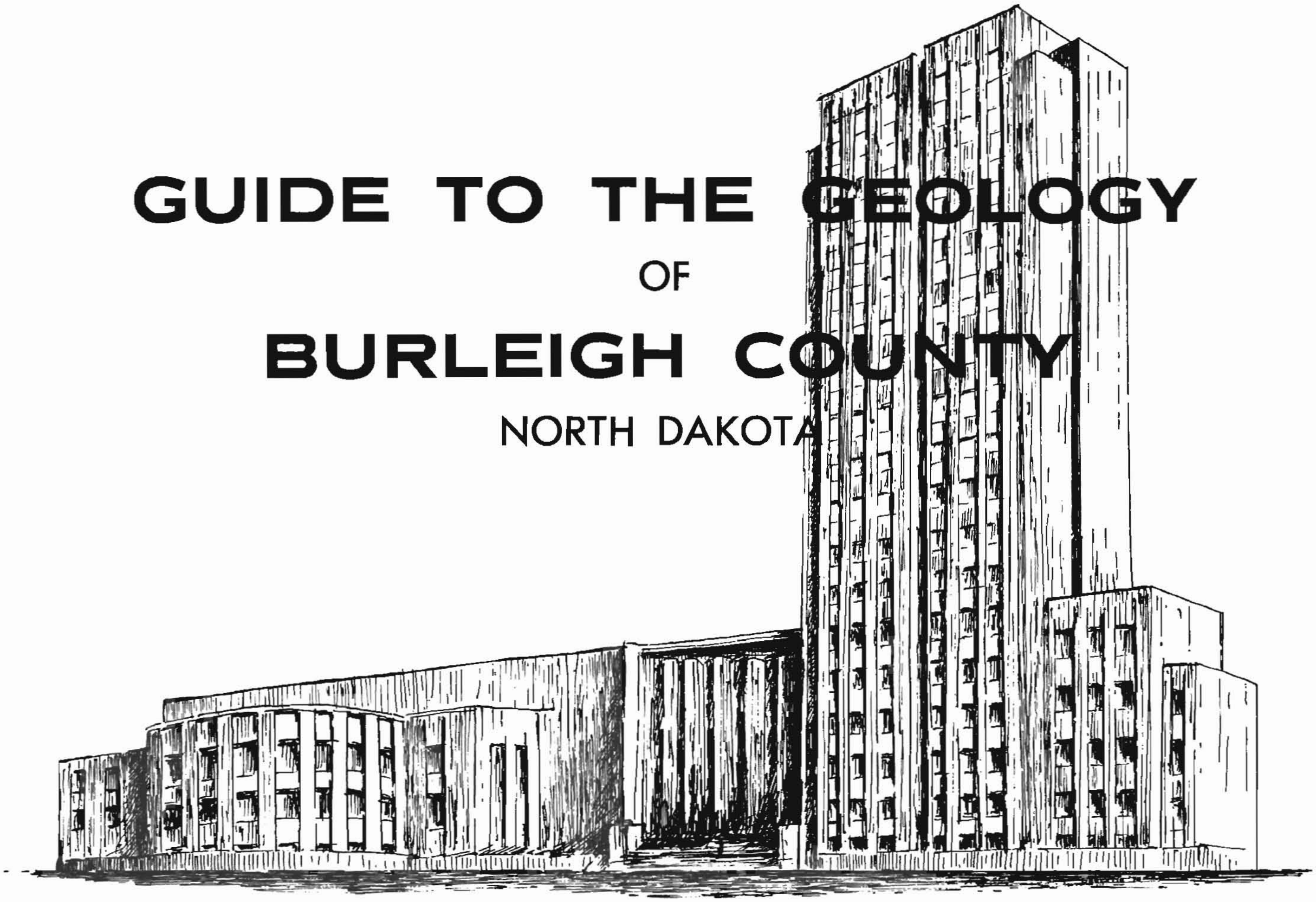
GUIDE TO THE GEOLOGY

OF

BURLEIGH COUNTY

NORTH DAKOTA



by

JOHN P. BLUEMLE

and

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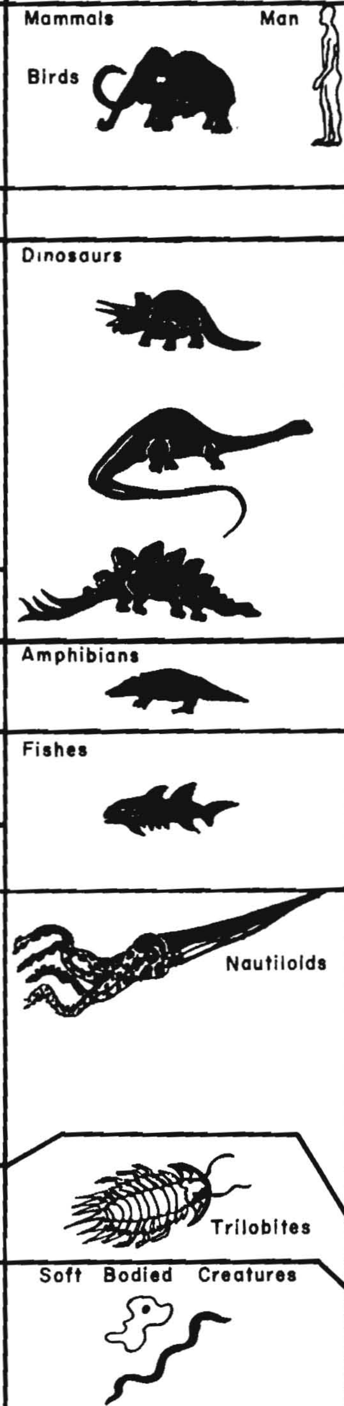
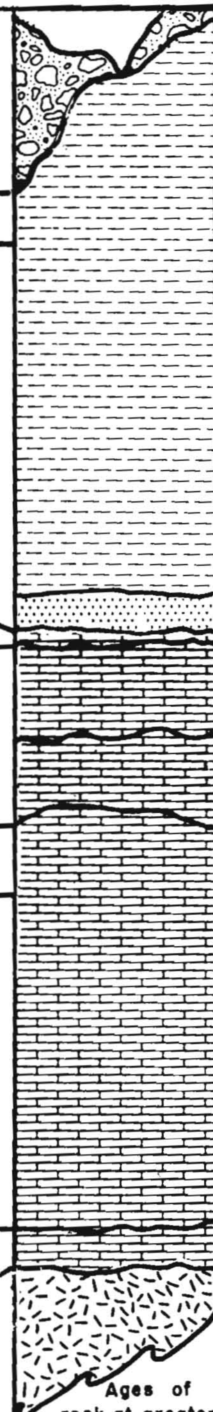
MISCELLANEOUS SERIES NO. 42

NORTH DAKOTA GEOLOGICAL SURVEY

E. A. NOBLE, State Geologist

Age (Millions of Years Ago)	Time Units & Thickness		Typical Animals	Main Rock Types	Depth in Feet
1	Cenozoic "Recent Life"	Pleistocene Epoch 0-165'	Mammals, Birds, Man	Glacial boulders clay gravel, sand and silt. Covers all but the southwest corner of North Dakota.	500
60		Paleocene Epoch		Erosion	
	Mesozoic "Middle Life"	Cretaceous Period 1600-2000	Dinosaurs	Erosion. Shale, exposed in deeper valleys of Burleigh County. Lowermost Cretaceous rocks are sands of the Dakota Group which is water-bearing.	1000, 1500
135		Jurassic 0-100'		shale, limestone and siltstone some "redbeds". Erosion	
	Paleozoic "Ancient Life"	Mississippian 0-600'	Amphibians	Erosion. Mainly limestone. Some shale at base	2000
350		Devonian 50-400'	Fishes	Erosion. Mainly limestone	
400		Silurian 0-100'		Erosion. Mainly limestone	2500
		Ordovician Period 700-1000'	Nautiloids	Mainly limestone. Lower part is shale and sandstone	3000
500		Cambrian 0-80'	Trilobites	Mainly sandstone & Limestone. Erosion. Erosion	3500
600	Cryptozoic "Concealed Life"	Precambrian	Soft Bodied Creatures; Little or no Life	Mainly granite rocks & metamorphosed sediments. Ages of rock at greater depths are not known.	4000
1200 to 5000					





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ILLUSTRATIONS

GUIDE TO THE GEOLOGY OF BURLEIGH COUNTY, NORTH DAKOTA

by

John P. Bluemle and Jack Kume

This booklet is provided to explain briefly a few general geologic concepts, relate them to the geology of Burleigh County, and point out a few scenic and geologic features along field trip routes. The information in this guidebook is based on one (Bulletin 42) of a series of North Dakota Geological Survey bulletins that deals with the geology and ground water resources of the various counties of the state.

The science of geology is concerned with the history of the earth, its composition, and its structure. Geology strongly affects the way we live. Although it is not possible to study the geology of Burleigh County in great detail in a small booklet such as this one, we can look at some important concepts and go on from there to look at some examples in Burleigh County. Time does not permit one to see the geology of Burleigh County in a day, although one can sample it adequately by making the suggested stops along prepared field trip routes described in this booklet. Therefore, it is hoped that interested individuals will take many similar excursions in the field, stopping and observing the geology in areas not covered on the four trip routes.

The reader interested in a more detailed treatment of the geology of Burleigh County can obtain North Dakota Geological Survey Bulletin 42, Part I, from the Survey offices in Grand Forks or from the North Dakota State Water Commission in Bismarck. For the reader interested in learning more about geology in general, a listing of suggested reading is included at the end of this booklet. For further information on ground water in Burleigh County, see North Dakota Geological Survey Bulletin 42, Part III.

General Geology

The earth can be divided into three zones: core, mantle, and crust (Fig. 1). The core is the innermost zone of the earth. It is mainly iron with some nickel and cobalt. The inner core is probably solid, and the outer core may consist of the same elements in a molten form. The core is the most dense of the three zones. The mantle, which surrounds the core, is a solid zone of materials rich in iron and magnesium.

The crust, the upper surface of which includes the ground we walk on, is the hard, outer layer of the earth. Although the crust is about 6 to 30 miles deep, it is only a thin skin on a world that is almost 8,000 miles in diameter. The components of the crust include such rocks and minerals as limestone, sandstone, shale, coal, iron, nickel, basalt, granite, and many others. These crustal rocks are not as dense and do not have as high an iron content as the rock of the mantle and core.

In Burleigh County, all the rock types we will be concerned with belong to the earth's crust. It is convenient to group these rock types in three categories: 1) the granitic rocks; 2) the sedimentary rocks excepting the glacial drift; and 3) the glacial drift.

The granitic rocks of the crust are the oldest and deepest of the three rock types with which we are concerned. The top of the granite sequence is generally from 6,000 to 8,000 feet below

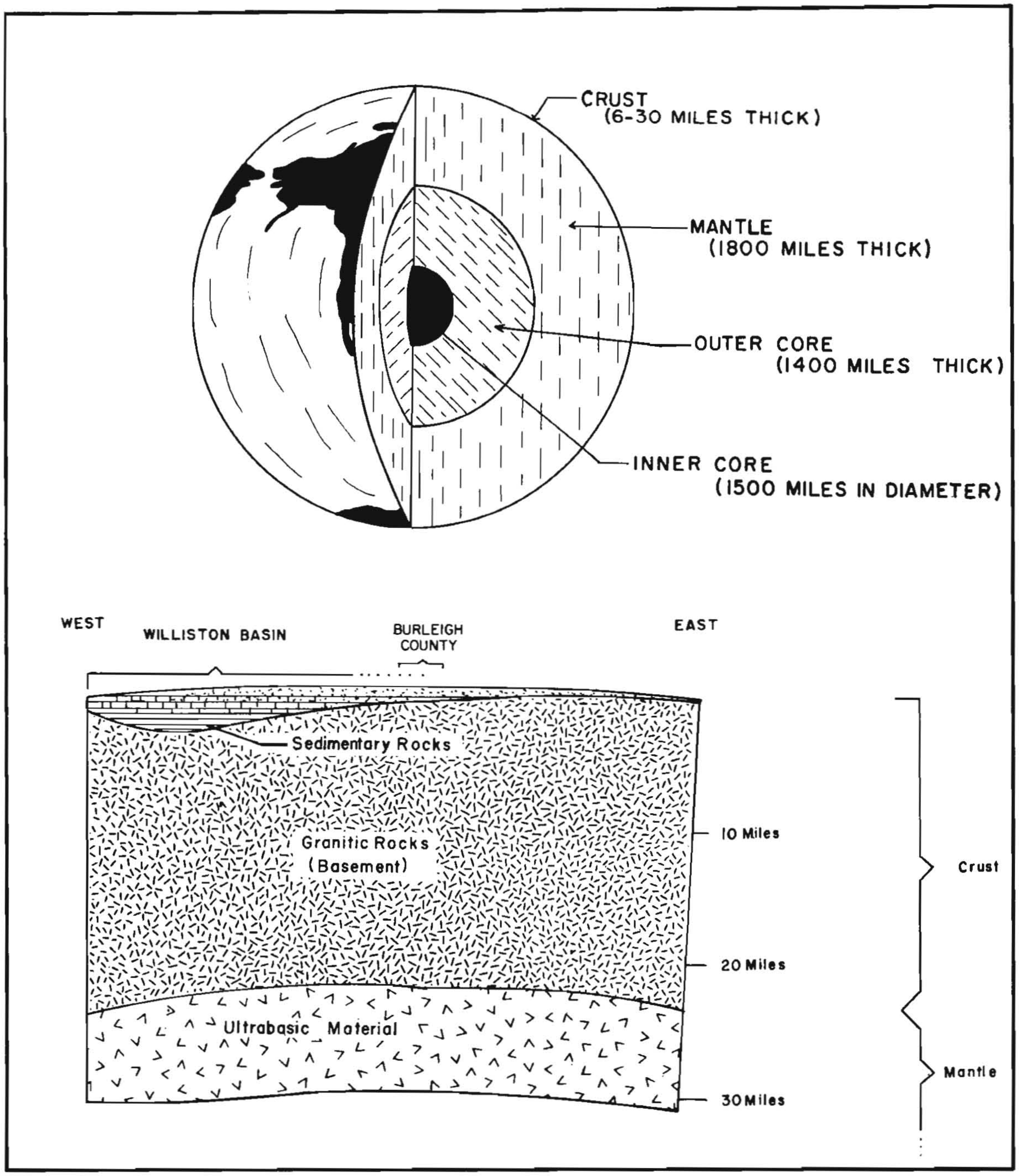
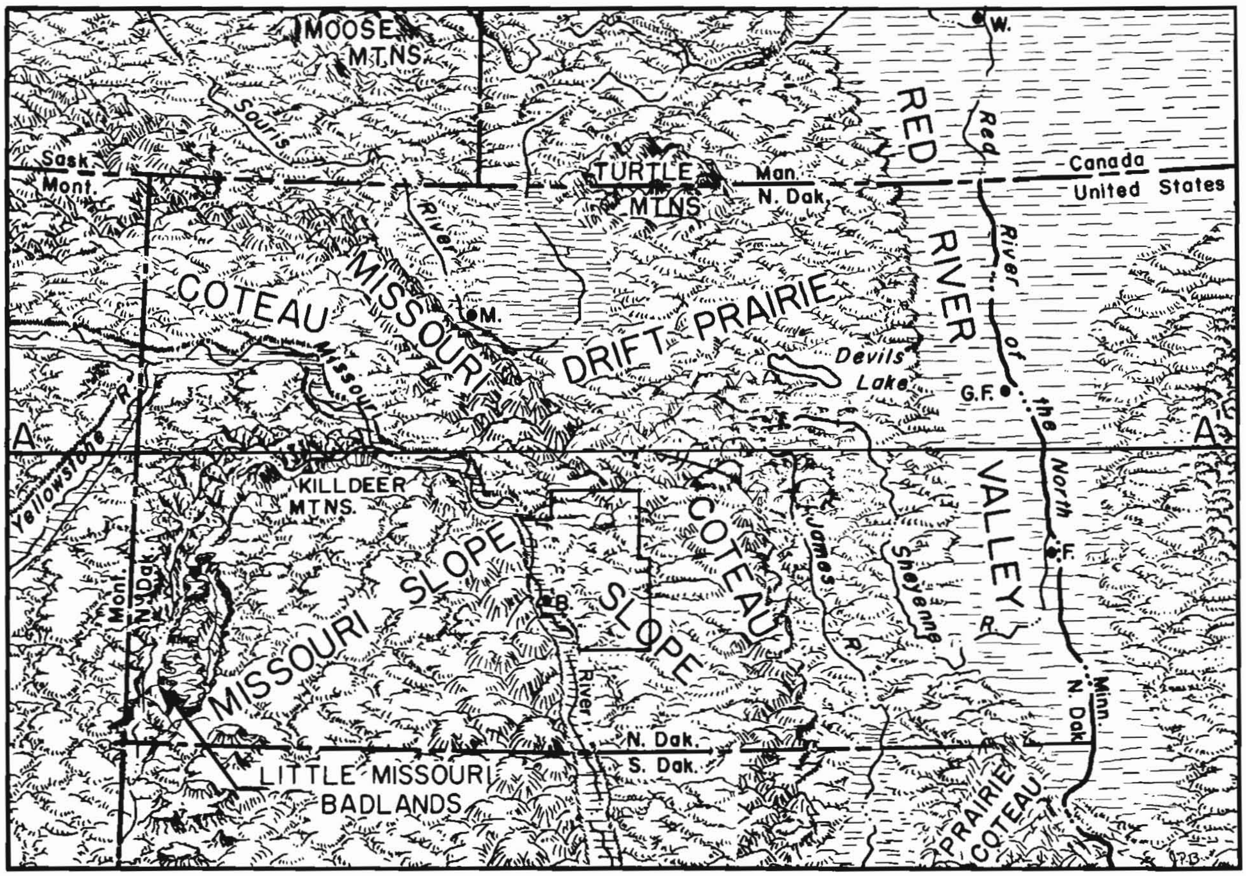


FIGURE 1. The upper portion of this figure shows the earth with a segment removed to show the internal zones. The lower portion shows an east-west cross-section through the earth's crust in the North Dakota area. It shows the Williston Basin, the area of thick sedimentary rocks, and the underlying granitic rocks.



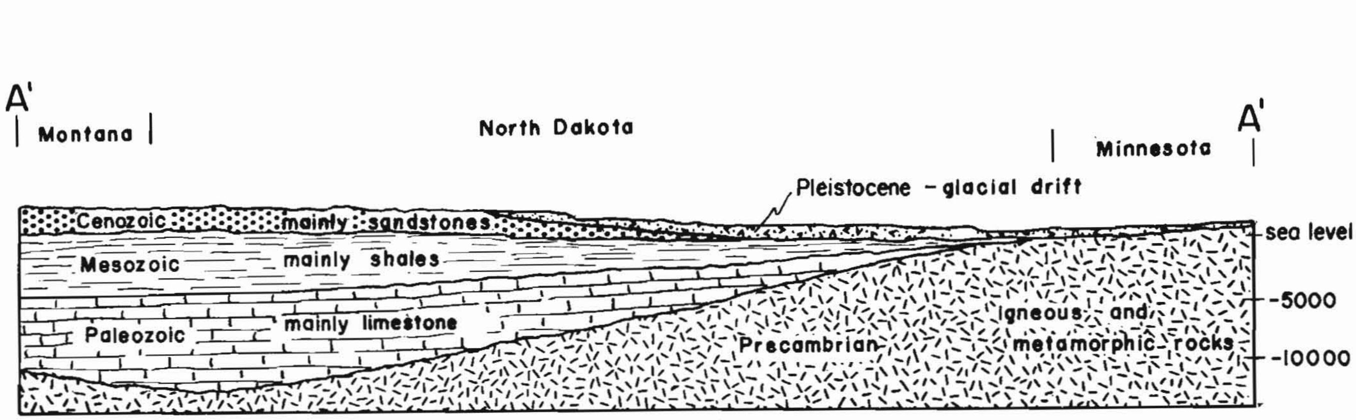


FIGURE 2. Physiographic map of North Dakota showing the location of Burleigh County. The cross-section A-A' shows how the sedimentary rocks are thicker in the Williston Basin in the western part of the state.

the surface in Burleigh County, but in the western part of the state, granitic rocks are 15,000 feet below the surface. The granite formed more than 600 million years ago when magma (molten rock) cooled and solidified.

The sedimentary rocks that lie on top of the granite consist of layers of sediments (minute particles of rocks and minerals) that were deposited in shallow seas. These seas covered North Dakota during much of the past 600 million years. The sedimentary rocks are mainly limestone, shale, and sandstone. They were formed when sediment was eroded from nearby land when it was above sea level. Rivers and streams carried the sediments to the seas just as much of our rich North Dakota topsoil is carried to the Gulf of Mexico today. In Burleigh County there are 6,000 to 8,000 feet of sedimentary rocks, but in western North Dakota, near the center of the Williston Basin, the sedimentary rocks are more than 15,000 feet thick in places (Fig. 2). Sedimentary rocks can be observed best in exposures along valley walls and on the steep-sided buttes and ridges of Burleigh County.

The third of the three rock categories that occurs in Burleigh County is the glacial drift. The landscape over most of North Dakota developed during the Ice Age (Pleistocene epoch) that lasted from about one million years ago up to about 10,000 years ago. During that time, the state was covered by glaciers several times. The most recent glaciation began about 75,000 years ago and lasted until about 10,000 years ago. Only the southwest part of the state escaped glaciation. Figure 3 shows the area of North America that was glaciated during the Ice Age.

Much of the glaciated portion of North Dakota is covered by thick glacial deposits consisting of everything from sand and clay to boulders. Before the glaciers advanced over North Dakota, the area was probably hilly, much like the southwest part of the state today. The glaciers smoothed down and covered much of the old, rocky, hilly land surface and filled old valleys with loose deposits of ground-up material. In the time since the glaciers left the state, weathering and bacterial decay action have modified many of these surface materials into soils. The present soils of North Dakota are fertile partly because they have minerals and trace elements (minute amounts of elements such as copper, zinc, and manganese) brought in by glaciers from other areas.

Sedimentary Rocks of Burleigh County

Although 6,000 to 8,000 feet of sedimentary rocks are present beneath the surface of Burleigh County, only the uppermost rock formations are exposed so that they can be seen by the casual observer. Figure 4 shows the geologic sequence that is exposed in Burleigh County.

The Fox Hills Formation is a gray to olive colored marine sandstone with some interbedded shale. It is exposed along the shores of Long Lake. The Hell Creek Formation is light gray to brown, continental, interbedded sandstones, carbonaceous shales, shales, mudstones, and a few lignite seams (Fig. 5). It is best exposed in the bank of the Missouri River south of Bismarck and the bluffs south of Bismarck, Menoken, and McKenzie. The Ludlow Formation is a thin, yellow to brown, continental sandstone interbedded with brownish-gray to black carbonaceous shales and lignite. It is best exposed in the bluffs along Apple Creek south of Bismarck. The Cannonball Formation is a marine, interbedded sequence of yellowish-brown, yellow gray, and olive gray sandstones, shales, siltstones, and lenticular limestones. It is extensively exposed in Burleigh County, but it is best exposed along the valley walls of the Missouri River and the bluffs north and south of Bismarck, Menoken, and McKenzie. The Tongue River Formation, of continental origin, contains a basal yellowish-gray and olive gray cross-bedded unit (Figs. 6 and 7) overlain by interbedded yellowish-orange, yellow, and brown shales, and sandstone. Lignite beds are also present. The formation is exposed in the buttes and ridges east and west of Baldwin and Wilton.

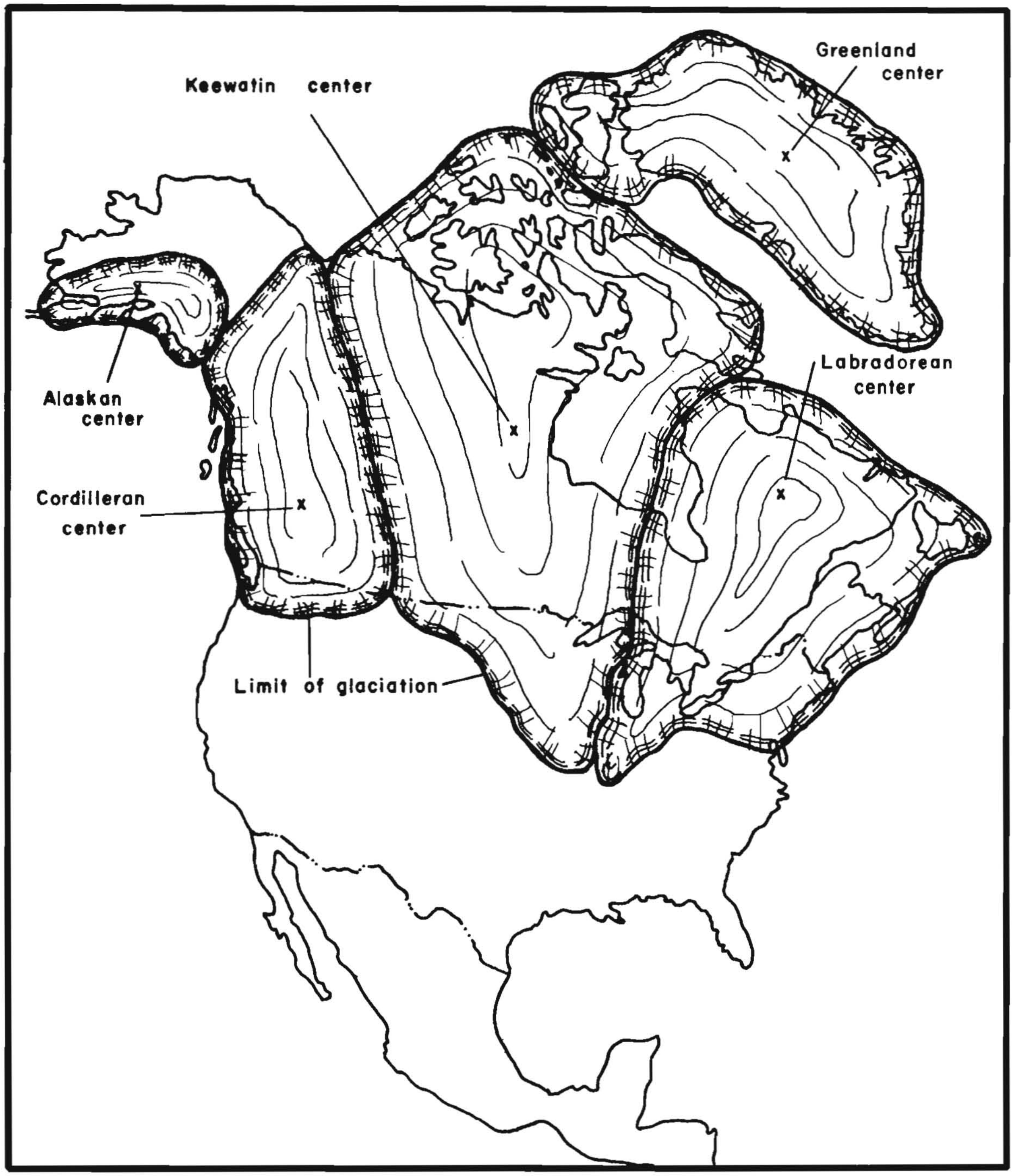


FIGURE 3. The above map of North America shows the limits of continental glaciation during the Ice Age. The main centers of snow accumulation from which the ice moved are shown. North Dakota was glaciated by ice that moved from the Keewatin center west of Hudson Bay.

ERA	SYSTEM	SERIES	GROUP	FORMATION	THICKNESS	LITHOLOGY
CENOZOIC	TERTIARY	PALEOCENE	Ft. Union	Tongue River	0-215 Feet	Sandstone Shale Lignite
				Cannonball Ludlow	0-340 Feet	Sandstone Siltstone Shale Lignitic Shale
MESOZOIC	CRETACEOUS	UPPER CRETACEOUS		Hell Creek	0-280 Feet	Mudstone Sandstone Lignite
			Montana	Fox Hills	0-300 Feet	Sandstone Shale
				Pierre	946-1020 Feet	Shale

FIGURE 4. Stratigraphic column of the preglacial sedimentary rock formations exposed at the surface in Burleigh County.

FIGURE 5. Hell Creek and Cannonball Formations cropping out along Apple Creek southwest of the Annunciation Priory (Stop 2, Field Trip 1).

FIGURE 6. Cannonball and Tongue River Formations exposed north of Bismarck (Stop 10, Field Trip 3).

FIGURE 7. Cross-bedded sand and sandstone at the base of the Tongue River Formation (near Stop 10, Field Trip 3).

The Ice Age in Burleigh County

The Ice Age, or Pleistocene epoch, ended about 10,000 years ago, which is only a short part of geological history (Fig. 8). During the Pleistocene epoch, a great ice sheet, like that in Greenland today, formed in Canada west of Hudson Bay. Thousands of feet of snow that accumulated there was, by its own weight, compressed into ice. Finally, the pressure resulting from the weight of so much overlying ice caused the edge to move slowly southward into North Dakota. The tremendous mass of ice flowed first through the valleys, filling and overflowing them. Then it spread over the uplands, bypassing the higher hills for a time but overriding even these when it became thick enough. Rock and surface materials of all kinds were picked up by the ice and ground into smaller fragments such as gravel, sand, silt, and clay. This material, moving along with the slowly flowing ice, was later deposited far to the south when the edge of the glacier finally melted back. The material that melted out of the glacier formed the rolling landscape now typical of northern and eastern Burleigh County. In places, water flowing from the melting ice washed away the silts and clays, leaving flat gravel and sand plains. In other places there was little washing, and hills composed of a mixture of everything from clay to boulders remained.

If a person could go back in time about 12,000 years, he would probably find it hard to recognize Burleigh County! The great ice sheet covered much of the northern part of the state and its edge probably crossed parts of Burleigh County. The huge sheet of dirty ice stretched away to the northern horizon as far as the eye could see. Near its edge it was only a few hundred feet thick but farther north it was several thousand feet thick. Small streams of dirty, sediment-laden water flowed from the melting ice and collected in ponds and larger and larger streams until it flowed as huge rivers cutting the valleys now occupied by the Missouri River and the smaller streams.

When the ice melted away, the newly exposed land surface was rough, uneven, and poorly drained. There were many ponds. Some chunks of ice that had not yet had time to melt were buried by debris, and when they finally did melt, the overlying materials slumped into the resulting holes. Today one can see these potholes in many places in Burleigh County.

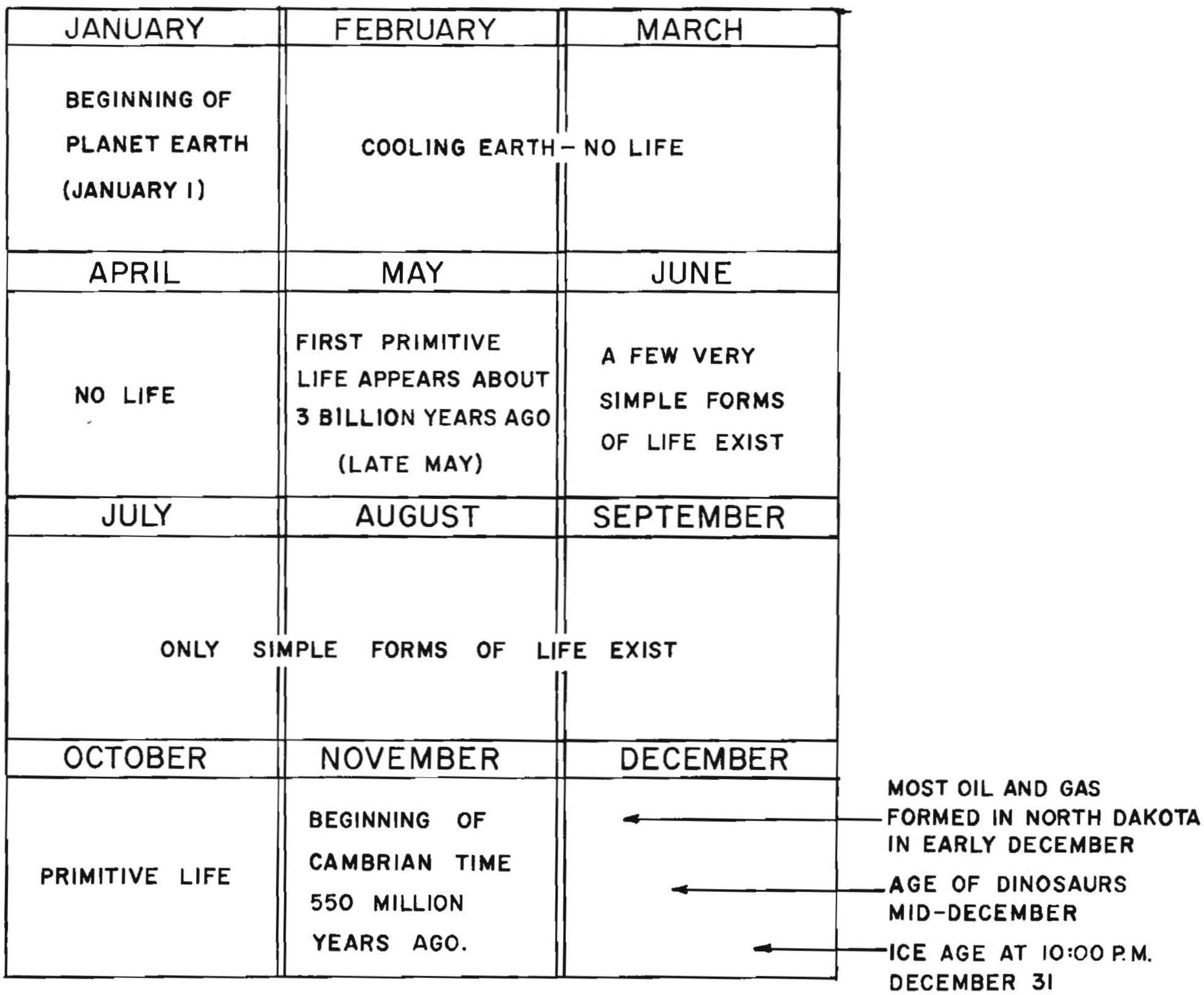
Cold, damp winds blew off the melting ice during the short summer season and rainfall was abundant. The winters were probably no colder than our present-day North Dakota winters but there was much more snow. In general, the climate was probably much like the climate today in parts of northern Manitoba.

A few miles to the south, where the ice had been a few years earlier, dense forests of spruce and tamarack grew. Elephant-like wooly mammoths and mastodons roamed the area along with herds of giant bison, elk, and caribou. Primitive pre-Indian man probably inhabited the area also, eking out a meager existence in the unfriendly surroundings.

Thus, the last great geologic episode in Burleigh County ended, leaving the rolling hills and plains to be covered by tall prairie grasses as the climate became milder and drier. The mammoths and mastodons died off and herds of buffalo took their place. Indian hunters who moved into the area went undisturbed, except by other Indians, until about 10,000 years later when Europeans finally arrived.

Description of Some of the Features Left by the Glaciers

In eastern Burleigh County a low range of knobby hills formed when materials collected at the edge of the melting glacier. This range of hills, shown in dark green on Plate 1 (in the pocket at the end of this booklet), is called the Long Lake end moraine. It is named for Long Lake in the



CALENDAR OF THE EARTH'S HISTORY

FIGURE 8. The above diagram represents all 5 billion years of the earth's history compressed into a single year. The earliest life forms did not appear on the earth until late in April of our imaginary year. Dinosaurs came on the scene in mid-December and lasted only six of our imaginary days. The Ice Age began in North Dakota at 8:40 p.m. on December 31 and ended only two minutes before midnight. Primitive man arrived on earth about 10:20 p.m. in the midst of the Ice Age. At 20 seconds before midnight, Christ was born and at 10 seconds America was discovered by Leif Ericson. So, as you can see, the two thousand years since Christ was born may seem like a long time to most of us, but, geologically speaking, they are only an instant in the total history of the earth.

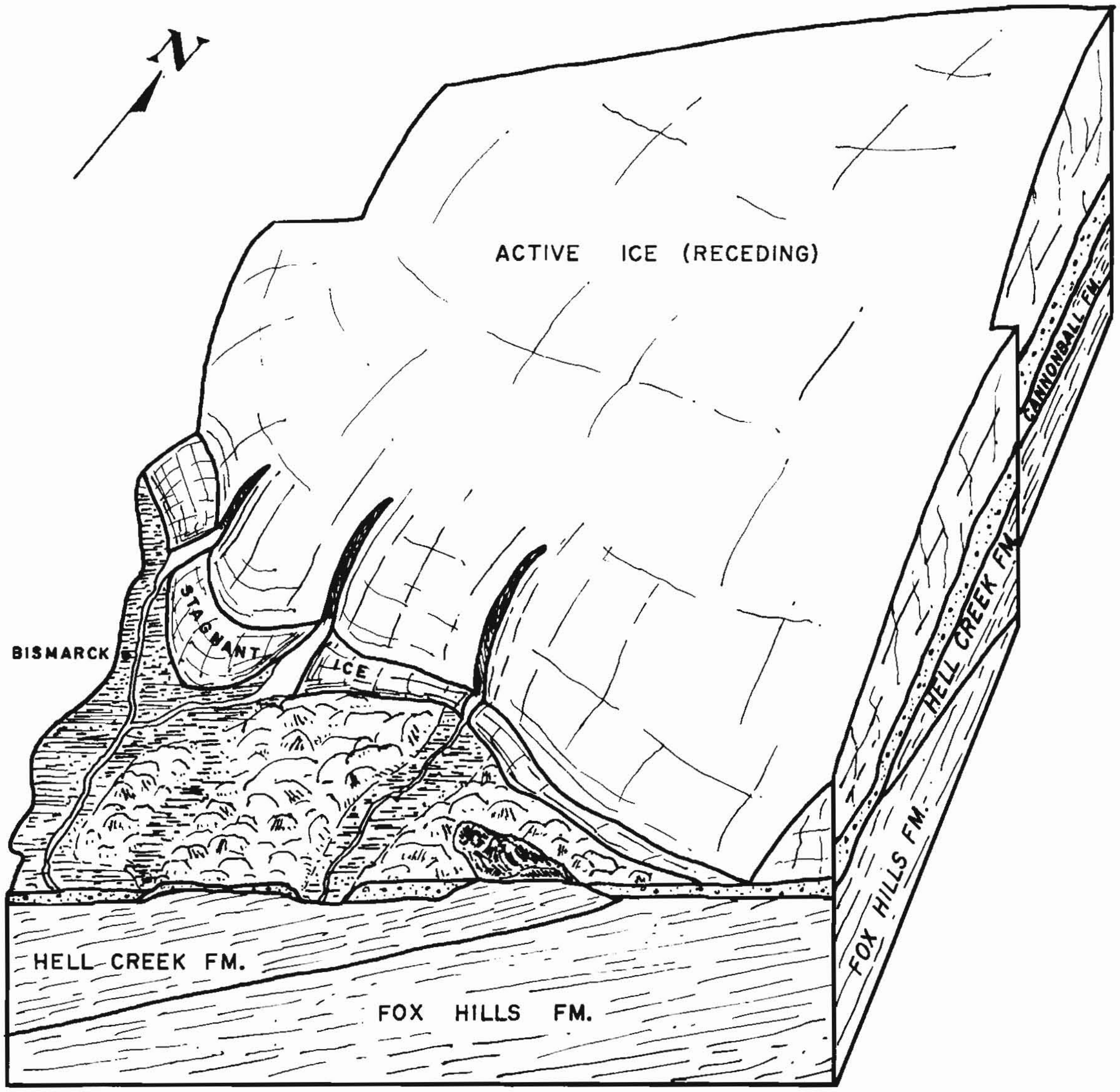


FIGURE 9. This diagram, along with the three that follow, shows the development of the glacial landscape in Burleigh County. For purposes of illustration, the thickness of the ice and scale of the landforms has been greatly exaggerated. The diagrams end at the county line so the reader can see the area in cross-section and get a better idea of what was happening. The above illustration shows the glacier covering all but southwestern Burleigh County. As the margin receded, areas of stagnant ice were left behind. The glacier picked up rocks, sand, and clay as it moved along and the base of the moving glacier in places actually consisted of more debris than ice. Water flowing from the melting ice deposited sand and gravel plains such as the one in the Bismarck area. The surface of the glacier near the edge of the ice was dirty with deep cracks and crevasses. Lakes stood in lower areas near the edge of the glacier and streams flowed through the cracks toward the ice margin.

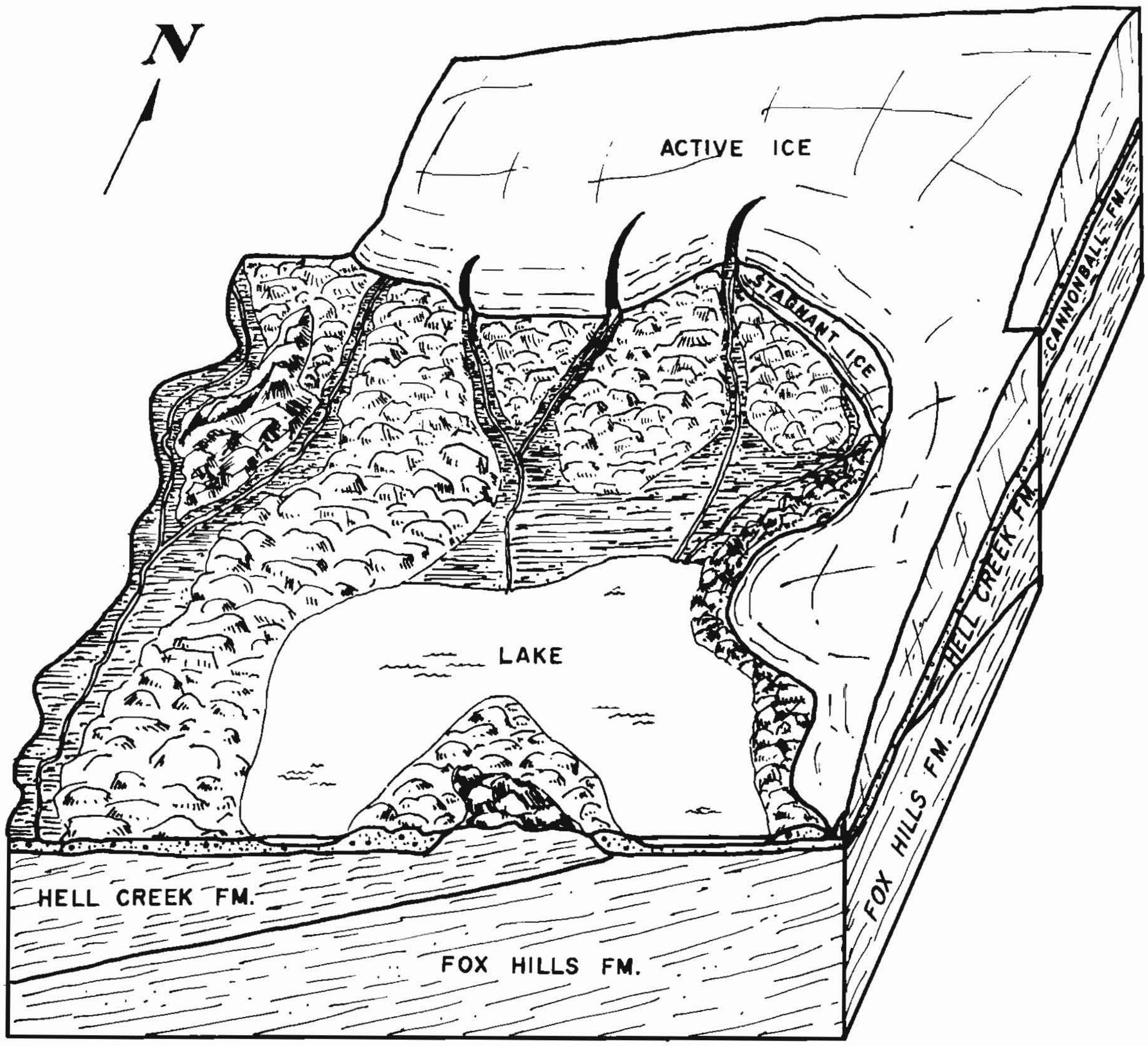


FIGURE 10. The active ice shown on this diagram had wasted back so that its edge crossed northern and eastern Burleigh County. A large lake, Glacial Lake McKenzie, formed in front of the receding glacier in southern Burleigh County as streams from the glacier fed large amounts of water and sediments into the lake. Later, after the lake drained, these sediments remained as a very flat lake plain. On the above diagram, the active glacier front in eastern Burleigh County was in near equilibrium, melting back at about the same rate as the ice moved forward, and the Long Lake end moraine was deposited as debris piled up at the edge of the moving ice.

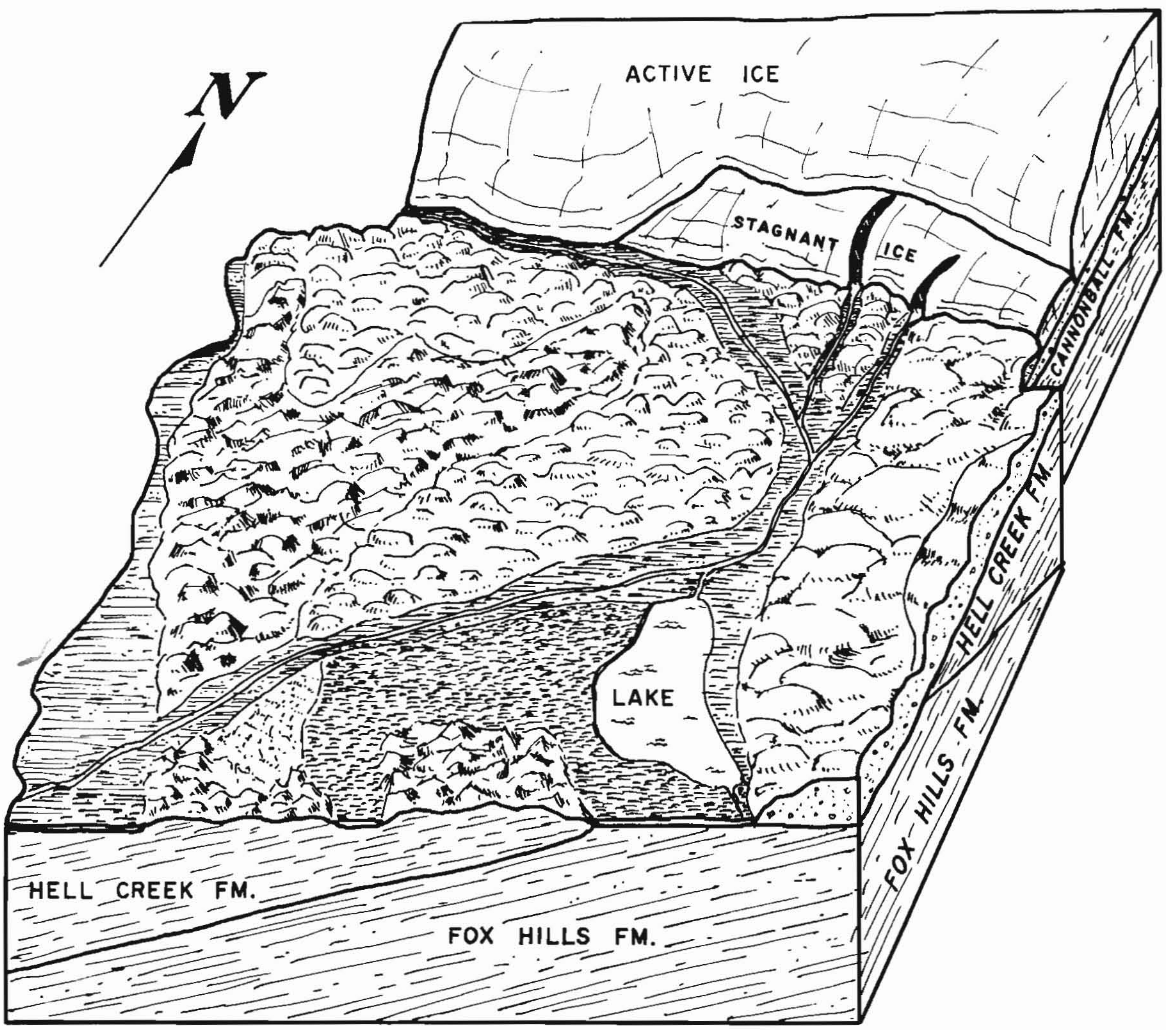


FIGURE 11. The ice sheet shown on this diagram had melted back so that it covered only northern Burleigh County. In many areas the cover of glacial deposits was, and still is, thin; and bedrock, such as the Fox Hills, Hell Creek, or Cannonball Formations, still forms the hills. These areas generally have rougher topography than do those where glacial deposits are thicker. Glacial Lake McKenzie had nearly drained and only a small lake remained.

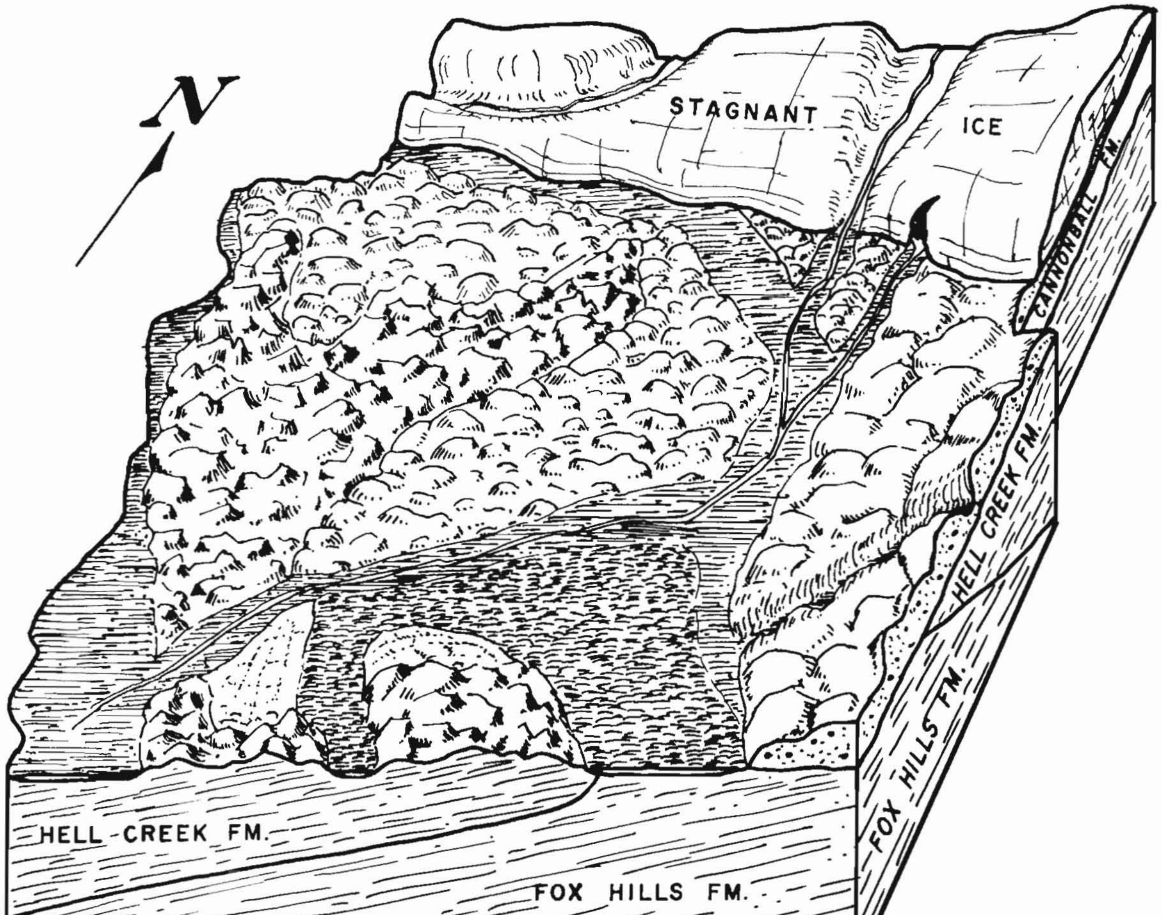


FIGURE 12. On this diagram the active ice sheet had receded from Burleigh County and only stagnant ice remained in the north. When this melted, an area of dead-ice moraine remained (see text). The landscape shown on the above diagram was not much different than it is today.

southeastern corner of the county and called an end moraine because it formed at the edge or "end" of a lobe of, or advance of, glacier ice. The end moraine is underlain mainly by sandy, gravelly and bouldery clay (known as "glacial till" or simply "till") and has poor drainage, steep slopes, and bouldery surfaces. In some places are small ridges that may have formed when a short advance of ice "bulldozed" the material into shape.

The area in northern Burleigh County, shown in brown on Plate 1, is very hilly with abundant potholes and is called dead-ice moraine. Its overall appearance is much like end moraine and it is composed of bouldery and gravelly clay (till) as is end moraine. However, this hilly area formed in a different manner than did end moraine. Here, large areas of the glacier became detached from the actively moving ice. They were then covered by many tens of feet of sand, silt, clay, gravel, and boulders that were piled there by the nearby active ice. When the underlying ice eventually melted, this overlying debris slumped and slid, forming mounds and hills on and around the "dead" ice. In places, the dead ice was thinner than in others. Debris tended to pile into these lows on the dead ice surface. When the ice melted, these areas became hills. In places where the ice was thick and was thus covered by only thin debris, large potholes are now found. On the Malaspina glacier in Alaska, where such a situation exists today, dense forests grow on the debris that covers the ice. Large areas of North Dakota were similarly forested about 10,000 years ago.

The light green area in the central part of the county map is sheet moraine, a thin layer of glacial drift draped over a rugged bedrock slope. The glacial deposits in this area are discontinuous, and in many places preglacial sedimentary rocks are exposed. Although areas of sheet moraine are rather hilly in Burleigh County, this is due to the relief that had developed on the underlying sedimentary rocks before the time of the glacier. Sheet moraine has about the same composition as end moraine and dead-ice moraine.

Areas shown in yellow on Plate 1 are sand and gravel that was deposited by water that flowed in streams from the melting glacier. As the water flowed away from the ice it collected in bigger and bigger streams until it finally flowed in tremendous rivers. The valleys these rivers flowed in are known as meltwater trenches. A few of the larger meltwater trenches are those now occupied by Long Lake, Random Creek, Apple Creek, and, of course, the Missouri River.

The pink areas shown in northern Burleigh County are also sand and gravel. However, in these areas, the land is much more rugged than in the areas shown in yellow. Here, sand and gravel was deposited on stagnant ice, just as till was deposited on stagnant ice in the areas of dead-ice moraine. When the stagnant ice eventually melted, the sand and gravel surface, which had been relatively flat, collapsed to its present rugged configuration.

In the south-central part of the county in the McKenzie-Menoken-Moffit area, is an area of lake sediments (shown in light blue on Plate 1). This lake plain formed when a large proglacial and ice-marginal lake, Glacial Lake McKenzie, developed adjacent to the Long Lake glacier. The silts and clays that were deposited in the lake formed a smooth flat area.

Economic Geology

In 1962 Burleigh County ranked sixth in the state in production of sand and gravel, which is presently the most valuable mineral resource in the county. Deposits of sand and gravel are found in such places as on the terraces along the Missouri River and on the sand and gravel outwash plains. Of these, the best sources of high quality gravel are the river terraces.

Water occurring as ground water in sand and gravel aquifers and as surface water in rivers, streams, and lakes are valuable resources. About 70 percent of the domestic and stock wells obtain water from the sedimentary (preglacial) rock aquifers. Such supplies may generally be obtained at depths of less than 300 feet and are preferred for household use because the water is softer than some of that obtained from the overlying glacial drift deposits. Yields per well are not large from the near-surface sedimentary rock aquifers, but the Dakota Sandstone, present at depths of about 2,800 to 3,200 feet, could provide large quantities of sodium sulphate type water.

The seven major aquifers in buried ancient channel deposits generally consist of sand and gravel that averages 30 feet in thickness. Thickest accumulations are along the northeastern flanks of the channels. Ground-water movement is west to southwest. The best areas for development are along the central axes of the channels and as near as possible to the recharge areas, that is, those areas where water enters the aquifers from the surface.

Surficial sand and gravel deposits, generally less than 20 feet thick, form four major aquifers. At places these serve as excellent recharge areas for deeper aquifers. In addition, four major aquifers composed of alluvium mixed with sand and gravel occur in the stream valleys along the western border of the county. The best areas for development are near the Missouri River where the river provides recharge of good quality water.

About 7 million acre-feet of water is stored in glacial drift and alluvial aquifers underlying almost 150,000 acres in Burleigh County. About half of this water would be available to properly constructed wells.

Lignite from the Tongue River Formation is a valuable mineral resource in Burleigh County. Coal is being strip-mined in the Wilton area (Fig. 13). "Scoria," or clinker, made up of baked sediments formed adjacent to the burning coal seams, occurs east of Wilton (Fig. 14) and is used for surfacing roads.

No commercial oil production has yet been found. Boulder erratics and resistant sandstones can be used as riprap. Slabby sandstone has been used locally for a decorative building stone. Clay deposits are abundant but are not being utilized.

FIGURE 13. Lignite strip mine in the Tongue River Formation near Wilton, North Dakota (Stop 12, Field Trip 4).

FIGURE 14. Scoria (rock that has been baked by burning lignite) in the Tongue River Formation near Wilton, North Dakota (Stop 13, Field Trip 4).

Field Trip 1

Southwest Burleigh County--Bismarck to McKenzie

Road Log

Miles	Description of Stops
	Bismarck. Built mainly on the Cannonball Formation (sandstone, siltstone, shale) from Broadway northward; built upon the Penitentiary gravel and Wachter alluvial terraces from Broadway southward.
0.0	Main and Airport Road. Travel south on Airport Road, which is on the Penitentiary Terrace. It is the highest (1,680 feet elevation) and thickest (170 feet) gravel terrace deposit in the Missouri River Trench along Burleigh County.
1.2	Lincoln Terrace (Fig. 16). Second highest (1,660 feet elevation) and second thickest (150 feet) gravel terrace deposit.
0.3	Turn right (west). Municipal Airport is to the east. Note gravel pits in terrace along the road for next 0.5 mile.
0.5	Turn left (south). Wachter Terrace is to the west. Lincoln Terrace for next mile. Note steep terrace escarpment (edge).
0.4	STOP 1. Lincoln Terrace gravel exposures. Note the width of the trench floor (7 mi.). Observe the composition and appearance of the terrace deposit. Leave pit, continue south.
0.6	Escarpment of Lincoln Terrace. Travel on Wachter Terrace.
0.2	Turn left (east).
0.4	Escarpment of Lincoln Terrace. Travel by Ft. Lincoln Nursery and Military Reservation.
0.7	Turn right (south). Ground water irrigation area, two wells, one on each side of the road. Aquifer in terrace gravels.
1.6	Floodplain. Apple Creek has cut through Lincoln Terrace and has eroded the steep walls of the sedimentary rock bluffs. These walls contain excellent exposures of sedimentary rocks.
0.4	Sedimentary Rock bluff. STOP 2. Hell Creek, Ludlow, and Cannonball Formations (Fig. 6). Base to middle of hill is Hell Creek Fm., upper hill is Cannonball Fm., with a thin Ludlow Fm. in between them. Note the slope erosion and the formation bedding, composition, and color. Leave stop, continue south up bluff slope.
1.0	

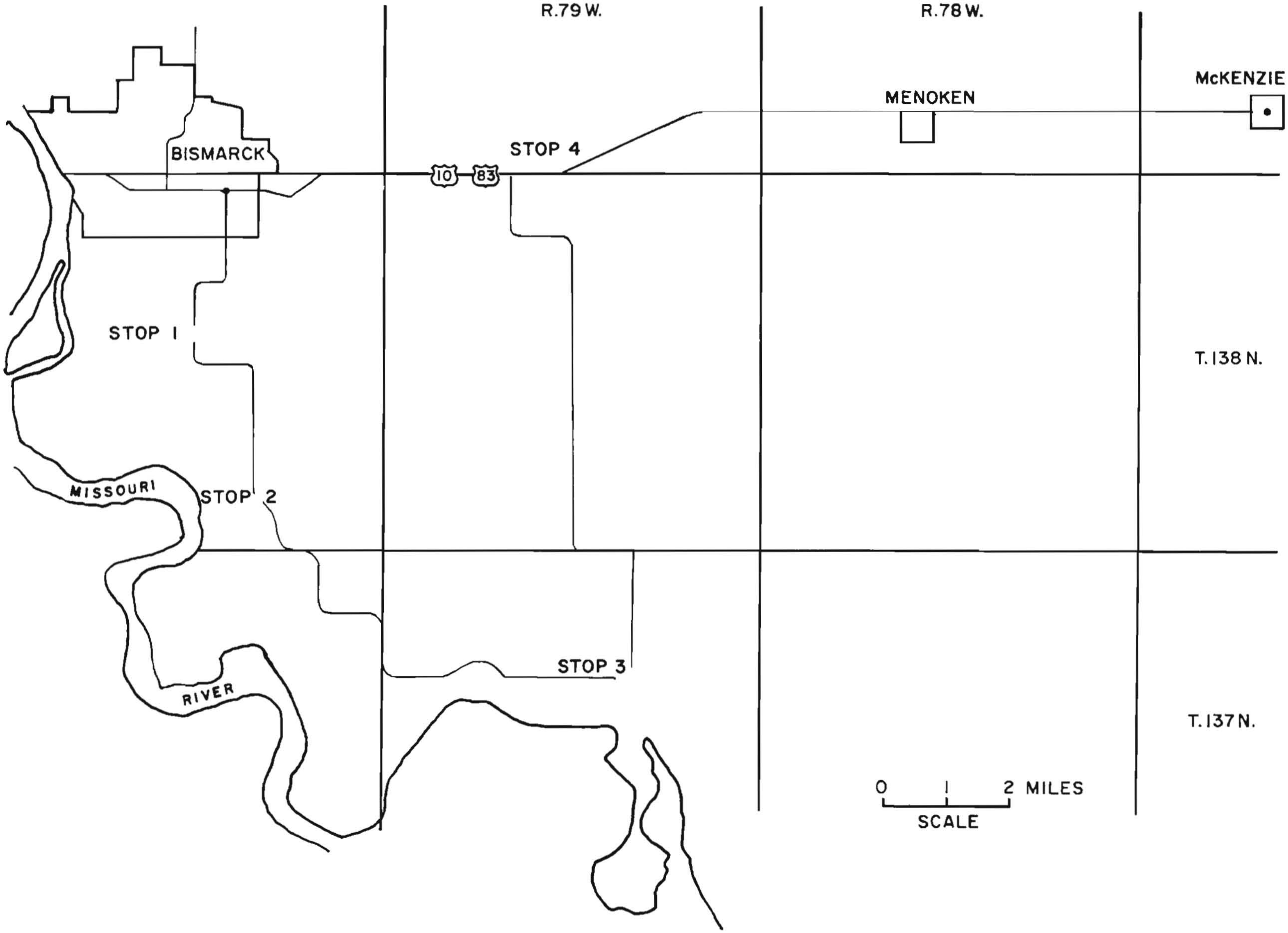


FIGURE 15. Route Map, Field Trip 1, Burleigh County.

FIGURE 16. Lincoln Terrace south of Fort Lincoln (flat surface in the foreground). View is south toward Apple Creek.

Turn left (east). Annunciation Priory on hill crest to the right. Follow main road, curves south in a mile.

1.7

Turn left (east). Follow main road, curves south in a mile.

2.0

Turn left (east). Two isolated small pinnacles of Hell Creek Fm. Note the gray color which suggested the local name "Somber beds."

0.5

Upland valley. Probably a preglacial valley and meltwater trench now covered by windblown sand.

1.5

Dune sand. Low rounded mounds of sand. Also, a few exposures of Hell Creek Formation.

2.4

Turn left (north). Schoolhouse.

0.2

STOP 3. Sand dune and blowout (Fig. 17). Note the dune shape, sand size and color, deflation basin, and vegetation. Leave dune, continue north.

1.8

Turn left (west). Sedimentary rock hill is made of the Cannonball Fm.

1.0

Turn right (north). Sand dunes and blowouts.

1.0

Cannonball Formation. Note roadcut exposures for next mile.

1.0

Glacial till on older sedimentary rocks.

1.2

Dune sand.

0.9

Hell Creek Formation. Note the narrow abandoned valley ahead.

0.3

Spillway. One of three major water outlets for Glacial Lake McKenzie. The other two are Glencoe Trench and Badger Creek Trench.

0.4

Trench drainage divide. Composed of glacial till and outwash gravel.

0.2

Turn left (west). Travel on former U. S. Highway 10.

0.3

Apple Creek floodplain.

0.7

Turn right (north).

1.0

Turn right (east). Travel on U. S. Highways 10 and 83.

1.2

Deep road cut into Cannonball Fm. and glacial outwash gravel.

STOP 4. Molluscan shell site and Apple Creek meltwater trench. The shells are mostly Pleistocene (Ice Age), but a few are much older reworked Paleocene shells. The shells are most abundant in the sand on the north side of the road. Apple Creek trench was a major meltwater route. A thick valley fill (150 feet) of glacial outwash gravel and alluvium occurs in this partly filled trench. Leave site and continue east. For the next 2.8 miles the route is along and within Apple Creek valley.

FIGURE 17. Sand dune and blowout southeast of Bismarck (Stop 3, Field Trip 1).

FIGURE 18. Prison Farm and Wachter Terraces and the Cannonball Formation cliffs along the River Road north of Bismarck (Field Trip 3).

2.8

McKenzie proglacial lake plain. Travel on this lake plain as far as McKenzie.

2.1

Pothole or kettle in lake plain. Formed from an isolated buried block of ice.

0.6

Menoken.

4.0

McKenzie Slough.

1.5

McKenzie. Built on a lake plain.

ADDITIONAL POINTS OF INTEREST IN SOUTHWEST BURLEIGH COUNTY

1. State Penitentiary. East of Bismarck on U. S. Highway 10 and 83.
2. Oahe Dam Reservoir. Southeast of Bismarck along the Missouri River near the Emmons County line.
3. State Capitol.
4. Fraine Barracks. West side of Bismarck.

Field Trip 2

Southeast Burleigh County--McKenzie to Driscoll

Road Log

Description of Stops

McKenzie. Built on a lake plain. This area was once covered by a proglacial lake, Glacial Lake McKenzie.

0.0

U. S. Highway 10 and 83 and a north-south section line road junction in McKenzie. Travel east on the highway which is on the lake plain.

1.6

Glacial outwash plain. This is part of a continuous gravel apron along the distal edge of the Long Lake end moraine.

0.5

Long Lake end moraine. This is the distal (outer) edge of the middle loop. Note the boulders on the ground and the rising slope of the land.

0.9

Turn right (south). Travel down the end moraine slope.

1.1

Glacial outwash plain (gravel).

1.3

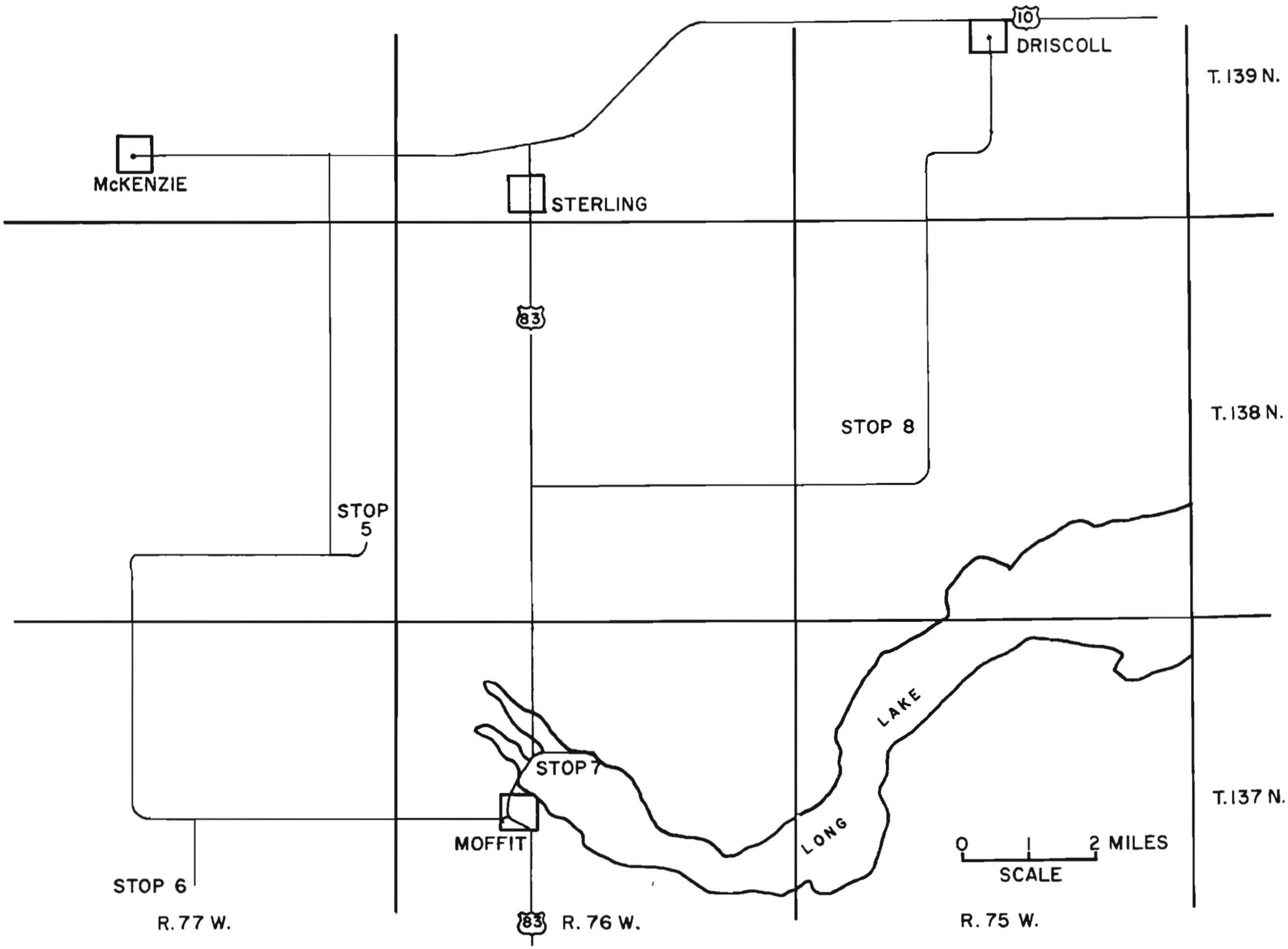


FIGURE 19. Route Map, Field Trip 2, Burleigh County.

McKenzie lake plain.

1.0

Random Creek. Data from a test hole drilled at this bridge revealed the thickest (231 feet) valley fill in the county. A significant meltwater trench breached the middle loop of the Long Lake end moraine through Random Creek trench. This creek dissects the lake plain and flows into Apple Creek.

1.6

Ground water irrigation wells. Three irrigation wells (1/8 mile northwest, 1 1/2 miles northwest, and 1/8 mile southeast) have tapped into buried gravel aquifers and pump up to 1,000 gallons per minute.

0.7

Long Lake Creek. One of two creeks that dissect the lake plain.

0.3

Turn left (east). Travel 0.5 mile east to gravel pit on north side of road.
STOP 5. Gravel pit. Exposure of gravel overlain by lake clay. Similar to the buried gravels being tapped for ground water irrigation. Leave pit, go back to road junction (0.5 mile west), and continue west. Cross Northern Pacific Railroad tracks.

2.0

Edge of lake plain and McKenzie Basin. A thin glacial till cover occurs on the Hell Creek Formation.

1.0

Turn left (south).

1.0

Dune sand. Eastern edge of a large sand dune area that extends six miles to the west.

0.4

Cross Soo Line Railroad tracks.

0.1

Upland sedimentary rock area. Hell Creek Formation. A few patches of till.

2.5

Turn left (east).

1.0

Turn right (south). Schoolhouse at road junction. Travel to the sedimentary rock ridge.

1.0

Cannonball Formation ridge crest.
STOP 6. Paleocene Fossil site. Fossil crabs, mollusks, bones, and sharks' teeth have been collected in this sand blowout on the west side of the road. Leave exposure, turn around, and go back north to the road junction at the schoolhouse.

1.0

Turn right (east). Schoolhouse. Travel toward Moffit. Note a few glacial boulders on the Hell Creek Formation surface.

4.1

McKenzie lake plain.

0.6

Moffit. Built upon McKenzie lake plain. Adjacent to a tremendous meltwater trench cutting through the Long Lake end moraine. The site of Long Lake National Wildlife Refuge.
Turn left (north). Travel on U. S. Highway 83.

1.0

Turn right (east). Cross Long Lake Creek.

1.0

Turn right (south) off main road onto a trail to top of knob with a lookout shelter and

picnic grounds. Stop here.
STOP 7. Fox Hills Formation and Long Lake meltwater trench. Observe indurated thin bedded sandstone (more Fox Hills Formation exposures are 1.5 miles east of here). Note the huge trench through which an enormous amount of meltwater flowed from the wasting glaciers. Leave lookout shelter, return to main road, and head back toward U. S. Highway 83.

1.0
Turn right (north). Travel on U. S. Highway 83. McKenzie lake plain.

4.0
Turn right (east). Travel along the middle loop margin of the Long Lake end moraine.

1.5
Sheet moraine. A flat till plain.

2.0
Distal margin of south loop of Long Lake end moraine. Note the sharp rise in slope of this end moraine, the north-south till ridges, and the boulders on the ground.

2.5
Turn left (north). Note the peak one mile ahead, next stop.

1.0
STOP 8. Perched lake deposit. An isolated peak of lake clay elevated as much as 100 feet above the adjacent end moraine surface. Lake sediments were deposited in an ice-walled lake. When the ice melted, only a knob of clay and silt remained. A test hole here revealed 35 feet of clay upon 153 feet of till. Note the bedding. Two similar deposits occur in the next 2 miles. Leave stop, continue north. Observe kettles or potholes and till ridges along the way.

1.0
Perched lake deposit. Hill on east side of road. This is an interlobate area between the south and middle loops. Topography is quite rugged.

0.6
Perched lake deposit. Hill with tower, west side of road.

2.4
Turn right (east).

1.0
Turn left (north). Travel to Driscoll.

0.3
Proximal (ice side) of middle loop of Long Lake end moraine. Enter ground moraine. Hills to the west are the middle loop of the Long Lake end moraine.

ADDITIONAL POINTS OF INTEREST IN SOUTHEAST BURLEIGH COUNTY

1. Chaska Historic Site. Four miles north of Driscoll.

2. Long Lake National Wildlife Refuge. Headquarters one mile south and three miles east of Moffit.

Field Trip 3

West Central Burleigh County--Bismarck to Baldwin

Road Log

Description of Stops

Bismarck Junior College. Built on the dissected sedimentary rocks of the Cannonball Formation (sandstones, siltstones, shales). Note the surface boulders. A half mile east lies a meltwater trench. Leave college, travel north (0.5 mi.) and northwest (0.9 mi.) toward Pioneer Park.

1.4

Pioneer Park.
STOP 9. Cannonball Formation. Roadcuts along this winding road as it descends toward the river provide excellent exposures. Note color, bedding, and composition. Fossil evidence in the form of *Halymenites*, a branching, tubelike, rusty, (seaweed?) form. Leave park, travel north on River Road. Terraces on the west are Prison Farm and Wachter Terraces. Steep banks on right are the Cannonball Formation. Across the river is the Mandan Refinery.

4.6

Burnt Creek bridge. This valley was a glacial meltwater trench during the Wisconsin glaciation.

1.3

Turn right (north) off of River Road. This gravel road makes three bends before the next junction (0.3 mile north, 1 mile east, 0.5 mile north, 1 mile east). Cannonball Formation exposures.

2.8

Turn left (north). This road makes two bends before next stop (one mile north, 0.5 mile west, 0.5 mile north).

2.0

STOP 10. Cannonball and Tongue River Formations (Fig. 6). Excellent exposure of formation contact. Note very thin bedded shales and siltstones overlain by a cross-bedded friable sandstone (basal sandstone of Tongue River Formation) that is easily eroded by the wind. This displays the change in deposition from a marine sea to a continental shallow waterway that was swampy at times (hence the lignite). Leave exposure, travel north. Note excellent exposure of Tongue River Formation along the road (especially 0.3 mile north).

0.5

Riverview School No. 1.

1.0

Turn left (west). Ball Butte north of road junction.

0.3

Coal Butte. Coal seam exposed on west slope. Molluscan fossils occur in roadcut at crest of butte. Clams in north roadcut.

1.0

Basal sandstone. Note blowouts along curve in road. Cross-bedding is well-displayed. There are several bends in the road; travel west to River Road.

1.5

River Road. Turn right (north). Gently sloping alluvial covered sedimentary rock terraces and the Prison Farm Terrace occur on west side of the road.

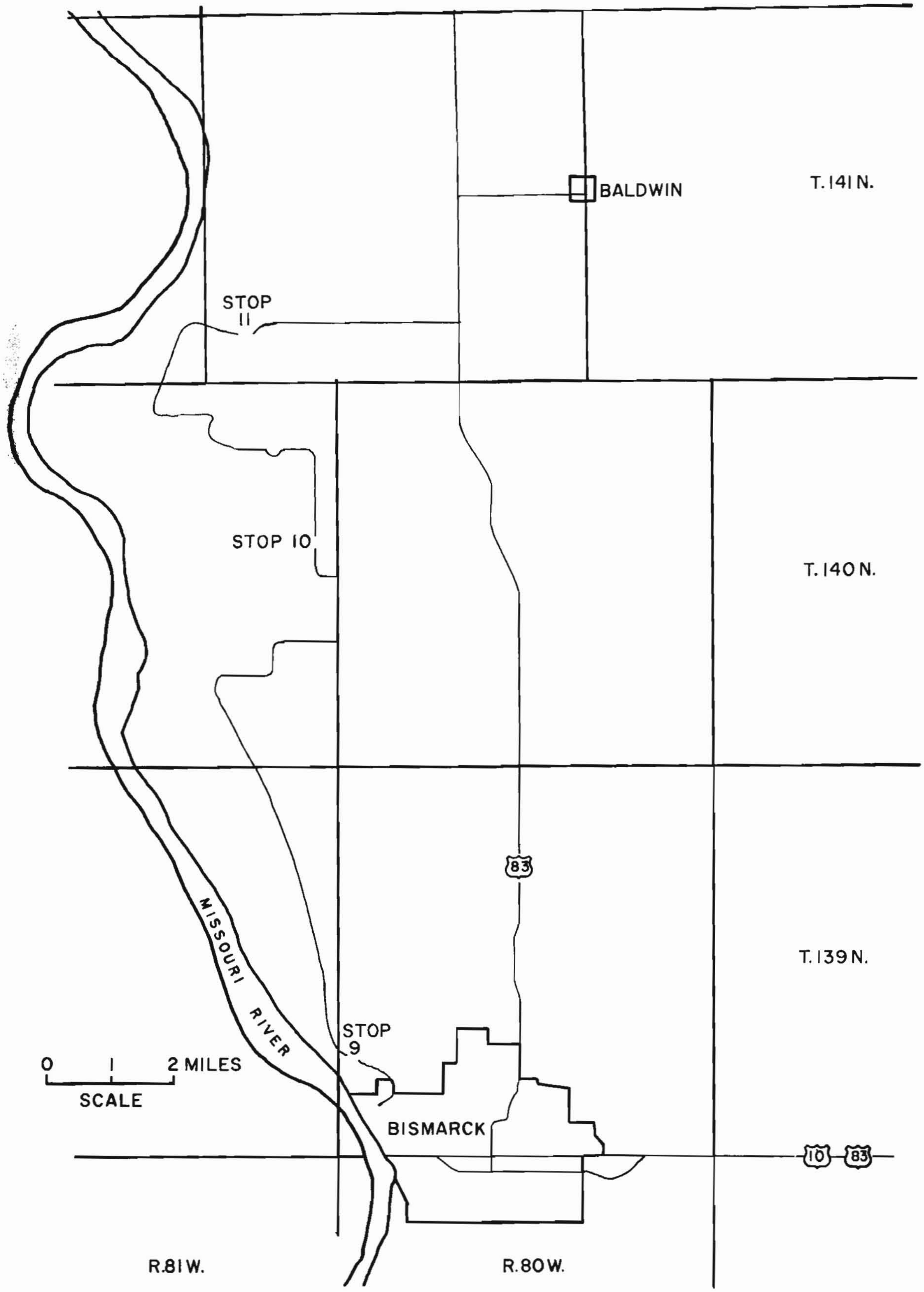


FIGURE 20. Route Map, Field Trip 3, Burleigh County.

1.5

Curve in road to the east. Note the trench floor. Here it is 2.1 miles wide, whereas 4 miles upstream it narrows to 1 mile wide. South of Bismarck it is 7 miles wide.

0.2

Road junction. Leave River Road (it continues north) and travel east toward the buttes ahead.

0.8

STOP 11. Tongue River Formation. Exposed here is the resistant butte-capping unit containing a cross-bedded sandstone and conglomerate, the basal sandstone unit, and the formation contact. Climb butte on north side of road to observe the resistant unit. Leave butte, travel east up the steep, dissected, trench wall.

1.7

Edge of the Missouri River Trench. Note the difference in dissection (erosion) east of the trench. Till-covered upland or sheet moraine.

1.6

U. S. Highway 83. Turn left (north). Travel on highway.

1.0

Road junction. Tongue River Formation. Fossils can be collected in roadcuts 0.2 mi. north or 0.5 mi. east. Reworked or detrital fossils can be collected in gravel piles 1.6 miles east.

1.0

Turn right (east) off of highway and travel to Baldwin. Lignite beds in roadcut.

2.0

Baldwin. Built within Burnt Creek meltwater trench. Basal sandstone of Tongue River Formation occurs here.

ADDITIONAL POINTS OF INTEREST IN WEST CENTRAL BURLEIGH COUNTY

1. Double Ditch Indian Village Historic Site. 10 miles north of Bismarck on River Road.

2. River Road. From Bismarck north to McLean County. One of the most beautiful and scenic routes in the county.

3. Keever Butte. 5 miles south and 2 miles east of Baldwin. Tongue River Formation.

4. Solberg Butte. 6 miles south and 6 miles east of Baldwin. Tongue River and Cannonball Formations.

5. Indian Mounds. East of Pioneer Park and River Road on the crest of the steep bank.

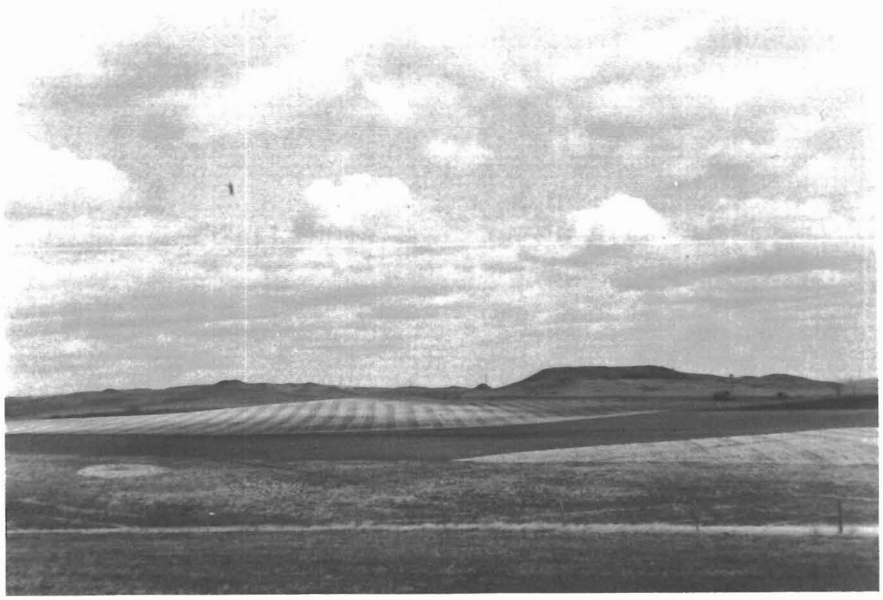


FIGURE 21. Burnt Butte and badlands north of Bismarck.

FIGURE 22. Scoria overlain by baked glacial till (Stop 13, Field Trip 4).

Field Trip 4

Northern Burleigh County--Wilton to Wing

Road Log

Miles — Description of Stops

Wilton. Built on a thin till plain (sheet moraine) that overlies the Tongue River Formation, which here is 215 feet thick and contains 5 coal beds.

0.0

Soo Line Railroad crossing at the east edge of town on the road to Regan. Travel east.

0.7

Strip mine dumps.

0.8

Road junction to Wilton city dump in strip mine pit. Take an excursion through the abandoned strip mine. Turn left, take road through the mined area, turn around and return to road junction. Note sedimentary rock bedding, amount of overburden, mine cuts, and dump piles. From road junction, travel east on road to Regan.

1.0

Turn right (south).

0.6

Circular depressions on west side of road (Fig. 24). Caused by the caving of coal mine tunnels.

0.4

Road junction. Leave the main road, drive south and southeast into strip mine area.

STOP 12. Ecklund Coal Mine (Fig. 13). Active lignite mining operation. Dozers and scrapers strip off overburden from coal bed. Till is well-exposed in the pit walls, especially near the road junction. Leave pit, return to road junction, travel east.

1.6

STOP 13. Scoria pit. North side of road. Baked sediments from the burning of underlying coal beds (Fig. 22). Note the scoria color, hardness, and composition. Note the overlying till with boulders. Note any baked till; if so, burning has taken place since glaciation. Leave pit, travel east.

0.4

Turn left (north). Next 8 miles will be across sheet moraine.

1.4

Northern Pacific Railroad tracks.

3.6

Turn left (west). Meltwater trench.

3.0

North Dakota Highway 41. Turn right (north).

0.5

STOP 14. Tongue River Formation fossil shell site (Fig. 25). East roadcut. Sandstone, shale, limy claystone. Very fossiliferous, mostly gastropods and pelecypods (snails and clams). Leave site, travel north.

0.8

Meltwater trench along distal (outer) margin of dead-ice moraine.

0.2

Dead-ice moraine.

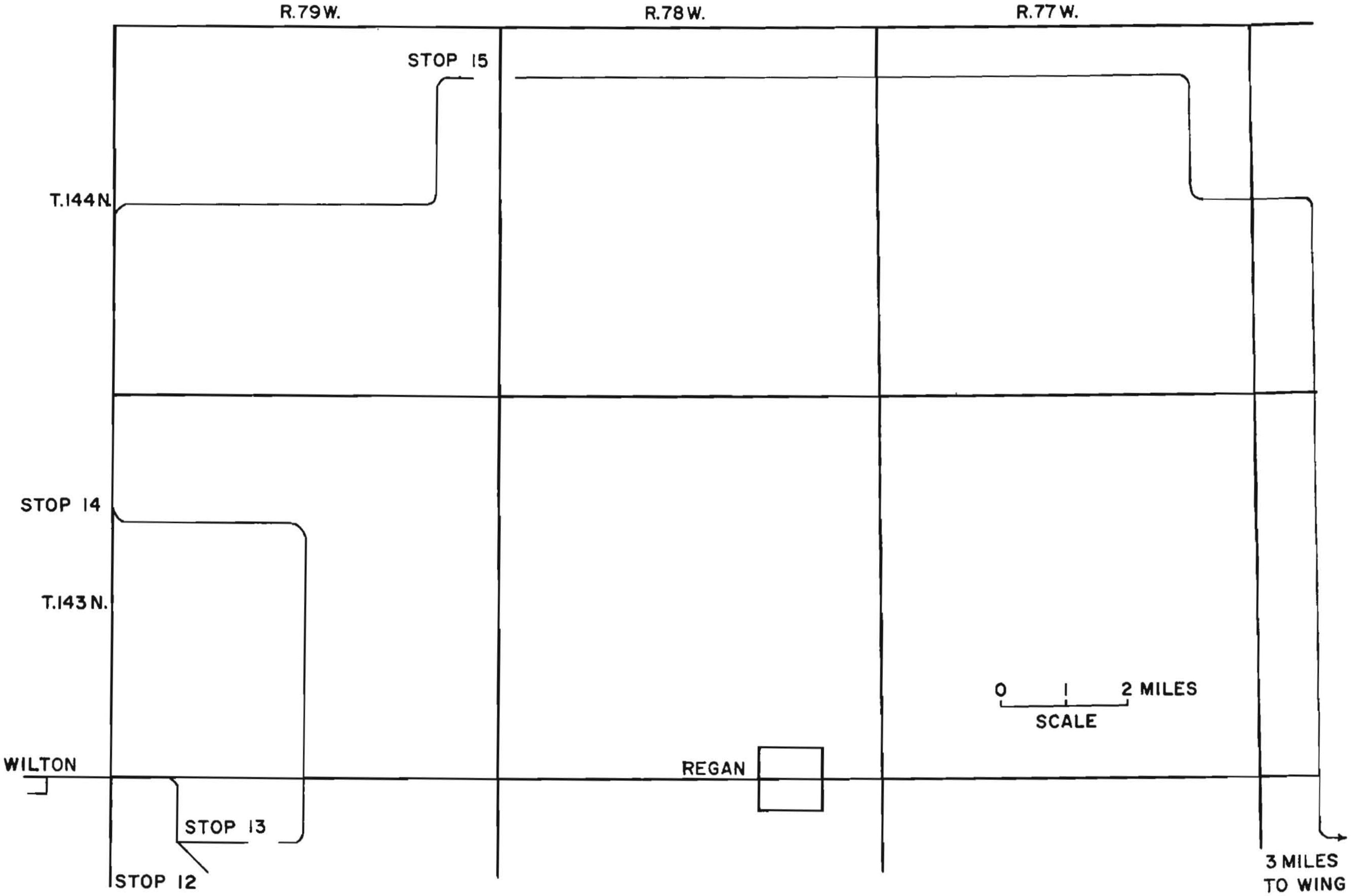


FIGURE 23. Route Map, Field Trip 4, Burleigh County.

2.2

Painted Woods Creek meltwater trench. This was a significant meltwater drain at the end of the Ice Age.

0.3

Dead-ice moraine.

1.0

Turn right (east) off of North Dakota Highway 41. Dead-ice moraine.

5.0

Turn left (north) after crossing meltwater trenches. School No. 5.

2.0

Kettle chain. Turn right (east). Several steep-sided aligned kettles. These were formed when debris-covered ice blocks melted, causing collapse of the overlying materials.

0.4

STOP 15. Pleistocene (Ice Age) fossil site. South roadcut in the middle of the road curve. The shells at this site were determined to be 10,100 years old by measuring the amounts of radioactive materials in them (Carbon 14 method). Leave the site, travel east along kettle chain.

1.0

Dead-ice moraine.

2.7

Glacial outwash gravel plain in Painted Woods Creek valley.

2.0

Dead-ice moraine. Note hummocky ("knob and kettle") glacial drift topography. Numerous kettles occur in a hilly till plain.

2.1

Johns Lake Church.

2.9

Collapsed glacial outwash topography. This hummocky gravel occurs along the margin of the Streeter end moraine which is the belt of ridged till hills to the north.

1.1

Turn right (south). Streeter end moraine to the north.

0.4

Dead-ice moraine. Pelican Lake to the east.

1.6

Turn left (east). Schrunk School No. 2.

0.9

Collapsed glacial outwash topography. This is Streeter outwash that was deposited on slightly older stagnant ice. When the buried ice melted, the outwash plain "collapsed" (was let down unevenly). The result was a hilly gravel plain.

1.1

School No. 2. Turn right (south). Bunce Lake to the west. Next 5.1 miles are along collapsed outwash.

5.1

Dead-ice moraine.

1.9

Tongue River Formation.

1.0

Haystack Butte on east side of road. Note exposures in roadcuts.

0.7

Dead-ice moraine.

0.7

FIGURE 24. Circular depressions caused by tunnel collapse of an abandoned coal mine in the Wilton, North Dakota area (Field Trip 4).

FIGURE 25. Fossil gastropod shells (snails) of the Tongue River Formation near Wilton, North Dakota (Stop 14, Field Trip 4).

Northern Pacific Railroad crossing. Collapsed outwash.

0.5

Turn left (east). Travel toward Wing.

0.7

Dead-ice moraine.

1.3

Collapsed outwash and dead-ice moraine.

1.0

Wing. Built on dead-ice moraine and collapsed outwash topography. A gravel ridge on the west side of town is an ice-contact feature (it formed in a crack in the ice). The underlying sedimentary rocks are the Cannonball Formation, and exposures of it along North Dakota Highway 14 are best seen from the edge of town to 9 miles south.

ADDITIONAL POINTS OF INTEREST IN NORTHERN BURLEIGH COUNTY

1. Kames (conical hills of gravel). Seven miles south and 7 miles west of Wing. In this three-square mile area containing many sedimentary rock (Tongue River Formation) ridges, three excellent groups of kames are present. Gravel pits mark their locations.

2. Fossils. Three miles east and 3.5 miles north of Wing. Ice Age shells in west roadcut along a kettle rim. The shells are 9,990 years old (Carbon 14 method).

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