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E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

NO. 69

STRUCTURES AND STRATIGRAPHY OF SOUTHWESTERN BUTTE COUNTY

by

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University of South Dakota
Vermillion, South Dakota
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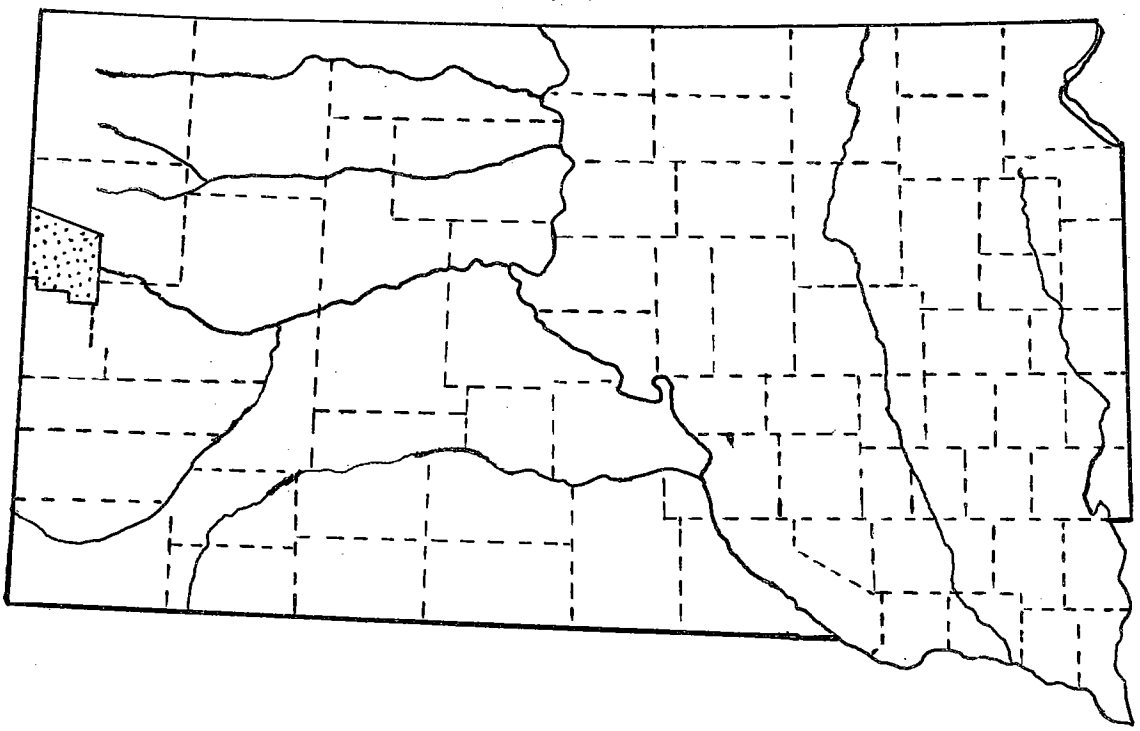
INDEX MAP



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STRUCTURES AND STRATIGRAPHY OF SOUTHWESTERN BUTTE COUNTY

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I. INTRODUCTION

THE PROBLEM

Southwest Butte County is an area underlain by Cretaceous rocks, which dip gently northeastward to form the northeast flank of the Black Hills. On the west and southwest flanks of the Hills in Wyoming, these same Cretaceous rocks locally yield commercial quantities of oil and gas. The possibility of a similar occurence of oil and gas in Butte Co. has prompted this study.

The principal problem was to determine what geologic structures are present and the bearing of such structures on the accumulation of oil and gas in substantial amounts. Although the problem was one of structure, emphasis has been placed on stratigraphy, for all the field evidence of the geologic structures is based primarily on stratigraphic interpretations.

This work was done as part of the Oil and Gas Resources program of the State Geological Survey of South Dakota, under the supervision of Dr. E. P. Rothrock, State Geologist.

This report incorporates previous work done in this area by Bruno C. Petsch, Survey Staff Geologist (1949).

ACKNOWLEDGMENTS

The writer acknowledges innumerable instances of aid and advice offered by Bruno C. Petsch. The field assistance of

Robert C. Wilson in both surveying and geology was greatly appreciated.

METHODS OF WORK

The most consistant and easily discernable stratigraphic horizons in the area were mapped with the plane table and alidade. The survey was started from and tied into bench marks established by the U.S. Geological Survey and the U.S. Coast and Geodetic Survey. All traverses were double rodded to insure maximum vertical control. Horizontal control was checked by section corners. Mapping was done on a scale of 2500 feet to one inch. Good stratigraphic sections were measured in detail.

LOCATION AND AREA

The area described in this report covers about 288 square miles on the western edge of South Dakota. It lies in the southwest portion of Butte County and the northeast corner of Lawrence County. The city of Belle Fourche is approximately in the center of the area.

II. DESCRIPTIVE STRATIGRAPHY

INTRODUCTION

The area is covered by Upper Cretaceous strata ranging from Dakota formation upward to the Carlile formation. These formations are shown in Figure 1. The following sections are based on the field observations of the writer and Mr. Petsch (1949) and detailed well logs (Baker 1947, 1951). Additional paleontological information has been obtained from the literature. The stratigraphic nomenclature is that used by the South Dakota State Geological Survey.

For convenience, in the following descriptions, the exposed formations are grouped into one section and those which do not outcrop in this area in another. The descriptions in each group start with the oldest formation. Each subsequent formation is the next younger and lies on top of the one preceeding it.

SURFACE FORMATIONS

CRETACEOUS SYSTEM

DAKOTA FORMATION Meek and Hayden 1862

This was named for exposures in Dakota County, northeast Nebraska. The Dakota formation of the Black Hills area was called the Fall River formation by Russell (1927). The Dakota of the Black Hills has, however, been shown to be in the same stratigraphic position as that to the east so the name, Fall River, has not been accepted by the South Dakota Geological Survey.

Outcrops: This is one of the principal ridge-forming formations of the Cretaceous and outcrops are very abundant. South of Belle Fourche it forms the dividing ridge between Hay Creek and Redwater River. Near the state line it forms a ridge just north of Hay Creek. Southwest of Belle Fourche, in Lawrence County, it outcrops on the dividing ridge between Spring and False Bottom Creeks as well as a high area south of Baldy Peak.

Lithology: South of Belle Fourche the Dakota can be divided into three lithofacies. The basal facies is a massive white, medium to fine grained sandstone grading upward into thin bedded, white to buff, sometimes rusty, medium to fine grained sandstone. Locally there is a buff siltstone and dark brown carbonaceous shale above the massive sandstone. The middle facies consists of buff, purple, rusty and white interbedded, thin, fine sandstone and shales. The upper facies is principally buff to rusty, massive, cross bedded, medium grained sandstone. These subdivisions are present to the west but not as easily separated.

Thickness: The Dakota varies in thickness from 40 to 70 feet in this region.

Contacts: Both the lower contact (sandstone to clay) and the upper contact (sandstone to shale) are sharp lithologic breaks.

Paleontology: The formation is devoid of fossils in this area.

GRANEROS FORMATION Gilbert 1896

The shale underlying the Greenhorn formation and overlying the Dakota formation was named the Graneros formation in 1896 from good exposures along Graneros Creek in Pueblo County, Colorado. Since then, it has been subdivided in descending order into the Belle Fourche, Mowry, Newcastle and Skull Creek members.

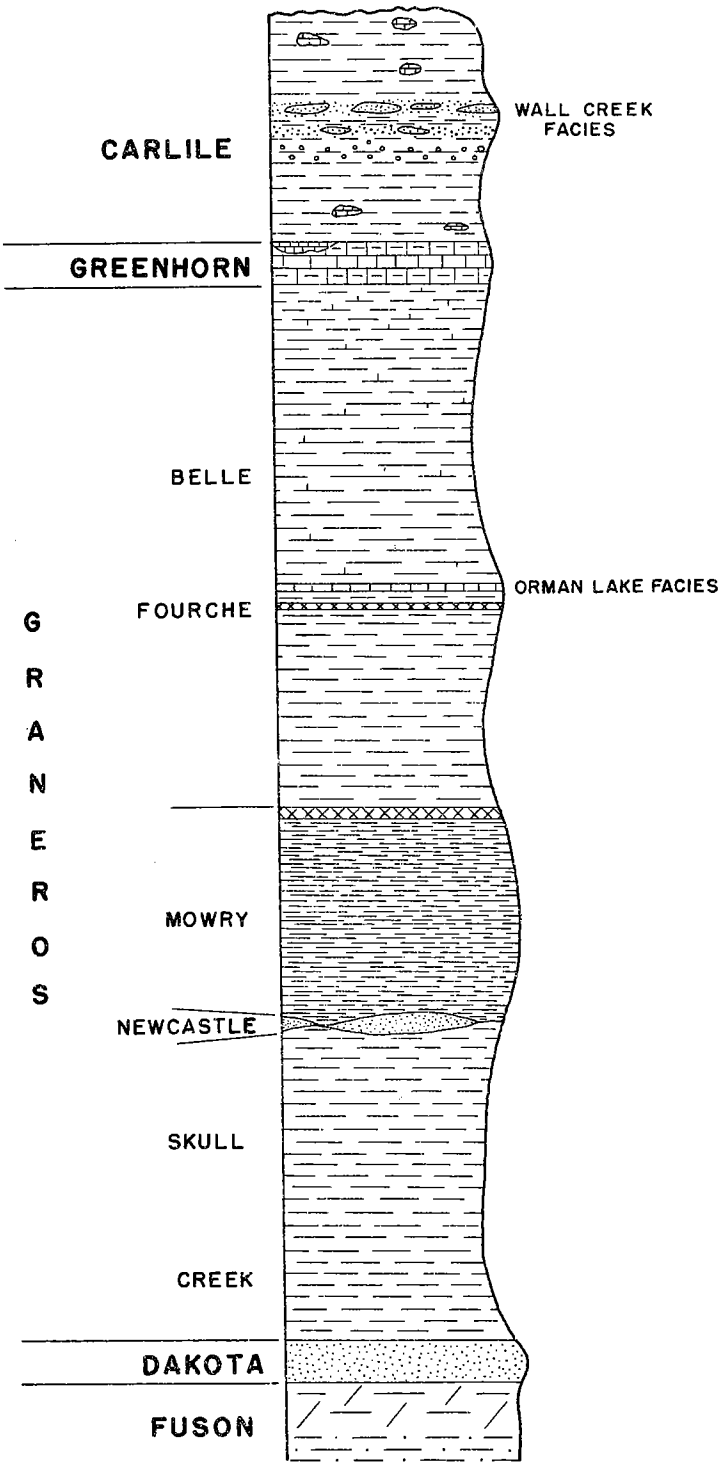
SKULL CREEK MEMBER Collier 1922

This is a basal member of the Graneros and its type locality is the exposures along Skull Creek, southeast of Osage, Wyoming.

Outcrops: Outcrops are usually rare as the member is normally "grassed over". However they can be found in road cuts along highways and county roads and in middle Hay Creek valley, Willow Creek valley and lower False Bottom Creek valley. The accompanying geologic map, Plate IV, shows the areal distribution.

FIGURE 1

GENERALIZED COLUMNAR SECTION OF SURFACE FORMATIONS IN SOUTHWESTERN BUTTE COUNTY



Lithology: This member consists entirely of dark grey fissile shales with scattered fine sandstone concretions. Wing (1940) reported an 18-inch to 24-inch bentonite bed associated with 3-feet to 8-feet septarian concretions in the Skull Creek member.

Thickness: The thickness of the Skull Creek varies from approximately 250 feet to 370 feet.

Contacts: The basal contact with the Dakota formation is a sharp lithologic break (black shale - white sandstone). The upper contact with Newcastle member (sandstone) is also sharp and distinct. However in the local absence of the Newcastle the Skull Creek underlies the Mowry siliceous shale member. The contact is gradational but the greater resistance of the Mowry to erosion aids in discerning the contact.

Paleontology: Macrofossils are extremely rare, the only diagnostic form being Inoceramus belluensis Reeside (Cobban, 1951). There are occasional forams.

NEWCASTLE MEMBER Hancock 1920

This sandstone member of the Graneros lies above the Skull Creek and was named for the good exposures at Newcastle, Wyoming.

Outcrops: Outcrops of this member are very intermittent occurring at St. Onge Peak, north and south of Baldy Peak, on the east side of False Bottom Creek valley and on the north side of Hay Creek valley. Areal distribution is shown by Plate IV.

Lithology: The member is principally a grey to brownish buff, quartzose sandstone with angular to subangular fragments. It is massively bedded. An 8± foot bed of grey fissile shale overlies the massive sandstone. This shale in turn is overlain by another thinner bed, 7± inches, of sandstone. Above the second sandstone is a thin 18" bed of slightly ferruginous pebble conglomerate characterized by tubular black chert pebbles in a very coarse quartzose sand.

Thickness: The thickness varies from 3 to 8 feet where it is present.

Contacts: Both the upper and lower contacts with the Mowry and Skull Creek shales are sharp lithologic breaks.

Paleontology: A few plant fossils have been found in the Newcastle member.

MOWRY MEMBER Darton 1904

This is the middle shale member of the Graneros formation named for the numerous exposures along Mowry Creek, northwest of Buffalo, Wyoming.

Outcrops: The Mowry siliceous shale outcrop usually forms a low pine covered ridge. Outcrops are especially numerous along the ridge between the Belle Fourche River and Middle Creek, west of Belle Fourche, and on the northeast side of False Bottom Creek. Areal distribution is shown on Plate IV.

Lithology: The Mowry is a dark grey to grey siliceous, fissile shale with abundant bentonite beds. The bentonites are light grey to greenish grey in color and vary from 1 inch to 3 feet in thickness. There is one 3-foot bentonite bed (the Clay Spur bentonite) at the top of the member that is very consistent throughout this area and is quarried for commercial use. There are local thin (1 inch) fine sandstone lenses and near the top there are occasional fine sandstone lenses ("concretions") containing bands of cone-in cone limestone.

Thickness: The Mowry member is 250 feet thick in this area.

Contacts: The lower contact of this member with the Newcastle is a sharp lithologic break (sand to siliceous shale). Where the Newcastle is absent, the contact is gradational over several feet. The upper contact is marked by a 3-foot bentonite bed. The basal Belle Fourche member is also characterized by oligonite (Fe-Mn concretions).

Paleontology: There are numerous fish scales, but other fossils are absent.

BELLE FOURCHE MEMBER Collier 1920

This is the upper member of the Graneros formation. The type locality is along the Belle Fourche River near Wind Creek, Crook County, Wyoming. This member can be separated into three lithofacies: the upper shale, Orman Lake, and the lower shale facies. Collier (1922) included the Orman Lake and the upper shale facies in the Greenhorn. Rubey (1930) and Cobban (1951) in a recent paper have followed this classification. This revision has not been adopted by the State Geological Survey.

LOWER SHALE FACIES

This facies comprises the lower part of the Belle Fourche member and is well exposed in the valley of Middle Creek, northwest of Belle Fourche.

Outcrops: The best outcrops are usually found just below the small escarpment of the Orman Lake facies along Middle Creek valley and around Haystack Buttes. Elsewhere outcrops are "grassed over" or covered by alluvium.

Lithology: It is dominantly a dark grey fissile shale with occasional bentonite beds up to a foot thick. The clastic particles are mostly of clay size, but there are subangular to rounded silt and sand grains of quartz and calcite. The lower 29 feet of the facies is characterized by numerous reddish-brown iron-manganese ("oligonite") concretions with several bentonite beds. West of Sec. 20, T. 9 N., R. 2 E., and $8\frac{1}{2}$ to $11\frac{1}{2}$ feet below the top of the facies is a bed of grey-white bentonite* with rusty mottling. This bed, one foot thick at its easternmost exposure thickens westward to 3 feet 8 inches near the state line. Locally, just above this bentonite is a fine light grey sand, partly indurated, and varying in thickness from 2 to 12 inches. Associated with this sand are abundant selenite crystals.

* This bentonite is not the usual high-swelling type, but instead slakes rapidly when placed in water (Wing, 1940).

Thickness: The thickness varies from 252 to 277 feet in this area.

Contacts: The lower contact is sharply marked by the top of the thick Clay Spur bentonite of the Mowry member. The upper contact is also a sharp lithologic break (shale to calcarenite.)

Paleontology: Cobban (1951) lists the following megafossils from the upper strata:

Inoceramus aff: I. fragilis Hall and Meek
Exogyra columbella Meek
Pseudomelania hendricksoni Henderson
Borrisjakoceras n. sp.
"Puzosia n. sp.
Mantelliceras n. sp.
Acanthoceras? n. sp.

Pelagic foraminifera are present, of which Globigerina sp. has been identified.

ORMAN LAKE FACIES Petsch 1949

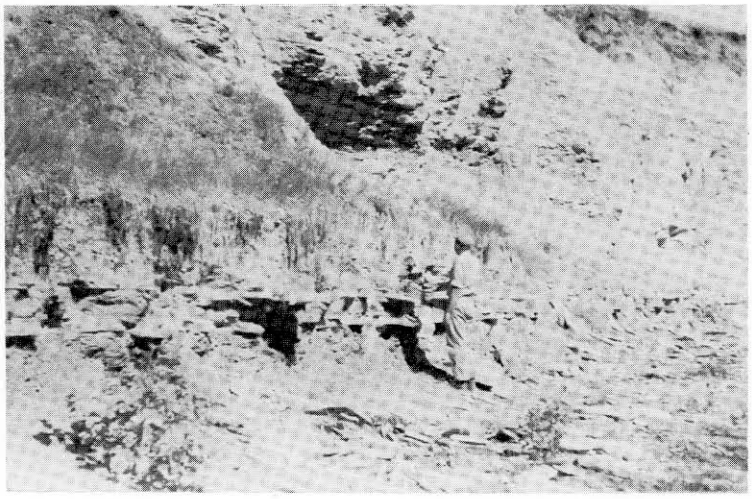
This is the best mapping horizon in the Upper Cretaceous strata in this area. It was originally called the Middle Creek limestone by Wing (1940), but since the name was preoccupied, Petsch (1949) renamed it the Orman Lake from exposures on the west and south sides of Orman Lake. It was also called the Bull Creek sandy limestone by Moore (1949).

Outcrops: This facies, which is characterized by its ledge-forming tendencies, forms a low escarpment and ridge between Middle and Crow Creeks, northwest of Belle Fourche, and another south of Susie Peak. These ridges have abundant outcrops, but elsewhere outcrops are generally restricted to artificial and stream cuts. Exposures are also present on the slopes of Haystack Buttes ridge. All outcrop areas of the facies are characterized by slabs of calcarenite.

Lithology: This facies is a buff to light grey, medium and fine grained calcarenite.* The coarse clastic fragments are principally angular to subangular shell fragments (Inoceramus prisms) together with occasional shark teeth

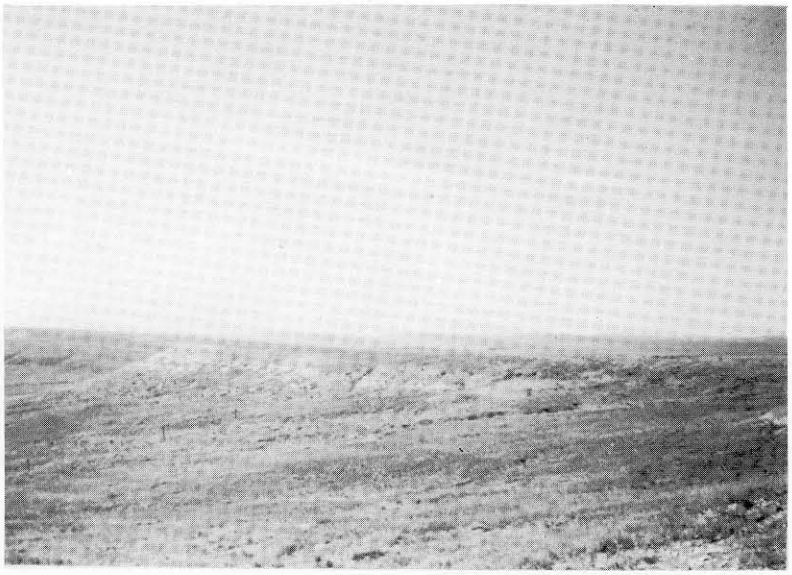
* A calcarenite is a clastic limestone in which the particles are of sand size.

PLATE I



Bruno Petsch

An exposure of the Orman Lake limestone facies of the Belle Fourche Member along Stinking Water Creek in Sec. 36, T.8N., R.4E.



R. E. Stevenson

The low escarpment between Middle and Crow Creeks topped by the Orman Lake facies. The white layer is the three-foot bentonite which lies about nine feet below the limestone. Sec. 12, T.9N., R.1E.

and teeth fragments and fish scales and are set in a matrix of finely comminuted carbonate. There is some secondary gypsum as veinlets and disseminated crystals. Rubey (1930) reported pyrite in varying amounts. There is a thin irregular stratification with individual beds varying from $\frac{1}{4}$ to 2 inches in thickness. Some of the bedding planes show well developed current ripple marks having an approximate index of 5, and indicating a northwards current direction. Most of the facies show a distinct parallelism of planar fragments (especially fish scales). Locally in sections 18 and 19, T. 9 N., R. 2 E., there is a 4-inch rusty, grey-white bentonite in the middle of the facies, above and below which the calcarenite is rust stained.

Thickness: The Orman Lake varies in thickness from 5 to 15 inches and shows a definite thickening to the west (to at least 4 feet in Crook County, Wyoming.

Contacts: Both the upper and lower contacts of the Orman Lake facies are sharp lithologic breaks (shale to calcarenite).

Paleontology: All fossils are fragmentary. The facies is characterized by abundant Inoceramus cf. I. fragilis Hall and Meek. Occasional fragments of a large Prionocylus cf. P. wyomingensis Meek were found. Cobban (1951) found the following ammonites:

Dunveganoceras cf. D. pondi Haas
Mantelliceras cf. M. canitaurium Hass
Metoicoceras cf. M. whitei Hyatt
subspecies - praecox Hass

There are numerous fish teeth and scales from which Dunkle (Cobban 1951) identified:

Isuras appendiculata (Agassiz)
I. desorii (Agassiz)
Squalicorax falcatus (Agassiz)
Ptychodus whipplei Marcau

UPPER SHALE FACIES

This is the upper part of the Belle Fourche member. Collier(1922) placed this facies in the Greenhorn in the Osage, Wyoming area, and Rubey (1930) and Cobban (1951) have followed this classification for the Northern Black Hills, but this revision has not been adopted by the State Geological Survey.

Outcrops: Exposures are very few as the facies is generally covered by alluvial deposits or "grassed over". Scattered outcrops can be found in Crow Creek valley and west of Haystack Buttes.

Lithology: This facies is a dark grey fissile shale with occasional local thin beds of light grey, fine grained sandstone and horizons of calcareous fine sandstone lenses. One of the sandstone beds lying about 18 feet below the top of the facies is slightly bituminous. The uppermost strata locally contain a few bentonite beds. This facies contains scattered lenticular bodies of grey marl.

Thickness: This lithofacies varies in thickness from 283 to 437 feet in this area. (220' in the Seyler-Anderson oil test).

Contacts: The basal contact with the Orman Lake is a sharp lithologic break (shale-calcarenite). The upper contact with the Greenhorn formation is very gradational, the non-calcareous shales of the Belle Fourche slowly giving way to the calcareous shales of the Greenhorn. This contact is difficult to find without the aid of an acid bottle.

Paleontology: The fossils are restricted to foraminifera, mostly pelagic forms.

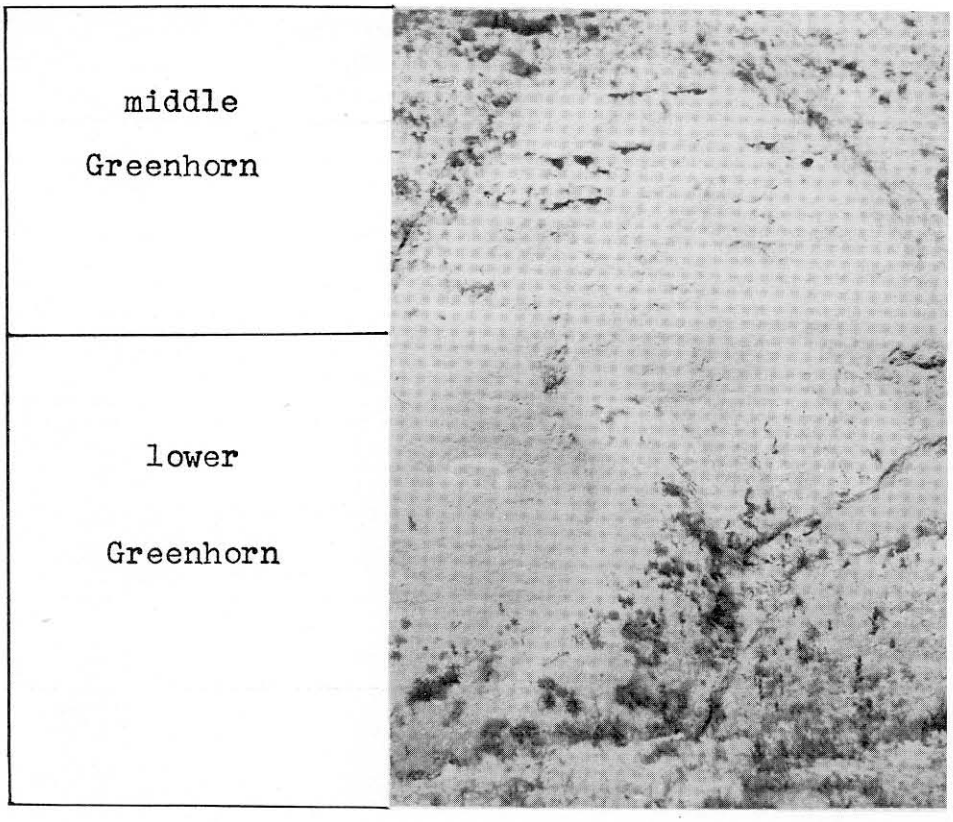
GREENHORN FORMATION Gilbert 1896

This formation was named for its exposures near Greenhorn station, 14 miles south of Pueblo, Colorado. This is a very persistent formation, appearing in the subsurface of the northern great plains of the United States.

In most outcrop areas in the western part of this region the Greenhorn consists of a slabby calcarenite underlain and overlain by calcareous shales, marls or chalk.

Outcrops: The middle Greenhorn forms gentle non-continuous escarpments and ridges extending across the area north of the Belle Fourche River and Crow Creek. Exposures on these ridges are scattered, the best ones being in the east central

PLATE II



R. E. Stevenson

An exposure of the middle and lower Greenhorn Formation. The middle Greenhorn is characterized by calcarenite slabs and lighter color. Sec. 30, T.9 N., R.3 E.

R. E. Stevenson

An outcrop of the lenticular limestone mass in the upper Greenhorn in the NW¼, Sec. 21, T. 10N., R. 1 E. This is a conglomerate with a calcilutic matrix.

part of T. 9 N., R. 2 E. Exposures of the upper and lower Greenhorn are very rare and scattered through the outcrop area.

Lithology: The upper and lower portions of the formation consist dominantly of light to dark grey fissile calcareous shale. There are a few interbeds of shale and flat lenses of grey calcarenite. The middle portion is the typical Greenhorn; a light grey, fine to medium grained clacarenite with a very fine grained carbonate matrix containing pieces of mollusk shells and interbeds of light grey, grey, or brown calcareous shale. The clastic fragments are principally angular to subrounded shell fragments, scattered shark teeth and numerous large pieces of Inoceramus shells. There are also a few scattered quartz grains. Some of the shale interbeds are characterized by biconvex discoidal (lenticular) crystals of selenite (Miers and Bowman, 1929, p. 306, 593). These shales also contain scattered angular to subrounded shell fragments. At most localities, about 2½ feet below the top of the middle portion is a 6-inch bed of grey-white bentonite.

At the contact between the Greenhorn and the overlying Carlile in SE¼, Sec. 7, and NW¼, Sec. 21, T. 10 N., R. 1 E., along Ghost Creek there are large lenticular limestone masses. These consist of five distinct lithologies: (1) a very light grey chemical limestone* characterized by multi-directional close spaced jointing and occasional fossils, (2) a light grey and brown medium grained coquinoid calcarenite characterized by an irregular thin sub-bedding, (3) a light grey conglomerate consisting of partially rounded pebbles and cobbles of lithology(2) imbedded in a calcilutic matrix. These cobbles range up to 4" x 4" x 4" in size. The matrix contains a few scattered quartz grains and a fairly abundant semi-micro fauna, (4) a light grey medium grained calcarenite, similar to the middle portion of the formation, and (5) an abundantly fossiliferous light grey calcilutite. Of these lithologies the first is by far the most abundant, the others occurring as lenses and irregular shaped bodies within.

Thickness: The lower calcareous shale varies in thickness from 15 to 25 feet, the middle calcarenite from 9 to 20 feet, and the upper calcareous shale from 7 to 13 feet. However, where the large limestone lenses are present the upper Greenhorn is at least 31 feet thick. The formation is 31 to 75 feet thick.

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* May be in part calcilutite which is a clastic limestone whose texture is that of silt or clay.

Contacts: The upper and lower contacts are very gradational and difficult to discern without an acid bottle.

Paleontology: This formation is characterized by abundant Inoceramus labiatus Schlotheim, mostly fragmental. There are also occasional foraminifera present.

Two of the five lithologies of the large limestone lenses of the upper Greenhorn have distinct and different faunal assembleges. The conglomerate contains:

Globigerina
A small hexacoral
Acmae cf. A. parva Meek and Hayden
Inoceramus cf. I. labiatus Schlotheim
A turritellid-like gastropod

The fossiliferous calcarenite contains:

Acmae cf. A. parva Meek and Hayden
Inoceramus labiatus Schlotheim
I. umbonatus Meek and Hayden
Baculites
Metoiceras n. sp.
Ptychoceras n. sp.

CARLILE FORMATION Gilbert 1896

The shales overlying the Greenhorn formation were called the Carlile formation after the good exposures near Carlile Station, 21 miles west of Pueblo, Colorado. They were divided into two members by Rubey (1930), the lower unnamed, and the upper or Turner member. A sandy facies marking the base of the Rubey's Turner member of the Carlile in this area has been correlated with the Wall Creek member of the Frontier formation to the west in Wyoming.

Outcrops: Exposures are fairly numerous as these shales have a poor vegetative cover. The lower sandy horizon, and some of the concretionary horizons uphold low ridges along which outcrops are abundant. Exposures are best seen along the Crow-Owl Creek divide and east of Orman Lake and south of the Belle Fourche River and also west of Susie Peak. The areal distribution is shown on Plate 4.

Lithology: The formation, with the exception of the Wall Creek is composed of grey to dark grey shale with (1) large scattered dolomitic and limy septarian concretions, (2) a horizon (restricted to the unnamed member) of numerous fossiliferous buff to brown limestone and red brown ironstone concretions. The shale is principally silt and clay particles but there are scattered subangular to rounded quartz grains, subrounded to rounded calcite grains, and mica flakes. The shale locally contains melanterite and thin bentonites in its basal portion. The Wall Creek facies (this is Unit 1 of the Turner member, Cobban /1951/) as seen from the detailed section in Fig. 1, consists of four lithologies: (1) Lenticular masses of buff to grey, thin to medium bedded fine grained sandstone. These lenses range in size up to 4 x 16 x 21 feet, the average size being approximately 3 x 5 x 6 feet. In the vicinity of Orman Lake, these lenses locally change or alternate with an approximately 1½-foot bed of sandstone, identical with the lenses in composition. They may have 1 to 3-inch layers of cone-in-cone limestone. Locally there are wave or oscillation ripple marks with an approximate index of 5. (2) A white to light grey, very fine grained semi-consolidated (friable) quartzose sand whose grains are angular to subangular. It is locally mottled with rust streaks. (3) A dark grey to grey fissile sandy siltstone. (4) A thin irregular bedded medium grained sandstone. It is composed of about 75% angular to subrounded and in part etched quartz grains and 25% subrounded to rounded, polished dark grey chert grains of low sphericity with scattered shark tooth fragments. This sandstone occurs at two different horizons and alternates with lenses of lithology 1. (5) A grey to brown conglomerate characterized by numerous shark teeth. The conglomerate consists of oblate subrounded dark chert pebbles in a matrix of lithology 4.

Thickness: The formation varies in thickness from 600 to 800 feet. The Wall Creek facies lying 86 to 126 feet above the base is 20 to 60 feet thick and shows a definite thickness increase to the west.

Contacts: The lower contact with the Greenhorn is gradational and is hard to find without the aid of an acid bottle. The upper contact with the Niobrara is fairly sharp (shale to marl), but is difficult to find because of a soil cover.

Paleontology: The principal faunal zone of the Carlile lies just beneath the Wall Creek facies. The Carlile and Wall Creek faunas are essentially identical and will not be listed

separately. The faunal list follows:

Gumbelina sp.)
Globigerina sp.) Not in Wall Creek
Undetermined foraminifera)
Exogyra sp.
Inoceramus cf. I. labiatus Schlotheim
Turritellid gastropod
Collignoniceras cf. C. woolgari Mantell
Scaphites carlilensis Meek and Hayden
S. ventricosus Meek and Hayden
Undetermined ammonite
Shark teeth and fish vertebrae

W. A. Cobban (1951) reports the following forms from the Carlile strata underlying the Wall Creek facies:

Membraniopora sp.
Nuculana sp.
Inoceramus cf. I. fragilis Hall and Meek
Ostrea n. sp.
Exogyra sp.
Borrisjakoceras sp.
Proplacenticeras sp.
Collignoniceras hyatti (Stanton)
Scaphites carlilensis Morrow
Scaphites arcadiensis Moreman
Homarus brittonestris Stenzel
Linuparus grimmeri Stenzel
Linuparus watkinsi Stenzel
Berycoid fish

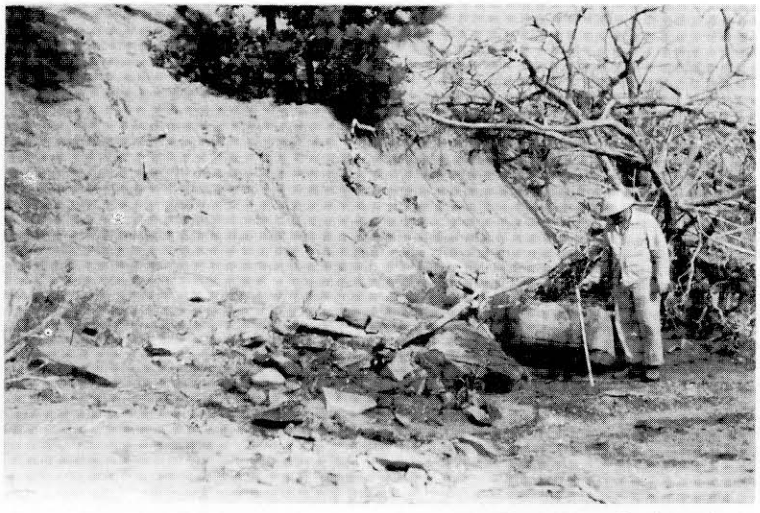
He also lists the following forms from the Wall Creek facies:

Inoceramus dimiduis White
Prinonocyclue macombi Meek
Scaphites warreni Meek and Hayden
Scaphites warreni var. ubiquitosus Cobban
Scaphites veterinovus Cobban
Scapanorhynchus raphiodon (Agassiz)
Isurus appendiculata (Agassiz)
Squalicorax falcatus (Agassiz)
Plychodus whipplei Marcou
Osmeroides transversus (Cockerell)
Syllaemus latifrons Cope
Berycoid fish

PLATE III

Bruno Petsch

Sandstone lenses of the Wall Creek facies of the Carlile shale in Sec. 11, T. 9 N., R. 3 E.



Bruno Petsch

Talus blocks of Newcastle sandstone in Stinking Water Creek in Sec. 21, T. 7 N., R. 4 E.

TABLE I

SUBSURFACE TIME AND ROCK UNITS

FOUND IN BUTTE COUNTY

MESOZOIC	Lower Cretaceous	Fuson Formation Lakota Formation
	Upper Jurassic	Morrison Formation Sundance Formation
	Permo-Triassic	Spearfish Formation Minnekahta Formation Opeche Formation
PALEOZOIC	Pennsylvanian	Minnelusa Formation
	Lower Mississippian	Pahasapa (Madison) Formation Englewood Formation
	Middle Ordovician	Whitewood Formation Platteville (Black River) Formation St. Peter Formation
	Upper Cambrian	Deadwood Formation

SUBSURFACE FORMATIONS

The subsurface formations of Paleozoic and Mesozoic age are shown in tabulated form in Table 1. Following are brief descriptions of the formations based on well cuttings described by Baker (1947, 1951).

CAMBRIAN SYSTEM

DEADWOOD FORMATION Darton 1901

Lithology: Principally greenish grey to red glauconitic medium grained sandstone with interbeds of course limy sandstone, greenish grey to pink glauconitic dolomite, brownish grey limestone and usually a basal conglomerate.

Thickness: The total thickness of the Deadwood in subsurface of Butte County is not known as no wells have penetrated to the basement. The Seyler-Anderson well encountered 249' of Deadwood without reaching basement.

Diagnostic Fossils: Dicellomus, Lingulella, Obolella and trilobite fragments may be found.

ORDOVICIAN SYSTEM

ST. PETER FORMATION* Owen 1847

Lithology: White to pink, fine to coarse grained quartz sandstone. Grains are subrounded and etched. In the upper portion there is a partial cementing with marcasite and pyrite, the rest being partially cemented with lime.

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* In North Dakota and Canada the St. Peter and Platteville (Black River) are called the Winnepeg formation.

Thickness: In this area the St. Peter ranges from 47 to 110 feet in thickness.

Diagnostic Fossils: It is unfossiliferous except for fucoidal markings.

PLATTEVILLE FORMATION* Bain 1905

Lithology: There are two fairly distinct lithofacies present in this formation. The lower facies is a fissile red to green and greenish grey bentonitic shale slightly sandy at the base and scattered minute black phosphatic nodules. The upper facies consists of interbedded greenish brown limy siltstone, grey fine to coarse grained sandstone, grey silty sandstone, and grey siltstone. Some of the sandstone has a dolomitic cement.

Thickness: The thickness of this lower member varies from 90 to 118 feet.

Diagnostic Fossils: There are numerous conodants (see Furnish, Barragy and Miller [1936]). Also present are brachiopods and trilobites.

WHITEWOOD FORMATION Darton 1904

Lithology: Yellow to pink, grey and brown finely crystalline dolomite with a few interbeds of limestone. Some greenish dolomitic shale in upper part.

Thickness: The formation ranges from 150 to 540 feet in thickness.

Diagnostic Fossils: Maclurites, Endoceras, and Receptaculites.

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* This is also called the Black River shale.

MISSISSIPPIAN SYSTEM

ENGLEWOOD FORMATION Darton 1901

Lithology: Principally purplish dolomitic siltstone with occasional interbeds of dolomite. Greenish-grey colors sometimes dominate.

Thickness: In the subsurface the thickness varies from 0 to 50 feet. Outcrops in the Black Hills give thicknesses of 30 to 60 feet.

Diagnostic Fossils: Numerous Kinderhookian brachiopods and corals.

PAHASAPA FORMATION Darton 1901

Lithology: The Pahasapa is generally a buff to red, coarse to fine grained dolomite. There are some buff interbeds of coarse to fine grained limestone which is partly oolitic. There also are a few beds of greenish silty dolomite. The formation is quite vuggy and is the cavern maker of the Black Hills. It is also a cliff maker and forms the largest escarpments in the Hills.

Thickness: Subsurface thicknesses of this formation vary from 410 to 740 feet.

Diagnostic Fossils: Spirifer centronatus and other Burlington and Keokukian corals, brachiopods, pelcypods, and gastropods.

PENNSYLVANIAN SYSTEM

MINNELUSA FORMATION Winchell 1875

Lithology: Sandstone, dolomite and limestone constitute the principal lithologies of the Minnelusa. The dolomite

varies from cream to buff, pink, and purple in color; is generally dense, but some is coarse grained; it very rarely contains chert; and it may be cavernous or vuggy. The sandstone is pink to grey in color; usually has a calcareous cement; is fine to medium grained with occasional larger grains; grains are angular to subrounded and in part etched; is sometimes poorly sorted; and may sometimes be limy. The limestone, which is the least abundant of the three, is cream to pink in color; dense to fine grained (sugary); magnesian in part; occasionally cherty and occasionally oolitic.

There is a basal lateritic zone, 25 to 40 feet thick consisting of red and brown shale, silty clay, and fine sandstone with buff-brown cavernous limestone. There are also several red "marker beds" of purple red fissile shale. Numerous beds of white to pink anhydrite are encountered in most of the subsurface sections.

In the Northern Ordnance Government No. 1 well a bed of greenish bentonitic siltstone and a grey to lavender bentonite were reported.

Thickness: The formation varies from 610 to 1000 feet in subsurface thickness.

Diagnostic Fossils: Fossils are not abundant but Chaetetes milleporaceous and Mesolobus mesolobus occur in the lower portion. Elsewhere there are brachiopods, corals, and pelecypods.

PERMIAN SYSTEM

OPECHE FORMATION Darton 1901

Lithology: This formation is principally red siltstone with interbeds of red claystone and sandy siltstone, pink calcareous medium grained angular sandstone, and white gypsum (alabaster in part) and anhydrite. The top few feet of the formation are green in color.

Thickness: The subsurface thickness of the Opeche strata varies from 70 to 117 feet.

Diagnostic Fossils: None

MINNEKAHATA FORMATION Darton 1901

Lithology: Reddish buff to brownish grey dense crystalline limestone constitutes the most of this formation. There are occasional interbeds of reddish buff coarsely crystalline limestone, light brown dense bituminous limestone (black oil in fractures), and buff to brown anhydrite.

Thickness: Subsurface thicknesses vary from 45 to 60 feet.

Diagnostic Fossils: Fossils are very rare, but fish and crustacean remains have been reported.

TRIASSIC SYSTEM

SPEARFISH FORMATION Darton 1899

Lithology: This formation is principally dark to light red siltstone and claystone with occasional interbeds of gypsum and anhydrite.

Thickness: The Spearfish formation varies in thickness from 440 to 920 feet.

Diagnostic Fossils: None

JURASSIC SYSTEM

SUNDANCE FORMATION Darton 1899

Lithology: The Sundance formation contains a great variety of lithologies of which grey, brown or green, in part calcareous and glauconitic micaceous bentonitic siltstone are

most abundant. Other lithologies are green to grey bentonite and bentonitic clay, grey to cream dense limestone, light green glauconitic silty limestone, light grey slightly glauconitic fine sandstone, and grey to green glauconitic fine sandstone.

Thickness: Subsurface thicknesses in this area vary from 380 to 490 feet.

Diagnostic Fossils: The formation contains a molluscan fauna of which Belemnites densus is dominant form. Ostracods are the principal microfossil.

MORRISON FORMATION Eldrige 1896

Lithology: This formation contains a great variety of lithologies, but is principally buff, brown, green or grey bentonitic siltstone. Interbeds of light to dark grey, buff or green bentonite, grey claystone, grey-green partly calcareous siltstone, grey fine grained bentonitic sandstone, and buff coarse grained sandstone. In general the formation is extremely varicolored.

Thickness: The formation varies from 160 to 295 feet in subsurface thicknesses.

Paleontology: Scattered throughout the formation are reptilian remains. Occasional fresh water mollusks may be found.

CRETACEOUS SYSTEM

LAKOTA FORMATION Darton 1899

Lithology: The formation is principally a coarse, micaceous, quartose sandstone whose grains are angular to subrounded and partly etched. There may be local coal and claystone beds.

Thickness: The subsurface thickness varies from 60 to 150 feet.

Diagnostic Fossils: None

FUSON FORMATION Darton 1901

Lithology: The formation consists principally of reddish light to dark grey bentonitic siltstone with abundant small brown manganosiderite pellets and reddish bentonitic clay.

Thickness: Subsurface thicknesses vary from 115 to 150 feet.

Diagnostic Fossils: None

III. STRUCTURAL GEOLOGY

The regional dip of 230 to 300 feet per mile in a N. 45° E. direction in this area is that of the northeast flank of the Black Hills uplift, the primary tectonic element of western South Dakota. On this gentle slope two sets of flexures have been determined by structural contouring* (see Plate 4); one striking northwest and consisting of the Box Elder anticline and Crow Creek syncline; the other, striking slightly west of north contains the Whitewood and Belle Fourche anticlines and the Dry Creek syncline.

WHITEWOOD ANTICLINE**

This structure was described briefly by Darton and O'Harra in 1909. Forty years later it was named and described by Petsch (1949). It is the largest of the secondary tectonic elements in this area. The axis of the Whitewood structure extends northwestward N. 8° W. into this area from the vicinity of Whitewood, Meade County. The axis (gently undulatory) curves to a N. 16° W. strike in the northern part of this region passing a mile west of Fruitdale and 0.2 mile east of Susie Peak. The structure is over 26 miles in length and about 8 miles wide. The amplitude varies from 290 feet to 1,150 feet in this area. The east flank ranges in dip from 156 to 310 feet per mile; the lesser dips are generally confined to the northern part of the structure. The west flank dips are gentler, varying from 145 to 170 feet per mile. The axis of the Whitewood anticline plunges northward at 86 to 200 feet per mile. There are two small areas of local closure along the structural axis, one of 55 feet in Sections 30 and 31, R. 4 E., T. 9 N. and the other of 25 feet in Section 27, R. 3 E., R. 9 N. On the north flank of the structure near the northwest corner Sec. 34, T. 8 N., R. 4 E., there is a small flank anticline. This small parasitic fold is 2 miles long, 1 mile wide and has a possible closure of 10-20 feet.

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* Horizons used for contouring were: (1) top of the Orman Lake facies of the Belle Fourche member of the Graneros formation; (2) base of the middle Greenhorn formation; and (3) top of the coarse sand horizon of the Wall Creek member of the Carlile formation.

** This description of the Whitewood anticline is based on "North Part of the Whitewood Anticline" by B. Petsch, S. Dak. Geol. Survey, R. I. 65, and innumerable discussions with Mr. Petsch.

DRY CREEK SYNCLINE

This downwarp lies between and roughly parallels the Whitewood and Belle Fourche structures. The axis strikes approximately north-south in the south but changes to N. 15° W. in the north and lies 1 or 2 miles west of the Whitewood axis. It is over 16 miles in length and is from 4.5 to 6 miles in width. The amplitude is 365 feet. Dips on the west flank vary from 145 to 170 feet per mile southward. The east flank is much steeper, the dips ranging from 210 to 285 feet per mile. There is no evidence of plunge or closures.

BELLE FOURCHE ANTICLINE

This structure was first mentioned by Darton and O'Harra in 1909. Its axis passes through the town of Belle Fourche, striking north-south to N. 30° W. south of the town, and north-south to N. 21 W. to the north. It extends 13 miles into this area and varies in width from 2.5 to 7 miles. The amplitude of the Belle Fourche structure varies from 190 feet in the north to 510 feet in the south. Flank dips to the east range from 200 to 285 feet per mile, the west flank dips gently at the north (160 feet per mile) but steepens to 30° south of Belle Fourche. Darton and O'Harra (1909) reported dips up to 70° in the latter area, but the writer could find none greater than 30°. The anticline plunges northwestward 125 to 200 feet per mile. Structural contouring of the area indicated no closures on this structure.

BOX ELDER ANTICLINE

Wilson (1922) briefly mentioned this structure in his report on the oil possibilities in South Dakota, but gave no description. The axis of this structure, just north of the Crow Creek - Owl Creek divide, strikes S. 45° E. nearly diagonally across T. 10 N., R. 1 E., disappearing 1½ miles west of U.S. Highway 85. The anticline is 11 miles long and between 1.7 and 1.9 miles in width. The amplitude varies between 130 and 160 feet. The dip of the southwest flank of the structure is 100 feet per mile in the northwest but increased to 290 feet per mile southeastward. The northeast flank has an average dip of 240 feet per mile. The Box Elder Anticline plunges 80 feet per mile southeastward. The structure has a closure of 42 feet.

CROW CREEK SYNCLINE

This is the companion structure to the Box Elder anticline to which it is parallel. Its axis strikes N. 47° W. and lies ½ to 3/4 miles south of the Box Elder axis. It is 9 miles long and is from 1 to 1½ miles wide and has an amplitude of 150 feet. The northwest flank dip is 100 feet per mile near the state line but increases to 290 feet per mile southeastward. The southwest flank has a dip of 140 feet per mile. The structure plunges 20 to 60 feet per mile northwestward.

IV. OIL AND GAS POSSIBILITIES

INTRODUCTION

Two important commodities in the modern way of life are oil and gas. The western United States with its increasing industrialization has a great need for additional amounts of these two products of the earth. This need for additional supplies of oil and gas was the underlying cause of this investigation.

In the preceeding portions of this report, the stratigraphy and structural features of southwestern Butte County have been described. These descriptions and associated observations are the basis for the following discussion of oil and gas possibilities of this area.

SOURCE BEDS

Source beds are those strata in which the oil and gas originated. Very little is known of possible source beds in this area, but they are likely to be bituminous shales and limestones.

RESERVOIR BEDS

Reservoir beds are the porous and permeable strata from which oil and gas are produced. Possible reservoirs in this area can be subdivided into two types: sandstone and limestone.

As possible sandstone reservoirs there are:

1. Sandstone strata of the Deadwood and St. Peter formations. In the State Royalty No. 1 well at Camp Crook, Harding County, 50 miles north of this area, 17 feet of the upper 50 feet of the St. Peter was saturated.

2. The thick sandstone beds of the Minnelusa are possible reservoirs, as they are productive on the southwest edge of the Black Hills. The best oil shows in Fall River County south of the Hills are in the Minnelusa.

3. The sandstone members of the Sundance and Morrison formations are possible producing horizons. Sands of the lower Sundance and lower Morrison are productive in the Lance Creek field on the southwest edge of the Black Hills.

4. The Lakota and Dakota sandstones which produce oil in nearly all the fields along the southwestern flank of the Black Hills, are possible shallow reservoir strata. An oil test northwest of Belle Fourche (see page 31) reported petroliferous Lakota sands.

5. The Newcastle sandstone member of the Graneros, which is the producing horizon in the Wyoming field along the west flank of the Black Hills, might provide shallow production in the northern part of the area mapped. The test drilled northwest of Belle Fourche was said to contain traces of oil in the Newcastle.

Possible limestone reservoir strata are:

1. Lower Paleozoic limestones (Whitewood) when crushed, fractured or locally vuggy.

2. Upper Paleozoic limestones (Pahasapa) are productive to the north in the Baker-Glendive field in southeastern Montana. The Pahasapa limestone is usually very porous, but the Minnekata is dense and would probably have to be tectonically crushed or fractured to obtain permeability.

OIL AND GAS TRAPS

Possible oil and gas traps in southwestern Butte County fall into two categories: (1) structural and (2) stratigraphic.

Of the three anticlinal structures mapped only two show closures and these are of small magnitude. There is no physical evidence at present that these structures continue to depth, but considering the regional tectonics it is reasonable to expect that the larger structures, i.e. Whitewood and Belle Fourche anticlines, are present at depth. The closures may increase or decrease with depth. Closure on these structures together with good reservoir strata might produce oil in commercial quantities. One well to the south in Lawrence County (Weller-Weisman No. 1) has been drilled on a closure on Whitewood anticline without encountering any oil or gas. Another

well (Harmon-Olson No. 1) is being drilled on another small closure on same structure. A well drilled prior to 1922 on the Box Elder anticline is reported (Wilson 1922) to have had an oil show in Newcastle sandstone.

Possible stratigraphic traps might result from the wedging out of the Newcastle sand southward up dip. It is 125 feet thick in the State Royalty No. 1 at Camp Crook in Harding County, but has thinned to 12 feet at the Harding-Butte County line (Northern Ordnance Government No. 1), and where it outcrops in southernmost Butte County, it is lenticular and locally absent.

Another possible stratigraphic trap would be based on differential permeability of sandstones coupled with regional dip or other structures. Unfortunately this type of trap requires drilling to locate.

V. Appendix

OIL TESTS AND DEEP WELLS OF BUTTE COUNTY

The State Geological Survey has records of 9 oil tests in Butte County and three other deep wells of stratigraphic importance. According to Wilson (1922) at least 15 other oil tests have been drilled.

OIL TESTS

Blanche - Hamilton No. 1

Location: SE¼, NE¼, Sec. 32, T. 8 N., R. 1 E.

Company: Wy-Tex Oil Company

Drilled: 1932-33

Depth: 1529 feet

Remarks: Gas show at 1260 (Minnelusa sands). Oil and gas show at 1529 (Minnelusa sand). Plugged.

Tri-State - Jermiason No. 1

Location: SE¼, Sec. 35, T. 9 N., R. 3 E.

Company: Tri-State Oil and Refining Company

Drilled: 1932

Depth: 300-500? feet

Remarks: Plugged? No shows reported.

Two Top No. 1

Location: T. 10 N., R. 6 E.

Company: Local Capital

Drilled: 1938

Depth: 1100? feet

Remarks: Not plugged. No shows reported.

Two Top No. 2

Location: SE¼, NE¼, Sec. 30, T. 10 N., R. 6 E.

Company: Hal Blakeman

Drilled: 1940

Depth: 2860/ ? feet

Remarks: Newcastle at 2146?, several gas? shows.

Hafner No. 1

Location: Sec. 30, T. 9 N., R. 7 E.

Company: M. E. Hafner

Drilled: 1948

Depth: 1150 feet

Remarks: Gas show, well capped.

Teepee Buttes No. 1

Location: SW¼, SW¼, NE¼, Sec. 33, T. 9 N., R. 7 E.

Company: Teepee Buttes Joint Venture

Drilled: 1950

Depth: 2752 feet

Remarks: Oil show at 1330-1345 (in Codell sand of Carlile formation).

Seyler - Anderson No. 1

Location: SW cor., SE¼, SW¼, Sec. 12, T. 8 N., R. 5 E.

Company: Wm. Seyler Company

Drilled: 1949

Depth: 5759 feet

Remarks: No shows reported. Plugged.

Harmon - Olson No. 1

Location: NE¼, NE¼, Sec. 27, T. 9 N., R. 3 E.

Company: R. P. Harmon et. al.

Drilled: 1951-

Depth: 3240 feet (January 1952)

Remarks: Heavy flow artesian water at 2840 drilling.

OTHER DEEP WELLS

Seyler Stratigraphic Test

Location: SE¼, Sec. 27, T. 9 N., R. 3 E.

Company: Wm. Seyler Company

Drilled: 1948

Depth: 788 feet

Amerada Stratigraphic Test No. 5

Location: Sec. 29, T. 8 N., R. 7 E.

Company: Amerada Petroleum Corporation

Drilled: 1951

Depth: ?

Remarks: Completed as a water well.

Newell Experimental Farm Well

Location: Sec. 24, T. 9 N., R. 5 E.

Company: U. S. Department of Agriculture

Drilled: 1934

Depth: 4400 feet

Remarks: A trace of gas at 1650 feet (Pierre formation).

Following is an excerpt from "Oil in South Dakota" by R. A. Wilson, South Dakota Geological and Natural History Survey, Bulletin 10.

> "Belle Fourche Area: A well drilled about six miles northwest of Belle Fourche on an anticline trending in a northwest direction through T. 10 N., R. 1 E., started in the Graneros shale and is said to have penetrated to the Lakota sand at a depth of 1,530 feet. A thin sand said to be three or four feet thick and lying about 250 feet above the Dakota was found to contain traces of oil. This is probably the sand that is petroleum-bearing at Newcastle (Newcastle sand). The Lakota was also slightly petroliferous. Water was encountered in the Dakota, and the other sands.
>
> "St. Onge: A general north-south trending fold-east and north of St. Onge, and which from surface evidence does not appear to be closed, has been tested by twelve shallow wells. This structure is superimposed upon the large anticline marked on the map. The structure is defined by the Mowry and Graneros shales. The detailed logs of these wells have not been obtained. Gas was encountered in a thin, lenticular sand, apparently the Newcastle. The gas in one well is reported to have had considerable pressure. Analysis showed an important nitrogen content and a trace of helium."

FIGURE 2

SUBSURFACE SECTION RUNNING N.80°E. FROM THE WYOMING LINE

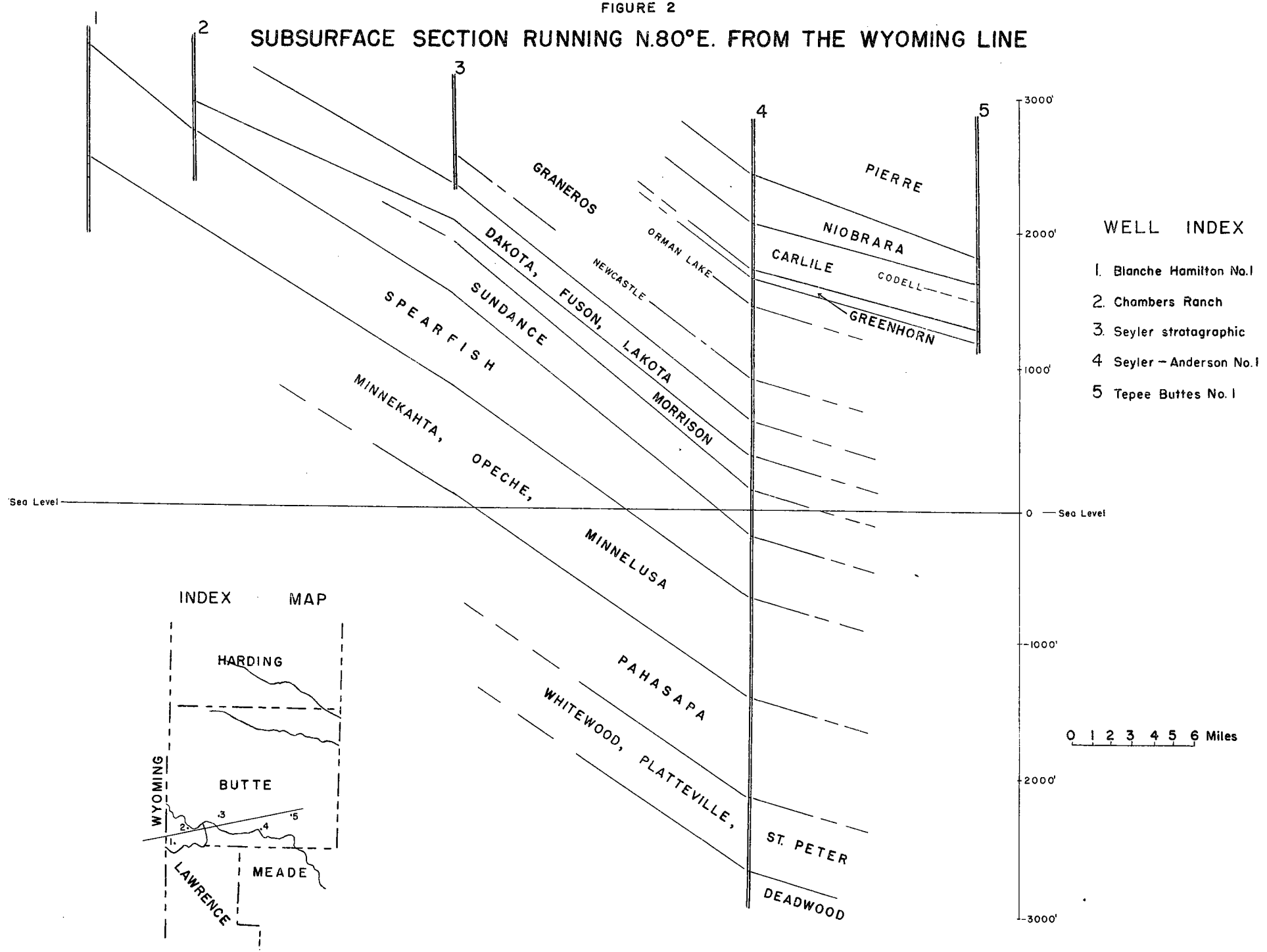
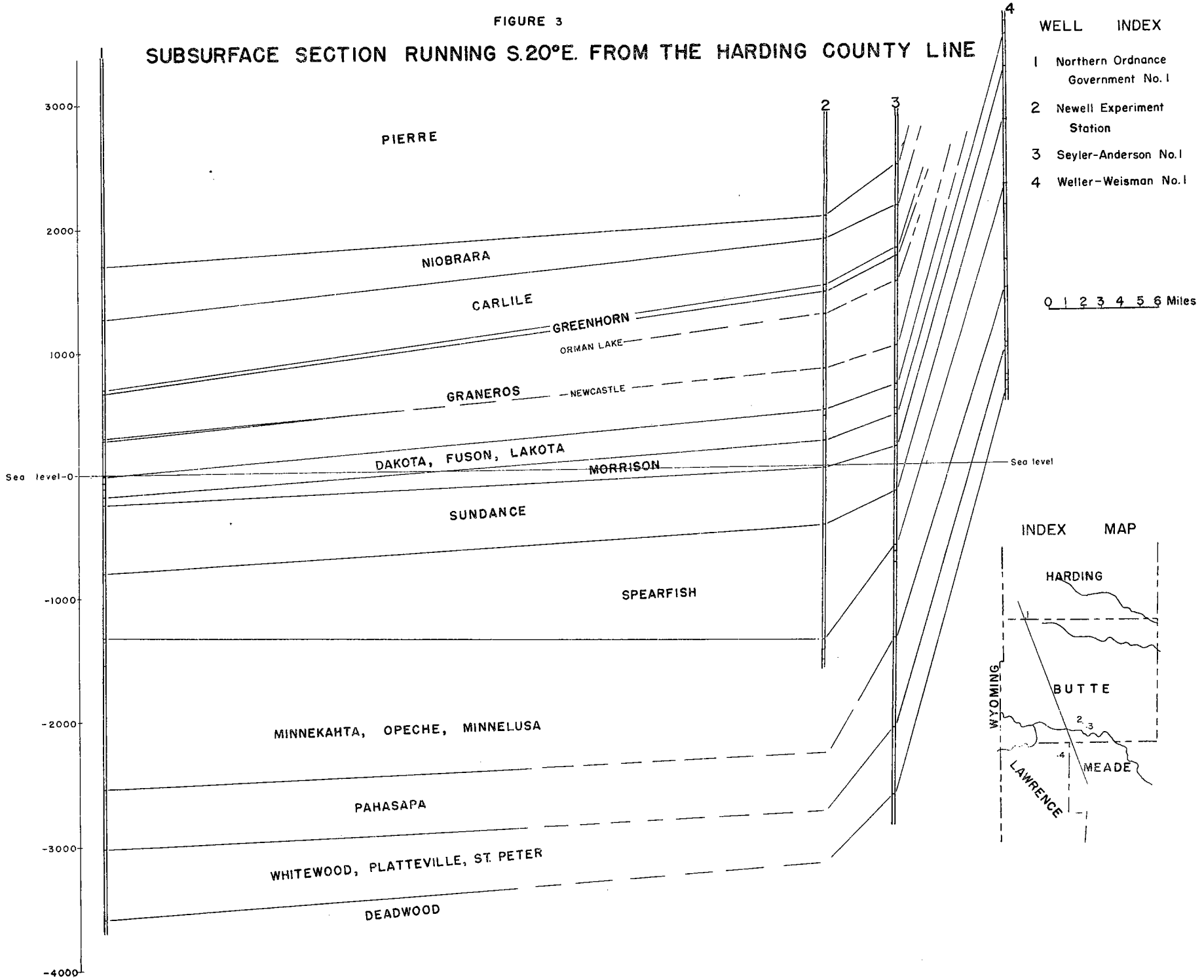


FIGURE 3

SUBSURFACE SECTION RUNNING S.20°E. FROM THE HARDING COUNTY LINE



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