SOUTH DAKOTA GEOLOGICAL SURVEY
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STATE OF SOUTH DAKOTA
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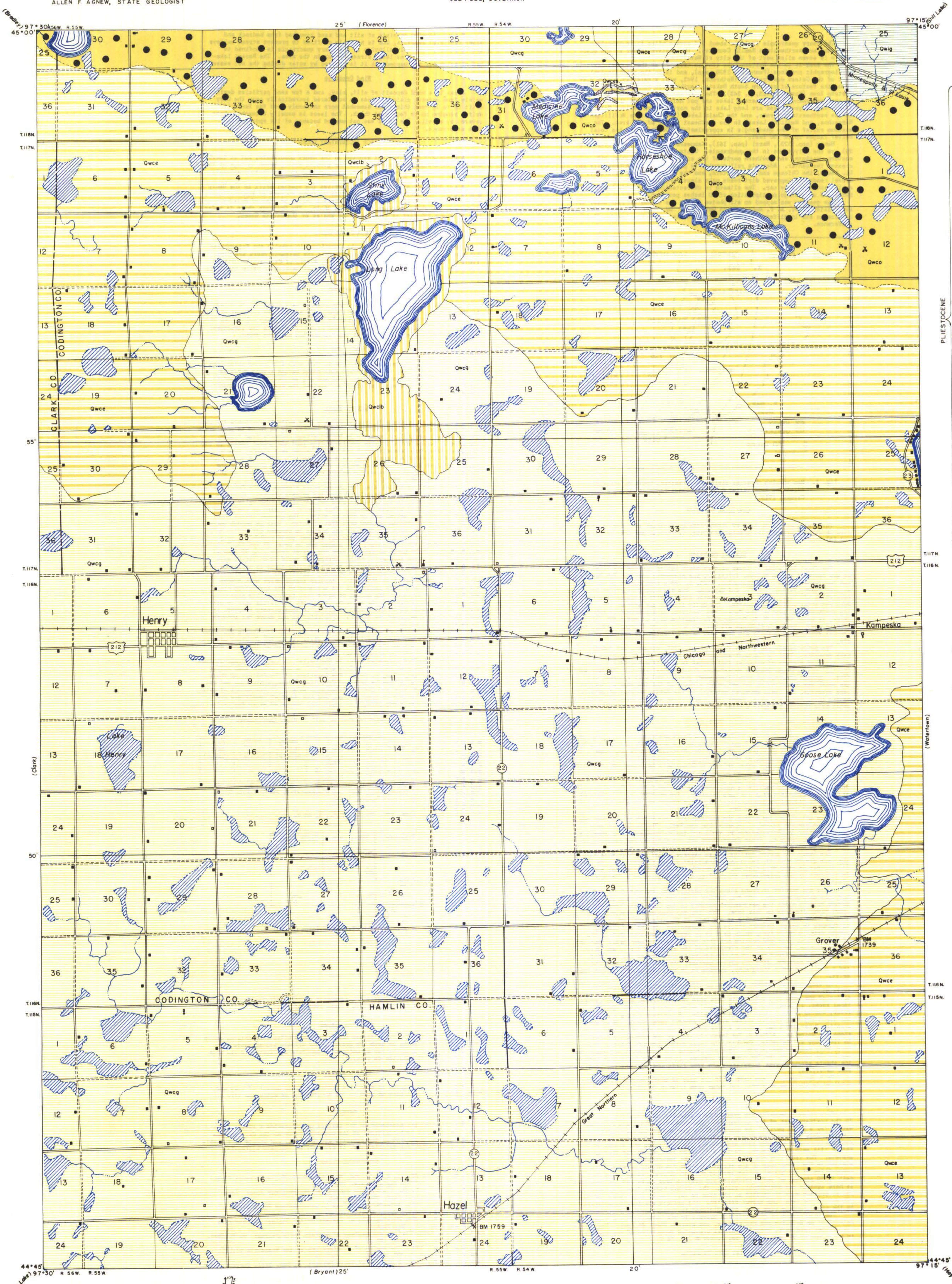
GEOLOGY of the HENRY QUADRANGLE SOUTH DAKOTA



EXPLANATION

QUATERNARY — PLIESTOCENE — WISCONSIN

Qwclb — Cary Lake Beds
(Parallel-bedded deposits of silt, sand, and clay; evident by strand lines above shores of some lakes and in some cases rimmed with boulders.)

Qwces — Cary Eskers
(Narrow steep-sided ridge-like accumulations of till and sand and gravel; deposited by meltwater in ice channels.)

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.)

Qwlg — Iowan (?) Ground Moraine
(Plateau-like acculations 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 1739
Bench Mark
(monument showing exact altitude above sea level)

▲ Kampeka
Triangulation Station
(monument marking exact geographic location)

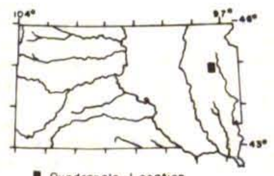
House, school, and church

Geology by Merlin J. Tipton
Assisted by D. L. Dugle, D. G. Jorgensen
Vertical and horizontal control surveyed from triangulation and level line of Federal surveys
Drafted by D. G. Jorgensen 1958

TRUE NORTH / MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION 1958

Scale 1:62 500
1 ½ 0 2 3 4 Miles

Vermillion, South Dakota
1958



Quadrangle Location

Henry Quadrangle

INTRODUCTION

The Henry quadrangle includes about 214 square miles in southwestern Codington and northwestern Hamlin Counties. The eastern border of the quadrangle is seven miles west of the city of Watertown.

The area is in the Western Lake section (fig. 1) of the Central Lowlands physiographic province (Fenneman, 1938, map), and is on the north-central part of 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 quadrangle has no rivers or streams of any consequence, but numerous lakes and pot holes are found throughout the area. The largest lakes are Long Lake in the northwestern corner, Goose Lake in the southeastern corner, and the Chain Lakes (which include McKilligan's, Horseshoe, and Medicine Lakes) in the northeast corner of the area. The maximum relief of the quadrangle is approximately 200 feet, and the local relief ranges up to 100 feet.

Henry (pop. 323), Hazel (pop. 161), Kampeska (pop. 25), and Grover (pop. 25) are the only towns in the quadrangle. State Routes cross the northeastern, eastern, and southern parts of the area, and U. S. Highway 212 crosses the center. Adequate rail service is provided by the Minneapolis and St. Louis, the Chicago and Northwestern, and the Great Northern railroads. 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.

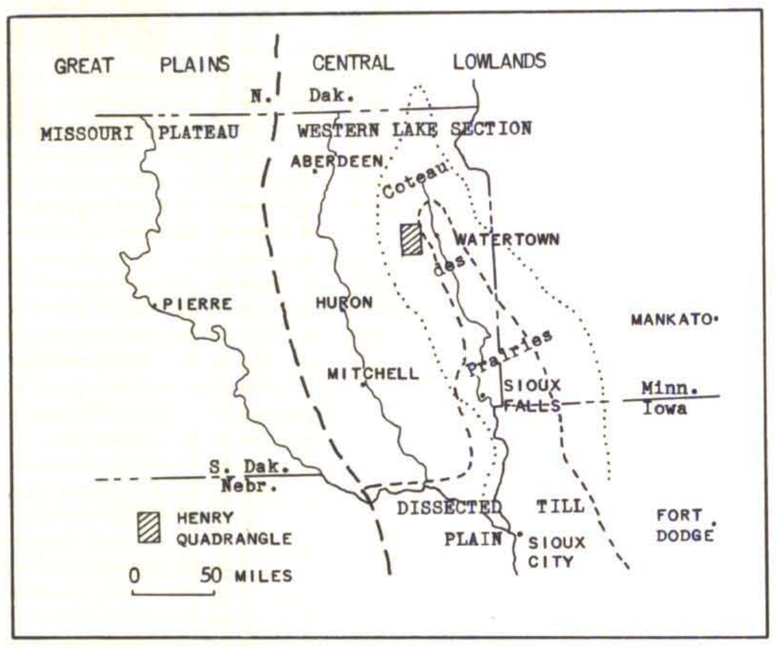


Fig. 1. Map showing physical divisions of eastern South Dakota and adjoining area (after Rothrock, 1943; Fenneman, 1938; and Carman, 1915).

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 are, 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, 1958), 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 Henry quadrangle is of Cary age except for a small patch of Iowan (?) till in the northeastern 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).

The 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.

Cary ground moraine covers the southwestern two-thirds of the quadrangle and has an average relief of no more than ten feet. The surface of this ground moraine 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 Iowan (?) ground moraine has an average relief slightly more than 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 northeastern border of the Cary ground moraine. The end moraine along the eastern edge of the ground moraine marks the easternmost advance of the Cary drift from the James River ice lobe in this area. The Cary end moraine is easily distinguished from the ground moraine to the west in that the local relief (the difference in height between knolls and depressions) on the end moraine ranges from 15 to 20 feet, which is 5 to 10 feet greater than that of the ground moraine. The end moraine has 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 Cary end moraine, like the ground moraine, has many closed depressions and a swell and swale topography; showing it to be a poorly drained and young drift.

An unsuccessful attempt was made to differentiate the Cary and Iowan (?) tills by using composition of the four to eight mm. size pebbles. The composition of the Cary till samples in this size range 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 showed 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. This overlapping and similarity in composition may be the result of too few samples; however, it 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 a generally east-trending channel in the northern part of the quadrangle. The outwash deposits are collapsed except for a small part of the channel along the eastern border of the quadrangle. This collapse was caused by the melting of blocks of ice deposited contemporaneously with the sand and gravel. In some cases the blocks of ice rafted till onto the outwash, leaving a 10-to-20 foot deposit of till on the gravels. The resulting uneven topography of the collapsed outwash is very similar to the topography of the surrounding end and ground moraine. 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 gravels 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, and average about 46 feet. The thickness ranges from zero, where ice blocks prevented deposition of the gravels, to a maximum of 90 feet in sec. 12, T. 117 N., R. 54 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 Henry quadrangle is too limited to map. An unusually extensive deposit is mappable, however around the twin basins of Long and Stink Lakes. Here the strand line consists of a more or less continuous bench that stands about 30 feet above the present lake level. The bench is lined by ice-rafted boulders along the southwest side of Long Lake. These ice-rafted boulders show a northeasterly prevailing wind during late Cary time, the approximate age of the glacial lake.

Stream and Lake Deposits

Recent alluvium consists of silt and sand reworked from bedrock and older surficial deposits, and is normally confined to present stream valleys and lake beds. The only alluvium in the Henry 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, ranging up to 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 Henry 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 Henry 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 channel 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 Henry quadrangle is in the sands and gravels of the Cary outwash channel. However, because this channel is collapsed it does not contain as much water as a normal non-collapsed outwash channel. This channel contains an average of 46 feet of sand and gravel and 14 feet of water. The channel covers about 10,800 acres and contains 150,000 acre-feet of water. This is enough water to supply domestic needs but probably not enough to support irrigation on a large scale. However, a few places in the channel could probably supply sufficient water for irrigation; such places are in secs. 27 and 28, T. 117 N., R. 55 W., where about 50 feet of sand and gravel containing 35 feet of water was penetrated in a drill hole. Irrigation would be difficult even in this area because the fine texture of the deposits tends to result in low permeability. The fine texture will probably necessitate the gravel-packing of most irrigation wells in this area. Another factor which will hinder irrigation in this outwash channel is the presence of the ice-rafted till, which will tend to reduce the amount of water that can percolate back into the reservoir as recharge. The distribution of the ice-rafted till is difficult to determine as it is covered by gravel in some places; however, it must be fairly widespread, as till was penetrated in and above the outwash in several drill holes.

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.

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, 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.

Table 1. Water analysis* of shallow well in Henry 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	&Mn .1	10	-	-	-
Outwash***	190	85	28	7	500	1	10	0.1	22	317	0	48

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

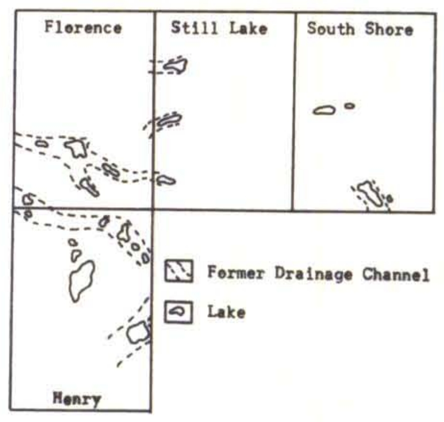


Fig. 2. Map of Henry and adjacent quadrangles showing inferred former drainage channels (modified from Flint, 1955, pl. 7).

Sand and Gravel

The Cary outwash channel covers about 17 square miles and contains about 780,000,000 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 material 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.

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