SOME FACTORS AFFECTING THE SEDIMENTATION OF THE DAKOTA SANDSTONE, OF THE SOUTHWEST POWDER RIVER BASIN, WYOMING, AND THE RELATIONSHIP BETWEEN STRUCTURE, SEDIMENTATION AND OIL ACCUMULATION

by

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INTRODUCTION

Scope of Investigation

The objectives of the study of the Dakota sandstone in the southwest Powder River Basin were: (1) to determine some of the environmental and tectonic factors affecting the deposition of the Dakota sandstone throughout the area; (2) to determine an indicated relationship between the texture and the permeability of the sand; (3) to analyse the mineralogy of the Dakota for a possible relationship to petroleum accumulation; and (4) to indicate the relative influence of sedimentation and structure on the accumulation of oil in the Dakota sandstone of the southwest Powder River Basin. These objectives were accomplished by the preparation of isopach, isolith, and lithofacies maps, and a size analysis and a petrographic analysis of representative samples of the Dakota sandstone.

Area Covered by This Investigation

The area included in this study is shown in Plate I. It is located in a large, asymmetrical, structural basin known as the Powder River Basin that lies on the eastern flank of the Rocky Mountains. The Powder River Basin is bounded by the Big Horn Mountains and Powder River uplift on the west, the Black Hills and associated folding to the north on the east, the Casper Mountain and Hartville uplift on the south and southeast, and the Bull Mountain syncline, in central Montana, on the north. Although confined to the southwestern portion of the Powder River Basin the area covered by this study embraces approximately 100,000 square miles in parts of Converse, Natrona, and Johnson counties, Wyoming.

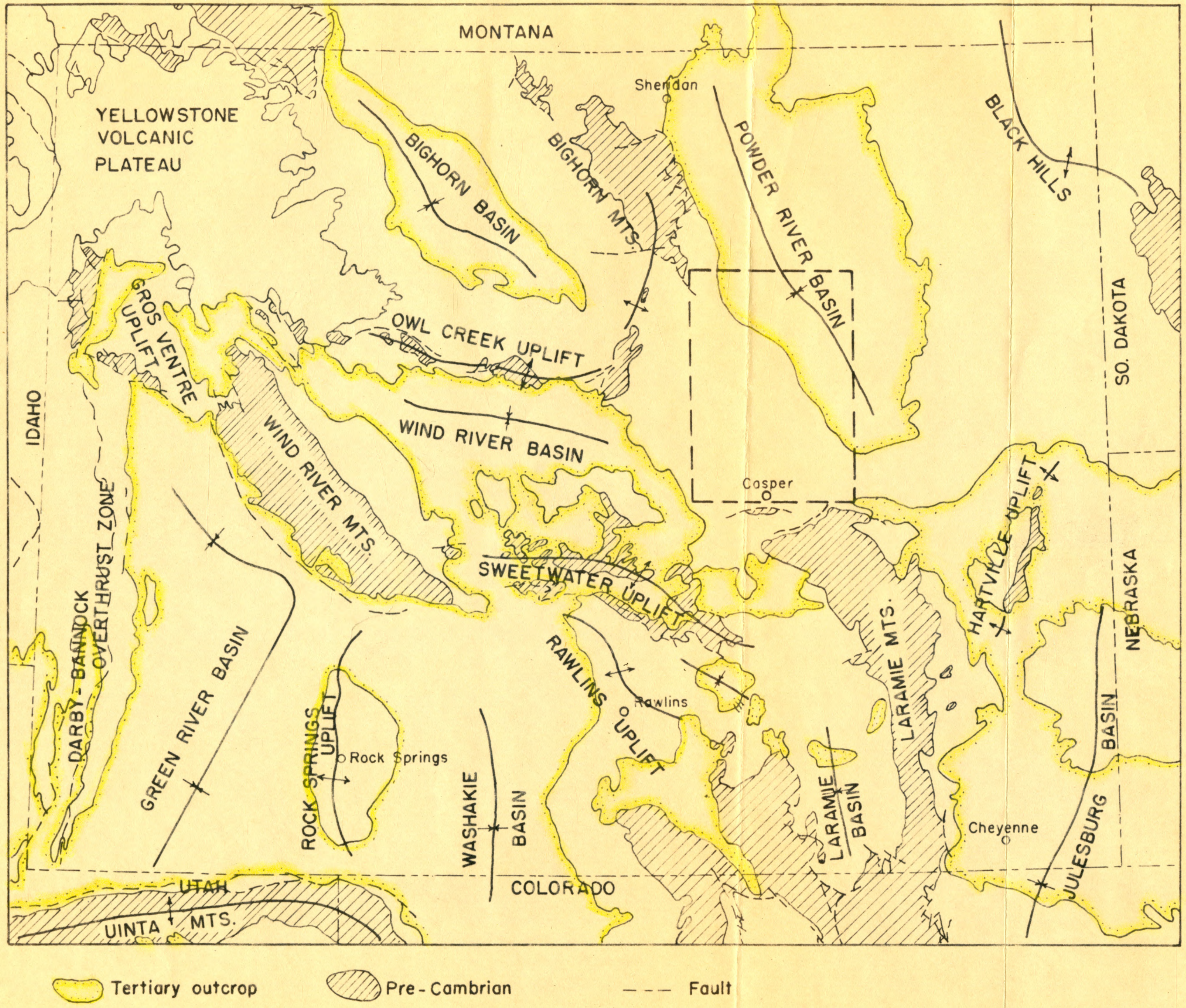
Nomenclature of the Lower Cretaceous

In the Black Hills the Dakota sandstone is the uppermost unit of the Dakota group. The Dakota group from bottom to top consists of three formations: Lakota, Fuson and Dakota. The basal Lakota unit which is predominately a hard, gray, massive, coarse grained, and crossbedded sandstone is generally conglomeratic and makes a sharp contact with the subjacent Jurassic Morrison formation. Lying conformably between the massive Lakota and Dakota sandstones is the Fuson formation which is principally a unit of varicolored shales and thin bedded sandstones. The upper formation, the Dakota sandstone, is predominately a brown, iron stained sandstone interbedded with shale. The lower portion is generally more massive and less argillaceous than the upper portion. It varies in thickness from 70 to 160 feet and makes a gradational contact with the overlying Colorado group (Darton 5).

The Coverly group was defined by Darton (4) at extensive exposures near Cloverly, Wyoming, as the beds subjacent to the Colorado group and superjacent to the Jurassic Morrison formation. Though the Dakota sandstone at the type locality was

EXPLANATION OF PLATE, I

Map of Wyoming, with heavy dashed lines showing the relationship of the thesis area to the intermontane basins and present uplift areas (18).


MONTANA
YELLOWSTONE
VOLCANIC
PLATEAU
Sheridan
BIGHORN BASIN
BIGHORN MTS.
POWDER RIVER BASIN
BLACK HILLS
GROS VENTRE
UPLIFT
OWL CREEK UPLIFT
SO. DAKOTA
IDAHO
WIND RIVER BASIN
WIND RIVER MTS.
Casper
HARTVILLE UPLIFT
DARBY - BANNOCK
OVERTHRUST ZONE
SWEETWATER UPLIFT
NEBRASKA
GREEN RIVER BASIN
RAWLINS
UPLIFT
Rawlins
LARAMIE MTS.
ROCK SPRINGS
UPLIFT
Rock Springs
WASHAKIE
BASIN
LARAMIE
BASIN
JULESBURG
BASIN
Cheyenne
UTAH
COLORADO
UINTA MTS.
Tertiary outcrop
Pre-Cambrian
Fault

present only as a varicolored shale it was correlated as being equivalent to the Dakota sandstone of the Black Hills. The Dakota sandstone, of this report, is considered to be the upper formation of the Cloverly group.

According to George R. Downs (6):

> In the western part of the Powder River Basin the Cloverly formation forms the lower portion of the Lower Cretaceous. The Cloverly closely resembles the Lakota, Fuson and Dakota of the Black Hills, but the threefold division is not as distinct and the lithology and thickness more variable than in the latter area.

Recent studies by Reeside (14) have indicated, by fossil evidence, that the boundary between lower and upper Cretaceous should be drawn at the base of the Muddy sandstone, or at the top of the soft, light gray Thermopolis shale, instead of at the top of the Dakota sandstone as previous work has indicated.

Dakota Sandstone--At its outcrop on the Tisdale anticline 15 miles west of Teapot dome, the Dakota sandstone consists of a 14 foot bed of shaley sandstone, the upper layers of which are strongly ripple marked. This bed, though comparatively thin, is found at many places throughout the region and appears to be of wide aerial extent (Wegeman 20). Subsurface studies indicate that it is a highly variable lithologic unit. The predominant gross lithologic aspect in the southwest Powder River Basin is a sandy shale (Plate IV). A sandstone phase is concentrated along a northwest-southeast trend in the south central portion of the study area. The total thickness of the Dakota unit varies from 30 feet on the west to 70 feet on the southeast side of the area.

A typical stratigraphic section penetrated by a bore hole in the southwest Powder River Basin is illustrated in Plate II. Although the illustrated section does not compare with the outcrop section described above, it does resemble the Dakota group of the Black Hills.

METHOD OF STUDY

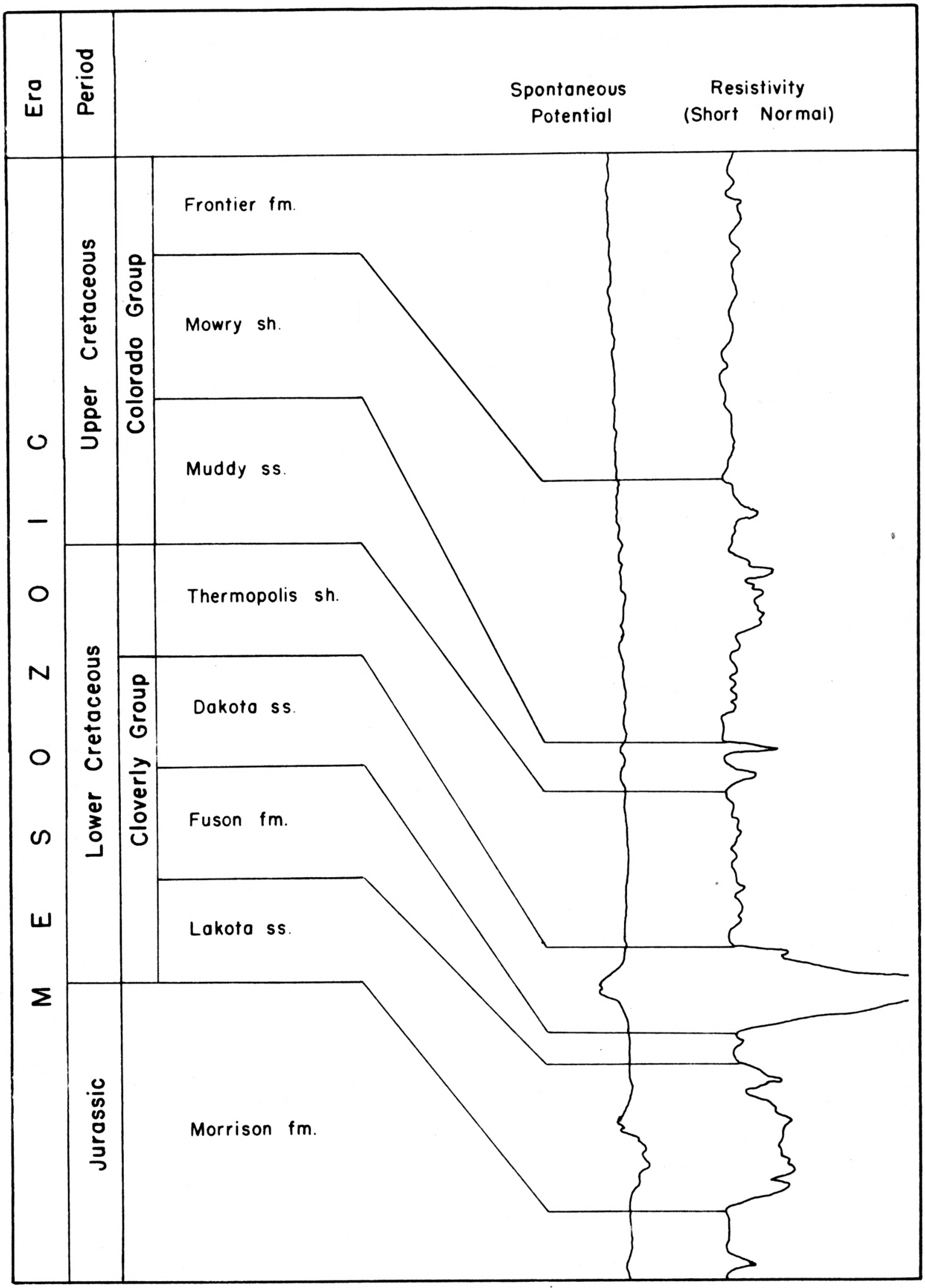
The data used in the construction of the isopach, isolith and lithofacies maps accompanying this report was compiled from the electrical logs of 141 wells supplemented by 27 ligholological logs and 35 cored intervals. The use of electrical logs as a means of studying the subsurface is a relatively new practice; therefore, a brief discussion of the principals and methods of electric interpretation will be given.

Electrical Log

An electric log commonly consists of four curves: a spontaneous potential curve recorded to the left of a center line and three resistivity curves recorded to the right. The spontaneous potential curve indicates the relative permeability of the traversed formations; the three resistivity curves indicate formation boundaries and provide data to evaluate the fluid content of the formations. The three resistivity curves in use at the present time are called the short normal, the long normal and the lateral.

EXPLANATION OF PLATE, II

Diagram, showing the formations that overlie and underlie the Dakota sandstone. Adapted from the electrical log of Phillips Petroleums No. 1 McNeil, in the Glenrock area.


Era
Period
Spontaneous Potential
Resistivity (Short Normal)
M E S O Z O I C
Upper Cretaceous
Lower Cretaceous
Jurassic
Colorado Group
Cloverly Group
Frontier fm.
Mowry sh.
Muddy ss.
Thermopolis sh.
Dakota ss.
Fuson fm.
Lakota ss.
Morrison fm.

The spontaneous potential anomalies in a bore hole are due primarily to the natural electromotive forces generated by two different electrial phenomena. The first is the electrochemical cell formed between the drilling fluid, the fluid in the permeable zone, and the shale surrounding the permeable zone. The second is the electrokinetic or streaming potential which is caused by the invasion of the drilling fluid into the permeable zone.

Whether their origin be electrochemical or electrokinetic the electromotive forces give rise to a current, which flows through the permeable layers, then spreads into the impervious formations, and returns to the mud filling in the hole. The current returning to the hole is measured by an electrical device and is recorded on the electrical log as the spontaneous potential curve.

The characteristics and amplitude of the spontaneous curve depended on several factors: the salinity of the drilling fluid and formation fluid, the resistivity of the superjacent and subjacent formations, the bed thickness, the hole diameter, the amount of shaley material in the permeable zone, and the depth of invasion by the drilling fluid.

The spontaneous potential was interpreted by its behavior with respect to the shale base line, generally a reasonably straight line that was parallel, close, and to the left of the center line on the electrical log. Permeable sections were indicated by deflections to the left of the shale base line. Impermeable sections were expressed by the shale base line or by deflections toward the shale base line. The spontaneous potential curve is a guide to the lithology provided that the unit under study is a sandstone or a sand-shale sequence by discriminating relative permeability.

The resistivity curves recorded the resistance of a volume of a rock cube one meter on each side. The curves differed in the spacing and arrangement of the electrodes which determined the depth of penetration and the direction of flow of the induced current. The two normal curves were symmetrical devices that recorded the same reading regardless of the direction of travel; short and long were prefixes to denote the relative spacing and depth of penetration of the curves. The normal curves provided the best definition of bed boundaries. The lateral curve was the deep penetration curve, a nonsymmetrical device that was influenced by the direction of travel. It largely nullified the effect of the infiltration of drilling fluid.

Because of various factors such as bed thickness, electrode spacing, bore hole diameter, and drilling fluid resistivity, the resistivity curves were an expression of apparent rather than true formation resistivity. For the most part they recorded the resistivity of the formation fluid content, the conductive media for the current. The resistivity curves were, therefore, a record of the salinity of the formation water. The interpretation based on these principals recognized a shale base line, paralleling the log center line and to the right of it, as the expression of a rock unit whose waters retained their high deposition salinity to provide low resistance to the passage of the induced current. A change of salinity from the normal marine, to brackish, or to fresh water produced a corresponding increase in resistivity. A change in porosity and permeability from the porous and impervious character of clays and shales also increased the measured resistivity. The curve, therefore, distinguishes these fluid and textural changes by characteristic peaks to the right of the shale base line. These resistivity anomolies define bed boundaries and provide data to determine the units fluid content.

Construction of Isopach Map

The construction of an isopach map from subsurface data was facilitated by the electrical log. Formation boundaries were indicated by a characteristic electrical diagram, which was represented graphically by the resistivity curves. The electrical diagram was used both to determine the total thickness and to trace the formation, by correlation, from one area to another. The Dakota sandstone is especially suited to this treatment, and its thickness and aerial distribution may be determined throughout the southwest Powder River Basin.

The characteristic electrical diagram for the boundaries of the Dakota sandstone was determined by comparing several wells with cored intervals to their respective electrical logs. After these logs were marked they were used as key logs in the correlation of the remaining logs.

The total thickness of the Dakota sandstone for each of the wells studied was taken from the electrical logs and entered by the proper well location on the overlay of the base map of the southwest Powder River Basin. The data for the isopach map was then contoured with the assumption that there was uniform thickening or thinning between wells.

Construction of Isolith Map

The isolith map of the Dakota sandstone was prepared to show the thickness and distribution of the net sandstone. The shale, sandy shale, and siltstone content of the Dakota sandstone was subtracted from the total thickness in the preparation of the net sandstone isolith map. Determination of the net sandstone was accomplished by comparing available cored intervals to their respective electrical logs and coloring the respective lithology on the electrical log. These electrical logs were then used as key logs from which the lithology of correlated electrical logs was interpreted regardless of the availability of additional lithological logs. The lithologic log was not, therefore, used as conclusive evidence of the lithology of that particular bore hole, but was used in conjunction with the electrical log of that bore hole and the nearest available key log. In wells having only electrical logs the lithology was determined by comparing the electrical log of that particular bore hole to the nearest key log. The net sandstone of the Dakota was taken from the electrical log of each bore hole, plotted and contoured as in the isopach map.

Construction of Lithofacies Map

The lithofacies map of the Dakota sandstone was prepared to give an aerial view of the facies change that takes place in the southwest Powder River Basin. The lithofacies map (sand/shale ratio map) was constructed by dividing the total shale, sandy shale, and siltstone into the net sandstone. The ratios of the Dakota sandstone were then plotted and contoured as in the foregoing map.

The sand/shale ratio map was converted to a lithofacies map of the Dakota sandstone by using a lithologic triangle adapted from Krumbein and Sloss (10). The ratio lines corresponding to the divisions on the lithologic triangle were converted to fractions and drawn in with heavy lines. The facies change was then represented graphically on the lithofacies map.

The lithofacies map and isolith map were combined on one single map to aid in map interpretation, and to show the indicated relationship between the net sandstone of the Dakota and the facies change that takes place in the Dakota sandstone of the southwest Powder River Basin.

Texture Analysis

The texture of a sedimentary rock is usefully characterized by knowledge of the size, shape and arrangement of the rock constituents, of these attributes, this study is confined to the geological significance of the grain size and to the general shape of the individual grains.

Disaggregation--Thin section analysis revealed that the Dakota sandstone was held with an extremely tight bond of silicia, therefore, extreme caution was observed in disaggregation. A mortar and pestle was used to disaggregate the sand to a point where only small clusters of grains were held together with a silicia bond. During this operation the sample was checked periodically with a binocular microscope to minimize breakage of the individual grains. Upon completion of the initial disaggregation a 200 gram sample was treated with a boiling solution of concentrated potassium hydroxide for two hours. Upon completion of the above treatment the sample was washed with deionized water until it tested neutral with litmis paper. This treatment removed the silica bond between the individual grains, thus, giving complete disaggregation. The sample was then treated with a fifty percent solution of hydrochloric acid to remove the calcareous material that was present.

Determination of Texture--Grain size distribution was determined by the conventional sieve analysis, and the results of the eight analysis are represented in Plate V. As seen in Plate V the majority of the samples are well sorted and fall in the very fine to fine grained sand with only a small percentage falling in the silt and medium grained sand class.

Determination of Shape--The shape of the individual grains was determined by examination of the disaggregated sample under the binocular microscope, in conjunction with the grains observed in the thin sections. The grains tend to be predominately sub-angular to angular with only a very small percentage showing higher degrees of rounding.

Thin Section Analysis

Quanatitive mineral analysis were made from thin sections utilizing the grain count method which gives results nearly equivalent to those obtained by the volume percentage method. The grain count method involves counting a sufficient number of mineral grains to give a representative percentage. In this analysis two hundred or more grains were considered to be sufficient to give a representative percentage. The mineral population was counted on successive traverses of the slide. Each individual mineral was counted as it crossed the middle cross hair. Upon completion of the mineral count the total number of grains counted was divided into the number of grains of each mineral encountered on the thin section, thus, giving the volume percentage of the minerals present which is represented in Table 1.

In addition to being the most abundant mineral, the quartz grains were sutured, some showed undulose extinction, and a few were found in optical continunity with one another. The sutured grains in conjunction with the fine texture are probably the most important factors that effect porosity and permeability of the Dakota sandstone. The mineral chlorite is primarily found as interstitial material, but in some thin sections it is larger in grain size than the average quartz grain.

The meager amount of information that was available indicated that the percentage of chlorite increases off the major structural trend, found in the southwest Powder River Basin. Calcite was present as irregular masses varying in size from that of the average sand grain to several times the size of an average sand grain.

Heavy Mineral Analysis

The heavy mineral population of the Dakota sandstone is very sparce. It is represented by only the most stable heavy minerals: zircon, tourmaline, muscovite along with coated minerals and a very few opaques. The zircon is euhedral to subhedral in outline with the majority of the minerals falling in the former class. The tourmaline grains were subhedral to anhedral with a large percentage falling in the latter class. The muscovite grains were rather ragged around the edges.

REVIEW OF PREVIOUS WORK

Geological History of The Rocky Mountains

From Middle Cambrain time through the remainder of the Paleozoic Era, there were two major breaks in the sedimentary cycle and one very pronounced uplift in the Rocky Mountain region. The breaks in the sedimentary cycle are represented by the Silurian, which is absent, and the Devonian which is represented by only a very thin veneer of sediments (Bauer 3). The major deformation, the building of the ancestorial Rocky Mountains, was initiated at the close of the Mississippian period. These mountains remained high throughout the remainder of the Paleozoic Era, and contributed many sediments until their burial in the early stages of the Mesozoic Era (Dunbar 7).

The Mesozoic Era is represented, in a major portion of the Rocky Mountains, by a terrestral type of deposition with one major and several minor breaks in the sedimentary cycle. The major break in the sedimentary cycle was a short lived marine invasion during Jurassic Sundance time. With the close of the Jurassic period came the Nevadian disturbance which produced the Mesocordilleran geanticline. This geanticline was subject to erosion throughout the Cretaceous period and contributed sediments both to the east and west (Dunbar 7). The oscillating Cretaceous sea left a long and varied sedimentary sequence which is represented throughout the Rocky Mountains by a thick sequence of sands and shales with only minor amounts of limestone. It was during the early portion of this sand-shale sequence that the Dakota sandstone was deposited. With the last retreat of the great Cretaceous seas, marine sedimentation came to an end on this part of the continent. The Larmide orogeny began in the latter part of the Cretaceous period and molded the accumulated sediments into the structural forms that we recognize today. Epeirogenic rather than orogenic movements dominated the area in the Cenozoic with numerous pulsations and periods of relative stability recorded in the structural pattern. By the middle of the Cenozoic Era, the Rocky Mountains, as we know them today, were expressed in their present form as a result of re-elevation and sculpturing by the rejuvenated streams.

Minor Tectonic Structures in Central Wyoming

There were apparently no major tectonic structures in central Wyoming during Jurassic Morrison or lower Cretaceous Cloverly time. Minor structural features, however, have been implied from the available geological evidence.

Recent mapping by Love (12) indicated that there were two rather conspicious areas of thinning in the Morrison-Cloverly interval in the Sweetwater uplift area and in western Natrona and eastern Fremont counties. Love suggests that during, or at the close of, Cloverly time gentle folds trending northwest developed in the Lost Soldier-Big Sand Draw area and in the Alcova-Lost Cabin (Powder River uplift) area. These suggested uplifts are based on the distribution of thick and thin stratigraphic sections for there is no marked unconformity between any of the formations.

Source of Sediments

There is considerable controversy as to the source or sources from which the Cretaceous sediments were derived especially those representing the Dakota sandstone of the southwest Powder River Basin. Previous investigation has pointed to three possible source areas any one or combination of which could have supplied the sediments: the Mesocordilleran geanticline, the Jurassic Morrison formation, and the Sioux uplift lying to the east of the Cretaceous sea.

During the Nevadian disturbance at the close of Jurassic times the Mesocordillerian geanticline was formed and contributed sediments to the east and west throughout Cretaceous time. This very spectacular tectonic structure was often rejuvenated throughout Cretaceous time. In upper Cretaceous time it bristled with volcanic activity to produce the numerous bentonite beds (volcanic ash) that are scattered through the upper Cretaceous sediments (Dunbar 7).

With the close of the Jurassic period came the advancing, oscillating, Cretaceous seas which reworked the Jurassic Morrison and lower Cretaceous sediments and redeposited them in a series of sands and shales during lower Cretaceous time.

According to Bartram (1):

> The lowest sandstone is the basal sand of the enroaching upper Cretaceous sea, which reworked materials left on the Jurassic and lower Cretaceous flood plain and redeposited them in an irregular group of sandstone, sandy shale, and shales. This zone is 100-300 feet in thickness and in most places contains two, three, or even four or five individual sandstone, which are local lense of limited extent, and not unbroken sheet sands. Throughout the Rocky Mountains this zone of sandy material is everywhere found at the base of the marine section, but one individual basal Dakota sand does not exist as generally believed. The usual practice is to select three sandstones in this zone and, if the lowest one is coarse and congomeratic, to give it the name

Lakota or an equivalent name and to regard it as lower Cretaceous, to call the middle sandstone the true Dakota or an equivalent name if it has black shale above it, and to give the highest one the name Muddy or an equivalent name.

The eastern extremity of the early Cretaceous seas was marked by a line north through eastern Kansas, central Iowa, and central Minnesota. East of the early Cretaceous seas was a broad uplift, described by Eardley (8) as an epirogenic uplift area which was subject to erosion during early Cretaceous time.

METHODS OF FORMING SAND BODIES

The origin of the Dakota sandstone might be deducted from the features of the sand bodies and the associated rocks that are revealed by bore holes and a few samples of sand. The features include the texture of the sand, distribution of the sand, thin section analysis, and the mineralogy of the sand. The method of origin of these ancient sand bodies may be revealed by comparison of their features with those of modern sand deposits.

Off Shore Bars

According to Bass (2):

> The shallow near-shore waters of our present marine water bodies and some of the large fresh water lakes are bordered by narrow bodies of sand elongated parallel with the shore, but lying a short distance basinward. These are known as offshore bars or barrier bars.

These bars are formed by large waves approaching the shore, and, therefore, approach the shallow bottom, the lower part of the wave scours the bottom, carrying forward the sediments that lie there. The forward motion of the wave is retarded by the friction of its lower part with the sea floor; the upper part of the wave continues its forward motion; the water piles up, and the wave structure collapses, thus, dripping its load of sediments. The collapsing wave is commonly called a breaker. After the forward movement ceases and the water returns down the slope, forming a current known as an undertow. This returning current carries much of the fine sediment that was carried forward by the wave and deposited at the point of collapse. The action at the larger waves excavates a marine cliff in the sea floor at the line of the breakers and deposits debris on the bench just above the cliff, which in many parts of the coast line is a mile or more from shore. Continued excavation builds a ridge of debris on the ocean floor parallel with, but some distance from the shore. In time the ridge is built above the water level and appears as islands of sand, called off shore bars. The body of water between the islands of sand and the shore is called a lagoon. Between the islands of sand are waterways known as tidal inlets, which connect the open sea with the lagoon (Johnson 9).

According to Bass (2):

> The waves that beat against the offshore bars rarely strike perpendicular, most of them generated by the wind, strike at an angle; and the current as it returns seaward is deflected along the bar and, therefore, sets up currents known as long shore currents which run parallel with the trend of the bars.

The incoming breakers erode sand from the seaward face of the bars of sand and it is transported along the face of the bars by the long shore current, filling in the low places and lengthening the bars. As this process is continued the bars are lengthened and the number of tidal inlets reduced. The closing of the inlets concentrates the flow of the tidal waters in the few inlets that remain open, and, thus, increases the current through them. These currents form deeply excavated channels through the remaining inlets. There is a constant conflict between the long shore currents which try to fill the inlets and the tidal currents which keep them open (2).

According to Bass (2):

> Offshore bars are commonly characterized by their narrow elongated lenslike form; in cross section they have relatively plane-like lower surfaces and convex upper surfaces; the individual lenses may be arranged en echelon. They should be enclosed within strata that exhibit uniform bedding, which is characteristic of sediments deposited in still bodies of water. The sand in off shore bars should be in part irregularly cross-bedded, due to deposition by conflicting currents and waves. The sand grains in off shore bars are characteristically well sorted and largely devoid of silt and clay. Off shore bars are transitory structures and are probably preserved only rarely.

Beaches

A beach is a mechanically derived deposit of clay, silt, sand, shell, or gravel on the shore and on the seaward slope from the shore. It is more or less a line of active debris transportation along the shore and offshore. The beach sand shifts back and forward over the shore faces as the wave conditions change. The comparatively flat zone that extends from the outer margin of the shoreface to the edge of the continental shelf is called the offshore. The foreshore is the ordinary high and low water marks. The back shore is the part of the shore that is only covered during storms. Beaches may grade into tidal marshes or gently sloping muddy shores, but are generally quite distinct (Trask 19).

As a beach builds seaward, it forms a beach plain on which a series of parallel or nearly parallel ridges may form. These ridges, called beach ridges, represent lines of growth. When these beaches are sandy, they generally have a laminated structure, where the material is of fairly uniform texture, the laminations may be very distinct.

Beach sands are commonly well sorted, usually laminated deposits of clay, silt, sand, gravel and shell, formed in the littoral zone, by the action of the waves. They are usually long, thin, and narrow and are most likely to be preserved where the land is sinking. Only concentrates of the more stable heavy mineral are found in these deposits (Trask 19).

Stream Deposits

Streams, because of their turbulent motions and strong currents during flood periods, are more likely to deposit a heterogeneous mass of material than that which is spread by the waves and currents of the ocean; the stream deposits are characterized by discontinuous lenses of coarse and fine sediments, commonly cross-bedded, the slope of the cross-bedded layers are steep and in one direction. If the stream deposits fill only the stream channel the resulting sandstone will be a cast of the stream valley, its aerial extent will be a narrow, elongated, continuous, somewhat meandering pattern, and will be valley shaped in cross section.

Streams that are present in uplift areas have steep gradients and carry large quantities of sediments, the quantities of sediments that are carried depend upon the seasonal climatic fluctuations. As the streams approach the plains the gradient diminishes abruptly, which checks the velocities of flow; the streams are unable to transport the sediments and they are dropped. These sediments fill the main stream channel; then, the streams split into numerous parts called distributaries that spread the sediments outside the old stream channel; the resulting deposit is known as an alluvial fan. If the process continues long enough, fans of several stream deposits may coalese to form a sheet like deposits (Bass 2). The sheet like sand deposits may be winnowed and reworked by an enroaching sea into deposits that are similar in outline to offshore bars.

Sand bodies form in a great number of diversified ways, which are to numerous to mention here; so only those pertinent to this study were discussed.

INTERPRETATION

Dakota Isopach Map

The Dakota is a unit of very pronounced thickness variability as indicated by the Dakota isopach map, Plate III. There is a very conspicious zone of thinning along the western margin of the study area which is indicative of, at least, a minor tectonic structure. This thinning is related to the thinning mapped by Love (12) and seems to confirm the presence of a minor tectonic structure during Dakota time along the same line of folding as the present day Powder River uplift. The central portion of the report area is marked by a rather broad area in which stability persisted and only minor variations in thickness existed. This zone is probably related to the lagoonal phase, of shoreline development. There is a zone of very pronounced thickening of section along the southeastern part of the thesis area. This zone is probably related to the wave cut cliff phase of shoreline development and is adjacent to local sand development. This thickening is related to petroleum production and would indicate, at least, a slight increase in the depth of the sea to the east, as there is a considerable decrease in the amount of coarser clastic material to the east and adjacent to the local sand development. The foregoing information indicates that the Dakota sandstone was deposited under shoreline conditions. A major portion of the Dakota sandstone is related to the wave cut cliff phase of shoreline development.

EXPLANATION OF PLATE, III

Map showing an aerial view of the thickness variability of the Dakota sandstone, and the relationship between thickness and the present producing areas.

PLATE III

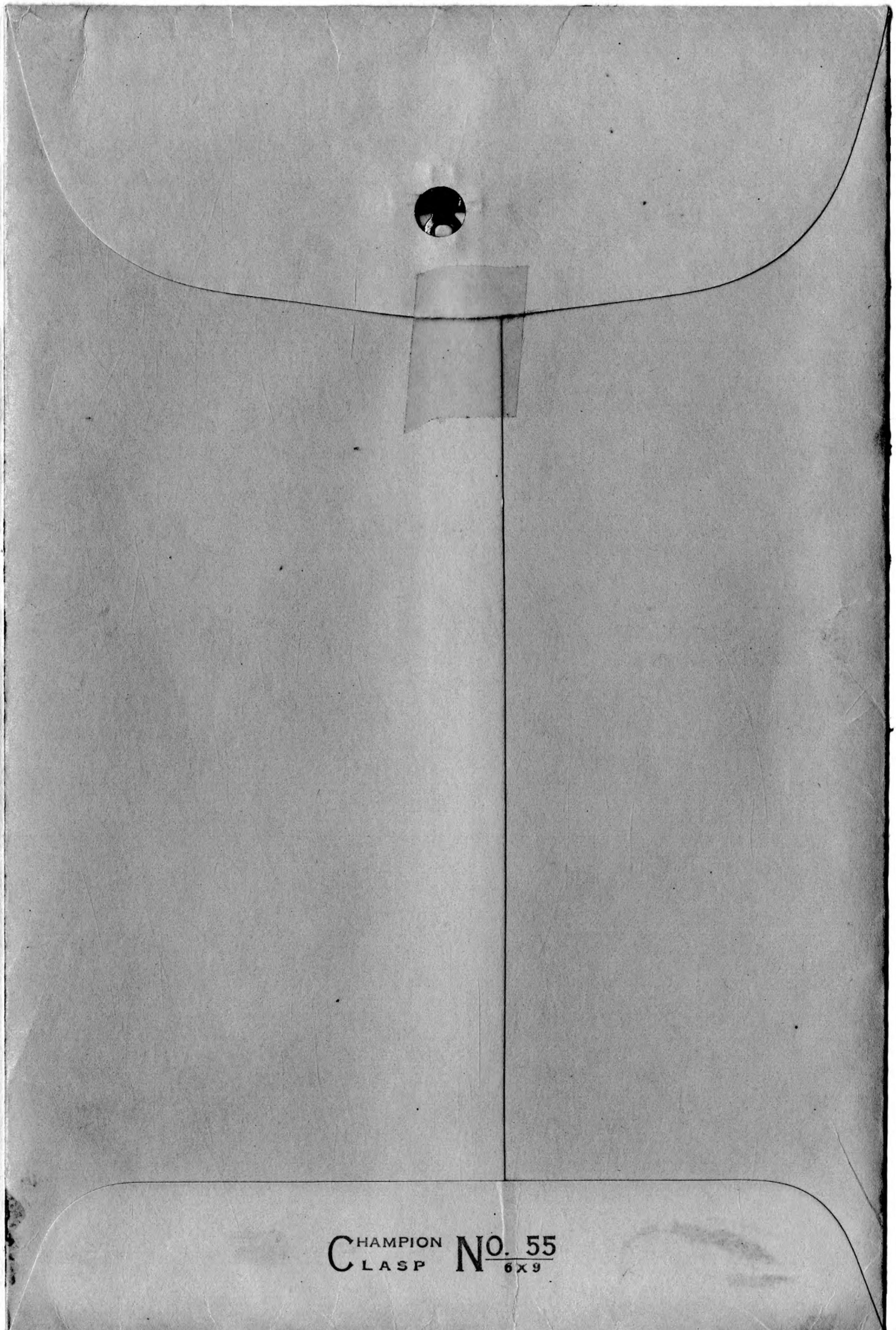


PLATE III

DAKOTA SANDSTONE

ISOPACH MAP

OF THE

SOUTHWEST POWDER RIVER BASIN

CONTOUR INTERVAL 5'

SCALE: 1" = 5 MILES

Dakota Isolith Map

The Dakota isolith map, Plate IV, displays a unit in which the net sandstone content is highly variable in thickness and very erratic in development. There is a very distinct thinning along the western portion of the isolith map which is related to previous work by Love (12). In the north central portion of the study area there is a stable zone in which the net sandstone content is nearly uniform. It is hypothesized that the loci of the present uplift was initiated at or near the close of Dakota time which resulted in the offshore bars being destroyed by wave action, thus, spreading the sand very uniformally over a broad area. There is a very conspicuous thickening of the net sandstone in a northwest-southeast trending zone in the south central part of the study area. This thickening is related to the wave cut cliff phase of shoreline development. These conditions seem to confirm the isopach map, emphasizing that shoreline conditions controlled the environment under which the Dakota sandstone was deposited. The Dakota producing area falls within a zone of increased sand content and indicates that production seems to be related to an increase in the net sand content. On the southeastern side of the area the net sandstone decreases very rapidly with a considerable increase in the amount of very fine clastic material, which is indicative of deeper water sedimentation.

EXPLANATION OF PLATE, IV

Map showing the relationship between the facies change that takes place in the Dakota sandstone of the southwest Powder River Basin, the net sandstone present and the present producing areas.

PLATE IV

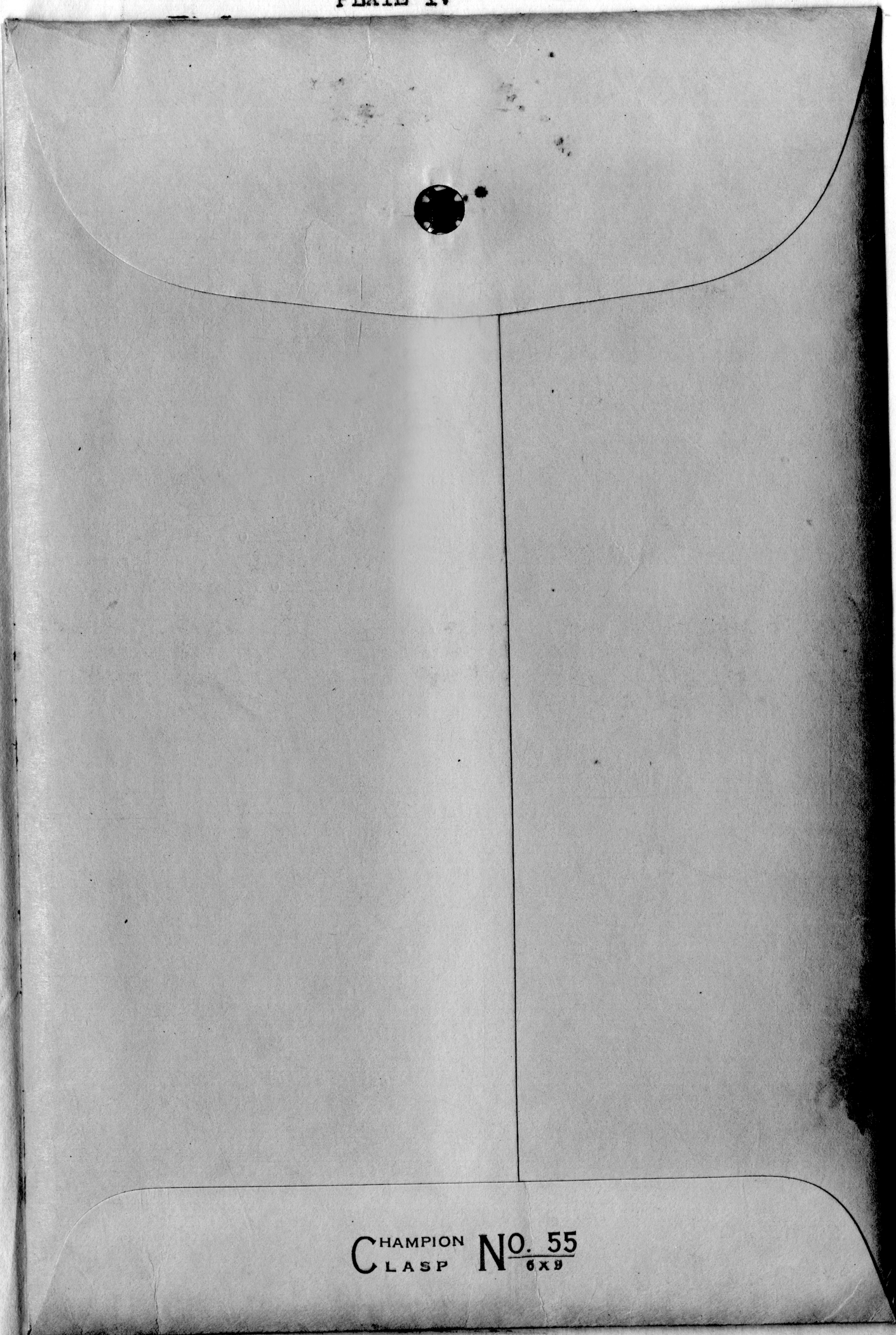


PLATE IV

DAKOTA SANDSTONE

ISOLITH - LITHOFACIES MAP

OF THE

SOUTHWEST POWDER RIVER BASIN

CONTOUR INTERVAL 10'

SCALE: 1" = 5 MILES

Dakota Lithofacies Map

The Dakota lithofacies map, Plate IV, displays an aerial view of the gross lithologic aspects of the Dakota. On the western margin of the thesis area the amount of fine clastic material increases along a zone co-incident with the thinning both of the net sandstone and the over-all Dakota section. This thinning is, in all probability, related to that previously mapped by Love (12). There is a very distinct increase in the clastic ratio in a narrow northwest-southeast trending zone in the south central portion of the study area. This increase in clastic ratio is related to the wave cut cliff phase of shoreline development, and in turn is related to the accumulation of petroleum. The relationship of sedimentation to petroleum accumulation can be observed in the productive trends where there is a significant increase in the clastic ratio. There are two areas to the west of the present line of production, which are out of control and are probably elongated rather than the shape shown in Plate IV, but have a high clastic ratio and warrant further consideration in any future exploration activity in the southwest Powder River Basin. The southern area has a minor amount of production at Midway dome, but there is still considerable room for exploration. The northern area was confirmed by Houston Oil Company's Dakota discovery at the No. 1 Burke Ranch located in Section 18, Township 37 North, Range 78 West and will probably see considerable drilling activity in the very near future.

Size Analysis

The modes of the size analysis fall into three different grade sizes, five modes fall in the one-eighth millimeter grade size, three modes fall in the one-two-fiftysixth millimeter grade size, and one mode fell in the one-quarter millimeter grade size; therefore, the one-eighth millimeter grade size is the dominant size. It is noted, in Plate I, that although the sediments vary over a small number of grade sizes, the porosity remains reasonably constant, whereas, the permeability varies over a wide range. This leads to the possibility that porosity is a function of the texture of the sandstone, and that permeability has no apparent relationship to the texture.

Thin section analysis of number 8 and 9, Plate V, indicated that the suturing of grains was not as pronounced as that found in number 1, 5, and 6. Higtograms numbers, 1 and 8, 5 and 9, are very similar in texture, however, the permeability in number 8 and 9 is nearly ten times the permeability of number 1 and 5. From the above observance it is concluded that additional study along these lines may throw some light on the permeability in the Sage Spring Creek area.

Thin Section Analysis

The thin sections revealed that the Dakota sandstone is made up dominantly of the mineral quartz, with small percentages of chlorite, chert, calcite, muscovite and plagioclase making up the remainder of rock. The volume percentage of each constitutient is represented in Table 1.

EXPLANATION OF PLATE, V

A series of histograms, in the Sage Spring Creek area, representing the relationship that exists between texture and porosity and permeability. The average porosity and permeability was taken from Chemical and Geological Laboratory reports, provided by Amerada Petroleum Corporation, Casper, Wyoming.

PLATE V

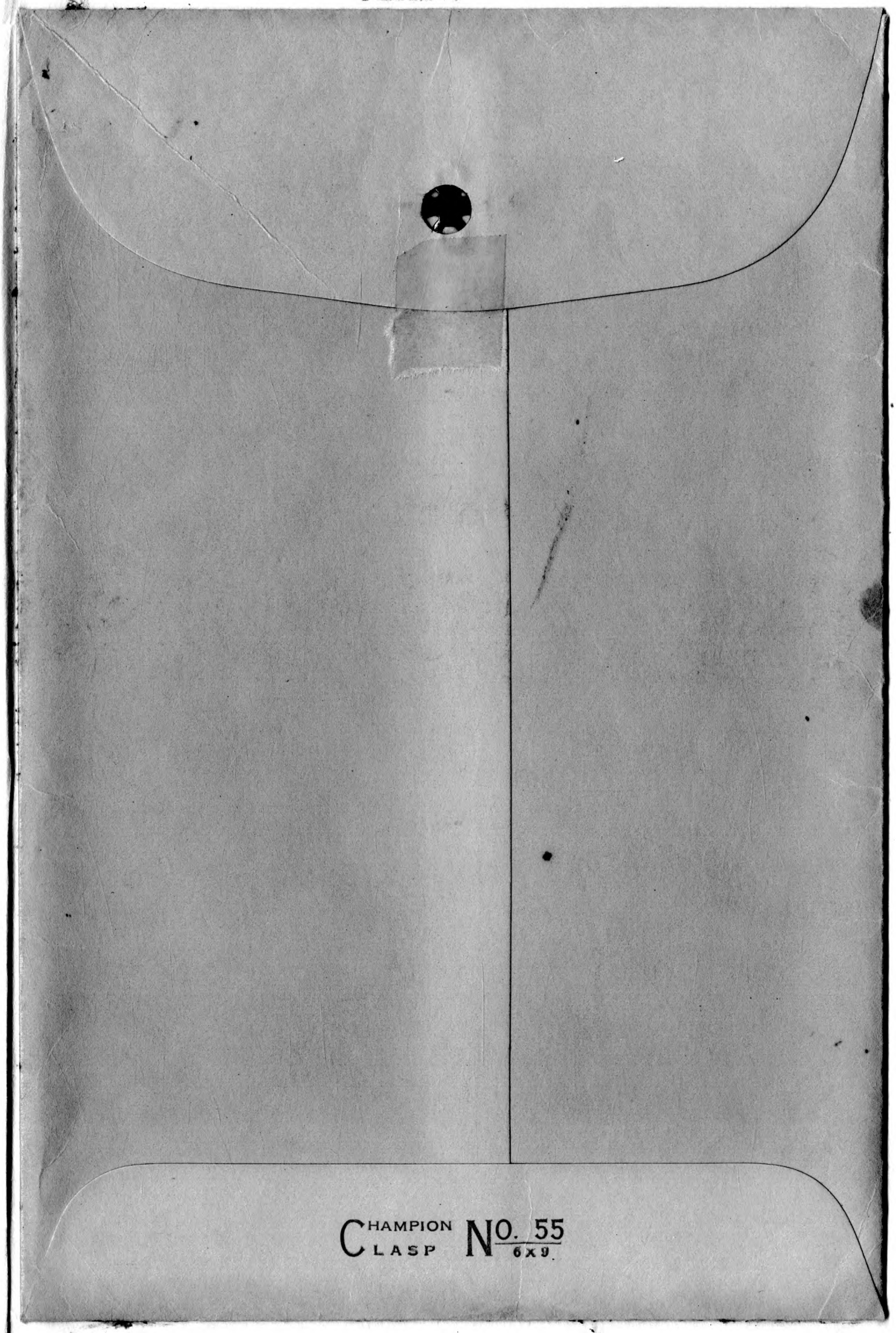


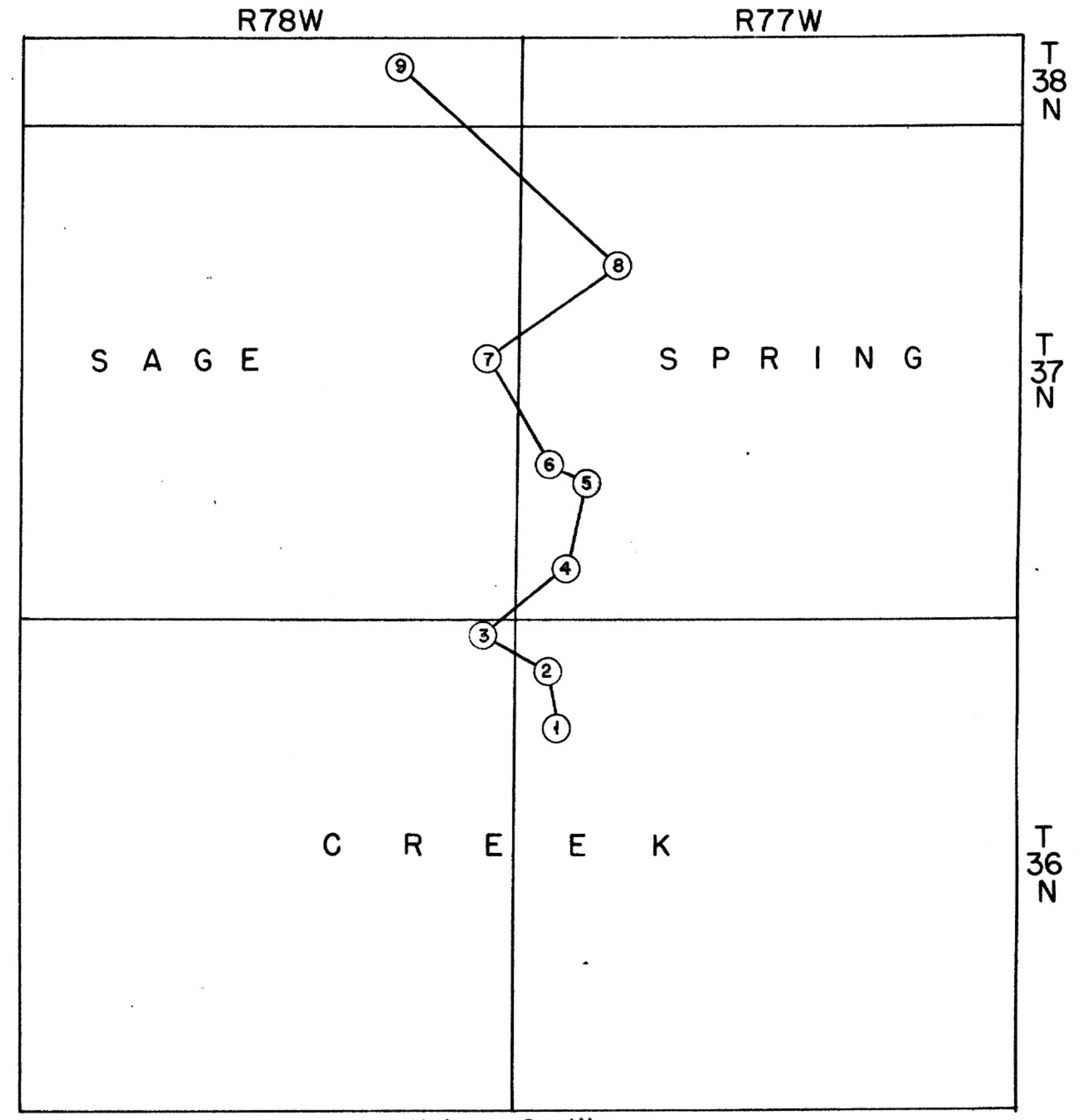
PLATE V

	①	②	③	④	⑤	⑥	⑦	⑧	⑨
	AMERADA NO. 4 UNIT SEC. 7, T36N, R77W	AMERADA NO. 11 UNIT SEC. 6, T36N, R77W	AMERADA NO. 7 UNIT SEC. 1, T36N, R78W	AMERADA NO. 12 UNIT SEC. 31, T37N, R77W	AMERADA NO. 2 UNIT SEC. 30, T37N, R77W	AMERADA NO. 3 UNIT SEC. 30, T37N, R77W	AMERADA NO. 10 UNIT SEC. 13, T37N, R78W	AMERADA NO. 27 UNIT SEC. 8, T37N, R77W	AMERADA NO. 6 UNIT SEC. 35, T38N, R78W

	①	②	③	④	⑤	⑥	⑦	⑧	⑨
Average Porosity	13.59%	12.29%	10.94%	13.18%	10.47%	11.67%	9.45%	11.02%	14.31%
Average Permeability	13.02 md.	12.03 md.	11.91 md.	9.69 md.	7.96 md.	3.00 md.	4.96 md.	33.05 md.	46.03 md

SIZE ANALYSIS
OF
DAKOTA SANDSTONE

HORIZONTAL SCALE: 1" = 1 MILE



Natrona Co., Wyo.
INDEX MAP

The amount of suturing of quartz grains varies from bore hole to bore hole and is probably the result of intrastratal solution. The relationship between suturing and intrastratal solution in all probability is the reason for the very pronounced changes of permeability that are observed.

Chlorite, although one of the minor constitutients of the Dakota sandstone, is interpreted as being the result of washing and winnowing of the sediments, thus, removing the fine material which consisted of hydrous aluminum silicates and redeposition of the finer material in water of increased depth. Upon burial and diagensis the sediments undergo low grade metamorphic changes, due to load metamorphism, which convert the hydrous aluminum silicates into chlorite.

Calcite occurs as grains and as interstitial material, in some thin sections quartz grains are found embedded in irregular masses of calcite. The calcite is believed to represent the calcite that was carried and deposited by subsurface waters, or is the result of solution and redeposition of calcareous fossil shells.

Although minor, the presence of chert would indicate that the sandstone is not a first cycle sand, but was derived from pre-existing sediments.

Heavy Minerals

The heavy mineral populations are significant, in fact, they are very low both in variety and amount.

Table 1. Thin section analysis; percent material by volume

Location	Production:		Quartz	Chlorite	Chert	Calcite	Muscovite	Trace Minerals
	Oil	Dry	%	%	%	%	%	%
Amerada No.1 USA Brannan Sec.29, T33N, R78W.		X	74.9	22.1	---	0.5	2.5	---
True & Brown No.1 Tank Farm Sec.34, T34N, R74W.		X	61.4	37.2	---	---	1.4	---
Phillips No.1 Sand Creek Sec.7, T34N, R75W.		X	85.0	10.6	0.9	3.3	---	---
Phillips No.1 Brown Brubaker Sec.33, T34N, R75W.	X		83.5	11.1	0.7	---	4.7	---
Phillips No.27 S. Cole Sec.5, T34N, R76W.	X		87.0	7.7	1.9	1.4	1.4	Plagioclase 0.5
Ralph Lowe No.1 B Kolacny Sec.9, T34N, R76W.		X	87.0	7.4	0.4	2.5	2.7	---
Gen. Petr. F 32-26G Sec.26, T35N, R77W.	X		85.0	4.4	2.8	7.0	0.8	---
Amerada No.11 Unit Sec.6, T36N, R77W.		X	89.5	7.62	2.38	---	.41	---
Amerada No.4 Unit Sec.7, T36N, R77W.	X		86.5	3.4	2.5	6.8	0.8	---
Amerada No.7 Unit Sec.1, T36N, T78W.		X	90.0	5.2	1.8	0.8	1.8	Tourmaline 0.4

Table 1. (concl.)

Location	Production: Oil	Production: Dry	Quartz %	Chlorite %	Chert %	Calcite %	Muscovite %	Trace Minerals %
Phillips No.1 Werner Sec.20, T37N, R75W.		X	78.0	17.4	1.7	---	2.6	---
Amerada No.27 Unit Sec.8, T37N, R77W.		X	86.0	4.2	4.2	5.2	0.4	---
Amerada No.3 Unit Sec.30, T37N, R77W.	X		89.9	.79	3.5	2.36	2.76	Plagioclase 0.39
Amerada No.2 Unit Sec.30, T37N, R77W.	X		95.0	1.16	2.32	0.4	3.8	Tourmaline 0.4
Amerada No.1 Unit Sec.30, T37N, R77W.	X		87.9	3.9	3.9	2.8	1.6	---
Amerada No.12 Unit Sec.31, T37N, R77W.	X		91.5	1.9	3.22	---	3.8	---
Carter No.1 Burke Ranch Sec.36, T37N, R77W.		X	92.5	1.6	4.1	---	1.6	---
Amerada No.10 Unit Sec.13, T37N, R78W.		X	92.0	3.9	1.5	0.4	2.3	---
Amerada No.6 Unit Sec.35, T38N, R78W.	X		93.5	3.4	1.7	0.4	0.9	---

According to Krumbein and Sloss (10):

> The effects of differential solution (intrastratal solution) are particularly noticeable with respect to the heavy minerals in detrital sediments. Numerous workers have observed that Paleozoic sediments have simpler heavy mineral suites than Mesozic and Tertiary rocks.

The presence of only the most stable heavy minerals, such as zircon, hornblend, and muscovite, is probably the result of intrastratal solution.

Relationship of Structure and Sedimentation to Oil Accumulation

Oil accumulation in the Dakota sandstone is a result of two factors, structure and sedimentation. The relationship between structure and the present producing areas are represented in Plate VI. A majority of the production is obtained from a northwest-southeast trending zone in the south center portion of the thesis area, only two and possibly three of these areas produce from structures that have known closure, the remaining areas produce on the noses and flanks of the major structural trend. The aerial distribution of the net sandstone and the facies change that takes place in the Dakota sandstone of the southwest Powder River Basin is represented in Plate IV. A major portion of the production is obtained from zones in which the sandstone is twenty or more feet thick, within these zones of sand concentration there is a variance in permeability which is due to intrastratal solution and is thought to be one of the major factors in forming stratigraphic type traps for oil accumulation.

CONCLUSIONS

Although the Dakota sandstone is a highly variable lithologic unit, it is present in the subsurface throughout the southwest Powder River Basin. Thin section analysis indicate that the Dakota is made up dominantely of the mineral quartz, and would be classed as an orthoquartzite. The texture of the sand, in the Sage Spring Creek area, indicates that it is a well sorted sand, with a predominance of the sand falling in the one-eighth millimeter grade size. The texture is related to porosity, but no relationship exists between texture and permeability. The absence of a diversified heavy mineral suite is significant and suggests that intrastratal solution was the primary factor responsible for removing all but the most stable minerals. Intrastratal solution also is probably responsible for the suturing of the quartz grains, which has had direct bearing on the permeability of the sand.

Certain features of the Dakota sandstone can be applied to two and possibly several type of sand deposits, other features appear to fit only one or possibly two types of deposits. In summary, the following features appear to be significant: the narrow elongated sand bodies which grade laterally into sandy shale and shale phases; the sand bodies make a gently curved line similar in outline to recent shorelines; the sand is fine textured with a majority of the sand falling in the mode; the minor amount of crossbedding; the shale in cores has fissility and is well bedded. These features lead to the conclusion that

EXPLANATION OF PLATE, VI

Map showing the structure on the Dakota sandstone daturm, of the southwest Powder River Basin and its relationship to the present producing areas (14).

PLATE VI

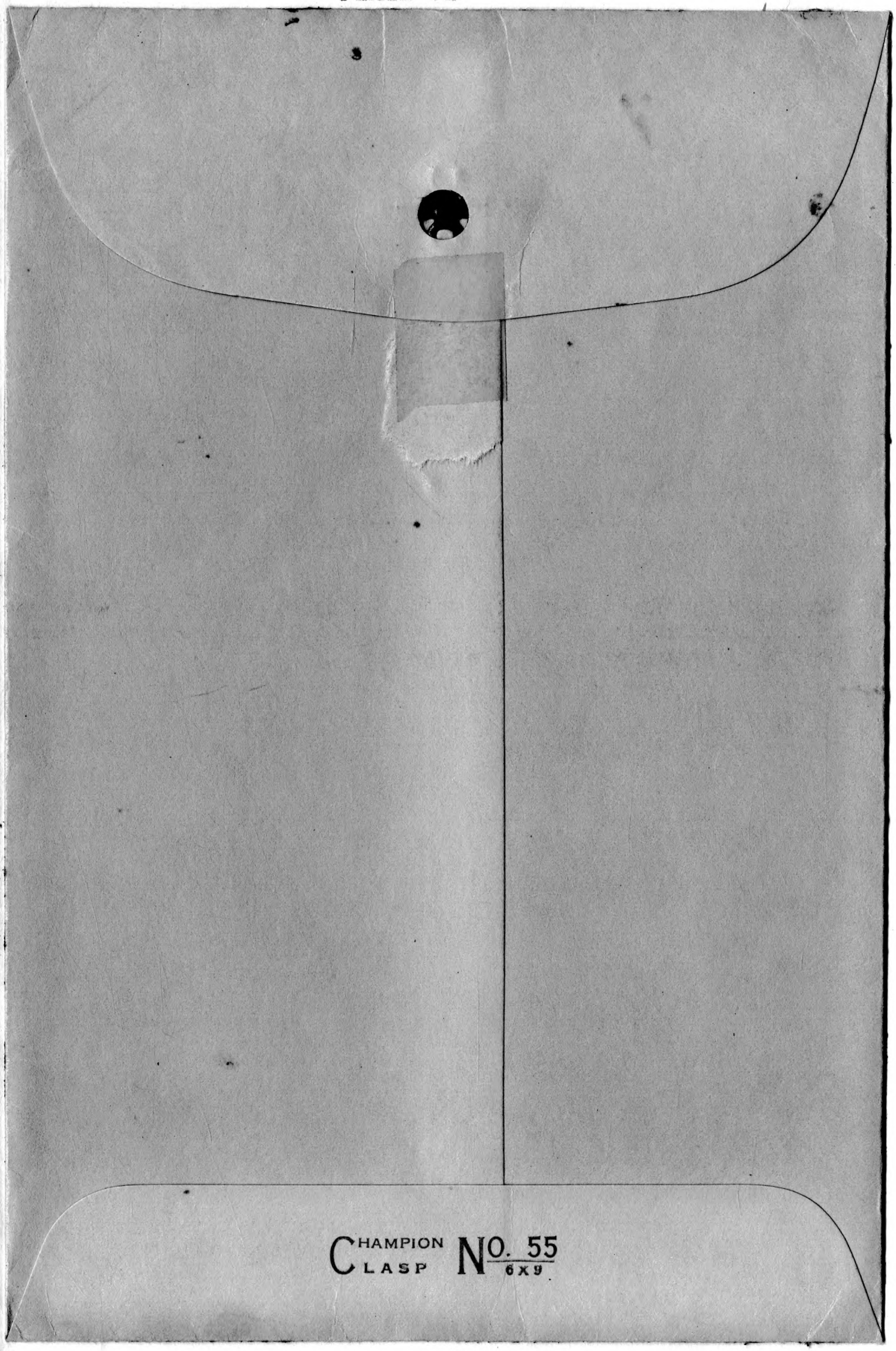
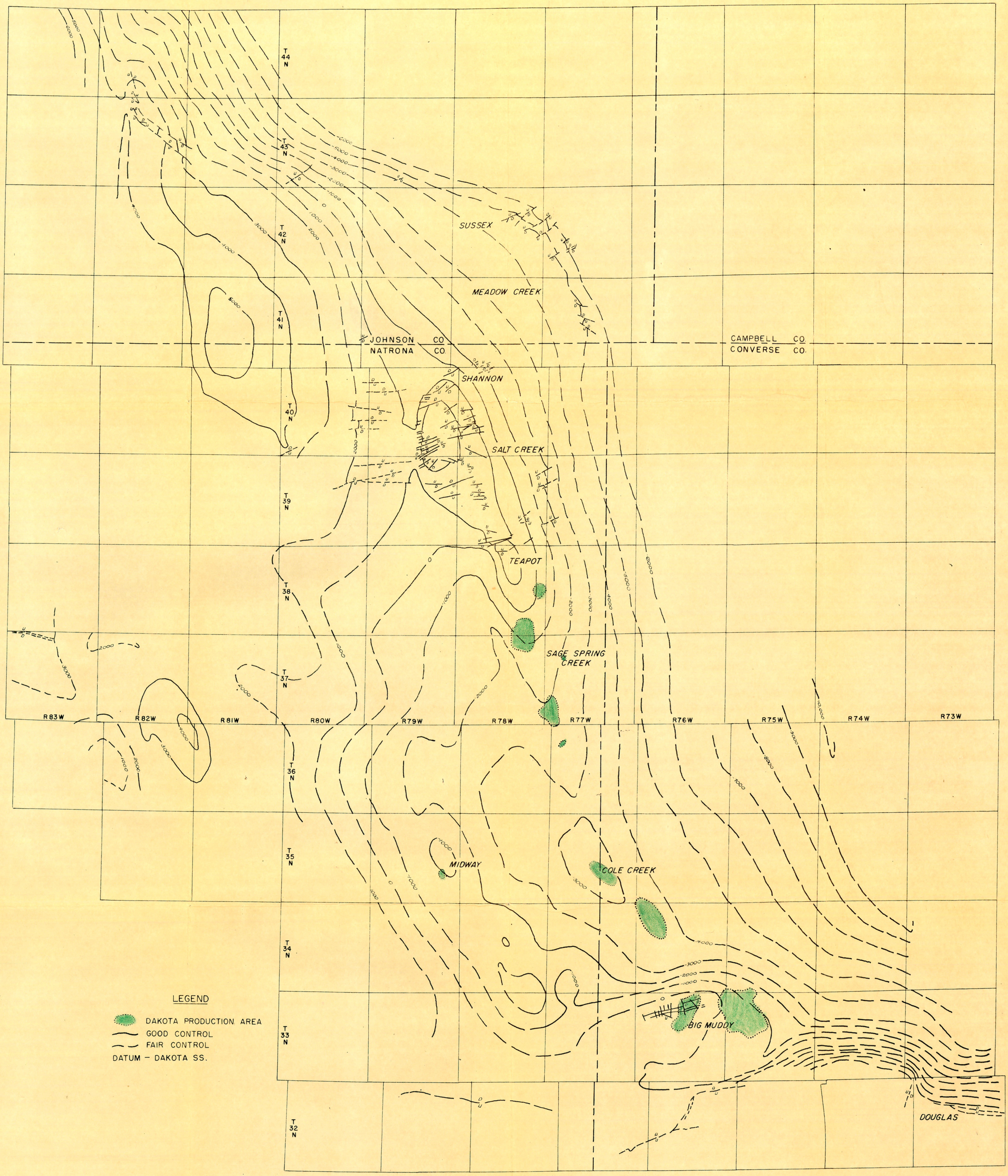


PLATE VI



STRUCTURE

OF THE

SOUTHWEST POWDER RIVER BASIN

CONTOUR INTERVAL 1000'

SCALE: 1" = 5 MILES

the Dakota sandstone was formed adjacent to an ancient shore line that existed during Dakota time.

Oil accumulation is related to structure, sedimentation, and the shoreline environment which was apparently favorable for oil accumulation.

ACKNOWLEDGMENT

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APPENDIX

Table 1. Location of wells by legal description.

Well No.	Company	Well	Area	County	Location Description	Sec. T. R.
1	S.W. McLaughlin	No.1 State	Deer Creek	Converse	NW NE SE	7-32N-76W
2	C.U. Bay	No.1 V.R. Ranch	Deer Creek	Converse	NE NW NE	18-32N-76W
3	L.W. Winkler & Sons	No.1 State	S. Big Muddy	Converse	SE SE NW	10-32N-77W
4	Yellowstone Drilling Co.	No.1 State A	Hat Six	Natrona	SW NE SE	1-32N-78W
5	Greer & Delhi	No.1 State	Wildcat	Natrona	SW NW	36-32N-78W
6	Phillips Petr. Co.	No.1 Tank	Careyhurst	Converse	NW NW NW	2-33N-74W
7	Trigood Oil Co.	No.1 C & NW	Glenrock	Converse	C N½ SW SE	3-33N-75W
8	Phillips Petr. Co.	No.1 McNeal	Glenrock	Converse	SW NE NW	4-33N-75W
9	Phillips Petr. Co.	No.1 A Glenrock	Glenrock	Converse	SW NE	5-33N-75W
10	Trigood Oil Co.	No.4 Young	Glenrock	Converse	SW NE SE	6-33N-75W
11	Farwest-Hancock-Cont.	No.7 State 8	S. Glenrock	Converse	NE NW NW	8-33N-75W
12	Ajax Oil	No.1 Scott	Wildcat	Converse	NE SW SE	12-33N-75W
13	J.D. Sprecker	No.1 Lam	Wildcat	Converse	NW SE SE	15-33N-75W
14	Farwest-Hancock-Cont.	No.1 State Olin	S. Glenrock	Converse	NW NW NW	16-33N-75W
15	Farwest-Hancock-Cont.	No.3B State 17	S. Glenrock	Converse	SE NE SE	17-33N-75W
16	Farwest-Hancock	No.2 V.R. Ranch	S. Glenrock	Converse	SW NW NE	19-33M-75W
17	Black Hills Drilling	No.1 Bixby-Carey	Wildcat	Converse	NE NE NE	25-33N-75W
18	Southern Production	No.3 Gardner State	Big Muddy	Converse	SE NW	1-33N-76W
19	Southern Production	No.1 Fenex	Big Muddy	Converse	SE NW	2-33N-76W
20	Continental Oil Co.	No.24 Jones 3-10	Big Muddy	Converse	SE SW SW	3-33N-76W
21	Continental Oil Co.	No.14 Elk Horn	Big Muddy	Converse	SE SW SW	4-33N-76W
22	Continental Oil Co.	No.35 Cary	Big Muddy	Converse	SE NE NE	8-33N-76W
23	Continental Oil Co.	No.61 Whiteside	Big Muddy	Converse	-- -- --	9-33N-76W
24	Continental Oil Co.	No.16 State 10	Big Muddy	Converse	NW NE NW	10-33N-76W
25	Dyer Drlg. Co. So. Prod.	No.1 McCauley St	Big Muddy	Converse	SW NE	12-33N-76W
26	Dyer Drilling	No.16-1-D State	Big Muddy	Converse	SW SW	16-33N-76W
27	Steel Drlg. Co.	No.1 Steel Gov't.	Big Muddy	Converse	SE SE SE	17-33N-76W
28	Continental Oil Co.	No.2 Humphrey	Big Muddy	Converse	NE NE NW	18-33N-76W
29	Western Oil Field Inc.	No.1 Barber St.	Wildcat	Converse	SE NW	22-33N-76W
30	Ajax Oil Co.	No.1 Barber St.	Deer Creek	Converse	E½ SW NE	34-33N-76W
31	Continental Oil Co.	No.5 Pool	Big Muddy	Converse	SW SE SE	12-33N-77W
32	Brinkerhoff-Delaney	No.1 State A	W. Big Muddy	Natrona	SE SE	17-33N-77W

Table 1. (cont.)

Well No.	Company	Well	Area	County	Location Description	Sec. T. R.
33	Seaboard & Tidewater	No.54-33 Lathrop	Hat Six	Natrona	SW SW NE	33-33N-77W
34	*Amerada	No.1 USA Brannan	Wildcat	Natrona	SW NW NE	29-33N-78W
35	*True & Brown	No.1 Tank Farm	E. Glenrock	Converse	SW NW SE	34-34N-74W
36	*Phillips Petr.	No.1 Sand Creek	Sand Creek	Converse	SE SE	7-34N-75W
37	*Phillips Petr.	No.1 Brown-Brubaker	Glenrock	Converse	SW SW SW	33-34N-75W
38	*Phillips Petr.	No.27	S. Cole	Converse	SW SW NW	5-34N-76W
39	Phillips Petr.	No.11 Unit	S.Cole Creek	Converse	SW SE NW	6-34N-76W
40	Phillips Petr.	No.7 Unit	S.Cole Creek	Converse	SW SE SE	7-34N-76W
41	Phillips Petr.	No.5 Unit	S.Cole Creek	Converse	SW SW SW	8-34N-76W
42	*Ralph Lowe	1-B Kolacny	S.Cole Creek	Converse	SW SW SW	9-34N-76W
43	Ralph Lowe	No.4 State	S.Cole Creek	Converse	SW NE SW	16-34N-76W
44	Phillips Petr.	No.2 Cole	S.Cole Creek	Converse	SW NW NW	17-34N-76W
45	Ralph Lowe	No.2 Wilson	S.Cole Creek	Converse	SW SW NE	19-34N-76W
46	Phillips Petr.	No.6 Cole	S.Cole Creek	Converse	SW NE NW	20-34N-76W
47	R.L. Manning	No.1 Dewitt	S.Cole Creek	Converse	SW SE SE	21-34N-76W
48	Ralph Lowe	No.1 Combs	N. Big Muddy	Converse	SW NW SE	28-34N-76W
49	Stanolind O & G	No.1 Hayden	N. Big Muddy	Converse	NE SE	34-34N-76W
50	So. Production	No.1 Burns	N. Big Muddy	Converse	SW NE	35-34N-76W
51	So. Production	No.1-C Gardner-St.	N. Big Muddy	Converse	SE SW	36-34N-76W
52	Trigood Oil Co.	No.1 Domino	S.Cole Creek	Converse	NE NE	12-34N-77W
53	Sohio Petr. Co.	No.1 Beavan	Geary Dome	Natrona	SE SW	27-34N-77W
54	Superior Oil Co.	No.36-29	Geary Dome	Natrona	SW NE SW	29-34N-77W
55	Continental Oil Co.	No.1 Unit	N. Geary Dome	Natrona	NW NE NE	10-34N-78W
56	General Petr. Co.	No.7-8-G	Cole Creek	Natrona	NW SE SW	8-35N-77W
57	General Petr. Co.	No.28-16-S	Cole Creek	Natrona	-- -- --	16-35N-77W
58	General Petr. Co.	No.62 Gov't.	Cole Creek	Natrona	SE NW NE	21-35N-77W
59	Sinclair O & G	No.1 Marvin Smith	Cole Creek	Converse	NE SE NE	23-35N-77W
60	*General Petr.	F 32-26-G	Cole Creek	Converse	C SW NE	26-35N-77W
61	Phillips Carter	No.1 Gov't.	Midway	Natrona	NE SE NE	23-35N-79W
62	Commercial Oil	No.1 Rubush	Wildcat	Natrona	NE NE SE	25-25N-80W
63	**Amerada Petr. Corp.	No.11 Unit	Sage Sp. Ck.	Natrona	SW NE	6-36N-77W

Table 1. (cont.)

Well No.	Company	Well	Area	County	Location Description	Location Sec. T. R.
64	**Amerada Petr. Corp.	No.4 Unit	Sage Sp. Ck.	Natrona	SE NW NE	7-36N-77W
65	Amerada Petr. Corp.	No.15 Unit	Sage Sp. Ck.	Natrona	SE NE	18-36N-77W
66	Brinkerhoff Drlg.	No.1 Gov't.	S.Sage Sp Ck	Natrona	SE NW	21-36N-77W
67	**Amerada Petr. Co.	No.7 Unit	Sage Sp. Ck.	Natrona	NW NE	1-36N-78W
68	Carter	No.1 Gov't.	20 Mile	Natrona	SE SE SE	27-36N-79W
69	E.N. Hope	No.4 Gov't.	Castle Creek	Natrona	NE NE NE	32-36N-81W
70	Lyle & Sims Drlg. Co.	No.1 Gowin	Wildcat	Natrona	NE NW SE	1-36N-82W
71	Cities Service	No.1 Gov't.	Wildcat	Natrona	NW NE SW	22-36N-82W
72	*Phillips Petr.	No.1 Unit	Werner	Converse	SE NE	20-37N-75W
73	Amerada Petr. Corp.	No.17 Unit	Sage Sp. Ck.	Natrona	NW SW NW	8-37N-77W
74	**Amerada Petr. Corp.	No.27 Unit	Sage Sp. Ck.	Natrona	SW SW	8-37N-77W
75	Amerada Petr. Corp.	No.19 Unit	Sage Sp. Ck.	Natrona	SE SW	29-37N-77W
76	Amerada Petr. Corp.	No.1 Unit	Sage Sp. Ck.	Natrona	SW SE	30-37N-77W
77	**Amerada Petr. Corp.	No.2 Unit	Sage Sp. Ck.	Natrona	SE NE	30-37N-77W
78	**Amerada Petr. Corp.	No.3 Unit	Sage Sp. Ck.	Natrona	NE NW	30-37N-77W
79	Amerada Petr. Corp.	No. 21 Unit	Sage Sp. Ck.	Natrona	NW SW	30-37N-77W
80	Amerada Petr. Corp.	No.9 Unit	Sage Sp. Ck.	Natrona	NW NE	31-37N-77W
81	**Amerada Petr. Corp.	No.12 Unit	Sage Sp. Ck.	Natrona	SE NE	31-37N-77W
82	Amerada Petr. Corp.	No.14 Unit	Sage Sp. Ck.	Natrona	NW NW	31-37N-77W
83	Amerada Petr. Corp.	No.8 Unit	Sage Sp. Ck.	Natrona	SW NE SW	2-37N-78W
84	Crude Oil Producers	No.1 Gov't.	Sage Sp. Ck.	Natrona	NE NW	3-37N-78W
85	*Amerada Petr. Corp.	No.29 Unit	Sage Sp. Ck.	Natrona	C SW SE	11-37N-78W
86	**Amerada Petr. Corp.	No.10 Unit	Sage Sp. Ck.	Natrona	SW SE	13-37N-78W
87	Amerada Petr. Corp.	No.18 Unit	Sage Sp. Ck.	Natrona	SE SE	25-37N-78W
88	*Carter Oil Co.	No.1 St. Burke	SE Castle Ck	Natrona	SE SE SE	36-37N-79W
89	Seaboard-Atlantic	No.61-27 Gov't.	SE Castle Ck	Natrona	NE NW NE	27-37N-80W
90	E. N. Hope	No.1 Gov't.	W Castle Ck.	Natrona	SE NE SW	1-37N-82W
91	Pure Oil Co.	No.1 Unit	Wildcat	Natrona	SE SE	36-37N-82W
92	Frank Morgan	No.1 Frank Morgan	Wildcat	Natrona	SW SE NW	5-37N-83W
93	Trigood-Stanolind	No.1 Gov't-Duncan	E Teapot	Natrona	NE SW	30-38N-77W
94	Trigood	No.2 Duncan	E Teapot	Natrona	NW NW	30-38N-77W

Table 1. (cont.)

Well No.	Company	Well	Area	County	Location	
					Description	Sec. T. R.
95	U. S. Navy	No.3 1-G-10	Teapot	Natrona	CS½ SW NW	10-38N-78W
96	Trigood	No.1 Gov't.	E Teapot	Natrona	NE NW	24-38N-78W
97	Trigood	No.3 A Gov't.	E Teapot	Natrona	SE SE SW	24-38N-78W
98	Trigood	No.4 E Gov't	E Teapot	Natrona	NE SE	24-38N-78W
99	Brinkerhoff	No.5 Midland-Gov't.	N Sage Sp Ck	Natrona	NE NE	25-38N-78W
100	Amerada Petr. Corp.	No.1 USA English	N Sage Sp Ck	Natrona	SE SW	26-38N-78W
101	Trigood Oil Co.	No.5 Gov't	W Teapot	Natrona	SE SE SW	27-38N-78W
102	Amerada Petr. Corp.	No.22 Unit	N Sage Sp Ck	Natrona	SE NE	34-38N-78W
103	Amerada Petr. Corp.	No.2 USA English	N Sage Sp Ck	Natrona	NE NW	35-38N-78W
104	Amerada Petr. Corp.	No.13 Unit	N Sage Sp Ck	Natrona	NE NE	35-38N-78W
105	Amerada Petr. Corp.	No. 26 Unit	N Sage Sp Ck	Natrona	NE SE	35-38N-78W
106	Amerada Petr. Corp.	No.24 Unit	N Sage Sp Ck	Natrona	NE SW	35-38N-78W
107	**Amerada Petr. Corp.	No.6 Unit	N Sage Sp Ck	Natrona	SW NE	35-38N-78W
108	Crude Oil Producers	No.1 Gov't-Tomberlin	W Teapot	Natona	SW SW	2-38N-79W
109	Atlantic Ref. Co.	No.1 Gov't.	SE Castle Ck	Natrona	SE SW SW	32-38N-80W
110	Continental Oil Co.	No.8 Castle Creek	Castle Ck.	Natrona	SW SW NE	22-38N-81W
111	E. N. Hope	No.3 Gov't	Wildcat	Natrona	NW SW SE	29-38N-82W
112	U. S. Navy	No.1-33 T.P. Gov't.	Teapot	Natrona	NW NE SE	33-39N-78W
113	Stanolind O & G	No.1 Roy Hylton	Wildcat	Natrona	SW	29-39N-80W
114	Sinclair O & G	No.1 E. Salt Ck.	E Salt Ck.	Natrona	SE SE SW	10-40N-78W
115	Keniland O & G	No.1 Gov't	Wildcat	Natrona	SE SE SE	15-40N-78W
116	Stanoling O & G	No.29 TPX Unit	Salt Ck.	Natrona	NW	26-40N-79W
117	Norris Oil	No.88-25 Gov't.	Wildcat	Natrona	SE SE SE	25-40N-81W
118	American Liberty	No.1 Irwin	Wildcat	Johnson	NW NW NW	7-41N-77W
119	American Liberty	No.1 Irvine	E Meadow Ck.	Johnson	NW SE NE	18-41N-77W
120	Sharples Oil Corp.	No.1-A-19-Gov't	E Sussex	Johnson	NE NE NW	19-41N-77W
121	Continental Oil Co.	No.90 Unit	Meadow Ck.	Johnson	NE NW SW	1-41N-78W
122	Continental	No.45 Unit	Meadow Ck.	Johnson	NE SW SW	2-41N-78W
123	Sinclair O & G	No.1 Unit	Meadow Ck.	Johnson	SW NW SW	5-41N-78W
124	Continental Oil Co.	No.26 Meadow Ck.	Meadow Ck.	Johnson	NE NW SE	9-41N-78W
125	Continental Oil Co.	No.A-46 Unit	Meadow Ck.	Johnson	NE SE NE	10-41N-78W

Table 1. (concl.)

Well No.	Company	Well	Area	County	Location Description	Location Sec. T. R.
126	Continental Oil Co.	No.1 Unit	Meadow Ck.	Johnson	NE NE NW	11-41N-78W
127	Continental Oil Co.	No.B-110 Meadow Ck.	Meadow Ck.	Johnson	SE	13-41N-78W
128	Continental Oil Co.	No.56 Unit	Meadow Ck.	Johnson	NE NW SE	14-41N-78W
129	Continental Oil Co.	No.107 Unit	Meadow Ck.	Johnson	NE NE NW	16-41N-78W
130	McCauley et.al.	No.1 Gov't-Weadick	Meadow Ck.	Johnson	SW SW SE	22-41N-78W
131	Brinkerhoff-Pioneer	No.1 Gov't-Pioneer	Wildcat	Johnson	NE NE NE	25-41N-78W
132	Tidewater Oil Co.	No.74-21 Unit	Wildcat	Johnson	SW SE NE	21-41N-81W
133	Continental Oil Co.	No.15 Sussex	Sussex	Johnson	SE NE SW	15-42N-78W
134	Continental Oil Co.	No.7 Unit	Wildcat	Johnson	NE SE NW	17-42N-78W
135	Continental Oil Co.	No.12 Unit	Sussex	Johnson	SE	18-42N-78W
136	Continental Oil Co.	No.14 Unit	Sussex	Johnson	SE NE NE	22-42N-78W
137	Continental Oil Co.	No.8 Unit	Sussex	Johnson	SE NW NW	23-42N-78W
138	American Liberty	No.1 Federal Land	Sussex	Johnson	SE SE SE	27-42N-78W
139	Delhi Oil Corp.	No.2 Federal Hill	Sussex	Johnson	SE SW NE	35-42N-78W
140	Continental Oil Co.	No.3 State	N Meadow Ck.	Johnson	NW NW SW	36-42N-78W
141	Continental Oil Co.	No.1 W. Sussex	Wildcat	Johnson	NW SE NW	8-42N-79W
142	Continental Oil Co.	No.50 Unit	Sussex	Johnson	NW NE NE	14-42N-79W
143	Continental Oil Co.	No.10-B W. Sussex	W Sussex	Johnson	NW NW SE	1-42N-80W
144	Earl Mallette	No.1 Gov't.	Wildcat	Johnson	NW NE SE	4-42N-80W
145	Husky Oil Co.	No.1 Gallup	Wildcat	Johnson	NE SW SE	31-43N-79W
146	Stanolind O & G	No.1 Gov't-Mains	Wildcat	Johnson	SW SW	19-44N-81W
147	Continental Oil Co.	No.1 Unit	N. Kaycee	Johnson	NE SW SE	9-44N-82W

Well numbers in this table correspond to well numbers in Tables 2 and 3.

* Thin section analysis.

** Thin section analysis, size analysis, and heavy mineral analysis.

Table 2. Data derived from electric logs.

Well No.	Depth to top of Dakota	Depth to base of Dakota	Total thickness of Dakota	Total Ss of Dakota	Sand/Shale ratio	Remarks
1	5,090	5,143	53	17	.47	Lith. Log
2	5,604	5,720	56	15	.37	---
3	4,784	4,835	51	15	.42	---
4	3,522	3,567	48	12	.33	Lith. Log
5	1,490	1,545	55	10	.22	---
6	9,255	9,314	59	34	1.36	Lith. Log
7	7,596	7,667	71	50	2.30	---
8	6,938	6,997	59	30	1.03	Cored
9	7,000	7,060	60	32	1.14	---
10	6,406	6,463	57	32	1.28	---
11	6,513	6,568	55	27	.97	---
12	8,149	8,207	58	40	2.22	Lith. Log
13	8,207	8,267	60	35	1.40	Cored
14	6,199	6,267	68	35	1.06	---
15	6,100	6,167	67	40	1.48	---
16	6,071	6,130	59	46	3.54	---
17	4,458	4,517	59	38	1.81	Lith. Log
18	4,982	5,029	47	31	1.94	---
19	4,546	4,596	50	26	1.08	---
20	4,293	4,348	55	33	1.50	---
21	4,202	4,250	48	24	1.00	---
22	4,244	4,291	47	19	.68	---
23	4,190	4,247	57	34	1.47	---
24	4,340	4,400	60	27	.82	---
25	5,551	5,610	59	30	1.03	---
26	4,507	4,558	51	20	.64	---
27	4,547	4,596	49	19	.61	---
28	4,384	4,434	50	20	.67	---
29	5,088	5,138	50	18	.56	Cored
30	6,130	6,181	51	18	.54	Lith. Log
31	4,459	4,506	47	18	.58	---

Table 2. (cont.)

Well No.	Depth to top of Dakota	Depth to base of Dakota	Total thickness of Dakota	Total Ss of Dakota	Sand/Shale ratio	Remarks
32	5,447	5,490	43	22	1.05	Lith. Log
33	4,033	4,080	57	20	.54	Lith. Log
34	-----	-----	--	--	----	---
35	-----	-----	--	--	----	---
36	10,959	11,016	57	18	.46	Cored
37	7,036	7,094	58	30	1.07	Lith. Log
38	-----	-----	--	--	----	---
39	8,423	8,472	49	22	.80	Cored
40	8,275	8,328	53	24	.83	Cored
41	8,295	8,344	49	24	.96	---
42	-----	-----	--	--	----	---
43	8,637	8,692	55	22	.66	---
44	8,217	8,270	53	20	.60	---
45	8,962	9,012	50	18	.56	---
46	8,250	8,302	52	20	.62	---
47	8,618	8,660	42	19	.82	---
48	8,333	8,382	49	18	.58	---
49	6,659	6,718	59	18	.44	---
50	7,398	7,456	58	27	.87	---
51	5,653	5,708	55	28	1.03	---
52	8,606	8,659	53	22	.71	---
53	6,785	6,832	47	8	.21	Lith. Log
54	6,232	6,276	44	10	.30	Cored
55	7,226	7,272	46	19	.70	---
56	8,339	8,390	51	23	.82	Lith. Log
57	7,910	7,960	50	24	.92	---
58	7,930	7,979	49	26	1.13	---
59	8,943	8,992	49	22	.81	Lith. Log
60	-----	-----	--	--	----	---
61	5,930	5,978	48	28	1.40	---
62	4,998	5,045	47	8	.21	---

Table 2. (cont.)

Well No.	Depth to top of Dakota	Depth to base of Dakota	Total thickness of Dakota	Total Ss of Dakota	Sand/Shale ratio	Remarks
63	7,344	-----	--	33	----	Cored
64	7,486	-----	--	26	----	Cored
65	7,773	7,320	47	16	.52	Cored
66	8,556	8,604	48	26	1.18	Lith. Log
67	7,371	7,420	49	32	1.88	Cored
68	7,248	7,290	42	15	.56	Cored
69	3,626	3,668	42	6	.17	---
70	1,392	1,434	42	6	.17	---
71	2,668	2,710	42	5	.13	Lith. Log
72	13,027	13,080	53	12	.29	Cored
73	7,219	-----	--	17	----	Cored
74	7,340	7,386	46	25	1.19	Cored
75	7,486	7,534	48	30	1.66	Cored
76	7,249	7,304	55	40	2.66	Cored
77	7,297	7,346	49	26	1.13	Cored
78	7,145	7,188	43	18	.72	Cored
79	7,288	7,329	41	31	3.10	Cored
80	7,259	-----	--	26	----	Cored
81	7,288	-----	--	24	----	Cored
82	7,190	-----	--	48	----	Cored
83	6,256	6,302	46	24	1.09	---
84	7,056	7,102	46	20	.77	Cored
85	-----	-----	--	--	----	---
86	6,853	6,894	41	18	.78	Cored
87	7,282	-----	--	48	----	Cored
88	6,731	6,772	41	19	.86	Lith. Log
89	4,692	4,738	46	5	.12	Lith. Log
90	4,056	4,098	42	8	.23	---
91	1,422	1,466	44	5	.13	Lith. Log
92	1,497	1,531	34	0	----	---
93	6,398	6,441	43	30	2.30	Cored

Table 2. (cont.)

Well No.	Depth to top of Dakota	Depth to base of Dakota	Total thickness of Dakota	Total Ss of Dakota	Sand/Shale ratio	Remarks
94	6,150	-----	--	27	----	---
95	3,745	3,787	42	14	.50	Cored
96	5,589	-----	--	14	----	---
97	5,675	-----	--	20	----	---
98	5,865	-----	--	15	----	---
99	5,909	-----	--	24	----	---
100	5,397	-----	--	38	----	Cored
101	6,208	6,251	43	14	.48	---
102	6,036	-----	--	16	----	Cored
103	5,556	5,597	41	26	1.73	Cored
104	5,637	5,681	44	26	1.44	Cored
105	5,771	5,820	49	26	1.13	Cored
106	5,869	5,916	53	15	.39	Cored
107	5,661	-----	--	--	----	Cored
108	5,382	-----	--	9	----	Cored
109	3,250	3,293	43	8	.23	---
110	3,176	3,223	47	8	.20	---
111	4,157	4,195	38	6	.19	---
112	3,724	3,767	43	12	.38	---
113	2,651	2,696	45	8	.21	---
114	5,823	5,866	43	12	.38	Lith. Log
115	6,280	6,322	42	12	.30	Lith. Log
116	2,315	2,360	45	12	.36	---
117	1,315	1,360	45	10	.28	---
118	7,378	7,422	44	12	.38	---
119	7,661	7,703	42	12	.40	Lith. Log
120	7,608	7,652	44	12	.38	Lith. Log
121	7,306	7,350	44	12	.38	---
122	7,622	7,664	42	11	.35	---
123	7,502	7,546	44	13	.42	---
124	7,488	7,533	45	10	.29	---

Table 2. (concl.)

Well No.	Depth to top of Dakota	Depth to base of Dakota	Total thickness of Dakota	Total Ss of Dakota	Sand/Shale ratio	Remarks
125	7,453	7,497	44	14	.47	---
126	7,392	7,436	44	14	.47	---
127	7,433	7,476	43	12	.39	---
128	7,388	7,432	44	13	.42	---
129	7,111	7,156	45	12	.36	---
130	7,115	7,158	43	11	.34	Lith. Log
131	7,561	7,605	44	12	.38	Lith. Log
132	404	455	51	10	.24	Lith. Log
133	7,699	7,743	44	12	.38	---
134	7,740	7,783	43	13	.43	---
135	7,440	7,483	43	11	.35	---
136	7,355	7,395	40	12	.42	---
137	7,400	7,442	42	13	.44	---
138	7,767	7,810	43	13	.43	---
139	7,708	7,752	44	14	.46	---
140	7,545	7,591	46	13	.39	---
141	5,918	5,962	44	8	.22	Lith. Log
142	7,798	7,841	43	12	.39	---
143	5,982	6,026	44	12	.38	---
144	4,573	4,617	44	12	.38	---
145	7,709	7,754	45	13	.40	---
146	4,848	4,894	46	10	.27	Lith. Log
147	2,040	2,082	42	8	.23	Lith. Log.

Well numbers in this table correspond to well numbers in Table 1.

LITHOGICAL LOG AND CORED INTERVAL DESCRIPTIONS

1. 5090 Top of Dakota

Lith. Log

5090-5102	Sandstone, medium sub-angular to slightly sub-rounded, glassy with slight to medium oil stain, some tripolitic chert included, fairly porous.
5102-5103	Shale, gray-green to dark olive green, sub-waxy.
5103-5118	Sandstone, fine to very fine, sub-angular, coarse sandstone bedded, tight, interbedded with dark gray-green shale.
5118-5168	Shale, gray-green to dark olive green, sub-waxy, with very fine, sub-angular sandstone.

4. 3522 Top of Dakota

Lith. Log

3534-3550	Sandstone, white, fine grained, sub-angular to rounded, well sorted, flakes of muscovite, fair porosity, poor permeability, calcareous.
3550-3555	Shale, black, platy.
3555-3557	Siltstone.
3557-3570	Shale, black, platy.

6. 9255 Top of Dakota

Lith. Log

9257-9262	Sandstone, light gray, fine, angular, greenish, well sorted, slightly micaceous with few partings black silty shale.
9262-9298	Sandstone, white to light gray, few shale partings, bleeding free oil.
9298-9303	Shale, black, sandy with interbeds fine gray sand.
9303-9331	Shale, black, silky to finely sandy, hard, fissle, upper 8 feet interbedded with Dakota type sandstone.

8. 6938 Top of Dakota

Cored

6940-6970	Recovered: 8½ feet black shale, 1 foot gray silty sandstone, 15½ feet sand and shale, 5 feet silty sand with irregular oil stain.
6970-6978	Recovered: 3 feet oil stained siltstone.
6978-7008	Recovered: 30 feet saturated sand.

12. 8149 Top of Dakota

Lith. Log

8160-8180	Sandstone, white, fine angular, tight, scattered pink grains, some glassy, thin parting and interbeds dark gray shale.
8180-8190	Sandstone, white, medium, sub-angular, tight to medium porous, soft dark gray interbeds.
8190-8207	Sandstone, medium, angular, slightly porous to porous, clean light brown oil stain to oil saturated, grading into white porous sandstone with light oil stain.
8207-8230	Shale, dark gray.

13. 8207 Top of Dakota

Cored

8198-8231	Recovered: 29½ feet shale with streaks of saturation.
8231-8242	Recovered: Sand and shale with slight staining.
8242-8254	Recovered: 12 feet shale with sand stringers.

17. 4458 Top of Dakota

Lith. Log

4458-4485	Sandstone, brownish-gray, fine to very fine, tight, minutely micaceous, some slightly pyritic, thin interbeds dark gray shale (probably ribbon sand).
4485-4490	Sandstone, finely medium, angular, well sorted, slightly porous, some flecks black carbonaceous material, interbeds dark gray shale.

17. (cont.)

4490-4505	No samples.
4505-4513	Sandstone, gray, fine, angular, glassy, tight, slightly micaceous, few laminated, black carbonaceous inclusions, partings dark gray shale.
4513-4520	No samples.
4520-4538	Shale, dark gray, some bentonite and sandstone partings.

29. 5088 Top of Dakota

Cored

5095-5109	Recovered: Sand and shale.
5109-5122	Recovered: 6 to 9 feet saturated sand, hard and tight, 3 feet streaked saturation.
5122-5135	Recovered: Hard and tight sand thinly streaked with saturation and streaks of shale.

30. 6133 Top of Dakota

Lith. Log

6133-6139	Sandstone, gray-tan, very fine to fine, subangular, micaceous, hard with black shale partings.
6139-6141	Shale, dark gray, minutely micaceous, silty.
6141-6145	Sandstone, light gray, very fine to fine, subangular, hard, tight, micaceous, trace pyrite, tripolitic, with black shale partings.
6145-6147	Siltstone, brown, calcareous with few carbonaceous inclusions, faint stain.
6147-6150	Siltstone, white, slightly calcareous with carbonaceous shale partings.
6150-6152	Siltstone, brown with minute carbonaceous inclusions and black shale partings, slicken sides, calcite filled.
6152-6158	Siltstone, tan, thinly interbedded with dark gray waxy shale, pyrite nodules.
6158-6160	Sandstone, gray-tan, very fine to fine, angular, hard, tight, few pyrite inclusions and black shale partings.
6160-6163	Sandstone, light gray, very fine to fine, subangular, quartzitic to slightly porous, few orange grains, no stain.

30. (cont.)

6163-6167	Sandstone, light tan, fine to finely medium, angular, slightly calcareous with orange grains, tight to slightly porous, micaceous.
6167-6171	Sandstone, light gray, fine, sub-angular with orange grains, green and white mica, tight to slightly porous.
6171-6175	Sandstone, as above with black, micaceous, shale partings.
6175-6185	Sandstone gray, very fine, sub-angular, hard, tight, micaceous with black micaceous shale partings.
6185-6190	Shale, brown to black, carbonaceous.

32. 5447 Top of Dakota

Lith. Log

5446-5488	Sandstone, light gray, very finely sucrose, finely micaceous, slightly calcareous, tight, interbeds dark gray silky shale.
5488-5520	Shale, dark gray to black, silky, thin streaks bentonite.

33. 4033 Top of Dakota

Lith. Log

4032-4035	Sandstone, fine to very fine, sub-angular, thinly laminated.
4035-4045	Shale, gray, dark gray, minutely micaceous, papery with some gritty to sandy streaks.
4045-4050	Sandstone, tan, fine to very fine, sub-angular slightly micaceous, hard, tight.
4050-4052	Shale, gray, dark gray, silky, minutely micaceous, very fissil.
4052-4060	Sandstone, as above, some gray to dark gray.
4060-4065	Sandstone, tan, fine to medium, sub-angular to sub-round, fairly tight.
4065-4069	Shale, as above.
4069-4087	Sandstone, tan, gray, fine to medium, sub-angular, fairly tight.
4087-4090	Shale, as above.
4090-4092	Sandstone, as above.
4092-4100	Shale, as above.

36. 10959 Top of Dakota

Cored

10980-11023	Recovered: 2 feet silty shale, 3 feet sandstone oil saturated, tight, 3½ feet silty shale, 2 feet sand oil saturated, 9 feet siltstone shaley, 10 feet silty shale.
11023-11048	Recovered: 11 feet shale, 14 feet shale, silty, gray cast.

37. 7036 Top of Dakota

Lith. Log

7034-7050	Sandstone, light gray, fine to very fine, angular, tight, calcareous, minutely micaceous with some inclusions black carbonaceous material, interbeds dark gray to black silky shale.
7050-7059	Sandstone, light tan, fine, medium to medium sub-angular, tight to slightly porous.
7059-7061	Sandstone, as above, medium angular, medium porous, good stain.
7061-7072	Sandstone, as above, finely medium, slightly porous, light stain.
7072-7080	Sandstone, as above, micaceous.
7080-7100	Shale dark gray to black with interbeds sandstone, light gray to white, fine to finely medium angular, sucrose, minutely micaceous tight to slightly porous.
7100-7105	Sandstone, gray, fine, soft bentonitic, salt and pepper.
7105-7115	Shale, as above, some partings sandstone, pyrite crystal clusters and inclusions with trace cherty, quartzitic, medium pyritic sandstone.

39. 8423 Top of Dakota

Cored

8417-8450	Recovered: 10 feet silt, 9½ feet sandy shale, 7½ feet oil sand saturated, with vertical fractures.
8450-8462	Recovered: 9½ feet shaley sand.
8462-8495	Recovered: 3 feet sandy shale, 29 feet black shale, 1 foot oil sand.

40. 8275 Top of Dakota

Cored

8293-8324	Recovered: 5½ feet sand fractured with saturation, 2 feet shaley sand, 9 feet saturated sand with fractures, 2 feet shaley sand with streaks saturation, 12½ feet shale with sand streaks.

53. 6785 Top of Dakota

Lith. Log

6790-6801	Sandstone, gray-tan, very fine to fine, tight, hard, calcareous with thin partings micaceous shale.
6801-6808	Shale, gray to dark gray, minutely micaceous.
6808-6810	Sandstone, tan, fine to finely medium, sub-angular to sub-rounded, fair porosity and oil stain.
6810-6814	Sandstone, light gray, fine to finely medium, sub-angular to sub-round, tight, hard, slightly micaceous and calcareous, few carbonaceous inclusions with few thin shale partings.
6814-6815	Shale, dark gray, minutely micaceous with interbedded fine sandstone streaks.
6815-6816	Sandstone, light tan, fine to finely medium, sub-angular to sub-round, tight, hard, sub-glassy, slightly calcareous.
6816-6825	Sandstone, gray to dark gray, shaley with interbedded gritty shale.
6825-6864	Shale, dark gray, minutely micaceous with interbedded bentonite streaks.

54. 6232 Top of Dakota

Cored

6243-6273	Recovered: 3 feet sandstone with shale streaks, 4½ feet shale with some sand streaks, 5 feet shale and siltstone, 1½ feet sandstone with shale streaks, 1 foot dark gray shale, sandy, 13 feet sandstone with interbedded shale, 2 feet shale sandy.

56. 8339 Top of Dakota

Lith. Log

8335-8345	Shale, dark gray, platy-fissle.
8345-8355	Sandstone, light brown, very fine grained sub-angular to sub-rounded, poorly sorted.

59. 8943 Top of Dakota

Lith. Log

8940-8943	Shale, dark gray, slightly arenaceous.
8943-8956	Sandstone, white, fine-medium grained, sub-angular to sub-rounded, well sorted, quartzitic.
8956-8970	Shale, dark gray, slightly arenaceous.
8970-9000	Sandstone, white, fine to medium grained, sub-angular to sub-rounded, calcareous.

63. 7344 Top of Dakota

Cored

7340-7342	Medium grained, very hard, tight shaley sand.
7342-7344	Medium grained, slightly porous saturated sand interbedded with thin layers of gray shale.
7344-7346½	Medium grained, slightly porous saturated sand.
7346½-7349½	Medium grained sand with spotted stain and interbedded with thin layers of dark gray shale.
7349½-7351	Medium grained, slightly porous sand.
7351-7354	Medium grained, slightly porous sand with thin layers of black carbonaceous shale.
7354-7360	Medium grained, slightly porous saturated sand with horizontal and vertical fractures.
7361-7361½	Medium grained, saturated tight sand interbedded with thin layers of gray shale.
7361½-7376	Medium grained, hard, tight, saturated sand with vertical and horizontal fractures and interbedded with thin layers of gray shale.

64. 7486 Top of Dakota

Cored

7487-7488	Fine grained, hard, tight, slightly carbonaceous sand.

64. (cont.)

7488-7488'4"	Sandy shale.
7488'4"-7488'9"	Fine grained, very hard and tight, glassy sand with paper thin shale partings.
7488'9"-7493'2"	Fine grained, hard, tight, sandy shale.
7493'2"-7493'5"	Gray shale.
7501-7505'2"	Medium to fine grained, angular, slightly porous, saturated sand.
7505'2"-7507'2"	Medium grained, micaceous, tight, saturated sand.
7507'2"-7508	Medium grained, angular, tight, slightly carbonaceous saturated sand.
7508-7512'4"	Fine grained, hard, tight sand with paper thin, gray, slightly carbonaceous shale partings.
7512'4"-7522	Fine grained, hard, tight, shaley sand.

65. 7773 Top of Dakota

<u>Cored</u>

7757-7766½	Black, brittle shale.
7766½-7774½	Medium grained, very hard, tight, sandstone interbedded with thin layers of black shale.
7774½-7777	Black shale interbedded with thin layers of medium grained, hard, tight sandstone.
7777-7785½	Black shale interbedded with thin layers of medium grained hard and tight sand.
7785½-7789	Medium grained, slightly porous, saturated sand with traces of carbonaceous residue.
7789-7802	Fine grained, hard, tight, cross-bedded sand, interbedded with black shale. Shale percentage increases toward the base.

66. 8556 Top of Dakota

<u>Lith. Log</u>

8500-8555	Shale, gray to black, platy with light gray sandstone interbedded.
8555-8565	Sandstone, white, fine to medium grained sub-angular to sub-rounded, well sorted, clean.
8565-8575	Shale, gray to black, platy.
8575-8595	Sandstone, white, fine to medium grained, sub-angular to sub-rounded, well sorted clean.
8595-8610	Shale, dark gray to black, platy with inter-bedded gray fine grained sandstone.

67. 7371 Top of Dakota

Cored

7361-7369	Gray shale.
7369-7376	Hard, tight, saturated sand.
7376-7381	Shaley sand and shale interbedded.
7381-7385	Hard, tight, saturated sand.
7385-7390	Sand and shale interbedded.
7390-7392½	Hard, tight, saturated sand.
7392½-7411	Interbedded sand and shale.
7411-7413	Sand, saturated.
7413-7413½	Hard, tight, barren sand.
7413½-7427½	Gray and black shale.

68. 7248 Top of Dakota

Cored

7251-7275	Recovered: 5 feet rotten shale, 2 feet sandstone light gray, hard and tight, shaley, silty, 11 feet sand and shale, 6 feet black rotten shale.

71. 2668 Top of Dakota

Lith. Log

2672-2680	Sandstone, fine, angular, pyritic, micaceous, rusty in part, tight.
2680-2685	Shale, light greenish-gray, with ferruginous stain.
2685-2705	Shale, dark gray, sub-silky.
2705-2710	Sandstone, gray, fine, angular to slightly sub-angular, glassy, slightly salt and pepper, with pale green shale inclusions.
2710-2732	Shale, light gray to greenish-gray, slightly pyritic.

72. 13027 Top of Dakota

Cored

13005-13050	Recovered: 25 feet black shale, 6 feet shale hard and tight, 14 feet shale and sand.
13052-13078	Recovered: 13 feet shale with sand streaks, 11 feet sand hard and tight, ½ foot black shale, 1½ feet sand hard and tight.

73. 7219 Top of Dakota

Cored

7231-7234½	Hard, tight, fine grained sand, saturated, fair odor and fluorescence.
7234½-7236	Interbedded black shale and fine grained sand.
7236-7238	Hard, tight, fine grained sand.
7238-7239	Sandy shale.
7239-7242	Hard, tight, fine grained sand, bleeding oil, fair odor and fluroescence.
7242-7243	Sandy shale.
7243-7246	Fine grained sand with streaked stain interbedded with black shale.
7246-7247½	Hard, tight, fine grained sand.
7247½-7248½	Sand and black shale.
7248½-7252	Hard and tight, fine grained, gray to white sand.
7252-7259	Black, very slightly sandy shale, slight trace vertical fracture.
7259-7263	Black shale.

74. 7340 Top of Dakota

Cored

7346-7355	Shale, black, carbonaceous with trace pyrite.
7355-7357	Sandstone, fine grained, hard, poor to fair porosity and permeability, even saturation, fair odor, trace black shale.
7357-7360½	Sandstone, as above, with many black shale inclusions.
7360½-7360'9"	Shale, black, pyritic.
7360'9"-7364	Sandstone, as above, with asphaltic residue.
7364-7368	Sandstone, as above, spotty saturation, slight bleeding dead oil.
7368-7376	Sandstone, fine grained, hard and tight, and a few thin beds of interbedded black shale.
7376-7378'6"	Shale, black, silky, with trace of fine grained sandstone interbedded.
7378½-7390	Shale, black.

75. 7486 Top of Dakota

Cored

7480-7486½	Shale, dark gray, platy.
7486½-7491½	Sandy shale, light gray, hard.

75. (cont.)

7491½-7493½	Sand, hard, shaley, fine grained, saturated, bleeding and bubbling oil.
7493½-7494½	Sandy shale, light gray, hard.
7494½-7495	Sand, shaley, as above.
7495-7515	Sand, fine grained, hard, saturated, fair odor, with scattered dark gray shale partings, vertical fractures throughout, bleeding oil along fracture planes.
7515-7516	Sand, very hard, tight, fine grained, excess bleeding of oil.
7516-7520½	Light gray, slightly sandy shale.
7520½-7522	Shaley sand, hard, some saturation and dead oil stain.

76. 7249 Top of Dakota

<u>Cored</u>

7248-7257	Gray, fine grained sandstone, showed good staining.
7257-7262	Gray, medium hard, fairly tight, fine grained sandstone, completely saturated.
7262-7263½	Gray, hard, lime cemented sandstone.
7263½-7268	Gray, fine grained, tight sandstone.
7276-7277½	Black sandy shale with small sand streaks.
7277½-7285'8"	Black shale with streaks of white sand.

77. 7297 Top of Dakota

<u>Cored</u>

7317-7318'11"	Black, silty shale.
7318'11"-7322	Gray, silty shale, and gray medium to fine grained, quartzitic sand.
7322-7323	Interbedded sand and shale, as above.
7323-7328½	Medium grained, slightly porous, tight, saturated sand with paper thin shale partings.
7329½-7336'9"	Saturated sand with three one to two inch shale breaks.
7336'9"-7343'1"	Gray, silty shale with interbedded thin sands.
7343'1"-7355	Gray to black shale with a few thin silty seams.

78.	7145	Top of Dakota

Cored

7145-7154	Gray to black, slightly sandy shale.
7154-7157	Fine grained, very hard, tight, saturated sand.
7157-7157½	Shaley sand with very slight show of oil.
7157½-7163½	Fine grained, very hard, tight, saturated sand.
7163½-7166½	Shaley sand.
7166½-7168½	Medium to fine grained, tight, saturated sand bleeding oil.
7168½-7170½	Very fine grained, hard, tight, shaley sand.
7170½-7171'3"	Very hard, tight sand.
7171'3"-7181½	Gray shale very slightly sandy.

79.	7288	Top of Dakota

Cored

7275-7283	Shale, dark gray, rotten, platy, friable.
7283-7293	Shale, dark gray, hard, with thin stringers of fine grained sand increasing toward the base.
7293-7322	Sandstone, saturated, fine grained, hard, tight, with seams and traces of carbonaceous residue.
7322-7323	Interbedded dark gray shale and fine grained sandstone.

80.	7259	Top of Dakota

Cored

7255-7261	Black to gray, soft shale.
7261-7264	Fined grained, hard, tight, sandstone, patchy stain, slight bleeding.
7264-7266	Hard shale.
7266-7275	Medium grained sand, good odor and fluorescence, good odor, slight bleeding, few vertical fractures.
7275-7279½	Fine to medium grained sand, fair saturation and fluorescence, good odor, slight bleeding, few vertical fractures.
7279½-7282	Very fine grained sand, fair saturation, good fluorescence, slight odor and bleeding.
7282-7282½	Gray-black hard shale.
7282½-7286½	Gray to tan medium grained sand with few shale laminations and vertical fractures, good odor, fair saturation, bleeding oil and water.
7286½-7287	Interbedded black shale and medium grained sand with spotted saturation and slight bleeding of oil and water.

81. 7288 Top of Dakota

Cored

7285-7288	Black fissle shale with minor sandstone streaks.
7288-7289	Medium grained, hard, tight, sandstone with spotted saturation.
7289-7294	Medium grained sandstone, medium porosity, with horizontal and vertical fractures, bleeding oil and gas.
7294-7298½	Medium to fine grained, hard, very slightly porous sandstone with trace interbedded shale and with horizontal and vertical fractures throughout, fair odor.
7298½-7298'7"	Black, pyritic, carbonaceous, shale, interbedded with medium grained, very hard, tight, glassy, fused, white, sandstone.
7298'7"-7299	Medium to fine grained, slightly porous, saturated sandstone, fair odor and fluorescence.
7299-7304	Medium to fine grained, slightly porous to hard, tight, saturated sandstone with thin laminations of black shale and containing some black shale inclusions, horizontal and vertical fractures, sandstone has fair odor and flourescence and was bleeding oil.
7304-7310	Medium grained, slightly porous, hard, saturated sand with minor black shale inclusions and horizontal and vertical fractures, fair odor and flourescence and slight bleeding of oil from fractures in part.

82. 7190 Top of Dakota

Cored

7186-7188	Black shale.
7188-7226	Medium grained, angular, slightly porous, saturated sandstone with trace intermittant black shale and carbonaceous residue inclusions, vertical fractures throughout, fair odor and fair to good fluorescence, slight bleeding of oil throughout.
7226-7235½	Medium to fine grained, hard, tight, shaley sandstone becoming progressively more shaley toward the base, vertical fractures throughout.
7235½-7236	Medium grained, slightly porous, saturated sandstone with carbonaceous residue inclusions, poor odor, fair spotted fluorescence.

84. 7056 Top of Dakota

<u>Cored</u>

7039-7087	Recovered: 19 feet shale, gray to black, fissle, friable. 16 feet shale, very hard, micaceous, dark gray, nodular. 6 feet, as above, with thin stringers, hard, white, fine grained sand. 4 feet sand, fine grained, hard and tight bleeding oil, fair odor and fluorscence. 3 feet sand, slightly shaley, fine grained, hard, some vertical fractures.

86. 6853 Top of Dakota

<u>Cored</u>

6842-6856	Dark gray to black, fissle shale with abundant pyrite bleds at 6852 feet.
6856-6857	Light gray, finely crystalline, sandy limestone top three inches of which was a fine grained quartzite.
6857-6860	Fine grained, quartzitic, calcareous hard, tight, cross-bedded sand with very thin black shale laminations.
6860-6862	Intercalated dark gray to black shale and fine grained, hard, tight sand.
6862-6871	Soft black shale with thin, fine grained sandstone stringers.
6871-6880½	Fine to medium grained, hard sandstone with vertical fractures in upper part. Spotted saturation and bleeding gas and bubbling oil in lower part.
6880½-6883	Hard, black shale with some sandy streaks.

87. 7282 Top of Dakota

<u>Cored</u>

7282-7312	Medium grained, saturated sand with scattered thin shale partings, slightly porous, highly fractured, slight bleeding along fractures.
7312-7324	Medium grained, angular, slightly porous sand, vertical fractures, good to fair fluorescence and fair odor.
7324-7329½	Very hard, tight, fine grained sand inter-bedded with thin layers of black shale.
7329½-7331½	As above, with spotted stain.

87. (cont.)

7331½-7333	Fine grained, tight, saturated sand, fair odor and good flourescence, slight vertical fractures.
7333-7337	Black shale slightly sandy.

88. 6731 Top of Dakota

Lith. Log

6728-6733	Sandstone, salt and pepper, very fine to fine, sub-angular, hard, tight, calcareous.
6733-6741	Shale, black, minutely micaceous, soft, pyritic with sandy inclusions.
6741-6745	Sandstone, light gray, very fine to fine, sub-angular to sub-rounded, calcareous, hard, tight, fractured.
6745-6748	Sandstone, white, fine to very fine, sub-angular to sub-rounded, hard, tight, with black shale inclusions.
6748-6750	Shale, dark gray, minutely micaceous, gritty to sandy.
6750-6753	Sandstone, white to gray, fine sub-angular to sub-rounded, calcareous, hard, tight, slightly fractured.
6753-6756	Shale, black minutely micaceous with thin interbedded sandstone laminations.
6757-6762	Sandstone, as above, with thin black shale partings.
6762-6766	Shale, black minutely micaceous, pyritic.
6766-6777	Sandstone, very fine to fine, shaley, slightly calcareous.
6777-6779	No samples.
6779-6820	Shale, black, gritty with thin streaks of glassy sandstone.

89. 4692 Top of Dakota

Lith. Log

4682-4708	Shale, black, minutely micaceous.
4708-4712	Sandstone, fine, angular to sub-angular, tight, slightly micaceous.
4712-4730	Shale, as above.
4730-4755	Shale, black, minutely micaceous, fissle.

91.	1422	Top of Dakota

Lith. Log

1380-1420	Shale, dark gray to black, some sandy and slightly calcareous.
1420-1425	Sandstone, light gray, very fine, angular, micaceous with minute orange specks, slightly calcareous.
1425-1458	Shale, black, silky, fissle.
1458-1460	Sandstone, tan and white, fine to medium, calcareous, tight, some quartzitic, micaceous.
1460-1480	Shale, black, silky, fissle.

93.	6398	Top of Dakota

Cored

6409-6415	Recovered: Saturated sand, non-porous with some fractures.
6415-6422	Recovered: 1 foot sand, hard, fine grained, tight, 6 feet sand, hard with shale streaks.
6422-6441	Recovered: 14 feet siltstone, 5 feet black shale.

95.	3745	Top of Dakota

Cored

3748-3787	Recovered: 16 feet black flakey shale, very fine grained, 10 feet sandstone, fine to very fine, silty and tight with black shale partings, 5 feet sandstone and shale, as above, 7 feet shale, black, fissle.

100.	5397	Top of Dakota

Cored

5385-5392½	Black shale.
5392½-5399½	Medium to fine grained, very hard, tight sandstone interbedded with black shale.
5399½-5400	Medium grained, very hard, tight, fused, glassy sandstone.
5400-5402	Medium grained, hard, tight sandstone interbedded with black shale, horizontal and vertical fractures.

100. (cont.)

5402-5403	Medium grained, slightly porous, saturated sandstone with traces of pyrite and some carbonaceous residue, horizontal and vertical fractures.
5403-5404	Medium grained, slightly porous, saturated sandstone with large amount of carbonaceous material and vuggy porosity.
5404-5409	Black shale.
5409-5414½	Fine grained, hard, tight sandstone interbedded with black shale, trace of pyrite inclusions.
5414½-5433	Medium grained, fairly porous, saturated sandstone with two minor shale inclusions.
5433-5434	Black shale interbedded with traces of medium to fine grained, tight sandstone.

102. 6036 Top of Dakota

<u>Cored</u>

6017-6035	Shale, dark gray, fissle, rotten.
6035-6037	Shale, dark gray, very firm, slightly sandy.
6037-6039	Sandstone, fine to very fine grained, light gray, hard and tight, some vertical fractures.
6039-6044	Shale, dark gray, hard, slightly sandy.
6044-6045	Shale, dark gray, with few thin and scattered sand partings.
6045-6045'3"	Sand, light gray, very hard and tight, sub-angular, fine grained.
6045'3"-6046	Shale, dark gray, interbedded with thin stringers of sand.
6046-6053	Shale, dark gray to black, firm and fissle.
6053-6053½	Sand, saturated, fine grained, sub-angular, with traces of carbonaceous residue, vertical fractures, fair to good porosity and permeability.
6059-6064'2"	Sandstone, saturated, fine grained, with seams of carbonaceous residue, vertical fractures, trace of pyrite, fair porosity and permeability.
6064'2"-6065	Interbedded, fine grained, hard and tight sandstone with dark gray shale.
6065-6066	Shale, light to dark gray, slightly sandy becoming less sandy toward the base.

103.	5556	Top of Dakota

Cored

5551-5566	Interbedded fine grained, cross-bedded, white sandstone and black shale, with black shale increasing toward the base.
5566-5567	Fine grained, hard, tight, saturated sandstone, bleeding oil from vertical fractures.
5567-5568	Interbedded fine grained, hard, tight, white sandstone and black shale.
5568-5569½	Fine grained, hard, tight, saturated sandstone, bleeding oil from vertical fractures.
5569½-5571	Interbedded fine grained, hard, tight sandstone and black shale.
5571-5577	Fine grained, hard, tight, saturated sandstone, bleeding oil from vertical fractures.
5577-5578	Interbedded fine grained, hard, tight, white sandstone and black shale.
5578-5579	Fine grained, cross-bedded sandstone.
5579-5583	Thinly interbedded fine grained sandstone and black shale.
5583-5586	Finely crystalline, sandy, hard, tight limestone with disseminated pyrite.
5586-5587½	Fine to medium grained gray sandstone, traces of staining and with vertical fractures bleeding slight amount of oil.
5587½-5588	Medium grained, gray to white sandstone, finely micaceous in part, scattered light stain.
5588-5595	Thinly interbedded, very fine to fine grained, gray sandstone with some cross-bedding and dark gray shale with pyrite blebs.
5595-5607	Dark gray to dark olive green shale.

104.	5637	Top of Dakota

Cored

5640-5642	Fine grained, very hard, tight sandstone interbedded with black shale.
5642-5647	Black shale.
5647-5652	Fine grained, hard, tight sandy shale interbedded with black shale.
5652-5653	Fine grained, very hard, tight saturated sandstone, vertical fractures and some carbonaceous residue.
5653-5653'1"	Black shale.
5653'1"-5653½	Fine grained, hard, tight, saturated sandstone with vertical fractures and carbonaceous residue.

104. (cont.)

5653½-5655	Medium grained, slightly porous, saturated sandstone with vertical fractures and black carbonaceous residue.
5663-5671½	Medium grained, slightly porous, angular, saturated sandstone with fractures and trace of carbonaceous residue.
5671½-5672½	Sandstone, as above, with darker stain.
5672½-5673½	Medium grained, slightly porous, darkly stained sandstone with vertical fractures.
5673½-5679½	Fine grained, very hard, tight sandstone interbedded with black shale.
5679½-5683½	Black shale.

105. 5771 Top of Dakota

Cored

5777-5778	Shale, hard, black.
5778-5782'4"	Sandstone, fine grained, hard, tight, trace vertical fractures.
5782'4"-5793	Shale, gray, with scattered streaks of fine grained barren sandstone.
5793-5794	Sandstone, fine grained, hard, tight.
5794-5796	Shale, dark gray, hard.
5796-5798	Sandstone, fine grained, hard, tight, fair to poor saturation, fair odor, slight vertical fracture.
5798-5799	Sandstone, fine grained, hard, tight, very carbonaceous.
5799-5805	Sandstone, fine grained, very hard, tight, good to fair saturation, vertical fractures.
5805-5817	Sandstone, fine grained, interbedded with dark gray shale.
5817-5822	Shale, dark gray.

106. 5869 Top of Dakota

Cored

5885-5886	Shale, dark gray, platy.
5886-5895	Shale, dark gray, hard, nodular with thin stringers of fine grained sand increasing toward the base.
5895-5896½	Sand, very fine grained, slightly shaley, hard and tight.

106. (cont.)

5896½-5900	Sand, very fine grained, light gray to white, very hard and tight, with faint odor and light stain, irregular thin beds of black sandy shale.
5900-5902	Sand, fine grained, hard and tight, vertical fractures.
5905-5940	Shale, black, hard, finely laminated.

107. 5661 Top of Dakota

<u>Cored</u>

5676-5679	Fine grained, tight sandstone, saturated.
5679-5694	Black shale with sand stringers.
5694-5695	Fine to medium grained sand with abundant carbonized wood.
5695-5696	Fine to medium grained, cross-bedded sand with slight bleeding of oil along bedding planes and from tight vertical fractures.
5696-5697	Fine to medium grained, hard, tight, barren sand.
5697-5698	Fine grained, tight, sand.
5709-5710½	Fine grained, hard, tight, very shaley sand.
5710½-5715½	Medium grained, porous sand, with horizontal and vertical fractures and a few black shale inclusions.
5715½-5726	Very fine grained, very hard, very tight sand interbedded with gray shale.

108. 5382 Top of Dakota

<u>Cored</u>

5303-5354	Recovered: 10 feet, black shale, 4 feet, shale with sand and lime lenses, 5 feet black shale, 1 foot black shale with hard, tight sand lenses, 21 feet black shale, 9 feet black shale with streaks of hard sand.
5354-5404	Recovered: 17 feet 4 inches, black shale, 8 inches, fine bentonitic sand, 14 feet black shale with silt near the base, 6 feet 2 inches sand, gray, fine grained, hard and tight, with thin shale stringers, 11 feet 8 inches interbedded shale and siltstone.
5404-5430	Recovered: 5 feet black shale, 10 feet shale with very fine sand, 9 feet black shale with trace of silt, 3 feet black shale.

114. 5823 Top of Dakota

Lith. Log

5823-5829	Sandstone, tan, fine, angular, slightly porous, faint stain.
5829-5833	Sandstone, light tan, very fine, sub-angular, micaceous.
5833-5843	Shale, dark gray silky.
5843-5847	Siltstone, gray, minutely micaceous.
5847-5867	Shale dark gray to black, silky, splintery.

115. 6280 Top of Dakota

Lith. Log

6278-6280	Sandstone, light tan, very finely sucrose, slightly calcareous, tight with light stain.
6280-6284	Shale, dark gray to black silky.
6284-6289	Sandstone, tan-gray, very finely sucrose, angular, tight, shale interbeds, as above.
6289-6291	Sandstone, tan, very finely angular, micaceous, tight.
6291-6355	Shale, dark gray to black, silky, minutely micaceous, splintery.

118. 7661 Top of Dakota

Lith. Log

7650-7664	Siltstone, light gray, slightly micaceous.
7664-7670	Sandstone, light gray, very fine grained, well sorted, shaley.
7670-7680	Siltstone, light gray, slightly micaceous.
7680-7690	Sandstone, light gray, very fine grained, well sorted, shaley.
7690-7700	Siltstone light gray, slightly micaceous.

120. 7608 Top of Dakota

Lith. Log

7627-7630	Sandstone, tan, very fine to fine, sub-angular, medium oil stain.
7630-7634	No samples.

120. (cont.)

7634-7637	Shale, black, minutely micaceous, fissil, silky.
7637-7640	Sandstone, tan, fine to finely medium, sub-angular, medium oil stain, muscovite flakes.
7640-7645	Shale, black, minutely micaceous, fissil, silky.
7645-7675	Sandstone, fine to very fine, gray, sub-angular, slightly calcareous, shale interbeds.

130. 7115 Top of Dakota

<u>Lith</u>. <u>Log</u>

7095-7125	Thin streaks, gray sandstone, tight, fine, with minute green shale inclusions, interbeds black to dark gray shale.
7125-7135	Sandstone, white, finely sucrose, slightly calcareous.
7135-7145	Shale, dark gray to black, silky, fissle.
7145-7155	Sandstone, gray, very finely sucrose, some slightly calcareous, with interbeds of shale, as above.
7155-7170	Shale, as above, with streaks gray, fine to very finely sucrose sandstone.

131. 7561 Top of Dakota

<u>Lith</u>. <u>Log</u>

7561-7575	No samples.
7575-7577	Sandstone, light gray, very finely sucrose, tight with faint stain.
7577-7585	Shale, dark gray to black, silky.
7585-7603	Sandstone, gray, very finely crystalline, sucrose, slightly micaceous, tight, slightly calcareous with very faint stain, interbeds shale, as above.

132. 404 Top of Dakota

<u>Lith</u>. <u>Log</u>

403-413	Sandstone, light brown, very fine, sub-angular, shaley.
413-440	Shale, medium gray, silky, papery.
440-500	Shale, dark gray, minutely micaceous, papery.

141. 5918 Top of Dakota

Lith. Log

5880-5930	Shale, dark gray.
5930-5965	Sandstone, light gray, finely sucrose, tight trace rust color, interbeds dark gray shale.
5965-5997	Shale, dark gray, with trace pale green, silky, soft shale.

146. 4848 Top of Dakota

Lith. Log

4877-4885	Sandstone, gray brown, fine grained to very fine grained, tight.
4885-4920	Shale, gray to black, dense.

147. 2040 Top of Dakota

Lith. Log

2035-2040	Sandstone, gray, fine to very fine, slightly calcareous, tight.
2040-2055	No samples.
2055-2065	Shale, dark gray, silky.
2065-2070	Sandstone gray, fine to very fine, slightly calcareous.
2070-2080	Shale, varigated, silky soft, slightly bentonitic.
2080-2135	Shale, gray to dark gray, silky, with faint dark greenish tinge.

Well numbers in this table correspond to well numbers in Tables 1 and 2.

SOME FACTORS AFFECTING THE SEDIMENTATION OF THE DAKOTA SANDSTONE, OF THE SOUTHWEST POWDER RIVER BASIN, WYOMING, AND THE RELATIONSHIP BETWEEN STRUCTURE, SEDIMENTATION AND OIL ACCUMULATION

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ABSTRACT OF A THESIS

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SCOPE

The investigation of the Dakota sandstone has had the following objectives: (1) to determine the environmental and tectonic factors affecting the sedimentation of the Dakota sandstone; (2) to determine the relationship between texture and permeability; (3) to analyse the mineralogy; (4) to indicate the relative influence of sedimentation and structure on the accumulation of oil.

Procedure

In order to carry out the objectives of this investigation a definite method of study was followed.

Selected electrical logs were used to obtain the data for the isopach, and isolith-lithofacies maps, which show graphically the thickness variation, the zones of sandstone concentration and the facies changes that are present in the Dakota sandstone of the southwest Powder River Basin.

Sieve analysis was utilized to determine the texture of the sandstone. Texture was then compared to porosity and permeability to give the indicated relationship.

The petrographic microscope was used to examine thin sections for the volume percentage of each mineral present. These percentages were used to classify the sandstone and to compare the mineralogy with the producing areas.

Summary of Findings

A combination of factors of the various segments of this investigation support the conclusion that the Dakota sandstone was deposited under environmental conditions that are related to shoreline deposits.

Analyses indicated that the texture of the sandstone is related to porosity but has no relationship to permeability.

The absence of all but the most stable heavy minerals and the suturing of sand grains suggests that intrastratal solution may have affected the permeability of the sandstone.

Oil accumulation is related to structure, sedimentation, and to the shoreline environment which was apparently favorable for oil accumulation.