NORTH DAKOTA GEOLOGICAL SURVEY

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Guidebook

for

Geologic Field Trip

in the

BISMARCK-MANDAN AREA, NORTH DAKOTA

by

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Grand Forks, North Dakota, 1957

GEOLOGIC FIELD TRIP IN THE BISMARCK-MANDAN AREA

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INTRODUCTION

Purpose

This guidebook is one of a series prepared specifically for use by Boy Scouts of America during the month of October, 1957, which has been designated "Geology Month in Scouting". This guidebook series provides guides to field tours to points of geological interest around various cities in North Dakota. They will be useful not only to the Boy Scouts but to other individuals who are interested in the geology of the particular area in which they live and to tourists who may be interested in some of the most interesting geological features in the state. These guides cover in a general way the geological processes important in landscape formation in the area. For obvious reasons no extensive discussion of geological principles are included in the reports. Each trip route was chosen because it best and most conveniently portrayed the geologic events of the particular area, and is only one of many that could be taken in that vicinity. After following this logged route it is hoped that the individual will take other similar excursions in the area identifying similar phenomena illustrated by this trip.

The road log included herein is designed to show as many different geologic phenomena as possible within reasonable driving distance of Bismarck and Mandan, especially deposits and events which shaped the landscape in the region southwest of these cities. The trip covers about 125 miles and follows the river road west of the Missouri River to the Cannonball River, thence west on N. D. highway 21 to the Breien area, and thence back to Mandan on N. D. highway 6. In wet weather stops 4 and 5 should be omitted and the alternate trip (see Plate 6), at the end of the first log should be followed.

What is Geology?

The word "geology" is taken from two Greek words which mean literally "earth study". One might ask the reason for this study.

In the first place, everybody should be interested in geology simply because of the fact that it concerns the earth on which we dwell. Therefore, if we are intelligent human beings, we should wish to know as much as we possibly can about the planet on which we live. One of the really interesting things about geology is that it shows man's adaptation to his environment as clearly or more clearly than any other subject available to him.

Secondly, there is also the possibility of interest in geology from the professional standpoint. Geologists are employed by State and Federal Surveys and in teaching as well as by oil and mining companies. Although the profession of geology is not a large one compared to other professions, it is an extremely important one, as it is the geologists who locate for us the basic raw materials on which our civilization rests.

GEOLOGY OF THE AREA

General Statement

The Williston Basin was originally a shallow depression in the igneous and metamorphic rocks of the earth's crust which has been invaded many times by the sea since Cambrian (see Plate 2) time. The North Dakota part of the Williston basin was a plain of igneous and metamorphic rocks with numerous residual hills on it. The early shallow seas, lapping up on to this plain which sloped gently to the west, were supplied with sand and clay by rivers which emptied into them from the area to the north and northeast. These seas deposited many formations (see Plate 3) of great thickness as the shallow basin continued to sink slowly throughout geologic time.

Near the end of the Mesozoic the seas retreated from the basin, and North Dakota has been land and received continental sediments for the last 80,000,000 years except for a brief length of time in the Paleocene. These sediments add up to approximately 15,000 feet in the deepest part of the Williston Basin in North Dakota near Tioga.

Only the formations above the Niobrara are well exposed at the surface in North Dakota. Information on the subsurface formations comes principally from wells drilled for oil since the discovery of oil in the Williston Basin in April, 1951. Study of the strata, their extent, kind of rock, and fossil content constitutes the field of stratigraphy.

STRATIGRAPHY

Fox Hills formation. - In the eastern part of North Dakota the Cretaceous Pierre shale underlies the glacial deposits; but in the area of this trip southwest of Bismarck, the Fox Hills, also of Cretaceous age, is the oldest formation exposed. The Fox Hills formation, then, lies at the bottom of the exposed geologic column in Morton County and will be seen only in the extreme southeast part of the county along the Cannonball River. Here the Fox Hills is about 175 feet thick and is composed of soft, poorly cemented, buff colored sand and sandstone overlain by a banded sandstone and shale sequence. The heavy buff sand at the base becomes cemented by silica deposited from percolating ground waters at certain horizons and stands out as yellow (due to the small amount of iron oxide or limonite present) sandstone ledges. These can be seen along the banks of the river in the lower part of the section at stop 5. There the banded shale and sandstone sequence overlies the heavier ledges below. The Fox Hills sandstone was the last marine Cretaceous (see Plate 3) formation in North Dakota.

Hell Creek formation. - The Hell Creek formation is widely exposed in the bluffs of the Missouri and Cannonball Rivers. Along the Cannonball River and south of Breien in Sioux County, the Hell Creek forms extensive flats and badland areas.

The Hell Creek is about 250 feet thick in this area and consists of several different lithologies or kinds of rock. Mostly it is gray sand with numerous brown to black lignitic shales. This sand and shale, though hard when dry, is easily eroded by the occassional torrential rains of this semi-arid region. Thus, when not protected

by vegetation, the Hell Creek forms rugged buttes with steep sides which are greatly gullied by rivulet erosion (see Plate 5, Fig. 2). Aiding in the forming of steep-sided buttes are the common zones of brownish black, limonitic nodules. These nodules become cemented from the outside in by iron and manganese-bearing ground-water and develop a shiny look. Since they are very resistant to erosion, the zones of nodules frequently cap buttes in this area.

Shaly or clayey zones within the Hell Creek become extremely sticky and slippery when wet. Hence the formation is subject to frequent landslides or slump, (see Plate 4, Fig. 2). South of Huff is a huge area that has slid to its present position some time ago, probably in the Pleistocene or glacial time.

Flats developed on the Hell Creek formation are usually composed of light gray sand and are barren of vegetation. However, two plants are more commonly found on the Hell Creek formation than on other formations in this area; these are the prairie plantain and red mallow.

The Hell Creek formation is almost entirely continental in origin; that is, it was deposited on land by shallow streams meandering across a broad, swampy, alluvial plain. In the marshes (the vegetation of which formed the lignite and lignitic shales) lived the last of the great dinosaurs which became extinct at the end of the Cretaceous. Dinosaur bones are very scarce and very hard to find, however, in this area.

For a very brief time near the close of the Cretaceous and near the beginning of deposition of the Hell Creek formation the sea invaded this area and deposited about 30 feet of gray shaly sand. This is called the Breien member of the Hell Creek formation, and is only a small local deposit. At stop 5 the top six feet of the exposure belongs to the Hell Creek formation; the next 31 feet below are the Breien member of the Hell Creek formation. In this section the Breien member begins above a purplish-brown lignitic shale 37 feet below the top of the bluff. However, it is usually quite difficult to tell the Breien member from the Hell Creek above and below.

Ludlow formation. - The Ludlow formation is also a non-marine or continental formation which is about 20 feet thick in this area where it underlies the Cannonball formation. It is composed of gray shaly sand interbedded with lignitic shales and thin streaks of lignite. Lignite is brownish coal that has formed from the partial decomposition of plants which grew on a marshy plain. During this process the liquids and gases were driven off and only carbon and a small amount of brownish plant material remains in a very much compacted or compressed state. It may be possible to find a few small pieces of recognizable plant fossils in the lignitic shale at stop 4 or stop 7.

Cannonball formation. - The Cannonball formation of Paleocene age (see Plates 2 and 3) represents the last invasion of North Dakota by the sea. After the Cannonball sea retreated from North Dakota about 60,000,000 years ago, the state has been land ever since. The eastern shore of this sea was probably in central Burleigh County while the western shore was in the vicinity of Bowman and New England, North Dakota. In the other direction it ran up into the Prairie Provinces of Canada and presumably south to the Gulf of Mexico. The Cannonball formation has never been identified outside of North Dakota and the adjacent part of South Dakota (see geologic map, Plate 1).

This formation consists of 250 to 300 feet of shales, sands, and sandstone.

The lower part of the formation is composed of thick, dark gray to black, clay shales. It is this thick sequence of dark shale that can be seen along the Heart River west of Mandan and is being used to make light weight aggregate at the Molite plant west of Mandan. The upper part of the formation consists of light gray, tan, or white sand with occassional ledges of hard, yellowish brown, limonitic sandstone. These hard ledges can be seen at stop 8 and are the rock that holds up the flat benches or table-like lands between stops 7 and 8 south of Mandan (see Plate 6).

The Cannonball is a very interesting formation because it was first described along the Cannonball River, because it interfingers along its edges to the west with continental beds of the Ludlow (which here underlies the Cannonball), and because it contains marine fossil gastropod (snail) and pelecypod (clam) shells. These fossils can be found in great abundance in the sands along N. D. highway 6 south of St. Anthony (as at stop 8). It should be noted that the Cannonball River was named for the large round concretions or hard masses, locally called "cannonballs" in the Fox Hills formation, not in the Cannonball formation. Two of these can be seen in the museum parking lot at Fort Lincoln.

Tongue River formation. - The Tongue River formation consists of up to 1000 feet of silty shale, lignitic shale, and lignite in the western part of the state. The North Dakota Badlands along the Little Missouri River are mostly in this formation.

In this area we will see the Tongue River only in the distance where buttes are capped by occassional hard sandstones of this formation. There are abundant shiny pebbles of this hard, tan sandstones in part of the area however (stop 5). This sandstone, common around Flasher and Carson, is so hard that it resembles the metamorphic rock, quartzite, and is hence called quartzitic sandstone or orthoquartzite.

Fort Union group. - The Paleocene formations, namely the Ludlow, its marine phase, the Cannonball, and the Tongue River are often spoken of together as the Fort Union group.

GLACIAL GEOLOGY

During Pleistocene time (see Plate 2) continental glaciers, such as are found only on Greenland and Antarctica today, advanced over much of North Dakota. Only the southwestern part of the state was not covered by the ice (see inset map, Plate 1).

The latest invasion of the glacier advanced little beyond a prominent north-south escarpment in central North Dakota known as the Coteau du Missouri. When the glacier overrode this escarpment it lost its force and dropped great quantities of glacial sand and gravel in a sweeping arc across the state forming a zone of hills known as the Max or "Altamont" moraine (see inset map, Plate 1).

An earlier glacier had advanced beyond this arc, however, and deposited its load in the area of this strip. However the ice edge was very thin here and left only thin deposits. The glacial deposits in this area are of three kinds: erratic boulders, thin till, and outwash.

Glacial boulders (rocks more than 10 inches in diameter) are called erratics when they are not of local rocks. Since the local formations are mostly soft, the rocks were quickly ground up by glacial action. Much of the glacial material is rocks which are very hard and are igneous or metamorphic rocks which have been transported by the glacier to this region from Canada. Hence these are "foreigners" called erratics.

Till is a stiff, tough clay full of rocks up to boulder size which has been dropped by the glacier. Till is unsorted and unstratified (that is, not bedded or layered).

Glacial outwash, on the other hand, is fairly well sorted as to size of material and is deposited in beds or layers. Thus glacial outwash gravel may occur in one place and outwash sand in another, but they are rarely mixed evenly all together as is till.

Erratic boulders stud the fields in some areas and thin deposits of till are found in some places (as at stop 4). However these deposits are never as thick as in the region north and east of Bismarck.

The trip crosses Cantepeta Creek which was a large preglacial stream entering the Cannonball River near Solen. Thus as the glacial ice melted, this stream carried vast amounts of meltwater. Consequently, outwash deposits are common along the sides of this old valley especially in the lower part.

PHYSIOGRAPHY

Physiography is the study of land forms and their development. This trip lies entirely within the Glaciated Missouri Plateau Section of the Great Plains Province. However, there are a number of smaller features which are worthy of note.

The first of these is the Missouri River and its present flood plain. If it is low water when we cross the Missouri River bridge you will be able to see the many sandbars which choke the bottom in low water stage. The broad, shallow Missouri with its broad flood plain is typical of a mature stream. A mature stream is one which by its meandering has cut a wide flat valley in contrast to a youthful stream which flows in a more or less V shaped valley. The Missouri River actually changes its winding course quite often. An example of this is Fort Lincoln which has been reduced from about 800 acres in 1934 to about 500 acres in 1957. During this time the river has changed course several times (during flood stage), so that land that belonged to the State Park now belongs to the State Penitentiary grounds east of the river.

In Pleistocene times the major streams in this area carried much melt-water from the glacier and were also flowing at a higher level. As they did this, they deposited sand and gravel along their bottom just as the Missouri does today. Since then they have cut to lower levels and left gravel terraces at high levels along the valley. Such terraces can be seen in Bismarck just before crossing the Missouri River bridge and west of the river between Fort Lincoln and Fort Rice where the road follows along a terrace for many miles. This terrace gravel is valuable for construction and road surfacing.

A different kind of terrace can be seen in the Solen area along the Cannonball River. Here the river, when it flowed at a higher level has not deposited material but has cut a wide valley in bedrock of several formations. Since it has now cut downward again, it has left level benches or terraces along the sides which are called strath terraces.

South of Breien we will enter (stop 6) the northern part of a small badlands area developed on the Hell Creek formation. Badlands, from the words of the early French explorers, mauvais terres, meaning literally bad lands, are formed in semi-arid climate when occassional very heavy rains erode poorly cemented or consolidated formations. These badlands are not so extensive nor are "bad" as those along the Little Missouri River; but you can see that the steep buttes, narrow ravines, and sharp crests and pinnacles offerred a great obstacle to travel across the area in pioneer days.

This semi-arid area, almost devoid of vegetation, is in direct contrast to the grass and farmlands of the upland north of Breien. Here the striking feature is the several extensive levels formed on resistant sandstones in the Cannonball formation. Most conspicuous of these is the upland, or No. 3 Cannonball bench, and the sub-upland, or No. 2 Cannonball bench. Watch for these levels as we proceed north on N. D. highway 6 from the Cannonball River. The preglacial valley of Cantapeta Creek cuts deeply into the upland southeast of St. Anthony toward Solen however.

Although the area of this trip was glaciated, the till and outwash were so thin that, unlike most of North Dakota, the land forms were little affected by glaciation.

ECONOMIC GEOLOGY

Useful for building purposes are the glacial erratics and some of the sandstones of the Fox Hills formation. This can be well seen at the museum at Fort Lincoln. The sand and gravel of the terraces is used in concrete aggregate and for road gravel. Locally a few of the lignites in the Ludlow have been mined, but they are so thin that it is not profitable. North of Bismarck, however, lignite in the Tongue River formation is profitably mined.

Of unusual interest in this area is the Molite, Inc. light weight concrete aggregate plant west of Mandan. This is made by expanding or bloating shale in a rotary kiln at high temperatures. Concrete made with this aggregate has a weight of 60 to 100 lbs. per cubic foot as compared with 150 lbs. per cubic foot for concrete made with sand and gravel.

Man must always be aware of the geological conditions which would cause landslide which would damage his property, the nature of sands and sandstones which might bear water, and the underlying rocks from which his soil comes. You will see several different soils developed on different rocks; note which are the best and most productive. The Northern Great Plains Field Station of the Soil Conservation Service southwest of Mandan is continually testing the soil and experimenting with various plants adapted to this region.

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Publications on the geology of North Dakota are available from the North Dakota Geological Survey, Campus Station, Grand Forks. A list of these publications and their price is available on request.

Topographic maps of certain areas in North Dakota are available from the U.S. Geological Survey, Denver Federal Center, Denver, Colorado. A map index to the areas mapped is available from this address on request.

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0.00

Start 6th and Thayer Sts. Facing south on 6th St. (U.S. highway 83).

.15

Turn right (west) on U. S. 10 (Main Ave.).

.35

Camp Hancock Historic Site Museum.

.45

Northern Pacific underpass. Between here and bridge over the Missouri River you are driving on a terrace of the Missouri. Downtown Bismarck is located on such a terrace although the Capitol Building is built on the Cannonball formation.

1.20

Morton County line (center of bridge). Look north to railroad embankment cut into dark shale of the Cannonball formation just southeast of railroad bridge. Excellent gypsum crystals and reddish-brown sandstone concretions and marcasite nodules can be collected in these high railroad cuts. The Cannonball formation is well exposed to the north along the river road to the Double Ditch Indian Village. Along the way the Tongue River formation caps the top of the hills.

1.15

Jerry's Supper Club north of highway. Here the highway is on the broad flood plain of the Heart and Missouri Rivers. Bad floods as have occurred in the past will now largely be controlled by Garrison Dam on the Missouri to the north and Heart Butte Dam on the Heart River south of Glen Ullin, as well as the dike around the city of Mandan. Bluffs to southwest and Crying Woman Hill, the high hill north of Mandan, are of Cannonball shales and sandstone.

1.75

Flood gate of Missouri River dike.

.20

Underpass.

.45

Turn left (south) on 6th St. toward Fort Abraham Lincoln State Park.

.05

Underpass.

.65

Bridge over Heart River.

.10

Pit in sand and silt deposited by Heart River when it flowed at much higher stage during the Pleistocene or ice age. Well preserved snail shells have been collected from the sand at the south end of this pit.

.95

On hill to west note boulders (erratics) of granite and other igneous rocks brought from Canada by the glaciers and left here when the glacier melted. You will see many more such boulders during the trip. Glacial deposits indicate that the glaciers covered this region in the past (more than 10,000 years ago). The road here is on a poorly defined terrace of the glacial Heart and Missouri Rivers.

.60

On the west side of the road is a small cut in Cannonball shale with a few discontinuous sandstone ledges showing on the west side of the road. The Heart River meanders in a wide bend very close to the bluff just below.

.20

Entering Fort Abraham Lincoln State Park. Cannonball shale west of road.

.30

Turn right (west) on road to Old Fort McKeen.

.40

STOP 1. Blockhouse of Fort McKeen. Fort McKeen was established in 1872 as infantry post for protection of workers on the Northern Pacific railroad, but was no longer needed when Fort Abraham Lincoln was founded as a cavalry post. The foundations in the fort area are original foundations of the post buildings. The present block houses are restorations of the original blockhouses.

View from top of blockhouse: - Looking east the river in the foreground is the Heart River; it makes a big bend to join the Missouri to the southeast. The bluffs on the east side of the Missouri River to the southeast are composed of continental shales and sandstones of the Hell Creek formation. Those west of the river are of Hell Creek and the marine sands of the Cannonball formation.

The upland surface in the foreground to the south is held up by more resistant sandstone beds in the Cannonball formation. This is typical Missouri Plateau country, glaciated, yet little affected by the glaciers. The high buttes to the southwest are capped by the Tongue River formation as is Little Heart Butte, the lone conical butte almost due south of Ft. McKeen. High buttes on horizon to northwest are also capped by Tongue River sandstone.

North of Fort McKeen beyond Mandan can be seen the towers of the Mandan Refinery of the Standard Oil Company which processes North Dakota oil piped from the oil fields in the northwestern part of the state. Leave parking lot and proceed downhill.

.40

Turn right (south) toward Fort Abraham Lincoln.

.20

Turn left into Museum parking lot. Note the large sandstone concretions "cannonballs" which came from the Fox Hills formation to the south and from which the Cannonball River got its name. The Cannonball formation was named from the river.

.10

STOP 2. Museum building. The Museum is built of stones cut and shaped from granite boulders collected within seven miles of the park. The flagstones are Cannonball and Fox Hills sandstone collected from somewhat greater distances. The restorations and buildings of the park were built in 1934 by CCC labor under the direction of the State Historical Society. At one time about 800 acres was included in the park property; but the Missouri River has changed course, and now only about 500 acres remain within the park.

Ft. Abraham Lincoln was established by President Grant in 1873 as a cavalry post to answer an ever-growing demand and need for mounted troops to cope with the Indians. The fort was the base of the Seventh U. S. Cavalry and the starting place for General George A. Custer's 1874 expedition with Dr. H. N. Winchell, Geologist, to investigate the report of gold in the Black Hills.

The ill-fated Custer expedition in which 264 men and Gen. Custer were killed at the battle of the Little Big Horn River in Wyoming also left from Fort Lincoln. The two-mile column of 1200 men, 1700 animals and 150 wagons which left May 17, 1876, wound its way over the hills up the draw at the northwest corner of the fort. Following Custer's defeat, the post continued its function of protecting the railroad workers (Northern Pacific completed in 1883) but was finally abandoned in 1891. Local settlers destroyed the buildings within a few years and removed the lumber to build houses and other buildings on the frontier. The original flagstaff and the foundations of the fort buildings are to be seen south of the Museum.

North of the Museum building are re-constructed lodges of the Slant Indian Village which was occupied by Mandan Indians from about 1650 to 1750. Sites for 75 earth lodges have been found; smallpox had decimated the population so that the village was in ruins when the Lewis and Clark expedition moved up the river (See Plate 5, Fig. 1).

.10

Leave the parking lot, turn left, and drive slowly to the right around Ft. Abraham Lincoln parade ground. General (then Lt. Colonel) Custer's house was the center one of seven west of road opposite the flagstaff.

.80

Turn right (south) on river road at southeast corner of the fort. You are traveling across Recent alluvial gravels of a small tributary creek entering the Missouri from the west.

1.10

Road goes up onto Pleistocene gravel terrace. Except where cut by the Little Heart River the road runs on this terrace for the next eleven miles and in a few places on the terrace after that.

3.50

Exposure of the Hell Creek formation to the west.

.55

Bridge over Little Heart River.

.75

Gravel pit east of road. Gravel is removed from pits in the terrace for road surfacing and construction purposes.

1.00

Schmidt station. Note the terrace gravels exposed to east and the level surface of the terrace ahead. Yet note that the terrace surface slopes slightly upward to the foot of the bluffs of the Hell Creek formation where material was brought down the bluffs by small streams and gullies tributary to the Missouri when the river ran at this level in Pleistocene times.

1.30

The two isolated buttes east of river in Burleigh County are called Twin Buttes and are in the Hell Creek formation.

1.85

Opposite Sugarloaf Butte, an isolated hill similar to Twin Buttes, in Hell Creek shales and sandstones. All of the buttes ahead and to the west are in the Hell Creek formation. Note in Sugarloaf Butte, and in those ahead, that many of the beds seem to slant or dip downward toward the one below. This feature is called cross-bedding by geologists and is especially common in continental deposits (deposits laid down on land) such as the Hell Creek and the Tongue River formations.

The streams which spread these deposits on the land surface have alternately scoured the underlying deposits and then filled the scour with similar fine sands. This can be observed in the ever-shifting pattern of the sand bars in the Missouri River (or any other large stream) today. In this manner the Missouri scoured its west bank to remove material from Fort Lincoln State Park and deposit sand on the east side on land that belongs to the State Penitentiary. So in the geologic past, rivers have changed their courses leaving scour-and-fill which we observe as cross-bedding.

Try to trace the more resistant sandstone ledges with your eye and note that they are very local, rarely extending more than a few feet. This is typical of continental deposits while some marine deposits carry unvaryingly for long distances. Darker streaks in the formation are usually more clayey or shaly zones, and the light gray zones are purer, cleaner sand.

Note that patches of Hell Creek appear by the roadside peeking through a very thin veneer of gravel or sand cover. Southward as the bluffs are approached the road runs on Hell Creek formation rather than a gravel terrace.

2.45

STOP 3. Outcrop of Hell Creek. Just above the road level in the fine gray sand is a zone of coarser sandstone which is stained reddish brown by the concentration of iron oxide (limonite $Fe_2O_3 \cdot 2H_2O$) and manganese minerals which have cemented it to hard rock. Although this and similar thin zones bear more iron than the rest of the formation, iron is not present in commercial quantities, although the pebbles look quite like iron ore.

The gray color and the "grooved" appearance caused by erosion by rain water are characteristics of the Hell Creek formation (see Plate 5, Fig. 2).

2.00

Huff station. Turn right (west) at corner just south of station. OMIT THIS STOP IF MUDDY.

1.20

Hell Creek-Ludlow contact. Contact is a lignitic shale zone in road about 30 feet north of corner.

.10

Sandstone ledge in Cannonball formation.

.10

STOP 4. Park cars at top of hill and walk back down to bend in road.

This stop is one of the few accessible places this far east where it is possible to see the lignitic continental shales of the Ludlow formation between Cretaceous (Mesozoic era) Hell Creek formation and the marine beds of the Paleocene (Cenozoic era). Farther west, in the Badlands for instance, the Ludlow becomes very thick and bears thick lignites. Between the Missouri River and these continental beds of the western part of the state the last interior sea deposited the Cannonball formation which grades laterally westward into the Ludlow, its land phase. Here, however, the Ludlow comes down the stratigraphic column to lie below the Cannonball sand and shales. This is about as far eastward as the Ludlow is present, there being only a few feet in Emmons County in a similar position.

At this locality there are 18 feet of brown lignitic shales, thin lignites, and brownish sands of the Ludlow above the greyer Hell Creek sands and clay below. The upper unit of the Hell Creek is 17 feet of bentonitic clay shale. Eight inches of black lignite about 5 1/2 feet above the base of the Ludlow can be dug from the bank east of the road at, or just north of the bend. About four feet higher is 4 feet of distinctive brown lignitic shale in the bank at the bend in the road. The Cannonball begins in the interval now covered about two feet higher in the section.

The Cannonball extends to the top of the hill where it is overlain by glacial till. Much better exposures of the Cannonball will

be seen later in the trip; the principal interest here is seeing the Ludlow near its easternmost exposure.
The clear crystals that may be found are gypsum ($CaSO_4.2H_2O$) and are soft and may be scratched with the fingernail. The bright brassy mineral is pyrite (FeS_2) or "fool's gold". Both of these occur commonly in shales.
Turn around and descend hill to Huff.

1.30

Turn right (south).

1.10

Road over hill to west. Look to southwest and notice the mass of shale detached and standing free in front of the bluff. This is one of the biggest, if not the biggest, landslides in North Dakota (see Plate 5, Fig. 3).

.90

Opposite main landslide mass. Drive slowly.
A landslide can be told by the local irregular hummocky topography and unusual slope of the top of the slid mass. Also compare the level of the light grey sand in the Hell Creek with this same grey sand on the prominent hill near the road northwest of the landslide. Can you see that in the slide this sand is lower?
Similar, but smaller and older (because they are grassed over), slides occur for some miles south of here but none reaches the size of this area. These slides are caused by the bentonitic clay beds within the Hell Creek becoming wet and slippery; clay will not pass water but will absorb it and become plastic.

2.40

The high, level buttes east of the river in Emmons County are of Hell Creek capped by Cannonball.

2.30

Road to west over hill. IF MUDDY take this road to St. Anthony as shown on alternate route given at end of this trip. Continue south on main route.

1.50

Road east to present village of Ft. Rice.

1.10

Opposite site of old Ft. Rice .3 mile to east.
Fort Rice was established by Gen. Sully in 1864 and abandoned in 1878 after Ft. Abraham Lincoln and Ft. Yates were established in 1873 and 1877, respectively, making Ft. Rice no longer needed. Plans on board and signs by foundations identify the original structures; block houses have been reconstructed.

.35

Narrow bridge.

.65

Road turns west across subdued hills of Hell Creek. Note the difference in vegetation supported by this part of the Hell Creek and the rich land on glacial outwash which we have been following and the grasslands supported by the Cannonball to be seen later in the trip.

1.30

Road turns south.

3.55

Small wooden bridge over creek.

.85

Top of hill. Dissected land ahead is Cannonball River and its tributaries cut into Fox Hills sandstone.

.50

Small wooden bridge.

.20

Road turns southwest.

.30

Sand and brown sandstone of Fox Hills by road.

.10

Take right fork of road at bottom of hill. Winding road ahead along Cantepeta Creek, a tributary of the Cannonball River.

.10

Stream laid gravel in road bank north of road.

.85

White wooden bridge over Cantepeta Creek.

1.80

Road turns west.
Fox Hills sandstone on north bank of creek. Broader level valley of Cantepeta Creek seen west of two wooden bridges over the meandering creek. Cantepeta Creek was a preglacial stream and carried much more water in Pleistocene times when the glaciers melted. In some places this formed a wide valley with fairly well developed terraces formed as the stream now cuts into its former valley.

1.20

Small wooden bridge. Back up on to Hell Creek.

.25

Take right fork in road.

1.40

Turn left (south).

2.15

Turn right (west).

3.15

Turn left (south) on main road to Solen.

1.10

Turn left (east) at cemetery.
OMIT IF MUDDY.

2.65

Turn left (north) at entrance to farm.

.25

STOP 5. Stop at top of hill where road straightens out along fence. Climb through fence and walk northeast to brow of hill facing high exposure beyond small valley. The lower two-thirds of the bluff and the banks of the Cannonball River to the southeast is all Fox Hills. Note that the harder yellow sandstone of

the lower part of the Fox Hills formation makes a conspicuous level bench (technically a strath terrace) into which the river is cut to the east, south, and southwest.
The contact between the Fox Hills and the Hell Creek is about two-thirds up the bluff at the bottom of the darker band below the conspicuous lighter grey cross-bedded sand. The base of the Breien member of the Hell Creek lies at the top of the purplish-brown shale above this lower part of the Hell Creek. The Breien member extends to within six feet of the top of the cliff. The upper six feet is again Hell Creek formation. The Breien is a relatively local marine member near the base of the Hell Creek non-marine beds and is thus the youngest marine deposit of the Mesozoic era. Its greatest thickness, 31 feet, is shown in this exposure (see Plate 5, Fig. 4).
The hills and buttes to the southwest and north are of Hell Creek formation. Farther west beyond the towns of Solen (town to west-southwest) and Breien is the type area of the Cannonball formation along the banks of the Cannonball River. Beyond this, the high buttes on the western horizon are capped by the Tongue River formation of Paleocene age.
On the surface of the ground notice cobbles and boulders of many different kinds of rocks. Some of these are fragments of iron-stained sandstone from the Hell Creek formation and common tannish orange quartzitic sandstone which is very hard and resistant from the Tongue River. It is this hard quartzitic sandstone which caps the buttes of Tongue River to the west. Others of these are definitely erratics or foreign to this region and are of granite and other igneous rocks brought to this area from Canada by the glaciers.
Turn around and retrace route to cemetery on the Solen road.

2.95

Turn left (south) at cemetery toward Solen. Be careful on curve in road.

.80

Bridge over Cannonball River.
Entering Solen. Continue straight ahead one block past stop sign. Turn left (east) one block then right (south) across railroad tracks.

.45

Turn right (west) on N. D. highway 21.

.70

Hill of Hell Creek to south.

.10

Hell Creek cuts on both sides of road.

1.80

Green house north of road belonged to Joseph Crowghost, Pvt., U. S. Indian Scouts. The house, built in 1910, was moved in spring of 1957 from original site about two miles west, to its present location by Crowghost's grandson, who now occupies it.

.90

Entrance to drive around hills and across fields to Crowghost cemetery. Driving with care it is possible to make this interesting trip, but it is impractical with a caravan or busses.

.30

Directly south of Crowghost cemetery below butte of Hell Creek. In this cemetery are buried the U. S. Indian Scouts, Crowghost and Ironhorse and others including Walter Two Bulls and his wife, Anna Hairychin, parents of Crowghost.
In the arroyo west of the cemetery is an excellent section extending from the Fox Hills up into the Hell Creek and including the type section of the Breien member of the Hell Creek. At this locality, basal, brown, lignitic shale of the Hell Creek is channeled into light gray sandstone and makes a very sharp, easily recognizable contact.

.80

Rolling hills and buttes (on horizon) all of Hell Creek.

2.55

Turn south on N. D. highway 6.

.35

Butte of Hell Creek east of road. Note cross-bedding at south end of this butte.

2.70

STOP only long enough to take picture. Do not leave cars. High buttes ahead are of Hell Creek probably capped with yellow Cannonball sandstone. They are about 90 feet high.

.80

STOP 6. Opposite small butte east of road.
This stop well shows the cross-bedding in the Hell Creek formation. The abundant dark purplish-brown shiny rocks are concretions of iron and manganese oxides such as we saw earlier.
Hit or kick the sand of the butte. Note how hard it is. It is this feature which allows it to stand in the sheer cliffs with the badland-like appearance so characteristic of the Hell Creek. Yet when it is wet it is relatively easily eroded by hard rains. This causes the gullying common in the Hell Creek.
Turn around at next small crossroads and retrace route toward N. D. highway 21.

4.20

Junction of N. D. highway 6 with N. D. highway 21 from east. Continue north on N. D. highway 6.
Look to northeast. Volcanic ash in Fox Hills sandstone behind church.

.35

Bridge over Cannonball River.

.25

Bridge.

.20

Road to Breien.

.05

Railroad tracks.

4.35

STOP 7. Road cut showing both top and bottom of the Ludlow formation.
Hell Creek - Ludlow contact at south end of small cut east of road. There is 26.7 feet of Ludlow here. The Ludlow-Cannonball contact is at top of cut.

.30

Road cut in Cannonball formation.

.70

Driving up onto what has been called the number one Cannonball bench; also seen in the low hills ahead. The number two, or upland, Cannonball bench is at top of high hill ahead. These benches or level places in the topography are caused by levels of more resistant sandstone in the Cannonball formation. The interval between them seems quite consistent and has been used for mapping the geologic structure of the region.

.70

Cut east of road in sandstone which holds up the second Cannonball bench.

.30

Top of cut; up onto second Cannonball bench. Tiny fossil snails have been found in the nodular limestone seen at top of cut. While this guide was being prepared a 3 foot log 7 inches in diameter of petrified wood which had been bored by shipworms (which are really small clams) was found. It was apparently driftwood in the Cannonball sea.

.50

Turn right (east) on N. D. highway 6. N. D. highway 21 turns west toward Flasher.

.80

Highway curves north.

2.60

Cuts east of highway in Cannonball shaly sand.

1.20

Cannonball sand in ditch west of road.

.80

Cannonball sand cuts and sand blowout.

1.20

Entering alluvial valley of South Branch of Little Heart River. Hills ahead in Cannonball.

1.20

STOP 8. Pull well off the road. Look at the cuts on both sides of the road, but be CAREFUL OF TRAFFIC.
Note the hard sandstone zone which holds up the upland (see Plate 5, Fig. 5). The grey Cannonball sand is covered by chips of hard limonitic sandstone which have weathered out of the sand. On the east side of the road Halymenites is fairly abundant.

The true interpretation of this fossil is in doubt. Note that it commonly branches; this has led some to contend that it is the cast of a seaweed. Other paleontologists interpret it as the burrow of a marine animal which has been filled with sand. White shells of fossil marine clams and snails can be found on the surface of the sand. When they are found partly buried in the sand they are damp and extremely fragile and almost impossible to remove whole. When dry they become quite hard; you should wrap them in tissue to prevent their rubbing together on the return trip.

1.90

Cannonball cut. Little Heart Butte to northeast is held up by the Tongue River formation as are the buttes to the west. Ahead is the preglacial valley of Cantepeta Creek which we crossed on its lower end.

1.90

Road to St. Anthony to west.

1.20

Little Heart Butte to east. The Cannonball-Tongue River contact is near the base of the butte but is mostly covered.

12.90

Northern Great Plains Field Station, Soil Conservation Service. East of road is a poor exposure of Cannonball with glacial drift at top.

.10

Bridge over Heart River.

.55

Road turns east.

.10

Approach of Northern Pacific Railroad overpass.

.15

Junction with U. S. highway 10. Turn left (west).

.50

Bridge over Heart River.
Look to north to dark shale bluffs of the lower Cannonball formation. The apparent dip of beds is caused by slump. You are driving on the flood plain of the Heart River.

.70

Opposite Molite, Inc. lightweight aggregate plant (see Plate 5, Fig. 6). This aggregate is made by roasting the dark shales of the Cannonball formation to make pellets of baked clay. This is used in making concrete wherever light weight is necessary.

2.5

Bridge over Heart River.
Cannonball bluffs ahead.

.65

Drive slowly. This is a landslide area which is ruining U. S. highway 10 and threatening the railroad below. What features that you have seen are causing this landslide?

.45

Turn around and return to Bismarck.
END OF LOG.

ALTERNATE (WET WEATHER) TRIP

Follow preceding road log to gravel road 6.7 miles south of Huff. Turn right (west) on this road and proceed to St. Anthony. Follow N. D. highway 6 south to Stop 6 and then pick up on the regular trip.

Huff.

6.70

Turn right (west).

.50

Lignitic shale of Hell Creek formation in the road ditch.

1.00

Road turns south around butte of Hell Creek formation capped by Ludlow (?).

.20

Slow over wood bridge over Rice Creek.

2.40

The road is now on the Ludlow formation, but its contact with the Hell Creek is not visible.

.60

Road here on Cannonball formation, but the contact with the Ludlow is covered.

.30

Off of Cannonball formation back onto Ludlow.

.40

Road turns west. Off Ludlow back down onto Hell Creek formation.

.55

Bridge. Hill of Cannonball formation to west.

.55

Up onto Ludlow formation. The Hell Creek formation is visible in valley to the west near farm.

.90

Crossroads. Here the road goes off the Ludlow and up onto the Cannonball formation. The road runs on the Cannonball from here to St. Anthony.

5.20

Road turns north. High buttes northeast of road are capped by the Tongue River formation. To the northwest is Little Heart Butte. The Cannonball-Tongue River contact is low down on the slope but is mostly covered.

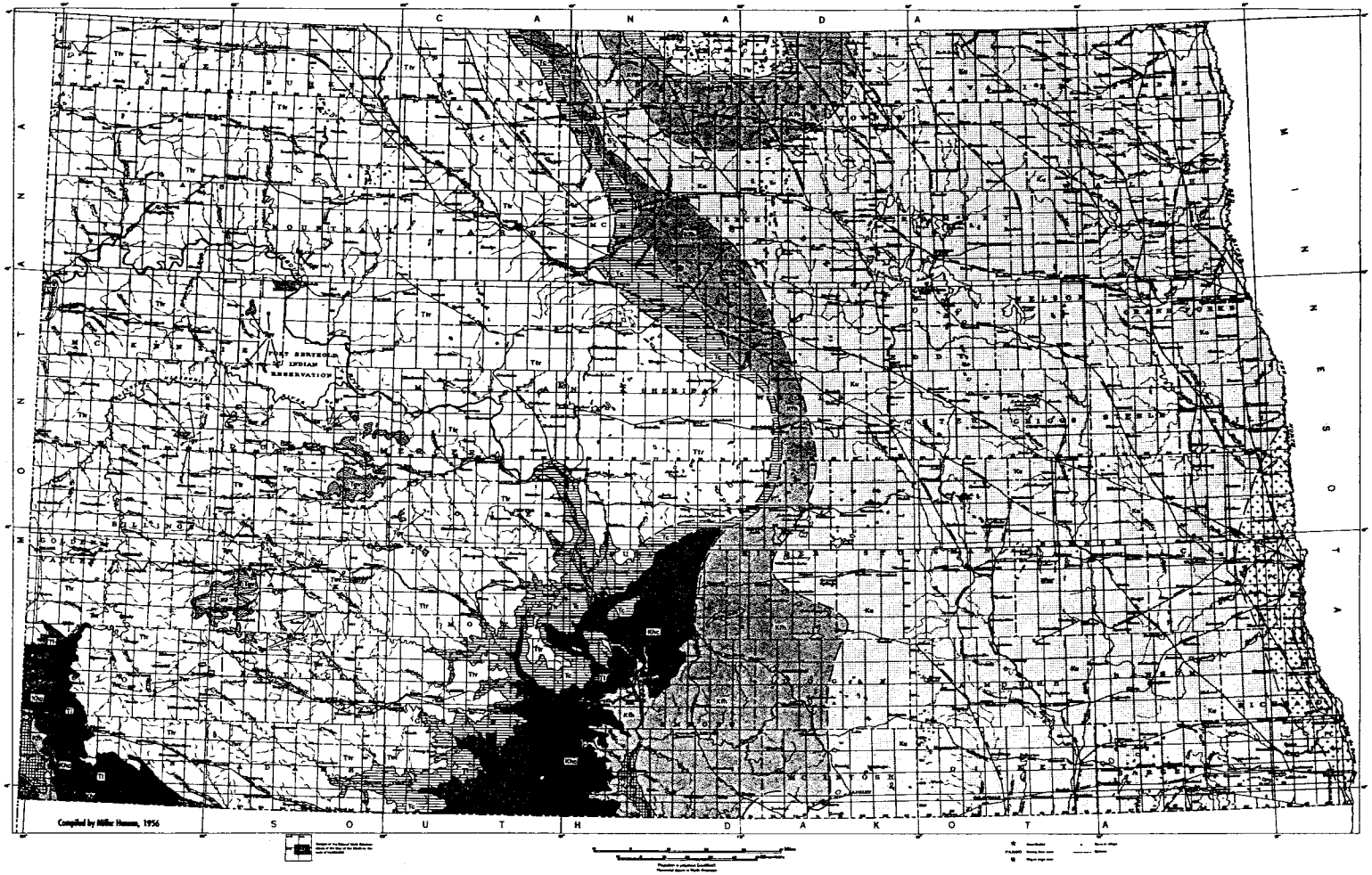
6.20

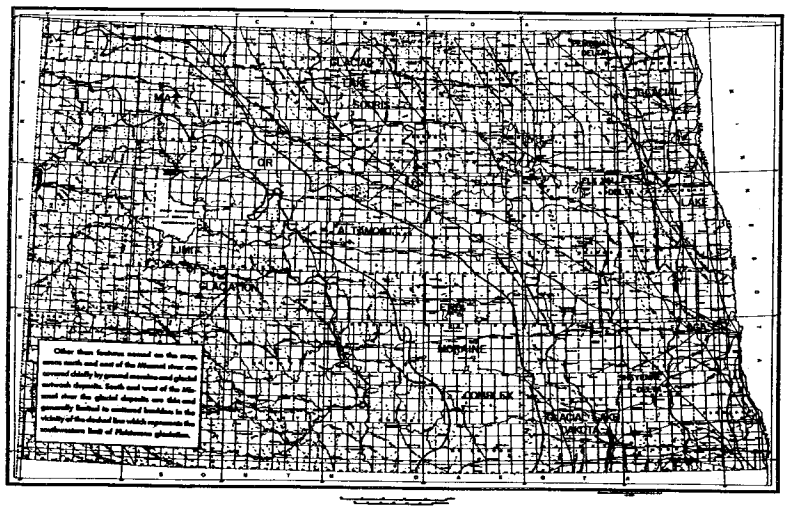
Turn left (south) on N. D. highway 6 and proceed to point where N. D. highway 21 leaves N. D. highway 6 to go east to Solen. Pick up regular road log at this point (see Plate 6), and proceed to Stop 6.

NORTH DAKOTA GEOLOGICAL SURVEY

GEOLOGIC MAP OF NORTH DAKOTA

WILSON M. LAIRD, State Geologist





MAJOR GLACIAL FEATURES OF NORTH DAKOTA

Sources of Data

All Cretaceous and Tertiary contacts in the northwestern part of the state are taken by permission of the Director, U. S. Geological Survey from an unpublished bedrock map of northwestern North Dakota by Richard W. Lemke, Geologist, U. S. Geological Survey. The area mapped by Mr. Lemke lies north of 47°30'00" north latitude and is bounded approximately on the east side by the 100°00'00" west longitude line.

The south-central and southwestern portions of the map have been prepared from the same sources listed on the North Dakota Geological Survey "Preliminary Geologic Map of North Dakota", published in 1952. Additional information has been obtained from well logs and North Dakota Ground Water Studies.

As new information becomes available, all inferred contacts will be extensively refined.

LEGEND

Twr	White River	Oligocene
Tgv	Golden Valley	Eocene
Ttr	Tongue River	Paleocene
Tc	Cannonball	
Tl	Ludlow	
Khc	Hell Creek	Cretaceous
Kfh	Fox Hills	
Kp	Pierre	
Ku	Chiefly Pierre, includes Colorado and Dakota groups.	
P€	Igneous and metamorphic rocks	Pre-Cambrian

Known contacts

Inferred contacts

TABLE OF GEOLOGIC TIME

Time Units	Years ago	Approximate Duration of time	Approximate Percentage of Total time
Phanerozoic Eon	(to beginning)		
CENOZOIC ERA			
Tertiary Period			
Recent Epoch	11,000		
Pleistocene Epoch	1,000,000		
Pliocene Epoch	12,000,000	11,000,000	
Miocene Epoch	25,000,000	13,000,000	
Oligocene Epoch	35,000,000	10,000,000	70,000,000 ≠ 2%
Eocene Epoch	60,000,000	25,000,000	
Paleocene Epoch	70,000,000	10,000,000	
MESOZOIC ERA			
Cretaceous Period	130,000,000	60,000,000	
Jurassic Period	165,000,000	35,000,000	130,000,000 ≠ 3%
Triassic Period	200,000,000	35,000,000	
PALEOZOIC ERA			
Permian Period	235,000,000	35,000,000	
Pennsylvanian Period	260,000,000	25,000,000	
Mississippian Period	285,000,000	25,000,000	
Devonian Period	325,000,000	40,000,000	350,000,000 ≠ 9%
Silurian Period	350,000,000	25,000,000	
Ordovician Period	410,000,000	60,000,000	
Cambrian Period	550,000,000	140,000,000	
Cryptozoic Eon			
PRECAMBRIAN ERA			
Late Precambrian	1,035,000,000	3,500,000,000	
Early Precambrian	3,850,000,000		

TERTIARY	RECENT	ALLUVIUM	
	PLEISTOCENE	GLACIAL DRIFT	
	PLIOCENE	PRE-PLEISTOCENE GRAVELS	
	MIOCENE		
	OLIGOCENE	WHITE RIVER	
	EOCENE	GOLDEN VALLEY	
	PALEOCENE	SENTINEL BUTTE	FORT UNION GROUP
		TONGUE RIVER	
		LUDLOW ≷ CANNONBALL	
CRETACEOUS		HELL CREEK ≷BREIEN≷	
		FOX HILLS	MONTANA GROUP
		PIERRE	
		NIOBRARA	COLORADO GROUP
		CARLILE	
		GREENHORN	
		BELLE FOURCHE	
		MOWRY	DAKOTA GROUP
		NEWCASTLE "MUDDY"	
		SKULL CREEK	
		FALL RIVER	
		FUSON	
		LAKOTA	
JURASSIC		MORRISON	
		SUNDANCE	
		PIPER	
TRIASSIC		SPEARFISH	
PERMIAN		MINNEKAHTA	
		OPECHE	
PENNSYLVANIAN		MINNELUSA	
		"AMSDEN"	
MISSISSIPPIAN		HEATH	BIG SNOWY GROUP
		OTTER	
		KIBBEY	
		CHARLES	MADISON GROUP
		MISSION CANYON	
		LODGEPOLE	
		ENGLEWOOD	
DEVONIAN		LYLETON	QU'APPELLE GROUP
		"NISKU"	SASKATCHEWAN GP.
		DUPEROW	
		SOURIS RIVER	BEAVERHILL LAKE GROUP
		DAWSON BAY	
		PRAIRIE EVAP.	ELK POINT GROUP
		WINNIPEGOSIS	
		ASHERN	
SILURIAN		INTERLAKE GROUP	
ORDOVICIAN		STONY MOUNTAIN UPPER / LOWER	
		RED RIVER	
		WINNIPEG	
CAMBRIAN		CAMBRIAN	

PLATE 3 - GEOLOGIC FORMATION TABLE FOR NORTH DAKOTA. ONLY THE FORMATIONS ABOVE THE CARLILE ARE EXPOSED AT THE SURFACE; THE OTHERS ARE KNOWN ONLY FROM WELLS.

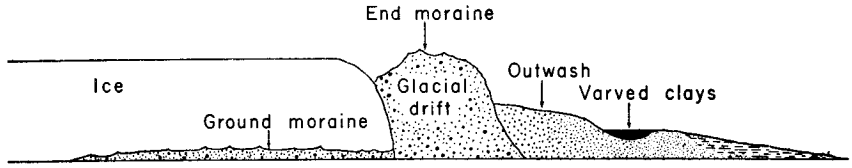


Figure 1. - Diagram showing glacial features associated with the front of an ice sheet.

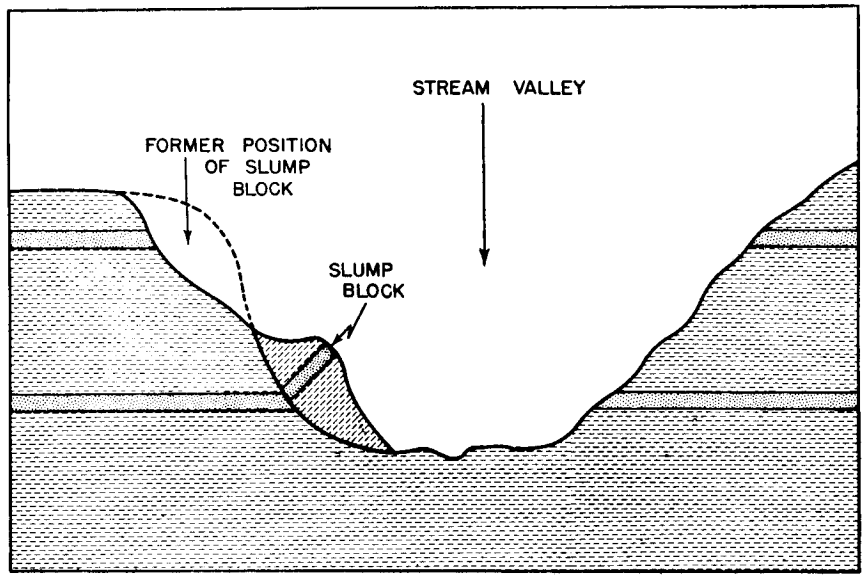


Figure 2. - Cross-section diagram showing a slump block or landslide caused by slippage on a clay or shale surface lubricated by ground water.

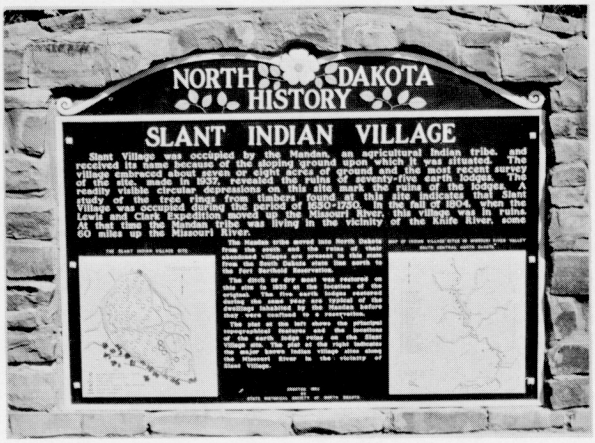


Fig. 1 - State Historical Society sign at stop 2.

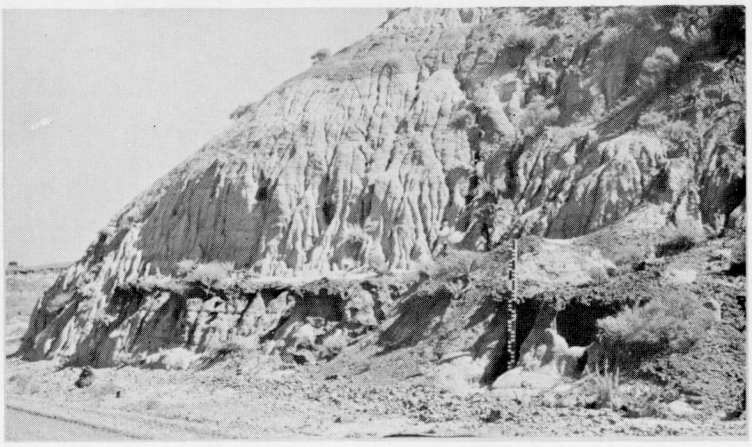


Fig. 2 - Bluff of Hell Creek showing typical rivulet erosion. Stop 3.

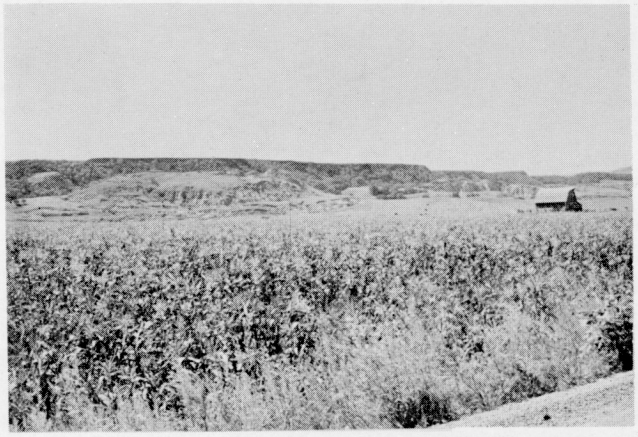


Fig. 3 - Large landslide mass of Hell Creek and Ludlow shales south of Huff.

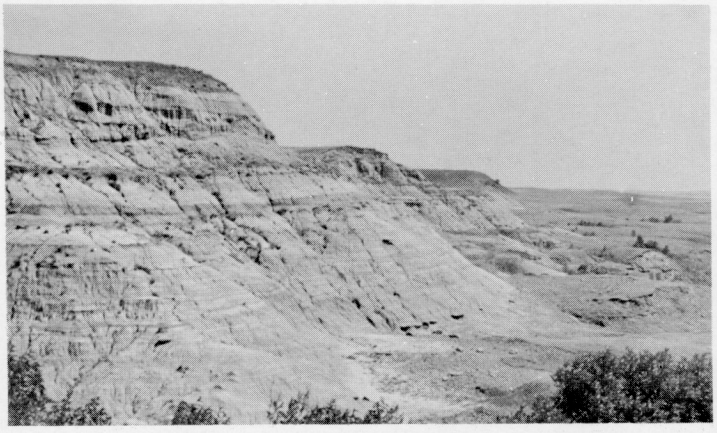


Fig. 4 - North bluff of Cannonball River of Hell Creek formation. The Breien member (6 to 36 feet below top) is at its thickest here, stop 5.

Fig. 5 - Fossiliferous Cannonball sandstone at stop 8. Cub Scout ("field assistant") is 4 feet 6 inches tall.

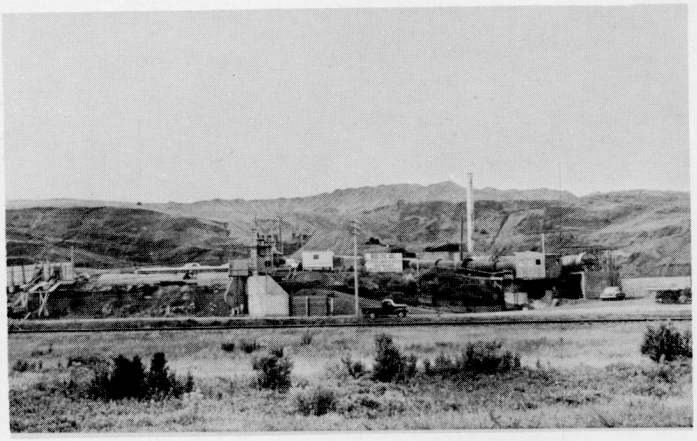
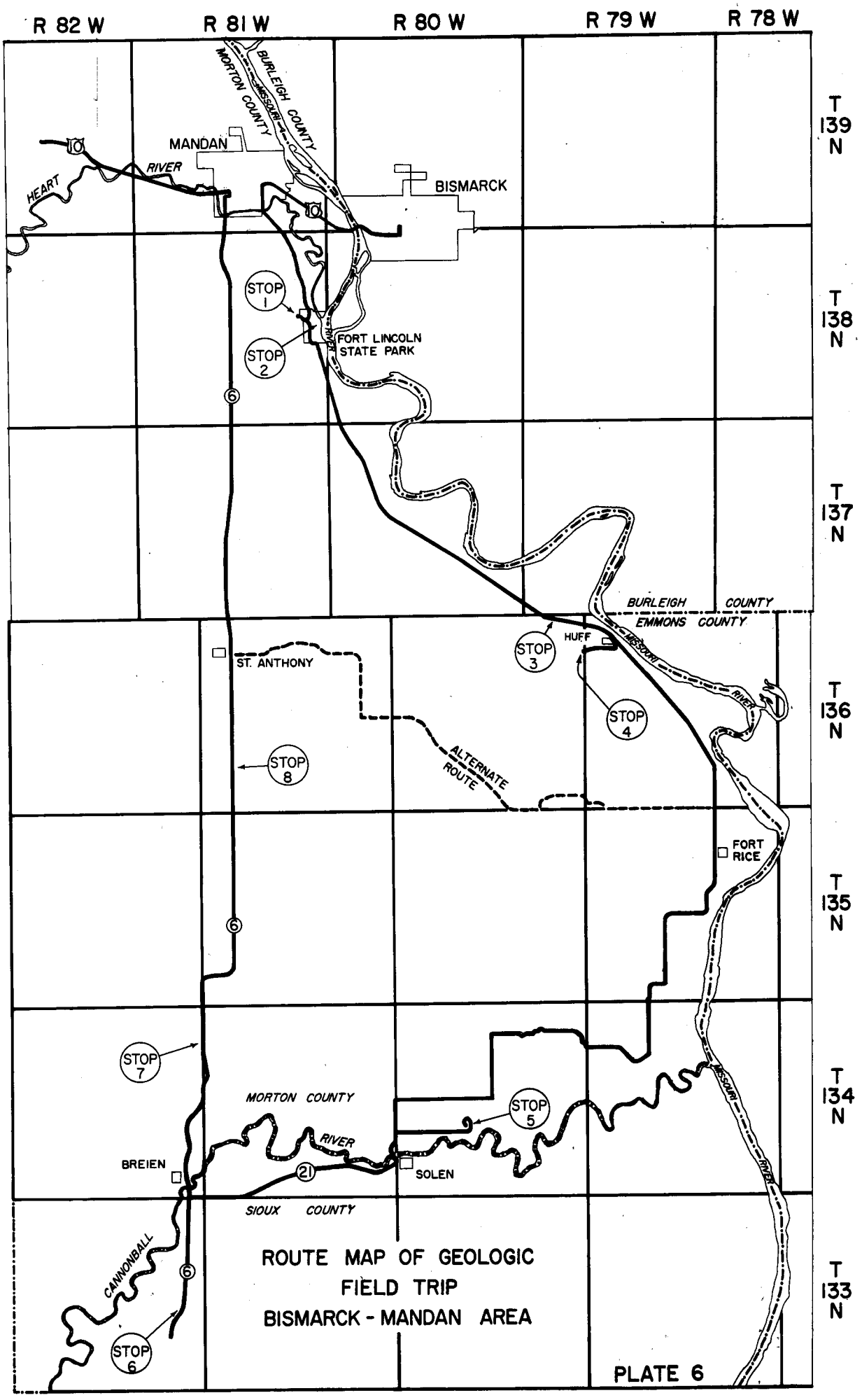


Fig. 6 - Molite Inc. plant west of Mandan using Cannonball shale for making light weight concrete aggregate.


R 82 W
R 81 W
R 80 W
R 79 W
R 78 W
T 139 N
T 138 N
T 137 N
T 136 N
T 135 N
T 134 N
T 133 N
MORTON COUNTY
BURLEIGH COUNTY
MISSOURI RIVER
MANDAN
BISMARCK
HEART RIVER
10
STOP 1
STOP 2
FORT LINCOLN STATE PARK
6
BURLEIGH COUNTY
EMMONS COUNTY
MISSOURI RIVER
HUFF
STOP 3
STOP 4
ST. ANTHONY
STOP 8
ALTERNATE ROUTE
FORT RICE
STOP 7
MORTON COUNTY
RIVER
STOP 5
BREIEN
21
SOLEN
SIOUX COUNTY
CANNONBALL
STOP 6
ROUTE MAP OF GEOLOGIC FIELD TRIP
BISMARCK - MANDAN AREA
PLATE 6