State of Michigan
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Geological Survey Division

Water Investigation 11
GROUND WATER AND GEOLOGY OF BARAGA COUNTY, MICHIGAN

by
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Prepared in cooperation with the Water Resources Division of the Geological Survey, United States Department of the Interior

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Contents

Figures

PREFACE

The purpose of this report is to provide information needed in the search for water supplies from wells and springs in Baraga County.

For many years the state and federal geological surveys have cooperated in producing basic information on water resources in Michigan. This report is one product of that continuing program; and was made possible by the assistance of county agencies, municipalities, industrial concerns, well drillers, and many local residents.

Detailed records on wells and chemical analyses are included in the several tables in the Appendix at the rear of the report.

The basic information on the bedrock geology of Baraga County was furnished by Robert C. Reed of the Geological Survey Division, Department of Natural Resources. The report was reviewed by Arthur E. Slaughter of the Geological Survey Division, Department of Natural Resources. Artwork is by Jim Campbell.

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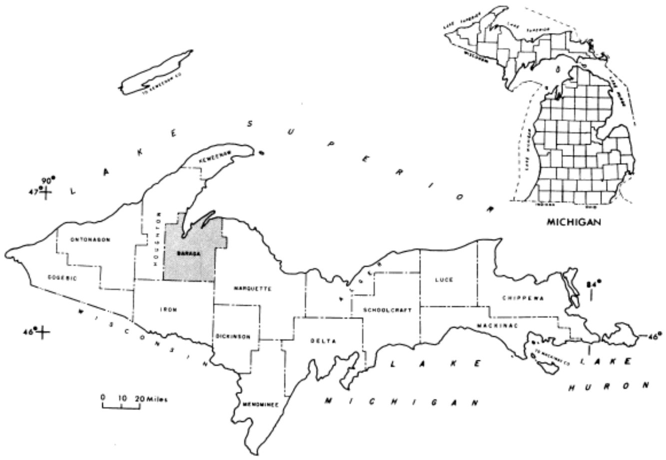

Figure 1. Location of Baraga County report area in northwestern part of Michigan's Northern Peninsula.

ABSTRACT

Most wells In Baraga County obtain water from beds of sand and gravel in morainal and lakebed deposits or from the Jacobsville Sandstone. Yields of wells range from a few to as much as 115 gallons per minute, but most wells probably yield less than 10 gpm. Large areas, where igneous and metamorphic rocks crop out or are covered only by thin drift, are unfavorable for obtaining enough ground water for even a domestic supply. Quality of water from most wells is satisfactory, although most water supplies are hard and some are high in iron content. Some of the deeper wells in the Jacobsville Sandstone may yield salty water. Most large public water supplies are obtained from Lake Superior, but some smaller supplies are obtained from wells and springs.

INTRODUCTION

Nearly all rural residents in Baraga County depend on ground water for their domestic supplies, whereas two of the three municipal water supplies are obtained from Lake Superior. Yields of most wells are small, and in some areas it is practically impossible to obtain a supply adequate for a modern household.

This report describes the occurrence of ground water in glacial and bedrock aquifers and summarizes data on representative wells and springs. Maps showing the surface distribution of glacial materials and bedrock formations (in pocket) are keyed to the availability of ground water in the various aquifers. Included also is a map showing hydrologic data on selected wells.

Descriptions of public water supplies from all sources are included as permanent records for evaluation of future changes. Data on other wells and springs are included in the appendix.

Cooperation and Acknowledgments

For many years the State and Federal geological surveys have cooperated in making investigations of the water resources in Michigan. This report is a product of such an investigation. Assistance in obtaining data used in this report was provided by well drillers, local public officials, and village and rural residents. Bedrock geology was furnished by Robert C. Reed, Mining Geologist with the Geological Survey Division. A. E. Slaughter, State Geologist, provided encouragement and assistance in the study and reviewed the final report.

Well-Numbering System

The well-numbering system used in this report relates well location to the rectilinear system of land subdivision with reference to the Michigan prime meridian and base line. The first two parts of a well number designate the township and range; the last part designates the section and the well number within the section. Thus, "49N 33W 18-2" is the second well inventoried in section 18, Township 49 North, Range 33 West. Locations and hydrologic data of selected wells are shown on plate 1 (in pocket).

Geography

Baraga County is in the northwestern part of the Northern Peninsula of Michigan (fig. 1). The 1970 census shows a county population of 7,789, about half of which live in or near the towns of L'Anse and Baraga. Manufacturing and logging are the principal contributors to the economy. Since 1950 agriculture has rapidly declined in economic importance and at present only 6 percent of the county's 904 square miles is farmed. Beef and dairy products account for most of the farm income. Tourism, although increasing, is at present a small contributor to the economy. In 1964, tourist expenditures equaled about 4 percent of the total retail sales.

Topography and Drainage

Baraga County is generally hilly. Large rolling hills cover the northwest part of the county, except for a broad level plain along the Sturgeon River (pl. 1). A large relatively flat sandy plain lies north of the Sturgeon River in the west-central part. North and east of U. S. 41 the hills are steep, and many large rock outcrops are present. Altitudes in this area range from 1,500 to more than 1,900 feet. Mt. Curwood (altitude 1,980 feet), the highest point in Michigan, is in this upland area. South of U.S. 41 and M-28 the hills become less steep, and broad valleys and fewer rock outcrops are present.

Altitudes range from just over 600 feet in marshy areas along Huron and Keweenaw Bays to more than 1,900 feet near the headwaters of the Peshekee River in the east-central part of the county.

Most of Baraga County is drained by the Sturgeon River (fig. 2). The Falls River and several small streams drain the north-central part and flow into Keweenaw Bay. In the northeast part, the Silver, Slate, and Ravine Rivers flow into Huron Bay. The Huron River flows into Lake Superior. The Spruce and Peshekee Rivers, which drain a small area on the east side of the county and several streams in the south tier of townships, are part of the Lake Michigan drainage basin.

GEOLOGY

The most conspicuous surface geologic feature of Baraga County is the Peshekee Upland, 1,500 to more than 1,900 feet in altitude, in the east-central part of the county (fig. 2). Precambrian bedrock is exposed or is thinly mantled with drift in the Peshekee Upland and also in large areas in the southwestern part of the county (pl. 2). Glacial drift is also thin or absent in places in the northern part, especially in areas bordering Keweenaw and Huron Bays. Areas of thicker drift occur in the Baraga Plains, Sturgeon River Valley, and the Keweenaw Moraine. Geologic maps (pl. 2) show the areal distribution of glacial deposits and bedrock.

Bedrock Formations

Lower Precambrian

Lower Precambrian rocks, chiefly composed of granite and gneiss, occur in the Peshekee Upland in the east-central part of the county (pl. 2). Topographically, this rock unit stands several hundred feet above the adjacent bedrock formations. Banded gneiss is common in this unit --- a result of engulfment and assimilation of former volcanic and sedimentary rocks by granite magmas near intrusive contacts. Older Keewatin volcanic and sedimentary rock units also occur, but are poorly represented in Baraga County as compared with Marquette County to the east. Only scattered remnants have been preserved within the layered masses of Laurentian granitic type rocks.

Middle Precambrian

Middle Precambrian rocks occur in the northeast, central, and southern parts of the county (pl. 2). The major part of the middle Precambrian rock unit is composed of Michigamme Slate and associated clastic rocks. The unit may be as thick as a few thousand feet. The Marquette Syncline, which contains iron formations, extends westward from Marquette County into the eastern part of Baraga County. Minor amounts of iron ore have been mined from the iron formations.

Upper Precambrian

The lower and middle Precambrian rock units in Baraga County are cut in places by east-west trending diabase dikes. These dikes, of late Precambrian age, though numerous, are of small areal extent and are not mapped on plate 2.

Cambrian or Precambrian Jacobsville Sandstone

The Jacobsville is a light-red to brown medium-grained quartz sandstone containing bleached spots or layers. It includes beds of fine-grained sandstone, shale, and conglomerate. The Jacobsville subcrops in the northwestern part of the county, thinning to the southeast, and pinching out at the south end of Keweenaw and Huron Bays.

The formation dips northward 1 to 5 degrees and thickens rapidly to more than 1,000 feet. Massive and crossbedded Jacobsville Sandstone is exposed in cliffs or underlies beach sand along Keweenaw and Huron Bays.

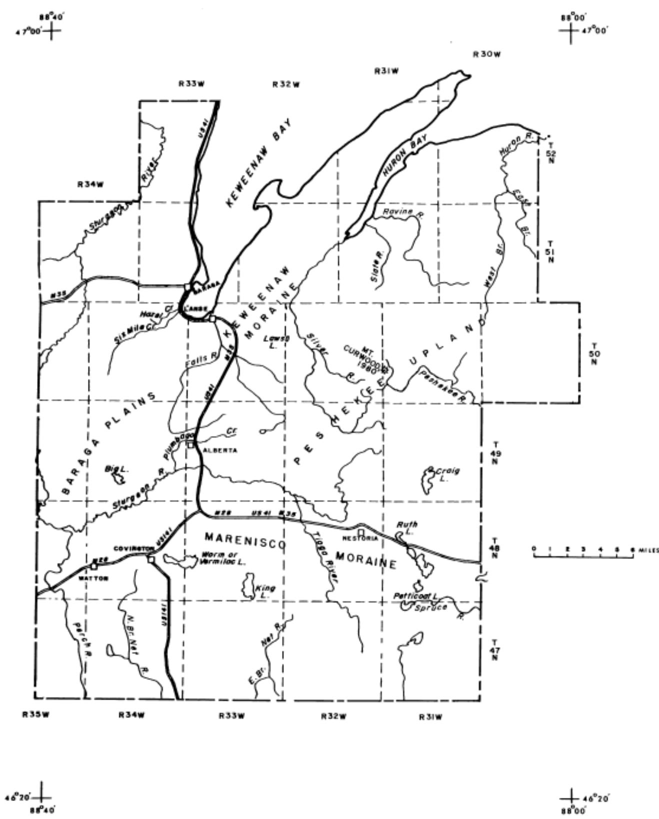

Figure 2. Principal physiographic features of Baraga County, Michigan.

Glacial Formations

During the Pleistocene Epoch, Baraga County was traversed by vast sheets of glacial ice, which advanced and receded at least four times from the Labrador center in eastern Canada. The surficial glacial features were formed during the recession of the most recent of these glacial advances, known as the Valders advance, which terminated on the Precambrian highlands in southern Baraga County about 11,000 years ago. Baraga County was covered by the Keweenaw Lobe, a sublobe separated from the main Superior Lobe by the highlands of the Keweenaw Peninsula northwest of Baraga

County. The Keweenaw Lobe moved southwestward in Keweenaw Bay, then spread generally southeastward onto the highlands.

As the Keweenaw Lobe melted back to the position of the Keweenaw Moraine in Houghton and Baraga Counties, a series of preglacial lakes formed from ponded melt waters. These lakes later merged into one big lake, glacial Lake Duluth, which probably occupied the western part of the Superior Basin. During the time of glacial Lake Duluth, another lake, glacial Lake Baraga, occupied the area west of Alberta known as the Baraga Plains. Hughes (1963, p. 209) implies that Lake Baraga may have existed as a small, but separate, glacial lake, at least during the early stages of Lake Duluth when the ice stood on the Keweenaw Moraine. The lake may have been connected with Lake Duluth during its later stages.

Unstratified Deposits

Unstratified glacial deposits, or glacial till, is deposited directly from the ice with little washing or sorting of material. The result is a heterogeneous mixture of clay, silt, sand, gravel, and boulders. Till was deposited as moraines during intervals when the rate of melting at the ice margin nearly equaled the rate of ice advance. Ground moraines, or till plains, were formed either by lodgement (plastering down of till at the bottom of the moving ice), or by ablation (the deposition of till by the melting and evaporation of stagnant ice). Till deposited by the Valders ice in northern Baraga County is generally pink. The coloring was caused by red hematite-rich clay from glacial Lake Keweenaw, which occupied the Superior Basin during an interglacial period before the Valders advance.

The most extensive deposits of till in Baraga County occur north and west of the Precambrian highlands. Much of the till was washed by glacial lakes, which deposited a thin layer of lake clay or sand over the till. Till also occurs in the highlands as discontinuous knolls, ridges, and as thin coverings on slopes and valley walls. The dominant surface features in the highland area, however, consist of rock knobs and swamps. Several small drumlins or drumlinoid features, possibly rock-cored, were identified by Leverett (1929) in the south-central part of the county. Leverett noted that the drumlins and drift ridges are oriented south-southwestward, parallel to the general direction of ice movement.

<u>Moraine and ground moraines</u>: Three major moraines were identified in Baraga County by Leverett (1929). The Keweenaw Moraine (fig. 2), which was deposited as a part of the terminal margin of the Keweenaw Bay Lobe and roughly follows the outline of Keweenaw Bay, is the best developed. The southeast edge of this moraine is banked against a steep slope of the Peshekee Upland. Much of the northwestern part of the moraine, especially southwest of L'Anse, is water-washed. Some of the till in this area could be classified as ground moraine.

The second major moraine, mapped as the Marenisco Moraine by Leverett (1929) and Martin (1957), lies in the southern third of the county south of the Sturgeon River (fig. 2). Except for somewhat thicker drift in the southeastern part of this area, and in the area north and west of Covington, the drift is limited to thin coverings on slopes plus isolated ridges, a few of which resemble drumlins. No attempt was made to map these isolated features on plate 2.

A third morainal area, 1 to 3 miles wide, extends northeastward from the Marenisco Moraine near Covington. The area was mapped as the Covington Moraine by Leverett (1929). The Covington Moraine is not delineated on figure 2, as its surface expression is little more than a thickening of the otherwise patchy veneer of drift covering parts of the highland area. Another area of thin moraine occurs northwest of the Keweenaw Moraine. The deposits here are water-washed and overlie the Jacobsville Sandstone.

Stratified Deposits

Stratified drift, in contrast to glacial till, is deposited at or near contact with the ice ablation-front or from sediment-laden glacial meltwater that eventually discharges into glacial lakes at some distance from the melting ice. This drift material is washed, sorted, and deposited in layers. The coarse materials are concentrated in areas of fast-moving water in contact with or bordering the ice, whereas the finer materials are carried outward and deposited farther from the ice, where velocities have lower energy. Two general types of stratified drift are identified, according to origin, with respect to the glacial ice. They are classified as ice-contact and proglacial stratified drift.

<u>Ice-contact stratified drift</u>: Ice-contact stratified drift features include eskers, kames, kame terraces, and kettles. These features result from deposition of sediment from meltwater in direct contact with the stagnant ice and are more closely associated with till than other types of stratified drift. Ice-contact drift is identified by extreme ranges in grain size, included bodies of till, and deformation in bedding due to slumping caused by melting ice.

Eskers are distinct ridges of stratified drift deposited in crevasses or tunnels at or near the base of the ice. Several eskers, as long as 4 miles, occur in the southwestern part of Baraga County.

Kames are steep-sided (generally cone-shaped) hills of ice-contact drift deposited by melt water in notches along the ice margin or in small open areas (moulins) surrounded by ice. Kettles (pits formed by delayed melting of drift-buried ice blocks) are often associated with kames, forming the characteristic "kame and kettle" topography found in many morainic areas. Kames and kettles occur in some areas of the Keweenaw and Covington Moraines in west-central Baraga County. Also, kame terraces, narrow flat-topped accumulations of stratified drift laid down by streams between a glacier and a valley wall, probably occur along the borders of some of the linear swamp-filled depressions in southwest Baraga County.

Proglacial stratified drift: Proglacial stratified drift includes outwash, stream, and lake sediments deposited by meltwater beyond the ice margin.

Outwash is deposited as broad plains along the border of a moraine. Valley-train outwash is deposited in valleys in front of the ice. Valley-train outwash grades upstream into ice-contact deposits.

The largest area of outwash in Baraga County is at the outer margin of the Keweenaw Moraine bordering the north side of the Baraga Plains. Some of this outwash is partly covered by lake sand and thin clay or silt deposited in glacial Lake Baraga. Small areas of out-wash occur in stream valleys and bedrock depressions in other parts of the county, but the outwash in most of these areas is overlain by swamp deposits and Holocene alluvium.

Lake plain and stream deposits consist of stratified layers of sand, silt, and clay deposited by proglacial melt water in the form of lake beds, beaches, stream benches, bars, and deltas. Areas of thin lake clay or sand deposited during higher glacial lake levels overlie till in most of the areas of moraine and ground moraine in the northern part of the county. These areas were differentiated on the basis of soil data. In this report, they were mapped as water-washed or water-laid moraine and ground moraine, because most of the till in these features shows surface evidence of water washing.

The largest area of lake plain sediments, deposited in glacial Lake Baraga, is in west-central Baraga County. These sediments are probably as much as 200 feet thick, and consist mostly of stratified lake sand with seams of lake clay. This area is probably underlain by a "U" shaped valley of glacial origin. Large areas of sand and clay stream benches or terraces of the Sturgeon River occur in the northwestern part of the county. Smaller areas of sandy lake beds and stream benches are limited mostly to the northern part. Some beach deposits, formed during high levels of glacial Lake Nipissing, are found along Keweenaw and Huron Bays.

Areas underlain by more than 4 feet of muck and peat are mapped as swamp in this report. Stratified stream sand, gravel, and contiguous areas of muck and peat of Holocene origin are mapped as Holocene alluvium. Alluvium occurs in practically all stream valleys, but the most extensive deposits are in the Sturgeon River valley in northwestern Baraga County.

Large areas of swamp occupy depressions and stream valleys between areas of near-surface or exposed bedrock in the southern part of the county. Generally, these areas are associated with areas of Holocene alluvium too small to map, and probably contain some out-wash at depth. Several small areas of manmade land, consisting of stamp sand (mill tailings) and waste rock, occur along the southern and western shores of Keweenaw Bay.

GROUND-WATER RESOURCES

Availability

Although most wells in the county yield only small supplies of water, ground water is an essential resource to most residents of farms and small villages. Much of the county is sparsely populated, and the occurrence of ground water is not well defined. A few springs are tapped for water supplies, but most ground-water supplies are obtained from wells. Hydrologic data of selected wells are summarized on plate 1 and table 1. Logs of wells are given in table 2.

Wells

Most ground-water supplies in Baraga County are obtained from drilled wells 4 to 7 inches in diameter and 50 to 300 feet deep (tables 1 and 2). About half the wells visited were drilled wells completed in bedrock. In the northwest part of the county many wells finished in bedrock, and a few deep wells finished in glacial drift, flow above land surface. In a few sandy areas small diameter drive points are used. In areas where the glacial drift consists of clay and silt, some households obtain water from large-diameter dug wells. Most dug wells are about 12 feet deep. A few very shallow wells yield water of such poor quality that it is not used for drinking or cooking.

Wells yielding water from bedrock are generally cased through overlying glacial drift and a few feet into rock. Drilled wells yielding water from glacial drift are cased down to the top of the water-bearing formation and screened in the production zone. Dug wells are generally more successful then drilled wells where the earth material is not very permeable. The large infiltration area and storage capacity of the dug well makes it possible to utilize a small rate of inflow of water. However, shallow dug wells may be subject to contamination from surface sources. Driven wells can be used only where earth materials are permeable enough to allow an adequate amount of water to enter the small-diameter drive point.

Springs

Most springs used as a water supply have been developed by enlarging the pool in the discharge area and installing a concrete or wooden box, or short length of culvert, to prevent collapse of the sides of the pool and keep out surface water. Most springs are about 3 feet in diameter and 3 to 4 feet deep and yield less than 3 gpm (gallons per minute) (table 3). If an electric pump is used, the culvert or box must be large enough to provide adequate water storage. There probably are many springs in the county that have not been developed because they are too far from the point of intended use.

Quality of Water

Most wells and springs in Baraga County yield water suitable for household and most other uses (tables 3, 4, and 5). Of the wells visited that are finished in glacial drift, more than half yield water that has iron concentrations of more than 0.3 mg/l (milligrams per liter), the maximum recommended concentration for drinking water according to the U. S. Public Health Service (1962). Only a few waters can be classed as very hard (more than 180 mg/l), and they rarely contained objectionable amounts of chloride (more than 250 mg/l). Less than half the wells tapping bedrock aquifers produce water containing more than 0.3 mg/l iron or more than 120 mg/l hardness. Well 52N 33W 9-1, which taps a sandstone aquifer at a depth of 496 feet, is the only well visited that yields water containing objectionable amounts of chloride. However, several bedrock wells in the northern part of the county reportedly were abandoned because of very salty water. Water from springs is apt to be soft to moderately hard but may contain objectionable amounts of iron (table 3). Most spring water tested was acidic with some samples showing pH readings as low as 5.8. The quality of the water in the various aquifers is included in the section on Sources and Potential of ground water.

During times of low flow the chemical composition of water from streams is generally similar to that of water from shallow aquifers, because most of the water in the streams is ground-water discharge. Water from all the streams sampled is soft to moderately hard (less than 120 mg/l), and low in dissolved solids, as indicated by specific conductance (table 6). Dissolved oxygen content of water from the streams sampled ranges from 9.0 to 10.2 mg/l, which is normal for this area.

Water from lakes is similar to water from streams, although it is generally a little softer and has a lower specific conductance (table 7).

Sources and Potential

The availability of water in glacial drift and bedrock aquifers is shown on the geologic maps on plate 2 (in pocket).

Glacial-drift Aquifers

About half the wells in Baraga County obtain water from the glacial drift. Most drift wells are less than 100 feet deep, but several in the northwest part are more than 200 feet deep. Reported yields of wells in glacial aquifers range from a few to as much as 115 gpm (table 8). Water from most wells in the drift is high in iron and most shallow wells yield water with low pH. None of the drift wells yield water that is too salty for drinking.

<u>Moraines, ground moraines, and water-laid moraines</u>: Most wells in the county that yield water from the glacial drift are in areas mapped as moraine or ground moraine. Three types of moraine are delineated on the surficial map (pl. 2), but well data are insufficient to demonstrate any differences in yields of wells in the different types. However, differences in composition suggest that the moraine mapped as 1 on plate 2 (above glacial lake level) will yield less water to wells than moraines mapped as 2 and 3. Most wells in morainal materials yield enough water for domestic supplies, and a few yield more than 30 gpm. Water is soft to very hard and may be high in iron content. Most wells yield water suitable for domestic use.

<u>Lake-plain and stream benches</u>: The largest reported well yield in the county was from a well in glacial lakebeds. This well, at Camp Baraga, yielded 115 gpm with 32 feet of drawdown (table 8). The areas of lakebeds in the western part of the county (pl. 2) will probably yield moderate supplies to wells, but only a few wells have been drilled in these deposits. Water may be hard and high in iron content but is otherwise of satisfactory quality.

<u>Swamp deposits and Holocene alluvium</u>: A large area of alluvium and swamp deposits occurs in the Sturgeon River valley in the northwestern part of the county (pl. 2), but few wells yield water from these materials. Elsewhere, alluvium and swamp deposits occur in smaller patches. A few wells yield small supplies of water from these deposits. Where Precambrian igneous and metamorphic bedrock is near the surface, these deposits may be the most practicable source of ground water. Water may be high in iron content.

<u>Bedrock outcrops and areas of thin drift</u>: Areas mapped as bedrock outcrop and thin drift are generally unfavorable for obtaining water from the drift. Supplies are generally inadequate, and iron content may be very high. The availability of water in the underlying bedrock aquifers is described below.

Bedrock Aquifers

About half the wells in the county yield water from bedrock. More than half of these obtain water from the Jacobsville Sandstone. Outside the area of Jacobsville subcrop (pl. 2), most wells in bedrock obtain water from fractured metamorphic rocks of middle Precambrian age, generally logged by well-drillers as "slates".

<u>Jacobsville Sandstone</u>: The Jacobsville Sandstone is the most productive bedrock aquifer in Baraga County and probably is the most reliable source of ground water. Few wells in the Jacobsville fail to yield enough water for domestic use, although two were reported abandoned because they yielded salty water. Most wells in the Jacobsville are 100 to 300 feet deep and penetrate 50 to 250 feet of the sandstone (table 2). Reported yields of wells in the Jacobsville range from 1.5 to 50 gpm, whereas specific capacities range from 0.01 to 2.5 gallons per minute per foot of drawdown (table 8).

Water from the Jacobsville is generally satisfactory for domestic use, although most wells yield water that is moderately hard to very hard. Hardness, as calcium carbonate, ranges from 36 to 520 mg/l. Most wells yield water with hardness greater than 100 mg/l. Iron content ranges from 0.1 to 5.0 mg/l, and most wells yield water containing less than 0.3 mg/l iron.

Marquette Range Supergroup: The metamorphic rocks of the Marquette Range Supergroup yield water to a few wells near L'Anse and Covington. Water is apparently obtained from openings along fractures near the top of the bedrock. Reported yields of wells in these rocks will yield smaller amounts. Water from most wells in the Marquette Range Supergroup is moderately hard to very hard but is generally suitable for domestic use.

Laurentian granites and gneisses: Only one well for which records are available is known to obtain water from the granite and gneiss. This well, 42 feet deep, yields water for a domestic supply, but the yield is not always adequate for this use. The water has a hardness of 100 mg/l and iron content of 0.3 mg/l.

WATER DEVELOPMENT

Municipal Supplies

There are three municipal water systems in Baraga County, but only one uses ground water. A brief description of these systems is given below.

Ford Forestry Center at Alberta

Ford Forestry Center is owned and operated by Michigan Technological University. About 100 people live and work at the Center.

Water for domestic use is supplied from two large springs, which have been developed in an area of springs and seeps half a mile southeast of town. Each spring is protected by a covered concrete box 10 feet square by 8 feet deep. Water seeps up through sand and maintains a fairly constant level just below land surface. Water from both springs is stored in an 8,600-gallon tank. Altitude of the springs and storage tank is about 100 feet higher than the altitude at the townsite. Water is distributed to consumers by gravity flow at a pressure of about 35 pounds per square inch. Chlorine is added before the water enters the distribution system. The two springs are considered as one source and are assigned number 49N 33W 18-2.

Water for fire protection is obtained from an impoundment on Plumbago Creek, which also supplies water for a mill pond.

Chemical analysis of public supplies obtained from Lake Superior

	L'Anse	Baraga
Date Sampled	2/64	7/59
Dissolved solids in mg/l	54	52
Silica (SiO_2)	3	7
Iron (Fe)	0	0
Manganese (Mn)	0	--
Calcium (Ca)	16	12
Magnesium (Mg)	2.5	2.9
Sodium (Na)	1.8	--
Potassium (K)	0.4	--
Sodium and potassium (Na+K)	--	2.7
Bicarbonate (HCO_3)	58	56
Carbonate (CO_3)	0	--
Sulfate (SO_4)	2	2
Chloride (Cl)	0	1
Fluoride (F)	0	0
Nitrate (NO_3)	1.4	--
Hardness ($CaCO_3$)	45	42
pH	8.0	--
Specific conductance (micromhos at 25°C)	95	--

L'Anse

The Village of L'Anse obtains its water supply from Lake Superior. A 12-inch intake pipe extends 1,000 feet into the lake. An average of 600,000 gallons of water per day is required to supply about 1,000 customers. Chlorine is added to the water.

Baraga

The Village of Baraga also obtains its water from Lake Superior. The intake pipe extends 800 feet into the lake. A 100,000-gallon elevated storage tank is located on a hill at the west edge of town. Chlorine is added to the water. About 350 customers are served by the water system.

Parks and Institutions

Baraga County has many campgrounds, roadside parks, and public access sites operated by several public agencies. Some have no water supply because they are located in areas where ground water is difficult to obtain. Where water supplies are available, they are described in the following paragraphs. Chemical analyses of water from most of these wells and springs are shown in tables 3 and 4.

The water supply for Baraga State Park is now from the Village of Baraga. Well 50N 34W 1-1, drilled in 1927, supplied water to the park for several years but the well failed to meet the increased demand as park facilities were expanded. This well has now been abandoned.

Water for Big Lake State Forest Campground is supplied by a hand pump on well 49N 34W 28-1. The well is 22 feet deep and finished in sand.

The Beaufort Lake State Forest Campground water supply is from well 48N 31W 21-1. This well has a 4-inch casing and is 97 feet deep. The well is completed in fine sand and is equipped with a hand pump. Water is of good quality except for the high iron content.

Laws Lake State Forest Campground has one well, 50N 32W 18-1, which was jetted through sand and gravel to a depth of 22 feet. This well has a 2-inch casing and a hand pump. Water is soft with a very high iron content.

Sturgeon River Campground, operated by the U. S. Forest Service, is supplied by a 5-inch drilled well (48N 35W 11-1) 66 feet deep, completed in bedrock. Pumping-test results indicate a yield of only 2 gpm from this well. The water is very hard but otherwise is of good quality. The well is equipped with a cylinder-type hand pump.

L'Anse Township operates a park about 1½ miles north of the Village of L'Anse. Three closely spaced springs have been developed by excavating the discharge area and installing covered boxes 2 feet square and about a foot deep. Water seeps up through bedrock into these boxes, then flows through pipes to a 12-by 12-foot concrete reservoir. From the reservoir, water flows by gravity to outlets in the park, which are about 50 feet lower in elevation. Total yield is about 3 gpm from the three springs, which have been considered as one source and assigned number 51N 33W 25-1.

L'Anse Township operates another park on Keweenaw Bay east of Pequaming known as Second Sand Beach Park. A hand pump on well 52N 32W 33-1 supplies enough water for park needs, but the water has very high iron content and a yellow color. Many park patrons obtain water for drinking and cooking from other sources. The well is reported to be 167 feet deep and is finished in bedrock.

Arvon Township Park is on the shore of Huron Bay about a mile southwest of the Village of Skanee. Well 52N 31W 27-2 has a hand pump and supplies an adequate amount of good quality water.

The U. S. Forest Service operates a picnic and rest area where M-28 crosses Perch River. Water is supplied by hand pump from well 48N 35W 34-1. This is a 5-inch drilled well 33 feet deep and finished in bedrock.

Tioga Roadside Park is maintained by the Michigan State Highway Department as a rest and picnic area where U. S. 41 crosses the Tioga River. Water is supplied by a hand pump on well 48N 32W 8-1. Yield from the well is small, but the water is of good quality.

The Michigan Corrections Department in cooperation with the Michigan Department of Natural Resources operates Baraga Corrections Camp in section 14 of T.49 N., R. 34 W. An average of 80 people live and work at the camp. Well 49N 34W 14-1 supplies an adequate amount (115 gpm) of good quality water to meet camp needs (tables 4 and 8). The well is 139 feet deep with a 6-inch casing and 16 feet of 10 slot screen set in medium sand (table 2).

Motels and Resorts

Most motels in the county are located within the service area of municipal water systems. About 3 miles south of L'Anse a resort complex consisting of a store, service station, 15 cabins, and the owner's residence obtains water from a 5-inch well 45 feet deep in bedrock (well 50N 33W 22-1).

Lakeside resorts generally obtain water from drilled wells tapping bedrock aquifers. A 6-inch drilled well (well 52N 32W 34-1), 187 feet deep finished in bedrock, supplies water to six cottages and two homes at a resort on Sand Bay.

Household Supplies

In the northwestern part of the county most household wells are finished in bedrock at depths between 140 and 200 feet. A few wells are more than 300 feet deep. Some wells in drift and some wells in bedrock flow to the surface. East of Keweenaw Bay, domestic wells are about equally divided between bedrock and glacial-drift aquifers. In this area bedrock wells may yield salty water at depths greater than 200 feet. A few households obtain water from shallow dug wells or springs.

Well data are scarce in the central part of the county. Most household wells inventoried are less than 100 feet deep, and are finished in glacial drift. Most households near Herman (pl. 1) obtain water from shallow dug wells that have very low yields.

In the Watton-Covington area most domestic wells are less than 100 feet deep and are completed in glacial drift. Bedrock wells in this area may be as much as 150 feet deep, but most are less than 100 feet deep. Most older homes near Watton have large-diameter dug wells.

Drilled domestic wells near Three Lakes may be completed in either glacial drift or bedrock at depths from 50 to 125 feet. Some dug wells are only 12 feet deep.

Recreational Cottages and Camps

Most of the summer cottages along the shores of Keweenaw and Huron Bays have drilled wells completed in bedrock. On the west side of Keweenaw Bay well depths range from 100 to 200 feet, whereas along the shore of Huron Bay most wells in bedrock are less than

100 feet deep. On the peninsula north of Aura most cottage owners either have a spring as a source of water or draw their water directly from Keweenaw Bay.

There are many summer cottages in the Three Lakes area, most of which have drilled wells completed in glacial drift. Water from the drift in this area may contain 5 mg/l or more of iron. Nearly all the cottages with drilled wells have electric pumps and modern plumbing systems.

Hunting and fishing camps are scattered throughout the wilderness areas of the county where electricity is not available. Many of these camps are located where ground water is difficult to obtain. Some owners have developed springs, others have large diameter dug wells with hand pumps, and some do not have wells because the expense and difficulty of construction would not be justified by their limited use.

Farm Ponds

In 1969 the U. S. Soil Conservation Service reported 140 farm ponds in Baraga County. The size of the ponds ranges from less than an acre to several acres. Probably half the ponds are fed mainly by springs or ground-water seepage. The rest receive most of their water from surface runoff.

Most ponds were built as a source of water for pastured livestock, but some have been stocked with fish. At least five strawberry growers use pond water for irrigation and to combat late spring frosts.

Water Power

The rivers of Baraga County have not been extensively used to produce electric power. The Upper Peninsula Power Company operates a generating plant at Prickett Dam on the Sturgeon River. The storage reservoir is about 4 miles long by half a mile wide and extends about 2 miles into Houghton County.

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The State Geological Survey collects, interprets, and disseminates basic information on the geology and mineral resources of Michigan.

Its activities are guided by public service available to all who are interested in the use or development of our resources, the protection of our environment, and sound land use management.

Geologic information is basic to these practices, and geologic reports are an important aspect of public service.

The MICHIGAN GEOLOGICAL SURVEY and the UNITED STATES GEOLOGICAL SURVEY have cooperated for many years producing basic information on water resources.

This report, one of many county, city, and area reports, is a product of that continuing program.

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ITEMS IN POCKET

Plate 1. Hydrologic data of selected wells and topography of Baraga County, Michigan.

Plate 2. Geology and availability of ground water in Baraga County, Michigan.

ERRATA

During the time interval between the printing of plate 2 and final report preparation, certain changes in terminology by the U. S. Geological Survey made necessary the following corrections:

Plate 2

EXPLANATION: Change "SWAMP DEPOSITS AND RECENT ALLUVIUM," type 7 and 8, to read "SWAMP DEPOSITS AND HOLOCENE ALLUVIUM."

BEDROCK GEOLOGY: Change "MIDDLE PRECAMBRIAN (ANIMIKE) METAMORPHICS AND IRON FORMATION" to read, "MIDDLE PRECAMBRIAN (MARQUETTE RANGE SUPER-GROUP) METAMORPHICS AND IRON FORMATION."