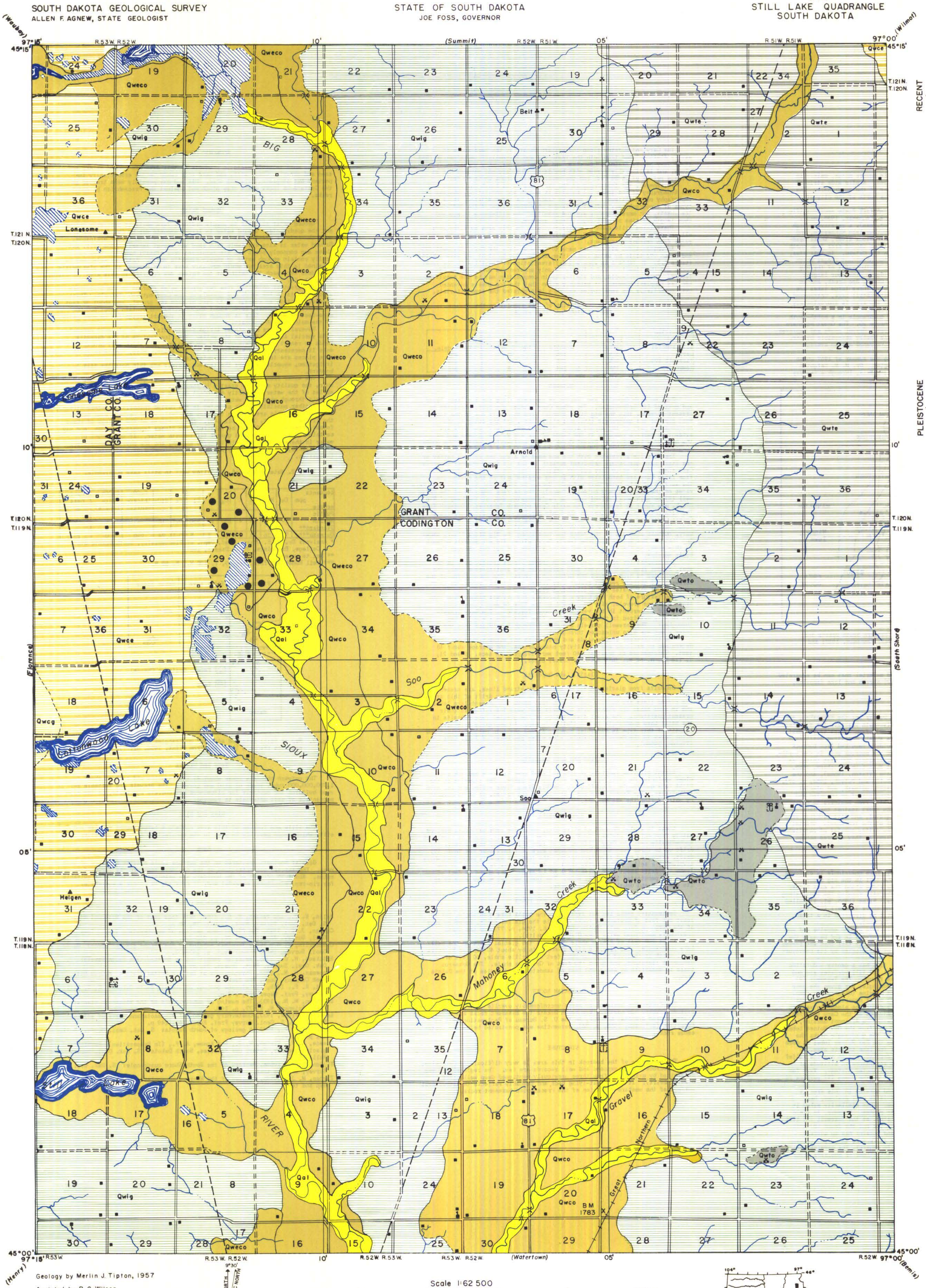
SOUTH DAKOTA GEOLOGICAL SURVEY
ALLEN F. AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

GEOLOGY of the STILL LAKE QUADRANGLE SOUTH DAKOTA



Geology by Merlin J. Tipton, 1957

Assisted by R. C. Wilson

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

Drafted by R.H. Benson

TRUE NORTH
MAGNETIC NORTH
9°30'
APPROXIMATE MEAN DECLINATION 1958

Scale 1:62 500

1 1/2 0 1 2 3 4 Miles

Vermillion, South Dakota
1958

Quadrangle Location

EXPLANATION

QUATERNARY

RECENT

Qal — Alluvium

(Floodplain deposits of silt and sand in valleys of larger streams)

PLEISTOCENE — WISCONSIN

Qwco — Late Cary Outwash

(Stratified meltwater deposits of sand, gravel, and silt; in floodplains)

Qweco — Early Cary Outwash Terraces

(Stratified meltwater deposits of sand, gravel, and silt; 10-20 feet above late Cary outwash. Collapsed areas shown by dotted pattern)

Qwce — Cary End Moraine

(Ridge-like accumulations of till; characterized by rough topography, undrained depressions, and boulder-strewn surface)

Qwcg — Cary Ground Moraine

(Relatively flat accumulations of till; characterized by swell and swale topography, undrained depressions, and boulder-strewn surface)

Qwto — Tazewell (?) Outwash Terraces

(Stratified meltwater deposits of sand, gravel, and silt; about 15 feet above early Cary outwash terraces)

Qwte — Tazewell (?) (Bemis) End Moraine

(Ridge-like accumulations of till; characterized by smooth slopes, and very few undrained depressions or boulder-strewn areas)

Qwig — Iowan (?) Ground Moraine

(Plateau-like accumulations of till; characterized by well developed drainage, smooth slopes, very few boulders, and no undrained depressions)

Contact
(dashed where approximately located)

Gravel Pit

x BM 1783
Bench Mark
(monument showing exact altitude above sea level)

Belt
Triangulation Station
(monument marking exact geographic location)

House, school, and church

Cemetery

Still Lake Quadrangle

INTRODUCTION

The Still Lake quadrangle includes about 214 square miles, mainly in north-central Codington and western Grant Counties. A mile wide strip of Day County is included in the northwestern border of the quadrangle. The southern border of the mapped area is seven miles north of the city of Watertown.

The area is in the Western Lake and Dissected Till Plain sections (fig. 1) of the Central Lowlands physiographic province (Fenneman, 1938, map), and is on the Coteau des Prairies (Rothrock, 1943, map), a relatively high plateau-like feature of eastern South Dakota, southwestern Minnesota, and northwestern Iowa (Carman, 1915, p. 243). The Big Sioux River, whose headwaters are just north of the quadrangle, crosses the mapped area from north to south, and has eroded a long narrow trough on the Coteau. In this area, the trough is bordered on the east and west by two prominent ridges which rise 200-300 feet above the floor of the trough. Tributaries of the Big Sioux River drain the adjacent flanks of both ridges. The four largest tributaries in this area (Gravel Creek, Mahoney Creek, Soo Creek, and an unnamed creek), enter the Big Sioux from the east. Three large lakes are present along the western border of the quadrangle (Still Lake, Cottonwood Lake, and Lonesome Lake). The maximum relief of the area is approximately 300 feet, and the local relief ranges up to 100 feet.

U. S. Highway 81 crosses the center of the quadrangle in a north-south direction and is joined from the east by State Route 20. The Great Northern Railroad crosses the southeastern part of the area. Gravel roads and improved dirt roads make almost any part of the quadrangle easily accessible by car. The climate is characterized by a wide temperature range and an average precipitation of 20 inches per year.

The geology was mapped on air photos during the summer of 1957 under the supervision of Dr. A. F. Agnew, State Geologist. Dr. M. M. Leighton lent invaluable aid in differentiating the drift sheets, through a two-day field conference.

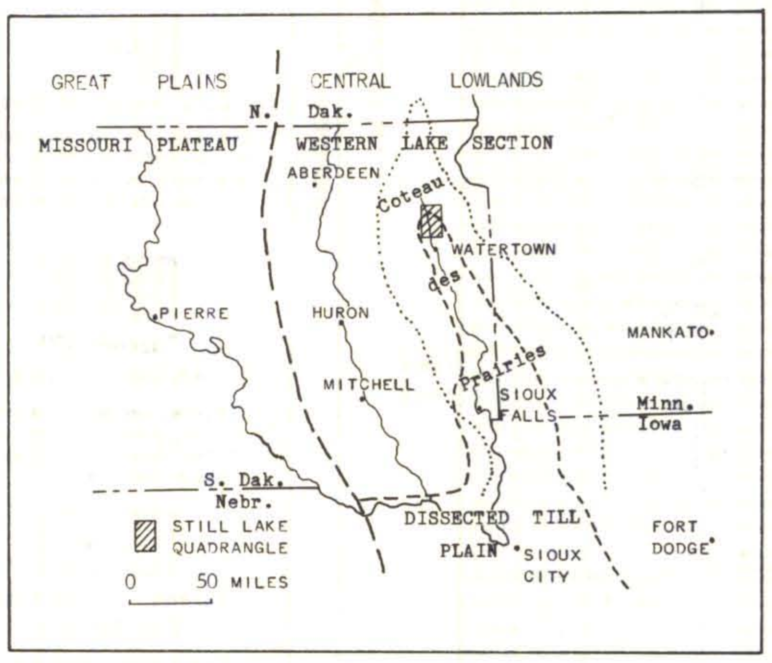


Fig. 1. Map showing physical divisions of eastern South Dakota and adjoining area (after Rothrock, 1943; Fenneman, 1938; and Carman, 1915).

SURFICIAL DEPOSITS

The quadrangle is covered by unconsolidated material that can be separated into three main groups: (1) glacial deposits, (2) stream and lake deposits, and (3) wind deposits.

Glacial Deposits

The first ice sheet to cover eastern South Dakota was the Nebraskan, and it was followed by the Kansan, Illinoian, and Wisconsin sheets. The Wisconsin had four separate advances (Leighton, 1933, p. 168), from oldest to youngest, the Iowan, Tazewell, Cary, and Mankato. The ice sheets deposited drift consisting of clays, silts, sands, gravels, and boulders reworked from bedrock and older surficial deposits. The drift lies on the bedrock and, in the north-central part of the Coteau des Prairies, is approximately 500 feet thick, as shown by the U. S. Bureau of Reclamation well at Watertown (Erickson, 1955, p. 24), the Match #1 Drake oil test at South Shore (Tipton, 1958a), and the Oil Ventures #1 Naessig oil test near Webster (Bolin and Petsch, 1954, p. 17).

The drift is divisible into three groups: till, outwash, and glacial lake deposits. Till is the most abundant, and consists of an unsorted and unstratified mixture of material that ranges in size from boulders to clay. The till was produced through abrasion by the ice sheet against the land surface. Outwash consists of stratified sand, gravel, and silt reworked from the drift and deposited by the meltwater streams of the ice sheet. Glacial lake deposits, the least-abundant material in the drift, consist of parallel-bedded silt, sand, and clay, deposited from streams as they entered ponded water held behind temporary glacial dams.

Till

The till exposed at the surface in the Still Lake quadrangle is of Iowan (?), Tazewell (?), and Cary age. In general, the till in the Big Sioux trough is Iowan (?) in age, the till forming the ridge along the east border of the quadrangle is Tazewell (?) in age, and the till forming the ridge along the west border of the quadrangle is Cary in age. Flint (1955, pl. 1) called the above Iowan (?) till Tazewell in age, and the above Tazewell (?) till Cary in age. This and other related problems will be discussed in a later publication (Steece, Tipton, and Agnew, In Preparation).

Till surfaces can be divided topographically into ground moraine and end moraine. Ground moraine is till that was carried forward in and beneath the ice and deposited from its under surface. End moraine is till that was formed into ridge-like accumulations along the margin of the glacier by its conveyor-belt and snowplow action.

In the Still Lake quadrangle the Iowan (?) till has a gently undulating ground moraine surface, and the Cary and Tazewell (?) till surfaces are end moraines which form ridges on either side of the trough. The Tazewell (?) end moraine, along the eastern border of the quadrangle, was given the name "Bemis" by Leverett (1932, p. 57). The Altamont moraine (Chamberlin, 1883) lies east of the Bemis moraine, and a small part of it crosses the extreme northeastern part of the quadrangle. The Cary end moraine along the western border of the quadrangle marks the easternmost advance of the Cary ice from the James lobe and correlates topographically with the Altamont moraine, which marks the westernmost advance of the Cary ice from the Des Moines lobe. The Bemis end moraine along the eastern border of the quadrangle marks the westernmost advance of the Tazewell (?) ice from the Des Moines lobe; it does not have a corresponding moraine from the James ice lobe in this area.

The Iowan (?) ground moraine is very well drained, has an average relief of 15-20 feet and smooth slopes, and a striking accordance in altitude of the interfluves which gives the impression of a dissected plateau. Very few boulders and no undrained depressions are present on the Iowan (?) surface in this area.

The topography of the Bemis (Tazewell ?) end moraine in this area is similar to the Iowan (?) ground moraine in that it is well drained, has smooth slopes and very few undrained depressions. This similarity makes it difficult to distinguish the two moraines on air photos. However, in field mapping the two moraines are readily differentiated, as the Tazewell (?) till is marked by a high prominent ridge-like end moraine and the Iowan (?) till surface is relatively flat. The Tazewell (?) end moraine has an average relief of 25-30 feet, and the local relief (the difference in height between knolls and depressions) ranges up to 60 feet. In general, the moraine has very few boulders on its surface but small concentrations of boulders occur locally.

The Cary end moraine along the western border of the quadrangle is easily distinguished from both the Iowan (?) and Tazewell (?) moraines in that it is very poorly drained, has steep and abrupt slopes, many undrained depressions, and is liberally strewn with boulders. The Cary end moraine has an average relief of 15-20 feet and the local relief ranges up to 50 feet.

In general, the topography of the Cary moraine is rough and rugged and the topography of the Iowan (?) moraine is smooth and undulating, whereas the topography of the Tazewell (?) moraine seems to be intermediate. These three types of topography may reflect different characteristics of the individual ice sheets, but more probably are the result of the difference in age and thus length of time of post-depositional erosion.

These three tills cannot be differentiated in this area by lithology; all are gray to buff, unleached, locally oxidized in their upper parts, and range from friable to compact.

An unsuccessful attempt was made to differentiate the Cary, Tazewell (?) and Iowan (?) tills by using composition of the four to eight mm. size pebbles (table 1.). In Table 1 an apparent differentiation of the tills in the local rocks and the limestone and dolomite is only apparent as many samples overlapped. This overlapping and similarity in composition may be the result of too few samples; however, it probably shows that the ice sheets advanced over essentially the same routes and thus incorporated the same materials.

Table 1. Pebble composition of till samples in the four to eight mm. size range.

composition / till samples	local rocks	granite	other ign. & meta.	ls. & dolo.
Cary	31%	17%	9%	43%
Tazewell (?)	21%	20%	11%	48%
Iowan (?)	15%	18%	9%	58%

Outwash

Cary outwash deposits are present in channels along the Big Sioux River and most of its tributaries. Two other Cary outwash channels, unrelated to present streams, join the Big Sioux channel from the west; one in the southwest part of the quadrangle (includes Still Lake), and the other in the northwestern part of the mapped area. Tazewell (?) outwash channels are evident as terrace remnants at the heads of Soo and Mahoney Creeks and at the head of a tributary of Gravel Creek in the southeastern part of the quadrangle.

The Cary ice associated with the end moraine along the western border of the Still Lake quadrangle deposited outwash in the Big Sioux channel in early Cary time. These early Cary outwash deposits were cut by outwash deposits from later Cary ice associated with an end moraine west of the quadrangle. The surface of this later Cary outwash (Qwcvo) is 10-20 feet lower than the terraces of the earliest Cary outwash (Qweco). The terrace remnants of the Tazewell (?) outwash were derived from the Bemis moraine and, at the head of Soo Creek, are about 15 feet above the early Cary outwash Terraces. Outwash from the Altamont moraine cut through the Bemis moraine and deposited gravels in Gravel Creek and the unnamed creek in the northeastern part of this area. These Cary outwash channels from the Altamont moraine coalesce with the later Cary, outwash channels of the James ice lobe along the Big Sioux River, showing that the Des Moines ice lobe (early Cary) either did not deposit outwash in this area, or the early Cary meltwater streams did not cut through the Bemis moraine.

The composition of the Cary outwash gravel varies locally but, in general, ranges from 30-50 percent soft carbonates and argillaceous rock, and the remainder is hard igneous and metamorphic rocks. The composition of the Tazewell (?) terrace remnant gravel also varies locally but ranges up to 75 percent soft carbonates and argillaceous rock.

The texture of both the Cary and Tazewell (?) gravels ranges from fine sand to coarse gravels, with 40 percent in the fine to very coarse sand range, and 30 percent in the very fine gravel fraction. The Cary gravels are locally oxidized in the upper four to five feet, and are unleached throughout. The Tazewell gravels are more thoroughly oxidized than the Cary gravels but are also unleached throughout.

The thicknesses of the sands and gravels in the outwash channels were determined by drilling and resistivity measurements, and average about 43 feet. Thicknesses as great as 140 feet were recorded in secs. 16 and 21, T. 118 N., R. 52 W., just south of Gravel Creek.

Glacial Lake Deposits

Deposits from glacial lakes, as evident by strand lines, are present above the shores of some lakes and pot holes in the Cary drift of this area. The strand lines are usually two to five feet above the present lake levels, and in some cases are rimmed with boulders that were ice-rafted to their present positions. The areal distribution of the glacial lake deposits in the Still Lake quadrangle is too limited to map. An unusually extensive deposit of this type is mappable, however around the twin basins of Long and Stink lakes in the Henry quadrangle, nine miles southwest of Still Lake (Tipton, 1958b).

Stream and Lake Deposits

Recent alluvium consists of silt and sand reworked from bedrock and older surficial deposits by present streams and lakes. The alluvium in the Still Lake quadrangle is confined to the Big Sioux River valley and its main tributaries. The Recent lake-bed alluvium was not mapped, as it is covered by water during the wet seasons.

Wind Deposits

Loess is a wind deposit of silt, clay, and a few sand particles derived mainly from outwash plains. In the Still Lake quadrangle, loess is scattered sporadically over the Cary drift up to 1½ feet thick, over the Tazewell (?) drift up to three feet thick, and somewhat more uniformly over the Iowan (?) drift, averaging about four feet thick. The loess is usually unleached where covered by a soil. An unusually thick deposit of loess is present on the Iowan (?) drift about four miles north of Lonesome Lake, where 14 feet of loess was penetrated in a drill hole. The loess was not mapped because of its sporadic and usually thin occurrence.

SUBSURFACE SEDIMENTARY ROCKS

Sedimentary rocks are not exposed in the Still Lake quadrangle, but at least 800 feet of Cretaceous rocks underlie the glacial drift, based on logs of the Torguson farm well (Bolin and Petsch, 1954, p. 77) and the three previously mentioned wells (see Glacial Deposits).

About 280 feet of Pierre shale underlies the glacial drift in the Still Lake quadrangle. The Pierre shale is underlain by about 40 feet of Niobrara marl, which is followed below by 200 feet of Carlile shale, 50 feet of Greenhorn limestone, and about 150 feet of Graneros shale. The Graneros shale is underlain by about 250 feet of sandstones and shales of the Dakota Group.

PRECAMBRIAN ROCKS

The Cretaceous sedimentary rocks unconformably overlie the Precambrian basement rocks. In northeastern South Dakota the basement rocks are normally light-colored granite; however, in the U. S. Bureau of Reclamation well at Watertown (Erickson, 1955, p. 24), serpentine was penetrated below the Cretaceous rocks.

STRUCTURE

The structure of the bedrock in this area is very difficult to determine, as the bedrock is not exposed and well records are few. The regional dip was determined by using data from three previously mentioned deep wells (see Glacial Drift). It shows flat-lying beds and probably reflects the structural surface of the western extension of the Precambrian basement rocks.

ECONOMIC GEOLOGY

The most valuable geologic products in this area are ground water, and sand and gravel. Clay, silt, and hard rock could become economically important but at present are not used. Oil and gas possibly were trapped in the Cretaceous rocks where they pinch out against the Precambrian basement rocks.

Ground Water

Ground water adequate to supply ordinary farm wells is available throughout the quadrangle. Ground water in larger amounts may be found in the outwash channels or possibly in buried stream channels from former drainages. Ground water is also available from sand and gravel lenses in the till, but these are commonly small and are recharged very slowly; however, they generally contain enough water to supply domestic wells. Artesian water may be obtained in this area but would probably have to be pumped, as the piezometric head does not reach the height of the Coteau des Prairies in this area (Erickson, 1955, pl. 1).

The greatest potential area for ground water storage in the Still Lake quadrangle is in the sands and gravels of the Cary outwash channels. These channels contain an average of 43 feet of sand and gravel, and about 32 feet of water. The channels cover about 26,000 acres and contain about 800,000 acre-feet of water. This is enough water to support irrigation on most parts of the main outwash channels.

Several factors may hinder irrigation in this area or at least necessitate special construction of the wells. The fine texture of the deposits tends to result in low permeability and sand pumping, which will probably make it necessary to gravel-pack most of the wells. Also, the terraces in some places are too far above the water table to supply enough water for irrigation, especially where the terrace gravels are thin near the till borders.

The water from the outwash is generally of good quality (table 2). However, the quality may vary greatly in short distances as the chemical properties of the water are partly dependent on the composition of the sands and gravels through which the water flows.

Another possible source of water is the buried channels of former streams, which drained this area before the Cary glaciations and perhaps even before the Illinoian (Flint, 1955, pl. 142). The locations of the valleys of these former streams (fig. 2) can be inferred from linear topographic lows, and may contain deposits of sand and gravel filled with water. If the amount of water in these buried channels is great enough, and the physical conditions are suitable, the channels may provide an additional source of water for irrigation.

Table 2. Water analysis* of shallow well in Still Lake quadrangle.

contents ppm / source	Ca	Mg	Na	K	SO_4	N	Cl	Fe	SiO_2	$CaCO_3$ (bicarbonate)	$CaCO_3$ (carbonate)	Hardness ($CaCO_3$)
Public Health Standard**	-	125	-	-	250	10	250	0.1	10	-	-	-
Outwash***	72	36	14	2	53	1	5	0.1	24	290	0	19.3

* Analyst: Dr. O. E. Olson, Head, Dept. of Biochemistry, South Dakota State College, Brookings, South Dakota, 1957.

** Not to exceed.

*** Neil Rudebusch farm, sec. 9, T. 120 N., R. 52 W.

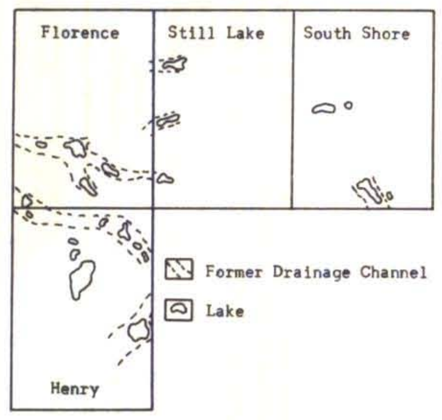


Fig. 2. Map of Still Lake and adjacent quadrangles showing inferred former drainage channels (modified from Flint, 1955, pl. 7).

Sand and Gravel

The outwash channels cover about 41 square miles and contain about 1,700,000,000 cubic yards of sand and gravel. The gravels are suitable for road building and possibly for bituminous or concrete aggregate, if the high percentage of soft materials is removed.

Clay and Silt

The tills and loesses of this area contain a large amount of clay and silt, which could possibly be used in the manufacture of brick and tile.

Rock

Glacial boulders scattered on the surface could provide a source of hard rock. The largest concentrations of the boulders occur on the Cary end moraine. About 75 percent of the boulders are granitic, and should be suitable for rip-rap, structural material and, if crushed, as concrete aggregate.

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