NORTH DAKOTA GEOLOGICAL SURVEY

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Miscellaneous Series #40

GEOLOGIC FIELD TRIP FROM GRAND FORKS, NORTH DAKOTA TO KENORA, ONTARIO

By

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FIELD TRIP FROM GRAND FORKS TO KENORA

Part 1. Red River Valley from Grand Forks to Winnipeg

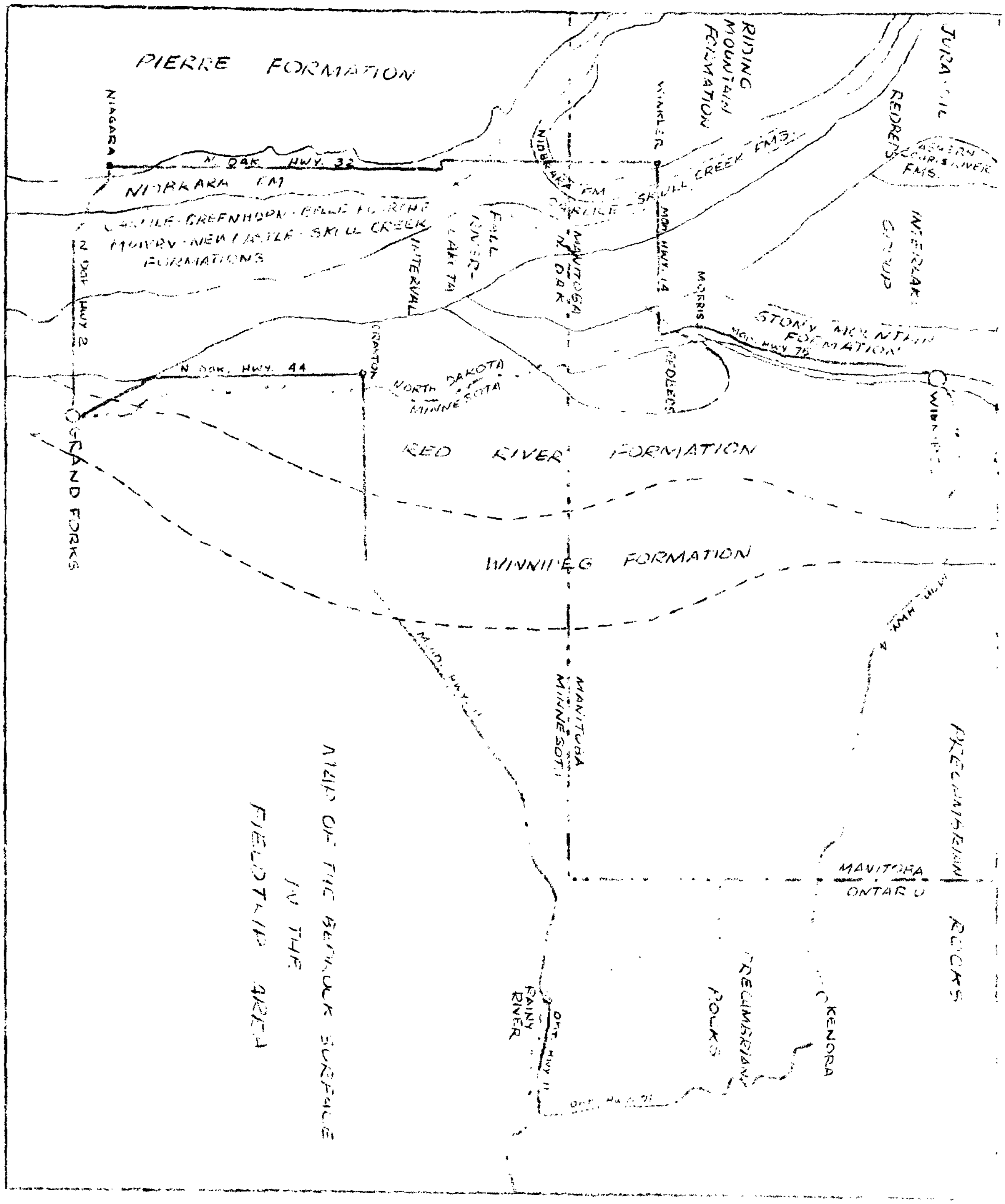
00.0 Start. Junction of U. S. Highway 2 and railroad tracks west edge of Grand Forks (elev. 833). You are slowly ascending from the basin of glacial Lake Agassiz. As you drive west over the lake plain, notice that the horizon to the west seems to ascend, rather than sink. This is due to the gradual rise in elevation toward the Pembina Escarpment. You will see much of this escarpment as you go north into Pembina and Cavalier Counties.

00.4 Weighing station to left. To the right side of the road, watch for areas covered with white salts. Note the small, red-stemmed plant---a halophyte ---the only plant that will grow in some of these areas. It is an indicator of areas of saline ground water discharge. The salts seemingly disappear after a rain because the moisture washes them to the B horizon. As the water in the soil percolates upward, it carries the dissolved salts with it and, with evaporation, the salts are left on the surface until the next rain.

01.9 Notice the silty soil in the roadcuts. The lake sediments are of three main types, sand, silt, or clay, depending on the relation of the area to streams emptying into glacial Lake Agassiz and the sorting of material by currents within the lake. Most of the soil in the Grand Forks area is silty with small amounts of sand. Notice the lack of boulders in the fields. Along beach ridges to the west, boulders are more common due to concentration near the shore of the lake. Scattered boulders can be seen in fields; these may have been rafted into place by icebergs on the lake.

04.0 Road to Grand Forks International Airport. A flowing artesian well in the Dakota Sandstone is located south of the road here.

06.9 Bridge over Freshwater Coulee. Notice the beaded windbreaks throughout eastern Grand Forks County. This area is a region of groundwater discharge from the edge of the Lower Cretaceous Dakota Sandstone. (see geologic map, Fig. 1). The saline groundwater that is escaping at the land surface affects plant growth in several adverse ways. One of the more interesting of these is reflected by the beaded windbreaks, which are located on areas of micro-relief on the lake plain. This micro-relief, a result of large ice blocks being blown over the shallow lake and scraping and grooving the lake floor (Clayton, et. al, 1965), distributes the saline water in the following way: the salt is flushed from the lower areas by precipitation whereas it is left in the higher areas because the precipitation rapidly runs off the surface. The soils on the lower areas are mainly Chernozems, while those of the higher areas are mainly salty Solonchaks. Thus, trees grow best over the depressions where salt concentrations are lowest.



PIERRE FORMATION
NIAGARA
N. DAK. HWY. 32
NIOBRARA FM
CARLILE · GREENHORN · BELLE FOURCHE
MOWRY · NEW CASTLE · SKULL CREEK
FORMATIONS
N. DAK. HWY. 2
INTERVAL
FALL RIVER-LAKOTA
MANITOBA
N. DAK.
NIOBRARA FM
CARLILE · SKULL CREEK FMS.
WINKLER
MAN. HWY. 14
RIDING MOUNTAIN FORMATION
JURASSIC
REDBEDS
INTERLAKE GROUP
MORRIS
STONY MOUNTAIN FORMATION
MAN. HWY. 75
N. DAK. HWY. 44
DRAYTON
NORTH DAKOTA
MINNESOTA
REDBEDS
GRAND FORKS
RED RIVER FORMATION
WINNIPEG FORMATION
MAN. HWY. 11
MANITOBA
MINNESOTA
MAP OF THE BEDROCK SURFACE
IN THE
FIELDTRIP AREA
PRECAMBRIAN ROCKS
MANITOBA
ONTARIO
PRECAMBRIAN ROCKS
KENORA
RAINY RIVER
ONT. HWY. 11

08.0 Bridge over Saltwater Coulee. The only noticeable depressions in the lake plain are these coulees.

08.5 Good exposures of lake silts.

09.6 Ojata strandline, one of the lower Lake Agassiz beaches (elev. 875). Part of the Ojata beach complex on which the University of North Dakota Biological Station is located about two miles to the south. Notice that the beach is about 0.2 miles wide.

10.5 Edge of depression is characterized by saline water, soils and vegetation. This large depression extends northward for several miles and terminates in Kelly Slough, a national wildlife preserve. According to Laird, (1959), the depression was eroded by saline water moving upward from the Dakota Formation and sapping the surface materials. An alternative hypothesis (Joe Downey, personal communication) suggests that during glaciation of the area, water flowing beneath the ice was forced into the permeable Dakota sandstones because of the great hydrostatic and geostatic pressure of the overlying water and ice. Upon deglaciation, large quantities of water were released from the contact between the Dakota sandstones and the underlying Paleozoic rock. The rapid movement of this water resulted in the erosion of the overlying lake sediment. The discharging water was at a maximum immediately after deglaciation and has since decreased to its present rate.

11.3 End of salt springs.

13.1 Grand Forks Air Force Base entrance to right. Town of Emerado to left.

13.8 Emerado strandline (elev. 900). Although it has been suggested that some of the strandlines originated as offshore bars, this is unlikely, because cuts through the ridges always show typical beach bedding.

14.1 Railroad crossing. Notice the gravel sieving plant to right where material from the Emerado beach is processed.

14.5 End of divided highway. You are now on a broad diffuse beach that extends for several miles.

16.7 Descent down west edge of beach.

17.3 Lower Blanchard strandline (elev. 940).

17.5 Middle Blanchard strandline (elev. 950).

17.8 Upper Blanchard strandline (elev. 960). Notice the boulder piles. This area is till that was eroded by waves at the edge of the lake. Only small patches of lake sediment remain.

18.8 McCauleyville-Campbell beach complex (elev. 980 to 1000). The McCauleyville ridge is the lowest formed while glacial Lake Agassiz drained southward. Lower strandlines formed while the lake drained northeastward along the ice front.

19.1 Campbell beach terrace with gravel pit.

19.3 Gully

19.8 Entrance to Turtle River State Park.

20.2 Turtle River

22.8 Tintah strandline (elev. 1045).

23.4 Norcross strandline (elev. 1080).

23.7 Here begins the sandy soil of the Elk Valley Delta. Notice the many windbreaks. They are even more necessary in this sandy region than in the lake silt of the lake plain. The Elk Valley Delta is a deposit of sand that was deposited by a glacial meltwater system that discharged into Lake Agassiz. Further north, the deltaic deposits are coarser.

23.8 Turtle River

24.1 Junction Highway 18 and Highway 2.

28.6 Great Northern Railroad tracks.

30.7 Herman strandline (elev. 1170). The Herman strandline represents the highest level reached by Lake Agassiz. Notice how the topography on the Drift Prairie west of the Herman strandline is more rolling than it is to the east. On the western horizon is the Pembina Escarpment, which is an erosional bedrock escarpment that is held up by the hard, siliceous Odonah Member of the Pierre Formation. It forms the western edge of Glacial Lake Agassiz and was also the western edge of the preglacial Red River Valley.

37.6 Junction Highway 32 and Highway 2. Turn right (north). The town of Niagara is to the south of the road.

38.2 Pierre Formation in road cut on west side of road across gully.

42.3 Minuteman II missile site, east side of road.

48.0 Forest River.

51.0 Dahlen esker to the northwest. The following is a quote from Kume, 1966:

> Approximately 12,000 radiocarbon years B. P. (before present), the Wisconsinan glacier, the main ice mass, was mostly in Canada, but an ice lobe projected into the broad Lake Agassiz basin of North Dakota and Minnesota. During the waning stages of this lobe and while the ice margin was on the Pembina Escarpment in the Dahlan vicinity, the Dahlen esker was deposited.

The Dahlen esker was deposited by a meltwater stream in an ice-walled channel, most likely a tunnel, near the base of a stagnant zone of the ice lobe. The stream flow probably was from east to west, toward the margin of the ice lobe. The flow direction, although suggested mostly by the position of the ice lobe, may be indicated by a kame near the terminus of the northeast branch. Kames differ from eskers by forming in a surface opening in the ice rather than in a tunnel or ice-walled channel. The possibility exists that the water entered an opening in the ice and then flowed through an ice-walled channel or tunnel. The meltwater stream deposited outwash in the surface opening and within its stream course now marked by the esker ridge.

Subsequent ablation of the adjacent ice resulted in the deposition of ablation till and boulders upon the stream sediments. Sediment collapse and slump also occurred as the adjacent ice, especially the underlying ice, ablated. Contemporaneously with the deposition of the esker, a low-relief till plain called ground moraine, was deposited in the area adjoining the esker.

Following the deposition of the Dahlen esker, ablation continued until the margin of the ice lobe had retreated five miles east. The glacier, because of an increase in activity, attained a stable position or stillstand. During this stillstand and along this active ice margin a till ridge, the Edinburg end moraine, was deposited. Meltwater flowed along the ice margin in a channel formed between the end moraine on the east and the Pembina Escarpment on the west. Within this channel in the Dahlen vicinity an outwash plain was deposited, and to the south where the channel extended into an inlet of glacial Lake Agassiz, a delta-lake plain was deposited.

52.0 Soo Line Railroad crossing.

52.8 Middle Branch Forest River.

53.1 Road to Fordville to east.

53.6 Soo esker to right parallels the road. The Lankin esker is 3 miles farther north. These two eskers are prominent features with an overall branching aspect. They have very bouldery surfaces and a discontinuous cover of till over a gravel core. In some places, however, till occurs through the total thickness of the eskers. This is true also of the Dahlen esker. Several dozen smaller eskers located a few miles to the west belong to the same drainage system that formed in the stagnant glacier and deposited the Soo and Lankin eskers.

The two eskers, along with the Dahlen esker to the south, are located on an eastward-sloping area that was at the edge of a proglacial lake prior to the forming of glacial Lake Agassiz. Only patches of lake sediment occur in the area but heavy concentrations of boulders resulted from the extensive washing of the till surface by waves at the edge of the lake. The Lankin esker in particular has been modified by wave action at its southern end where the petition of the Herman strandline coincides with it.

Friestad (1966) and later Pederson and Reid (1969) consider the Soo and Lankin eskers to be end moraines, but this is incorrect.

54.7 Soo Line Railroad crossing.

55.1 Roadcut through the Soo esker. Notice that the esker is mainly till here.

58.0 Roadcut through the Lankin esker. Notice the bedded sands. This feature formed when active ice stood to the east and stagnant ice to the west. Water flowed southward between the active ice margin and the edge of the stagnant ice.

58.2 Lake plain. Notice the flatter topography here compared to the rolling till plain to the south over which you have been driving.

61.6 Edinburg end moraine one mile west of highway, Pembina Escarpment to west. The highway here follows the Elk Valley Delta, which in this area is covered by thin, discontinuous lake sediment.

65.8 Junction Highway 32, and Highway 17. Continue northward.

66.5 Terrace of Park River.

67.0 South Branch of Park River. The river begins its cut through the Edinburg end moraine here. West of here the river flows over the Elk Valley Delta and has a valley that is only 10 to 20 feet deep. East of the end moraine it flows through a comparable valley, but its valley through the end moraine is over 100 feet deep.

67.5 River bank east of bridge has about 15 feet of glacial till overlain by 6 feet of horizontally bedded gravel overlain in turn by 5 feet of silty sand. The gravel is outwash from the end moraine and the silty sand is alluvium.

68.4 Edinburg end moraine.

68.6 Notice the many boulder piles to the west.

71.4 Garfield church to the west.

73.2 Railroad crossing at Edinburg.

73.3 Upper Herman strandline.

74.4 Road parallels the middle Herman beach and then crosses it.

74.8 Gravel pit on middle Herman beach.

75.1 Middle Branch of Park River. The edge of the lake plain in this area trends north-northwest so as you drive north, you cross progressively younger beaches.

79.4 Gardar corner.

79.6 North Branch of Park River. Notice the Pembina Escarpment to the west.

81.4 Norcross strandline. Notice how coarse and poorly sorted the gravel is here. This segment of beach is probably a reworked ridge of glacial till and the area is a washed till plain. Notice the many different types of glacial boulders in this pit. Among the most common rocks found are granite, schist, diorite, limestone and shale. Many of these are exposed in place northeast of here in Ontario, and will be pointed out in Part 2 of this fieldtrip roadlog.

82.5 Junction Highway 32 and Highway 66. Continue northward.

83.0 Church to east.

86.1 Campbell beach escarpment, a wave-cut cliff. Icelandic Lutheran Old Peoples Home to west. Town of Mountain.

90.2 Tongue River.

91.1 Edge of Pembina Delta. Notice the fine sand. Much of the topography here is due to the wind blowing the sand into dunes. This rather sharp edge of the delta on the east is often called "First Mountain". The Pembina Escarpment containing the Cretaceous shales is called "Second Mountain".

94.1 Junction Highway 5 and Highway 32. Turn left (west).

97.2 Junction Highway 5 and Highway 32. Turn right (north). South of here is the townsite of Concrete, the site of an old cement plant. In the Fifth Biennial Report of the North Dakota Geological Survey, 1908, the following accounts of the cement plant and the workings are given:

> The cement rock of the Pembina Mountains was discovered some years ago by Professor E. J. Babcock, who subsequently became interested with several others in the establishment of a cement mill on the Tongue River. The product manufactured is a natural hydraulic cement which has found a ready market. The products include bricklayer's cement, hydraulic cement, Northern cement plaster, Northern fiber and Northern stucco. With improvements recently made the plant has a capacity of 500 barrels per day.
>
> The workings of the cement company reveal the character of the cement rock at this place. One tunnel extends nearly 900 feet into the face of the bluff and discloses two small faults or slips.

The cement rock was produced from the Cretaceous Niobrara Formation.

99.6 Good view of Pembina Escarpment to west.

103.4 Good outcrop of sand in road cut to east.

105.9 Gravel pit on east. Notice the large number of Pierre Formation shale cobbles and pebbles.

According to Upham, the Pembina gorge was formed during the melting of the ice sheet. This gorge, which is up to 400 feet deep and a mile wide, resulted when meltwater from glacial Lake Souris overflowed through the present Pembina valley. The large quantities of sediments, consisting chiefly of granites and Pierre shale, were carried along by the stream and deposited at the river's mouth in Lake Agassiz because of the checking of the stream current by the standing lake water.

106.8 Sand and gravel bank of west side of road demonstrates ice contact features. This outcrop shows interesting phenomena associated with the front of a melting ice sheet. During the glacial period, the ice front must have been very near this locality at the time these deposits were laid down. The ice was depositing the glacial till directly while the water caused by the melting of the ice was carrying away the coarser material which was deposited as outwash. The finer materials were apparently deposited in an ice-front lake and are rather evenly bedded, a fact which indicates deposition in standing water.

107.3 Terrace along Pembina River.

107.5 Masonic Hill to west (left). Good view of Pembina River gorge.

108.0 Pembina River.

108.1 Walhalla city limits. At junction of Highway 32 and County Road 55, turn left on County Road 55.

112.1 Turn right (north). Gravel pit on right after ½ mile.

115.1 Turn left (west).

116.1 Gravelline farm bedrock exposure. Carlile shale containing abundant large concretions and selenite crystals. Notice the abundant yellow sulphur and the odor of sulphur in the gulley. The Carlile shale is the oldest bedrock formation exposed in North Dakota.

(Approximate mileage to Winnipeg)

Retrace route back to Walhalla.

123.0 Walhalla city limits. Turn left (north) on Highway 32. Follow Highway 32 to Winkler, Manitoba.

154.0 Winkler, Manitoba. Turn right (east) at junction of Highway 32 and Highway 14. Follow Highway 14 to junction with Highway 75.

181.0 Turn left (north) at junction of Highways 14 and 75.

192.0 Morris, Manitoba on Highway 75.

197.0 Western Gypsum on right (east) side of road, Highway 75. Turn right up long driveway approaching the Silver Plains Mine. Gypsum and red beds of the Jurassic Amaranth Formation occur in this area under a 105-feet cover of glacial lake clay and till. The Jurassic rocks in the mine area occur from a depth of 105 to 250 feet, and consist of, in descending order:

15 feet: interbedded red and green shale and gypsum.

75 feet: predominantly gypsum; an increase in dolomite content in the lower part.

55 feet: "Amaranth red beds"; an upper shaly sandstone and a basal sandy breccia zone.

The mine section is the upper part of the main gypsum zone. The deposit was discovered in 1961 during an extensive exploration program in southern Manitoba by Western Gypsum Products Limited. An adit on a 1 to 4 slope was begun early in 1963, but an aquifer in the till caused one year's delay in the completion. Grouting was unsuccessful, but the aquifer was finally penetrated using freezing methods. Production began in August, 1964.

197.0 Turn right (north) from entrance to Western Gypsum onto Highway 75.

233.0 Junction Highway 75 and Trans-Canada Highway 100. Turn right (northeast) on Highway 100.

243.0 Turn left (north) on Highway 59 at junction of Highway 100 and 59.

249.0 Turn left (west) on junction of Highway 59 and Highway 59A.

251.0 Junction of Highway 59A and St. Mary's Road, the location of St. Boniface Seminary.

End of Part 1 of the Field Trip.

FIELD TRIP FROM GRAND FORKS TO KENORA

Part 2. Winnipeg to Kenora

(Manitoba Part, mileage 0 to 120.9, is adapted from a roadlog by Dr. Frank R. Karner, U.N.D.)

00.0 Junction of Manitoba Highways 4 and 9A northeast of Winnipeg. Drive east on Highway 4. The road crosses the plain of glacial Lake Agassiz.

2.5 Notice the topographic rise to the east onto the Precambrian shield. Take note of the change in topography when you drive onto the shield.

7.8 Notice the glacial boulders along the road.

10.1 Garson. At the nearby quarries, the Selkirk Member of the Red River Formation (Tyndall Stone) can be seen. It has been used for numerous buildings in the Winnipeg area, among them those on the campus of the University of Manitoba, the Manitoba Provincial Capitol Building, the airport buildings, Eaton's and the Hudson Bay Store.

According to Holland (1966):

> Only rocks above the Cat Head Member of the Red River Formation are exposed at the surface near Winnipeg. The other units occur only in the subsurface. Remember that these rocks are about 460 million years old.

SILURIAN	Interlake Group
	Stonewall Formation - 22'
	Stony Mountain Formation - 145'
	Gunton Member - white limestone - 50'
	Penitentiary Member - yellowish dolostone - 20'
	Gunn Member - reddish gray shaly limestone - 75'
ORDOVICIAN	Red River Formation - 250'
	Selkirk Member - gray, mottles, dolomitic limestone - 97'
	Cat Head Member
	Dog Head Member
	Winnipeg Formation
	Roughlock Member
	Icebox Member
	Black Island Member
CAMBRIAN	Deadwood Formation

13.6 Junction Highways 4 and 12. Continue east on Manitoba Highway 4.

19.6 Beausejour

21.5 Notice the numerous glacial boulders in the fields and along fences. Although this area was covered by glacial Lake Agassiz, not much lake sediment was deposited.

31.0 Gravel pit to south.

39.9 Junction Highway 4 and 11. Continue southeast on Manitoba Highway 4.

48.4 Whitemouth. Watch for the first outcrops of Precambrian bedrock.

55.1 Notice the asymmetrical shape of the outcrops. These features, termed "Roches Moutennee" or "sheepback rocks", are the result of shaping by the glacier, which moved over the rock, thereby streamlining it.

70.3 Rennie.

74.7 Roadside Table. It might be worthwhile to take time to study the rock in the outcrops north and south of the road.

84.6 The Lily Pond. This is probably a glacial meltwater channel. Many of the valleys in the area were used by glacial meltwater. They commonly have some sand and gravel along the edges, but it is generally rather restricted. A few feet away from the channels, the sand and gravel give way to granites again.

86.9 Notice the glacial striations to the right side of the road. They indicate ice movement toward the west.

88.1 Green Bay Road.

88.5 Glacial meltwater channel, right side of raod.

88.7 Small granite quarry.

89.6 To the north of the main road, just west of a gravel road to the north, is an excellent exposure of K-feldspar pegmatite along with considerable milkyquartz. Notice the metamorphosed sediments beneath the granite pegmatite. The contact between acidic and basic rocks is just east of here; good exposures of basalt can be seen about 100 yards to the east.

90.3 Penniac Bay, West Hawk Lake. Notice the type and structure of rocks in the road cut.

91.3 Junction Highways 4 and 301. Continue on 4 east to the junction with Highway 1.

92.9 Junction Highways 4 and 1. Take Highway 1 west.

101.9 Trans-Canada Pipeline Compressor Station. Here can be seen typical basaltic pillow lavas of the Falcon Lake-Kenora greenstone belt. Reference: Wilson, H. D. B. and Brisbin, W. L., 1965, Road log, Geological Association of Canada Tour of Northwestern Ontario. Follow Highway 1 east.

108.6 Falcon Lake complex, outer margin. See excerpt from Davies, J. F., Bannatyne B. B., Barry, G. S., and McCabe, H. R., 1962, Geology and Mineral Resources of Manitoba, Department of Mines and Natural Resources, Winnipeg. Continue east on Highway 1.

111.2 Junction, exit to Highway 4, West Hawk Lake. Exit to Highway 4 north.

112.8 Junction Highway 4 and 301. Take Highway 301 south.

114.0 Junction Star Lake Road., Blocks 4, 5, and 6. Take the north fork of the south fork of Star Lake Road.

114.7 Prospect pit in core of Falcon Lake complex. Notice the rock types and the compositional variation in the complex. Return.

115.4 Highway 301. Drive north.

116.2 Quarry in greenstone. Notice the glacial striations.

116.6 Junction Highways 301 and 4. Take Highway 4 southeast.

117.4 West Hawk Lake beach. Return to Highway 1 via Highway 4 north and exit road.

118.6 Junction Highway 1. Drive east on Highway 1.

120.9 Ontario-Manitoba border. Continue east on Ontario Highway 17.

(End of adaptation from Karner. The part of the roadlog that follows was made with the help of J. F. Davies((personal communication))

121.8 Three outcrops, two north of the road and one south, show classic examples of slip folding. The apparent strike is east-west but the actual strike is north-south. For beginners, the westernmost outcrop is best (please do not mutilate). The most prominent structural feature in this area is the east-west regional foliation, which is superimposed on other features to some extent in virtually every outcrop.

122.9 Exposure of typical coarse gabbro south of road.

124.2 Exposure of an intermediate agglomerate in which the lighter fragments are clearly visible.

124.7 Junction Highway 17 and Shoal Lake Road. Turn south (right) on Shoal Lake Road.

124.8 Poor exposure of basic pillow lavas.

125.0 Banded sediments. Good glacial striations can be seen here.

126.8 Junction with trail to right (west). Leave car and walk west along trail. About 0.1 mile from Shoal Lake Road is a good exposure of bedded sandstone and graywacke with some graded bedding. About 50 yards further is a boulder conglomerate. About 0.1 mile further is an exposure of an unconformity between volcanics and porphyry and conglomerate with chert. Just northwest of this an unconformity between basic lavas and sediments can be seen. Adjacent to these, to the northwest, are pits from which gold was extracted from a stretch-pebble conglomerate.
Return to Shoal Lake Road and continue driving southward.

128.2 Classic example of boulders stretched east-west and good bedding north-south.
Return to Highway 17.

131.5 Junction of Shoal Lake Road with Highway 17. Turn right (east).

131.9 Exposure, south side of highway showing banded sediments and garnetiferous boudinage structure.

132.5 Excellent dacite pillows north side of road.

135.0 Across road and just west of the picnic tables along Moth Lake is an exposure of acid agglomerate and volcanic conglomerate and breccia. Notice the good bedding.

135.9 Good exposure, south side of road, of mixed basic and acid volcanic rocks.

137.5 Glacial outwash and till in roadcut, north side of road.

138.1 Excellent exposure, south side of road, of the contact between basalt and granitic rock. Good intrusive features can be seen here. Notice how the darker minerals have weathered out leaving the surface of the rock white except for the blasting surfaces.

139.7 Exposure of granodiorite with dark, lensy inclusions. Notice the foliation and orientation of the inclusions or xenoliths.

157.8 Kenora city limits. Eastward between Kenora and the junction of Highway 71, the road leaves the greenstone belt and enters an area of hybrid granite with many greenstone fragments.

FIELD TRIP FROM GRAND FORKS TO KENORA

Part 3. Kenora to Grand Forks

00.0 Longbow Corners. Turn right (south) at junction of Highways 17 and 71.

At 1/3 mile past the turnoff of the Witch Bay Road on Highway 71, notice the diabase dike cutting granitic rocks.

Two miles south of Andy Lake on Highway 71, notice the outcrop of sediments containing thin magnetite iron formation and some garnets.

47.0 Entrance to Sioux Narrows Provincial Park.

49.0 Town of Sioux Narrows.

51.0 Sioux Narrows Provincial Park. Notice the many evidences of glaciation. Notice the islands in the lake.

78.0 Outcrop showing large black inclusions in granite at Bass Lake, just north of Nestor Falls on Highway 71.

79.0 Nestor Falls, Ontario.

120.0 Gabbro exposures, one mile north of junction of Highways 71 and 11 along the highway.

121.0 Junction of Highways 71 and 11. Turn right (west) on Highway 11. Follow Highway 11 to Rainy River, Ontario.

158.0 Cross toll bridge from Rainy River, Ontario into Baudette, Minnesota. Continue on Highway 11 to the west. Notice that Highway 11 follows the east side of the McCauleyville sand ridge that was crossed twice in the first part of the field trip.

292.0 Drayton, North Dakota. Turn left (south) at junction of Highway 11 and Highway 44.

342.0 University of North Dakota

End of field trip.

BIBLIOGRAPHY

Bannatyne, B. B., 1959. Gypsum-Ahydrite Deposits of Manitoba: Dept. of Mines and Natural Resources, Mines Branch Pub. No. 58-2

Clayton, Lee, Laird, W. M., Klassen, R. W., and Kupsch, W. O., 1965. Interesting Minor Ridges on Lake Agassiz Plain: Jour. Geology, v 73, no. 4, p. 652-656.

Davies, J. C., 1965. Geology of the High Lake-Rush Bay Area, District of Kenora, Ontario. Dept. of Mines Geol. Report 41, p. 57.

Davies, J. F., Bannatyne, G. S., Barry, G. S., and McCabe, H. R., 1962. Geology amd Mineral Resources of Manitoba: Manitoba Dept. of Mines and Natural Resources, Mines Branch, p. 190.

Friestad, H. K., 1968. Description and Genesis of Selected Glacial Deposits, Walsh County, North Dakota (Unpublished masters thesis, UND).

Kume, Jack, 1966. The Dahlen Esker of Grand Forks and Walsh Counties, North Dakota: Prov., N. D. Acad. Science 20, p. 119-123.

Laird, W. M., 1944. The Geology and Ground Water Resources of the Emerado Quadrangle: North Dakota Geol. Survey Bulletin 17, p. 35.