SOUTH DAKOTA GEOLOGICAL SURVEY
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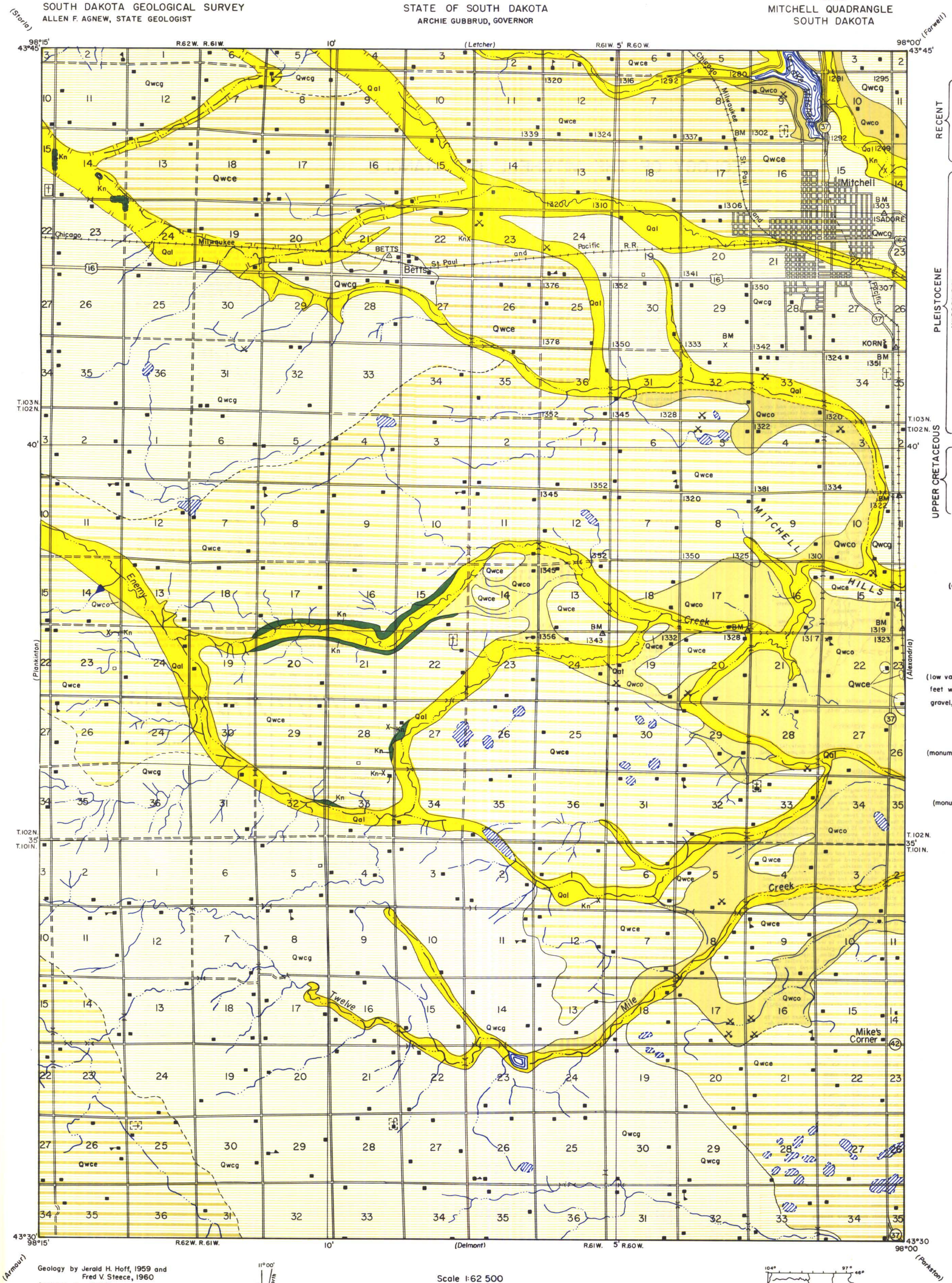
STATE OF SOUTH DAKOTA
ARCHIE GUBBRUD, GOVERNOR

GEOLOGY of the MITCHELL QUADRANGLE SOUTH DAKOTA



EXPLANATION

QUATERNARY

RECENT

Qal — **Alluvium**
(Semistratified deposits of clay-silt and fine sand, humic; 0-12 feet; in stream flood plains.)

PLEISTOCENE — WISCONSIN

Qwco — **Cary Outwash**
(Stratified deposits of fine sand to coarse gravel laid down by glacial meltwater streams; 0-30 feet thick;

Qwce — **Cary End Moraine**
(Ridge-like accumulations of till characterized by relatively rough topography and boulder-strewn surface.)

Qwce — **Cary Ground Moraine**
(Relatively flat accumulations of till characterized by swell and swale topography and few boulders.)

UNCONFORMITY

CRETACEOUS — UPPER CRETACEOUS

Kn — **Niobrara Formation**
(Light-to medium-gray chalk which weathers orange buff, interbedded with thin shaly marl; fossiliferous.)

Geologic Contact
(dashed where approximately located)

Gravel Pit

Meltwater Channel
(low valley sag as much as 15 feet deep and 200 feet wide, with flat bottom; floored with sand, gravel, till, or bedrock.)

XBM 1328
Bench Mark
(monument showing exact altitude above sea level)

▲BETTS
Triangulation Station
(monument marking exact geographic location.)

Radio Station & T V KORN
House, school, and church

Cemetery

Geology by Jerald H. Hoff, 1959 and Fred V. Steece, 1960
Assisted by H. D. Wong

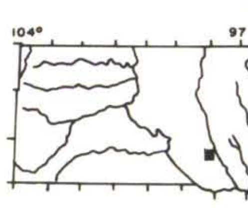
Vertical and horizontal control from U S Geological Survey topographic map of Mitchell 7½ minute Quadrangle and triangulation and level lines of Federal Surveys.
Drafted by Bruno C. Petsch, 1961

11°00'
True North
Magnetic North
Approximate Mean Declination 1959

Scale 1:62 500

1 0 1 2 3 4 Miles

Vermillion, South Dakota
1961



■ Quadrangle Location

MITCHELL QUADRANGLE

GEOLOGY OF THE MITCHELL QUADRANGLE

by

J. H. Hoff and F. V. Steece

INTRODUCTION

The Mitchell Quadrangle includes about 216 square miles of Davison County in southeastern South Dakota. The area lies within the James Basin, a part of the Central Lowlands Physiographic Province (fig. 1).

The northern part of the area is drained by Firesteel Creek, which enters the James River less than a mile east of the quadrangle; the central part by Enemy Creek, which enters the James River about 6 miles east of the quadrangle, and the southern part by Twelve Mile Creek, which enters the James River about 13 miles southeast of the quadrangle. The creeks are intermittent, but Enemy Creek and Firesteel Creek flow continuously during years of higher than average precipitation. The James River flows southward east of the quadrangle.

Lake Mitchell, formed by a power dam on Firesteel Creek in the extreme northeastern part of the quadrangle, and a small reservoir on Twelve Mile Creek in the south-central part of the quadrangle are the only permanent bodies of water in the area.

Mitchell (pop. 12,555 in 1960) is the county seat of Davison County and is the only incorporated area within the quadrangle. Betts is an unincorporated village 5½ miles west of Mitchell. The quadrangle is served by U. S. Highway 16 across the northern part, and State Route 37 along the eastern edge; State Route 42 serves the quadrangle for ¼-mile in the southeast corner. County gravel roads are good and provide all-weather access to most of the area. The Chicago, Milwaukee, St. Paul, and Pacific Railroad and the Chicago, St. Paul, Minneapolis and Omaha Railroad provide rail service to the area. Commercial passenger bus service is available in Mitchell, and North Central airlines serves the Mitchell metropolitan area.

The climate is characterized by a wide range of temperature and records at the Mitchell Weather Station show an average annual temperature of 47.7 degrees. The average annual precipitation is approximately 21 inches. Agriculture is the principal industry, with corn and small grain being the chief crops. Beef and dairy cattle, hogs, and sheep are also raised.

The surface geology was mapped on high altitude air photos during the summer of 1959 by J. H. Hoff and in 1960 by Fred V. Steece, as part of the State Geological Survey's program of studying the economic resources of South Dakota. H. D. Wong collaborated in the field work. Detailed information was provided by hand-auger borings, supplemented by the South Dakota State Geological Survey's jeep-mounted auger drill, which had a depth limitation of 80 feet.

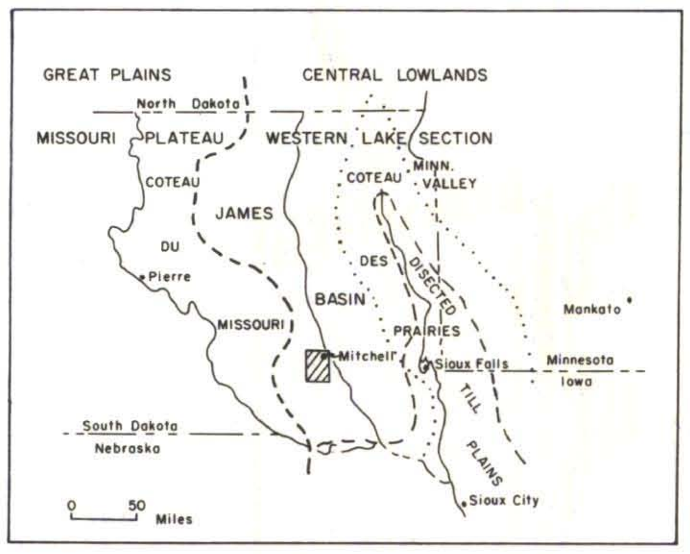


Fig. 1 Index map of South Dakota showing location of Mitchell Quadrangle in relation to the physiographic divisions (Rothrock, 1943; Carman, 1915)

SURFICIAL DEPOSITS

The Mitchell quadrangle is covered by unconsolidated material which can be divided into four groups: glacial deposits, stream deposits, wind deposits, and stream-wind deposits.

Glacial Deposits

The glacial material within the quadrangle was deposited by the Cary ice, the third advance of the Wisconsin ice sheet, which represents the last of the four major subdivisions of the Pleistocene Epoch. The material is drift consisting of clay, silt, sand, gravel, and boulders which were removed from bedrock or were reworked from older surficial deposits. According to well records in the files of the South Dakota State Geological Survey, this drift ranges in thickness from 15 feet in the west-central part of the quadrangle to about 125 feet in the southeastern and southwestern parts of the area. The average thickness of drift in the Mitchell quadrangle is about 50 feet.

The drift is divisible into two groups, till and outwash deposits. Till is the most abundant and consists of unsorted and unstratified material ranging up to boulder size in a clay-silt matrix. The constituents of the till were derived through abrasion of the underlying land surface, incorporated into the ice, and let down when the ice melted forming ground moraine; some of the material was deposited in front of the advancing ice as ridges and mounds when the ice began its retreat forming end moraine. Outwash deposits consist of silt, sand, and gravel reworked from the drift by glacial meltwater streams, and later redeposited in stratified and relatively well-sorted beds.

The till exposed at the surface is probably Cary in age (Steece, Tipton, Agnew, 1960, p. 3a) although it was mapped by Flint (1955) as Mankato. Both the end moraine and ground moraine in the area are well drained. End moraine is the material formed in ridge-like accumulations around the edges of the glacier, whereas ground moraine is the material deposited under the ice sheet. The end moraine is distinguished from the ground moraine by its greater local relief and higher elevation. Distinct end moraine remnants (the Mitchell Hills), with a maximum local relief of approximately 80 feet, trend southeasterly in the east-central part of the quadrangle. The ground moraine normally has a local relief of approximately 10 feet, and thus presents a nearly level, gently rolling till plain. Wong (1960) in the Alexandria quadrangle to the east has mapped ground moraine adjacent to end moraine in this quadrangle. This discrepancy results from emphasizing different criteria. Aligned small ridges have been mapped as minor moraines in much of the quadrangle by Gwynne (1951), and are shown in Figure 2.

Outwash deposits cover an area of approximately 20 square miles in the east-central part of the quadrangle. The outwash material was derived from meltwaters of the ice that built the end moraine to the north and west. The outwash material ranges in size from silt to gravel, and is generally poorly sorted.

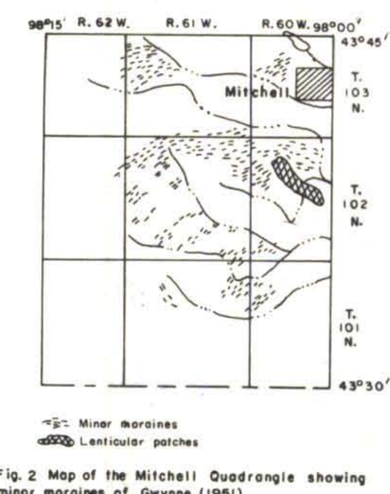


Fig. 2 Map of the Mitchell Quadrangle showing minor moraines of Gwynne (1951)

Small remnants of gravelly till project as hills 30-40 feet high, above the nearly flat outwash plain in Secs. 22, 23, and 26, T. 102 N., R. 60 W., about a mile south of the Mitchell Hills.

The sand and gravel varies locally in composition but generally contains 10-45 percent carbonate rocks derived from the underlying Niobrara chalk, 5-20 percent argillaceous rocks, and the remainder igneous and metamorphic rocks.

In the northern part of the quadrangle are several wide, shallow, drainage-ways up to half a mile in width, covered with 2-8 inches of Recent alluvium and soil, resting on Niobrara chalk. These drainage-ways probably represent stream channels formed during the period of greatest glacial melting and the consequent large supply of melt water. In these drainage-ways, at widely separated intervals, are hillocks ranging in size from 50 to 150 feet along their greatest axis and up to a maximum of 10 feet in height. These hillocks are composed of sand and gravel and constitute the remains of a much more extensive body of outwash sand and gravel which has been removed by erosion.

The thickness of the outwash sand and gravel averages approximately 12 feet, with a maximum of 30 feet.

Stream Deposits

Recent alluvium consists of silt and a little sand, reworked from bedrock and older surficial deposits by present-day streams. Alluvium is found along all of the present drainage channels. The alluvium reaches a maximum thickness of approximately 12 feet at places along Enemy Creek and Twelve Mile Creek in the western part of the quadrangle, and a minimum of approximately 2 inches in the shallow drainage channels in the northern part of the quadrangle. The average thickness of alluvium is about 2 feet.

Wind Deposits

Loess is wind-deposited silt and clay derived mainly from the outwash plain and till plain. In this area loess deposits are sporadic and thin, generally less than 6 inches thick. The loess was therefore not mapped separately.

Wind-Stream Deposits

Much of the area of outwash deposits is covered by material that closely resembles silty till, but which apparently was not laid down directly by the glacial ice. This material reaches a maximum thickness of 3 feet and averages approximately 1 foot in thickness. It is unstratified and consists of clay to silt-size particles with sparsely scattered pebbles ¼-2 inches in diameter. This material probably represents deposition by both wind and water during the periods of further withdrawal of the ice sheet, and thus the smaller supply of water in the depositing streams. A second possibility is that the clay and silt size material may have been deposited as loess, and that the pebbles were introduced by working upward from underlying gravel beds. Such pebbles work up under the action of alternate freezing and thawing and typically leave a trail of disrupted material in their wake. However, the lack of such trails at exposures in the Mitchell quadrangle has led to the adoption of the former explanation.

BEDROCK

The Niobrara chalk is exposed along the bluffs of Enemy Creek and the unnamed creek six miles to the north, and along road cuts in ditches in the shallow drainage channels in the northern part of the quadrangle. In the Mitchell quadrangle the Niobrara is a dark-gray chalk which weathers to a light orange-buff color and which alternates with thin layers of gray, shaly marl. The chalk in the Mitchell area is characterized by an abundance of fossil oysters and by many septarian concretions. The Niobrara reaches a maximum of about 60 feet in the subsurface of the southwestern part of the quadrangle.

Conformably underlying the Niobrara chalk in the subsurface is the Carlile Formation which averages approximately 100 feet in thickness in the quadrangle. Todd (1903) reported 270 feet of sand and shale of the Carlile Formation from a well at Mitchell. This probably represents an exceptionally great thickness of Carlile. The Carlile consists of medium- to dark-gray shale at the base, and the Codell sandstone member at the top. The Codell varies greatly in thickness in this area, but averages approximately 10 feet; a maximum thickness of 30 feet was measured at an exposure 3 miles east of the eastern border of the quadrangle (Wong, 1960).

The Carlile Formation rests unconformably on the Precambrian Sioux quartzite throughout most of the quadrangle. Todd (1903), however, reported that a well in the SW¼ sec. 25, T. 103 N., R. 61 W., drilled into dark-gray granite at 500 feet.

The electric log of the Wingett well drilled in the SE¼ sec. 34, T. 103 N., R. 60 W., shows the following sequence:

Depth in Feet	
0- 35	till
35-134	Carlile shale
134-TD	Sioux quartzite

The log of the well at Mitchell reported by Todd (1903) indicates the following sequence:

Depth in Feet	
0-130	till
130-170	sand (Codell ?)
170-440	shale with sand layers (Carlile ?)
440-540	sand and shale (Dakota ?)
540-765	(bottom) quartzite

STRUCTURE

The Mitchell quadrangle is in part of the Stable Interior of the United States, and is characterized by essentially flat-lying Cretaceous sedimentary rocks which rest unconformably upon Precambrian basement rock. The Precambrian Sioux Formation has been subjected to slight structural activity and dips approximately 4 degrees to the southwest throughout the area (Baldwin, 1949), but local dips as great as 7 degrees have been mapped in the Alexandria quadrangle to the east (Wong, 1960).

ECONOMIC GEOLOGY

The most valuable geologic products in this area are ground water, and sand and gravel. Chalk is present in large quantities and has been used as building stone in the past, but is not used at the present time.

Ground Water

Sufficient ground water to supply farm needs is found throughout the quadrangle.

The outwash sands and gravels contain water that is of good quality (table 1), and is sufficient in quantity to supply the domestic needs of the farmers in the area. This is supplemented by sand and gravel lenses in the drift which could supply a limited quantity of fairly good quality water.

Nearly all ground water present is derived from precipitation. Rain or melting snow either percolate directly downward to the water table or drain off as surface water. Surface water will either evaporate, escape to the ocean, or if the water table is low it will percolate downward from the ground surface, saturating the porous material below the surface. If the saturated material is permeable, the contained water will then move laterally down the hydraulic gradient, and is then said to be in transient storage. Therefore recharge, or the addition of water to an aquifer, is accomplished in three ways:

1. Direct percolation derived from rain or snow-melt.
2. Percolation from surface bodies of water.
3. Water in transient storage.

The amount of ground water which can be stored in an aquifer is dependent upon the percentage of void space in the aquifer and the volume of the aquifer. The amount of sand and gravel in the Mitchell quadrangle capable of containing water is comparatively small--about 320 million cubic yards, of which about half is saturated with water, (based on drill hole information). Recharge in the Mitchell quadrangle is dependent upon local precipitation exclusively. For these reasons it is felt that the outwash area would not furnish a large enough or dependable enough supply of water for large-scale irrigation or for a water supply for a large urban population.

Water of acceptable quality for irrigation or domestic use (table 1) may be obtained in large quantities from the Codell sand member of the Carlile Formation, and from the sand lenses in the shales of the Carlile. Nowhere in the quadrangle would it be necessary to drill deeper than 200 feet to reach these water-bearing strata, and the Codell sand is within 50 feet of the surface throughout much of the quadrangle. Because of the larger supply of water available and the greater dependability of this source, the Codell sandstone is recommended for development.

Flint (1955) suggested the presence of several preglacial valleys (fig. 3), which contain buried deposits of sand and gravel, and may be water bearing.

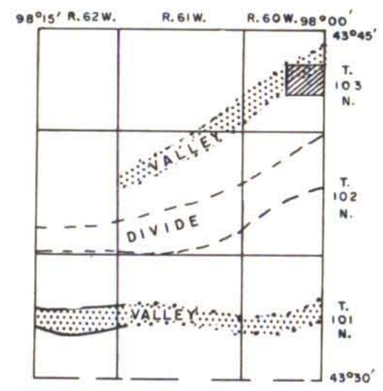


Fig. 3 Map of the Mitchell Quadrangle showing prediversion drainage system. (After Flint, 1955)

Sand and Gravel

The outwash area covers approximately 20 square miles and contains approximately 320 million cubic yards of sand and gravel. This gravel is suitable for road metal, bituminous aggregate or concrete aggregate if the large amount of carbonate rocks (chalk) and argillaceous rocks (shale) are first removed; furthermore, there are numerous local deposits of gravel which have a low percentage of carbonate and argillaceous rocks, and are suitable for road metal or bituminous aggregate without processing.

Chalk

Large amounts of chalk are available in this area from the Niobrara Formation. This chalk is found near the surface, and in the northwestern part of the quadrangle is covered by only 2-8 inches of overburden. The chalk in the Mitchell area has been used as building stone in the past and Todd (1903) reported that it is easily worked and sufficiently durable for use as a building stone. Chalk of the same formation has been used in the manufacture of cement near Yankton, South Dakota, 75 miles to the south.

Table 1.--Water Analyses of Samples from Wells in the Mitchell Quadrangle**

Source of Water	Calcium	Sodium	Magnesium	Iron	Manganese	Chloride	Sulphate	Fluoride	Hardness	Total Solids	Class for Irrigation *
"wash" (1)	410	100	83	0	0	110	1314	0	1364	2308	II
Codell (2)	37	476	0	0	0	101	629	0	89	1528	III
Sand lense in Carlile (3)	406	123	80	Tr.	Tr.	150	1290	0	1329	2344	II
Codell (4)	103	328	26	0	0	70	842	0	363	1748	III
Wash (5)	383	75	74	0	0	144	1253	0	1259	2372	II
Wash (6)	277	2.16	69	10.4	Tr.	94	1205	1.4	994	2100	II
Publ. Health Standards (not to exceed) (7)		125		0.3	0.3	250	250			1000	

* Class I - excellent to good; Class II - good to injurious; Class III - injurious to unsatisfactory

** Analyses by S. Dak. State Chemical Laboratory, Vermillion, 1960

References

Baldwin, Brewster, 1949, A Preliminary Report on the Sioux Quartzite: S. Dak. Geol. Survey Rept. Invest. 63, 34 p.

Carman, J. E., 1917, The Pleistocene Geology of Northwestern Iowa: Iowa Geol. Survey, v. 26, p. 233-445.

Flint, R. F., 1955, Pleistocene Geology of Eastern S. Dak: U. S. Geol. Survey Prof. Paper 262, 171 p.

Gwynne, C. S., 1951, Minor Moraines in South Dakota and Minnesota: Bull. Geol. Soc. America, v. 62, p. 233-250.

Rothrock, E. P., 1943, Geology of South Dakota, Pt. I: The Surface: S. Dak. Geol. Survey, Bull. 13, 88 p.

Steece, F. V., Tipton, M. J., and Agnew, A. F., 1960, Eastern South Dakota: Gdbk. 11th Ann. Field Conf., Midwest Friends of the Pleistocene, S. Dak. Geol. Survey, 21 p., 8 illust.

Todd, J. E., 1903, Mitchell Quadrangle: U. S. Geological Survey Folio No. 99, 7 p.

Wong, H. D., 1960, Geology of the Alexandria Quadrangle: S. Dak. Geol. Survey, map and text.