570-2585 A little fine grey sandstone
 2585-2605 Dakota sandstone, grey and brown, fine, partly recrystallized, porous, angular to subangular
 2605-2650 Considerable shale, blue grey and brown grey
 2650-2684 Some grey sandstone
 2684-2686 Lignite, impure
 2692-2702 Lakota sandstone, grey, fine grained
 2710 Sandstone
 2756-2775 Sandstone, cream, coarser, medium to coarse grained, partly recrystallized, angular to subround, porous

2780 Sandstone, cream, finer, partly recrystallized
 2787-2805 Morrison clay, white, brown, grey, green grey, ben-
 tonitic at base, a few small chert pebbles
 2805-2825 Sandstone, cream, fine grained, porous
 2825-2855 Mudstone, brown, purple and yellow
 2855-2905 Sandstone, cream, limy cement
 2905-3027 Shale, dark blue grey, with sandstones, light grey
 or cream, fine grained, some clay, light green grey,
 silty, bentonitic, also brown, red and purple clay,
 some bentonite, green and grey, with scattered quartz
 grains. As usual in this sequence, extensive cavings
 make exact determinations difficult
 3027-3055 Sandstone, cream, fine grained, subround, poorly
 sorted, Unkpapa
 3055-3070 Sundance limestone, light and darker grey, small
 specks glauconite
 3070-3125 Siltstone, grey, with considerable glauconite
 3125-3130 Sandstone, cream, glauconitic
 3140-3145 Mudstone, dull green, bentonitic
 3145-3150 Sandstone, cream, fine grained, sparse glauconite
 3190-3200 Clay, terra cotta
 3200-3230 Siltstone, terra cotta and red brown
 3230-3240 Siltstone and fine sandstone, light red brown and
 cream
 3240-3375 Clay and siltstone, light green grey, bentonitic
 3375-3474 Sandstone, cream, fine grained
 3474-3478 Shale, green grey, dark grey and black
 3478-3500 Spearfish siltstone, salmon
 3500-3520 Anhydrite, white
 3520-3550 Anhydrite, white, cream and buff
 3550-3590 Mudstone, dark salmon
 3590-3640 Anhydrite
 3640-3670 Siltstone, red, and anhydrite
 3670-3720 Minnekahta dolomite, cream to buff, finely crystal-
 line, becomes pinkish limestone near base, some anhy-
 drite
 3720-3735 Opeche anhydrite, pink and buff, siltstone, lavender
 and purple
 3735-3780 Siltstone, purple and red brown
 3780-3800 Sandstone, cream, fine grained, siltstone, salmon
 3800-3820 Siltstone, salmon
 3830-3840 Sandstone, cream, fine grained
 3840-3850 Minnelusa limestone, cream, finely crystalline
 3850-3875 Sandstone, cream, fine grained, angular to subround,
 poorly sorted, some large grains, porous
 3875-3920 Shale, dark blue grey to black; may be cavings
 3920-3955 Sandstone, buff and salmon
 3955-3958 Siltstone, dark salmon
 3958-3965 A little chalcedony
 3965-4020 Anhydrite, light grey, partly pink
 4020-4050 Sandstone, cream, fine grained, non-limy cement
 4050-4055 Anhydrite, grey

4055-4065 Anhydrite, light grey, spotted, with large insoluble residue of sulphate
 4065-4078 Probably fine silica rock, with sponge spicules, some grey chert, anhydrite, light grey
 4078-4085 Anhydrite, white
 4085-4100 Anhydrite, white, faintly pink, fine sandstone and siltstone
 4100-4135 Anhydrite, grey, pink and salmon
 4135-4150 Sandstone, medium to fine grained, anhydrite cement
 4150-4165 Sandstone and siltstone, salmon, buff and cream, coarser below
 4165-4180 Anhydrite, cream and grey, in part sandy
 4180-4205 Anhydrite, grey, sandstone, cream and salmon
 4205-4210 Anhydrite, grey
 4210-4215 Anhydrite, brown grey
 4215-4220 Dolomite, light brown grey, sponge spicules
 4220-4225 Dolomite, light brown grey, very fine powdery or amorphous
 4225-4230 Sandstone, light grey to pink, fine grained, poorly sorted
 4230-4240 Dolomite, light brown grey, fine texture
 4240-4255 Sandstone, pink-spotted cream, cement dolomitic
 4255-4260 Anhydrite, white
 4260-4275 Dolomite, medium grey, anhydritic, dirty, fine grained, vuggy
 4275-4285 Anhydrite, sandstone, siltstone and dolomite
 4285-4290 Dolomite, medium to light grey, spotted
 4290-4315 Siltstone to fine sandstone, light grey
 4315-4340 Mostly anhydrite, perhaps partly grey dolomite
 4340-4345 Sandstone, light grey, fine grained
 4345-4350 Shale, black, shiny, bituminous, finely fissile, compact
 4350-4360 Dolomite, dark grey, sugary, with larger secondary crystals, some oil saturation, vuggy, fossil casts
 4360-4365 Dolomite, light and medium grey, sugary, quite vuggy, sandy and silty
 4365-4375 Dolomite, creamy buff, medium sized rhombs, fine powdery matrix of limestone, stylolitic, limestone, dove, finely crystalline
 4375-4395 Limestone, dove, lithographic, with calcite veins
 4395-4405 Dolomite, dove, fine powdery texture
 4405-4415 Anhydrite, light grey, spotted
 4415-4425 Sandstone, light grey, fine grained
 4425-4430 Anhydrite, light grey
 4430-4435 Anhydrite, light grey, and dolomite, light grey, vuggy
 4435-4440 Dolomite, anhydrite and sandstone, light grey
 4440-4450 Sandstone, light grey, fine grained, poorly sorted, angular to subround
 4450-4455 Shale, black, bituminous
 4455-4500 Dolomite, grey, brown grey, dove and dark, brown, fine powdery texture, chert, light blue, 4465'

4500-4515 Limestone, light grey and dark brown grey, fine texture, dolomite, calcite veins

4515-4520 Shale, black, if not cavings

4520-4530 Sandstone and siltstone, light grey, show of oil

4530-4535 Anhydrite, spotted white and light grey

4535-4540 Dolomite, light dove, fine sugary, vuggy, sponge spicules

4540-4550 Limestone, cream dove, lithographic, flaky

4550-4555 Sandstone, grey, porous, fine grained, subangular

4555-4566 Limestone, light dove grey, altered oolitic

4571-4575 Dolomite, finely crystalline, very vuggy

4575-4578 Sandstone, cream buff, fine grained, vuggy, porous

4578-4580 Limestone, light dove, lithographic, flaky

4580-4585 Dolomite, brown grey, partly limy, fine grained, with translucent chert

4585-4595 Dolomite, anhydritic, brown grey, with translucent chert

4595-4605 Limestone, cream, fine texture, silty and sandy below

4605-4615 Limestone, cream, silty, fine grained

4615-4625 Dolomite, cream, fine rhombic

4625-4630 Dolomite, pyritic (very small cubes), sandstone, pyritic, bentonite, light green and grey, siltstone, red, numerous large etched sand grains

4630-4652 Siltstone to fine sandstone, cream, subangular, poorly sorted, limy cement, pinkish below 4645', bentonite, bright green, flaky

4652-4655 Siltstone, mudstone and sandstone, lavender, brick red, brown

4655-4668 Same, some bentonitic laterite, some also purple, somewhat sandy

4668-4680 Sandstone, purple and maroon, clayey, bentonite, light green, sandy, limy cement, sand poorly sorted, subangular to subround, some etched, some large grains, a few carnelian grains

4680-4698 Clay, purplish, bentonitic, sandy, sandstone cream-splotched and purple, azurite

4698-4713 Some sponge spicules in purple clay, 4700'-10', small turgite nodules, largely clay, bentonitic, sandy, purple, small quartz and carnelian pebbles, malachite

4713-4735 Large amount of cream sandstone in purple clay, some yellow and brick red clay

4736-4760 Sand, cream and red, coarser, subangular, partly recrystallized

4760-4770 Chert, pebbles (?), light yellowish cream, translucent

4780-4790 Cavings

4790-4795 Sandstone, mostly pink, some cream

4795-4810 Chert, milky, sandstone, pink all sizes, non-round grains, etched, some recrystallized, chert pebbles, some apparently decomposed

4810-4865 Pahasapa (Madison) limestone, cream, lithographic, secondary calcite in vugs

4865-4875 Much pink-splotched secondary cavern filling of dolomite and calcite. Lost returns.

4875-4975 Lost returns

4975-4980 Pre-Cambrian granite, cored

19. AMERADA PETROLEUM CORP. RED EAGLE 1, Center NW. $\frac{1}{4}$ NW. $\frac{1}{4}$ NE. $\frac{1}{4}$, Sec. 25, T. 36 N., R. 48 W., Shannon County, 330' S. and 2310' W. of NE. corner Sec. 25. Altitude 3344' der-
rick floor.

- 0- 325' No cuttings. Niobrara and Carlile
 325- 330 Marl, dark blue grey, spotted with rather sparse chalk pellets, greywacke, bentonite, with biotite, phlogopite and a small amount of basic green mineral
 330- 360 Shale, dark blue grey, small flattened chalk particles, seams of lighter siltstone, chlorite, brown mica, fish remains
 360- 375 Same but less chalk
 385- 400 Globigerina, Inoceramus prisms, Textularia, shale, fine flaky, limy, bentonitic and silty
 400- 405 Shale, more chalky, bituminous, fish remains
 405- 415 Sandstone, medium size grains, abundant small chalk pellets and Globigerina, impure limestone, fish and Inoceramus prisms, top Greenhorn
 415- 440 Greenhorn limestone, light grey, impure, fine crystalline, many Globigerina and Inoceramus prisms, fish remains, white bentonite, 435'-40'
 440- 445 Foraminifera extraordinarily abundant, especially Globigerina
 445- 460 Graneros shale, dark blue grey, chalk spotted, Globigerina
 460- 465 Globigerina abundant, Inoceramus
 465- 470 Limestone, grey, fine texture
 510- 530 Less chalk spots in shale
 530- 555 Fish scales and Globigerina common, chalk spots more scattered
 555- 570 Some laminae of limy silt, many Globigerina, still chalky
 570- 580 Still less chalk
 580- 600 Very small chalk dots, shale, flaky, bentonitic, Globigerina, Inoceramus, fish remains
 600- 615 Limestone, light grey, fairly large crystals, some quite clayey, Inoceramus and fish
 615- 620 Sandstone, grey, dirty, fine grained, glauconitic, fish
 620- 655 Bentonite, white, probably layers of Inoceramus and fish fragment limestone interbedded with bentonitic shales carrying many small Inoceramus fragments
 655- 690 Inoceramus fragments scarcer, fish, shale, darker, quite bentonitic
 690- 750 Foraminifera scarce or lacking, dark grey shale, much bentonitic mud, no chalk
 750- 755 Sandstone, medium grained, grey, subangular, poorly sorted, pyrite and chalcopyrite cement
 755- 765 Sandstone, light brown grey, micaceous, ligniferous, part limy cement, medium grained

765- 785 Shale, dark blue grey, light brown iron carbonate
 concretion, 770'-75'
 785- 790 Sandstone, light grey, fine grained
 790- 800 Shale, dark blue grey, brown clay ironstone concre-
 tions, bentonitic
 805- 810 Iron carbonate, bentonitic, fine grained, light
 butternut brown
 810- 820 Sandstone, medium grained, subangular, pyrite
 cemented, chalcopyrite and bornite
 820- 840 Shale, dark blue grey
 840- 845 Siltstone, brown iron carbonate cement
 845- 860 Shale, blue grey
 860- 865 Lignite, very bituminous, coking
 865- 880 Shale, perhaps with sandstone interbeds
 880- 885 Sandstone, light brown grey, fine grained, bentonitic
 885- 890 Siltstone, light grey, sandy
 890- 905 Shale, sandy, blue grey
 905- 930 Sandstone, grey, dark chert and biotite particles,
 probably mostly shale
 930- 965 Shale with buff soft limestone
 965- 990 Shale, silvery grey (Mowry ?), bentonitic, soft
 990-1000 Sandstone, light grey, fine grained, micaceous,
 carbonaceous
 1015-1020 Concretions
 1020-1025 Siltstone, red brown
 1025-1035 Sandstone, light grey, quite fine grained, carbo-
 naceous, some unsorted and partly rounded, medium
 sized grains, 1030'-35'
 1035-1050 Bentonite, light grey drab, hardened
 1050-1055 Sandstone, coarse, subangular, lignite
 1055-1075 Shale, somewhat lighter grey than usual
 1075-1080 Red brown "rusty" beds, fish scales
 1090-1145 Clay ironstone concretions
 1145-1265 Shale, dark blue grey
 1265-1270 Shale, dark blue grey, silty, Globigerina
 1270-1300 Some shale, red brown
 1300-1345 Dakota sandstone, light grey, fine grained, mica-
 ceous, poorly sorted, subangular to subround
 1345-1350 Shale, dark blue grey
 1350-1363 Siltstone, brown and brown red
 1363-1400 Some sandstone
 1400-1440 Cavings
 1440-1450 Sandstone, medium grey, carbonaceous, micaceous,
 limy cement, fine grained
 1450-1465 Manganosiderite or rhodochrosite pellets in grey
 siltstone or very fine sandstone, somewhat bento-
 nitic, brown red mottled, bentonite, drab
 1465-1480 Fuson siltstone, purple and maroon, bentonite, drab,
 mottled, brown, red and yellow
 1480-1500 Siltstone and fine sandstone, grey and brown, ben-
 tonitic matrix

1505-1510 Sandstone, light grey, fine grained, porous, sub-
angular, poorly sorted, partly recrystallized

1510-1515 Shale, dark blue grey, fissile

1515-1525 Sandstone, like at 1505'-10'

1525-1545 Some sandstone, light brown

1545-1560 Shale and bentonite, lignitiferous

1560-1605 Bentonite beds, grey drab

1605-1610 Sandstone, light grey, medium grained, subangular
to subround, porous, pyrite cement

1610-1619 Lakota sandstone, large grains, some grit size,
some rose quartz, etched, angular to subround, some
recrystallized

1619 Lost circulation

1619-1625 Limestone, light yellow buff, amorphous, looks
like caliche

1625-1660 Sandstone, grey, fine to medium grains, etched,
subangular to subround, porous, marcasite, some
large grains, **non-sorted**, many grains recrystal-
lized, becomes coarser downwards, considerable
pyrite cement, 1642'

1660-1692 Grit, partly subround, etched, some rose and citrine
quartz grains, pyrite between grains

1692-1698 Bentonite, light leek green, silty

1698-1705 Cavings, some bentonite, drab, lavender, mottled
with red brown

1705-1744 Sandstone, cream, fine to medium grained, permeable,
some dolomitic cement, poorly sorted, subangular,
some grey chert grains, grades down into claystone,
light grey

1744 Morrison siltstone, mottled brown red, yellow
brown, purple, lavender, bentonitic

1745-1750 Bentonite, dove grey, silty

1750-1755 Siltstone, light brown grey

1755-1765 Bentonite, dove grey

1765-1770 Bentonite, dove grey, lavender and light green

1770-1775 Siltstone, light grey, bentonitic, light grey, fine
texture

1775-1780 Bentonite, light green grey and lilac

1780-1800 Bentonite, lavender, silty, with fine sand below

1800-1830 Sandstone, cream, fine grained, subangular, porous,
chert cement in part, denser below

1830-1835 Limestone, brown grey, sandy

1835-1845 Sandstone, orange mottled, fine grained

1845-1850 Sandstone, yellow, fine grained

1850-1855 Sundance bentonite, dull green, sandstone, glauco-
nitic, fine grained

1855-1860 Limestone, cream, amorphous

1860-1865 Cavings

1865-1870 Bentonite, splintery, dull green, grey and brown,
some limestone, brown, very fine and dense

1870-1880 Cavings

1880-1895 Sandstone, grey spotted, fine grained, some glauconite, minute pellets dull greasy dull green hydrous iron silicate

1895-1900 Bentonite, dark dull green

1900-1905 Bentonite, grey, silty

1905-1910 Clay, light green grey, bentonitic, silty

1910-1925 Bentonite, grey drab

1925-1930 Siltstone, light green grey, bentonitic, dove bentonite

1930-1935 Sandstone, light grey, fine grained, porous

1935-1940 Bentonite, lavender

1940-1960 No cuttings

1960-1970 Siltstone, light red brown, bipyramidal quartz

1970-1974 Sandstone, cream, fine grained, porous

1975-2000 Sandstone and siltstone, light red brown, porous, fine grained

2000-2065 Sandstone and siltstone, light green grey, small amount glauconite, bentonitic, a little coarser and less sorted in lower part

2065-2080 Siltstone, red brown

2080-2105 Sandstone, light grey, fine to coarse rounded and etched grains

2105-2140 Spearfish siltstone, dark brown red, micaceous, calcite crystals

2140-2150 Limestone, light brown grey, with larger calcite crystals and dogtooth spar, vuggy, coarse to fine texture

2150-2160 Siltstone, dull brown red

2160-2175 Siltstone with scattered etched rounded quartz grains, brown red

2175-2180 Siltstone, brown red

2180-2195 Limestone, cream to light brown grey, vuggy, much dogtooth spar, sandstone, fine, red brown

2195-2220 Limestone, light brown grey, vuggy, much dogtooth spar, crystalline

2220-2235 Anhydrite, white to blue

2235-2255 Limestone, grey (?), and red beds

2255-2260 Siltstone, red brown

2260-2270 Anhydrite, cream, pink-tinged

2270-2275 Siltstone, bright brown red

2275-2280 Anhydrite, cream brown

2280-2290 Sandstone, light grey green, some pink, silty

2290-2300 Anhydrite and brown red siltstone

2300-2310 Anhydrite, pink-splotched

2310-2340 Siltstone, bright salmon

2340-2345 Anhydrite

2345-2355 Minnekahta dolomite, pink buff, fine sugary

2355-2365 Limestone, pinkish buff, fine sugary, some yellow below 2360'

2365-2375 Dolomite, buff and yellow, pink stained, fine sugary

2375-2380 Limestone, light grey brown, small crystals, calcite veined

2380-2410 Opeche siltstone, brown, hard, dolomitic
 2410-2430 Siltstone and sandstone, brown red, splotched green
 grey
 2430-2440 Anhydrite, cream, with siltstone, light salmon,
 dolomite
 2440-2475 Anhydrite, cream, and blue, pink tinged
 2475-2500 Siltstone, dark salmon, calcite crystals
 2500-2505 Sandstone, dark salmon, medium grained, subround
 2505-2515 Siltstone, dark salmon
 2515-2530 Siltstone, maroon, micaceous, considerable medium
 grain, etched, subround sand
 2530-2535 Sandstone, cream
 2535-2560 Siltstone, sandy
 2560-2570 Sandstone, cream, fine to medium grained, subround,
 porous
 2570-2575 Sandstone, light pink, fine grained, porous, limy
 cement
 2575-2580 Siltstone, salmon, micaceous
 2580-2645 Sandstone and siltstone, salmon, fine grained, sub-
 angular to subround
 2640-2645 Siltstone, dark salmon
 2645-2650 Sandstone, buff, subangular grains, fine grained
 2650-2655 Sandstone and siltstone, salmon
 2655-2660 Sandstone, salmon, subround to subangular
 2660-2665 Sandstone and siltstone, salmon
 2665-2670 Siltstone and claystone, salmon
 2670-2680 Sandstone, salmon, fine grained
 2680-2715 Siltstone, dark salmon
 2715-2760 Sandstone, salmon, fine grained
 2760-2775 Sandstone, cream, fine grained
 2775-2780 Sandstone, salmon, fine grained
 2780-2785 Anhydrite, light brown grey
 2785-2795 Sandstone, pink, fine grained
 2795-2800 Siltstone, salmon
 2800-2805 Anhydrite, white and blue grey
 2805-2810 Dolomite, grey, fine sugary vuggy, shale, black,
 bituminous
 2810-2825 Dolomite, mixed with anhydrite, grey with small
 dark spots, porous
 2825-2835 Sandstone, medium grey, pink mottled, nonsorted,
 insoluble cement
 2835-2840 Quartzite, pink, fine to medium grained
 2840-2845 Anhydrite, light brown grey, fairly coarsely crys-
 talline
 2845-2850 Dolomite, grey, fine sugary, vuggy
 2850-2860 Dolomite, grey, with anhydrite, cream and light
 grey, fairly coarsely crystalline, fossils
 2860-2865 Limestone, grey, sugary, small rhombs, vuggy, fos-
 siliferous
 2865-2875 Anhydrite, limestone, dolomite, quartzite, red
 2875-2890 Sandstone, pink cream, medium grained, subangular
 to subround, etched, quartzite cement

2890-2895 Anhydrite, dolomitic, pink stained dove, fine texture

2895-2900 Anhydrite, cream

2900-2905 Siltstone, salmon, with light grey spots

2905-2910 Anhydrite, cream to light grey

2910-2945 Anhydrite, cream and light brown grey, well crystallized

2945-2955 Dolomite, dark grey, dirty, sugary, with secondary anhydrite, shale, black, bituminous

2955-2965 Anhydrite, cream and dove, sandstone, light grey, fine grained

2965-2975 Dolomite, dark grey, fine sugary

2975-2990 Anhydrite, cream and light dove

2990-3005 Limestone, dolomitic, cream, vuggy, altered oolites

3005-3010 Limestone, dolomitic, pink brown, fine texture

3010-3015 Limestone, dolomitic, light grey, fine texture

3015-3020 Limestone, dove grey, lithographic

3020-3025 Dolomite, brown grey, sugary

3025-3040 Anhydrite, cream grey

3040-3045 Limestone, grey and red brown, fine texture

3045-3050 Dolomite, light grey, pink tinged, sugary

3050-3055 Dolomite, light brown, small rhombic crystals

3055-3060 Dolomite, cream buff, medium sized rhombs

3060-3075 Dolomite, cream, buff, fine sugary, partly altered oolites, vuggy

3075-3080 Dolomite, light blue grey, fine powdery texture

3080-3105 Limestone, dove, lithographic, lavender tinged below 3090'

3105-3110 Limestone, dolomitic, cream, fine powdery texture

3110-3145 Dolomite, light grey, fine powdery texture

3145-3200 Dolomite, light grey, stained faintly pink, small rhombs, vuggy

3200-3205 Limestone, pink, medium sized crystals

3205-3215 Limestone, magnesian, cream, small rhombs and fine powdery, faint pink tinge, less magnesian in lower part

3215-3220 Limestone, light pink, sugary rhombic

3220-3225 Limestone, light pink, sugary rhombic, dolomitic

3225-3230 Dolomite, light pink, sugary rhombic

3230-3235 Limestone, cream, pink tinged, sugary rhombic

3235-3240 Limestone, light grey cream, fine powdery to fine rhombic

3240-3250 Limestone, medium grey, light green grey and lavender, bright green glauconite, small dolomite rhombs and quartzose silt

3250-3255 Limestone, cream, lithographic to fine crystalline

3255-3260 Dolomite, cream, fine rhombic

3260-3270 Limestone, cream, fossiliferous, altered oolites

3270-3275 Limestone, cream, fine powdery texture

3275-3285 Dolomite, cream, fine powdery texture, faint greenish tinge, some red laterite

3285-3290 Limestone, cream and brown grey, fine powdery, clay, sandy, red

3290-3295 Limestone, cream grey, sandy, fine powdery texture

3295-3305 Laterite, maroon and purple, with fine sand grains, some coarse rounded and etched sand, light green splotches, bentonite, sandy, bright light green

3305-3315 Sandstone, yellow and light grey

3315-3325 Sand, coated dark brown red grains, fine to medium to coarse grains, angular to subround, larger grains in matrix of vermillion clay

3325-3340 Sandstone, light buff, fine grained, dolomitic cement

3340-3345 Laterite, maroon, sandy

3345-3353 Dolomite, light yellow and grey, cavernous, fine sugary

3353-3358 Small nodules of dark grey and red hematite cementing sand grains, arkosic fragments of orthoclase, biotite and quartz

3358-3367 Pre-Cambrian granite, feldspar largely kaolinized, some albite, abundant biotite, some orthoclase and phlogopite, stained with turgite (hydrous hematite)

20. AMERADA PETROLEUM CORP. MILDRED VORHEES 1, SE. $\frac{1}{4}$ NE. $\frac{1}{4}$ SW. $\frac{1}{4}$,
 Sec. 25, T. 10 S., R. 8 E., Fall River County. Altitude 3332'.

- 0- 40' No cuttings
 40- 75 Chadron (lower White River) conglomerate, caliche-cemented, angular milky chert and quartz, black obsidian, silicified wood, selenite, satin spar, iron oxide nodules, red silts at base
 75- 380 Pierre bentonitic clay, blue grey with greenish tinge, small biotite and muscovite flakes, pyritized ammonites, locally **silty** and limy. Hauerite cements Inoceramus prisms at 150'-65'. Aragonite and cubical nodules of hauerite, 165'-80'. Psuedotetrahedral (sphenoidal) chalcopryrite in coxcomb marcasite and bentonite, 180'-95'. Tan clay ironstone below 225'. Shell fragments, 240'-60'. Clay ironstone, tan, 280'-300', with aragonite cone-in-cone there and lower down.
 380- 460 Sharon Springs shale, dark blue grey, bituminous, faintly chalky, fish remains
 460- 500 Niobrara marl, grey, with numerous small flattened chalk pellets, more chalk in lower part
 500- 520 Shale, very dark blue grey, bituminous, with small amount chalk pellets
 520- 630 Marl, grey, chalky, some oil staining, 580'-630'
 630- 660 Carlile shale, blue grey, small percentage minute chalk pellets
 660- 700 Globigerina marl, with chalk pellets and shell fragments, light grey
 700- 730 Shale, dark blue grey, considerable chalcopryrite, 720'-730'
 730- 740 Some limestone, light grey, very finely crystalline
 750- 790 Considerable claystone, yellow and crimson
 790- 830 Calcite, honey yellow and colorless, limestone, light blue grey, fine texture, probably septarian concretion zone
 810- 850 Considerable octahedral, nonworn magnetite, pyritized fossils
 850 Some small almandine garnets, dodecahedral, exceptional **abundance** pyrite, dark grey scoriaceous, amorphous substance, bornite, considerable chalcopryrite, Cristellaria
 860 Large fragment chalcedony, light blue white, cementing fine sands, grey fine silty limestone
 890 Some sandstone, grey, fine grained
 900- 910 Some blue grey chert or chalcedony, pyritized globular organisms, single and also in aggregates of much smaller spheres, Cristellaria, fish remains, red and yellow iron oxide fragments, vesicular slag, shell fragments, some pyritized, grey medium and angular **grained** sandstone with biotite and serpentine fragments, small Globigerina, Belemnitella

940- 950 Shale, very dark blue grey
 960- 980 Bornite and chalcopyrite, shale as just above
 990-1000 Shale, largely silty and chalky, blue grey
 1000-1040 Shale with small flakes of chalk, very dark blue grey
 1040-1050 Large piece of bornite, shale, dark blue grey,
 missing intervals above due to extensive caving
 1070-1100 Greenhorn limestone, light grey, impure, fish remains,
Globigerina and Inoceramus prisms, cement in part
 pyrite and chalcopyrite, limestone has coarse to
 fine crystals with calcite veins, numberless loose
Globigerina 1090'-1100'
 1100-1200 Graneros shale, dark blue grey, cavings suggest fine
 grained sandstone at base of Greenhorn. Some shale
 has interbedded sand laminae with a little serpen-
 tine and a few blebs of chalk
 1200-1220 Shale, very dark blue grey, Globigerina
 1220-1240 Shale, dark blue grey, very small chalk particles
 1240-1260 Shale, grey, with a silvery sheen, bornite, chalco-
 pyrite
 1260-1270 Bornite and black shale
 1270-1290 Perhaps a little grey fine grained sandstone, chal-
 copyrite
 1290-1390 Shale, black, some grey scoriaceous material, con-
 cretions and fish remains
 1390-1400 Clay ironstone, dark brown grey, medium crystals,
 magnetite
 1400-1420 Some magnetite
 1420-1440 Concretions more abundant
 1440-1480 Some sandstone, grey, coarse, angular, pyrite and
 chalcopyrite cements, abundant Inoceramus prisms
 1480-1520 Sandstone, light grey, fine grained, muscovitic,
 some bornite cemented. Coarse angular sandstone
 with rounded chert particles, pyrite cemented,
 large percentage of sulphides, including chalcopy-
 rite, as cement of sand and Inoceramus prisms
 1520-1550 Sandstone, very light grey, fine, angular grains,
 limy cement, muscovitic, coarser downwards, possibly
 black felsitic diabase, magnetic and fine grained,
 garnet rock, also magnetite. Some dark brown
 siderite cementing silt
 1550-1620 Shale, dark blue grey
 1620-1635 Muddy (Newcastle) sandstone, light grey, muscovi-
 tic, fine grained, angular, fine white powdery
 matrix, fish and small chert fragments. Resist-
 ivity log indicates probable sandstone from 1475'-
 1510' and 1530'-85'.
 1645 Some shale, silty, purplish
 1655-1680 Some sandstone, light grey, medium grained, shale,
 dark blue grey
 1680-1700 Shale, bentonitic, some lighter blue grey
 1700-1730 Some sand with garnet fragments

1730-1740 Some ironstone concretions
1740-1925 Shale, dark blue grey, flaky, concretions. Casing run to 1836'

1925-1960 Dakota sandstone, brown to grey, fine grained, angular to subangular, some medium sized grains and dark chert fragments, limy cement, some carbonaceous material. Sandstone abundant after circulating at 1951'

1960-1970 Sandstone, light grey, medium grained, angular grains, muscovitic, less cement than next above

1970-1995 Dark brown red magnetic iron oxide stone, some magnetite cemented sandstone, some jet (wood) fragments

1995-2000 Manganosiderite or rhodochrosite pellets, magnetic, crimson and brown, in varicolored bentonite matrix

2000-2020 Fuson clay and siltstone, terra cotta, varicolored bentonitic clay

2020-2025 Abundant lignite, some pyritized

2025-2040 Clay and shale, bentonitic, various shades of gray

2040-2045 Sandstone, light grey, medium grained, porous, angular grains, carbonaceous and muscovitic

2045-2065 Sandstone, partly cemented by pyrite and chalcopyrite

2065-2070 Mainly shale, dark blue grey, fissile

2070-2080 Lakota sandstone, light grey, largely fine grained

2080-2090 Sandstone, some pink and cherry red, ferruginous cement

2090-2100 Considerable lighter grey and green grey shale

2100-2105 Sandstone, light grey, very fine grained, micaceous

2105-2110 Bentonite, yellow and tan, some mottled red and crimson

2110-2150 Cavings: sandstone, shale, bentonite, some large etched sand grains

2150-2180 Grit size sandstone, etched angular grains, some citrine and rose, some recrystallized. Below 2165' increase in porosity, mostly loose grains, some rounded

2180-2190 Practically all grit. Base Lakota

2190-2195 Morrison, increase in bentonite

2195-2200 Limestone, cream, lithographic, and sandstone, cream, fine grained, limy cement, bentonite, light green and drab, iron and copper sulphide crystals, sand grains partly rounded, striated prism chalcite cementing sandstone

2200-2215 Bentonite light green, drab, light olive yellow, some fine sand grains

2215-2220 Limestone, cream, lithographic, containing sparse sand grains

2220-2250 Bentonite, somewhat darker than above, sparse sand grains, chalcopyrite

2250-2265 Limestone, light grey, lithographic, carbonized reeds

2265-2270 Clay, bentonitic, terra cotta, brown and drab, light green

- 2270-2275 Sandstone and lithographic limestone, light grey, bentonitic. Sandstone is fine grained with limy cement
- 2275-2280 Limestone, cream grey to drab, lithographic
- 2280-2285 Clay, terra cotta and lavender, bentonitic and sandy
- 2285-2295 Apparently most limestone as above but less pure. Some sandstone and bentonitic clay
- 2295-2305 Sandstone with limy or bentonitic matrix, fine grains scattered
- 2305-2310 Quartzite, cream to light pink, milky white opal cement. Angular medium sized quartz grains, some chlorite aggregates. Some porous loosely cemented sandstone. Matrix before silicification may have been bentonite. Many sand grains recrystallized
- 2310-2320 Sandstone, less cemented, grains recrystallized, coarse angular sandstone at base with some chalcopryrite, rose quartz grains, some quartzitic cement, some grains grit size
- 2320-2345 Cavings, miscellaneous shale, clay, **bentonite**, sandstone, coal, limestone, fissile shale containing sand grains, some light grey bentonitic clays
- 2345-2370 Sandstone and siltstone, light grey, very fine grained, limy cement, very small light mica flakes, chalcopryrite, 2360'-65' in prevalent siltstone
- 2370-2375 Limestone, lithographic, light brown grey, and bentonite and siltstone, lavender to brown, sandy, bornite
- 2375-2380 Sandstone, light grey, fine grained, small octahedrous magnetite, locally quartzite
- 2380-2385 More matrix than sand grains
- 2385-2390 Shale, dark blue grey, some silty
- 2390-2395 Sandstone, light grey, fine grained
- 2395-2405 Limestone, light grey, finely crystalline to powdery, sandy and some sandstone
- 2405-2410 Limestone, magnesian, light dove grey, with scattered small round and angular sand grains
- 2410-2415 Unkpapa sandstone, pink, angular, fine grained, some limy cement
- 2415-2420 Sandstone, both medium grey and pink, dolomitic cement, carbonaceous, partly recrystallized, apparently partly permeable, some light sea green sandy bentonite (caving?)
- 2420-2435 Sandstone, salmon, fine grained, angular and subangular, some larger grains, dolomite cement, fairly porous, matrix of red clay
- 2435-2495 Sandstone, salmon, with some cream, much mauve-colored and sea green sandy caving bentonite, etched sand grains, some pink sandstone; colors other than salmon in thin bands and streaks; coarser and less sorted in lower part

- 2495-2505 Sandstone, crimson splotched clay cementing the grains
2505-2515 Sundance limestone, light grey and white spotted, breccia of broken shell fragments cemented with finely crystalline white calcite, small elliptical to spherical concretionary brown calcite pellets, some bright green glauconite pellets in fine grained sandstone in lower part
- 2515-2520 Siltstone, light grey; small white mica flakes
2520-2535 Clay, silty and bentonitic, flaky, medium grey, with white mica flakes and diminutive "golf ball" pyritized, probably plant fruit, fossils
- 2535-2545 Sandstone, grey, fine grained, and siltstone, glauconitic, shale, grey, bentonitic; mostly sandstone, with more glauconite than higher up
- 2545-2575 Sandstone, light grey, fine grained, abundantly glauconitic, limy cement, angular grains, dark chert fragments, plant fragments, partly permeable, white mica flakes
- 2575-2615 Sandstone more abundant and permeable, less glauconite and finer below, thin darker grey silt laminae near base
- 2615-2635 Sandstone, fine grained; and siltstone, light salmon, small white mica flakes, silt a little darker and in fine laminae
- 2635-2670 Sandstone, cream, fine grained, porous, coarser than next above, some rose quartz
- 2670-2675 Siltstone, brown drab, limy cement
2675-2705 Sandstone, light grey, silty, very fine grained, limy cement, sparse glauconite, some dark green grey bentonite films increasing downwards
- 2705-2710 Mostly grey clay cavings of Morrison
2710-2725 Sandstone, lavender, medium grained, angular, porous, poorly sorted, many small and some large grains, etched, poorly rounded, limy cement. Downwards color becomes bright salmon, almost crimson. Recrystallized sand grains
- 2725-2745 Perhaps clay, light green, bentonitic, and siltstone in both, but much sandstone
- 2745-2765 Bentonite, brown drab, yellow, light green, clay with fine glauconitic sand laminae, possibly some light grey fine fossiliferous sandstone. Nearly all cavings, 2700-2790
- 2785-2815 Spearfish siltstone, dark brown red (dark salmon), mainly siltstone, striated twinned chalcocite in light drab caving bentonite at 2805-2810
- 2815-2860 Higher percent mudstone, dark salmon, with white leached spots, anhydrite veinlets
- 2860-2870 Anhydrite, fine crystalline, cream in part, mostly pink or red stained
- 2870-2880 Siltstone, as higher, white mica flakes
2880-2885 Sandstone, cream, coarse grained, rounded, etched, insoluble cement

2885-2900 Siltstone, bright brick red, light grey spots
2900-2985 Largely cavings but perhaps in red siltstone interbedded with anhydrite
2985-2990 Siltstone, red
2990-2995 Perhaps mostly anhydrite
2995-3015 Siltstone, bright brick red, with vein anhydrite or perhaps interbedded anhydrite. Splotches of anhydrite increase downwards and some of the siltstone has rounded and etched, partly large size, quartz grains
3015-3035 Increase in anhydrite apparently mixed with or interbedded with bright red siltstone, some fine sandstone with larger etched rounded grains
3035-3070 Siltstone and fine sandstone, dark salmon
3070-3075 Sandstone, cream, very fine grained
3075-3110 Minnekahta limestone, cream to pink, lithographic to fine crystalline, some bright green stain, anhydrite zone at top. Minute bornite crystals in limestone in upper 10'. Stained purple maroon at base where limestone is more coarsely crystalline
3110-3115 Opeche siltstone, dull maroon, compact, slightly dolomitic
3115-3120 Dolomite, dull maroon to grey, veined and splotched with anhydrite
3120-3130 Siltstone, lavender to light purple, dolomitic
3130-3145 Siltstone, purple, with anhydrite, small segregations of colorless and milky chert and red to deep orange jasper in anhydrite, some bright green either of a secondary copper, nickel or hydrous iron silicate mineral
3145-3160 Mostly cavings, but perhaps siltstone and fine sandstone, dull dark red
3160-3170 Anhydrite, white, and siltstone, dark salmon
3170-3210 Siltstone, dull dark red, with anhydrite containing dark salmon dots
3210-3225 Same with fine grained angular sandstone
3225-3235 Sandstone, cream, fine grained angular to subround
3235-3245 Siltstone, dark red and light brown
3245-3255 Minnelusa sandstone, cream to orange, poorly sorted, same etched grains fine to coarse, angular to subround, porous, feldspathic
3255-3265 Sandstone, cream, fine grained
3265-3300 Probably mainly siltstone, somewhat sandy, dull dark maroon red, perhaps with interbeds of buff to orange fine grained sandstone
3300-3305 Perhaps increase in sandstone
3305-3315 Sandstone, buff to orange, fine grained, permeable, angular
3315-3345 Siltstone, usual red color, white mica flakes some claystone, possibly a little dove lithographic limestone; mostly cavings
3345-3350 Sandstone, buff to reddish, fine, angular, porous, partly recrystallized grains

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| 3350-3365 | Siltstone, dark brown red, micaceous, scattered angular quartz grains at top |
| 3365-3380 | Sandstone, dull pink fine grained, somewhat silty, porous, partly recrystallized, lower part in part buff |
| 3380-3395 | Siltstone, dark brick red, with a little vein anhydrite |
| 3395-3425 | Sandstone, buff and pink, fine grained, a little coarser and all dull pink and micaceous below 3405, silty below 3420, a small amount of anhydrite |
| 3425-3440 | Siltstone, dark brick red, some fine pink sandstone, 3430-3435 |
| 3440-3450 | Anhydrite, cream, finely crystalline, with considerable alabaster |
| 3450-3485 | Anhydrite, light to dark brown grey, with milky chert and alabaster |
| 3485-3495 | Dolomite, grey, fine granular, intermixed with clayey anhydrite |
| 3495-3505 | Anhydrite and alabaster |
| 3505-3520 | Sandstone, pink and white, some large rounded etched grains in finer angular ones, dolomitic cement, considerable porosity, based by dove lithographic limestone |
| 3520-3525 | Anhydrite, grey, clayey |
| 3525-3535 | Dolomite, grey, earthy, sugary and vuggy, partly with larger crystals, giving a "porphyritic" texture |
| 3535-3540 | Dolomite, cream, semi-lithographic |
| 3540-3550 | Anhydrite, white and light pink, finely crystalline, with alabaster |
| 3550-3570 | Sandstone, lavender to white, mottled, quite fine and silty, micaceous, dolomite cement; the white is coarser and angular grained. In lower part mostly cream sandstone, with the mottled apparently at the top. Large grains rounded, poorly sorted, partly porous |
| 3570-3585 | Limestone, dolomitic, brown grey, sugary, vugs partly refilled, likely originally fossiliferous; becomes buff below; contains rare chalcopyrite and a little milky chert |
| 3585-3590 | Probably sandstone, cream, coarse to medium grained, poorly sorted, subround to subangular, porous, largely recrystallized grains |
| 3590-3595 | Sandstone, fine grained, light salmon, permeable, poorly sorted, subround to angular, spotted with cream |
| 3595-3615 | Dolomite, buff to pink, lithographic, anhydrite, pink, grey, white |
| 3615-3630 | Anhydrite, white and light grey |
| 3630-3640 | Sandstone, salmon, mostly medium grained, partly rounded, insoluble cement, poor sorting, some large size grains |
| 3640-3665 | Anhydrite, grey and white |

3665-3670 Dolomite, dark grey, deposited simultaneously with anhydrite particles

3670-3680 Sandstone, pink to red brown, poorly sorted, various size grains, dolomitic cement

3680-3700 Dolomite, dove, fine powdery texture, some pink staining, silty near base

3700-3710 Anhydrite, mostly white

3710-3725 Dolomite, cream to light grey, finely crystalline, dense, flaky, scattered larger crystals, originally fossiliferous

3725-3745 Dolomite, light pink, fine texture to lithographic

3745-3762 Dolomite, lavender, fine texture, with cream bands, powdery texture

3762-3775 Red marker, clay, magenta, finely colloidal and flocculent, laminated, shaly, with very fine white mica flakes, probably a caterite

3775-3780 Sandstone, cream to buff with faint green tinge, very fine grained, dolomitic cement

3780-3785 Shale, glossy black, very bituminous, compact

3785-3800 Dolomite, brown, fine sugary, some anhydrite splotches, slightly bituminous, considerable clayey matter, sponge spicules, white at base

3800-3805 Shale, black, very bituminous, grading at top to dolomite

3805-3810 Limestone, dolomitic, clayey and grey dolomitic siltstone, small dolomite rhombs in calcite matrix

3810-3815 Sandstone, light grey, very fine grained

3815-3820 Limestone, light grey brown, fine sugary

3820-3832 Limestone, dove, lithographic, flaky, dolomite, light cream grey, pink stained, fine sugary texture

3832-3840 Dolomite, light brownish grey, finely rhombic, somewhat vuggy

3840-3845 Sandstone, light grey, small scattered grains in dolomite matrix, possibly some red siltstone

3845-3850 Dolomite, light grey, fine powdery texture

3850-3860 Sandstone, light grey, fine and angular grains, dolomite cement, coarser and less sorted below. Large increase in magenta shale at 3855-3860 which may be caving, anhydrite at base

3860-3870 Sandstone, light grey and white

3870-3874 Siltstone, light grey, limy cement, very thinly laminated, resembles a natural cement rock

3874-3885 Sandstone, light cream grey, dolomitic cement, poorly sorted, fine to medium grained, subround and etched to angular grains

3885-3890 Shale, black, very bituminous

3890-3899 Sandstone, as at 3874-3885 with some chalcopyrite as cement

3899-3905 Dolomite, grey, very fine powdered sugar texture, clayey, vuggy, a little milky chert

3905-3920 Dolomite, dark blue grey, very clayey, fine texture, becomes lighter and purer below after passing through zone of sooty dolomite

3920-3945 Dolomite, buff, fine powdered sugar texture, with some limy dark blue grey shale, 3925-3930, vugs increasing in lower part

3945-3950 Dolomite, pink, fine grained vuggy, with large amount of dogtooth spar and some bipyramidal quartz in vugs, color produced by fine red clay

3950-3955 Sandstone, pink, fine grained, angular grains, porous

3955-3975 Dolomite, light grey, vuggy, fine grained to lithographic

3975-3980 Dolomite, pink, lavender and light grey, lithographic cavernous, with rhombic crystals coating vugs

3980-3985 Sandstone, light pink, small quartz grains scattered through dolomite matrix, vuggy

3984-3990 Dolomite, cream, with pink spots, fine texture with some coarser rhombs, vuggy

3990-4000 Dolomite, pink, fair sized rhombs with open spaces between

4000-4010 Dolomite, cream, fine powdery, full of solution holes

4010-4015 Dolomite, grey, fine rhombic to lithographic, vuggy, lighter grey below

4015-4025 Dolomite, cream, secondary calcite, containing some large etched subangular quartz grains

4025-4045 Sandstone and grit, white, grains angular, unassorted, limy cement, much recrystallized quartz or small quartz crystals

4045-4055 Same with brick red to lavender lateritic clay matrix

4055-4070 Sandstone, cream, medium and fine grained, limy cement, mostly angular grains, larger ones etched, glassy orthoclase (sanidine) fragments

4070-4075 Sandstone, conglomeratic, fragments of hydrated sericite schist, rose and citrine quartz grains

4075-4100 Laterite, sandy, and sandstone with laterite matrix, lavender, salmon and maroon, mottled light green grey and salmon sandy clay, feldspar and quartz fragments

4100-4110 Chert, light yellowish

4110-4120 Dolomite, cream, fine rhombic, very cavernous

4120-4125 Siltstone, cream and pink-lavender, dolomitic cement

4132-4142 Pre-Cambrian biotite-muscovite schist cut by graphic granite, at top with kaolinized feldspar and epidotized ferromagnesian minerals albite in perthite, large muscovite flakes, graphic granite contains light greenish yellow, either vanadium or uranium, mica

21. WOODWARD OIL COMPANY, GERTRUDE SCHMITT 5, Sec. 4, T. 12S,
R. 4E., Fall River County.

- 0- 60 Sand and fine gravel, weathered brownish tan Niobrara marl with chalk pellets, fragments of quartz, chert and selenite.
- 60- 90 Niobrara marl, grey, with flattened chalk pellets, Cristellaria, Globigerina.
- 90- 100 Somewhat purer chalk.
- 100- 120 Marl, blue grey, numerous flakes of phlogopite mica, many Globigerina, large amount of bentonitized volcanic ash, fish fragments. Transition between Niobrara and Carlile
- 120- 220 Carlile claystone, dark blue grey, micaceous and bentonitic, with small chalk pellets, notably at 140' to 150', somewhat silty, Globigerina and a few Inoceramus prisms. Chalcopyrite 210'-220'
- 220- 260 Sandstone, light grey, fine grained, angular, micaceous (phlogopite), very small amount glauconite, some dark grey chert grains, coarser at base
- 260- 310 Claystone, medium grey, silty, finely laminated layers of clay and silt
- 310- 320 Sandstone, grey, fine grained, interlaminated with siltstone
- 320- 440 Claystone and siltstone interlaminated, phlogopite, small specks of glauconite, Globigerina and a few Inoceramus prisms
- 440- 485 Shale, dark blue grey, with small chalky spots, interlaminated siltstone, Inoceramus prisms and Globigerina. Grades down into Greenhorn
- 485- 500 Greenhorn limestone, grey, composed of Globigerina and Inoceramus prisms
- 500- 530 Largely chalk-spotted dark grey marl, chalk decreasing downwards, some blue grey bentonite, numerous Inoceramus prisms and Globigerina
- 530- 940 Graneros shale, dark blue grey, darker and more compact than Carlile. Bentonitic, somewhat chalky, slakes easily, Chalcopyrite 580'-590'. Fish remains, somewhat bituminous, small flakes of white mica. Large admixture of bentonite below 650', also with interlaminae of quartzose silt. Below 800' the shale is dark blue grey and non-limy with very fine white mica flakes. Anomia at 840'-850'. Lighter blue grey below 850'.
- 940- 950 A little fine sandstone
- 950-1040 Shale, medium blue grey, finely micaceous
- 1040-1120 Muddy or Newcastle sandstone, light grey, fine grained, lignite fragments. Large flakes muscovite mica, some coarse angular grains of quartz and chert, fish remains, gas-producing, sandy bentonite with coarse sand grains at 1060'-70' with fine sand grains, 1085'-90'. Sandstone from 1090 to 1120', medium to coarse angular grains, very lignitic.

1120-1210 Thermopolis (Skull Creek) shale, blue grey and brown drab, bentonitic

1210-1220 Some sandstone, fine grained, muddy, dark grey, with small amount glauconite

1220-1310 Shale, dark blue grey, bentonitic

1310-1330 Dakota (Fall River) sandstone, light grey, medium grained, angular, considerable pyrite cement, a few larger, rounder grains

1330-1350 Shale (?) dark blue grey, silty, with sandstone as just above

1350-1360 Fuson manganosiderite or rhodochrosite pellet horizon (occurs in hole No. 4 at 1360'-1365')

1360-1420 Shale, dark blue grey, fissile

1420-1440 Sandstone, light grey, fine grained, some carbonaceous siltstone. Matrix of white bentonite, 1430'-1440'

1440-1450 Shale, as above

1450-1470 Loose sand, light grey, subrounded, etched, medium to coarse, some ashy bentonite

1470-1520 Shale as above, some dark bentonite

1520-1530 Minnewaste limestone, cream, very fine powdery texture, containing fine sand

1530-1560 Probably top Lakota sandstone, light grey, fine grained, angular. ChalcOPYrite; cuttings mainly shale (probably caving)

1560-1600 Sand, loose, medium to large grains, subround and etched, chalcOPYrite rather abundant at top

1600-1610 Sandy bentonite, light grey

1610-1650 Sandstone, light grey, fine grained, angular

1650-1660 Probably base Lakota sand, loose, medium to coarse, angular to subround, etched. Considerable chalcOPYrite. Some sand recrystallized

1660-1680 Cavings

1680-1690 Probably Morrison, cavings and lavender to brown yellow bentonite

1700-1710 Some drab bentonitic shale

1710-1740 Sandstone, Unkpapa (?), cream, fine grained, recrystallized. Likely the oil horizon in hole No. 4. Becoming **coarser** below, poorly sorted, permeable, some larger and more rounded etched grains

1740-1750 Sundance sandstone, grey, fine, glauconitic, light green bentonite

1750-1776 Siltstone, dark grey

1776-1796 Sandstone, light grey, fine grained, with small glauconite particles, bentonite, light lavender

1796-1802 Sandstone, medium grey, fine grained, quite glauconitic, a little dove fine textured limestone.

Camptonectes and Pachyteuthis

1823-1826 Sandstone, medium grey, fine, glauconitic, Pachyteuthis

1826-1832 Shale, blue grey, bentonitic, "golf ball" fossil, small black organic fragments

The section is continued downwards in cuttings from SCHMITT NO.4, 660' W. of E. line, 660' N. of S. line, Sec. 4, T. 12S, R. 4E.

- 1832-1870 Cavings of shale, a little loose sand and bentonite
1870-1880 Bentonite, light drab, with small sand grains in it, some light grey muscovitic siltstone and light green bentonite
- 1880-1920 Sundance sandstone, light grey, fine to medium grained, with light grey siltstone with minute particles of bright green glauconite, matrix is drab bentonite, also bentonite, light drab and green
- 1920-1980 Sandstone, light grey, small glauconite pellets, medium to fine grained, subangular, some light drab bentonite in the sandstone
- 1980-2050 Same, with grey and drab siltstone, bentonitic, small pyritized "golf ball" organisms, lavender and green pentinite, micaceous grey siltstone, Pachyteuthis (Belemnites) fragments at 2050'
- 2050-2060 Detrital (water-worn) bornite in fine sandstone
2060-2100 Sandstone, purple pink, fine, some dark maroon brown iron oxide stone, chalcopyrite, hauerite (?), glauconite more prevalent than higher up, molluscan fragments
- 2100-2110 Shale, drab, bentonitic
2110-2130 Sandstone, light grey and light green, small amount glauconite, cavings mostly dark brown grey bentonitic shale, also lavender, light grey and light green grey bentonite
- 2130-2160 Mostly as just above, some sandstone, 2130'-2140'
2160-2180 Sandstone, brown red, Pachyteuthis, also sandstone, light grey, interlaminated with dull brown red, some lavender, fine to medium grained, some dark brown fine chert particles, some small light green bentonite balls in the glauconite sandstone
- 2180-2190 Some siltstone, dark grey, with larger darker green glauconite nodules, sandstone as just above, light grey bentonite full of biotite flakes
- 2190-2290 Spearfish mainly siltstone, salmon, sandstone, dark brown red, locally leached white, a little anhydrite, white
- 2290-2320 Almost all cavings
2320-2340 Anhydrite, white and light pink, much cavings
2340-2390 Siltstone, dark salmon, some red fine sandstone, locally bleached white
- 2390-2440 Minnekahta limestone, white, light grey and light pink, very fine powdery texture, top likely at 2395'
- 2440-2460 Opeche siltstone, lavender and purplish
2460-2490 Siltstone, salmon, some grey medium grained sandstone
- 2490-2500 Probably Minnelusa sandstone, silty, pink to lavender and medium red, fine grained with some larger, poorly sorted, siltstone, clayey, red

2500-2510 Some sandstone, light grey, coarse, angular
 2510-2520 Sandstone, pink, unsorted, fine to coarse, angular
 to subangular, porous, also grit in a red clay matrix,
 brown drilling mud
 2520-2550 Cavings
 2550-2560 Perhaps some very fine light grey dolomite
 2560-2600 Sandstone, light grey poorly sorted, considerable
 coarse angular grains
 2600-2670 Besides usual cavings of Fuson and Sundance there
 is coarse light grey sandstone, and very fine grained
 carbonate rock, the coarse grained angular light grey
 sandstone contains dark brownish chert particles,
 large frosted grains in bluish white matrix
 2670-2690 Some anhydrite, white
 2690-2730 Dolomite, light grey, mainly anhydrite, white
 2730-2760 Anhydrite and sandstone, light grey, medium grained,
 porous
 2760-2770 Limestone, dolomitic, and dolomite, light grey,
 finely crystalline, vuggy, some milky chert
 2770-2820 Anhydrite, white, finely crystalline
 2820-2850 Dolomite, light brown grey cream, fine grained, per-
 haps some anhydrite
 2850-2860 Anhydrite, white, and sandstone, light grey, medium
 to coarse, subround to subangular, some frosted
 grains
 2860-2880 Sandstone, light grey and salmon, medium to fine, an-
 hydrite, white and probably siltstone, salmon
 2880-2910 Anhydrite, white
 2910-2915 Dolomite, light brown finely crystalline, spotted
 with white anhydrite
 2915-2920 Dolomite, light brown, fine rhombic
 2924 Dolomite, light brown, perhaps some buff fine grained
 sandstone
 2925-2950 Sandstone, cream, medium grained, porous
 2950-2960 Dolomite, light brown grey, fine sugary
 2960-2970 Anhydrite
 2970-2980 Dolomite, medium grey, finely crystalline, secondary
 veins, small vugs
 2980-2990 Increase in anhydrite, with stylolitic dolomite
 2990-3015 Dolomite, as above, mixed with considerable anhydrite
 3015-3025 Siltstone, sandy, dark purplish red
 3025-3030 Limestone, light grey, fine powdery texture, some
 very vuggy, secondary calcite
 3030-3035 Considerable dog tooth spar crystals, beginning at
 3025'
 3035-3055 Dolomite, very spongy and cavernous, light grey
 travertine-like, many dog tooth spar crystals,
 small to fairly large, some clustered, some per-
 fect scalenohedrons, some attached to very black,
 very fissile manganiferous shale and to salmon and
 scarlet residual clay. The solution zone perhaps
 extends from 3025' to 3080'.

3055-3080 Dolomite, medium and light grey, fine powdery,
 vuggy, dog tooth spar
 3080-3085 Anhydrite and dolomite
 3085-3090 Anhydrite more prevalent
 3090-3095 Anhydrite and brown grey fine textured dolomite
 3095-3100 Shale, black, bituminous
 3100-3105 Sandstone, light pink, medium to coarse grained,
 porous, subangular to subround, limy cement
 3105-3115 Cavings mostly, possibly salmon siltstone
 3115-3135 Dolomite, light grey, very fine powdery texture,
 some milky chert, sandstone, purple, brown, yellow,
 dolomite grades down into limestone, light brown
 grey
 3135-3145 Dolomite, dark grey, finely crystalline
 3145-3155 Dolomite, grey, very fine texture, silty, lighter
 grey beneath, secondary vein anhydrite
 3155-3170 Possibly sandstone and siltstone, grey, purplish
 and lavender, unsorted, poorly cemented sandstone
 3170-3175 Considerable coarse sand, bipyramidal quartz crystals,
 considerable secondary calcite but mostly cavings
 which may be cavernfill since here circulation and
 hole were lost. There is some chalcopyrite

There is exceptionally large amount of sandstone in
 all the Cretaceous formations.

22. MORTON DRILLING CO. and WOODWARD. GOVERNMENT NO. 1, Sec. 4,
T. 10S, R. 4E. Fall River County

(cuttings are very poor, owing to large amount of
cavings)

- 0- 60 Graneros shale, drab and blue grey, Mowry facies,
hard, fish scales
- 60- 80 Shale, blue grey, soft slaking bentonitic
- 80- 110 Sandstone, light grey, fine grained, insoluble cement,
marcosite nodules, flakes of muscovite, plant frag-
ments, chlorite and numerous heavy mineral grains,
pyritized "golf ball" fossils (plant fruit?)
- 110- 140 Shale, blue grey, with grey and white bentonite
- 140- 170 Shale, bentonitic, considerable sandstone, not cemented,
somewhat coarser than above but still fine grained,
fish, plant and shell fragments
- 170- 190 Large sized quartz and flint sand size grains in silty
matrix
- 190- 220 Some tan clay ironstone concretions, brown and grey
sandstone, angular, unsorted grains, clayey
- 220- 230 Sandstone, light grey, medium grained, angular, porous
larger grains subrounded and etched, hardened ben-
tonite, grey, lavender, light green
- 230- 250 Considerable clay ironstone
- 250- 280 Quartzite, grey, and sandstone, brown
- 280- 300 Limestone, light grey, fine textured, sandy
- 300- 350 Interlaminated fine sandstone and shale, grey, ben-
tonite, slaking, chalcopryrite and Inoceramus prisms
- 350- 360 Shale, dark blue grey, mostly bentonite, slaking
rapidly in water, some sandy and sandstone at top
with a little glauconite
- 360- 430 Some chalcopryrite and Inoceramus prisms
- 440- 470 Fall River (Dakota) sandstone, grey, fine grained,
some pyrite cemented, angular, carbonaceous
- 470- 480 Fuson siltstone, dark reddish brown, abundant brown
rhodochrosite or manganosiderite pellets about size
of medium sand grains and soluble in concentrated hy-
drochloric acid; their matrix is mainly brown and
grey somewhat silty bentonite
- 500- 510 Bentonite, grey drab
- 510- 520 Lignite, dirty, with much marcasite replacing wood
- 520- 540 Sandstone, light grey, fine grained, angular, some
larger partly rounded etched grains, laminated and
carbonaceous
- 540- 560 Sandstone, clayey, fine to coarse, poorly sorted,
partly recrystallized
- 560- 570 Bentonite, hard, brittle, containing small angular
sand grains, light green grey and light cream
- 575- 580 Sandstone, cream, fine grained, angular, with some
coarse round grains, matrix of white bentonite

580- 600 Mostly bentonite, light grey
600- 630 Mostly bentonite, light grey and lavender, sandy,
partly rounded sand grains
630- 650 Increase in sand
650- 660 Bentonite, grey and lavender
660- 680 Mostly sand, some coarse, etched, partly rounded
680- 690 Increase in sand
690- 730 Lakota (?) sandstone, light grey, fine grained, an-
gular, perhaps contains small particles of chlorite
(at least some clear green mineral grains)
730- 740 Clay, grey, bentonitic, with some light grey sand-
stone
740- 760 Bentonite, grey, full of small sand grains
760- 770 Sandstone, light grey, fine to medium grained, an-
gular
770- 790 Minnewaste (?) limestone, light grey, finely crystal-
line, sandy
790- 800 Sandstone, light grey, very fine grained
800- 840(?) Bentonite, light drab, silty and sandy, with numerous
dark grey and drab ostracods
840- 860 Unkpapa (?) sandstone, light grey, fine grained,
micaceous
860- 870 Shale, dark grey, very thinly laminated, some brown
bituminous, fish remains, chalcopyrite or bornite
870- 920 Sandstone, light grey, fine grained, angular, car-
bonaceous
920- 930 Bentonite, whitish, sandy
930- 940 Siltstone, grey
940- 990 Unkpapa (?) sandstone, white to buff, permeable,
fine grained, angular, partly recrystallized
990-1000 Limestone, light grey, dull, amorphous
1000-1010 Bentonite, light grey, sandy
1010-1040 Limestone, light grey, containing many coarse rounded
and etched sand grains
1040-1080 Sandstone, light grey, fine grained, and siltstone,
light grey, bentonitic
1080-1100 Sundance siltstone, light grey, glauconitic
1110 Chalcopyrite
1140-1160 Pachyteuthis
1160-1215 Sandstone, grey, fine grained, glauconitic, porous
1215-1220 Sandstone, cream, fine grained
1220-1250 Siltstone, red brown, sandy
1250-1270 Bentonite, green, grey and lavender (cavings?)
1270 Pachyteuthis and "golf ball" fossil (much caving
1270-1310)
1310-1350 Sandstone, cream, fine grained, glauconitic, some
greyish with more glauconite
1350-1410 Sandstone, light grey, fine grained, glauconitic, limy
cement
1410-1440 Limestone, medium grey, finely crystalline
1440-1490 Sandstone, light brown grey, fine grained, limy and
silty

1490-1520 Siltstone, brown, bentonitic
 1520-1550 Sandstone, cream, fine grained, angular, porous,
 some etched and medium rounded grains
 1550-1580 Spearfish siltstone, dark salmon, sandy
 1580-1590 Anhydrite, cream, some faint pink
 1590-1610 Siltstone, dark salmon, sandy
 1610-1630 Anhydrite
 1630-1680 Siltstone, dark salmon, with small spots of anhydrite,
 sandy
 1680-1715 Anhydrite, pink stained, with some very fine and
 dense dolomite in lower part
 1715-1770 Siltstone, dark salmon, small sparse sand grains
 1770-1785 Largely sandstone, light salmon, fine grained
 1785-1790 Minnekahta limestone, buff, magnesian, very fine
 sugary
 1790-1830 Limestone, light grey, lavender stained, fine sugary,
 may contain some anhydrite, darker lavender in
 lower part
 1830-1850 Opeche siltstone, dull lavender, and some purple
 claystone
 1850-1860 Some milky chert and anhydrite, rather coarsely
 crystalline
 1860-1880 Siltstone, maroon
 1880-1890 Mudstone, dark salmon, containing a few sand grains,
 some sandstone and siltstone
 1890-1895 Anhydrite and sandstone, light brownish red, fine
 grained
 1895-1910 Sandstone, light brown red, mostly angular, fine
 grained
 1910-1920 Sandstone, pinkish buff, mostly angular, fine
 grained
 1920-1950 Siltstone, dark salmon, with some fine orange sand-
 stone
 1950-1980 Sandstone, light salmon, fine grained
 1980-2000 Claystone and fine grained sandstone, dark salmon
 2000-2030 Minnelusa sandstone, light brown red, poorly sorted,
 subround grains, a little coarser than that above
 2030-2040 Limestone (?) fine grained, light grey, sandy, some
 oolitic
 2040-2070 Anhydrite
 2070-2090 Dolomite, light brown grey, fine sugary
 2090-2100 Sandstone, cream, fine to medium grained, poorly
 sorted, partly subround
 2100-2110 Limestone, magnesian, light brown grey, sugary and
 vuggy
 2110-2120 Dolomite, light grey, dense, with numerous white
 sponge spicules
 2120-2140 Limestone, magnesian, light brown grey, sugary and
 vuggy
 2140-2150 Sandstone, cream, fine to medium grained, poorly
 sorted, some subround grains

2150-2160 Limestone, magnesian, light grey, fine grained
 2160-2220 Anhydrite
 2220-2230 Sandstone, light grey, fine to medium grained,
 poorly sorted
 2230-2250 Limestone, light grey, fine texture
 2250-2260 Anhydrite
 2260-2290 Dolomite and magnesian limestone, light brown grey,
 sugary and vuggy
 2290 Sandstone, grey, fine to medium, partly rounded
 and etched
 2300-2330 Cavings
 2330-2390 Apparently dolomite, brown grey, probably some anhy-
 drite and sandstone, obscured by cavings
 2390-2410 A little light grey translucent chert in dolomite (?)
 2410-2420 Probably anhydrite
 2420-2440 Dolomite, grey, fine sugary, some apparently sandy
 2440-2450 Shale, black, bituminous, with very fine mica flakes
 2450-2460 Sandstone, grey, fine angular grained
 2460-2500 Dolomite, grey, fine sugary, dense, flaky
 2500-2520 Limestone, dolomitic, light brown grey, fine dense,
 with vein anhydrite
 2520-2530 Same, with milky chert
 2530-2550 Anhydrite, grey
 2550-2580 Limestone, dolomitic, medium grey, fine sugary,
 sandy at base
 2580-2600 Anhydrite and sandstone, light grey
 2600-2610 Limestone, dolomitic, grey, sandy
 2610-2620 Sandstone, light grey, fine grained
 2620-2650 Anhydrite, sandstone, white, dolomite, light grey,
 fine grained, dense
 2650-2690 Sandstone, light grey to buff, fine grained, per-
 meable, limy cement
 2690-2700 Anhydrite and dolomite
 2700-2710 Limestone, light grey, fine texture
 2710-2730 Anhydrite and dolomite
 2730-2800 Laterite, lavender and purple, clayey and sandy,
 some tan and brown, some with light grey spots.
 Some red and yellow jasper pebbles at 2760-2770, con-
 siderable anhydrite, pink and grey, at 2790-2800,
 brachiopods
 2800-2810 Sandstone, cream, medium grained, recrystallized
 grains fairly well rounded and polished to subangu-
 lar
 2810-2820 Large amount of coarse, subround etched sand grains,
 red coated, together with finer angular grains in a
 friable sandstone
 2820-2870 Madison (Pahasapa) limestone, white, fine powdered
 sugar texture, stained pinkish by weathering, oolitic.
 Becomes coarser crystalline in lower part
 2870-2880 Limestone, light creamy white, dense, dull porcell-
 aneous
 2880-2890 Limestone, pink, fine grained

2890-3000 Limestone, light creamy white, dense, dull porcell-
aneous. Stylolites with turgite residues, flaky
fracture, locally with larger crystals, altered
oolites and dogtooth spar in vugs. Some milky chert
at 2920.

3004 Total depth.