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Wilson M. Laird, State Geologist

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Guidebook for Geologic Field Trip in the JAMESTOWN AREA, NORTH DAKOTA

by

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GEOLOGIC FIELD TRIP IN THE JAMESTOWN 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 Jamestown. Emphasis is placed on geological phenomena on this trip, especially the glacial materials associated with the "Altamont" moraine west of Jamestown and the Pipestem Creek drainage system. This trip covers about 85 miles and follows U. S. highways 52 and 281 out of Jamestown and thence west up onto the "Altamont" end moraine at the edge of the Missouri Plateau. From the moraine the route goes through the James River valley, past Spiritwood Lake, then to U. S. highway 10 and return to Jamestown via the Stutsman County Recreation Area.

The writer gratefully acknowledges the assistance of Dr. Wilson M. Laird, State Geologist, in preparing this guidebook.

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

Geological Processes Important in the Formation of Landscape in this Area

Before discussing the geological history of this area, it is necessary to discuss briefly some of the processes which have gone into the making of the landscape which we see today. Generally speaking, there are any number of geological processes which would be discussed, but the two most important from the standpoint of landscape formation in this area are the work of running water and the work of glaciers.

The work of running water can be largely described as that work done by streams and running water other than streams, particularly sheetwash. When rain falls it may do any one of several things. It may sink into the ground, it may evaporate, or it may run off. If the first two things happen, it is not of immediate interest to us; but if run-off occurs, it is certainly of interest to us from the standpoint of geological work done.

Water falling on an initial slope first runs off in the form of sheetwash; however, as time goes on and initial irregularities are accentuated by the water running off in a sheet, the run-off tends to become concentrated in certain well-defined paths. These paths are used time and time again as more and more water falls on this slope until an intermittent stream is developed. A stream which flows only part of the year is classified as an intermittent stream.

When an intermittent stream cuts down deeply enough so that it intersects the underground water table, the underground water table will then feed the stream and it will flow the year around. This, then, is known as a permanent stream.

In the early stages of stream development, the cross sectional topographic profile of a stream will tend to be V-shaped. In other words, the stream is still actively cutting downward and is not swinging from side to side cutting the banks. Actually the stream itself does a relatively small amount of cutting as far as the V is concerned since it cuts only at the bottom of the V. Most of the material from the sides of the valley is brought into the stream by the processes of mass wastage which include creep, landslides, and rockfalls. This material is dropped into the stream and carried away by the stream. The stream, therefore, acts not only as an eroding* agent but also as a carrying agent. This stage of stream development is called youth, and the stream is said to be youthful.

As time goes on the stream becomes older from the standpoint of topographic age. It reaches down to what is known as base level. This is the lowest level to which a stream can cut; and it is determined by the level of the body of water into which the stream flows or even temporarily by some other obstruction such as a layer of hard rock. Base level is reached only at the lower end of a valley, for enough slope must remain upstream to maintain the flow of water. At this stage the stream begins to swing from side to side, cutting first one bank and then the other. The end result of this is a valley which is more U-shaped than V-shaped and tends to have a rather broad, flat bottom. This is the mature stage of stream development.

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*Erosion in the broadest sense includes all of the processes by which earthy or rock material is loosened and removed from any part of the earth's surface.

This bottom, of course, is first cut by the actual lateral swinging of the stream, however, the flatness is further accentuated by the deposition of material on the stream bottom. If the area in which the stream flows is uplifted, the stream will again start downcutting and will form a new valley bottom. The sands, gravels, and clays deposite on the old valley floor will be cut away leaving banks on either side which are known as terraces.

The second major process which has been most important in the formation of the landscape in this area is that of glaciation.

A brief description of how glaciation works is in order at this point. During the Pleistocene period of geologic time (See Plates 2 and 3), to the north of us in Canada there were large accumulations of ice each year until they reached thicknesses of several miles. This was caused by the fact that there was more snow accumulating during the winter than was melting in the summer. As a result of this, large ice masses accumulated, similar in many respects to those which are found in the Antarctic continent today as well as on the ice cap of the island of Greenland.

As the ice accumulated to great thicknesses, it began to flow outward by plastic deformation within the ice mass itself. The edges of the ice sheet moved most rapidly and tended to conform to pre-existing topography. As a result of this the edge of the ice sheet became quite lobate or irregular.

As the ice moved forward, it did a considerable amount of erosion and picked up a great amount of material and incorporated it in the body of the ice. This material was ground up as the ice moved along with some of the material being ground very fine like clay. Other stones which were harder tended to resist this grinding action. Such material, when deposited by the glacier, forms an unsorted, non-stratified sediment called till. Till is composed of stiff clay full of rocks varying in size up to boulders. Of particular interest in this area is the predominance of granite and limestone boulders in some of the glacial till and in the outwash associated with the glacial till. These materials are not native at the surface in North Dakota; and it is apparent that they have been carried by the glacier to their present position, many hundreds of miles in some instances, south of the outcrop from which they came originally. In other exposures of till, especially those near the bedrock, fragments of Pierre shale predominate.

When the edge of the ice sheet reached its maximum extent, it began to drop material rapidly (See Plate 4, Fig. 1). This was particularly noticeable at the forward edge of the glacier where the melting probably just about balanced the forward flow. This resulted in a deposit having a very characteristic knob and kettle type topography known as an end moraine. As the ice front moved backward on melting and then stopped temporarily, it left similar moraines, although somewhat smaller; these are known as recessional moraines.

Material deposited directly beneath the ice are spoken of as ground moraines. It has a swell and swale type topography and is not so pronounced in its relief as is the knob and kettle topography of the end or recessional moraines.

Water, of course, is important in modifying the effects of glaciation. As the ice melted, great floods of water washed out in front of the ice tending to carry with it much of the material which was imbedded in the ice and also that which had been deposited in front of it. This material washed out in front of the ice tends to be somewhat rudely bedded and is referred to as outwash. Other glacial features associated with material being washed out on or near the glacier front are kames and eskers.

Kames (~~See Plate 5, Fig. 1~~) are usually formed by streams of water on top of the ice which flow into a hole in the ice known as a moulin or plunge hole. Some of the sands, gravels and clays carried by the water are deposited in the hole. When the ice walls melt the material in the hole will slump, and resulting deposit is a more or less cone-shaped mound, known as a kame.

As might be expected, kames vary a great deal in size. Kames as high as 120 feet and with a diameter of one third of a mile at the base, are known in North Dakota.

Eskers are the result of deposition by glacial streams flowing in or under the ice. With the melting of the glacier these deposits remain as long, narrow, winding, essentially flat-topped landforms.

One of the interesting things about the gravel in this particular area and one of the things which makes the gravel considerably less valuable for construction purposes is the presence of considerable amounts of Pierre shale pebbles. Shale pebbles break down on weathering and are thus useless for concrete aggregate. The gravel is useful for railroad ballast and gravel surfacing of road, however. The Pierre shale is the bedrock formation in this area and several outcrops of it will be seen in the course of the field trip.

GEOLOGY OF THE AREA

Preglacial Geology

The preglacial geology of this area will be described only briefly in view of the fact that there is relatively little known and not a great deal of it can be seen.

The Pierre shale formation is the bedrock of this particular area. This formation was deposited during the later period of Cretaceous time (See Plate 2 and 3). The Pierre formation consists of a gray, calcareous, fine grained, rather evenly but thinly bedded shale which in many places contains fossils. So far in this area, no fossils have been found, but the outcrops are relatively few and these outcrops have not been extensively studied for the occurrence of fossils.

This formation was laid down in a great inland sea which extended the entire length of North America from the Arctic to the Carribean. The deposits consist of very fine sediments such as clays and silts in this particular area but westward towards the source of the sediments which was located in the vicinity of the Rocky Mountains, the materials became coarser. While this formation is not known to contain oil or gas in North Dakota, its equivalents in the southwestern corner of North Dakota and in Wyoming and Montana do contain oil and gas.

Of special interest in the Pierre is several layers of bentonite. Bentonite is a kind of sticky clay formed from the decomposition of ash ejected from volcanoes to the west near the end of the Cretaceous when the Rocky Mountains were being formed. It is white, light green, or light blue when fresh but on exposure near the surface becomes cream colored. Five of these bentonite beds are exposed along the James River and one of them can be dug from the Pierre shale at Stop 5.

From the end of Cretaceous time up to the recent there was apparently little or no deposition in this particular area. In other words, the main geological process going on was that of erosion of the land surface by running water.

The exact preglacial topography of this area is not known. However, if we compare in our minds the probable appearance of this area without the glacial cover, with other unglaciated areas, we probably would get some ideas as to what the preglacial topography looked like. In preglacial time, the country was rolling with rather sharp sided buttes. Very likely, the country may have looked something like southwestern North Dakota or northwestern South Dakota does today. In this area the most pronounced preglacial feature was the bedrock escarpment marking the edge of the Missouri Plateau to the southwest. The height of the escarpment has been increased by the deposition of glacial morainal material on it.

Undoubtedly, the preglacial stream patterns were dendritic or in other words the streams and tributaries make a pattern on a map more or less like the branches of a tree and the main trunk. Unquestionably, present day Pipestem Creek, the James River and Seven Mile Coulee are preglacial valleys which were partially buried by the ice and the material which the ice carried. The course of these preglacial drainage systems is not fully known. Their headwaters was to the north, perhaps in the Turtle Mountain area, and they flowed together just south of Jamestown and hence into South Dakota to empty into what is now the Missouri River.

Glacial Geology of the Area

The glacial features of the area are chiefly the result of one of the most recent advances of the ice sheet. Very likely the material forming most of the moraines in this area was deposited during the latest advance of the Pleistocene ice.

The principal end moraine in this area is part of the great complex of terminal moraines known in South Dakota as the Altamont moraine. This great band of end moraines, lying on the preglacial bedrock escarpment and thus forming the Coteau du Missouri, sweeps in an arc through North Dakota and is aligned with a similar set of moraines known as the Max morainal complex which trends northwest from Max, North Dakota, to the northwest corner of the state (See inset map Plate 1). In the Jamestown area, all of these moraines have not been mapped in detail, and hence the extension of the South Dakota name, Altamont, without further field tracing is not fully justified. The part of this morainal system covered in this trip northwest of Jamestown has been named the Hawk's Nest moraine after the Hawk's Nest Hills southwest of Carrington. The Hawk's Nest end moraine lies about 10 miles west of Jamestown. The topography of this end moraine is markedly more rugged than that of the Drift Prairie in the immediate vicinity of Jamestown. While the Drift Prairie is characterized by swell and swale topography, the end moraine is characterized by an abundance of kettle holes (See Plate 5, Fig. 1).

As melting exceeded southward flow of the glacier the ice front retreated northward, although the ice within the glacier pushed always southward. Where it paused in the northward retreat, the glacier formed recessional moraines. Two of these are crossed in this trip. One of these is the Antelope moraine west of Jamestown, and the other the Kiester recessional moraine east of Jamestown.

As the glacier spread southward the preglacial stream valleys in the area became clogged with till and outwash sand and gravel. As the glacier started to retreat, large quantities of meltwater cleared or partially cleared, the old channels forming the series of terraces seen in Pipestem Creek valley, the James valley and in the valley of Seven Mile Coulee.

In glacial times this stream did much more work than the James River which is much the larger today. While the James and Seven Mile Coulee channels were still blocked by ice, Pipestem Creek was engaged in active erosion.

The terraces are numbered as in the diagram below. Thus erosion of the till in the higher portion of the channel formed Terrace No. 4 lying just below the upland. Terrace No. 3 consists of cross-bedded outwash sand and gravel and lies from 15 to 50 feet below the No. 4 level. Terrace No. 2 lies 20 to 45 feet below Terrace No. 3, and it consists of stratified sand and silt. The present stream channel is the No. 1 level and it lies from 5 to 25 feet below Terrace No. 2.

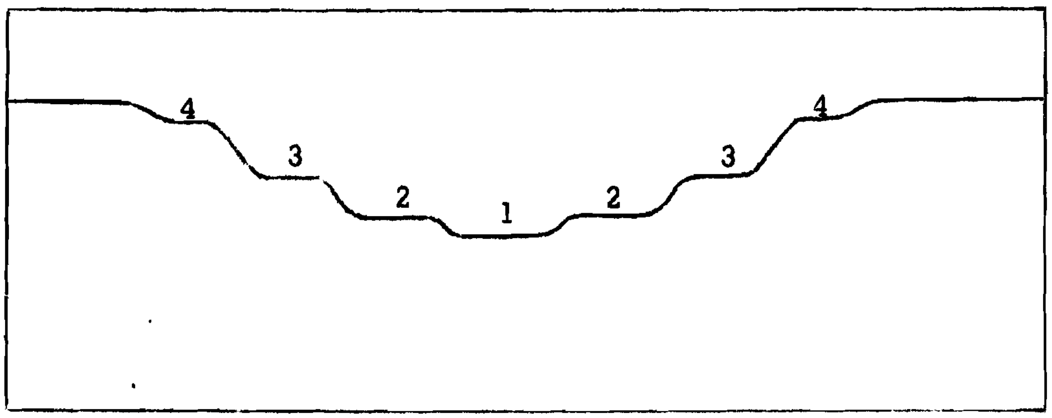


Diagram showing the various terrace levels in Pleistocene drainage channels of the Jamestown area.

Where the preglacial drainage channels have not been completely re-excavated such as in the old Seven Mile Coulee channel north of Spiritwood Lake, a series of lakes has been developed in the drift-choked channel. Spiritwood, Blue, and Medicine Lakes are lakes formed in this manner. Rush Island Lake north of the village of Spiritwood is also a lake now dammed up by glacial debris in a preglacial tributary of Seven Mile Coulee.

It is interesting to note that these several streams are nearly parallel north of Jamestown. This is partly due to the fact that they were preglacial streams flowing southward at the foot of the escarpment and partly because they reflect the shape of the edge of the ice lobe in this area. Their glacial history is that of streams flowing along the edge of the ice sheet. The history is very complex in this area, however, and much more work needs to be done to decipher the story of the Pleistocene or glacial age in this part of North Dakota.

REFERENCES FOR ADDITIONAL READING

General References

Emmons, W. H., Thiel, G. A., Stauffer, C. R., and Allison, I. S., 1955, Geology, Principles and Processes: McGraw-Hill Book Co. Inc., New York. Fourth Edition. (General text on physical geology).

Dunbar, C. O., 1949, Historical Geology: John Wiley & Sons, Inc., New York. (General text on historical geology).
Flint, R. F., 1957, Glacial and Pleistocene Geology: John Wiley & Sons, Inc., New York, (Advanced college text which, however, contains a wealth of readable information on glacial geology).
Hainer, J. L., 1956, The Geology of North Dakota: North Dakota Geol. Survey, Bull. 31. (General booklet on the geology of the state).
Longwell, C. R., and Flint, R. F., 1955, Introduction to Physical Geology: John Wiley & Sons, Inc., New York. (General text on physical geology).
Stovall, J. W., and Brown, H. E., 1954, The Principles of Historical Geology:Ginn and Co., Boston. (General text on historical geology).
Willard, D. E., 1921, The Story of the Prairies: Ihling Bros. Everard Co., Kalamazoo, Michigan. (Although out of date this book contains the geological story behind landscape formation in North Dakota).

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.

Specific References on this Area

Kresl, R. J., 1956, Geology of the Lower Pipestem Creek Area, North Dakota: North Dakota Geol. Survey, Rept. of Invest. 25.
Paulson, Q. F., 1952, Geology and Occurrence of Ground Water in the Streeter Area, Stutsman, Logan, and Kidder Counties, North Dakota: North Dakota Ground-water Studies, No. 20.
Todd, J. E., 1896, The Moraines of the Missouri Coteau and Their Attendant Deposits: U. S. Geol. Survey, Bull. 144.
Willard, D. E., 1909, Description of the Jamestown, Eckelson, and Tower Quadrangles: U. S. Geol. Survey, Folio 168.

JAMESTOWN FIELD TRIP ROAD LOG

0.00 Assemble on First Avenue North (U. S. highways 52 and 281) on the east side of street facing north just north of Third Street Northwest (U. S. highway 10 east).

.20

Turn left (west) on Fifth Street Northwest following U. S. highways 52 and 281.

.40

Cross James River and turn right (north).
Just west of this turn on the upland is located Fort Seward Historic Site. Fort Seward, named for William H. Seward who was Secretary of State under Lincoln, was in existence from 1872-1877. Manned by two companies of infantry, the fort served as protection for Northern Pacific Railway crews and early settlers in the James River valley, and as a railhead for Fort Totten 81 miles to the north.
Here the highway goes up out of the James River valley onto the general upland surface.

.30

Till outcrop west of road. Till is unsorted, unstratified (non-layered), stiff clay mixed with gravel. This material was laid down under the glacial ice or was dumped off the edge of the ice without being reworked by meltwater. Meltwater or outwash deposits tend to be washed clean of the clay that characterizes till; also outwash is layered or bedded while till lacks noticeable bedding.

.40

Note boulders in the fields to the east. These boulders are not shale which underlies the glacial deposits in this area but are igneous rocks (such as granite) brought down by the glaciers from Canada and hence are called glacial erratics.

3.20

Highway curves northwest. Here you are riding over ground moraine which is glacial debris spread by the glacier as the ice front receded to the north. Ground moraine is composed of both till and outwash and is characterized by the swell and swale type of topography you see here rather than the rougher topography of end moraine such as you will see later in the day. See Plate 6 for the eastern limit of the end moraine.

1.40

Turn left (west) across railroad tracks on gravel road. The low hill ahead is a recessional moraine. Recessional moraine is similar to ground moraine but is a slightly more pronounced topographic form caused by a slight pause in the retreat of the ice front enabling the glacier to dump more material. This is probably the Antelope moraine which is much more prominent in South Dakota.

.50

Small creek on west side of recessional moraine. Note the number of glacial erratics washed from this moraine.

2.10

The sandy hills to the south of the road are small kames. Kames are conical or rounded hills formed when outwash (sand and gravel) carried by meltwater is deposited in a plunge hole in the ice or off the edge of the glacial ice. Slumping of this material when the ice melts gives the rounded aspect to the hills.

.20

Good view of Pipestem Creek valley to the southwest. Note that it is a large valley with a small (underfit) stream in it. Pipestem Creek was a large preglacial river channel, and during the Pleistocene it was a major drainage spillway rather than being an insignificant creek as it is today. Note also the several different terrace levels within the valley.

.30

Turn right (north).

.20

Turn left (west).

.50

Turn right (north).

.40

The continuous linear ridge to be seen on the horizon to the east is an esker. Eskers are long, narrow, ridges of sand and gravel resulting from the deposition of sand and gravel by streams running in or underneath the ice. They are common sources of valuable sand and gravel today.

1.40

Turn left (west).

1.20

Two small linear hills crossed by road are small recessional moraines on the east edge of the Pipestem Creek valley.

.50

Pipestem Creek bridge. Drive slowly. Here (and in the tributaries of Pipestem Creek to follow) various terrace levels can be seen. These terraces were formed when the Pleistocene Pipestem River, flowing at higher levels than now, cut out the deposits which the glacier left in the preglacial Pipestem valley. These terraces are numbered in the following manner, but you should remember that they were cut in reverse order as the Pipestem became a smaller and smaller creek (See diagram on page 6). The present stream channel is level No. 1. The broad flat beyond the bridge is Terrace No. 2. The higher level beyond is Terrace No. 3. At the edge of the upland is Terrace No. 4. Commonly one or more of these levels may be cut entirely away by following stream action so that they cannot all be seen in every profile.

.10

Terrace No. 3. Note dark soil on top of the terrace in the gravel pit south of the road.

.20

Terrace No. 4. Terrace 4 is cut in till in some places and in others it is cut in the Pierre shale bedrock.

.10

Ground moraine of the general upland surface.

1.20

Note the hills of recessional moraine to the north beyond the small valley, a tributary of Pipestem Creek. To the west, in the distance, is the end moraine which forms the edge of the Coteau du Missouri or Missouri Plateau.

1.30

Bridge.

.20

Bridge.

.10

STOP 1. Sand and gravel pit south of road at edge of No. 4 terrace. This stop gives a good idea of the nature of outwash material. Note bedded nature of the sand and gravel and lack of very fine material or clay. Observe the soil at the west edge of the pit. The darker color is humus or organic matter left by the decay of plants which grew on the original sand terrace. The soil has formed just since Pleistocene times.

Note the kinds of pebbles found within the gravel. The light gray ones are limestone and dolomite brought by the glacier from Canada, and red and black pebbles are igneous and metamorphic rocks (granite, gneiss, quartzite, etc.) also brought from Canada. Also there are a few chips of hard gray shale from the Pierre formation (Cretaceous in age), the bedrock in this area, which we will see later in the day.

The gravel pit is in the edge of Terrace No. 4 and the bottom land is Terrace No. 2. The No. 3 terrace has been cut away here during the formation of the No. 2 level.

.30

No. 2 level. Terraces 3 and 4 are not well developed here.
As we travel west note the approach to the end moraine or Coteau du Missouri.

2.80

Up onto the end moraine. This is part of the great complex of moraines known in South Dakota as the Altamont moraine. This great band of end moraines forming the Coteau du Missouri sweeps in an arc through North Dakota and is aligned with a similar set of moraines in the Minot area known as the Max moraine. In the Jamestown area, all of these moraines have not been mapped in detail; but this portion of this vast morainal system has been named the Hawk's Nest moraine after the Hawk's Nest Hills southwest of Carrington. Note the difference in topography between the end moraine and the ground moraine that we have been seeing. End moraine is much more hilly with knob and kettle topography more common than in the swell and swale topography of the ground moraine.

3.20

Turn right (north) at school. The broad valley ahead is probably a small area of ground moraine in the larger end moraine and also acted as a spillway for glacial meltwater.

1.00

Turn left (west).

1.00

Turn right (north).

1.80

Large kettle hole in the moraine. Note the undrained marshy nature of this depression surrounded by till. A kettle hole or kettle is formed when a detached ice block (covered or surrounded by till) melts in place preventing the ordinary deposition of till in this area.

.40

STOP 2. Till road cut on east edge of kettle chain (See Plate 5, Figs. 1 and 2). A kettle chain is a series of several joined or nearly joined undrained depressions formed when huge masses of stagnant ice melted. In other words it is a chain of kettle holes. Kettle holes and kettle chains may or may not have water in them today. Those which do are locally called potholes or sloughs (respectively), but are more properly called kettle lakes. These kettle lakes commonly have boulder lines or concentrations of boulders around their edges at the present water level. These boulder lines are formed when the finer material is washed by wave action from the surrounding till banks leaving the larger and heavier boulders behind.

Dig into the till outcrop. This is gray to brownish gray pebbly or cobbly till. Contrast the tough resistant nature of the till with the loose, unconsolidated nature of the outwash seen at the last stop. Note that here there is a great deal of clay with the rocks embedded in it causing it to be tough yet sticky and gummy when wet. Where the till is especially clayey it is locally called gumbo. Note also that there is no bedding nor sorting of the particles according to size. Instead clay, sand, pebbles, and cobbles are all deposited together. These features are characteristic of till and are due to the fact that it was not worked over by glacial water.

Examine the till closely for different kinds of pebbles. There are about the same kind here that you found in the terrace gravel but perhaps slightly more Pierre shale. Many of the pebbles are weathering or decomposing right in place. These will have a ring of soft rock or sand around the pebble giving a "ghost" outline to the original pebble. If you find one completely weathered away you have a true "ghost"!

Many of the rocks (especially limestone and dolomite pebbles because they are softer) have scratches or striations on them made by the grinding, sliding action of them against their neighbors when carried along within the glacial ice. Some of these pebbles have smooth faces or facets on them where they have been worn flat. This is very quickly worn away by stream action, so these markings distinguish glacial gravel from ordinary stream gravel.

Note the erosion or gullying beginning on this unprotected face of a relatively new road cut.

.90

Turn right (east). Kettles and kettle chains are abundant in this area. There are also numerous cuts in till along the road ahead.

.70

Excellent kettle hole south of road.

.20

Turn left (north).

1.40

STOP 3. Having curved around hill the road here goes north along the section line.

This is a brief stop to afford a view of typical end moraine country. Contrast this with the ground moraine topography on the upland around Jamestown.

1.10

Road curves around kettle chain.

1.00

Turn right (east).

.20

Good view ahead of the Drift Prairie to east from the Coteau du Missouri or the edge of the Missouri Plateau. All of the area southwest of here is the Missouri Plateau. Here you are at the edge of the plateau. This elevation, known as the Coteau du Missouri, is formed by the end moraine which accentuates an actual bedrock escarpment below. The glacier over-riding this escarpment in the Pierre shale "ran out of steam" and dropped its load here on the edge of the Missouri Plateau. This is partly due to the obstacle of the bedrock escarpment and partly due to lack of supply of ice to the glacier to the north. Coteau is a French word meaning a small hill; hence the early French travelers in this region likened this area to a small range of hills. It is a range of hills indeed; but not because they were dissected from a continuous ridge, but because of the end moraine piled on top of the original bedrock escarpment.

1.10

Old pit (north of road) in pocket of outwash gravel overlain by bedded silt. We are now going down off the end or terminal moraine.

1.80

School on right. We are now on ground moraine with the end moraine and the Coteau du Missouri behind us.

2.50

No. 2 terrace. Terraces 3 and 4 are missing here.

.30

Bridge over Pipestem Creek.

.30

Back onto upland and ground moraine.

3.20

Railroad tracks.

.05

Turn right (southeast) on U. S. highways 52 and 281.

3.40

Turn left (east) on gravel road just north of Buchanan.

3.00

Till in low road cut north of road.

.20

Road curves left to go down off ground moraine into James River valley.

.30

STOP 4. Outcrop of till and Pierre shale (Cretaceous) south of road on the west side of the James River.
Here the top of the road cut is composed of "normal" brownish pebbly till not unlike that which we saw at stop 2. Below this is till composed primarily of fragments of Pierre shale. Note that the pebbles of Pierre shale are deranged so that when these pieces are broken down by the weather into little

flakes the bedding planes are seen to be at all different angles.
On down the hill the Pierre shale crops out. Here the Pierre is black or bluish gray, fissile (will split readily into thin flakes), clay shale. Note that the bedding planes are horizontal and not at angles as in the till composed of loose Pierre shale fragments.
In the ditch fractures in the shale (known as joints) can be seen. These can be distinguished by the brownish staining of iron oxide (the mineral limonite — $Fe_2O_3 \cdot 2H_2O$) along them. The limonite is carried in the ground water and deposited along the joints or cracks in the shale through which it flows just as iron and lime deposits or scale may eventually clog a water pipe.
In some places limonite similarly cements the Pleistocene terrace gravels into a hard conglomerate. The joints are caused by release of pressure when the overlying bedrock is removed.
Up the road a bit is an excellent exposure of outwash silt in contact with the underlying till.

.20

Bridge over James River. In Pleistocene times the James River was not as large a stream as the Pipestem; and while there are good terrace developed along the James in some places, they are commonly not as well developed as in the Pipestem drainage system. Note that the James River valley is narrower than that of the Pipestem.

.90

Note the extent of the dissection here near the James River. There are many depressions here, but they are not kettles for they all drain into the James.

.40

STOP 5. This will be a short stop to dig cream-colored bentonite out of the Pierre shale in the low road cut south of the road. There are several zones of this sticky light colored clay in the Pierre shale. They were formed by the weathering of volcanic ash which fell into the Pierre sea from volcanoes far to the west during the time the Rocky Mountains were just beginning to form.
The bentonite will be found about half way up the low cut where a vague line is visible across the shale chips on the surface.

.20

Pierre shale -- Pleistocene till contact north of road.

2.00

Junction with N. D. highway 20. Continue east on gravel road.

1.20

The low hills to the north and those in the distance to east are kames. These hills are a subdued northern part of the Kiester moraines.

2.50

Crossing a small coulee that is the present drainage of Spiritwood Lake and the headwaters of Seven Mile Coulee. At the east end of Spiritwood Lake is a wide valley that was the outlet in Pleistocene times. Just before entering the coulee a kame can be seen east of the coulee.

1.00

Road north to Spiritwood Lake Legion Pavilion.

.30

Ahead is the broad Pleistocene spillway or drainage channel for meltwater. Spiritwood Lake and Blue Lake, Rudolph Lake and Medicine Lake to the northwest are all part of this broad valley (as is Seven Mile Coulee south of here) which is a preglacial stream valley. The lakes were formed when the preglacial [illegible]

2.70

Turn right (west) on gravel road (2 miles north of Johnson's siding). Here we travel three miles over a recessional moraine. Recessional moraine is much like ground moraine but is more hummocky than ground moraine but less hummocky than end moraine.

3.00

Turn left (south).

2.00

Turn right (west) across Seven Mile Coulee. Drive slowly. Note the flat area west of the coulee just below the level of the upland. This is an upper terrace level; that is, the earliest Pleistocene terrace. We have been travelling on this terrace most of the way since we turned south.
This is the same coulee that was unterraced in the vicinity of Spiritwood Lake; but here the closeness of the glacier when it paused long enough to deposit the nearby recessional moraine, provided sufficient meltwater to cut terraces in this valley.

.10

Lower terrace level. Note old gravel pit north of road.

.20

Culvert over Seven Mile Coulee.

.20

STOP 6. Upper terrace level, west side of Seven Mile Coulee. Looking up and down along the coulee you can see the upper terrace level and the lower terrace with the gravel pit below it. The upper level would correspond to Terrace No. 4 in the Pipestem drainage system and the lower terrace to No. 3. Here, however, there is no No. 2 terrace so these numbers are not applicable, and they are merely designated the upper and lower terrace levels.
This small stream obviously did not cut this broad valley, but Seven Mile Coulee was an important Pleistocene drainage spillway.

.10

Turn left (south). You are here on the ground moraine upland.

3.20

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

.40

Top of Kiester moraine. Note the kame hills far to the north along the moraine. These are the ones near Spiritwood Lake that you just passed. Note also the gravel pit south of the road.

.50 Highway curves left (south).

1.00 Highway curves right (west).

3.40 Airport to north.

.60 Turn right (north) on N. D. highway 20.

2.10 Turn left (west) just south of drive-in theater.

.20 Enter Stutsman County Recreation Area.

.40 Lakeside resort.

.20 Continue south around bend to left. Here bluish gray Pierre shale is exposed on the outside of the bend.

.30 Pierre shale overlain by till east of the road.

.80 Leave fenced recreation area. Turn right (west) across dam. Drive slowly. From the east end of the dam notice the Pierre shale overlain by buff weathering till south of the dam.

At a higher level north of the dam on the south side of the road down to the beach and boat landing area at the foot of the dam can be seen till composed of deranged fragments of Pierre shale like we saw at stop 4.

Here the James River valley is relatively narrow compared with its greater width in town where Pipestem Creek flows into it.

The Jamestown Dam and Reservoir was constructed by the Bureau of Reclamation in the years 1952-54. It is a part of the Missouri River Basin Project authorized by the Flood Control Act of 1944. The dam is an earth-filled structure 86 feet high with a crest length of 1,420 feet. The reservoir has a storage capacity of 230,000 acre-feet and is for flood control to avert such severe floods as 1948 and 1950. Its long-range purpose is as regulator and irrigation control for flow to the La Moure and Oakes Sections of the Garrison Diversion Unit. Note the use of large erratic boulders to riprap the dam.

.45 Turn left (south) toward town.

Just north of the corner here at the overlook there is an eight foot granite boulder. It has been flattened (faceted) on the east side by glacial action. If time permits we can stop to examine it and drive down to the lake to examine the till of Pierre shale fragments.

As you drive to town note that there is Pierre shale exposed on the south side of the dam east of the river also.

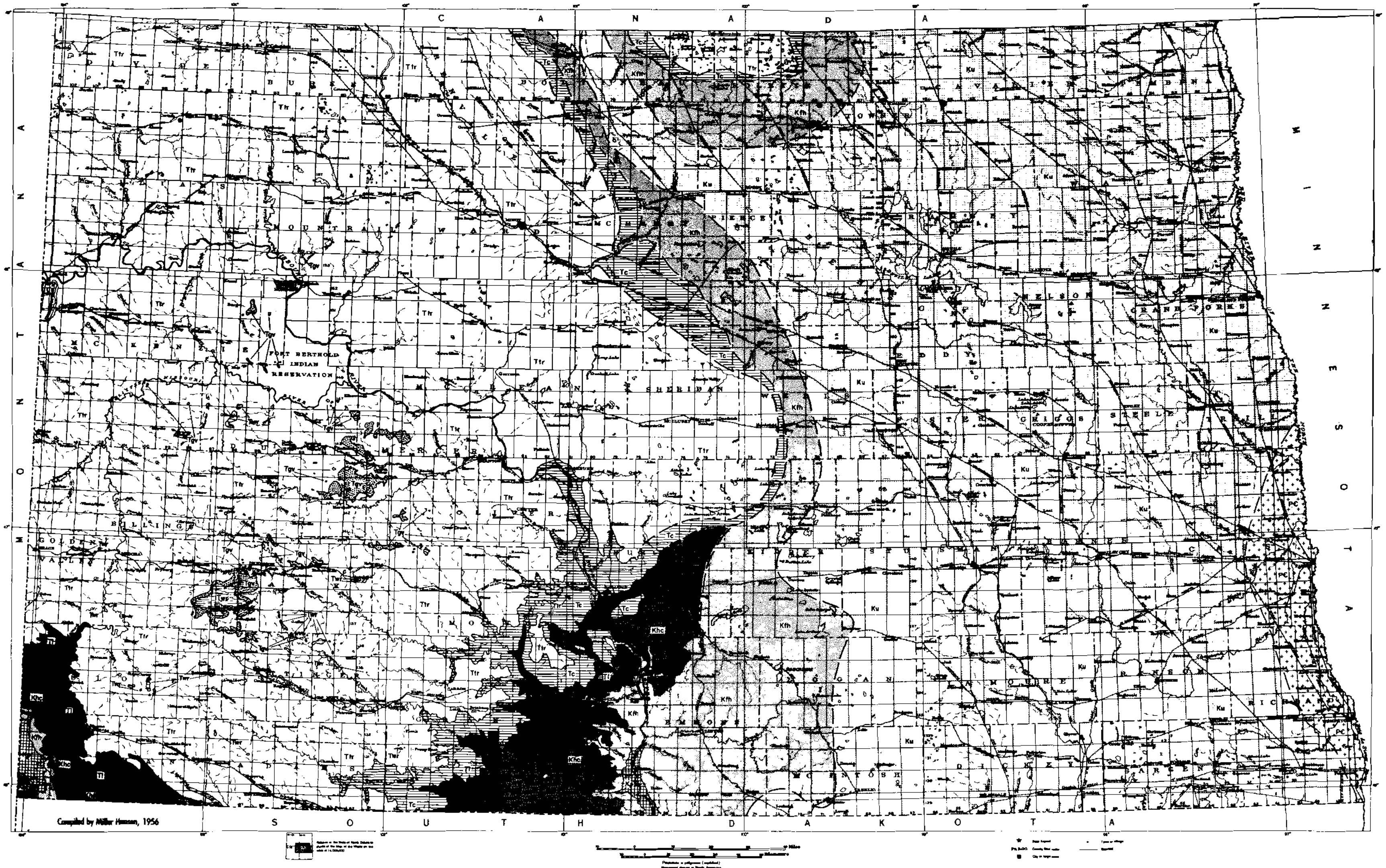
.20 Till in cut west of road.

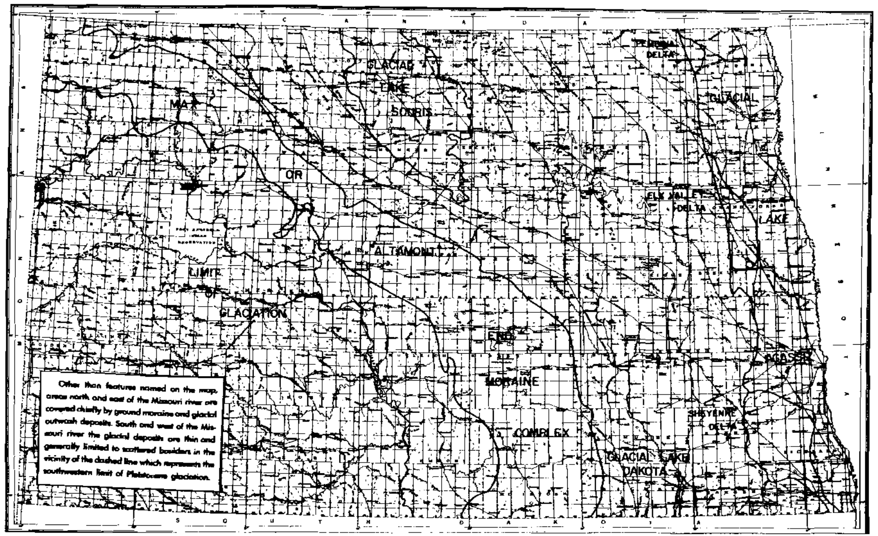
.15 Pierre shale exposed in ditch at south end of road cut west of road.

.15

Junction of U. S. highways 52 and 281 with U. S. highway 10.

End of log.





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	
Tc	Cannonball	Paleocene
Tl	Ludlow	
Khc	Hell Creek	
Kfh	Fox Hills	
Kp	Pierre	Cretaceous
Ku	Chiefly Pierre, includes Colorado and Dakota groups.	
P€	Igneous and metamorphic rocks	Pre-Cambrian
	Known contacts	
	Inferred contact	

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 $\neq$ 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 $\neq$ 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 $\neq$ 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		

PLATE 2

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	
MISSISSIPPIAN		"AMSDEN"	
		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	
		STONY MOUNTAIN 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.

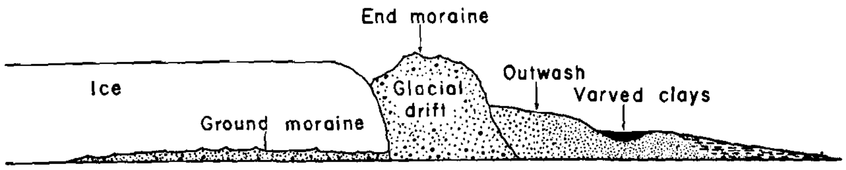


Figure 1. - Diagram showing glacial features associated with the front of an ice sheet.

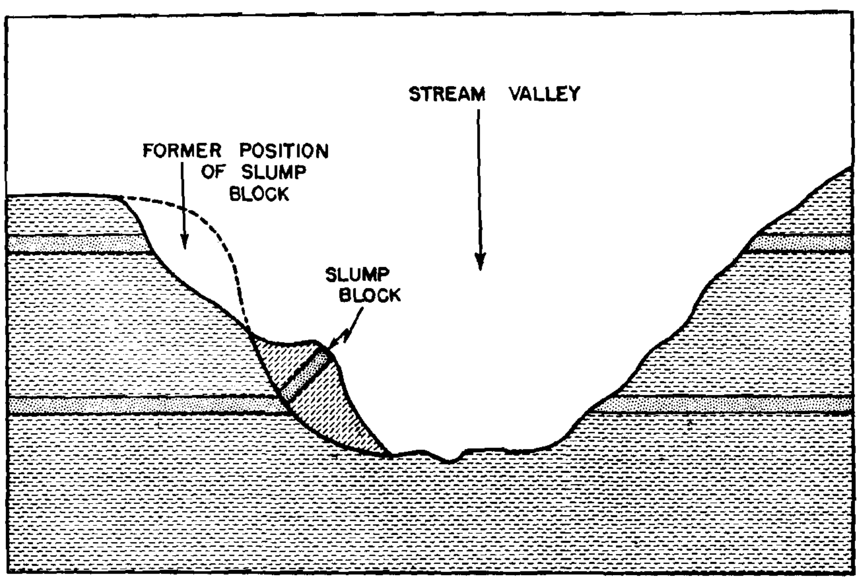


Figure 2. - Cross-section diagram showing a slump block or landslide caused by slippage on a clay or shale surface lubricated by ground water.

Fig. 1 - Kettle lake in the end moraine at stop 2.

Fig. 2 - Glacial till outcrop at stop 2.

Fig. 3 - View southwest over kettle chain and hummocky topography of end moraine from stop 3.

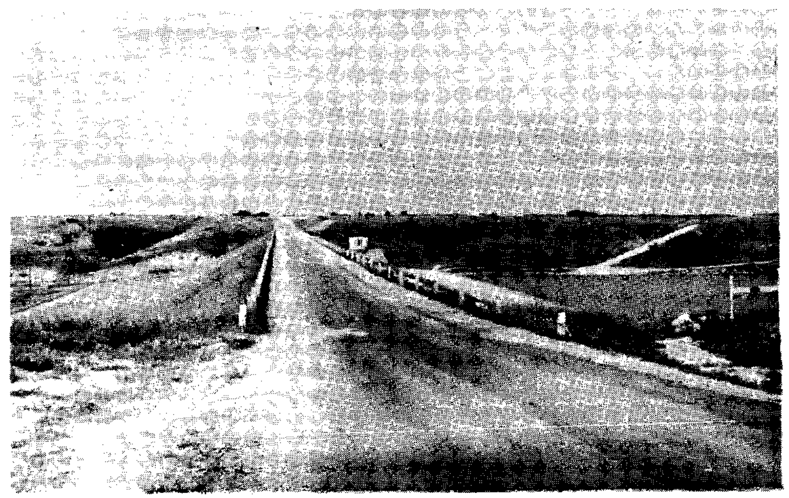
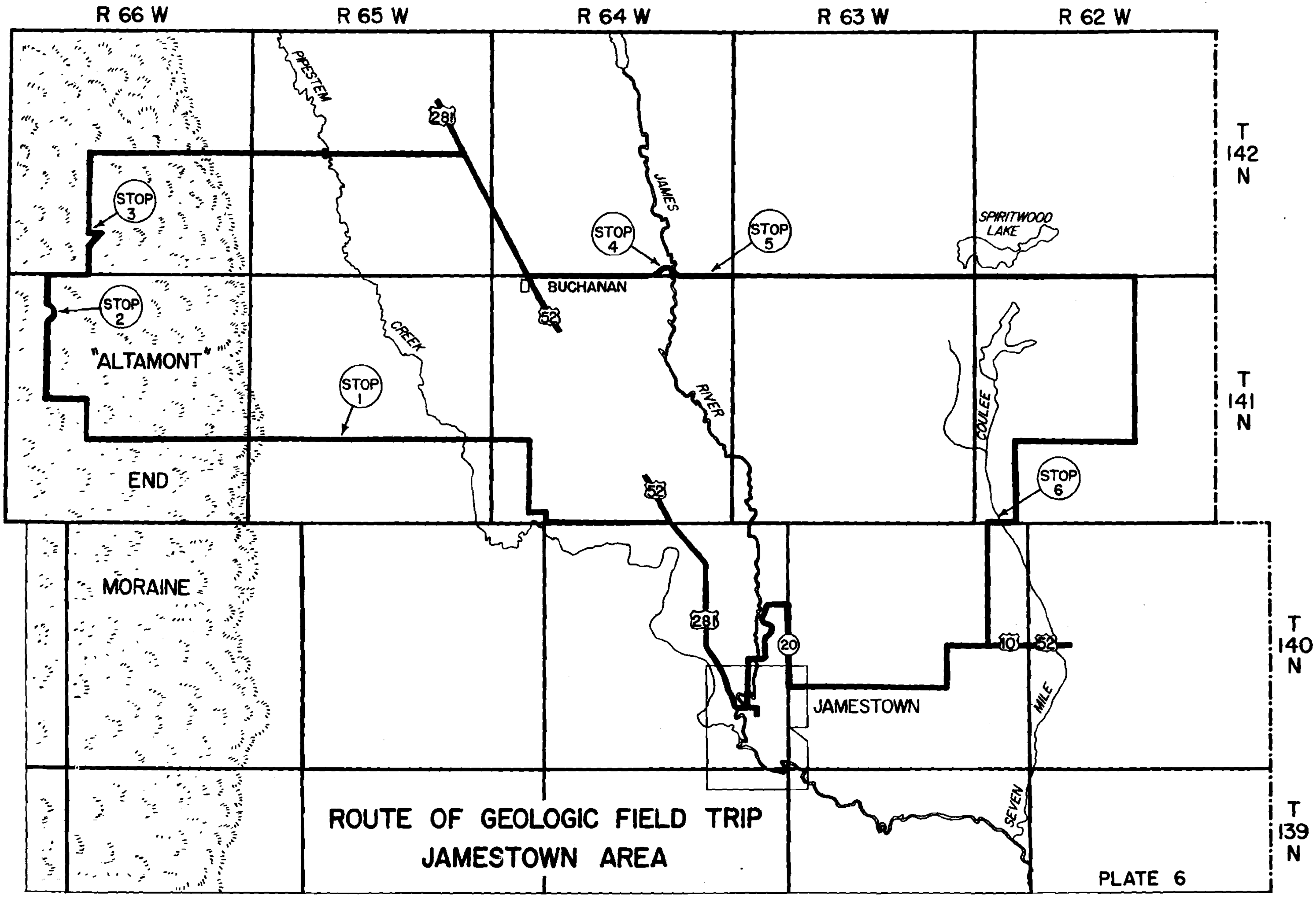


Fig. 4 - Jamestown dam, Stutsman County Recreation Area, looking west. Note exposure of Pierre shale below till south of the dam.



ROUTE OF GEOLOGIC FIELD TRIP
JAMESTOWN AREA

PLATE 6