SOUTH DAKOTA GEOLOGICAL SURVEY

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GEOLOGY of the GLENCROSS QUADRANGLE SOUTH DAKOTA

EXPLANATION

RECENT

Qal — Alluvium
(Floodplain deposits of gravel, silt, sandy clay, and clay in present stream valleys.)

Qlf | Qlp — Landslide Deposits
(Slumped material consisting of Fox Hills (Qlf) Formation along breaks of tablelands; and of Pierre (Qlp) Formation along Moreau River.)

Qt — Terrace Deposits
(Terrace deposits of sand and gravel.)
Qt 1 = 2000 feet
Qt 2 = 1900 feet
Qt 3 = 1850 feet
Qt 4 = 1800 feet

Qb — Boulder Till Residuum
(Boulder concentrations south of tablelands.)

QUATERNARY

UNCONFORMITY

UPPER CRETACEOUS

FOX HILLS

Kfc — Colgate Member
(Gray, fine to very fine-grained, cross-bedded graywacke sandstone and oyster coquina; caps buttes in northeastern part of the area. Thickness as much as 34 feet.)

Kfb — Bullhead Member
(Alternating layers of brown to gray clay-shale containing streaks of silt; forms slopes below butte caps. Thickness 25-35 feet.)

Kftl — Timber Lake Member
(Greenish to buff, medium to very fine-grained, "salt and pepper" sandstone with reddish-brown ferruginous cemented areas. Thickness 80-115 feet.)

Kftc — Trail City Member
(Interlensing bluish-green coarse sand to sandy silt, dark-gray to gray silty clay, and clay; scattered gray fossiliferous limestone concretions. Thickness 48-100 feet.)

PIERRE

Kpu — Upper Pierre Unit
(Dark bluish-gray blocky to fissile clay-shale and fissile bentonitic shale. Thickness about 280 feet.)

Kpvc — Virgin Creek Member
(Light to medium-gray bentonitic shale. Thickness more than 150 feet.)

Geologic Contact
(dashed where approximately located)

Gravel Pit

X BM 1900
Bench Mark
(monument showing exact altitude above sea level)

X 2009
Spot Altitude

House, School, and Church

Oil Test

Indian Reservation

GLENCROSS QUADRANGLE

Geology by W. A. Pettyjohn 1960
Assisted by Alan U. Lange

Vertical and horizontal control surveyed from triangulation and level lines of Federal surveys

Drafted by Alan U. Lange, 1960

APPROXIMATE MEAN DECLINATION, 1960

Scale 1:62 500

Vermillion South Dakota
1961

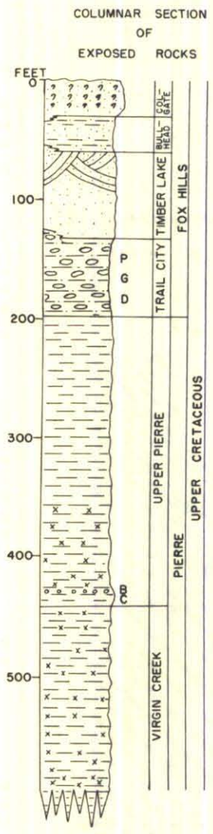
Tertiary Sediments

Quadrangle Location

GEOLOGY OF THE GLENCROSS QUADRANGLE

by

W. A. Pettyjohn



KEY TO COLUMNAR SECTION

OYSTER BEARING SANDSTONE
ALTERNATING BANDS OF SILT AND CLAY
CROSS-BEDDED SANDSTONE
SILTSTONE WITH LIMESTONE CONCRETIONS
CLAY-SHALE, IN PART BENTONITIC

KEY TO FOSSIL ZONES

P-Protocardia subquadrata
G-Gervillia recta and Limopsis parvula
D-Discoscaphites nicolletii
B-Baculite
C-Crab

INTRODUCTION

The Glencross quadrangle contains about 213 square miles in north-central Dewey County and south-central Corson County. The area is located in the prairie grasslands of the northern part of the Great Plains Physiographic Province. The northern part of the quadrangle is a gently rolling, eastward sloping erosional plain with a few sandstone or oyster-bed capped buttes. The eastern, central, and southern parts of the area have been incised into broad valleys by the Moreau River and its tributaries. Deep arroyos cut into grass-covered colluvial slopes, and many gravel-covered, flat-topped terrace remnants are scattered throughout the quadrangle. This area appears to be the cut-plain remnant of a large erosional terrace sloping southeast toward the Moreau River.

The walls of the Moreau River valley (SE part of quadrangle) are almost vertical in some areas but in most places they are gentle and contain slumped areas (Qlp). In the southern part of the Glencross quadrangle more than 80 percent of Moreau River valley wall slopes are covered by slumped clay-shale of the Pierre Formation (Kpu, Kpvc). Farther north along the breaks separating the tablelands of the Timber Lake Member (Kftl) from the dissected areas to the south is a continuous northeast-southwest abrupt slope, formed by the cropping out of the Trail City Member (Kftc) of the Fox Hills Formation. This ridge has been affected in part by slump.

The Moreau River meanders generally eastward across its floodplain, with a gradient of about 5 feet per mile. The major Moreau River tributaries, the Whitehorse, Little Moreau, Veo, Jewett, and Jolley Creeks, are intermittent streams which meander south and southeast over narrow, well-developed mature floodplains. Other than the Moreau River, the only permanent bodies of water are Spring Lake in the north-central part of the quadrangle, Whitehorse Lake in the southwestern part, and stock dams. Intermittent playa-like ponds are present in the northern third of the mapped area.

Maximum topographic relief in the Glencross quadrangle is about 600 feet, with altitudes ranging from 2225 feet at Dog Butte to 1630 on the Moreau River floodplain (SE corner of the mapped area). Local relief may range up to 250 feet, being greatest along the sides of the terraces.

The climate of the Glencross quadrangle is semiarid, with a mean annual rainfall of 17.2 inches and an average temperature of 44.4 degrees F. at the U. S. Weather Bureau station at Timber Lake, 4 miles to the west. It is a lightly populated ranching area containing 1 family per 3½ square miles. The village of Glencross in the northwest part has a population of 27, and the Indian village of Whitehorse in the south-central part has a population of about 40 families. State Route 8 crosses the northern part of the quadrangle. A small network of unsurfaced roads and trails are present in the northern part of the mapped area, but wet weather makes these roads nearly impassible.

The mapping of the Glencross quadrangle was done with the assistance of Alan Lange in the summer of 1960 under the supervision of Dr. A. F. Agnew, as part of the State Geological Survey's program of studying the State's economic mineral resources. The geology was mapped on air photos, and in the southern half on U. S. Geological Survey topographic maps. Elevations in the northern half were determined with a Kollsman altimeter.

EXPOSED SEDIMENTARY ROCKS

Surface formations include shale, silt, sand, and clay of the Late Cretaceous Pierre and Fox Hills Formations. Terrace deposits are numerous in the southern and southeastern parts of the quadrangle. Intermittent boulders are present along the breaks of the tablelands in a northeast-southwest trending arc.

Pierre Formation Meek and Hayden, 1862

The Pierre Formation (commonly called Pierre shale) was named for exposures at Ft. Pierre, South Dakota (65 miles southeast of the Glencross quadrangle), and has been divided into six members along the Missouri River Valley (Searight, 1937). It is difficult to distinguish the boundaries of the upper two members (Elk Butte and Mobridge) in the Glencross quadrangle; therefore, these strata in this report are referred to as Upper Pierre (Kpu). The Virgin Creek Member, which underlies the Upper Pierre unit, is present in the extreme southeastern part of the quadrangle, although the upper boundary of this unit is difficult to distinguish.

The division of the Pierre Formation by Searight into members along the Missouri River was logical because the river flows in a very broad sense parallel to the strike of this unit. However, there is a great increase in thickness, many facies changes appear to the west and south, and the fauna changes also. Therefore the writer was unable to use the members of Searight for a significant distance from their type localities.

The Pierre Formation is exposed in the southern half of the Glencross quadrangle. About 80 percent of it is slumped, as is especially evident along the Moreau River and its affluents. Probably a great deal more slumping has occurred than has been mapped, as it is difficult to distinguish slumping because of the well-developed dendritic drainage pattern and grassy areas.

Virgin Creek Member, Searight, 1937

The Virgin Creek Member is a light- to medium-gray fissile shale containing a number of thin bentonite beds. The upper part of this member may contain a number of iron-stained limestone concretions. The writer found abundant specimens of small gastropods, pelecypods, and scaphopods, as well as Foraminifera in Section 35, T. 16 N., R. 27 E. About 150 feet of the Virgin Creek Member is exposed in this quadrangle.

The Virgin Creek-Upper Pierre boundary is difficult to locate either by fauna or lithology. The brown color which Searight believed to be indicative of the calcareous Mobridge Member is intermittently present through the Pierre outcrop area, regardless of lithology or topography. The writer believes that this is not a good criterion for the recognition of the lower part (Mobridge) of the Upper Pierre unit in the Glencross quadrangle, because it appears that the brown coloring is a weathering characteristic and is present wherever the slopes are gentle. The writer used as the upper boundary of the Virgin Creek, the base of the "crab zone" reported by Rothrock (1947, p. 11). This boundary is necessarily arbitrary because of slumping and the grassy areas of the Pierre Formation.

Upper Pierre Unit

The Upper Pierre is dark bluish-gray blocky to fissile clay-shale and fissile bentonitic shale. A few thin streaks of silt are present in the upper part of this unit. Scattered selenite crystals and dikes, iron-stained joint cracks, rusty streaks, and thin bentonites are present throughout this unit. Local haloes of white melanterite may be present on bentonitic outcrops. Local intermittent layers of yellowish jarosite (?) are present in the upper part and at the top of this unit. The Upper Pierre Unit is about 280 feet thick in the Glencross quadrangle. An intermittent limestone concretion zone may be present near the lower boundary of this unit; the light-gray concretions are barren of fossil material. Directly underlying this concretion layer is a Baculite zone which is easy to distinguish, and subjacent to the Baculite zone is a "crab zone". The "crab zone" was used as the boundary between the Upper Pierre Unit and the underlying Virgin Creek Member. The fauna of the Upper Pierre is small in number and is limited to fragments of Baculites sp., Inoceramus sp., crabs, and Foraminifera.

Fox Hills Formation, Meek and Hayden, 1862

The type area for this formation is the Fox Hills on the Cheyenne-Moreau River divide, about 25 miles south of the Glencross quadrangle. Four members of the Fox Hills Formation are recognized in this area.

Trail City Member, Morgan and Petsch, 1945

This member was named for exposures near Trail City, South Dakota, about 4 miles east of the Glencross quadrangle. Exposures of the Trail City Member (Kftc) are present in both slumped and non-slumped parts of the area where it is dissected by the tributaries of the Moreau River.

The Trail City Member is composed of interlensing bluish-green coarse sand to sandy silt, dark-gray to gray silty clay, and clay. This unit weathers to a buff color slightly lighter than the overlying Timber Lake Member. Local patches of selenite crystals and rosettes, and several intermittent layers of yellow jarosite (?) are present throughout the Trail City Member. Fairly distinct, though intermittent, are layers of spherical to lenticular locally fossiliferous dense to sandy blue-green to light-gray limestone, and red-brown ferruginous sandy concretions. The limestone concretions are very hard, and weather to a red-brown soft sandy material.

Dr. R. E. Stevenson (oral communication, 1960) pointed out to the writer Waage's arrangement of marine fossils in the concretions of the Trail City Member. The fossil zones are named for index forms, but these index fossils are neither limited to the zone nor are they necessarily the dominant forms. The concretion zones are not present everywhere in the Trail City Member, and thus do not permit exact correlation from outcrop to outcrop. Furthermore, the concretion zones are barren of fossils in many outcrops. The basal concretionary layer (lower 30 feet) is characterized by an abundance of the ammonite, Discoscaphites nicolletii. The next higher fossil zone, 5-18 feet thick, contains an abundance of the pelecypods Gervillia recta and Limopsis parvula. The highest fossil unit, 7 feet thick, has been called the Protocardia subquadrata zone, but it also contains an abundance of Pteria nebrascana and Limopsis parvula. A barren concretion zone may be next above the underlying fossiliferous zones.

The Trail City Member in the Glencross quadrangle ranges in thickness from 48 to 100 feet. The Trail City-Pierre contact appears to be transitional in all outcrops, and it is marked upward by an increase in silt and by a color change from gray to buff. A jarosite (?) zone is present at the top of the transition zone in many areas. However, this zone must be used with caution, for several jarosite (?) layers may be present throughout the transition zone.

Timber Lake Member, Morgan and Petsch, 1945

The Timber Lake Member was named for exposures near Timber Lake, South Dakota, about 3 miles west of the Glencross quadrangle. The sands and sandstones of the Timber Lake Member (Kftl) crop out in about 30 percent of the mapped area, forming the tablelands in the northern and northwestern parts. The Timber Lake Member is partly non-indurated sand and partly laminated greenish to light-gray to buff medium- to very fine-grained graywacke sandstone, which locally contains glauconite. Thin and massive cross-bedding is present throughout the sandstones. In the upper part of this unit, 1- to 2-inch layers of reddish-brown iron-cemented sandstone are present between the massive cross-bedding planes. This part is also marked by an abundance of the problematic fossil Halymenites major.

The Timber Lake Member contains an abundance of 2- to 18-inch ledges of reddish-brown ferruginous fine-grained sandstone. These ledges may extend some distance (5 to 25 feet) laterally, and locally produce rough spots in the unimproved country roads and trails. Numerous subspherical reddish-brown sandy concretions are scattered throughout the unit.

Idonarca nebrascensis and Halymenites major are the major guide fossils of the Timber Lake Member in this quadrangle, but many other forms are also present. The lower part of the Timber Lake Member is clayey in most parts of the mapped area, and thus the Trail City-Timber Lake contact appears to be both irregular and transitional in most places. There are no good exposures of the complete thickness of the Timber Lake Member in the Glencross quadrangle, and only two damsites provided ungrassed outcrops exhibiting the lower contact. This member ranges in thickness from 80 to 115 feet.

Bullhead Member, Stevenson, 1956

The type locality for the Bullhead Member is about 20 miles northnorthwest of the Glencross quadrangle. Only five small buttes contain this lithologic unit in the mapped area. All of the outcrops are grassed over and covered with talus. The Bullhead Member forms the lower part of the buttes capped by the Colgate Member. The Bullhead Member is composed of a series of thin alternating layers of brown to gray clay-shale, containing streaks of silt. Orange-brown limonitic concretions are scattered throughout the unit.

The only fossils found were scattered specimens of Ostrea glabra, which might have been derived from the overlying oyster-dominated Colgate Member. The Bullhead ranges in thickness from 25 to 35 feet. The upper and lower contacts are grassed over, but it appears that both are gradational.

Colgate Member, Calvert, 1912

The Colgate Member, which caps the tableland buttes in the northwest part of the quadrangle, contains two facies. The sandstone facies is a siliceous and calcareous-cemented gray "salt and pepper" ledge-forming unit composed of fine to very fine-grained graywacke, has shaly to flaggy bedding, and is cross-bedded. Locally it contains silt and clay streaks and oscillation ripple marks. Ripple marks on Dog Butte strike N. 54°E., showing that the wind was from the northwest or southeast. The Colgate Member on top of Dog Butte (Sec. 18, T. 17 N., R. 26 E.) is an oyster-sandstone facies composed of about 50 percent shells of Ostrea glabra. Large (3 feet by 4 inches) and small pieces of siliceous wood are present throughout this member. The writer found the following fossils in the Colgate Member: Ostrea glabra, O. subtrigonalis, Corbicula subelliptica, C. occidentalis, Anchura spp., and worm borings. The Colgate ranges in thickness up to about 34 feet.

Surficial Deposits

Unconsolidated surficial deposits include glacial till residuum and alluvial material. Thin intermittent layers of loess, small areas of glacial till residuum, and glacial erratics were not mapped separately.

Till Residuum

Boulder concentrations are present intermittently in a northeast-southwest arc that generally marks the edge of the tablelands. The boulder residuum (Qb) appears to lie dominantly on the dissected parts of the Trail City Member and the uppermost part of the Upper Pierre unit; however, a few boulders lie on the lower parts of the Timber Lake Member. The residuum consists of boulders, cobbles, and pebbles (84 percent granite, 5 percent greenstone, 4 percent gneiss, 3 percent diorite, 1 percent gabbro, and 3 percent others), and may have a loess matrix; the lack of carbonate boulders is characteristic. The boulders vary greatly in size, the average being 1½ feet across, and the maximum about 10 feet in diameter. They are subangular to round, and some exhibit striations.

Flint (1955, p. 86) considers the residuum to belong to the Iowan substage of the Wisconsin glacial stage, but Stevenson (1960) has assigned the deposit to the Illinoian (?) glacial stage.

Flint's reasoning for an Iowan assignment is based on the fact that the boulders extend farther west in the valleys than on the interfluves; thus the residuum was formed later than the present deeply dissected topography, which he agrees was formed after the Illinoian glacier had reached its maximum extent.

Stevenson's argument for the Illinoian (?) age determination is based on pebble counts from the various terrace gravels. He states (written communication, 1960), "the highest terrace gravels have abundant glacial material indicating that the glaciation occurred prior to the main downcutting sequence of the Missouri which is Illinoian according to Warren".

Landslide Deposits

The Pierre Formation has a tendency to slump, and landslide deposits are especially evident along the Moreau River and its affluents. The rotation of materials in slide blocks (Qlp) on curved soles in Sections 8 and 9, T. 15 N., R. 27 E. initially suggests hogbacks of an eroded anticline; however, a more thorough study exposes their true nature. Ungrassed slopes showing displaced layers of bentonite provide evidence concerning the large amount of sliding throughout the area south of the tablelands.

Slumping has and is taking place along the breaks separating the tableland from the dissected area (Qltc). Slumping along the breaks is noticeable because the color change between the Upper Pierre and the Trail City Member provides a mappable datum. Displacements as great as 30 feet were noted.

Mapping of slumped material in most localities proved difficult because the slopes are covered with vegetation, except for a few ungrassed outcrops along stream courses. At least some slumping has taken place at each exposure; therefore, it may be assumed that most of the area south of the tablelands has been displaced in this manner to some extent.

Alluvial Deposits

In the Glencross quadrangle two types of alluvial deposits are present, terrace deposits and alluvium.

Terrace deposits (Qt) were implaced during the down-cutting of the Moreau River and the Little Moreau, Whitehorse, Veo, Jolly, and Jewett Creeks. The entire area south and southeast of the tablelands appears to be a dissected remnant of a large southeast-sloping terrace. Scattered flat-topped gravel-covered buttes are present throughout this area. The terraces range in size from 2 acres to about 6 square miles. Their surfaces usually slope two or three degrees toward the streams, but the overall trend is southeasterly toward the Moreau River.

The terrace deposits consist of gravel, pebbles, sand, and clay, having a wide range in composition. A large percentage of ironstone is present throughout every terrace. The coarse material has a sand matrix and usually appears as channel fillings and lenses. The thickness varies from a few inches to a maximum of 14 feet.

Apparently there were five major periods of downcutting during the formation of the terraces. The present Moreau River flood plain has a maximum relief across the quadrangle of about 50 feet, from 1720 to 1670 feet above sea level. Major terrace levels are present at altitudes of 2000 (Qt1), 1900 (Qt2), 1850 (Qt3) and 1800 (Qt4) feet, the present Moreau River floodplain has an altitude of 1700 feet). However, some terraces are not distinct, but show a gradual slope from 2000 to 1800 feet. All the terraces at 1800 feet are present on the southeastern side of the Moreau River or in its floodplain, with the exception of one a mile northeast of Whitehorse (Sec. 12, T. 15 N., R. 26 E., and Sec. 7, T. 15 N., R. 27 E.). This fact and the general topography of the area indicate that meanders of the Moreau River were dominantly on the north side of the present flood plain, until comparatively recent time.

Alluvium (Qal) is reworked Pierre Formation and sandy clay with lenses of sand and gravel along the floodplains of the Moreau River and its major tributaries.

SUBSURFACE ROCKS

The thickness and lithology of subsurface rock units are shown in Table 1. These data are based on preliminary studies by the South Dakota State Geological Survey geologists of samples and electric logs from the following oil test and water well in the quadrangle: Herndon #1 Merkel (SE¼SE¼ sec. 27, T. 17 N., R. 27 E.) and the Whitehorse water well (SE¼SW¼ sec. 12, T. 15 N., R. 26 E.).

STRUCTURAL GEOLOGY

The Glencross quadrangle is situated on the eastern flank of the Williston (Dakota) Basin. The regional dip is to the northwest at a rate of only 12 feet per mile, making the sedimentary rocks in this area nearly flat-lying (see cross-section A-A'). Preliminary studies show that the rocks in the subsurface have a general tendency to thicken toward the west and northwest. Determination of structure of surface rocks is difficult because of the slumping of the Pierre Formation.

ECONOMIC GEOLOGY

The principal mineral resource in the Glencross quadrangle is ground water, available at depths as great as 117 feet in the northern part of the mapped area. Sand, gravel, crushed rock and rip-rap have been produced in this area. Bentonitic shale is present in the southern and southeastern two-thirds of the area. Oil and gas are other potentially economic mineral resources.

Ground Water

The Fox Hills Formation yields water in the northern part of the Glencross quadrangle. The Timber Lake Member is the best water-bearing zone in the area, and wells that obtain water from this sand are 35-74 feet deep. Generally, water from the Timber Lake sand is of excellent chemical quality (table 2). The city well at Timber Lake produces about 150 gallons per minute from a well 70 feet deep.

The Trail City Member of the Fox Hills Formation contains water at depths of 47-117 feet. The water from this member is high in sodium, sulfate, and total solids, but is being used for domestic purposes anyway.

In the southern and southeastern two-thirds of the quadrangle the Fox Hills Formation has been eroded away. Water may be obtained, however, from the jointed clay-shales of the Pierre Formation. This water is high in sulfate, sodium, and total solids (table 2), making it unsuitable for most domestic uses or for irrigation. It can be used, however, without treatment for stock. Wells in the Pierre Formation usually have low capacities and in a year's time may produce less than 10 gallons per day, and drying up completely in 3 to 5 years.

Water is produced from the larger terraces near the Moreau River, at depths of 15-50 feet. The water is of somewhat better chemical quality (table 2) than that from the Trail City and Pierre. The recharge of water to the terraces depends on rain and snow, and thus the water withdrawal may exceed the recharge.

Numerous small springs issue from the contact of the Pierre Formation and the overlying terrace gravels in small ravines along the Moreau River and Little Moreau Creek. Water is also obtained from the Moreau River and Little Moreau Creek floodplains. A 26-foot well, one mile west of Whitehorse, produces 25 gallons per minute. Care must be taken to have such water analyzed often because the bacteriological quality may change rapidly.

Water of good quality and sufficient quantity is difficult to find near Whitehorse, and consequently few wells are present in this area. Because of the lack of water and difficulties in transportation of water either from Timber Lake or Mobridge, much of the Indian population near Whitehorse uses water from Whitehorse Lake for all domestic purposes. The bacteriological purity of this water is questionable, but the writer could find no one who had become sick as a result of drinking it.

A 2021-foot flowing well in Whitehorse provides artesian water from the Newcastle Formation. In July, 1954, it flowed 10 gallons per minute. This water is not good for domestic use, stock, or construction (table 2). Concrete made from this water cracks and crumbles within 3 to 5 years, while casing rusts out in a shorter period of time. Stock will not drink this water.

Table 2.--Chemical Analyses of Water from the Glencross Quadrangle

Source of Water	Parts Per Million							
	Ca	Mg	Na	SO_4	Cl	Fe	Total Solids	Hardness
1. Standard limits		125		250	250	0.3	500	120
2. Timber Lake	56	5	13	26	4	none	236	160
3. Timber Lake	130	23	55	164	9	none	624	420
4. Trail City	64	32	1280	2439	66	0.6	4268	291
5. Pierre	105	10	800	1634	157	none	2974	302
6. Terrace	157	32	400	869	42	--	1920	524
7. Moreau River floodplain	No data, marked "Satisfactory for drinking at this time", July 7, 1960.							
8. Newcastle Fm. (artesian)	29.6				3549	0.6		$CaCO_3$ 140

1. U. S. Bureau of Public Health (1946)
2. Casewell farm, Sec. 14, T. 17 N., R. 24 E.
3. O'Leary farm, Sec. 24, T. 15 N., R. 23 E.
4. Thill farm, Sec. 2, T. 16 N., R. 26 E.
5. Glencross store, Sec. 9, T. 17 N., R. 26 E.
6. Marshall farm, Sec. 27, T. 16 N., R. 27 E.
7. Foster farm, Sec. 11, T. 15 N., R. 26 E.
8. Whitehorse store, Sec. 12, T. 15 N., R. 26 E.

Analyses 2-6 by State Chemical Laboratory, Vermillion, S. Dak., 1959, 1960
Analysis 7 by S. Dak. State Dept. of Health, Pierre, S. Dak.
Analysis 8 supplied by U. S. Bureau of Indian Affairs, 1960

Boulders

Boulders from the till residuum have been used in the past for rip-rap. Many of the older dams have spillways reinforced with this material. Because the main concentrations of boulders are scattered in the deeply dissected parts of the quadrangle, they are difficult to remove because there are no roads or trails in this area.

Gravel

Terrace deposits along the Moreau River contain gravel suitable for surfacing roads. These deposits range in thickness from a few inches to 14 feet, but a large percentage of sand and some clay are usually present. A relatively large percentage of ferruginous material prohibits the use of this material for concrete aggregate. Seven pits along the Moreau River have produced road metal.

Sand

Some of the sands in the terraces could possibly be used for concrete. A zone 3½-feet thick in the center of Section 9, T. 15 N., R. 26 E. contains well-sorted medium-grained quartz sand. Most of the sands, however, contain a large percentage of ferruginous material. Sands of the Timber Lake Member could possibly be used in making concrete and plaster.

Sandstone

The Colgate Member is a hard massive to thin-bedded unit consisting dominantly of fossil oyster-bearing sandstone in this quadrangle. It could be used for rip-rap, but in the Glencross quadrangle it is limited to a very small area.

Shale and Clay

Bentonitic clay-shales of the Pierre Formation may be used to make earth stock dams because they are excellent sealing materials. Some of the non-bentonitic shales could possibly be used in the manufacture of bricks. The upper Pierre clay-shale in the vicinity of Mobridge (20 miles to the east) is potentially suitable for the manufacture of lightweight aggregate (Cole and Zetterstrom, 1954, p. 30).

Oil and Gas

Gas has been produced from the Lower Cretaceous Dakota Group near Pierre, South Dakota. The same stratigraphic unit was penetrated by a deep well at Whitehorse, and produced only foul water. The same zone was penetrated in the Herndon #1 Merkel oil test, (Sec. 27, T. 17 N., R. 27 E.) but the water was not analyzed. This oil test was continued down to the Ordovician Red River dolomite, which is productive in several Williston Basin oil fields, but this test was dry.

Table 1.--Character and Thickness of Subsurface Rock Units

Series	Group or Formation	Thickness	Lithology
Cretaceous	Pierre Formation	1045±	Dark-gray clay-shale, bentonitic clay containing seams of bentonite, limonitic and calcareous concretions.
	Niobrara Formation	330	Light- to dark-gray speckled marl and calcareous clay-shale.
	Carlile Formation	420?	Medium- to dark-gray shale.
	Greenhorn Formation	60	Light-gray sandy limestone containing Inoceramus, gray to white calcareous shale.
	Belle Fourche-Mowry Formations	400-375	Upper: dark-gray shale Lower: siliceous shale, siltstone, and local bentonite seams.
	Newcastle Formation	140	White quartzose sandstone and light-gray siltstone with interbedded shale.
	Skull Creek Formation	167	Medium- to dark-gray micaceous shale containing siderite pellets.
	Inyan Kara (Dakota) Group	33+	White, red, and gray sandstone, dark-gray glauconitic siltstone, dark-gray fissile shale containing siderite pellets. Coarse quartzose sandstone in lower part.
Jurassic	Morrison Formation	110+	Variegated clay and shale, some gray siltstone and sandstone.
Triassic	Piper ? Formation to Spearfish ? Formation	120+	Light-gray dense limestone and dolomite. Red claystone, shale and siltstone containing anhydrite.
Pennsylvanian	Minnelusa Formation	332	White sucrosic dolomite with pink intergranular anhydrite, pink dense dolomite; vari-colored shale, red sandstone, gray to pink sandy dolomite and anhydrite.
Mississippian	Big Snowy Group	302±	Dark-gray, red and green shales with buff limestone; black, gray to brown shale and coal; light-gray to red coarse sandstone and grit, buff sucrosic dolomite, vari-colored reddish brown and gray shales.
	Madison Group	561±	Charles Formation: white to gray dense limestone; white anhydrite, blue anhydrite at base. Mission Canyon Formation: buff to gray granular limestone. Lodgepole Formation: buff to gray dense limestone and oolitic limestone.
	Englewood Formation	153±	Orange to buff siltstone, calcareous siltstone with vari-colored shale.
Devonian ? Silurian	Undifferentiated strata	210±	Buff and gray dense limestone and calcareous shale; dark-gray shale; white calcareous sandstone; white and pink dolomite; white, gray and pink limestone and dolomitic limestone.
Ordovician	Red River Formation	149+	Gray limestone, some calcite sandstone and buff dolomite.
	Winnipeg Formation	170-180	Green fissile shale, basal quartzose sandstone.
Cambrian	Deadwood Formation	180-230	Buff sandstone and glauconitic sandstone; glauconitic dolomite and dolomitic sandstone.
Precambrian			Granite and schist.

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