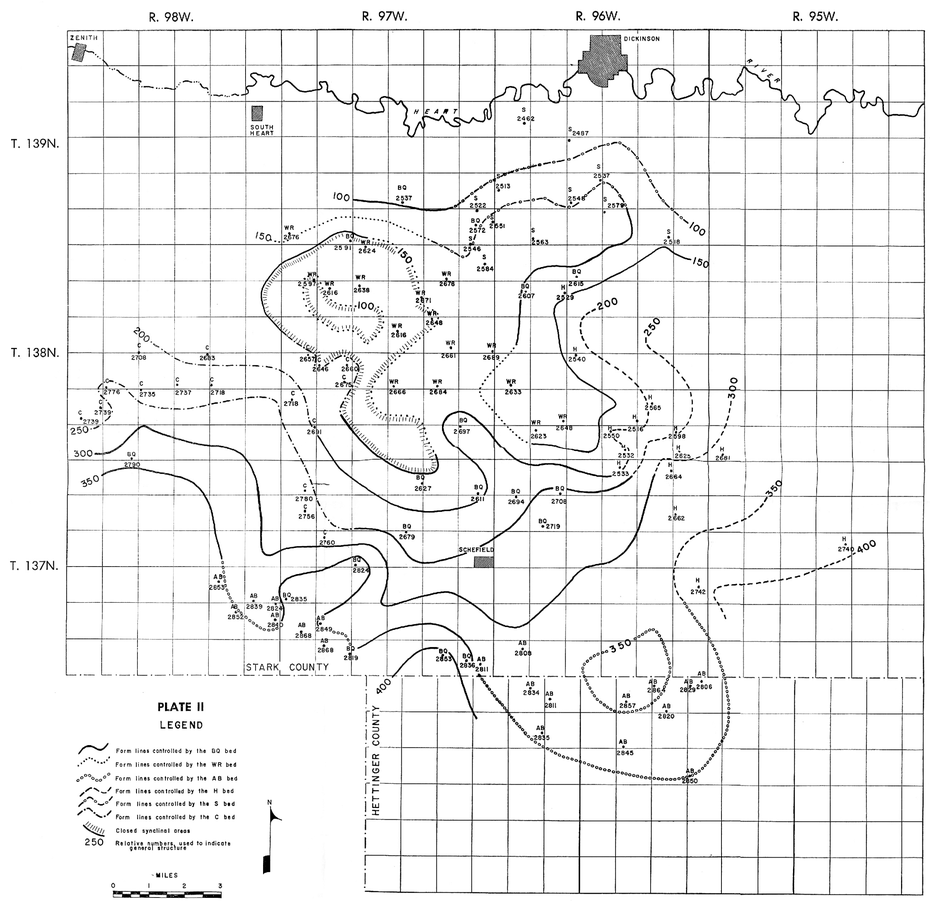



**PLATE II**

LEGEND

- Form lines controlled by the BQ bed
- Form lines controlled by the WR bed
- Form lines controlled by the AB bed
- Form lines controlled by the H bed
- Form lines controlled by the S bed
- Form lines controlled by the C bed
- Closed synclinal areas
- 250 Relative numbers, used to indicate general structure

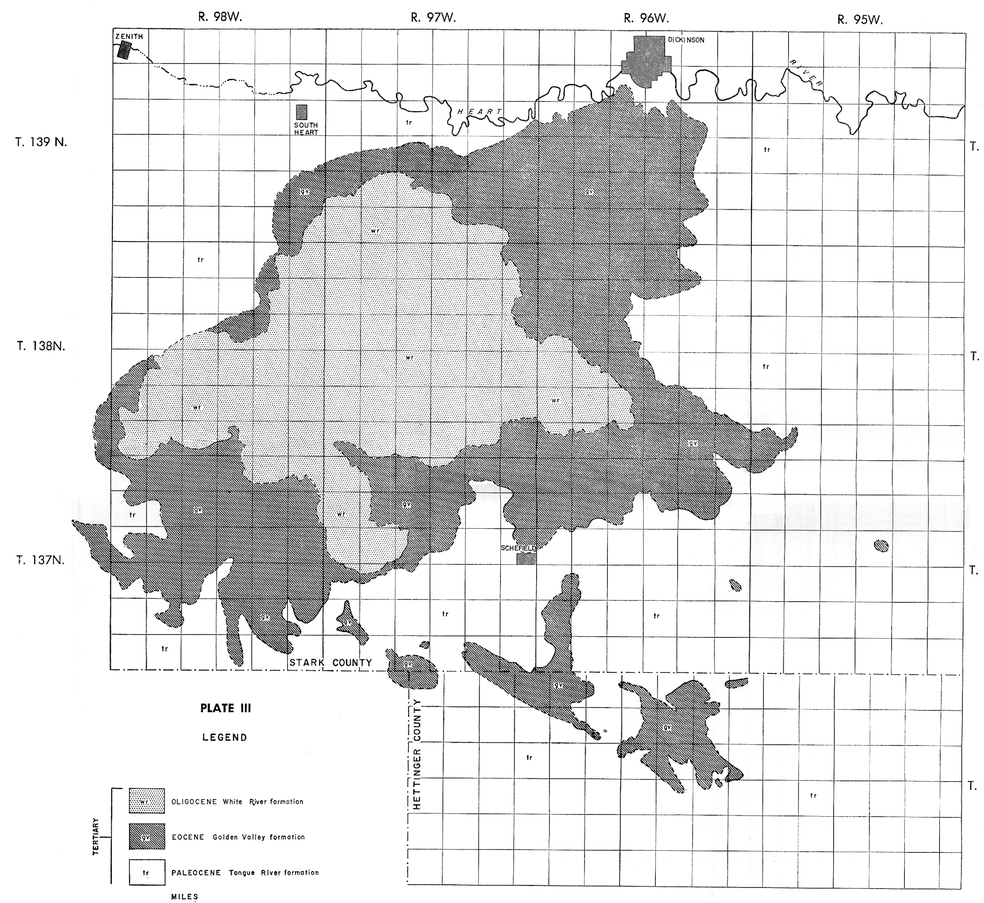



**PLATE III**

LEGEND

TERTIARY

- OLIGOCENE White River formation
- EOCENE Golden Valley formation
- PALEOCENE Tongue River formation

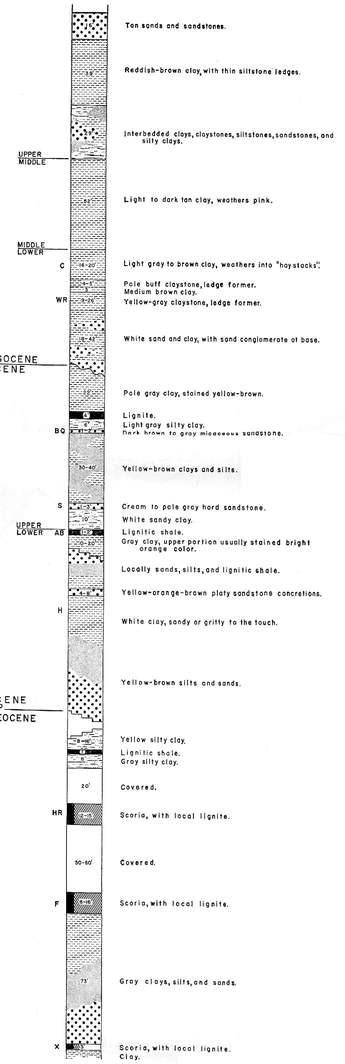
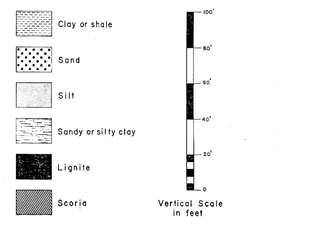



FIGURE 1

LEGEND




## ABSTRACT

In southeastern Billings County and southwestern Stark County, North Dakota, beds of continental origin are exposed at the surface. These beds are Tertiary in age and belong to the following formations; Tongue River (Paleocene), Golden Valley (Eocene), and White River (Oligocene).

Pre-Oligocene erosion is responsible for an unconformity of undetermined magnitude. As a result of the unconformity and limiting factors in correlation and problems of stratigraphy, the map for the eastern part of the area was drawn with form lines rather than structure contours.

A small synclinal basin covering approximately two townships is the most significant structure noted in the area. The central portion of this basin is partially divided by a dome of low relief, nearly three miles in width.

In the western part of the area a structure map was drawn from elevations taken on three persistent lignite beds

Economic materials found within the area of study include lignite, "scoria", clay and oil.

## INTRODUCTION

### Location and Topography

The area mapped in this report is largely situated in southwestern Stark County, with smaller portions extending into east central and southeast Billings County and northwestern Hettinger County, North Dakota. The area is situated for the most part on a rolling plain which slopes eastward from an elevation of approximately 2800 feet near the western edge of the area to 2400 feet near the eastern edge.

The region southwest of Dickinson is frequently referred to as the "Little Badlands", covering nearly 90 square miles. The term "Little Badlands" was derived from the noted "Badlands" associated with the Little Missouri River, located some 9 to 12 miles west of the area covered in this report. The area is sparse in vegetation and has been dissected by rains and streams sculpturing the area into odd forms such as deeply eroded gullies, "hay stack"-like mounds, and bare buttes and ridges. This area is drained by the Heart River and its tributaries. The Heart River flows from west to east and is located in the north central portion of the area. The Northern Pacific Railroad and U. S. Highway 10 are favorably situated in the valley formed by the Heart River.

### Previous Work

A. G. Leonard (1925 pp. 140-146) describes and outlines the extent of the Fryburg and Heart River lignite beds of the Tongue River formation in northwestern Stark County, North Dakota. Clapp and Babcock (1906) in a discussion of the Tertiary clays of North Dakota describe and present measured sections with an indication of the areal extent of clays in Stark County undoubtedly belonging to the Eocene Golden Valley formation.

Benson (1952) gives the first detailed description of the Golden Valley formation in which he has included measured sections and descriptions from the "Little Badlands" area. Benson's (1951) "Geologic Map of North Dakota Southwest of the Missouri River" portrays the areal extent of the Golden Valley formation as well as the underlying *Tongue River* and overlying White River formations.

The White River formation in the Stark County area is described in two papers, the first by A. G. Leonard (1922) and the second by M. F. Skinner (1951).

### Field Procedure

Field work for this report was done between the middle of July and the first week in September, 1953. Elevations were taken by means of Paulin altimeters with accuracy limits of 2 feet. United States Coast and Geodetic Survey elevations were used along 3 routes. They were: (1) the Northern Pacific Railroad, traversing the area east-west in the north central part of the area, (2) along North Dakota State Highway 22 running north-south near the eastern edge of the area, and (3) along U. S. Highway 85 north from Belfield near the western edge of the area covered in this report. Networks of temporary benchmarks based on the U. S. C. & G. S. elevations were laid out where needed. Frequent checks of stratigraphic elevation points were made to establish bench marks.

State Highway Department maps, on a scale of 1 inch to the mile, were used and elevations, notes, and outcrop patterns were recorded directly on these.

The area is readily accessible by section line roads with few exceptions. In almost any event the section right of way is maintained.

### Acknowledgments

To S. P. Fisher of the North Dakota Geological Survey and to his field assistants, Fritz Roth and Charles Waldren, students at the University of North Dakota, go credit for the major portion of the field work done for this report. To Miller Hansen, Assistant State Geologist, the writer is deeply indebted for advice and help in the preparation of this report.

## FRYBURG — SOUTH HEART AREA

The classification of sediments exposed in the area of this report is as follows:

TERTIARY SYSTEM
- Oligocene series
  - White River formation
- Eocene series
  - Golden Valley formation
- Paleocene series
  - Fort Union group
    - Tongue River formation

### Stratigraphy

The name Tongue River was first applied by Taff (1909, p. 129) to lignite-bearing beds underlying the approximate equivalent of the old Sentinel Butte shale of "Eocene" age. The Sentinel Butte shale is presently recognized in North Dakota as being an upper facies of the Tongue River formation, the entirety being Paleocene in age. The Tongue River formation in respect to its present usage includes all sediments above the Ludlow-Cannonball and below the Golden Valley formation of Eocene age.

The surface in the Fryburg — South Heart area consists of sediments from the Tongue River formation. Three lignite beds from this formation were recognized and considered to be of sufficient areal extent to merit the mapping of structure on these beds.

The generally low relief of this area results in the paucity of outcrops making the stratigraphic section difficult to correlate with other sections of the Tongue River formation. It is sufficient for the purpose of this report to state that lignite beds used in mapping occur high in the Tongue River formation. For detailed descriptions and sections of the Tongue River formation the reader is referred to Report of Investigation No. 11 of the North Dakota Geological Survey, "Geology of West-central McKenzie County, North Dakota" by S. P. Fisher and to a Report of Investigation in preparation, "Structural Geology of the Skaar-Trotters area, McKenzie and Golden Valley Counties, North Dakota" by S. P. Fisher.

The relative stratigraphic position of these 3 lignite beds can be seen from the composite columnar section Fig 1. These lignites have been extensively burned and with few exceptions are presently represented by thin ash beds. The ash beds are conspicuous in as much as they are overlain by sediments baked and disclored as a result of the burning of the lignite below. The predominate color of the baked sediments is a deep red. This baked and discolored sediment, formed by the burning of the lignite is termed clinker. Locally the term "scoria" has been applied to this clinker, but correctly used the term "scoria" applies to rocks of volcanic origin.

The Fryburg and Heart River lignites are described by A. G. Leonard (1925 pp. 140-146). The Heart River lignite varies from 12 to 15 feet in thickness and the Fryburg lignite, 8 to 16 feet thick, lies 50 to 60 feet lower in the section. The Heart River and Fryburg lignites have been mined in the areas where the beds have been spared from burning. A lignite bed, represented by its clinker, occurs 73 feet below the Fryburg bed. This bed below the Fryburg has been designated X in this report. It was used locally for structural mapping in the western edge of the area covered in this report.

### Structure

Plate I is a surface structure map, with a contour interval of 20 feet, of the South Heart—Fryburg area. The Fryburg bed was used as a datum for the purposes of contouring. The Heart River and X beds were lowered or raised respectively according to their stratigraphic interval to the Fryburg bed. Each station is designated by a letter representing the bed found at that station and with the stratigraphic interval used to raise or lower that bed to the datum.

The structure portrayed by this map (Plate I) is essentially a "homocline", dipping more sharply to the east in the western-most portion of the area. The regional dip exhibited in the area is 25 feet per mile eastward. Probably the chief influencing factor controlling this dip is the synclinal area southwest of Dickinson. This is evidenced near the easternmost edge of the area where the beds assume a south-easterly dip.

The predominate structural feature of the area, extending from South Heart to Fryburg, is an eastward trending nose and westward trending synclinal reentrant. This predominate structural feature may be observed on Plate I in the northern half of Townships 139N. Southwest of Zenith is a small dome found in the northwest corner of Township 139N. and Range 98W.

Fisher (1953) states, "That vertical movements accompying the growth of the North American Cordillera affected the plains region in Paleocene time . . . " Dove (1922 p. 247) shows that beds of the Fort Union group reflect the structure of the Nesson anticline in Williams County, North Dakota. This affords evidence that the Laramide structural movement was effective in North Dakota at least until Paleocene time. From this evidence it is reasonable to assume that the surface structure in the Fryburg—South Heart area might possibly reflect the subsurface structure to considerable depths as well.

There was no visible evidence of faulting on the surface in the area of this report. Faulting, however, should be given some consideration and may occur in the subsurface of this area. Benson (1952), Fisher (1953), and others state that surface structure very likely accentuates with depth into the subsurface. In light of this evidence the predominate structural feature exhibited (Plate I), the east-west trending nose and reentrant, may possibly be the result of a fault in the subsurface.

## LITTLE BADLANDS SYNCLINE AREA

The Little Badlands area, southwest of Dickinson, is situated for the most part in Township 138N., Range 97W., with portions extending into the adjacent townships. The area covers nearly 90 square miles.

### Stratigraphy

The very nature of the syncline itself and the surrounding topography presents a difficult problem in stratigraphy. Sufficient stations were unobtainable to tie satisfactorily the Fryburg and Heart River lignites of the preceding area into the Little Badlands area. In view of the circumstances, the two are considered and discussed as separate areas with the exception of generalizations which can be reasonably made.

### White River Formation

Meek and Hayden (1857) used the name White River for sediments found near the mouth of the White River in south central South Dakota. Cope (1884) discovered beds in North Dakota which he assigned to the White River formation. In 1905, Douglas (1908) visited the Little Badlands area southwest of Dickinson, where he described beds belonging to the White River formation.

The Little Badlands area contains the largest deposits of the White River formation known in the state. It undoubtedly once covered a considerable area throughout the state, as is evidenced by its presence in numerous high buttes scattered throughout the southwestern part of North Dakota. The present deposits have escaped destruction by being favorably located in respect to drainage and erosional agents as well as by structural position. Leonard (1922 p. 219) divides the White River formation in the Little Badlands area, into the lower, middle and upper members. These 3 members were recognized in the field and are shown on Fig. I.

The base of the lower member is composed of sands and clay 18 to 42 feet thick, with numerous well rounded pebbles composed of felsite porphyry and other igneous rocks disseminated throughout the sand near the base. Overlying this is a series of claystones, 17 to 34 feet in thickness, separated by clays. This bed has been designated WR for the purposes of this report. At the top of the lower member is a bed of clay 16 to 20 feet thick, which is gray to brown and weathers to light gray. At the surface this clay shrinks and cracks, resulting in a rough shell of weathered material three to four inches thick. This outer shell appears as a jumbled mass of warped clay fragments, adhering one to the other, with the smaller pieces (up to ½" in diameter) slacking off and forming little talus slopes at the base of the exposure. This clay presents a peculiar rounded weathering surface resembling hay stacks. This readily recognizable clay has been designated C in this report.

The middle member is a light to dark tan clay, weathering to pink. Intermittent claystone ledges 1 to 2 feet thick and 6 to 8 feet apart, containing clay gall inclusions, occur throughout the sections. Skulls and other bones of mammals are common in these beds. The most frequently found fossils are those of the Oreodon and the term "Oreodon beds" is sometimes applied to this middle member of the White River formation (Leonard 1922, p. 219).

The upper member is composed of a series of sand, clay, claystones, and siltstones which are predominantly light tan in color. This member was found to be approximately 80 feet thick, however, the top of this member could not be found and the section may well be thicker than that described in this report. This member has largely been removed by erosion in the area and is found only in the higher buttes and ridges.

The Oligocene beds of South Dakota are well noted for their vertebrate faunal assemblage. A list of these fossils has been published by J. R. Macdonald (1951). Several bones were found during the course of the field work for this report; however, they were not of sufficient quality to merit identification. Leonard (1922), in his study of the White River formation of North Dakota, collected a number of skulls, jaws and other bones from the Little Badlands area. These fossils were identified by Mr. J. W. Gidley of the United States National Museum, who found them to be typical White River Oligocene mammals as follows:

*Merycoidodon culbertsoni* (Leidy), skulls and jaws.
*Leptomeryx evansi* Leidy. Portion of skull and lower jaws.
*Caenopus occidentalis* (Leidy). Upper milk molars.
*Hyaenodon horridus* Leidy. Pieces of lower jaw.
*Cynodictus gregarius* Cope. Left lower jaw.

The Oligocene beds rest unconformably on the underlying beds of Eocene age. This unconformity is well shown in places throughout the area studied in this report. In Section 32, Township 139N., Range 97W., the beds of the White River formation channel nearly 20 feet into the Eocene marker bed. In Section 17, Township 138N., Range 98W., the marker bed has been completely removed from the area.

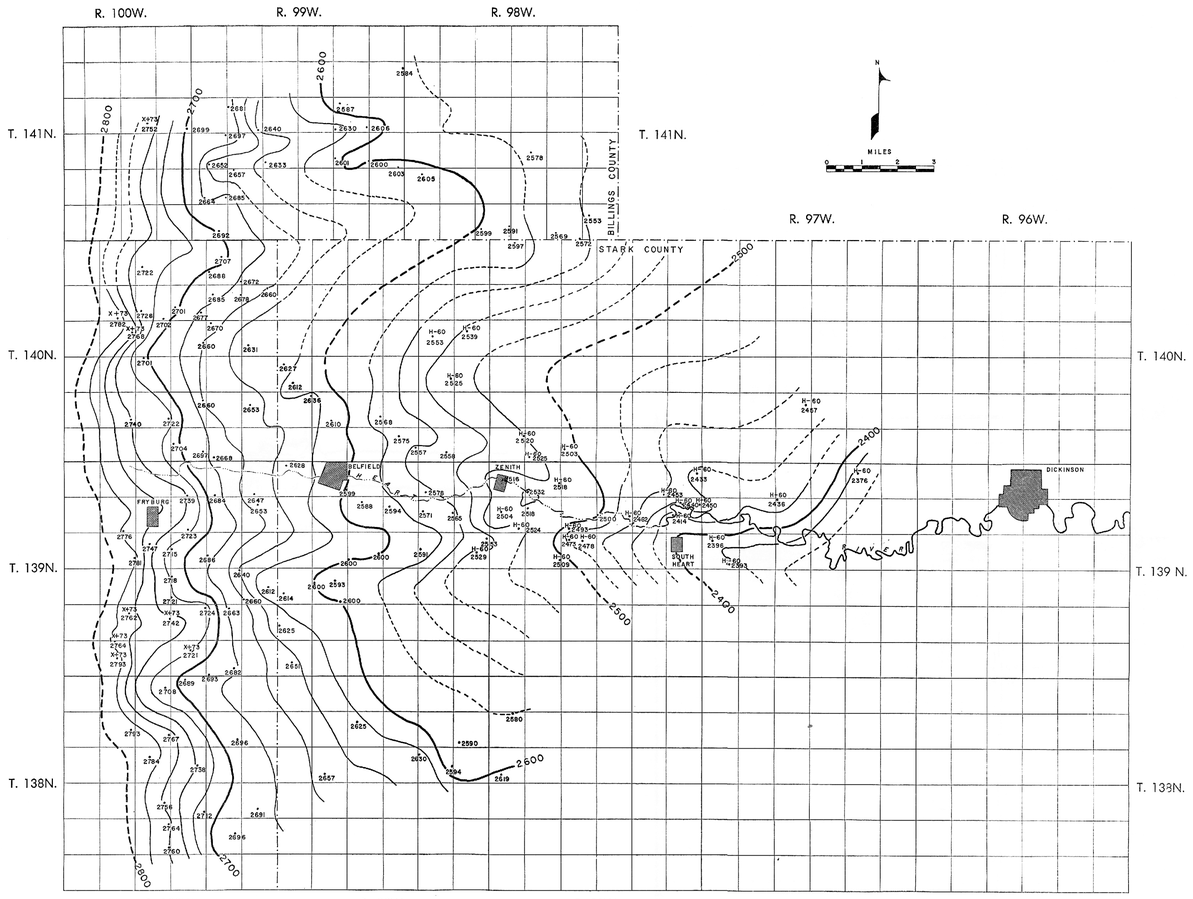



PLATE I

## Golden Valley Formation

The Golden Valley formation was named by Benson and Laird (1947). This formation received its first detailed description by Benson (1952). The reader is referred to this report for a more detailed description of the formation in this and adjoining areas.

Benson (1952), divided the Golden Valley formation into an upper and lower member. This division was easily recognized in the Little Badlands area. However the outcrops are not typical, largely as a result of the unconformity between beds of Eocene and Oligocene age.

The base of the lower member, seldom exposed, consists of pale olive gray shale, sand and purplish brown lignitic shales. The middle unit of the lower member, sometimes referred to as the "marker bed", varies in thickness from 0 to 20 feet. This unit is composed of a white-to very light gray clay which is silty near the top; the upper ½ to ⅓ generally being stained a bright orange color. The top unit of this member consists of 2 to 4 feet of yellowish gray silty clay, overlain by a lignitic zone. This lignitic zone is quite conspicuous and occurs wherever the marker bed is found. Benson (1952) refers to this bed and maps it in the Knife River area as the Alamo Bluff coal bed wherever it is found to be over 2 feet in thickness. It seldom attains this thickness in the Little Badlands area and consists chiefly of a carbonaceous or lignitic shale. This carbonaceous zone, at the top of the lower member, is referred to as the AB bed in this report.

The upper member is for the most part poorly exposed. It consists of clays, silts and two recognizable sandstones. The stratigraphically lower sandstone occurs 11 feet above the AB zone and is referred to as the S bed in this report. The S bed is a 1 to 3 foot thick, hard, cream to pale gray sandstone shiny or quartzitic on exposure, with a yellow spotty stain, carbonaceous spots and stems. The stain is sometimes reddish brown. The carbonaceous stems are usually weathered out leaving an intricate network of tubes.

The upper sandstone bed has been designated BQ and is found 40 feet above the S bed. The BQ bed is a dark brown to dark gray micaceous sandstone containing woody tubes and imprints with a sparkly film of quartz crystals on some surfaces.

The upper member of the Golden Valley formation has been thinned in places as a result of an erosional period at the close of Eocene time, resulting in the unconformity between beds of Eocene and Oligocene age. The northwestern edge of the area, seemingly underwent a greater period of erosion than did the southeastern portion. In section 17 of Township 138 N., Range 98W., the upper member and marker bed of the lower member are missing. Throughout the same area, where the marker bed crops out, the characteristic bright orange stain is not present in the upper ⅓ of the bed. This may be attributed to the bleaching of the beds during a longer interval of exposure.

Benson (1952) collected numerous plant fossils from the Golden Valley formation and these are listed in his report of the Knife River area. The floating fern *Salvinia preauriculata* Berry, is the most diagnostic fossil plant found.

In reference to the fossil Salvinia, Benson (1952) says, "Plants in general evolve less rapidly than animals. As a result most plant species are fairly long ranging and difficult to use in age determinations unless a fairly complete floral assemblage is collected. In the northern Great Plains and Rocky Mountain front region, however, the base of the Eocene (Wasatch) is marked by the sudden appearance of the floating fern, *Salvinia preauriculata* Berry."

The base of the Golden Valley formation is poorly exposed in the Little Badlands area. In the clay pit near the town of Hebron, in northwestern Morton County, the marker bed rests on 4 feet of Harnisch lignite of the Tongue River formation on the west side of the pit. The Harnisch lignite is cut out by the marker bed on the east side of the pit and in both instances the basal unit of the lower member of the Golden Valley formation is absent. In the bluffs formed by the Heart River, southwest of Dickinson, the lower member of the Golden Valley formation is gradational with underlying beds of the Tongue River formation of Paleocene age. Benson (1952) states, "Where the lower member consists chiefly of clay and shale the contact appears to be conformable even gradational." Apparently local channeling at the close of Paleocene, or in early Eocene time, is responsible for the beds being locally unconformable.

A bed termed H in this report occurs locally on the western edge of this area (Plate II). The H bed is a dead white, locally ashy white clay which weathers to rounded "buttresses" with a surface sandy or gritty to the touch. However, it easily crushes to powder with very minor grit. It is topped by 4 to 8 feet of coarse, platy sandstone concretions with rounded bases. Individual plates of sandstone usually taper to a thin edge on one side. These concretions weather to a yellow brown color.

The H bed is tentatively included in the Eocene Golden Valley formation. The lithology of the H bed closely resembles that of the lower Eocene clays, principally the marker bed. It is dissimilar to the lithology of the underlying beds of the Tongue River formation. Seager (1942) in reference to the unnamed member of the Eocene (Golden Valley formation) of western North Dakota writes, "Large, bright yellow, calcareous sandstone concretions not exceeding 6 feet in diameter, imbedded in an ashy matrix, are characteristic of this formation. The concretionary zone is overlain by a bed that appears to contain volcanic ash, and it is in turn overlain by not more than 15 feet of yellow bentonitic clay." The yellow bentonitic clay mentioned by Seager is presumably the marker bed referred to in this report. At Long Butte, Township 137N., Ranges 94 and 95 W., the H bed directly underlies 10 to 20 feet of purplish-stained Eocene clays.

The H bed is found at an interval of approximately 45 feet below the AB bed. It attains a maximum thickness of 40 feet, the base unexposed, in section 36, Township 138N., Range 96W.

## Structure

Plate II is a form line map indicating the relationship of beds and showing the general structure of the area. Form lines are so termed to indicate less control or control less accurate than that demanded of actual structure contours. Several limiting factors necessitated the use of form lines for this area rather than contours. The writer feels that these limiting factors should be enumerated to give the reader more of an understanding regarding the problems involved and the complexity of the area. These limiting factors are: (1) leasing of the beds by virtue of their continental deposition, (2) discontinous outcrops, (3) possibility of unobserved local channelling at the base of the Golden Valley formation, (4) the unconformity at the base of the White River formation and (5) the necessity of using beds of the White River formation, which lie above the unconformity and mask the area in the center of the syncline.

In all, 6 different beds are used in the mapping of this area, and the form line map (Plate II) was constructed by using 6 separate contour maps. Each bed, except BQ, which is widely scattered throughout the area, is situated in a separate locale which made this approach feasible. This widespread distribution of the BQ bed, although there were insufficient stations to merit contouring on it alone, served as a basis for controlling the form lines. Each separate locale was contoured on its own datum. The particular stratigraphic interval between the beds in that area was used to connect the contour lines of one locale to another. The different locales may be seen on the map (Plate II), and are represented by various line symbols. The line symbols indicate as well, that the form lines are controlled by a particular bed represented by the symbol used.

The numbers found on the form lines are relative. They show not actual but relative elevations. The numbers are used merely to enable the reader to visualize more readily the form lines in relationship to one another, and to indicate the generalized structure of the area. As stated above, form lines have been used on Plate II rather than structure contours. In view of this fact, conclusions should not be drawn from the form lines as to closure and strict relationship between structures.

The beds in the region vary from a dip of 5 degrees to less than 20 feet to the mile; however, beds exhibiting a 5 degree dip are unusual and the major portion of beds have an average dip of 20 to 50 feet to the mile.

The major structural feature of this map (Plate II) is a syncline. A minor fold in Township 138N., Ranges 96 and 97 W. is exhibited by the lower elevations read on the WR bed cast and west of the WR bed elevation in section 13 Township 137N., Range 97W. This fold separates the syncline into two portions with the greater structural depression on the west side.

Near the southeastern edge of the map (Plate II) in Township 137N., Range 96W. of Stark County and extending into Hettinger County in Township 136N. and Ranges 96 and 97W., is a broad dome.

The geologic map of the Little Badlands area (Plate III) supports both the syncline and dome mentioned above, as is shown by the outcrop pattern of the formations. The beds of the White River formation in turn are surrounded by beds of Golden Valley and Tongue River formations in the synclinal area, and beds of the Tongue River formation being nearly surrounded by the Golden Valley formation in the area of the dome.

As has been stated previously in this report, the surface structure possibly reflects the structure of the subsurface and the structure may be accentuated with depth.

## ECONOMIC MATERIALS

It is not within the scope of this report to dwell in detail on the various materials of economic importance found within the area studied. This portion of the report is devoted to a brief description and discussion of the materials with a view to giving the reader references which might aid in finding more information on the subject.

Materials of economic importance consist of lignite, "scoria", clay, and oil.

The area of this report was formerly an important lignite producing district, the lignite being produced from beds of the Tongue River formation. There are still considerable reserves of lignite; however, probably due to economic conditions these beds are not presently being mined to any great extent. These lignite beds are mined in small operations, chiefly for private use. Leonard and others (1925) discuss the lignite deposits of North Dakota, the prospects, development and evaluation of lignite lands, a description of the lignite deposits by counties, the character, composition, and utilization of lignites, and a list of the lignite mines in the state.

Clinker, better known locally as "scoria", is used by individuals and local concerns for road metal. When crushed the "scoria" serves as an excellent road material and is plentiful in the Flyburg-South Heart area.

Clapp and Babcock (1906) give a detailed report of clays in North Dakota some undoubtedly belonging to the Golden Valley formation of Eocene age. A recent report by Manz (1953) covers firing and other tests on clays from eighteen areas in west North Dakota. Clays sampled were found to be suitable for stoneware, sewer pipe, and red brick.

In the spring of 1951 North Dakota became an oil state by the discovery of oil in the Amerada Petroleum Corporations No. 1 Clarence Iverson in Williams County, North Dakota. Four wells have been drilled in the area of this report in 1953. These wells are: (1) Plymouth Oil Company No. 1 Fisher located in C, SW, NE, of section 11, Township 137N., Range 98W. (2) Amerada Petroleum Corporation No. 1 May, located in C, NW, NE, of section 9, Township 139N., Range 100W. (3) Amerada Petroleum Corporation No. 1 Logan located in C, SE, SW, of section 4, Township 139 N., Range 100W. (4) Amerada Petroleum Corporation No. 1 Franchuk, located in C, NW, SW, of section 10, Township 139 N., Range 100W.

The Plymouth No. 1 Fisher was abandoned as a dry hole although shows of oil and gas were reported.

Amerada's No. 1 Franchuk is being drilled at the writing of this report, with production expected in the Mission Canyon formation of Mississippian age.

Amerada's No. 1 May and No. 1 Logan are producing wells and production is from the Mission Canyon formation of Mississippian age. Oil was also encountered in Amerada's No. 1 Logan in the Heath sandstone of Mississippian age.

The tops of some of the formations as determined by the North Dakota Geological Survey of the Amerada Petroleum Corporation's No. 1 May are listed as follows:

| FORMATION | DEPTH |
|---|---|
| Pierre | 1922 |
| Niobrara | 4052 |
| Greenhorn | 4642 |
| "Muddy" | 5292 |
| Dakota silt | 5555 |
| Dakota sand | 5594 |
| Jurassic | |
| Morrison | 5922 |
| Sundance | 5987 |
| Piper | 6147 |
| Triassic | |
| Spearfish | 6695 |
| Permian | |
| Minnekahta | 7375 |
| Pennsylvanian | |
| Minnelusa | 7695 |
| Mississippian | |
| Amsden | 7925 |
| Big Snowy | 8240 |
| Kibbey | 8457 |
| Charles | 8710 |
| Mission Canyon | 9403 |
| Lodgepole | 9742 |
| Englewood | 10412 |
| Devonian | 10485 |
| Silurian | 11735 |
| Ordovician | 12140 |

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NORTH DAKOTA GEOLOGICAL SURVEY

WILSON M. LAIRD, State Geologist

# *Surface Structure of Western Stark County and Adjacent Areas of North Dakota*

by
JOHN W. CALDWELL

Report of Investigations No. 14

Grand Forks, North Dakota, 1954