SOUTH DAKOTA GEOLOGICAL SURVEY
ALLEN F. AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

GEOLOGY of the FLORENCE QUADRANGLE SOUTH DAKOTA

EXPLANATION

PLEISTOCENE / WISCONSIN / QUATERNARY

Qwco — Cary Outwash
(Stratified meltwater deposits of sand, gravel, and silt; 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 Cary outwash)

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 1753
Bench Mark
(monument showing exact altitude above sea level)

△ Cooley
Triangulation Station
(monument marking exact geographic location)

House, school, and church

Cemetery

Geology by Merlin J. Tipton

Assisted by D. G. Jorgensen, R. C. Wilson

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

Drafted by J. H. Hoff

APPROXIMATE MEAN DECLINATION 1958

Scale 1:62500

1 1/2 0 1 2 3 4 Miles

Vermillion South Dakota
1958

■ Quadrangle Location

Florence Quadrangle

INTRODUCTION

The Florence quadrangle includes about 214 square miles, mainly in northwestern Codington and southeastern Day Counties. A quarter-mile wide strip of Clark County is included at the western border of the quadrangle. The southeastern corner of the mapped area is about six miles northwest of the city of Watertown.

The area is in the Western Lake section (fig. 1) of the Central Lowlands physiographic province, (Fenneman, 1938) 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). No rivers or streams of any consequence are present in the quadrangle; three permanent lakes, however, each with an area of more than half a square mile, are in the southern part (Lake Nicholson, Kings Lake, and an unnamed lake). Three intermittent lakes (Grass Lake, Dry Lake, and Sumner Slough) are also in the southern part of the quadrangle, and have areas of more than half a square mile. The maximum relief of the quadrangle is approximately 200 feet, and the local relief ranges up to 100 feet.

Florence (pop. 226) and Wallace (pop. 188) are the only towns in the mapped area. State Route 20 crosses the southern part of the quadrangle diagonally, and is paralleled by the Minneapolis and St. Louis Railroad. 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.

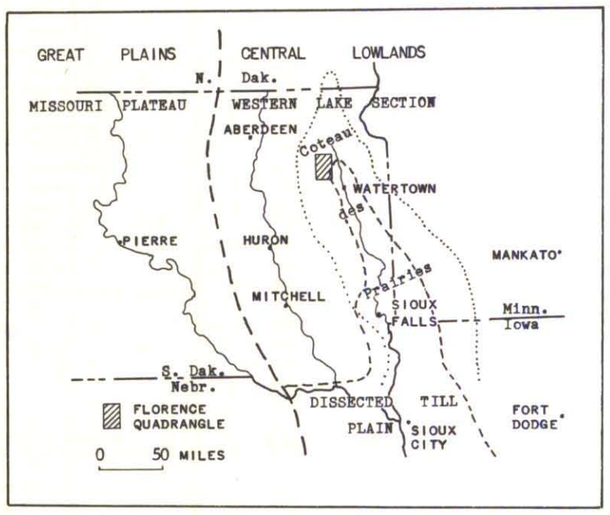

Fig. 1. Map showing physical divisions of eastern South Dakota and adjoining area (after Rothrock, 1943; Fenneman, 1938; and Carman, 1915).

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, 1958b), 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 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 Florence quadrangle is of Cary age, except for a small patch of Iowan (?) till in the southeastern corner, which was called Tazewell by Flint (1955, pl. 1). The exact age of the Iowan (?) till cannot be determined, at present, beyond the supposition that it is Iowan or older. This and other related problems will be discussed in a later publication (Steece, Tipton, and Agnew, In Preparation).

Cary till 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.

The Cary ground moraine has an average relief of no more than ten feet, and is characterized by swell and swale topography with numerous undrained depressions. These depressions are not kettles, but probably resulted from uneven lodgement of the till beneath the Cary ice. The average relief on the Iowan (?) ground moraine is slightly more than on the Cary ground moraine, owing to post-glacial stream dissection. The Iowan (?) surface is very well drained, has smooth slopes and a striking accordance in altitude of the interfluves, which gives the impression of a dissected plateau.

Cary end moraine is found along the eastern and western borders of the quadrangle. The eastern end moraine marks the easternmost advance of the James River ice lobe in this area. The western moraine is probably a recessional moraine. Both Cary end moraines are easily distinguished from the intervening Cary ground moraine; in general, the local relief (the difference in height between knolls and depressions) on the end moraines ranges from 15 to 20 feet, which is 5 to 10 feet greater than that of the ground moraine. The end moraines have many more boulder-strewn areas than the ground moraine, because of the steepness of the slopes on the ridges which has allowed more rapid erosion of the sediments surrounding the boulders. The end moraine, like the ground moraine, has many closed depressions even on the highest parts of the ridge, showing it to have a very young, poorly drained topography. The width of the end moraine ranges from one to several miles.

An unsuccessful attempt was made to differentiate the Cary and Iowan (?) tills by using the composition of the four to eight mm. size pebbles. The composition of the Cary till samples averaged about 31 percent local rocks, 17 percent granite, 9 percent other igneous and metamorphic rocks, and 43 percent limestone and dolomite. A corresponding analysis of the Iowan till samples shows about 15 percent local rocks, 18 percent granite, 9 percent other igneous and metamorphic rocks, and 58 percent limestone and dolomite. Although the Iowan (?) samples are apparently higher in limestone and dolomite, and lower in local rocks than are those of the Cary, many samples overlapped. Although this similarity and overlapping in composition may be the result of too few samples, it more probably shows that both ice sheets advanced over essentially the same route and thus incorporated the same materials.

Both the Iowan and Cary tills are gray to buff, unleached, locally oxidized in their upper zones, and range from friable to compact.

Outwash

Cary outwash deposits are present in two southeast trending channels, in the southwestern part of the quadrangle. The Cary channel in the southwestern corner of the quadrangle is collapsed, as is the western part of the other Cary channel. This collapse was caused by the melting of blocks of ice deposited contemporaneously with the sand and gravel. The resulting uneven topography of the collapsed outwash is very similar to the topography of the surrounding end and ground moraine. Two small terrace remnants of a former Tazewell (?) outwash channel are present near Florence.

The composition of the gravel varies locally but, in general, ranges from 30 percent to 50 percent of soft carbonates and argillaceous rock, and the remainder is hard igneous and metamorphic rocks. The texture ranges from fine sand to coarse gravel, with 40 percent in the fine to very coarse sand range and 30 percent in the very fine gravel fraction. The gravels are locally oxidized in the upper four to five feet, and unleached throughout.

The thicknesses of the sands and gravels in the outwash channels were determined by drilling and resistivity measurements, and average about 38 feet for the channel in the southwestern corner of the area, and about 21 feet for the channel near Florence and Wallace. In the former channel, a maximum of 57 feet of sand and gravel was penetrated in the SE¼ sec. 18, T. 118 N., R. 55 W., and in the other channel a maximum of 65 feet was penetrated in the SE¼ sec. 33, T. 119 N., R. 55 W.

Glacial Lake Deposits

Glacial lake deposits, as evident by strand lines, are present above the shores of some lakes and pot holes in the quadrangle. 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 Florence quadrangle is too limited to map. An unusually extensive deposit of this type can be seen around the twin basins of Long and Stink lakes in the adjacent Henry quadrangle, seven miles southwest of Florence (Tipton, 1958a).

Stream and Lake Deposits

Recent alluvium consists of silt and sand reworked from bedrock and older surficial deposits by present streams and lakes. The only alluvium in the Florence quadrangle is confined to present lake beds, as no large streams occur in the area. 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. Loess is scattered sporadically over the Cary drift up to 1½ 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. The loess was not mapped because of its sporadic and thin occurrence.

SUBSURFACE SEDIMENTARY ROCKS

Sedimentary rocks are not exposed in the Florence 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 probably underlies the glacial drift in the Florence 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 some parts of 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 Florence quadrangle is in the sands and gravels of the Cary outwash channels. These channels do not contain as much water as might be expected, because of the collapsed nature of parts of this outwash. The channel between Wallace and Florence has an average thickness of 21 feet of sand and gravel. The collapsed part of this channel contains about six feet of water, and the non-collapsed part contains about 11 feet of water. This channel covers about 6,000 acres and contains 51,000 acre-feet of water. The collapsed outwash channel in the southwest corner of the area has an average of 38 feet of sand and gravel, and 27 feet of water. This channel covers about 3,800 acres and contains 88,000 acre-feet of water. The total of 140,000 acre-feet of water is enough to supply domestic needs but not enough to support irrigation on a large scale. However, a few places in both channels could probably supply sufficient water for irrigation; such places are in secs. 17, 18, and 21, T. 118 N., R. 55 W., in the southwest channel, and in secs. 10, 11, and 15, T. 118 N., R. 54 W., in the other channel. Irrigation would be difficult even in the above mentioned areas because the fine texture of the deposits tends to result in low permeability. This fine texture will probably necessitate gravel-packing of most irrigation wells in this area.

The water from the outwash is generally of good quality (table 1). 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.

Table 1. Water analysis* of shallow well in Florence 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 Standards**	-	125	-	-	250	10	250	&Mn 0.3	10	-	-	-
Outwash***	141	90	47	22	360	12	34	0	25	310	40	43

* Analyst: Dr. O. E. Olson, Head, Dept. of Biochemistry, South Dakota State College, Brookings, South Dakota, 1957.
** Not to exceed.
*** Charles Martin farm, sec. 15, T. 118 N., R. 54 W.

Another possible source of water is from the buried channels of former streams, which drained this area before the Cary glaciations and perhaps even before the Illinoian, (Flint, 1955, p. 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.

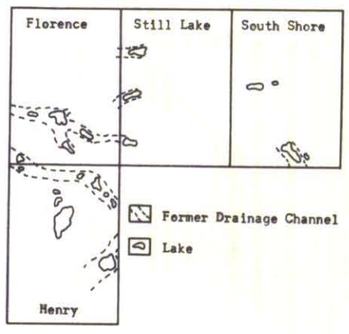

Fig. 2. Map of Florence and adjacent quadrangles showing inferred former drainage channels (modified from Flint, 1955, pl. 7).

Sand and Gravel

The Cary outwash channels cover about 15 square miles in the Florence quadrangle, and contain approximately 423,000,000 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 moraines. About 75 percent of the boulders are granitic, and should be suitable for rip-rap, structural material and, if crushed, as concrete aggregate.

REFERENCES CITED

Bolin, E. J., and Petsch, B. C., 1954, Well logs east of the Missouri River: S. Dak. Geol. Survey, Rept. Invest. 75, 95 p.

Carman, J. E., 1915, The Pleistocene geology of northwestern Iowa: Iowa Geol. Survey, Annual Rept. 26, p. 243-445.

Erickson, H. D., 1955, Artesian conditions in northeastern South Dakota: S. Dak. Geol. Survey, Rept. Invest. 77, 39 p.

Fenneman, N. M., 1938, Physiography of Eastern United States: McGraw-Hill Book Company, Inc., New York.

Flint, R. F., 1955, Pleistocene geology of eastern South Dakota: U. S. Geol. Survey, Prof. Paper 262, 173 p.

Leighton, M. M., 1933, The naming of subdivisions of the Wisconsin Glacial Age: Science, N. S. 77, p. 168.

Rothrock, E. P., 1943, A geology of South Dakota: S. Dak. Geol. Survey, Bull. 13, pt. 1, map.

Steece, F. V., Tipton, M. J., and Agnew, A. F., (In Preparation), Revised glacial geology, Coteau des Prairies, South Dakota: S. Dak. Geol. Survey, Bull.

Tipton, M. J., 1958a, Geology of the Henry quadrangle: S. Dak. Geol. Survey, map and text.

Tipton, M. J., 1958b, Geology of the South Shore quadrangle: S. Dak. Geol. Survey, map and text.