Introduction

Rival No. 2 quadrangle is in northwestern Morth Dakota, adjacent to the Dominion of Canada on the north and about 50 miles from the east border of Montana. The bedrock in this quadrangle is largely mantled with glacial deposits. These surficial deposits together with the prevailing climatic conditions have largely determined the type of cultural development in the area. For this reason, emphasis in this report is on the

classification and description of the surficial deposits. classification and description of the surficial deposits.

The base of the report is the geologic map. The map explanation includes lithologic descriptions and distinctive topographic features of the map units. The largest part of the text and the table of said and gravel

analyses below are in tabular form see that manifest descriptions and distinctive topographic features of the northwest are dry and often strong and cause blizzards in winter and analyses below are in tabular form so that specific information may be found without extensive reading and interpretation. Generalized geologic cross sections show inferred depth to bedrook. Other depth relations for

specific locations are given in the explanation.

Nost of the subsurface data in this report are inferred from drill hole logs and water well information provided by the North Dakota State Geological Survey, the U. S. Bureau of Reclamation, and the Ground Water Division of the U. S. Geological Survey.

Rival No. 2 quadrangle is in the glaciated Missouri plateau section of the great plains physiographic province. The ground surface is generally flat or slightly undulating; it dips gently to the northeast, except for the area shown on the map as the terminal moraine which is composed of Dakota. a disorderly arrangement of hills and enclosed depressions. The terminal Brosion continued until the Pleistocene epoch when glaciers moved

General Geology and Engineering Geology of Rival No. 2 Quadrangle, North Dakota by R. C. Townsend and Arthur L. Jenks

moraine is also called the Missouri coteau and is a belt of glacial debris 10 to 25 miles wide and extending northwest into Canada and southeast for many miles in North Dakota. The West Branch of Shore Creek and the East Branch of Shore Creek are the only well-developed streams (intermittent)

The climate is northern continental and is characterised by wide annual and diurnal temperature ranges, limited precipitation, low humidity, and strong winds. According to weather bureau records, January temperahills to be eroded.

dust storms in summer. The average frost penetration is approximately four feet and reaches a maximum of six and one-half feet.

Brief Geologie History The sediments of the Fort Union formation were deposited in the

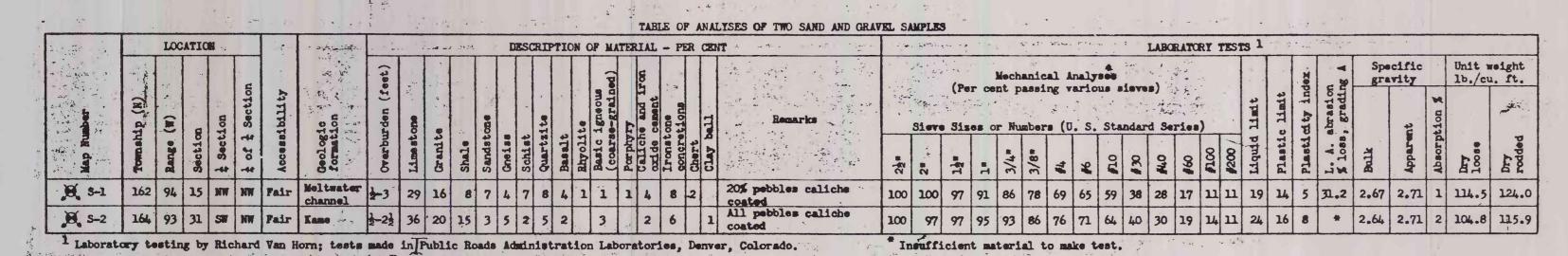
Paleocene epoch in an environment characterized by large continental swamps and lagoons. Organic matter accumulated in the swamps and was intercalated with beds of marl, silty clay, silt, and fine sand. These beds accumulated to a thickness of more than 500 feet and were slightly hardened and compacted by their own weight, turning the organic material to coal. Deposition stopped and was followed by a period of erosion during which the soft weak beds of the Fort Union formation were easily eroded, making an uneven terrain, similar to present-day badlands in North and South

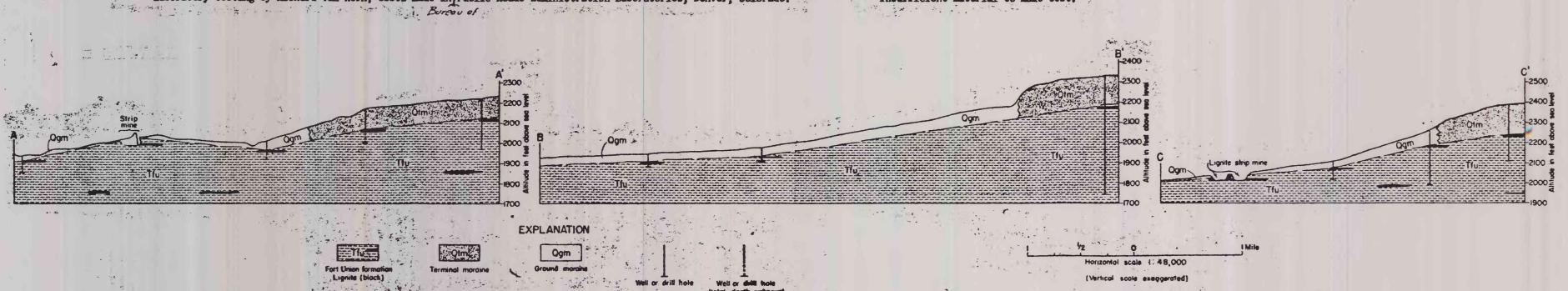
southward over the area at least twice and perhaps several times. The glaciers were heavily laden with rock material which was caught in the ice flowing from areas in Canada. Streams draining northward in the Fort Union formation were dammed by the first advance of glacial ice and valleys were partially or wholly filled with sediment carried by the streams and with rock material of all sises washed from the ice. Each successive advance of ice thus tended to smooth the terrain by causing valleys to be filled and

The last advance of the ice was during Late Wisconsin time, and during this glaciation the deposits making the present ground surface were formed. The erosion surface of the underlying bedrock is higher in altitude under the terminal morains than it is under the ground moraine plain to the north. The bedrock high was a barrier to extensive southward advance of the ice. It was in the vicinity of this barrier that the ice margin remained longest and the huge terminal moraine was deposited. The eaker in the southeastern part of the quadrangle was formed when ica covered most or all of this area. Ground moraine was deposited under the glacier during the advance of the ice and while the terminal moraine was being deposited

at the margin of the ice. When the ice margin began to recede northward, the flow of meltwater was restricted to the sone between the terminal morains and the ice itself, forming meltwater channels. Sand bars were formed in the meltwater channels. As the ice margin moved northward, the first meltwater channels formed were abandoned and others were formed at the edge of the ice. The material in the kames on the ground moraine plain was deposited at the receding margin of the ice. The glacier disappeared relatively recently and the glacial deposits remain as the ice left them, virtually undisturbed by

MIT		TERRAIN AND NATURAL SLOPES	DRAINAGE AND PERMEABILITY	COLPACTION	STABILITY A STABILITY	POSSIBLE USE	ORIGIN OF DEPOSIT
	Scattered small deposits in glacial meltwater channels (Qgc, see below). Thickness: generally 5 ft. to 12 ft. Bar sand may extend below ground level of surrounding meltwater channels.	Low mounds elongate in shape with flat to rolling surface and gently sloping sides.	Naterial loose and porous; locally elightly compacted. Permeability moderate to high. Drainage good. Water table near surface in most places because of high water table in meltwater channels.	Easily worked with hand tools except below water table. Compaction fair.	Low strength when dry; very weak when wet. Low angle slopes necessary in cuts. I Poor foundation material. Frost heave: medium in undrained material.	Poer concrete admix, except for sweetening, because of amali size, poor grading, and silt and mica content. Good pervious fill where fine material needed.	Channel bars formed in meltwater channels in Pleistocene time.
MELTYATER CHANN	Form network over ground moraine plain. Two primary channels; 1) Complex system of channels trending SE from Sec. 34, T. 163 N., R. 95 W., 2) channel occupied intermittently by West Branch Shore Creek. Other channels tributary and secondary. Sediments in primary channels known to be at least 23 ft. thick in places. Deposits less than 6 ft. thick common in tributary and secondary channels. Channels widen to shallow basinlike areas in places.	Valleys characteristically elongate, flat- floored and sinuous, with gently eloping sides. Wide, shallow basinlike areas generally very flat with inconspicuous and indefinite boundaries. Valleys trending away from terminal moraine are V-shaped with moderate to steep slopes, and evidence of small landslides and soil creep is abundant. Undrained depressions common.	Materials deposited in channels generally permeable but poorly drained because surrounding ground morains is impervious; permeability low in clays. Undrained aloughs and marshy areas common; subject to flooding. Most channels have very gentle gradients down which surface runoff water moves slowly by seepage and discontinuous intermittent streams. Channels trending from terminal moraine have moderate to high gradients; water flows in these valleys only during the most prolonged rains. Branches of Shore Creek are only well-developed drainage in the quadrangle. (See sample analysis S-1 below.)	Easily worked with hand tools above water table. Depth to water table 2-15 ft.; water table high in wide basinlike areas. Quicksand reported in shallow farm wells. Moisture control necessary for compaction of fine material.	Low to medium strength depending on material and ground water conditions. Surface material generally silty and clayey with low strength when wet. Low angle slopes necessary in cuts. Frost heave: moderate to high in silt and clay.	Coarse materials used lo- cally as road metal. Lo- cal concentrations of gravel used for concrete aggregate and road metal. (See analysis of sample, S-1, below.) Shallow wells productive except in dry periods. Roads in channels subject to flooding and trafficability difficult after rains.	Valleys cut by 1) melt- water from glacier or isolated ice blocks, 2) water from heavy snows and rains during and im- mediately after glacial period. Primary channels cut along ice margin dur- ing melting of glacier. Material in valleys was carried off glacial ice or from glacial deposits.
KA	Widely scattered over ground moraine plain, but generally in or near melt-water channels. Indistinct and very small deposits not mapped. Height above ground moraine plain: 10-50 ft. Locally deposits extend to at least 20 ft. below level of ground moraine plain.	Shape of small kames roughly conical; larger kames highly irregular. Slopes moderate to very gentle. Large kames have gently undulating surface.	Drainage generally fair to excellent except in large kames where undrained depressions have impervious clay floors. Drainage may be poor in deposits composed largely of silt and clay. Sand and gravel highly permeable. Clay lenses locally make perched water tables. Water table may be encountered at level of surface of surrounding deposits.	Easily excavated with light machinery, but boulders may be large and abundant enough to require special handling. Gravel may be removed by dragline or power shovel. Special equipment necessary to compact silt or silty sand.	Low to high strength depending on material. Road cuts in kames generally stable at 1 on 1. Frost heave: none in coarse material; slight to high in sand and silt.	Source of sand and gravel for concrete aggregate, pervious fill, and highway material. Material for aggregate requires wash- ing. Overburden can be removed by tractor. (See sample analysis S-2 below.)	Material washed from glacial ice and deposited in holes and cracks in glacier or in reentrants in margin of ice.
ESKER	long, sinuous deposits superposed on terminal moraine in SE quarter of quadrangle. Trend of larger eaker is NE; tributary esker about 1 mi. in length trends NW. Maximum thickness probably as great as 35 ft.	Narrow ridges with roll- ing, uneven tops and steep sides character- istic; few undrained de- pressions. Gradient of long profile of ridge coincides with slope of terminal moraine.	Drainage very good except where impervious till closely underlies surface. Material generally very permeable.	Same as kame except clay and silt not abundant.	Same as kame.	Same as kame except over- burden slight.	Deposited by a glacial stream flowing in or under glacial ice.
CROUND MORAINE		Surface flat to gently rolling and contains numerous undrained depressions and glacial kettles. Surface inclined downward slightly from terminal moraine.	locally fair where till cover very thin over Fort Union formation.	Hard, compact, tough; plastic when wet and breaks into blocky fragments when dry. Difficult digging with hand tools, but easily worked with power tools. Local "hardpan" or caliche zone from 6 in. to 3 ft. thick. Scattered large boulders may require special handling. Sheepsfoot and rubber-tired rollers make good compaction. Subject to wind erosion where not compacted and sod cover absent.	High stability in road cuts but may gully. When compacted properly, has high strength. Good foundation material; settling negligible. Tends to break into blocky masses when dry; plastic and sticky when wet. Frost heave; medium.	Good impervious fill if compacted. Unsurfaced roads; stable when dry, very difficult trafficability when wet. Subgrade: good if drainage controlled. Scattered boulders are possible source of riprap, pervious fill, and crushed rock.	Glacial debris deposited under the glacier.
TERMINAL	Covers most of southern one-third of quadrangle; second only to ground moraine in areal extent. Thickness: generally less than 100 ft. but locally may be 150 ft. See cross sections below. Differs from ground moraine in 1) rougher terrain, 2) abundant boulders, 3) origin (See origin of deposit).	Terrain rough; abundant knobs, irregular ridges, kettles and other undrained depressions. Slopes steep to moderate. Tops of hills rounded.	Generally same as ground moraine except kettles and other undrained depressions deeper. Minor surface drainage 1-2 mi. south of contact with ground moraine; all drainage in northerly direction.	Same as ground moraine except boulders more abundant both on surface and buried in till.	Same as ground moraine.	Same as ground moraine except roads may require cut and fill because of rough terrain.	Glacial debris deposited in front or at margin of the glacier.
FORT UNION FORMATION	Underlies surficial (glacial) deposits in entire quadrangle. Large exposures in the belt of atrip mining between highway 5 and terminal moraine, and in the extreme NE corner of the quadrangle. Most natural exposures are along sides of meltwater channels and are small in areal extent. Data on thickness meager but formations probably at least 500 ft. thick, See cross sections below.	The Application of the Control	Drainage fair in ailt and fine sandstone; clays impervious. Seepage springs present at base of outcrops. Many lignite beds and fine sandstone are water-bearing.	Difficult excavation with hand tools but easily worked with power tools except for scattered large masses of hard limy siltstone. Where excavation intersects lignite, unwatering may be necessary. Hoisture control necessary to compact clays and silty clays, but silts and clays compact fairly well with roller equipment.	Subject to landsliding in other areas; moisture control necessary for stabilization. Partially cemented silts weather easily due to leaching of lime cement. Frost heave: bad in silts.	Clays may be good fill if moisture controlled. Lignite and sandy layers are sources of water. Lignite is strip mined in areas shown on map where overburden is generally less than 50 ft. Sandy layers too fine and variable for most uses. Poor road metal because silts and clays unstable when wet. Subgrade poor because of probable frost heave.	Lake, lagoon, and swamp deposits.





GENERALIZED GEOLOGIC CROSS SECTIONS ALONG LINES A-A', B-B' AND C-C' SHOWING RELATIONS OF GLACIAL MATERIAL TO FORT UNION FORMATION

U. S. Geological Survey OPEN FILE REPORT This report is preliminary and has not been edited or reviewed for conformity with Geological Survey standards or nomenclature.

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GEOLOGIC MAPPING AND MINERAL RESOURCE INVESTIGATIONS GEOLOGICAL SURVEY MISSOURI - SOURIS, NORTH DAKOTA R. 95 W. 8,00 0 Base compiled by Topographic Geology mapped in 1947 by R.C. Townsend **PRELIMINARY** Branch, U.S. Geological Survey. and Arthur L. Jenke assisted by R.W. Fary, Jr. Drofting by Gladys H. Benedict and Frank F. Mooney. APPROXIMATE
MEAN DECLINATION
1947

U. Seological Survey.

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UNITED STATES DEPARTMENT OF THE INTERIOR

EXPLANATION

Low mound of well-sorted medium to fine-grained amountelidated sand; rudely stratified and nearly horizontally bedded. Contains lenses and thin layers of silt and fine gravel as source as I inch. Clay content l

Glacial Heltwater Channel

Valleys where glacial meltunter flowed and accessulated. Host valleys

out in ground moraine and in most places partially filled with de-

materials in flat floors of wide channels; deposits of gravel, marl, and clay, and minor amounts of boulders also present. Sloping sides of channels are locally covered with trace to 6 feet of silt. (See sample analysis S-1 below.)

Missellaneous kames, undifferentiated as to origin; knobs, low mounds, and irregularly shaped hills of unconsolidated glacial outseab. Silt and sand most abundant, but elsy, gravel, and boulders also present.

Coarse sand and gravel poorly sorted and rudely stratified. Fine sand and silt sorted in steeply dipping to horizontal lenses and discontingous layers; cross-bedding common. Fost common rock types present; granite and linestone abundant; platy shale; ironstone nodules, and sones of lignite fragments common; caliche roce mear top and locally at depth. (See sample analysis S-2 below.) Deposits locally contain till.

Kaleer Long, narrow, simuous ridge composed escentially of interbedded sand,

Glacial till; chiefly unstratified calcureous, plastic clay containing scattered stones of all kinds ranging in size from publies to boulders. Locally contains lenses and irregular measure of unconsolidated silt, sand, and gravel. Color buff (oxidised) at and near surface; gray to blue-gray at depth. Caliche some near surface common. Ground normains covered in places by thin mantle of fine send and silt, particularly adjacent to meltwater channels. Cobbies and boulders scattered over surface. Sand-size gypsum crystals abundent near surface.

End moraine; similar to ground morains, but surface consists of abundant knobs, irregular ridges, kettles, and undrained depressions; boulders abundant.

Port Union Formation

Interstratified beds of clay, silt, fine sandstone, and lignite; silt and clay predominate. The clay (silty to fatty) and silt (clays) to sandy) are compacted to soft clay shale and soft silty shale in places. Some comentation by calcium carbonate in most beds. Sandstone is mostly buff or yellowish buff; silts, buff or gray; clays, gray (blue-

mostly buff or yellowish buff; silts, buff or gray; clays, gray (bluegray when wet). Some uniform silts have a distinctive "salt-and-pepper"
appearance. Clays nostly plastic. Lignite seams at least 8 ft. thick
and material slakes easily on exposure. Slso sontains lenzes and irregular masses of hard limy siltstone, thin layers and nodules of
ironstone, fossil plants and fossilised wood. Stratification excellest,
but beds not continuous over wide arms. Locally beds have minor undulations with dips as great as 32 degrees.

RELIABILITY OF PAP SHIT BOUNDARIES (All boundaries except Ft. Union formation based on combined interpre-tation of topography and lithology)

SHARPLY DEFEND GETLEGEE CONTACT (Conspicuous topographic change or merked lithologic gradation)

DOTERRED AND GRADATIONAL CHOLOGIC CONTAC

(Humber of item below refers to member in diamond on map)

Top Ft. Union formation less than 110 ft. from surface Top Ft. Union formation 40 ft. from surface. Top Pt. Union formation less than 60 ft. from surface Top Ft. Union formation less than 40 ft. from surface. Top Ft. Union formation less tham 50 ft. from surface. Top Ft. Union forwation less than 120 ft. from surface. 34 ft. pebbly clay over Pt. Madem for ation.
Top Ft. Union formation less than 180 ft. from surface.

Top Ft. Union formation 35 ft. from surface.

110 ft. pebbly clay over Ft. Union formation.

28 ft. pebbly clay over clay.

Top Ft. Union formation less than 60 ft. from surface.

Top Pt. Union formation less them 40 ft. from surface Top Ft. Union formation less them 90 ft. from surface

Top Pt. Union formation less than 140 ft. from surface.
Top Pt. Union formation less than 134 ft. from surface.
Top Pt. Union formation less than 80 ft. from surface.
Top Pt. Union formation less than 142 ft. from surface.

Top Ft. Union formation less than 125 ft. from surface. Top Ft. Union formation less than 70 ft. from surface.

7. Top Ft. Union formation less than 70 ft. from surface.
7. Top Ft. Union formation less than 150 ft. from surface.
8. Top Ft. Union formation less than 255 ft. from surface.
9. Top Ft. Union formation 270 ft. from surface.
10. Top Ft. Union formation less than 155 ft. from surface.
2. Top Ft. Union formation less than 200 ft. from surface.
3. Top Ft. Union formation less than 125 ft. from surface.

Sample from sand and gravel pit analysed (Number refers to sample—see facing page)

Key map of North Dakota showing location of Rival No. 2 Quant

LIGHTTE HIMES

LITERITTENT STREAM

POORLY DRAINED AREA DITERSTITEMELY HARSHY

ABAHDOLED LIGHTE WINE

MISSOURI RIVER BASIN