GROUND WATER FOR PUBLIC WATER SUPPLY AT WINDIGO, ISLE ROYALE NATIONAL PARK, MICHIGAN

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DEFINITION OF TERMS

Altitude. The vertical distance of a point or line above or below the National Geodetic Vertical Datum of 1929. The National Geodetic Vertical Datum of 1929 (NGVD of 1929) is a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." In this report, all altitudes are above NGVD of 1929.

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. Also called a ground-water reservoir.

Bedrock. Designates consolidated rocks.

Ground water. Water in the ground that is in the saturated zone from which wells, springs, and ground-water runoff are supplied.

Recharge. The process by which water is infiltrated and is added to the zone of saturation. Also, the quantity of water added to the zone of saturation.

Water table. That surface in an unconfined water body at which the pressure is atmospheric. It is defined by levels at which water stands in wells having shallow penetration into saturated material.

CONVERSION FACTORS

The inch-pound units used in this report can be converted to the (SI) metric system of units as follows:

Multiply inch-pound unit	By	To obtain metric unit
inches	2.54	centimeters (cm)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
square miles (mi^2)	2.590	square kilometers (km^2)
gallons per minute (gal/min)	0.06309	liters per second (L/s)

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ABSTRACT

Three test holes drilled at Windigo in Isle Royale National Park in 1981 indicate that the ophitic basaltic lava flows underlying the area contain little water at depths less than 175 feet and cannot be considered a source for a public water supply. The holes were 135, 175, and 71 feet deep. One hole yielded about 1 gallon of water per minute; the other two yielded less. Glacial deposits seem to offer the best opportunity for developing a ground-water supply of 5 to 10 gallons per minute.

INTRODUCTION

Water supplies that can be economically developed are needed in public-use areas at Isle Royale National Park (fig. 1). Although Lake Superior is nearby and is being tapped, the quality of water from the lake and its associated bays is not always suitable for human consumption. If ground water were available, supplies could be developed more economically than by filtering and treating water from the lake.

Purpose

This report provides information regarding the exploration for ground-water supplies at Windigo on Isle Royale (fig. 2) and evaluates ground water as a potential source for public supply.

Previous Studies

The first major report that contained information relating to the water-bearing and transmitting ability of the rocks at Windigo was written by Lane (1898). The report discussed geologic conditions associated with copper deposits and mining 2 to 3 miles east and northeast of Windigo. Studies by Doonan, Hendrickson, and Byerlay (1970) show that bedrock on the Keweenaw Peninsula (fig. 1), which is similar to that at Windigo, yields only small quantities of water. Reports by Huber (1973a, 1973b, 1975) describing geologic conditions on a parkwide basis provide indirect information on ground-water on the island.

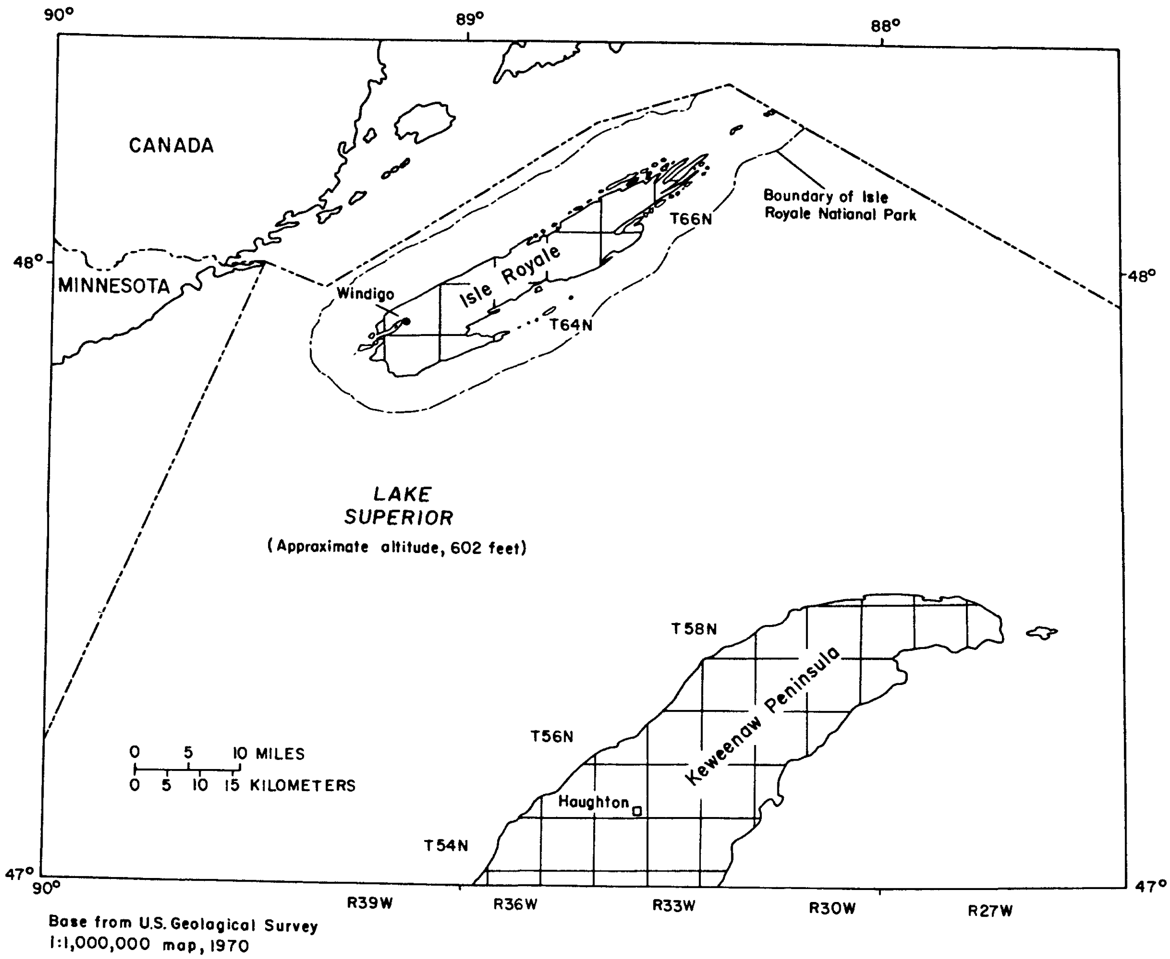

Figure 1.--Location of Isle Royale National Park, Michigan

Location and General Features

Isle Royale National Park, 55 miles north-northwest of Houghton, Michigan, comprises 800 square miles of land and water. The park contains more than 200 islands; only the larger of these are shown on figure 1. The largest, Isle Royale, is 45 miles long and as much as 9 miles across. Windigo is near the southwest end. The highest point on the island is 795 feet above the level of Lake Superior.

Isle Royale is mostly wilderness. The only roads and vehicles are those used by the Park Service for maintenance. At Windigo, there is a ranger station, powerhouse, water tank, boat dock, small store, employee bunkhouses, residences, and campsites.

Isle Royale's first major recognition was related to native copper. Indians dug many pits to locate the metal, finding one copper nugget weighing

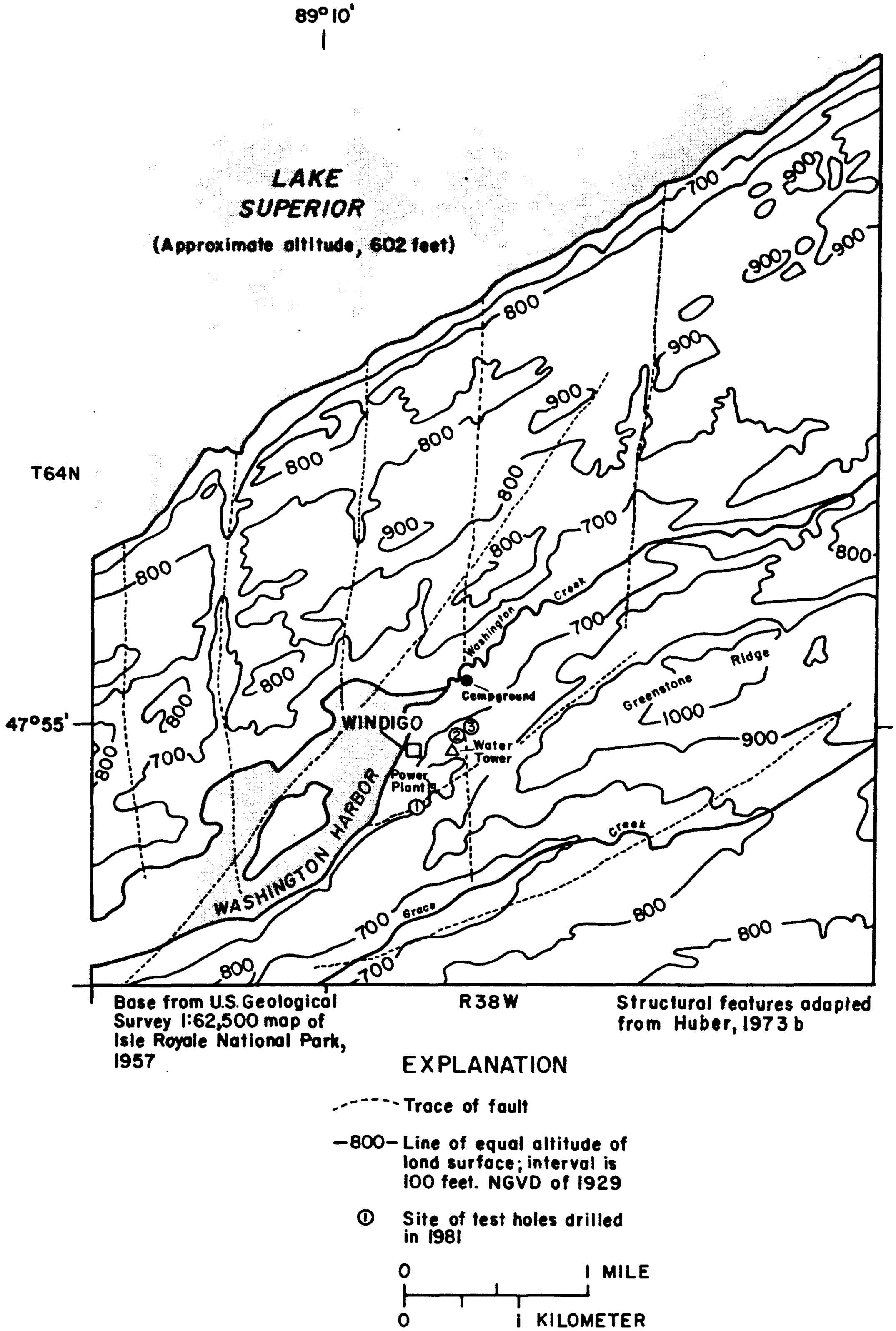

Figure 2.--Windigo area and location of 1981 test holes for water supply.

nearly 6000 pounds. By 1850, copper mining on a commercial scale was being attempted on the island. No economic deposits were found, however, and by the turn of the century, mining had ceased.

Geologic Conditions

Windigo is underlain by bedrock of Precambrian age and glacial deposits of Pleistocene age. Bedrock, primarily an undifferentiated series of basaltic lava flows, is at or near surface in most of the higher ground. These rocks, called the Portage Lake Volcanics, have been described by Lane (1898) and Huber (1975). The principal rock comprising the flows is ophite (Huber, 1975), a rock having crystals of pyroxene in a darker matrix. Some rocks have cavities or vesicles that have been filled with minerals; these rocks are called amygdaloidal rock or amygdaloids. Porphyrite, a rock with plagioclase crystals in a finer grained groundmass, was found in test hole 3. The volcanic rocks were formed more than a billion years ago. They were originally horizontal but were later bowed downward at angles of as much as 50 degrees to form the basin now occupied by Lake Superior (fig. 3). Isle Royale is on the northwest rim of this basin. The edges of softer rocks in the volcanic sequence have been eroded, forming valleys. Between these valleys, the tilted harder rock forms ridges, such as Greenstone Ridge. This ridge-and-valley topography extends the full length of the island. Sedimentary rocks crop out at places south of Windigo along the southern margin of Isle Royale.

Glacial deposits, a series of boulders, gravel, sand, silt, and clay, generally occur in areas of lower altitude in buried valleys along tributaries to Washington Harbor; they occur in higher areas as thin surficial layers. They are most extensive along Washington Creek. Their maximum known thickness is 80 feet. These deposits formed during the last million years as continental glaciers overrode Isle Royale.

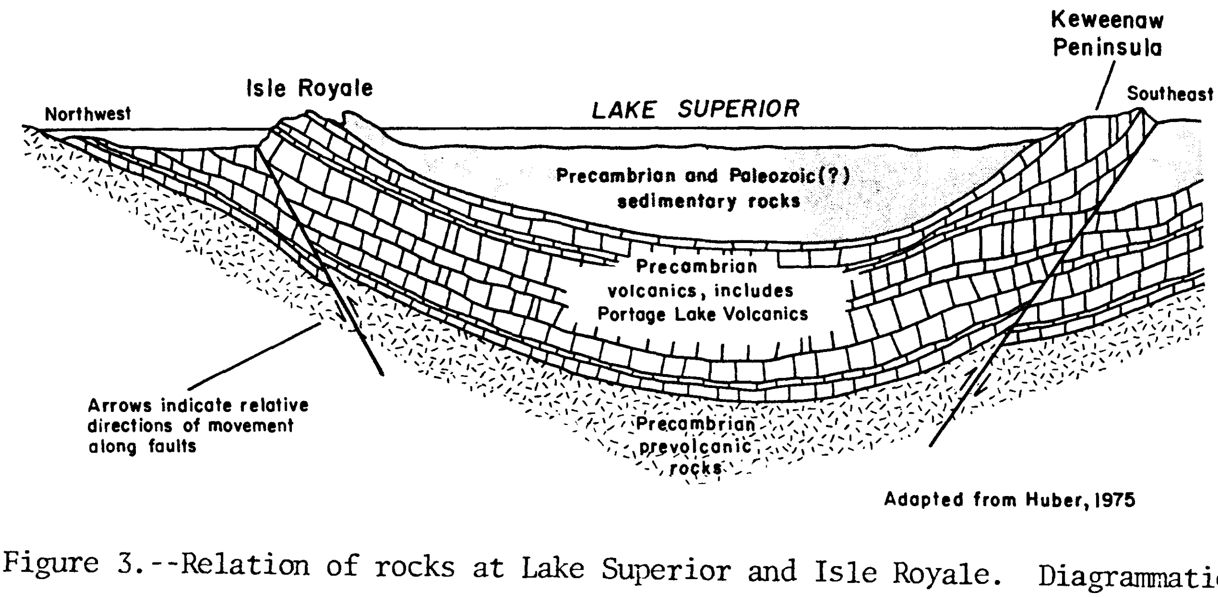

Figure 3.--Relation of rocks at Lake Superior and Isle Royale. Diagrammatic.

Locating Suitable Sources of Water

The best sources for obtaining the needed quantity of water--5 to 10 gal/min--seemed to be in fractured and jointed zones associated with faulting in bedrock and in sand and gravel in the glacial deposits. Initially, it was believed that there were no glacial deposits of significant thickness or suitable lithology near water-storage and power facilities, and the deposits were not considered a potential source of water for public supply. Wells deeper than 150 feet were not thought suitable because (1) fractures and joints in the bedrock generally decrease in size and number with depth and are probably scarce at depths greater than 100 to 150 feet; (2) glacial deposits were not expected to be more than 100 feet thick; and (3) water from depths of 200 feet or more was likely to be salty.

METHODS AND RESULTS OF INVESTIGATION

Information from previous reports and visual inspection of surficial materials were used to determine the best sites for test holes.

Test Drilling

Three test holes were drilled in 1981 in the vicinity of Windigo to search for sufficient quantities of water for a small public supply. The holes, the first drilled on the island for the sole purpose of locating water supplies, are identified by numbers 1, 2, and 3. They had 6-inch diameters and were drilled by the cable-tool method. Samples of rock materials were collected at least every 5 feet. No water samples were collected.

Test hole 1 was drilled at a site in a small valley near an unnamed perennial stream flowing from Greenstone Ridge (fig. 2). This site was selected because it was near water and power facilities. Also, it seemed that the valley might be oriented along a fault, that glacial deposits might have significant thickness, and that the perennial stream indicated a possibility of inducing recharge by pumping. The drill penetrated 80 feet of glacial deposits before reaching bedrock. The deposits were mostly a mixture of sand, silt, clay, and gravel (table 1). Some large boulders made drilling difficult. Because most samples contained clay (indicating relatively low permeability), and because there was no strong flow of water to the well, the glacial deposits were believed to be unable to yield water at the needed rate of 5 to 10 gal/min. The casing was driven down to near the top of bedrock, and the drilling continued. After the drill had penetrated 55 feet of black fine-grained ophite basalt, the hole was stopped at a depth of 135 feet because of the tightness of the formation. The static water level stood at 13 feet below ground level at an altitude of 650 feet--about the level of the nearby perennial stream, but some 50 feet above the water level in nearby Washington Harbor (fig. 2). The source of the water in this test hole is not known definitely, but most water is probably from sand and gravel zones near the base of the glacial deposits. However, some water may have entered the hole from the zone between 115 and 120 feet below ground level, where slickensides and chlorite veins indicate fracturing. A pumping test indicated that test hole 1 would not yield more than about 1 gal/min; the water level was drawn down

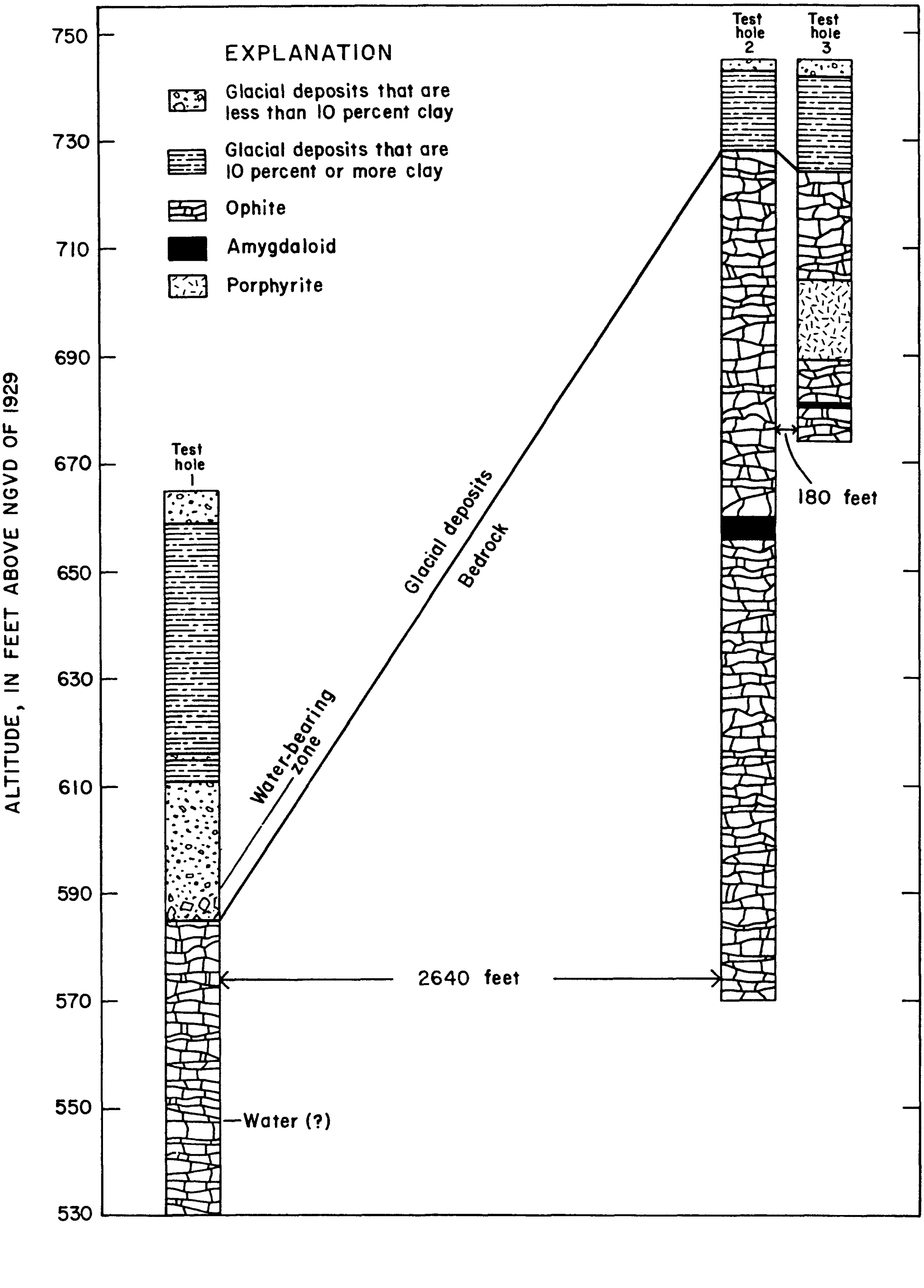

Figure 4.--Lithology of materials in test holes.

to the bottom of the hole within a few minutes. The hole was abandoned and grouted.

Test hole 2 was drilled at a site on the south side of an old trail that led to Greenstone Ridge, 650 feet northeast of Windigo's water storage tank and 550 feet due east of the employee's bunkhouses. This site was selected because it was not too distant from water and power facilities and because it seemed to be on the extension of a north-trending fault (Huber, 1973b, 1975). Surficial evidence for faulting at this site is:

(1) a saddle or low point between bedrock outcrops, indicating an area more susceptable to erosion, such as a fractured and jointed area;

(2) the outcrop on the west side of the saddle is amygdaloidal basalt; whereas, that on the east side is coarse ophitic basalt; and

(3) variations in topographic features south of the test hole site reflect a fault trace.

The drill penetrated 17 feet of clay, silt, and gravel in glacial deposits before striking bedrock (table 2). The deposits contained little or no water. From 17 feet to the bottom of the hole at 175 feet, bedrock was mostly black fine-grained ophite basalt. The hole was extended beyond 150 feet to determine if there were any sedimentary or pyroclastic rocks at the site; none were found. Some evidence of faulting was found from 85 to 88 feet and from 125 to 130 feet. The static water level was 24.3 feet below land surface at an altitude of about 720 feet--some 120 feet above the water level in Washington Harbor. However, a bailing test indicated that test hole 2 would yield less than 0.5 gal/min. The hole was abandoned and grouted.

Test hole 3 was drilled 180 feet east of hole 2. This site was selected after further reconnaissance indicated that the faulted zone sought by hole 2 might actually be a little farther to the east. Hole 3 was 71 feet deep and penetrated 21 feet of glacial deposits before reaching bedrock (table 3). Bedrock was primarily ophite, containing porphyrite and a 1-foot zone of amygdaloid. The amygdaloid from 64.5 to 65.5 feet may correlate with that from 85 to 89 feet in hole 2 (fig. 4). A bailing test of hole 3 indicated a yield of 0.1 gal/min. The hole was abandoned and grouted.

CONCLUSIONS AND DISCUSSION

The 1981 test drilling on Isle Royale indicates that bedrock at Windigo at depths of less than 150 feet will not yield sufficient water for a public supply. No sedimentary or pyroclastic rocks, or subsurface fracture or joint systems were found. Information from the 1981 test holes, along with evidence from bore holes drilled in the late 1890's, indicates that no major change in lithology of the bedrock can be expected at least to a depth of 175 feet. Even then, there is no assurance that water from that depth, if available, would be of good quality. In some places on the Keweenaw Peninsula, water from similar rock at these greater depths is salty. Thus, further exploration of the bedrock near water-storage and power facilities would probably prove unproductive.

Glacial deposits seem to offer the only opportunity for developing a ground-water supply sufficient for public needs at Windigo. The two most promising sites are along the unnamed creek near test hole 1, drilled in 1981, and along Washington Creek.

The site along the unnamed creek seems more promising after evaluation of the data from the first test hole. Test hole 1 yielded a small quantity of water and revealed a significant thicknesses of glacial deposits in the valley. The best site for drilling seems to be about 200 feet east of Washington Harbor and 100 feet from the unnamed creek. At this site, glacial deposits may be as much as 100 feet thick and, with careful development, may yield enough water to meet the needs at Windigo. Boulders in the subsurface would slow the normal drilling rate. Several 8 to 10-inch diameter wells, 25 to 50 feet apart, may be needed. These wells would have to be drilled with a cable-tool rig and all sand and gravel zones evaluated very carefully. More than one zone would probably have to be screened.

The site or sites along Washington Creek could be near, or upstream, from the campground. Although there is no specific information for this area, data from test hole 1 and visual inspection indicate that the glacial deposits may be 50 to 75 feet thick and may contain water-bearing sand and gravel zones. Considerable clay but few boulders may occur. Exploratory work may be necessary at several sites before installation of a production well. The work could be done by a small auger powered by a tractor or other vehicle. After augering, a 1½- or 2-inch diameter drive point could be driven, probably by hand, to a depth that will provide sufficient water for a pumping test and sampling. If, as expected, the materials along Washington Creek are unconsolidated beds of sand, gravel, and clay, this installation could be readily accomplished with a minimum of equipment and manpower.

If the two sites in glacial deposits suggested above cannot be developed, then hope of obtaining a ground-water supply of 5 to 10 gals/min at Windigo is remote.

REFERENCES

Doonan, C. J., Hendrickson, G. E., Byerlay, J. R., 1970, Ground water and geology of Keweenaw Peninsula, Michigan Geological Survey Division, Michigan Department of Natural Resources, Water Investigation 10, 41 p.

Huber, N. K., 1973a, Glacial and postglacial geologic history of Isle Royale National Park, Michigan, U.S. Geological Survey Professional Paper 754-A, 15 p.

_____, 1973b, Geologic map of Isle Royale National Park, Keweenaw County, Michigan: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-796, 1 Sheet (Scale 1:62,500).

_____, 1975, The geologic story of Isle Royale National Park, U.S. Geological Survey Bulletin 1309, 66 p.

Lane, A. C., 1898, Geologic Report on Isle Royale, Michigan, Geological Survey of Michigan, vol. VI, Part 1, p. 105.

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Table 1.--Lithologic description of materials from test hole 1

(T.64 N., R.38 W., section 29DCDC1. Latitude: 47°54'37", longitude: 089°09'29". Altitude about 665 ft above National Geodetic Vertical Datum of 1929. Drilled July 28, 1981. Lithologic description by N. G. Grannemann and F. R. Twenter)

Lithologic description	Depth to top
GLACIAL DEPOSITS, undifferentiated.	
Sand and gravel, trace of silt. Sand is medium to coarse grained, subrounded, tan; gravel is fine to coarse grained, subangular to subrounded. About 80 percent sand and 20 percent gravel.	0
Sand, gravel, and cobbles, trace of silt. Sand is very fine to very coarse grained, subrounded, tan to brown; gravel is fine to coarse grained, subangular. About 80 percent sand, 15 percent gravel and 5 percent cobbles.	2
Sand, silt, clay, and gravel, few cobbles. Sand is very fine to very coarse grained, subrounded, tan to brown; silt is tan; clay is red to brown; gravel is medium to coarse grained, angular to subangular. About 50 percent sand, 20 percent silt, 20 percent clay, and 10 percent gravel.	6
Silt, sand, and clay, some gravel, few cobbles from 20 to 29 feet. Silt is red to tan; sand is very fine to medium grained, subrounded; clay is red to brown; gravel is fine grained, subrounded. About 70 percent silt, 15 percent sand, 10 percent clay, and 5 percent gravel.	8
Silt, sand, clay, and cobbles, some gravel. Silt is tan; sand is very fine to medium grained, subrounded; clay is brown; gravel is fine grained, subrounded. About 60 percent silt, 20 percent sand, 10 percent clay, and 10 percent cobbles.	30
Gravel, sand, and silt, trace of clay, few cobbles. Gravel is fine to coarse grained, subangular to subrounded; sand is very fine to medium grained, few coarse grains, subrounded, mostly tan; silt is tan. About 40 percent gravel, 40 percent sand, and 20 percent silt.	49
Silt, gravel, sand, and clay, few cobbles. Silt is tan to gray; gravel is fine to coarse grained, angular to subrounded; sand is very fine to fine grained, rounded; clay is tan to red. About 60 percent silt, 20 percent gravel, 10 percent sand and 10 percent clay.	50

Table 1.--Lithologic description of materials from test hole 1--continued

Lithologic description	Depth to top
Gravel, clay, and silt, some sand, few cobbles. Gravel is fine to coarse grained, subangular; clay is red to brown; silt is tan; sand is very fine to very coarse grained, subrounded, tan. About 45 percent gravel, 25 percent clay, 25 percent silt and less than 5 percent sand.	52
Sand, gravel, and silt, some clay, few cobbles. Sand is very fine to very coarse grained, subangular, tan, black, and white; gravel is fine to coarse grained, subangular; silt is tan. About 60 percent sand, 30 percent gravel, and 10 percent silt.	54
Silt, gravel, cobbles, sand, and clay. Silt is tan; gravel is fine to coarse grained, angular; sand is very fine to medium grained, subangular, tan to black; clay is red to brown. About 40 percent silt, 30 percent gravel, 15 percent cobbles, 10 percent sand, and 5 percent clay.	59
Large boulder (?). Most of day spent drilling this 2 feet. Casing stopped at 78 feet leaving an uncased zone to the top of bedrock. Thus, all samples below this point may contain fragments from the glacial deposits. Two pebbles from 135 feet had flat surfaces showing glacial straie.	78
BEDROCK, Portage Lake Volcanics, undifferentiated	
Ophite, trace of calcite, limonite (?), hematite, and tan secondary mineral (analcime ?); some clay and silt probably caving from 78 to 80 feet.	80
Ophite, trace of calcite, hematite, and tan secondary mineral (analcime ?); few flecks of copper; some clay, silt and rounded gravel probably caving from 78 to 80 feet.	85
Ophite, trace of copper, calcite, quartz, hematite, and chlorite; from 115 to 118 feet chlorite deposits and slickensides on several large rock samples indicate structural movement.	110
Ophite, trace of copper, calcite, quartz, and tan secondary mineral (analcime ?).	120
Depth of hole	135

Table 2.--Lithologic description of materials from test hole 2

(T.64 N., R.38 W., section 28CBBC1. Latitude: 47°54'54", longitude: 089°08'59". Altitude about 745 feet above National Geodetic Vertical Datum of 1929. Drilled Aug. 8, 1981. Lithologic description by N. G. Grannemann from samples collected by driller)

Lithologic description	Depth to top
GLACIAL DEPOSITS, undifferentiated.	
Sand and silt, some clay. Sand is very fine to coarse grained, subangular, tan to red; silt is tan to brown; clay is brown.	0
Clay, silt, sand, and gravel, some cobbles. Clay and silt are gray to brown; sand is very fine to very coarse grained, subrounded, tan to clear, mostly quartz; gravel is fine to coarse grained, subangular.	2
Boulders	9
Clay, silt, sand, and gravel, some cobbles. Clay and silt are red to brown; sand is very fine to coarse grained, subangular, mostly black; gravel is fine to coarse grained, angular.	10
BEDROCK, Portage Lake Volcanics, undifferentiated. Silt and clay in samples below this point probably result from disintegration of massive rock by drill.	
Ophite, some felsitic porphyrite, trace of limonite. Ophite is very fine to fine grained and black; porphyrite has red groundmass and white to blue phenocrysts (zeolite?), phenocrysts are medium grained; limonite is a secondary coating.	17
Ophite, trace of calcite; some silt and clay. Ophite is very fine grained and black.	20
Ophite, trace of copper, calcite, porphyrite, and red to white secondary mineral (analcime?). Ophite is very fine to fine grained, is black, red, and green; porphyrite has red very fine grained groundmass and blue to white phenocrysts (zeolite?)--some phenocrysts are calcite.	40
Ophite, trace of calcite and tan secondary mineral (analcime?); some silt and clay. Ophite is very fine grained, is red to black.	70

Table 2.--Lithologic description of materials from test hole 2--continued

Lithologic description	Depth to top
Amygdaloid, contains chlorite, quartz, calcite, and trace of copper and tan secondary mineral (analcime?). Amygdaloid has very fine grained, red groundmass; amygdules are white to green and coarse grained.	85
Ophite, trace of chlorite, calcite, quartz, and a tan secondary mineral (analcime?); some silt and clay. Ophite is very fine grained and black, some chlorite phenocrysts.	89
Ophite, trace of calcite, chlorite, and a tan secondary mineral (analcime?). Ophite has very fine grained black groundmass, trace of red and green, some chlorite phenocrysts.	90
Ophite, trace of tan secondary mineral (analcime?), some silt and clay. Ophite has very fine grained black groundmass.	110
Ophite, trace of calcite, tan secondary mineral (analcime?), and a few red phenocrysts (hematite?). Ophite has very fine grained black groundmass, trace of red, green, and white, phenocrysts are coarse grained.	115
Ophite, some copper oxide and native copper, trace of calcite and tan secondary mineral (analcime?). Ophite has very fine grained black groundmass. Zone has more copper than any other encountered in this well.	125
Ophite, trace of copper, chlorite, hematite (?) and tan secondary mineral (analcime?). Ophite has very fine grained black groundmass.	130
Ophite, trace of copper and tan secondary mineral (analcime?), some silt and clay. Ophite has very fine grained black groundmass.	145
Ophite, trace of copper, chlorite, hematite (?), porphyrite, calcite, and tan secondary mineral (analcime?). Ophite has very fine grained black groundmass, trace of red and green.	155
Depth of hole	175

Table 3.--Lithologic description of materials from test hole 3

(T.64 N., R.38 W., section 28CBBC2. Latitude: 47°54'55", longitude: 089°08'58". Altitude about 745 ft above National Geodetic Vertical Datum of 1929. Drilled Aug. 14, 1981. Lithologic description by N. G. Grannemann)

Lithologic Description	Depth to top
GLACIAL DEPOSITS, undifferentiated.	
Sand, gravel, silt, and boulders. Sand is very fine to medium grained, subrounded to rounded, stained red; gravel is medium to coarse grained, subrounded; silt is red. About 50 percent sand, 30 percent gravel, and 20 percent silt. Boulder at 2 feet.	0
Clay, silt, sand, gravel, and cobbles. Clay and silt are brown to tan; sand is very fine to very coarse grained, subangular to subrounded; gravel is fine to coarse grained, subangular, mostly black; cobbles are mostly basalt. About 50 percent clay, silt, and sand, and 50 percent gravel and cobbles.	3
Clay, silt, sand, gravel, and cobbles. Clay and silt are red to brown, gray from 20 to 21 ft; sand is very fine to medium grained, subangular; gravel is fine to coarse grained, angular to subangular, mostly black; cobbles are mostly basalt. About 60 percent clay, silt, and sand, and 40 percent gravel and cobbles.	15
BEDROCK Portage Lake Volcanics, undifferentiated. Clay in samples below this point probably results from disintegration of massive rock by drill.	
Ophite, trace of copper, calcite, chlorite, limonite(?) and tan secondary mineral (analcime?). Ophite has very fine grained groundmass.	21
Ophite, trace of calcite, copper, clay, and hematite (?). Ophite has very fine grained black groundmass, some red to brown clay.	30
Porphyrite, some quartz, calcite, and clay, trace of copper from 47 to 56, chlorite from 53 to 56, and zeolite (?) from 44 to 47. Porphyrite has very fine grained red to black groundmass with white to green coarse grained phenocrysts; clay is red.	41

Table 3.--Lithologic description of materials from test hole 3--continued

Lithologic description	Depth to top
Ophite, trace of calcite, quartz, and chlorite. Ophite has very fine grained black groundmass.	56
Amygdaloid, breccia, some quartz, calcite, copper, zeolite (?), and chlorite. Amygdaloid has medium to coarse red groundmass, some white, blue, and green amygdules.	64.5
Ophite, trace of chlorite, clay, calcite, and zeolite (?). Ophite has very fine grained black groundmass; clay is red. Clay, as well as some undescribed amygdoidal rocks in sample caved from 64.5 to 65.5 level.	65.5
Depth of hole	71