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MAJOR AQUIFERS IN MINER COUNTY, SOUTH DAKOTA

by

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DEFINITION OF TERMS

AQUIFER - A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

BEDROCK - Any solid rock exposed at the earth's surface or overlain by unconsolidated rock material.

CONFINED AQUIFER - An aquifer located between two relatively impermeable geologic units.

GLACIAL DRIFT - Rock material, such as boulders, till, or outwash, transported and deposited by glacial ice or water derived from melting glacial ice.

GLACIAL OUTWASH - Stratified, sorted, unconsolidated rock material (usually sand and gravel) deposited by glacial melt water.

GLACIAL TILL - Unstratified, unsorted, unconsolidated rock material (ranging from fine clay particles to large boulders) deposited directly by glacial ice.

HYDRAULIC GRADIENT - The rate of change of hydrostatic head per unit distance of flow at any given point and in any given direction in an aquifer.

HYDROSTATIC HEAD - The level which for a given point in an aquifer, marks the top of a column of water that can be supported by the hydrostatic pressure of the water at that point.

HYDROSTATIC PRESSURE - The pressure exerted by the water at any given point in a body of water.

POTENTIOMETRIC SURFACE - An imaginary surface to which water will rise in a tightly cased well. This surface represents the hydrostatic head occurring in any well in a given aquifer.

STORAGE COEFFICIENT - The volume of water that an aquifer can release from or take into storage per unit surface area of aquifer per unit change in hydrostatic head.

TRANSMISSIVITY - The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient.

WATER HARDNESS CLASSIFICATION RANGE - A hardness (soap consuming ability) classification for water based on calcium and magnesium concentration:

Milligrams per liter	Grain per gallon	Description
0- 60	0- 3.5	Soft
61-120	3.6- 7.0	Moderately hard
121-180	7.1-10.5	Hard
Greater than 180	Greater than 10.5	Very hard

INCH-POUND TO METRIC CONVERSION TABLE

Factors for converting inch-pound units to metric units are shown below to four significant figures.

Inch-pound unit	Multiplied by	Equals metric unit
foot	0.3048	meter
gallon	3.785	liter
gallon per minute	0.0631	liter per second
mile	1.609	kilometer
square mile	2.590	square kilometer

SIGNIFICANCE OF SOME CHEMICAL AND PHYSICAL PROPERTIES OF DRINKING WATER

(Modified after Barari, 1972)

Chemical Constituents	Significance	Recommended limits (milligrams per liter)
Calcium (Ca) and Magnesium (Mg)	Cause most of the carbonate hardness and scale-forming properties of water by combining with carbonate and bicarbonate present in the water. Seldom can be tasted except in extreme concentrations.	None
Sodium (Na)	Large concentrations in combination with chloride will give water a salty taste. Large concentrations will limit water for irrigation and industrial use.	None
Chloride (Cl)	Large concentrations in combination with sodium give water a salty taste. Large concentrations also will increase corrosiveness of water.	250 *
Sulfate (SO_4)	Large concentrations of sulfate in combination with other ions give a bitter taste to water and may act as a laxative to those not used to drinking it. Sulfates of calcium and magnesium will form hard scale.	250 *
Hardness	Hardness equivalent to carbonate and bicarbonate is called carbonate hardness. Hardness in excess of this amount is noncarbonate hardness. Hardness in water consumes soap and forms soap curd. Also will cause scale in boilers, water heaters, and pipes. Good drinking water can be very hard.	None

Chemical Constituents	Significance	Recommended limits (milligrams per liter)
Dissolved solids	Total of all dissolved constituents. Water containing more than 1,000 milligrams per liter of dissolved solids may have a noticeable taste; it may also be unsuitable for irrigation and certain industrial uses.	500 *

* U.S. Environmental Protection Agency "National Secondary Drinking Water Regulations", July 19, 1979 (recommended limits)

ABSTRACT

Thousands of years ago glacial meltwater deposited layers of outwash sand and gravel over much of Miner County, South Dakota. These deposits occur throughout the county at depths ranging from 0 to 500 feet below land surface. In places, the deposits are hydrologically connected and form major glacial-outwash aquifers.

The Floyd aquifer underlies about 180 square miles of Miner County and ranges from 10 to 100 feet in thickness. Wells completed in the aquifer may yield as much as 1,200 gallons per minute. Other outwash aquifers underlie an additional 195 square miles of Miner County and range from 10 to 50 feet in thickness.

Several Cretaceous bedrock aquifers also contribute to the ground-water resources of Miner County. The Niobrara Formation is the uppermost bedrock aquifer and underlies all but the southwest corner of the county. It ranges in depth from 60 to 600 feet below land surface and has a thickness ranging from 10 to 120 feet.

The Codell Sandstone Member of the Carlile Shale underlies the Niobrara Formation throughout the county at depths ranging from 120 to 720 feet below land surface. Thickness of the Codell ranges from 10 to 100 feet.

The Dakota Sandstone underlies most of northwest Miner County and is separated from the Codell by limestone and shale. Depth to the Dakota ranges from about 350 to 1,000 feet below land surface and thickness ranges from 10 to 400 feet.

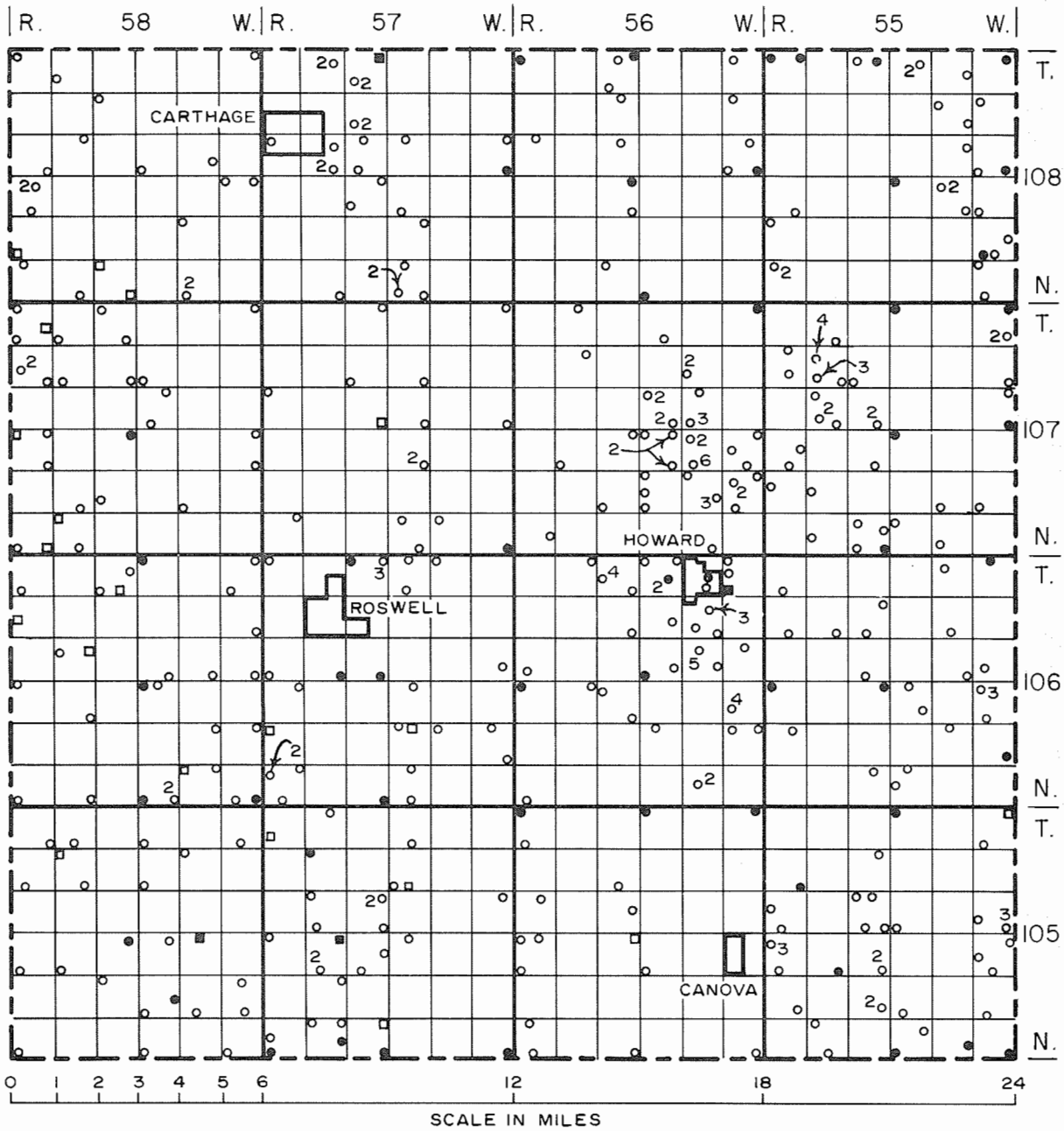
The Dakota is underlain by the Precambrian Sioux Quartzite which rises toward the south to form a steep ridge. Local weathering in the Sioux Quartzite has produced joints and fractures that contain relatively large amounts of water.

Each of the aquifers in Miner County provides adequate supplies of water for domestic and stock use. The Floyd aquifer offers the greatest potential for irrigation, industrial, or municipal development.

INTRODUCTION

The purpose of this pamphlet is to make preliminary information available regarding the location, availability, and quality of ground water in Miner County, South Dakota. Information presented here has been collected during a 4-year study by the U.S. Geological Survey and the South Dakota Geological Survey (fig. 1).

Copies of this publication may be obtained from either the U.S. Geological Survey office in Huron or the South Dakota Geological Survey office in Vermillion. Either of these offices may



- □ Observation well. Lithologic log available.
- ■ Observation well. Lithologic log and electric log available.
- $_{3}$○ Test hole. Lithologic log available.
- ● Test hole. Lithologic log and electric log available.

Additional wells or test holes within the same 160-acre tract are indicated by the number shown.

Figure 1. Map showing location of observation wells and test holes in Miner County for which data are available.

be contacted if additional information on Miner County is needed.

GLACIAL-OUTWASH AQUIFERS

Thousands of years ago glacial ice covered much of eastern South Dakota. As the glaciers advanced, pulverized bedrock and soil was deposited as glacial drift in great thicknesses. As the ice began to melt, large streams of water cut channels through the drift. The rapidly moving water washed finer rock fragments (silt and clay) down the stream channels and at the same time deposited large quantities of coarser rock fragments (sand and gravel). It is these deposits of sand and gravel that form the glacial-outwash aquifers discussed in this report.

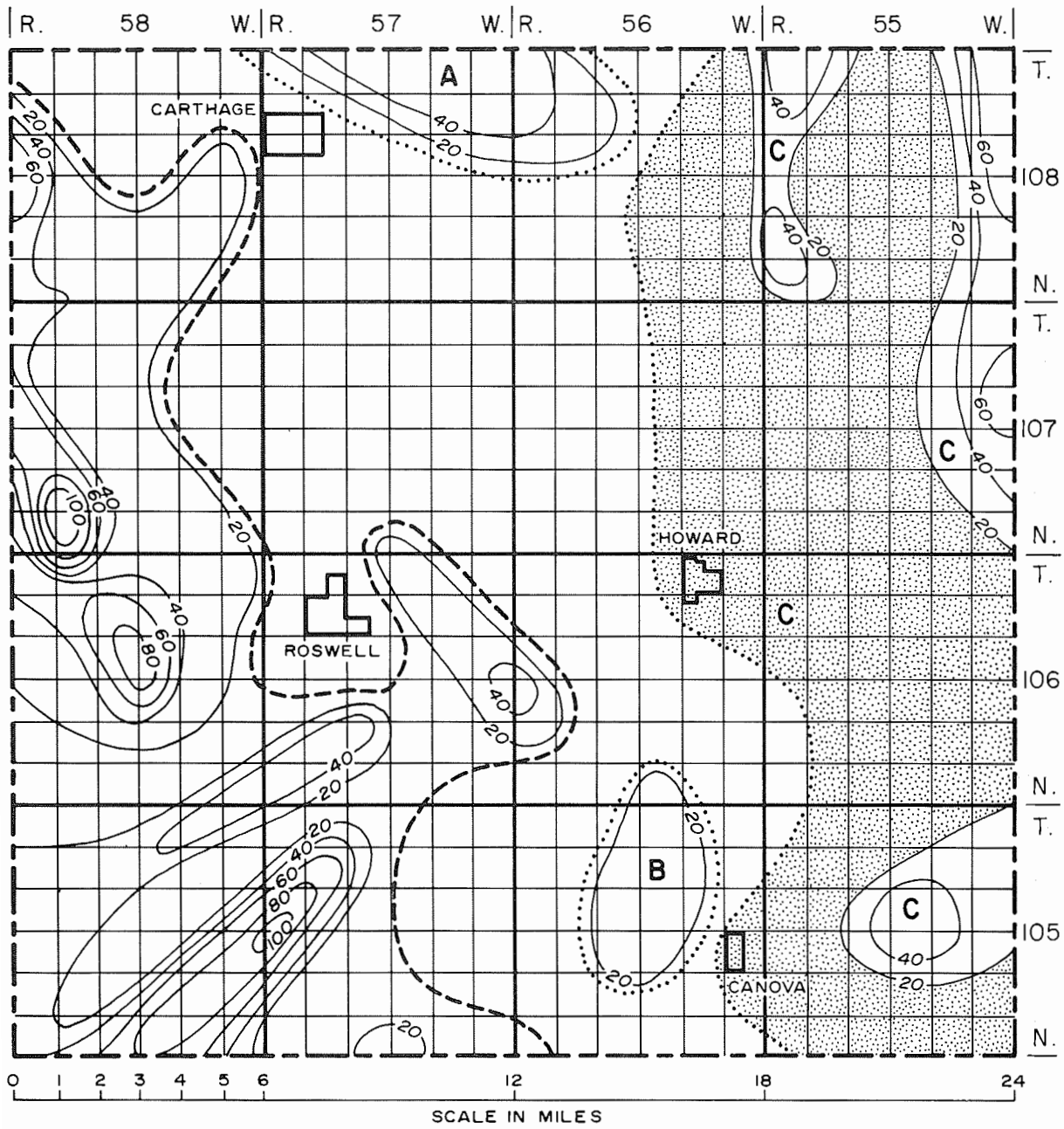
Floyd Aquifer

The Floyd aquifer underlies about 180 square miles of western Miner County (fig. 2). Sand and gravel deposits interfinger throughout the Floyd causing aquifer thickness and depth below land surface to vary considerably. Aquifer thickness ranges from about 10 to 100 feet and averages 50 feet. The top of the auqifer is as much as 150 feet below land surface, however, the top usually occurs at a depth of about 75 feet.

The northern one-half of the Floyd aquifer generally is confined by overlying till and the underlying Pierre Shale, which is relatively impermeable. Water levels are about 35 feet below land surface (water-level altitudes are given in fig. 3). The southern one-half of the aquifer is confined by overlying till. The Niobrara Formation or the Codell Sandstone Member of the Carlile Shale underlie the Floyd aquifer in this area. The Floyd is hydrologically connected to the Niobrara and Codell, and water levels range from 2 to 115 feet below land surface.

Storage coefficients and transmissivity values determined from aquifer tests indicate that potential yields could be as much as 1,200 gallons per minute (sufficient for irrigation, municipal, and industrial use) from properly-constructed wells. Most wells completed in the aquifer yield between 5 and 100 gallons per minute and are used for domestic and stock purposes.

The quality of water in the aquifer varies, but dissolved ions are predominantly sodium, calcium, magnesium, bicarbonate and sulfate. Dissolved-solids concentrations range from 1,000 to 2,290 milligrams per liter and average 1,550 milligrams per liter; hardness ranges from 75 to 3,150 milligrams per liter and averages 910 milligrams per liter. The chemical characteristics of water from the Floyd aquifer are acceptable for domestic, municipal or industrial, stock, and irrigation purposes.

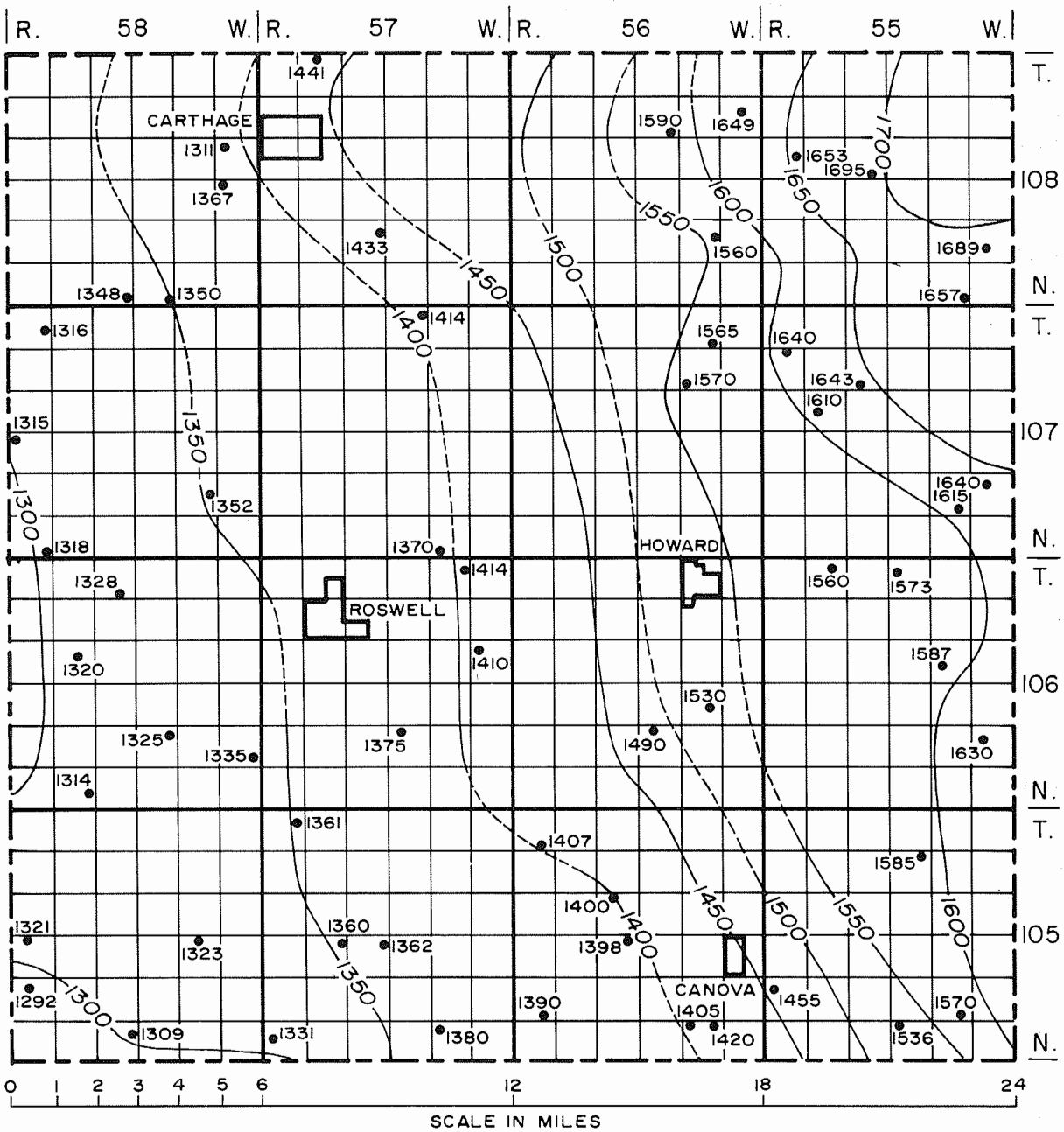


Approximate boundary of the Floyd aquifer.

Approximate boundary of local aquifers A, B and C. Stippled area indicates where sand and gravel occurs as irregular lenses.

Line of equal thickness of saturated sand and gravel. Contour interval is 20 feet.

Figure 2. Map showing location and combined sand and gravel thickness of major glacial outwash aquifers in Miner County.



1328 Well. Number is altitude of water level above National Geodetic Vertical Datum of 1929.

1650 Potentiometric contour. Shows altitude at which water will stand in a cased well. Contour dashed where material is less permeable. Contour interval is 50 feet. Datum is National Geodetic Vertical Datum of 1929.

Figure 3. Map showing generalized potentiometric water levels for major glacial outwash aquifers in Miner County.

Local Glacial-Outwash Aquifers

Eastern and central Miner County is underlain by many local aquifers that occur in outwash deposits. Each of these aquifers seems to be isolated for the most part by till, which restricts hydrologic connection to other glacial-outwash and bedrock aquifers.

Local aquifer A underlies about 20 square miles of north central Miner County. Gravel is the dominant aquifer material occurring in several thin lenses and one thick basal unit. The larger basal unit ranges from 20 to 50 feet in thickness. The top of the basal unit occurs at depths between 125 and 200 feet below land surface.

Water levels range from 6 to 75 feet below land surface. Due to the overlying confining till and the underlying Pierre Shale, recharge to the aquifer may be slow.

Available well-yield data are limited. However, based on material size and aquifer extent, potential yields of more than 300 gallons per minute may be obtained from properly-constructed wells.

Water from the upper layers of aquifer A contains dissolved-solids concentrations of between 500 and 575 milligrams per liter and averages 540 milligrams per liter; hardness ranges from 360 to 450 milligrams per liter and averages 400 milligrams per liter. Water from these layers is suitable for domestic and stock purposes and is presently (1980) used for these purposes. There is insufficient data to determine the water quality of the underlying basal unit of aquifer A.

Local aquifer B underlies about 10 square miles of south central Miner County. Sand and gravel are the dominant aquifer material and occur in one large deposit. Aquifer B ranges from 10 to 40 feet in thickness. The top of the aquifer ranges from 90 to 125 feet below land surface.

Till confines most of the aquifer; however, there seems to be some hydrologic connection with the underlying Niobrara Formation. Water levels in aquifer B range from 75 to 77 feet below land surface.

Present well-yield data are limited. However, based on material size and aquifer extent, potential yields of 300 gallons per minute may be obtained from properly-constructed wells.

Water from the aquifer has dissolved-solids concentrations ranging from 1,330 to 1,430 milligrams per liter and averages 1,380 milligrams per liter; hardness ranges from 425 to 610 milligrams per liter and averages 500 milligrams per liter. Water from the aquifer is suitable for most domestic and stock purposes and is presently (1980) used for these purposes.

Local aquifer C underlies about 165 square miles of eastern Miner County and consists of thin lenses of sand and gravel, which usually are separated by glacial till. These outwash lenses range in thickness from 10 to 50 feet at depths ranging from land surface to 500 feet below land surface. As many as 10 separate lenses have been penetrated in test holes drilled to bedrock.

The hydrologic connection of these lenses is limited except where the sand and gravel is in contact with the underlying Niobrara Formation. Water in the aquifer is both confined and unconfined with water levels ranging from 5 to 162 feet below land surface.

Because the permeable lenses vary in composition, extent, and recharge capacity, the water yield from aquifer C may vary substantially. A city well in Canova pumps 70 gallons per minute but, most wells completed in the aquifer yield water at significantly smaller rates. Potential well yields of up to 300 gallons per minute may be possible from properly-constructed wells in the aquifer. Water from the aquifer may be suitable for domestic and stock well development and may have potential for increased municipal and irrigation uses. At present (1980), water being pumped from the aquifer is used for domestic, stock, and municipal purposes.

Water from the aquifer is predominantly calcium, calcium-magnesium, sulfate and bicarbonate types. Dissolved solids concentrations range from 375 to 2,300 milligrams per liter and average 1,075 milligrams per liter. Hardness ranges from 1,300 to 2,600 milligrams per liter and averages 2,240 milligrams per liter.

BEDROCK AQUIFERS

Three principal Cretaceous bedrock aquifers underlie various parts of Miner County. The Niobrara Formation and the underlying Codell Sandstone Member of the Carlile Shale were deposited in ocean environments millions of years ago, whereas the Dakota Sandstone was deposited in flood-plain and delta environments at an even earlier time.

Niobrara Formation

The Niobrara Formation is the uppermost bedrock aquifer and underlies about 550 square miles of Miner County. The formation varies in composition from chalk to marl and appears as a gray calcareous clay in drill cuttings. The Niobrara Formation is about 120 feet thick in northern Miner County, gradually thins towards the south, and is completely absent in the southwest part of the county. The formation lies at depths ranging from 60 to 600 feet below land surface.

The Niobrara aquifer generally is confined by overlying till and Pierre Shale but seems to be hydrologically connected with overlying sand and gravel and the underlying Codell Sandstone Member of the Carlile Shale. Wells discharging from the Niobrara may flow in parts of west-central Miner County; however, in other areas, water levels usually occur at an average of 115 feet below land surface. Water levels range from 6 feet above land surface in flowing wells to a maximum depth of 200 feet.

The Niobrara aquifer presently (1980) is being pumped by small- to medium-yield wells for domestic, stock, and municipal purposes. Although it may be possible to obtain yields from the Niobrara that are sufficient for irrigation, such pumpage may decrease the production of existing domestic and stock wells. Data are too few to determine the maximum potential well yields.

Water from the Niobrara Formation is dominated by sodium and sulfate ions, which along with hydrostatic-head measurements indicates some recharge from deeper aquifers. Dissolved-solids concentrations range from 850 to 2,700 milligrams per liter and average 1,600 milligrams per liter; hardness ranges from 275 to 1,500 milligrams per liter and averages 725 milligrams per liter.

Codell Sandstone Member of the Carlile Shale

The Codell Sandstone Member of the Carlile Shale underlies about 560 square miles of Miner County. It is overlain by the Niobrara Formation and underlain by the Greenhorn Limestone. The Codell is a fine- to medium-grained sandstone interbedded in places with the Carlile Shale. The sandstone occurs at depths ranging from 120 to 720 feet below land surface and generally ranges in thickness from 10 to about 100 feet.

Water quality and hydrostatic-head information indicate that in southwestern Miner County the aquifer is recharged primarily from deeper aquifers and discharge is into both the overlying glacial outwash and the Niobrara Formation. In other parts of the county, hydrostatic heads in the bedrock and glacial aquifers are about the same. In these areas, the underlying bedrock provides recharge to the glacial aquifer when the hydrologic head of the glacial aquifer is below that of the bedrock. When the hydrostatic head of the bedrock is below that of the glacial aquifer the bedrock will receive recharge from the glacial aquifer. Water levels in the Codell aquifer range from 15 to 235 feet below land surface.

At present (1980), little is known about potential aquifer yields because most wells produce only small yields for domestic use. The effect of large-capacity wells, for irrigation and industry, on present wells is unknown at this time.

Dissolved-solids concentrations in water from the Codell aquifer range from 800 to 2,400 milligrams per liter and average

1,600 milligram per liter. Hardness ranges from 35 to 1,000 milligrams per liter and averages 400 milligrams per liter.

Dakota Sandstone and Sioux Quartzite

The Dakota Sandstone underlies 335 square miles in the northwest one-half of Miner County where it is separated from the Codell Sandstone Member by the overlying lower part of the Carlile Shale, Greenhorn Limestone, and Graneros Shale (from top to bottom). The formation is a fine-grained sandstone interbedded with siltstone, shale, and carbonate beds. The Dakota occurs at depths ranging from about 350 to 1,000 feet below land surface and reaches thicknesses of about 400 feet along the northern edge of the county. The Dakota Sandstone thins towards the southeast and is absent just northwest of Howard where the underlying Precambrian Sioux Quartzite forms a steep ridge.

The Dakota aquifer is confined by overlying shales and carbonate beds that pinch out on the Sioux Quartzite ridge. These overlying shales and carbonate rocks are separated from the quartzite ridge by a weathered zone of quartzite "wash" that allows water to migrate up to the overlying Niobrara Formation, Codell Sandstone Member of the Carlile Shale, and outwash sand and gravel aquifers. The Sioux Quartzite wash is a source of water for many wells in Miner County.

Wells completed in the Dakota Sandstone may have shallow water levels or even flow in parts of western Miner County; but on the average, water levels are about 110 feet below land surface. Water levels in the Dakota aquifer range from 25 feet above land surface in flowing wells to a maximum depth of 260 feet. Water levels in the Sioux Quartzite wash range from 75 to 90 feet below land surface.

Wells completed in the Dakota yield as much as 200 gallons per minute but smaller yields are more common. The water is used for domestic, stock, and municipal purposes. Properly constructed wells in the Sioux Quartzite wash may yield as much as 200 gallons per minute.

Water from the Dakota Sandstone is dominated by sodium and sulfate ions. Dissolved-solids concentrations range from 1,430 to 2,750 milligrams per liter and average 2,500 milligrams per liter; hardness ranges from 34 to 1,100 milligrams per liter and averages 300 milligrams per liter.

The dominant ions in water from the Sioux Quartzite wash are sodium and sulfate. Dissolved-solids concentrations range from 1,550 to 2,100 milligrams per liter and average 1,900 milligrams per liter. Hardness ranges from 650 to 800 milligrams per liter and averages 700 milligrams per liter.

A summary of aquifer characteristics for Miner County is given in table 1.

LARGE-CAPACITY WELLS AND IRRIGATION POTENTIAL

The Floyd is the most favorable aquifer for the development of large-yield wells necessary for crop irrigation. Maximum well yields of 1,200 gallons per minute may be available and water quality is suitable for plant growth.

Prior to well construction, test holes commonly are drilled at and around the selected site to determine aquifer thickness, depth to the top of the aquifer, depth to water, and grain size of the aquifer material. This information can be used to properly design the production well (selection of the proper pump and slot size and placement of the screen). Controlled pumping of a test well for at least several hours will indicate the yield of the aquifer at that locality and provides a representative water sample for chemical analysis.

REFERENCES

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Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water: U.S. Geol. Survey Water-Supply Paper 1473, 363 p.

South Dakota Geological Experiment Station, 1959, Salinity and livestock water quality: Brookings, South Dakota, Bull. 481, p. 10-12.

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TABLE I. Summary of aquifer characteristics for Miner County.

Aquifer	Areal extent (square miles)	Aquifer material	Aquifer thickness (feet)	Depth to top of aquifer (feet)	Depth to water (feet)	Potential well yield (gallons per minute)	Range of dissolved solids (milligrams per liter)	Average dissolved solids (milligrams per liter)	Range of hardness (milligrams per liter)	Average hardness (milligrams per liter)	Predominate ions
Floyd aquifer	180	Sand and gravel	10-100	25- 150	2-115	1,200	1,000-2,290	1,550	75-3,150	910	Sodium, calcium, magnesium, bicarbonate, and sulfate
Local aquifer A	20	Gravel	20- 50	125- 200	6- 75	300	500- 575	540	360- 450	400	Insufficient data
Local aquifer B	10	Sand and gravel	10- 40	90- 125	75- 77	300	1,330-1,430	1,380	425- 610	500	Insufficient data
Local aquifer C	165	Sand and gravel	10- 60	Land surface to 500	5-162	300	375-2,300	1,075	1,300-2,600	2,240	Calcium, magnesium sulfate and bicarbonate
Niobrara aquifer	550	Chalk and marl	10-120	60- 600	+6-200	Insufficient data	850-2,700	1,600	275-1,500	725	Sodium and sulfate
Codell aquifer	560	Fine-to medium-grained sandstone interbedded with Carlile Shale	10-100	120- 720	15-235	Insufficient data	800-2,400	1,600	35-1,000	400	Insufficient data
Dakota aquifer	335	Fine-grained sandstone, siltstone, shale, and carbonate rocks	10-400	350-1,000	+25-260	200	1,430-2,750	2,500	34-1,000	300	Sodium and sulfate
Quartzite aquifer	575	Quartzite	Insufficient data	100- ?	75- 90	200	1,550-2,100	1,900	650- 800	700	Sodium and sulfate

+ Indicates water level above land surface.