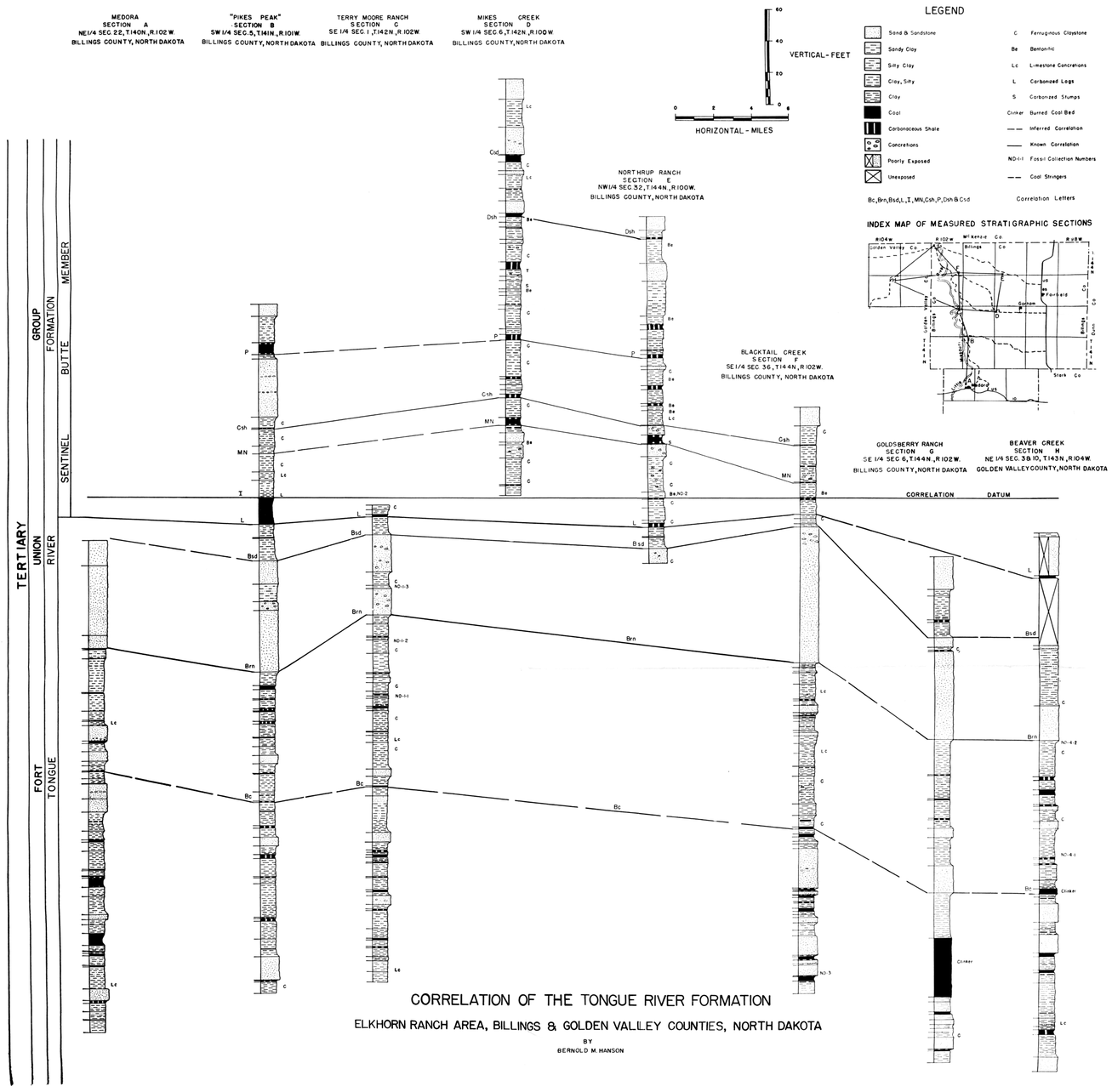
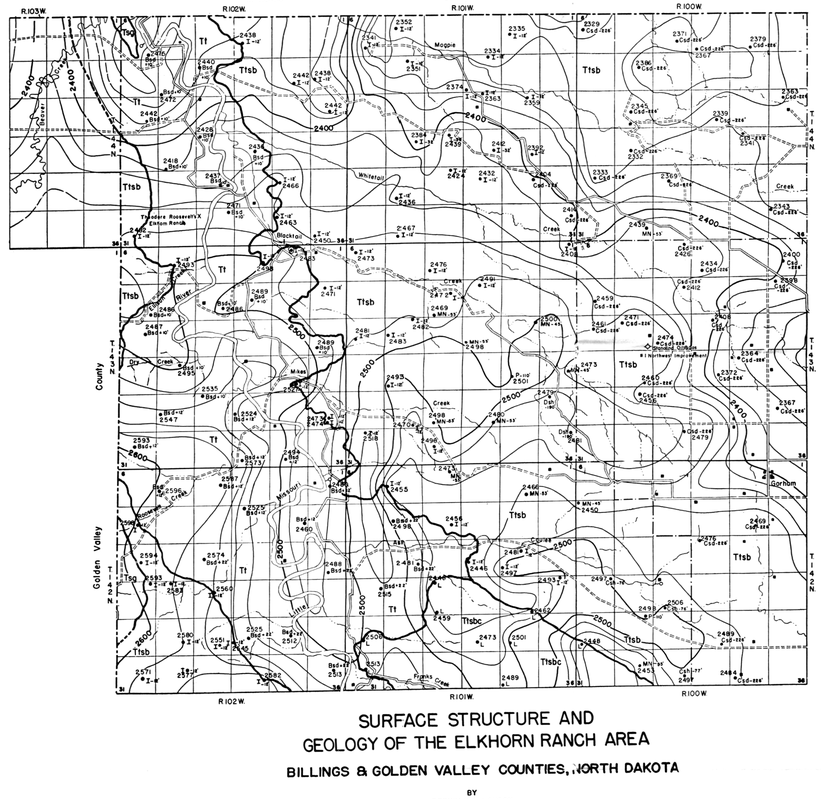


CORRELATION OF THE TONGUE RIVER FORMATION

ELKHORN RANCH AREA, BILLINGS & GOLDEN VALLEY COUNTIES, NORTH DAKOTA

BY

BERNOLD M. HANSON



NORTH DAKOTA GEOLOGICAL SURVEY
WILSON M. LAIRD, State Geologist

Geology of the Elkhorn Ranch Area, Billings and Golden Valley Counties, North Dakota

by

BERNOLD M. HANSON

Report of Investigations No. 18

Grand Forks, North Dakota, 1955

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Tsg Surface Gravels
Ttsb Sentinel Butte member
Ttsbc Sentinel Butte clinker
Tt Tongue River formation
Known Contact
Inferred Contact
Structure Contours Drawn on base of "L" Clinker, Contour Interval 20 Ft. Datum is mean sea level
Control Points
Correlation Letters below "L" datum
Correlation Letters above "L" datum
Graded Roads
Unimproved Roads
Buildings
Spring
Dam
Perennial Streams
Intermittent Streams
Government Land Boundary
County Boundary
Oil & Gas test (dry hole)

Abstract

The Elkhorn Ranch area lies in the most dissected area of the badlands on the western flank of the Williston Basin. Terraces along the Little Missouri River valley are important physiographic features.

In this report the Sentinel Butte is considered as a member of the Tongue River formation. The sediments in the Tongue River formation indicate the environmental conditions that prevailed during Paleocene time.

The regional dip is about 20 feet per mile to the northeast. Several folds are present as shown on the combined geologic and structure contour map. A correlation chart is presented which shows in detail the sections measured in preparation for the structure contouring.

Introduction

The name for the area covered by this report was taken from Theodore Roosevelt's famous Elkhorn Ranch, occupied by him in 1881, 1890, and 1891.

Location and Accessibility

The Elkhorn Ranch area lies in northwestern Billings and northeastern Golden Valley Counties, in west-central North Dakota. The area studied comprises Townships 142, 143, and 144 North, Ranges 100, 101, 102, and the east one-half of 103 West, near the central part of the Williston Basin.

Although ranching has been carried on in this area since the late 1850's, no first class roads have yet been constructed in this immediate area. The area may be reached by traveling north on the mail route which extends from the South Unit of Roosevelt National Park to the Billings-McKenzie County line. This is the only north-south road within the area which can be traveled by car. There are three east-west roads which are passable during dry weather. Although there are no bridges crossing the Little Missouri River in this locality, it is possible to ford the river at three locations during dry weather.

During the spring of 1954 several seismograph parties operated in this vicinity and many bulldozed trails were made which can now be traveled by four-wheel drive vehicles. All roads are generally impassable during the winter months, but ranchers who live along the river often drive to town on the frozen river. The eastern one-third of the area is farm land and more thickly populated than the western part, so numerous section-line roads exist in that region.

Purpose of Investigation

The purpose of this investigation was: (1) to prepare an areal geologic map of the area; (2) to describe and measure detailed stratigraphic sections, which would aid in correlating rock units in this area with those found in adjoining areas; and (3) to delimit all structural features by means of structure contours.

Previous Geologic Investigations

The geology of this area was first described by F. B. Meek and F. V. Hayden (1862). At that time a well exposed section near old Fort Union, Dakota Territory, was described and named the Fort Union group. The location of old Fort Union is near the junction of the Yellowstone and Missouri Rivers, now called Buford, North Dakota. This location is approximately 60 miles northwest of the Elkhorn Ranch area.

A. G. Leonard (1908) mapped the lignites in southwestern North Dakota including the area mapped for this report.

Thom and Dobbin (1924) considered the Tongue River member as the lower member of the Fort Union formation. Their regional correlation from Livingston, Montana to Sentinel Butte, North Dakota, covered a distance of approximately 400 miles.

Hares (1928) mapped the Upper Cretaceous, Tertiary and Quaternary rocks in the Marmarth Lignite field, the northern boundary of which is located approximately 30 miles south of the Elkhorn Ranch area.

Stebinger (1912) mapped the lignites, and prepared a structure contour map of an 800-square mile are lying immediately south of Sidney, Montana, and some 80 miles west of the Elkhorn Ranch area.

Fisher (1954) mapped the area adjoining the Elkhorn Ranch area to the west.

Several oil companies have carried out geophysical and surface geological investigations in the area, but their reports have not been made available to the public.

Although the presence of coal was long known in this area, the lack of commercial beds made the area unattractive for mining, hence it was slighted geologically until the discovery of oil in the Williston Basin. The ranchers mine the lignite for their own use.

Field Work

The field investigation was started on August 4, 1954, and was completed by October 1, 1954. Eight stratigraphic sections were measured with an Abney hand level, a six foot rule and a 100 foot steel tape. The rock units were described in the field and samples from each lithologic unit were collected and later examined in the laboratory. The measured stratigraphic sections are located near Medora, North Dakota and at other locations farther north within the area mapped. Section "H" was measured to correlate the beds in this area with those in the Skaar-Trotters area, mapped by Fisher (1954).

In order to establish elevations upon stratigraphic units, for the purpose of constructing a structure contour map, temporary bench marks had to be established within the area. The only existing primary elevation control near the area is located on U. S. Highway No. 85, along which the U. S. Coast and Geodetic Survey has established a second order level line, extending from Belfield to Watford City, North Dakota. This north-south level line lies four miles east of the eastern part of the area mapped. Elevations were carried from this control by means of a Paulin altimeter to temporary bench marks established in the Elkhorn Ranch area. Three altimeters were used on the initial loop, and the temporary bench marks were spaced about four miles apart, depending on the terrain. A second loop was run to check the initial values obtained and the elevations were checked to within a tolerance of two feet. Three separate loops were then run through the area on the east-west roads, and the values obtained were tied-in with previously determined elevations, in order to establish more accurate vertical control.

A plane table and alidade were used to extend the elevation control net to points west of the Little Missouri River. Starting from elevations established by the alidade, another series of loops were run with altimeters to obtain temporary bench marks. After the temporary bench marks were established, geological correlations were made, a datum bed was chosen, and elevations were established on the datum at selected points. A resistant standstone bed, Bsd, was used for a datum along the Little Missouri River where the principal bed was not present.

The eastern one-third of the area was mapped in the same manner as that along the Little Missouri River except that a sand stratum Csd, stratigraphically higher than the datum bed, was used. The vertical distance between the sand bed and the datum bed was measured, and adjusted elevations calculated for the datum bed.

In the southern part of the area a prominent clinker bed exists which has been designated by the letter "L". This clinker bed extends for about three miles north of the southern boundary of the area, and caps all the buttes in that vicinity. Although this clinker bed is not very extensive, and is much thicker than the clinker bed in the Skaar-Trotters area, it was determined that it is the same bed described by Fisher (1954) in the Skaar-Trotters area. The base of clinker bed "L" was used for the datum plane in structure contouring.

By using substitute beds ranging in position from 226 feet above to 45 feet below the datum bed, it was possible to establish control points for structural contouring of the entire area.

Aerial mosaics were used to find the exact location of each point used for structural contouring. These were then plotted on a State Highway Department map of the same scale, which in turn was used as a base map on which the structural contours were drawn.

Laboratory Work

Samples were collected from each measured section and were later examined under a binocular microscope in the laboratory. Resulting observations were combined with the descriptions made at the outcrop for the final description of rock units. Numerous fossil shells were collected from the clays and sands. Most of these were gastropods and pelecypods which were later identified by Dr. A. B. Shaw and Miss Barbara Swain at the University of Wyoming, and condsidered by them to be of Paleocene age. Although these fossils were not used for correlation purposes, they were indicative of the type of deposition which took place in the area.

Acknowledgements

Special thanks are due Dr. Wilson M. Laird, State Geologist of North Dakota oy whom the writer was employed during the 1954 field season as a geologist with the North Dakota Geological Survey; to Mr. Miller Hansen, Assistant State Geologist of North Dakota, who supervised the field work and gave many helpful suggestions in the mapping; and to Dr. G. L. Bell, Department of Geology, University of North Dakota, who field-checked the area and also gave many helpful suggestions.

Physiography

The terraces in the Elkhorn Ranch area form some of the more conspicuous topographic features. They are found at four principal levels and stand out prominently from the badlands topography. In general, there are two types of terraces represented here: those formed in the upper old Little Missouri River valley, which are usually cut-rock terraces, and those which are alluvial-filled and formed during the damming or ponding of the Little Missouri River. Several buttes in the area rise above the general level of the rolling prairie. The Little Missouri River flows from south to north along the west side of the area.

The Elkhorn Ranch area lies in the most rugged part of the North Dakota Badlands. This badland topography was caused by sheet wash, stream and wind erosion. Precipitation in this region is generally light, averaging about 12 inches per year. Most of the rain occurs in the form of cloudbursts and these rapid downpours are very effective in eroding the unconsolidated sands and soft clays. The streams have cut deeply into the unconsolidated beds and have formed a network of steep-sided canyons, gorges, ravines and gullies. This network embraces the area drained by the Little Missouri River and its tributaries.

Ash Coulee has a year-round flow and is fed by a large spring. This spring which is located at the base of a thick coal bed, has a flow estimated at 30 gallons per minute. The other creeks in this area flow intermittently.

Exposures

Exposures of the rock units are generally excellent, but the entire thickness of the Tongue River formation is not exposed within the mapped area. In addition to the exposed beds, approximately 800 additional feet of this formation lies below the outcrops.

The lower part of the Sentinel Butte member of the Tongue River formation is present in the area investigated, erosion having removed the upper part. The rocks of this unit are not well exposed, and only a few steep cliffs are found which do not have talus slopes covering the outcrops. All the strata in the eastern three-fourths of the area dip about one-half degree to the northeast, and therefore progressively younger strata are exposed in that direction. The contact between the Sentinel Butte member and the underlying beds of the Tongue River formation is quite pronounced because it is picked at a color change; dark brown Sentinel Butte shale is found resting on gray to tan Tongue River beds. Locally this contact can also be picked at the base of the prominent and persistent clinker bed.

In order to correlate satisfactorily the rock units in this area, it was necessary to measure and compare several sections since lateral changes in these sediments take place rapidly.

Stratigraphy

The upper 350 fet of the Tongue River formation is well exposed in the bluffs bordering the Little Missouri River along its entire course through the Elkhorn Ranch area. The lower 750 feet of the formation is exposed between the mapped area and Marmarth, North Dakota, some 30 miles to the south. At the latter locality the Tongue River formation rests comformably on the Ludlow formation. The total thickness of the Tongue River formation including the Sentinel Butte member is about 1600 feet. The Tongue River formation can be traced westward from this area into Montana; south to Marmarth, North Dakota and southwest to Sheridan, Wyoming, an overall distance of about 400 miles.

The Sentinel Butte member of the Tongue River formation borders the Little Missouri River and is also exposed in bluffs in the eastern three-fourths of the Elkhorn Ranch area. Its total thickness is about 500 feet, but only the lower 250 feet is present in this area.

The upper part of the Sentinel Butte member does not crop out in the Elkhorn Ranch area, but is well exposed in the North Unit of Roosevelt National Park, about 30 miles north of the mapped area. At this locality Dr. Laird showed the writer the upper part of the Sentinel Butte member which differs from the lower part by being more bentonitic and lighter in color.

The contact between the Sentinel Butte member and the underlying part of the Tongue River formation is locally picked at the base of the most persistent and prominent clinker bed or on the basis of the characteristic lithologies,—the Tongue River light tan to gray colored sand and clay and the Sentinel Butte brown sands and clays. Fisher (1954) used the base of a clinker bed which he designated as bed "L" as the datum for structure contours in the Skaar-Trotters area. He traced the formation well into Montana and correlated the rock units with those described by Stebinger (1912). The "L" bed described by Fisher is equivalent to the "K" bed described by Stebinger in eastern Montana. Clinker bed "L" was noted in the Elkhorn Ranch area and designated by the same letter.

The stratigraphic succession discussed in this report includes only those rocks in the upper 350 fet of the Tongue River formation, the lower 250 feet of the Sentinel Butte member of the Tongue River formation of Paleocene age; and the surface gravels of Miocene or Pliocene age.

Tongue River Formation

Age and Correlation: Taff (1909) named and described the Tongue River Coal group; and designated a type section near Sheridan, Wyoming. Thom and Dobbin (1924) introduced the name Tongue River member of the Fort Union formation into North Dakota because of the lithologic similarity of the rocks at Taff's type section to the rocks in western North Dakota.

The Tongue River continued to be called a member of the Fort Union formation until Dorf (1940) reclassified it as a formation of the Fort Union group.

Seager, et. al., (1942) reversed this procedure and applied the name Tongue River member to these rocks. The usage was continued until 1954 when Fisher used the name as a formational designation.

Leonard (1908) recognized three divisions of the Fort Union, the Lower, Middle, and Upper. The middle Fort Union was called the Tongue River member by Thom and Dobbin (1924).

Hennen (1943) recognized a "marker bed" in this area which he called "sandstone 21.... He used this bed in an attempt to establish an east-west correlation from Sentinel Butte, North Dakota to a point northeast of Bismarck, North Dakota, a distance of over 165 miles. The writer did not note this "marker bed" in an area of good exposure. On the basis of the rapid lateral changes observed in all other sandstone beds, the writer doubts that any single sandstone stratum is continous over the entire area.

Lithology: The rocks of the Tongue River formation crop out as light yellow to buff calcareous sands, with resistant calcareous sandstone ledges in places, gray to tan clays and numerous carbonaceous shales and lignites.

The sands in the Elkhorn Ranch area are tan, buff, cream, yellow and white with a lesser showing of brown and gray. For the most part the sands are fine to medium-grained, sub-angular to sub-rounded, calcareous, unconsolidated, and contain numerous biotite and muscovite flakes. Some of the sands have black hematitic grains and the combination of the biotite and hematite gives the sand a salt and pepper appearance. Many fresh exposures of sand show banding. This banding extends laterally through the stratum and is apparently formed by ferruginous staining of the individual quartz grains.

Numerous small irregularly shaped marcasite concretions occur within the sands. When these concretions are exposed they weather to limonitic masses up to two inches in diameter, red and orange in color and with concentric structure. There are several theories on the formation of the marcasite and pyrite concretions but nearly all agree that there must be a reducing condition present during the deposition of the sediments to produce the iron sulfide (Twenhofel, 1932). The sand must have been deposited in a lake environment, with relatively quiet water, because sand occurs in thin lenses intermittently distributed throughout most of the beds. This type of deposition is also indicated by the well-bedded, fine-grained, sub-angular character of the sands.

Resistant sandstone ledges occur throughout the sands and occasionally some are found in the upper part of clay beds. The sandstone is calcareous and under a binocular microscope some well developed calcite crystals can be seen. About 40 per cent of the matrix of this sandstone consists of calcite and the sand grains that are present are sub-angular to sub-rounded. Biotite, muscovite and black hematitic grains were found in most of the sandstones. At a single locality near the Elkhorn Ranch, section 33, T. 144N., R. 102W., a sandstone marked by symmetrical oscillation ripple marks was noted. This sandstone was fine-grained and slabby. Near Black Top Butte, section 36, T. 144N., R. 102W., some irregularly shaped small sandstone concretions were noted which varied in size up to five inches in length. These concretions were weathered out of the resistant sandstone and are composed of the same material as the sandstone.

Calcareous clay pellets were noted near the base of some of the sands and appeared to extend laterally. These pellets varied in size from 1/8 inch to 3 inches in diameter.

(CONTINUED ON OLDER SIDE)

GEOLOGY OF THE ELKHORN RANCH AREA

(CONTINUED)

Near Medora, North Dakota, a resistant quartzitic sandstone was exposed near the base of Section A. The silica, which cements the sandstone, is apparently secondary in origin. Tracing this seven foot-eight inch bed laterally, the sandstone is cemented with silica for about 75 feet, changing to a calcareous cemented sandstone which extends laterally for about 100 feet, and grading into an unconsolidated sand which is very fine-grained, with flakes of biotite. The quartzitic sandstone was not noted in any other exposures in the Elkhorn Ranch area because the northeast dip of the rocks carries this zone below ground surface.

The following fresh water fossil shells were found in a sandstone in Section F. They were identified by Dr. A. B. Shaw as:

LIOPLACODES TENUICARINATA	(Meek and Hayden) 1857
PLEUROLIMNAEA TENUICOSTA	(Meek and Hayden) 1856
VIVIPARUS RAYNOIDSIANUS	(Meek and Hayden) 1861
FLUMINICOLA PROTEA	Yen 1948
ELLIPTIA PRISCUS	(Meek and Hayden) 1856
MICROPYRGUS MINUTULUS	(Meek and Hayden) 1856
LIOPLACODES SP. INDET.	
CARINORBIS SP. INDET.	
OSTRACODES	
GYRAULAS MILITARIS	(White) 1880

The Viviparids (Liplacodes) indicate that the enclosing rocks were fluviatile deposits. These forms in living fauna exist in streams and rivers of various sizes (Yen, 1948).

The clays for the most part are gray to tan in color, but exhibit varying shades of brown, white, buff and greenish blue. They are platy, laminated and some are flaky. There are small diagonal joint patterns in the clays across the bedding planes. Some of the clay is extremely sandy, some limonitic, some silty and nearly all calcareous.

Concretions of limestone occur in clays throughout the upper part of the Tongue River formation. These limestone concretions are grey, dense, finely crystalline and break with conchoidal fractures. Ferruginous material coats the exposed surface of the fracture planes.

Excellently preserved fresh water fossil shells were found in the clays and were identified by Dr. A. B. Shaw as:

VIVIPARUS RETUSUS	(Meek and Hayden) 1856
SPHAERIUM FORMOSUM	(Meek and Hayden) 1856
FERRISSIA MINUTA	(Meek and Hayden) 1856
GYRAULUS PARVULUS	(Meek and Hayden) 1856
CAMPELOMA NEBRASCENSIS	(Meek and Hayden) 1856
PLEUROLIMNAEA TENUICOSTA	(Meek and Hayden) 1856
VIVIPARUS PECULIARIS	(Meek and Hayden) 1856
CARBULA MACTRIFORMIS	(Meek and Hayden) 1856

Again these fossils indicate a fluviatile type of deposition and the same environmental conditions must have prevailed during the deposition of the clays as existed when the sands were deposited.

Numerous lignite and carbonaceous shale beds are present in the Elkhorn Ranch area and vary from a few inches to 16 feet in thickness. The lignites are black to brown, brittle, shiny and break in plates parallel to the bedding planes. In several of the exposures lignites are stained with a yellow limonitic material. Gypsum, pyrite and marcasite occur as impurities throughout the lignites. The lignite in surface exposures is powdery. Lignite contains a high percentage of moisture and on exposure to air, evaporation causes water loss and shrinkage, with attendant cracks in the lignite.

The carbonaceous shales are brown, very platy and usually thinner than the lignites. Carbonaceous shale stringers separated by thin beds of shale are common in the clays. Layers of carbonaceous shale usually occur above a lignite bed.

The red clinker beds which occur at different levels are probably the most noticeable rocks in the area. Several coal beds have burned in the Elkhorn Ranch area thereby discoloring the overlying sediments by baking and by oxidation. The clinker is more resistant than the clays and sands and where present, caps the buttes and protects them from erosion.

East of the Annear Ranch, Section 15, T. 143 N., R. 102 W., a good exposure of clinker was found which indicates three coal beds. It consisted of:

Clinker	5′
Ash bed	1′
Green to brown fused bed	6′
Ash bed	0′ 6″
Clinker	3′
Ash bed	1′
Total	16′ 6″

The former position of the burned coal bed is marked by a thin reddish white and very powdery ash bed at the base of the clinker.

Tongue River—Sentinel Butte member contact

The upper part of the Tongue River formation is a series of brown, to gray bentonitic clays, silty clays and sands with numerous carbonized and silicified logs, stumps and iron coated sandstone concretions up to three feet in diameter. These somber beds constitute the Sentinel Butte member of the Tongue River formation.

The contact between the Tongue River formation and Sentinel Butte member has been placed at the above described color change by such workers as Leonard (1908), Hares (1928), Brown (1948), Fisher (1954) and the writer.

The base of the prominent basal clinker bed, exposed in the South Unit of Roosevelt National Park, locally is the contact between the light-colored Tongue River formation and the darker Sentinel Butte member. This particular clinker bed, which caps the buttes and hills, can be traced northward for a distance of 20 miles to a point near the southern boundary of the mapped area. Northeast of this point the clinker is not exposed because of the northeast dip of the rocks. North of this point the contact grades from a clinker bed to a carbonaceous shale bed one foot thick. Here the lithologic color change is noticeable between the Tongue River formation and the Sentinel Butte member. The buff to light gray Tongue River formation underlies a dark bentonitic Sentinel Butte member clay which has numerous silicified logs. North of this area the contact is similar except there are no silicified logs and stumps in the Sentinel Butte bentonitic clay. The contact is exposed in five of the eight measured stratigraphic sections. In section 20, T. 143 N, R. 101 W. the lower part of the Sentinel Butte member is exposed in an isolated butte. The Sentinel Butte member is exposed on both sides of the Little Missouri River Valley and the contact where exposed is well defined. West of Section "E" the contact of the two lithologies is so well defined and marked that it is visible from a distance of about one mile. In the eastern part of the mapped area the contact was covered by the younger rocks of the Sentinel Butte member.

Sentinel Butte member

Age and Correlation: Leonard (1908) applied the name Sentinel Butte to a group of lignite beds south of the town of Sentinel Butte, North Dakota. At that time he included all but the lowest lignite bed of the Sentinel Butte coal group in the upper member of the Fort Union formation. The contact between the upper and middle divisions was taken as the boundary between the lighter clays and sands of the middle member and darker clays of the upper. Leonard considered the Fort Union to be of early Eocene age. Leonard (1911, p. 534) described the Sentinel Butte as follows:

> In Billings County, North Dakota, an upper member of the formation appears in the tops of higher ridges, divides and buttes, and resembles somewhat the Lance beds in its color and its many brown ferruginous, sandstone concretions. The lower member constitutes the typical yellow and light gray Fort Union and this is the only one present over most of the region. Where both occur, the contrast between the upper and lower members is so well marked and their contact so clearly defined that it can readily be distinguished even at a distance and traced without difficulty, where ever it is exposed.

Thom and Dobbin (1924) correlated the Sentinel Butte shale with the Intermediate coal group (Taff, 1909) and the Kingsbury conglomerate which crops out on the east side of the Bighorn Mountains, Wyoming. The Kingsbury conglomerate at that time was considered to be Eocene in age. On the basis of this evidence the Sentinel Butte shale was also considered to be Eocene in age and the equivalent to rocks called Wasatch in other areas. Hares (1928) discussed the possible age of the shale and designated it as Fort Union formation (?), although his opinion favored a Wasatchian age for the Sentinel Butte shale.

Brown (1948) and Benson (unpublished manuscript, 1952) suggested that the Paleocene-Eocene boundary be placed at the top of the Sentinel Butte shale. This was suggested because "all of the fossil plants of the Sentinel Butte shale and its lateral equivalent appear to be Fort Union species" (Brown, 1948, p. 1272). Brown (1948), Benson (1952), and the United States Geological Survey have assigned the same rocks to the Sentinel Butte but consider them a member of the Fort Union formation.

LITHOLOGY The sands in the Sentinel Butte member are similar to those in the Tongue River formation except in color. The clays in the Sentinel Butte member are darker and contain more silt than the lower lying Tongue River but were probably deposited under similar environmental conditions. Numerous iron coated sandstone concretions, which range in size from six inches to three feet are exposed in the silty clays. These concretions could not be used for correlation because they occur at different intervals throughout the member.

The bentonitic material found in numerous clay beds in the Sentinel Butte member is very conspicuous in the outcrop because when the bentonite dries, a rough weathered surface is formed by the shrinking and warping of the clay fragments. In some of the beds the bentonite is difficult to distinguish from the clays because of the high silt content in the clays and the weathering effect is not so noticeable. Bentonite is an end product of weathering of volcanic ash. The nearest known volcanoes were several hundred miles away toward the west or southwest and it is most likely that rivers and streams carried the volcanic ash into this region during upper Paleocene.

Numerous ferruginous claystone bands up to three inches thick appear both in the Tongue River formation and in the Sentinel Butte member but are more common in the latter. These bands are more resistant than the clays, and protect the lower clays from erosion.

Fresh water fossil shells were not so abundant in the Sentinel Butte member as in the Tongue River formation, but a limited collection was made by the writer and identified by Dr. A. B. Shaw as follows:

GYRALUS SP. INDET.	
OSTRACODES	
VIVIPARUS SP. INDET.	
MICROPYRGUS MINUTULUS	(Meek and Hayden) 1856

These fossil shells indicate a fluviatile type deposition; therefore, the environmental condition in Sentinel Butte time must have been similar to that in Tongue River time.

There is a sparse representation of lignites in the Sentinel Butte member; however there are numerous carbonaceous shale beds, varying from a few inches to five feet in thickness. In the lower shales of the Sentinel Butte member large and extensive areas of silicified logs and stumps are found.

Miocene (?)

At two localities surface gravels and boulders were noted in the Elkhorn Ranch area, one west of the Goldsberry ranch on the top of the bluff at section 6, T. 144N., R 102W, and the other west of the Terry Moore ranch on the Billings-Golden Valley County line. These gravels were composed of pieces of petrified logs, boulders of porphyrtic igneous rock, quartzite, quartz, chert and granite. The boulder deposit west of the Terry Moore ranch covers an extensive area as shown on the geologic map. The boulders are sub-rounded, an indication of transportation from a considerable distance. The composition indicates they could possibly be derived from the Black Hills or the Big Horn Mountains. The age of these gravels is not known by the writer but according to Alden (1924) they are probably upper Miocene or early Pliocene.

Problems of Correlation

Within the Elkhorn Ranch area there are numerous examples of gradations from one type rock to another both vertically and laterally. The measured sections indicate this feature.

With few exceptions the sandstone beds cannot be relied upon to continue any distance or to remain at the same horizon. The writer established elevations on only two sandstone beds designated as "Bsd" and "Csd". The sand designated Bsd of the Tongue River formation was used along the Little Missouri River where the principal datum bed was not present. This sand bed was well exposed and could be traced along the outcrops.

In the eastern one-third of the area elevations were established for structure contouring on a Sentinel Butte member sandstone, designated "Csd", which was stratigraphically higher than the datum bed. The exposures of this bed were isolated and difficult to find. Most of this area is farm land and the few exposures found were in gullies.

Fisher (1954) used the designation "Brn" for a sand in the Tongue River formation. It is best exposed in Section "H" as shown on the correlation chart. This sand in Section "H" was correlated with the sand in the Elkhorn Ranch area on the basis of the lithologies above and below the sand bed.

Although the lignites may be locally replaced by carbonaceous shales or may be split by clay seams, some which are several feet thick, they are the most persistent of all the beds in the area. For this reason and because lignites are often marked by red clinker beds, most of the elevations are based upon one or more lignites. Lignite (Bc) was noted in Section "H" and correlated with the equivalent lignites in the mapped area.

The base of Bed "L" which was used as the datum plane for structural contouring, is best developed in the southern part of the Elkhorn Ranch area. Locally the base of this bed is the contact between the Tongue River formation and the Sentinel Butte member.

Beds "P" and "MN" were the same beds used by Fisher (1954) and are in the Sentinel Butte member. Bed "MN" is characterized by the large silicified logs, stumps and bentonitic clay. Bed "P" is a fairly thick and extensive carbonaceous shale toward the north part of the area and a lignite bed in the eastern part of the mapped area.

The base of Bed "I" was used by the writer as a datum bed for correlation and is best developed in Section F. This bed contains a one foot carbonaceous shale overlain by a bentonitic clay. Although this shale varies in thickness it is distinctive because it is the lowest bentonitic bed in the Sentinel Butte member.

A carbonaceous shale (Dsh) was used for structure contouring when the other letter beds were not exposed. It was noted in two sections and best developed in the east central part of the mapped area.

Structure

The Elkhorn Ranch area is not in a complex structural region but several folds are present and are portrayed bythe structure contours. The geologic map delimits the folds which exist in the area. The stratigraphic horizon here used is the base of bed "L", which lies at the Tongue River-Sentinel Butte contact. The same datum was used in the Skaar-Trotters area by Fisher (1954).

The beds in the mapped area dip about 20 feet per mile to the northeast with two exceptions, west of the Goldsberry ranch the rocks appear to strike north-south and dip ½° W., and in the south-central part of the area the beds appear to strike N. 30° W., and dip ½° NE.

No faulting is indicated on the surface in the mapped area. Several springs were noted in the area but there is no apparent relationship between the springs and faulting. A normal stratigraphic succession is exposed above and below the springs, and the springs usually occur near the base of a coal or sand bed.

Folds

The folds or aniclinal axes have not been drawn or named in the mapped area but three fairly extensive folds exist. The most prominent fold is located in the southwest corner of the mapped area. The elevations of the datum bed rise about 100 feet in three miles. The contours indicate a nose of an eastward plunging anticline. The closure is not known because the western half of this fold has not been mapped. If surface structure is reflected at depth it is possible that this fold would be fairly extensive.

Another fold is indicated in the north one-half of T. 144 N., R. 102 W. In this locality the elevations of the beds rise about 80 feet in a mile. Although this fold is not very extensive, there is considerable relief on "L" bed. A fold with closure of 40 feet is present in Twps. 141 and 142 N., R 101 W.

A series of folds with a northeast-southwest trend are indicated centering around T. 142 N., R. 101 W. These are more irregular than the previous folds and this irregularity can best be explained by the eastward movement of the rocks in the southwestern fold.

A northeastward dipping monocline is present in Twps. 143 and 144 N., R. 100W. This monocline originates near the fold in the central part of the area and probably continues east beyond the mapped area.

Age of Deformation

Exact dating of the deformation in this area is not possible because of the absence of post-Paleocene rocks. At various localities east of the mapped area, isolated buttes contain remnants of Eocene rocks.

Fisher (1953) states: "The vertical movements accompanying the growth of the North American Cordillera affected the plains region in Paleocene time . . . " Dove (1922) indicates that the beds of the Fort Union reflected the structure of the Nesson anticline in Williams County, North Dakota.

This affords evidence that the Laramide orogeny continued at least until the close of Eocene.

The Oligocene rocks in North Dakota occur as isolated remnants and lie on Eocene and Paleocene rocks. A widespread unconformity at the base of the Oligocene White River formation separates this unit from the older formation (Seager et. al., 1942). Therefore, regional folding closed by early Oligocene time.

References

Alden, W. C. "Physiographic development of the northern Great Plains," Geol. Soc. Am. Bull., vol. 35, pp. 385-424, 1924.

Benson, W. E., "Geology of the Knife River area," U. S. Geol. Survey open file report, 1952.

Brown, R. W., "Correlation of Sentinel Butte shale in Western North Dakota," Am. Assoc. Petrol. Geol. Bull., vol. 32, No. 7, pp. 1265-1274, 1948.

Dorf, E., "Relation between floras of type Lance and Fort Union formation," Geol. Soc. Am. Bull., vol. 51, pp. 213-235, 1940.

Dove, L. P., "The geology and structure of the east side of Nesson anticline," Univ. of North Dakota, Quart. Jour., vol. 12, No. 3, pp. 240-249, 1922.

Fisher, S. P., "Geology of west central McKenzie County, North Dakota," North Dakota Geol. Survey, Report of Investigations No. 11, in two sheets, 1953.

———————,— "Structural geology of the Skaar-Trotters aera, McKenzie and Golden Valley Counties, North Dakota," North Dakota Geol. Survey, Report of Investigations No. 15, 1954.

Hares, C. J., "Geology and lignite resources of Marmarth field, southwestern North Dakota," U. S. Geol. Survey Bull., 775, 1928.

Hennen, R. V., "Tertiary geology and oil and gas prospects in Dakota Basin, North Dakota," Am. Assoc. Petro. Geol. Bull., vol. 27, No. 12, pp. 1567-94, 1943.

Leonard, A. G., "Geology of southwestern North Dakota, with special reference to the coal," North Dakota Geol. Survey. Fifth Biennial Report, pp. 30-111, 1908.

———————, "The Cretaceous and Tertiary formations of western North Dakota and eastern Montana," Jour. Geol., vol. 19, pp. 533-43, 1911.

Meek, F. B., and Hayden, F. V., Phila. Acad. Nat. Sci. Proc., vol. 13, p. 433, 1862.

Seager, O. A., et. al., "Stratigraphy of North Dakota," Am. Assoc. Petrol. Geol. Bull., vol. 26, No. 8, pp. 1414-1423, 1942.

Stebinger, E., "The Sidney lignite field, Dawson County, Montana," U. S. Geol. Survey Bull., 471, part II, pp. 284-318, 1912.

Taff, J A., "The Sheridan coal field, Wyoming," U. S. Geol. Survey Bull., 341, pp. 123-150, 1909.

Thom, W. T., Jr., and Dobbin, C. E., "Stratigraphy of Cretaceous-Eocene transition beds in eastern Montana and the Dakotas," Geol. Soc. Am. Bull., vol. 35, pp. 481-506, 1924.

Twenhofel, W. H., "Treatise on Sedimentation," 2nd ed , The Williams and Wilkins Co., Baltimore, Md., 1932.

Yen, T-C, "Paleocene fresh-water mollusks from southern Montana," U. S. Geol. Survey Prof. Paper, 214-C, pp. 36-37, 1948.