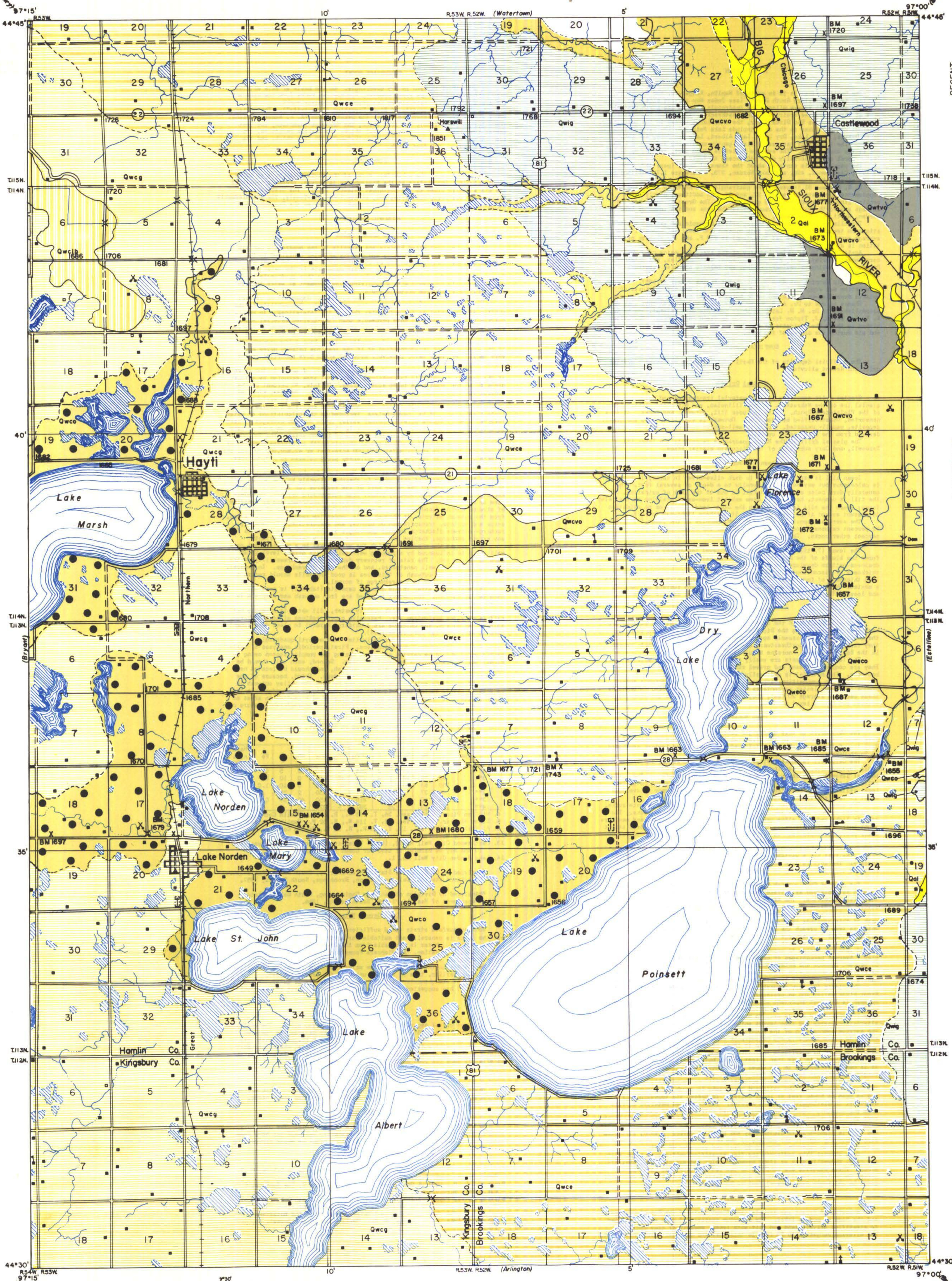
SOUTH DAKOTA GEOLOGICAL SURVEY
ALLEN F. AGNEW, STATE GEOLOGIST

STATE OF SOUTH DAKOTA
JOE FOSS, GOVERNOR

GEOLOGY of the HAYTI QUADRANGLE SOUTH DAKOTA



EXPLANATION

RECENT

Qal — Alluvium

(Semistratified deposits of gravel, sand and silt; humic; brown to black; 0-20 feet thick; in stream flood plains and lakebeds.)

QUATERNARY — PLEISTOCENE — WISCONSIN

Qwclb — Cary Lake Deposits

(Stratified gray and light-brown well-sorted fine sand, silt and clay; fossiliferous; ranges from 3-70 feet in thickness.)

Qwcvo — Middle? Cary Valley Train Outwash

(Stratified deposits of brownish-gray to bluish-gray poorly-sorted fine sand to coarse gravel; unoxidized; level topography; sandy loam soil; ranges from 15-95 feet in thickness.)

Qwco — Middle? Cary Plain Outwash

(Semistratified to stratified poorly-sorted fine sand to coarse gravel and till inclusions; rugged "pitted" topography; ranges from 15-92 feet in thickness.) Stippled where collapsed.

Qweco — Early Cary Outwash

(Stratifed brown fine sand to coarse gravel; weathered; contains abundant iron-oxide; these terrace remnants stand about 25 feet above valley floor; exposed thickness 25 feet.)

Qwce — Cary End Moraine

(Boulder-clay till consisting of olive-gray to olive-brown calcareous silt and clay with rock fragments; friable; ranges up to 100 feet in thickness; rugged undrained knob and kettle topography.)

Qwcg — Cary Ground Moraine

(Boulder-clay till, like till in End moraine; rough, undrained swell and swale topography; ranges up to 50 feet in thickness.)

Qwto — Tazewell Outwash

(Stratified poorly-sorted sand and gravel; terrace remnants; oxidized; ranges from 10-30 feet thick.)

Qwig — Iowan? Ground Moraine

(Boulder-clay till consisting of olive-gray to olive-brown calcareous friable to compact silt and clay with rock fragments; mostly unoxidized; ranges up to 150 feet in thickness; level and well-drained topography; calcareous loess cover up to four feet thick.)

Contact (dashed where approximately located)

Gravel pit

X BM 1737 Bench Mark (monument showing exact altitude above sea level)

△ Sheridan Triangulation Station (monument marking exact geographic location)

House, school, and church

Cemetery

Geology by Fred V. Steece, 1957

Assisted by R.C. Wilson, D.G. Jorgensen, R.H. Van Holdt

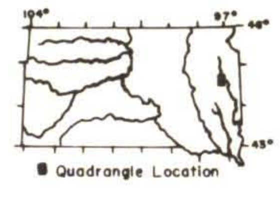
Vertical and horizontal control surveyed from triangulation and level lines of Federal surveys

Drafted by R.H. Benson

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

Scale 1:62 500 — 1/2 0 1 2 3 4 Miles

Vermillion, South Dakota
1958



■ Quadrangle Location

Hayti Quadrangle

INTRODUCTION

The Hayti quadrangle is in parts of Hamlin, Kingsbury, and Brookings Counties in northeastern South Dakota (see Index Map reverse side); it occupies about 215 square miles. The quadrangle lies in the north-central part of the Coteau des Prairies upland (Rothrock, 1943, map). The drainage is controlled by the Big Sioux River, the only large stream in the quadrangle. Numerous natural lakes in the area include Lake Poinsett, the largest lake in South Dakota, Marsh Lake, Dry Lake, Lake Albert, Lake St. John, and Lake Norden. The topography has nearly flat, gently undulating and rugged knob and kettle expressions. The average relief is 50-60 feet, ranging up to 150 feet. Local relief normally does not exceed 40 feet.

The population is centered about the towns of Hayti (pop. 413, 1950 census), Castlewood, 498, and Lake Norden, 373. There are 1.7 dwellings per square mile in the area.

U. S. Highway 81 traverses the quadrangle from north to south and is supplemented by State Routes 21, 22, and 28. In addition, nearly every section line is marked by a good gravel road. The Great Northern and the Chicago and North Western railroads serve the area and the towns of Lake Norden, Hayti, and Castlewood.

The climate of the area is characterized by rapid and extreme fluctuations in temperature, with long cold winters and short hot summers. The average annual temperature (at Watertown) is 43° F. and the average precipitation is about 21 inches.

Agriculture is the chief industry of the area, the major crops being corn, wheat, barley, oats, alfalfa, soybeans, sorghum, flax, and potatoes. Potato distributing, livestock-raising, and resorts are also important industries.

Geologic mapping was done on air photos in the summer of 1957. Outcrop information was supplemented by hand auger borings, and the thickness of outwash deposits was determined by 36 holes drilled by jeep-mounted augers.

Thanks is due to Dr. A. F. Agnew under whose supervision this work was accomplished, to Dr. M. M. Leighton whose comments were helpful, and to Dr. K. Y. Lee and M. J. Tipton for their help in field conferences. The writer wishes to thank the residents of the Hayti quadrangle for their cooperation and aid during the course of the work.

SURFICIAL DEPOSITS

The surficial deposits of the Hayti quadrangle are Pleistocene glacial drift and Recent alluvium.

Glacial Drift

Glacial drift comprises all the material transported and deposited by glacial ice of the Nebraskan, Kansan, Illinoian, and Wisconsin glacial stages of the Pleistocene Epoch. Drift includes till, outwash, and loess. Till is nonsorted, nonstratified boulder clay. Outwash is stratified sand and gravel deposits, usually unsorted. Loess is well-sorted wind blown silt and clay derived from the ablation of outwash.

The glacial drift in the Hayti quadrangle represents the Iowan (?), Tazewell, and Cary substages of the Wisconsin glacial stage.

Iowan (?) Substage

Iowan till is dark olive-gray to dark olive-brown in color; it normally is calcareous but may be leached locally to a depth of several feet. The generally dark color of the fresh till is due to the lack of oxidation. Where the till is compact, however, it does exhibit iron-oxide staining on the joint faces; where the till is friable, on the other hand, little or no oxidation is present except after long exposure; it weathers light-tan to buff.

The average composition of the 4-8 mm. pebbles of the Iowan (?) till is 52 percent carbonate rocks, 8 percent igneous and metamorphic rocks, and 40 percent other rocks. The thickness of the Iowan (?) till ranges up to 146 feet.

The Iowan (?) till is characterized by level topography except where it forms the bluffs of the Big Sioux valley. It has a well-integrated dendritic drainage pattern developed on its surface. The till is overlain by a variable thickness of discontinuous brownish-yellow calcareous loess which has a maximum thickness of four feet. A silt or clay-loam, brownish-black soil, with a maximum thickness of three feet, is developed on the surface of the till and loess. The soil is normally leached to a depth of about 8-10 inches.

Tazewell Substage

Tazewell deposits in the quadrangle are remnants of valley outwash preserved as terraces along the Big Sioux River in the northeastern corner of the quadrangle. The Tazewell age of the deposits is based on the fact that they can be followed northeastward along Stray Horse Creek to their source in the Bemis (Tazewell) moraine about 25 miles east of Hayti.

The Tazewell remnants are small, averaging about a square mile in area. They are composed of sand and gravel ranging in texture up to very coarse boulders. The material is ordinarily well-weathered and contains abundant iron-oxide. In composition carbonate, and igneous and metamorphic rocks predominate over lesser percentages of other rocks. In exposed thicknesses these deposits average 20 feet; they stand 10-30 feet above the lower valley outwash and have a level surface.

Cary Substage

The Cary drift in this quadrangle consists of till, outwash, and glacial lake deposits, laid down by the first two of three possible advances of the Cary ice of the James Lobe which followed the James River lowland southward in South Dakota.

The Cary till is characterized by rugged knob and kettle and swell and swale topographies. Undeveloped drainage is shown by the abundance of natural lakes and the absence of streams on the till's surface. The maximum relief in end moraine is 150 feet. The average relief is about 50-60 feet. Local relief varies from ground to end moraine. In the former it averages about 20 feet and in the latter about 45 feet.

The average composition of the Cary till is 39 percent carbonate rocks, 10 percent igneous and metamorphic rocks, and 51 percent other rocks. The till is light and dark olive gray to light and dark olive brown, and weathers light-buff. It is calcareous throughout and normally is not oxidized except after prolonged exposure. In thickness the Cary till ranges from 20 to 100 feet and averages about 45-50 feet.

Very thin discontinuous brownish-yellow calcareous loess overlies the till. The till has a variable thickness of silt and clay-loam soil on the surface. The soil is dark brown or black in color and is usually leached near the top; it ranges up to 1$\frac{1}{2}$ feet in thickness but averages about six inches.

Two ages of Cary outwash are recognized in this quadrangle. Early Cary outwash is preserved as terrace remnants east of Dry Lake and adjacent to the Cary end moraine. The Early Cary age of this outwash is evidenced by several factors: it is adjacent to the end moraine which represents the easternmost Cary advance of the James ice lobe; it was derived from the outwash of this moraine; the remnants stand above the lower valley train outwash which is seen to breach the moraine from Lake Florence to east of Hayti suggesting Middle (?) Cary age for the latter.

The Early Cary outwash is composed chiefly of poorly-stratified, poorly-sorted sand and medium to coarse gravel, containing minor amounts of silt and clay. Average percentages of constituents are 50 percent carbonate rocks, 30 percent igneous and metamorphic rocks, and 20 percent other rocks. The material has considerable iron-oxide which serves locally as cement. The soil mantle on these remnants is dark brown sand loam about 8-12 inches thick.

The Middle (?) Cary outwash occurs as valley train deposits in the Big Sioux River valley and as collapsed or pitted plain-outwash. The valley train outwash is the most important of the Middle (?) Cary deposits. This material consists of sand and gravel with lesser amounts of silt and clay. It is normally unoxidized and is gray to brown in color. The material occurs in alternating coarse and fine layers which are often coarser near the source. The average composition of the Middle (?) Cary outwash is 45 percent carbonate rocks, 43 percent igneous and metamorphic rocks, and 12 percent other rocks. The topography of the valley train is level to gently undulating. This outwash is mantled by a variable thickness of sandy loam and silty loam soil. The soil normally is less than a foot thick, but locally may be 2$\frac{1}{2}$ feet thick; it is generally leached in the upper few inches. The valley train outwash ranges in thickness from 12-93 feet and averages about 49 feet.

The collapsed plain-outwash occupies positions immediately adjacent to the Cary end moraine. The collapsed topography is rough and uneven, exhibiting as much as 50-60 feet of local relief. In places its topography is difficult to distinguish from end moraine. The collapsed material differs from end moraine, however, in being composed chiefly of sand and gravel with some till inclusions. The material is commonly unstratified to poorly stratified fine to coarse gravel, sand, silt, and clay. The material in unoxidized and thus is light-gray to bluish-gray and brown in color. A sandy silt-loam discontinuously mantles the surface of the collapsed outwash. The outwash ranges widely in thickness from 10-90 feet and averages 48 feet.

Cary glacial lake sediments are fine stratified well-sorted sand, silt, and clay, generally gray or light brown in color and are commonly fossiliferous. These deposits are confined to the low area north of Lake Marsh marked Qwclb (reverse side) and in smaller lakes in the area. The sediments range in thickness from several feet to 70 feet.

Recent Alluvium

Alluvium of Recent age occupies the flood plain of the Big Sioux River and the beds of modern lakes. The alluvium consists of dark semistratified to stratified gravel, sand and silt with lesser amounts of clay and humus. The alluvium ranges up to 20 feet in thickness and averages about three feet.

SUBSURFACE ROCKS

No bedrock is exposed in the quadrangle. On the basis of data obtained from well logs around the area, however, Precambrian rocks form the basement and are unconformably overlain by Cretaceous sedimentary rocks.

The Precambrian consists of Sioux Formation ("quartzite"). The Cretaceous strata are, in ascending order, the Dakota Group (A. F. Agnew, personal communication, May 1958), 150 feet thick; the Graneros Formation, 155 feet thick; the Greenhorn Formation, 31 feet thick; the Carlile Formation, 196 feet thick; the Niobrara Formation ("chalkstone"), 93 feet thick; and the Pierre Formation, 243 feet thick.

STRUCTURE

The structure of the subsurface rocks of the Hayti quadrangle is relatively simple. The surface of the Precambrian is uneven, probably erosional and has a gentle slope to the northwest (Steece, 1953). The Cretaceous strata are relatively flat-lying and, as mentioned previously, lie unconformably on the basement. In places, Cretaceous rocks overlap on the Precambrian.

ECONOMIC GEOLOGY

Shallow Ground Water

All the unconsolidated Pleistocene deposits in the quadrangle contain interstitial waters. The quantity and quality of water contained in the outwash exceeds that found in any of the other materials. The level at which the water is maintained in the outwash materials is the water table. This normally conforms to the topography and thus in this quadrangle it slopes generally southward with a resulting slow movement of water through the porous material from north to south.

The occurrence of ground water in the outwash is dependent on several factors, including permeability, porosity, and extent. Permeability is the ability of a material to transmit water through its interstices. In general, coarse-grained material is more permeable than fine-grained material with similiar grain arrangement. Porosity is the amount of pore space in a given material. Porosity is dependent on grain shape rather than size; thus a material may have a high degree of porosity and yet have a low permeability if the pores are not interconnected or if the openings between pores are very small. An ideal water reservoir material would have spherical grains one to two inches in diameter.

An equally important factor determining quantity of water is the extent of the deposit in which it is contained. The total area occupied by outwash deposits in the quadrangle is 46 square miles. Of this, 90 percent can be considered as potential source of shallow ground water. However, since 41 percent is collapsed plain-outwash and since this latter is so variable in character and thickness, it is not recommended as a consistent source for irrigation water. It is, nevertheless, included in the calculations of water reserve. Twenty square miles of normal valley train outwash averages 49 feet in thickness. The average depth to water is 15 feet. Thus, 34 feet of saturated outwash material underlies the surface of 12,800 acres. The 700,000,000 cubic yards of saturated sand and gravel therein, with an average porosity of 30 percent, contains approximately 130,000 acre-feet or 42,820,000,000 gallons of water. The water reserve in the collapsed plain-outwash is 113,000 acre-feet or 37,440,000,000 gallons.

The average annual precipitation at Watertown is about 21 inches (U. S. Weather Bureau). Most of this water is absorbed directly by the porous soil on the outwash, forming the major part of the recharge for the materials. Recharge is also accomplished by runoff from surrounding uplands, by underflow or slow percolation of water in the gravels downstream, and by overflow of streams during flood periods. The main discharge or removal of water from the outwash material is through wells, underflow away from source areas, seeps and springs, transpiration by plants, and evaporation. In general, recharge exceeds discharge in this quadrangle so that underflow accounts for any excess recharge, keeping the water table annually fairly constant.

Recovery is the process by which the water level in a pumping well or a well which is influenced by a pumping well resumes its normal level after pumping has ceased. The rate of recovery depends on the permeability of the material which the well penetrates, and on the rate of recharge. In general, the recovery in the outwash of this area is good and wells should return to normal in a short time if the recharge if normal.

The quality of water in the outwash deposits (table 1) is generally good for irrigation. The waters analyzed are from outwash and sample 4 is from till.

Although sample four is high quality water, till water is normally not satisfactory for irrigation use. Excessive concentrations of sodium, boron, sulfate, carbonate, and chloride are considered harmful to plant development (see Steece, 1958 for further details).

The use of outwash water for irrigation in the Hayti quadrangle is recommended, with several qualifications. First, periodic analyses of irrigation water should be carried out often during the pumping season owing to higher salt concentrations by re-circulation. Second, each well should be deep enough to completely penetrate the outwash, and should be located near the center of the outwash, rather than its borders. Third, because of the porous nature of the soil on the outwash and because the valley outwash is relatively level, sprinkler irrigation would probably be more adaptable than ditch irrigation. Fourth, wells should be located with caution in areas of collapsed plain-outwash owing to the variability and unpredictable nature of the materials there.

Table 1. Analyses of Water Samples in the Hayti Quadrangle

Constituent ppm / No.	Ca	Mg	Na	K	HCO_3	CO_3	SO_4	NO_3	Cl	Fe	Hardness $CaCO_3$
4*	94	38	18	3	265	50	160	0	5	0	390
5*	80	29	10	4	255	40	65	0	10	0	320
6*	188	63	30	6	280	40	433	0	10	1.0	242
12**	98	37	24		281	-	150	2	32	.02	396
13**	145	48	68		410	-	150	40	59	0	560
14**	147	53	24		381	-	326	0	9	.24	584

4. William Piper, SW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 36, T. 115 N., R. 53 W., Hamlin County.
5. Eldon Bleeker, SW$\frac{1}{4}$SW$\frac{1}{4}$ sec. 25, T. 114 N., R. 52 W., Hamlin County.
6. Al Flakus, NW$\frac{1}{4}$NW$\frac{1}{4}$ sec. 19, T. 113 N., R. 52 W., Hamlin County.
12. Hayti City Well No. 1.
13. Castlewood City Well No. 2, (NOTE: Concentrations of NO_3 in excess of 10 ppm may be harmful if used for human consumption.)
14. Lake Norden City Well No. 1.

*Analyzed by O. E. Olson, Station Biochemistry, South Dakota Agricultural Experiment Station, College Station, Brookings, South Dakota, 1957.

**Analyzed by Division of Sanitary Engineering, South Dakota State Department of Health, Pierre, South Dakota, 1956.

Deep Ground Water

Some subsurface strata yield sufficient water for most domestic purposes, but the water is generally not suitable for irrigation use because of quality and/or quantity. Water is available from the Dakota Group, the Codell sand of the Carlile Formation, the Niobrara Formation ("chalkstone"), and the Sioux Formation

Many wells in the quadrangle draw water from sand lenses in the tills. As mentioned earlier, this is usually unsuited for irrigation use.

Buried stream channels may yield domestic supplies of water. Flint (1955, map, plate 7) has suggested the presence of several of these in the Hayti quadrangle.

Sand and Gravel

Sand and gravel deposits of the area occupy 29,440 acres. The estimated reserve of these is 2,565,000,000 cubic yards. The material is composed chiefly of carbonate and igneous and metamorphic rock fragments with less than 2 percent silt and clay. Minor percentages of shale, chalk, and clay-ironstone (limonite) are present as deleterious materials. In general, the material is good for road metal and concrete aggregate.

Clay

The tills in the area contain 60 percent silt and clay. Brick-making and ceramic industries could find an abundance of clay for their needs.

Oil and Gas

No oil or gas has been found in Eastern South Dakota. The pinchouts formed by the Cretaceous strata and the Precambrian basement may have been sites for oil accumulation in the past; and thus might be worth prospecting.

REFERENCES CITED

Flint, R. F., 1955, The Pleistocene Geology of Eastern South Dakota, U. S. Geol. Survey Prof. Paper 262, 173 p.

Rothrock, E. P., 1943, A Geology of South Dakota, Part 1, The Surface, S. Dak. Geol. Survey, Bull. 13, 88 p.

Steece, F. V., 1953, Precambrian Basement Complex of South Dakota, Unpubl. Seminar Report, State University of South Dakota, Vermillion.

__________, 1958, Geology and Ground Water Resources of the Watertown-Estelline Area, South Dakota, S. Dak. Geol. Survey Rept. Invest. 85, p. 29-34.