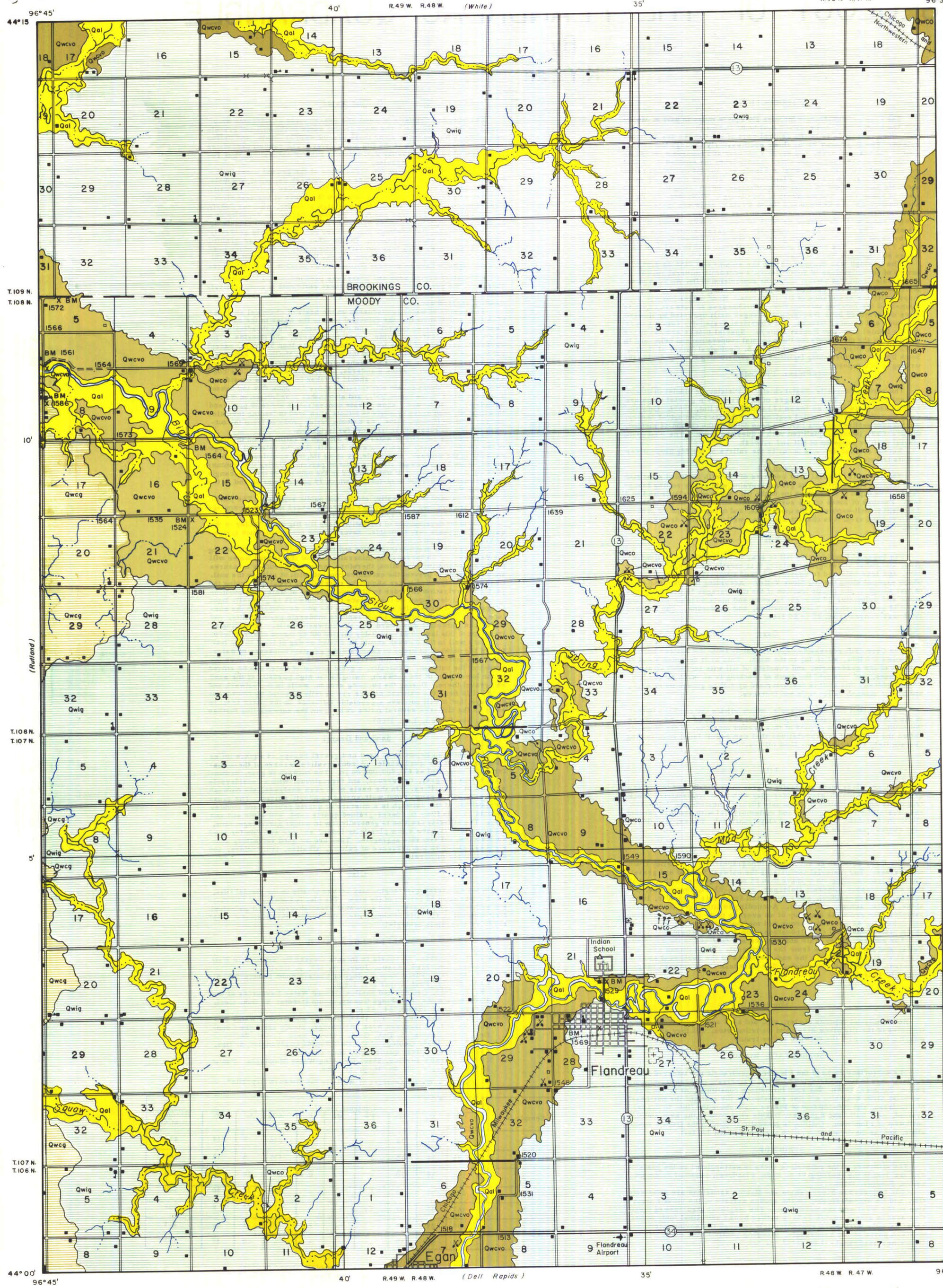
SOUTH DAKOTA GEOLOGICAL SURVEY
ALLEN F. AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA
RALPH HERSETH, GOVERNOR

GEOLOGY
of the
FLANDREAU QUADRANGLE
SOUTH DAKOTA



EXPLANATION

RECENT

Qal
Alluvium
(Alluvial silt, sand and gravel along the Big Sioux River and its tributaries.)

WISCONSIN

Qwcvo
Cary Outwash-Valley Train
(Chiefly silt, sand, and gravel; in the Big Sioux and its tributaries.)

Qwco
Cary Outwash Terrace
(Chiefly sand and gravel; remnants along the Big Sioux and its tributaries. About 30 feet above present stream beds.)

Qwcg
Cary Ground Moraine
(Sandy till, gray to brownish-or greenish-gray; generally rolling surface; local stratified sand lenses.)

Qwig
Iowan? Ground Moraine
(Pebble-clay till, gray to brownish-gray, somewhat bluish-to blackish-gray, compact, mostly oxidized; well-integrated drainage pattern, and undulating topography; local stratified sand lenses.)

PLEISTOCENE — **QUATERNARY**

Geologic Contact
(dashed where approximately located)

Gravel Pit

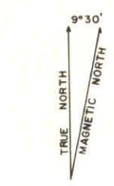
X BM 1572
Bench Mark
(monument showing exact altitude above sea level.)

X 1552
Spot Altitude

△ INDIAN SCHOOL
Triangulation Station
(monument showing exact geographic location.)

House, School, and Church

Geology by K.Y. Lee, 1958
Assisted by C.F. Harris
Vertical and horizontal control surveyed from triangulation and level lines of Federal surveys
Drafted by H. D. Wong

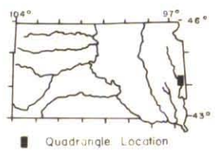


APPROXIMATE MEAN DECLINATION 1958

Scale 1:62 500

1 1/2 0 1 2 3 4 Miles

Vermillion, South Dakota
1960



Quadrangle Location

FLANDREAU QUADRANGLE

GEOLOGY OF THE FLANDREAU QUADRANGLE

By

K.Y. Lee

INTRODUCTION

The Flandreau quadrangle includes 216 square miles in part of Moody and Brookings Counties, in east-central South Dakota.

The quadrangle is in the central part of the Coteau des Prairies upland. The Big Sioux River flows southeasterly through the central part of the mapped area, and turns southerly at Flandreau; its major tributaries in the quadrangle enter mainly from the northeast. Local relief is up to 132 feet a mile west of Flandreau, and the maximum relief of the quadrangle is 162 feet. Flandreau (pop. 2193) is the county seat, and State Routes 13 and 34 cross the quadrangle, intersecting three miles south of Flandreau. The mainlines of the Chicago, Milwaukee, St. Paul, and Pacific, and the Chicago and North Western railroads traverse the southeastern part and the northeastern corner of the quadrangle respectively, and a well-developed network of county roads serves most of the area. The climate is characterized by a great temperature range and by rapid fluctuations in temperature; the mean annual temperature is 44.7 degrees. The average annual rainfall from 1935 to 1957 was 23.7 inches at Flandreau Weather Station.

The geology was mapped during the summer of 1958 as part of a series of investigations of South Dakota's economic mineral resources by the State Geological Survey, under the supervision of Dr. A. F. Agnew, State Geologist. The geology was plotted on air photos and planetable maps, with the assistance of Cecil Harris. Hand-auger borings supplemented the outcrop information. Thicknesses of outwash deposits were determined by a jeep-mounted auger drill operated by Howard Loitwood and Spencer Brooks, and electrical resistivity surveys were run by Daniel Lum and Robert Benson. Special thanks are due to the residents of the quadrangle for their cordial cooperation and help, and to J. E. Powell, District Engineer of the U. S. Geological Survey at Huron, South Dakota, for furnishing facilities and contributing counsel during the writing of this report.

SURFICIAL DEPOSITS

The surficial deposits consist chiefly of Pleistocene glacial drift and Recent alluvium. Two substages of the Wisconsin glacial stage are recognized tentatively as Iowan (?) and Cary (Flint, 1955). Only the Cary deposits have been studied regionally by the State Geological Survey; and because earlier deposits have not been dated by the carbon-14 method, the pre-Cary Iowan is qualified with a question mark. The Wisconsin glacial drift is made up of till and outwash.

Recent alluvial deposits occur in the valleys of the Big Sioux River and its tributaries.

Iowan (?)

The Iowan (?) glacial drift consists of till with included stratified sand lenses, and is mapped as ground moraine with gently rolling topography. The depth of leaching on top of the till ranges generally from 1 to 2 feet. Patches of loess on the surface of this till are up to 6 feet thick. This drift is well-exposed in the quadrangle, and occupies about 80 percent of the mapped area; it is characterized by a well-integrated drainage pattern.

Till

The Iowan (?) pebble-clay till is gray to brownish- and yellowish-gray, somewhat bluish-gray to black; it is mostly oxidized in the upper part, and less oxidized to unoxidized, and compact in the lower part, where exposed along the Big Sioux Valley. According to a detailed study of four samples, the pebble fraction of the till averages 58 percent limestone and dolomite, 30 percent igneous and metamorphic rocks, and about 12 percent shale, clay-ironstone, and sandstone. The exposed thickness ranges from 20 to 60 feet.

Cary

The Cary drift represents deposits mainly from the eastern limb of the James ice lobe, which lay to the west. This drift occupies about 20 percent of the quadrangle, and consists of till with included stratified sand lenses, and outwash; the depth of leaching is as much as one foot. Topographically this drift is characterized by rolling ground moraine_/, and by flat outwash valley train and terraces.

_/ In the Dell Rapids quadrangle, which adjoins the southern border of the Flandreau quadrangle, Tipton (1959) has mapped as end moraine the southern extension of part of this ground moraine. This disparity shows the different interpretations that can result from emphasizing certain field criteria rather than others.

Till

The Cary till is made up chiefly of gray to greenish- and brownish-gray, somewhat bluish-gray boulder-clay with sand-rich matrix. Rock fragments consist mainly of carbonate rocks (limestone and dolomite), and crystalline rocks (igneous and metamorphic) with about 10 percent clastic rocks (shale, sandstone, and clay-ironstone). The exposed thickness ranges from 20 to 45 feet.

Outwash

The Cary outwash is subdivided topographically into valley train and terrace. The material comprising the outwash is sand and gravel. The sand fraction consists of more than 85 percent quartz, with about 15 percent accessory minerals (feldspar, pyrite, chert, tourmaline, pyroxene, and iron-oxides), and some small fragments of granite, limestone, slate, schist, and shale. According to lithologic study of five samples, the gravel is made up of an average of 46 percent limestone and dolomite, 42 percent igneous and metamorphic rocks, 10 percent shale, sandstone, and clay-ironstone, and 2 percent chert.

The outwash valley train and terrace are confined to the Big Sioux Valley and its tributaries from the northeast. The outwash sand and gravel were derived from the end moraines to the northwest and the northeast, outside the quadrangle. The thickness of the outwash ranges from 4 to 44 feet.

Alluvium

Recent alluvial deposits of clay, silt, and sand and gravel occur along the sides of the Big Sioux River and its tributaries, and they are intermingled locally with the outwash valley train.

SUBSURFACE ROCKS

The subsurface rocks of the Flandreau quadrangle are inferred from drillers' logs in the quadrangle (A. Rude, Flandreau; personal communication, Summer, 1958). The rock formations constitute pink to red Precambrian Sioux quartzite and fine sandstone to the east and the northeast of Flandreau, and 200-300 feet of Pierre shale above the fine- to coarse-grained, red, buff, and light-gray Dakota sandstone to the west and the northwest of Flandreau. Drilling is generally stopped in the Dakota sandstone, and the maximum penetration of holes is about 700 feet.

STRUCTURE

The structure of the subsurface rocks is extrapolated on the basis of drillers' logs in the quadrangle (A. Rude, Flandreau, personal communication, Summer, 1958).

The Cretaceous Pierre shale and Dakota sandstone are relatively flat, and lie unconformably on the eroded surface of the Sioux Formation to the west and the northwest. The regional structure of these Cretaceous strata seems to be a rather broad anticlinal fold, whose crest extends northward approximately through the northwestern and western parts of the quadrangle, plunging gently to the north into the Brookings quadrangle (Lee, 1958, p. 12).

ECONOMIC GEOLOGY

The Wisconsin glacial drift is of major economic importance in the mapped area. The outwash deposits of sand and gravel are good water-bearing sediments, and are used in construction industries. Clay, derived mainly from glacial tills, is potentially important for ceramic ware.

Ground Water

The outwash deposits of sand and gravel yield an adequate water supply in the quadrangle. The main ground water in the outwash gravels and sands flows generally along these pre-outwash channels, and drains along the present course of the Big Sioux River. The rainfall percolates downward through the sandy soil into the zone of saturation, thus recharging the outwash deposits.

The factors controlling the occurrence of the ground water in the outwash are the physical properties of the outwash deposits, and their distribution. The physical properties of the outwash include porosity and permeability, which are deduced on the basis of textural study. Generally, well-sorted sediments have high porosity, whereas poorly sorted sediments are less porous. Permeability is the capacity of a deposit to transmit water under hydraulic head. A sediment containing very small interstitial openings may be very porous, but it is generally difficult to force water through it. On the other hand, a coarse-grained sediment that may have less porosity, commonly is much more permeable than a fine-grained sediment. In the Flandreau quadrangle, the outwash deposits have an average porosity of 25 percent. Rather coarse and moderately sorted sand and gravel are predominant in the outwash; therefore, the passage of fluids through these sediments is comparatively easy. Thus the processes of discharge, recharge, and recovery are readily carried out.

The quality of water is discussed on the basis of chemical analyses (Table 1), which show that the principal ions in the water in the outwash deposits, are sulfate, calcium, and magnesium. The subordinate ions are sodium, nitrate, chloride, iron, manganese, and fluoride. The carbonate hardness of these waters is mostly less than 500 ppm, except for the city water of Flandreau, and the waters from McGlone's and Weston's wells; thus these waters are generally satisfactory for human uses (U. S. Public Health Service Standards, 1946). Nevertheless, the concentrations of sulfate and nitrate should be taken into serious consideration. Sample 5 shows sulfate concentration above 250 ppm; this ion causes a laxative effect on the human body, and also makes poor irrigation water. Samples 1, 2, 4, 6, and 7 show nitrate concentration above 10 ppm, and this impurity may cause cyanosis in infants when used in feeding formulas and for drinking (Comly, 1945). As a whole, water produced from the outwash deposits is generally satisfactory for irrigation.

The storage capacity of water in the outwash is estimated on the basis of the average porosity of each outwash deposit; thus the potential storage capacity in the outwash, as a whole, is about 112,000 acre-feet, of which the Big Sioux River outwash contains about 86 percent. During the summer of 1958, the total amount of water stored in the outwash of the quadrangle was estimated at 60,200 acre-feet, of which 79 percent was stored in the Big Sioux Valley.

Water is used for domestic, stock, and public supplies. The public supplies are confined to the city of Flandreau, where the water pumpage per year averages about 7,100,000 gallons.

The future development of irrigation along the Big Sioux Valley in the quadrangle appears very favorable. Several items concerning such irrigation deserve mention however.

As a result of evapo-transpiration and re-circulation especially during the dry season, an increase in mineralization of the ground water will probably accompany irrigation; therefore, necessary counter measures should be taken to prevent the excessive concentration of salts in the soil. Chemical analysis of water should be carried out regularly during the period of irrigation in order to observe changes of water composition.

The soil developed on the surface of the outwash is generally light in texture, and more silty and sandy than the soil developed on the surface of the tills; the former has a rapid to moderate permeability, and water can percolate downward into the outwash easily. Accordingly, irrigation of this land could be suitably carried out by means of sprinklers.

Each well in the outwash should be drilled or dug at least to the bottom of the outwash in order to penetrate the greatest thickness of water-saturated material. Wells for irrigation should not be located near the border of the outwash. Generally, a great amount of water can be stored in the lower part of the outwash, owing to the high porosity of the sand and gravel there. During the pumping season, wells in the outwash and in the tills near the outwash border are usually affected by continuous pumpage, but it will not have appreciable influence on the water level in wells in the till area several miles away from the outwash (for further details, see Powell, Lee, 1960).

Sand and Gravel

The outwash deposits of sand and gravel occupy 34 square miles (16 percent) of the quadrangle. A conservative reserve of these materials is computed as 671,000,000 cu yd. The outwash is gray, brownish- to reddish-gray, calcareous, and ferruginous, with a considerable amount of impurities. On the basis of screen analyses, the outwash sand and gravel ranges from well-sorted to poorly sorted. The gross composition of the outwash is a mixture of quartz pebbles and cobbles associated with fine- to coarse-grained quartz sand, and some silt and clay. The silt-clay fraction is generally low in weight percentage; thus, these materials have a low plasticity index, and are suitable for road construction and concrete aggregate. They are not good refractory substances, owing to the presence of calcite, alkalies, iron-oxides, and other silicate minerals.

Clay

In the Flandreau quadrangle, clay occurs chiefly in the glacial tills, which cover about 50 percent of the area. The clay is brownish-, bluish-, and yellowish-gray to gray, and somewhat greenish-gray. The principal clay mineral in the tills is nontronite. Generally, this material could serve as a ceramic material.

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Comly, H. H., 1945, Cyanosis in Infants Caused by Nitrates in Well Water: Am. Med. Assoc. Jour., v, 129, p. 112-116.

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Table 1.--Water Analyses of Wells in the Outwash Deposits*

Sample No.	Contents (ppm)									
	Ca	Mg	Na	Fe	Mn	F	SO_4	Cl	N	Hardness ($CaCO_3$)
1	131	41	14	-	-	-	216	8	14	444
2	98	35	15	2	-	0.4	155	5	15	388
3	155	35	10	4	Tr	0.4	247	22	6	533
4	175	37	13	2	-	-	219	21	80	589
5	167	46	29	Tr	3	-	311	22	8	608
6	98	29	8	-	-	-	81	7	60	363
7	114	31	19	-	-	-	96	10	32	413

*Analyst D. J. Mitchell, State Chemist, State Chemical Laboratory, University of South Dakota, Vermillion, South Dakota, 1958.

1. Albert W. Teal, Sec. 9, T. 108 N., R. 49 W.
2. Mrs. Wilber C. Gullickson, Sec. 16, T. 108 N., R. 49 W.
3. Virgil T. Weston, Sec. 9, T. 107 N., R. 48 W.
4. A. M. McGlone, Sec. 20, T. 107 N., R. 47 W.
5. City Well No. 3, Flandreau, Sec. 27, T. 107 N., R. 48 W.
6. Robert Hammer, Sec. 29, T. 107 N., R. 48 W.
7. City Well, Egan, Sec. 7, T. 106 N., R. 48 W.